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An Integrated Low-Energy Ventilation System to Improve Indoor Air Quality and Thermal Comfort of Primary School Buildings in the Cold Climate Zone of China

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Abstract

Indoor air quality (IAQ) and thermal comfort in schools are serious concerns in China because they have significant effects on student health, academic performance and learning productivity. Due to the financial limitations and the requirements of building design regulations, primary school buildings in China are commonly naturally ventilated. However, the applicability of natural ventilation dramatically depends on the suitability of the local climate. On ambient air pollution days and in the cold winter or hot summer seasons, natural ventilation cannot deliver clean air and provide a thermally comfortable environment. Air purifiers have become popular for mitigating indoor air pollution. However, air purifiers are not always efficient and cannot dilute CO_2 concentrations in closed spaces. Additionally, some purifiers may generate ozone gases as they remove other air pollutants. Furthermore, many governments have rejected the installation of air purifiers in classrooms because of the power shortages, financial limitations and inadequate space.

To solve these issues, an integrated low-energy ventilation (ILEV) system was invented. The system includes four main parts: a solar chimney, natural ventilation, earth-to-air heat exchangers (EAHEs), and a sunspace with plants. These four parts form the ILEV system, which can be employed by primary school buildings in the cold climate zone of China. In the system, fresh air is preheated or precooled to the temperature of the undisturbed soil by EAHEs and is then supplied to the sunspace. The air is cleaned in the sunspace by the plants and is further supplied to the classrooms. Finally, the waste air inside classrooms is released through the solar chimney by stack effects.

To explore the performance of the ILEV system, a typical school building located in the cold climate zone of China was selected. The case study building was redesigned to install the ILEV system based on the School Building Design

Regulation-2011 (SBDR-2011) and the Public Building Energy Saving Standard-2015 (PBESS-2015).

The research methods in this work involve the dynamic thermal modelling (DTM), computer fluid dynamics (CFD) simulations and experimental measurements. The experimental methods were used to explore the abilities of plants to remove air pollutants ($PM_{2.5}$ and PM_{10}). The DTM provided hourly classroom data regarding the average indoor air temperature, relative humidity, airflow rates, CO_2 levels and heat gains throughout the calendar year. The CFD simulations verified the fluidity of the ILEV system and provided a steady state analysis of the internal air flow distribution in classrooms. An energy simulation model created in GBSWARE was used to quantify the energy consumption of the case study building. Revit models of the case study building were used to generate material take-off sheets. These sheets indicate the additional incremental material costs and estimate the payback period of the ILEV system.

The simulation results and experimental data indicate that the air temperatures inside the classrooms were maintained in the range of 15°C to 27°C throughout the year. The internal CO_2 concentrations averaged approximately 900 ppm in all classrooms. In addition, the indoor $PM_{2.5}$ and PM_{10} concentrations were only 48% and 64% of the current PM concentrations in primary school classrooms, respectively. The ILEV system consumed approximately 2% of the energy currently consumed by the cast study primary school buildings. Consequently, over 90% of the CO_2 emission was reduced. The payback period of the ILEV system was 9.7 years. Compared to other renewable technologies, the ILEV system only requires 19% of its lifespan to recoup the initial costs and provides economic benefits over 40 years.

In summary, a low-energy system was designed to provide clean air and a thermally comfortable indoor environment in the primary school buildings

located in the cold climate zone of China. This system can save energy, reduce CO_2 emissions and provide significant economic benefits.

Acknowledgment

Firstly, I would like to express my sincere gratitude to my supervisor Dr Wu Deng for the continuous support of my Ph.D. study and related research, for his patience, motivation, and immense knowledge. His guidance helped me in all the time of research and writing of this thesis. I could not have imagined having a better supervisor for my Ph.D. study.

My sincere thanks also goes to Dr Rosangela Tenorio for her professional guidance, unwavering supports, stimulating suggestions, comments and patience in reading through numerous papers and multiple drafts of this thesis.

Furthermore, I would like to thank all my friends in the University of Nottingham for their help.

My special thanks and warmest appreciation to all my family members specially my wife, my son, my parents, my sister, and my in-laws for their great support. It would have been impossible for me to carry out this research without them.

List of publications

Journal publications

(1) **Peng, Z**., Deng, W., Hong, Y.D. (2019). Investigation of Thermal Sensation of Occupants in Domestic Buildings Located in Different Regions of China. *International Journal of Sustainable and Green Energy,* Vol. 8, No. 3, 2019, pp. 45-55. doi: 10.11648/j.ijrse.20190803.11.

(2) Hong, Y.D., Deng, W., Ezeh, C.I., **Peng, Z.** (2019). Attaining sustainable high-rise office buildings in Warm-Summer-Cold-Winter climates: A case study on Frankfurt. *International Journal of Low-Carbon Technologies.* DOI: IJLCT-2019-029.R1 (EI Compendex and Sciences Citation Index Expanded, Impact Factor: 1.054).

(3) **Peng**, **Z**., Deng, W., Hong, Y.D. (2019). Materials Consumption, Indoor Thermal Comfort and the Associated Energy flows of Urban Residential Buildings: Case Studies in the Cold Climate Zone of China. *International Journal of Building Pathology and Adaptation.* https://doi.org/10.1108/IJBPA-01-2019-0007 (EI Compendex).

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(1) Hong, Y.D., Deng, W., Hong, S.H., **Peng, Z.** (2019). Modeling Optimum Retrofit Package Measures for Existing Low-rise Office Building Prototypes in Shanghai. In: *MIT Applied Energy A+B Symposium (AEAB 2019)*.

(2) **Peng, Z.** Deng, W and Hong, Y.D. (2019) Investigation of Indoor Air Quality and Identification of Plant's Capabilities in Removing Air Pollutants in Urban Residential Buildings. In: *the 3rd International Conference on Sustainable Development and Green Buildings.* Shanghai, China, 14-16 March 2019. (EI Compendex).

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(5) Xue-Yong Wang., **Zhen Peng**., Xiao-Qian Yu., Jun Zhao., and Lin Wang.

Intelligent Architecture Design and Research Based on Smart City. *2016 International Conference on Mechanics and Architectural Design*: pp. 156-161. Suzhou, Jiangsu, China, 2016. 05.14-05.15.

Upcoming journal publications:

(1) **Peng, Z.**, Deng, W., Tenorio, R. (2019). An Integrated Low-Energy Ventilation System to Improve Indoor Air Quality and Thermal Comfort of Primary School Buildings in the Cold Climate Zone of China. *Sustainable Cities and Society*. (Second-round reviewing, EI Compendex and Sciences Citation Indexed, Impact Factor: 4.624).

(2) **Peng, Z.**, Deng, W., Hong, Y.D. (2019). An Experimental Work to Investigate the Capabilities of Plants to Remove Air Pollutants. *International Journal of Low-Carbon Technologies* (under reviewing).

(3) Hong, Y.D., Deng, W., Ezeh, C.I., Hong, S.H., **Peng, Z.** (2019). Building energy retrofit measures in Hot-Summer-Cold-Winter climates: a case study on Shanghai. *Energies* (under reviewing).

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λ	Thermal conductivity (W/m·K)
C_{ps}	Specific heat (J/kg·K)
ϕ	Moisture content of soil (kg/kg)
ϱ	Density (kg/m^3)
t	The time (Day)
z	The depth of earth (m)
CE	Convective energy
SR	Solar Radiation
LR	Long-wave Radiation
LE	Latent heat flux
T_a	The average soil surface temperature (K)
T	The soil temperature (K)
h_{sur}	The conductivity coefficient of the soil (W/m·K)
u	The ground surface wind velocity (m/s)
A_m	The amplitude of ambient air temperature (K)
b	The capacity of absorption and radiation (J/kg·K)
S	Local solar radiation (W)
ε_L	The long wave emissivity
ΔR	An empirical coefficient factor which related to ground soil relative humidity, surface air relative humidity, and ambient air temperature, etc.
P_a	The ground real saturated vapor pressure (Pa)
P_S^S	The ground surface saturated vapor pressure (Pa)
r_a	Ground surface air relative humidity (%)
f	Influential coefficient which is relevant to the ground surrounding environment and humidity
$\dot{m}$	Mass flow air rate (kg/s)
T_{in}	Inlet air temperature (K)
T_{out}	outlet air temperature (K)
D	the diameter of the pipe (m)
L	length of the pipe (m)
N_p	the number of pipes
ε	The effectiveness of EAHE system
Q_h	The total heat transferred (kg/s)
C_{air}	The specific heat of air (J/kg·K)
h_{air}	The convective heat transfer coefficient (W/m^2·K)
A	The internal surface area of the pipe (m^2)

ΔT	The logarithmic average temperature difference (K)
T_{EUT}	The annual average ambient air temperature (K)
NTU	The number of transfer units
K	Thermal conductivity of air (W/m·K)
N_u	The Nusselt number
R_e	The Reynolds number
P_r	Prandtl number
f	friction factor for smooth pipes
v_a	velocity of air through the pipe (m/s)
u_{air}	the dynamic viscosity of air (kg/m·s)

Section 6.3, Chapter 6

ΔP	pressure difference between the indoor air and ambient air caused by temperature difference (Pa)
g	Acceleration due to gravity (9.81m/s)
ρ_{ext}	Ambient air density (kg/m^3)
ρ_{int}	Indoor air density (kg/m^3)
h_{inlet}	The height of inlet opening above datum (m)
T_{ext}	Outdoor air temperature
T_{int}	Indoor air temperature
h_2	The height of outlet of the stack above datum (m)
h_1	The height of inlet of the stack above datum (m)
Q_s	Air flow rate through an opening (m^3/s)
C_d	Discharged coefficient (0.61)
A_{eff}	Effective free structure opening area (m^2)
ϱ	Air density (kg/m^3)
h_{npl}	The height of neutral pressure level above datum (m)
Q_{total}	Total air flow rate through the stack (m^3/s)
P_w	Pressure differences due to the wind (Pa)
C_p	is the pressure coefficient
P_w^{inlet}	Pressure difference between the inside and outside of inlet due to the wind (Pa)
P_w^{outlet}	Pressure difference between the inside and outside of outlet due to the wind (Pa)
P_{ref}	The standard atmosphere pressure (Pa)
v	The wind speed (m/s)
C_P^{inlet}	Pressure coefficient at inlet
C_P^{outlet}	Pressure coefficient at outlet
Q_w	The air flow rate due to wind effects (m^3/s)

Section 6.4, Chapter 6

α	The efficiency of the solar heat collecting plate

τ	The transmission coefficient of glass
$\bar{S}(t)$	The average solar radiation (W/m^2)
h_f	The U-value of the glass (W/m^2·K)
T_p	The temperature of solar collecting plate (°C)
$\bar{T}_f$	The temperature of fluid inside of stack (°C)
U_L	The heat losses coefficient (W/m^{2}K)
T_O	The average ambient air temperature (°C)
G	The air flow rate (kg/s)
c_p	The specific heat at a constant pressure (J/kg·K)
Δx	The infinitesimal unit (m)
w	The width of heat collector (m)
T_i	Indoor air temperature (°C)
l	Represents the length of the solar chimney (m)
A_o	Represents the solar heat absorbing areas (m^2)
C_d	The discharge coefficient
H	The height of solar chimney (m)
θ	The angle of inclination of the solar heat collecting plate
$I_{D\theta}$	Direct solar radiation on the solar heat collecting plate (W)
I_{DN}	The solar direct radiation on the plate of the collector (W/m^2)
i	The incidence angle
I_O	The constant value of solar radiation (W/m^2)
P	The coefficient of atmospheric transmittance
m	The mass of the atmosphere (kg)
I_{dH}	The sky scattering radiation direct on the plate of solar heat collector (W/m^2)
$I_{S\theta}$	The total solar radiation on the plate of solar heat collector (W/m^2)
HG_g	The total solar heat gains for the solar chimney (W/m^2)
HG_τ	The solar heat gains due to the solar radiation (W/m^2)
HG_α	The solar heat gains due to the solar radiation absorbed by glasses (W/m^2)
I_{Di}	The solar direct radiation on the glass with an incidence angle of i (W/m^2)
I_d	The solar diffuse radiation on the glass (W/m^2)
τ_{Di}	The transmittance coefficient of solar direct solar radiation with an incidence angle, i
τ_d	The transmittance coefficient of solar diffuse solar radiation
a_{Di}	The radiation absorptivity of the glass for the solar direct radiation
a_d	The radiation absorptivity of the glass for the solar diffuse radiation
R_a	The heat transfer resistance for the outer surface of the glass (K/W)
R_r	The heat transfer resistance for the inner surfaces of glass (K/W)

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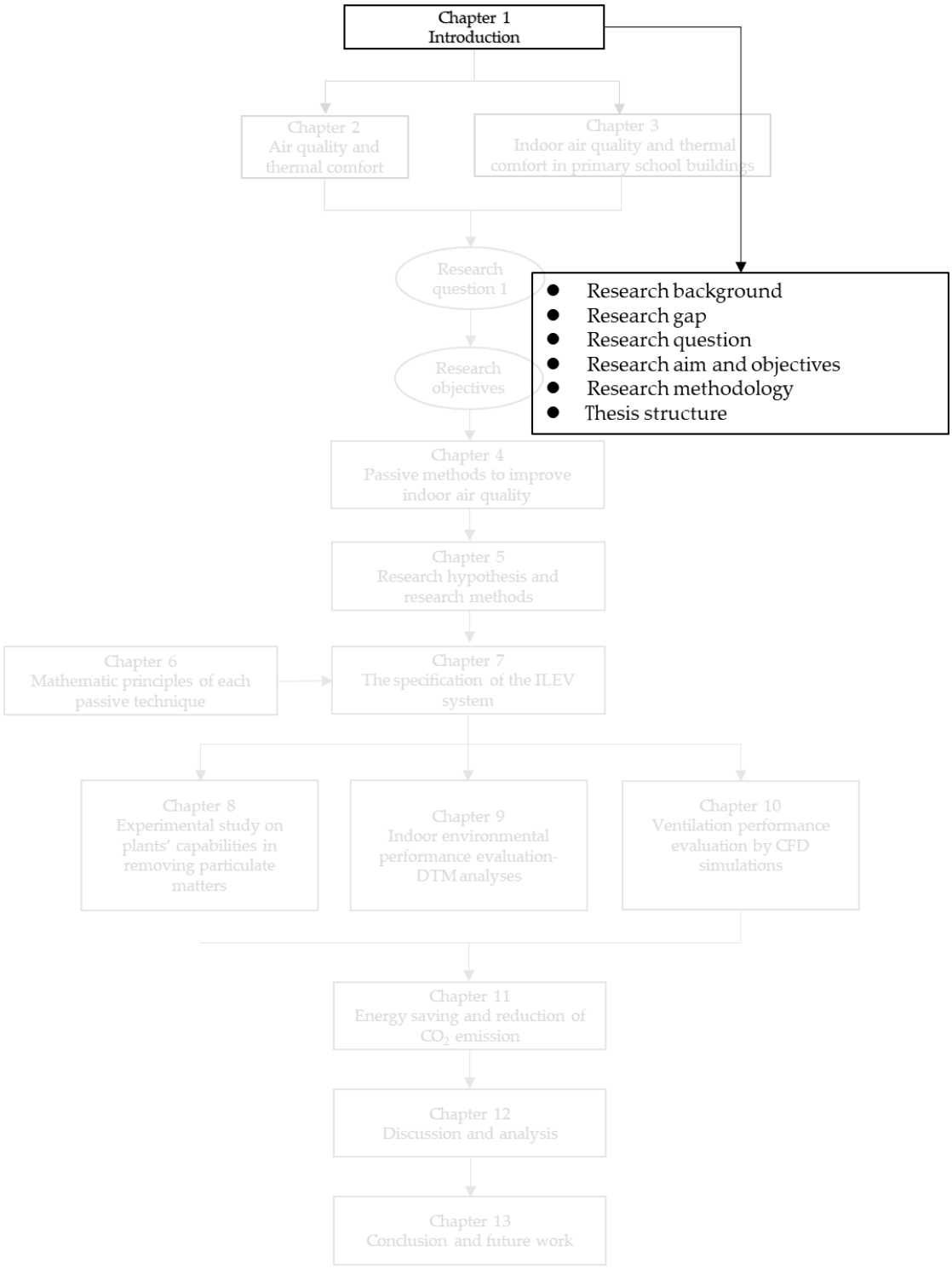
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Chapter 1: INTRODUCTION



The content of Chapter 1

1.1. Research Background

Air is an indispensable part of human life, and good air quality is fundamental to human health. The air consists of many gases, such as nitrogen, oxygen, and inert gases, in varying proportions. The air also contains gases such as hydrogen, carbon monoxide (CO), nitrous oxide (NO), carbon dioxide (CO_2), and sulphur oxide (SO). Air is naturally clean and suitable for human life. However, air pollution has rapidly increased since industrialisation in the 1800s. Fossil fuels, such as coal and oil, were the primary energy sources for the industrial revolution, and the combustion of fossil fuels increases the levels of air pollutants. Studies have found that greenhouse gases, such as CO_2, methane, and NO have become more abundant since the industrial revolution (Figure 1.1) (Intergovernmental Panel on Climate Change (IPCC), 2007). Air pollutants have reached high levels today than at any other time during the past hundred years (Schilt et al., 2010). The resulting air pollution has serious affected human health. In 1952, smog, which is formed by fog and air pollutants, killed at least 4000 people over several days in London (Bell et al., 2004). In 1948, industrial air pollution led to 20 deaths and 7000 illnesses in Donora, Pennsylvania (Bachmann et al., 2017).

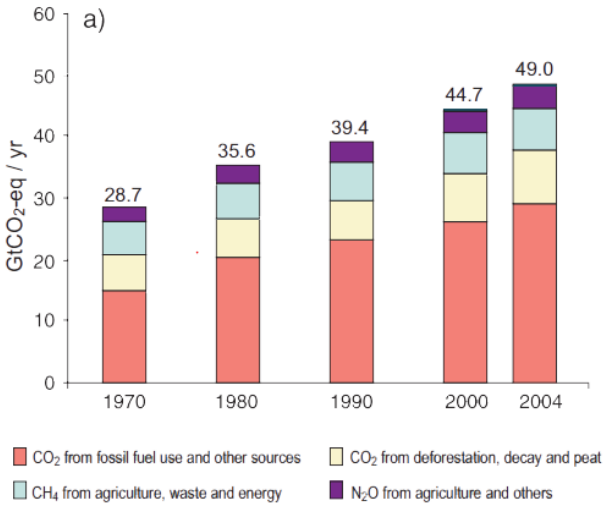


Figure 1.1. *The increasing of greenhouse gases*

Source: Intergovernmental Panel on Climate Change (IPCC) (2007)

In the current world, air pollution is the largest killer worldwide and a threat to the survival of humanity (World Health Organization (WHO), 2017). In 2016, the World Health Organization (WHO) stated that outdoor air pollution has increased 8% globally in recent years. Additionally, approximately 6.5 million deaths can be attributed to air pollution each year. Moreover, air pollution is worse in developing countries than in developed countries because the energy structure in most developing countries still mainly relies on fossil fuels (WHO, 2016).

Ambient air pollution has been one of China's most serious environmental issues recent years (Ministry of Environment Protection (MEP), 2002; MEP, 2007; MEP, 2011). The Chinese economy still mainly depends on fossil fuels (Lin, 2012). Consequently, the ambient air is profoundly influenced (Moore, 2018). Because air pollution has reached critical levels, the Chinese government has pledged to address the problem of air pollution and launched several air cleaning plans in recent years. However, despite considerable efforts made by the government, it will still take China approximately 30 years to fundamentally tackle air pollution issue based on the experiences of developed countries such as the UK and USA, as estimated in the Annual Report from Xue (2014).

High exposure to air pollution can cause health problems such as couching, difficulty breathing, and congenital disabilities. Therefore, people must reduce the time they spend outdoors. However, it may not be safe to stay indoors either, as many researches have indicated that indoor air pollution levels may be two to five times higher than outdoor air pollution levels (US EPA, 2018). Indoor air pollution is significantly affected by the outdoor air pollution (Huang et al., 2007). Another critical factor that influences indoor air pollutant levels is building defects. Riley et al. (2002) found that indoor air pollutant concentrations can be significantly influenced by the infiltration of pollutants from the ambient air through cracks in buildings. Tian et al. (2009) stated that building airtightness is one of the key

factors that influences the exposure levels of occupants to air pollutants. In addition, indoor occupants' activities, such as smoking, people's movement and cooking, also affect the indoor air quality (IAQ) (Abt et al., 2000; Long et al., 2000).

Children have been considered small adults in many studies of health effects (Kleinman, 2018). However, there are many differences between children and adults when exposed to unhealthy air. First, children take in more air pollutants because they breathe a higher amount of air at a faster rate than adults (Landrigan, 1998; Faustman et al., 2000). Second, children may respond to air pollution differently than adults. Children are more sensitive and vulnerable to the adverse health effects of air pollution than adults because of their immature immune systems (Buka et al., 2006). Therefore, air quality has been recognized as one of the most important factors that affects the health of children. Children generally spend over 30% of their life in school, and approximately 70% of this time is in an indoor environment based on school days (Bakó-Biró et al., 2004). Thus, classrooms are the place that children spend the most time when they are not at home. Therefore, IAQ in classrooms plays an important role in maintaining a safe, healthy, and comfortable indoor environment for children.

1.2. Research Gap

Natural ventilation is the oldest way of mitigating issues with the indoor air environment before the invention of mechanical ventilation. Such ventilation removes excess CO_2 and regulates the indoor air temperature using natural forces. Currently, natural ventilation provides an attractive design strategy due to the excellent energy savings potential. Various projects have been completed involving the natural ventilation of public buildings, such as in the Queens Building in Leicester, UK, the Lanchester Library in Coventry, UK and the Low-Energy Demo Building of Tsinghua University in Beijing, China. However, the applicability of natural ventilation dramatically depends on the suitability of the local climate (Kolokotroni et al., 2006). In recent years, the applicability of natural ventilation in different climate regions has been evaluated around the world. Artmann et al. (2007) studied the applicability of natural ventilation in public buildings throughout Europe, and the results indicated that natural ventilation is inefficient in southern Europe because of the warm local weather conditions, especially during the hot summer months. Su et al. (2009) found that natural ventilation is not appropriate in winter and transition seasons in Shanghai, China, due to the low ambient air temperature. Tan and Deng (2017) evaluated the potential of natural ventilation in different climate zones in Australia and concluded that cold climate zones have the lowest natural ventilation potential because of the cold weather conditions.

Because of the effects of climate on the potential of natural ventilation, integrated systems of natural ventilation and passive air precooling or preheating techniques have become attractive options. In recent years, studies (e.g., Maerefat and Haghighi, 2010; Benhammou et al., 2015) have investigated passive methods that can be coupled with natural ventilation strategies, such as using earth-to-air heat exchangers (EAHEs) and solar chimneys. EAHEs use the Earth's constant soil

temperature to warm or cold air before it flows inside a space. Additionally, solar chimneys can enhance the air flow rate for natural ventilation. Such integrated systems can overcome the drawbacks of conventional natural ventilation systems and ensure that buildings can be naturally ventilated in the hot summer and extremely cold winter seasons. However, integrated systems still cannot provide a healthy indoor environment since air pollutants from ambient air pollution cannot be filtered during the ventilation process. Published studies have investigated the relationship between the natural ventilation potential and ambient air pollution. For example, a study conducted by Tong et al. (2016) stated that in general, northern China has a low natural ventilation potential due to ambient air pollution in recent years. Peng et al. (2017) suggested that natural ventilation can actually reduce the IAQ when the ambient air is not clean.

Since natural ventilation has become less commonly applied to address air pollution in the ambient environment in recent years, new methods have been developed to address such issues. Mechanical ventilation systems with built-in air purifiers or individual air purifiers have become popular. In China, a market study showed that the sales volume of household air purification systems has increased dramatically since 2013, when the people first realised that the severity of the decades-long air pollution problem (Zhu, 2013). However, some research has verified that air purifiers are not always efficient, and some may be harmful to the health of occupants (Li et al., 2015). For example, some air purifiers generate ozone gases as they remove other air pollutants. Moreover, not all people can afford air purifiers, especially those that provide better cleaning abilities are extremely expensive. Even for the government, air purifiers are not an option for solving indoor air pollution problems. Taking primary school buildings in China as examples, in 2015, the Hangzhou government and Beijing government rejected a parent-led proposal to install air purifiers in every classroom because of the financial shortage (Education Department of Hangzhou, 2017; Education

Department of Beijing, 2015). Apart from these cost problems, air purifiers are not the optimal choice for mitigating air pollution in many cases. For example, people prefer to close windows and doors on days with high air pollution levels and turn on air purifiers inside. However, the IAQ could still decline due to the aggregation of CO_2 because most air purifiers cannot dilute CO_2 concentrations in closed spaces. Moreover, in countries with national energy structures that still rely on coal and oil, air purifiers may decrease the ambient air quality by cleaning indoor air for human, but because they consume electricity and increase building energy consumption, they indirectly increase fossil fuel consumption, which contributes to polluting the ambient air.

In consideration of the drawbacks of air purifiers, plants, as a passive air cleaner, might be an alternative option for IAQ. In past decades, many studies have demonstrated that plants can be used to easily and affordably combat indoor air pollution (Tarran et al., 2007; Pegas et al., 2012). Researchers have intensively investigated the capabilities of plants to remove various air pollutants. However, the methods of using plants to clean air in these studies were only applicable for plants in a closed indoor space, and plants were not treated as a part of the ventilation systems. The role of plants in achieving the goal of cleaning air has not been extensively studied.

In China, most classrooms in public primary school buildings are naturally ventilated (Hou et al., 2015; Liang et al., 2017). The reason for the dominance of natural ventilation is two-fold. First, regulations related to the design of primary school buildings in China encourage the application of natural ventilation. For example, the School Building Design Code (GB50099-2011) states that school buildings in the hot summer and cold winter, hot summer and warm winter, and temperate climate zones should be ventilated with windows open throughout the year. Additionally, school buildings in the severe cold and cold climate zones

should be naturally ventilated, except in winter. Second, local governments could not afford to install mechanical ventilation systems in all public primary schools, and, moreover, school administrators have needed to save money to compensate for electricity consumption (Zhang, 2010). Thus, in most primary school classrooms, fresh air can be only introduced through windows and doors (Peng et al., 2017). On ambient pollution days, pollutants can be transported into classrooms. Additionally, in winter, when the most serious air pollution occurs frequently in China, windows and doors are often closed to maintain a comfortable indoor air temperature, and ventilation occurs via infiltration. In such a situation, the IAQ will be negatively influenced due to infiltration of the ambient air pollutants.

Previously, many studies (e.g., Liddament, 1996; Humphreys and Nicol, 2000; Seppänen and Fisk, 2002) evaluated the potential and clear benefits of the conventional natural ventilation systems and the integration of natural ventilation strategies and passive precooling or preheating techniques (e.g., EAHEs). Moreover, the capabilities of plants, as air cleaners, have been widely demonstrated. However, an extensive literature review indicated that no studies have focused on new ventilation systems that can provide clean air and thermal comfort for a broader range of weather conditions (e.g., during hot summer and extremely cold winter months and on air pollution days) while consuming little energy. Furthermore, although studies regarding the capabilities of plants in removing air pollutants have been conducted, no research has been conducted on the role of plants as a component in a natural ventilation system. Most studies related to IAQ in China were conducted in office buildings and residential houses (Peng et al., 2017). The IAQ and thermal comfort in primary school buildings have not been extensively investigated. An important knowledge gap remains for integrated ventilation systems that combine natural ventilation, plants, and

passive techniques. The potential performance of such a system has not been extensively investigated, especially for primary school classrooms.

1.3. Research Question

From the discussion above, a gap remains between reality and the pursuit of clean air and thermal comfort in the indoor environment in China. Notably, in primary school buildings, which are crowded and full of energetic students, a new integrated low-energy ventilation system (ILEV system) that combines natural ventilation, plants, and passive cooling or heating techniques should be developed to tackle air pollutions issues. The following research questions are addressed in this study.

1) How extensive is ambient air pollution in China?
    - *Ambient air quality in China*
    - *Indoor air quality in classrooms of primary school buildings in China*
    - *Influential factors*
2) Can low-energy technologies be combined to develop an ILEV system?
    - *Natural ventilation*
    - *Plants*
    - *Passive precooling and preheating techniques (e.g., EAHEs)*
    - *Solar chimneys*
3) How efficient is the ILEV system in mitigating indoor air pollution and thermal discomfort problems?
    - *Experimental study of plants*
    - *Dynamic thermal modelling (DTM)*
    - *Computer fluid dynamics (CFD) simulations*
4) What are the environmental and the economic benefits of the proposed ILEV system?
    - *Energy reduction*
    - *CO_2 emissions*
    - *Payback period*

1.4. Research Goal and Objectives

The primary goal of this Ph.D. work is to evaluate the thermal comfort and IAQ in primary school buildings in the cold climate zone of China and determine the capability of a designed ILEV system to improve the IAQ and thermal comfort and reduce building energy consumption. The goal of this research is achieved through the following objectives:

- Conduct a detailed literature review regarding the IAQ and thermal standards, and passive methods that can improve IAQ and reduce building energy consumption.
- Conduct field measurements of IAQ and thermal comfort in primary school buildings in the cold climate zone of China. Evaluate the correlation between IAQ and the ventilation system used.
- Establish an experimental model for investigating the capability of plants to remove air pollutants. Perform field measurements of air quality in an experimental model and identify to what extent plants can clean the air.
- Establish a mathematical coupled model of the ILEV system and provide detailed information on each component in the ventilation system, including the opening size, number of plants, internal air temperature and ventilation performance.
- Conduct CFD simulations and DTM modelling to validate the effectiveness of the ILEV system. Identify the internal flow pattern and indoor environment performance in primary school classrooms.
- Evaluate the potential energy-savings benefits and payback period based on the material consumption.

1.5. Research Methodology

The methodology is developed as a systematic plan to determine the answers to given research questions. This approach outlines the framework in which the research is to be conducted and identifies the detailed methods used to achieve the research objectives (Creswell, 2009). The selection of a research methodology largely depends on the type of research (Benz and Newman, 1998). The basic types of research can be broadly divided into nine categories (Table 1.1).

Table 1.1. Types of Research

	Types	Introduction
1	Descriptive research	Description of the state of affairs as it exists at present; report what has happened or what is happening
2	Analytical	Facts or information was already available
3	Applied	Action research; conducted to solve the problem of the organization setting
4	Fundamental	Conducted to develop some new theories
5	Quantitative	Based on the measurements of quantity or amount
6	Qualitative	Concerned with qualitative phenomenon
7	Conceptual	Related to abstract ideas or theory; used by philosophers and thinkers
8	Empirical	Data based research; relies on experience or observation
9	Others	Mixed of research types 1-8

Source: Kothari (2004).

For the different types of research in Table 1.1, two basic research methods can be used: quantitative and the qualitative methods (Kothari, 2004). Quantitative methods dominated social science research from the late 19th century through the middle of the 20th century, and qualitative methods have become more common since the latter half of the 20th century (Creswell, 2009). Recently, interest in mixed methods (mix of quantitative and qualitative methods) has increased, and such mixed method has been widely accepted (Creswell, 2009). In past decades, there has been a widespread debate regarding the relative merits of quantitative and qualitative methods. Some researchers believed the quantitative methods are more scientific and objective and that qualitative methods are more theoretic and subjective (Hughes, 1997). However, others have suggested that quantitative and qualitative methods can be used in combination to answer different research

questions with different objectives (Bryman, 2006). In addition, some researchers (Benz and Newman, 1998; Eisner, 1991) have argued that both qualitative and quantitative methods could be simultaneously used to answer the same research question. There is still no unified opinion regarding which method is more suitable for academic research (Panas and Pantouvakis, 2010). The selection of a research method mainly depends on the research purpose, research process, method of data collection, method of data analysis, and the interests of the researchers. Therefore, in practice, three methods are available: quantitative, qualitative, and the mixed methods. According to Creswell (2009), the applications of these three methods are as follows:

- Quantitative methods are for

  > "testing objective theories by examining the relationship between variables. These variables, in turn, can be measured, typically on instruments, so that numbered data can be analysed using statistical procedures."

- Qualitative methods are for

  > "exploring and understanding the meaning individuals or groups ascribe to a social or human problem. The process of research involves emerging questions and procedures, data typically collected in the participant's setting, data analysis inductively building from particulars to general themes, and the researcher making interpretations of the meaning of the data."

- Mixed methods are for

  > "inquiries involving collecting both quantitative and qualitative data, integrating the two forms of data, and using distinct designs that may involve philosophical assumptions and theoretical frameworks. The core assumption of this form of inquiry is that the combination of

qualitative and quantitative approaches provides a complete understanding of a research problem than either approach alone."

Thus, quantitative methods always involve numerical data produced by surveys, questionnaires, field measurements, real experiments, or other statistical methods. Moreover, the data are analysed with a wide range of numerical techniques, from simple graphs to complicated mathematical models. Qualitative methods always involve non-numerical data. Data are usually gathered from a wide variety of sources, such as interviews and personal descriptions. The data are oftern divided into different groups and themes for analysis in an interpretative manner. Qualitative methods aim to provide a complete detailed description of the research subject. Mixed methods are characterised by both quantitative and qualitative methods. In such methods, information or data is both quantitatively and qualitatively collected to accurately identify aspects of a phenomenon or a research topic from different angles using different approaches and techniques.

Quantitative methods often poorly describe the study context incompletely interpret a phenomenon. Qualitative methods have limitations associated with descriptions or interpretations of researchers based on their personal experience, knowledge, and cultural background. Therefore, by using the combination of quantitative and qualitative methods, the weaknesses of each method can be offset by the strengths of the other.

Based on the differences between quantitative and qualitative methods, the types of research methods can be categorised as shown in Table 1.2.

Table 1.2. Types of methods for each research approaches

Quantitative Approach	Survey - numerical data	Qualitative Approach	Description
	Correlation method		Observations
	Experimental study		Case study
	Empirical study		Interview
	Analytical study		Questionnaire
	Case study		Survey-descriptive

	Comparative		Schedule

Source: Kothari (2004).

In this research, quantitative and qualitative methods are both employed to fill the described research gap, answer relevant questions, and address the objectives of this Ph.D. work. A quantitative method is mainly used to determine the IAQ (Chapter 3) and establish and validate the mathematical model of the ILEV system (Chapters 6, 7, 8, and 9). The data were from field measurements (Chapters 3 and 8), software simulation results (Chapter 9) and official databases (Air Quality Platform, Yearbooks, and official reports). Additionally, these data were further analysed using simple graphs, figures, and complicated mathematical calculations.

A qualitative method is mainly used to identify the current air pollution level in China (Chapters 2 and 3), the factors that influence the IAQ (Chapters 2 and 3), the current measures taken to combat air pollution (Chapter 2), and the passive methods involved in the ILEV system (Chapters 4, 5 and 6). This method is mainly based on a critical literature review. Qualitative data were categorized into different groups. For example, the factors that influence IAQ were divided into three group: influential factors from the outdoor environment, influential factors from the indoor environment and building defects.

Figure 1.2 shows a diagram of the relationship between the research methodology and the research questions of this Ph.D. work. The diagram clearly shows the key points of each research question and the related research methods. For example, there are two critical points for the research question regarding ambient air pollution: the description of official reports and official monitoring data. These two key points were addressed with descriptive (qualitative) and analytical (quantitative) methods, respectively.

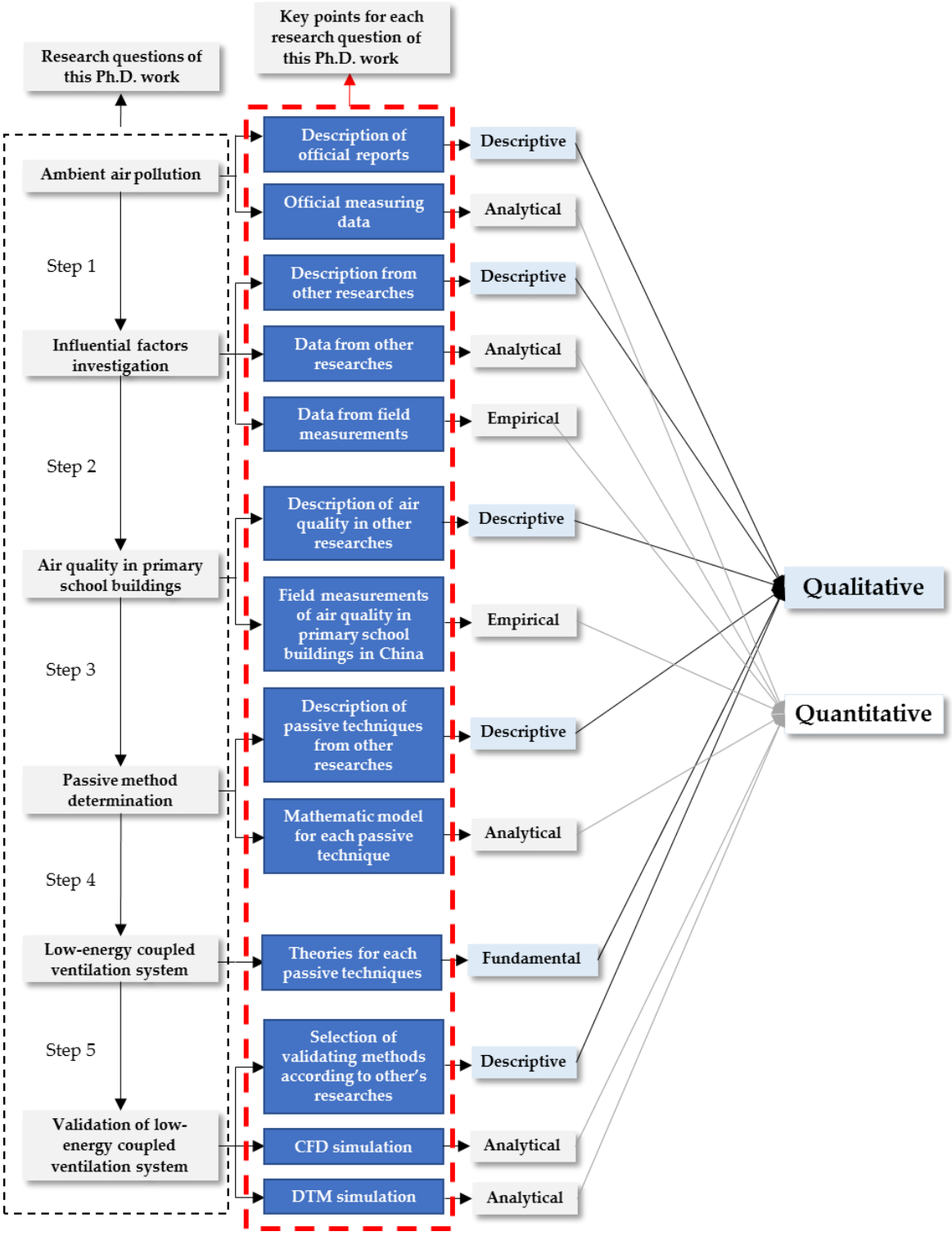


Figure 1.2. *The relationship between the research methodology and the research questions*

1.6. Thesis Structure

The structure of this Ph.D. work is consistent with the research process (Figure 1.3). Chapter 2 highlighted the ambient air pollution environment and influential factors. A critical discussion was provided regarding the research gaps, questions, and objectives addressed in this study. Field measurements of the IAQ in Chapter 3 gave insight into the current IAQ in primary school buildings in the cold climate zone of China. The primary data results indicated that natural ventilation is ineffective in mitigating ambient air pollution and that the influential factors reviewed, and research gap discussed in Chapter 2 are correct. Chapters 2 and 3 provided reasons for the review of passive methods, with the objectives of improving IAQ and thermal comfort and reducing building energy consumption. Chapter 4 introduced various passive methods (plants, EAEHs, solar chimneys, and natural ventilation) and provided a foundation for the research hypothesis. Using the findings from Chapters 2, 3, and 4, a new ILEV system was proposed in Chapters 5, 6 and 7. The research hypothesis was then theoretically and experimentally validated in Chapters 8, 9 and 10. In Chapter 11, the benefits of the designed ILEV system were critically analysed. Conclusions were drawn to provide design implications for future primary school buildings in the form of a new passive ventilation system (Chapter 13).

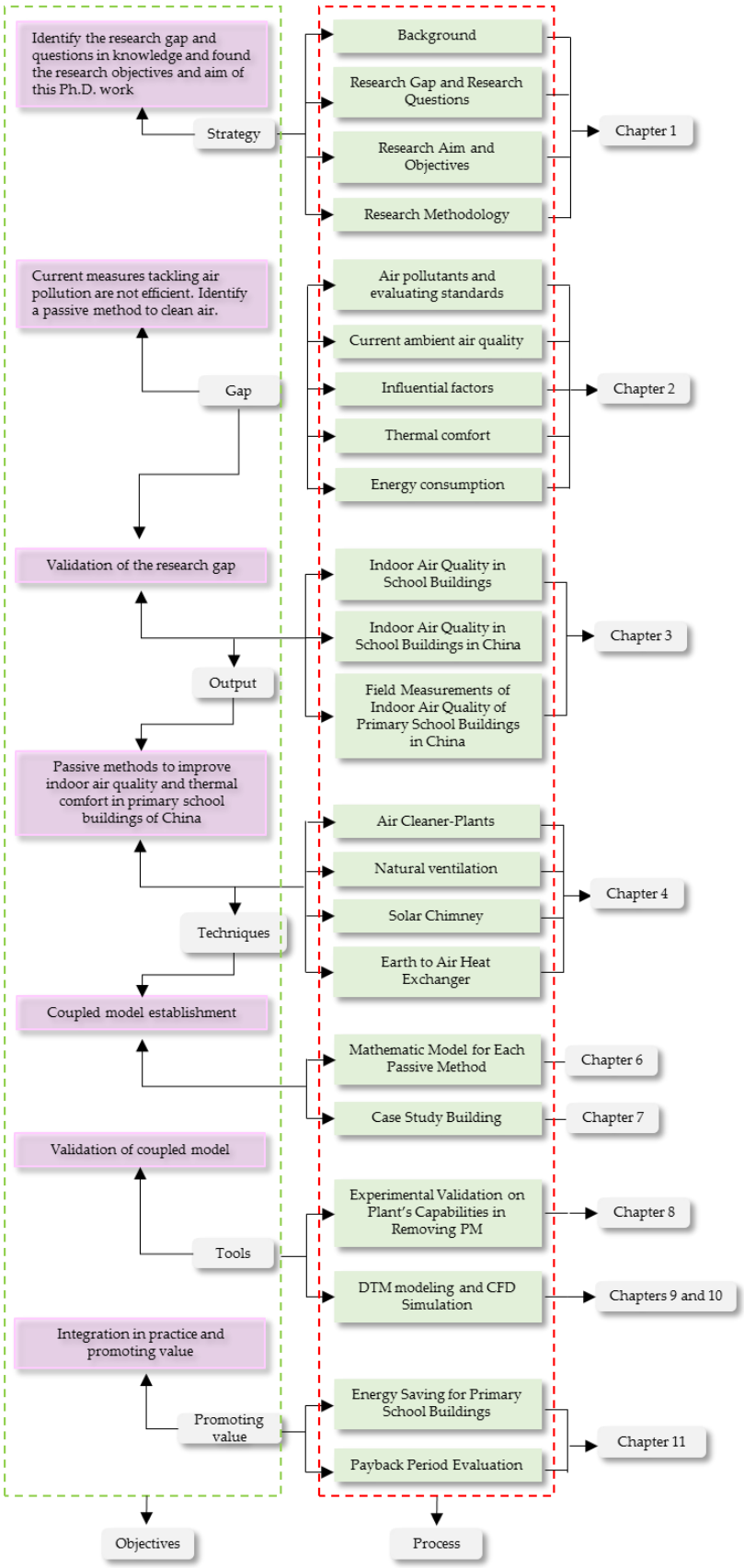
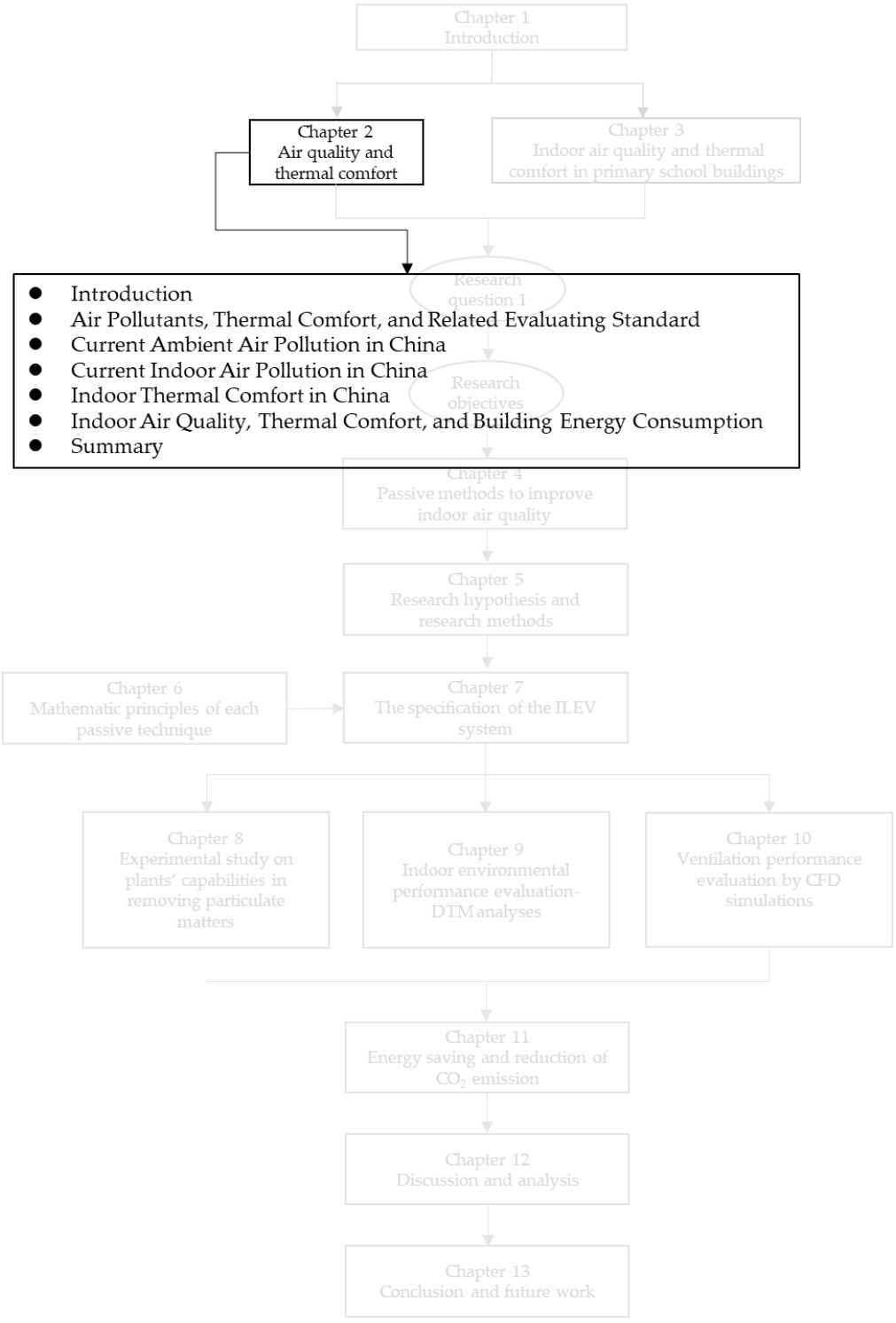


Figure 1.3. *Thesis structure*

Chapter 2: AIR QUALITY AND THERMAL COMFORT



The Content of Chapter 2

2.1. Introduction

In this chapter, the published studies on air pollution and IAQ are reviewed to validate the existence of the research gaps disscussed of this Ph.D. work. The chapter starts with a literature review on the common air pollutants and their evaluation standards, and a description of the current ambient air quality is then provided. Next, the three factors that influence the IAQ, i.e., ambient air pollution, indoor activities, and building conditions, are discussed. Additionally, the measures currently being used to mitigate indoor air pollution are given in detail.

The chapter concludes that the current measures used to mitigate indoor air pollution are inefficient and energy intensive. A new system that is able to simultaneously improve IAQ and reduce energy consumption is needed.

2.2. Air Pollutants, Thermal Comfort, and Related Evaluating Standard

2.2.1. Air pollutants and their sources

An air pollutant is defined as a substance (solid, liquid or gas) in the air that can have adverse effects on humans and the environment. Such substances can be produced by human activities or naturally exist. The following list summarises the primary air pollutants, their sources and the corresponding effects on human health.

- **Carbon dioxide**: CO_2 is typically produced naturally and by human activities, such as burning coal, oil, and wood chips and accounts for approximately 0.04% (400 parts per million) of the atmosphere (Team, 2018; Vaughan, 2018).
- **Ozone**: O_3 is a vital constituent of the troposphere and can increase the risk of certain lung diseases and result in signs and symptoms such as shortness of breath and chest pain. Fossil fuel combustion can emit ozone into the atmosphere. In an indoor environment, some types of equipment, like laser printers and projectors, release O_3 and consequently increase indoor O_3 levels.
- **Odour**: odour is the smell emitted by volatilized chemical compounds, people, and various building materials. People who remain in a room for a sufficiently long period may not be aware of an odour because their olfactory senses rapidly adjust to the odour (Fanger, 1988). Exposure to odours can result in health effects ranging from mild discomfort to more severe symptoms.
- **Volatile organic compounds** (VOCs): VOCs are a large group of organic chemicals that easily evaporate at typical room temperatures. Some VOCs are toxic and can easily affect occupant health, especially in vulnerable groups, such as children, infants and those that suffer from asthma and allergies (Mendell, 2007). Common indoor VOCs inclusde decane, butoxyethanol,

isopentane, limonene, styrene, xylenes, perchloroethylene, and formaldehyde. Various products, such as wood furniture and carpets, can produce VOCs.

- **Particulate matters (PMs)**: PM is a complex mixture of tiny solid particles and liquid droplets found in the air. The United States Environmental Protection Agency (EPA) classifies particle pollution into two groups: "Inhalable particles-PM_{10}" and "Fine particles-$PM_{2.5}$". PM_{10} includes particles with a diameter larger than 2.5 micrometres and smaller than 10 micrometres, and $PM_{2.5}$ includes particles with a diameter of 2.5 micrometres or smaller. These two types of particles vary in size and shape and be composed of hundreds of different chemicals. Most of these chemicals are emitted from construction sites, smokestacks, unpaved roads, and power plants. Furthermore, PM_{10} and $PM_{2.5}$ generally lead to serious health problems by passing through the nose and throat to the lungs.
- **Nitrogen oxides (NO), sulphur oxides (SO), and carbon monoxide (CO)**: NO, SO and CO are widespread pollutants produced by incomplete combustion of fossil fuels. The skin and mucous membranes of the eyes, nose, throat, and lungs can be irritated by these three types of pollutants. Moreover, the high concentrations of oxidation pollutants can cause inflammation and irritation in the respiratory system.

All the pollutants discussed above influence the IAQ regardless of the outside or indoor sources that produce them. However, IAQ is not only influenced by these common air pollutants. According to the Chinses IAQ Standard-2002 (CIAQS-2002), the parameters used to evaluate the indoor environment include not only chemical parameters (e.g., SO_x, NO_x, CO_x, HCHO, PM, and TVOCs), but also physical parameters, also called thermal comfort parameters, such as the temperature, air supply rate and relative humidity.

2.2.2. Thermal comfort

Thermal comfort is defined as "the condition of the mind in which satisfaction is expressed with the thermal environment" (American Society of Heating Refrigerating and Air Conditioning Engineers (ASHRAE), 2010). This satisfaction is crucial for the health and well-being of occupants, as well as productivity (Taylor et al., 2008; Wagner et al., 2007). Moreover, thermal comfort has significant effects on the energy consumption of a building associated with the heating, cooling and ventilation systems. This energy is often provided by fossil fuels, which contribute to greenhouse gas emissions and climate change. Therefore, thermal comfort plays a vital role in building sustainability (Yao et al., 2009).

The thermal comfort sensation is affected by the exchange between the human body and the surrounding environment (Mariana et al., 2010). Typically, people prefer to associate thermal comfort directly with the air temperature. However, many experiments (Berglund, 1978) have found that the thermal comfort performance is influenced significantly by six parameters and comfortable indoor environment can only be achieved when the six influential factors are in proper balance. These parameters are as follows:

- The activity level of a person, commonly referred to their metabolic rate;
- The clothing insulation level, commonly referred to as the clothing index;
- The movement of air (m/s);
- The average radiant temperature (°C);
- The indoor relative humidity; and
- The indoor air temperature (°C);

Furthermore, the sensation of thermal comfort differs among individuals, even in the same indoor environment. Different climatic areas, such as the tropics and cold regions, may require different thermal parameters (Djongyang et al., 2010). People

commonly want variations in the thermal environment, and changes in some air properties are pleasurable (de Dear, 2009). To define the standards of thermal comfort, extensive research work has been conducted in past decades, covering many aspects related to indoor thermal comfort. Some researchers established models (Fanger, 1970; de Dear and Brager, 1998) and indices (Gagge et al., 1986); others performed laboratory experiments (Fanger, 1970; Nakano et al., 2002) and field surveys (Lin and Deng, 2008; Han et al., 2007); and some developed thermal standards and evaluation methods (Olesen and Parsons, 2002; de Dear and Brager, 2002). These works made significant contributions to the establishment of thermal evaluation standards, e.g., the Ergonomics of Thermal Environment and the ASHRAE Handbook on Thermal Comfort (Malchaire, 2005; Parsons et al., 2005). The standards focus on the correlations among thermal comfort criteria and occupant satisfaction and health issues and establish appropriate thermal conditions to achieve thermal satisfaction in at least 80% of occupants in an indoor environment (Charles, 2003). Moreover, such standards are developed for static and uniform thermal conditions, and occupants are considered comfortable in well-defined ranges of thermal conditions, regardless of their race, age or sex (Parsons et al., 2005; Han et al., 2007).

Currently, two coexisting approaches are available to define thermal comfort: the heat-balance approach and the adaptive approach (Doherty and Edward A, 1988). Generally, the heat-balance approach uses experimental laboratory-collected data, and the adaptive approach uses data from field studies of occupants in an indoor environment.

2.2.2.1. The Heat-Balance Approach

The heat-balance approach is based on Fanger's experiments in a controlled climate chamber involving 1,296 young Danish students using a steady state heat transfer model (Fanger, 1970). The 1,296 students were exposed to different

thermal environments, and their feelings about how hot or cold each environment was were recorded. The seven-point thermal sensation scale of the ASHRAE was used to represent the feelings of students, and the scale is as follows.

(i) ±1 → slightly warm or cool

(ii) ±2 → warm or cool

(iii) ±3 → hot or cold

(iv) 0 → neutral (neither cool nor warm)

Fanger's model combined heat balance theory with the physiology of thermoregulation and used six influential factors (Berglund, 1978) to define a range of comfortable temperatures for occupants in an indoor environment. To predict conditions in which thermal neutrality will occur, Fanger created a comfort equation and further expanded it to the seven-point ASHRAE thermal sensation scale using the data collected from 1,296 participants (Fanger, 1970). Finally, the comfort equation became known as the "Predicted Mean Vote" (PMV) index. Then, the PMV was incorporated into the "Predicted Percentage of Dissatisfied" (PPD) index. Fanger's PMV-PPD model has been widely used and accepted for designs and field assessments of thermal comfort (Lin and Deng, 2008).

- **The Predicted Mean Vote (PMV)**

The PMV index was established by Fanger's model to predict the mean response of a large group of people based on the ASHRAE thermal sensation scale. Participants were exposed to climate chambers and asked to describe their feelings using the ASHRAE seven-point scale of thermal sensation. Then, a mean vote, which represented the mean value of the occupants' feelings for a given thermal condition, was obtained. Fanger's equation is used to calculate the PMV for a particular combination of the six influential factors (the air temperature, mean radiant temperature, relative humidity, airspeed, metabolic rate, and clothing insulation level) (Fanger, 1970):

$$\mathrm{PMV} = (0.303\mathrm{e}^{-0.036M} + 0.028)\mathrm{L}$$

where M is the metabolic rate and L is the thermal load, which is defined as the difference between the internal heat production and heat loss to the actual environment for a person at a comfortable skin temperature and the evaporative heat loss by sweating at a practical activity level.

Currently, the PMV index is popular for predicting the thermal comfort of an indoor environment. However, accurate predictions can only be achieved under homogenous conditions (Alahmer, 2011). In non-homogenous conditions, such as in vehicular cabins, the PMV index cannot provide accurate predictions. The PMV can be quantified by estimating personal factors (e.g., human activity and clothing insulation levels) and measuring the environmental factors (e.g., the air temperature, air velocity, radiant temperature, and relative humidity). The PMV can also be determined using thermal simulation software, such as IES-VE or Energy Plus. The use of thermal simulation software to calculate the PMV has been widely accepted because such methods are cost effective and save time.

- **The Predicted Percentage of Dissatisfied (PPD)**

Although the PMV can predict comfort levels of an indoor environment, it is not sufficient for defining the feeling of discomfort. For example, warm or cold (±2) cannot express how dissatisfied people are. Thus, Fanger developed another equation to convert the PMV to the PPD. The PPD equation can be used to predict the number of thermally dissatisfied individuals. The following equation gives the relationship between the PPD and PMV.

$$\mathrm{PPD} = 100 - 95\exp[-(0.03353PMV^4 + 0.2179PMV^2)]$$

Figure 2.1 shows the curve of the relationship between the PMV and PPD. Although the PMV displays better performance (equal to zero) than the PPD, 5% of the occupants are still dissatisfied, mainly because of the differences of each

approach in the assessment of thermal comfort from one person to another (Djongyang et al., 2010).

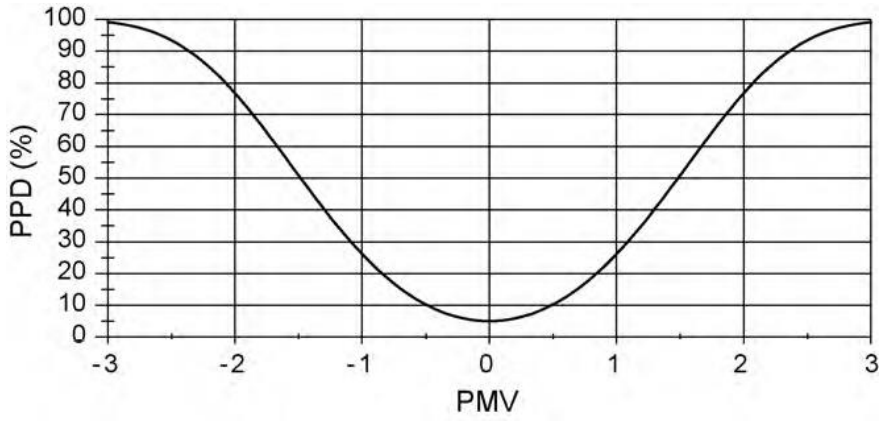


Figure 2.1. *PMV and PPD*

Source: Djongyang et al. (2010)

Currently, using simulation software to calculate the PPD is the most popular approach because it does not require large time or and human resource inputs.

2.2.2.2. Adaptive approach

An adaptive approach is developed based on field studies, with the goal of analysing the actual comfort level of the thermal environment. This actual level is affected by the specific thermal context and the behaviours and expectations of occupants (Djongyang et al., 2010). An adaptive approach normally provides reliable information about the actual comfort level of the workplace and the corresponding interrelated parameters. Moreover, some factors that chamber studies cannot produce, such as the everyday habits of occupants, various clothing insulation levels, and unrestricted activity levels, can be analysed based on the data recorded in field studies (Cena and de Dear, 2001). Therefore, in recent years, many researchers have used an adaptive approach to evaluate the thermal comfort of an indoor environment. However, such approach typically requires much more time and human resources inputs than other approaches because the data are

obtained via field studies, such as surveys, interviews, field measurements, and questionnaires.

2.2.3. The evaluation standards of IAQ and thermal comfort

In society today, there is an increased focus on improving IAQ and thermal comfort in buildings. However, due to environmental concerns and the rising cost of fuel, human living standards cannot be enhanced by consuming more energy. Thus, specific thermal comfort standards have been defined corresponding to the local conditions (e.g., climatic, cultural, or suitability conditions). As a result, many researchers have conducted studies to investigate the expectations of various individuals regarding the indoor environment. Humphreys and Nicol (2002) presented a series of data reflective of the most comfortable indoor temperature that people expect. Additionally, de Dear and Brager (1998) stated that occupants have different indoor climate requirements for air-conditioned buildings and naturally ventilated buildings. In addition to these academic studies, governments have published many regulations to specify standards for building thermal performance. For example, in the UK, some such regulations are as follows:

- Approved Document L1A - Work in New Dwellings,
- Approved Document L2A - Work in New Buildings Other Than Dwellings,
- Greener Buildings,
- Good Practice Guides,
- CIBSE GUIDE A; Environment Design,
- CIBSE GUIDE B; Heating, Ventilating, Air Conditioning, and Refrigeration,
- Building Bulletin 101, and
- National Air Quality Objectives.

In China, the principal relevant building regulations are as follows:

- Chinese IAQ Standard-2002 (CIAQS-2002),

- Design Code for Heating Ventilation and Air Conditioning of Civil Buildings- GB50736-2012, and
- National Ambient Air Quality Standards in China (NAAQS-2012).

Table 2.1 and Table 2.2 summarise the limit values for some air pollutants based on WHO guidelines and UK regulations. Additionally, Table 2.3 summarises the recommended values from the NAAQS-2012 and CIAQS-2002 in China.

Table 2.1. Air quality standards from WHO

Substance	Mean	Guideline value	Source
$PM_{2.5}$	Annual mean	10μg/m³	WHO: Air Quality Guidelines for IAQ-selected pollutants
	24-hour mean	25μg/m³	
PM_{10}	Annual mean	20μg/m³	
	24-hour mean	50μg/m³	
Ozone	8-hour mean	100μg/m³	
Nitrogen dioxide	Annual mean	40μg/m³	
	1-hour mean	200μg/m³	
Sulfur dioxide	24-hour mean	20μg/m³	
	10-minutes mean	500μg/m³	
CO_2	24-hour mean	<1000ppm	
CO	8-hour	10mg.m^{-3}	
HCHO	30-minute	0.1mg.m^{-3}	
	Long-term	0.2 mg.m^{-3}	

Table 2.2. Air quality standards in the UK

Substance	Mean	Guideline value	Source
$PM_{2.5}$	Annual mean	25μg/m³	UK National Air Quality Objectives; CIBSE Guide A
PM_{10}	Annual mean	40μg/m³	
	24-hour mean	50μg/m³ not to be exceeded 35 times/year	
Ozone	8-hour mean	100μg/m³ not to be exceeded over 10 times/year	
Nitrogen dioxide	Annual mean	40μg/m³	
	1-hour mean	200μg/m³ not to be exceeded over 18 times/year	
Sulfur dioxide	24-hour mean	125μg/m³ not to be exceeded over 24 times/year	
	1-hour mean	350μg/m³ not to be exceeded over 24times/year	
CO_2	Occupied period	Acceptable level: <600ppm	
		Complain level: 600-1300ppm	
		Very bad: 1300ppm	

CO	8-hour mean	10mg.m^{-3}	
HCHO	30 min	0.1mg.m^{-3}	

Table 2.3. Air quality standards in China

Substance	Mean	Guideline value		Unit
		Grade I	Grade II	
Sulfur dioxide	Annual mean	20	60	μg/m^3
	24-hour mean	50	150	
	1-hour mean	150	500	
Nitrogen dioxide	Annual mean	40	40	
	24-hour mean	80	80	
	1-hour mean	200	200	
CO	24-hour mean	4	4	mg.m^{-3}
	1-hour mean	10	10	
CO_2	24-hour mean	1000		PPM
Ozone	8-hour mean	100	160	μg/m^3
	1-hour mean	160	200	
PM_{10}	Annual mean	40	70	
	24-hour mean	50	150	
$PM_{2.5}$	Annual mean	15	35	
	24-hour mean	35	75	
TSP（Total suspended）	Annual mean	80	200	
	24-hour mean	120	300	
NOx	Annual mean	50	50	
	24-hour mean	100	100	
	1-hour mean	250	250	
TVOCs	8-hour mean	0.6		mg.m^{-3}
HCHO	One-hour mean	0.1		mg.m^{-3}

Source: NAAQS-2012 and CIAQS-2002

All these evaluation standards are based on threshold values for different average periods. For example, the standards from WHO and in China only give the limit values for a variety of air pollutants, and the standards in the UK not only provide the limit values but also set the number of times an exceedance occurs as an evaluation parameter for some air pollutants, such as PM_{10}, NO_X, SO_X, and ozone. However, only China has set two grades to evaluate air quality. Grade II has a lower limit value than Grade I. According to the explanation from NAAQS-2012,

Grade I limits are applicable in particular regions, such as national parks and wetland gardens. Grade II limits apply to all other areas, such as urban and industrial areas. Generally, the limit value of Grade I in China is similar to the WHO and UK requirements. Comparatively, Grade II limits are lower than those of Grade I and the UK and WHO standards. The low requirements of Grade II in the Chinese standard may not adequately protect people (Yanga et al., 2013). Taking PM as an example, the annual mean PM_{10} limit of Grade I is 40 $\mu g/m^3$, which is identical to the UK requirement but two times higher than the WHO standard. The annual mean $PM_{2.5}$ limit of Grade I is stricter than the UK value (15 $\mu g/m^3$ vs. 25 $\mu g/m^3$) but not as strict as the WHO limit. Chemical pollutants, such as sulphur dioxide, have lower limit values in the WHO standards compared to those in other standards (20 $\mu g/m^3$ for the WHO vs. 50 $\mu g/m^3$ of China). The UK set the same limit value as the WHO for carbon monoxide but, has a more stringent CO_2 requirement than China and the WHO. China, the UK and WHO standards all set an annual mean limit value of 40 $\mu g/m^3$ for nitrogen dioxide. Overall, the WHO standards are the strictest for most air pollutants, and the UK and Chinese standards are more stringent in regard to nitrogen dioxide and carbon monoxide. In other words, the WHO standards focus on smog and health effects related to air pollution, and the UK and Chinese standards focus more on the combustion efficiency of fossil fuels to combat global warming.

Apart from these air pollutants, thermal factors, such as the temperature, relative humidity, and air supply rate, should be considered in standards because they influence the indoor environment. ASHRAE (2010) proposes six thermal comfort influential factors and divides them into two groups: personal factors and environmental factors. The personal factors consist of the metabolic rate and clothing insulation level. The environmental factors include the air temperature, mean radiant temperature, air speed, and humidity. These factors are related to the time and region, as well as the culture, habits and customs of individuals, and

result in very diverse thermal comfort standards. In the UK, some thermal standards are as follows:

- Guide A-Environment Design, from the Chartered Institution of Building Service Engineers (CIBSE),
- CIBSE Guide B, Heating, Ventilating, Air Conditioning, and Refrigeration,
- Approved Document F, and
- Building bulletin 101.

In China, the relevant thermal standards are as follows:

- Code for design of heating, ventilation, and air conditioning (GB50019-2003),
- Code for design of civil buildings (GB50352-2005),
- National Ambient Air Quality Standard-2012 (NAAQS-2012), and
- Chinese IAQ Standard-2002 (CIAQS-2002).

Tables 2.4 to 2.7 summarise the thermal requirements associated with the above thermal standards.

Table 2.4. Suggested winter dry-resultant temperatures

Building/room type	Temperature (°C)	Building/room type	Temperature (°C)
Education Buildings		**Factories**	
-teaching spaces	19-21	-heavy work	11-14
-lecture halls	19-21	-light work	16-19
-seminar rooms	19-21		
Dwellings		**Sedentary work**	19-21
-living room	20-23	**Computer room**	19-21
-bathroom	26-27	**Sports**	
-bedroom	17-19	-halls changing	22-24
-Kitchens	17-19	-hall	13-16
Hospital		**Swimming pools**	
-wards	22-24	-changing	22-24
-nurses' station	19-22	-hall	13-16

Source: CIBSE Guide B.

Table 2.5. Suggested summer dry-resultant temperatures

Building/room type	Temperature (°C)	Building/room type	Temperature (°C)
Education Buildings		**Factories**	
-teaching spaces	21-23	-heavy work	
-lecture halls	21-23	-light work	
-seminar rooms	21-23		
Dwellings		**Sedentary work**	21-23
-living room	23-25	**Computer room**	21-23
-bathroom	26-27	**Sports**	
-bedroom	23-25	-halls changing	24-25
-Kitchens	21-23	-hall	14-16
		Swimming pools	
Hospital		-changing	24-25
-wards	23-25	-hall	23-26
-nurses' station	21-23		

Source: CIBSE Guide B.

Table 2.6. Air supply rate

Building type	Suggested air supply rate (litres per second per person)
Education Buildings	
-teaching spaces	8
-lecture halls	8
-seminar rooms	8
Dwellings	
-living room	0.4–1 ACH to control moisture
-bathroom	15 $L.s^{-1}$
-bedroom	0.4–1 ACH to control moisture
-Kitchens	60 $L{\cdot}s^{-1}$
General building areas	
-corridors	8
-entrance halls	8
-kitchens	-
-toilets	>5 ACH
-waiting areas	8
Indoor air speed (m/s)	Mean air speed of 0.25m/s. In most cases, for buildings with air temperatures between 18°C and 28°C, air velocity should be between 0.1m/s and 0.3m/s.

Source: CIBSE Guide A.

Table 2.7. Thermal standards of China

Physical properties	Parameters	Units	Standards	
	Temperature	°C	22-28	For summer cooling air
			16-24	For winter heating air

	Relative humidity	%	40-80	For summer cooling air
			30-60	For winter heating air
	Fresh air in mass	$m^3/h \cdot p$	30	
	Air flow rate	m/s	0.3	For summer cooling air
			0.2	For winter heating air

Source: CIAQS-2002.

The Chinese thermal standard is entirely different from the UK standard. Specifically, the Chinese standard provides a broader range of air temperatures than does the UK standard. For example, in winter, China sets the range of 16-24°C as the comfortable indoor temperature range for the main function spaces in a building, and the UK sets a range of 19-24°C for most indoor building spaces, except entrance halls and store rooms. Moreover, the UK sets different air temperature requirements for different types of rooms, and the Chinese standard is less specific. The limit values of the ventilation rate are quite similar. China sets a limit of 30 $m^3/h \cdot p$ (8.3 L/s·p), which is slightly higher than the value recommended by the CIBSE requirement (8 L/s·p). In addition, China suggests that the airflow velocity inside buildings with comfortable air temperatures should be approximately 0.2 m/s in winter and 0.3 m/s in summer. The UK standard states that in most cases, for buildings with air temperatures ranging from 18°C to 28°C, the airflow velocity should be ranged approximately from 0.1 m/s to 0.3 m/s to maintain a thermal comfortable indoor environment.

In addition to the standards from the UK and China, published studies have provided recommended indoor air velocities for buildings to achieve comfortable air temperatures. For example, Orosa and Pliveira (2012) stated that the airflow velocity inside buildings should never be higher than 0.9 m/s in summer or lower than 0.15 m/s in winter. Boduch and Fincher (2009) provided a table to show the correlation between the airflow velocity and occupants feelings (Table 2.8). Notably, airflow speeds slower than 1 m/s created a pleasant indoor thermal environment.

Table 2.8. Airflow velocity impacts

Airflow velocity (m/s)	Occupants feelings
0.254≤airflow velocity	Unnoticed
0.508≥ airflow velocity>0.254	Pleasant
1.016≥airflow velocity >0.508	Generally pleasant, but causing a constant awareness of air movement
1.524≥airflow velocity >1.016	From slightly draft to annoyingly draft
airflow velocity≥1.524	Requires corrective measures if work and health are to be maintained at high efficiency

Source: Boduch and Fincher (2009)

2.3. Current Ambient Air Pollution in China

Ambient air pollution has been one of China's most serious environmental issues recent years (Ministry of Environment Protection (MEP), 2002; MEP, 2007; MEP, 2011). The Chinese economy still mainly depends on fossil fuels (Lin, 2012). Consequently, the ambient air is profoundly influenced (Moore, 2018). The key air pollutant in urban areas of China are suspended $PM_{2.5}$ and PM_{10} (Gao et al., 2016). The PM concentrations in many cities have exceeded the guideline values of the NAAQS-2012 (Zhang and Crooks, 2012). Shao et al. (2006) illustrated that over three-quarters of the population in urban areas is exposed to air quality levels that do not meet the NAAQS-2012, and the primary contaminant in the ambient air is PM. Rohde and Muller (2015) found that high air pollutant levels are widespread throughout the northern and central parts of China, not only in the major cities and geologic basins, but also in small cities and plain areas. They further noted that in the north-eastern corridor, which extends from Beijing to Shanghai, the air pollution is extremely severe. Table 2.9 shows the average provincial $PM_{2.5}$ concentrations in 2015, 2016 and 2017 in China. The $PM_{2.5}$ concentrations in all provinces and municipalities exceed the annual Grade I limit set by the NAAQS-2012. Moreover, only 6 provinces (Guangdong, Guizhou, Fujian, Yunnan, Xizang, and Hainan) met the Grade II annual guideline.

Table 2.9. Summary of average provincial $PM_{2.5}$ concentrations

Province or Municipality	Yearly average $PM_{2.5}$ concentrations ($\mu g/m^3$)		
	2015	2016	2017
Henan	80.7	77.0	77.7
Beijing	80.4	63.4	64.6
Hebei	77.3	62.2	73.7
Tianjin	71.5	63.4	72.4
Shandong	66.4	64.1	60.3
Hubei	65.9	59.7	58.6
Jiangsu	56.6	57.4	52.8
Shanxi	56.4	56.0	67.5
Anhui	55.1	57.8	62.3
Chongqing	55.0	54.8	49.6
Liaoning	55.0	46.4	50.6
Jilin	54.4	43.0	48.2

Shanghai	53.9	54.4	43.1
Xinjiang	53.7	71.9	66.1
Hunan	52.5	49.3	48.4
Shannxi	52.0	55.9	65.3
Zhejiang	47.7	46.9	42.3
Sichuan	46.7	51.2	49.3
Ningxia	45.8	45.8	47.2
Jiangxi	42.8	44.4	48.7
Qinghai	42.6	38.8	33.6
Gansu	41.2	37.3	41.8
Inner Mongolia	41.0	35.4	38.4
Guangxi	40.2	37.1	40.6
Heilongjiang	39.4	31.7	40.5
Guangdong	34.0	31.0	34.2
Guizhou	31.7	32.8	32.6
Fujian	28.7	30.2	28.5
Yunnan	28.0	30.0	28.5
Xizang	25.4	21.7	19.1
Hainan	19.3	17.6	18.9

Source: http://www.greenpeace.org.cn/

In addition to PM, the concentrations of the other air pollutants, such as nitrogen oxide, carbon monoxide, and sulphur oxides, have increased in recent decades. Data from the MEP (2011) indicated that SO_2 emissions had increased to 25.5 Mt/year in 2005, 27% higher than the emissions level in 2000. Additionally, NOx emissions increased by over 100% and 200% due to the installation of new power plants and increases in the vehicle population, respectively, between 2005 and 2015.

The 13th Fiver-Year Energy Development Plan of China claimed that over the next 10 years, coal will remain the dominant energy source in China. Therefore, in the future, China will face more severe air pollution problems (NDRC and NEA, 2016).

2.4. Current Indoor Air Pollution in China

Sinton et al. (1995) reported that indoor air pollution has been a severe problem in China since the 1970s. Currently, over 60% of the Chinese population has expressed concern regarding the IAQ, especially in public facilities and the workplace (Prnasia, 2018). The China Indoor Environment Monitoring Committee (CIEMC) stated that the current primary indoor air pollutant in China is PM (Song, 2013). Investigations of the IAQ in buildings have supported the concerns of citizens (Li et al., 2014; Zhang et al., 2014; Cui et al., 2011).

In addition to $PM_{2.5}$, many researches have also demonstrated that the IAQ in China is affected by other air pollutants, such as TVOCs, HCHO, and benzene (Qiu, 2012; Cao et al., 2013). Some of these air pollutants are generated by internal decorations, and others are from the chemical components used in wooden furniture, such as adhesives and paints.

In general, indoor air pollution in China has become a severe problem, and the primary air pollutants is PM. Moreover, other air pollutants influence the IAQ. The reasons behind such problems vary and are discussed in the following sections.

2.4.1. Outdoor influential factors on IAQ

Undoubtedly, ambient air can contribute to the pollution load in indoor air. Outdoor air pollutants can penetrate a building through cracks and air leakages or be introduced by ventilation systems, such as exhaust fans, stacks, and wind. Taking PM as an example, Abt et al. (2000) and Chao and Cheng (2002) stated that indoor PM is either from the emissions of indoor sources or from the infiltration of ambient air. Kuo and Shen (2010) observed similar increasing concentrations of $PM_{2.5}$ and PM_{10} in both indoor and outdoor environments on a heavy pollution day and suggested that outdoor PMs are transported inside through building

ventilation systems. Baek et al. (1997) concluded that the ambient air quality is an essential factor in determining the quality of indoor air.

In China, ambient PM also plays an important role in determining IAQ. Xiang et al. (2016) investigated indoor and outdoor concentrations of PMs in public buildings in Shanghai, and the results indicated that indoor PM levels are mainly affected by the outdoor levels. Shi et al. (2015) suggested that outdoor PM can contribute to over 50% of the indoor PM concentrations. Chen and Zhao (2011) found that outdoor PM levels have substantial effects on indoor PM levels in rooms with few indoor PM sources.

In addition to PM, other outdoor air pollutants, such as CO_2, NO_x, VOCs, and SO_x, also influence the IAQ. Data from the US Department of Energy indicate that atmospheric CO_2 emissions have increased from 280ppm to the present value of 368 ppm since the beginning of industrialization; therefore, in some areas close to industrial centres, the indoor CO_2 concentrations could be higher than indoor concentrations in non-industrial areas (Keeling and Whorf, 2004). Rivas et al. (2014) stated that indoor VOC concentrations and CO_2 levels are significantly affected by the corresponding outdoor concentrations. Wen and Zheng (2004) found that buildings located in industrial areas in China have higher CO_2 and SO_2 levels than buildings located in urban and suburban areas.

Thus, based on the analyses above, ambient air quality is one of the most important influential factors that affects indoor air pollution levels.

2.4.2. Indoor influential factors on IAQ

Pollution in the indoor environment can be two to five times more toxic than that in the outdoor environment due to indoor air pollution sources (US EPA, 2018). Montgomery and Kalman (1989) indicated that indoor air pollution levels are higher than outdoor levels because some indoor sources can emit large quantities

of air pollutants. In addition, people spend 90% of their time indoors in modern society. Thus, the identification of indoor pollution sources is crucial since they are the key factors that influence the IAQ (Schweizer et al., 2006). Pollutants from indoor sources are mainly related to cooking, heating, indoor equipment, and human activities. For example, chemical sources, such as adhesives, carpeting, upholstery, manufactured wood products, copy machines, pesticides, and cleaning agents, may emit VOCs. Additionally, biological contaminants, such as bacteria, moulds, pollen, and viruses, may breed in stagnant water that has accumulated in ducts, humidifiers and drain pans, or where water has collected on ceiling tiles, carpeting, or insulation (US EPA, 1991). Thermal rehabilitation and renovations can have adverse effects on the IAQ because buildings are sealed prior to these processes, and the new materials release more VOCs, benzene and formaldehyde. The indoor activities of individuals, such as cooking over unvented biomass fires, can also release large quantities of formaldehyde and degrade the IAQ (Zhang and Smith, 1999). Murr and Garze (2009) also noted that the pattern and intensity of occupant activities within a space are correlated with the indoor concentrations of PMs. For example, smoking, cooking, heating, and cleaning significantly contribute to fine, ultrafine and nanoparticles emissions. Monn et al. (1997) studied the ratios of indoor PM concentrations to outdoor PM concentrations (I/O ratios) in naturally ventilated domestic buildings in Switzerland. The study mainly found that smoking in buildings led to I/O ratios over 1.8 and that buildings without indoor emission sources and low levels of occupant activity had an I/O ratio approximately 0.7. Bo et al. (2017) stated that in a working environment, PM concentrations mainly dependent on the materials used, production methods, and work typologies.

In China, the IAQ is also influenced by internal activities, such as cooking and smoking. Shi et al. (2015) found that the 24-hour mean PM_{10} concentrations for a family with two smokers could reach 70.4 $\mu g/m^3$. In public buildings, such as

hotels in Shanghai, the indoor average PM concentrations can reach three times the NAAQS-2012 requirements due to cooking activities (Xiang et al., 2016).

Thus, indoor sources and internal occupant activities are two of the main influential factors that affect the IAQ. Indoor air pollutants are emitted from indoor sources, such as wooden products, or are generated by internal activities, such as cooking and smoking.

2.4.3. Effects of air leakage and airtightness on IAQ

The definition of the Air leakage is the unintentional or accidental penetration of outside air into a building. This process can also be called air infiltration or adventitious ventilation. Leakage is relatively unpredictable, and the flow rate and pathways change with the pattern of building cracks and the air pressure difference between the indoor and outdoor environment of the building fabrics. Ambient air pollutants flow inside when the outside air enters a building through leakages in the building fabrics, such as roofs, windows, and walls. Many studies have found that ambient air pollutants are more likely to have adverse effects on IAQ in buildings with low levels of airtightness[1]. For example, Blondeau et al. (2005) found that building airtightness strongly affects the I/O ratios of indoor air pollutant concentrations to outdoor air pollutant concentrations. Chen et al. (2016) found that PMs with a diameter smaller than 0.5μm are easier to penetrate into buildings with low level of airtightness than those with high airtightness levels. Hänninen et al. (2010) stated that the airtightness levels of building fabrics should be increased to decline ambient air pollutant transportations from outside to inside environment.

[1] Building airtightness (also called envelope airtightness) can be defined as the resistance to inward or outward air leakage through unintentional leakage points or areas in the building envelope.

In China, the airtightness requirements were divided into 5 levels in 2002 based on the GB/T7106-2002 building regulation. In 2008, a new building regulation, GB/T7106-2008, divided airtightness into 8 levels, and the higher the level is, the better the airtightness. Prior to 2005, building regulations only set airtightness requirements for residential buildings. The earliest airtightness requirements for public buildings were established by the China Public Building Energy Saving Standard-2005 (PBESS-2005), and level 4 was the minimum acceptable airtightness level in 2005. Now, the minimum requirement has been upgraded to level 6 according to the latest standard published in 2015 (PBESS-2015). Therefore, public buildings completed before 2005 typically have an airtightness level of 4. C. Chen et al. (2017) suggested that improvement of airtightness levels can reduce the ambient air pollutant penetration. Z. Chen et al. (2017) investigated the indoor PM I/O ratios for public buildings with different airtightness levels (3, 4, 5, and 6) under laboratory conditions. Table 2.10 summarise the investigation results.

Table 2.10. I/O ratios of $PM_{2.5}$ concentrations in public buildings with different airtightness levels

Airtightness level	3	4	5	6
I/O ratios of $PM_{2.5}$ concentrations	0.657	0.582	0.519	0.456

Source: Z. Chen et al. (2017)

As shown in Table 2.11, the I/O ratios of the $PM_{2.5}$ concentrations decrease with increasing building airtightness level. However, even for buildings with an airtightness level of 6, 45.6% of outdoor $PM_{2.5}$ can penetrate inside.

Therefore, improving airtightness is essential to reducing air pollutant penetration. However, the ventilation rate should also be considered in improving the airtightness level, expecially for naturally ventilated buildings. For example, a high level of airtightness can lead to the aggregation of CO_2 in naturally ventilated buildings, which can decrease the IAQ.

2.4.4. Ventilation mode and IAQ

Natural ventilation, as the most conventional ventilation method, has some drawbacks regarding mitigating indoor environment problems. First, traditional natural ventilation systems are not able to provide thermal comfort in cold winter and hot summer months. Tan and Deng (2017) found that natural ventilation is not appropriate in the cold temperature zone of Australia because it cannot provide a thermally comfortable indoor air temperature. Y. Chen et al. (2017) investigated the applicability of natural ventilation around the globe and found that countries such as Singapore and Malaysia have little potential for adopting natural ventilation systems due to the hot and humid local weather throughout the year.

Second, natural ventilation cannot deliver clean air on polluted days. In recent years, given the effects of climate on the applicability of natural ventilation systems, people have begun to develop advanced natural ventilation technologies, such as solar chimneys and EAHEs (Artmann et al., 2007). However, these advanced technologies only enhance the natural ventilation applicability based on the air temperature and humidity, and do not consider the effect of ambient air pollution. Yang et al. (2015) investigated the IAQ of naturally ventilated buildings next to a street canyon and mainly found that outdoor air pollutants from traffic emissions have significant effects on the IAQ. Martins and Graça (2017) stated that in European cities, outdoor PM levels have adverse effects on the use of natural ventilation. Park et al. (2014) noted that indoor PM concentrations substantially vary in naturally ventilated buildings because of the effects of various window opening conditions and the unsteadiness of wind flows on the penetration of outdoor PMs. Tong et al. (2016) stated that in general, natural ventilation in most cities in North China cannot supply clean air due to heavy ambient air pollution.

Therefore, although natural ventilation has excellent potential for reducing building energy consumption, it is ineffective in environments with polluted ambient air.

In China, most buildings are naturally ventilated (Shi et al., 2015) because building regulations encourage natural ventilation in most types of buildings. There are five climatic zones in China, namely, the severe cold, cold, hot summer and cold winter, temperate, and hot summer and warm winter (Thermal Design Code for Civil Building-GB50176-93), as shown in Figure 2.2. These five climate zones are defined in light of the coldest and hottest average monthly dry-bulb temperatures[2].



Figure 2.2. *The five major climate zones of China*

Source: Thermal Design Code for Civil Buildings-GB50176-93

Most Chinese building regulations have specific ventilation requirements for buildings located in different climate zones. For example, the Code for the Design of Civil Buildings (GB50352-2005) states that under suitable weather conditions, buildings should be naturally ventilated through the opening of windows in all

[2] Severe Cold climatic zone: the coldest mean monthly dry-bulb temperature: <-10°C; Cold climatic zone: the coldest mean monthly dry-bulb temperature: -10°C-0°C; Hot Summer and Cold Winter climatic zone: the coldest mean monthly dry-bulb temperature: 0°C-10°C and the hottest mean monthly dry-bulb temperature: 25°C-30°C; Hot Summer & Warm Winter climatic zone: the coldest mean monthly dry-bulb temperature: >10°C and the hottest mean monthly dry-bulb temperature: 25°C-29°C; Temperate region: the coldest mean monthly dry-bulb temperature: 0°C–13°C and the hottest mean monthly dry-bulb temperature: 18°C–25°C.

climate zones. Thus, in practice, natural ventilation in China significantly reduces the ability of a building to avoid ambient air pollution.

Because of the drawbacks of natural ventilation systems, mechanical ventilation systems, such as air conditioners, and air purifier systems have gradually become popular in China. Mechanical ventilation can provide an adequate ventilation rate, and air conditioners can supply air at a comfortable air temperature. Air purifier systems have drawn considerable attention due to the need for cleaning air (Lin, 2017). However, despite the benefits of these active artificial systems, indoor air pollution still exists in buildings equipped with these systems. For example, mechanical ventilation systems and air conditioners usually have no built-in filters; thus, ambient air pollutants can be directly transported inside through air intake mechanisms. Additionally, some air purifiers generate ozone when they remove other air pollutants (Li et al., 2015). Therefore, the use of these artificial systems cannot fully eliminate the adverse effects of indoor air pollution on the health of occupants.

2.4.5. Current measures to mitigate air pollution in China

To combat the air pollution problem, the government of China has prioritised tackling the issue. Since 2012, hourly and real-time ambient air pollution data were provided to the public by a national air reporting system which consists of 945 monitoring stations in 190 cities (China State Council, 2013). At this time, hourly and real-time ambient air pollution data were provided to the public. Based on these data, residents can know the ambient air quality at any time of day. Moreover, the NAAQS-2012 was updated and became stricter for PM_{10} and some chemical air pollutants, such as NO_x and SO_x. In 2013, the State Council implemented the Air Pollution Prevention and Control Law (China State Council, 2013). The action plan contains many essential measures aimed at reducing air pollutant emissions by 3% in the following five-year period (2013-2017). Since the

energy conservation and emission reduction objectives are two-fold, most of the measures in the action plan target improvements in energy-savings and emission mitigation. For example, the government pledged to reduce coal consumption from approximately 67% of the national total energy use in 2012 to 65% by 2017. Under this policy, thousands of polluting factories were forced to shut down, particularly in North China. In addition to these strict policies from the central government, local governments have also implemented aggressive emission control measures. In 2013, the Beijing government set limitations on burning coal for power plants, and high-polluting vehicles were also removed from the road to decrease the PM concentrations in the city. Hebei, Tianjin, and Liaoning also implemented regulations for the prevention and control of air pollution in 2014. In the summer of 2015, a new version of the Air Pollution Prevention and Control Law, also called as the New Air Law, was revised and passed by the National Congress, and it came into effect on January 1, 2016. The New Air Law required cities to regularly release and submit definitive plans to ensure that local governments were focused on meeting air quality standards. The New Air Law has been recognized as the most important document for improving air quality over the next 15 years.

However, despite these national and local policies regarding air pollution control, heavy air pollution has not ceased. A report published by the Ministry of Environmental Protection (MEP) of China in 2017 indicated that only 84 prefecture-level cities out of 338 in China met the Grade II requirements of NAAQS-2012 in 2016. Moreover, 254 cities failed to meet the NAAQS-2012, accounting for 75.1% of all cities. Thus, air pollution cannot be drastically improved in a short period. Policymakers should consider the effectiveness of the control measures and supply the necessary inputs for regional policymaking and the management of air pollutant emissions.

Since it is impossible to eliminate ambient air pollution in a short time, residents have begun to implement air pollution mitigation measures inside their homes. In Beijing, a market study showed that the sales volume of household air purification systems has dramatically increased since 2013, when the severe air pollution issue became well publicized in the city (Zhu, 2013). In 2011 and 2012, 1.12 million and 1.26 million air purification systems were sold, respectively (Zhao, 2014). Then, an extreme increase occurred in 2013, and the total number of air purification systems sold reached 2.4 million. In 2016, China sold over 7.69 million air purification systems, three times the number in 2013. Moreover, a report from ASKCI CONSULTING (2017) indicated that air purification systems are more popular in autumn and winter than in summer and spring, which is consistent with air pollution tends in China.

However, some studies have verified that these air purification systems cannot completely clean the air to a level that meets the Chinese and the WHO IAQ standards (Li et al., 2015). Moreover, not all families can afford these products. In addition, these products consume electricity, increase building energy consumption, and indirectly increase fossil fuel consumption, such as coal consumption (in 2015, coal combustion in China contributed to approximately 69% of the total national energy consumption), which contributes to ambient air pollution.

In general, the current government measures cannot mitigate ambient air pollution in a short period. Moreover, residential measures implemented to combat indoor air pollution have some adverse effects on the ambient air environment. Therefore, residents must find new solutions to indoor air pollution problems.

2.5. Indoor Thermal Comfort in China

In China, the heating system is owned by the governments, and only residential buildings in northern China have central heating systems installed. Cooling services are usually selected by occupants, and air conditioners are most common. Residential buildings in South China use air conditioners to heat buildings in winter and cool buildings in summer. Public buildings are heated or cooled by air conditioners in both North and South China. However, some public buildings, such as school buildings, which are owned by the public and have a regular usage pattern, and hotels, which serve a similar function as the residential buildings, can be heated by the central heating systems.

Recently, with rapid economic development and updates to the new building design standards (e.g., in 2015, the PBESS was updated from 2005 version), the indoor thermal environments in buildings have been improved (Li et al., 2018). However, indoor thermal discomfort problems remain. For example, Yuan et al. (2010) investigated five office buildings and three commercial buildings in Xi'an, and the results indicated that thermal discomfort problems existed in all the newly constructed buildings. Additionally, Luo (2013) found that thermal discomfort is a common problem in newly public buildings in Shandong Province.

Thus, according to the analyses above, special attention still should be given to the thermal environment performance of buildings in China.

2.6. Correlation between Indoor Air Properties and Building Energy Consumption

IAQ and thermal comfort are important factors that affect not only human health in a room space but also building energy consumption. Initially, IAQ and thermal comfort were regulated by creating an adequate ventilation rate. However, increasing the ventilation rate may lead considerable heat loss, which would in turn increase the need for space heating or cooling, as well as energy consumption. There is an inevitable connection among IAQ, thermal comfort and the energy consumed for heating, cooling and ventilation.

In ancient times, natural ventilation was the only way for people to draw outdoor air inside; however, due to the drawbacks of natural ventilation systems, mechanical ventilation measures and air conditioners were eventually invented to provide conditioned air (conditioned ventilation). However, conditioned ventilation can significantly increase building energy consumption (Fisk et al., 2011; Seppänen et al., 2006). Orme (2001) stated that energy consumption related to conditioned ventilation accounts for over half of the total building energy consumption. Figure 2.3 illustrates that the average proportion of energy consumption associated with IAQ in the investigated countries is 67.9% (for space heating and cooling).

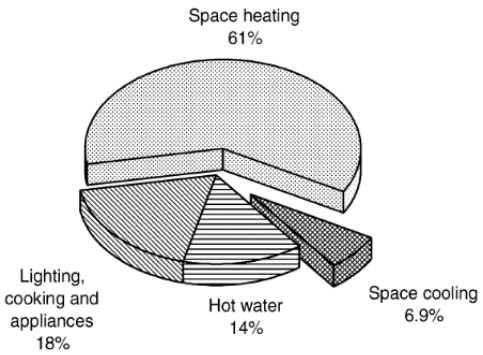


Figure 2.3. *End-use shares of delivered energy use in the service and residential sectors*
Source: Orme (2001)

The International Energy Agency (IEA, 2018) claims that on average, ventilation, space cooling, and space heating account for almost 40% of building energy consumption. In the USA., IAQ-related energy consumption accounts for 44% of building energy consumption in the commercial sector (25% for space heating, 10% for ventilation and 9% for space cooling) (Figure 2.4).

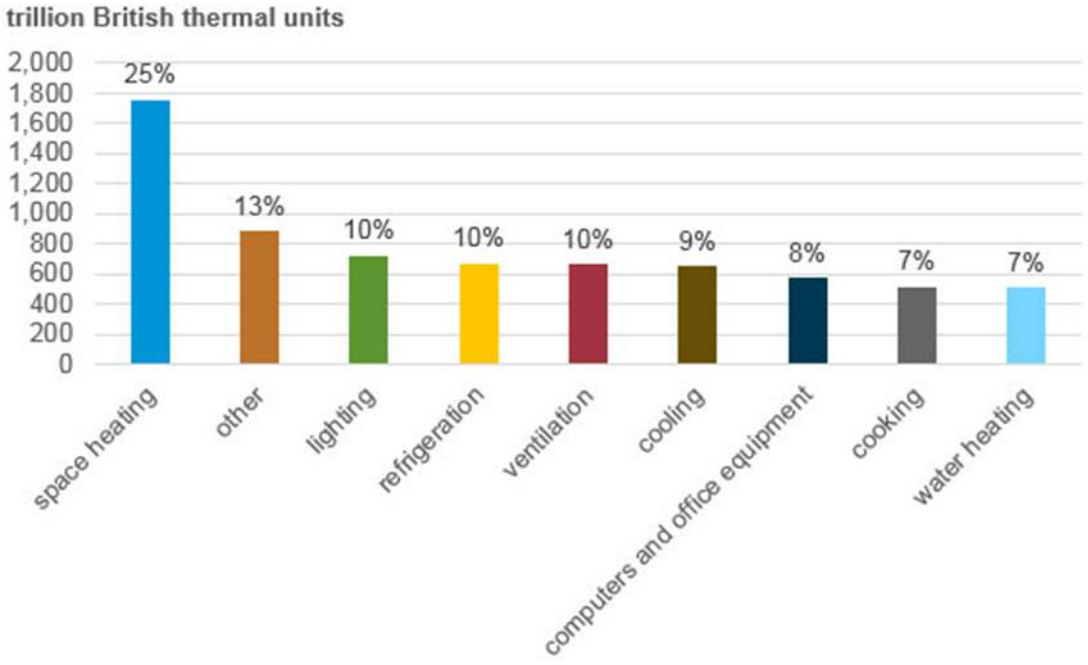


Figure 2.4. *Energy use in U.S. commercial buildings by end users (2012)*

Source: Source: IEA (2018)

In addition to space heating, space cooling and ventilation, building energy consumption has increased due to the use of air cleaning equipment. In large public buildings, air filters are often installed as a part of an HVAC system, and in residential buildings, people often use household air purifiers. According to a report from ASKCI CONSULTING (2017), 27% of families in the USA., and 17% of families in Japan have installed air purifiers. However, air filters and air purifiers consume electricity. Moreover, increased air pollution can lead to higher operating costs for air filters (Montgomery et al., 2012).

In China, energy consumption related to IAQ is highly related to building energy consumption. The energy consumed for space heating accounts for over 40% of total building energy consumption in North China (Tsinghua University Building Energy Efficiency Research Centre, 2009), and space cooling accounts for 20% of building energy consumption throughout the country. In the public building sector, air conditioners contribute to 22% of total building energy consumption. Building energy consumption in China has recently increased due to the popularity of air purifiers. Severe air pollution in China has led to dramatical growth in the sales volume of the household air purification systems. Air purifiers consume electricity, directly decrease building energy consumption and indirectly increase coal consumption, as 74.4% of electricity in China was generated by coal combustion in 2016 (China Electric Power Enterprise Association, 2016). Li et al. (2016) conducted a study to investigate the energy consumption of air purification systems in Beijing in 2015. The researchers found that over 72.8% of families in Beijing had installed air purifiers, and the air purifiers increased electricity consumption by 201.6 million kW·h in 2015 (equal to the total electricity consumption in Turkey in 2014) (The World Factbook, 2015).

Therefore, a conflict exists between IAQ and building energy consumption. On one hand, air purifiers can reduce indoor air pollution to a certain extent. On the other hand, installing air purifiers can increase energy consumption, which consequently leads to sequential ambient air and indoor air pollution.

2.7. Summary

This section introduced the common air pollutants and related evaluation standards, and then reviewed the current ambient air quality and IAQ levels in China. Additionally, the factors that influence the indoor and outdoor environments in China were analysed.

The current ambient air quality measures in China are not sufficient for meeting the Chinese air quality standards and WHO limit values. The primary air pollutants are $PM_{2.5}$ and PM_{10}. The principal reasons for the extreme air pollution includes fossil fuel combustion by power plants and the heating demand for buildings in winter. In recent years, ambient air pollution has become a health concern throughout society.

Indoor air pollution also exists in many buildings in China. The IAQ is significantly affected by ambient air pollution, especially in naturally ventilated buildings. Air pollutants are transported inside through windows, doors, and cracks. The airtightness level is another factor that has a significant influence on IAQ. Creating buildings with a good seal can reduce unwanted ambient air penetration. High airtightness levels are associated low I/O ratios and pollution levels. Natural ventilation is ineffective in reducing air pollution, limiting the application of natural ventilation in polluted ambient environments. Occupants can also affect the IAQ by smoking, cooking, running, wearing cosmetics or scents, or producing body odours.

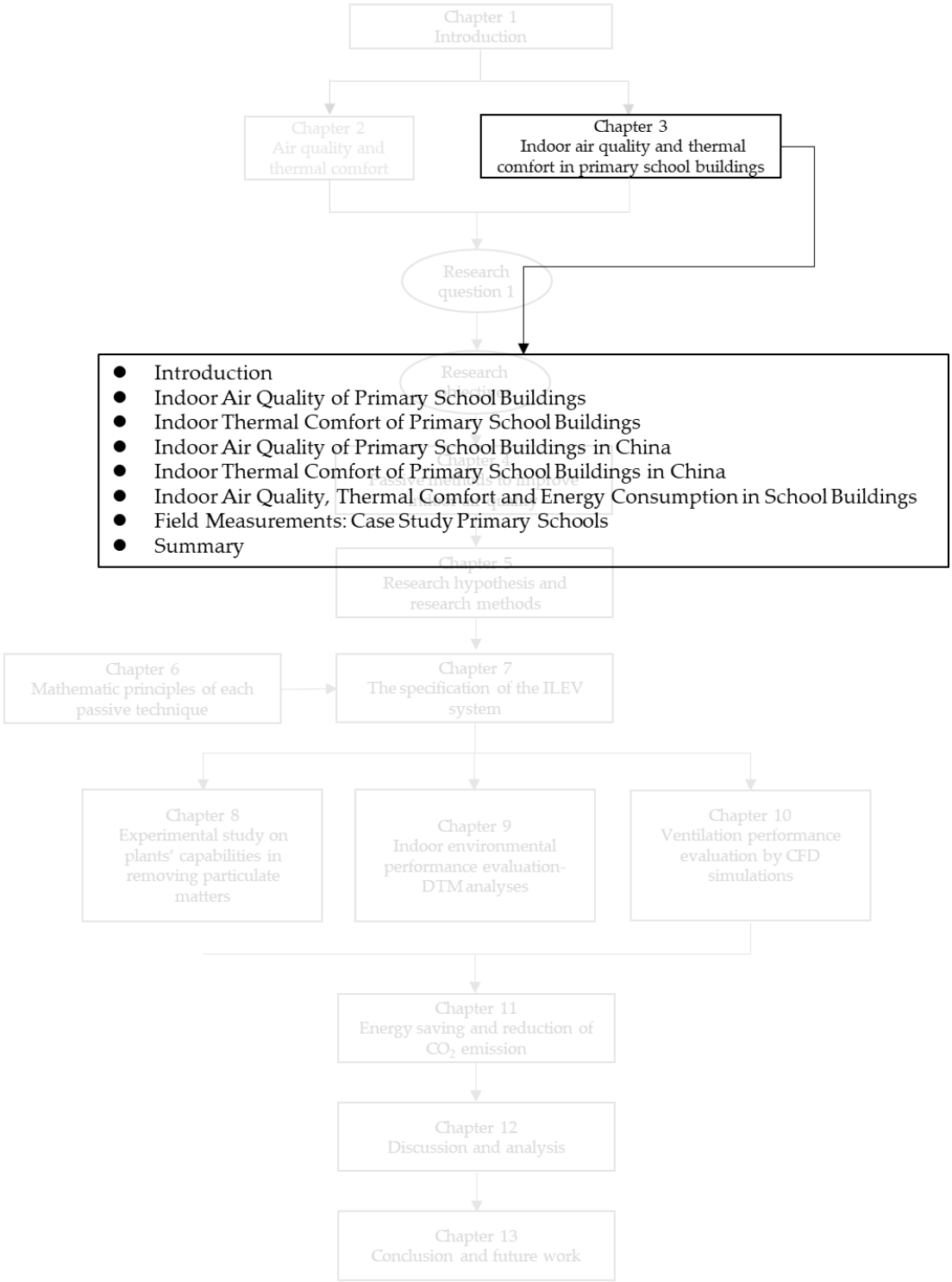
Since the dominant energy source in China is coal, air pollution cannot be eliminated in a short period. Moreover, the dominance of natural ventilation increases the exposure of occupants to air pollutants originating from the outside air. As a result, sales of air purifiers are booming in China as people attempt to protect themselves from air pollution. However, air quality experts have noted

that air purifiers cannot completely clean the air and satisfy the Chinese and WHO IAQ standards. In addition, air purifiers are expensive and unaffordable for many families. Moreover, they consume electricity, which comes from burning coals, and thereby increasing the ambient air pollution.

The discussion provided above suggests that humans are trapped in a vicious cycle. It is clear that natural ventilation can increase human exposures to some pollutants, particularly if the outdoor air is highly polluted. However, ventilation is generally an essential part of life. Air purifiers can temporarily clean the air, but they also increase ambient air pollution by consuming fossil fuels. Overall, a new, energy efficient and cost-effective method is needed to combat air pollutions in China, especially because long-term energy savings is critical for the sustainable development of the national economy and environment.

China has achieved considerable economic growth during the past forty years. However, this achievement has result in air pollution problems. The next chapter will focus on the IAQ and thermal comfort performance in primary school buildings in China, and field measurements will be conducted in a case study of primary schools to verify the existence of air pollution in classrooms.

Chapter 3: IAQ AND THERMAL COMFORT IN PRIMARY SCHOOL BUILDINGS



The content of Chapter 3

3.1. Introduction

Children are sensitive to exposed to air pollutants they breathe a higher amount of air at a faster rate than adults (Landrigan, 1998; Faustman et al., 2000). Bakó-Biró et al. (2004) found that children pay over 30% of their life at school, and approximately 70% of this school hours is inside an educational space. Raysoni et al. (2013) also claimed that students spend more time in classrooms when they are away from home than in any other building or outside. Therefore, the IAQ in classrooms has become a significant health issue. In Chapter 3, a review of the IAQ in classrooms of primary school buildings is presented, and the factors that influence both the indoor and outdoor environments are discussed.

Moreover, field measurements are collected to verify the potential air pollution problems in Chinese primary schools. The results showed that the IAQ in the studied buildings does not meet the requirements of the Chinese and WHO standards. Thus, the issue remains between saving energy and purifying indoor air to eliminate pollution.

3.2. IAQ of Primary School Buildings

Studies have indicated that air pollution in the school environment is correlated with the performance of students (Mohai et al., 2011; Twardella et al., 2012). In addition, Mendell and Heath (2005) and Peters et al. (1997) stated that indirect indicators, such as school absenteeism, provide evidence of the effects of air pollution on student health. Moreover, poor IAQ is the main cause of respiratory diseases, such as asthma, rhinitis, and rhinoconjunctivitis, among students (Cui et al., 2013; Madureira et al., 2015). In 2010, the WHO (2010) reported that the indoor environment was the source of 36% of respiratory diseases and 22% of chronic diseases among students. Therefore, IAQ is one of the most important factors related to student health.

However, in practice, air pollution issues in classrooms exist in many countries. Haverinen-Shaughnessy et al. (2010) found that 87% of primary school classrooms had indoor air issues in the southwestern USA. Wheeler et al. (2000) stated that the indoor concentrations of PM_{10} in UK primary schools exceeded the corresponding outdoor readings. Heudorf et al. (2009) stated that the levels of PM_{10} in a three-week study in German classrooms were 69±19 $\mu g/m^3$, which were higher than the WHO requirements. An investigation of IAQ conducted by Mainka et al. (2015) indicated that VOC levels in classrooms were significantly higher than the related limit criteria in Gliwice, Poland.

Griffiths and Eftekhari (2008) found that some classrooms in East London exhibited a CO_2 level that exceeded 1500 ppm, and this level was higher than the acceptable value of 600 ppm from the CIBSE Guide A. Lee and Chang (2000) indicated that indoor CO_2 concentrations in Hongkong schools increased by over 1000 ppm in winter, even in rooms with ceiling fans. Heudorf et al. (2009) found that the levels of CO_2 in German primary schools averaged 1459 to 1051 ppm.

Santamouris et al. (2008) stated that the CO_2 concentrations in naturally ventilated classrooms in Athens were higher than 1000 ppm on average.

Thus, indoor air pollution in school buildings remains a common problem worldwide that affects student health.

3.3. Indoor Thermal Comfort of Primary School Buildings

In addition to air pollution, indoor thermal comfort has a significant effect on the academic performance of students. Many studies (Wargocki et al.,1999; Fisk, 1999; Mendell and Heath, 2005) have been performed to investigate the correlations between the indoor thermal environment and student performance and productivity. A study conducted by the University of Tulsa (2015) indicated that adequate ventilation and thermal comfort in classrooms can improve the average academic achievement of students. In addition, a thermally comfortable indoor environment can reduce health issues. Mendell and Heath (2005) found that poor indoor thermal conditions can affect student health and directly impair student concentration and memory. Therefore, the indoor thermal environments of classrooms are a notable public concern.

However, although thermal comfort has raised public concern, thermal discomfort in classrooms commonly exists worldwide. In the UK, Barbhuiya et al. (2013) found that overheating problems have decreased the thermal comfort in primary school buildings. Abdeen et al. (2014) stated that in upper Egypt, primary schools have a high level of thermal discomfort due to the hot ambient air temperature. James and Christian (2012) indicated that classrooms in Ghana above the ground floor have reduced thermal conditions due to excessive solar heat gains. Samad et al. (2017) found that primary school classrooms in Malaysia do not provide ideal thermal comfort level and that the indoor air temperature ranges from 28°C to 34.5°C.

Based on the discussion above, thermal discomfort remains a common indoor environment problem that has significant effects on student health, academic performance and learning productivity.

3.4. IAQ of Primary School Buildings in China

3.4.1. Current IAQ in Chinese primary school buildings

In China, primary school buildings usually have no mechanical ventilation systems, and the only method to bring air into classrooms is to open doors and windows (Peng et al., 2017). Moreover, in winter, to maintain a warm inside temperature, windows and doors are often closed. Therefore, two consequences often occur in winter when China has most severe air pollution: the air exchange rate is inadequate, and indoor air pollutant level increases due to the influences of air infiltration and occupant activities.

Studies associated with indoor air performance in China have mainly concentrated on toxins produced by chemical materials (such as formaldehyde and benzene) and they were commonly conducted in domestic houses and large-scale public buildings (e.g., office buildings, shopping malls and museums). The IAQ in classrooms of primary school buildings and the influential factors have not been extensively investigated. Only a few relevant case studies were available for review. For example, Yi et al. (2007) found that the IAQ in investigated primary schools in Shanghai did not meet the national standard, and the CO_2 concentrations ranged from 810 ppm to 1330 ppm during teaching hours. Moreover, the average PM concentrations was 450 $\mu g/m^3$, 6 times higher than the guideline value (75 $\mu g/m^3$) of the NAAQS-2012. The study concluded that low ventilation rates were the main reasons for the high levels of CO_2 and PM. Lin et al. (2013) stated that the $PM_{2.5}$ concentrations in a primary school building in Guangzhou did not meet the NAAQS-2012 requirements, as the values were above 60 $\mu g/m^3$. Hou (2016) found that the highest CO_2 concentrations in two primary school buildings in Beijing during the teaching periods were above 2500 ppm due to inadequate ventilation rates.

In addition to academic studies, news reports have detailed public concern regarding the IAQ in primary school buildings. In July 2015, Beijing announced that the government began research on the installation of air purifier systems in public primary school classrooms (Education Department of Beijing, 2015). In Hangzhou 2015, many parents sent letters to the government demanding the installation of air purifier systems in classrooms (Education Department of Hangzhou, 2017). In 2017, two representatives of the National People's Congress and the Chinese People's Political Consultative Conference proposed the installation of air purifier systems in primary schools to combat indoor air pollution (Liu, 2016). Therefore, IAQ in primary school buildings is a significant concern in the research community and the public.

3.4.2. The influence of ambient air pollution

Studies of the IAQ in school classrooms have demonstrated that the increased levels of air pollutants in the ambient environment have influenced the indoor the air quality of classrooms (e.g., Canha et al., 2015; Daisey et al., 2003; de Gennaro et al., 2013; Razali et al., 2015). For example, Zwoździak et al. (2013) indicated that PMs inside the classroom are mainly from the ambient environment through infiltration. Hänninen et al. (2010) suggested that ambient air pollution has a critical effect on indoor air pollution. Brunekreef et al. (1997) noted that schools near roadways and industrial areas usually have more children suffering from bronchial hyperresponsiveness and positive allergic sensitization issues. Amato et al. (2014) found that in Barcelona, 53% of the indoor PMs in 39 investigated primary schools was from seven outside sources: mineral, traffic, road dust, metallurgy, sea spray, secondary sulphates and organics and heavy oil combustion.

Thus, based on the analysis above, ambient air quality is one of the most important factors that affects the indoor air pollution levels in school buildings.

3.4.3. The influence of indoor activities

In a classroom, the factors that influence the indoor environment are similar to those that affect other indoor environments. For example, furniture in classrooms, perfumes, and experimental equipment often generate VOCs. CO_2 levels usually increase due to student respiration. However, the factors related to the PM level in a classroom differ from those in other indoor environments because classrooms have higher occupancy rates and indoor activities are more intense (i.e., children are more energetic and active than a typical adult). Moreover, classrooms have unique indoor PM sources, such as chalk, that are uncommon in other indoor environments.

Some studies have shown that the resuspension of PMs by indoor student activities affects the indoor PM concentration in classrooms during occupied periods (e.g., Yang et al., 2009; Mullen et al., 2010). Lefcoe and Inculet (1975) found that the indoor PM concentrations are affected significantly by indoor activities, such as children playing and blackboard cleaning. Raunemaa et al. (1989) reported that the amount of time that children spend indoors have significant effects on the average levels of indoor PMs. Moreover, Majumdar et al. (2011) indicated that writing on a blackboard with chalk in a classroom significantly contributes the production of $PM_{2.5}$ and PM_{10}. Lin et al. (2015) found that chalk can generate considerable quantities of PMs. Jai Devi et al. (2009) indicated that PMs in classrooms are mainly generated by chalk, even by some labelled as anti-dust chalks.

The above studies highlight the unique characteristics of the indoor environment in primary schools. For example, children are more energetic than adults, and internal classroom activities are intensive, with a high potential for the resuspension of PMs. Moreover, the use of chalk significantly contributes to the PM concentration.

3.4.4. The influence of airtightness levels

As noted in section 2.7.1, building airtightness in China is currently divided into 8 levels according to the GB/T7106-2008 building regulation. Public buildings are now required to have a minimum airtightness level of 6 based on the PBESS-2015. For public buildings constructed between 2005 and 2015, the compulsory required airtightness level is 4. Therefore, primary school buildings, as one type of public building in China, typically have an airtightness of level 4 or 6, depending on the year of construction. However, primary school buildings constructed before 2005 generally have airtightness levels below 4 since there was no airtightness level requirement prior to 2005.

There is little research available regarding the correlation between airtightness levels and indoor air pollution in classrooms of primary school buildings. However, the discussion in section 2.7.1 indicated that airtightness levels of public buildings have significant effects on the penetration of outdoor air pollutants. In particular, a study conducted by Z. Chen et al. (2017) in public buildings in China with different airtightness levels should be highlighted. The study mainly investigated the ratios of indoor $PM_{2.5}$ concentrations to outdoor $PM_{2.5}$ concentrations in public buildings with airtightness levels ranging from 3 to 6. The results indicated that buildings with low airtightness levels generally had high PM I/O ratios, and even for buildings with an airtightness level of 6, I/O ratios still reached approximately 0.46.

Primary school buildings, as public buildings in China, have the same airtightness levels as the other types of public buildings studied by Z. Chen et al. (2017). Thus, undoubtedly, a high airtightness level can reduce the ambient air pollutant penetration inward in school buildings.

3.4.5. Influence of ventilation mode

In China, most classrooms in public primary school buildings are naturally ventilated (Hou et al., 2015; Liang et al., 2017). Thus, the only method to allow ambient air flows into classrooms is to open doors or windows. Dong and Zhang (2011) stated that in Chengdu, over 58.3% of teachers and students would like to ventilate their classrooms via windows during school hours. The reasons for the dominance of natural ventilation in primary school buildings are similar to those for other types of buildings (section 2.7.2). First, building regulations related to primary school buildings encourage natural ventilation in suitable weather conditions. For example, the School Building Design Code (GB50099-2011) states that school buildings in the hot summer and cold winter, how summer and warm winter, and temperate climate zones should be ventilated with open windows throughout the year. Additionally, school buildings in the severe cold and cold climate zone should be naturally ventilated, except in winter. Some building regulations also recommend ventilation strategies according to the functions of rooms. For example, the Design Code for Heating, Ventilation, and Air Conditioning of Civil Buildings (GB50736-2012) requires that rooms with special functions, such as laboratories and kitchens, to have mechanical ventilation systems. Conversely, in rooms such as teaching spaces and reading rooms, the prioritized ventilation option is natural ventilation. The second reason for the dominance of natural ventilation is the cost. Local governments cannot afford to install mechanical ventilation systems in public primary schools. Moreover, school administrators need to save money to pay for electricity consumption (Zhang, 2010). Finally, noise from mechanical ventilation equipment is one of the barriers restricting the popularity of such systems in school classrooms (Dong and Zhang 2011).

Due to the dominance of natural ventilation and its inherent limitations in filtering ambient air pollutants, the indoor air pollutant levels in most primary school buildings exceed the requirements of the Chinese standards.

3.4.6. Current measures to tackle indoor air pollution in classrooms of Chinese primary school buildings

On December 8 and 18, 2015, Beijing issued its first and second red alerts for severe ambient air pollution (Environment Protection Department of Beijing, 2015). Schools were ordered to shut down until the government granted clearance. Since these events, many local governments have developed emergency plans for the occurrence of heavy air pollution. The emergency plans require schools to shut down when heavy air pollution occurs. Thus, shutdowns have become a standard way of dealing with air pollution in schools. In days without extreme air pollution, air purifiers are the only tools schools use to combat air pollution. However, many local governments have rejected proposals to install air purifiers in primary school classrooms. For example, in December 2015, the Beijing government announced that they could not install air purifier systems in all public primary school buildings due to power shortages, financial limitations and inadequate room space (Education Department of Beijing, 2015). In Hangzhou, the Education Department of the Hangzhou government rejected a proposal to install air purifiers in primary school classrooms due to a financial shortage (Education Department of Hangzhou, 2017). Therefore, in reality, most primary schools have no effective measures for coping with severe air pollution. The typical practice is to close doors and windows and reduce the intensity of student outdoor activities.

3.5. Indoor Thermal Comfort of Primary School Buildings in China

As introduced in section 2.5, primary school buildings in northern China are typically heated by a central heating system in winter and cooled by air conditioners in summer. In some village areas or undeveloped areas where central heating systems are uncommon, tradition methods such as burning coal remain the dominant ways to generate heat. Moreover, most classrooms in public primary school buildings are naturally ventilated (Hou et al., 2015; Liang et al., 2017). Thus, the ventilation rate is related to the outdoor surrounding environment. Few studies have focused on the thermal environment in primary school buildings in China, and only a few studies are available to review. For example, Qu and Lv (2008) found that over 30% of students were dissatisfied with the indoor thermal environment in city areas of Shenyang. Wang et al. (2017) found that in Qinghai, none of the investigated primary school buildings have indoor thermal environments that meet the CIAQS-2002 and WHO standard. A similar study from Wang et al. (2016) stated that primary school buildings in village areas of Shanxi also had poor indoor thermal environments due to the low air temperatures and excessive infiltration rates in winter. Bai et al. (2015) found that the indoor thermal performance in primary school buildings in Xi'an did not meet the thermal requirements of the CIAQS-2002 and WHO standard in spring due to the high indoor air temperature and low wind speed.

Other than studies introduced above, few studies have concentrated on the thermal performance in primary school buildings, especially in the cold climate zone.

3.6. IAQ, Thermal Comfort and Energy Consumption in School Buildings

Energy consumption in schools is an essential component of public building sector energy consumption. For example, in Ontario, Canada, school buildings contribute to 30% of energy consumption in the public building sector (ECO, 2016). Moreover, a significant portion of the energy consumed in school buildings is related to the IAQ, and, as indicated in section 2.6, there are strong connections among the IAQ, thermal comfort and the energy consumed by building heating, cooling, and ventilation. Figure 3.1 indicates that primary school building energy consumption related to the IAQ contributes to 67% of total building energy consumption in the USA.

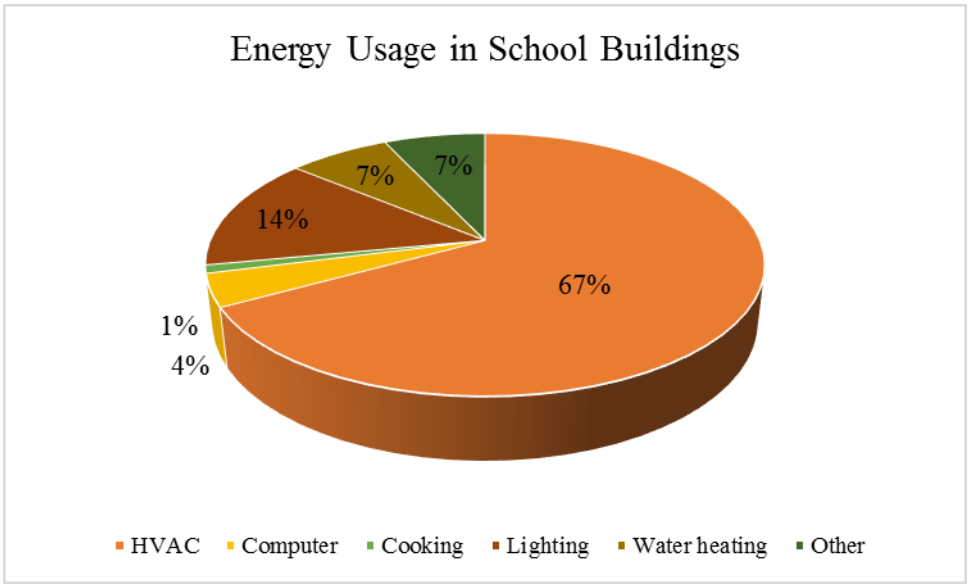


***Figure 3.1**. Energy usage in school buildings*

Source: EIA (2003)

Figure 3.2, which is derived from the study of Wolfram and knittel (n.d.), shows that space cooling, space heating, and ventilation account for 22%, 5% and 22% of the total electricity consumption in school buildings, respectively.

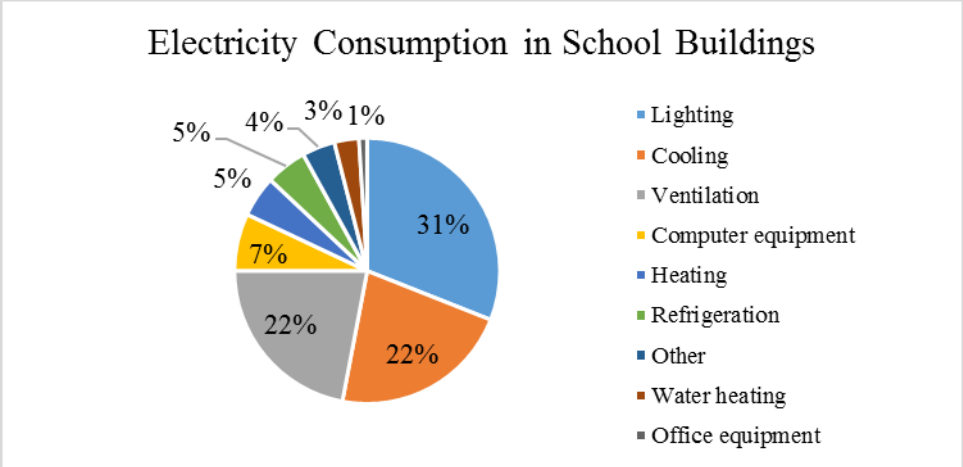


Figure 3.2. *Electricity consumption in school buildings*

Source: Wofram and Knittel (n.d)

A report from Xcelenergy (n.d.) stated that in a typical school building in the USA, space heating and cooling contributes to 52% of total energy consumption (Figure 3.3).

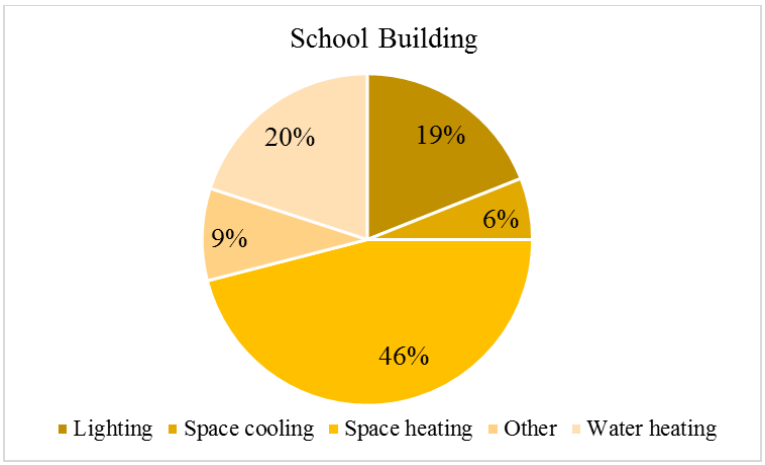


Figure 3.3. *Energy use in school buildings*

Source: Xcelenergy (n.d.)

In China, very few studies have focused on the correlation between energy consumption and the control of the indoor environment (air quality and thermal comfort) in primary school buildings. Only two published studies are available to review. One is from Yang (2015), who found that energy consumption related to the IAQ (space heating, cooling, and ventilation) in school buildings contributes

to over 50% of total building energy consumption. Additionally, Li (2017) suggested that energy consumed to regulate the IAQ accounts for 60% of total school building energy consumption in China.

In addition to space heating and cooling, the use of air purifiers in school classrooms can increase building energy consumption. However, to date, no studies have been conducted regarding the increase in energy consumption due to the installation of air purifiers in primary school buildings. The potential effects on local electricity generation and the environment remain largely unknown.

3.7. Field Measurements: Case Study Primary Schools

As introduced in sections 3.2 and 3.3, the IAQ and thermal comfort in primary school buildings in China have not been extensively studied. Notably, in heavily polluted areas, the influential factors related to indoor sources and outside sources remain unclear. Therefore, field measurements were made in a case study of primary schools. The ultimate goal of the field measurements was to provide a detailed description of IAQ performance in classrooms of primary schools and identify the primary air pollutants. Moreover, field measurements can guide the direction of potential solutions to air pollution problems considering the relevant influential factors in primary school classrooms.

3.7.1. Location selected

With a vast territory, China has an extreme variety of climates, ranging from subtropical in the southern provinces to subarctic in the north-eastern regions. Severe air pollution frequently occurs in the northern part of China. According to the latest report from the National Environmental Protection Department, Hebei, Tianjin, Beijing, Shandong, and Henan were the five provinces with the worst air pollution in 2017. All these provinces are located in the cold climate zone. Additionally, among these five provinces, Shandong is the largest coal consumer and second largest emitter of air pollutants (NBS and NDRC, 2016).

Considering the data sources and availability, Tai'an city, located in central Shandong, was selected as the study area. Totally, 9 naturally ventilated primary school buildings located in Tai'an city were selected as case studies. These schools were constructed at different years in fully compliance with different versions of building construction regulations.

3.7.2. Selected primary school buildings

Figure 3.4 shows the locations of the 9 studied primary school buildings, and Table 3.1 summarise their characteristics. All the classrooms selected have a similar number of students, as well as similar floor areas and floor heights to facilitate comparisons. However, these buildings were constructed in different years and therefore are regulated by different building compliances standards. For example, Schools A, B, and C were completed without considering a building energy saving standard because China had no thermal requirement for public buildings prior 2005. School D was refurbished in 2005 when the China PBESS-2005 took effect, so it has external insulations, double-glazed windows, and an airtightness level of 4. School E was constructed in 2015 based on the latest version of the China PBESS. Therefore, it has the thickest insulation layer (lower U-values) and a higher airtightness level (level 6) than the other schools. Schools F, G, H, and I are similar to School D since they were all constructed in compliance with the 2005 version of the Public Energy Saving Standard.

Schools A, B, and C use air conditioners to heat the air in winter, and the other schools heat air using the urban central heating systems, provided by the government. Windows and doors are usually closed to maintain a stable indoor temperature in winter and reduce air pollutants transport from outdoor.

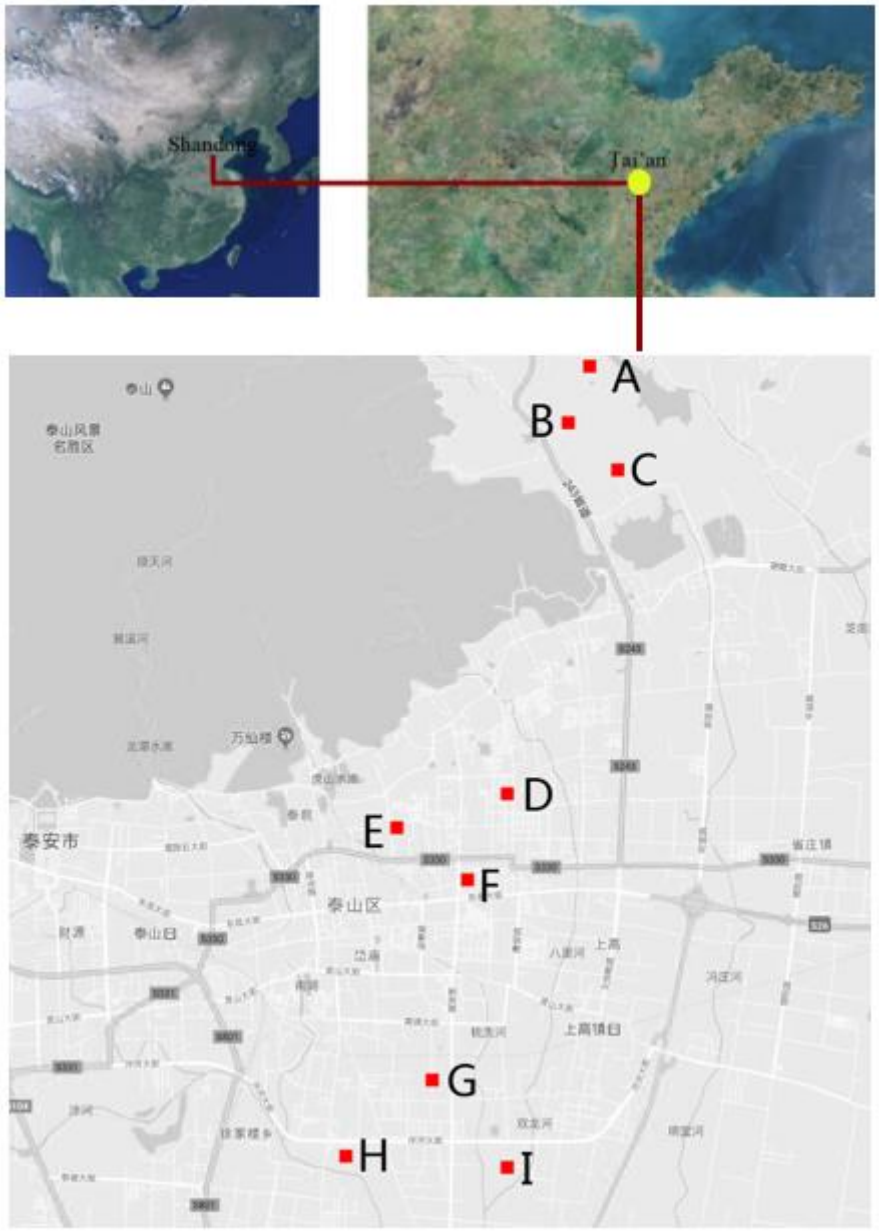


Figure.3.4. *The case study schools in Tai'an City.*

Table 3.1. The characteristics of selected schools

	A	B	C	D	E	F	G	H	I
Size of classroom (m^2)	68	66	65	72	68	70	71	68	67
Number of students	40	45	43	40	55	45	46	43	43
Height of classrooms (m)	3.6	3.3	3.4	3.6	3.6	3.6	3.5	3.6	3.6
Constructed year	1997	2003	1996	Refurbished in 2005	2015	2005	2005	2007	2008
Wall-U value ($W/(m^2K)$)				0.6	0.38	0.6			

Roof-U value ($W/(m^2K)$)				0.55	0.28	0.55			
Window type	Single glazed			Double glazed	Triple glazed	Double glazed			
Window U value ($W/(m^2K)$)	-			2.3	1.9	2.3	2.3	2.3	2.3
Airtightness	≤3(Q≥3.0)			4(2.5≥Q＞2.0)	6(1.5≥Q＞1.0)	4 (2.5≥Q＞2.0)			

Note: (1). Q is the air volume flow rate per meter in length of cracks per hour ($m^3/m{\cdot}h$).

Field measurements were made from 8:00 am to 5:00 pm between 20 November 2016, and 10 December 2016. The investigated parameters includes $PM_{2.5}$, PM_{10}, VOCs, CO_2, relative humidity, and the indoor air temperature. The evaluation criteria were the Chinese standards, the WHO standards and the CIBSE standards (Tables 2.2.1-2.2.7).

During the measurement period, windows were all closed because of the cold outside weather, and the measurement equipment was placed 1.5 m above floor level at the centre of each classroom. Outdoor PM_{10} and $PM_{2.5}$ levels were measured with a DUST TRAK model 8530 from TSI Inc., USA, and the indoor PM_{10} and $PM_{2.5}$ levels were simultaneously recorded with a portable hand-held BRAMC-SMART-126 monitor from China. The temperature, relative humidity, TVOC concentration, and CO_2 concentration were measured with an HTV-M detector from the PPM Company, UK (Appendix I). Because the DUST TRAK model 8530 cannot measure the levels of $PM_{2.5}$ and PM_{10} at the same time, thus, outdoor $PM_{2.5}$ was measured in the morning hours, and outdoor PM_{10} was measured in the afternoon hours. Table 3.2 summarise the measurement details for the 9 primary schools.

Table 3.2. The measuring details

School name	Date	Time	Classroom
A	11th November 2016	8:30 to 16:00	Occupied
	13th November 2016	8:30 to 16:00	Unoccupied
C	14th November 2016	9:14 to 16:28	Occupied
B	16th November 2016	8:45 to 16:25	Occupied

E	20th November 2016	9:10 to 16:59	Unoccupied
	25th November 2016	8:00 to 16:25	Occupied
D	21st November 2016	7:56 to 16:27	Occupied
F	28th November 2016	9:06 to 16:08	Occupied
G	30th November 2016	8:10 to 16:36	Occupied
	3rd December 2016	8:00 to 16:00	Unoccupied
I	5th December 2016	8:22 to 16:00	Occupied
H	8th December 2016	9:01 to 16:05	Occupied

Additionally, measurements were also made during unoccupied periods in Schools A, G, and E to identify the potential correlations between the indoor PM concentrations and outdoor PM concentrations. At these times, the classrooms were empty and cleaned in advance (e.g., chalk ash and dust were removed as much as possible). Then, before the measurements, the windows and doors were closed for an entire night.

3.7.3. Measurement results

3.7.3.1. $PM_{2.5}$ and PM_{10} in occupied classrooms

Tables 3.3 to 3.8 summarise the measurment results of $PM_{2.5}$ and PM_{10} during occupied periods. School A exhibited the highest $PM_{2.5}$ level of 306 μg/m^3 and School D displayed the lowest $PM_{2.5}$ level of 36 μg/m^3. The highest value of indoor PM_{10} was 251 μg/m^3 and was observed in School G, and the lowest level was 9 μg/m^3, which was observed in School D. The mean indoor $PM_{2.5}$ and PM_{10} concentrations during occupied periods of classrooms ranged from 46 μg/m^3 to 190 μg/m^3 and 30.2 μg/m^3 to 205 μg/m^3, respectively.

The lowest and highest $PM_{2.5}$ levels were approximately 2 and 5 times the requirements established by the WHO and Chinese standards. The PM_{10} concentrations in Schools D and H meet the 24-hour mean WHO and Chinese standards. However, in the other schools, the PM_{10} levels were approximately 1.2 to 4 times higher than the guideline values set by the WHO and Chinese standards.

Additionally, the average outdoor $PM_{2.5}$ and PM_{10} levels were above the limit values of the WHO and Chinese standards, except in the afternoon in School H. Therefore, severe pollution occurred in both the indoor and outdoor environments.

Table 3.3. Results of $PM_{2.5}$ in school A, B and C (occupied) (μg/m³)

	School A		School B		School C	
	Indoor $PM_{2.5}$	Outdoor $PM_{2.5}$	Indoor $PM_{2.5}$	Outdoor $PM_{2.5}$	Indoor $PM_{2.5}$	Outdoor $PM_{2.5}$
8:00-9:00	306	229	65	43	155	143
9:00-10:00	207	164	55	40	191	198
10:00-11:00	131	103	61	27	215	218
11:00-12:00	116	78			196	181
Highest	306	250	78	54	246	294
Lowest	108	63	48	22	147	132
Mean	190	144	60	37	189	185

Table 3.4. Results of $PM_{2.5}$ in School D, E, F (occupied) (μg/m³)

	School D		School E		School F	
	Indoor $PM_{2.5}$	Outdoor $PM_{2.5}$	Indoor $PM_{2.5}$	Outdoor $PM_{2.5}$	Indoor $PM_{2.5}$	Outdoor $PM_{2.5}$
8:00-9:00	43	61	134	139	146	145
9:00-10:00	41	89	127	97	147	130
10:00-11:00	54	101	126	100	154	110
11:00-12:00					146	89
Highest	73	186	148	174	202	160
Lowest	36	49	107	82	126	76
Mean	46	84	129	112	148	119

Table 3.5. Results of $PM_{2.5}$ in school G, H and I (occupied) (μg/m³)

	School G		School H		School I	
	Indoor $PM_{2.5}$	Outdoor $PM_{2.5}$	Indoor $PM_{2.5}$	Outdoor $PM_{2.5}$	Indoor $PM_{2.5}$	Outdoor $PM_{2.5}$
8:00-9:00	242	217	55	50	112	142
9:00-10:00	147	180	66	51	98	110
10:00-11:00	192	160	75	52	106	107
11:00-12:00	171	145	116			

Highest	274	251	97	68	130	177
Lowest	158	138	44	44	85	89
Mean	188	176	78	51	105	120

Table 3.6. Results of PM_{10} in school A, B and C (occupied) ($\mu g/m^3$)

	School A		School B		School C	
	Indoor PM_{10}	Outdoor PM_{10}	Indoor PM_{10}	Outdoor PM_{10}	Indoor PM_{10}	Outdoor PM_{10}
13:00-14:00			60	54	168	123
14:00-15:00	124	83	64	54	137	111
15:00-16:00	98	66	62	52	126	100
16:00-17:00			55	56		
Highest	148	93	74	76	202	169
Lowest	86	59	44	44	104	87
Mean	111	75	60	54	144	111

Table 3.7. Results of PM_{10} in school D, E, and F (occupied) ($\mu g/m^3$)

	School D		School E		School F	
	Indoor PM_{10}	Outdoor PM_{10}	Indoor PM_{10}	Outdoor PM_{10}	Indoor PM_{10}	Outdoor PM_{10}
13:00-14:00	51	58	118	108	188	71
14:00-15:00	21	37	129	111	131	69
15:00-16:00	12	37	110	110	106	64
16:00-17:00					98	69
Highest	58	85	144	121	228	94
Lowest	9	26	101	100	80	57
Mean	30	49	120	110	139	71

Table 3.8. Results of PM_{10} in school G, H and I (occupied) ($\mu g/m^3$)

	School G		School H		School I	
	Indoor PM_{10}	Outdoor PM_{10}	Indoor PM_{10}	Outdoor PM_{10}	Indoor PM_{10}	Outdoor PM_{10}
13:00-14:00	191	177	46	14	103	10
14:00-15:00	197	187	32	16	109	109
15:00-16:00	206	197	26	18	107	107
16:00-17:00	226	205	27	18	106	106
Highest	251	243	55	27	131	118
Lowest	179	173	19	10	92	92
Mean	205	192	33	17	106	83

3.7.3.2. $PM_{2.5}$ and PM_{10} in unoccupied classrooms

Tables 3.9 and Table 3.10 show the indoor $PM_{2.5}$ and PM_{10} levels in Schools A, G, and E during the unoccupied period. All the indoor average values of $PM_{2.5}$ exceeded the guideline values of the Chinese and WHO standards. The highest indoor concentration of $PM_{2.5}$ was 189 μg/m³, and the lowest was 29 μg/m³.

Table 3.9. Results of $PM_{2.5}$ in school A, G and E (unoccupied) (μg/m³)

	School A		School G		School E	
	Indoor $PM_{2.5}$	Outdoor $PM_{2.5}$	Indoor $PM_{2.5}$	Outdoor $PM_{2.5}$	Indoor $PM_{2.5}$	Outdoor $PM_{2.5}$
8:00-9:00	66	98	177	308	58	120
9:00-10:00	56	72	142	257	33	99
10:00-11:00	50	50	119	225	35	88
11:00-12:00	49	57	121	205	35	79
Highest	101	112	189	351	67	134
Lowest	71	35	107	193	29	75
Mean	81	69	139	249	41	97

Table 3.10. Results of PM_{10} in school A, G and E (unoccupied) (μg/m³)

	School A		School G		School E	
	Indoor PM_{10}	Outdoor PM_{10}	Indoor PM_{10}	Outdoor PM_{10}	Indoor PM_{10}	Outdoor PM_{10}
13:00-14:00	69	86	155	233	47	92
14:00-15:00	72	91	163	245	45	86
15:00-16:00	72	82	161	256	46	78
16:00-17:00			162	261	44	72
Highest	78	108	189	269	56	96
Lowest	65	61	142	225	40	70
Mean	72	86	161	249	46	82

3.7.3.3. Temperature performance in occupied classrooms

Table 3.11 summarise the measurement results for air temperatures inside the classrooms during the occupied period. Schools A, B, and C did not meet the requirement based on the range between 16°C and 24°C recommended by the

CIAQS-2002 and 19°C-21°C by the CIBSE standard. The highest average indoor air temperature was 20°C in School E, and the lowest average indoor air temperature was 14.17°C in School C. The average indoor air temperatures in School F, H and I met the minimum limit value of the CIAQS-2002 but were 1°C or 2°C lower than the guideline values of the CIBSE.

Table 3.11. Results of indoor air temperature of classrooms (occupied) (℃)

	A	B	C	D	E	F	G	H	I
8:00-9:00	13.14	15.77	14.98	19.74	19.38	17.69	18.95	17.61	17.31
9:00-10:00	13.70	14.39	13.95	19.44	19.93	17.31	19.65	17.65	17.82
10:00-11:00	14.26	16.12	13.52	19.30	20.15	17.28	19.34	17.92	18.01
11:00-12:00	14.74	15.70	14.74	19.44	20.13	16.42	19.18	17.65	18.00
12:00-13:00	14.47	15.80	14.67	19.22	19.77	16.98	17.47	17.18	17.67
13:00-14:00	15.03	16.38	14.41	19.00	19.75	16.66	16.95	16.79	17.65
14:00-15:00	15.84	16.11	13.61	18.89	20.23	17.06	17.51	16.66	18.09
15:00-16:00	15.93	15.59	13.42	18.49	20.26	17.37	18.86	16.57	18.12
Highest	16.1	17.9	16.4	19.9	21	19.9	23	18.6	18.34
Lowest	13	14.2	13.10	17.6	19.2	14.2	13.1	16.02	17.14
Mean	14.68	15.78	14.17	19.18	20	17.02	18.5	17.22	17.84

In Schools D and E, the highest mean indoor air temperatures were greater than 19°C, which met the requirements of both the CIAQS-2002 and CIBSE standards. During the measurement period, the highest and lowest air temperatures in School G were 23°C and 13.1°C, respectively.

3.7.3.4. CO_2 performance in occupied classrooms

Table 3.12 summarise the indoor CO_2 concentrations during occupied periods. The average CO_2 level exceeded the requirements (1000 ppm) of the CIAQS-2002 and WHO standards. School G displayed the highest level of 4744 ppm and School F exhibited the lowest level of 476 ppm. The average values were between 1039 ppm and 1592 ppm.

Table 3.12. Results of indoor CO_2 concentrations of classrooms (PPM)

	A	B	C	D	E	F	G	H	I
8:00-9:00	1698	992		1295	1652		2863	1154	1685
9:00-10:00	2039	1410	933	1597	2590	1614	4107	1470	2642
10:00-11:00	1502	1256	968	1113	2014	1102	1317	1543	2054
11:00-12:00	1546	1641	1145	1271	1582	861	1119	1365	1614
12:00-13:00	915	846	934	793	1050	491	598	955	1071
13:00-14:00	1139	983	1286	765	836	833	685	758	853
14:00-15:00	1273	1252	1121	1217	1205	1276	567	1099	1229
15:00-16:00	1564	1208	879	1264	1223	1467	2110	1509	1247
Highest	2337	2479	1593	2150	3354	4137	4744	2258	3421
Lowest	713	776	817	578	737	476	477	662	752
Mean	1443	1211	1039	1154	1509	1084	1592	1236	1539

3.7.3.5. VOCs performance in occupied classrooms

The measurement results in Table 3.13 indicate that VOCs have relatively limited effects on the IAQ. All the average VOC concentrations met the requirement of the Chinese standard (0.6 mg/m^3). Notably, the highest mean value was 0.457 mg/m^3, and the lowest mean value was 0.311 mg/m^3.

Table 3.13. Readings of indoor TVOCs concentrations of selected classrooms (mg/m^3)

	A	B	C	D	E	F	G	H	I
8:00-9:00	0.446	0.331		0.445	0.32		0.29	0.420	0.328
9:00-10:00	0.477	0.398	0.361	0.457	0.375	0.430	0.343	0.431	0.385
10:00-11:00	0.446	0.373	0.375	0.434	0.411	0.342	0.328		0.369
11:00-12:00	0.440	0.356	0.401	0.463	0.385	0.359	0.313	0.410	0.352
12:00-13:00	0.422	0.328	0.380	0.439	0.354	0.312	0.289	0.437	0.324
13:00-14:00	0.450	0.323	0.371	0.431	0.340	0.327	0.284	0.415	0.319
14:00-15:00	0.474	0.353	0.353	0.470	0.352	0.369	0.311	0.408	0.350
15:00-16:00	0.499	0.364	0.317	0.445	0.382	0.384	0.321	0.444	0.360
Highest	0.550	0.428	0.590	0.530	0.450	1.060	0.376	0.500	0.423
Lowest	0.410	0.304	0.310	0.370	0.310	0.300	0.268	0.350	0.301
Mean	0.457	0.353	0.365	0.448	0.368	0.360	0.311	0.423	0.350

3.7.3.6. Relative humidity performance in occupied classrooms

The average measured relative humidity varied from 30% to 70%, and the levels in the majority of measurement period were within the limits of the Chinese standards (30%-60% for winter heating air) (Table 3.14). School A exhibited the highest relative humidity level of over 60%, and School B displayed the lowest level of approximately 30%. The highest mean value recorded was 70.63% in School A, and the lowest mean value was 36.45% in School B.

Table 3.14. Readings of indoor relative humidity of selected classrooms

	A	B	C	D	E	F	G	H	I
8:00-9:00	68.27	37.78	60.57	58.59	39.54	45.55	48.85	51.04	47.45
9:0010:00	69.62	41.86	63.51	60.15	45.13	44.59	51.32	54.00	54.16
10:00-11:00	68.3	36.01	64.42	60.91	44.43	44.53	41.40	56.20	53.31
11:00-12:00	70.99	39.52	61.93	63.43	44.57	37.79	41.98	56.24	53.48
12:00-13:00	71.02	36.09	50.89	58.77	38.42	32.72	39.67	54.35	46.11
13:00-14:00	72.72	32.14	48.72	57.32	36.50	42.90	43.14	53.44	43.80
14:00-15:00	70.89	34.81	42.19	60.57	38.47	38.41	41.75	52.11	46.17
15:00-16:00	70.72	33.58	35.86	57.3	37.63	53.27	52.67	49.99	45.16
Highest	73.9	56	65.4	67.9	51.9	55.4	55.3	62.47	62.28
Lowest	65.6	30.4	34.5	45.2	33.5	29.9	34.9	44.07	40.2
Mean	70.63	36.45	52.88	58.55	40.27	41.23	45.27	54.15	48.33

3.7.4. Discussion

The measurement results of PMs and CO_2 did not meet the related standards. Additionally, the indoor thermal comfort requirements were not satisfied in most schools. However, the relative humidity and VOC levels had limited effects on the IAQ and met the limits established by the Chinese and WHO standards.

3.7.4.1. $PM_{2.5}$ and PM_{10}

- Effects from the outdoor air environment

In winter, North China normally has the worst ambient air pollution due to the coal combustion for building heating (section 2.3). Table 3.15 presents the daily average ambient PM concentrations recorded at local ambient air quality monitoring stations during the measurement hours (EPD,2018). Figure 3.5 shows the comparisons between the daily average ambient PM concentrations and the requirements set by the NAAQS-2012.

Table 3.15. Daily mean PM concentration in measurement periods

Date	$PM_{2.5}$ (μg/m³)	PM_{10} (μg/m3)
11th November 2016	71	104
13th November 2016	135	194
14th November 2016	145	227
16th November 2016	53	74
20th November 2016	62	84
25th November 2016	87	112
21st November 2016	26	41
28th November 2016	71	105
30th November 2016	133	194
3rd December 2016	110	158
5th December 2016	152	224
8th December 2016	107	172

Source: Source: Ambient Air Quality Online Analysis Platform, provided by the Department of the National Environment Protection (https://www.aqistudy.cn/).

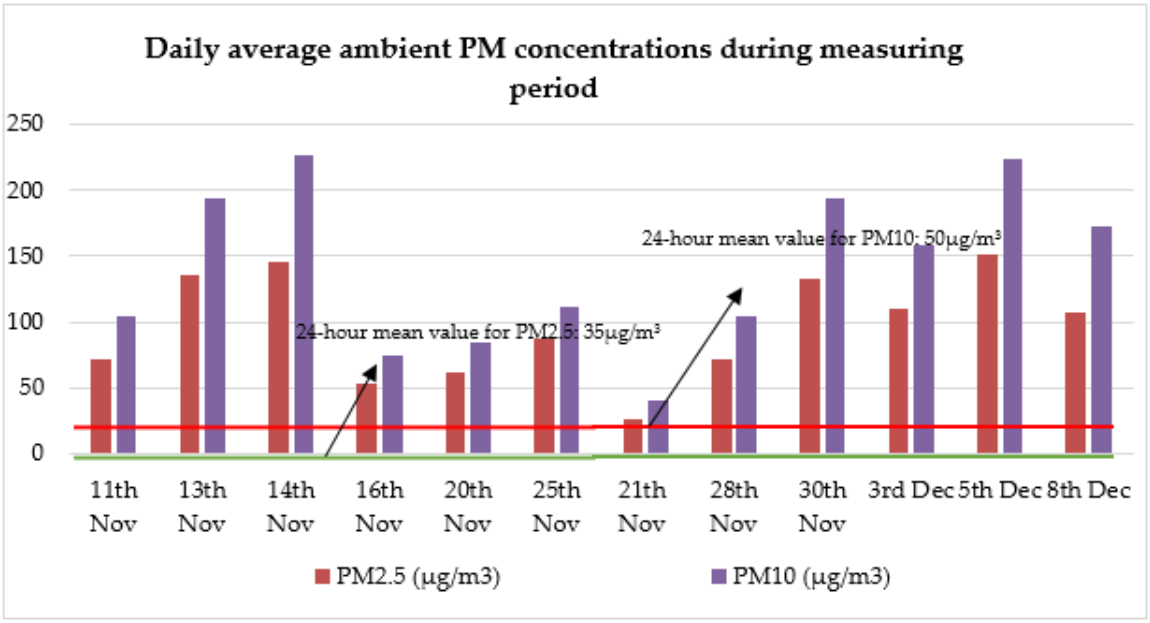


Figure 3.5. *Daily ambient mean PM levels during the measurement period.*

On the measurement periods, the outdoor PM concentrations exceeded the limit values of the NAAQS-2012 (35 μg/m^3 for $PM_{2.5}$ and 50 μg/m^3 for PM_{10}). Because IAQ is closely related to the outdoor pollutant levels, especially in primary school buildings that are naturally ventilated, ambient air pollutants can decrease the IAQ by flowing inside through windows and doors or penetrating building via air leakages in the building fabrics.

- Effects of building defects

The I/O ratios between the indoor PM concentrations measured in unoccupied classrooms and outdoor PM concentrations were used to reflect the effects of building defects, such as low airtightness levels. The classrooms were cleaned before the measurements. Thus, it was assumed that the indoor sources of PMs, such as student activities and the resuspension of chalk dust, were eliminated. In addition, the doors and windows were closed; therefore, penetrating through cracks in the building envelope was the only way for indoor PM aggregation to occur. Figure 3.6 summarises and compares the hourly average I/O ratios of PM concentrations in unoccupied classrooms during measurement period.

The lowest average I/O ratios were observed in School E, with values of 0.41 and 0.56 for $PM_{2.5}$ and PM_{10}, respectively, and School A had the highest average I/O ratios, with values of 0.83 and 0.82. School G ranked in the middle with values of approximately 0.6 on average. School E exhibited the best performances, which was expected since it has the highest airtightness level among the schools shown. School A was built before 2005, when building airtightness was not considered in the building design standards. Thus, air leakages and cracks in the building fabrics can be easily found (Figure 3.7).

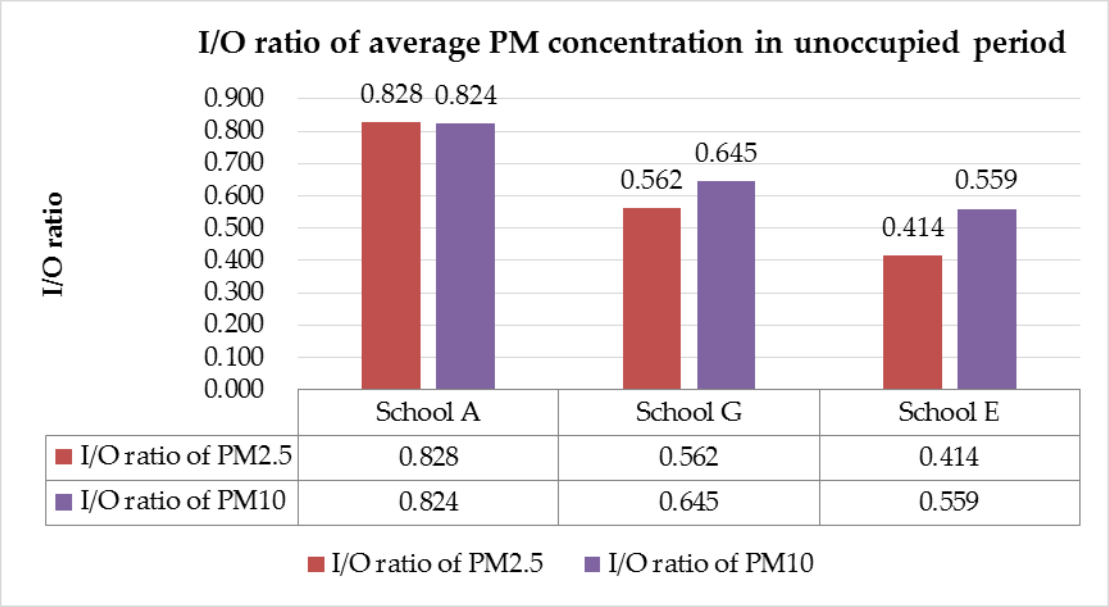


Figure 3.6. *Average I/O ratios during unoccupied periods.*



Figure 3.7. *Air leakages in studied buildings*

Figures 3.8 to 3.13 illustrate the indoor and outdoor PM concentrations in Schools A, G, and E during the unoccupied period. The trends in both indoor and outdoor PM concentrations were consistent. The indoor PM concentrations were more

stable than the outdoor PM concentrations. However, both the indoor and outdoor PM concentrations exhibited similar variations. For example, School G exhibited a similar increase in PM_{10} and a similar decrease in $PM_{2.5}$ in both the indoor and ambient environment. Therefore, in naturally ventilated buildings, the indoor air pollutant levels can be significantly increased by the infiltration of PMs.

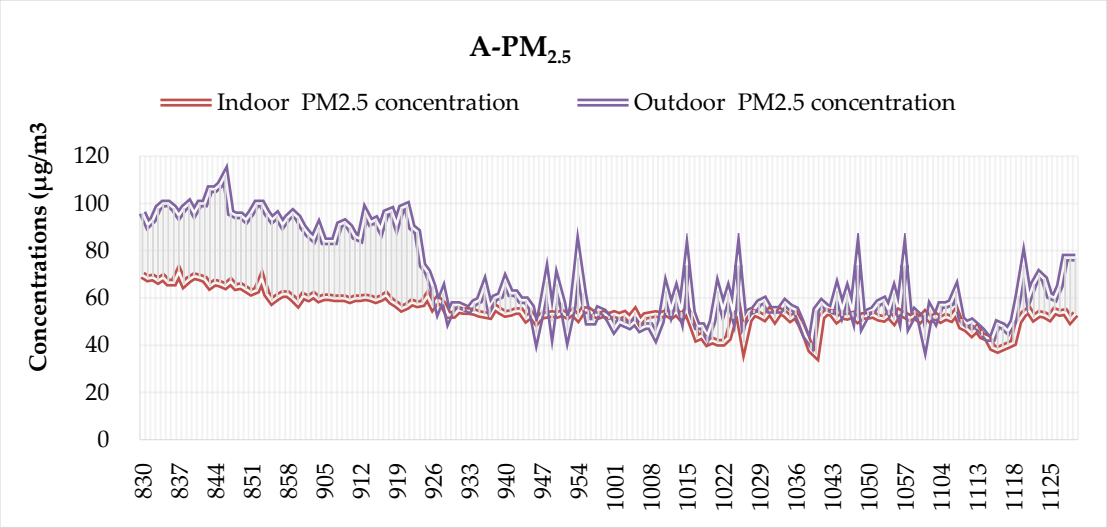


Figure 3.8. *Measurement results of $PM_{2.5}$ in School A (unoccupied periods).*

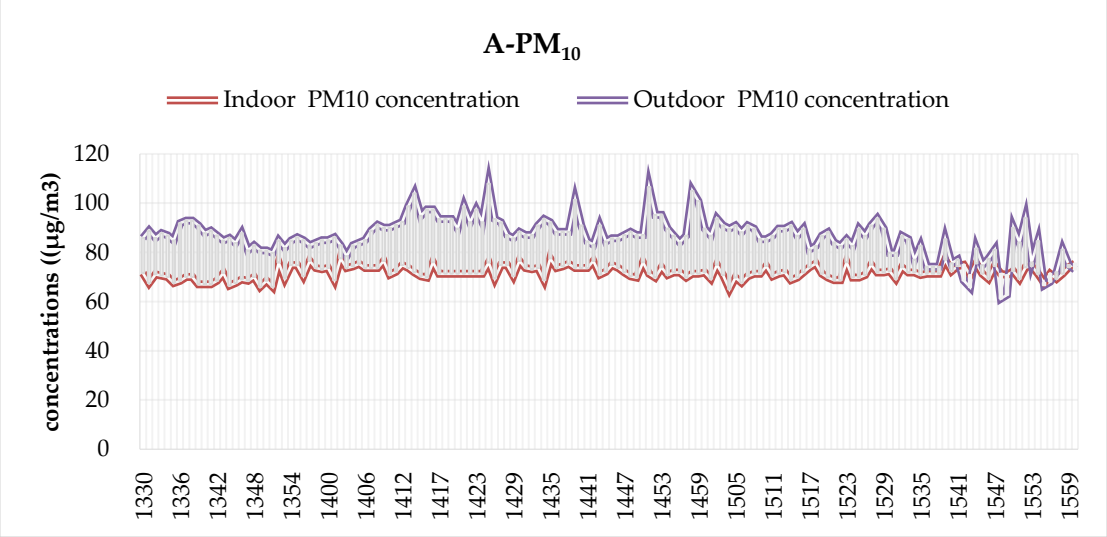


Figure 3.9. *Measurement results of PM_{10} in School A (unoccupied periods).*

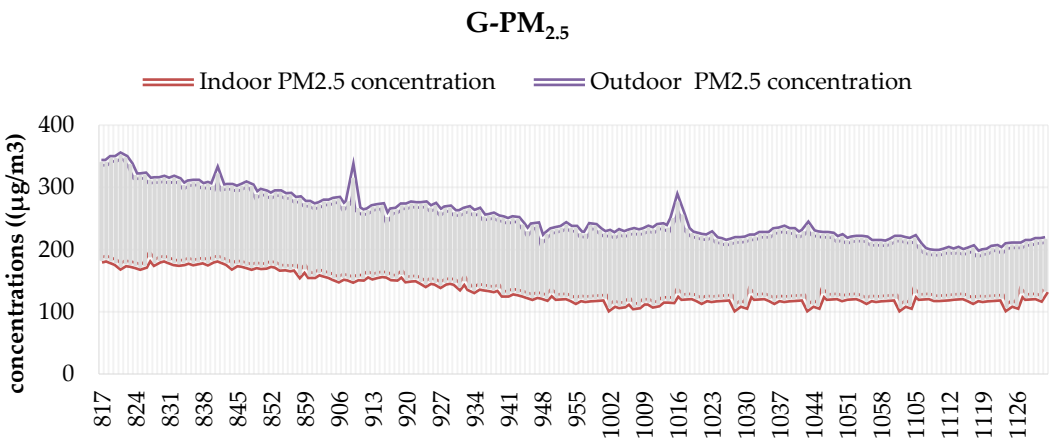


Figure 3.10. *Measurement results of $PM_{2.5}$ in School G (unoccupied periods).*

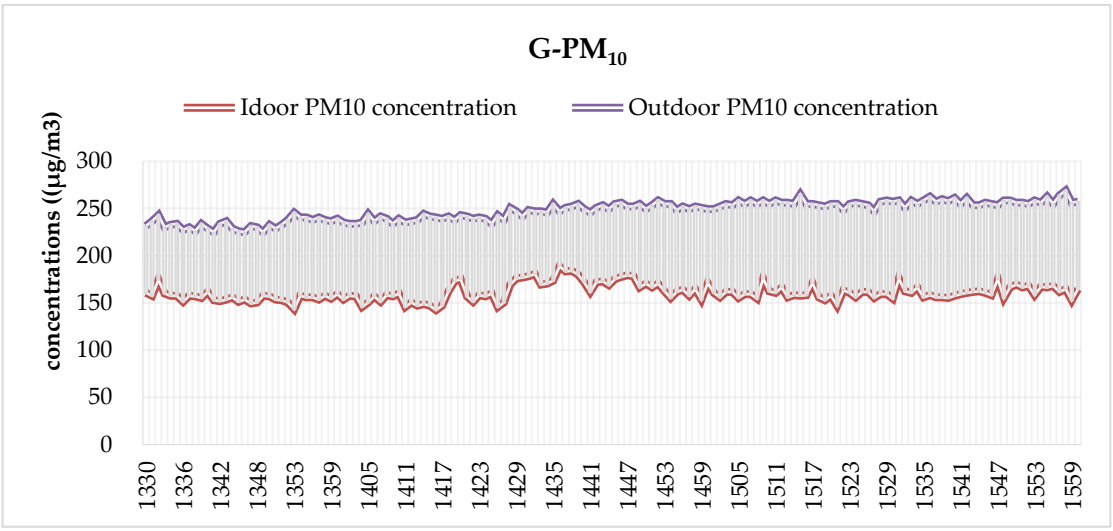


Figure 3.11. *Measurement results of PM_{10} in School G (unoccupied periods).*

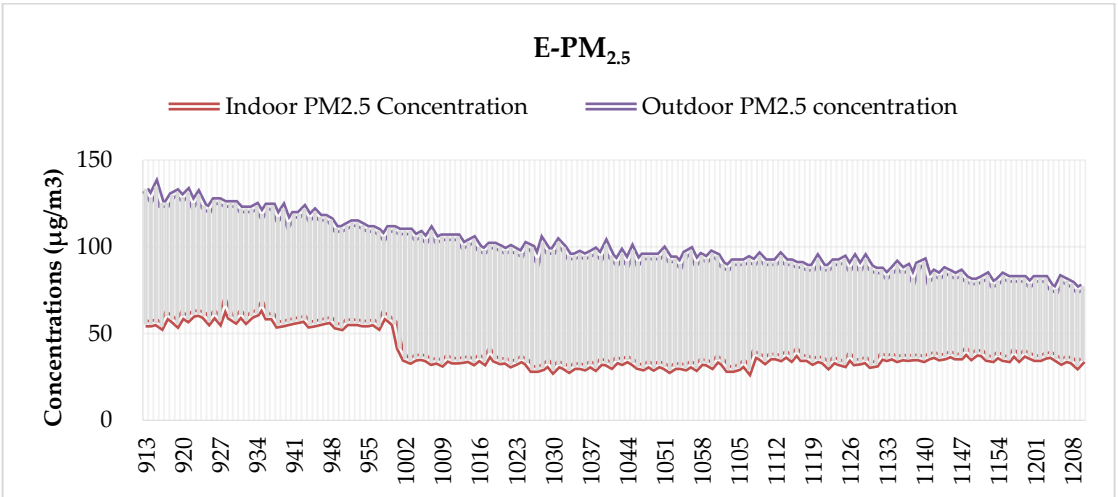


Figure 3.12. *Measurement results of $PM_{2.5}$ in School E (unoccupied periods).*

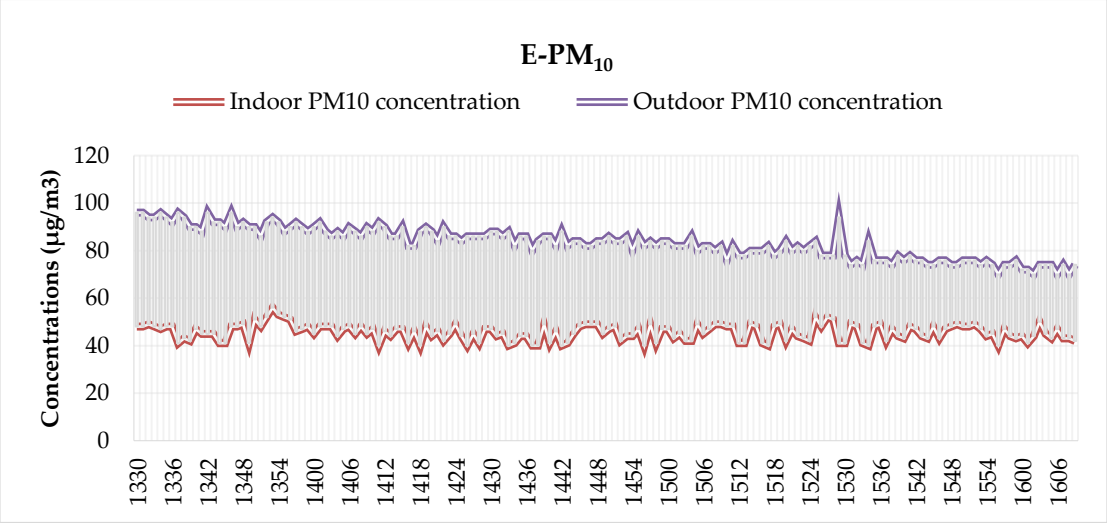


Figure 3.13. *Measurement results of PM_{10} in School E (unoccupied periods).*

- Effects of internal activities

Table 3.16, Table 3.17, Figure 3.14 and Figure 3.15 summarise and illustrate the I/O ratios during the occupied period. Overall, the average values were above 1, except those for Schools D and I. The highest ratios for $PM_{2.5}$ and PM_{10} were 1.73 in School B and 2.25 in School H, respectively, and the lowest ratios for $PM_{2.5}$ and PM_{10} were 0.60 and 0.68 in School D.

The ratios above 1 revealed that there were indoor sources that contributed to the indoor PM concentrations when a classroom was occupied. For example, student activities such as walking, running, and cleaning the blackboard increase the resuspension of PMs. The use of chalk also increases indoor PM levels. Figure 3.16 shows the chalk dust in selected classrooms.

Figures 3.17 to 3.34 show the indoor and outdoor PM levels during occupied periods in all the selected primary schools. The indoor and outdoor PM concentrations of some schools, such as A, C, G, and I, displayed similar trends. Taking A as an example, similar decreases in the indoor and outdoor PM concentrations were observed throughout the measurement period. Although the ambient PM concentrations displayed more significant variations in amplitude, the overall trends were consistent. In Schools B, E, D, F and H, the indoor and

outdoor PM concentrations did not coincide, likely because the intensity of indoor activities differed, and the ambient PM concentrations were unstable.

Table 3.16. Hourly average I/O ratio of $PM_{2.5}$ concentrations in occupied period

	A	B	C	D	E	F	G	H	I
8:00-9:00	1.36	1.54	1.09	0.73	0.98	1.02	1.11	1.09	0.80
9:00-10:00	1.29	1.44	0.99	0.51	1.31	1.14	1.03	1.29	0.90
10:00-11:00	1.49	2.22	0.99	0.56	1.28	1.49	1.20	1.44	1.0
11:00-12:00	1.48		1.08			1.58	1.18		
Average	1.35	1.73	1.02	0.60	1.19	1.24	1.12	1.27	0.91

Table 3.17. Hourly average I/O ratio of PM_{10} concentrations in occupied

	A	B	C	D	E	F	G	H	I
13:00-14:00		1.13	1.39	0.89	1.09	2.64	1.08	3.40	1.03
14:00-15:00	1.50	1.26	1.24	0.55	1.17	1.98	1.05	2.18	1.04
15:00-16:00	1.49	1.22	1.28	0.35	1.00	1.71	1.04	1.50	1.03
16:00-17:00		1.00				1.52	1.10		0.95
Average	1.50	1.16	1.30	0.68	1.09	2.03	1.06	2.25	1.03

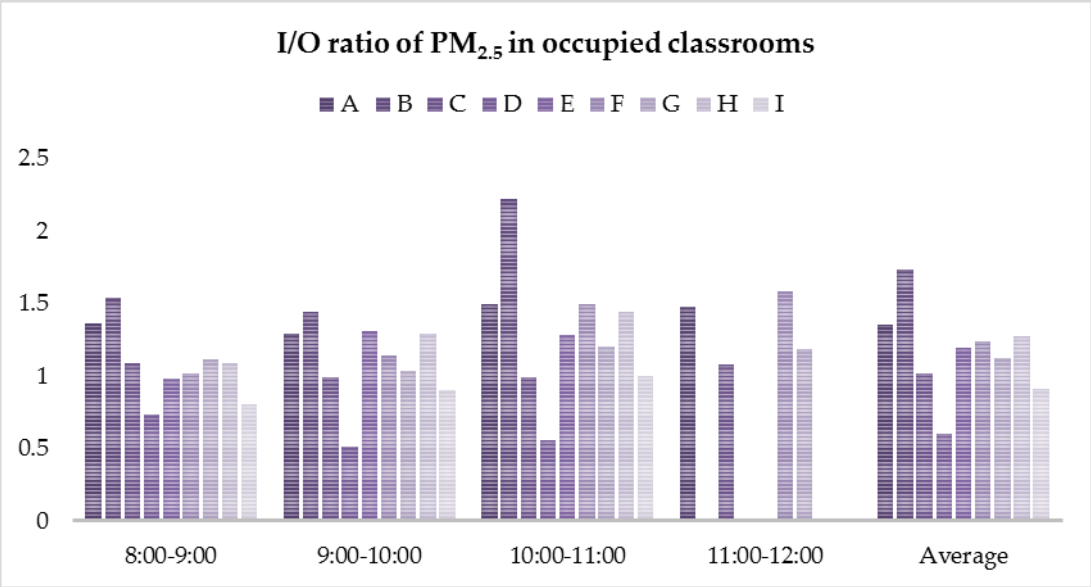


Figure 3.14. *I/O ratio of $PM_{2.5}$ in occupied classrooms*

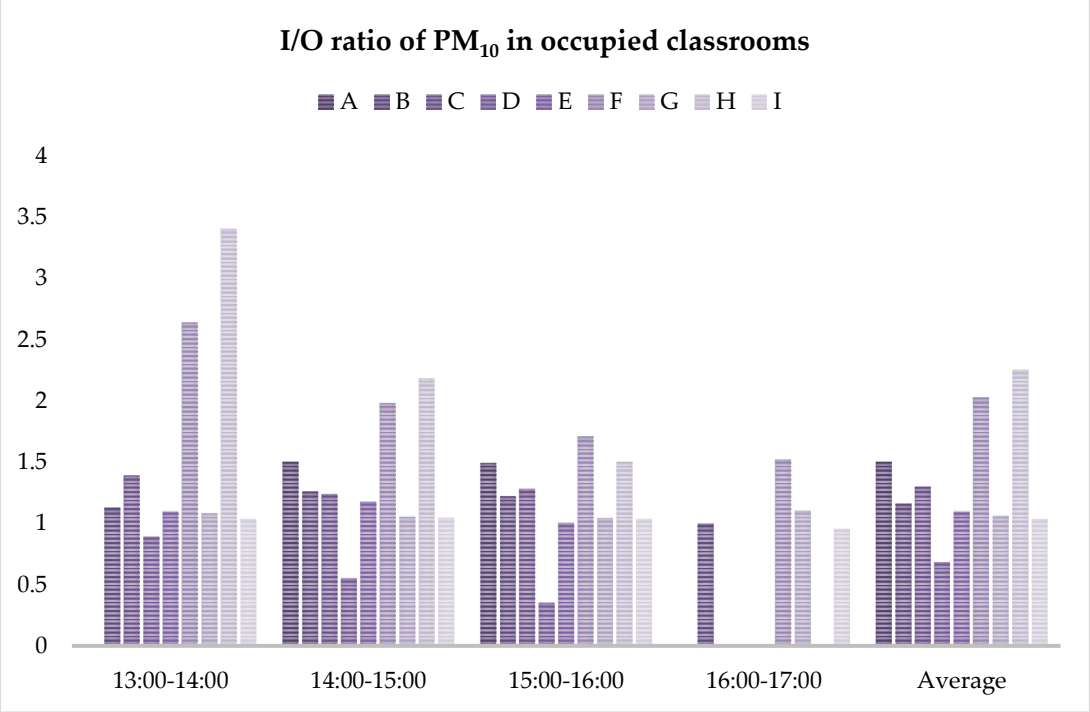


Figure 3.15. *I/O ratio of PM_{10} in occupied classrooms*



Figure 3.16. *Chalkdust in classrooms*

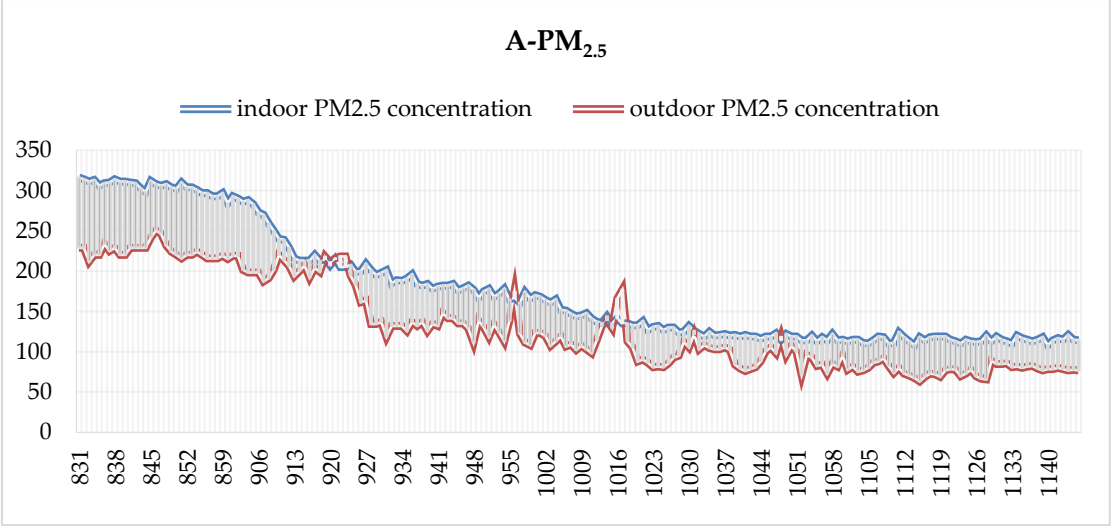


Figure 3.17. *Measurement results of $PM_{2.5}$ in School A (occupied periods)*

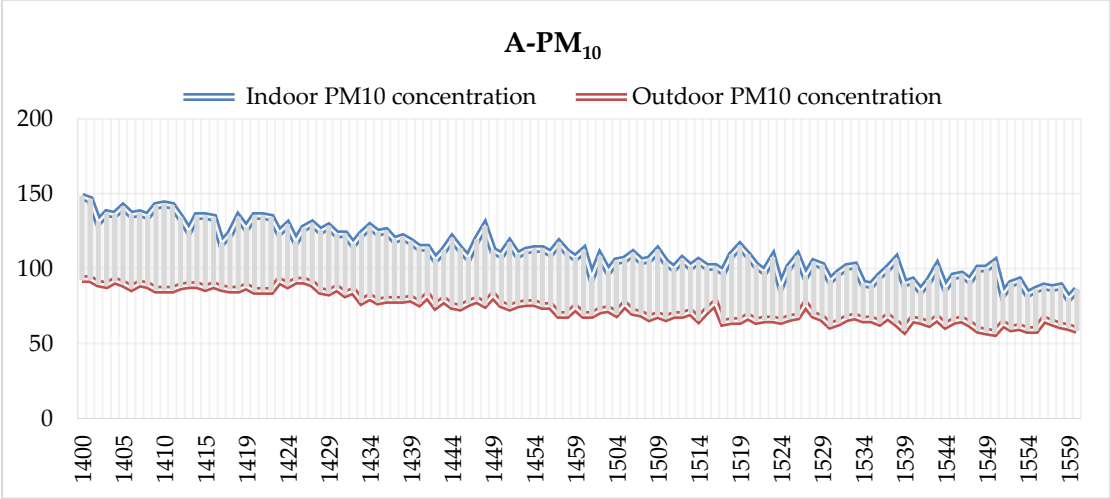


Figure 3.18. *Measurement results of PM_{10} in School A (occupied periods)*

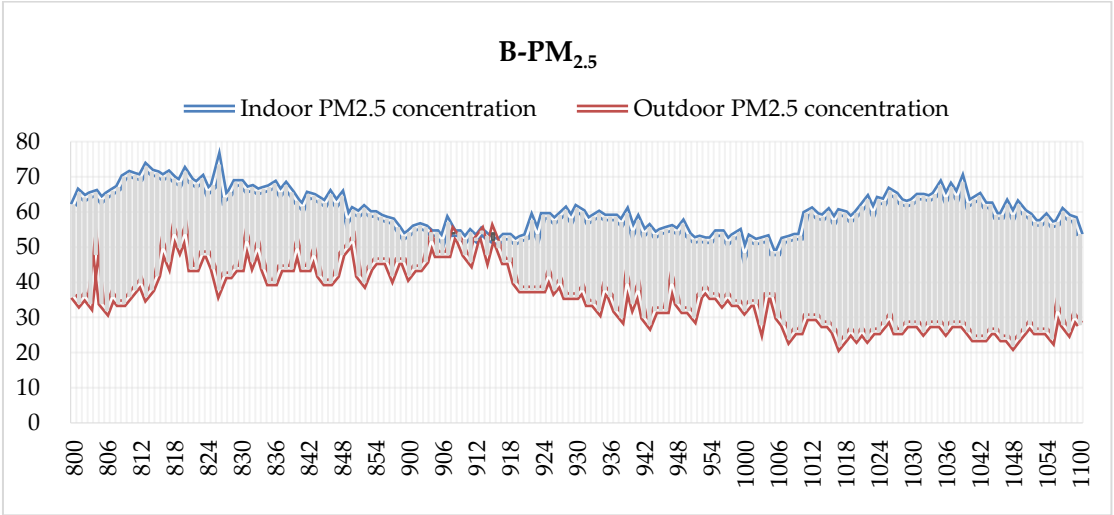


Figure 3.19. *Measurement results of $PM_{2.5}$ in School B (occupied periods)*

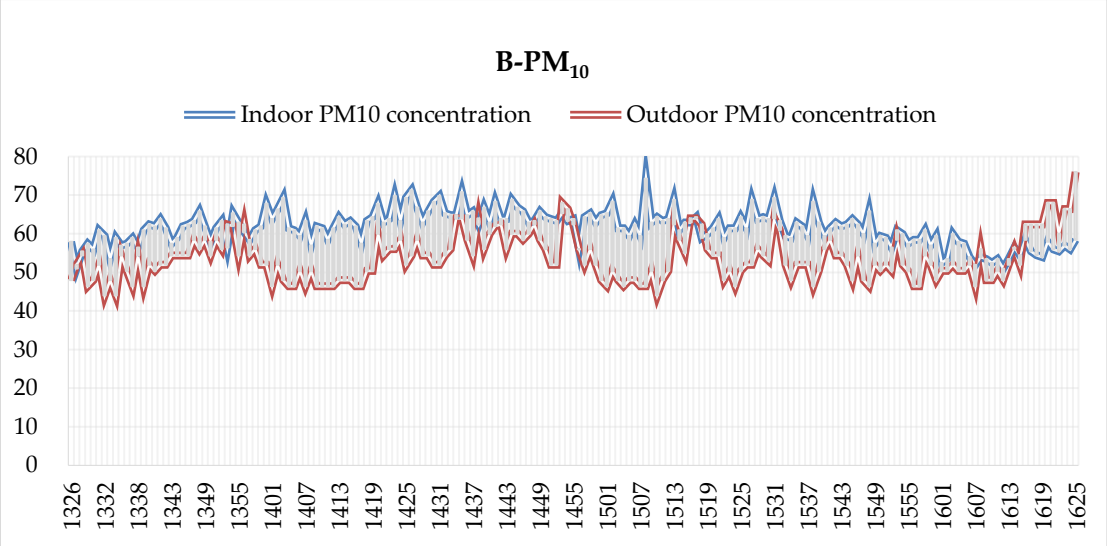


Figure 3.20. *Measurement results of PM_{10} in School B (occupied periods)*

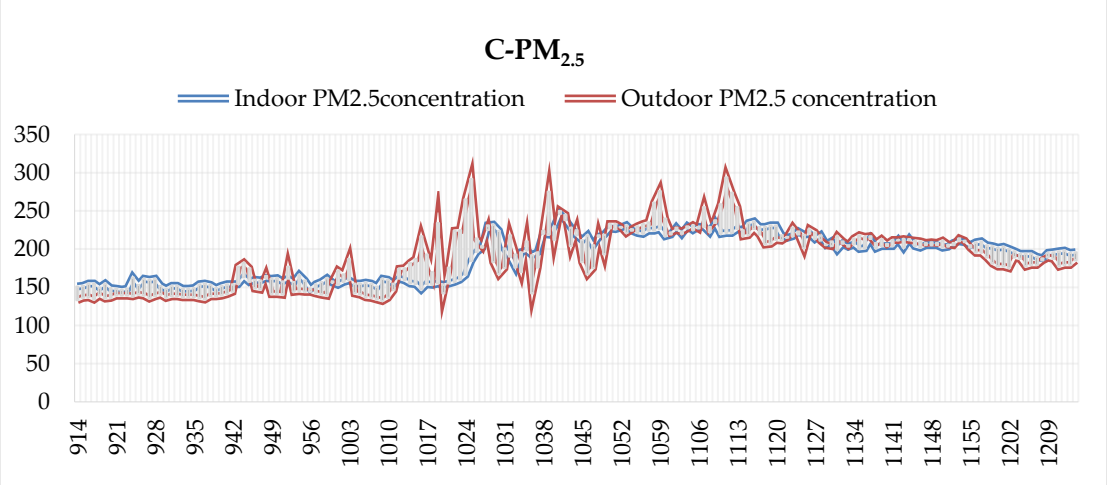


Figure 3.21. *Measurement results of $PM_{2.5}$ in School C (occupied periods)*

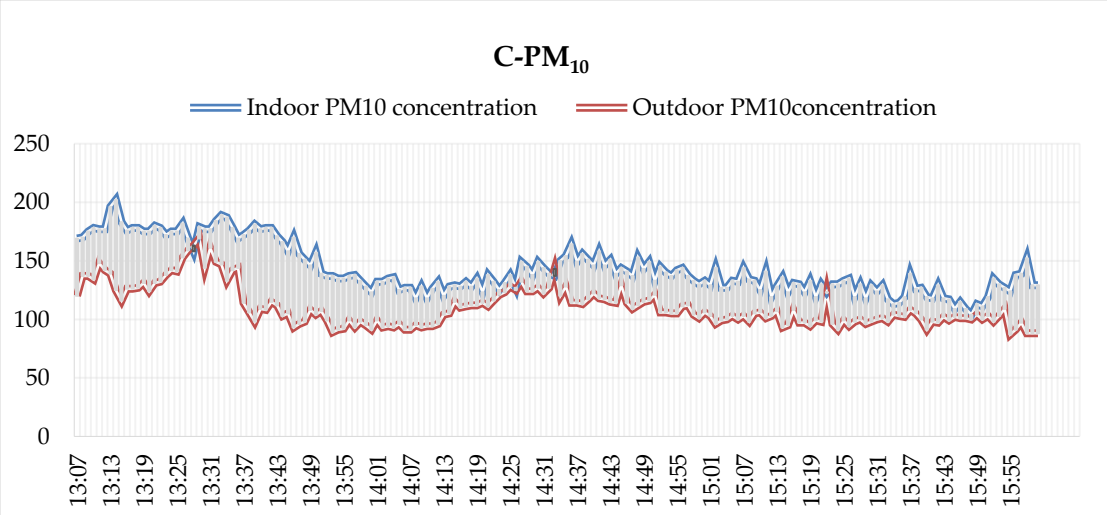


Figure 3.22. *Measurement results of PM_{10} in School C (occupied periods)*

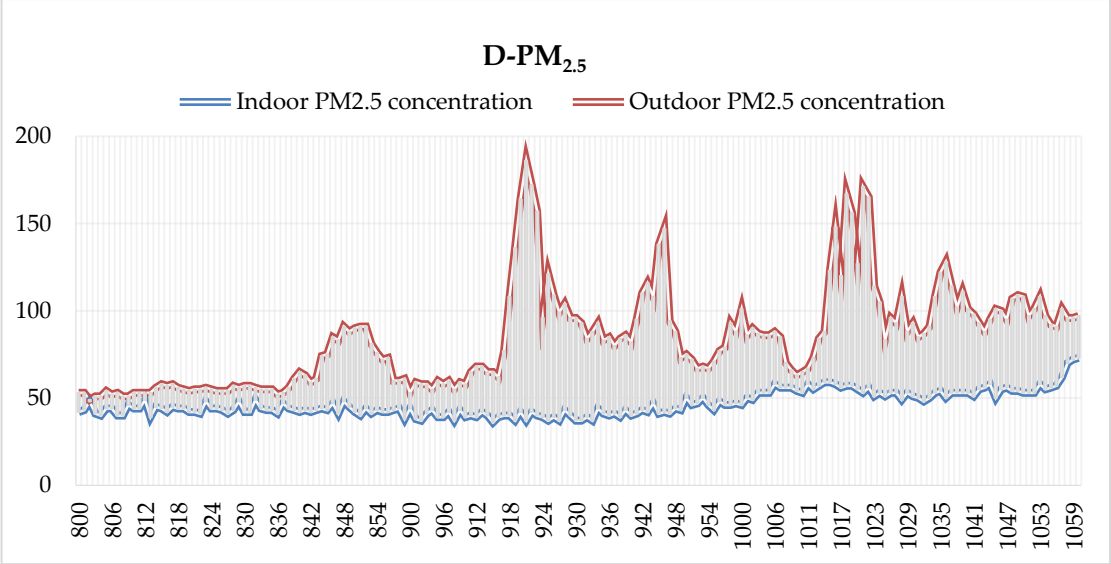


Figure 3.23. *Measurement results of $PM_{2.5}$ in School D (occupied periods)*

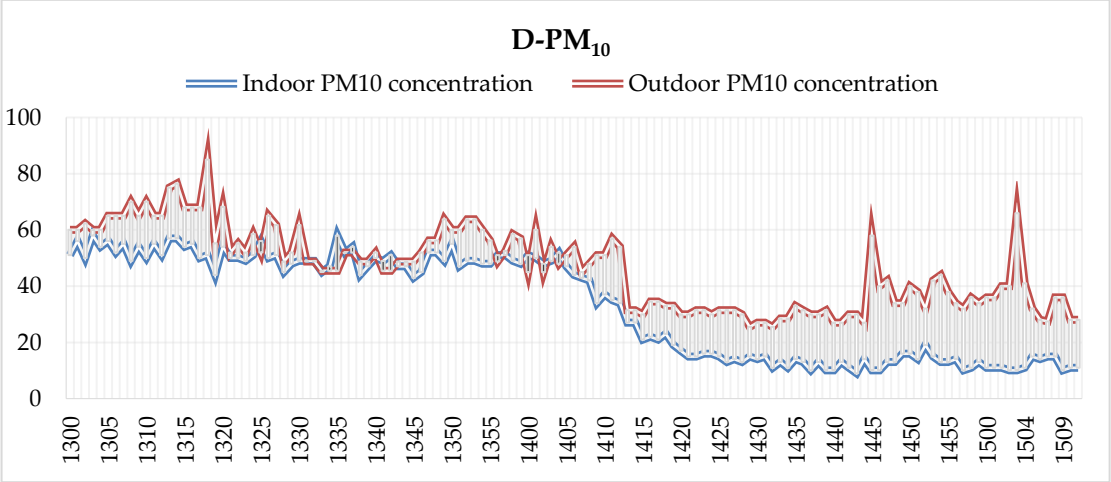


Figure 3.24. *Measurement results of PM_{10} in School D (occupied periods)*

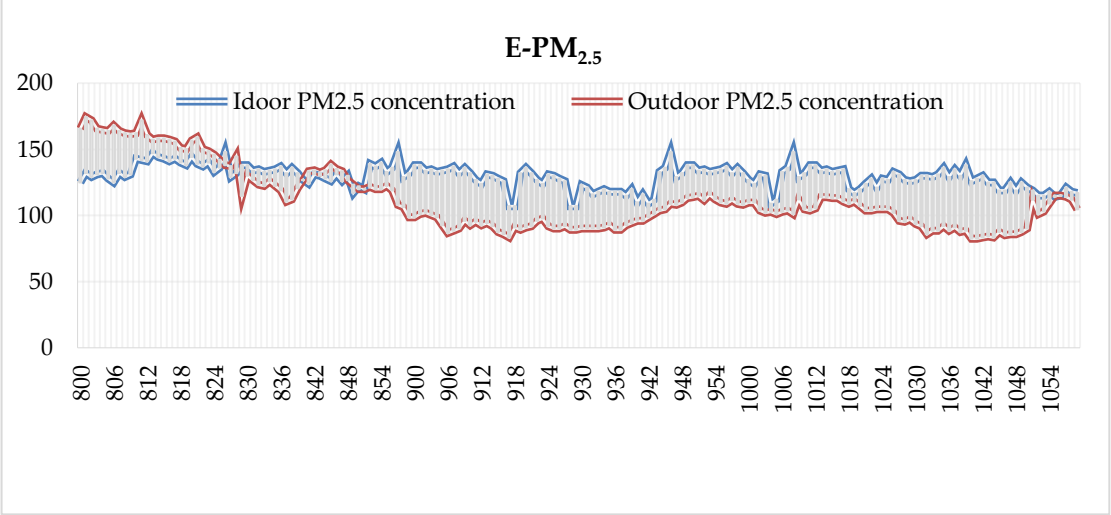


Figure 3.25. *Measurement results of $PM_{2.5}$ in School E (occupied periods)*

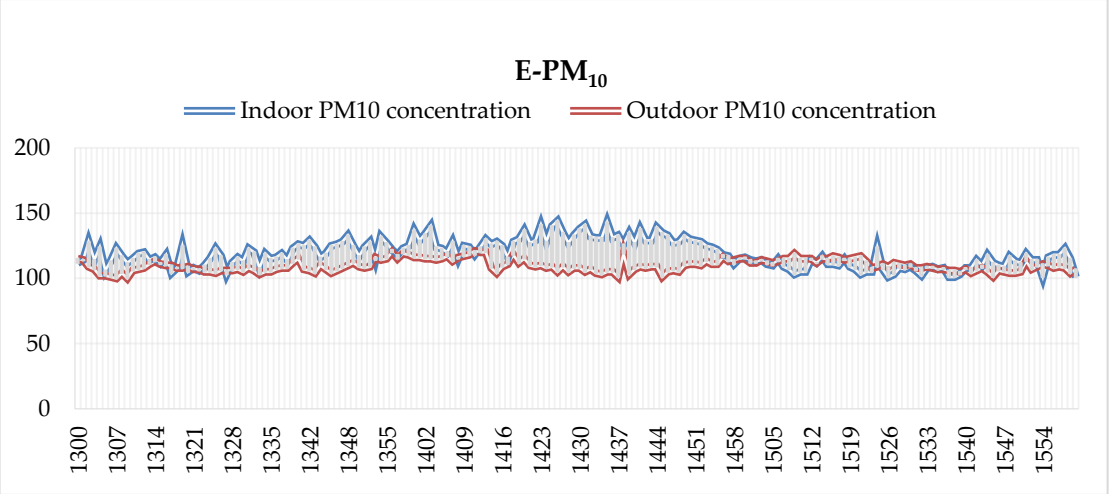


Figure 3.26. *Measurement results of PM_{10} in School E (occupied periods)*

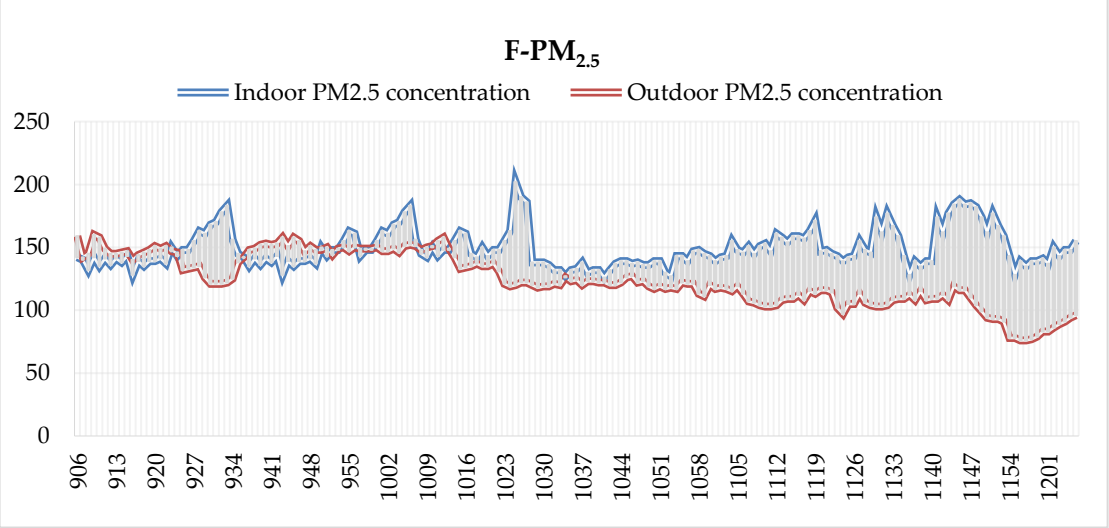


Figure 3.27. *Measurement results of $PM_{2.5}$ in School F (occupied periods)*

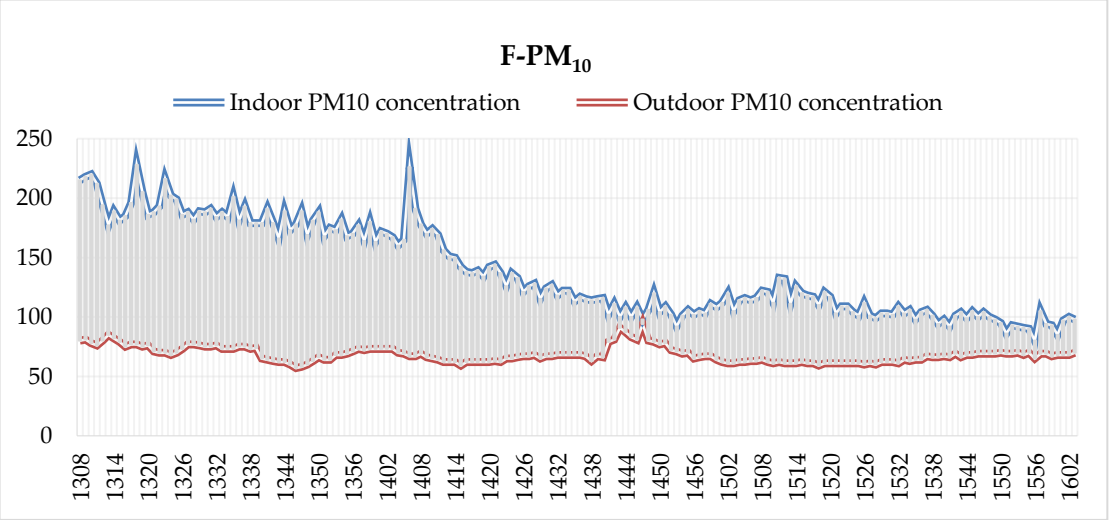


Figure 3.28. *Measurement results of PM_{10} in School F (occupied periods)*

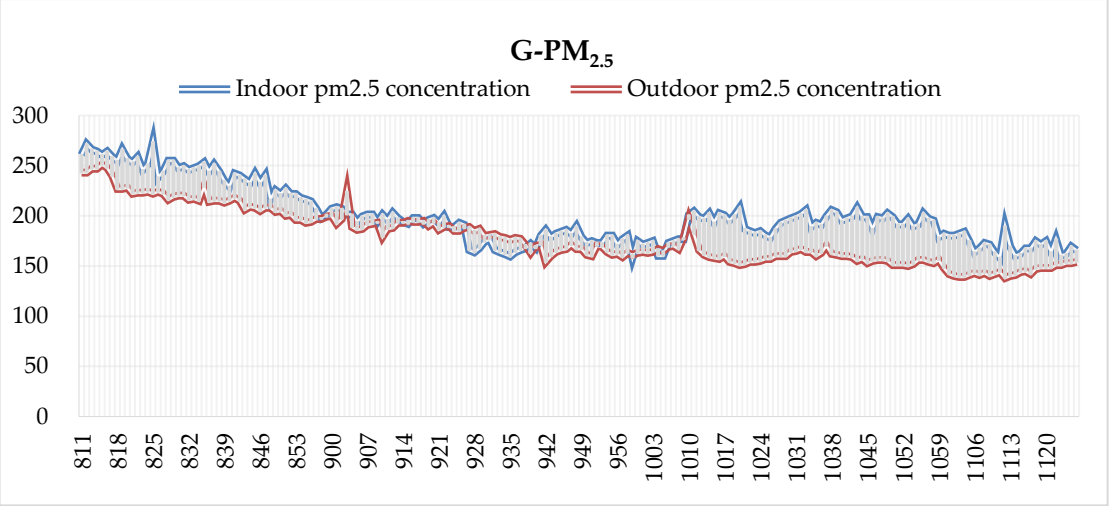


Figure 3.29. *Measurement results of $PM_{2.5}$ in School G (occupied periods)*

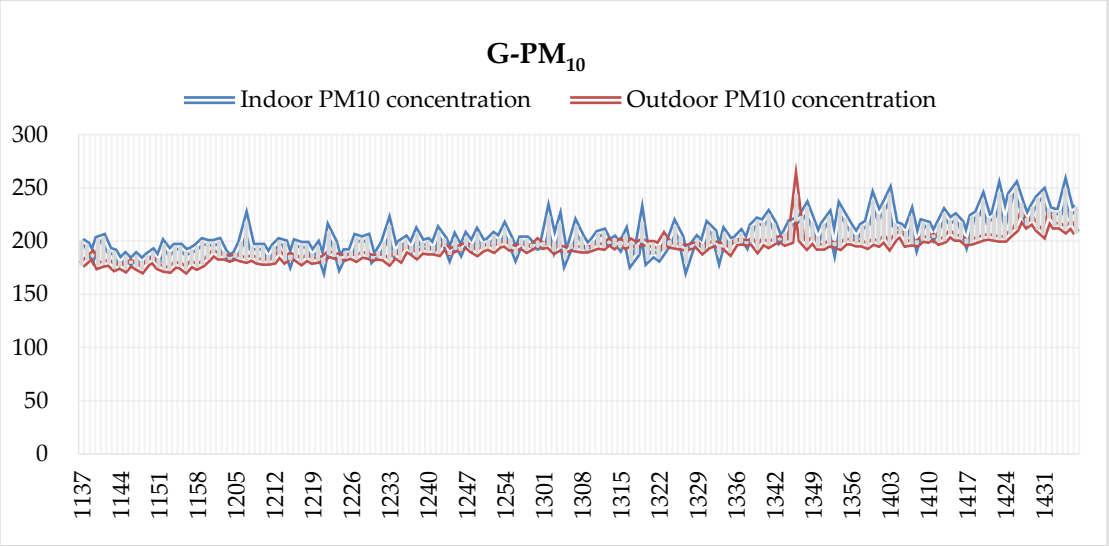


Figure 3.30. *Measurement results of PM_{10} in School G (occupied periods)*

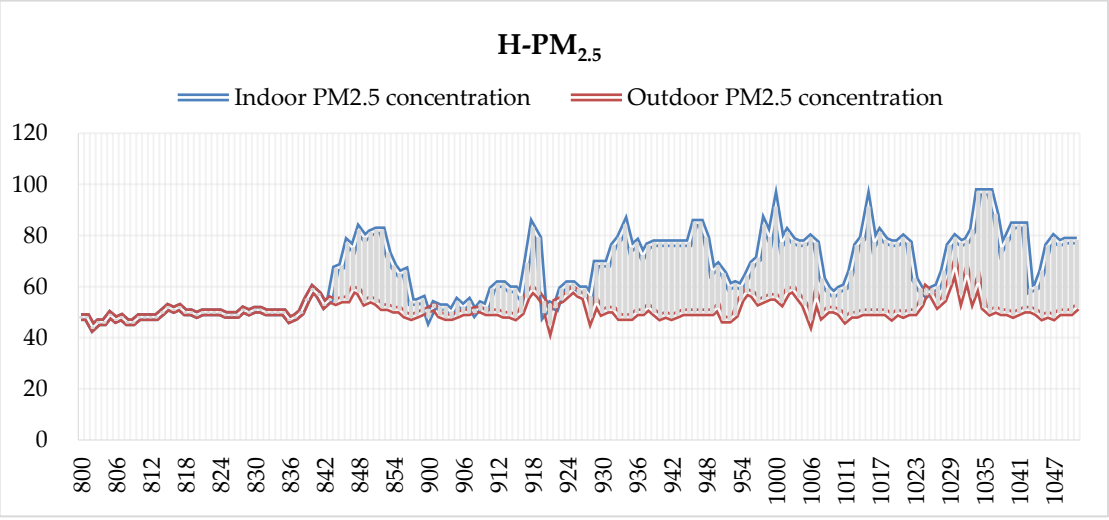


Figure 3.31. *Measurement results of $PM_{2.5}$ in School H (occupied periods)*

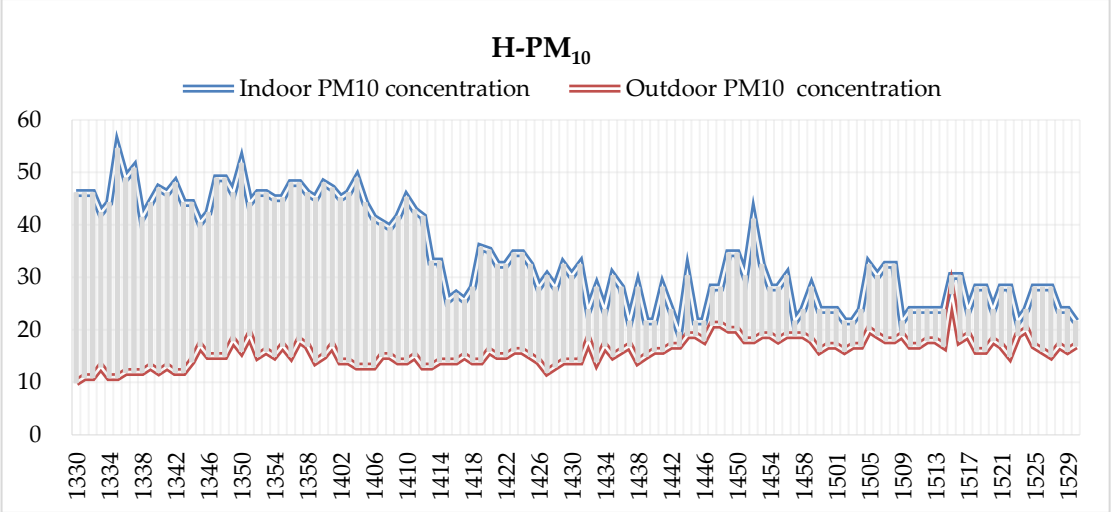


Figure 3.32. *Measurement results of PM_{10} in School G (occupied periods)*

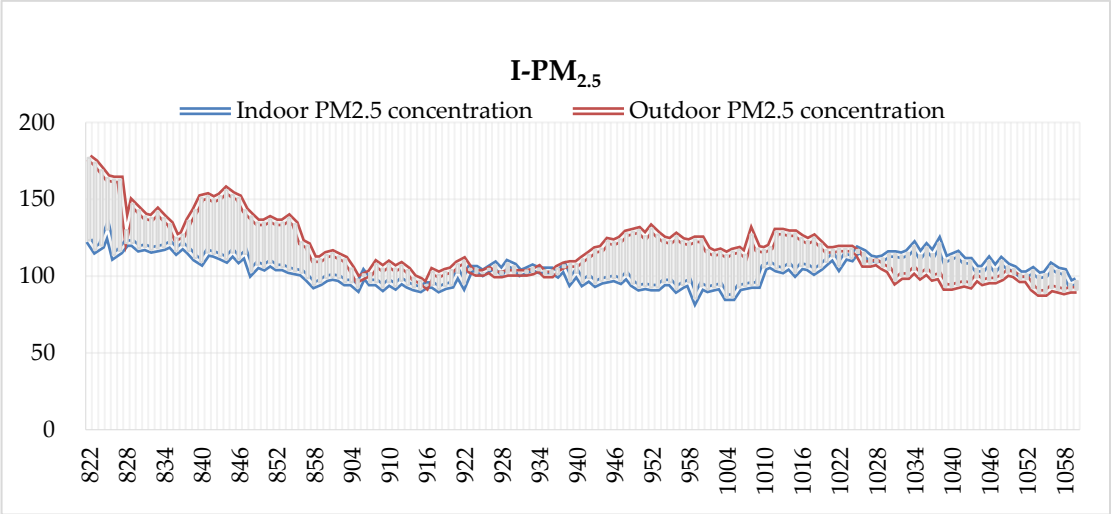


Figure 3.33. *Measurement results of $PM_{2.5}$ in School I (occupied periods)*

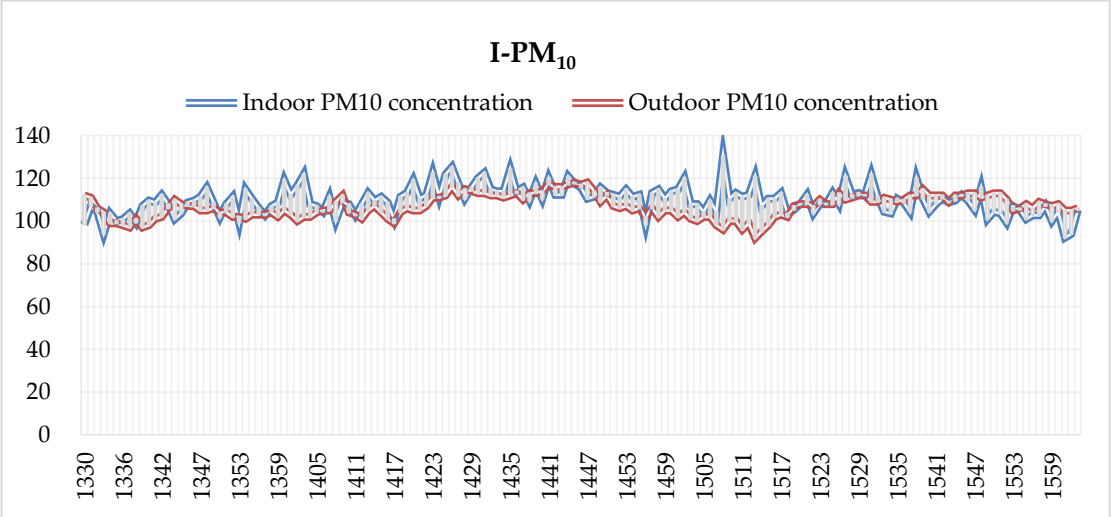


Figure 3.34. *Measurement results of PM_{10} in School I (occupied periods)*

3.7.4.2. Indoor air temperature

Air conditioners heat Schools A, B, and C in winter during school hours, and urban central heating systems heat Schools D, E, F, G, H, and I. Schools A, B, and C have lower indoor temperatures than the other schools. The indoor temperature is dynamic and primarily determined by five factors: the effectiveness of the heating system, heat loss, air infiltration, heat gains from indoor heat sources (lighting and metabolic sources), and solar radiation. The classrooms measured had a similar number of students and the same orientation. The lights were not in use during the measurement periods. It is reasonable to assume that the indoor air temperature were mainly influenced by three factors, i.e., the insulation level, effectiveness of the heating system and airtightness level. Figure 3.35 indicates that school E displayed the highest average indoor air temperature because it is the most airtight and has the thickest external insulation. Schools D and G have average indoor air temperatures above 18°C. Schools F, H, and I performed worse than D, E, and G but better than A, B, and C.

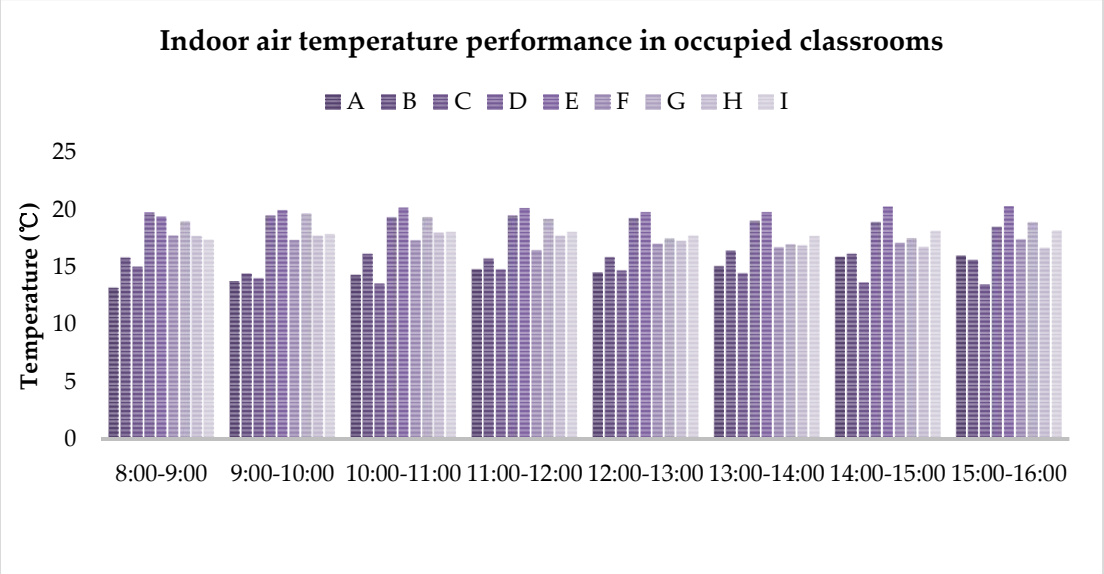


Figure 3.35. *Temperature performance in occupied classrooms.*

3.7.4.3. CO_2 concentrations

Figure 3.36 shows the CO_2 levels in selected schools on an occupied school day. Clearly, a rapid increase in CO_2 levels from 8:30–9:00 was observed, corresponding with the half-hour morning reading session at the beginning of a school day, when CO_2 was exhaled. During the lunch break between 12:00-13:00, the indoor CO_2 levels decreased rapidly to approximately 500–700 ppm. Then, the CO_2 concentrations increased again after students returned to their classrooms.

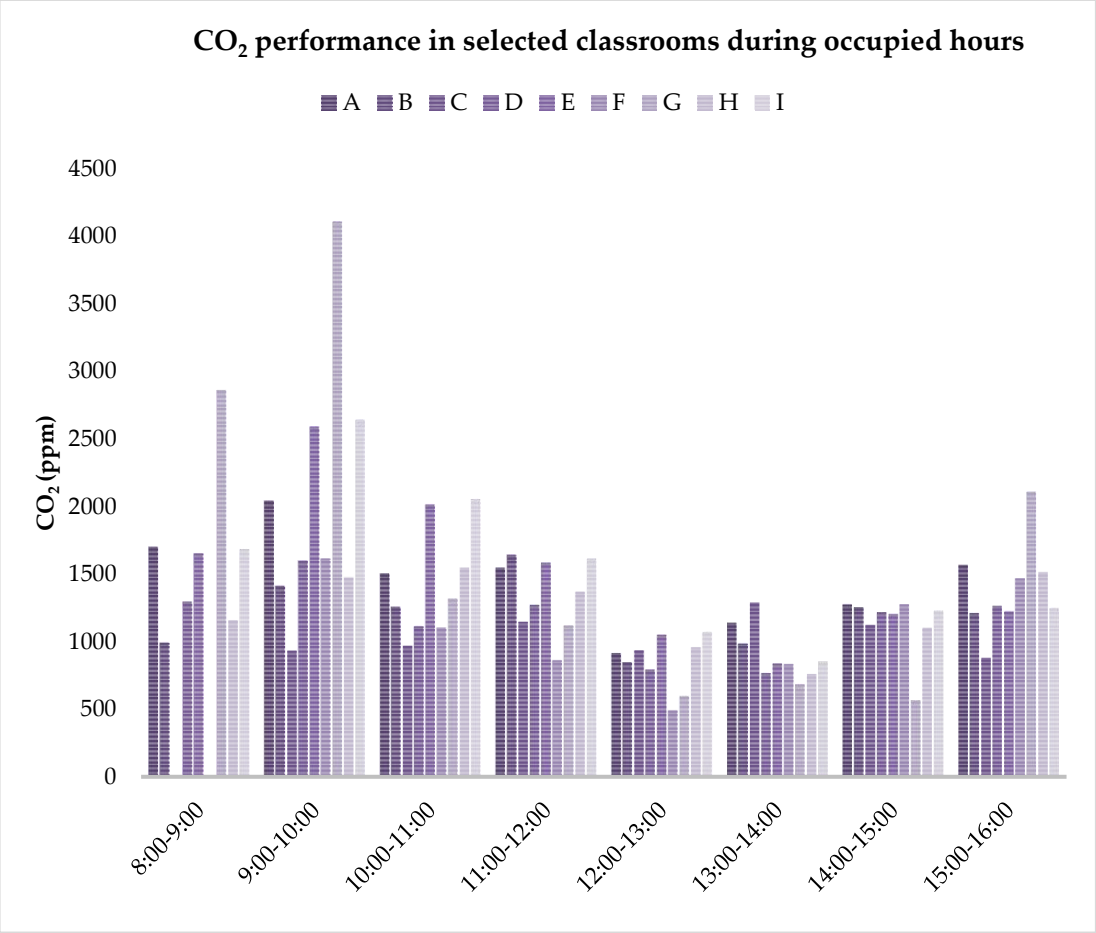


Figure 3.36. *CO_2 performance in selected classrooms during occupied hours.*

3.7.4.4. VOCs

The VOC levels met the recommended value of the CIAQS-2002. The VOC concentrations ranged from 0.20 mg/m^3 to 0.50 mg/m^3. Figure 3.37 illustrates the VOC trends during the measurement period. The concentrations of VOC were

relatively stable, and the amplitude of variations was 0.3 mg/m^3 throughout the measurement period.

Generally, VOC are emitted from building materials, indoor equipment, and occupants' activities. In this research, there were no chemical sources in the selected classrooms, and no electronic devices, such as printers and computers, were used in the nine tested classrooms. Tang et al. (2016) indicated that occupant emissions, such as isoprene, methanol, acetone, acetic acid, and skin oil, contribute to the indoor VOC concentrations. The study further explained that occupant-emitted VOCs account for 57% of the total concentration of VOCs in a well-ventilated classroom and that VOCs originating from ambient air generally account for 35% of the total VOC concentration. Thus, the VOCs in all the selected classrooms were mainly from student emissions and ambient air.

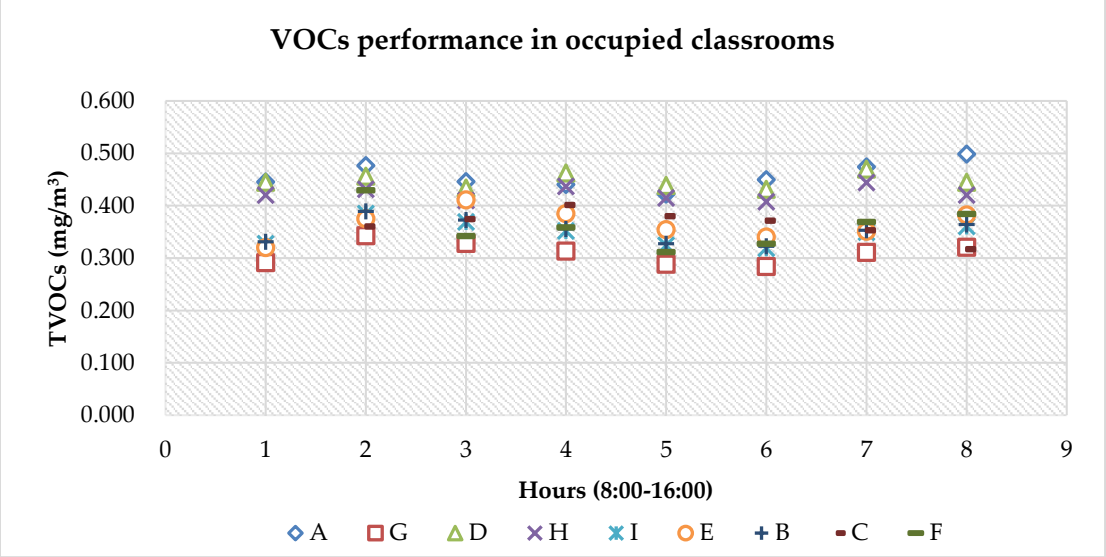


Figure 3.37. *TVCs performance in occupied classrooms.*

3.7.4.5. Relative humidity

Figure 3.38 shows the relative humidity levels in the selected classrooms in the occupied period. The relative humidity in all selected classrooms was between 30% and 70%. Therefore, during the measurement period, the guideline values of the CIAQS-2002 were met the majority of the time. Notably, the ambient relative

humidity on measurement days was within the range required by the Chinese standard, as shown in Table 3.18.

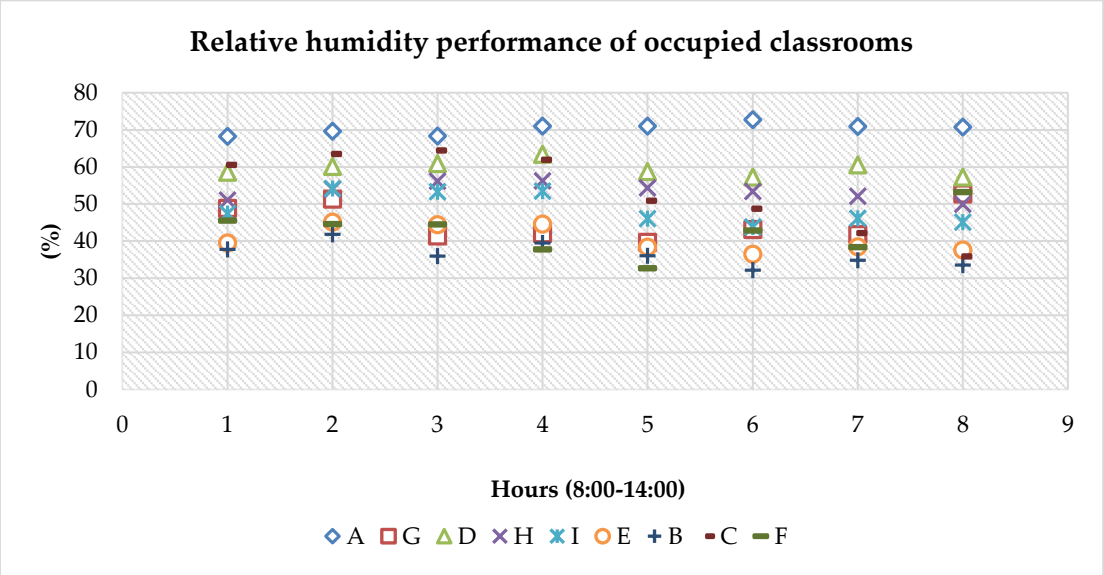


Figure 3.38. *Relative humidity in the occupied classroom*

Table 3.18. Ambient relative humidity in measured days in 2016

Date	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00
11th Nov	99%	96%	78%	70%	67%	63%	56%	53%	54%
13th Nov	82%	73%	69%	58%	51%	50%	50%	51%	55%
14th Nov	99%	97%	84%	72%	69%	63%	38%	31%	26%
16th Nov	76%	59%	43%	43%	41%	37%	38%	42%	52%
20th Nov	68%	64%	61%	61%	63%%	63%	63%	65%	70%
25th Nov	76%	56%	50%	41%	41%	34%	34%	31%	35%
21th Nov	89%	88%	95%	96%	80%	79%	76%	84%	75%
28th Nov	72%	60%	50%	42%	33%	29%	24%	25%	27%
30th Nov	80%	75%	70%	63%	63%	60%	58%	60%	62%
3rd Dec	97%	93%	66%	59%	59%	52%	51%	49%	51%
5th Dec	98%	96%	82%	78%	75%	65%	63%	57%	56%
8th Dec	62%	59%	58%	57%	46%	38%	33%	35%	41%

Source: Ambient Air Quality Online Analysis Platform, provided by the Department of the National Environment Protection (https://www.aqistudy.cn/).

3.7.5. Conclusions of the field measurements

The results of the field measurements indicate that none of the indoor pollution levels in the primary schools fully satisfied the IAQ standards. The following list provides suggestions derived from the analyses of the field measurements.

- The current building airtightness requirements are not adequate. The measurement results indicate that ambient PMs contribute to approximately 50% of the PMs in the classrooms. Thus, the current regulations regarding building airtightness should be increased.

- Retrofits are needed to seal air leakages in building envelopes. For example, using gypsum plaster to fill the cracks in building structures such as masonry concrete and timber frame.

- In naturally ventilated school buildings, a high airtightness level may cause an increase in CO_2 levels, especially in winter, as students always close windows and doors to keep a reasonable thermal comfort level. In such a situation, mechanical ventilation with built-in air purifiers or individual purifiers might be an option. However, as discussed in sections 2.4 and 3.4, some air purifiers are extremely expensive, and they all consume electricity and indirectly have adverse effects on the ambient air quality. Moreover, some air purifiers generate ozone when in operation. Therefore, air purifiers are not an optimal option.

- Additionally, measures, such as replacement of chalks and blackboards by projectors and whiteboards with markers, should be taken to remove PMs generated by occupant activities in the classroom.

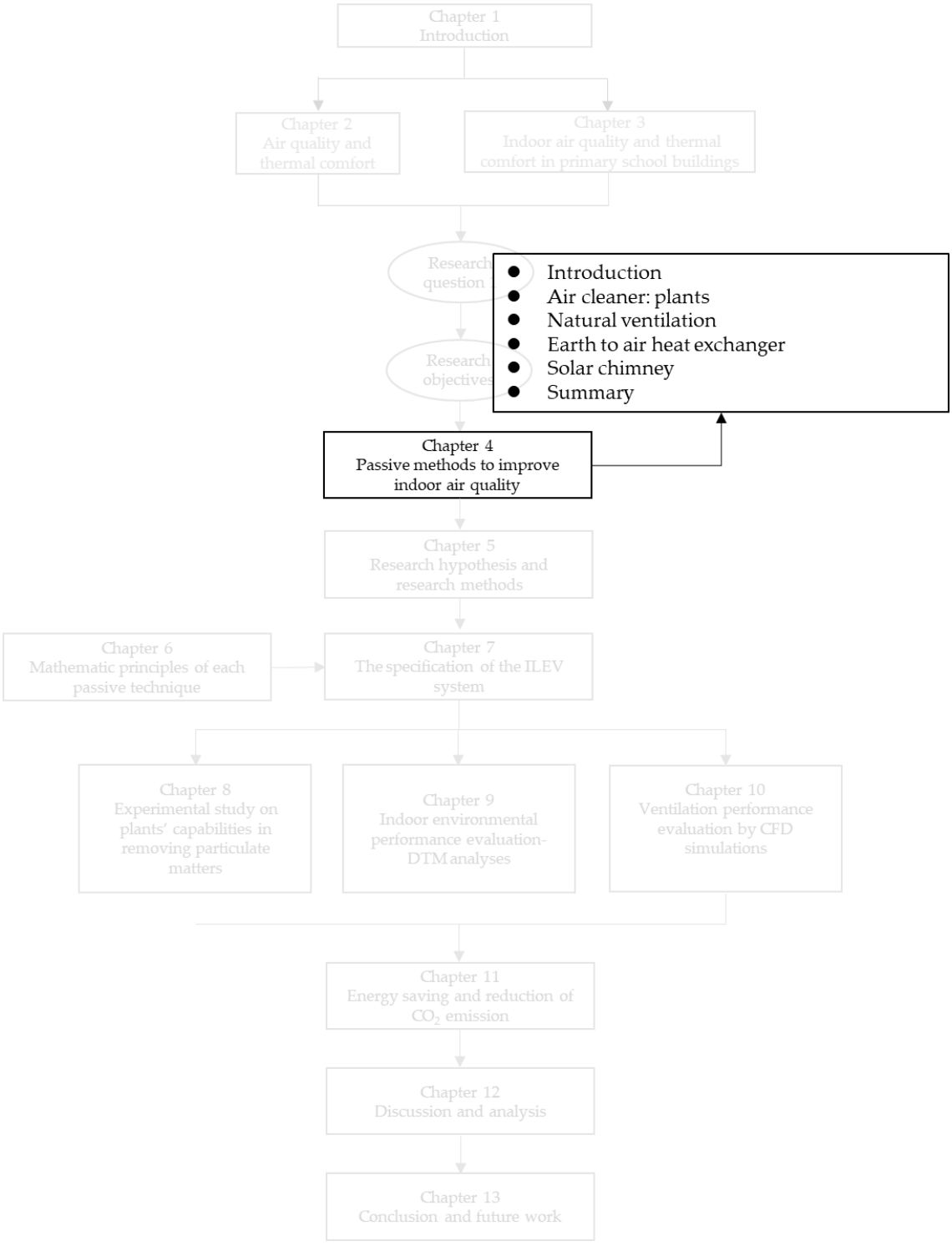
In conclusion, improving airtightness level of naturally ventilated school buildings can reduce the penetration of outdoor air pollutants. However, such a change will increase the risk associated with the CO_2 level. Mechanical ventilation with built-in air purifiers or individual purifiers might be an option. However, air purifiers increase building energy consumption and have adverse effects on the ambient air quality. Thus, from a long-term perspective, air purifiers are not an optimal method for tackling air pollution. Therefore, natural ventilation remains the

primary option for ventilating buildings. However, passive air cleaners should be installed in natural ventilation systems.

3.8. Summary

Chapter 3 reviewed the IAQ and the thermal comfort performance in primary school buildings around the world and in China. The literature review indicated that the IAQ in schools is a serious concern in many countries. Field measurements were performed in 9 case studies of primary schools to investigate the severity and amplitude of indoor air pollution in classrooms of primary school buildings in China. The findings suggest that natural ventilation is ineffective in delivering clean air when ambient air pollution exists. Air purifiers are not recommended since they are unaffordable, consume electricity and even produce ozone. Therefore, a new ILEV system, which combines natural ventilation and passive techniques, should be designed to combat indoor air pollution. In the next chapter, a literature review of the passive techniques that could be used in the ILEV system is conducted.

Chapter 4: PASSIVE METHODS TO IMPROVE IAQ



The content of Chapter 4

4.1. Introduction

As introduced in sections 1.2, 2.4 and 3.4, the current measures applied to mitigate air pollution have some limitations. Conventional natural ventilation cannot provide thermal comfort in the indoor environment in areas with unsuitable local weather conditions. Combinations of conventional natural ventilation and passive precooling or preheating techniques, such as EAHEs, can provide thermal comfort but are ineffective in filtering ambient air pollutants. Air purifiers also have some drawbacks. For example, some air purifiers are not as effective as they claim, and others with better cleaning abilities are expensive and unaffordable. Moreover, air purifiers consume electricity and generally cannot reduce CO_2 concentration in a closed space. Therefore, in this study, an ILEV system was designed specifically for primary school buildings in the cold climate zone of China, which, as indicated in section 3.7.1, is the zone with the most severely air-polluted cities in China.

Natural ventilation is the foundation of the new ILEV system since it provides excellent building energy savings. However, the cold climate zone has large seasonal temperature differences. Specifically, summers are warm to hot, and winters are cold. Over two-thirds of the year, the conditions are not suitable for natural ventilation (Y. Chen et al., 2017). Thus, to overcome the limitations of the local weather conditions, passive precooling and preheating techniques should be employed.

Passive techniques have attracted increased attention because they can reduce energy consumption and minimise environmental impacts by taking advantage of natural elements (Roaf et al., 2013). Passive techniques are strongly dependent on the local climate (UNEP, 2009) and the climatic conditions that vary over time. Thus, different passive techniques might be required in different seasons. There are three steps designers implement to select suitable passive techniques (Figure 4.1). First, the characteristics of the passive elements related to the design target

are analysed. Second, a specific technique should be selected based on an analysis of the climatic elements. Third, passive techniques should be appropriately combined to improve the thermal comfort level and increase energy savings.

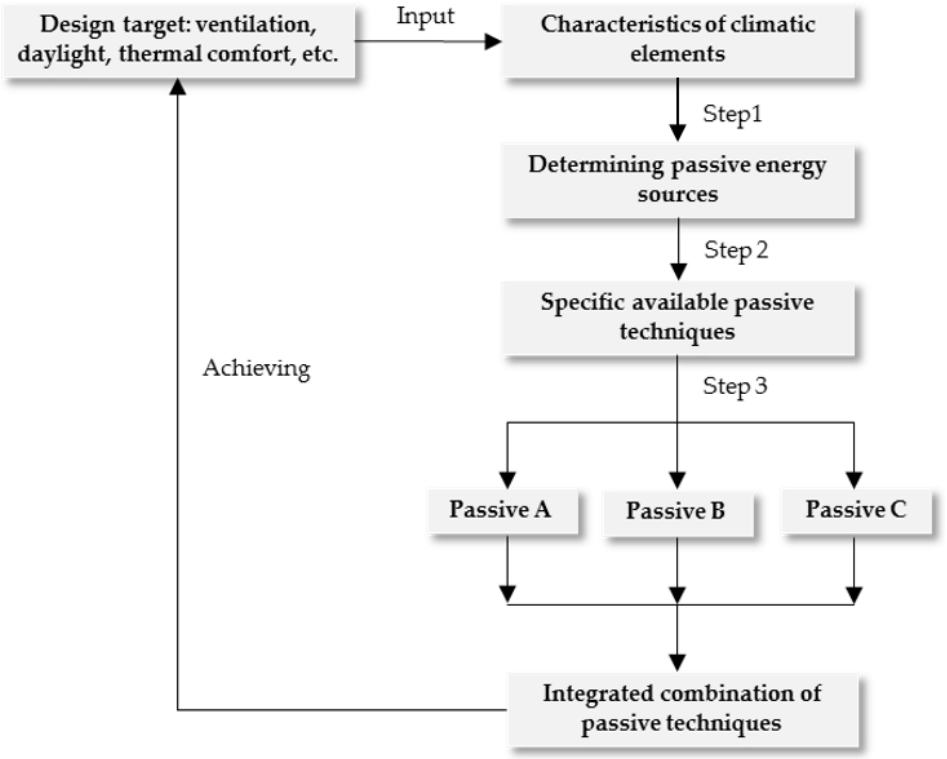


Figure 4.1. *The process of selecting passive techniques*

For the aim of this research, the natural ventilation system is combined with a preheating or precooling energy source to overcome the adverse effects of weather conditions. Preheating or precooling energy may come in the form of heat captured from the waste air in a building; for example, buildings with heat recovery systems can typically preheat or precool incoming fresh air. However, heat recovery systems are usually part of an HVAC system, and it is impossible to capture heat from the waste air in a natural ventilation system.

Another preheating and precooling energy source could be the heat absorbed by heavyweight building materials (thermal mass) or collected by solar panels. However, solar heat largely depends on the specific weather conditions, and the fluctuations in solar radiation can increase the complexity of the natural

ventilation design. Moreover, solar heat storage and absorption requires very specific building materials, which could lead to a significant increase in the building construction cost.

Soil at a given distance below ground surface can provide an effective preheating and precooling source since it has a more stable temperature than the ambient environment (Hootman, 2013). Thus, EAHEs, which supply air through buried pipes, have been widely used for many years. Hootman (2013) claimed that EAHEs are most effective in cold climates areas. Wang et al. (2014) evaluated the performance of EAHEs in northern China, and the results indicated that EAHEs can significantly improve the energy savings potential of a building. Wu (2013) found that EAHEs can significantly reduce building cooling and heating energy consumption in the cold climate zone of China.

Thus, in this study, EAHEs are an ideal preheating and precooling technique for the ILEV system.

The ILEV system should consume little energy, and there is a pressure drop when air is supplied through buried pipes. Therefore, a low energy technology should be used to offset the pressure drop and move air through the buried pipes. Various technologies can be used, such as wind catchers and solar chimneys. Wind catchers normally ventilate a building using wind. Thus, in a windless environment, a wind catcher normally cannot force the air to ventilate buildings. In addition, wind catchers increase the complexity of the design of natural ventilation since wind is the dominant driven force.

Solar chimneys are comparatively more suitable for the ILEV system. Many studies (e.g., Maerefat and Haghighi, 2010; Benhammou et al., 2015; Poshtiri et al., 2011; Yu et al., 2014) have demonstrated that the combination of a solar chimney and EAHEs provides more effective ventilation than EAHEs alone. Therefore, a

solar chimney, which can enhance the ventilation rate of the designed ILEV system is the second passive technique that is employed.

Given the ambient and indoor air pollution, a passive air cleaner should also be added to the ILEV system. Currently, many researchers (e.g., Darlington et al., 2001; Lohr and Pearson-Mims, 1996; Lohr, 2010; Wood et al., 2003) have shown that plants can effectively clean the air. The National Aeronautics and Space Administration (NASA) Clean Air Study has been conducted since 1989 (NASA, 1989) and has focused on investigating the abilities of plants to remove air pollutants from the indoor air. The study has found that certain types of indoor plants can naturally clean the air. Thus, plants are used as a passive air cleaner in the ILEV system.

Thus, based on the analyses above, the proposed ILEV system consists of four parts: natural ventilation, EAHEs, a solar chimney, and plants. Plants are mainly used to remove air pollutants from the supplied air. The EAHEs ensure that the thermal comfort level of the indoor environment is satisfactory. The solar chimney is responsible for enhancing the ventilation rate of the natural ventilation system.

In the next section, a literature review of these passive techniques is conducted, covering various aspects of each technique, such as history, development, benefits and simulation methods. The aim of the literature review is to provide evidence and support for the ILEV system.

4.2. Air cleaner: plants

As introduced in Chapter 2, the technologies (e.g., air purification systems) used to improve the IAQ are often unaffordable and unreliable. Alternatively, passive methods, such as the use of plants, have gained increased recognition. Many studies have tested the efficiency of plants in removing various air contaminants (e.g., Darlington et al., 2001; Lohr and Pearson-Mims, 1996; Lohr, 2010; Wood et al., 2003). Plants play a significant role in regulating climate changes. They have a considerable impact on the global climate and are highly related to the local weather conditions. Plants can lower temperatures, reduce energy use and remove air pollutants mainly through two processes: evapotranspiration and photosynthesis. Evapotranspiration involves the absorption of water from the soil, ocean, or waterbodies and the subsequent release of the water as vapour into the air through stomata, which increases the air humidity and decrease the air temperature. This process is part of the water cycle and influences the thermal comfort level of the air, especially in dry climate regions. Photosynthesis is a process used by plants to convert light energy into chemical energy and simultaneously release oxygen. Each year, 100-115 thousand million metric tons of carbon is converted into biomass by photosynthesis (Field et al., 1998). The atmospheric oxygen levels are maintained at a steady level by photosynthesis, and the energy necessary for life on Earth is provided (Bryant and Frigaard, 2006).

The atmospheric CO_2 concentration has rapidly increased from 280 ppm to more than 380 ppm since the industrial revolution; moreover, this concentration is predicted to reach 700 ppm to 1000 ppm by the end of the century (Team, 2018). However, Berkeley Lab (2016) found that the CO_2 levels in the atmosphere have stabilized in recent years because plants are removing more carbon from the air than in the past. The Conversation (2014) stated that land plants absorb approximately 25% of the carbon emissions produced by human activities. Milcu

et al. (2012) indicated that plants can remove much more CO_2 from the atmosphere than was previously believed. By absorbing CO_2, plants emit oxygen. Jing (1998) stated that plants play a significant role in human life by maintaining atmosphere oxygen levels and that the oxygen production level of some plants is greater than the CO_2 absorption level. In addition to stabilizing the oxygen level and reducing the atmospheric CO_2 level, plants also affect indoor CO_2 levels. Tarran et al. (2007) indicated that among 55 city offices, rooms with three or more potted plants had 10% lower CO_2 concentrations in an air-conditioned building and 25% lower concentrations in a non-air-conditioned building. Pegas et al. (2012) found that classrooms with plants in Aveiro, Portugal, had lower indoor CO_2 concentrations than did classrooms without plants.

Plants can also directly clean atmosphere by intercepting PMs (Beckett et al., 2000; Freer-Smith et al., 2004). Chen et al. (2014) claimed that some garden plants have the ability to remove PMs from the air and significantly improve the urban environmental quality. At the local scale, the inner portions of forest patches in urban areas exhibited significantly reduced concentrations of PMs compared to those near forest edges (Cavanagh et al., 2009). McDonald et al. (2007) claimed that in the West Midlands area of the UK, 110 tons of PM_{10} was removed per year by increasing the total tree cover from 3.7% to 16.5%. In Glasgow, the PM_{10} concentration was reduced by 2%, accounting for almost 4 tons per year, by increasing the tree cover from 3.6% to 8%. Nowak et al. (2013) stated that trees remove 4.7 to 64.5 tons of $PM_{2.5}$ annually in Syracuse and Atlanta. In the Greater London area, almost 852 - 2121 tons of PM_{10} is annually removed by the urban tree canopy (Tallis et al., 2011). In the United States, urban trees remove approximately 214900 tons of PM_{10} per year (Nowak et al., 2006).

Trees can also indirectly reduce PM concentrations. For example, trees can alter the air temperature, emit VOCs and influence building energy consumption (e.g.,

cooling the air temperature to reduce cooling energy consumption, shading buildings and reducing solar heat gains), as well as subsequently affect the emissions from power stations (Heisler, 1986; Nowak and Crane, 2002; Beckett et al., 1998). Thus, plants both directly and indirectly make great contributions in the cleaning of the ambient air.

In addition to removing PMs, plants also make a significant contribution to reducing chemical air pollutants, such as VOCs, ozone, NO_x, and SO_x. Tarran et al. (2007) performed laboratory studies and found that the VOC load was significantly reduced by plants. Papinchak et al. (2009) stated that chambers containing snake plants, spider plants and golden pothos had higher ozone depletion rates than chambers without plants. Rogers et al. (1977) found that plants have a high capacity for the uptake of nitrogen dioxide.

Therefore, based on the benefits noted above, indoor plants have become a design factor that influences energy savings and IAQ. Table 4.1 lists some indoor plants that can reduce indoor air pollution.

Table 4.1. Plants and their target air pollutants

Name of plant	Target air pollutants
Adiantum	Absorbs radiation from computer and printer
Aloe	Can "signal for help" when excessively
Rubber tree	Can be helpful in eliminating harmful substances
Asparagus	Can kill viruses and bacteria
Ivy	Absorbs formaldehyde
Cacti	Best in reducing radiation
Chlorophytum	Filters air
Clivia	Keeps air fresh in winter
Monstera	Improves air quality at night
Pachira	Absorbs smoke well
Kimberley queen fern	Formaldehyde, TVOCs
Chinese evergreen	TVOCs, formaldehyde

Source: NASA (1989)

As previously discussed, plants contribute to removing indoor air pollutants, such as PMs, VOCs and CO_2. Many studies, especially those conducted in chambers, have shown that plants can clean air. Wolverton et al. (1989) indicated that plants have the capability to remove contaminants from the air based on a laboratory study in a small and sealed chamber. Wood et al. (2003) investigated the effectiveness of plants in removing benzene and hexane in a small sealed space and found that the concentrations of benzene and hexane were reduced by 80% and 70%, respectively.

However, many studies have claimed that the laboratory results are not adequate evidence for concluding that the use of plants indoors can result in significant reductions in indoor air pollutant levels. Dingle et al. (2000) performed a field study in office buildings in Perth, Australia, to investigate the effectiveness of plants in removing formaldehyde. The results showed "no change in the formaldehyde concentrations with the addition of 5 or 10 plants in the room and only an 11% reduction in formaldehyde concentrations with 20 plants in the room". Another field experiment was conducted by the Association of Landscape Contractors of America (ALCA) and Healthy Buildings International (HBI) on two similar floors of an office building in Arlington, VA, USA (HBI, 1992). The study mainly concluded that no reductions in pollutant concentrations were found in the rooms with plants. However, this study did not report the number of plants used during the investigation. Wood et al. (2006) conducted a similar field study in Sydney, Australia. The study found that VOC concentrations in rooms with plants were randomly higher or lower than those in rooms without plants.

Therefore, conflicting conclusions were provided by different studies. On one hand, the reductions in pollutant concentrations by plants in chamber studies suggest that plants are capable of removing air contaminants. On the other hand, field studies have indicated that plants are not efficient in cleaning air in practical

settings. Two potential reasons for these difference in various studies are as follows.

- Firstly, most chamber studies were performed with many plants in a small space. Chambers can create a relatively stable environment for the plants. To observe the same effect in a real space, several times as many houseplants as required in the chamber may need to be included in the study. Installing one or two plants for a large space will not make a significant difference in terms of air quality.
- The second reason for the difference between the laboratory and field studies is that air pollutants in real buildings are constantly emitted by building materials and human activities. In some cases, it could be possible that materials produce air pollutants faster than plants remove them. Human activities also constantly affect the pollutant levels inside, and there may be not enough time for plants to completely absorb these pollutants. In the lab studies, the pollutants were only introduced once, and the air was then monitored to observe the reductions in pollutant concentrations. Therefore, laboratory studies and field measurements are very different cases.

Girman et al. (2009) claimed that in field studies, the results are difficult to use to evaluate the effectiveness of plants in removing air pollutants because the methods used are not extremely accurate and few field studies consider the effects of the ventilation system, indoor air pollutant sources, and human activities.

However, some real field studies found that plants can reduce inside air pollutant levels. Pegas et al. (2012) compared the IAQ in classrooms with plants and without in Aveiro, Portugal. Six plants were installed in a classroom of 52.5 m^2, and the study found that plants decreased the CO_2 concentration from 2004 ppm to 1121 ppm. Moreover, the total average VOC concentration in the classrooms without plants during periods of school hours was approximately 4 times higher than the

average concentration in classrooms with plants. Tarran et al. (2007) concluded that potted plants are very effective in reducing VOC levels in the real world. Moreover, potted plants can reduce the CO_2 levels in air-conditioned buildings and naturally ventilated buildings by approximately 10% and 25%, respectively. In a study by Meattle (2009), over 1200 potted plants were installed in an office building with approximately 4600 m^2 floor area. The study mainly found that the incidence of eye irritation, respiratory system, headache, lung impairment and asthma issues was reduced by 52%, 34%, 24%, 12%, and 9%, respectively, in the building with plants compared to the levels in other buildings. Thus, plants can clean air in practical settings. The questions that must be considered are related to the species of plants that should be used for passive pollutant removal and how many of plants are needed to effectively clean the air.

However, the process of removing air pollutants, such as via the absorption of CO_2 and release of O_2 during photosynthesis, is very complicated and affected by many environmental factors, such as the temperature, CO_2 concentration, and light intensity. Different species of plants have different requirements for the rate of photosynthesis, and it is difficult to determine how many plants must be introduced in a certain space for CO_2 removal and O_2 release. Moreover, studies have shown that certain plants can remove VOCs, but the pollutant removal results in these studies were expressed as percentage rather than as the mass of pollutant removed per unit time by a single plant (Girman et al., 2009).

In Chapter 3, the measurement results in primary school buildings showed that the primary air pollutants are $PM_{2.5}$ and PM_{10} and that inside PM concentrations are affected by the ambient PM levels, the building airtightness and internal activities, such as writing with chalk. The IAQ is also influenced by increases in CO_2 concentrations during period of increased activity.

A low level of airtightness can be improved by sealing gaps and cracks in buildings, and chalk can be replaced with markers. High levels of CO_2 can be reduced by improving the ventilation rate. Therefore, in the new ILEV system, plants are mainly used to remove PM, rather than CO_2, VOCs, and other chemical air pollutants.

4.3. Natural ventilation

4.3.1. Benefits and limitations of natural ventilation

Natural ventilation is attractive because it provides fresh air and an energy efficient building environment. Such ventilation can be driven by a wind pressure difference, a temperature difference or both factors. Well-designed naturally ventilated buildings continuously provide fresh air inside and reduce the abundance of stale air through designed openings, and buildings with natural ventilation consume less energy than those with different ventilation systems (Liddament, 1996). Studies have shown that occupants in naturally ventilated buildings have larger acceptable thermal comfort ranges than those in mechanically ventilated buildings (Humphreys and Nicol, 2000). In general, mechanical ventilation provides limited but constant conditions, and natural ventilation offers a broader range of conditions that closely reflect the outdoor weather pattern (de Dear and Brager, 2002).

However, natural ventilation systems also have limitations. For example, such systems are variable and depend on the outside weather environment. Moreover, wind and buoyancy forces are generally difficult to control. Therefore, natural ventilation systems only work when specific natural drivers are available. Additionally, in some extreme climate conditions, natural ventilation strategies cannot provide adequate fresh air and thermal comfort (Atkinson, 2009). In urban environments, natural ventilation is also less effective than in rural environments due to reduced wind velocity, urban heat island effects, pollution, and noise (Ghiaus et al., 2006). For example, Kukadia and Palmer (1998) stated that pollutants levels in a naturally ventilated building in Birmingham were generally more severe than those in a mechanically ventilated building, and the concentrations were closely related to daily external variations but at lower levels. Collignan et al. (2001) stated that it is difficult to naturally ventilate buildings on

ambient pollution days and prevent the transfer of outdoor air pollutants inside buildings.

However, these limitations do not mean that natural ventilation systems are not reliable. If properly designed, a natural ventilation system can provide a high air-change rate and consume little energy. Therefore, determining how to provide the required airflow rate is a critical issue in the early building design stages.

4.3.2. Research models used to simulate natural ventilation performance

In general, using acceptable natural ventilation strategies can create a comfortable indoor environment. In past decades, many types of modelling approaches have been commonly used to predict building ventilation performance. The leading research methods can be classified into four types of models: analytical and empirical models, multizone models, zonal models, and CFD models.

Analytical and empirical models are based on simple numerical analysis methods and are commonly used to predict the air flow rate and air velocity distribution under steady state conditions. In the prediction process, the air inside a building is assumed to be a non-viscous fluid controlled by the Bernoulli equation. In addition, the viscous loss of pressure at the air inlet can be estimated with the establishment of the relationship between volumetric airflow rate and pressure differences. Generally, this method is suitable for simple buildings (Li and Delsante, 2001; Li, 2000).

Multizone models are based on the Bernoulli equation and use a grid to divide the building into many parts; the parts communicate with each other through doors, windows, and leakages pathways (Orme, 1996). Over the last 20 years, many multizone models have been developed (Li et al., 2000). Feustel and Rayner-Hooson (1990) developed a software program called COMIS 3.0 in the IEA Annex 23 project. Li and Peterson (1990) extended and applied Lilliengren's (1989) simple

pressure difference formula in a multi-cell infiltration and exfiltration (MIX.0) model. Multizone models can predict the volumetric air flow rate of an entire building; however, they cannot provide temperature performance and air flow distribution information inside the building.

Zonal models are far more complicated and accurate than multizone models. Such models divide a room into several areas, and the parameters in each area are equal, such as the temperature and concentration of pollutants. The temperature performance and air flow distribution are investigated using mass and energy conservation equations. Additionally, several zonal models have been used to predict ventilation performance. For example, Inard et al. (1998) investigated the energy consumption and thermal comfort in dwelling cells using a zonal model approach. Wurtz et al. (1999) conducted a study of two- and three-dimensional natural and mixed convection simulations using modular zonal models of buildings.

CFD models have become important tools in ventilation research. These models are mainly used to assess the IAQ and thermal comfort levels, which are not easy to investigate with other methods (Chen, 2009). CFD simulations have successfully predicted the indoor air performance in many cases (Emmerich, 1997; Zhai, 2006). CFD methods also have other advantages, such as low labour costs, minimal equipment requirements and informative results (Jiang et al., 2004). Generally, three methods can be used for CFD predictions: direct numerical simulations (DNSs), large eddy simulations (LESs) and Reynolds-averaged Navier-Stokes (RANS) equation simulations with turbulence models. Zhai et al. (2007) reviewed the popular turbulence models that can be used to predict the indoor air performance and claimed that the performance of models was not always consistent for different flows. Additionally, the v2f-dav and RNG $\boldsymbol{k-\varepsilon}$ models, which are RANS modes, displayed better performance than other models. Yuan

(2007) conducted a study of the effects of building shape modifications on wind pressure differences for the cross-ventilation of a low-rise building. The paper compared three turbulence models: the standard $k-\varepsilon$, RNG, and SST models. The results indicated that the standard $k-\varepsilon$ model was stable.

4.3.3. Types of natural ventilation

4.3.3.1. Natural ventilation with single-sided openings

In a single-sided natural ventilation system, i.e., for a case with only one opening on a single wall (left part of Figure 4.2), air moves in and out of the room through the same opening, and the main driver is wind turbulence. A relatively low ventilation rate is typically generated. CIBSE Guide B (2005) advises that the maximum depth for this case be no over two times the floor-to-ceiling height (D<2H). For the case with two openings (right part of Figure 4.2), the ventilation rate is relatively high and can be enhanced by increasing the distance between the two openings in the vertical direction. CIBSE Guide B (2005) recommends a depth of approximately 2.5 times the floor-to-ceiling height for single-sided double opening ventilation (D<2.5H).

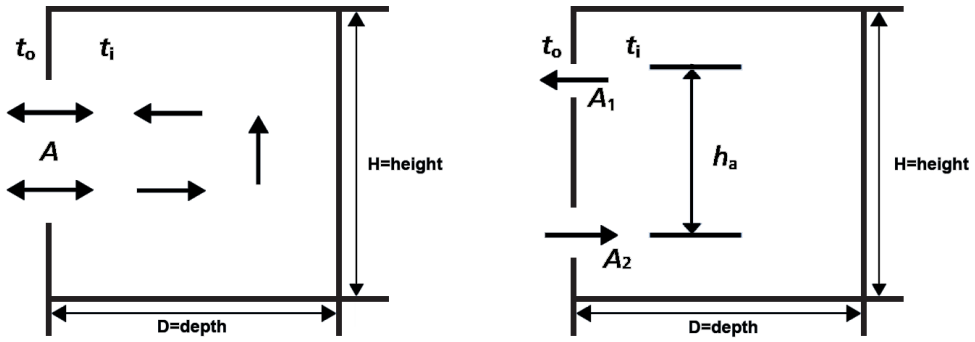


Figure 4.2. *Single-sided ventilation strategies (CIBSE Guide, 2005)*

4.3.3.2. Natural ventilation with cross openings

In cross natural ventilation strategies, two or more openings are located on opposite walls, as shown in Figure 4.3. The induced force is typically the wind (CIBSE Guide B, 2005). The fresh air, which is heavy, comes into the room through the low-level openings, and the waste air, which is warm, light and contains some pollutants, is exhausted via the high-level openings. The time required for the air to move across space should be less than the time needed for the air to rise to the height of the outlet. CIBSE Guide B (2005) recommends that the effective depth for cross-ventilation is no more than five times the floor-to-ceiling height.

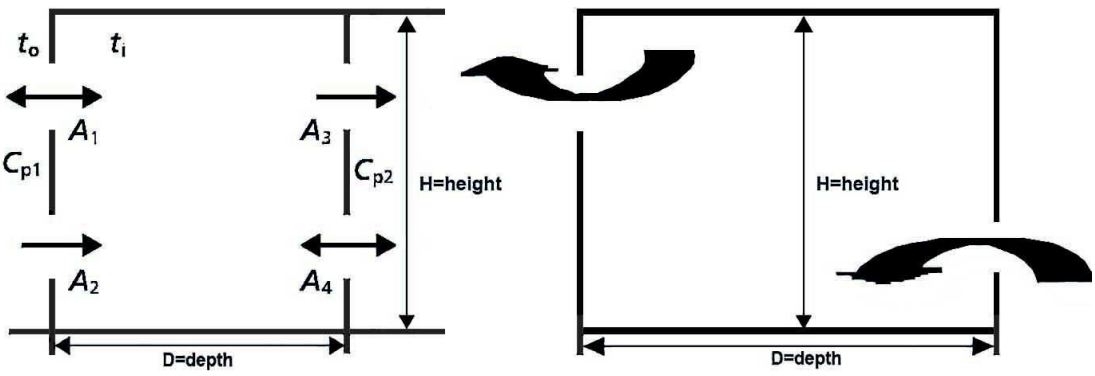


Figure 4.3. *Cross ventilation strategies*

Source: CIBSE Guide B (2005) (left) , Building Bulletin 101 (2006) (right)

4.3.3.3. Stack natural ventilation

Stack ventilation, as shown in Figure 4.4, is a type of ventilation strategy that use a driving force to promote outflow through corridors or adjacent spaces into a stack. Then, fresh air is introduced into the room through low-level openings. The driving forces are typically buoyancy forces induced by the density difference of the air between the indoor and outdoor environments (Khoukhia and Al-Maqbali, 2011). In the design of this type of ventilation strategy, Building Bulletin 101 (2006) advises that users should specify the height from the floor to the middle-height of

a low-level opening, as well as the height of the stack. The areas of the stack outlet and back wall vent should also be specified, and then the inlet area can be obtained by calculations. In CIBSE Guide B, the recommended depth for this ventilation strategy is five times the height from floor to ceiling. In high-rise or large non-domestic buildings, this stack ventilation is commonly positioned at the centre column of a building, such as in stairway and elevator shafts.

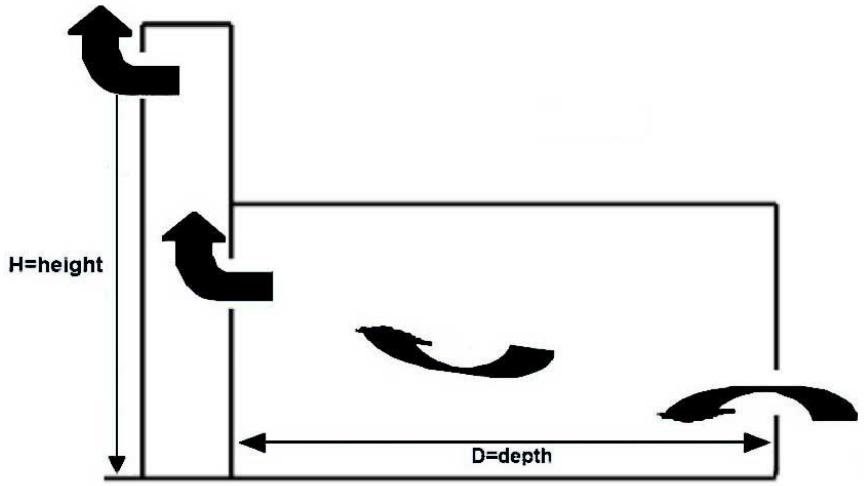


Figure 4.4. *Stack ventilation*

Source: Building Bulletin 101 (2016)

4.3.3.4. Wind-driven natural ventilation

The physical principles of wind-driven ventilation are similar to those of stack ventilation, but the main driver is wind rather than buoyancy. According to the recommendation of the CIBSE (2007), two main factors affect the distribution of pressures on the surfaces of a building:

- "wind speed and direction relative to the building: the local wind speed is affected by the type of terrain surrounding the building"

- "shape of the building: this provides the opportunity for the architectural form and detailing to enhance the potential for wind-driven ventilation"

Dalgliesh and Schriever (1968) stated that "the distribution of pressures and suction levels across a building largely depends on how it disturbs the air flow". As Figure 4.5 shows that the wind velocity increases from the low to high levels. In addition, CIBSE (2007) suggests that air normally flows from high surface pressure areas to low-pressure areas, and positive pressures always exist along building surfaces facing the wind. Moreover, the leeward surfaces will experience suctions effects.

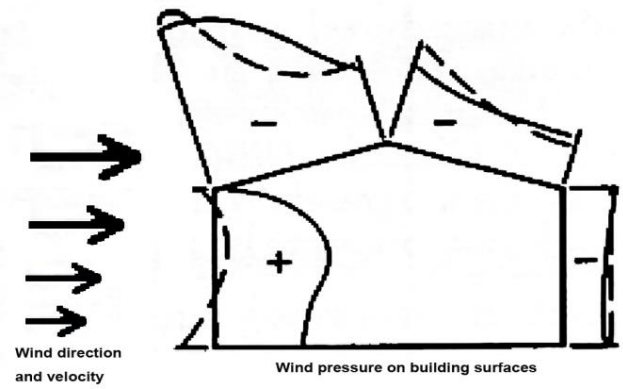


Figure 4.5. *Distribution of wind pressures (+) and suctions (-)*

Source: Dalgliesh and Schriever (1968)

4.3.4. Selection of natural ventilation types

As introduced in section 4.3.3, single-sided natural ventilation and natural cross-ventilation mainly rely on wind effects to generate a relatively low ventilation rates, and the recommended depth of a building plan is relatively small compared with that for stack ventilation. Thus, for school buildings that require high ventilation rates, these two natural ventilation strategies are not recommended.

Natural stack ventilation is driven by density differences between the indoor air and outdoor air. The outdoor air is drawn across the building and then is expelled through a high-level opening in a vertical channel, such as an atrium, stairwell, or chimney. Natural stack ventilation is stable because it minimises the effects of

wind and generates relatively high ventilation rates (Stabat et al., 2012). Moreover, natural stack ventilation can be combined with passive techniques, such as solar chimneys, which can further enhance the ventilation rate. Thus, in this study, natural stack ventilation is used in the ILEV system.

4.4. EHEAs

EAHEs have considerable potential due to their relatively low operating costs and excellent energy conservation efficiency. Air is supplied through buried pipes, and the temperature of the ground below a certain depth is essentially constant; therefore, during the supply process, ambient air temperature fluctuations are negligible. Coupled with a building ventilation system, EAHEs can provide preheated air in winter or precooled air in summer. Pipe loops are usually buried horizontally in the ground. As a natural material, deep soil, which acts as both a source and sink, is readily available in most places around the world. Thus, this method is sustainable and equivalent to using a renewable energy source. EAHEs release no toxic emissions and are thus not detrimental to the environment. Compared with ground source heat pumps (GSHPs), EAHEs do not require a refrigerant, such as water for cooling the air. Additionally, EAHEs have a long lifespan and require little maintenance.

4.4.1. The historical development of EAHEs

The earliest application of EAHEs was likely the nests built by ants (Figure 4.6) (Lobeck, 1939). Such nests are typically built above underground sources of water or in wet soil. In addition, one large nest provides shelter for millions of ants, and the ants require fresh air in the nest and must remove the excess heat. Ant nests consist of underground branched networks of passages and chambers. Surficial chambers are connected to lower chambers by vertical passages with branching lateral passages. The chambers are the main spaces for the ant activities, and the vertical passages act as ventilation stacks. In the lowest level of an ant nest, the air temperature is decreased by the underground water and then the air flows to the chambers via vertical passages. Therefore, due to stack effects, the air in the chambers is expelled, and fresh, cold air rises. Based on this process, the ant nest

maintains a steady temperature. Generally, the inside temperature of a nest is approximately 25-28°C. Notably, in winter, the inside temperature remains at approximately 20°C, even when the outside temperature is negative. The numbers of passages and chambers depend on the size of the nest, and in some cases, one passage may service several chambers. Moreover, several passages can act as one large stack for one large chamber.

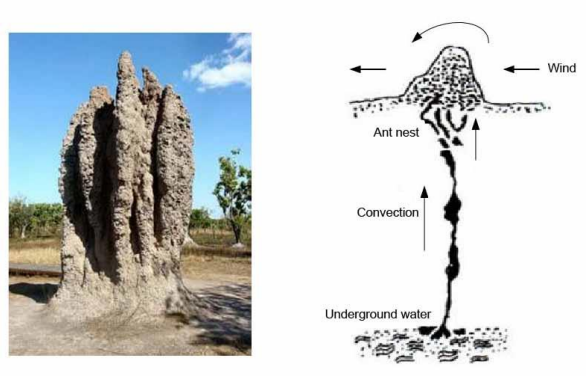


Figure 4.6. *Ant nest and convection principles*

Source: Wu (2013)

Five million years ago, buildings in the Middle East adopted EAHEs to provide cool air (Figure 4.7). The Persians designed a passive cooling system using wind catchers and EAHEs (Valipour and Oshrien, 2012; EI-Shorbagy, 2010). In natural conditions, EAHEs can significantly increase the thermal comfort of buildings in the Middle East. Fresh air is supplied via underground tubes, and the waste air is expelled by stack effects.

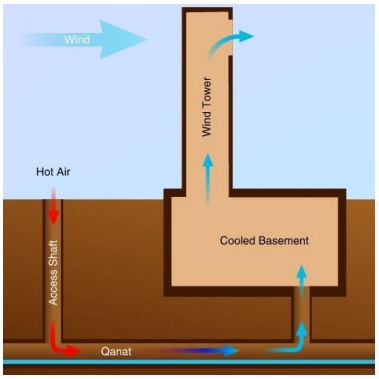


Figure 4.7. *EAHE and Wind-catcher*

Source: Wu (2013)

In 1877, one office building established by Hain and Alberts (1991) (Cited by Wu, 2013) was equipped with EAHEs to provide precooled air and preheated air for occupants, and this building may be the earliest design example in Europe (Figure 4.8). Many clay pipes, including one main pipe and other branch pipes, were buried below the building. In addition, fans or blowers were used to transfer air inside through the underground clay pipes. After the building was constructed, a patent was obtained for their design.

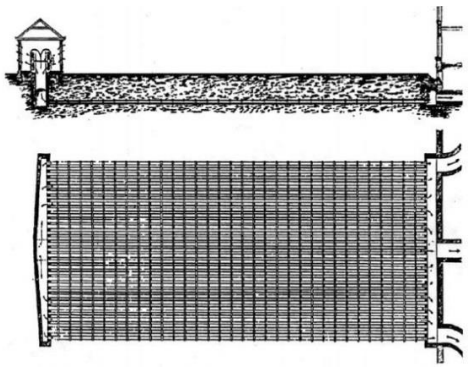


Figure 4.8. *Office building equipped EAHE*

Source: Wu (2013)

In 1973, due to the energy crisis, increased attention was given to research on EAHEs and their application. France, Germany, and Greece began studying EAHEs in the 1960s, and remarkable achievements have been accomplished regarding the efficiency, modelling and energy savings of EAHEs (Wu, 2013). The implementation of EAHEs in western developed countries has become relatively common since the mid-1990s. After the 1990s, EAHEs have been slowly adopted in North America. In recent years, India, Romania and other developing countries have made significant progress in applications of EAHEs (Wu, 2013).

4.4.2. Benefits of EAHEs

EAHEs provide promising passive actions due to their great energy savings potential, ability to maintain thermal comfort, and excellent indoor environment

performance. In 1994, Mihalakakou et al. (1994) claimed that EAHEs have great potential for reducing the building heating load in Dublin in winter. Santamouris et al. (1996) concluded that EAHEs can reduce the indoor air temperature by 3℃ to 10℃ and provide 28% to 60% of the cooling loads for greenhouses on summer days. Chel and Tiwari (2009) found that EAHEs can provide a thermally comfortable indoor environment in winter and summer. Moreover, the energy savings potential of a building with EAHEs is two times that of a building without EAHEs. Al-Ajmi et al. (2006) stated that EAHEs can reduce the energy demand of a typical house by over 30% in the peak summer season in Kuwait. Gidado and Amhed (2008) claimed that EAHEs provided a thermally comfortable indoor environment by consuming less energy in Nigeria. Tiwari et al. (2006) conducted experimental work on a greenhouse with an EAHE to validate a thermal model in New Delhi. The measurement results showed that the air temperature of the greenhouse increased by 8℃ in winter and decreased by 4℃ in summer. Ascione et al. (2016) analysed a case study of a net zero energy building in Palermo, south Italy. They evaluated the benefits related to the EAHEs regarding the reduction of the energy consumption and also the decreases in CO_2 emissions in the Mediterranean climate. The study concluded that on average, a primary energy reduction of 24-38% could be achieved annually. Stahl and Eng (2002) stated that EAHEs can provide 1200 kWh heating energy for buildings, equal to a 10% energy savings compared with buildings not equipped with EAHEs in Sweden.

Thus, based on the discussion above, EAHEs can supply air with a thermally comfortable temperature and achieve significant energy savings by supplying air with a temperature considerably different than that of ambient air.

4.4.3. Influential factors on the efficiency of EAHE

Various factors influence the efficiency of EAHEs, such as the local climate, soil temperature, pipe materials, heating and cooling loads. Pfafferott (2003) studied

three Central European office buildings equipped with EAHEs to characterise their efficiency. The study found that the performance of EAHEs was dependent on project-specific criteria. Notably, different projects have different climate backgrounds and design goals. Santamouris et al. (1996) investigated the factors that influenced the performance of EAHEs installed in greenhouses. The study mainly found that increasing the pipe length, decreasing the pipe diameter, increasing the buried depth and decreasing the air velocity inside the pipes significantly improved the thermal performance of the EAHEs. Wagner et al. (2000) indicated that increasing the pipe length and buried depth had positive effects on the performance of EAHEs. Bojic et al. (1997) performed a study to evaluate the performance of EAHEs in winter and summer, and found that in winter, the efficiency of EAHEs decreased at noon and increased at other times. In summer at noon, the cooling capacity of EAHEs was higher than that during other periods throughout the day. Kumar et al. (2003) developed a numerical model to predict the energy conservation potential and passive thermal performance of buildings. This model assessed the efficiency of EAHEs by incorporating the effects of the ground temperature gradient, surface conditions, moisture content and various design aspects of the EAHEs. The study stated that increasing the pipe length and decreasing the airflow velocity enhanced the performance of the EAHEs. Bansal et al. (2010) studied the effects of air velocity on the thermal performance of EAHEs. They concluded that the velocity of the air inside the pipes greatly affected the performance of the EAHEs. Stahl and Eng (2002) studied the effects of the pipe material on the performance of EAHEs and found that the relative humidity of the air at the outlet of concrete pipe could be maintained at 100% throughout the year and that the relative humidity at the outlet of a plastic pipe reached 100% in summer. Thus, plastic pipes displayed better performance in avoiding condensation.

The literature review above indicates that various factors can affect the performance of EAHEs. In practice, factors such as the pipe length, buried depth, local weather conditions, air flow velocity, heating and cooling loads, and pipe material should be considered in the design of EAHEs.

4.4.4. Types of EAHE

There are two general types of EAHEs: open-loop EAHEs (Figure 4.9) and closed-loop EAHEs (Figure 4.10) (Florides and Kalogirou, 2007).

- **Open-loop EAHE**

In an open-loop system, ambient air is directly supplied to target buildings through buried pipes to meet the heating or cooling requirements; then, the waste air is expelled through outlets. The air can be driven by natural forces when coupled with natural ventilation or by mechanical devices such as fans or blowers. The soil is used as a medium to directly heat or cool the supplied air according to the seasonal weather. The pipe material used should be extraordinarily durable and heat sensitive. In some cases, the open-loop EAHEs are combined with other operating systems, such as air conditioners, mechanical ventilation, and heat recovery systems.

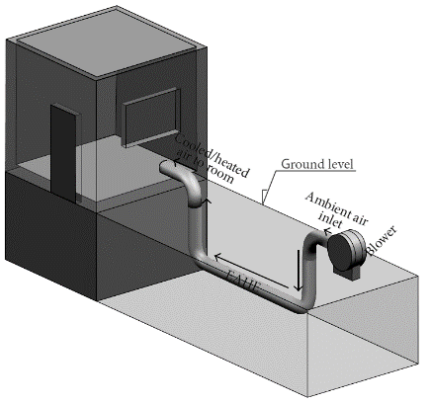


Figure 4.9. *Open-loop EAHE*

Source: Bisoniya et al. (2014)

In general, open-loop EAHEs have higher heating and cooling capacities than closed-loop systems. Moreover, open-loop EAHEs can avoid the circulation of contaminants throughout the system. Moreover, open-loop EAHEs are very flexible and can be easily and inexpensively applied to fit various building geometries and structural conditions; therefore, the installation costs and maintenance requirements are lower than those of other systems. Open-loop EAHEs can be combined with natural drivers, such as buoyancy from the temperature difference between the inside and outside air temperatures or pressure differences due to the wind. However, open-loop EAHEs have some disadvantages.; notably, they have more potential problems than conventional systems because they transport outside air pollutants directly into buildings if there is no filter or fresh air system installed. Therefore, in extremely polluted outside air conditions, open-loop EAHEs are not suitable for supplying cooled or heated air in buildings.

- **Closed loop EAHE**

In closed-loop EAHEs, air is circulated throughout building zones and buried pipes. Thus, a closed-loop system can also be called an internal circulation system. The building and system are isolated from the outside. The ambient air can only penetrate a building via air leakages pathways. Circulated air is driven by mechanical devices such as fans and blowers. In some cases, closed-loop EAHEs can also be coupled with other operating systems, such as air conditioners, mechanical ventilation, and heat recovery systems.

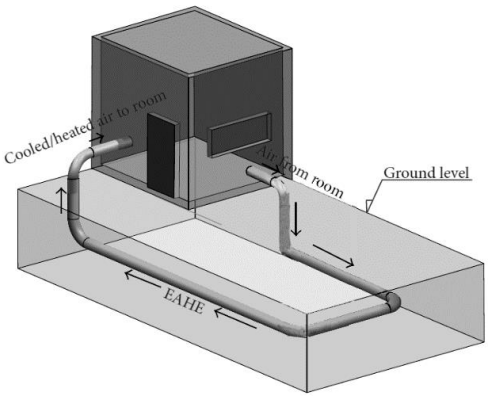


Figure 4.10. *Closed-loop EAHE*

Source: Bisoniya et al. (2014)

In general, closed-loop EAHEs are not preferred over open-loop EAHEs because they lower the heat exchange efficiency and often fail to meet the fresh air requirements of buildings. Additionally, indoor air contaminants, such as PMs, VOCs, and CO_2, can be continuously recirculated and never be transported outside. Therefore, closed-loop EAHEs can only provide changes in the air temperature. Additionally, they are not as flexible as open-loop EAHEs due to the contact and surface area limitations of circulated air and buried pipes. Consequently, the heating or cooling capacity can decrease in the long term. Moreover, the maintenance costs are higher than those of conventional heating and cooling systems and open-loop EAHEs.

- **Other EAHEs**

Open-loop and closed-loop EAHEs do not represent all types of EAHEs. A number of exchangers cannot be simply categorised based only on the loop configuration and connection scheme. In some cases, open- and closed-loop of EAHEs can be employed at the same time. In addition, loop configurations can differ, and the pipes can be buried in parallel or vertically. In addition, the heating and cooling medium can vary during different phases. One famous heat exchanger is the pond or lake loop exchanger (Figure 4.11)

It is counter-intuitive to think that a pond capped with winter ice can serve as an adequate geothermal heat source for a building during the heating season. Ponds and lakes absorb heat in spring, summer, and autumn. In addition, they release much of this heat in winter. Ponds or lakes normally include closed loops of pipes or tubes, and the pipes or tubes are weighted to prevent floating. The advantages of pond and lake loop systems include a high heat exchange efficiency, low costs and low maintenance requirements. However, such systems have inherent disadvantages. First, a pond or lake is required for the loop exchangers, and the water requires treatment if circulated. In addition, the water cannot be directly used because of potential problems related to heat exchanger fouling and pump suction issues. Additionally, pond and lake loop systems cannot be coupled with natural conditions; thus they require considerable electricity consumption.

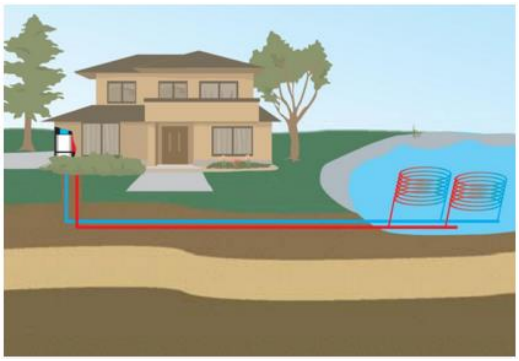


Figure 4.11. *Pond or lake loop system*

Source: Aztech Geo, (n.d.)

4.4.5. Simulation model development of EAHE

In Sweden, Claesson and Dunand (1983) conducted the earliest study of the extraction of heat from the ground in modern history. They analysed a steady state heat extraction model from a number of perspectives based on an entire cooling and heating system. Specifically, they considered the categories of pipes, quantity of pipes, configurations of pipes, effects of the ground surface temperature and the temperature distribution along the pipes. Equations with different boundary

conditions were employed to assess the performance of the heat exchangers. Additionally, the process of heat exchange was modelled by element superposition. Various processes can be isolated by superposition, and this approach provided a valuable and complex understanding of the heat extraction process.

In the mid-1980s, Oak Ridge National Laboratory (ORNL) developed a model suitable for EAHE calculations (Mei, 1986). Three EAHE models were produced according to the energy balance. One model incorporated a radially symmetrical temperature profile and considered the effect of frozen soil. Another model was based on a three-dimensional ground temperature distribution, which was influenced by heat transfer between the ground surface and ambient air. The final model evaluated the effects of ground heat transfer and thermal interference. A finite difference model based on a partial differential equation was used to obtain the solutions. The ORNL model divided the heat exchanger and surrounding soil into several segments along the X-axis and Y-axis according to the heat balance equation and linear source. The soil thermal characteristics, durability of pipes or tubes, changes in soil temperature and backfill materials were considered in the calculation process. Moreover, to simplify the required equations, some assumptions were made, for example, the model assumed that the soil was homogeneous. The research theories from Mei and Emerson (1985) and the experimental data from Hughes (1985) indicated that the ORNL model provides predications with high level accuracy and that the movement of moisture and frozen soil had little influence on the performance of EAHEs. Therefore, the ORNL model has become a design tool for EAHEs.

Lee and Strand (2006) developed a module to simulate earth pipes in the Energy-Plus program. There are three solution managers in Energy-Plus: the surface heat balance manager, the air heat balance manager and the building systems

simulation manager. The earth pipe module is implemented as part of the air heat balance manager. In addition, the authors made several assumptions to simplify the simulation process. For example, they assumed that the pipe surface temperature is uniform in the axial direction, the soil surrounding the pipe is homogeneous and has a constant thermal conductivity, and the pipe has a uniform cross-sectional area in the axial direction. The research mainly evaluated the effects of the pipe diameter, pipe length, volumetric ventilation rate inside the pipes and the depth of the buried pipes on the performance of the EAHEs.

In addition to mathematic models and the simulation program Energy-Plus, other CFD models are commonly used to predict the performance of EAHEs. CFD simulations are time-saving and cost-effective methods, compared with traditional wind tunnel tests (Douglas, 2011). In addition, the accuracy of CFD simulations has been verified. Thakur and Sharma (2015) stated that a consistent agreement can be achieved between CFD simulation results and experimental data. Wu et al. (2007) established a CFD model to evaluate the EAHEs' performance in South China. The study found that CFD simulations can provide reliable data for designers. Amanowicz and Wojtkowiak (2018) suggested that CFD models can be helpful in the design and optimization of EAHEs.

Thus, common simulation models for EAHEs include mathematical models, software simulation models (programs such as Energy-Plus), and CFD simulation models. Mathematic models have a long history and have been widely used. CFD models are more convenient and provide a time-saving and cost-effective method compared to other models.

4.4.6. EAHE application in China

In China, the application of EAHEs began with underground space design for public buildings. Since the 1960s, academic researchers in China have investigated

tunnel winds in underground spaces, such as in the Civil Air Défense Project. Mou (1982) studied the relation between tunnel winds and the heat exchange efficiency. An earth-to-air steady state heat exchange model was developed based on a constant heat-fluid and semi-infinite object heat transfer. Song and Zhu (2009) from Tsinghua University developed a calculation model for EAHEs by coupling a three-dimensional unsteady solid model and a one-dimensional fluid heat transfer model. Zhang (1981) from the Beijing Institute of Architectural Design Company analysed the cooling potential of EAHEs, introduced the concept of the heat transfer thickness and replaced the surface temperature with the soil temperature.

Some researchers have investigated the design parameters of EAHEs using numerical models verified with experimental data (Wu et al., 2006; Xia and Zhou, 2006). Previous studies found that the efficiency of heat transfer increases with the burial depth and the length of the pipes. Moreover, the larger the diameter of buried pipes is, the larger the heat transfer. Wu et al. (2007) investigated EAHEs on the campus of South China University of Technology. A system with EAHEs was built to meet the laboratory cooling demand, and data were collected during the summer period. The dimensions of pipes were 60 meters in length, and 200 mm in diameter, and the volumetric air flow rate was 1000 m^3. In addition, the pipes were buried at a depth of 3.75 m. The findings indicated that in the summer, the outlet air temperature was maintained at approximately 23.8°C to 29.5°C when the ambient air temperature ranged from 27.3°C to 37°C.

In other studies, underground tunnel winds were regarded as the heat source for heat pumps in the cold climate zone in China (Li et al., 2003; Gao and Li, 2010). These studies found that underground tunnel winds can significantly improve the performance of air-source heat pumps in winter and reduce energy consumption due to defrosting. Researchers from Chongqing University established an

underground tunnel wind ventilation system based on a theoretical analysis, numerical model and experimental measurements. The vertical tubes were buried at a depth of 23 m, and the inner diameter of the tubes was 80 mm. Measurements were recorded from July to August 2008. The data showed that the largest temperature difference of the air between the inlet and outlet of the tubes was 9.31°C. Therefore, they concluded that the system reached a steady state and was highly efficient when intermittently operated. Liu (2001) built an underground tunnel wind theoretical model based on experimental work at South China University. Dynamic simulations were combined with a building information model, weather data and tunnel wind parameters to develop a software package for predicting the effectiveness of underground tunnel wind ventilation systems. The research found that the predictions were very accurate and could be used to in the initial design stage.

Although some projects have reduced building energy consumption using underground tunnel wind ventilation systems. However, in most cases, such systems have been established only in buildings with underground air-raid shelter spaces. For buildings have no underground spaces, the underground tunnel wind ventilation systems cannot be used and may not meet the building requirements. Therefore, EAHEs provide a new option for these buildings. Directly using the soil as a source for cooling or heating air is an efficient way to passively improve the thermal comfort inside a room.

4.5. Solar chimney

Traditional natural ventilation systems are easily affected by weather conditions. In some cases, because of the small pressure difference, the volumetric airflow rate is relatively low and cannot meet the corresponding ventilation standards. Consequently, solar chimneys have drawn increased attention for passive solar house design due to their benefits associated with building ventilation and health improvements. These chimneys are natural ventilation devices that can provide buoyancy for airflows using solar radiation and therefore accelerate the process of transferring waste air outside and fresh air inside. Solar chimneys increase the air exchange rate, remove indoor air pollutants and ensure that the IAQ is satisfactory. In this process, solar energy is converted to kinetic energy, which drives the airflows.

Solar energy is the most important renewable energy worldwide because it is affordable, inexhaustible and clean; therefore, it will have substantial long-term benefits for human development. Moreover, renewable energies such as solar can reduce the reliance of society on fossil fuels, enhance sustainability, decrease environmental pollution and lower the costs of energy consumption. In real applications, solar energy utilisation can be categorised into two groups, namely: active solar and passive solar, based on the power supply. Solar chimneys are commonly used as a form of passive design. Specifically, these chimneys collect and absorb the energy from solar radiation and increases the buoyancy of heated air. There are no extra power supplies, and environmental pollutants are not produced during the process. Solar chimneys are popular in cases where cross-ventilation or stack ventilation may not be sufficient, or the designers do not want to use mechanical ventilation. Therefore, based on how they work, solar chimneys are typically constructed facing the sun and are painted black with matted surfaces. Moreover, solar chimneys are generally insulated from occupied spaces, so they

cannot transfer heat to the inside of a room and only provide ventilation services. Overall, in places where eco-friendly devices are needed, solar chimneys can offer significant help in removing waste air from a room or building without consuming any fossil fuel energy.

4.5.1. The history and development of solar chimney

In the 1950s, French engineer Felix Trombe made the Trombe wall famous after he built homes with Trombe walls in the French Pyrenees. Thus, Trombe walls should be considered the first successful application of solar chimneys. The structure of the Trombe wall is shown in Figure 4.12.

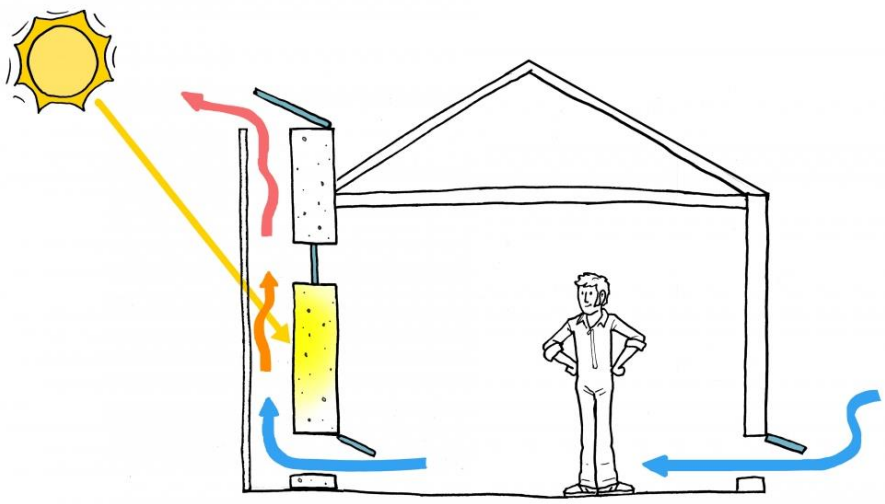


Figure 4.12. *Trombe wall*

Source: HVAC Variety (2018)

The heavy wall behind the pane of glass is used to absorb and store heat during the daytime, and the single-glazed surface insulates the wall from the external conditions. In winter, the vent on the top of the pane of glass should be closed, and the heavy wall absorbs and stores heat during the daytime and releases the heat into the space during the cold night. During the summer, the vent on the top of the glass can be opened to the outside, and an overhang above the wall prevents

overheating from the summer sun. The vent allows air inside in the narrow space to rise quickly and flow out of the wall; in this way, a solar chimney is created for cooling the building.

In recent decades, extensive studies on solar chimneys have been performed. A number of studies based on experimental measurements and numerical models have provided solutions for solar chimney design (Zalewski et al.,1997; Jie et al., 2007; Briga Sá et al., 2017). In addition, several types of solar chimneys have been developed, such as the Trombe wall structure, roof-mounted vertical solar chimney, wall-roof structure and solar chimney with wind catchers or a wind tower. Solar chimneys have been widely used in passive house design in many countries and have become a critical feature of solar houses.

4.5.2. Benefits of solar chimney

As a passive method that promotes natural ventilation, the potential benefits of solar chimneys are extensive. Barozzi et al. (1992) conducted numerical and experimental studies to evaluate the performance of a passive building equipped with a solar chimney in Nigeria. The building tested covers an area of 19.25 m^2, and the roof acts as a solar chimney to generate air flow through the hollow spaces in the building and provide cooling services. The paper mainly found that as expected, the solar chimney caused a pressure drop in the internal spaces, and fresh air flowed inside the building at a higher speed than before the chimney was installed. Bansal et al. (1993) developed a steady state mathematical model of a solar chimney that was used to promote stack ventilation. The research findings showed that high air flow rates can be obtained by solar chimney effects if the system is properly designed. Another study by Bansal et al. (1994) assessed the performance of a solar chimney coupled with a wind tower in a naturally ventilated building. The research results indicated that the solar chimney integrated with a wind tower can significantly improve the ventilation

performance when the ambient air moves at a slow speed. Ong (2003) proposed a simple mathematical model of a solar chimney in Malaysia and concluded that the solar chimney made a significant contribution to the natural ventilation system. Afonso and Oliveria (2000) compared a conventional chimney and a solar chimney in Porto, Portugal. The conventional chimney has no glass panels and was built entirely of brick. Additionally, parts such as the walls, ceilings and slab were made of concrete with external insulation. The performances of these two types of chimneys in a small building of 12 m^2 was evaluated. The paper concluded that the average ventilation efficiency was improved by 10% to 22% with the solar chimney based on climatic data from Portugal.

Thus, previous studies verified that solar chimneys can improve the ventilation rate in naturally ventilated buildings (Bansal et al., 1993; Chen et al., 2003; Spencer, 2001). However, in the design of a solar chimney, various factors, such as the dimensions and type of solar chimney, should be considered since they have significant effects on performance.

4.5.3. Influential factors on the performance of solar chimney

4.5.3.1. Effects of dimensions of the solar chimney

The height and width (distance between the glazed panel and heat collection wall) of a solar chimney are two main dimensional factors that affect the ventilation rate of the chimney. The effects of height and width on the performance of solar chimneys have been extensively analysed using small-scale and full-scale models. Spencer et al. (2000) investigated the effects of the width-to-height ratio of a solar chimney using a small-scale model built based on an electrolysis salt experiment. The study suggested that the airflow rate in the chimney can be increased by improving the width and height. However, when the ratio of the width to height is over 0.5, the air flow rate stabilises, and reverse air flow can be observed at the

outlet of the chimney. Duan (2009) also used an electrolysis salt experiment to show that increasing the size of the inlet opening can reduce the reserved air flow. Additionally, the optimum width-to-height ratios of a Trombe wall and roof-mounted vertical solar chimney were 0.08 and 0.5, respectively. Jing (2005) investigated the relationship between the width and height of a vertical solar chimney using a gas simulation method with a heating source in an experimental small-scale model. The research concluded that the optimum width-to-height ratio was 0.5 for the roof mounted vertical solar chimney.

In addition to experimental and simulation models, theoretical models have been used to investigate the relationship between the width and height of solar chimneys. Bansal et al. (1993) developed a steady state mathematical model of a solar chimney that was used to promote stack ventilation. The method used was based on theoretical analysis and considered openings of different size with varying values of the discharge coefficients. The findings showed that the volumetric airflow rate can be improved until the width to height ratio increased to a certain value. Moreover, Equation 4.5.3.1, which describe the relationship between the dimensions of the solar chimney and volumetric air flow rate, was proposed:

$$\dot{m} = C_d \varrho A_o [2gH (T_i - T_a)]^{0.5} / [(1+ A_o^2/ A_i^2)T_a]^{0.5} \text{ (Equation 4.5.3.1)}$$

Where $\dot{m}$ is the volumetric air flow rate, C_d is discharge coefficient (0.57), ϱ is the air density, A_i is the inlet areas, A_o is the outlet areas, H is the height of the solar chimney, T_a is the ambient air temperature, and T_i is the indoor air temperature. Studies conducted by Aboulnaga (1998) and Bansal et al. (1994) validated the accuracy of equation 4.5.3.1 using energy-balance methods. However, Chen et al. (2003) found that the volumetric air flow rates obtained by Bansal et al. (1993) were overestimated due to the underestimation of the pressure drop inside the solar chimney.

Previously, no studies have investigated the optimal relationship between the width and height of a solar chimney or optimal chimney design. The most common result obtained from previous studies is that increasing the width-to-height ratio of a solar chimney can enhance the ventilation rate inside the chimney until a certain threshold is reached.

4.5.3.2. Effects of the structure type of solar chimney

There are three common types of solar chimneys: Trombe walls, inclined roof solar chimneys, and vertical roof-mounted solar chimneys. Different types of solar chimneys have different suitability based on various conditions, such as the building location, cost, wind speed, and direction. Trombe walls can be included in the external fabric of a building and provide passive cooling or heating without occupying the inner building space. However, reverse air flows are more common in these cases due to the large pressure loss inside the chimney (Su et al., 2005).

Vertical roof-mounted solar chimneys normally exhibit better performance than Trombe walls because they have large pressure difference and small pressure loss (Su et al., 2005). Many studies (e.g., Barozzi et al., 1992; Bansal et al., 1993; Ong and Chow, 2003) have been conducted to evaluate the effectiveness of vertical solar chimneys and identified the most important influential factors. A numerical study was performed by Wang and Li (2004) to investigate the mass flow rate, temperature field and velocity field in a vertical solar chimney under steady state conditions. A large number of simulations was used to guide the construction design of the solar chimney and the results showed that the optimum width-to-height ratio was 0.5 for the vertical roof-mounted solar chimney. Afonso and Oliveria (2000) compared a conventional vertical chimney and a vertical solar chimney in Porto, Portugal. The conventional chimney had no glass panels and was completely built with brick. The performance of each type of chimney was evaluated in a small building of 12 m^2, and a thermal model was developed for

simulating solar chimneys. The paper concluded that the average ventilation efficiency was improved by 10% to 22% by installing the vertical solar chimney based on climatic data from Portugal. In addition, the solar chimney performed better in warm months than in cold months.

Inclined roof solar chimneys are the most effective among the three types of solar chimneys because they provide a more stable velocity field inside the chimney and a higher volumetric flow rate (Harris and Helwiq, 2007). The most important factor that influences inclined roof solar chimneys is the inclination angle (Su et al., 2005). Mathur et al. (2006a) found that the optimum absorber inclination varied from 40 degrees to 60 degrees depending on latitude. Bassiouny and Korah (2009) indicated that the optimum air flow rate was achieved when the chimney inclination angle was between 45 degrees and 70 degrees. Harris and Helwig (2007) claimed that for a south-facing chimney, an inclination angle of 67.5° from horizontal was optimum for the studied location.

Many studies have investigated the performance of three types of solar chimneys and the corresponding influential factors, such as the optimal width-to-height ratio and inclination angle. However, these findings were obtained based on specific background conditions. Until today, no research has given optimal design guidelines for solar chimney.

4.5.4. Simulation model development of solar chimney

Mathematical models based on the energy balance equation are commonly used for predicting the performance of solar chimneys. Such models evaluate the effectiveness of solar chimneys by analysing the processes of heat transfer between the heat collection walls and glazing panel. Ong (2003) proposed a one-dimensional steady state mathematical model based on the energy balance equation to analyse the temperature and velocity distributions inside a chimney.

Afonso and Oliveria (2000) developed a one-dimensional unsteady state mathematical model to analyse the air temperature and air flow velocity inside a chimney. Bansal et al. (1993) developed a similar mathematical model for a solar chimney. The calculation results indicated that the numerical predictions of the mathematical model were in good agreement with the experimental data.

Compared with mathematical models, CFD simulations are among the most popular methods used to predict the performance of solar chimneys because they provide detailed descriptions of the air temperature field distribution and air flow velocity distribution. Yedder and Bilgen (1991) conducted CFD simulations of the air temperature distribution field and air flow velocity inside a chimney based on two-dimensional laminar flow. In addition, the functional relationship between the Nu-number and Ra-number was given. Rodrigues et al. (2000) explored the air flow velocity and air temperature using a k–ε model for two-dimensional turbulent flow. The effects of the Nu-number and Gr-number on the ventilation performance of a solar chimney were analysed. Bacharoudis et al. (2007) compared the simulation results for six types of turbulence models and concluded that the k–ε model provided the best prediction of the performance of the solar chimney. Wang (2003) simulated solar chimney performance using the standard k–ε model and RNG k–ε model for different types of solar chimneys. The study suggested that the standard k–ε model combined with the non-equilibrium wall function method is recommended for three-dimensional simulations.

Currently, mathematical models and CFD simulations are the two main methods of predicating the solar chimney performance. However, both methods have some drawbacks. For example, mathematical models based on the energy balance equations typically ignore the thermal resistance of the glazing panel and heat collection wall. In addition, CFD simulation results highly depend on model selection (Su et al., 2005).

4.5.5. Solar chimney development in China

In China, solar chimneys have been widely used in traditional buildings. For example, the courtyard houses in Beijing, traditional houses in Xinjiang and Mongolian yurts, use stack effects for natural ventilation and smoke discharge. Thus, to some extent, these buildings have already employed the solar chimney design concept. Clearly, traditional Chinese societies knew about the characteristic benefits of this types of flow pattern.

Some studies of solar chimneys have been recently conducted in China. Most studies used numerical methods to simulate the performance of solar chimney devices. In addition, experimental methods were employed to verify the simulation results. Zhao (2004) conducted a numerical analysis of a solar chimney natural ventilation systems. The temperature and velocity fields were investigated under various conditions. The relationships between volumetric air flow rate and height and opening size of the solar chimney were analysed. Based on the numerical modelling results, the volumetric airflow rate was found to be relatively small when the airflow velocity inside the chimney was small; in this case, a wind blower or heat collection plate can be employed to increase the ventilation rate. Yang and Shi (2005) explored a simplified mathematical model of a solar ventilation wall based on the heat balance method and heat transfer theory. The study simulated the ventilation performance to determine the effects of the wall dimensions and local climate. The research conclusions indicated that increasing the width and height of the solar ventilation wall improved the ventilation rate. Moreover, increase in the solar radiation and ambient air temperature had positive effects on the performance of solar chimney. Wang (2003) analysed the characteristics of a Trombe wall using experimental simulation methods. The results indicated that the volumetric air flow rate could be increased by increasing the height of the solar chimney and intensity of solar radiation. Moreover, in most

cases, the optimum width-to-height ratio of solar chimney was 0.5, and this number was influenced by the sizes and positions of the air outlets and inlets. Jing (2005) performed a study of a solar chimney equipped with a one-sided vertical heat collection plate. The study concluded that there are optimum structural dimensions for solar chimney design. The best width-to-height ratio was 0.5 for a solar chimney 2 m high, 1 m long and 400 mm to 1200 mm wide. The air flow rate did not considerably change when the width-to-height ratio was greater than 0.5. Dai and Wang (2003) studied the pressure, air temperature and velocity in a solar chimney ventilation system. A numerical analysis and CFD k–ε model simulations were performed. Xu et al. (2010) studied a hybrid ventilation system in a school classroom with a solar chimney based on experimental measurements and software simulations. The authors focused on the effects of heat sources inside the room, the opening positions of the mechanical supply devices, the airflow velocity and ambient solar radiation levels on ventilation performance. The hybrid ventilation system was recommended for school design cases, and mechanical air supply devices were recommended for used in extreme weather conditions. Zhang et al. (2012) combined solar chimney and Trombe wall equations using heat transfer theory. In addition, a type of composite solar chimney ventilation system was designed. An assessment of the ventilation performances indicated that the dimensions of the solar chimney influenced the ventilation performance. Jing et al. (2013) analysed the indoor thermal environment under different levels of solar radiation using numerical software and found that as the intensity of solar radiation increased, the air flow velocity continuously increased and indoor thermal comfort improved. However, the magnitude of the air temperature increase decreased after a certain time. Liu et al. (2014) analysed the characteristics of the air temperature and velocity distributions using numerical simulation methods for the solar chimneys of various heights. The research outcomes suggested that changes near the absorbing wall were more obvious and those in

other areas had large effects on the discharge coefficient of heat transfer. The discharge coefficient of heat transfer improved as the height of the solar chimney increased. However, the magnitude of the increase decreased with time.

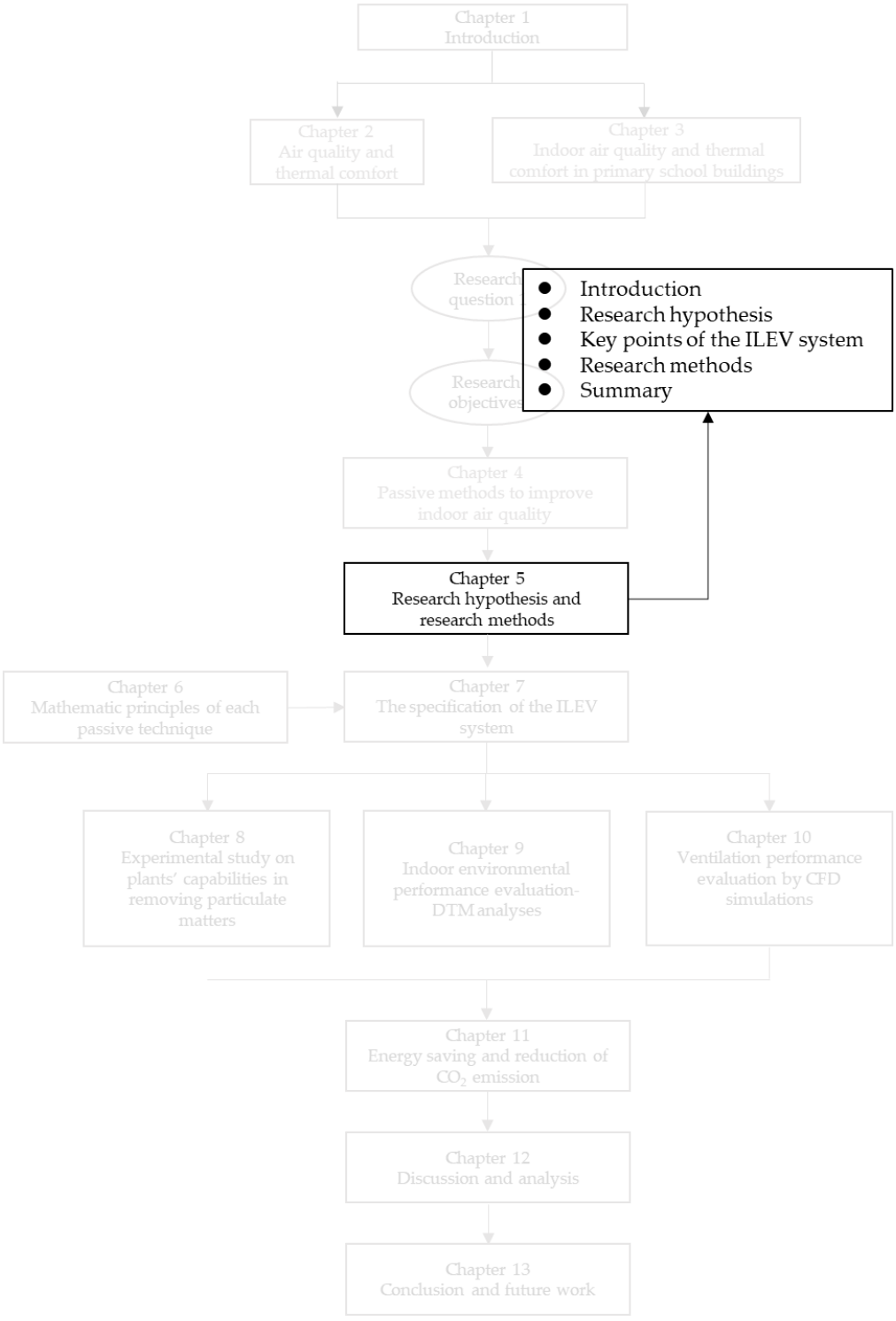
Generally, many studies of solar chimneys have been conducted in China, and the corresponding characteristics and influential factors have been fully investigated. Some of these studies were performed on the basis of theoretical analysis and mathematical models; others employed CFD simulations to predict the performance of solar chimneys. The methods and structures of these studies are similar to those of other studies worldwide. Therefore, they have reference value for this Ph.D. work.

4.6. Summary

In Chapter 4, literature reviews of 4 passive techniques that can potentially simultaneously to reduce energy consumption and increase IAQ were performed. The histories, benefits, development and influential factors of these techniques were critically reviewed. Plants, which act as passive cleaners, are mainly used to solve pollution problems related to the supplied air. EAHEs can provide preheated or precooled fresh air supplies, and solar chimneys can enhance air circulation and the ventilation rate.

In the next chapter, a hypothesis for a potential ventilation system will be proposed. The position and function of each passive technique in this system will be introduced in detail. The innovative concepts in this ventilation system will be further specified. In addition, the applicability of the system will be evaluated in the context of the relevant assessment standards.

Chapter 5: RESEARCH HYPOTHESIS AND METHODS



The content of Chapter 5

5.1. Introduction

In section 3.7, the field measurements indicated that the IAQ in the naturally ventilated buildings investigated did not meet the CIAQS-2002 and WHO requirements. Excessive CO_2 levels were caused by inadequate ventilation rates during the winter period. PM originated partly from outside air penetration and partly from indoor sources. Indoor sources, such as chalks, can be mitigated by using markers. However, schools have little to do with outdoor air pollution, which is a regional environmental problem. Some primary schools have considered using or begun using air purifiers to remove airborne pollutants transported by the incoming fresh air. However, air purifiers are not affordable for many public schools (refer to section 3.4.1). Furthermore, some air purifiers are ineffective in reducing air pollutant levels if the filters are not regularly replaced. Additionally, air purifiers may not be able to reduce CO_2 levels in closed and naturally ventilated indoor spaces. From a long-term perspective, air purifiers consume electricity, which can increase the building energy load and indirectly have adverse effects on the ambient air quality.

Therefore, traditional natural ventilation systems have some weaknesses in creating a satisfactory indoor environment, especially for periods of severe weather conditions when all doors and windows are closed. Such periods include the hot summer and cold winter, as well as on days with heavy ambient air pollution. The current measures used to overcome these weaknesses are not holistically effective. For example, EAHEs can precool or preheat the incoming fresh air to reduce ventilation heat loss; however, ambient air pollutants cannot be filtered with this approach. Air purifiers can temporarily clean indoor air, but they cannot control CO_2 levels generated inside, and from a long-term perspective, they are not an optimal option for reducing building energy consumption. Thus, building ventilation systems, which largely influence the IAQ, should be

redesigned, to develop an integrated system that is able to improve the IAQ and thermal comfort while consuming little energy.

5.2. Research hypothesis

Figure 5.1 shows an integrated system proposed to simultaneously reduce energy consumption, remove indoor air pollutants and improve the indoor thermal performance. The system includes four main parts: a solar chimney, natural ventilation, EAHEs, and a sunspace with plants. These four parts form an ILEV system that can be employed by primary school buildings in the cold climate zone of China. As Figure 5.1 shows, the sunspace with plants is positioned between the classroom and EAHEs. In addition, the solar chimney is connected to the northern façade of the classroom. The system operations can be summarised as follows:

1) Fresh air is supplied to the buried pipes and is then preheated or precooled to the temperature of the undisturbed soil.
2) The preheated or precooled air is cleaned in the sunspace by the plants.
3) The cleaned air is then supplied to the classroom.
4) The exhaust air is released through the solar chimney by stack effects.

The ILEV system is able to solve the problems highlighted in the earlier discussion.

- First, ambient air is cleaned in the sunspace before entering the indoor space.
- Second, fresh air is preheated or precooled by the EAHEs to reduce the energy consumption required for cooling and heating.
- Third, indoor comfort is increased because the EAHEs reduce the effects of the ambient climate.
- Fourth, small fans (Fans A, B and C) are installed to increase the air flow rate. In addition, the solar chimney is able to further increase the movement and transfer of the air mass.

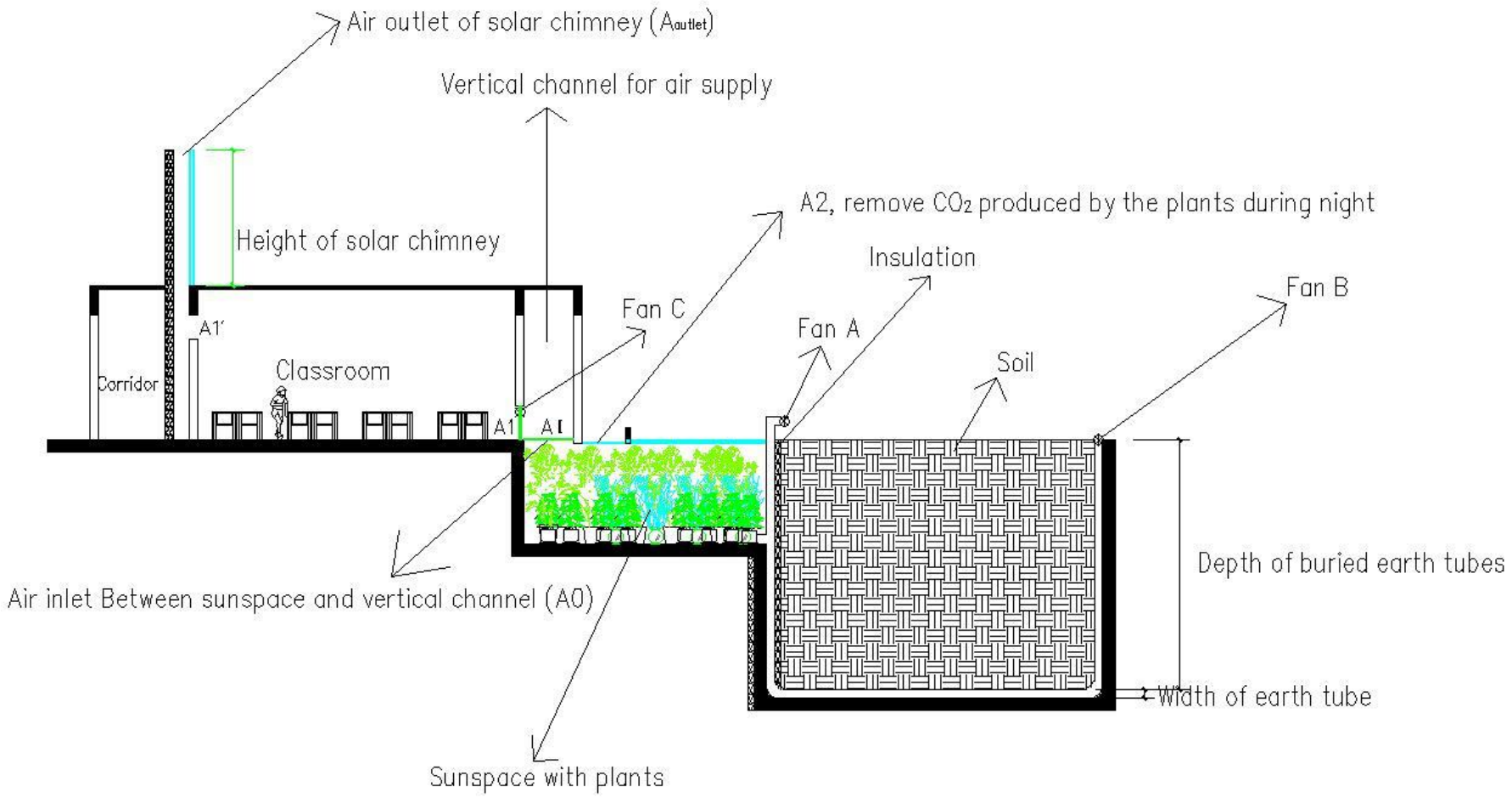


Figure 5.1. *Design scheme of the ILEV system*

5.3. Key points of the ILEV system

- **Standardised primary school buildings**

The ILEV system is specifically designed for primary school buildings located in the cold climate zone of China. China has a specific regulation for the design and construction of primary educational buildings: the Code for Design of School (GB50099-2011). To comply with the regulation, all school buildings in China have similar features, such as the number of students allowed per classroom, the total number of floors allowed for a building, the building orientation, the size and positioning of windows, and material specifications. Furthermore, the Public Building Energy Savings Standard (GB50189-2015) is used to regulate the energy efficiency design. This standard specifies the required thermal insulation performance of building elements. Therefore, school buildings should also have similar energy performance levels.

- **Operation of the EAHEs**

Normally, EAHEs are used to provide preheated air in winter or precooled air in summer (Fan B in Figure 5.1). In transition seasons, ambient air might be directly supplied to the sunspace because the air temperature is within the thermal comfort range (Fan A in Figure 5.1). Moreover, the EAHEs in this study are not only used to regulate the incoming air temperature during occupied periods but also to maintain the inside air temperature of the sunspace within a comfortable range for plants to survive and grow during unoccupied periods; therefore, the operation of the EAHEs largely depends on the ambient climate conditions. This topic will be discussed further in the following chapters.

- **The temperature inside of the sunspace**

In the ILEV system, plants are placed inside the sunspace, which provides an area for the plants to live and grow. The plants also work as filters and clean the air.

The air temperature inside the sunspace should be maintained at a range that meets the requirements for plant growth.

- **Fans are used to supply air**

A pressure drop exists in the EAHEs when the air is supplied by stack effects (Christophe et al., 2012). In addition, the heat exchange efficiency can be reduced if the wind is directly blowing into the buried pipes. Thus, to simplify the operation process and ensure the fluidity of the ILEV system, air at the inlet of the buried pipes is supplied by a small fan (Fan B in Figure 5.1). After heat exchange with the soil, the air temperature at the outlet of the buried pipes is identical to the temperature of the undisturbed soil. Then, air is supplied at a given rate to the indoor space to meet the ventilation requirement of the Chinese standard. In transition seasons, when the ambient air temperatures are within a comfortable range, air can be directly supplied to the sunspace by Fan A (Figure 5.1). Fan C (Figure 5.1) is used to supply air from the sunspace to the classroom when the pressure difference between the solar chimney and sunspace cannot achieve stack ventilation.

- **Photosynthesis is not considered**

The plants might reduce the CO_2 concentration and improve the oxygen level by photosynthesis. However, since the priority air pollutants are $PM_{2.5}$ and PM_{10} and the primary reason for the high CO_2 levels in classrooms is an inadequate ventilation rate (discussed in section 3.5), the photosynthesis rate and the changes in the concentrations of CO_2 and oxygen in the sunspace are not quantified in this research.

- **Evaluating standard for the ILEV system**

Both the international building regulations, such as standards from the UK and WHO, and the Chinese design standards are used to evaluate the performance of

the ILEV system. The local standards are more related to the local weather conditions and the requirements of thermal comfort of occupants. The international standards are used to assess the ILEV system from an international perspective.

- **10L•s-1 per person is chosen for the design of the ILEV system**

The requirements for the ventilation rate in classrooms vary in different building regulations in China. For example, the School Building Design Regulation-2011 (SBDR-2011) sets a value of 2.5 ACH as the minimum air exchange rate. The CIAQS-2002 recommends a minimum ventilation rate of 30 m^3/h per person, which is equal to 8.33 litres per second per person, to ensure that the indoor space has an adequate fresh air supply rate. However, CIBSE Guide A (section 8.4.1.2) states that "8 L/s fresh air is roughly equivalent to an increase of 600 ppm of CO_2, which, when added to the normal outdoor CO_2 concentration of 400 ppm, results in an internal CO_2 concentration of 1000 ppm". ASHRAE Handbook Fundamentals 2009 also suggests that 10 L/s per person is likely to provide acceptable IAQ according to the engineering experience and field studies. Based on the CIAQS-2002 standard of 1000 ppm as the minimum requirement for IAQ, 10 $L•s^{-1}$ per person is chosen for the ventilation design of the ILEV system.

- **Opening area of A2**

Plants give off CO_2 when they breathe at night. Thus, during the early morning hours, the indoor CO_2 concentrations might be in a high level inside the sunspace. Therefore, the fans (Fan B or Fan A) should be in operation before the start of school hours (e.g. half hour in advance). The aggregated CO_2 can be removed timely through the opening area of A2.

- **The sunspace is positioned below surface ground**

Currently, the SBDR-2011 requires teaching classrooms in primary school buildings to have over two hours of full sunshine through windows during the winter solstice day. Moreover, the Chinese Building Daylight Design Standard (GB50033-2013) also has mandatory requirements for daylight performance inside classrooms. Thus, the sunspace in the proposed system (Figure 5.1) is positioned below the surface ground to reduce the shading effects on the daylight performance of the adjoined classrooms.

5.4. Research methods

As introduced in section 1.5, Chapter 1, the selection of a research methodology largely depends on the type of research (Benz and Newman, 1998). Figure 5.2 shows the theoretical foundation for the research methodology and the specific research methods used in this research. It has been noted that both the qualitative and the quantitative approach were used in this research because this study involves different types of research. For example, a quantitative approach (DTM analysis, CFD simulations, experimental studies, GBSWARE+REVIT model) was mainly used to determine the thermal performance and the IAQ of the ILEV system (Chapter 9). A qualitative method (description, observation and case study) was mainly used to identify the current air pollution levels in China (Chapters 2 and 3), the factors that influence the IAQ (Chapters 2 and 3), the current measures taken to combat air pollution (Chapter 2), and the passive methods involved in the ILEV system (Chapters 4, 5 and 6).

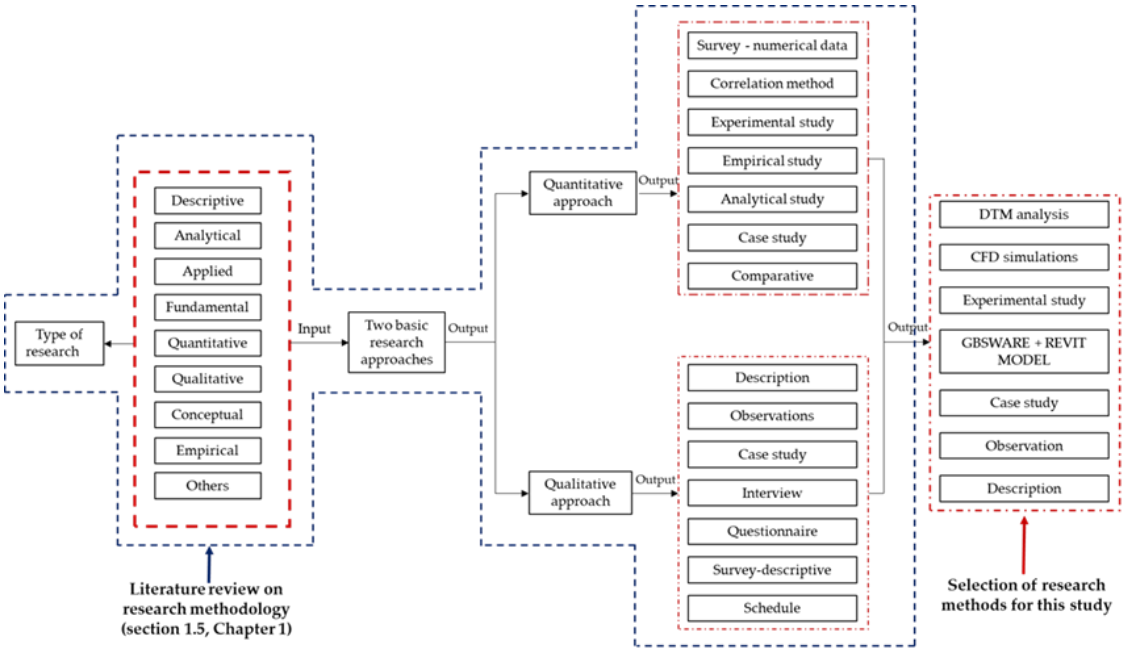


Figure 5.2. *The theoretical foundation of the research methodology and the selection of research methods*

Figure 5.3 presents a correlation of the research methods used in this work. A typical case study of primary school building is selected to explore the performance of the new system. The features of this typical building represent those of primary school buildings in the cold climate zone of China. The ILEV system and the typical building form a coupled model that provides thermal comfort and clean air under various ambient conditions.

The research methods in this work involve the DTM, CFD and experimental measurements (Figure 5.2). The DTM of buildings considers the external and internal thermal conditions over a given period or throughout the calendar year. Spaced-averaged values of indoor air temperatures and velocities are estimated with the model. The CFD simulation generates the internal air flow distribution fields and provides specific values of indoor air temperatures and velocities in a representative snap-shot in time. Input data for the CFD simulations can be generated by DTM. Thus, DTM and CFD simulations are often used in combination.

Experimental methods are used to explore the abilities of plants to remove air pollutants ($PM_{2.5}$ and PM_{10}) since no simulation methods are available to predict the performance of plant cleaning activities.

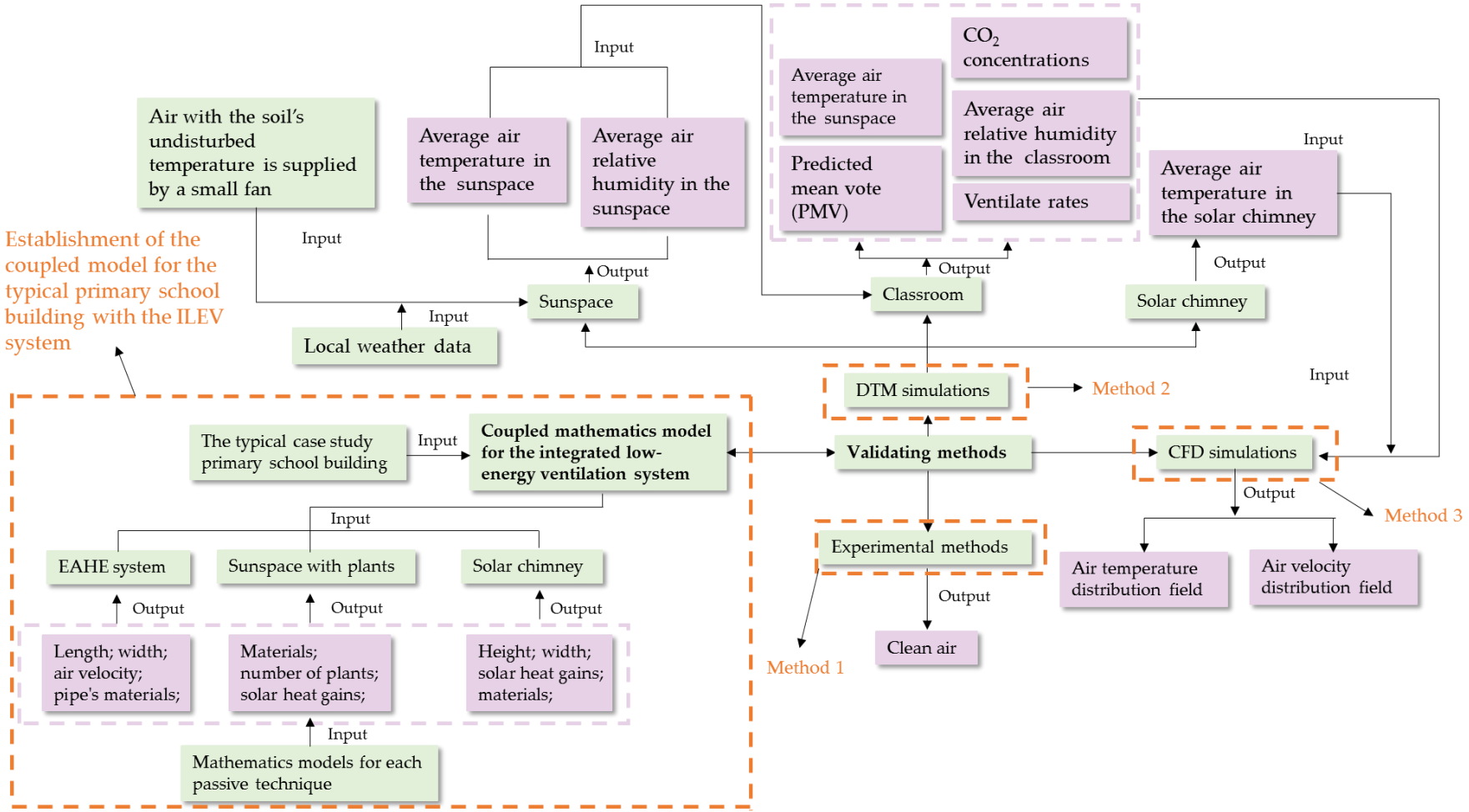


Figure 5.3. *Diagram of research methods*

DTM not only provides average values of various indoor air parameters but also outputs detailed values of building energy consumption. Revit models can generate material take-off sheets that can be used to estimate incremental costs of material inputs. Therefore, the combination of the energy consumption information from DTM and the costs of material inputs from Revit models can be used to determine the payback period. Thus, a comparison between current primary school buildings and redesigned primary school buildings can be performed. Specifically, based on the energy consumption and materials cost data from the take-off sheets, the payback period of the new ventilation system can be quantified (Figure 5.4).

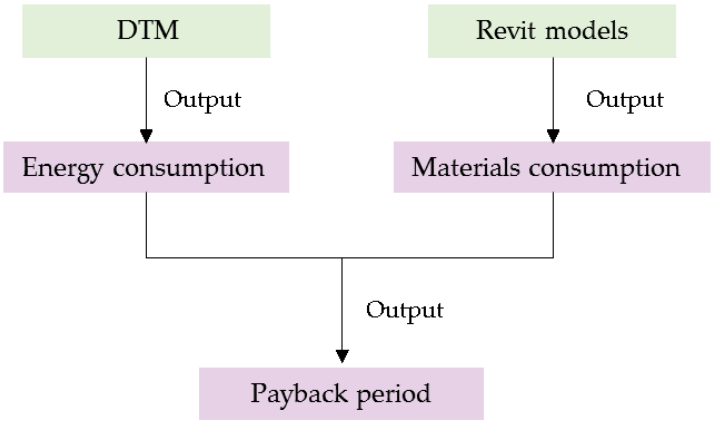


Figure 5.4. *Diagram of payback period quantification*

5.4.1. A case study school building in the cold climate zone of China

Case studies typically provide an in-depth understanding of research objectives since a detailed and holistic analysis can be performed. Therefore, a typical school building is selected in this study to explore the performance of the ILEV system, with the aim of improving IAQ and thermal comfort while consuming less energy. As noted in section 5.3, primary school buildings in China are designed according to the requirements of the local educational department and building regulations, such as the SBDR-2011 and PBESS-2015 (Table 5.1).

Table 5.1. Relevant policies and regulations for school building design

Policies and regulations	General requirements
SBDR-2011	Orientation; Dimension of classrooms; Number of students; Number of floors
PBESS-2015	Construction specifications; Energy-saving levels; U-value of building fabrics; Glazing type
Educational department	Equipment, such as computer, projector, printer; Type of rooms, such as lab rooms and classrooms; Number of students; Campus size

Based on these statutory requirements, typical primary school buildings in the cold climate zone should have the following features.

1) The maximum number of floors is 4.
2) The maximum number of students per classroom is 45.
3) Classrooms must have southward orientation.
4) The hallway should be located on the north side of the classroom.
5) The average floor area for a primary student is 1.35 m^2.
6) The maximum height and minimum height of a classroom are 3.6 m and 3 m, respectively.
7) The minimum air exchange rate for a classroom in a primary school is 2.5 ACH.
8) The minimum airtightness levels for a primary school building is 6.
9) The heating set point for the indoor air temperature is 16°C.
10) The cooling set point for the indoor air temperature is 22°C.
11) The maximum U-values of the roof, walls, window and door are 0.45 W/m^2K, 0.5 W/ m^2K, 3.0 W/ m^2K, and 2.0 W/ m^2K, respectively.
12) The daily average indoor concentrations of $PM_{2.5}$ and CO_2 should be less than 75 μg/m^3 and 1000 ppm, respectively, based on the requirements of the CIAQS-2002.

Figure 5.5 illustrates a typical floor plan and section plan for a primary school building in the cold climate zone of China. The number of floors is 4, and all classrooms have the same width, length, and height. There are 45 students in each

classroom. Figure 5.6 shows a typical south-facing façade of the primary school building. Based on the requirement of the SBDR-2011, the windows are all facing south, and the glazing area is 20% of the floor area of a classroom.

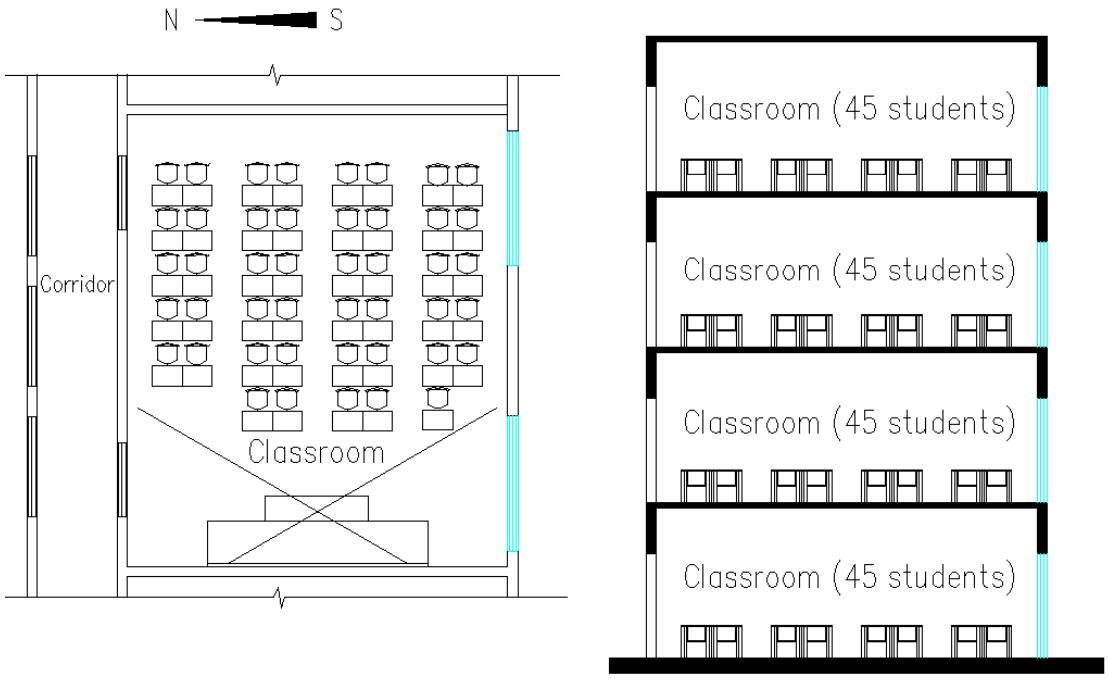


Figure 5.5. *Floor planning and section planning of a typical primary school building in the Cold Climate Zone of China.*

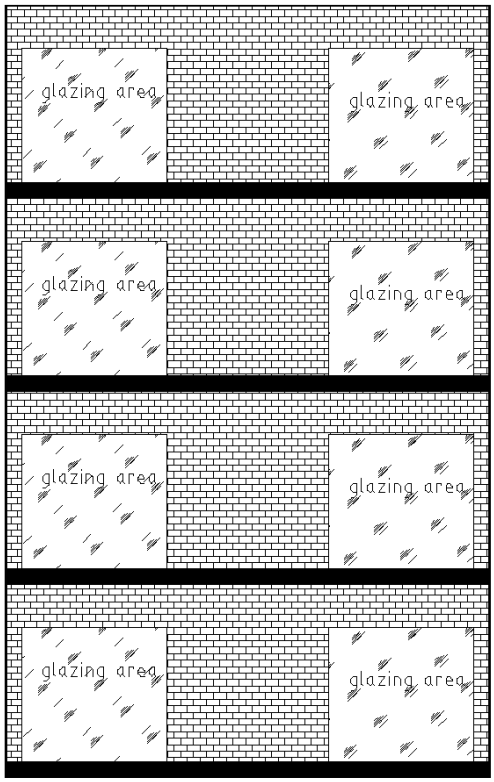


Figure 5.6. *A typical façade for a primary school building in the cold climate zone of China*

In this study, the typical building selected provides a real-life context and was constructed based on the latest versions of the SBDR-2011 and the PBESS-2015. The building is considered a representative primary school building in the cold climate zone of China based on the design, year of construction, and material specifications.

Therefore, an existing four-story building with 6 classrooms per floor constructed in 2015 for elementary education use is selected as a typical case study of a primary school building (Figure 5.7). The building is located in the east-central part of Tai'an city with a typical cold climate. There are 24 classrooms in the building, and 1080 students attend the school.



Figure 5.7. *Street view of the selected typical primary school building.*

Figure 5.8 and Figure 5.9 show the first-floor plan and section plan of one unit of the primary school building. Six units are arranged in a line, and each unit has four classrooms. The dimensions of each classroom are 9.6 m in length, 7.6 m in width and 3.6 m in height. In addition, all classrooms face south. The thermal insulation performance of the building fabrics meets the requirements of the PBESS-2015 (Table 5.2. Material specifications for building fabrics in the case study of the primary school building).

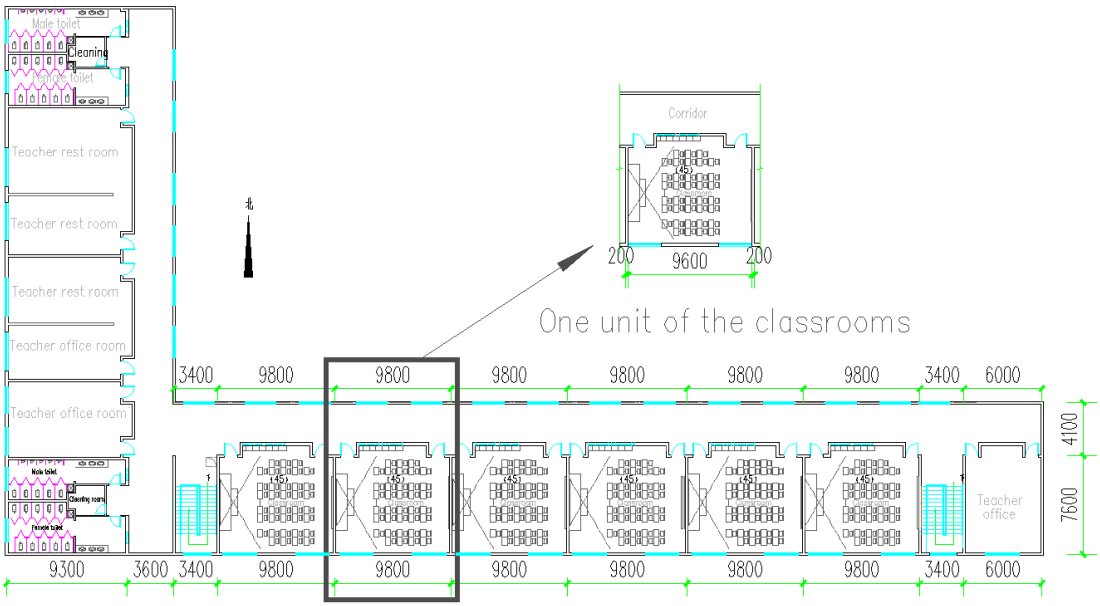


Figure 5.8. *First-floor planning of the selected primary school building (floor areas for teaching: 2328.2m² in total).*

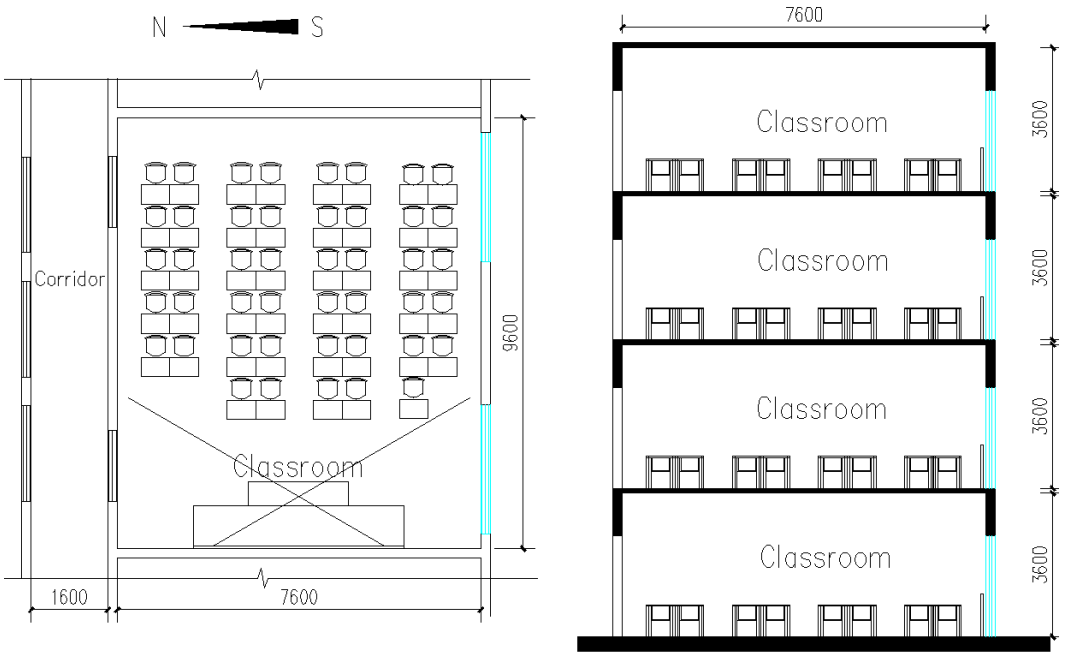


Figure 5.9. *Floor planning and section planning of the unit of classrooms.*

Table 5.2. Specifications of building fabrics of the selected primary school building

Fabrics	Structure	Parameters	Requirements of PEBSS-2015
Wall	Cement Mortar (20mm) + Rock Wool (85mm) + Concrete Block (200mm) + Cement Mortar (20mm)	U-value:0.33 W/ m²K	≤0.50 W/ m²K
Roof	Cement Mortar (20mm) + Extruded Polystyrene Board (XPS) (80mm) + Concrete Slab (120mm) + Cement Mortar (20mm)		≤0.45 W/ m²K
Window	5+12A+5+12A+5 Low-e (cavity 12mm)	U-value: 1.5W/ m²K	≤1.9 W/ m²K
	Width:2.8m; height: 3m	Total shading coefficient: 0.15	≤0.43
Door	Insulated metal door; Width:1m, height: 2m	1.5 W/ m²K	≤2.0 W/ m²K
Ground floor	Cement Mortar (40mm) + Concrete Slab (100mm) + XPS (20mm) + Cement Mortar (40mm)	0.8 m²K/W	≥0.60 m²K/W

5.4.2. Coupled model for the case study of the primary school building with the ILEV system

To test the ILEV system, it is incorporated into the selected primary school building with the goals of improving IAQ and thermal performance (the coupled model proposed is shown in Figure 5.10). Figures 5.11 and 5.12 describe the section and floor plans of the ILEV system in the case study building. Each unit of the classrooms is serviced by one sunspace and one solar chimney. Therefore, 6 sunspaces and 6 solar chimneys are built in total. Detailed information and parameters regarding the coupled model will be presented in Chapter 7.

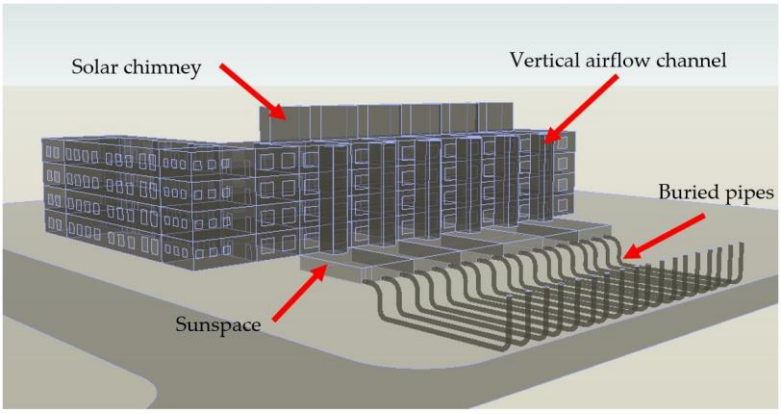


Figure 5.10. *The integrated low-energy ventilation system installed in the typical primary school building*

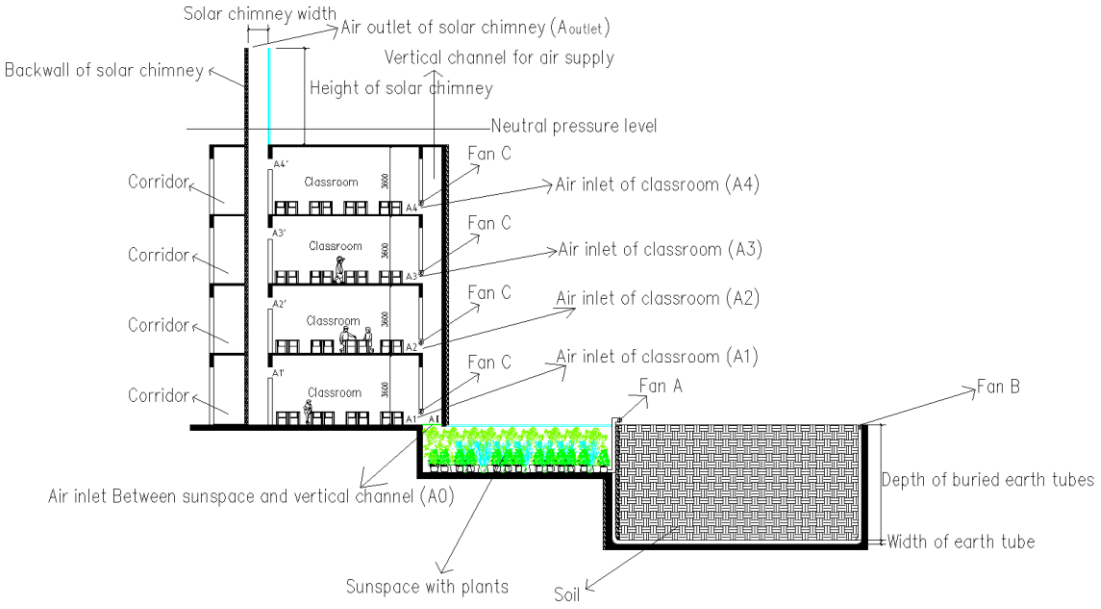


Figure 5.11. *Section planning of the ILEV system installed in the case study of the primary school building*

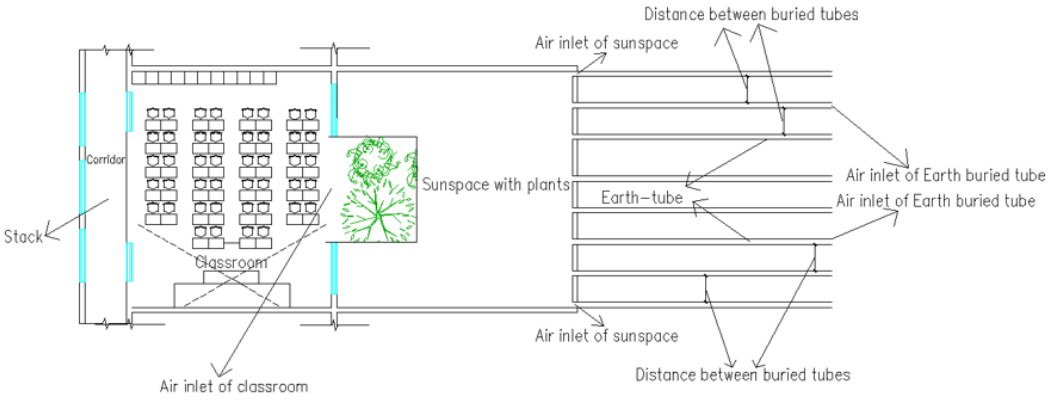


Figure 5.12. *Floor planning of the ILEV system installed in the case study of the primary school building*

5.4.3. Mathematics model establishment

A mathematical model (see details in Chapter 7) of the ILEV system should be established prior to system validation (Chapter 8). The diagram in Figure 5.13 shows the process used to establish the mathematical model of the ILEV system. Mathematical equations for each passive technique are presented, and the principles behind these techniques are introduced. Additionally, the factors that influence the design parameters of each technique will be analysed. Then, the mathematical model of the ILEV system will be built based on the mathematical equations for each passive technique.

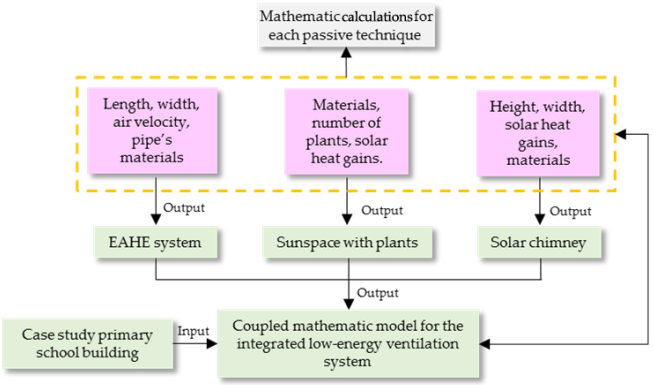


Figure 5.13. *Mathematic model establishment for the ILEV system.*

5.4.4. Computer-based modelling

Numerical techniques based on simulation tools can be used to predict the thermal performance of buildings prior to construction. Designers consider specific choices (e.g., the ventilation strategy, building configuration, and material specifications) for buildings based on the simulation results. Currently, DTM and CFD simulations are used in combination to overcome the individual deficiencies of each approach (Spentzou, 2015; Somarathne, 2003).

DTM involves building thermal modelling analysis considering the external and internal thermal conditions over a given period or throughout the calendar year. During the simulation process, it is assumed that the air is well mixed within spaces. Thus, the spatially-averaged values of indoor air properties (e.g., temperature, humidity, and CO_2 concentration), heating and cooling loads, and internal heat gains based on different variables and time steps can be obtained. DTM data are normally considered sufficiently detailed and close to the real values because hourly weather data (e.g., temperature, wind speed, humidity and solar radiation data), internal heat gains (e.g., gains from people, light, and equipment), operational conditions (HVAC systems) and building element specifications are considered in the simulations. However, DTM cannot predict the specific airflow distribution (temperature and velocity fields) in a given space.

CFD simulations usually provide a steady state analysis of detailed flow within a space of a building. The indoor air flow distribution fields are predicted, and specific values of air properties, such as temperature and velocity, are obtained. CFD simulations can be used to assess ventilation performance for both wind-driven and buoyancy-driven air flows. During the simulation process, it is assumed that the conditions in the model are constant, and the simulation provides predictions for a representative snap-shot in time. Input boundary

information, such as heat gains and average temperatures, can be obtained by DTM and input into CFD software.

Currently, there are many software packages for conducting DTM and CFD simulations (e.g., Energy-Plus, Design-Builder, IESVE, FLUENT and PHOENICs). For this study, the selection standards for the DTM and CFD simulation tools are reliability, accessibility and training available.

5.4.4.1. DTM analyses of thermal performances

The DTM simulates the thermal performance within a space by considering the thermal exchange between internal and external conditions for a given building. Currently, many DTM tools are internationally available. Table 5.3 provides a subjective evaluation of 10 popular simulation tools based on the selection standards employed in this study, and the results indicate that IESVE is the most suitable tool for this study.

Table 5.3. Selection of a simulation tool

	Reliability	Accessibility	Training available
HEED	√	×	×
Energy 10	√	×	×
Design-Builder	√	×	√
eQuest	√	×	×
DOE-2	√	×	×
Green Building Studio	√	×	×
IESVE	√	√	√
Energy-Plus	√	√	×
Energy-Plus with the Sketch up Plugin	√	√	×

In addition to the subjective evaluation in Table 5.3, published studies also have found that IESVE offers high accuracy and interoperability. For example, Attia et al. (2009) compared ten software packages and found that IESVE performs best due to its usability, graphical visualisation and interface management. Good agreement was observed between the IESVE simulation results and experimental data (Hamza, 2008; Chinnayeluka, 2011). Attia and De Herde (2011) stated that

IESVE is able of making estimations and predictions of building performance at a reasonable level of accuracy. In addition, IESVE has been tested and verified by both the CIBSE and ASHRAE. In the past decades, IESVE was selected as the most favourable simulation tool to evaluate building performance (Chinnayeluka, 2011). Therefore, the software package IESVE (IESVE, 2017) is selected for this work.

In IESVE, a three-dimensional model of the selected primary school building should be built based on CAD construction drawings. In addition, the following detailed information must be input into the model: the building configuration and orientation, local weather conditions, construction specifications, system operation conditions, building operation conditions, and internal heat gains. The DTM provides hourly data regarding the average indoor air temperature, airflow rates, CO_2 levels and heat gains throughout a calendar year. The flow diagram in Figure 5.14 illustrates the thermal simulations of the ILEV system. Notably, the local weather data will be input into the model, and the air temperature and air humidity in the sunspace can be calculated. Then, these data will be further used as inputs to model classrooms and the solar chimney. The air property values for classrooms and the solar chimney can be copied into Excel, and hourly data will be summarised to obtain the boundary conditions for CFD simulations.

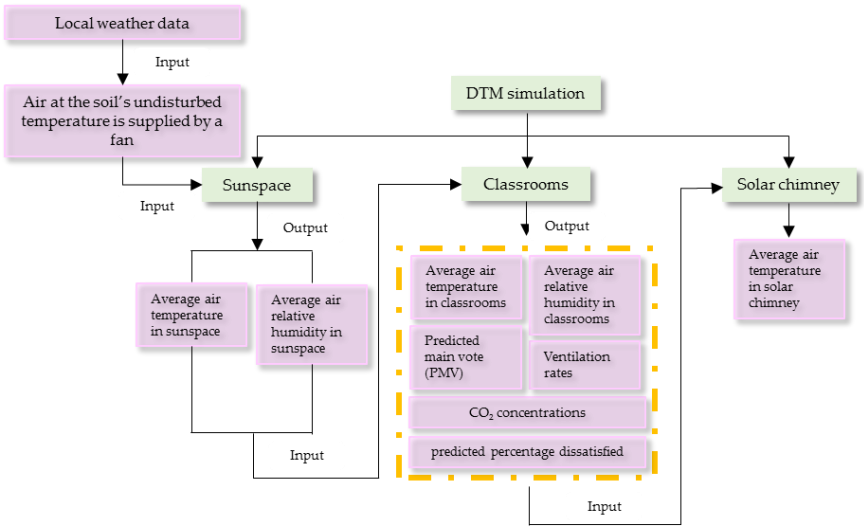


Figure 5.14. *Working process of the DTM simulations for the ILEV system.*

5.4.4.2. Computational Fluid Dynamics (CFD)

CFD models can provide detailed flow patterns in the various spaces of a building by calculating the air temperatures, velocity, and pressure distributions at numerous locations. CFD methods can save time and reduce costs compared with wind tunnel testing (Douglas, 2011) and real-scale field experiments (Montazeri et al., 2013). Moreover, CFD simulation results generally exhibit good agreement with experimental data (Cook et al., 2003). Currently, there are many commercial CFD software packages available, including CFX, PHOENICS, and FLUENT (Norton et al., 2007). In IESVE, a CFD analysis tool called MICROFLO can be used to perform CFD simulations (Figure 5.15). It was verified that MICROFLO can deliver CFD simulation results to a high level of accuracy which are similar to other CFD software packages, such as ANSYS Fluent and Star-CCM (Li, 2015). Considering the software available and training skills required, MICROFLO in IESVE is used to evaluate the ventilation performance of the ILEV system in this work. MICROFLO is specifically designed to model internal and external airflows and heat transfer in and around buildings. Moreover, the three-dimensional model of the primary school building created for DTM can be directly used in the CFD simulations with MICROFLO.

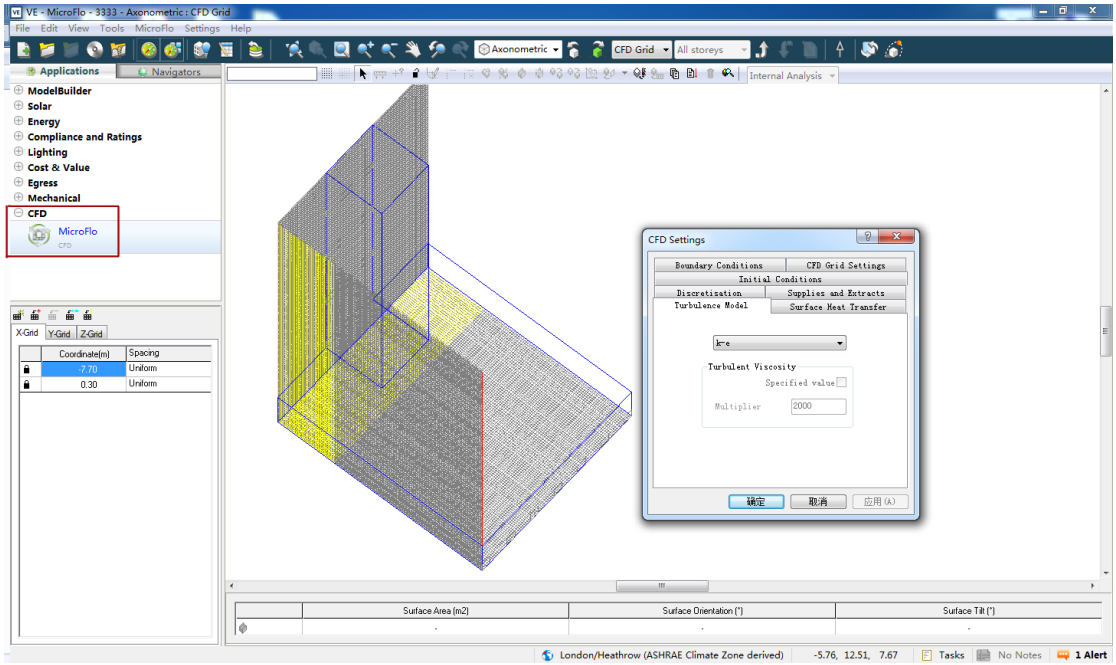


Figure 5.15. *MICROFLO in IESVE.*

The working process in MICROFLO involves three steps. First, the user must input the boundary information obtained from the DTM simulations. The data processor then solves the three-dimensional RANS equations, and the MICROFLO Viewer allows users to visualise the simulation results. The quality of the CFD simulation results largely depends on the pre-processing stage because the building configuration, construction materials, boundary conditions, and calculation iterations are input in this step. Furthermore, a satisfactory computational mesh is important for high-accuracy CFD modelling (Cook, 1998); thus, investigations of independent mesh solutions are considered in this study to reduce the errors in the simulation output. The aim of the mesh study is to determine the optimal number of cells in X-, Y-, and Z- directions so that further mesh improvements will not lead to significant changes within an acceptable simulation period (Cook, 1998).

5.4.5. Experimental study on plants' abilities in cleaning the air

As introduced in section 4.2, plants are effective in removing air pollutants, such as PM and CO_2. However, there are no simulation methods that can predict the

ability of plants to clean air. Most previous studies (Pegas et al., 2012; Tarran et al., 2007; Elkiey and Ormarod, 1980) were conducted based on experimental analyses (e.g., field studies or laboratory studies). Therefore, in this study, experimental work will be conducted to verify the capabilities of plants to remove air pollutants. A sunspace with plants inside should be built, and air will be supplied from one side of the sunspace and expelled from the other side. This process ensures that air moves past as many plants as possible. The PM concentrations will be simultaneously measured at the inlet and outlet of the sunspace. In addition, the I/O ratios will be used to analyse the trends of the inside PM concentrations. Detailed information regarding the experimental study of the capabilities of plants to remove PMs will be presented in Chapter 8.

5.4.6. Simulations for energy consumption

The case study of the school building introduced in section 5.4.1 is heated by the Urban Central Heating System in winter and cooled by air conditioners in summer. In spring and autumn, there is no active system to provide ventilation service. Thus, in total, 2 scenarios (scenarios 1 and 2) were created to investigate the energy consumption in primary school buildings (Table 5.4). Scenario 1 represents the current primary school building energy consumption in the cold climate zone of China. Scenario 2 was used to evaluate the energy performance of the ILEV system.

Table 5.4. Scenarios for simulations of building energy consumption

	Scenario 1	Scenario 2
Heating service	Urban Central Heating System (Energy source: coal)	ILEV system
Cooling service	Air conditioning (Electricity)	

Energy consumption in primary school building can be quantified with simulation software packages such as IESVE and Energy-Plus. However, in China, the most commonly used software to quantify energy consumption is GBSWARE (2016) because it directly considers the Chinese energy saving standards. GBSWARE was developed by Tsinghua University and Shenzhen SWARE Technology in 2000.

The software provides holistic solutions for modelling, predicting and verifying building performance throughout a building life cycle. GBSWARE was certified by the Ministry of Housing and Urban-Rural Development of the People's Republic of China (MOHURD) in 2005 (GBSWARE, 2016). Therefore, GBSWARE is used to quantify the energy consumption of primary school buildings.

5.4.7. Revit model for estimating the payback period

To install the ILEV system, the initial floor plan of the studied building must be redesigned. The addition of the solar chimney, sunspace, and EAHEs will increase material consumption and may result in high initial costs. To facilitate the cost-benefit analysis, Revit models of the current building and redesigned building with the ILEV system will be created to generate material take-off sheets. These sheets give the quantity of each material input per unit volume (m^3), which can be then converted to material weights (kg). Then, a comparison between the current building and redesigned building is able to be performed. According to the GBSWARE energy consumption results and the material consumption information from the take-off sheets, the payback period of the ILEV system can be calculated. The payback time is estimated according to the following equation.

$$\text{Payback time} = \text{Additional Cost} / \text{Annual Fuel Savings}$$

It should be noted that only material related costs are considered. Other cost, such as labour and transportation costs, are not considered because these costs are affected by various practical factors and are not appropriate for this Ph.D. project based on the project objectives and time and resource limitations.

5.5. Summary

This chapter summarises the limitations and drawbacks of the conventional methods of mitigating the indoor environmental issues in classrooms of primary school buildings, and a new ILEV system is proposed. The ILEV system includes four main passive techniques: solar chimneys, natural ventilation, EAHEs, and sunspaces with plants. The system is specifically designed for standardised primary school buildings in the cold climate zone of China. Plants act as a part of the ventilation system to reduce air pollutant levels. EAHEs preheat and precool the fresh air and act as temperature regulators for the sunspace to ensure that the air temperature is suitable for plant growth. The solar chimneys are used to improve the efficiency of natural ventilation (stack effects).

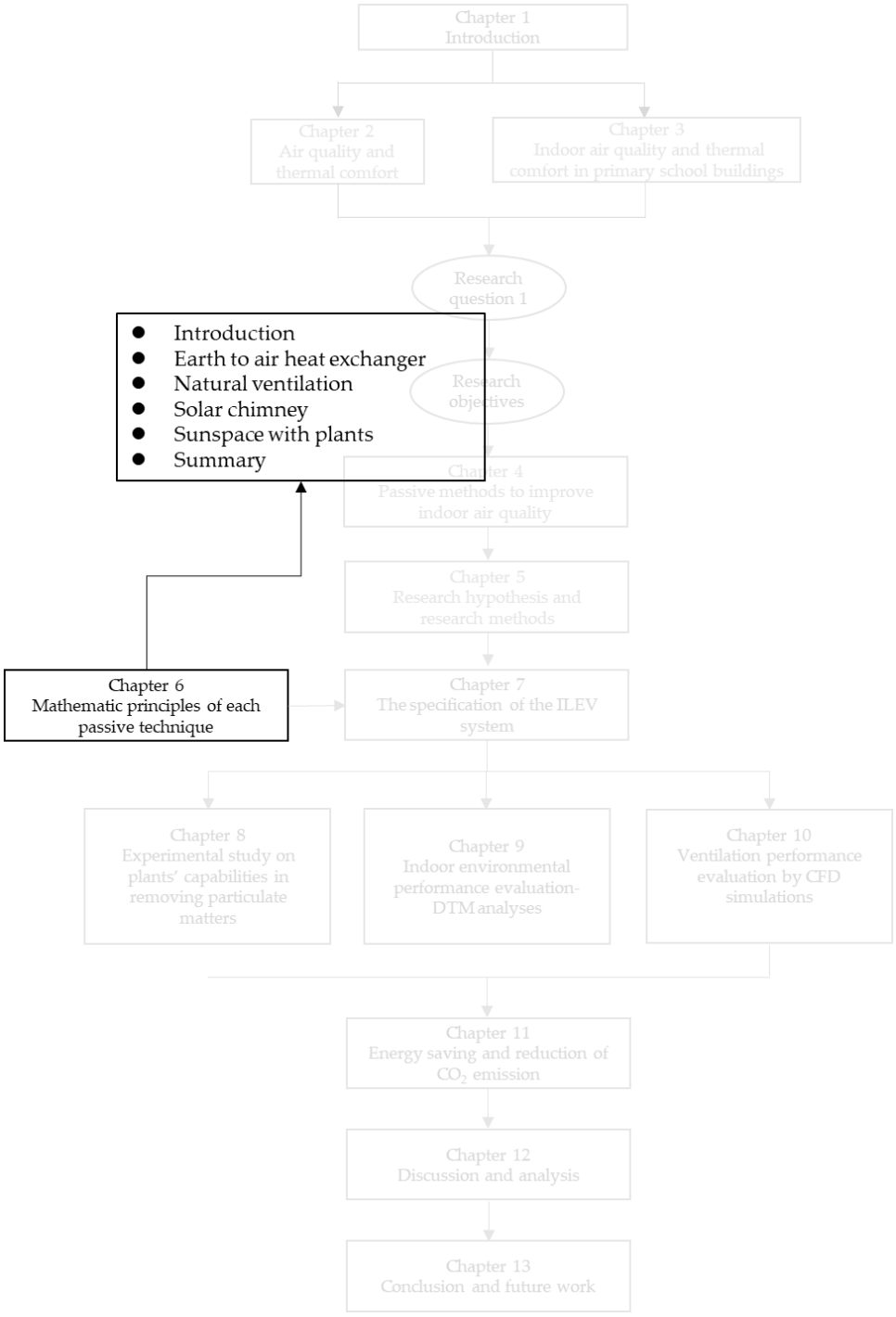
To validate the effectiveness of the system, research methods are proposed involving the following steps.

- First, an existing four-story primary school building in the cold climate zone of China constructed in 2015 based on the latest building design regulations was selected as a representative case study building.
- Second, numerical models of all passive techniques are developed, and a coupled mathematical model of the ILEV system is built to guide the redesign of the studied building.
- Third, a test of the ILEV system is conducted based on experiments, DTM and CFD simulations. Experimental studies are performed to investigate the abilities of plants to reduce air pollutant levels. Numerical data are collected from the experimental measurements, and the analysed results are presented as Excel graphs. CFD and DTM simulations provide a complete numerical description of the ventilation performance. Additionally, the air temperature distribution and air flow velocity are presented as numerical figures.

- Fourth, the energy consumption of the case study building is predicted using GBSWARE. In total, 2 scenarios were created to investigate the primary school buildings' energy consumption. Scenario 1 represents the current primary school building energy consumption in the cold climate zone of China. Scenario 2 was used to evaluate the energy performance of the ILEV system.
- Finally, Revit models are used to obtain the material consumption information for the current primary school building and redesigned building equipped with the new ILEV system. The payback period is estimated based on the material costs and annual energy savings.

Chapter 6 will review the numerical equations for each selected passive technique, and the factors that influence the design parameters for these techniques will be analysed. Then, a mathematical model of the ILEV system is built to guide the redesign of the case study building (Chapter 7).

Chapter 6: MATHEMATICAL PRINCIPLES OF PASSIVE TECHNIQUES



The content of Chapter 6

6.1. Introduction

Chapter 4 reviewed the features of each passive technique, and Chapter 5 presented the research hypothesis. This chapter discusses the mathematical principles behind these techniques and the effects of influential factors on the design parameters of each technique. The following list summarises the critical points of this chapter.

- The thermal characteristics of soil and the Earth's undisturbed temperature are identified, and the mathematical formulas of EAHEs are established.
- The mathematical formulations of natural ventilation strategies are determined, and the influences of buoyancy effects and wind effects are identified.
- The factors that have significant effects on the efficiency of the solar chimney, such as solar radiation, the height to width ratio of the airflow channel, the glaze type and the inlet dimensions of the solar chimney, are identified.
- The factors that affect the ability of plants to adsorb PMs are identified, and the quantity of PMs adsorbed by plants is determined based on published studies.

This chapter aims to provide a holistic methodology regarding the design parameters of each passive technique to establish a coupled mathematical foundation for the ILEV system.

6.2. EAHEs

6.2.1. Thermal characteristics of the soil

Soil acts as a heating or cooling source for EAHEs. The thermophysical characteristics of the soil are important factors that determine the soil heat exchange efficiency. Therefore, it is essential to identify the thermal parameters of the soil before installing EAHEs.

There are two main mechanisms of heat transfer within the soil: conduction and radiation. Conduction occurs between solids, such as soil and soil at different depths. Radiation occurs when dry and porous soil is directly exposed to the ambient environment at high air temperatures. In many cases, the heat transfer of EAHEs is mainly affected by the soil type and the soil moisture content; therefore, the thermal conductivity (λ) and specific heat (C_p) of the soil are the two main factors considered during the heat transfer process. Bose et al. (1985) provided an empirical equation for the thermal conductivity of soils with different densities and humidities.

$$\lambda = 0.144166 \times [0.9 \times \log_{10}(\phi \times 100) - 0.2] \times 10^{0.000624 \times \varrho} \quad (6.2.1.1)$$

Where ϕ is the moisture content of the soil (kg/kg) and ϱ is the density of the soil (kg/m^3). However, in most cases, the thermal conductivity of the soil does not remain in a steady state due to moisture content variations; moreover, the soil density frequently changes with the season and ambient climate changes. The ASHRAE standard 55 summarises some thermal conductivities for several types of soil (Table 6.1).

Table 6.1. The thermal conductivities of different soils

Type of soil	Density (kg/m^3)	Thermal conductivity (w/(m·K))
Heavy weight clay (moisture content 15%)	1925	1.4-1.9

Heavy weight clay (moisture content 5%)	1925	1.0-1.4
Light weight clay (moisture content 15%)	1285	0.7-1.0
Light weight clay (moisture content 5%)	1285	0.5-0.9
Heavy weight sand (moisture content 15%)	1925	2.8-3.8
Heavy weight sand (moisture content 5%)	1925	2.1-2.3
Light weight sand (moisture content 15%)	1285	1.0-2.1
Light weight sand (moisture content 5%)	1285	0.9-1.9
Granite	2650	2.3-3.7
limestone	2400-2800	2.4-3.8
Sandstone	2570-2730	2.1-3.5
Wet shale		1.4-2.4
Dry shale		1.0-2.1

Source: ASHRAE standard 55.

6.2.2. The undisturbed temperature of the Earth

The Earth's temperature is affected by various factors, such as solar radiation, surface evaporation, the ambient air temperature, the flow of underground water and the heat from the core of the Earth. However, at a certain depth, the soil temperature remains stable, and the effects of solar radiation, surface evaporation, and the ambient air temperature are negligible. This temperature is called the Earth's undisturbed temperature. The Earth's undisturbed temperature is a critical parameter for EAHEs. Assuming that the thermal conductivity of homogeneous soil is constant and there is no heating source within the soil, Carslaw and Jaeger (2011) proposed the following one-dimensional transient heat transfer equation:

$$\rho_S C_{ps} \partial T(z,t)/\partial t = \frac{\partial}{\partial z}[\lambda_s dT \frac{z,t}{dz}] \quad (6.2.2.1)$$

where ρ is the soil density in unit of kg/m^3, C_{ps} is the soil specific heat in unit of J/kg·K, t is the time (days), z is the depth below the surface (m) and λ is the thermal conductivity of the soil (W/m·K).

When z = 0, the following equation can describe the temperature of the soil based on the ground surface temperature (Krarti et al., 1995) (equation 6.2.2.2):

$$-k\left(\frac{\partial T}{\partial z}\right)_{z=0} = CE - LR + SR - LE \quad (6.2.2.2)$$

where CE (convective energy) is the convection between the surrounding ground environment and the ground surface, SR is solar radiation, LR is long-wave radiation, LE is the latent heat flux of evaporation.

Equation 6.2.2.3 describes the CE:

$$CE = h_{sur}(T_a - T) \quad (6.2.2.3)$$

where T_a is the ground surface temperature (K), T is the soil temperature (K), and h_{sur} is the conductivity coefficient of the soil (W/m·K).

Equation 6.2.2.4 gives the expression of h_{sur} :

$$h_{sur} = 0.5 + 1.2u^{0.5} \quad (6.2.2.4)$$

where u is the ground surface wind velocity (m/s).

Equation 6.2.2.5 shows the formula for the ground surface temperature based on combining equation 6.2.2.3 and equation 6.2.2.4:

$$T_a = T_{ma} + A_m[\exp(iwt + \varphi_a)] \quad (6.2.2.5)$$

where A_m is the amplitude of the ambient air temperature (K).

Equation 6.2.2.6 shows the calculation of SR:

$$SR = b \times S \quad (6.2.2.6)$$

where b is the capacity of absorption and radiation (J/kg·K) and S is the local solar radiation (W).

Equation 6.2.2.7 shows the calculation of LR:

$$LR = \varepsilon_L \times \Delta R \quad (6.2.2.7)$$

where ε_L is the long-wave emissivity and ΔR is an empirical coefficient related to the relative humidity of the soil, surface air relative humidity, and ambient air temperature (Clark and Allen, 1978).

Equation 6.2.2.8 shows the calculation of LE:

$$\mathrm{LE} = \mathrm{F}(u)(P_s^s - P_a) \quad (6.2.2.8)$$

where F(u) represents the ground surface air velocity and $\mathrm{F(u)} = 0.0168h_{sur}$. P_a is the real saturated vapor pressure at the ground surface (Pa). P_s^s is the saturated vapor pressure at the ground surface (Pa), which is expressed as follows:

$$\mathrm{P}_S^S = aT + b \ (263k < T < 303k) \quad (6.2.2.9)$$

where a=103 Pa/k and b=609 Pa.

Equation 6.2.2.10 gives the simplified form of equation 6.2.2.8 (Penman, 1963):

$$\mathrm{LE} = 0.0168f\,\mathrm{h}_{sur}[(aT_{sur} + b) - r_a(aT_a + b)] \quad (6.2.2.10)$$

where $\mathrm{r_a}$ is the relative humidity of air at the ground surface and f is an influential coefficient related to the surrounding ground environment and humidity (for saturated soil, f=1; for wet soil, f=0.6-0.8; and for the dry soil, f=0.4-0.5). Equation 6.2.2.11 shows the calculation of the temperature of the Earth based on the combination of equation 6.2.2.2 and the equation 6.2.2.10.

$$-k\left(\frac{\partial T}{\partial z}\right)_{z=0} = \left(1 + 0.0168f\,a\right)h_{sur}(T_{se} - T_s) \quad (6.2.2.11)$$

When $\mathrm{z} \to \infty, \left\{\frac{\partial T}{\partial z}\right\} = 0$, and combined with equation 6.2.2.11, the soil temperature at a certain depth and time can be expressed by equation 6.2.2.12 (Mihalakakou et al., 1997).

$$\mathrm{T}(z,t) = T_a + A_s \times e^{-z\sqrt{\frac{\pi}{aT}}} \times \cos\left\{\frac{2\pi}{T}t - \sqrt{\frac{\pi}{aT}}z\right\} \quad (6.2.2.12)$$

To simplify the calculation process, T_a is equal to the average soil surface temperature (°C) and A_s is the changing amplitude of soil surface temperature (°C).

Equation 6.2.2.13 describes the thermal diffusivity of the soil:

$$a = \lambda/\rho_s C_{ps} \quad (6.2.2.13)$$

where λ is the soil's thermal conductivity (W/m·K) and $\varrho_s C_{ps}$ is the volumetric specific heat capacity of the soil (KJ/m^{3}K).

6.2.3. The mathematic model of EAHE

The basic heat transfer equations have been used to develop a one-dimensional steady state model of EAHEs. Designers should consider the input parameters according to the conditioning demands of spaces, such as the airflow rate in kg/s($\dot{m}$), supplied air temperature (T_{in}) and intended outlet air temperature (T_{out}). The dimensional parameters of an EAHE include the length of the buried pipe (D), diameter of the pipe (L) and quantity of paralleled pipes (N_p).

The following assumptions simplify the estimation process of the one-dimensional equation for the EAHEs.

- The ground surface temperature is equal to the ambient air temperature, which is also equal to the inlet air temperature.
- The airflow in EAHEs is a Newtonian fluid flow and is incompressible.
- The soil thermal properties are constant, and at a certain depth, the undisturbed soil temperature is the same as the local annual average air temperature.

The thermal resistance of the pipe used can be considered negligible since the thickness of the pipe is small. Therefore, the temperature at the surface of the pipe is uniform and equal to the Earth's undisturbed temperature (Hrelkeld, 1970).

The method employed to calculate the rate of heat transfer of EAHEs is called the ε-number transfer unit (NTU) method (Bisoniya, 2015). ε represents the effectiveness of EAHEs. Heat transfer between air and the pipe surface, the pipe surface and the surrounding soil, and in the opposite directions occurs by conduction. Therefore, according to the heat transfer equations, the total heat exchanged with the buried pipes (heat released and absorbed) is expressed as follows:

$$Q_h = \dot{m}C_{air}(T_{out} - T_{in}) \quad (6.2.3.1)$$

where Q_h is the total heat transferred (kg/s), C_{air} is the specific heat of air (J/kg·K), T_{out} is the outlet air temperature of the pipe (K), and T_{in} represents the air temperature at the inlet of the buried pipes (K).

The heat transfer between the air and the pipe surfaces is in the form of convection; therefore, equation 6.2.3.2 reflects the total heat emitted or absorbed by the air:

$$Q_h = h_{air}A\Delta T \quad (6.2.3.2)$$

where h_{air} represents the heat move coefficient by hot air movement in unit of $W/m^2 \cdot K$, A means the internal surface area of the pipes (m^2), and ΔT is the logarithmic average temperature difference. This temperature difference can be described by equation 6.2.3.3:

$$\Delta T = (T_{in} - T_{out})/\ln[(T_{in} - T_{wall})/(T_{out} - T_{wall})] \quad (6.2.3.3)$$

where T_{wall} is equal to the Earth's undisturbed temperature (T_{EUT}).

By combining equations 6.2.3.1 through 6.2.3.3, the outlet air temperature of the pipes can be obtained exponentially as a function of Earth's unchanged temperature and inlet air temperature by removing Q_h.

$$T_{out} = T_{EUT} + (T_{in} - T_{EUT})e^{[-(hA/\dot{m}C_{air})]} \quad (6.2.3.4)$$

It is assumed that T_{EUT} is equal to the annual average ambient air temperature at locations where EAHEs are installed.

The NTU is a non-dimensional group (equation 6.2.3.5).

$$NTU = hA \div \dot{m}C_{air} \quad (6.2.3.5)$$

Equation 6.2.3.6 describes the effectiveness of the EAHEs (ε).

$$\varepsilon = 1 - e^{(-NTU)} \quad (6.2.3.6)$$

The NTU is a dimensionless group that influences the effectiveness of EAHEs, and ε is a function of the NTU. Figure 6.1 shows the variations in EAHA effectiveness.

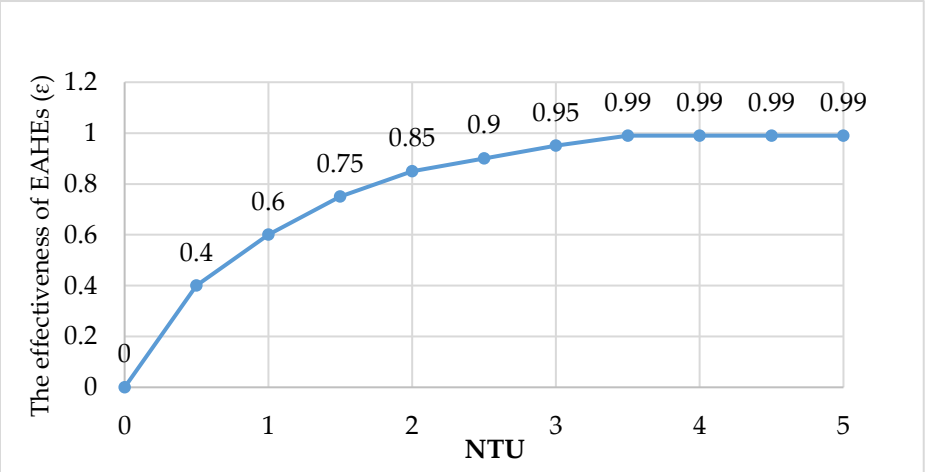


Figure 6.1. *The effectiveness of EAHEs as a function of the NTU*

Source: Bisoniya (2015)

An increase in the NTU has a positive effect on the effectiveness of EAHEs (Figure 6.1). However, the maximum effectiveness of EAHEs infinitely approaches 1. Thus, the air temperature at the outlet of the pipes is equal to the Earth's undisturbed temperature.

The key parameters that influence the NTU value are the coefficient of convective heat transfer (h_{air}), the inner surface area of the buried pipes (A) and the airflow

rate in kg/s (ṁ). The inner surface area of the buried pipes, as described by equation 6.2.3.7, is a function of pipe's diameter D and length.

$$A = \pi DL \quad (6.2.3.7)$$

Equation 6.2.3.8 shows the calculation of the convective heat transfer coefficient inside the pipe:

$$h_{air} = N_U K/D \quad (6.2.3.8)$$

where K means the thermal conductivity of air (W/m·K).

Equation 6.2.3.9 shows the calculation of the NTU based on the combination of equations 6.2.3.5, 6.2.3.7 and 6.2.3.8:

$$NTU = (N_u K\pi L)/(\dot{m}C_{air}) \quad (6.2.3.9)$$

where N_u is the Nusselt number, which is determined by the Reynolds number (R_e), Prandtl number (P_r) and friction factor of the pipes (f) (De Paepe and Janssens, 2003). Equation 6.2.3.10 represents N_u for airflow in pipes with sleek inner surfaces.

$$\text{If } R_e < 2300, \text{ then } N_u = 3.66 \quad (6.2.3.10)$$

$$\text{If } 2300 \leq R_e < 5\times10^6 \text{ and } 0.5 < P_r < 10^6, \text{ then } N_u = [f/8(R_e - 1000)P_r]/\left\{1 + 12.7\left[\left(\frac{f}{8}\right)p_r^{2/3} - 1\right]^{0.5}\right\} \quad (6.2.3.11)$$

Equation 6.2.3.12 represents the friction factor of pipes with smooth internal surface.

$$f = (1.82\log R_e - 1.64)^{-2} \quad (6.2.3.12)$$

The Reynolds number is related to the average air velocity and the diameter of the buried pipes, as described in equation 6.2.3.13:

$$R_e = (\rho v_a D)/u_{air} \quad (6.2.3.13)$$

where v_a is the flow speed of air in the pipes (m/s), D is the diameter of the pipes (m), and U_{air} is air dynamic viscosity in kg/m·s.

Equation 6.2.3.14 represents the calculation of the Prandtl number:

$$P_r = (\mu_{air} \times C_p)/K \quad (6.2.3.14)$$

where C_{air} is the air specific heat in unit of J/kg·K and K is the air thermal conductivity in the unit of W/m·K.

Equation 6.2.3.15 can be used to calculate the pressure drop of an EAHE:

$$\Delta p = fL/D\rho(v_a^2)/2 \quad (6.2.3.15)$$

If $R_e < 2300$, f can be expressed as $f = 64/R_e$ (6.2.3.16)

If $R_e \geq 2300$, f can be expressed as

$$f = (1.82 \log R_e - 1.64)^{-2} \quad (6.2.3.17)$$

where L is the length of the buried pipes, D is the pipe's diameter, and v_a is the airflow speed in the pipes.

Equation 6.2.3.15 indicates that the pressure drop of EAHEs can only be affected by the length of the pipes (L). The air velocity and the diameter of the pipes have indirect effects on the pressure drop. An increase in the diameter of the pipes and decrease in the air velocity will reduce the pressure drop. Conflicts exist among these parameters regarding the maximisation of the effectiveness of EAHEs. Therefore, in practice, designers should simultaneously optimise the pipe length, air velocity, and pipe diameter.

Since the air properties (C_{air}, K, and ρ) are defined in a specific local context, only the diameter of the buried pipes influences the Reynolds number. The length of the pipes (L) is a freelance parameter that influences the NTU once N_u has been

known. Moreover, the NTU linearly varies with the pipe length. Wu (2013) claimed that for a specific diameter of pipes, long pipes with slow airflow speeds have high efficiency. Therefore, in practice, EAHEs usually contain several pipes to achieve a relatively slow airflow speed. IEA Annex 28 (1999) suggested that the pipes in EAHEs should have a distance of at least 1 metre between them. Zeng (2012) found that for soil located 1 metre from the surface of the buried pipes, the temperature changes are usually smaller than 0.06°C after operation for over 48 hours. Thus, when two pipes are separated by 1 metre, the co-effects are negligible.

The relative humidity is another crucial parameter for the design of EAHEs. Conservation equations or psychometric charts can be used to estimate the relative humidity of the air at the outlet of buried pipes based on the characteristics of the ambient air. Typically, condensation will occur in summer when EAHEs cool the air. Thus, engineers need to take measures to remove the condensed water and decrease the relative humidity.

6.3. Natural ventilation

6.3.1. Natural ventilation due to buoyancy effects (stack)

Air temperature differences between indoor air and ambient air usually cause buoyancy-driven ventilation. Air at different temperatures has different air densities. Figure 6.2 shows that warm air is lighter than the cold air. Lighter air is likely to escape from high openings, and colder air will be driven inside through low openings. Therefore, the effectiveness of buoyancy-driven natural ventilation depends on the temperature difference between the inside air and outside air and the height differences between high and low openings.

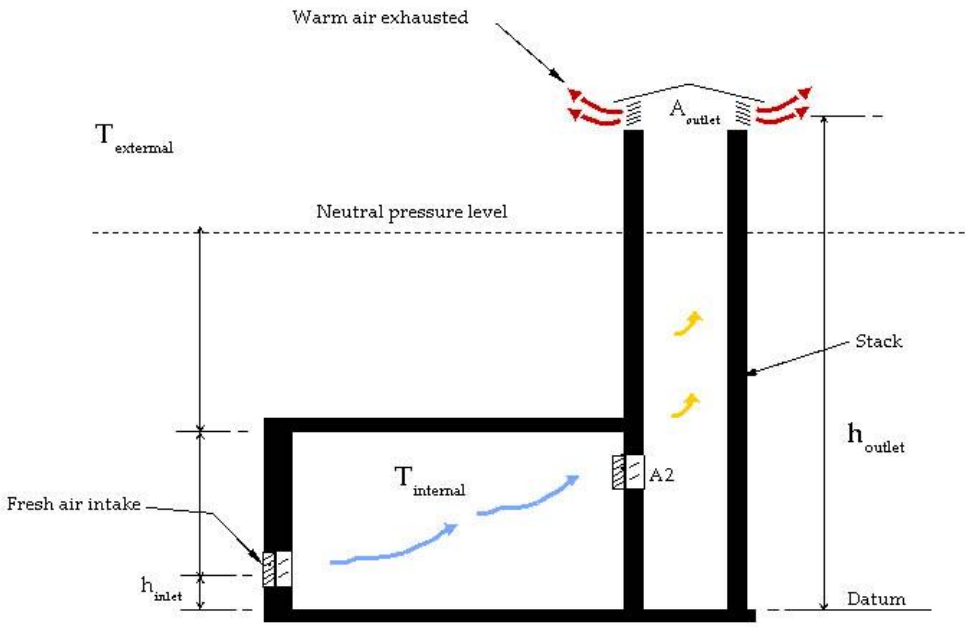


Figure 6.2. *Buoyancy effect of the natural ventilation system.*

(Drawn by the author)

Equation 6.3.1.1 describes buoyancy-driven ventilation (GIBSE Guide A, 2006):

$$\Delta P_s = g \times h_{inlet} (\rho_{ext} - \rho_{int}) \quad (6.3.1.1)$$

where ΔP is the pressure difference (Pa), ρ_{ext} is the ambient air density (kg/m^3), ρ_{int} is the indoor air density (kg/m^3), g is gravitational acceleration (9.81 m/s), and h_{inlet} is the height of the inlet above the datum (m).

Equation 6.3.1.2 provides the difference in the air density.

$$\rho_{ext} - \rho_{int} = \rho_{ext} \times T_{ext} \left(\frac{1}{T_{ext}} - \frac{1}{T_{int}}\right) \quad (6.3.1.2)$$

Additionally, the equation 6.3.1.3 gives the pressure difference.

$$\Delta P_s = \rho_{ext} g h T_{ext} \left(\frac{1}{T_{ext}} - \frac{1}{T_{int}}\right) \quad (6.3.1.3)$$

Equation 6.3.1.4 is used to estimate the pressure differences considering the height difference between the inlet and outlet:

$$\Delta P_s = -\rho_{int}\, g\, T_{int}\, (h_2 - h_1)\, (1/T_{ext} - 1/T_{int}) \quad (6.3.1.4)$$

where the h_2 is the height of the outlet of the stack above the datum (m), h_1 is the height of the inlet of the stack above the datum (m), T_{int} is the internal air temperature (K), and T_{ext} is the external air temperature (K).

The airflow rate through openings is another significant factor to consider in the design of buoyancy-driven ventilation systems. This value is a function of the opening areas and pressure differences, as expressed by equation 6.3.1.5:

$$Q_s = \text{room volume} \times \text{air exchange rate}/3600 \quad (6.3.1.5)$$

where Q_s is the airflow rate through an opening (m^3/s) and the room volume is a product of the room width, length and the height (m^3). Building design criteria usually provide the requirements for air exchange rates.

However, when considering Q_s as a function of opening areas and pressure differences, Q_s takes the form of equation 6.3.1.6:

$$Q_s = C_d\, A_{eff} \left(\frac{2\Delta P}{\rho}\right)^{0.5} \quad (6.3.1.6)$$

where C_d is the discharge coefficient (experimental: 0.61), ΔP is the pressure difference across the opening area (Pa), A_{eff} is the effective opening area of a structure (m^2), and ρ is the density of air. Equation 6.3.1.7 describes the airflow rate by combining equations 6.3.1.5 and 6.3.1.6:

$$Q_s = C_d\, A_{eff}\, [(2/\rho_{int})\, \rho_{int}\, g\, (h_{npl} - h)\, (T_{int} - T_{out})/T_{int})] \quad (6.3.1.7)$$

where ρ_{int} is air density inside the stack in unit of kg/m^3, g is the gravitational acceleration of 9.81 m/s, h is the height of the opening above the datum (m), T_{int} is the internal air temperature (K), T_{ext} is the external air temperature (K), A_{eff} is the effective opening area of the structure (m^2), h_{npl} is the height of the neutral pressure level above the datum (m), and C_d is the discharge coefficient (experimental: 0.61). A neutral pressure level (NPL) indicates that the outside pressure equals the internal air pressure. Moreover, to ensure the effectiveness of stack ventilation, the NPL is usually established above the roof of buildings. The transformation of equation (6.3.1.7) represents the calculation of the opening size of the air inlet.

$$A_{eff} = Q_s / \{C_d\, [\left(\frac{2}{\rho_{int}}\right) \rho_{int}\, g\, (h_{npl} - h)\, ((T_{int} - T_{out})/T_{ins})]\} \quad (6.3.1.8)$$

In stack ventilation, openings for airflow inside buildings are usually connected in series (indicated in Figure 6.2), and air flows through A_1 to A_2, and then to the NPL. Equation 6.3.1.9 describes the relationship between the effective opening and a single inlet opening.

$$1/(A_{eff}^2) = 1/(A_1^2) + 1/(A_2^2) + \cdots 1/(A_n^2) \quad (6.3.1.9)$$

$$\text{Assumed } A_1 = A_2 = \cdots A_n \quad (6.3.1.10)$$

Equation 6.3.1.10 can be used to calculate the sizes of A_1, A_2, and A_n.

The size of the outlet areas is a function of the total airflow rate and the height difference between the NPL and the stack outlet, as shown in equation 6.3.1.11:

$$A_{outlet} = Q_{total}/C_d\ [(2/\rho_{int})\ \rho_{int}\ g\ h\ (h - h_{npl})\ ((T_{int} - T_{out})/T_{ins})] \quad (6.3.1.11)$$

where Q_{total} is the total airflow rate through the stack (m^3/s) and h is the height of the stack outlet above the datum.

Multiple methods can be used to identify the indoor air temperature, such as using heat transfer equations or software simulations. Parameters such as the U-values of building fabrics, solar heat gains, internal heat gains, infiltration rate, and ventilation rate should be input in both equation-based calculations and software simulations. Currently, software simulations are more popular for predicating the hourly room air temperature under specific outside weather conditions. For the outdoor air temperature, designers usually statistically obtain the value from weather data.

6.3.2. Natural ventilation due to wind effects

Wind is created due to the pressure differences in the atmosphere. It always causes a positive pressure on the windward side and a negative pressure on the leeward side of buildings (Figure 6.3). To maintain a balance between the indoor air pressure and outdoor air pressure, ambient air usually flows inside through windward openings and leaves the building through leeward openings. Several parameters, such as the building dimensions, wind direction, wind speed and even the landscape around buildings, affect the pressure differences caused by wind.

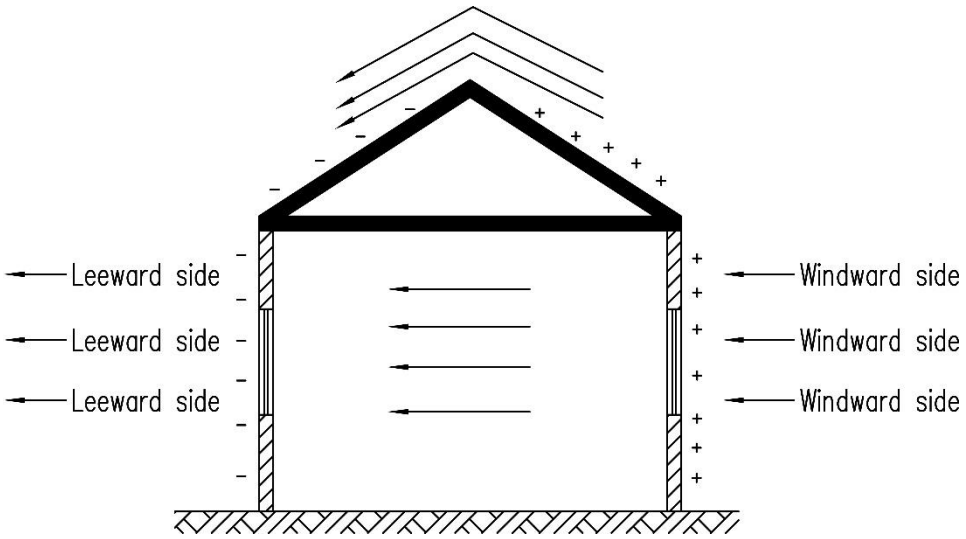


Figure 6.3. *Natural ventilation due to wind effects (CIBSE AM 10)*

Equation 6.3.2.1 gives the expression of the wind pressure at the height of a point on a building surface:

$$P_w = 1/2\rho v^2 C_p \quad (6.3.2.1)$$

where v is the wind speed at the height of the opening or a reference point on the building (m/s), C_p is the pressure coefficient and ρ is the air density (kg/m^3).

Equation 6.3.2.2 gives the expression of the pressure difference caused by wind.

$$P_w = P_w^{inlet} - P_w^{outlet} \quad (6.3.2.2)$$

Equation 6.3.2.2 can also be expressed in the form of equation 6.3.2.3:

$$\Delta P_w = [P_{ref} + \frac{\rho C_p^{inlet} v_r^2}{2}] - [P_{ref} + \frac{C_p^{outlet}}{2}) = (\rho v_r^2)/2 (C_p^{inlet} - C_p^{outlet}) \quad (6.3.2.3)$$

where ΔP_w is the pressure difference which is caused by wind (Pa), P_{ref} is the standard atmosphere pressure (Pa), ρ is air density under the standard atmosphere pressure (Kg/m^3), v is the wind speed (m/s), C_P^{inlet} is pressure coefficient at inlet, and C_P^{outlet} is the pressure coefficient at outlet. The value of C_p is affected by several factors, such as the wind direction, building shape, and orientation, surrounding buildings, vegetation and terrain features.

Equation 6.3.2.4 provides an expression of airflow rate caused by wind effects:

$$Q_w = A_{eff}\, C_d\, (2\Delta P_w/\rho)^{0.5} \quad (6.3.2.4)$$

where Q_w is the air flow rate due to wind effects (m^3/s), A_{eff} is the effective opening area (m^2), C_d is the discharge coefficient (experimental: 0.61), ΔP_w is the pressure difference, and ρ is the air density (kg/m^3).

Equation 6.3.2.5 describes the airflow rate generated by wind effects.

$$Q_w = A_{eff}\, C_d\, [\rho v_r\, (C_p^{inlet} - C_p^{outlet})]^{0.5} \quad (6.3.2.5)$$

Equation 6.3.2.5 can be transformed into an expression of the effective opening area, as shown in equation 6.3.2.6 (assuming $A_1=A_2=A_n$)

$$A_{eff} = Q_w \,/\, \{C_d\, [\rho v_r\, (C_p^{inlet} - C_p^{outlet})]^{0.5}\} \quad (6.3.2.6)$$

Single openings, A_1, A_2 and A_n can be calculated in the same way as equation 6.3.1.9 and 6.3.1.10.

6.3.3. Natural ventilation due to the effects of the combination of buoyancy and wind

There are two types of natural ventilation driven by the combination of wind and buoyancy. In the first type, The NPL is in the middle of openings (Figure 6.4), and in the second type, the NPL is above the openings (Figure 6.5)

- NPL is in the middle of openings

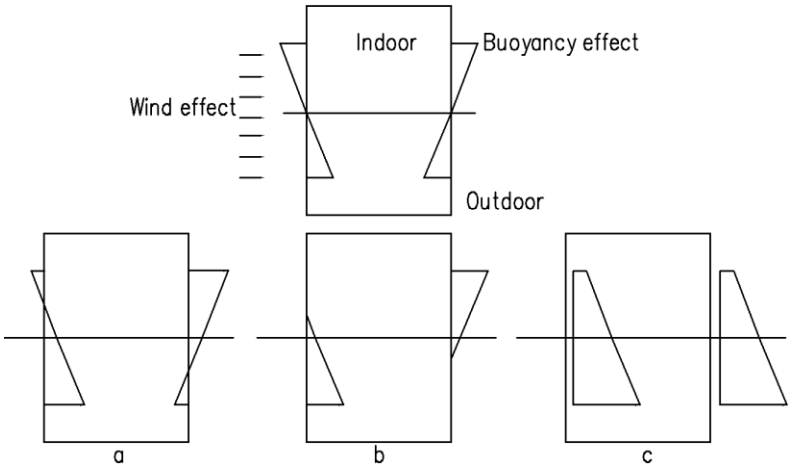


Figure 6.4. *Natural ventilation is driven by the combination of wind and buoyancy (Wang 2003).*

Assuming the inside air temperature is higher than the outdoor air temperature ($T_{int} > T_{ext}$), the NPL creates three scenarios

1) $\Delta P_{heat} > \Delta P_{wind}$ (Figure 6.4, a), and buoyancy is the main driving force to naturally ventilate the building; thus, $Q \backsimeq Q_{heat}$.
2) $\Delta P_{heat} \backsimeq \Delta P_{wind}$, (Figure 6.4, b), and buoyancy and wind have similar effects on the natural ventilation; thus, $Q \backsimeq Q_{heat} \backsimeq Q_{wind}$.
3) $\Delta P_{heat} < \Delta P_{wind}$, (Figure 6.4, c), and wind is the main driving forces to naturally ventilate the building; thus, $Q \backsimeq Q_{wind}$.

Therefore, the air flow rate depends on the largest driving force when the NPL is in the middle of openings.

- The NPL is located away from openings (stack)

In natural ventilation driven by buoyancy (Figure 6.5), the NPL is typically between the inlet openings and outlet openings. In this case, the total pressure difference should be the linear superposition of the buoyancy pressure differences and wind pressure differences (Equation 6.3.3.1):

$$P_{total} = | P_{heat} \pm P_{wind} | \quad (6.3.3.1)$$

As a result, the total air flow rate is as follows:

$$Q_{total} = | \ Q_{heat} \pm Q_{wind} \ | \quad (6.3.3.2)$$

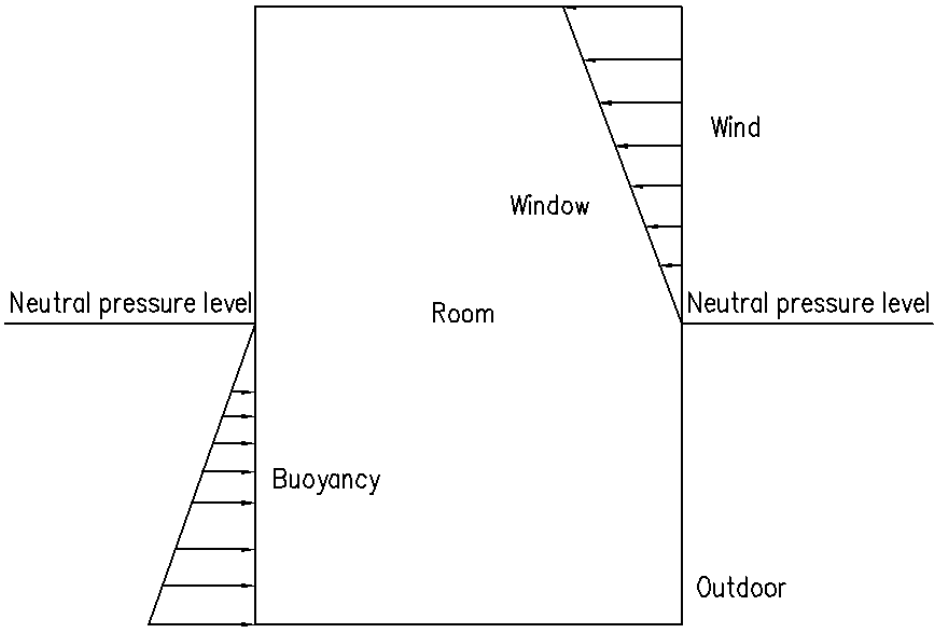


Figure 6.5. *The NPL is located away from openings (stack) (Wang 2003).*

6.4. Solar chimney

A solar chimney can improve natural ventilation by capturing the sun's energy. A chimney heats a column of air, and the air then rises, pulling fresh air inside the building. The effectiveness of solar chimney is mainly related to its dimensions, such as the width of the channel, the size of the outlet areas, and the local weather conditions.

6.4.1. The average air temperature and volumetric airflow rate inside a solar chimney

According to the energy balance equations, the air temperature and volumetric airflow rate in a chimney are functions of the solar heat gain and ambient air temperature (Figure 6.6). Equation 6.4.1.1 gives the energy absorbed per unit area of the heat-collecting plate (Duan, 2009):

$$(\alpha \cdot \tau) \cdot \bar{S}(t) = h_f\left(T_p - \bar{T}_f\right) + U_L(T_p - T_O) \quad (6.4.1.1)$$

where α is the efficiency of the solar heat-collecting plate, τ is the transmission coefficient of glass, $\bar{S}(t)$ is the average solar radiation (W/m^2), h_f is the U-value of the glass (W/m^2·K), T_p is the temperature of the solar plate (°C), $\bar{T}_f$ is the temperature of the stack fluid (°C), U_L is the coefficient of heat loss in the unit of W/m^{2}K, and T_O means the average ambient air temperature (°C).

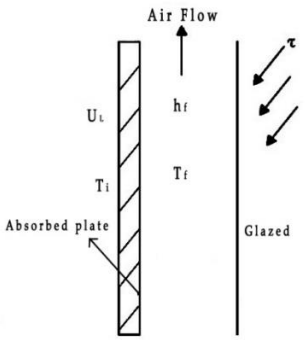


Figure 6.6. *The vertical solar chimney heat transfer process*
Source: Duan (2009)

Equation 6.4.1.2 gives the energy conservation equation for a fluid:

$$GC_p(dT_f)/dx\,\Delta x = h_f w\,\Delta x\,(T_p - T_f) \quad (6.4.1.2)$$

where G is the airflow rate (kg/s), c_p is the air specific heat under a constant pressure, Δx is an infinitesimal unit (m), and w is the width of the heat collector. When solving equation 6.4.1.2, the initial condition is x=0, and the average air temperature in the stack is equal to the indoor air temperature. Now, equation 6.4.1.3 gives a new form of the energy conservation equation for a fluid.

$$T_f\,(x) = T_p - (T_p - T_i)\exp(-Zx) \quad (6.4.1.3)$$

Equation 6.4.1.4 gives an expression for Z.

$$Z = (h_f \times w)/(G \times C_p) \quad (6.4.1.4)$$

The average air temperature in the stack ($\bar{T}_f$) is as follows.

$$\bar{T}_f = \frac{\int_o^l dx}{\int_o^l dx} = \frac{1}{l}\int_o^l T_f \cdot dx \quad (6.4.1.5)$$

Equation 6.4.1.6 gives a further transformation of $\bar{T}_f$ by combining equations 6.4.1.3, 6.4.1.4 and 6.4.1.5:

$$T_f = T_p - [(T_p - T_i)/(Z \times l)]\,[1 - \exp(-Z \times l)] \quad (6.4.1.6)$$

where l represents the length of the solar chimney (m). Equation 6.4.1.7 gives the temperature of the solar plate (T_p) based on the combination of equations 6.4.1.6 and 6.4.1.1.

$$T_p = ((\alpha \cdot \tau) \cdot \bar{S}(t) + U_l\,T_o + U_I\,T_i)/(U_L + U_i) \quad (6.4.1.7)$$

In this equation, U_I is defined as follows.

$$U_I = \frac{h_f}{Zl}\,[1 - \exp(Z \cdot l)] \quad (6.4.1.8)$$

For the boundary conditions x= l and T_f=T_{fo}, the temperature difference between the outlet air temperature (T_p) and room air temperature (T_i) can be expressed by equation 6.4.1.9:

$$T_{asfo} - T_i = T_p\,[1 - \exp(-Z \times l)] - T_i\,[1 - \exp(-Z \times l)] = (T_p - T_i)\,[1 - \exp(-Z \times l)] \quad (6.4.1.9)$$

Equation 6.4.1.10 provides an expression of the volumtric airflow rate by combining equations 6.4.1.1 to 6.4.1.9:

$$\mathrm{L} = \mathrm{C}_d A_o \sqrt{\frac{2gH \sin\beta[1-\exp(-Z\cdot l)][(\alpha\tau)\bar{S}(t)+U_L T_o+U_I T_i-T_i]/(U_L+U_I)}{T_i(1+A_r^2)}} \quad (6.4.1.10)$$

where A_o represents the solar heat-absorbing area (m^2), C_d is the discharge coefficient, and H is the height of the solar chimney (m).

6.4.2. Solar radiation calculation

- **Direct solar radiation**

In direct solar radiation, the solar rays hit the collector plate at the angle of 90°. Assuming the angle of inclination of the plate is θ, the direct solar radiation on the plate ($\mathrm{I}_{D\theta}$) can be obtained by equation 6.4.2.1:

$$\mathrm{I}_{D\theta} = \mathrm{I}_{DN} \cos \mathrm{i} = \mathrm{I}_O \, \mathrm{P}^m \cos \mathrm{i} \quad (6.4.2.1)$$

where I_{DN} is the direct solar radiation on the plate of the collector (W/m^2), i is the incidence angle, I_O is a constant value of solar radiation (W/m^2) ($1367 W/m^2$ from the World Meteorological Organisation (WMO)), P is the coefficient of atmospheric transmittance, and m is the mass of the atmosphere.

- **Diffuse solar radiation**

Solar heat collectors usually absorb two types of diffuse solar radiation: atmospherically scattered radiation and ground-reflected radiation. Ground-reflected radiation is relatively small, compared with atmospherically scattered radiation, and it is generally affected by the surrounding environment, such as the landscape and adjacent buildings. Thus, the calculation of diffuse solar radiation only considered atmospherically scattered radiation and is expressed in the form of equation 6.4.2.2:

$$\mathrm{I}_{dH} = 1/2\mathrm{I}_o \sin \mathrm{h} \, (1 - \mathrm{P}^m)/ \, (1 - 1.4 \ln \mathrm{p}) \quad (6.4.2.2)$$

where I_{dH} represents the atmospherically scattered radiation directly absorbed by

the plate of the solar heat collector (W/m^2). For a plate with an inclination angle of θ, the atmospherically scattered radiation, $I_{d\theta}$ is in the form of equation 6.4.2.3.

$$I_{d\theta} = I_{dH} \cos^2(\theta/2) \quad (6.4.2.3)$$

- **Total solar radiation calculation**

For any plate on a solar heat collector, equation 6.4.2.5 represents the total solar radiation.

$$I_{S\theta} = I_{D\theta} + I_{d\theta} \quad (6.4.2.4)$$

The total solar heat gain for a solar chimney includes two parts. One part is directly from the solar rays that penetrate the solar chimney. The other part is radiation reflected from glass. Normally, glass can absorb solar heat and re-reflect radiation to the ambient environment. Therefore, the re-reflected radiation becomes another part of the solar heat gain. Figure 6.7 explains the composite of the total solar heat gain for a solar chimney.

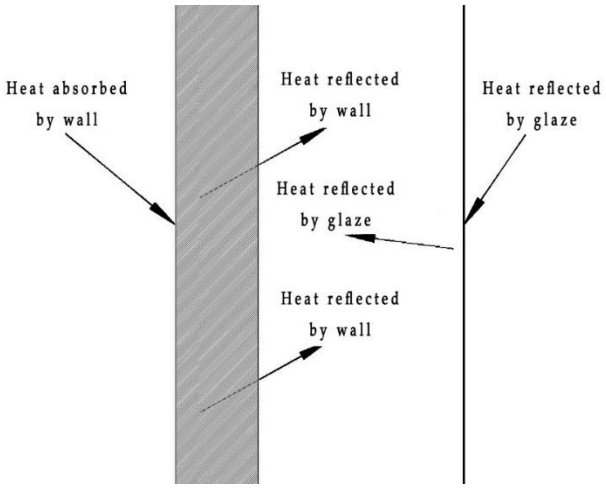


Figure 6.7. *The total solar heat gain for a solar chimney*

Source: Jing (2005)

Equation 6.4.2.5 gives the expression of the total solar heat gain of a solar chimney:

$$HG_g = HG_\tau + HG_\alpha \quad (6.4.2.5)$$

where HG_τ is the solar heat gain from direct penetration (W/m^2) and HG_α is the solar heat gains absorbed via glass absorption. Equation 6.4.2.6 gives the expression of HG_τ (W/m^2):

$$HG_\tau = I_{Di} \cdot \tau_{Di} + I_d \cdot \tau_d \quad (6.4.2.6)$$

where I_{Di} is the direct solar radiation on the glass with an incidence angle of I, I_d is the diffuse solar radiation for the glass, τ_{Di} is the transmittance coefficient of the direct solar radiation with an incidence angle of i, and τ_d is the transmittance coefficient of the diffuse solar radiation.

Equation 6.4.2.7 gives the expression of HG_α:

$$HG_a = \frac{R_a}{R_a+R_r}(I_{Di} \cdot a_{Di} + I_d \cdot a_d) \quad (6.4.2.7)$$

where a_{Di} is the radiation absorptivity of the glass for direct solar radiation, a_d is the radiation absorptivity of the glass for diffuse solar radiation, R_a is the heat transfer resistance of the glass's external surface (K/W), and R_r represents the heat transfer resistance of the inner surface of the glass (K/W).

6.4.3. The dimensions of a solar chimney

The height and width (gap between the glass and heat-absorbing wall) are the two key factors that significantly influence the effectiveness of a solar chimney (Figure 6.8). Spencer et al. (2000) suggested that the airflow rate in a chimney increases with the width and height. However, when the ratio of the width to height is greater than 0.5, the airflow rate becomes stable, and the reverse airflow occurs at the outlet of the chimney. Duan (2009) found that increasing the size of the inlet can mitigate this reverse airflow and that the optimum ratio for a roof-mounted vertical solar chimney was 0.5. Jing (2005) investigated a vertical solar chimney, and the results showed that the optimum ratio of the width to height was 0.5. Wang and Li (2004) concluded that the mass airflow rate inside a chimney increases with the width of the solar chimney and that the optimum width to

height ratio for a roof-mounted vertical solar chimney was much larger than that for a Trombe wall (0.5 to 0.1). Wang (2003) investigated the optimum ratio of width to height for a roof-mounted vertical solar chimney and a Trombe wall with results indicating that the best ratios for the Trombe wall solar chimney and the roof-mounted vertical solar chimney were 0.15 and 0.5, respectively.

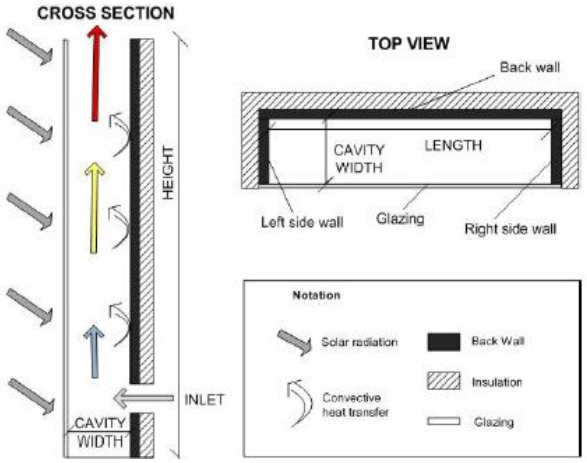


Figure 6.8. *The dimensions and properties of solar chimney*

Source: Spencer et al. (2000)

Yan (2008) investigated the performance of a roof-mounted vertical solar chimney in a four-storey primary school teaching building in the cold climate zone of China. The study found that the lowest effective height for a roof-mounted vertical solar chimney shared by four classrooms was 5 metres. Gontikaki et al. (2010) claimed that for a five-storey building, extending the solar chimney by at least one storey could improve the airflow rate at the top floor of the building. Ding et al. (2005) recommended extending the solar chimney by at least two storeies to ensure a sufficient airflow rate at the top floor of a prototype eight-storey office building.

6.4.4. The back wall of a solar chimney

The temperature fluctuations in the adjacent spaces increase as the solar heat gains in the solar chimney increase (Kumar et al., 1994). Afonso and Oliveira (2000) found that airflow rates inside solar chimneys decreased by 60% due to heat

transfer from the solar chimney to adjacent spaces. Gan (1998) reported that 40% of solar heat gains in a solar chimney was transferred to adjacent spaces via non-insulated back walls. Therefore, it is imperative to add insulation to the back walls and prevent extensive heat losses from the solar chimney.

Lee and Strand (2009) found that airflow rates inside a chimney can be increased by 42-57% when the absorptivity increases from 0.25 to 1 for the back wall. Harris and Helwig (2007) suggested that airflow rates can be increased by 10% by using back walls covered with low-e coatings. Wang (2003) advised that the inner surfaces of back walls should be black since the absorptivity of can reach 0.95.

6.4.5. The glaze type of solar chimney

Gan and Riffat (1998) and Harris and Helwig (2007) recommended that double glazing and triple glazing should be used to maximise the ventilation rate in winter. Gan (1998) also claimed that double glazing in a Trombe wall system can increase the induced airflow rate by 17%, compared to a Trombe wall with single glazing. The main reason for employing double or triple glazing is because these glazes can decrease the conductive heat loss and increase the heat gains from solar radiation simultaneously.

6.4.6. The inlet size of the solar chimney

The inlet of the solar chimney is the inlet at which air flows into the channels of the solar chimney from a room space. Studies have found that the inlet size of a solar chimney has a small influence on the effectiveness of the solar chimney compared to the width to height ratio (Wang and Li, 2004; Yan, 2008). Jing (2005) concluded that the inlet size of a solar chimney should be designed based on the entire ventilation system rather than solely on the solar chimney itself. Duan (2009) noted that the ideal inlet size for a solar chimney should be equal to the inlet size

of the room when a roof-mounted vertical solar chimney has an optimum width to height ratio.

6.4.7. The effects of wind and solar radiation

The intensity of solar radiation is one of the most determining factors in the performance of a solar chimney (Wang, 2003; Yan, 2008; Gan, 1998). Chen et al. (2003) found that a threefold increase in solar radiation can lead to a 38% improvement in the airflow rate in a solar chimney. Mathur et al. (2006b) reported that the performance of a solar chimney has a positive linear relationship with the intensity of solar radiation.

Wind is another important climatic parameter since it can have positive or negative effects on the performance of a solar chimney. Mathur et al. (2006b) found that the wind effects contributed to 23% of modelling errors (the difference between model predictions and experimental measurements). Therefore, in practice, designers should take measures to eliminate or reduce wind effects.

6.5. Sunspace with plants

6.5.1. The factors that influence plant adsorption of PMs

Plants are efficient in adsorbing PMs (Beckett et al., 2000; Zhang et al., 2014). The adsorption capacities of plants are mainly affected by their leaf function and leaf structure, such as the leaf surface texture, hair density, oil content, moisture level and surface area. Many studies have shown that plants adsorb PMs in three ways (Chai et al., 2002; Prusty et al., 2005; Tiwary et al., 2009). The first way is retention. Plants reduce the airflow velocity and PMs settle on the surfaces of leaves. The quantity that settles on the surfaces of leaves is based on the airflow velocity and PM concentration in the ambient air. However, PMs adsorbed by retention can return to the air easily if the airflow speed increases and deteriorate the stable surrounding environment (Prusty et al., 2005). Therefore, retention is a passive and unsteady way of adsorbing PMs and is easily affected by the surrounding conditions.

The second way is attachment based on the rough leaf epidermis and cuticle characteristics. PMs are fixed to the leaf surfaces by attachment, which is relatively stable, and it is difficult for the wind to blow away the PM. Chai et al. (2002) found that leaves with groove structures and dense cilia have better abilities to capture PMs than leaves with smooth surfaces or tumour structures. Sæbø et al. (2012) found that leaf properties, such as the hair density and wax cover, have positive effects on capturing PMs. Beckett et al. (2000) indicated that needle-leaved plants with more complicated leaf structures, and broad-leaved plants with high densities of cilia have high efficiency in adsorbing PMs.

The third way for plants to adsorb PMs is adhesion by the leaf exudates. Adhesion is the most stable way of capturing PMs and fixing them to the surfaces of leaves. Guo et al. (2007) stated that plants such as *Pinus tabuliformis*, are efficient in

capturing PMs since they regularly emit exudates. Freer-Smith et al. (2005) claimed that plants that can capture PMs with exudates play a vital role in shaping the urban natural environment. Wang and Li (2006) reported that the adsorption capacity of plants with leaf exudates is two times that of plants that do not emit exudates.

The leaf structure and surface characteristics determine the abilities of plants to adsorb PMs. However, there is a limiting boundary regarding the quantification of the PMs adsorbed by plants (Gao et al., 2007). Wang and Li (2006) stated that on clear and breeze days (wind velocity between 3.4-5.4 m/s), the adsorption capacity of *Euonymus japonicas* reached a maximum after 15 days. Qiu et al. (2008) found that typically, the PMs captured by plants cannot increase after 20 days in a natural state. Liu et al. (2013) obtained a similar conclusion after 24 days. Pope et al. (1999) indicated that the adsorption capacities of plants are different based on the species of plant and the surrounding environmental conditions.

6.5.2. PMs adsorbed by plants

Plants mainly adsorb inhalable coarse PMs (PMs with a diameter between 2.5 and 10 micrometres), fine PMs (PMs with a diameter of 2.5 micrometres or less), and ultrafine PMs (PMs with a diameter of 0.1 micrometres or less). Tomaševic et al. (2005) examined the size and size distribution of PMs adsorbed by horse chestnut (*Aesc ulus hippocentaur L.)* and Turkish hazel (*Corulys colurna L.*) using an electron microscope and found that the majority of PMs fixed to the leaves was fine PMs. Lubick (2018) revealed that houses with silver birch trees around them exhibited 50% reductions in the indoor PM concentrations compared to other houses. Moreover, a scan of silver birch leaves indicated that the hairy surfaces of the leaves trapped PMs. Wang et al. (2006) concluded that PM_{10} and $PM_{2.5}$ contributed to 98.4% and 64.2% of the PM composition that settled on leaf surfaces in Beijing. Zhao et al. (2008) found that *Euonymus japonicus* in Shijiazhuang, China, adsorbed

0.3843 g/m^2 per day of PMs on average. Of these PMs, 98.57% had a diameter less than 10 micrometres, and 66.7% had a diameter less 2.5 micrometres. Li et al. (2009) stated that the average quantity of PMs fixed on the leaves of *Euonymus japonicus* was 0.356 g/ m^2 per day and the average diameter of the fixed particulates was 1.91 micrometres. Wang and Li (2006) claimed that the majority of PMs adsorbed by *Euonymus japonicus* was $PM_{2.5}$ and PM_{10}, and found that the average and highest quantities of fixed PMs were 0.8614 g/m^2·d and 11.6197 g/m^2·d, respectively. Jia et al. (2012) analysed the adsorption capacities of 7 different plants and mainly found that plants are more efficient in adsorbing PMs with a diameter between 0 and 10 micrometres. Dai et al. (2013) claimed that PMs from 0-20 micrometres in diameter is more likely to be adsorbed by *Sophora Japonica.* Zhou et al. (2009) investigated the adsorption capacities of 7 potted plants in an indoor environment. The study found that *Philodendron cv. Xanadu* had the highest adsorption capacity, and 0.5047 g of PMs per unit surface area of leaves was fixed each day on average. *Sansevieria Trifasciata* exhibited the lowest adsorption capacity at 0.0083 g/m^2·d, and species such as *Epipremnum aureum, Pachira macrocarpa, Chlorophytum comosum, and Ficus microcarpa* displayed adsorption capacities ranging from 0.1472 g/m^2·d to 0.2069 g/m^2·d.

6.6. Summary

Chapter 6 reviewed the mathematical principles behind each passive technique and analysed the factors that influence the design parameters of these techniques. The following list provides the critical points for the design of ILEV system.

EAHE system,

- The NTU method can be used to estimate the effectiveness of the EAHEs and determine the length and width of the pipes to reach an expected air temperature.
- Pipes in the EAHEs should be separately placed, and the distance between pipes should be at least 1 meter.
- Soil located 1 metre from the buried pipes usually displays a temperature change smaller than 0.06°C, even when EAHEs run for over 48 hours. Thus, when two pipes are located at a distance of at least 1 metre, the co-effects are negligible.

Natural ventilation system

- The critical factor that affects the air exchange rate is the pressure difference between the indoor air and outdoor air. The bigger the pressure difference is, the higher the air exchange rate. Pressure differences are caused by temperature differences in buoyancy-driven ventilation.

Solar chimney,

- The height and width are the two critical factors that significantly influence the effectiveness of a solar chimney. Past studies found that 0.5 is an optimum ratio of the width to height for a vertical roof-mounted solar chimney (Duan, 2009; Wang, 2003; Spencer et al., 2000 and Jing, 2005).
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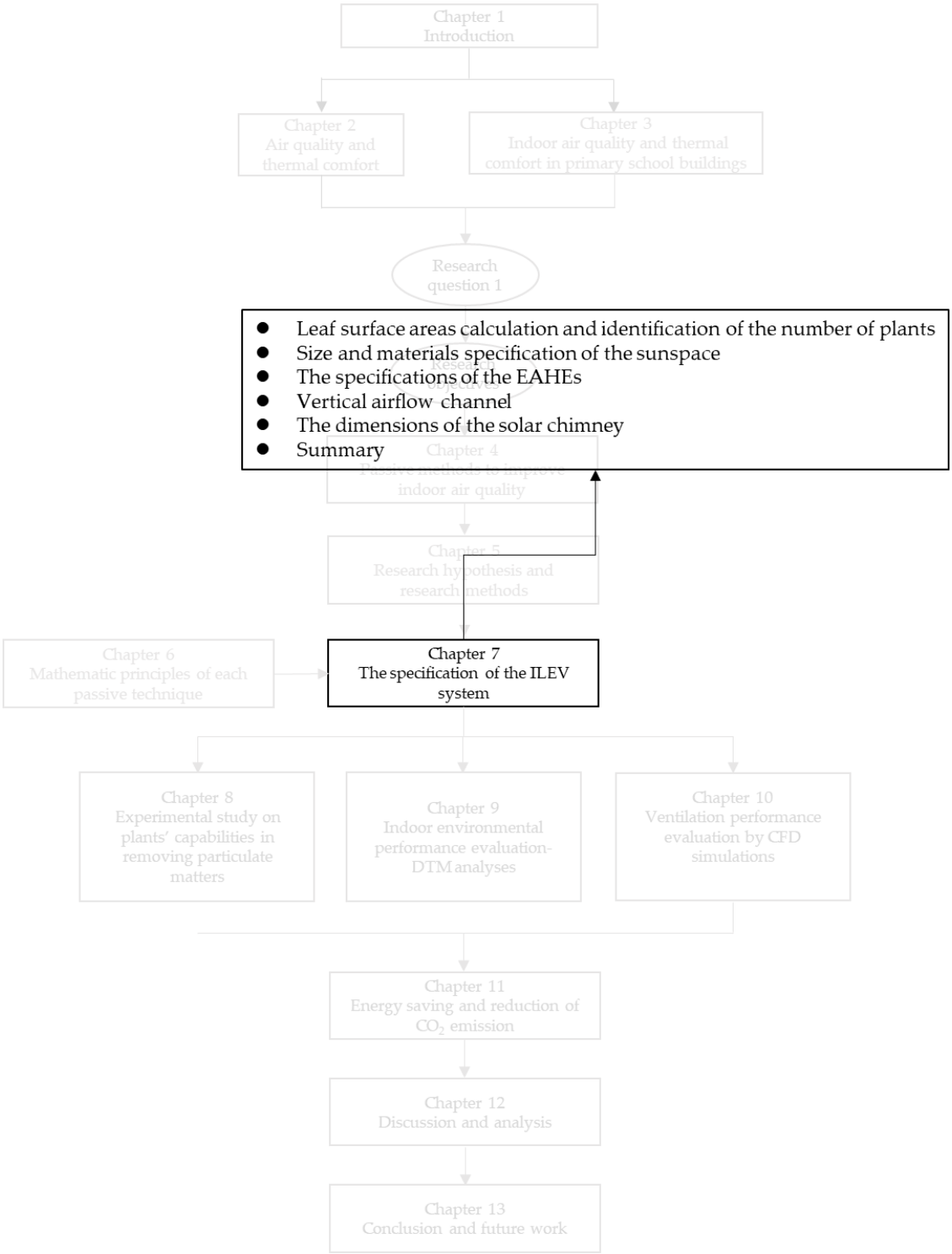
- Insulations should be added to the back walls of a solar chimney to decrease the heat loss and retain more solar heat within the chimney.
- Double glazing or triple glazing is better for a solar chimney to decrease the conductive heat loss and increase the solar heat gain simultaneously.
- The inlet of a solar chimney has a small influence on the effectiveness of the solar chimney. Published studies found that the ideal inlet size is equal to the size of the inlet of the room when a roof-mounted solar chimney has an optimum width to height ratio.

Plants,

- The leaf function and leaf structure are the two main factors that influence the plant adsorption of PMs.
- The adsorption capacities of plants differ based on the species of plant and the surrounding environmental conditions.

The points above can be used to create a mathematical foundation for the IELV system. Chapter 7 will build the mathematical model of the ILEV system based on the outputs of Chapter 6.

Chapter 7: COUPLED MODEL SPECIFICATION FOR THE ILEV SYSTEM



The content of Chapter 7

7.1. Introduction

Chapter 6 reviewed the mathematical principles of each passive technique that employed by the ILEV system. This chapter will further establish a coupled model of the ILEV system. The following list summarises the crucial issues addressed in this chapter:

- Identify the number of plants and the size of the sunspace for the ILEV system;
- Identify the undisturbed soil temperature at the location of the case study building;
- Identify the number of pipes needed and the geometric sizes (length and diameter) of the pipes in the EAHEs;
- Determine the dimensions of the vertical airflow channel that connects the sunspace and classrooms;
- Calculate the dimensions of the solar chimney; and
- Redesign the floor plans of the studied classrooms.

The issues identified in this chapter are used to establish a complete model of the ILEV system that will be applied in a case study of a school building redesigned based on the Chinese regulations. Moreover, the experimental method and software simulations will be applied to further explore the IAQ and the thermal performance of the redesigned building, as presented in Chapters 8, 9 and 10.

7.2. Leaf surface area calculation and the identification of the number of plants

Zhou et al. (2009) stated that the adsorption capacity of *Epipremnum aureum* is 0.2069 g per day per square metre of leaf surface areas, and *Epipremnum aureum* is common in flower market in North China. Moreover, the number of leaves of *Epipremnum aureum* can easily be counted, and the total surface areas of leaves can be determined without professional botany equipment. Therefore, this study selected *Epipremnum aureum* to remove PMs in the sunspace.

Table 7.1 summarises the average PM concentrations in Tai'an city, where the case study school building is located. The data from the past three years were used to create boundary conditions for the number of plants and to determine the dimensions of the sunspace. The Environmental Protection Department of the Shandong Provincial Government built the Urban Ambient Air Quality Platform to provide these data to the public. Currently, data from 2015 to 2017 are available.

Table 7.1. The average PM concentrations in Tai'an city (μg/m³)

Months	2015		2016		2017	
	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}
Jan	102	168	114	179	105	156
Feb	80	139	84	137	82	122
Mar	70	143	68	141	62	104
Apr	58	117	65	151	49	103
May	51	105	41	105	48	103
Jun	51	104	39	88	43	86
Jul	45	89	40	77	35	79
Aug	43	90	33	61	29	55
Sept	49	99	59	94	37	75
Oct	28	149	54	82	54	89
Nov	71	113	84	119	62	96
Dec	113	202	105	151	90	130
Daily Average	63	127	66	115	58	100
Daily Highest on average	278	302	249	298	198	272
Daily lowest on average	22	58	28	50	25	44

Source: Urban ambient air quality platform of Environment Protection Department of Shandong Provincial Government, http://58.56.98.78:8801/AirDeploy.Web/AirQuality/MapMain.aspx

In China, the summer holiday of primary schools is usually from July 1st to August 31st, and the winter holiday usually spans from January 15th to the middle of February. During these holidays, the school classrooms are unoccupied. However, students are usually required to return to campus for a one-day test during the middle of each holiday. Therefore, the established coupled model should consider the ILEV system's ventilation performance throughout the calendar year.

Table 7.1 shows that the highest average daily concentration of PM_{10} was 302 ug/m^3 over the past three years. Thus, 302 ug/m^3 can be used as a guideline value to determine the number of plants needed. Zhou et al. (2009) conducted the study in a clean and breezed indoor environment (air movement speed was between 3.4 m/s and 5.4 m/s), and the adsorption process was relatively stable. Therefore, assuming the leaves captured PMs at a constant speed (0.2069 g/m^2·d), the total PMs fixed in eight school hours per surface area of the leaves was 68966 ug (0.2069 $\times 1000000 \div 24 \times 8$ = 68,966 ug).

The following calculations indicate the amount of air required in the four classrooms.

Fresh air requirement (10 l/s/person) × number of occupants (45 students and 1 teacher) × number of classrooms (4) × 3600 × school hours (8) = 52,992 m^3.

The total amount of PM_{10} can be estimated as follows.

Highest PM_{10} concentration (302 μg/m^3) × required air volume (52,992 m^3) =16,003,584 ug (considering the worst case of air pollution: 302μg/m^3).

Next, the total surface area of the leaves of *Epipremnum aureum* can be determined as follows.

16,003,584 ÷ 68,966 = 232.05 m^2.

Many methods, such as the graticulation method and regression equations, can be used to estimate the surface area of leaves. Some devices, such as portable leaf area metres, can also directly measure the surface area of leaves (Xu et al., 2002). In this study, due to resource limitations, only scanners and drawing software, including Photoshop and AutoCAD, were used to quantify the leaf surface area (Appendix II). The scanners scanned a single leaf and imported the scanned picture into Photoshop and AutoCAD. Then, AutoCAD can directly provide the surface areas of leaves (Figure 7.2).

Due to the financial resource limitations, 20 potted plants were bought from the local market as studied samples. The 20 potted plants had similar heights, crown diameters and ages. The samples of leaves were collected randomly from the bottom, middle and top of each potted plant (labelled A, B, C, D, E, F, G, H, I, J…, and T). Figure 7.1 shows the dimensions of one of the plants. The height and crown diameter ranged from 1.8-2.0 m and 0.6-0.8 m respectively.



Figure 7.1. *An example of the 20 potted plants*

Table 7.2 summarises the number of leaves on each plant. The maximum number of leaves was 160 for plant H. Leaves falling and growing are two natural processes that occur simultaneously. Within a specified period, it is assumed that the number of leaves and the leaf surface area is constant. Therefore, the number of plants required in the sunspace can be determined based on Table 7.2.

Table 7.2. The quantity of leaves on selected plant

	A	B	C	D	E	F	G	H	I	J
Total number of leaves	159	152	147	159	145	141	142	160	148	153
	k	L	M	N	O	P	Q	I	S	T
	148	152	151	158	155	154	144	158	158	159



Figure 7.2. *Leaf surface area calculation. (Appendix II: scanned pictures of leaves from plant A)*

According to the empirical principles of the sampling survey, for a subject with a population less than 1000, the smallest number of viable samples should be at least 30% of the total population (Shao, 2012). Therefore, for the selected 20 plants, 50 leaves from each plant were collected as samples. Then, the overall leaf surface area was estimated based on these samples (Appendix III). Table 7.3 summarises the average leaf surface area data for each plant.

Table 7.3. Surface areas of sample leaves from the potted plants (A-T) (m^2)

Plants	Leaves surface areas of plants (m^2)		Leaves surface areas of plants (m^2)
A	Plant A: 0.0075 × 159 = 1.19	K	Plant K: 0.0075 × 148 = 1.11
B	Plant B: 0.0076 × 152 = 1.16	L	Plant L: 0.0076 × 152 = 1.16
C	Plant C: 0.0077 × 147 = 1.13	M	Plant M: 0.0084 × 151 = 1.27
D	Plant D: 0.0071 × 159 = 1.13	N	Plant N: 0.0079 × 158 = 1.25
F	Plant E: 0.0078 × 145 = 1.13	O	Plant O: 0.0072 × 155 = 1.12
E	Plant F: 0.0074 × 141 = 1.04	P	Plant P: 0.0077 × 154 = 1.19
G	Plant G: 0.0079 × 142 = 1.12	Q	Plant Q: 0.0074 × 144 = 1.07
H	Plant H: 0.0073 × 160 = 1.17	R	Plant R: 0.0076 × 158 = 1.20
I	Plant I: 0.0076 × 148 = 1.12	S	Plant S: 0.0072 × 158 = 1.14
J	Plant J: 0.0076 × 153 = 1.16	T	Plant T: 0.0074 × 159 = 1.18
Average surface areas of one plant	(1.19 + 1.16 + 1.13 + 1.13 + 1.13 + 1.04 + 1.12 + 1.17 +1.12 + 1.16+1.11 + 1.16 + 1.27 + 1.25 + 1.12 + 1.19 + 1.07 + 1.20 +1.14 + 1.18) / 20 = 1.16		

The average surface area for one plant was approximately 1.16 m^2. Then, based on the previous estimate of the leaf surface area required to remove PMs (232.05 m^2), the number of plants required in the sunspace was estimated as: 232.05÷1.16= 200. Thus, theoretically, 200 potted plants, with similar sizes and ages must be placed in the sunspace to clean the air.

However, the statistical methods used to estimate the leaf surface areas and the required number of plants are limited and only applicable for a short period because the number of leaves is continuously changing as the plants grow. In practice, the sunspace should have as many plants as possible because the leaf surface area positively correlated with the efficiency of plants to remove PMs. Moreover, plants must be well cultivated because leaves may drop at any time due to environmental stress, diseases or seasonal effects.

7.3. Sunspace size and material specifications

Each plant roughly occupied 0.5 m^2 of floor area according to the introduction in section 7.2. Therefore, the total floor area of the sunspace was designed as 100 m^2 (200×0.5), with a height of 2 m. To keep the width the same as the length of the classrooms (9.6 m in Figure 5.7, Chapter 5), the length and height of the sunspace were 10.4 metres and 2 metres, respectively. The temperature inside the sunspace should be above 10°C and below 30°C to ensure the healthy growth of plants (Sjwz.cn, 2018). For a sunspace without a mechanical system, the only factor that influences the inside air temperature is the solar heat gains. Solar heat gain mainly occurs through glazed roof of the sunspace. The properties of the roof used in this study were the same as those for the external windows. Table 7.4 summarises the properties of the roof, and Figure 7.3. gives the plan of the roof.

Table 7.4. The roof properties

Material	Outer layer	Cavity	Inner layer	Cavity	Inner layer
Thickness (mm)	5	12	5	12	5
Conductivity (W/m·K)	1.06		1.06		1.06
Angular Dependence	Fresnel		Fresnel		Fresnel
Gas		Air		Air	
Convection Coefficient (W/m^2K)		3.1684		3.1684	
Resistance value (m^2K/W)	0.0057	0.2956	0.0057	0.2956	0.0057
Transmittance value	0.160		0.160		0.160
Outside reflectance	0.489		0.489		0.072
Inside reflectance	0.214		0.214		0.072
Refractive Index	1.526		1.526		1.526
Outside Emissivity	0.837		0.837		0.837
Inside Emissivity	0.042		0.042		0.837
Visible Light Specified	No		No		No
U-value (W/m^2K)	1.5				
Total shading coefficient	0.15				
Glazed surface areas (m^2)	76.8				
Frame surface areas (m^2)	21.4				
Framework outer projection areas	45.2				
Total surface areas (m^2)	100				

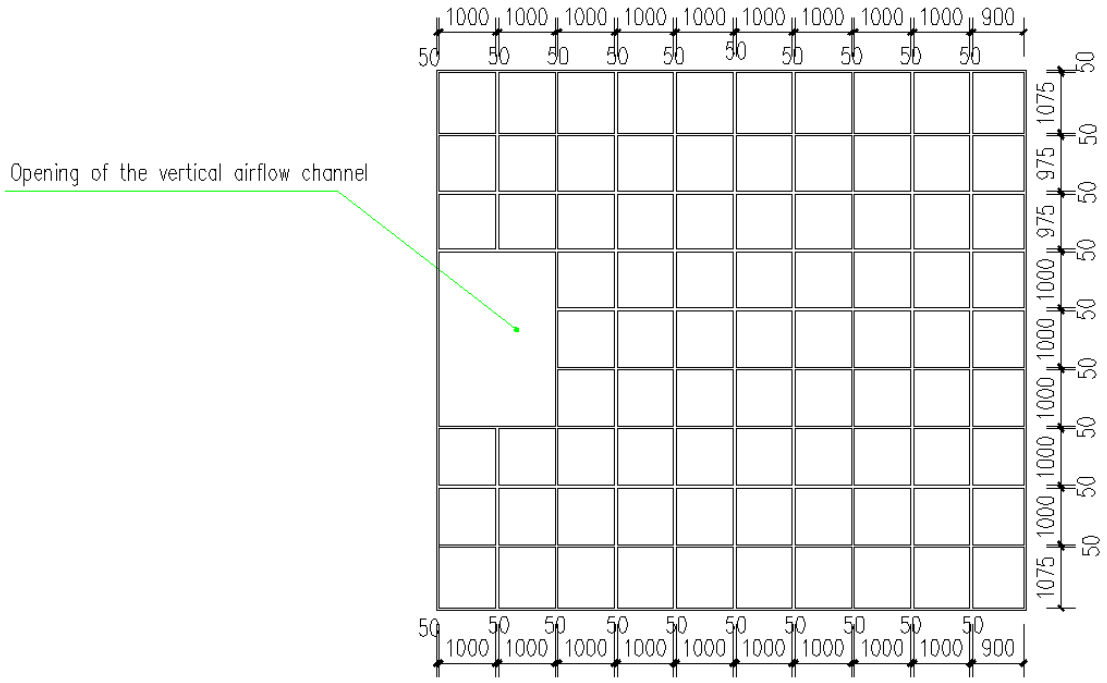


Figure 7.3. *The plan of the roof (unit: mm)*

7.4. The specifications of the EAHEs

The function of the EAHEs in the ILEV system is to regulate the air temperature inside the sunspace. Theoretically, EAHEs can provide air at various temperatures. However, in this study, to simplify the operation process of the ILEV system, it is assumed that air will be preheated or precooled to the Earth's undisturbed temperature. In Tai'an city, the average ground surface temperature and the range of the ground surface temperature are 15.7°C and 17°C, respectively (Gao, 2010). Moreover, Table 7.5 lists the soil properties in Tai'an city.

Table 7.5. The soil properties in Tai'an city

	Values	Unit
Type of soil	Clay	
Thermal transfer coefficient (λ)	0.85	w/m℃
volumetric specific heat capacity ($\rho_s C_{ps}$)	3000	KJ/m³℃

Source: (Gao, 2010)

The thermal diffusivity of the soil can be estimated by equation 6.2.2.13 (section 6.2.2, Chapter 6), and equation 6.2.2.12 (section 6.2.2, Chapter 6) can be used to estimate the Earth's undisturbed temperature at different depths. The soil temperature at different depths is a cosine curve function. Figure 7.4 shows the temperature performance at different depths in Tai'an city, and the soil temperature becomes relatively constant at 15.7°C when the depth reaches 12 m.

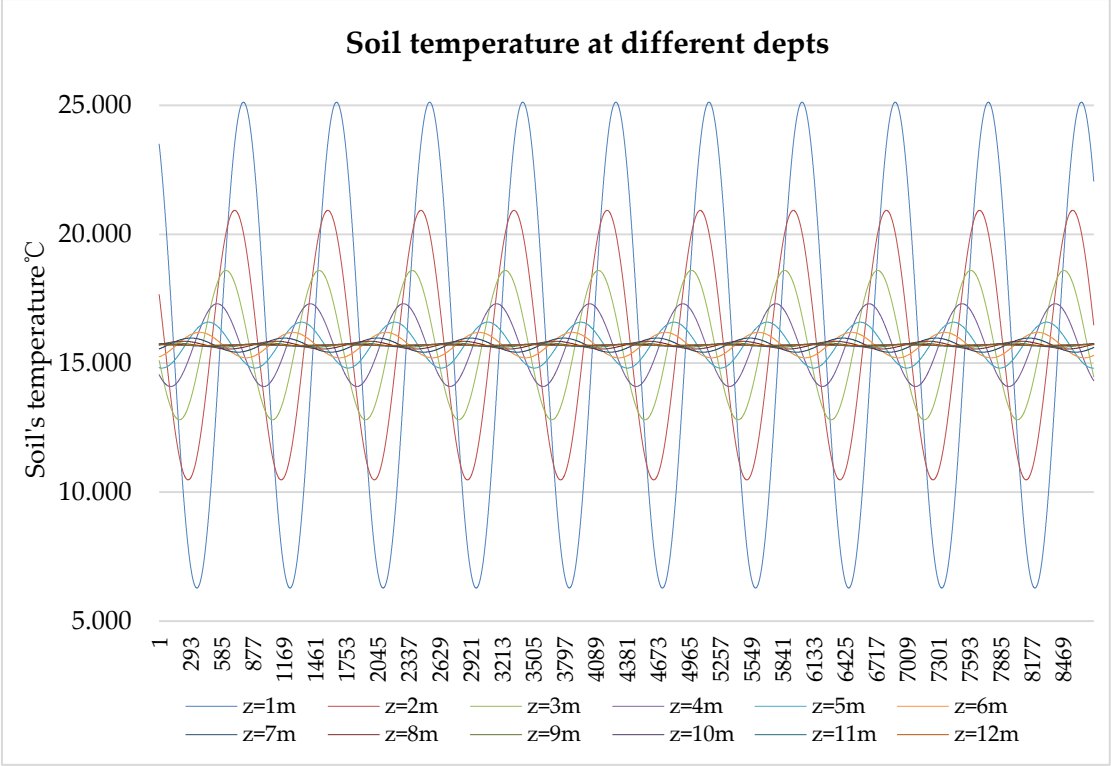


Figure 7.4. *The soil temperature at different depths in Tai'an city*

Table 7.6 gives the experimental data from the study of Gao (2010), which was also conducted in Tai'an city. The results indicate that the soil approaches the Earth's undisturbed temperature at a depth of 12 m. This is consistent with the calculation results in Figure 7.4.

Table 7.6 The temperatures of soil at different depth in Tai'an city

Soil	Soil temperature (℃)		
Depth	December	January	February
0	2.12	-1.02	0.27
1.00	8.86	4.79	3.69
2.00	13.41	9.52	7.38
3.00	16.10	12.93	10.61
4.00	17.41	15.12	13.07
5.00	17.80	16.33	14.76
6.00	17.66	16.85	15.77
7.00	17.28	16.93	16.27
8.00	16.83	16.77	16.44
9.00	16.41	16.51	16.40
10.00	16.08	16.25	16.27
11.00	15.85	16.03	16.11
12.00	15.71	15.86	15.96
13.00	15.64	15.73	15.84

14.00	15.61	15.68	15.76
15.00	15.60	15.65	15.71

Source: Gao (2010)

To obtain air at the undisturbed temperature of the Earth, the pipes should be buried 12 m below the ground. Then, the NTU method was used to calculate the dimensions of the pipes.

Based on the weather data from the China Meteorological Administration (2005), in Tai'an city, the lowest average ambient air temperature is -3°C in January, and the highest average ambient air temperature is 30.6°C in June. Therefore, there are two types of operation involving EAHEs.

In June, the supplied air is 30.6°C, and in January, the supplied air is -3°C. Based on the requirement of the air exchange rate for a primary school classroom (10L/s per person), the total volumetric airflow rate for a unit that includes four classrooms can be expressed as follows.

$$Q = 10 \times 46 \div 1000 \times 4 = 6624\ m^3/h = 1.84\ m^3/s.$$

There is no optimum choice for the diameter of the pipes in practice. However, many studies (Gao, 2010; Zeng, 2012; Wu, 2013) have found that the effectiveness of EAHEs decreases as the diameter of the buried pipes increases. Zeng (2012) indicated that the diameter should be smaller than 0.9 m to obtain a 50% heat transfer efficiency. This study selected pipes with a 500 mm diameter for the EAHEs. To eliminate the co-effects of the buried pipes, the minimum distance between pipes is 1 m (Zeng, 2012). In addition, the pipes should connect to the sunspace at the side farthest from the classroom to ensure that air can pass as many plants as possible. Thus, for a classroom with a length of 9.6 m, the total volumetric airflow rate that can be supplied by one pipe or seven pipes when using pipes with a 500 mm diameter (Figure 7.5).

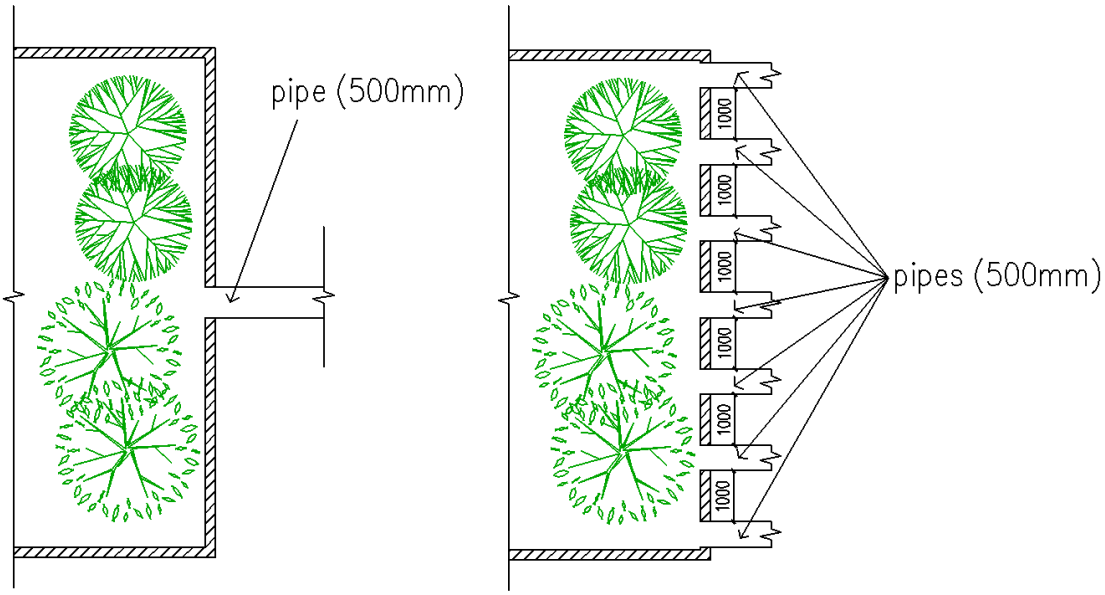


Figure 7.5. *The number of pipes used for the sunspace*

Consequently, when there is only one pipe available to supply air, the airflow velocity is as follows.

Q ÷ A (sectional area of the pipe) = 1.84 ÷ 3.14 ÷ 0.25 ÷ 0.25 = 9.4 m/s.

When there are seven pipes to supply air, the air flow speed is as follows.

Q ÷ A (sectional area of the pipe) ÷ 7 = 1.84 ÷ 3.14 ÷ 0.25 ÷ 0.25 ÷ 7 = 1.3 m/s.

Therefore, the air flow velocity ranges from 1.3 m/s to 9.4 m/s. However, according to the introduction in the section 6.5, Chapter 6, a stable environment has positive effects on the capabilities of plants to remove PMs from the ambient air. Moreover, the air flow velocity has adverse effects on the effectiveness of the EAHEs. Thus, an airflow velocity of 1.3 m/s should be used as an input parameter to estimate the length of the buried pipes.

The following assumptions are made to simplify the estimation process of the length of the EAHE pipes.

- The ground surface temperature is equal to the ambient air temperature, which is also equal to the inlet air temperature.

- The values of the air density, air specific heat capacity, air dynamic viscosity and air thermal conductivity are known at a static air temperature at the inlet.
- The polyvinyl chloride (PVC) pipes used for EAHEs have a uniform crosswise.
- The thermal resistance of the pipe material can be negligible due to the small thickness of the buried pipes used for the EAHEs (2mm).
- The temperature at the inner surface of the pipes is the same as the Earth's undisturbed temperature (15.7°C).
- The temperature at the surface of the pipes is uniform in the axial direction.

In January, the supplied air is -3°C, and the mass ventilation rate ($\dot{m}$), Prandtl number (P_r), Reynolds number (R_e), friction factor (f) and the Nusselt number (N_u) are calculated as shown in Table 7.7.

Table 7.7. Calculation results for the supplied air at -3°C

mass air flow rate ($\dot{m}$)	$1.3 \times 3.14 \times 0.25 \times 0.25 \times 1.308 = 0.27$kg/s
Prandtl number (P_r)	$1.725\times 10^{-5} \times 1.005 \times 10^{3} \div 2.442 \div 10^{-2} = 0.710$
Reynolds number (R_e)	$1.308 \times 1.07 \times 0.5 \times 10^{5} \div 1.725 = 40567$
friction factor (f)	$(1.82 \times \log 40567 - 1.64)^{-2} = 0.03$
Nusselt number (N_u)	$0.03 \div 8 \times (40567\text{-}1000) \times 0.710 \div [1 + 12.7 \times (0.03/8)^{0.5} \times (0.712^{2/3} - 1)] = 125.4$

Then, the NTU method is used to estimate the length of the pipes. The NTU is a function of the length of the buried pipes and the volumetric airflow rate (equation 7.3.1):

$$\mathrm{NTU} = \frac{\mathrm{hA}}{LmC_{air}} = \frac{\mathrm{N}_u\lambda}{D} \times \frac{\pi DL}{\rho V C_{air} L} = \mathrm{N}_u \pi \frac{\lambda}{C_{air}\rho} \times \frac{1}{V} \times L \quad (7.3.1)$$

where C_{air} is the air specific heat in the unit of J/kg·K, N_u is the Nusselt number, V is the volumetric airflow rate (m^3/h), and ρ is air density (kg/m^3),

The review in section 6.2.3 indicated that the NTU is 5 when the heat transfer efficiency of the EAHE system infinitely approaches 1. Thus, in January, the length of the buried pipe should be 52 metres based on the following estimation.

$$\frac{5}{L} = 125.4 \times 3.14 \times \frac{244}{1005 \times 1.308} \times \frac{1}{0.21 \times 3600}$$

$$\therefore \frac{5}{L} = 0.097\left(\frac{1}{m}\right)$$

$$\therefore \mathrm{L} = 51.5\mathrm{m}$$

In June, the supplied air is 30.6°C, and the mass air flow rate (ṁ), Prandtl number (P_r), Reynolds number (R_e), friction factor (f) and the Nusselt number (N_u), length of the pipe are calculated as shown in Table 7.8.

Table 7.8. Calculation results for the supplied air at 30°C

mass air flow rate (ṁ)	$1.3 \times 3.14 \times 0.25 \times 0.25 \times 1.177 = 0.25$kg/s
Prandtl number (P_r)	$1.846 \times 10^{-5} \times 1.005 \times 10^{3} \div 2.624 \div 10^{-2} = 0.707$
Reynolds number (R_e)	$1.177 \times 1.07 \times 0.3 \times 10^{5} \div 1.846 = 34111$
friction factor (f)	$(1.82 \times \log 34111 - 1.64)^{-2} = 0.04$
Nusselt number (N_u)	$0.04 \div 8 \times (34111\text{-}1000) \times 0.707 \div [1 + 12.7 \times (0.04/8)^{0.5} \times (0.707^{2/3} - 1)] = 114.13$

In this case, the ideal length of the buried pipes is 47 metres and is estimated as follows.

$$\frac{5}{L} = 114.13 \times 3.14 \times \frac{267}{1005 \times 1.177} \times \frac{1}{0.21 \times 3600}$$

$$\therefore \frac{5}{L} = 0.1347\left(\frac{1}{m}\right)$$

$$\therefore \mathrm{L} = 46.7\mathrm{m}$$

Therefore, when the supplied air is -3°C in January, the length of the buried pipe is approximately 52 m. In June, the buried pipes should be at least 47 m long to decrease the air temperature from 30.6°C to 15.7°C. The ideal pipes for June are 5 metres longer than the pipes used in January. Therefore, the pipes for the EAHEs should have a length of 52 metres to ensure that the air temperature at the outlet of the buried pipes is equal to the Earth's undisturbed temperature at any time in winter and summer.

Because of financial limitations, experiments were not performed to validate the accuracy of the estimation results for the EAHEs. Therefore, the estimation results were compared to those of a similar study carried out in the cold climate zone of China by Zeng (2012). The NTU method was also used in the study of Zeng (2012). Figure 7.6 indicates that the ambient air temperature decreased to 15°C from 30°C when the air flowed at 2 m/s through a buried pipe that was 50 m in length and 0.5 m in diameter. In addition, the research results of Zeng (2012) were consistent with those of several international studies.

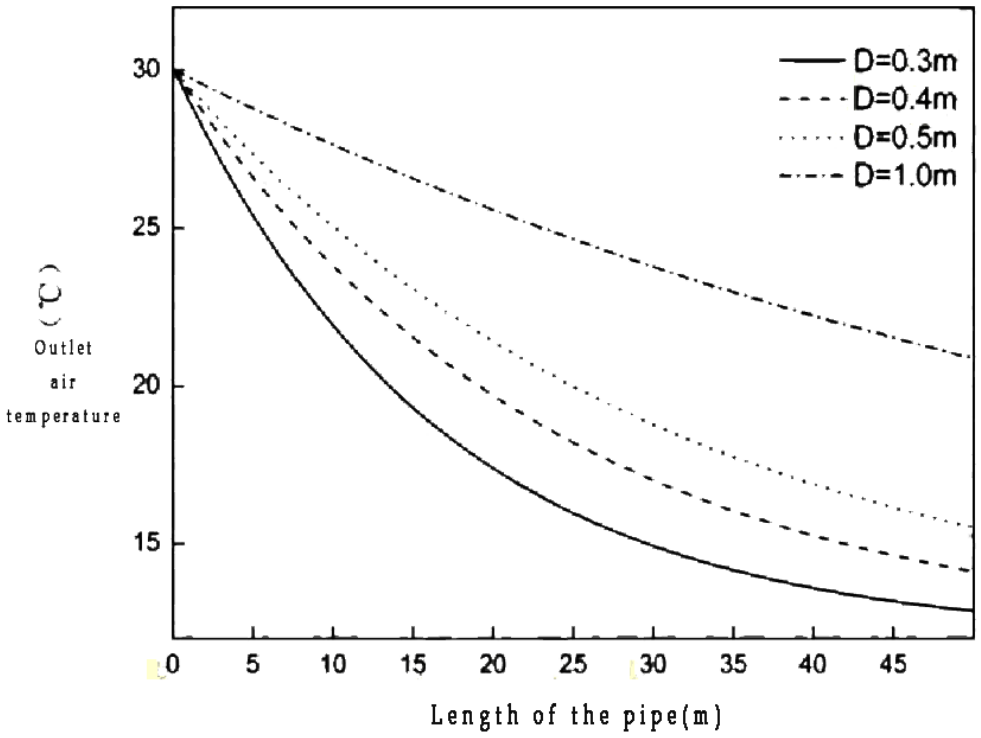


Figure 7.6. *The effectiveness of EAHEs (Zeng, 2012)*

For example, according to a comparison between the results of Zeng (2012) and the experimental data from the studies of Goswami and Dhaliwal (1985) and Goswami and Ileslamlous (1990), the air temperature at the outlet exhibited similar trends in all studies (Figure 7.7). Another comparison between the studies of Zeng (2012) and Benkert et al. (1995) indicated good consistency between the results (Figure 7.8).

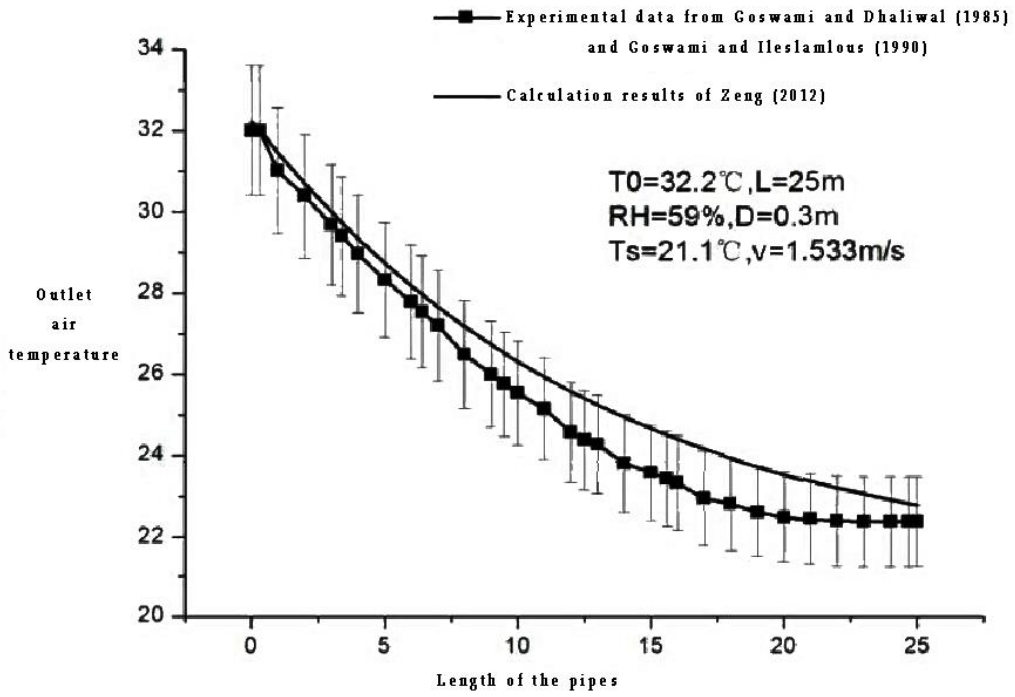


Figure 7.7. *Comparison of the studies of Zeng (2012), Goswami and Dhaliwal (1985) and Goswami and Ileslamlous (1990)*

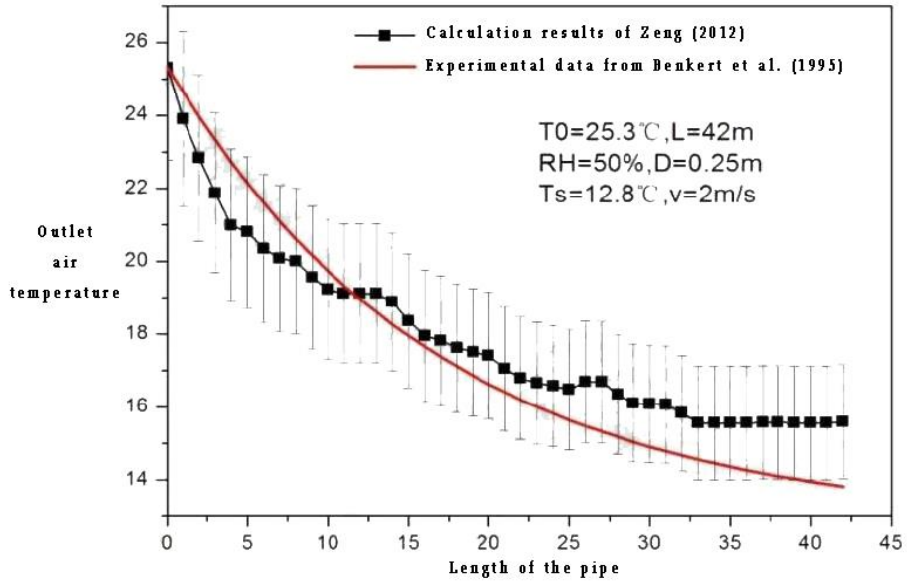


Figure 7.8. *Comparison between the studies of Zeng (2012) and Benkert et al. (1995)*

7.5. Vertical airflow channel

7.5.1. The connection between the sunspace and the classrooms

The sunspace connects the classrooms through a vertical airflow channel (presented in Figure 5.1, section 5.2, Chapter 5). In this study, a fan supplied air for the sunspace at a speed of 1.3 m/s, and the flow speed decreases when the air enters the sunspace because of the force loss of the fan and the blocking effects of plants. Then, the air will continuously flow into the vertical channel before it enters the classrooms. The air supplied by the fans may have effects on the inlet openings on the south-facing wall of the classrooms. Thus, this study aims to reduce the airflow speed in the vertical channel to a windless level. It is assumed that the air flows into the vertical channel through the opening A_0 at a speed of 1.3 m/s (presented in Figure 5.1, section 5.2, Chapter 5); then, the air flow speed inside the vertical channel is as follows:

$$V = \text{volumetric airflow rate} \div \text{area of } A_0$$

where V is the airflow speed inside the vertical channel and the volumetric airflow rate is 1.84 m^3/s.

According to the wind speed classification based on the Beaufort scale (Huler, 2004) (Table 7.9), wind speeds slower than 0.3 m/s create a windless environment (wind pressure ranges from 0 to 0.0025 Pa). Therefore, assuming the airflow speed is 0.3 m/s inside the vertical channel, the minimum opening area of the A_0 is 6.2 m^2 (1.84/0.3 = 6.13 m^2).

Table 7.9. Beaufort scale for land areas

Beaufort Number	Wind speed (m/s)	Description	Wind pressure (Pa)
0	< 0.3	Calm	0-0.0025
1	0.3 - 1.5	Light air	0.056-0.14
2	1.6 – 3.3	Light breeze	0.16-6.8
3	3.4 – 5.5	Gentle breeze	7.2-18.2
4	5.5 – 7.9	Moderate breeze	18.9-39
5	8 – 10.7	Fresh breeze	40-71.6

6	10.8 -13.8	Strong breeze	72.9-119
7	13.9 – 17.1	High wind, moderate	120.8-182.8
8	17.2 – 20.7	Gale, fresh gale	184.9-267.8
9	20.8 – 24.4	Strong/severe gale	270.4-372.1
10	24.5 – 28.4	Storm, whole gale	375.2-504.1
11	28.5 – 32.6	Violent storm	507.7-664.2
12	≥ 32.7	Hurricane force	664.2Pa-851

Source: (Huler, 2004)

Considering the distance (3 m) between the two windows on the south-facing external wall, the width of the vertical airflow channel is 2.1m (6.13/3 = 2.04m) as shown in Figure 7.9.

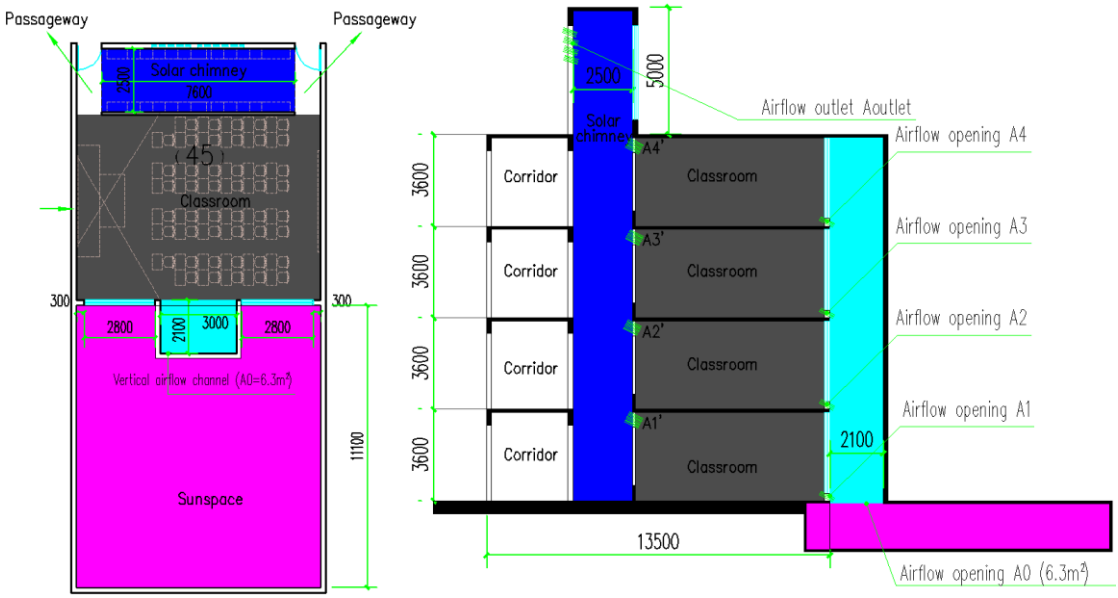


Figure 7.9. *Connection between the sunspace and the classrooms*

Overall, the primary function of the vertical airflow channel is to provide a windless space to temporarily store the air comes from the sunspace. Then, the classrooms are only ventilated by buoyancy effects. Moreover, the construction specification of the external walls of the vertical channel is kept the same as that for the school building fabrics (Table 5.1, Chapter 5).

7.5.2. Study of the internal airflow inside the sunspace and vertical channel

A CFD model was built in IESVE, the MICROFLO sub model was executed within the software package (Figure 7.10). Seven general supply diffusers were

positioned at the inlet side of the sunspace to supply ambient air at 1.84m^3/s to the vertical channel. Two parameters, the airflow speed and air pressure distribution, were studied for the ILEV system. It should be noted that the CFD simulations here are used to determine the airflow speed and the pressure distribution inside the vertical channel. In addition, the air temperature is not considered; thus, the walls, roof and floors are all considered adiabatic.

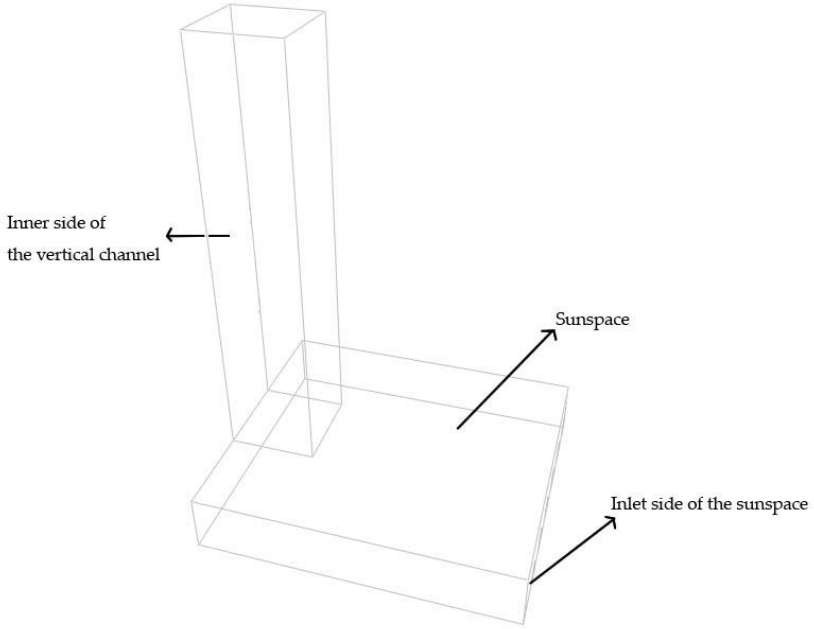


Figure 7.10. *CFD model built in IESVE*

To ensure that the simulation results were independent of the mesh resolution, six meshes in different sizes were studied, as summarised in Table 7.10. The number of cells was continuously increased from the previous mesh size for the X, Y, and Z axes. Figure 7.11 shows the convergence plot of mesh 1. All six meshes converged to an acceptable level and output similar results (Figure 7.12).

Table 7.10. Domain sizes, number of cells and the convergence iterations of the meshes used for the internal airflow study within the sunspace and vertical channel

Type	Domain size (x, y, z)	Quantity of cells	Convergence iterations

Mesh 1	19 × 14 × 27	7182	7000
Mesh 2	22 × 17 × 32	11968	4000
Mesh 3	30 × 20 × 41	24600	6000
Mesh 4	38 × 25 × 53	50350	10000
Mesh 5	44 × 36 × 64	101376	4700
Mesh 6	55 × 42 × 77	177870	5000

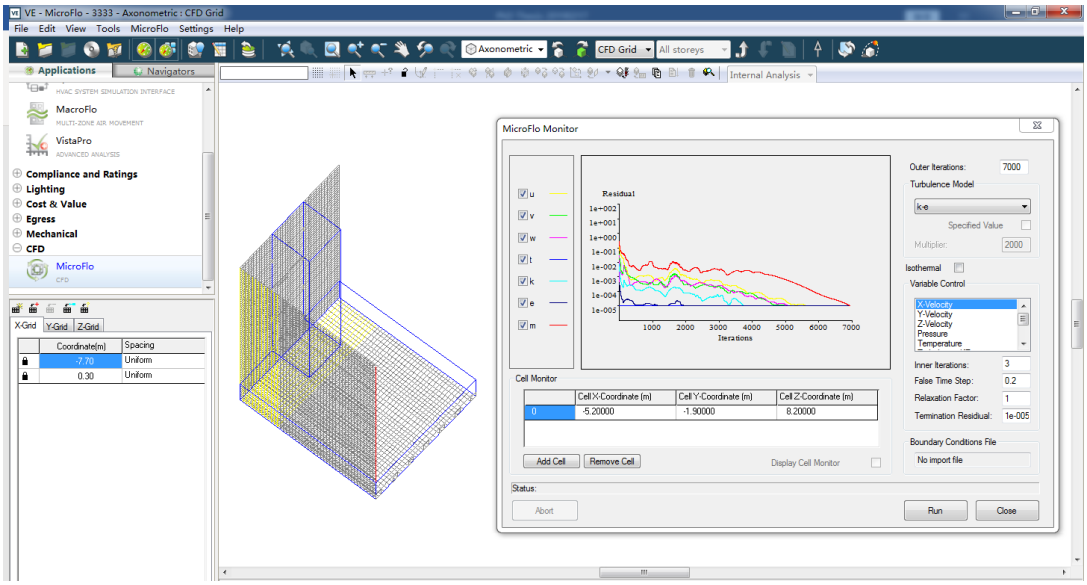


Figure 7.11. *Convergence plot of mesh 1*

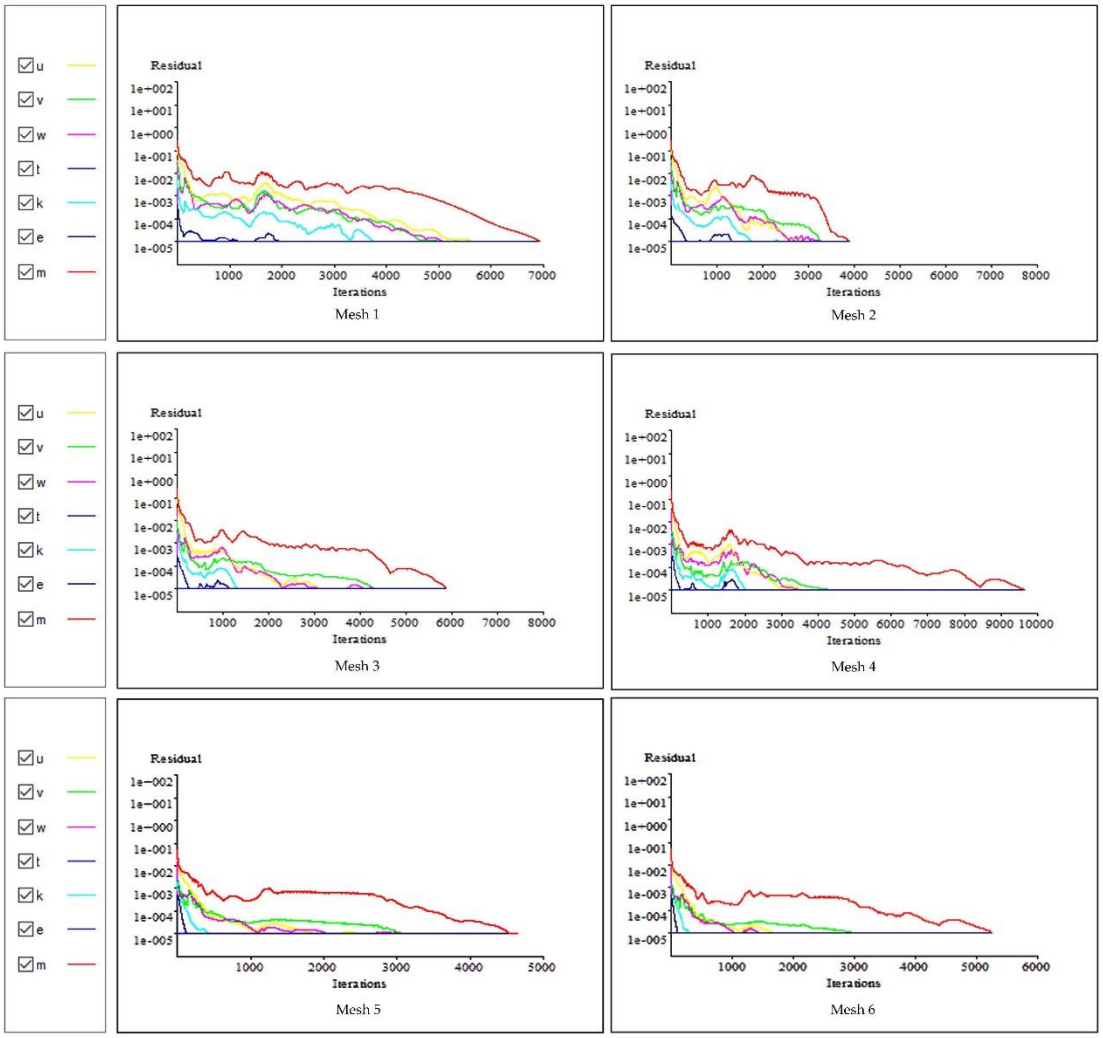


Figure 7.12. *Convergence plots showing the residuals for each variable*

Figure 7.13 indicates that there are no significant differences between the pressures at a user-specified monitoring point in the grid with different meshes (<-0.002 pa). Eventually, mesh 2 was chosen because it met the appropriate convergence criteria regarding the highest residual error reduction and the lowest computational time (4000 iterations) (Figure 7.12 and Figure 7.13).

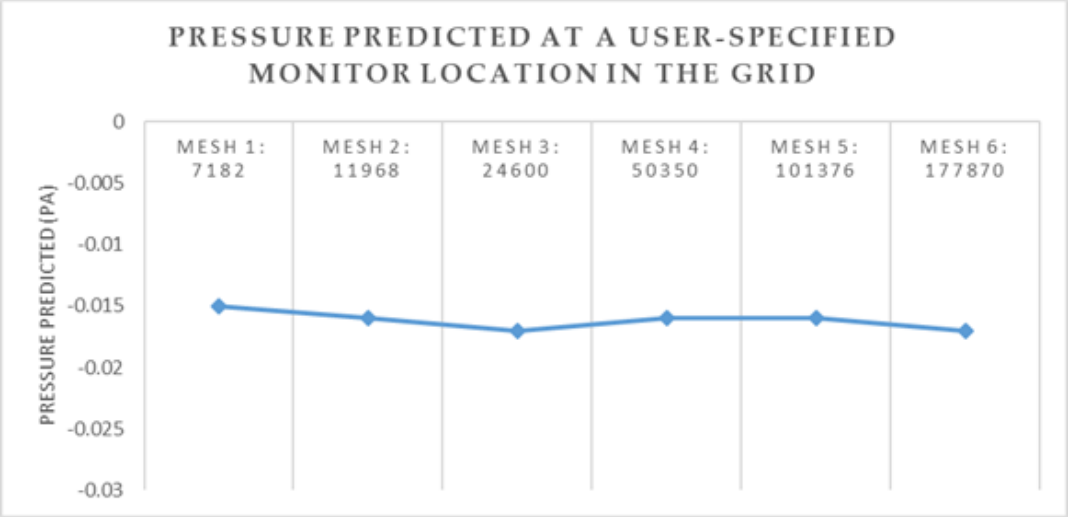


Figure 7.13. *Pressure predictions at a user-specified monitoring point in the grid*

7.5.3. Simulation results

Figure 7.14 shows the predicted pressure generated within the sunspace and the vertical channel. Very low negative pressures were generated inside the vertical airflow channel and the values ranged from -0.016 Pa to -0.001 Pa.

Figure 7.15 illustrates the airflow speed inside the sunspace and the vertical channel. The values ranged from 0.00 m/s to 0.28 m/s. Therefore, a windless internal environment exists in the vertical airflow channel.

Overall, the CFD simulation results indicate that the air supplied from the EAHEs at 1.3 m/s generates small negative pressure in the vertical airflow channel. Therefore, the vertical channel can be characterised as a windless environment based on the Beaufort scale. Ventilation of the classrooms is only influenced by buoyancy effects.

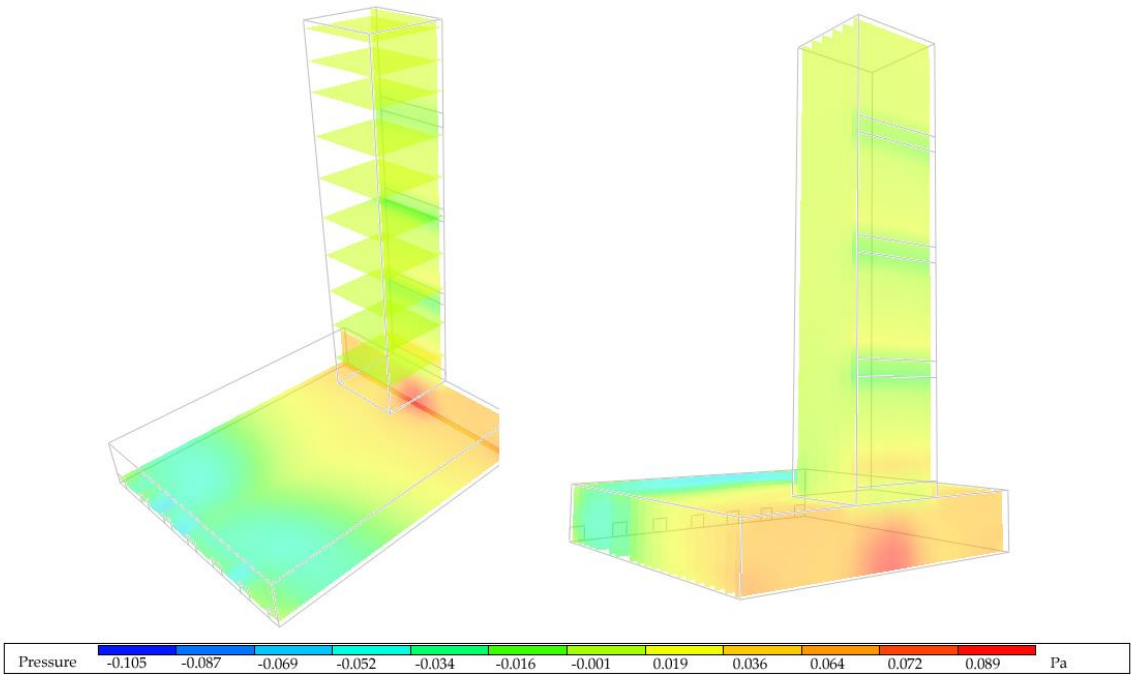


Figure 7.14. *Predicted pressure in the vertical channel and the sunspace*

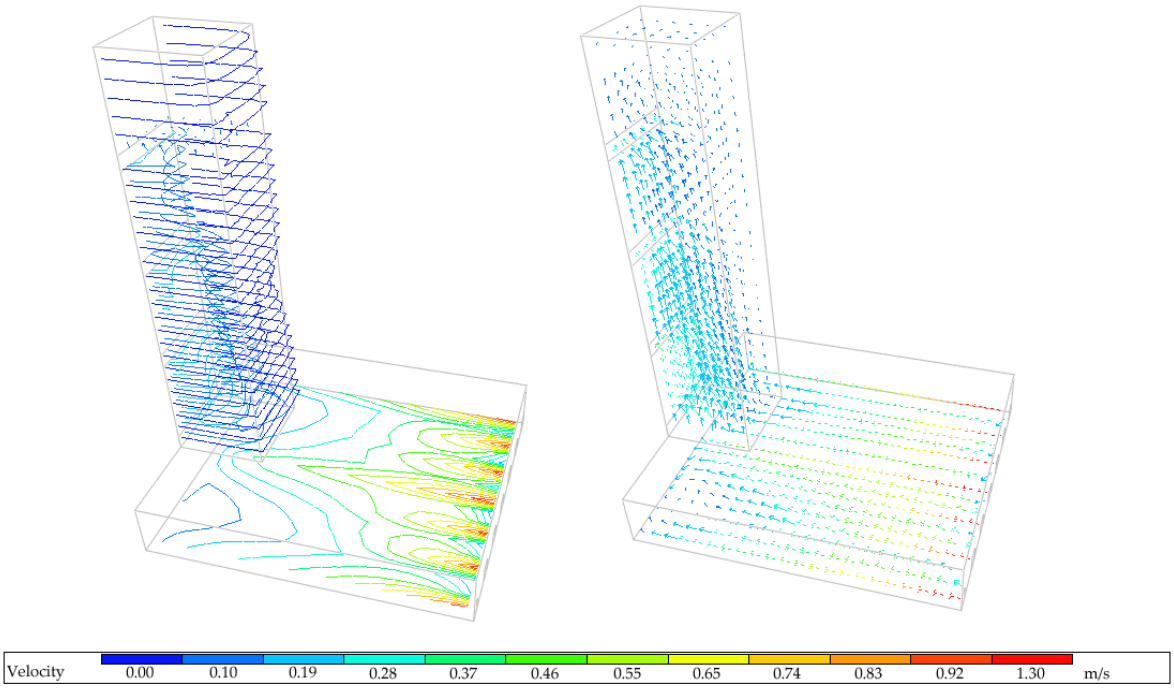


Figure 7.15. *Predicted airflow speed predicted in the vertical channel and the sunspace*

7.6. The dimensions of the solar chimney

Punyasompun et al. (2009) tested two types of solar chimneys for a three-storey building in Bangkok. The study mainly found that a shared solar chimney connected to each floor can induce higher airflow rates than the case of each floor having a separately solar chimney. Therefore, this study employed one solar chimney to serve four classrooms. The height of the solar chimney in this study is the same as that for the solar chimney employed in the study of Yan (2008), which found that a roof-mounted vertical solar chimney with a height of 5 m can provide a sufficient airflow rate for a four-storey primary school building in the cold climate zone of China. The width to height ratio used in this study is 0.5, as studies have claimed that 0.5 is the optimum ratio for practical contexts (Wang, 2003; Wang and Li, 2004; Jing, 2005). Figure 7.16 and Figure 7.17 show the redesign of the floor with a total solar chimney length of 7.6 m.

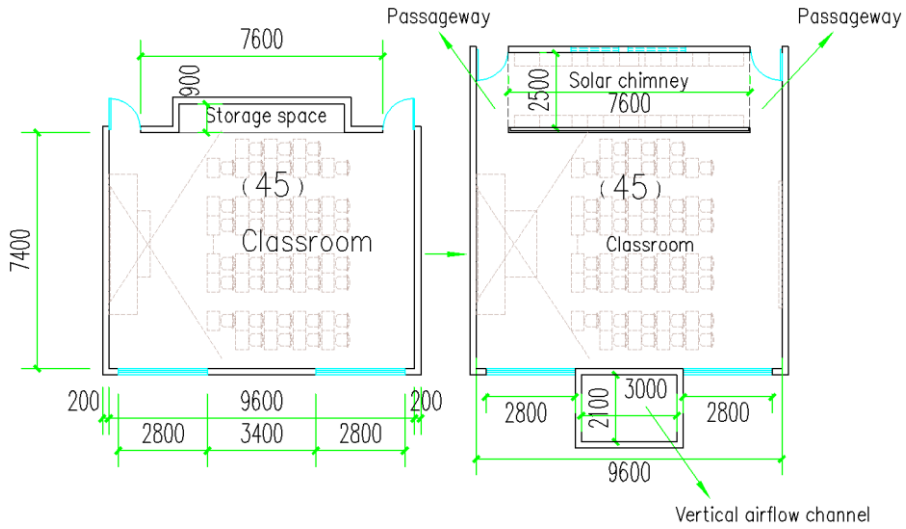


Figure 7.16. *Redesign of the floor plan of the primary school building (left: initial floor plan and right: redesigned floor plan)*

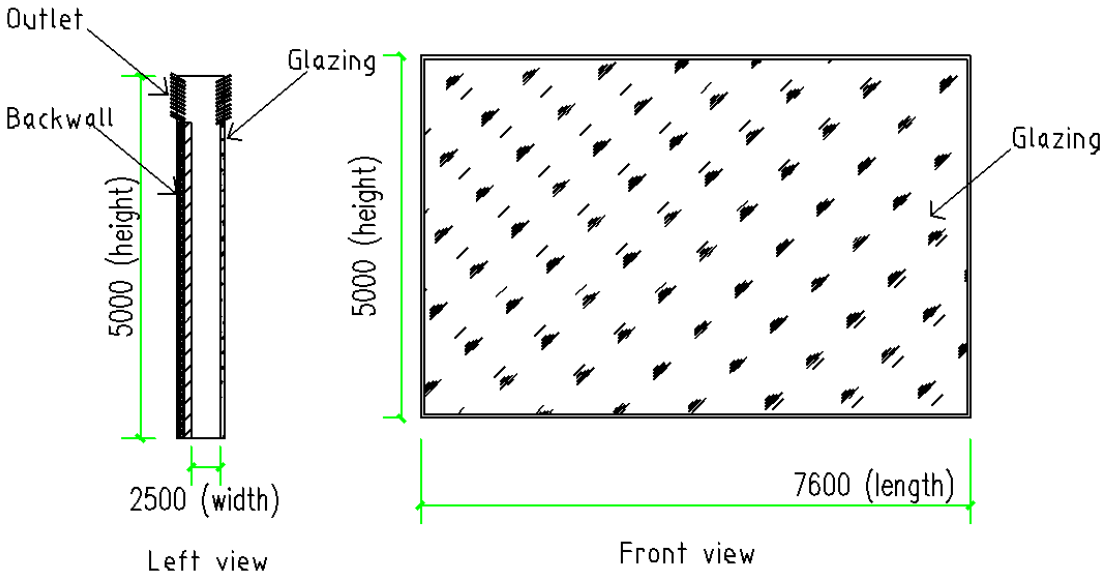


Figure 7.17. *Dimensions of the solar chimney*

It is assumed that the back wall and glazed panel have the same structural specifications as the external wall and external windows of the primary school building (Table 7.11). However, the low solar heat gain coefficient of the glaze panel may reduce the efficiency of the solar chimney. Therefore, the type of glaze used for the solar chimney should be optimally adjusted based on further analyses of the DTM simulation results in Chapter 9.

Table 7.11. Structural specifications for the solar chimney

Fabrics	Structure	U-value	Total shading coefficient
Backwall	Cement Mortar (20mm) + Rock Wool (120mm) + Concrete Block (200mm) + Cement Mortar (20mm)	0.33 W/ m^2K	
Glazing	5 + 12A + 5 + 12A + 5 Low-e	1.5 W/ m^2K	0.15

7.7. Summary

Chapter 7 provided detailed design parameters of the ILEV system. The following list gives the critical findings from this chapter.

- The average leaf surface area of the selected 20 potted plants was approximately 1.16 m^2, and the size of the sunspaces was 100 m^2.
- The length of the pipes was 52 m to meet the undisturbed soil temperature requirements in summer and winter.
- The sunspace was connected to the classrooms by a vertical airflow channel with a sectional area of 6.2 m^2 to create a windless environment in the vertical channel and ensure that the ventilation of the classrooms only relies on buoyancy effects.
- The length, width and the height of the solar chimney were 7.6 m, 2.5 m, and 5 m, respectively, based on the results of published studies and the redesigned floor plan of the case study building.

In addition to the findings summarised above, four points should be emphasised.

- First, the estimation of the leaf surface area in this study was based on the materials and financial resources currently available for this Ph.D. project. The research uses *Epipremnum aureum* to remove PMs in the sunspace. *Epipremnum aureum* is a common plant in North China and its capacity for removing air pollutants has been validated in the published studies (Liu et al., 2013; Zhou et al., 2009). Furthermore, the use of diverse plants might increase the absorption efficiency. However, this approach involves a botany study, which is beyond the scope of this Ph.D. project.

- Second, the glaze type of the sunspace was the same as that used for the external windows of the case study building. Theoretically, glazes with larger total shading coefficients could increase the solar heat gain of the sunspace;

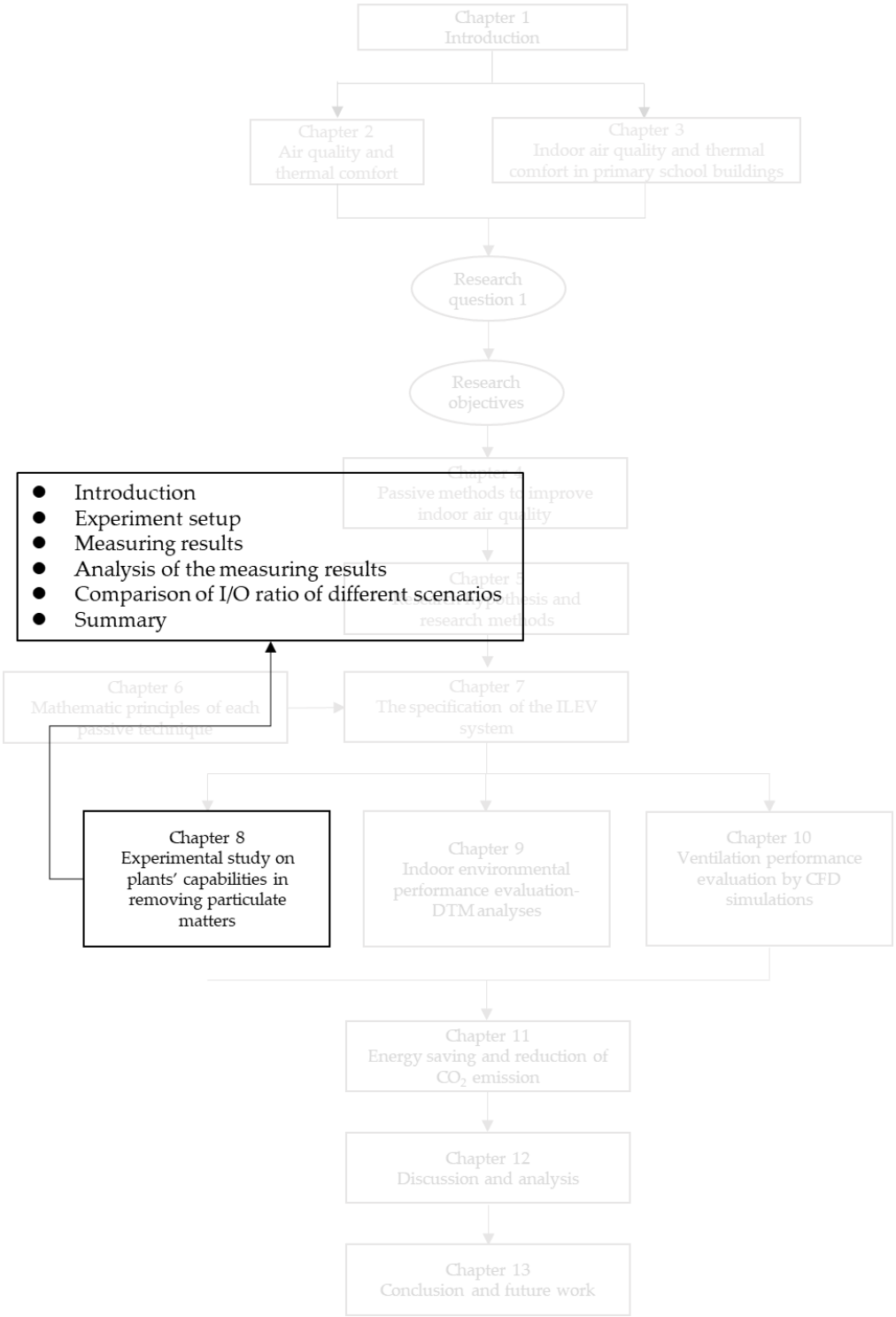
however, considering the scorching hot summers in Tai'an city, the relatively low value of 0.15 was used in this research.

- Third, increasing the insulation level of the back wall of the solar chimney could theoretically reduce the rate of solar heat loss. However, there are no accurate data available in the literature regarding the thickness of insulation in back walls. Moreover, considering the construction cost, the back wall insulation was the same as that used in the external walls of the case study building.

- Fourth, the glaze type of the solar chimney was the same to as that used for the external windows of the case study building. In practice, a solar chimney with a high shading coefficient can absorb more solar heat and increase the natural ventilation performance compared to a chimney with a low shding coefficient. In this Ph.D. work, the following chapters will further explore different solar shading coefficients for the glazing of the solar chimney.

In summary, this chapter established a complete model of the ILEV system. In addition, the outputs will be used in the following three validating techniques: experimental methods, DTM analysis, and CFD simulations, as presented in Chapters 8, 9, and 10. Chapter 8 introduces an experiment to evaluate the capabilities of plants to remove PMs. Chapter 9 and Chapter 10 explore the performance of the ILEV system based on DTM analyses and CFD simulations.

Chapter 8: AN EXPERIMENTAL STUDY OF THE CAPABILITIES OF PLANTS TO REMOVE PMS



The content of Chapter 8

8.1. Introduction

As noted in section 4.2, plants considerably contribute to improving air quality. However, there is no simulation method available to predict the performance of plants in PM removal. Thus, in this chapter, an experiment is conducted to investigate the capabilities of plants in the removal of PMs. There are two main issues addressed in this section: the ability of plants to remove PMs is assessed and confirmed, and the factors that influence the efficiency of plants in cleaning the air inside the sunspace are identified.

The experiment was designed based on the financial and material resources available for this Ph.D. project. The specifications of the coupled model of the ILEV system (introduced in section 7.2 and section 7.4) provide the foundation for the establishment of the experiment. For example, the plant investigated was *Epipremnum aureum,* and the number of the plants and the size of the sunspace were 200 and 100 m^2, respectively. Air was supplied from one side of the sunspace at a given airflow speed and then expelled from another side of the sunspace. The inside and the outside PM concentrations were simultaneously measured. The hourly data and I/O ratios collected were used to address the two main issues listed above.

8.2. Experimental setup

The experimental study established a greenhouse with a steel framework and polyethylene films to represent the sunspace designed in the ILEV system. The width, length, and height of the greenhouse were 1.4m, 14m, and 2m, respectively. The twenty potted plants used in the estimation of the leaf surface areas (Section 7.2) were placed inside the greenhouse (Figure 8.1). Figure 8.2 shows the established experimental greenhouse.

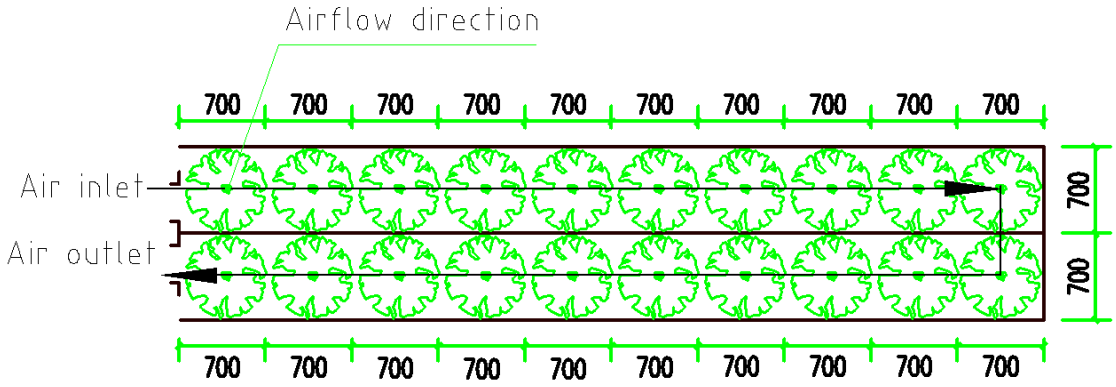


Figure 8.1. *The floor plan of the designed greenhouse (unit: mm)*



Figure 8.2. *The experimental sunspace*

To ensure that the air could pass through as many plants as possible, the structure was situated so that air flowed into the greenhouse from one side and left from the opposite side. The fan had a rated power of 50 W to generate an airflow rate of 225 m^3 per hour. Moreover, the diameter of the fan outlet was 100 mm. Therefore, the supplied air flow speed at the outlet of the fan was 8 m/s. Figure 8.3 shows a

connection between the fan and the pipes, which can create different airflow speeds. For example, when a pipe with a diameter of 400 mm was connected to the fan, an airflow speed of 0.5 m/s can be generated. The box in the middle acted as a connector between the pipes and the fan. The diameters of the selected pipes were 100 mm, 250 mm, and 300 mm, and each pipe corresponded to one air flow velocity (Table 8.1).

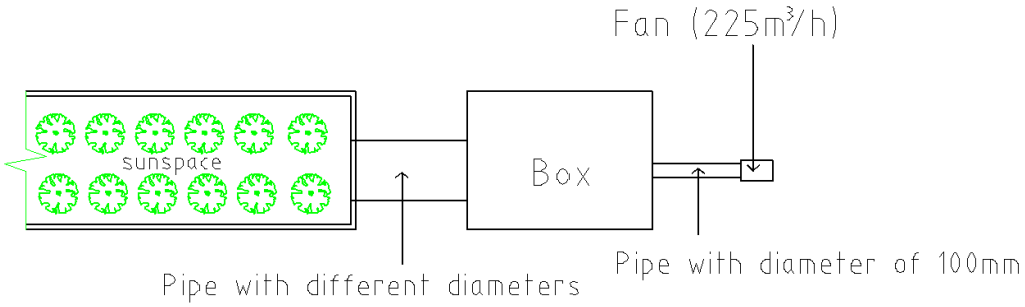


Figure 8.3. *The connection of the experimental system*

Table 8.1. The diameters of the selected pipes and the corresponding airflow speeds

The air volume flow rate of the fan	Diameters of the pipes	The corresponding air flow speed
0	0	Infiltration
225m³/h	100mm	8m/s
	300mm	0.9m/s
	250mm	1.3m/s

This study selected PVC pipes with different diameters for the measurements. Figure 8.4 shows the pipes and the fan used in this experimental study.



Figure 8.4. *The pipes and the fan used in this experimental study*

Two portable hand-held BRAMC-SMART-126 detectors that were certified by the Department of Environmental Protection of the Central Government, were used to simultaneously measure the PM concentrations at the inlet and outlet of the sunspace (Figure 8.5).



Figure 8.5. *The portable hand-held detectors of the BRAMC-SMART-126 detectors*

The PM removal performance of the greenhouse was measured in December 2017 and January 2018 (Appendix IV). The plants were cleaned in advance before the first measurements were made. For example, the plant leaves were washed one day before the measurements. Table 8.2 summarises the specific measurement period, and Figure 8.6 shows the actual measurements setup. To determine the influences of the plants on the inside concentration of PMs, measurements in different scenarios were made under the same conditions, except for the air supply speed, which was varied.

Table 8.2. A summary of the measurements

Scenarios	Measurements	Time	Values
1	No supply air; no plants inside of sunspace	25th December 2017	Hourly value
2	No supply air; sunspace with plants	27th December 2017	Hourly value
3	Air flowed at 8m/s; sunspace with plants	1st January 2018	Minute value
4	Air flowed at 1.3m/s; sunspace with plants	5th January 2018	Hourly value
5	Air flowed at 0.9m/s; sunspace with plants	6th January 2018	Hourly value



Figure 8.6. *The measurement in reality*

8.3. Measurement results

8.3.1. Scenario 1

Table 8.3 indicates the inside and outside PM concentrations and the I/O ratios of scenario 1. During the measurement period, there were no plants inside the enclosed greenhouse. Theoretically, the PMs in the greenhouse all originated from the outside air by infiltration. The measurement results show that the inside PM concentrations were approximately 75% of the outside PM concentrations on average. The enclosed greenhouse stopped almost 30% of the PMs from flowing inside.

Table 8.3. The $PM_{2.5}$ and PM_{10} levels on 25 December, 2017

Scenario 1						
Time	$PM_{2.5}$			PM_{10}		
	Indoor $PM_{2.5}$ concentration (ug/m^3)	Outdoor $PM_{2.5}$ concentration (ug/m^3)	I/O ratio of $PM_{2.5}$ concentrations	Indoor PM_{10} concentration (ug/m^3)	Outdoor PM_{10} concentration (ug/m^3)	I/O ratio of PM_{10} concentrations
00:00-01:00	74	116	0.64	89	133	0.67
01:00-02:00	75	114	0.66	88	130	0.69
02:00-03:00	82	117	0.71	91	134	0.68
03:00-04:00	75	111	0.67	89	127	0.70
04:00-05:00	82	117	0.70	90	133	0.68
05:00-06:00	76	112	0.68	89	128	0.70
06:00-07:00	81	117	0.70	90	133	0.68
07:00-08:00	77	112	0.70	90	128	0.71
08:00-09:00	82	113	0.73	91	128	0.72
09:00-10:00	83	116	0.72	91	132	0.70
10:00-11:00	78	105	0.74	82	118	0.70
11:00-12:00	66	71	0.97	71	79	0.95
12:00-13:00	51	53	0.98	56	57	0.98
13:00-14:00	46	54	0.87	51	59	0.86
14:00-15:00	54	69	0.78	58	76	0.77
15:00-16:00	57	67	0.84	61	74	0.83
16:00-17:00	56	68	0.83	61	75	0.82
17:00-18:00	58	68	0.85	62	76	0.82
18:00-19:00	55	67	0.84	60	74	0.81
19:00-20:00	57	71	0.80	61	79	0.78
20:00-21:00	56	64	0.89	61	71	0.86
21:00-22:00	55	64	0.85	59	72	0.83
22:00-23:00	56	68	0.83	60	76	0.80
23:00-24:00	54	63	0.86	58	70	0.83
Average	62	87	0.75	73	98	0.78

8.3.2. Scenario 2

To identify the effects of plants on the inside PM concentrations, the twenty potted plants were moved inside the enclosed greenhouse. The ventilation of the greenhouse still relied on infiltration. Table 8.4 summarises the measurement results for scenario 2. The results suggest that the inside PM concentrations was approximately 39% of the outside PM concentrations on average.

Table 8.4. The $PM_{2.5}$ and PM_{10} levels on 27 December 2017

Scenario 2						
Time	$PM_{2.5}$			PM_{10}		
	Indoor $PM_{2.5}$ concentration (ug/m^3)	Outdoor $PM_{2.5}$ concentration (ug/m^3)	I/O ratio of $PM_{2.5}$ concentrations	Indoor PM_{10} concentration (ug/m^3)	Outdoor PM_{10} concentration (ug/m^3)	I/O ratio of PM_{10} concentrations
00:00-01:00	58	173	0.34	79	198	0.40
01:00-02:00	59	156	0.38	76	178	0.43
02:00-03:00	58	132	0.45	69	151	0.46
03:00-04:00	59	115	0.51	64	131	0.49
04:00-05:00	59	120	0.49	64	138	0.47
05:00-06:00	54	106	0.51	59	121	0.49
06:00-07:00	52	101	0.52	56	114	0.49
07:00-08:00	57	141	0.42	65	163	0.42
08:00-09:00	53	212	0.26	67	244	0.28
09:00-10:00	50	216	0.23	67	247	0.27
10:00-11:00	51	220	0.23	67	248	0.27
11:00-12:00	59	163	0.37	67	183	0.38
12:00-13:00	61	132	0.46	67	146	0.46
13:00-14:00	50	116	0.43	53	127	0.42
14:00-15:00	44	108	0.41	47	119	0.40
15:00-16:00	42	112	0.38	45	123	0.37
16:00-17:00	47	121	0.39	51	134	0.38
17:00-18:00	32	136	0.24	35	153	0.23
18:00-19:00	47	164	0.29	51	185	0.28
19:00-20:00	53	144	0.37	57	162	0.35
20:00-21:00	55	138	0.40	59	156	0.38
21:00-22:00	57	138	0.42	62	155	0.40
22:00-23:00	61	150	0.41	66	171	0.39
23:00-24:00	62	150	0.41	67	171	0.39
Average	53	145	0.39	61	164	0.39

8.3.3. Scenario 3

In scenario 3, the airflow speed was 8 m/s. The indoor environment of the greenhouse was not as stable as that in scenarios 1 and 2 because the leaves of the potted plants were continuously moving. Table 8.5 presents the two-hour measurement results of the PM concentrations in both indoor and outdoor

environment in scenario 3. Because of the fast airflow speed, the inside PM concentrations increased to the same level as the outside PM concentrations after two hours of airflow. The I/O ratios also reached 1 and, at some points, even exceeded 1. Therefore, plants cannot continuously adsorb PMs in an unstable environment.

Table 8.5. The $PM_{2.5}$ and PM_{10} levels on 1 January 2018

Scenario 3						
	$PM_{2.5}$			PM_{10}		
Time	Indoor $PM_{2.5}$ concentration (ug/m^3)	Outdoor $PM_{2.5}$ concentration (ug/m^3)	I/O ratio of $PM_{2.5}$ concentration	Indoor PM_{10} concentration (ug/m^3)	Outdoor PM_{10} concentration (ug/m^3)	I/O ratio of PM_{10} concentration
08:00-08:05	108	178	0.61	120	215	0.56
08:05-08:10	104	188	0.55	115	225	0.51
08:10-08:15	128	189	0.68	140	232	0.61
08:15-08:20	135	196	0.69	148	235	0.63
08:20-08:25	151	203	0.75	168	241	0.70
08:25-08:30	167	204	0.82	185	244	0.76
08:30-08:35	168	197	0.86	189	235	0.80
08:35-08:40	173	205	0.84	199	252	0.79
08:40-08:45	177	215	0.82	201	254	0.79
08:45-08:50	178	217	0.82	199	261	0.76
08:50-08:55	173	235	0.74	195	279	0.70
08:55-09:00	186	228	0.82	208	270	0.77
09:00-09:05	187	225	0.83	208	267	0.78
09:05-09:10	184	215	0.85	203	271	0.75
09:10-09:15	185	214	0.87	210	251	0.83
09:15-09:20	187	217	0.86	212	254	0.83
09:20-09:25	186	211	0.88	211	250	0.84
09:25-09:30	193	212	0.91	213	254	0.84
09:30-09:35	199	248	0.81	222	299	0.76
09:35-09:40	225	284	0.79	252	344	0.73
09:40-09:45	242	260	0.93	273	313	0.87
09:45-09:50	251	245	1.02	282	301	0.94
09:50-09:55	249	238	1.05	280	285	0.98
09:55-10:00	242	230	1.05	271	279	0.97

8.3.4. Scenario 4

In scenario 4, the airflow speed was 1.3 m/s, and the indoor environment of the greenhouse was relatively stable because the leaves were not moving during the air supply process. Table 8.6 summarises the measurement results for scenario 4. The table shows that the inside PM concentration was approximately 55% of the outside PM concentrations during the 24-hour operating period. Compared to

scenario 2, the PM concentrations inside the greenhouse were 15% higher than those during the infiltration scenario.

Table 8.6. The $PM_{2.5}$ and PM_{10} levels on 5 January 2018

Scenario 4						
Time	$PM_{2.5}$			PM_{10}		
	Indoor $PM_{2.5}$ concentration (ug/m^3)	Outdoor $PM_{2.5}$ concentration (ug/m^3)	I/O ratio of $PM_{2.5}$ concentrations	Indoor PM_{10} concentration (ug/m^3)	Outdoor PM_{10} concentration (ug/m^3)	I/O ratio of PM_{10} concentrations
00:00-01:00	74	157	0.47	87	183	0.48
01:00-02:00	67	135	0.50	80	156	0.51
02:00-03:00	63	125	0.50	83	162	0.51
03:00-04:00	74	143	0.52	88	165	0.53
04:00-05:00	70	133	0.53	84	155	0.54
05:00-06:00	68	139	0.49	82	162	0.51
06:00-07:00	65	128	0.51	84	171	0.49
07:00-08:00	71	143	0.50	92	178	0.52
08:00-09:00	83	152	0.55	97	177	0.55
09:00-10:00	70	140	0.50	83	163	0.51
10:00-11:00	67	123	0.54	77	141	0.55
11:00-12:00	69	126	0.55	75	142	0.53
12:00-13:00	57	113	0.50	62	126	0.49
13:00-14:00	46	96	0.48	49	108	0.4
14:00-15:00	48	91	0.53	52	102	0.51
15:00-16:00	56	100	0.56	61	112	0.54
16:00-17:00	66	113	0.58	72	128	0.56
17:00-18:00	71	118	0.60	77	136	0.57
18:00-19:00	86	136	0.63	94	156	0.60
19:00-20:00	78	134	0.58	85	154	0.55
20:00-21:00	78	130	0.60	85	148	0.57
21:00-22:00	102	157	0.65	111	181	0.61
22:00-23:00	120	192	0.63	131	220	0.60
23:00-24:00	121	206	0.59	136	239	0.57
Average	73	133	0.55	83	155	0.54

8.3.5. Scenario 5

In scenario 5, the airflow speed was 0.9 m/s, and the indoor environment of the greenhouse was stable, as in scenario 4. Table 8.7 lists the measurement results. The results indicate that, on average, the I/O ratios of the PM concentration were 0.52 for $PM_{2.5}$ and 0.54 for PM_{10}. These values are similar to those in scenario 4 but higher than those in scenario 2.

Table 8.7. The $PM_{2.5}$ and PM_{10} levels on 6 January, 2018

Scenario 5						
Time	$PM_{2.5}$			PM_{10}		
	Indoor $PM_{2.5}$ concentration (ug/m^3)	Outdoor $PM_{2.5}$ concentration (ug/m^3)	I/O ratio of $PM_{2.5}$ concentrations	Indoor PM_{10} concentration (ug/m^3)	Outdoor PM_{10} concentration (ug/m^3)	I/O ratio of PM_{10} concentrations

00:00-01:00	15	33	0.46	17	38	0.46
01:00-02:00	17	37	0.48	22	43	0.51
02:00-03:00	21	44	0.48	26	50	0.52
03:00-04:00	27	53	0.51	31	61	0.51
04:00-05:00	31	55	0.58	36	62	0.58
05:00-06:00	36	71	0.51	48	85	0.57
06:00-07:00	36	81	0.44	54	93	0.58
07:00-08:00	42	78	0.54	48	89	0.53
08:00-09:00	38	75	0.51	51	95	0.54
09:00-10:00	48	90	0.53	62	108	0.58
10:00-11:00	62	113	0.56	77	136	0.58
11:00-12:00	66	123	0.54	81	141	0.58
12:00-13:00	81	155	0.53	91	176	0.52
13:00-14:00	56	130	0.44	64	147	0.44
14:00-15:00	39	80	0.50	44	88	0.52
15:00-16:00	37	73	0.51	42	81	0.52
16:00-17:00	28	68	0.41	32	76	0.42
17:00-18:00	26	58	0.45	29	65	0.46
18:00-19:00	27	59	0.45	30	67	0.45
19:00-20:00	29	59	0.49	34	66	0.52
20:00-21:00	42	61	0.68	47	69	0.69
21:00-22:00	51	80	0.64	59	91	0.65
22:00-23:00	55	89	0.62	63	103	0.62
23:00-24:00	63	99	0.65	72	114	0.64
Average	41	78	0.52	48	89	0.54

8.4. Analysis of the measurement results

8.4.1. Inside and outside PM concentrations

Figure 8.7 shows the PM concentrations in scenario 1. The inside PM concentrations were lower than the outside PM concentrations. Moreover, the trends of both the inside and outside PM concentrations were consistent. Therefore, since there were no inside sources of PMs, the indoor PMs originated from the transport of the outdoor PMs. In addition, in the enclosed space, the stable inside environment led to a low inside PM concentration, as more PMs sunk to the inner surfaces of objects in the greenhouse. However, there was a rapid decline in the outside PM concentrations between the time 11:00 and 13:00 followed by a rapid increase. Therefore, the inside PM concentrations were closed to the outside PM concentrations from 11:00-13:00.

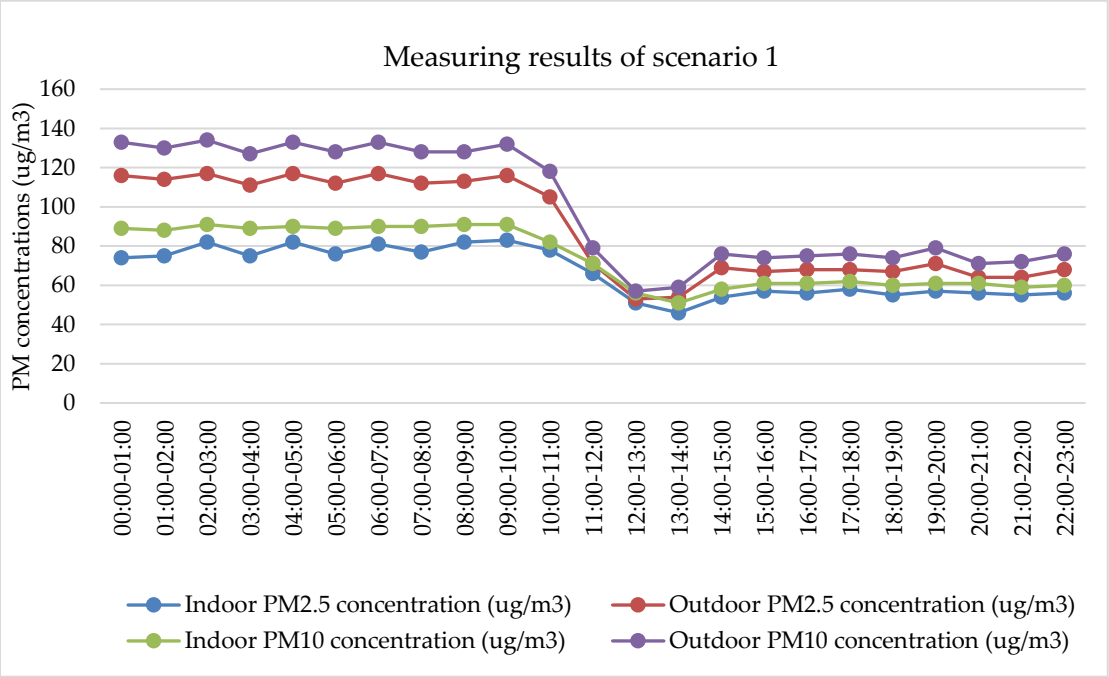


Figure 8.7. *The PM concentrations in scenario 1*

Figure 8.8 indicates the inside and outside PM concentrations in scenario 2. The trends for both the inside and outside PM concentrations were consistent. However, the inside PM concentrations were much more stable than the outside

PM concentrations. For example, from 7:00-10:00, the outside PM concentrations fluctuated greatly, and the inside PM concentrations remained stable. In addition, the inside PM concentrations in scenario 2 were also more stable than those in scenario 1.

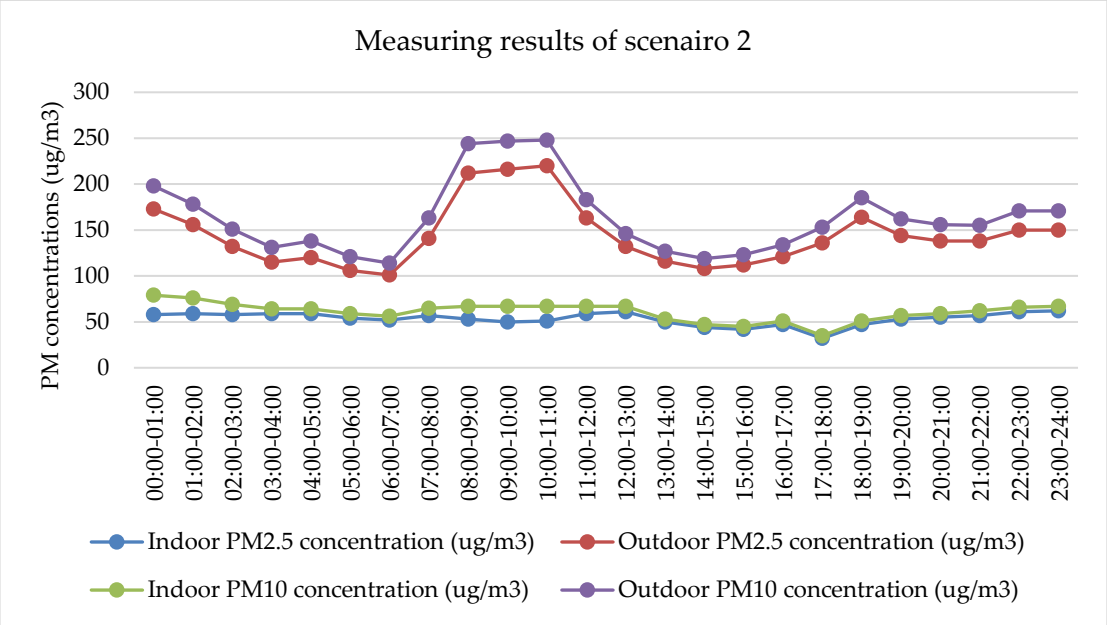


Figure 8.8. *The PM concentrations in scenario 2*

Figure 8.9 illustrates the PM concentrations in scenario 3. Overall, a consistent trend was observed. The inside PM concentrations were generally close to the outside PM concentrations at the given measurement times. After two hours of air supply, the inside and outside PM concentrations reached the same level. Compared to scenarios 1 and 2, it can be concluded that a fast airflow speed deteriorated the stable inside environment and caused the resuspension of PMs.

Figures 8.10 to 8.12 show the PM concentrations of scenarios 4 and 5. Notably, all the figures display a consistent trend between the inside and outside PM concentrations. Specifically, the inside PM concentrations were lower and more stable than the outside PM concentrations.

Therefore, for a space without any indoor PM sources, the ambient PM concentration was the only factor that influenced the indoor PM concentrations. This finding was also supported by the field measurements, as presented in section 3.7 of Chapter 3. Notably, in an unoccupied space, the inside PM concentrations are normally lower than the outside PM concentrations.

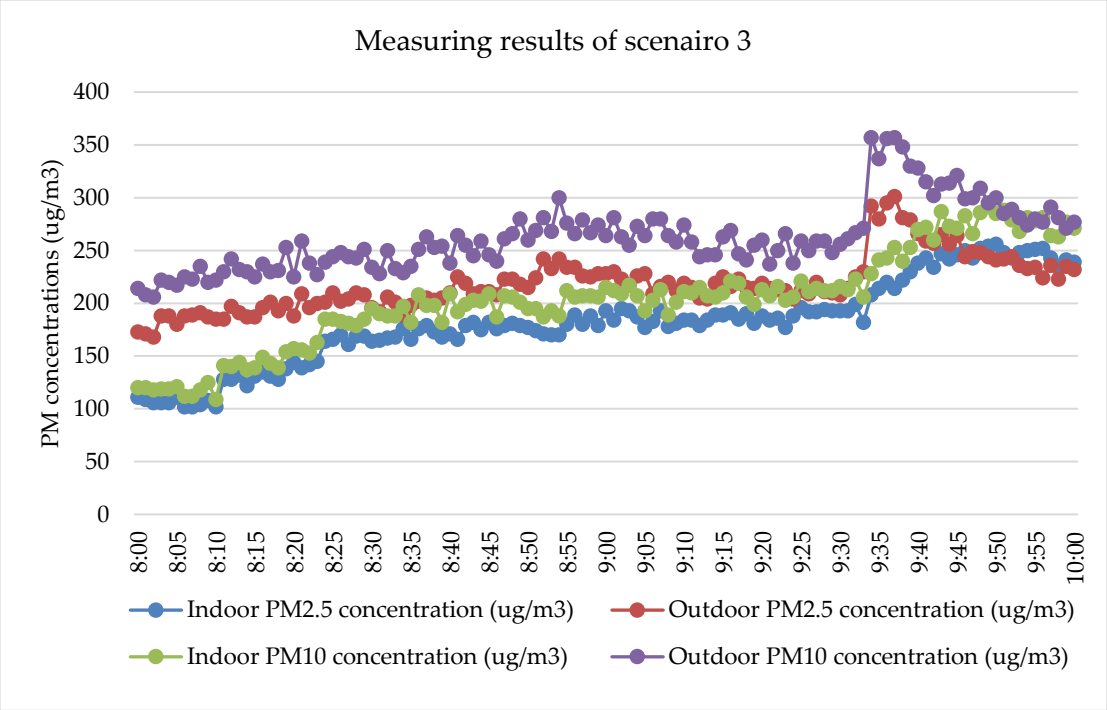


Figure 8.9. *The PM concentrations in scenario 3*

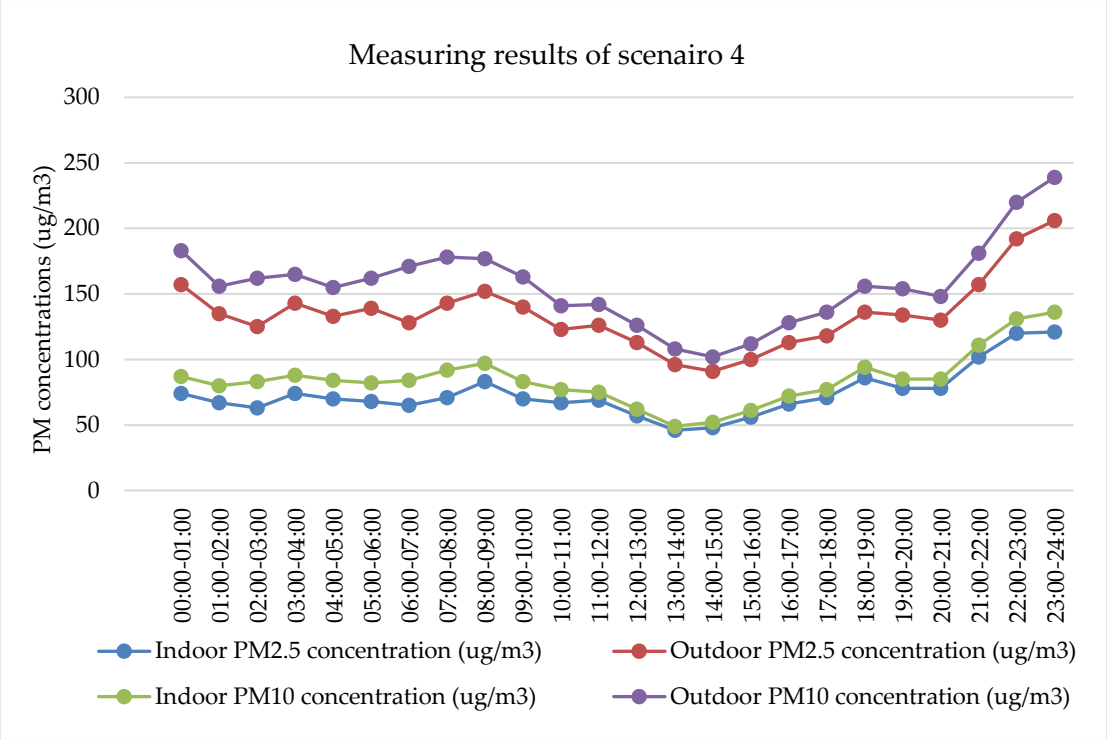


Figure 8.10. *The PM concentrations in scenario 4*

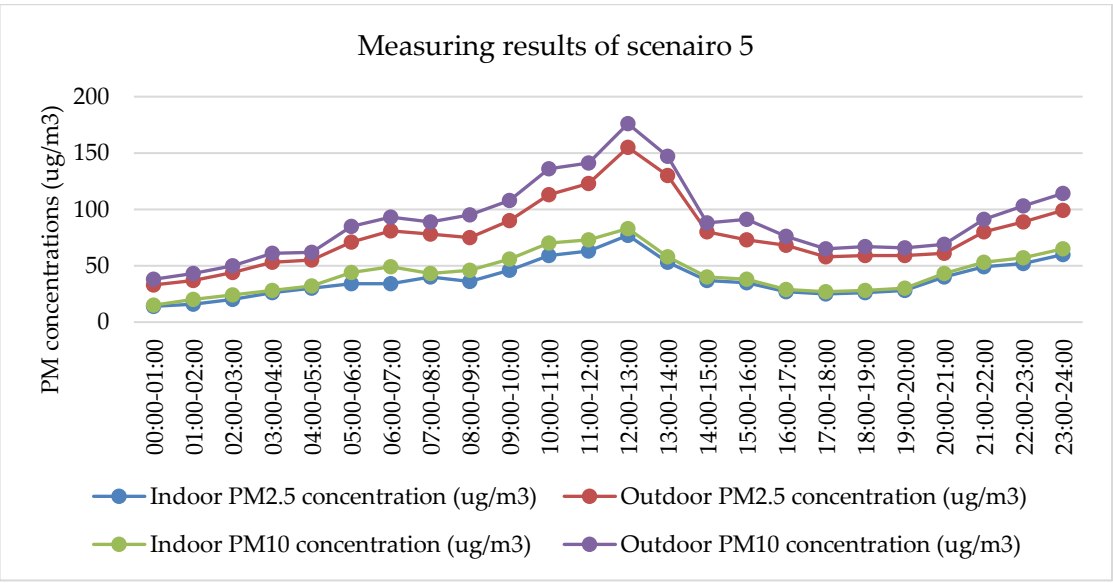


Figure 8.11. *The PM concentrations in scenario 5*

8.4.2. I/O ratios

Figures 8.12 and 8.13 compare the I/O ratios of different scenarios. Notably, a greenhouse with plants inside displays lower I/O ratios than a greenhouse without

plants inside, except in scenario 3, because the fast airflow speed deteriorated the stable inside environment and increased the resuspension of PMs.

For the greenhouse without plants in scenario 1, approximately 75% of the PMs were from the infiltration of outside PMs, and the results of scenario 2 revealed that the plants can remove approximately 30% (I/O ratio is 0.4 in scenario 2) of the PMs that infiltrated in scenario 1. The only difference between scenario 1 and scenario 2 was the presence of plants. Thus, the plants clearly increased the surface areas of the greenhouse, and more of the PMs originating from the outside landed on the surfaces of leaves.

In addition, as supported by the field measurements in Chapter 3, scenario 2 yielded a consistent conclusion: an enclosed space (e.g., classrooms or greenhouse) tends to have a lower PM concentration than the ambient environment because PM sinks in a stable indoor environment.

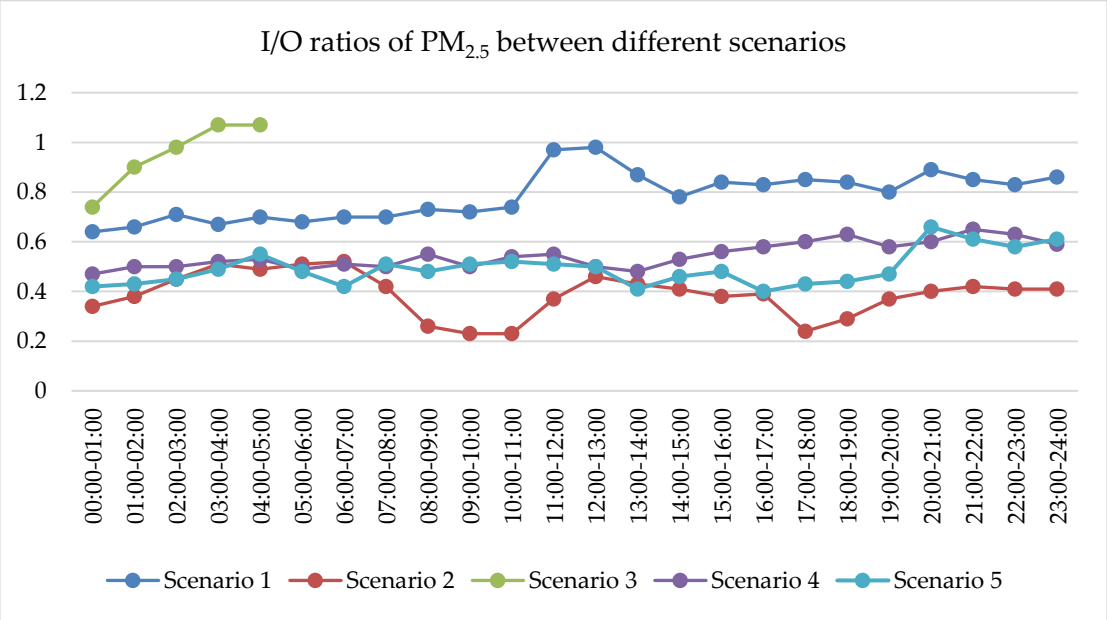


Figure 8.12. *A comparison of the I/O ratios of $PM_{2.5}$ in different scenarios*

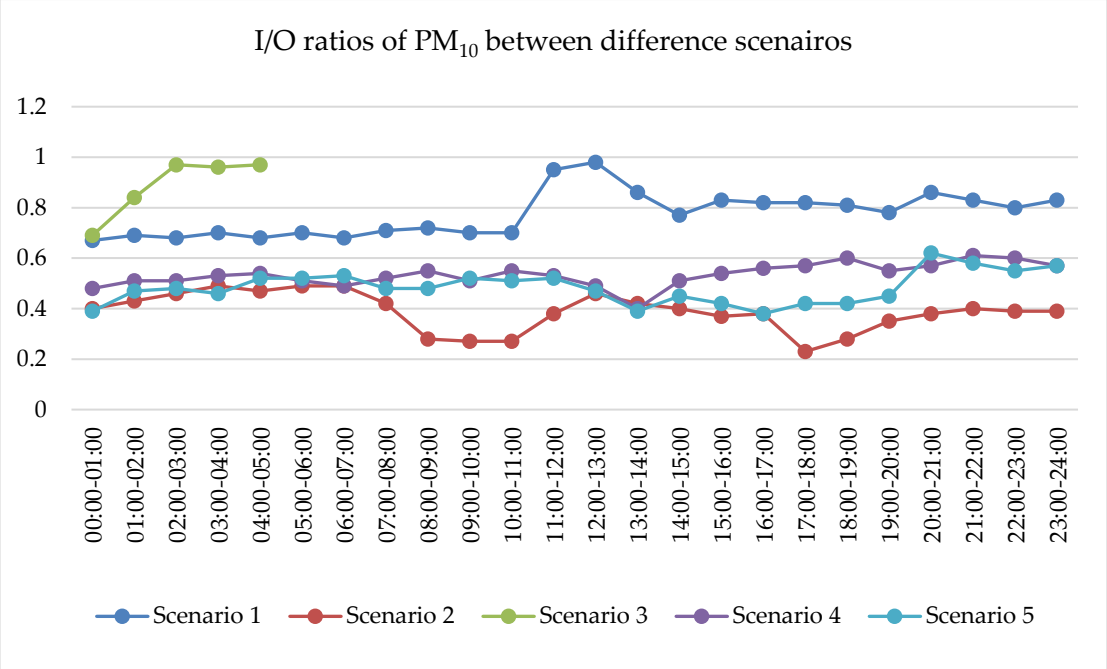


Figure 8.13. *A comparison of the I/O ratios of PM_{10} in different scenarios*

Scenarios 4 and 5 suggest that when the air flows at a relatively slow speed, a greenhouse with plants still has lower PM concentrations than those of the ambient air. A similar level of I/O ratios was observed in scenarios 4 and 5. At an air supply velocity of 0.9 m/s, scenario 5 displays the lowest average I/O ratios of $PM_{2.5}$. The average I/O ratios of PM_{10} concentrations in scenario 4 were the same to those of scenario 5.

The designed experiment includes two variables: the plants and airflow speed. The comparison between scenario 1 and scenario 2 highlighted the ability of the plants to remove PMs. The comparisons of scenarios 3, 4, and 5 revealed the effects of the airflow speed on the reducing the PM concentrations.

However, due to the limited financial resources available, the greenhouse was built with a steel framework and polyethylene films. Moreover, the polyethylene film sections of the greenhouse were connected with transparent adhesive tape (Figure 8.14), which might lead to a low level of airtightness. Considering the findings in section 3.7, if materials such as glass were used to build the greenhouse,

the airtightness level would be significantly improved. Hence, the I/O ratios could be further reduced.

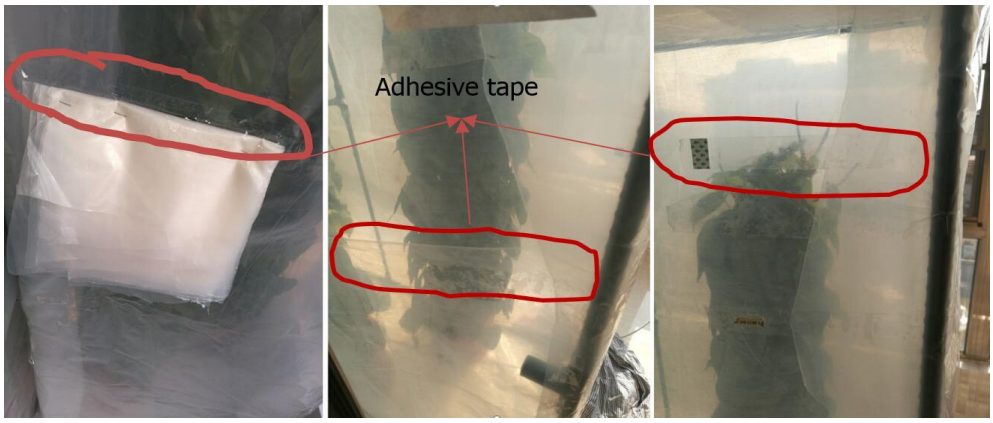


Figure 8.14. *Construction of the sunspace*

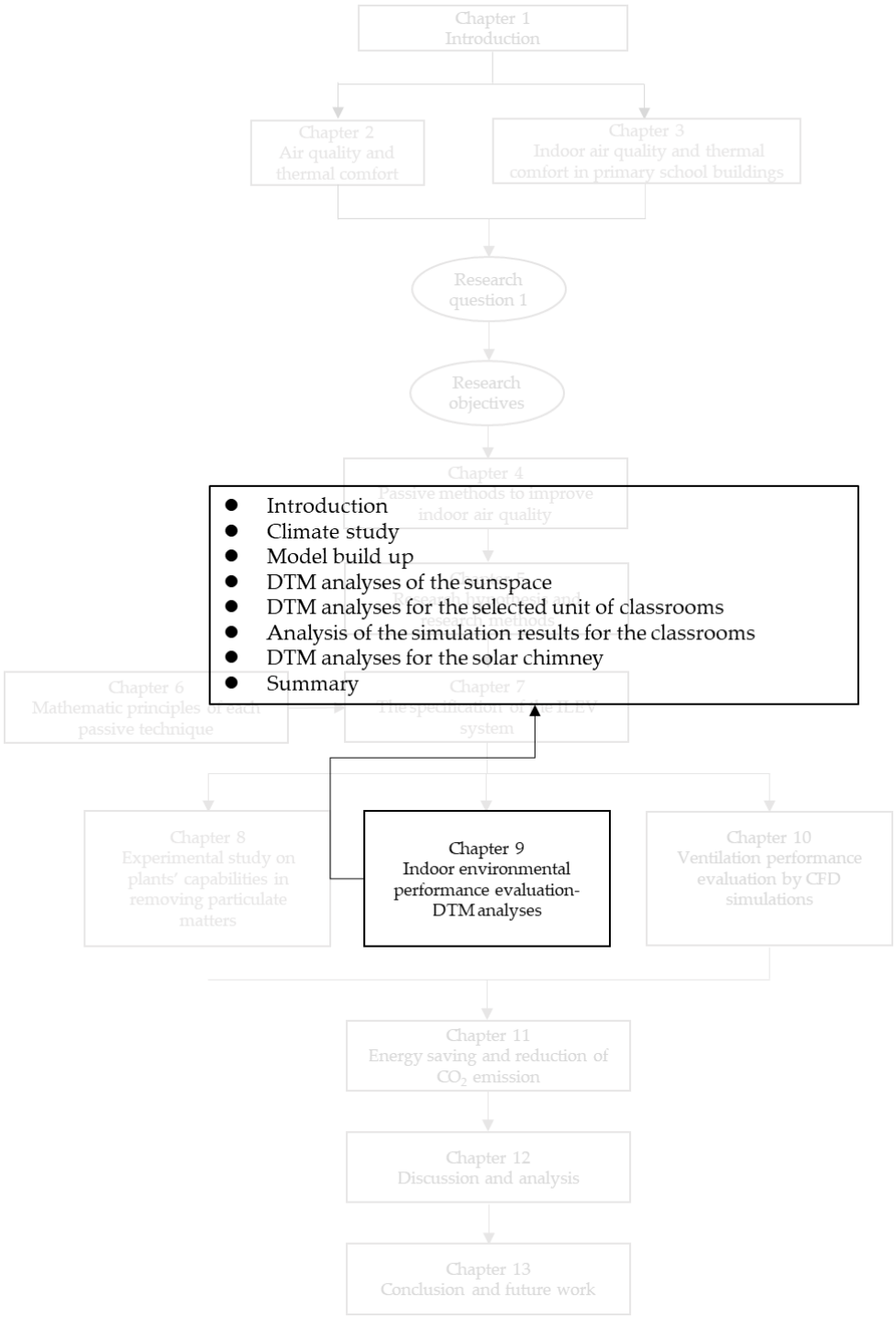
8.5. Summary

This chapter provided information about an experiment designed to evaluate the capabilities of plants to remove PMs. Overall, the measurement results yielded the following conclusions.

- An enclosed greenhouse has a lower level of PM concentration than the outside environment because the ventilation relies on infiltration.
- Plants can further reduce the inside PM concentrations because they increase the surface area of the greenhouse. Therefore, more PMs coming from outside can sink and land on the surfaces of leaves.
- The airflow speed can have adverse effects on the efficiency of PM removal by plants. A relatively slow air supply speed is beneficial for creating a stable indoor environment and increasing the efficiency of plants to reduce PM concentrations.

The next chapters will investigate the indoor thermal performance and fluidity of the ILEV system by applying the two modelling techniques presented in Chapter 5, i.e., the DTM and CFD methods. The DTM will explore the thermal performance (Chapter 9), and the modelling results will be used in CFD analyses, as presented in Chapter 10.

Chapter 9: INDOOR ENVIRONMENTAL PERFORMANCE EVALUATION BASED ON DTM ANALYSES



The content of Chapter 9

9.1. Introduction

In this chapter, DTM is performed to analyse the thermal comfort performance of the ILEV system. A climate study and an analysis of the air properties at the outlet of EAHEs form the foundation for DTM analyses of the sunspace and the classrooms. The air temperature and the relative humidity inside the sunspace will be estimated, and the results will be used as inputs in the DTM analyses of the case study building (Figure 5.7, Chapter 5). The results are then applied in the DTM analyses of the solar chimney. The following list summarises the crucial tasks addressed in this chapter:

- Identify the operational pattern of the EAHEs based on the climate study;
- Identify the air parameters of the sunspace;
- Assess the thermal comfort and IAQ of the case study building; and
- Investigate efficiency improvements for the solar chimney.

The critical classroom parameters investigated are air temperature, PMV values, relative humidity, and indoor CO_2 concentration (Appendix V). This chapter provides conclusions with regard to the overall thermal and ventilation performances of the case study building in which the ILEV system is deployed.

9.2. Climate study

A case study school building located in Tai'an city (located at 117.05 E longitude and 36.12 N latitude) was introduced in Chapter 5. The DTM analyses of the thermal comfort were performed based on the climate data set from Tai'an city.

The China Dedicated Meteorological Dataset (CDMD-SBTE), which is provided by the Climatic Data Centre of the China Meteorological Administration and Tsinghua University, includes hourly climate data for building thermal environment analysis. Meteorological data from 270 ground-based meteorological stations have been collected over the past forty years, and these data are available in Energy-Plus Weather (EPW) format, which can be input into IESVE.

Tables 9.1 to 9.3 summarise several vital parameters of Tai'an city from the data set, such as the ambient air temperature, relative humidity, and solar radiation level.

Table 9.1. The hourly average dry bulb temperature (°C) in each month

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
0:00-1:00	8.5	14.6	21.1	24.8	26.2	25.5	20.9	15.5	7.0	0.0	-1.2	1.4
1:00-2:00	8.2	14.1	20.6	24.3	25.7	25.2	20.5	15.2	6.8	0.0	-1.5	1.3
2:00-3:00	7.8	13.6	20.0	23.6	25.2	24.8	20.1	14.8	6.6	-0.1	-1.8	1.1
3:00-4:00	7.2	12.9	19.1	22.8	24.8	24.5	19.6	14.4	6.3	-0.3	-2.2	0.8
4:00-5:00	6.5	12.2	18.2	22.4	24.4	24.1	19.1	13.9	5.8	-0.6	-2.7	0.4
5:00-6:00	5.9	11.9	17.8	22.7	24.3	23.9	18.8	13.5	5.4	-1.0	-3.2	0.1
6:00-7:00	5.6	12.2	18.0	23.5	24.5	24.1	18.7	13.3	5.0	-1.3	-3.5	-0.1
7:00-8:00	5.8	13.0	18.9	24.6	25.1	24.5	19.4	13.7	4.9	-1.5	-3.6	0.2
8:00-9:00	6.7	14.1	19.9	25.8	25.9	25.2	20.7	14.7	6.3	-0.7	-3	1.0
9:00-10:00	7.6	15.1	20.9	26.9	26.7	26.0	21.9	15.8	8.2	0.4	-2	2.2
10:00-11:00	8.5	16.2	21.7	27.8	27.4	26.8	23.1	16.8	9.7	1.6	-1	3.3
11:00-12:00	9.5	17.1	22.5	28.6	28.0	27.6	24.1	17.7	10.8	2.8	0.1	4.4
12:00-13:00	10.5	18.1	23.2	29.2	28.6	28.4	25.0	18.6	11.6	3.8	1.1	5.5
13:00-14:00	11.5	19.0	24.1	29.7	29.2	29.0	25.8	19.4	12.1	4.6	2.0	6.5
14:00-15:00	12.5	19.8	25.0	30.3	29.6	29.5	26.5	20.1	12.5	5.0	2.7	7.3
15:00-16:00	13.2	20.2	25.7	30.6	29.7	29.7	26.8	20.4	12.7	5.1	3.2	7.6
16:00-17:00	12.9	19.7	25.5	30.1	29.2	29.3	26.4	20.0	12.2	4.6	2.9	7.2
17:00-18:00	12.3	18.7	24.8	29.3	28.5	28.6	25.6	19.2	11.2	3.7	2.4	6.2
18:00-19:00	11.5	17.6	23.9	28.4	28.0	27.9	24.6	18.2	10.0	2.6	1.7	5.1
19:00-20:00	10.7	16.6	23.2	27.5	27.7	27.2	23.6	17.3	8.9	1.6	0.9	3.9
20:00-21:00	10.0	16.0	22.5	26.7	27.4	26.7	22.8	16.6	8.0	0.7	0.2	2.9
21:00-22:00	9.7	15.6	22.1	26.2	27.2	26.3	22.1	16.1	7.5	0.2	-0.3	2.3
22:00-23:00	9.5	15.2	21.8	25.7	26.9	25.9	21.6	15.8	7.2	0.0	-0.7	1.9
23:00-24:00	9.3	14.9	21.6	25.3	26.6	25.6	21.2	15.4	7.0	0.0	-1.1	1.7

Source: China Dedicated Meteorological Data Set for Building Thermal Environment Analysis (2005).

Table 9.2. The hourly average solar radiation level (W/m^2) in each month

	Mar	Apr	Ma	Jun	Jul	Au	Sep	Oct	No	Dec	Jan	Feb
0:00-1:00	0											
1:00-2:00												
2:00-3:00												
3:00-4:00												
4:00-5:00												
5:00-6:00	0			11	1	0						
6:00-7:00	0	64	149	156	100	76	6	0				
7:00-8:00	139	199	226	230	118	86	139	60				40
8:00-9:00	212	253	343	270	188	194	161	112	130	139	149	150
9:00-10:00	229	343	390	315	182	238	200	228	111	162	186	159
10:00-11:00	287	266	484	342	226	278	191	324	158	293	248	196
11:00-12:00	375	451	467	329	264	244	226	311	284	233	218	277
12:00-13:00	327	412	482	388	199	309	300	320	357	233	245	288
13:00-14:00	349	402	492	363	237	305	334	352	315	230	255	317
14:00-15:00	336	438	511	378	248	376	269	374	334	317	254	215
15:00-16:00	324	403	482	424	281	327	131	310	274	138	274	247
16:00-17:00	379	397	450	382	294	315	312	196	26	0	98	238
17:00-18:00	101	322	417	311	250	265	117	0				
18:00-19:00	0		90	210	160	25	0					
19:00-20:00	0											
20:00-21:00												
21:00-22:00												
22:00-23:00												
23:00-24:00												

Source: China Dedicated Meteorological Data Set for Building Thermal Environment Analysis (2005).

Table 9.3. The hourly average ambient air relative humidity in each month

	Mar	Apr	Ma	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
0:00-1:00	47	52	49	63	84	85	76	68	58	59	56	59
1:00-2:00	47	52	50	64	86	85	78	69	58	58	57	60
2:00-3:00	48	52	51	65	87	86	79	70	59	58	58	61
3:00-4:00	50	53	53	65	88	87	80	72	59	58	60	62
4:00-5:00	51	53	54	65	88	87	80	73	60	59	62	63
5:00-6:00	53	52	55	65	88	88	80	74	60	60	63	63
6:00-7:00	55	52	56	64	88	87	80	75	60	61	64	64
7:00-8:00	55	51	56	63	87	86	78	74	59	61	64	63
8:00-9:00	54	49	55	61	85	84	75	72	58	60	63	61
9:00-10:00	51	46	52	58	82	80	71	68	55	57	60	58
10:00-11:00	48	44	49	55	79	76	67	64	51	54	57	55
11:00-12:00	43	41	46	52	75	72	62	58	48	50	52	51
12:00-13:00	39	38	43	50	72	68	58	53	44	47	48	47
13:00-14:00	35	37	40	48	70	65	55	49	42	45	45	44
14:00-15:00	33	36	38	47	68	63	53	47	40	44	42	42
15:00-16:00	32	37	38	46	68	63	53	46	41	45	41	43
16:00-17:00	33	38	38	47	68	65	54	47	43	47	42	44
17:00-18:00	35	40	40	49	70	68	56	50	45	40	43	47
18:00-19:00	37	43	42	51	71	71	59	53	49	54	45	50

19:00-20:00	39	46	44	53	74	75	63	56	52	57	48	54
20:00-21:00	42	48	46	56	76	78	66	59	55	59	50	56
21:00-22:00	43	50	48	58	78	81	69	62	57	61	52	58
22:00-23:00	44	51	49	60	80	83	71	64	58	61	53	59
23:00-24:00	45	51	50	61	83	84	73	66	59	60	54	59

Source: China Dedicated Meteorological Data Set for Building Thermal Environment Analysis (2005).

9.3. Model build up

A model with essential information, including the building construction specifications, internal heat gains, occupancy profiles, and climate data, was built in IESVE, as shown in Figure 9.1. The model contains three major parts: the studied primary school building, the solar chimney, and the sunspace. The case study building has six ILEV systems to serve the 24 classrooms.

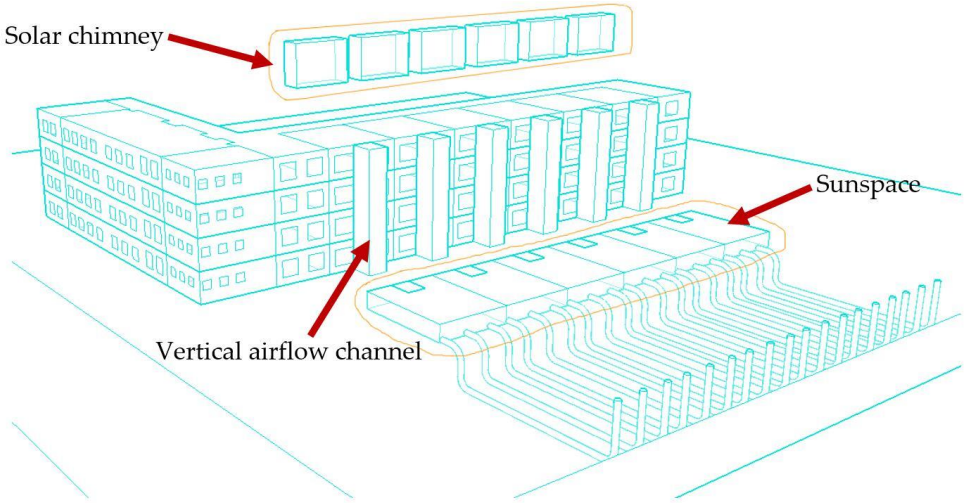


Figure 9.1. *The model of the case study building in IESVE*

To obtain the air properties of the air supplied to the classrooms, DTM analyses of the sunspace were performed. Then, the results were used as inputs in subsequent DTM analyses of the selected unit in the case study building (Figure 9.2).

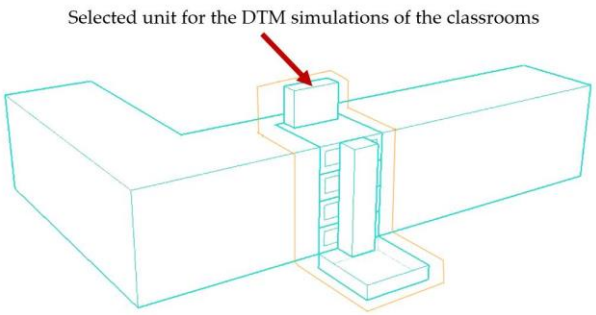


Figure 9.2. *Selected unit for the DTM analyses of the classrooms*

9.4. DTM analysis of the sunspace

9.4.1. Profiles for the DTM analyses of the sunspace

Following the introduction of the size and construction specifications of the sunspace in section 7.4, this section introduces the operating profiles for the supplied air in each month. In IESVE, the daily profile is directly related to the daily control of the ILEV system, and the results are imported and used for the weekly profile and yearly profile. Moreover, it is assumed that the plants have no effects on the air temperature and relative humidity inside the sunspace. Therefore, only heat gain from solar radiation influences the air temperature and relative humidity inside the sunspace.

The climate data in section 9.2 show that the air temperatures in winter months are relatively low (1.3°C on average, Table 9.1); therefore, the EAHEs must preheat the supplied air during school hours and maintain a suitable inside environment for the plants to survive and grow during unoccupied periods. Therefore, in December, January, and February, EAHEs will be in operation throughout the day, and the supplied air temperature is 15.7°C (Figure 9.3 and Figure 9.4).

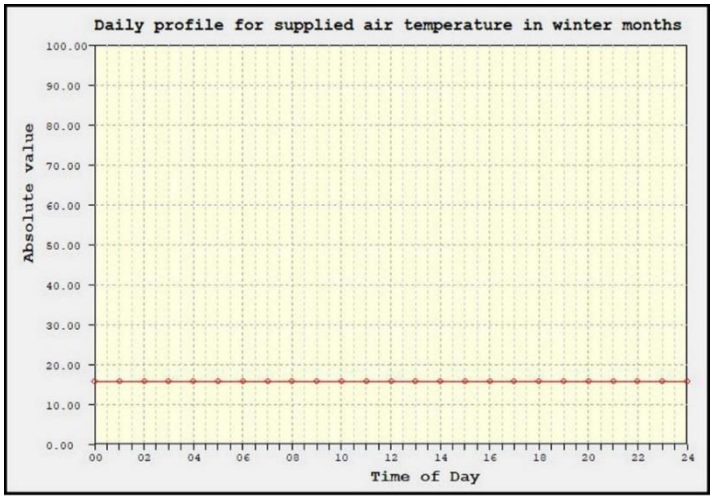


Figure 9.3. *Daily controlling profile of the supplied air temperature in winter months*

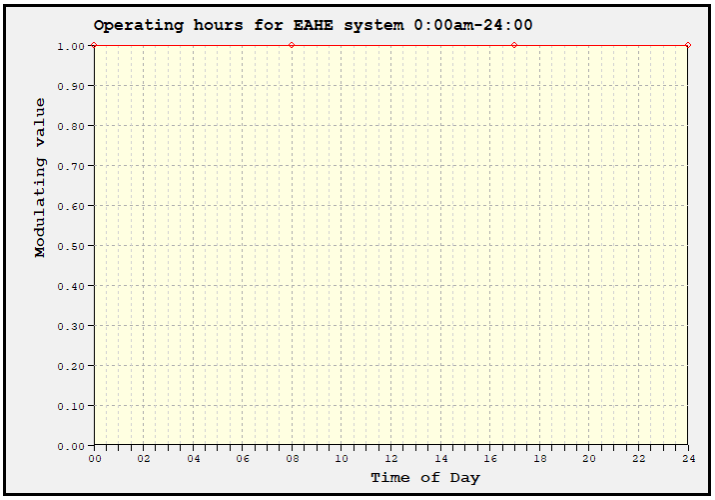


Figure 9.4. *Operating controlling profile for the EAHEs in winter months*

In summer, ambient air temperatures during school hours range from 24°C to 30.6°C (Table 9.1, section 9.2), which are already above the thermal comfort requirement of the indoor environment. Therefore, EAHEs should precool the supplied air during school hours. In unoccupied periods, the EAHEs will not be in operation because the ambient air temperatures are within the suitable range for plants (10°C to 30°C) (Table 9.1, section 9.2). Therefore, the ventilation of the sunspace during unoccupied periods only relies on infiltration, which is beneficial for maintaining low inside PM concentrations. Figures 9.5 and 9.8 show the daily profiles of the supplied air temperature and the operating profile of EAHEs in summer.

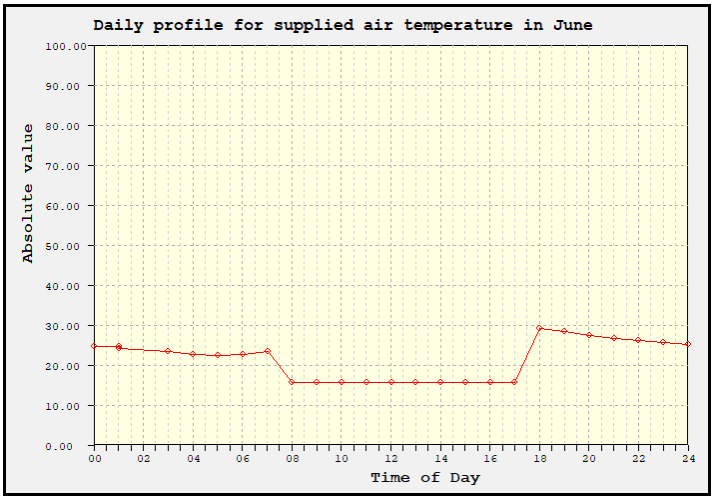


Figure 9.5. *Daily temperature profile for the sunspace in June*

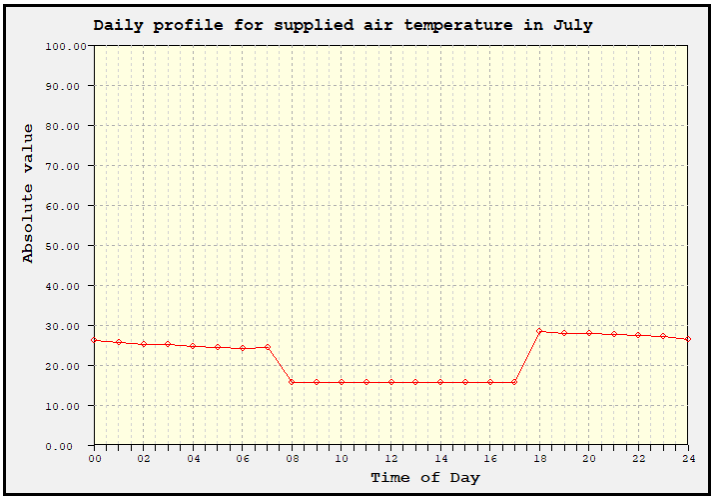


Figure 9.6. *Daily temperature profile for the sunspace in July*

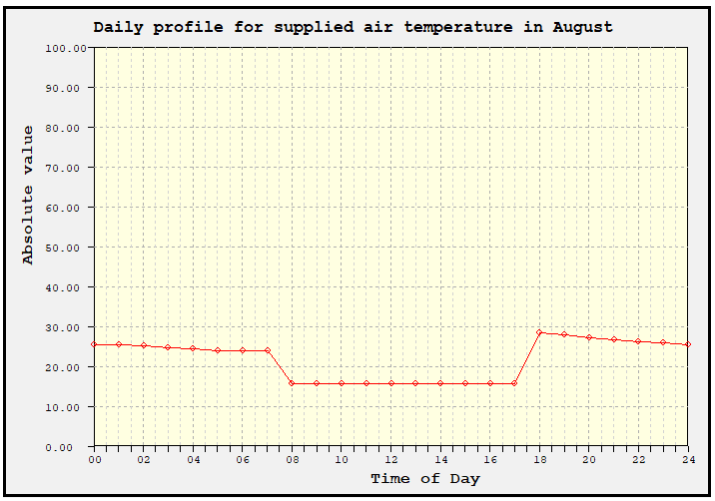


Figure 9.7. *Daily temperature profile for the sunspace in August*

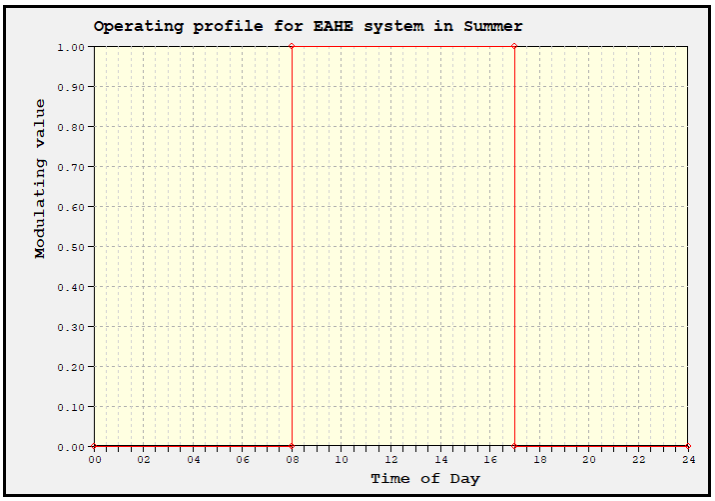


Figure 9.8. *Operating controlling profile of EAHEs in summer*

In March and November, the ambient air temperatures are higher than those in winter months but still lower than 10°C, except between 12:00 am and 21:00 pm in March and 11:00 am to 19:00 pm in November. To simplify the operating process of the ILEV system and maintain the air temperature at a comfort level for the plants inside the sunspace, EAHEs should be in operation throughout the day in these two months. Figures 9.9 and 9.10 illustrate the daily profile of the supplied air temperature and the operating profile of EAHEs in March and November.

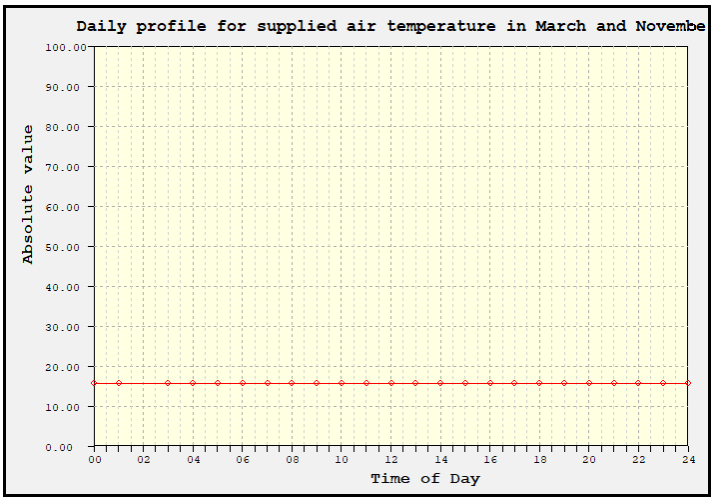


Figure 9.9. *Daily temperature profile for the sunspace in March and November*

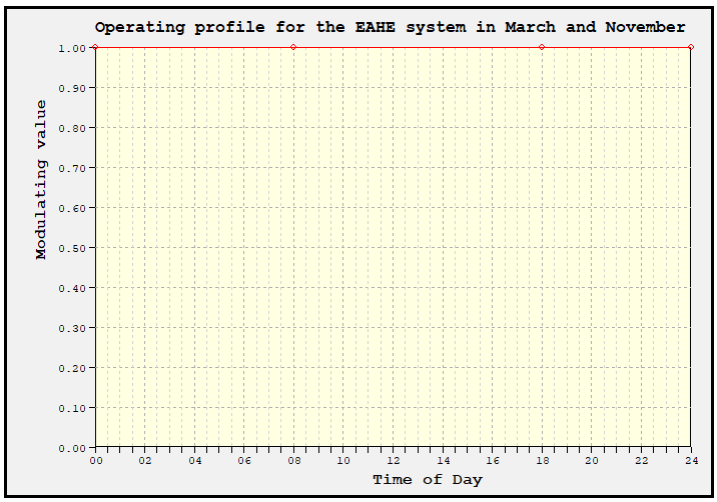


Figure 9.10. *Operating profile of the EAHEs in March and November*

In April and October, the average ambient air temperatures are 20.2°C and 20.4°C, respectively (Table 9.1, section 9.2). The air temperatures in these two months are suitable for plant growth. Thus, ambient air should directly flow into the sunspace

during occupied periods. In unoccupied periods, the ventilation of the sunspace only requires infiltration, which reduces the level of incoming ambient PMs and the energy consumption of the fan. Figures 9.11 to 9.13 show the daily profiles of the supplied air temperature and the operating profile of EAHEs in April and October.

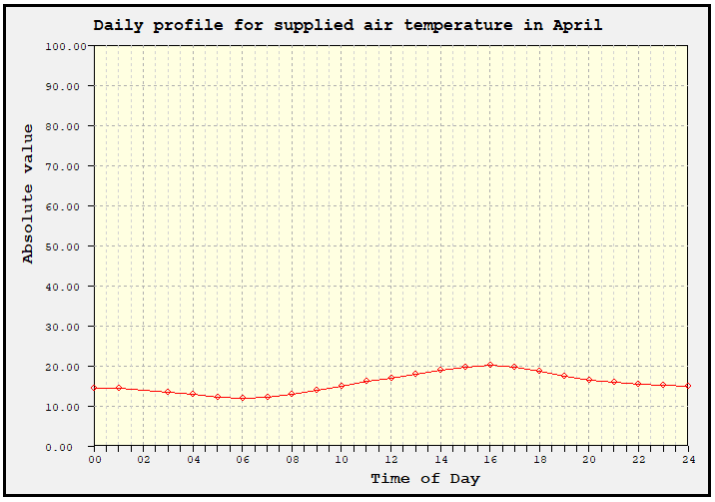


Figure 9.11. *Daily temperature profile for the sunspace in April*

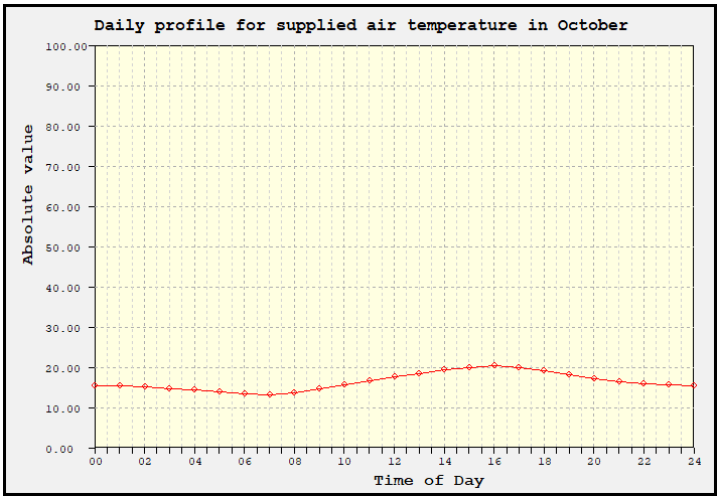


Figure 9.12. *Daily temperature profile for the sunspace in October*

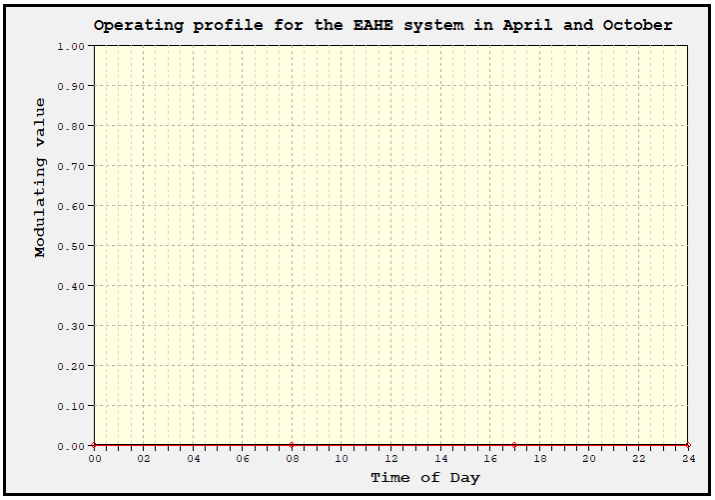


Figure 9.13. *Operating profile of the EAHEs in April and October*

In May and September, the ambient air temperatures in the occupied periods range from 19.9°C to 25.7°C and 20.7°C to 26.8°C, respectively, and these temperatures meet the minimum thermal requirements of the indoor environment (Table 9.1, section 9.2). Moreover, the air temperature will increase after entering the classrooms because of the internal heat gains. Therefore, to simplify the operating process, EAHEs should precool the ambient air during occupied periods in May and September before it enters the sunspace. In unoccupied periods, ambient air temperatures are within a range (between17.8°C and 25.6°C, Table 9.1, section 9.2) that is suitable for the plant growth and daily activities; thus, there is no air supply for the sunspace during unoccupied periods. This approach is beneficial for controlling the PM concentration in the sunspace and reducing energy consumption of the fan. Figures 9.14 to 9.16 show the daily profiles of the supplied air temperature and the operating profile of EAHEs in May and September.

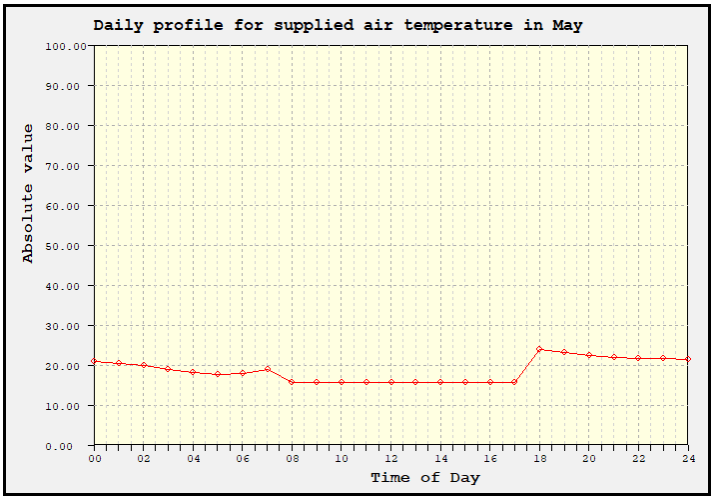


Figure 9.14. *Daily temperature profile for the sunspace in May*

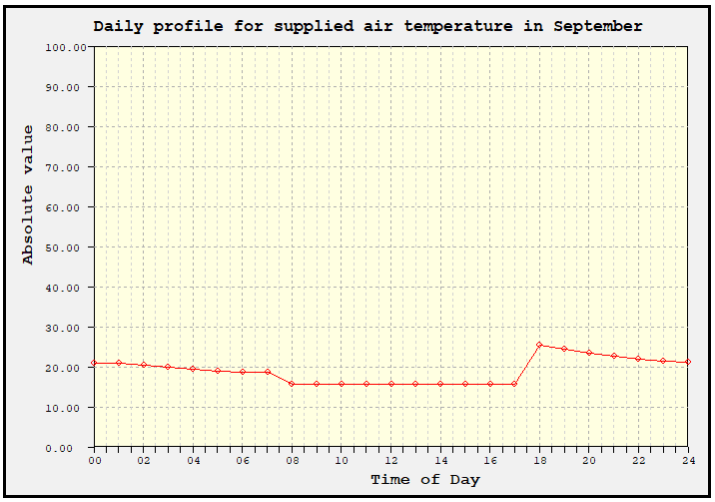


Figure 9.15. *Daily temperature profile for the sunspace in September*

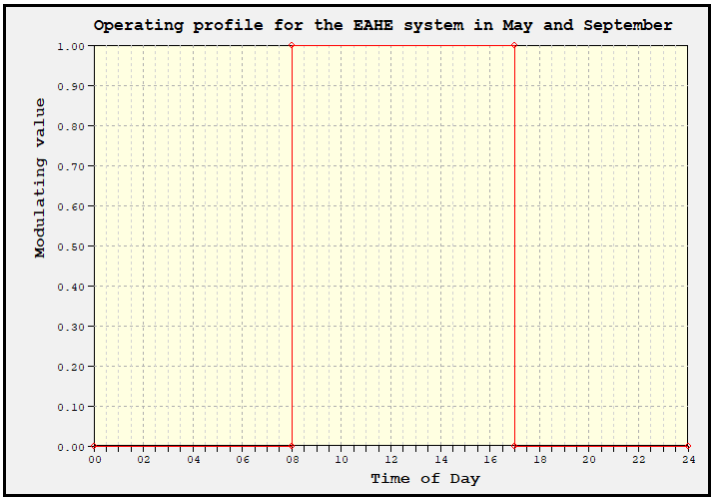


Figure 9.16. *Operating profile of the EAHEs in May and September*

9.4.2. Properties of supplied air for the sunspace

Based on the analyses in section 9.4.1, the operation of the EAHEs leads to different air properties at the outlet of the buried pipes, as indicated in Tables 9.4 and 9.5. For example, in April and October, the air temperatures are the same as the ambient air temperatures, and in other months, the air temperature is equal to the undisturbed soil temperature (15.7°C).

Table 9.4. Temperature of supplied air for the sunspace

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
0:00-1:00	15.7								15.7			
1:00-2:00												
2:00-3:00												
3:00-4:00												
4:00-5:00												
5:00-6:00												
6:00-7:00												
7:00-8:00												
8:00-9:00		14.1	15.7					14.7				
9:00-10:00		15.1						15.8				
10:00-11:00		16.2						16.8				
11:00-12:00		17.1						17.7				
12:00-13:00		18.1						18.6				
13:00-14:00		19.0						19.4				
14:00-15:00		19.8						20.1				
15:00-16:00		20.2						20.4				
16:00-17:00		19.7						20.0				
17:00-18:00												
18:00-19:00												
19:00-20:00												
20:00-21:00												
21:00-22:00												
22:00-23:00												
23:00-24:00												

Water condensation usually occurs when the EAHEs precool the supplied air. According to the guideline values from the CIAQS-2002, the relative humidity of the air in an indoor environment should be maintained between 30% and 60% in winter and 40% and 80% in summer. Moreover, there are no building regulations for the relative humidity in spring and autumn. Therefore, it is assumed that the acceptable humidity range is between 30% and 80% in spring and autumn. Based on the climate data in Tables 9.1 to 9.3, a psychrometric chart (Figure 9.17) was

used to estimate the relative humidity of the supplied air at the outlet of the buried pipes. Based on the psychrometric analysis, the relative humidity values are given in Table 9.5.

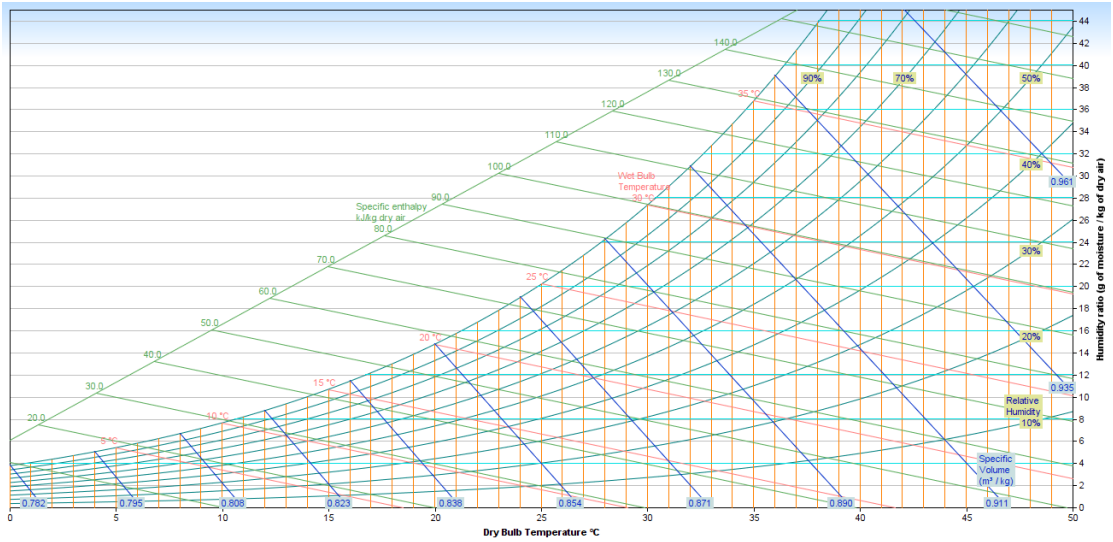


***Figure 9.17. The** psychrometric chart used to estimate the relative humidity*

Table 9.5. Relative humidity of the supplied air at the outlet of the EAHEs

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
0:00-1:00	29.2								32.6	20.2	17.6	22.4
1:00-2:00	29								32.1	19.9	17.5	22.6
2:00-3:00	28								32.2	19.7	17.4	22.6
3:00-4:00	28								31.6	19.4	17.5	22.5
4:00-5:00	27.7								31.0	19.4	17.4	22.2
5:00-6:00	27.6								30.2	19.1	17.1	21.7
6:00-7:00	28.1								29.4	19	16.9	21.8
7:00-8:00	28.4								28.7	18.7	16.8	21.9
8:00-9:00	29.7	49	71.7	100				72	31.1	19.5	17.3	22.5
9:00-10:00	29.8	46	72.1					68	33.5	20.1	17.8	23.3
10:00-11:00	29.8	44	71.3					64	34.4	20.8	18.2	23.9
11:00-12:00	28.6	41	70.3					58	34.9	21.0	17.9	23.9
12:00-13:00	27.8	38	68.6					53	33.7	21.1	17.8	23.8
13:00-14:00	26.6	37	67.3					49	33.2	21.4	17.8	23.9
14:00-15:00	26.8	36	67.5					47	32.5	21.5	17.5	24.1
15:00-16:00	27.2	37	70.4					46	33.8	22.2	17.7	25.2
16:00-17:00	27.5	38	69.5					47	34.3	22.4	17.7	25.1
17:00-18:00	28.1								33.6	17.9	17.5	25.0
18:00-19:00	28.1								33.7	22.3	17.4	24.6
19:00-20:00	28.1								33.2	21.9	17.6	24.5
20:00-21:00	28.9								33.1	21.2	17.4	23.3
21:00-22:00	29								33.1	21.2	17.4	23.5
22:00-23:00	29.3								33.0	20.9	17.3	23.2
23:00-24:00	29.6								33.1	20.6	17.1	22.9

Table 9.5 shows that in summer, water condensation occurs, and the average value during school hours is 100%. Typically, passive measures, such as passive drainage, can remove the water from EAHEs at sites where the water table is sufficiently deep and the soil has relatively high permeability. However, at some sites where passive drainage is not feasible, active measures, such as condensation towers or dehumidifiers, are the primary options for removing the condensed water. Figure 9.18 shows an example that uses a condensation tower to remove the condensed moisture. Typically, the buried pipes have an inclination angle of 1-3% so that the condensate water can directly flow to the lowest point, where the condensation tower is located (Elena et al., n.d.).

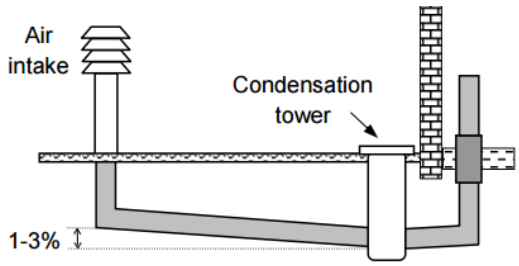


Figure 9.18. *The method used to remove condensed moisture*

Source: Elena et al. (n.d.)

In addition to removing the condensed water, the excessive humidity at the outlet of the EAHEs can be reduced by a desiccant or dehumidifier system. Desiccant dehumidification, such as that with silica gel, relies on adsorption or absorption. The desiccant absorbs water-vapor molecules from the air and reduces the relative humidity. The problem with desiccants is that they will stop absorbing when they reach saturation. Therefore, regular replacement is essential. In addition to traditional desiccants, some advanced desiccant-based dehumidification systems can also decrease the humidity of supplied air. For example, the "solid" desiccant dehumidification wheel, developed by Trane, an engineering company from the UK, can be applied (Figure 9.19).

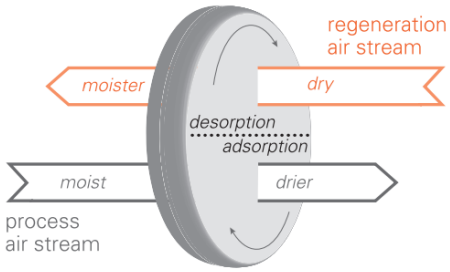


Figure 9.19. *"Solid" -desiccant dehumidification wheel*

Source: Trane (n.d.), https://www.trane.com/index.aspx

In this study, traditional desiccant dehumidification is a better choice for the sunspace since it removes the excess water vapor from the air in a more stable way. Therefore, this approach will benefit PM removal by plants in a relatively stable indoor sunspace environment.

In March, November and winter months, the supplied air at the outlet has a relatively low relative humidity, with a minimum value of 16.8%, and maximum value of 29.8%. The average values in these months are 20.5%, 17.5%, 28.4%, and 24%. In April, the value is a slightly higher than those in March and November. However, considering the reheating due to the solar heat gains in the sunspace, the relative humidity will further decrease to the same level as in March and November. Thus, the humidity of the supplied air in these months should be increased to meet the highest requirements of the CIAQS-2002.

In practice, many methods are available to increase the relative humidity of the air. For example, it is possible to install humidifiers inside the sunspace. Some passive methods are also feasible. For example, a shallow pan of water can be placed in the centre of the sunspace. Alternatively, a spray bottle can be used to create a fine mist inside the sunspace.

In this study, theoretically, the relative humidity of the air will decrease after it enters the sunspace due to the reheating by solar heat gains. Therefore, in this study, the relative humidity of the air at the outlet of the EAHEs in summer can

be directly used as an input for the estimation of the relative humidity inside classrooms. Dehumidification will be discussed later based on the simulation results of the DTM analyses of the sunspace.

9.4.3. DTM results for the sunspace

9.4.3.1. DTM results in winter

Tables 9.6 and 9.7, and Figures 9.20 and 9.21 present the DTM results of the sunspace in winter months. The average hourly air temperature in these three months was approximately 14.5°C. The highest and the lowest air temperatures during school hours were 15.65°C and 14°C, respectively. During the unoccupied periods, the air temperature inside the sunspace was between 14.35°C and 14.71°C on average.

Table 9.6. The hourly average air temperature in the sunspace in winter

	December	January	February
0:00-1:00	14.34	14.47	14.67
1:00-2:00	14.34	14.46	14.66
2:00-3:00	14.33	14.44	14.66
3:00-4:00	14.33	14.43	14.64
4:00-5:00	14.31	14.41	14.62
5:00-6:00	14.29	14.37	14.60
6:00-7:00	14.27	14.35	14.59
7:00-8:00	14.27	14.34	14.61
8:00-9:00	14.00	14.06	14.44
9:00-10:00	14.19	14.32	14.69
10:00-11:00	14.52	14.69	14.99
11:00-12:00	14.70	14.97	15.35
12:00-13:00	14.83	15.18	15.57
13:00-14:00	14.90	15.27	15.65
14:00-15:00	14.88	15.19	15.50
15:00-16:00	14.68	14.96	15.34
16:00-17:00	14.48	14.68	15.14
17:00-18:00	14.32	14.46	14.87
18:00-19:00	14.49	14.63	14.92
19:00-20:00	14.47	14.61	14.86
20:00-21:00	14.42	14.57	14.80
21:00-22:00	14.38	14.54	14.75
22:00-23:00	14.35	14.52	14.72
23:00-24:00	14.34	14.49	14.70
Average	14.44	14.60	14.89
Average (occupied period)	14.58	14.81	15.19
Average (unoccupied period)	14.35	14.47	14.71

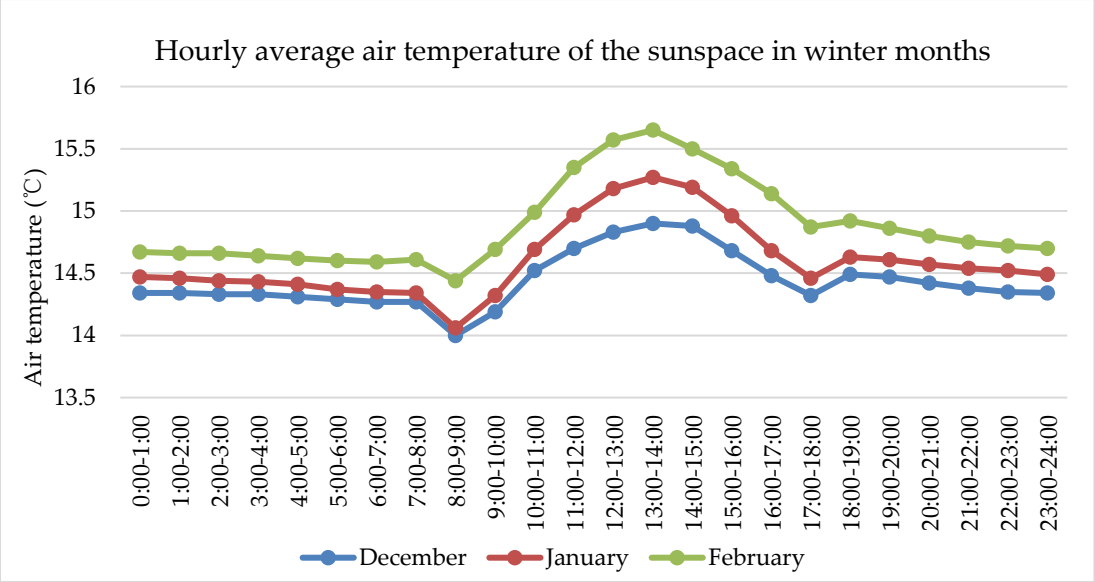


Figure 9.20. *Air temperature in the sunspace in winter months*

Table 9.7 indicates that compared with relative humidity of the air at the outlet of the buried pipes, the average relative humidity slightly increased because the air temperature slightly declined from 15.7°C to 14.5°C. However, this value is still much lower than the minimum requirement for the thermal comfort in an indoor environment (30%).

Moreover, the relative humidity will further decrease due to the reheating of the air inside the classrooms due to internal heat gains and solar heat gains. Therefore, in this study, a humidifier, which can increase the relative humidity on an as-needed basis, is recommended to use. The CIAQS-2002 sets 60% as the highest requirement for an indoor environment in the winter months. Therefore, the relative humidity of the air inside the sunspace should be increased to 60% before entering the classrooms.

Table 9.7. The hourly average relative humidity in the sunspace in winter

	December	January	February
0:00-1:00	22.5	19.8	24.6
1:00-2:00	22.2	19.7	24.9
2:00-3:00	22	19.6	24.9
3:00-4:00	21.7	19.8	25.0
4:00-5:00	21.7	19.7	24.1
5:00-6:00	21.4	19.4	24.3
6:00-7:00	21.3	19.2	24.3

7:00-8:00	21.0	19.1	24.9
8:00-9:00	22.2	20.0	24.9
9:00-10:00	22.2	20.0	24.6
10:00-11:00	22.0	19.6	23.4
11:00-12:00	22.2	18.8	22.8
12:00-13:00	21.5	18.6	22.5
13:00-14:00	21.7	18.3	23.2
14:00-15:00	21.8	18.1	24.0
15:00-16:00	22.5	18.0	25.8
16:00-17:00	24.0	18.6	26.7
17:00-18:00	24.7	19.2	26.7
18:00-19:00	23.9	19.5	26.6
19:00-20:00	24.5	19.2	26.5
20:00-21:00	24.2	19.5	25.4
21:00-22:00	23.5	19.4	25.7
22:00-23:00	23.6	19.4	25.5
23:00-24:00	23.3	19.5	24.3
Average	22.6	19.3	24.8
Average (occupied period)	22.2	18.9	24.2
Average (unoccupied period)	22.8	19.5	25.2

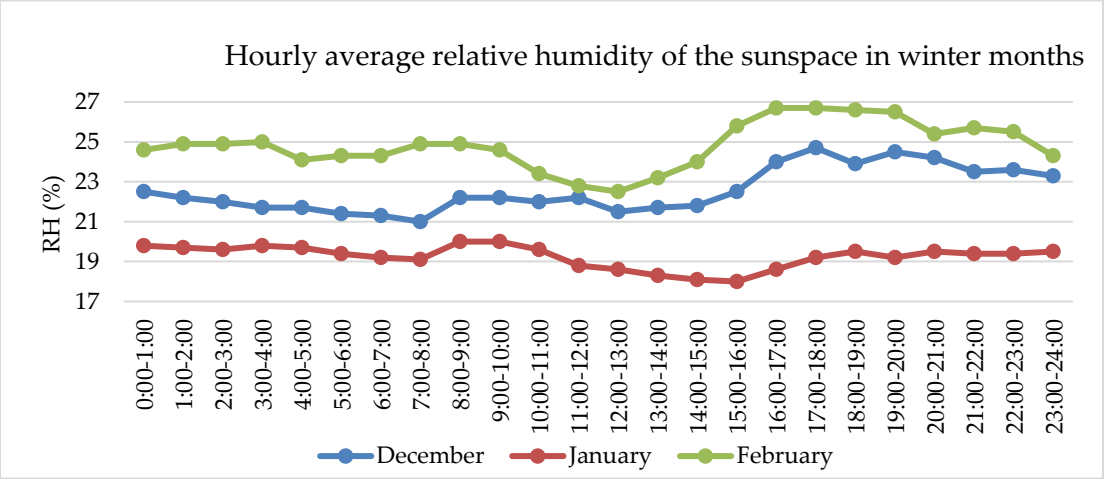


Figure 9.21. *Relative humidity in the sunspace in winter months*

9.4.3.2. DTM results in summer

Tables 9.8 and 9.9, and Figures 9.22 and 9.23 present the DTM results for the sunspace in summer. The average hourly air temperature during the school hours in summer was approximately 18.5°C, and the average air temperature in unoccupied periods was 5°C higher than the air temperature during school hours. Moreover, the highest and lowest air temperatures were 19.08°C and 18.09°C, respectively, during the occupied periods. The highest and lowest air temperatures during unoccupied periods were 24.97°C and 22.58°C, respectively.

Table 9.8. The hourly average air temperature in the sunspace in summer

	June	July	August
0:00-1:00	23.36	23.62	23.41
1:00-2:00	23.25	23.56	23.35
2:00-3:00	23.10	23.47	23.27
3:00-4:00	22.89	23.33	23.14
4:00-5:00	22.68	23.20	23.01
5:00-6:00	22.58	23.12	22.92
6:00-7:00	23.05	23.40	23.07
7:00-8:00	24.40	24.29	23.91
8:00-9:00	18.61	18.49	18.44
9:00-10:00	18.36	18.09	18.18
10:00-11:00	18.65	18.30	18.48
11:00-12:00	18.85	18.54	18.72
12:00-13:00	19.08	18.55	18.90
13:00-14:00	19.05	18.60	18.98
14:00-15:00	18.95	18.55	18.94
15:00-16:00	18.78	18.40	18.63
16:00-17:00	18.45	18.18	18.28
17:00-18:00	23.88	23.24	23.32
18:00-19:00	24.97	24.34	24.28
19:00-20:00	24.47	23.98	23.93
20:00-21:00	24.04	23.74	23.70
21:00-22:00	23.79	23.66	23.55
22:00-23:00	23.65	23.63	23.47
23:00-24:00	23.56	23.61	23.41
Average	21.77	21.66	21.64
Average (occupied period)	18.75	18.41	18.62
Average (unoccupied period)	23.47	23.48	23.45

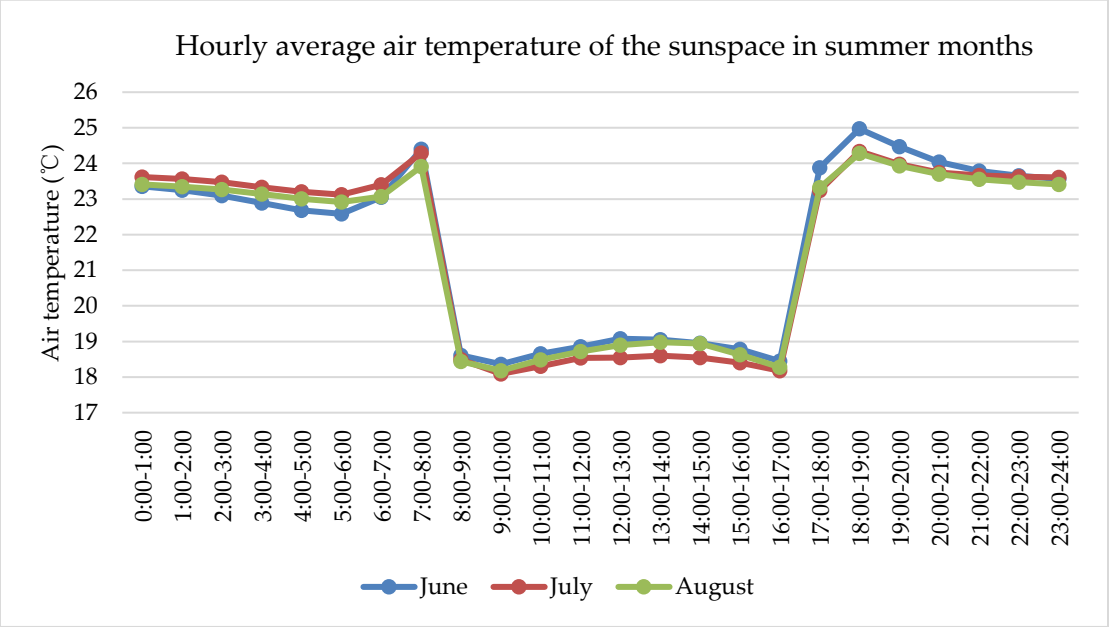


Figure 9.22. *Air temperature in the sunspace in summer*

Table 9.9 indicates that during the occupied periods, the relative humidity decreases from 100% to 80% on average since the temperature of the air increases from 15.7°C to 18.5°C due to the solar heat gains inside the sunspace. The average value was within the required range (40%-80%) of the CIAQS-2002. Thus, there is no need to adjust the relative humidity of the air before entering the classrooms. Moreover, Figure 9.23 indicates that the relative humidity inside the sunspace during the occupied periods is higher than that during the unoccupied periods because the air temperature during school hours is lower than that during unoccupied periods.

In the unoccupied periods, the air exchange between the sunspace and ambient environment occured via infiltration. Therefore, the relative humidity inside the sunspace was the same as the ambient relative humidity.

Table 9.9. The hourly average relative humidity in the sunspace in summer

	June	July	August
0:00-1:00	53.5	68.4	68.7
1:00-2:00	53.9	69.1	69.2
2:00-3:00	54.5	69.8	69.9
3:00-4:00	55.4	70.7	70.8
4:00-5:00	56.2	71.6	71.6
5:00-6:00	56.6	72.1	72.2
6:00-7:00	53.6	69.4	70.8
7:00-8:00	46.6	62.6	64.3
8:00-9:00	83.2	83.8	84.1
9:00-10:00	84.5	85.9	85.5
10:00-11:00	83.0	84.8	83.9
11:00-12:00	81.9	83.5	82.6
12:00-13:00	80.8	83.5	81.7
13:00-14:00	80.9	83.5	81.3
14:00-15:00	81.4	83.5	81.5
15:00-16:00	82.3	84.3	83.1
16:00-17:00	84.0	85.5	84.9
17:00-18:00	46.1	57.3	56.7
18:00-19:00	45.8	59.4	59.4
19:00-20:00	48.9	63.5	62.8
20:00-21:00	51.3	66.1	64.7
21:00-22:00	52.3	67.1	65.8
22:00-23:00	52.9	67.7	66.6
23:00-24:00	53.4	68.2	67.2
Average	63.5	73.4	72.9
Average (occupied period)	59.8	67.5	67.5
Average (unoccupied period)	60.1	67.9	66.7

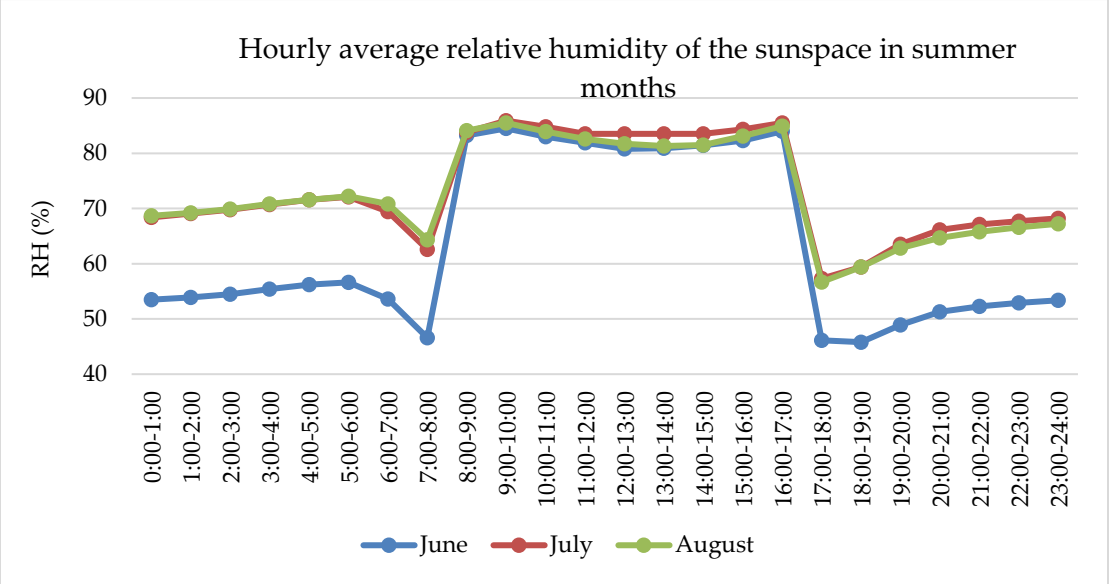


Figure 9.23. *Average relative humidity in the sunspace in summer months*

9.4.3.3. DTM results in March and November

Tables 9.10 and 9.11, and Figures 9.24 and 9.25 present the DTM results for the sunspace in March and November. The average hourly air temperature in March and November was approximately 15.4°C. Moreover, the highest and lowest air temperatures were 16.53°C and 14.85°C, respectively. During the occupied hours, the air temperature inside the sunspace was between 14.85°C and 16.53°C.

Table 9.10. The hourly average air temperature in the sunspace in March and November

	March	November
0:00-1:00	15.17	15.07
1:00-2:00	15.15	15.05
2:00-3:00	15.12	15.04
3:00-4:00	15.10	15.03
4:00-5:00	15.07	15.00
5:00-6:00	15.03	14.97
6:00-7:00	15.01	14.95
7:00-8:00	15.10	14.95
8:00-9:00	15.15	14.85
9:00-10:00	15.47	15.12
10:00-11:00	15.85	15.46
11:00-12:00	16.25	15.82
12:00-13:00	16.43	16.06
13:00-14:00	16.53	16.08
14:00-15:00	16.41	15.97
15:00-16:00	16.20	15.73
16:00-17:00	15.95	15.49
17:00-18:00	15.61	15.29

18:00-19:00	15.46	15.26
19:00-20:00	15.37	15.21
20:00-21:00	15.32	15.16
21:00-22:00	15.27	15.11
22:00-23:00	15.24	15.09
23:00-24:00	15.22	15.07
Average	15.52	15.28
Average (occupied)	16.03	15.62
Average (unoccupied)	15.22	15.08

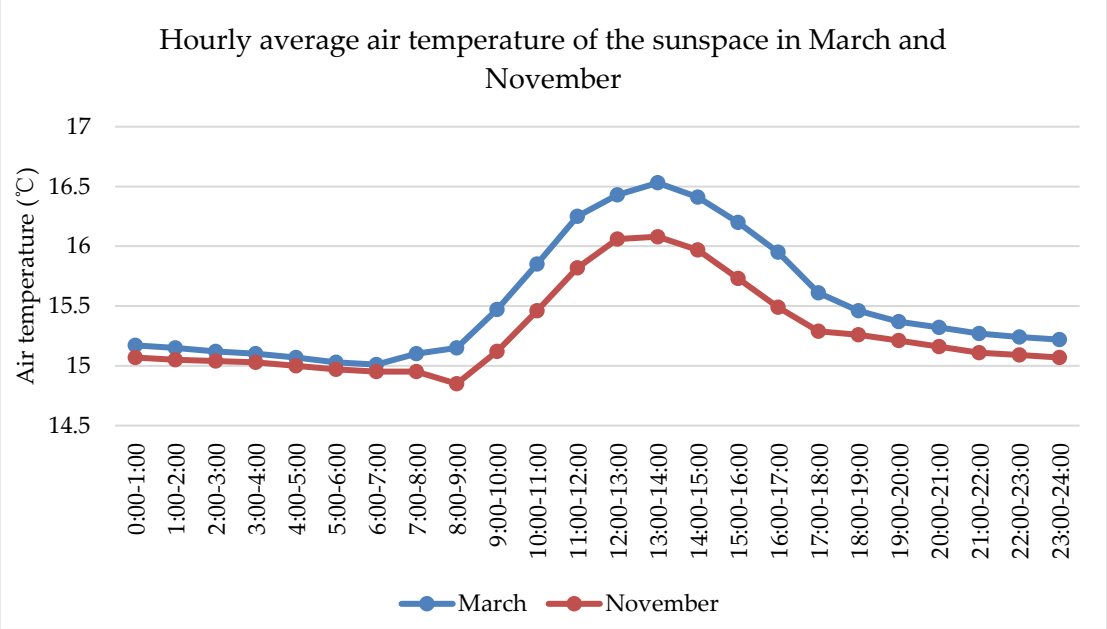


Figure 9.24. *Air temperature in the sunspace in March and November*

In March, the relative humidity of the air inside the sunspace was lower than the minimum required value established by the CIAQS-2002 (30%). In November, the relative humidity was slightly higher than the standard value. Moreover, the relative humidity will further decrease after the air enters the classrooms because of the reheating of the total heat gains (e.g., internal heat gains and solar heat gains). Thus, the relative humidity inside the sunspace should be improved to 60% because the climate characteristics in March and November are relatively similar to the weather characteristics in winter months.

Table 9.11. The hourly average relative humidity in the sunspace in March and November

	March	November
0:00-1:00	30.51	34.1
1:00-2:00	29.97	33.96
2:00-3:00	29.87	34.14

3:00-4:00	29.93	33.48
4:00-5:00	29.17	32.98
5:00-6:00	29.16	32.16
6:00-7:00	29.7	31.34
7:00-8:00	29.73	30.62
8:00-9:00	30.48	33.06
9:00-10:00	28.12	33.49
10:00-11:00	28.12	33.93
11:00-12:00	25.67	32.81
12:00-13:00	24.44	30.76
13:00-14:00	23.23	30.39
14:00-15:00	23.84	30.22
15:00-16:00	24.96	32.53
16:00-17:00	26.11	34.17
17:00-18:00	27.84	34.36
18:00-19:00	28.49	34.83
19:00-20:00	28.79	34.52
20:00-21:00	29.74	34.55
21:00-22:00	29.98	34.77
22:00-23:00	30.36	34.77
23:00-24:00	30.72	34.96
Average	28.29	33.20
Average (occupied)	26.11	32.37
Average (unoccupied)	29.60	33.70

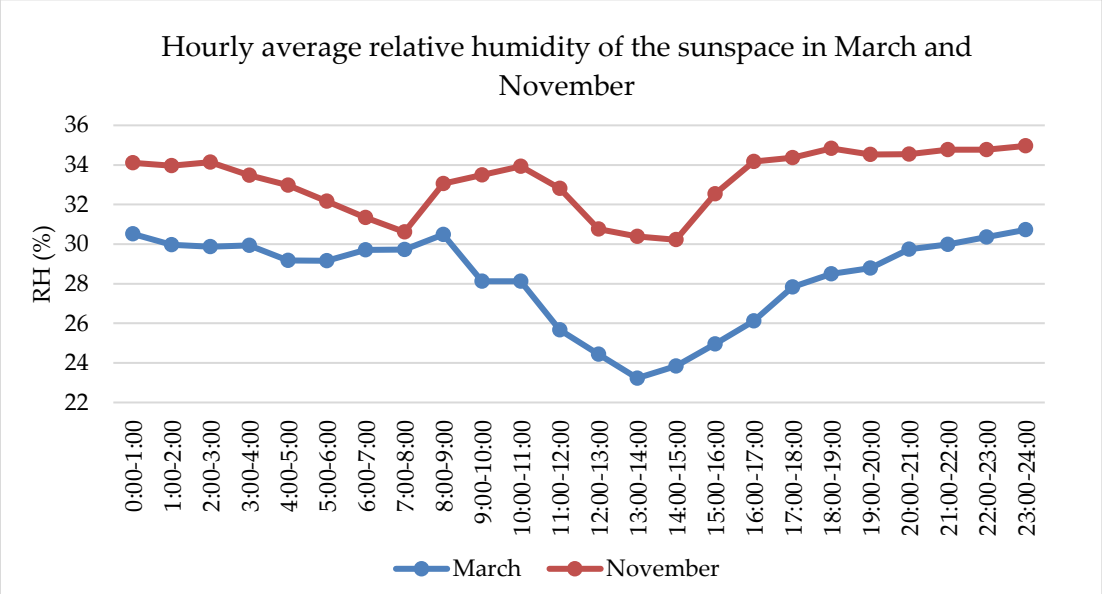


Figure 9.25. *Relative humidity in the sunspace in March and November*

9.4.3.4. DTM results in April and October

Tables 9.12 and 9.13, and Figures 9.26 and 9.27 present the DTM results for the sunspace in April and October. In the occupied periods, the inside air temperatures ranged from 14.56°C to 20.71°C. During the unoccupied periods, the

inside air temperature was between 15.28°C and 20.29°C. Figure 9.26 describes a consistent air temperature trend in April and October.

Table 9.12. The hourly average air temperature in the sunspace in April and October

	April	October
0:00-1:00	16.60	17.08
1:00-2:00	16.41	16.92
2:00-3:00	16.20	16.74
3:00-4:00	15.96	16.53
4:00-5:00	15.65	16.30
5:00-6:00	15.35	16.05
6:00-7:00	15.28	15.85
7:00-8:00	15.99	15.92
8:00-9:00	14.56	14.85
9:00-10:00	15.59	15.87
10:00-11:00	16.74	17.15
11:00-12:00	18.04	18.23
12:00-13:00	19.03	19.15
13:00-14:00	19.82	19.92
14:00-15:00	20.45	20.42
15:00-16:00	20.71	20.57
16:00-17:00	20.44	20.27
17:00-18:00	20.29	19.53
18:00-19:00	19.31	18.72
19:00-20:00	18.44	18.20
20:00-21:00	17.89	17.82
21:00-22:00	17.45	17.48
22:00-23:00	17.13	17.22
23:00-24:00	16.87	17.03
Average	17.51	17.66
Average (occupied)	18.38	18.49
Average (Unoccupied)	16.99	17.16

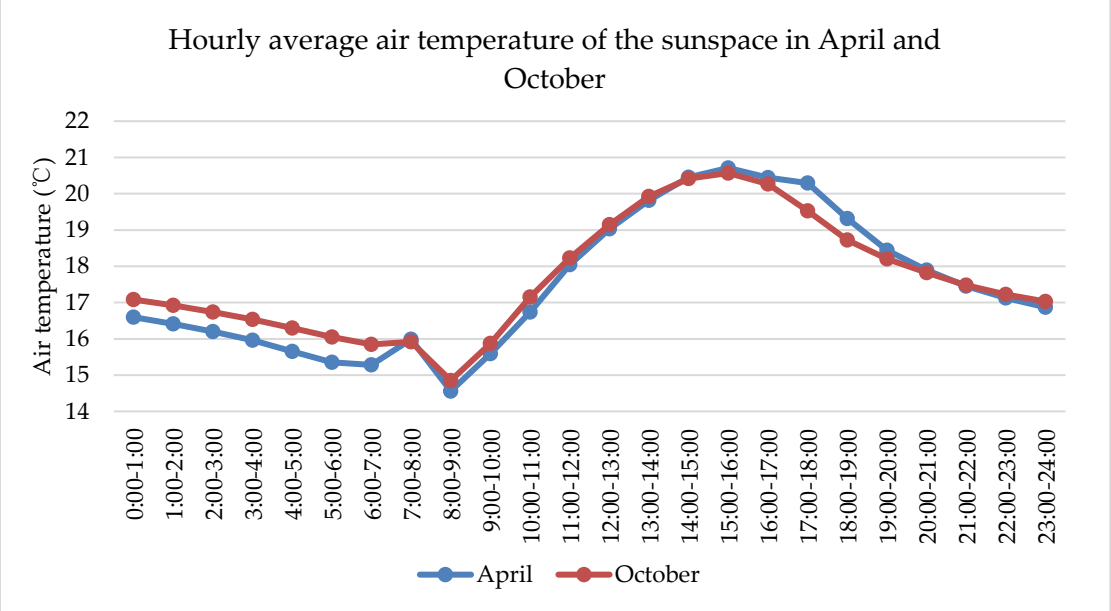


Figure 9.26. *Air temperature in the sunspace in April and October*

Table 9.13 shows that the average relative humidity inside the sunspace is approximately 40% in April and 50% in October. In the occupied periods, the relative humidity was lower than that during unoccupied periods. Since the ambient air directly flows into the sunspace; the inside relative humidity largely depends on the ambient relative humidity. Figure 9.27 illustrates a consistent trend for the average relative humidity of the air inside the sunspace in April and October.

Table 9.13. The hourly average relative humidity in the sunspace in April and October

	April	October
0:00-1:00	41.97	55.73
1:00-2:00	42.72	56.50
2:00-3:00	43.50	57.30
3:00-4:00	44.29	58.23
4:00-5:00	45.25	59.21
5:00-6:00	46.16	60.27
6:00-7:00	46.11	61.10
7:00-8:00	42.49	60.14
8:00-9:00	44.82	76.04
9:00-10:00	42.39	67.27
10:00-11:00	39.66	58.35
11:00-12:00	35.66	49.4
12:00-13:00	33.54	52.62
13:00-14:00	32.13	37.56
14:00-15:00	31.40	34.93
15:00-16:00	32.31	33.87
16:00-17:00	34.01	37.95
17:00-18:00	32.97	44.98
18:00-19:00	35.39	47.24
19:00-20:00	38.00	48.99
20:00-21:00	39.60	50.36
21:00-22:00	40.77	51.76
22:00-23:00	41.68	52.83
23:00-24:00	42.46	53.68
Average	39.55	53.29
Average (occupied)	36.21	49.78
Average (Unoccupied)	41.56	54.55

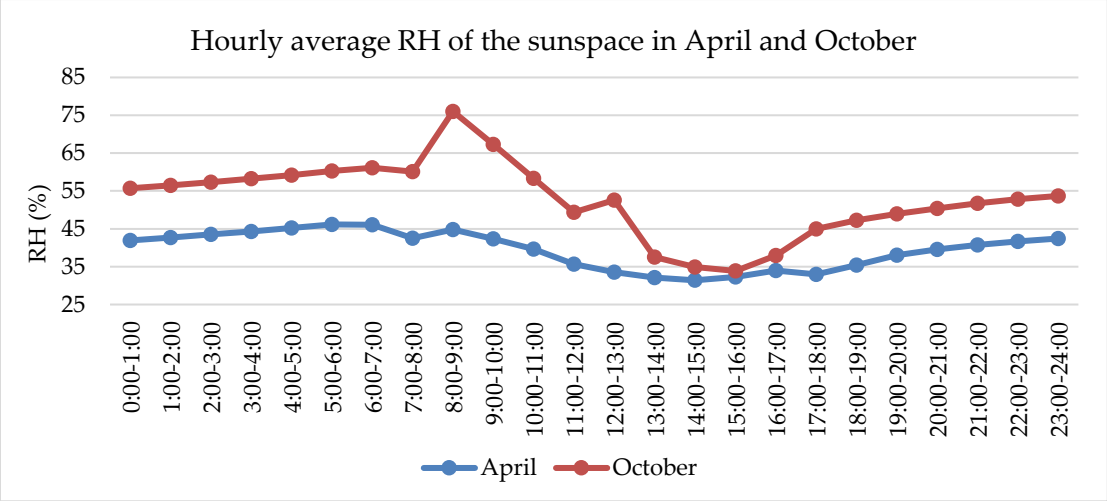


Figure 9.27. *Relative humidity in the sunspace in April and October*

9.4.3.5. DTM results in May and September

Tables 9.14, and 9.15, and Figures 9.28 and 9.29 present the DTM results for the sunspace in May and September. In the occupied periods, the average air temperature inside the sunspace ranged from 17.34°C to 18.44°C. Additionally, in the unoccupied periods, the average air temperature was approximately 20°C. Figure 9.28 indicates that the air temperature trends in May and September are similar.

Table 9.14. The hourly average air temperature in the sunspace in May and September

	May	September
0:00-1:00	19.93	20.54
1:00-2:00	19.82	20.44
2:00-3:00	19.67	20.32
3:00-4:00	19.50	20.16
4:00-5:00	19.25	20.00
5:00-6:00	19.03	19.84
6:00-7:00	19.23	19.77
7:00-8:00	20.20	20.38
8:00-9:00	17.36	17.34
9:00-10:00	17.48	17.41
10:00-11:00	17.90	17.71
11:00-12:00	18.16	18.01
12:00-13:00	18.29	18.35
13:00-14:00	18.32	18.44
14:00-15:00	18.24	18.21
15:00-16:00	18.02	17.83
16:00-17:00	17.71	17.60
17:00-18:00	21.57	20.84
18:00-19:00	21.80	21.57

19:00-20:00	21.15	21.28
20:00-21:00	20.76	21.09
21:00-22:00	20.47	20.87
22:00-23:00	20.31	20.71
23:00-24:00	20.22	20.59
Average	19.35	19.55
Average (occupied)	17.94	17.88
Average (unoccupied)	20.19	20.56

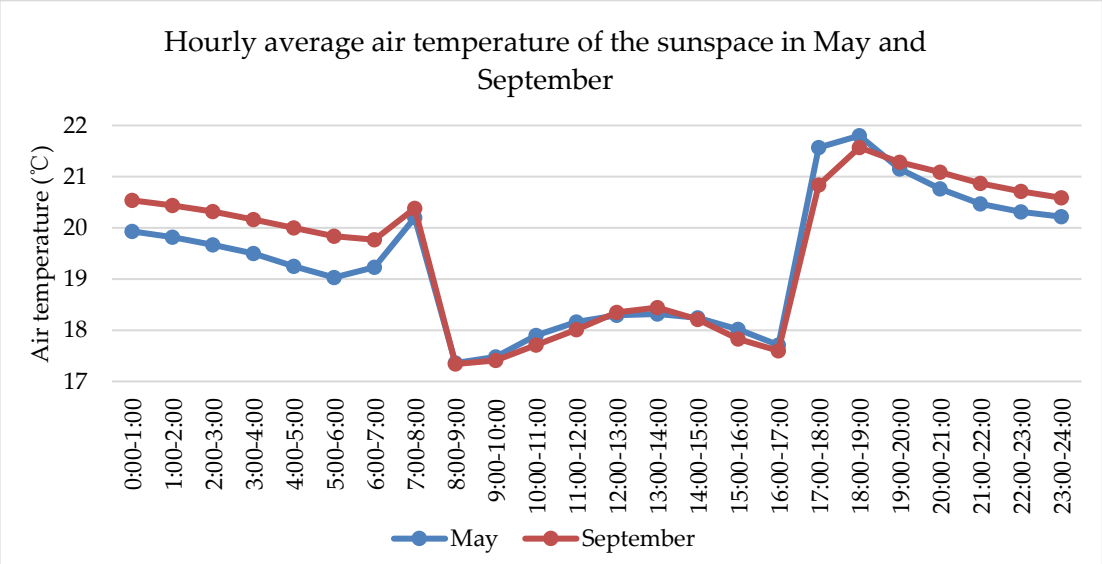


Figure 9.28. *Air temperature in the sunspace in May and September*

Table 9.15 shows that the average relative humidity inside the sunspace during the occupied periods ranges from 57.11% to 64.51% in May and 84.07% to 90.09% in September. The EAHEs decreased the supplied air temperature; thus, the relative humidity during the occupied periods was higher than that during unoccupied periods (Figure 29).

In the unoccupied periods, the air exchange between the sunspace and ambient environment occurs via infiltration. Therefore, the relative humidity inside the sunspace mainly depends on the ambient relative humidity. Figure 9.29 shows a consistent trend of the air between the indoor environment of the sunspace and the ambient environment during the unoccupied periods.

Table 9.15. The hourly average relative humidity in the sunspace in May and September

	May	September
0:00-1:00	43.51	57.79
1:00-2:00	44.11	58.46
2:00-3:00	44.82	59.21

3:00-4:00	45.67	60.09
4:00-5:00	46.69	60.96
5:00-6:00	47.54	61.83
6:00-7:00	46.25	62.16
7:00-8:00	41.24	57.81
8:00-9:00	64.51	90.09
9:00-10:00	63.67	89.7
10:00-11:00	61.14	88.01
11:00-12:00	58.69	86.37
12:00-13:00	57.11	84.54
13:00-14:00	57.17	84.54
14:00-15:00	59.93	84.07
15:00-16:00	59.98	85.29
16:00-17:00	61.17	87.35
17:00-18:00	36.29	51.87
18:00-19:00	36.19	50.28
19:00-20:00	38.82	52.61
20:00-21:00	40.58	53.89
21:00-22:00	41.72	55.11
22:00-23:00	42.49	56.03
23:00-24:00	43.06	56.82
Average	49.26	68.12
Average (Occupied)	60.37	80.66
Average (unoccupied)	42.60	56.99

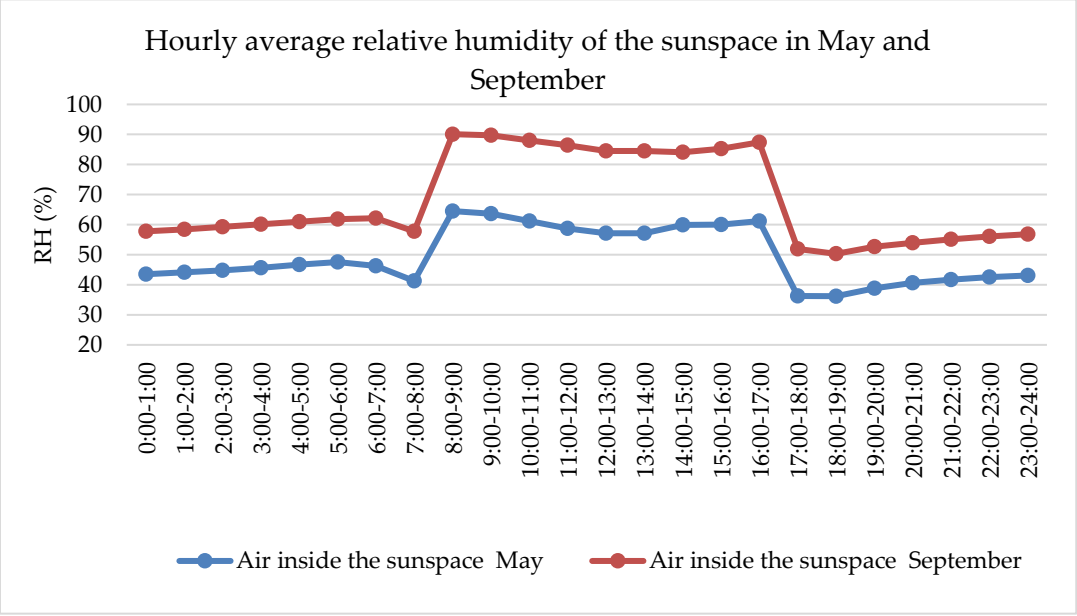


Figure 9.29. *Relative humidity in the sunspace in May and September*

9.4.3.6. Conclusions of the sunspace DTM results

The sunspace with plants acts as an air regulator for the classrooms. In this space, the air is cleaned, reheated and stored. Additionally, the sunspace creates a suitable indoor environment for the plants to grow in and survive. The most

important variable for the sunspace is the inside air temperature. Table 9.16 provides a summary of the air temperature performance inside the sunspace based on the DTM results in sections 9.4.3.1-9.4.3.5. The following list provides conclusions derived from the Table 9.16.

Table 9.16. A summary of the air temperature performance inside the sunspace

Months	Operation of EAHEs		Temperature inside the sunspace	
	Occupied hours	Unoccupied hours	Occupied hours	Unoccupied hours
March, November, and the winter months	Always on	Always on	14°C-16.5°C	14.3°C -15.6°C
May, September, and the summer months	Always on	Always off	17.3°C -19.1°C	19.0°C -25.0°C
April and October	Always off	Always off	14.6°C -20.7°C	15.3°C -20.3°C

- In May, September, and the summer months, the inside air temperature ranged from 17.3°C to 19.1°C during occupied hours and from 19.0°C to 25°C during unoccupied hours, respectively. Thus, overheating issue was successfully avoided because the EAHEs were in "always mode" during school hours. During unoccupied hours, the ambient air temperature was not high as in the daytime, thus, the inside air temperature was still with a comfortable range for the plants.
- In March, November, and the winter months, the inside air temperature ranged from 14°C-16.5°C during occupied hours and from 14.3°C -15.6°C during unoccupied hours, respectively. The inside temperature was relatively stable because the EAHEs were in operation throughout the day. Moreover, the temperature performance was within the range required for plants' grow and survive (10°C -30°C).
- In April and October, the inside air temperature ranged from 14.6°C -20.7°C during occupied hours and 15.3°C -20.3°C during unoccupied hours, respectively. The ambient air temperatures in these two months are suitable for plant growth. Thus, the EAHEs were in "always off" mode. The

temperature inside the sunspace was within the range required for plants' grow and survive (10°C -30°C).

9.5. DTM analysis for the selected classroom unit

Figure 9.30 shows the DTM model of classrooms created in the IESVE. The model contains data regarding the building properties, such as construction specifications, occupancy profiles, weather data, and the building location.

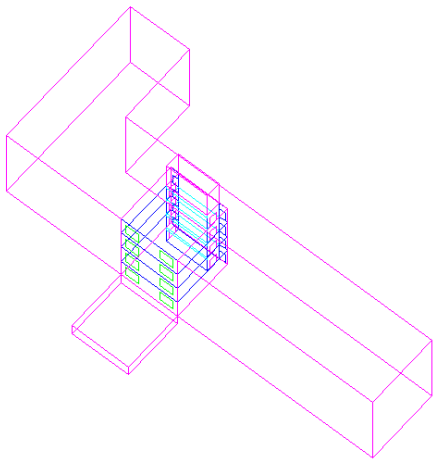


Figure 9.30. *DTM model of the classrooms*

Four parameters were studied to evaluate the indoor environment performance: the indoor air temperature, relative humidity, internal CO_2 levels, and PMV values. IESVE cannot set a control profile for the relative humidity of the supplied air inside the sunspace. Therefore, a psychrometric chart was used to directly estimate the relative humidity values in the classrooms.

9.5.1. Internal heat gains

On a typical school day, the lights are not in used, and a computer with a display screen is typically operated during school hours. Therefore, the internal heat gains are mainly from the students and the computer in the classroom. CIBSE Guide A suggests that the emissions of heat from an adult body averages approximately 115 W in a sedentary state (CIBSE Guide A, 2006). Moreover, the ASHRAE (2017) reported that the heat produced by children is approximately 75% that produced by adults. Moreover, based on the SBDR-2011, the maximum number of occupants

required for a primary school classroom is 46 (1 teacher and 45 students). Therefore, the internal heat gains emitted by occupants can be expressed as follows:

$$115\ \text{W} \times 45 \times 75\% + 115 \times 1 = 3996\ \text{W}.$$

The internal heat emitted by a computer with a display screen is approximately 187 W (CIBSE Guide A, 2006). Thus, the total internal heat gain was given as follows.

$$3996\ \text{W} + 187\ \text{W} = 4183\ \text{W}.$$

In IESVE, an internal heat gain of 4183 W was input for each classroom, and the profile of variation was set to "weekly profile for occupied period-continuous" during school hours (Figure 9.31).

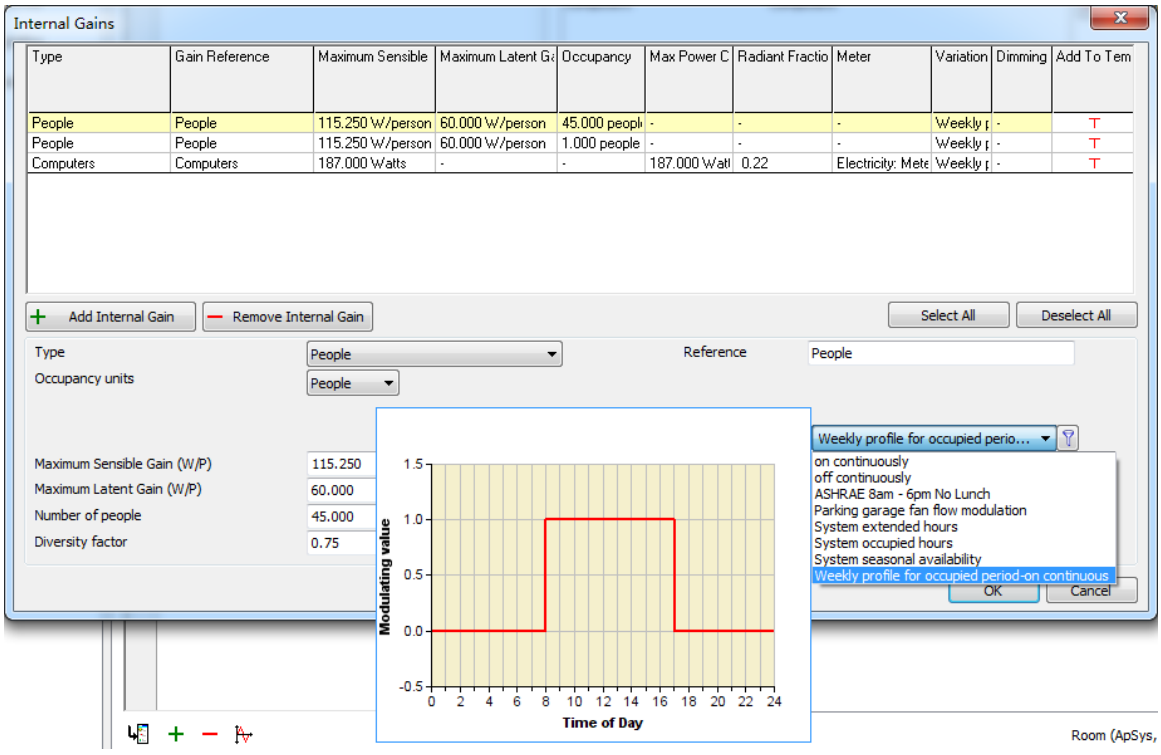


Figure 9.31. *Input panel of internal heat gains*

9.5.2. Infiltration settings for the classrooms

As discussed in section 3.7, public buildings completed after 2015 have an airtightness level of 6 based on the requirements of the latest standard of the PBESS-205. The national regulation of Graduations and Test Methods of the Airtightness Level for External Windows and Doors of Buildings (GB/T7106-2008) provides the following equation to estimate the infiltration rate:

$$Q = q \times L$$

where Q is the volumetric air flow rate through the cracks in building fabrics (m^3/h), q is the volume of air that flows through one unit joint length of the external windows and doors ($m^3/m \cdot h$), and L is the total length of the cracks (m). For buildings with an airtightness level of 6, q is typically between 1 $m^3/m \cdot h$ and 1.5 $m^3/m \cdot h$ (GB/T7106-2008). Therefore, this study selected the average value of 1.25 $m^3/m \cdot h$ to estimate the infiltration rate. The total length of the cracks in the studied primary school building is equal to the total perimeter of the external windows and doors (35.2 m). Therefore, the infiltration rate for each classroom was 0.171 ach based on the following equation.

$$Q = 1.25 \times 35.2 = 44 m^3/h$$

$$44 \div 9.6 \div 7.6 \div 3.6 = 0.17 ach$$

In IESVE, 0.17 was input for the DTM simulations of classrooms (Figure 9.32). Moreover, the variation profile was set to "on continuously". The infiltrated air temperature profile is the same as that for the climate data in Table 9.1.

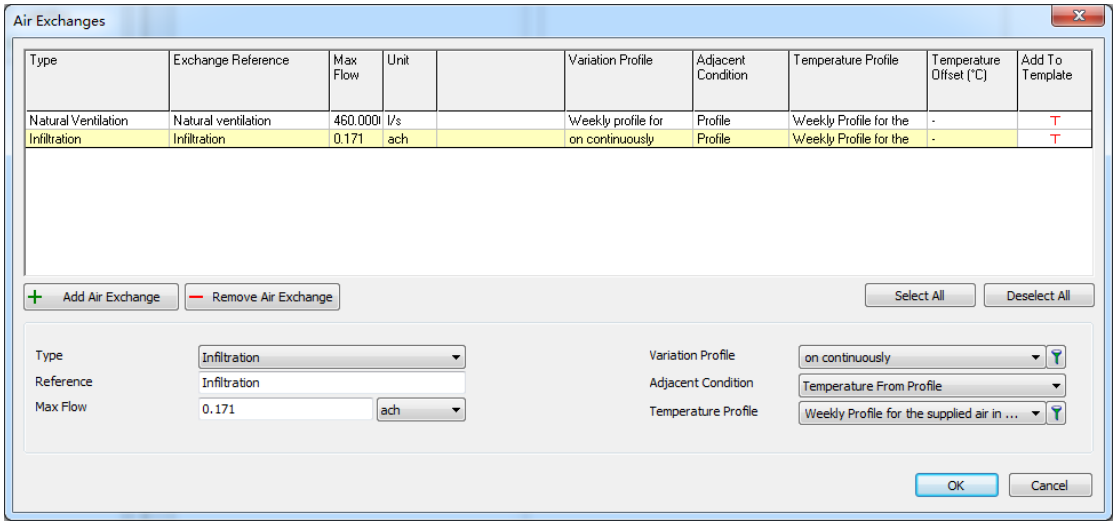


Figure 9.32. *Infiltration settings of classrooms*

9.5.3. Supplied air properties of the ILEV system

Tables 9.17 and 9.18 summarise the supplied air properties for the classrooms based on the DTM results of the sunspace in section 9.4. In winter months, March, and April, and from 13:00 pm-17: 00 pm in October, the low level of relative humidity inside the sunspace was increased to 60%.

Table 9.17. Temperature of supplied air for the classrooms

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
8:00-9:00	15.15	14.56	17.36	18.61	18.49	18.44	17.34	14.85	14.85	14.00	14.06	14.44
9:00-10:00	15.47	15.59	17.48	18.36	18.09	18.18	17.41	15.87	15.12	14.19	14.32	14.69
10:00-11:00	15.85	16.74	17.90	18.65	18.30	18.48	17.71	17.15	15.46	14.52	14.69	14.99
11:00-12:00	16.25	18.04	18.16	18.85	18.54	18.72	18.01	18.23	15.82	14.70	14.97	15.35
12:00-13:00	16.43	19.03	18.29	19.08	18.55	18.90	18.35	19.15	16.06	14.83	15.18	15.57
13:00-14:00	16.53	19.82	18.32	19.05	18.60	18.98	18.44	19.92	16.08	14.90	15.27	15.65
14:00-15:00	16.41	20.45	18.24	18.95	18.55	18.94	18.21	20.42	15.97	14.88	15.19	15.50
15:00-16:00	16.20	20.71	18.02	18.78	18.40	18.63	17.83	20.57	15.73	14.68	14.96	15.34
16:00-17:00	15.95	20.44	17.71	18.45	18.18	18.28	17.60	20.27	15.49	14.48	14.68	15.14

Table 9.18. Relative humidity of supplied air for the classrooms

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
8:00-9:00	60%		64.51	83.17	83.8	84.07	90.09	76.04	60%			
9:00-10:00			63.67	84.49	85.93	85.45	89.7	67.27				
10:00-11:00			61.14	82.97	84.81	83.85	88.01	58.35				
11:00-12:00			58.69	81.94	83.54	82.6	86.37	49.4				
12:00-13:00			57.11	80.77	83.49	81.68	84.54	52.62				

13:00-14:00		57.17	80.92	83.49	81.27	84.54		
14:00-15:00		59.93	81.43	83.49	81.48	84.07		
15:00-16:00		59.98	82.29	84.28	83.07	85.29	60%	
16:00-17:00		61.17	84.01	85.45	84.91	87.35		

Figure 9.33 shows the operating profile for ventilation in the studied building during school hours. Figures 9.34 to 9.45 show the control profiles for the supplied air temperature based on the data in Table 9.16.

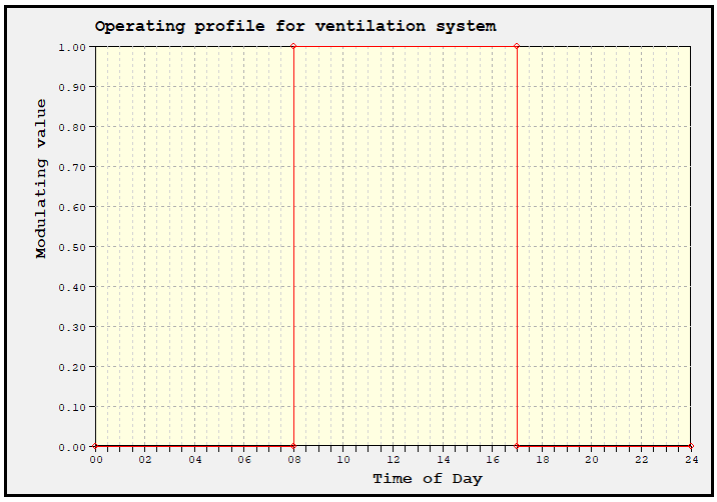


Figure 9.33. *Operating controlling profile for the ventilation system*

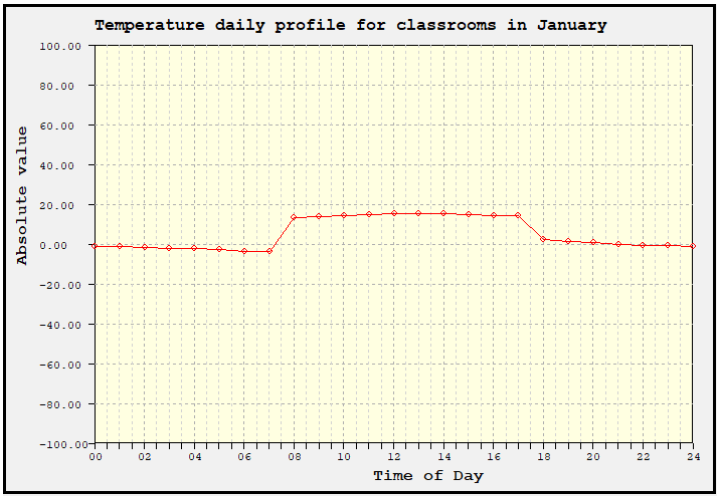


Figure 9.34. *Daily controlling temperature profile for classrooms in January*

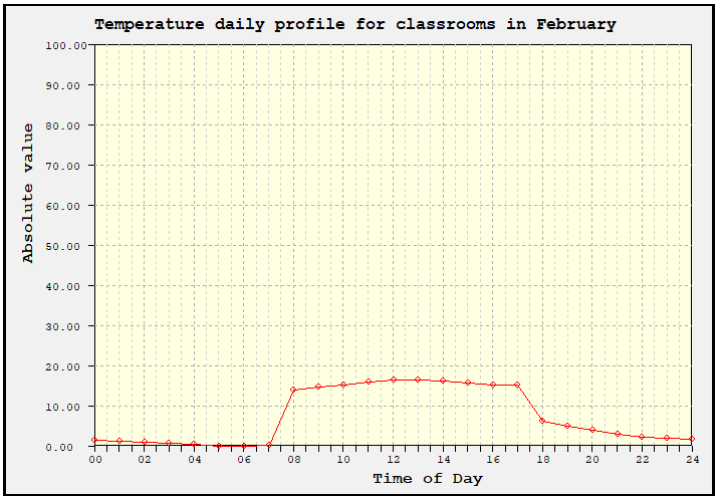


Figure 9.35. *Daily controlling temperature profile for classrooms in February*

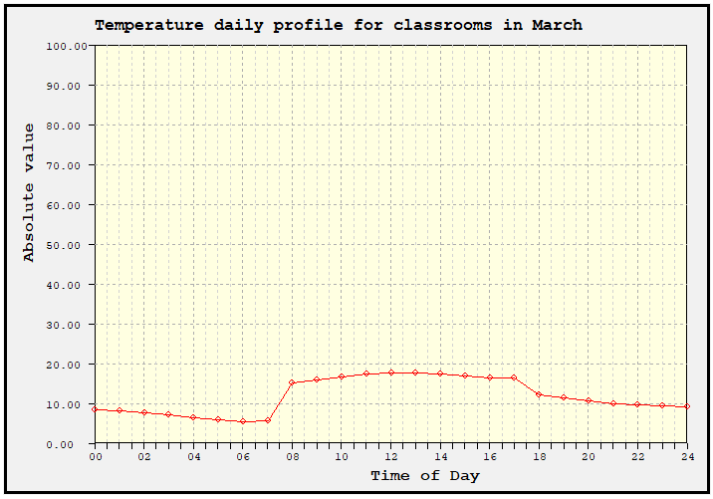


Figure 9.36. *Daily controlling temperature profile for classrooms in March*

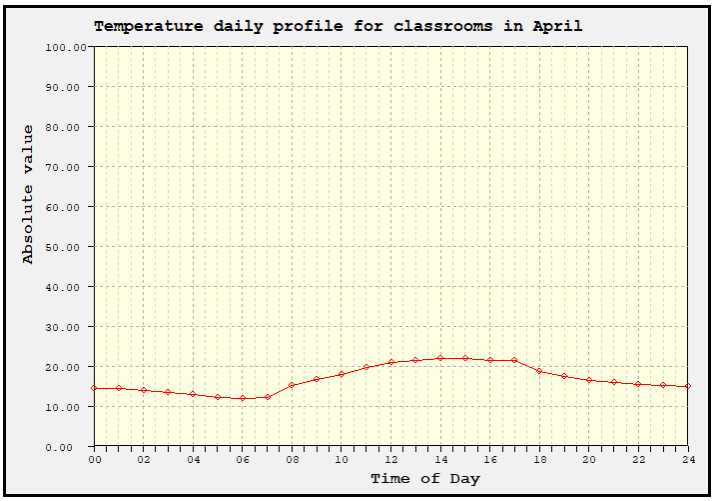


Figure 9.37. *Daily controlling temperature profile for classrooms in April*

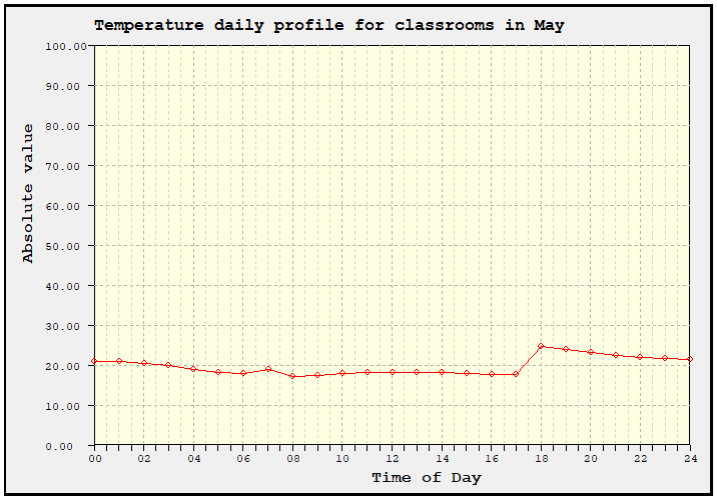


Figure 9.38. *Daily controlling temperature profile for classrooms in May*

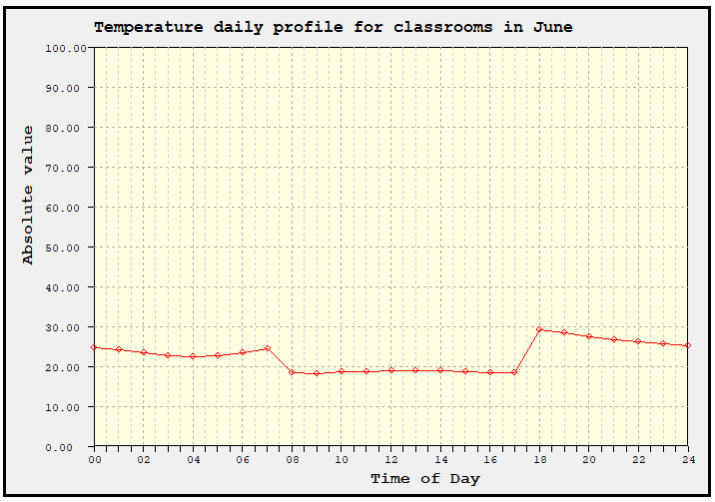


Figure 9.39. *Daily controlling temperature profile for classrooms in June*

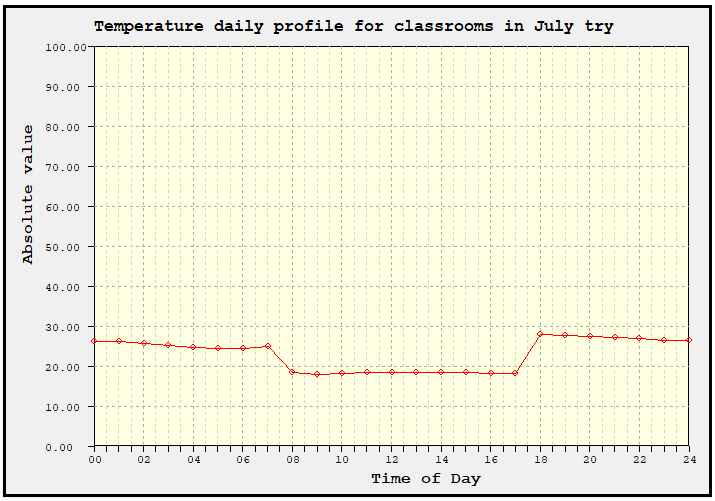


Figure 9.40. *Daily controlling temperature profile for classrooms in July*

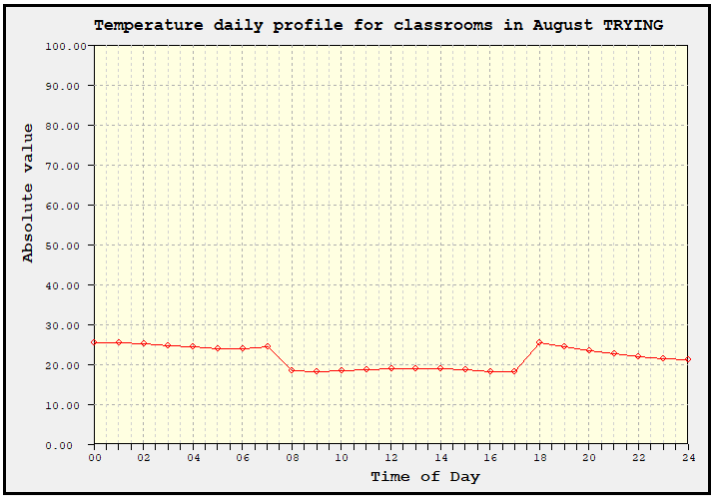


Figure 9.41. *Daily controlling temperature profile for classrooms in August*

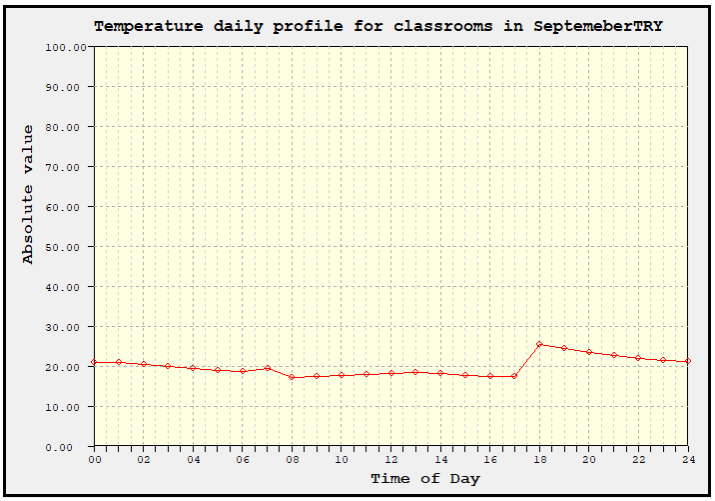


Figure 9.42. *Daily controlling temperature profile for classrooms in September*

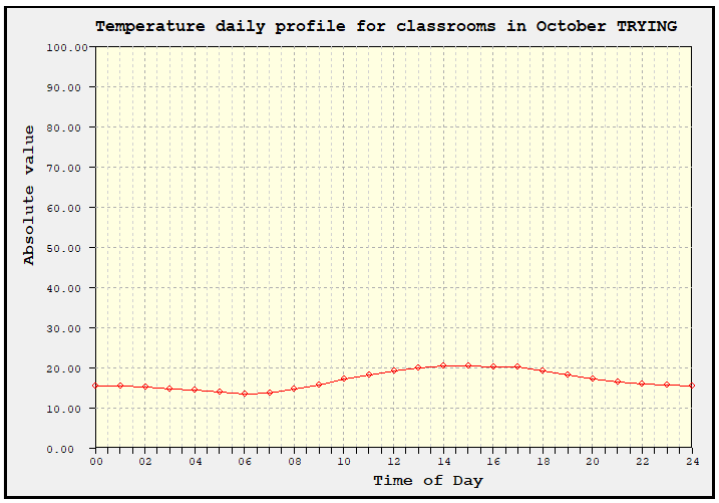


Figure 9.43. *Daily controlling temperature profile for classrooms in October*

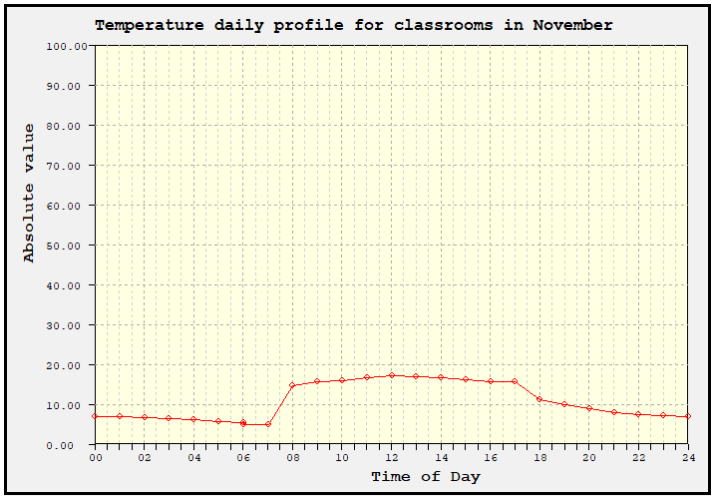


Figure 9.44. *Daily controlling temperature profile for classrooms in November*

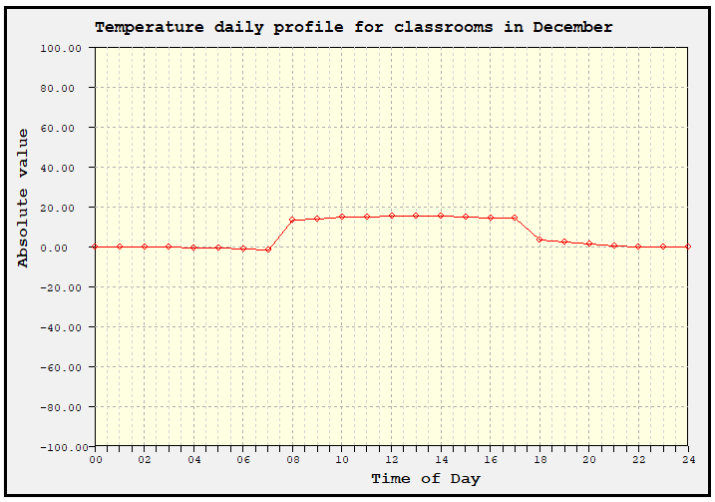


Figure 9.45. *Daily controlling temperature profile for classrooms in December*

9.5.4. DTM results of the classrooms

9.5.4.1. DTM results in winter

Tables 9.19 to 9.22 summarise the DTM results for the classrooms in winter. During most of the occupied hours, the internal air temperatures in classrooms were between 15.02°C and 19.35°C on average. Moreover, the air temperatures during the early hours were slightly lower than those at other times during occupied periods.

Table 9.19. The temperature performance of classrooms in winter

Months	Time	Classrooms

December	8:00-9:00	15.17
	9:00-10:00	16.64
	10:00-11:00	17.42
	11:00-12:00	17.89
	12:00-13:00	18.17
	13:00-14:00	18.35
	14:00-15:00	18.50
	15:00-16:00	18.36
	16:00-17:00	18.08
January	8:00-9:00	15.02
	9:00-10:00	16.19
	10:00-11:00	17.02
	11:00-12:00	17.54
	12:00-13:00	17.93
	13:00-14:00	18.13
	14:00-15:00	18.17
	15:00-16:00	18.07
	16:00-17:00	17.82
February	8:00-9:00	15.79
	9:00-10:00	17.35
	10:00-11:00	18.07
	11:00-12:00	18.67
	12:00-13:00	19.12
	13:00-14:00	19.35
	14:00-15:00	19.32
	15:00-16:00	19.21
	16:00-17:00	19.08

The relative humidity in all classrooms was 40% on average. The classrooms had the highest relative humidity of 54.50% at the beginning of the school day in February, and the lowest value was 38.44%, as observed at the end of the school day in February.

Table 9.20. The relative humidity of classrooms in winter

Months	Time	Classrooms
December	8:00-9:00	44.14
	9:00-10:00	42.72
	10:00-11:00	42.25
	11:00-12:00	41.77
	12:00-13:00	41.57
	13:00-14:00	41.57
	14:00-15:00	41.11
	15:00-16:00	40.87
	16:00-17:00	40.91
January	8:00-9:00	47.20
	9:00-10:00	45.60
	10:00-11:00	45.32

	11:00-12:00	45.20
	12:00-13:00	45.13
	13:00-14:00	45.00
	14:00-15:00	44.71
	15:00-16:00	44.23
	16:00-17:00	43.72
February	8:00-9:00	54.50
	9:00-10:00	49.19
	10:00-11:00	44.99
	11:00-12:00	43.42
	12:00-13:00	41.30
	13:00-14:00	39.80
	14:00-15:00	38.87
	15:00-16:00	38.52
	16:00-17:00	38.44

The internal CO_2 concentrations was approximately 900 ppm on average in all classrooms in winter because that the constant ventilation rate contributed to a steady reduction in internal CO_2 emissions in classrooms with a fixed occupancy density.

Table 9.21. The CO_2 concentrations of classrooms in winter months

Months	Time	Classrooms
December	8:00-9:00	833.48
	9:00-10:00	903.47
	10:00-11:00	909.24
	11:00-12:00	911.30
	12:00-13:00	912.09
	13:00-14:00	912.40
	14:00-15:00	912.53
	15:00-16:00	912.58
	16:00-17:00	912.61
January	8:00-9:00	832.06
	9:00-10:00	903.19
	10:00-11:00	909.21
	11:00-12:00	911.32
	12:00-13:00	912.11
	13:00-14:00	912.42
	14:00-15:00	912.54
	15:00-16:00	912.59
	16:00-17:00	912.61
February	8:00-9:00	833.67
	9:00-10:00	903.47
	10:00-11:00	909.16
	11:00-12:00	911.25
	12:00-13:00	912.07
	13:00-14:00	912.39

	14:00-15:00	912.52
	15:00-16:00	912.58
	16:00-17:00	912.60

The PMV value was -0.8 on average for all classrooms during school hours. The lowest value was -1.25 during the first school hour in December, and the highest value was -0.44 between 13:00 pm and 15:00 pm in February. The PPD revealed similar trends. For example, students were dissatisfied with the thermal performance during the early school hours when the PMV values were relatively low. Then, the dissatisfied percent decreased along with the increasing of PMV values during the rest of school hours.

Table 9.22. The PMV and PPD values of classrooms in winter months

Months	Time	Classrooms	
		PMV	PPD
December	8:00-9:00	-1.21	42.81
	9:00-10:00	-0.97	27.44
	10:00-11:00	-0.82	20.84
	11:00-12:00	-0.73	17.31
	12:00-13:00	-0.68	15.47
	13:00-14:00	-0.64	14.28
	14:00-15:00	-0.62	13.31
	15:00-16:00	-0.66	14.22
	16:00-17:00	-0.79	15.85
January	8:00-9:00	-1.25	50.79
	9:00-10:00	-1.08	32.68
	10:00-11:00	-0.96	25.07
	11:00-12:00	-0.85	21.20
	12:00-13:00	-0.77	18.41
	13:00-14:00	-0.73	17.18
	14:00-15:00	-0.72	16.83
	15:00-16:00	-0.74	17.28
	16:00-17:00	-0.79	18.73
February	8:00-9:00	-1.17	34.07
	9:00-10:00	-0.86	21.01
	10:00-11:00	-0.70	16.14
	11:00-12:00	-0.58	12.72
	12:00-13:00	-0.49	10.60
	13:00-14:00	-0.44	9.69
	14:00-15:00	-0.44	9.82
	15:00-16:00	-0.46	10.07
	16:00-17:00	-0.49	10.51

9.5.4.2. DTM results in summer

Tables 9.23 to 9.26 summarise the DTM results of the classrooms during summer months. The internal air temperature was 26.8°C on average. The highest internal air temperature was 27.42°C in August, and the lowest was 26.41°C in July.

Table 9.23. The temperature performance of classrooms in summer

Months	Time	Classrooms
June	8:00-9:00	26.52
	9:00-10:00	26.45
	10:00-11:00	26.64
	11:00-12:00	26.86
	12:00-13:00	27.03
	13:00-14:00	27.06
	14:00-15:00	27.00
	15:00-16:00	26.85
	16:00-17:00	26.69
July	8:00-9:00	26.59
	9:00-10:00	26.41
	10:00-11:00	26.56
	11:00-12:00	26.74
	12:00-13:00	26.84
	13:00-14:00	26.90
	14:00-15:00	26.86
	15:00-16:00	26.72
	16:00-17:00	26.59
August	8:00-9:00	26.77
	9:00-10:00	26.63
	10:00-11:00	26.85
	11:00-12:00	27.11
	12:00-13:00	27.30
	13:00-14:00	27.42
	14:00-15:00	27.38
	15:00-16:00	27.14
	16:00-17:00	26.90

The relative humidity performance in summer was relatively stable in all classrooms, and the average value was approximately 50%.

Table 9.24. The relative humidity of classrooms in summer

Months	Times	Classrooms
June	8:00-9:00	51.21
	9:00-10:00	51.62
	10:00-11:00	51.09
	11:00-12:00	50.53
	12:00-13:00	55.04

	13:00-14:00	54.89
	14:00-15:00	55.00
	15:00-16:00	52.94
	16:00-17:00	50.88
July	8:00-9:00	51.61
	9:00-10:00	52.16
	10:00-11:00	52.04
	11:00-12:00	51.74
	12:00-13:00	51.57
	13:00-14:00	51.63
	14:00-15:00	51.52
	15:00-16:00	51.79
	16:00-17:00	52.07
August	8:00-9:00	50.44
	9:00-10:00	50.63
	10:00-11:00	50.33
	11:00-12:00	50.02
	12:00-13:00	49.74
	13:00-14:00	49.58
	14:00-15:00	49.63
	15:00-16:00	49.94
	16:00-17:00	50.25

The internal CO_2 concentrations were the same as those in winter months since the occupancy density and ventilation rate were constant during school hours.

Table 9.25. The CO_2 concentrations of classrooms in summer

Months	Time	Classrooms
June	8:00-9:00	842.66
	9:00-10:00	906.32
	10:00-11:00	909.02
	11:00-12:00	910.37
	12:00-13:00	911.19
	13:00-14:00	911.71
	14:00-15:00	912.05
	15:00-16:00	912.27
	16:00-17:00	912.41
July	8:00-9:00	841.62
	9:00-10:00	905.89
	10:00-11:00	908.96
	11:00-12:00	910.46
	12:00-13:00	911.34
	13:00-14:00	911.85
	14:00-15:00	912.15
	15:00-16:00	912.31
	16:00-17:00	912.40
August	8:00-9:00	841.07

	9:00-10:00	905.69
	10:00-11:00	908.78
	11:00-12:00	910.33
	12:00-13:00	911.26
	13:00-14:00	911.82
	14:00-15:00	912.15
	15:00-16:00	912.36
	16:00-17:00	912.48

The average PMV value of the four classrooms was 1.4 in summer. The highest value was 1.50 in August and the lowest value was 1.26 in June. The PMV values in summer indicated a warm indoor thermal environment. Therefore, on average, 40% of students were dissatisfied with the thermal performance of classrooms.

Table 9.26. The PMV and PPD values of classrooms in summer

Months	Time	Classrooms	
		PMV	PPD
June	8:00-9:00	1.26	38.46
	9:00-10:00	1.26	38.25
	10:00-11:00	1.30	40.09
	11:00-12:00	1.33	41.99
	12:00-13:00	1.36	43.36
	13:00-14:00	1.36	43.40
	14:00-15:00	1.34	42.62
	15:00-16:00	1.32	41.21
	16:00-17:00	1.29	39.59
July	8:00-9:00	1.33	42.36
	9:00-10:00	1.29	40.18
	10:00-11:00	1.32	41.58
	11:00-12:00	1.36	43.42
	12:00-13:00	1.38	44.45
	13:00-14:00	1.39	45.08
	14:00-15:00	1.38	44.56
	15:00-16:00	1.35	43.10
	16:00-17:00	1.32	41.66
August	8:00-9:00	1.37	44.16
	9:00-10:00	1.34	42.54
	10:00-11:00	1.38	44.72
	11:00-12:00	1.43	47.51
	12:00-13:00	1.47	49.56
	13:00-14:00	1.50	50.88
	14:00-15:00	1.49	50.38
	15:00-16:00	1.44	47.72
	16:00-17:00	1.38	45.03

9.5.4.3. DTM results in March and November

Tables 9.27 to 9.30 summarise the DTM results for the classrooms in March and November. The internal air temperatures in March and November were similar and between 18°C and 22°C. The highest value was 21.26°C between 13:00 pm and 14:00 pm in March. The lowest value was 18.37°C during the first school hour in March.

Table 9.27. The temperature performance of classrooms in March and November

Months	Time	Classrooms
March	8:00-9:00	18.37
	9:00-10:00	19.58
	10:00-11:00	20.23
	11:00-12:00	20.75
	12:00-13:00	21.11
	13:00-14:00	21.26
	14:00-15:00	21.24
	15:00-16:00	21.08
	16:00-17:00	20.93
November	8:00-9:00	18.53
	9:00-10:00	19.70
	10:00-11:00	20.30
	11:00-12:00	20.81
	12:00-13:00	21.12
	13:00-14:00	21.18
	14:00-15:00	21.11
	15:00-16:00	20.91
	16:00-17:00	20.62

The relative humidity in all classrooms was 40% on average in March and November. There was no significant difference observed among the values during school hours. Therefore, the classrooms exhibited a stable relative humidity performance in March and November.

Table 9.28. The relative humidity in classrooms in March and November

Months	Time	Classrooms
March	8:00-9:00	39.96
	9:00-10:00	41.81
	10:00-11:00	41.79
	11:00-12:00	42.03
	12:00-13:00	41.94

	13:00-14:00	41.95
	14:00-15:00	41.67
	15:00-16:00	41.36
	16:00-17:00	40.92
November	8:00-9:00	42.00
	9:00-10:00	41.43
	10:00-11:00	41.37
	11:00-12:00	41.46
	12:00-13:00	41.47
	13:00-14:00	41.32
	14:00-15:00	41.31
	15:00-16:00	40.38
	16:00-17:00	40.30

The internal CO_2 concentration was at the same level as in other months since the occupancy density and ventilation rate were constant during school hours. The average CO_2 concentration in March and November was 900 ppm.

Table 9.29. The CO_2 concentrations in classrooms in March and November

Months	Times	Classrooms
March	8:00-9:00	835.01
	9:00-10:00	903.75
	10:00-11:00	908.81
	11:00-12:00	910.89
	12:00-13:00	911.83
	13:00-14:00	912.24
	14:00-15:00	912.43
	15:00-16:00	912.52
	16:00-17:00	912.57
November	8:00-9:00	835.35
	9:00-10:00	903.86
	10:00-11:00	908.85
	11:00-12:00	910.91
	12:00-13:00	911.84
	13:00-14:00	912.25
	14:00-15:00	912.43
	15:00-16:00	912.51
	16:00-17:00	912.56

The average PMV values of the four classrooms in March and November was -0.17. The highest value was 0.06 in November and the lowest value was -0.63, observed in March. The PMV values in March and November indicated a thermal comfortable indoor environment. Consequently, only approximately 6.9% of

occupants were dissatisfied with the thermal performance of classrooms in these two months.

Table 9.30. The PMV and PPD values of classrooms in March and November

Months	Times	Classrooms	
		PMV	PPD
March	8:00-9:00	-0.60	13.54
	9:00-10:00	-0.36	8.30
	10:00-11:00	-0.23	6.61
	11:00-12:00	-0.13	5.75
	12:00-13:00	-0.07	5.48
	13:00-14:00	-0.04	5.51
	14:00-15:00	-0.04	5.55
	15:00-16:00	-0.07	5.57
	16:00-17:00	-0.10	5.60
November	8:00-9:00	-0.56	12.42
	9:00-10:00	-0.32	7.96
	10:00-11:00	-0.20	5.83
	11:00-12:00	-0.09	5.50
	12:00-13:00	-0.02	5.42
	13:00-14:00	-0.01	5.23
	14:00-15:00	-0.02	5.42
	15:00-16:00	-0.06	5.53
	16:00-17:00	-0.11	5.62

9.5.4.4. DTM results in April and October

Tables 9.31 to 9.34 summarise the DTM results for the classrooms in April and October. The internal air temperatures were between 21.56°C and 25.74°C. The highest air temperature was 25.74°C between 15:00 pm and 16:00 pm in April. The lowest air temperature was 21.56°C during the first school hour in April.

Table 9.31. The temperature performance of classrooms in April and October

Months	Time	Classrooms
April	8:00-9:00	21.56
	9:00-10:00	22.32
	10:00-11:00	23.16
	11:00-12:00	24.07
	12:00-13:00	24.81
	13:00-14:00	25.33
	14:00-15:00	25.68
	15:00-16:00	25.74

	16:00-17:00	25.62
October	8:00-9:00	22.94
	9:00-10:00	23.57
	10:00-11:00	24.07
	11:00-12:00	24.51
	12:00-13:00	24.89
	13:00-14:00	25.05
	14:00-15:00	24.96
	15:00-16:00	24.68
	16:00-17:00	24.40

The relative humidity averaged 39.92% and 41.31% in April and October, respectively. The highest value was 44.84%, and the lowest value was 33.57%. The results in October were slightly superior to those in April.

Table 9.32. The relative humidity in classrooms in April and October

Months	Time	Classrooms
April	8:00-9:00	34.77
	9:00-10:00	36.65
	10:00-11:00	38.11
	11:00-12:00	39.75
	12:00-13:00	40.84
	13:00-14:00	41.71
	14:00-15:00	43.16
	15:00-16:00	42.15
	16:00-17:00	42.12
October	8:00-9:00	44.53
	9:00-10:00	41.41
	10:00-11:00	37.95
	11:00-12:00	33.57
	12:00-13:00	37.11
	13:00-14:00	43.65
	14:00-15:00	44.51
	15:00-16:00	44.84
	16:00-17:00	44.23

The internal CO_2 concentrations were the same as those in other months, with an average value of 900 ppm.

Table 9.33. The CO_2 concentrations in the classrooms in April and October

Months	Time	Classrooms
April	8:00-9:00	840.91
	9:00-10:00	905.71
	10:00-11:00	908.53
	11:00-12:00	909.97

	12:00-13:00	911.02
	13:00-14:00	911.63
	14:00-15:00	912.00
	15:00-16:00	912.24
	16:00-17:00	912.39
October	8:00-9:00	840.17
	9:00-10:00	905.80
	10:00-11:00	908.78
	11:00-12:00	910.18
	12:00-13:00	911.10
	13:00-14:00	911.65
	14:00-15:00	911.93
	15:00-16:00	912.13
	16:00-17:00	912.27

The PMV values in April and October were 0.61 and 0.72 on average, respectively. At the beginning of the school day, the values were low, and they then slightly increased to approximately 0.9 during the remainder of the school day. The PPD values in April and October indicated that approximately 17% of students were dissatisfied with the thermal performance of classrooms in these two months.

Table 9.34. The PMV and PPD values of classrooms in April and October

Months	Time	Classrooms	
		PMV	PPD
April	8:00-9:00	0.16	6.19
	9:00-10:00	0.29	7.28
	10:00-11:00	0.43	9.29
	11:00-12:00	0.58	12.57
	12:00-13:00	0.70	15.94
	13:00-14:00	0.78	18.52
	14:00-15:00	0.84	20.46
	15:00-16:00	0.86	20.96
	16:00-17:00	0.84	20.40
October	8:00-9:00	0.44	10.08
	9:00-10:00	0.58	12.65
	10:00-11:00	0.68	15.26
	11:00-12:00	0.76	17.80
	12:00-13:00	0.83	20.08
	13:00-14:00	0.86	21.13
	14:00-15:00	0.84	20.42
	15:00-16:00	0.79	18.65
	16:00-17:00	0.73	16.80

9.5.4.5. DTM results in May and September

Tables 9.35 to 9.38 summarise the DTM results for the classrooms in May and September. The internal air temperatures were 24.8°C and 25.6°C on average in these months. The highest air temperature was 26.19°C between 13:00 pm and 14:00 pm in September, and the lowest air temperature was 23.85°C during the first school hour in May.

Table 9.35. The temperature performance of classrooms in May and September

Months	Time	Classrooms
May	8:00-9:00	23.85
	9:00-10:00	24.24
	10:00-11:00	24.61
	11:00-12:00	24.91
	12:00-13:00	25.09
	13:00-14:00	25.16
	14:00-15:00	25.12
	15:00-16:00	24.98
	16:00-17:00	24.85
September	8:00-9:00	24.79
	9:00-10:00	25.00
	10:00-11:00	25.34
	11:00-12:00	25.68
	12:00-13:00	26.02
	13:00-14:00	26.19
	14:00-15:00	26.04
	15:00-16:00	25.73
	16:00-17:00	25.53

The relative humidity in May and September ranged from 36.81% to 56.16%. The average values in May and September were 38.69% and 54.35% on average, respectively.

Table 9.36. The relative humidity in classrooms in May and September

Months	Time	Classrooms
May	8:00-9:00	41.35
	9:00-10:00	40.77
	10:00-11:00	38.09
	11:00-12:00	38.23
	12:00-13:00	36.92
	13:00-14:00	36.81
	14:00-15:00	37.23

	15:00-16:00	39.34
	16:00-17:00	39.43
September	8:00-9:00	56.16
	9:00-10:00	56.02
	10:00-11:00	55.36
	11:00-12:00	54.59
	12:00-13:00	53.79
	13:00-14:00	53.68
	14:00-15:00	52.81
	15:00-16:00	52.89
	16:00-17:00	53.83

In May and September, the internal CO_2 concentration was 900 ppm on average, as in the other months.

Table 9.37. The CO_2 concentrations in classrooms in May and September

Months	Time	Classrooms
May	8:00-9:00	840.20
	9:00-10:00	906.04
	10:00-11:00	908.89
	11:00-12:00	910.35
	12:00-13:00	911.18
	13:00-14:00	911.64
	14:00-15:00	911.95
	15:00-16:00	912.15
	16:00-17:00	912.28
September	8:00-9:00	842.20
	9:00-10:00	906.89
	10:00-11:00	908.94
	11:00-12:00	910.04
	12:00-13:00	910.88
	13:00-14:00	911.44
	14:00-15:00	911.83
	15:00-16:00	912.09
	16:00-17:00	912.28

The PMV values in May and September were 0.80 and 1.07 on average, respectively. The lowest value was 0.60 during first hour in May. The highest value was 1.19 between 13:00 pm and 14:00 pm in September. Generally, in May and September, approximately 24.6% of students were dissatisfied with the thermal performance of classrooms in these two months.

Table 9.38. The PMV and PPD values in classrooms in May and September

Months	Time	Classrooms	
		PMV	PPD
May	8:00-9:00	0.62	14.85
	9:00-10:00	0.70	16.62
	10:00-11:00	0.78	18.66
	11:00-12:00	0.83	20.49
	12:00-13:00	0.87	21.67
	13:00-14:00	0.88	22.07
	14:00-15:00	0.87	21.83
	15:00-16:00	0.85	21.15
	16:00-17:00	0.83	20.48
September	8:00-9:00	0.91	22.53
	9:00-10:00	0.96	24.46
	10:00-11:00	1.03	27.28
	11:00-12:00	1.09	30.15
	12:00-13:00	1.16	33.32
	13:00-14:00	1.19	34.80
	14:00-15:00	1.16	33.24
	15:00-16:00	1.10	30.37
	16:00-17:00	1.06	28.70

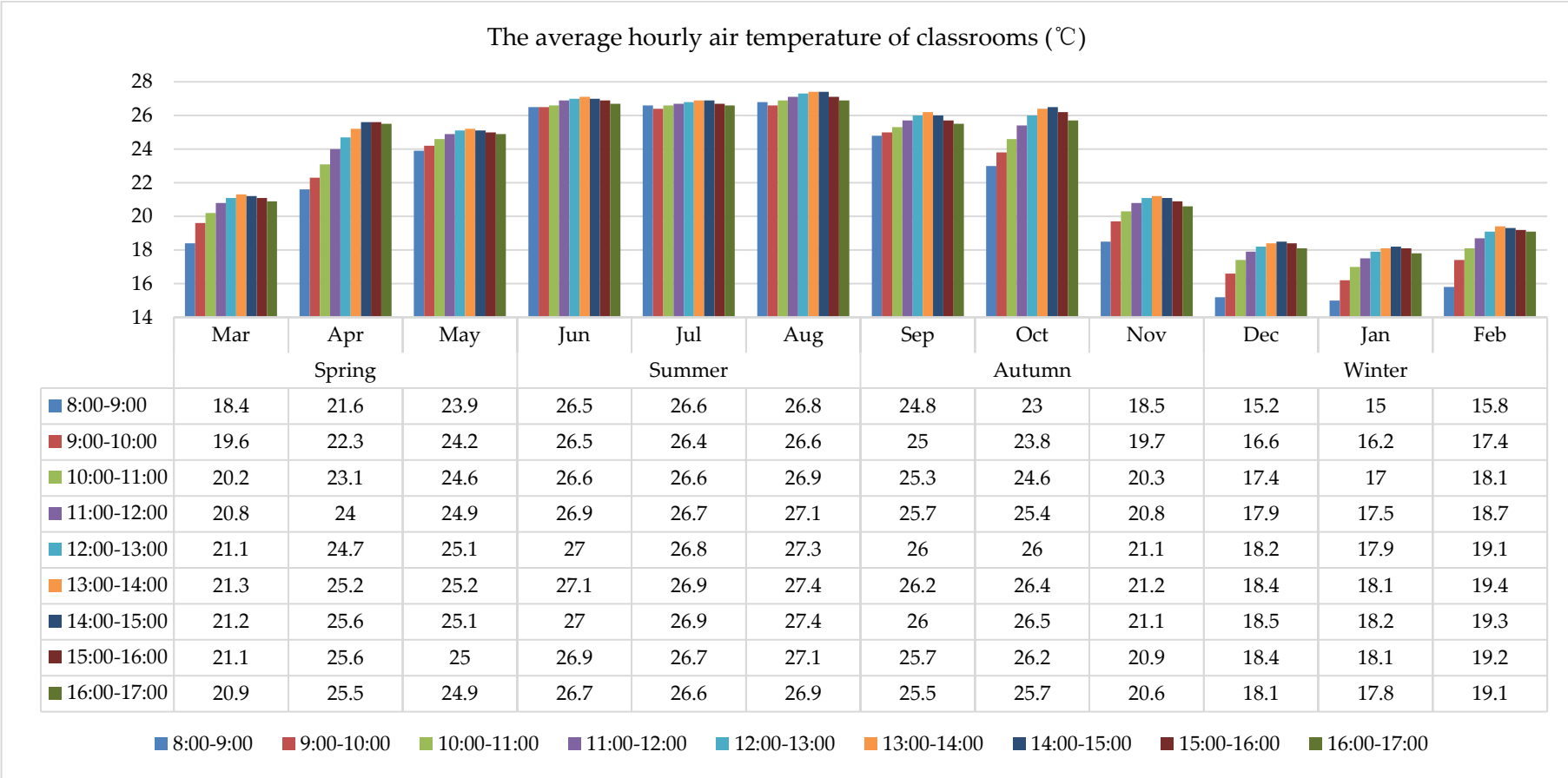
9.6. Analysis of the classroom DTM results

9.6.1. Indoor air temperature

Figure 9.46 presents the average hourly air temperatures in classrooms throughout the year. In winter, classrooms had a lower air temperature than in other months. In particular, at the beginning of the school day, the air temperature was between 15°C and 17°C. In February, the air temperatures were generally 1°C higher than the air temperatures in December and January. In summer, classrooms had a higher air temperature than in other months, and the values ranged from 26.4°C to 27.4°C. In March and November, the air temperatures in classrooms were similar, with values ranging from 18°C to 21°C on average. In September and October, classrooms had slightly higher air temperatures than classrooms in April and May, and the values ranged from 23°C to 26.5°C and 21.6°C to 25.6°C, respectively.

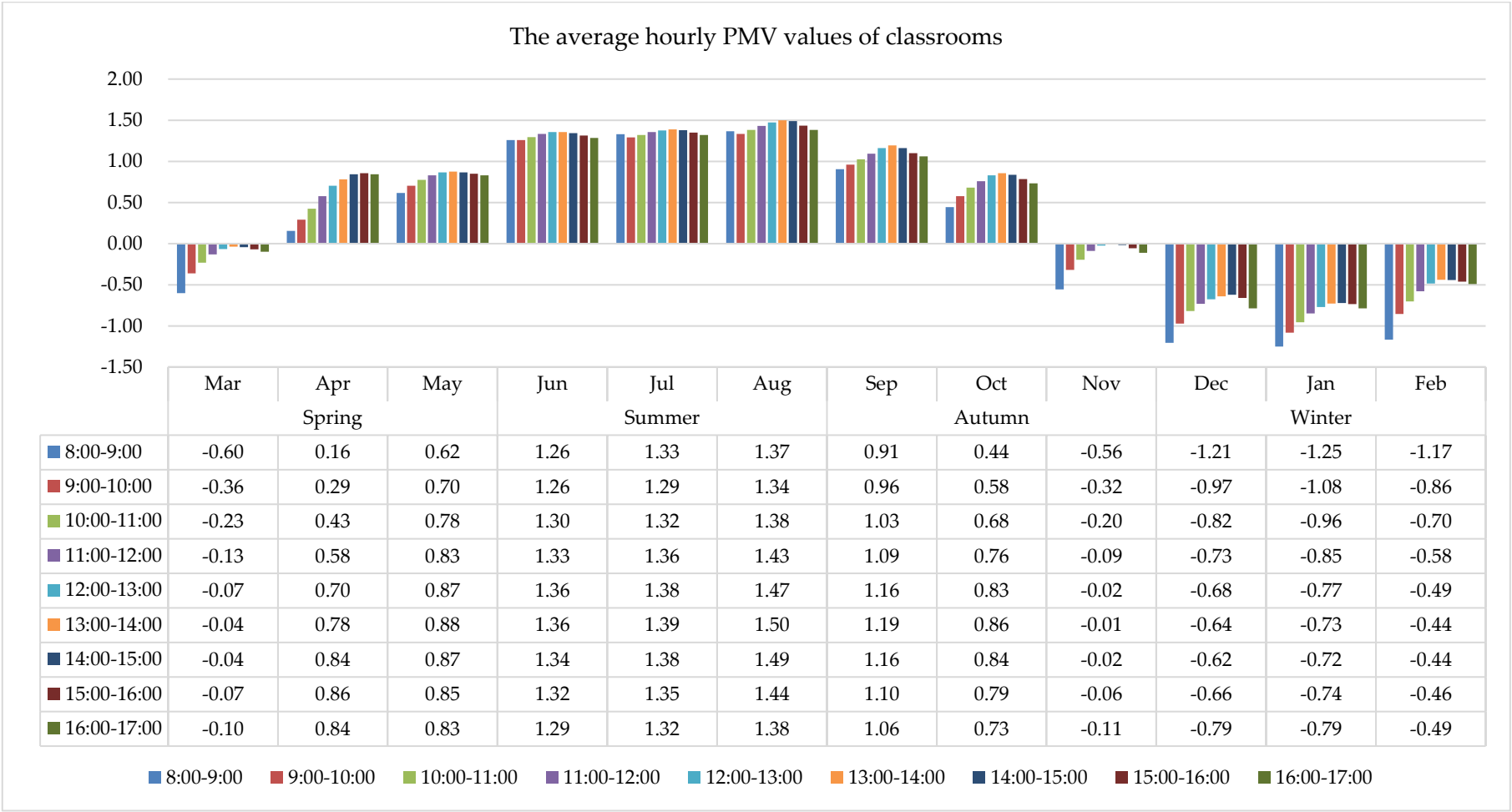
9.6.2. PMV

Figure 9.47 shows the average hourly PMV values throughout the year. The PMV values were consistent with the temperature values. For example, in winter, the indoor air temperature ranged from 15°C to 19°C, indicating a slightly colder than average indoor thermal environment. In summer, a warm indoor thermal environment was achieved, and the indoor air temperatures were between 26.4°C to 27.4°C. The PMV values in transition months were moderate. Specifically, these values were higher than those in winter but lower than those in summer. March and November exhibited a similar performance, and the values were all between -0.6 and -0.01. The PMV values in September and October were slightly higher than those in April and May, and the values ranged from 0.44 to 0.19 and 0.16 to 0.88, respectively.



	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
	Spring			Summer			Autumn			Winter		
8:00-9:00	18.4	21.6	23.9	26.5	26.6	26.8	24.8	23	18.5	15.2	15	15.8
9:00-10:00	19.6	22.3	24.2	26.5	26.4	26.6	25	23.8	19.7	16.6	16.2	17.4
10:00-11:00	20.2	23.1	24.6	26.6	26.6	26.9	25.3	24.6	20.3	17.4	17	18.1
11:00-12:00	20.8	24	24.9	26.9	26.7	27.1	25.7	25.4	20.8	17.9	17.5	18.7
12:00-13:00	21.1	24.7	25.1	27	26.8	27.3	26	26	21.1	18.2	17.9	19.1
13:00-14:00	21.3	25.2	25.2	27.1	26.9	27.4	26.2	26.4	21.2	18.4	18.1	19.4
14:00-15:00	21.2	25.6	25.1	27	26.9	27.4	26	26.5	21.1	18.5	18.2	19.3
15:00-16:00	21.1	25.6	25	26.9	26.7	27.1	25.7	26.2	20.9	18.4	18.1	19.2
16:00-17:00	20.9	25.5	24.9	26.7	26.6	26.9	25.5	25.7	20.6	18.1	17.8	19.1

***Figure 9.46**. DTM results of indoor air temperatures*



	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
	Spring			Summer			Autumn			Winter		
8:00-9:00	-0.60	0.16	0.62	1.26	1.33	1.37	0.91	0.44	-0.56	-1.21	-1.25	-1.17
9:00-10:00	-0.36	0.29	0.70	1.26	1.29	1.34	0.96	0.58	-0.32	-0.97	-1.08	-0.86
10:00-11:00	-0.23	0.43	0.78	1.30	1.32	1.38	1.03	0.68	-0.20	-0.82	-0.96	-0.70
11:00-12:00	-0.13	0.58	0.83	1.33	1.36	1.43	1.09	0.76	-0.09	-0.73	-0.85	-0.58
12:00-13:00	-0.07	0.70	0.87	1.36	1.38	1.47	1.16	0.83	-0.02	-0.68	-0.77	-0.49
13:00-14:00	-0.04	0.78	0.88	1.36	1.39	1.50	1.19	0.86	-0.01	-0.64	-0.73	-0.44
14:00-15:00	-0.04	0.84	0.87	1.34	1.38	1.49	1.16	0.84	-0.02	-0.62	-0.72	-0.44
15:00-16:00	-0.07	0.86	0.85	1.32	1.35	1.44	1.10	0.79	-0.06	-0.66	-0.74	-0.46
16:00-17:00	-0.10	0.84	0.83	1.29	1.32	1.38	1.06	0.73	-0.11	-0.79	-0.79	-0.49

Figure 9.47. *DTM results for PMV values*

9.6.3. PPD

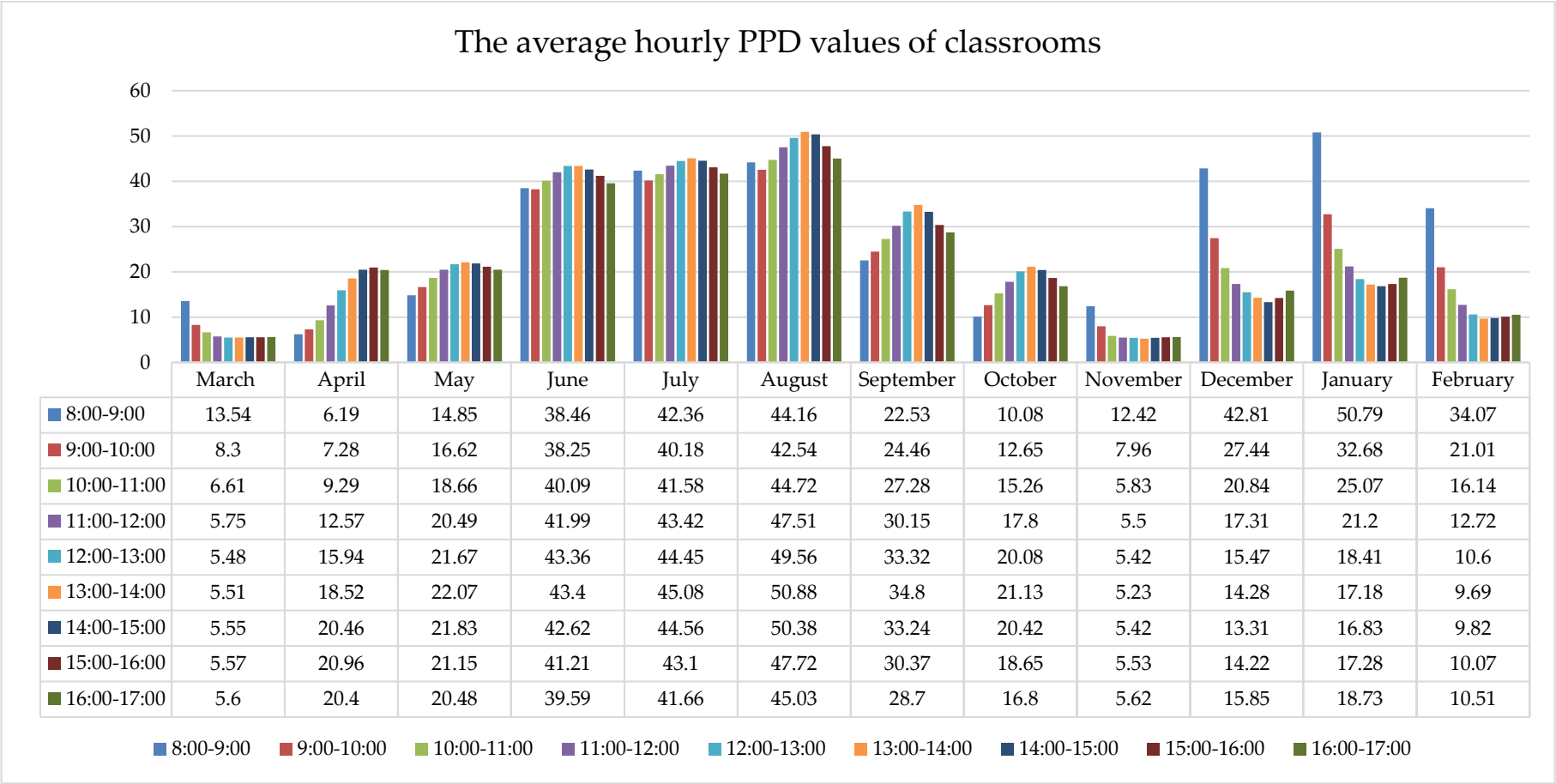
Figure 9.48 shows the average hourly PPD values throughout the year. The PPD values were consistent with the PMV values. For example, in winter and summer, more people were dissatisfied with the thermal comfort performance of classrooms since PMV values in winter and summer showed a slightly cold and warm indoor thermal environment, respectively. March and November exhibited the best performance because only approximately 6.9% of students were dissatisfied with the thermal environment of classrooms.

9.6.4. Relative humidity

Figure 9.49 shows the relative humidity performance of classrooms throughout the year. The levels of relative humidity in a classroom largely depends on those levels of the air inside the sunspace. For example, the highest relative humidity of the air inside the sunspace (all above 80%) were associated with the highest values in classrooms (all approximately 50%). Moreover, in March, April, November, and winter months, the relative humidity in classrooms was approximately 40%. At these times, the relative humidity of the air inside the sunspace remained at 60%.

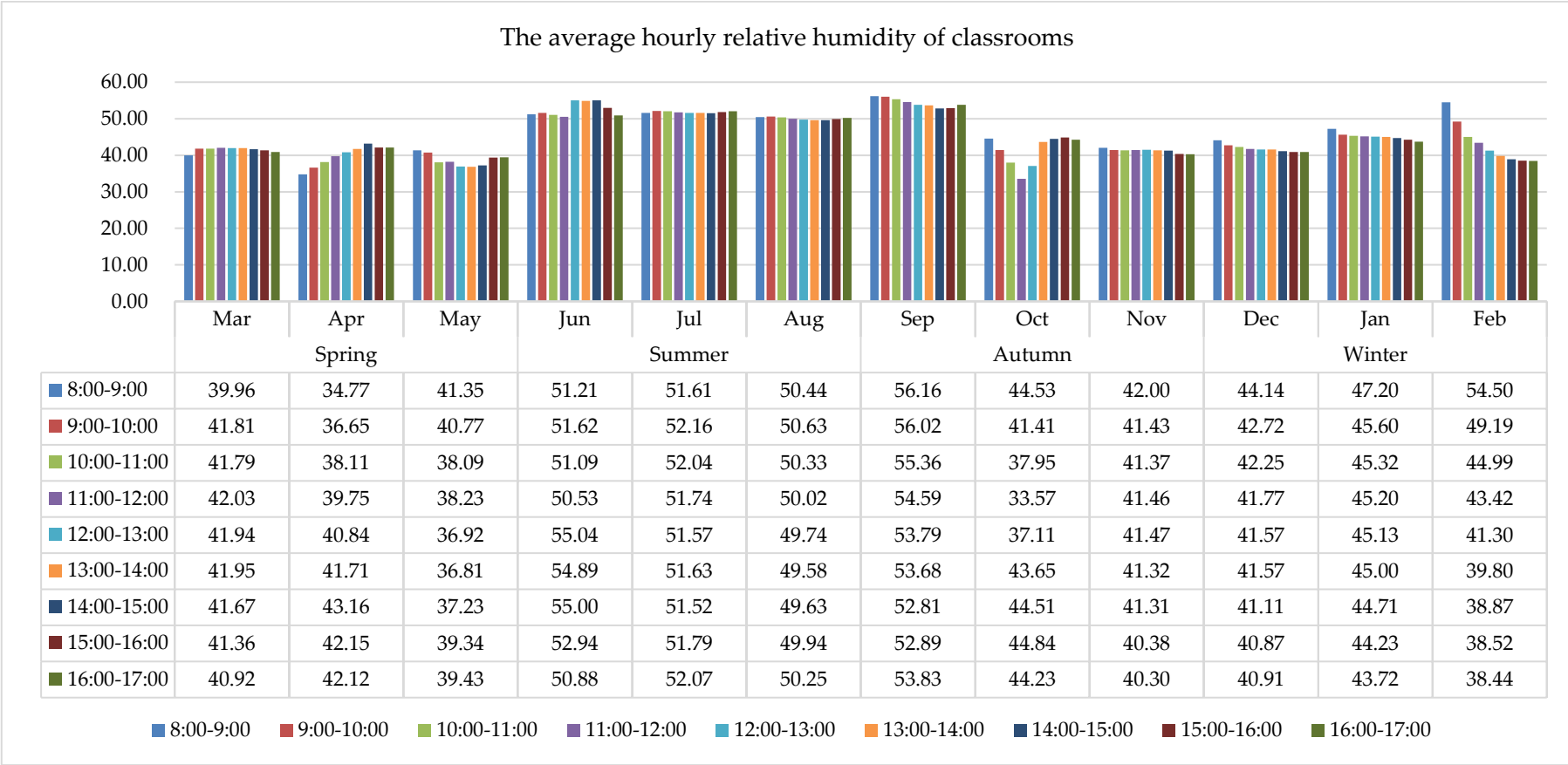
9.6.5. CO_2

Figure 9.50 shows the indoor CO_2 performance of classrooms throughout the year. The internal CO_2 concentration was 900 ppm on average because the occupancy density, and ventilation rate remained the same during school hours.



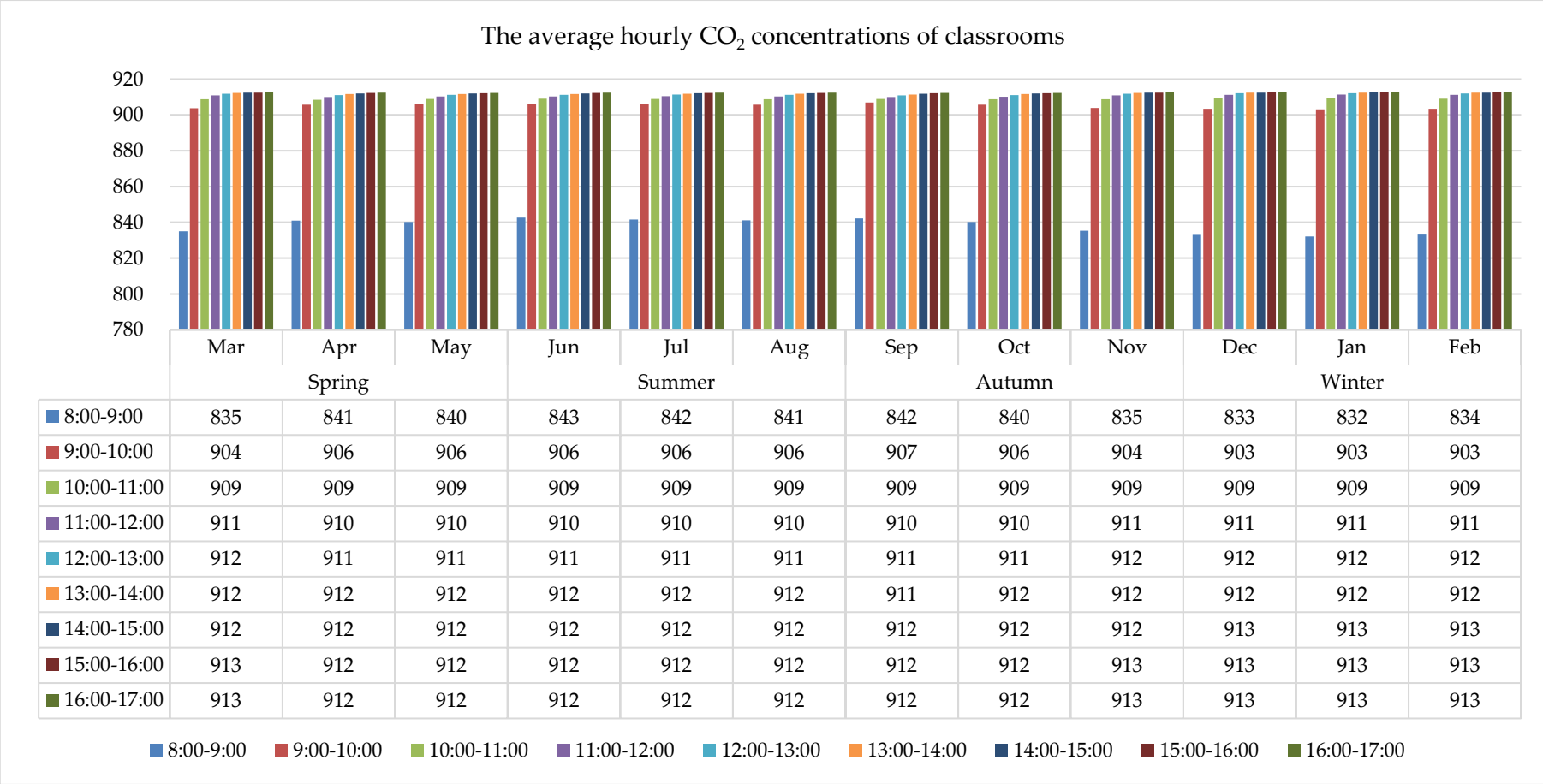
	March	April	May	June	July	August	September	October	November	December	January	February
8:00-9:00	13.54	6.19	14.85	38.46	42.36	44.16	22.53	10.08	12.42	42.81	50.79	34.07
9:00-10:00	8.3	7.28	16.62	38.25	40.18	42.54	24.46	12.65	7.96	27.44	32.68	21.01
10:00-11:00	6.61	9.29	18.66	40.09	41.58	44.72	27.28	15.26	5.83	20.84	25.07	16.14
11:00-12:00	5.75	12.57	20.49	41.99	43.42	47.51	30.15	17.8	5.5	17.31	21.2	12.72
12:00-13:00	5.48	15.94	21.67	43.36	44.45	49.56	33.32	20.08	5.42	15.47	18.41	10.6
13:00-14:00	5.51	18.52	22.07	43.4	45.08	50.88	34.8	21.13	5.23	14.28	17.18	9.69
14:00-15:00	5.55	20.46	21.83	42.62	44.56	50.38	33.24	20.42	5.42	13.31	16.83	9.82
15:00-16:00	5.57	20.96	21.15	41.21	43.1	47.72	30.37	18.65	5.53	14.22	17.28	10.07
16:00-17:00	5.6	20.4	20.48	39.59	41.66	45.03	28.7	16.8	5.62	15.85	18.73	10.51

Figure 9.48. *DTM results for PPD values*



	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
	Spring			Summer			Autumn			Winter		
8:00-9:00	39.96	34.77	41.35	51.21	51.61	50.44	56.16	44.53	42.00	44.14	47.20	54.50
9:00-10:00	41.81	36.65	40.77	51.62	52.16	50.63	56.02	41.41	41.43	42.72	45.60	49.19
10:00-11:00	41.79	38.11	38.09	51.09	52.04	50.33	55.36	37.95	41.37	42.25	45.32	44.99
11:00-12:00	42.03	39.75	38.23	50.53	51.74	50.02	54.59	33.57	41.46	41.77	45.20	43.42
12:00-13:00	41.94	40.84	36.92	55.04	51.57	49.74	53.79	37.11	41.47	41.57	45.13	41.30
13:00-14:00	41.95	41.71	36.81	54.89	51.63	49.58	53.68	43.65	41.32	41.57	45.00	39.80
14:00-15:00	41.67	43.16	37.23	55.00	51.52	49.63	52.81	44.51	41.31	41.11	44.71	38.87
15:00-16:00	41.36	42.15	39.34	52.94	51.79	49.94	52.89	44.84	40.38	40.87	44.23	38.52
16:00-17:00	40.92	42.12	39.43	50.88	52.07	50.25	53.83	44.23	40.30	40.91	43.72	38.44

Figure 9.49. *DTM results for relative humidity*



	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
	Spring			Summer			Autumn			Winter		
8:00-9:00	835	841	840	843	842	841	842	840	835	833	832	834
9:00-10:00	904	906	906	906	906	906	907	906	904	903	903	903
10:00-11:00	909	909	909	909	909	909	909	909	909	909	909	909
11:00-12:00	911	910	910	910	910	910	910	910	911	911	911	911
12:00-13:00	912	911	911	911	911	911	911	911	912	912	912	912
13:00-14:00	912	912	912	912	912	912	911	912	912	912	912	912
14:00-15:00	912	912	912	912	912	912	912	912	912	913	913	913
15:00-16:00	913	912	912	912	912	912	912	912	913	913	913	913
16:00-17:00	913	912	912	912	912	912	912	912	913	913	913	913

Figure 9.50. *DTM results for internal CO_2 concentrations*

9.7. DTM analysis of the solar chimney

9.7.1. Model setup for the solar chimney

The DTM results for the classrooms are used as inputs for the DTM analyses of the solar chimney. The materials and parameters introduced in section 7.3 are assigned to the glazed roof of the sunspace. For example, the U-value and the solar shading coefficient of the triple-glazed roof of the sunspace are 1.5W/m^{2}K and 0.15, respectively.

Air only flows into the solar chimney during occupied hours. Therefore, the variation profile, as shown in Figure 9.51, is set to "on" during the occupied hours and "off" during the unoccupied periods. Table 9.39 summarises the supplied air temperatures for the solar chimney, and Figures 9.52 to 9.63 show the operating profiles for each month.

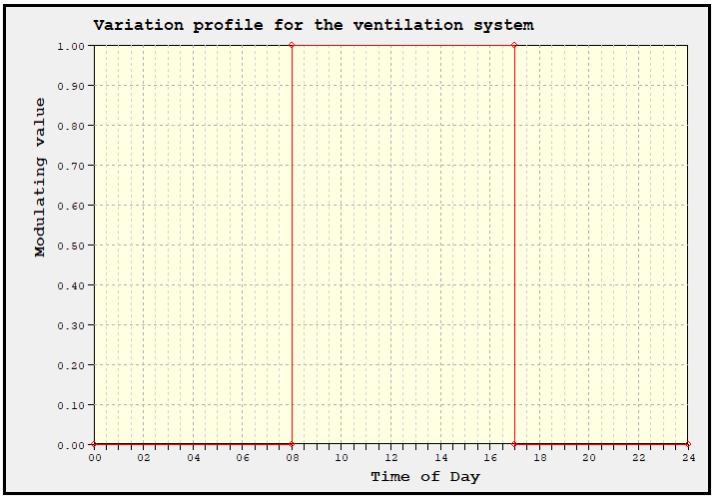


Figure 9.51. *Operating controlling profile for the ventilation system*

Table 9.39. Supplied air temperatures from classrooms to the solar chimney

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
8:00-9:00	18.4	21.6	23.9	26.5	26.6	26.8	24.8	23.0	18.5	15.2	15.0	15.8
9:00-10:00	19.6	22.3	24.2	26.5	26.4	26.6	25.0	23.8	19.7	16.6	16.2	17.4
10:00-11:00	20.2	23.1	24.6	26.6	26.6	26.9	25.3	24.6	20.3	17.4	17.0	18.1
11:00-12:00	20.8	24.0	24.9	26.9	26.7	27.1	25.7	25.4	20.8	17.9	17.5	18.7

12:00-13:00	21.1	24.7	25.1	27.0	26.8	27.3	26.0	26.0	21.1	18.2	17.9	19.1
13:00-14:00	21.3	25.2	25.2	27.1	26.9	27.4	26.2	26.4	21.2	18.4	18.1	19.4
14:00-15:00	21.2	25.6	25.1	27.0	26.9	27.4	26.0	26.5	21.1	18.5	18.2	19.3
15:00-16:00	21.1	25.6	25.0	26.9	26.7	27.1	25.7	26.2	20.9	18.4	18.1	19.2
16:00-17:00	20.9	25.5	24.9	26.7	26.6	26.9	25.5	25.7	20.6	18.1	17.8	19.1

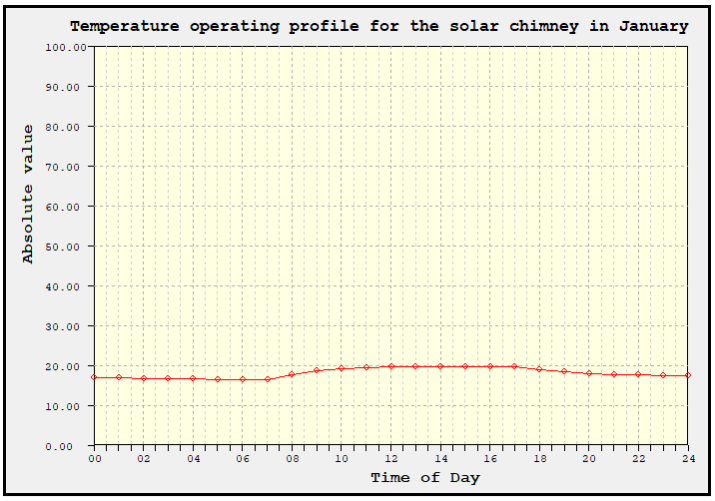


Figure 9.52. *Temperature operating profile for the solar chimney in January*

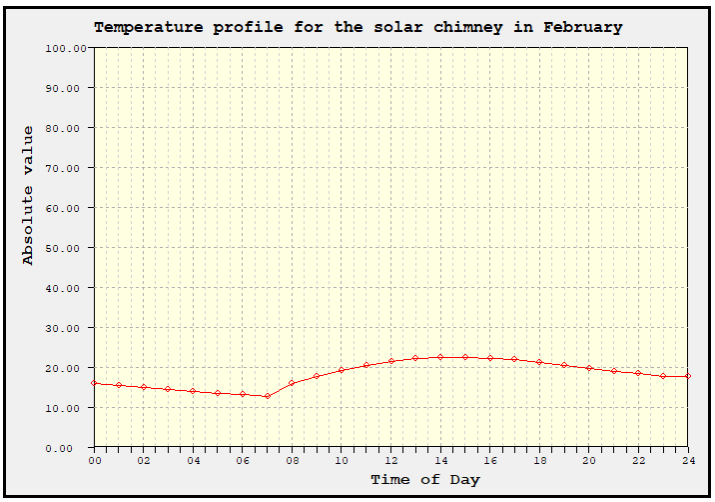


Figure 9.53. *Temperature operating profile for the solar chimney in February*

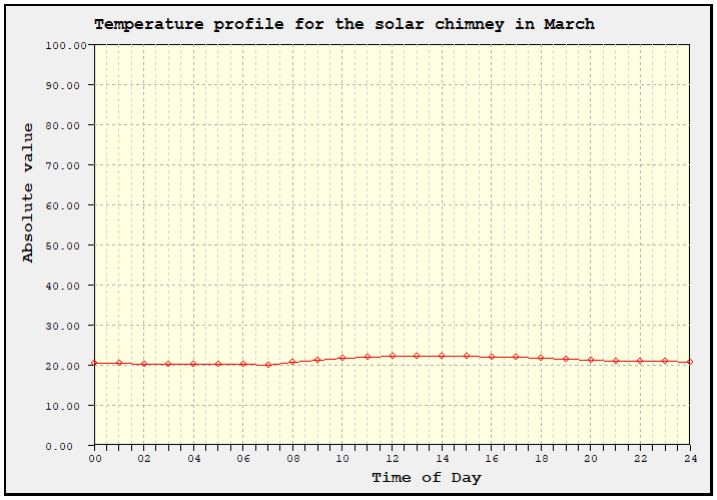


Figure 9.54. *Temperature operating profile for the solar chimney in March*

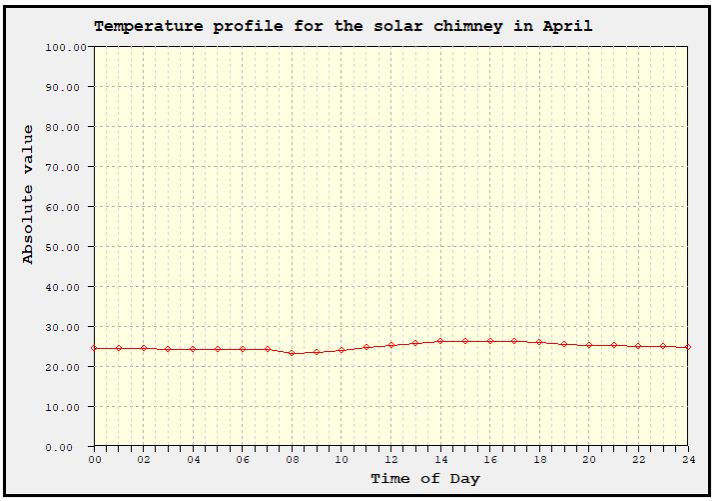


Figure 9.55. *Temperature operating profile for the solar chimney in April*

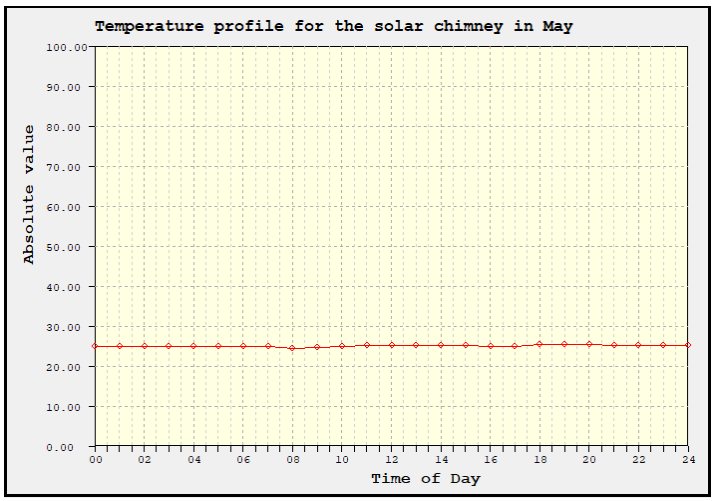


Figure 9.56. *Temperature operating profile for the solar chimney in May*

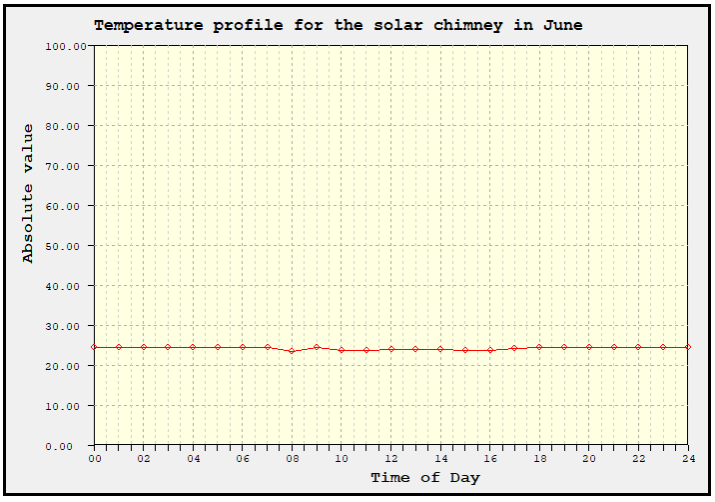


Figure 9.57. *Temperature operating profile for the solar chimney in June*

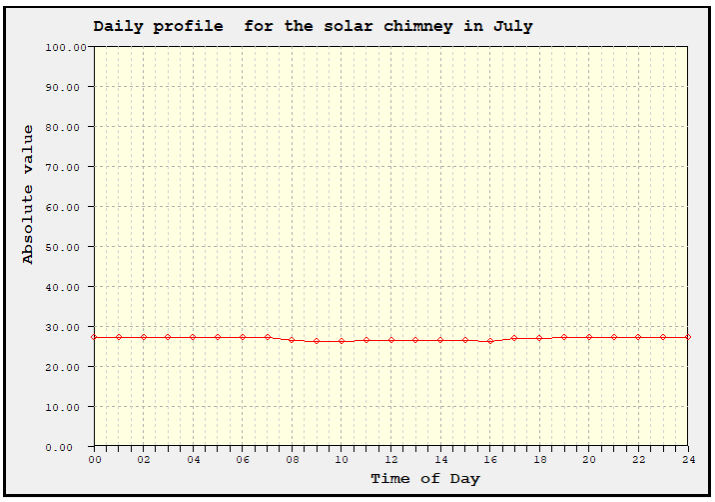


Figure 9.58. *Temperature operating profile for the solar chimney in July*

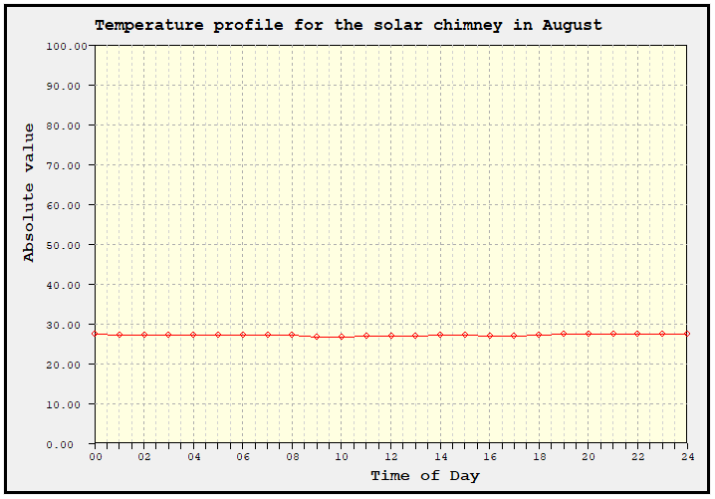


Figure 9.59. *Temperature operating profile for the solar chimney in August*

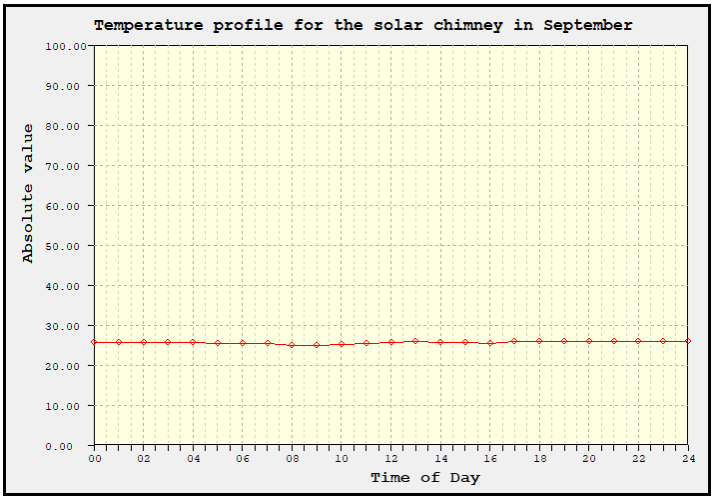


Figure 9.60. *Temperature operating profile for the solar chimney in September*

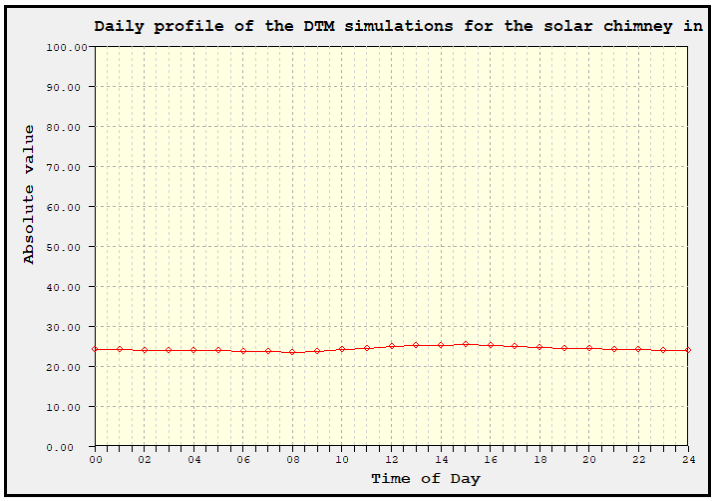


Figure 9.61. *Temperature operating profile for the solar chimney in October*

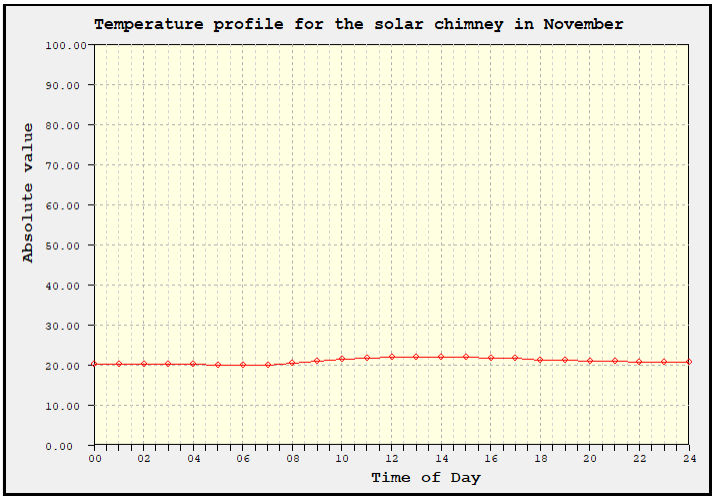


Figure 9.62. *Temperature operating profile for the solar chimney in November*

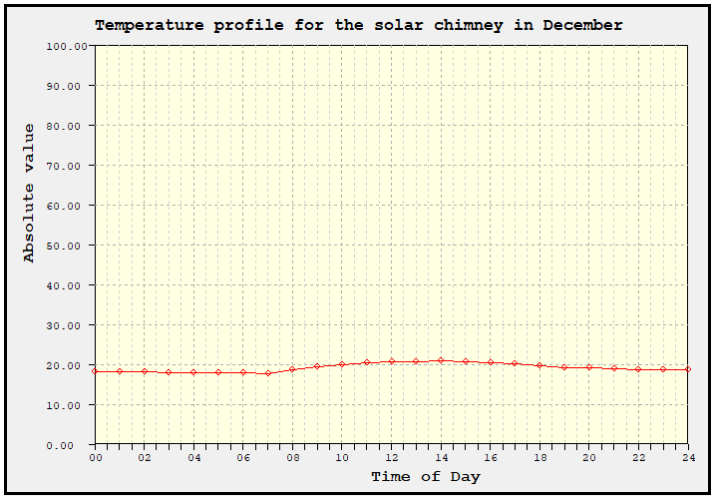


Figure 9.63. *Temperature operating profile for the solar chimney in December*

9.7.2. DTM results of the solar chimney

Table 9.40 summarises the air temperatures based on the DTM results for the solar chimney because the air temperature is the sole parameter that affects the ventilation system's performance.

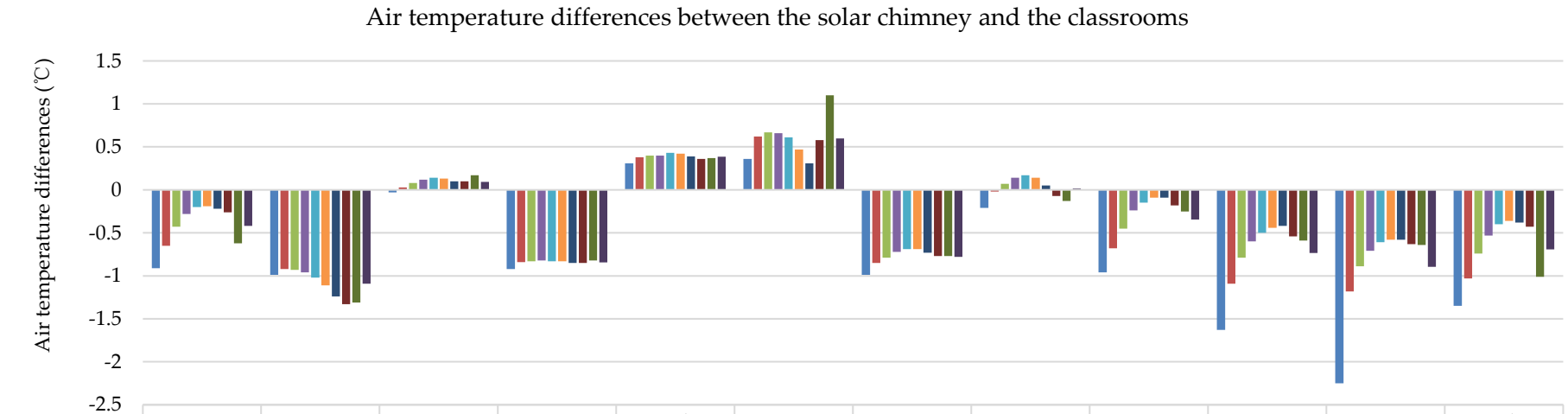
Table 9.40. DTM results for the air temperature in the solar chimney

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
8:00-9:00	17.46	20.56	23.82	25.60	26.89	27.12	23.80	22.74	17.57	13.53	12.77	14.44
9:00-10:00	18.92	21.37	24.27	25.61	26.79	27.25	24.15	23.76	19.02	15.55	15.00	16.32
10:00-11:00	19.79	22.18	24.69	25.81	26.95	27.52	24.55	24.71	19.85	16.62	16.13	17.33
11:00-12:00	20.47	23.03	25.03	26.04	27.14	27.77	24.96	25.53	20.56	17.29	16.83	18.14
12:00-13:00	20.91	23.70	25.23	26.20	27.27	27.91	25.34	26.20	20.97	17.67	17.32	18.72
13:00-14:00	21.07	24.12	25.29	26.23	27.32	27.89	25.50	26.57	21.09	17.91	17.55	18.99
14:00-15:00	21.02	24.33	25.22	26.15	27.24	27.69	25.31	26.57	21.02	18.08	17.59	18.94
15:00-16:00	20.82	24.31	25.08	26.00	27.08	27.72	24.96	26.16	20.73	17.82	17.44	18.78
16:00-17:00	20.31	24.21	25.02	25.86	26.96	28.00	24.76	25.55	20.37	17.49	17.18	18.07

9.7.2.1. Temperature differences between the solar chimney and the classrooms

Figure 9.64 illustrates the temperature differences between the solar chimney and the classrooms. In transition months, such as March, April, September, November

and some winter months, the air temperatures in the solar chimney were lower than the air temperatures in classrooms since the cold ambient weather, particularly in winter months, results in more heat inside the solar chimney being lost than is gained from solar heating. Moreover, the external glazing of the solar chimney (the same as that for the external windows in the classrooms) has a small total shading coefficient (0.15), which significantly decreases the absorbed solar heat gains. In July and August, the air temperatures inside the solar chimney were higher than those in classrooms due to the relatively high solar radiation level of the ambient environment. In May and October, the air temperature in classrooms were lower than the air temperatures in the solar chimney during the middle of the occupied period. At the beginning (May and October) and end of the school hours (October), the air temperatures in the solar chimney were lower than those in the classrooms due to the effects of the relatively cold ambient environment.



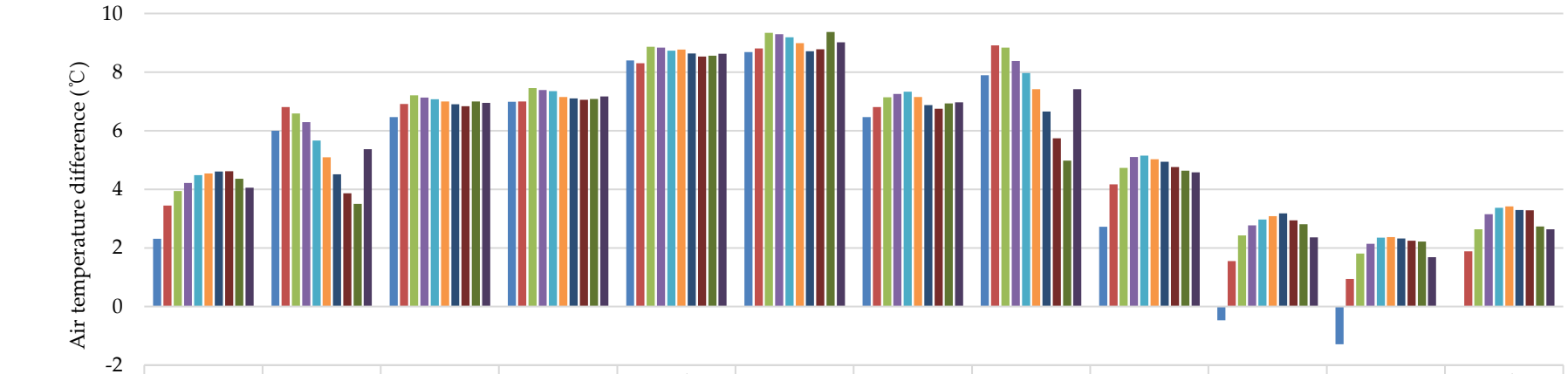
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
8:00-9:00	-0.91	-0.99	-0.03	-0.92	0.31	0.36	-0.99	-0.21	-0.96	-1.63	-2.25	-1.35
9:00-10:00	-0.65	-0.92	0.03	-0.84	0.38	0.62	-0.85	-0.02	-0.68	-1.09	-1.18	-1.03
10:00-11:00	-0.43	-0.93	0.08	-0.83	0.4	0.67	-0.79	0.07	-0.45	-0.79	-0.89	-0.74
11:00-12:00	-0.28	-0.96	0.12	-0.82	0.4	0.66	-0.72	0.14	-0.24	-0.6	-0.71	-0.53
12:00-13:00	-0.2	-1.02	0.14	-0.83	0.43	0.61	-0.69	0.17	-0.15	-0.5	-0.61	-0.4
13:00-14:00	-0.19	-1.11	0.13	-0.83	0.42	0.47	-0.69	0.14	-0.09	-0.44	-0.58	-0.36
14:00-15:00	-0.22	-1.24	0.1	-0.85	0.39	0.31	-0.73	0.05	-0.09	-0.42	-0.58	-0.38
15:00-16:00	-0.26	-1.33	0.1	-0.85	0.36	0.58	-0.77	-0.07	-0.18	-0.54	-0.63	-0.43
16:00-17:00	-0.62	-1.31	0.17	-0.82	0.37	1.1	-0.77	-0.13	-0.25	-0.59	-0.64	-1.01
On average	-0.42	-1.09	0.09	-0.84	0.38	0.60	-0.78	0.02	-0.34	-0.73	-0.90	-0.69

Figure 9.64. *Air temperature differences between the solar chimney and the classrooms.*

9.7.2.2. Temperature differences between the solar chimney and the sunspace

Although the air temperatures inside the solar chimney decreased in most of the occupied periods, they were still higher than those temperatures in the sunspace, except during the first occupied hour in January and December (Figure 9.65). In winter, the air temperature differences between the solar chimney and the sunspace ranged from -1.29°C to 3.42°C. For example, in January, the temperature difference was only approximately 1.6°C on average. Moreover, at the beginning of the school day in January and December, the air temperatures inside the solar chimney were 1.29°C and 0.47°C lower than the air temperatures inside the sunspace. Under such conditions, a downdraft, which can cause a reserve flow, might occur between the solar chimney and the sunspace. The air temperature differences were relatively significant in May, September, October and the summer months. For example, the air temperatures inside the solar chimney were 7°C, 8°C and 9°C higher than the air temperatures inside the sunspace in June, July and August, respectively. In March, April and November, the air temperatures differences were higher than those values in winter but lower than those values in May, September, October and the summer months.

Thus, to increase the air temperature in the solar chimney and further improve the ILEV system's ventilation efficiency, the total shading coefficient of the glazed panel of the solar chimney should be increased to improve the solar heat gains of the chimney, as discussed in the next section.



	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
8:00-9:00	2.31	6	6.46	6.99	8.4	8.68	6.46	7.89	2.72	-0.47	-1.29	0
9:00-10:00	3.45	6.81	6.91	7	8.3	8.81	6.81	8.91	4.17	1.55	0.94	1.88
10:00-11:00	3.94	6.59	7.21	7.45	8.86	9.34	7.14	8.84	4.73	2.43	1.81	2.64
11:00-12:00	4.22	6.29	7.13	7.39	8.84	9.29	7.25	8.38	5.1	2.77	2.14	3.15
12:00-13:00	4.48	5.66	7.07	7.35	8.73	9.19	7.33	7.97	5.15	2.97	2.35	3.37
13:00-14:00	4.54	5.09	7	7.15	8.77	8.99	7.15	7.42	5.03	3.08	2.37	3.42
14:00-15:00	4.61	4.51	6.9	7.1	8.64	8.71	6.87	6.65	4.94	3.18	2.32	3.29
15:00-16:00	4.62	3.86	6.84	7.05	8.53	8.78	6.75	5.74	4.76	2.94	2.25	3.28
16:00-17:00	4.36	3.5	7	7.08	8.56	9.37	6.93	4.98	4.64	2.81	2.22	2.73
On average	4.06	5.37	6.95	7.17	8.63	9.02	6.97	7.42	4.58	2.36	1.68	2.64

Figure 9.65. *Air temperature differences between the solar chimney and the sunspace*

9.7.3. DTM results for the solar chimney with a shading coefficient of 0.75

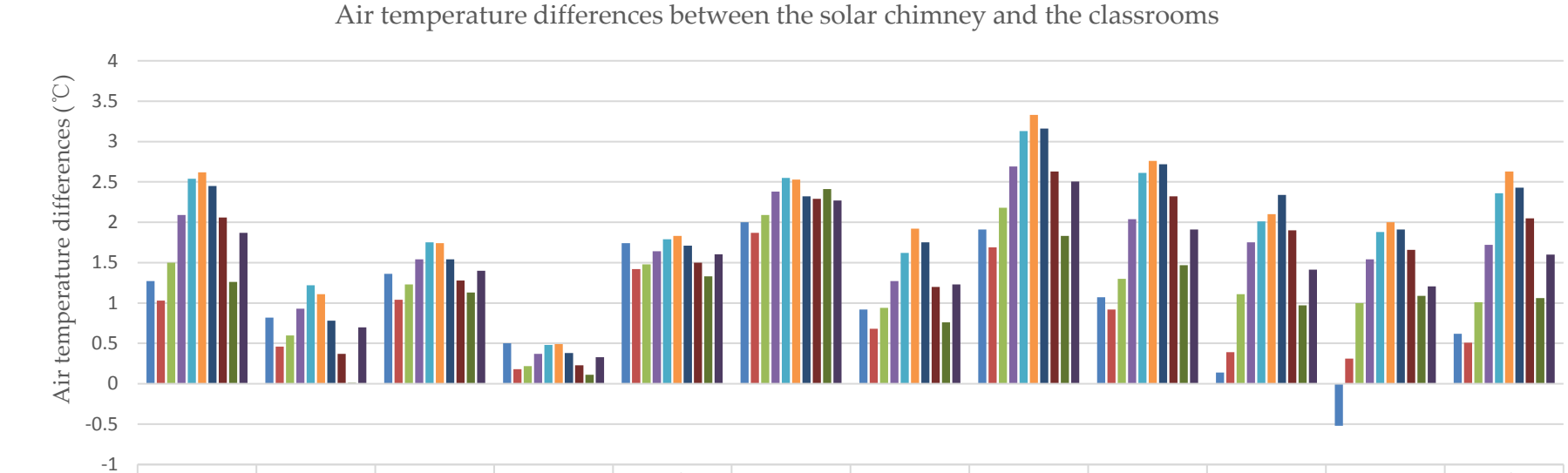
Many studies have shown that double glazing or even triple glazing can increase the performance of a solar chimney (section 6.4.5), particularly in winter, since these processes can decrease the conductive heat loss and increase the heat gains from solar radiation simultaneously. Therefore, the external triple glazing used in the studied primary school building was used in the DTM simulations of the solar chimney. However, the solar shading coefficient should be increased to a high level to absorb more solar heat for the solar chimney. The more recent version of the Chinese Thermal Design Code of Civil Buildings (GB50176-2016) sets 0.75 as the highest solar shading coefficient for the triple glazing. Therefore, the solar shading coefficient was increased to 0.75 for the second round of DTM analyses of the solar chimney. Table 9.41 provides the simulation results for the solar chimney when the solar shading coefficient was increased to 0.75.

Table 9.41. DTM results for the air temperature in the solar chimney (solar shading coefficient: 0.75)

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
8:00-9:00	19.64	22.37	25.21	27.02	28.32	28.76	25.71	24.86	19.60	15.30	14.50	16.41
9:00-10:00	20.60	22.75	25.28	26.63	27.83	28.50	25.68	25.47	20.62	17.03	16.49	17.86
10:00-11:00	21.72	23.71	25.84	26.86	28.03	28.94	26.28	26.82	21.60	18.52	18.02	19.08
11:00-12:00	22.84	24.92	26.45	27.23	28.38	29.49	26.95	28.08	22.84	19.64	19.08	20.39
12:00-13:00	23.65	25.94	26.84	27.51	28.63	29.85	27.65	29.16	23.73	20.18	19.81	21.48
13:00-14:00	23.88	26.34	26.90	27.55	28.73	29.95	28.11	29.76	23.94	20.45	20.13	21.98
14:00-15:00	23.69	26.35	26.66	27.38	28.56	29.70	27.79	29.68	23.83	20.84	20.08	21.75
15:00-16:00	23.14	26.01	26.26	27.08	28.22	29.43	26.93	28.86	23.23	20.26	19.73	21.26
16:00-17:00	22.19	25.53	25.98	26.79	27.92	29.31	26.29	27.51	22.09	19.05	18.91	20.14

9.7.3.1. Temperature differences between the solar chimney and the classrooms

Figure 9.66 shows the temperature differences between the solar chimney and the classrooms. The air temperatures inside the solar chimney were higher than the air temperature inside the classrooms during most school hours. The highest air temperature difference was 3.33°C between 13:00 pm and 14:00 pm in October. However, in January, the air temperature inside the solar chimney was 0.52°C lower than the air temperature in classrooms on average.

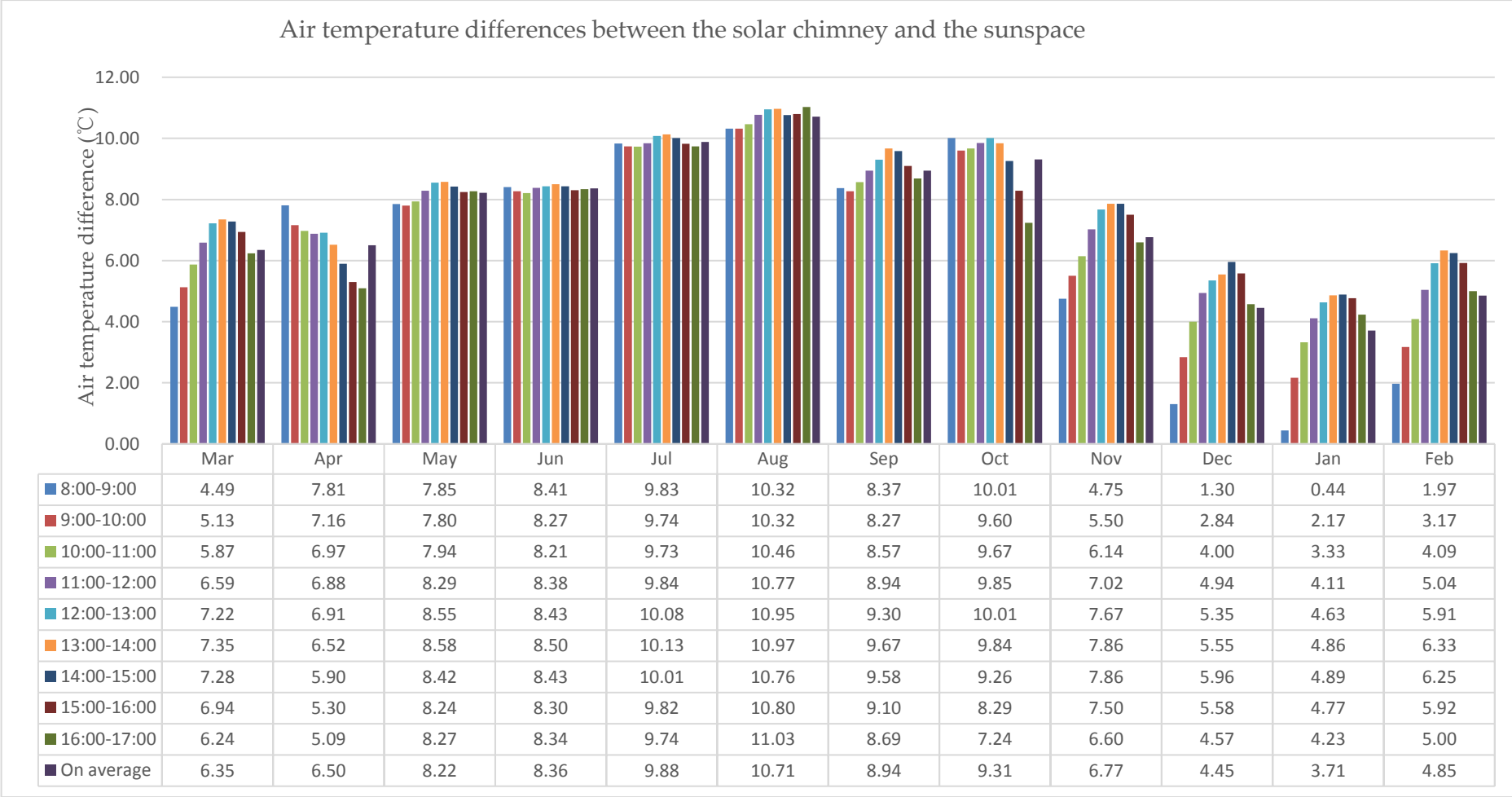


	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
8:00-9:00	1.27	0.82	1.36	0.5	1.74	2	0.92	1.91	1.07	0.14	-0.52	0.62
9:00-10:00	1.03	0.46	1.04	0.18	1.42	1.87	0.68	1.69	0.92	0.39	0.31	0.51
10:00-11:00	1.5	0.6	1.23	0.22	1.48	2.09	0.94	2.18	1.3	1.11	1	1.01
11:00-12:00	2.09	0.93	1.54	0.37	1.64	2.38	1.27	2.69	2.04	1.75	1.54	1.72
12:00-13:00	2.54	1.22	1.75	0.48	1.79	2.55	1.62	3.13	2.61	2.01	1.88	2.36
13:00-14:00	2.62	1.11	1.74	0.49	1.83	2.53	1.92	3.33	2.76	2.1	2	2.63
14:00-15:00	2.45	0.78	1.54	0.38	1.71	2.32	1.75	3.16	2.72	2.34	1.91	2.43
15:00-16:00	2.06	0.37	1.28	0.23	1.5	2.29	1.2	2.63	2.32	1.9	1.66	2.05
16:00-17:00	1.26	0.01	1.13	0.11	1.33	2.41	0.76	1.83	1.47	0.97	1.09	1.06
On average	1.87	0.70	1.40	0.33	1.60	2.27	1.23	2.51	1.91	1.41	1.21	1.60

Figure 9.66. *Air temperature differences between the solar chimney and the classrooms*

9.7.3.2. Temperature differences between the solar chimney and the sunspace

Figure 9.67 illustrates the air temperature differences between the solar chimney and the sunspace. The air temperatures inside the solar chimney were higher than the air temperatures of the sunspace throughout the occupied periods. The highest air temperature difference was 10°C on average in August, and the lowest air temperature difference was 3.71°C on average in January. In March, April, and November, the air temperatures in the solar chimney were approximately 6.5°C higher than the air temperatures in the sunspace. In May, June, July, September, and October, this number was greater than 8°C. The air temperature differences in winter months were relatively low and ranged from 0.44°C to 6.33°C. During the first and second teaching hours of the school day, the air temperature differences were only approximately 1.24°C and 2.73°C, respectively, on average.



	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
8:00-9:00	4.49	7.81	7.85	8.41	9.83	10.32	8.37	10.01	4.75	1.30	0.44	1.97
9:00-10:00	5.13	7.16	7.80	8.27	9.74	10.32	8.27	9.60	5.50	2.84	2.17	3.17
10:00-11:00	5.87	6.97	7.94	8.21	9.73	10.46	8.57	9.67	6.14	4.00	3.33	4.09
11:00-12:00	6.59	6.88	8.29	8.38	9.84	10.77	8.94	9.85	7.02	4.94	4.11	5.04
12:00-13:00	7.22	6.91	8.55	8.43	10.08	10.95	9.30	10.01	7.67	5.35	4.63	5.91
13:00-14:00	7.35	6.52	8.58	8.50	10.13	10.97	9.67	9.84	7.86	5.55	4.86	6.33
14:00-15:00	7.28	5.90	8.42	8.43	10.01	10.76	9.58	9.26	7.86	5.96	4.89	6.25
15:00-16:00	6.94	5.30	8.24	8.30	9.82	10.80	9.10	8.29	7.50	5.58	4.77	5.92
16:00-17:00	6.24	5.09	8.27	8.34	9.74	11.03	8.69	7.24	6.60	4.57	4.23	5.00
On average	6.35	6.50	8.22	8.36	9.88	10.71	8.94	9.31	6.77	4.45	3.71	4.85

Figure 9.67. *Air temperature differences between the solar chimney and the sunspace*

9.7.4. Analysis of the DTM results for the solar chimney

Figure 9.68 shows the air temperature differences between the solar chimney and the classrooms for both sets of DTM results. By increasing the solar shading coefficient from 0.15 to 0.75, the air temperature differences significantly increased. For example, in summer, the lowest value increased from -0.84°C to 0.33°C. In transition months, such as April, the air temperature difference increased by 1.79°C on average. In winter, the air temperature inside the solar chimney was 2°C higher than the air temperature inside the classrooms on average.

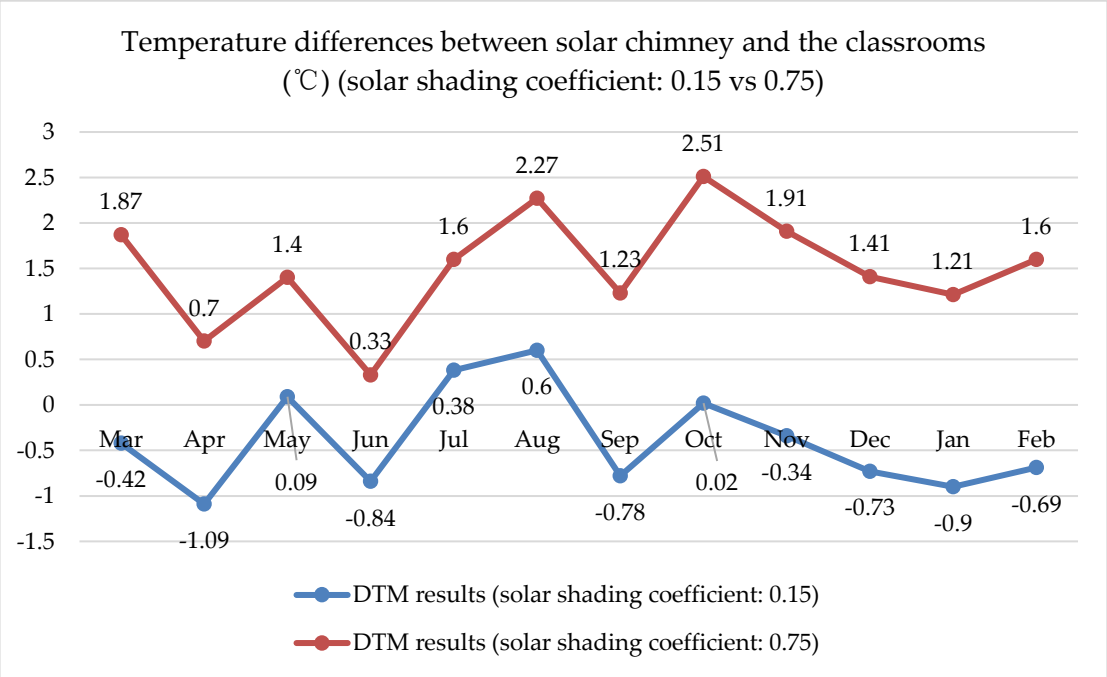


Figure 9.68. *Air temperature differences between the solar chimney and classrooms (solar shading coefficient: 0.15 vs 0.75)*

Figure 9.69 illustrates the air temperature differences between the solar chimney and the sunspace. Clearly, the air temperature difference increased by 2°C on average. Additionally, the highest and lowest values increased from 9.02°C to 10.71°C and 1.68°C to 3.71°C, respectively.

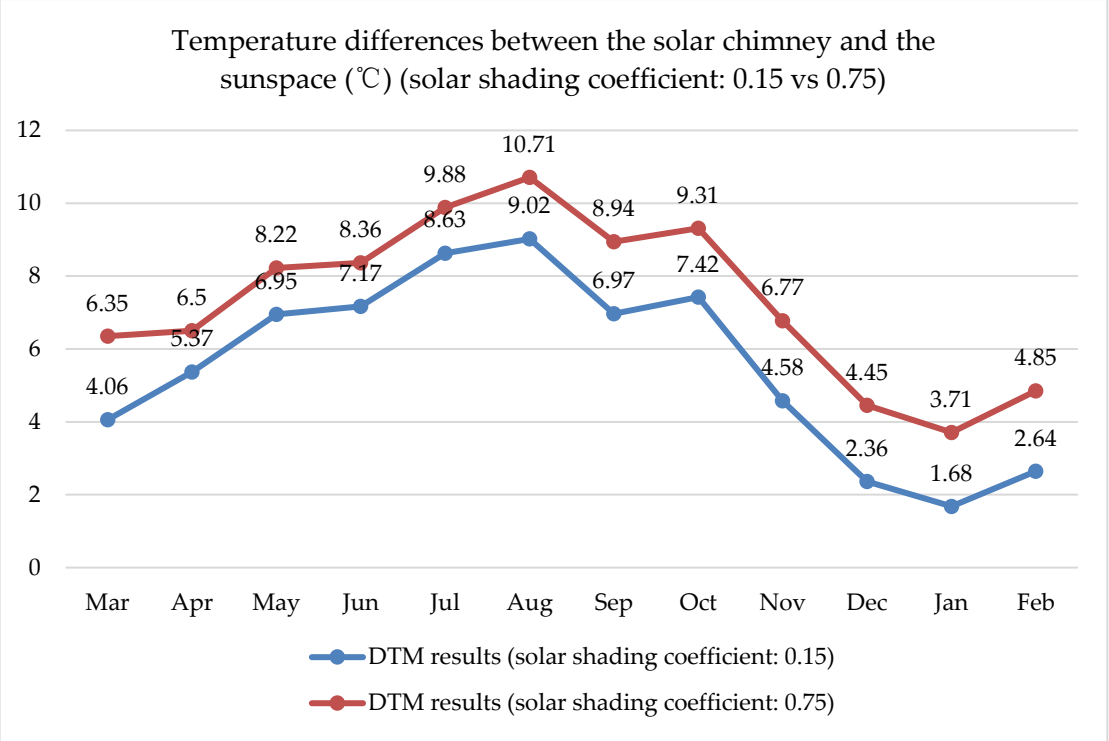


Figure 9.69. *Air temperature differences between the solar chimney and the sunspace (solar shading coefficient: 0.15 vs 0.75)*

Theoretically, the DTM results indicate that air can naturally flow from the sunspace to the solar chimney during most school hours, and the air temperatures predicted in the sunspace were lower than the air temperatures in the solar chimney. Increasing the solar shading coefficient from 0.15 to 0.75 further strengthens the buoyancy effects, and the air temperature differences increased by 2°C on average.

However, at the beginning of each winter month, the air temperature difference was below 3°C. Specifically, during the first hour of occupancy in January, the air temperature difference was only 0.44°C. Small air temperature differences could reduce the ventilation efficiency and require larger opening areas. Therefore, fan C, as shown in Figure 5.1 of section 5.2, could be an alternative option for supplying the air from the sunspace to the classrooms during the first two hours of occupancy of the teaching day in the winter months.

9.8. Summary

DTM analyses were performed to evaluate the indoor thermal environment of the primary school studied and the ventilation performance of the ILEV system. The DTM analyses were threefold and included the DTM analyses of the sunspace, DTM analyses of the classrooms, and DTM analyses of the solar chimney. The following list summarises the critical findings of this chapter.

- In March, November, and the winter months, the EAHEs were in "always on" mode, not only to preheat the supplied air during occupied periods but also to maintain a suitable indoor environment for plant survival and growth during unoccupied periods (Figure 9.70).
- In May, September, and the summer months, the EAHEs were only in operation during occupied periods. In unoccupied periods, the EAHEs were in "always off" mode because the ambient air temperatures were suitable for plant growth and survival. The ventilation of the sunspace with infiltration reduced the incoming ambient PM levels and fan energy consumption (Figure 9.70).

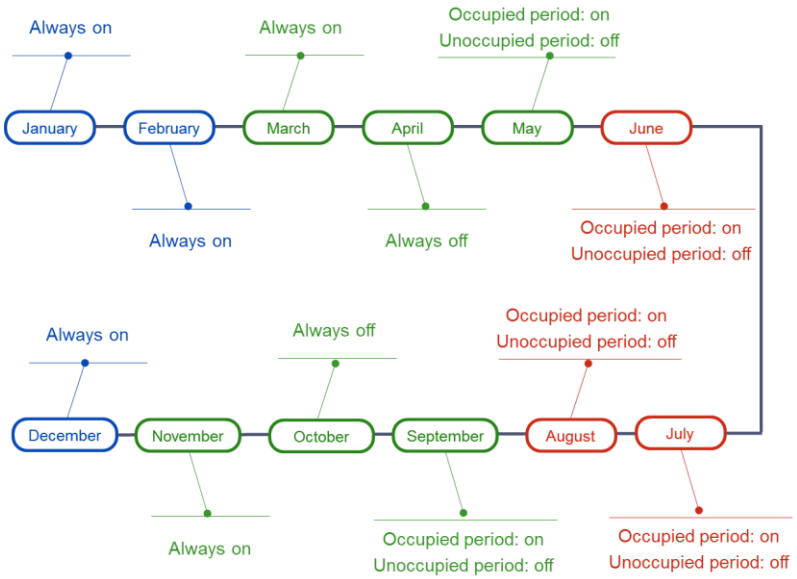


Figure 9.70. *Operation diagram for the EAHEs*

- In April and October, the air temperatures are suitable for plant growth. Thus, the air can directly flow into the sunspace during occupied periods. In unoccupied periods, infiltration was the only way to ventilate the sunspace and reduce the incoming of the ambient PM levels and fan energy consumption (Figure 9.70).

- The DTM simulations of the sunspace showed that the EAHEs successfully provided a thermally comfortable environment for plant growth and survival, and the average air temperature in the sunspace ranged between 10°C and 30°C.

- The relative humidity in the sunspace in March, October, and the winter months was increased to 60% with humidifiers before the air entered the classrooms.

- The DTM analyses of the classrooms indicated that the air temperatures inside the classrooms ranged from 15°C to 27°C on average. For example, in winter, the air temperatures inside the classrooms were between 15°C and 20°C in most of the occupied periods, and in summer, the internal air temperatures ranged from approximately 26°C to 27°C. In spring and autumn, the internal air temperatures fell between these ranges. During most occupied periods, the indoor air temperatures meet the requirements of the Chinese standard.

- The DTM analyses of the ILEV system reflected a stable indoor CO_2 concentration that averaged 900 ppm in the classrooms. This level is lower than 1000 ppm required by both the Chinese standard and WHO regulation.

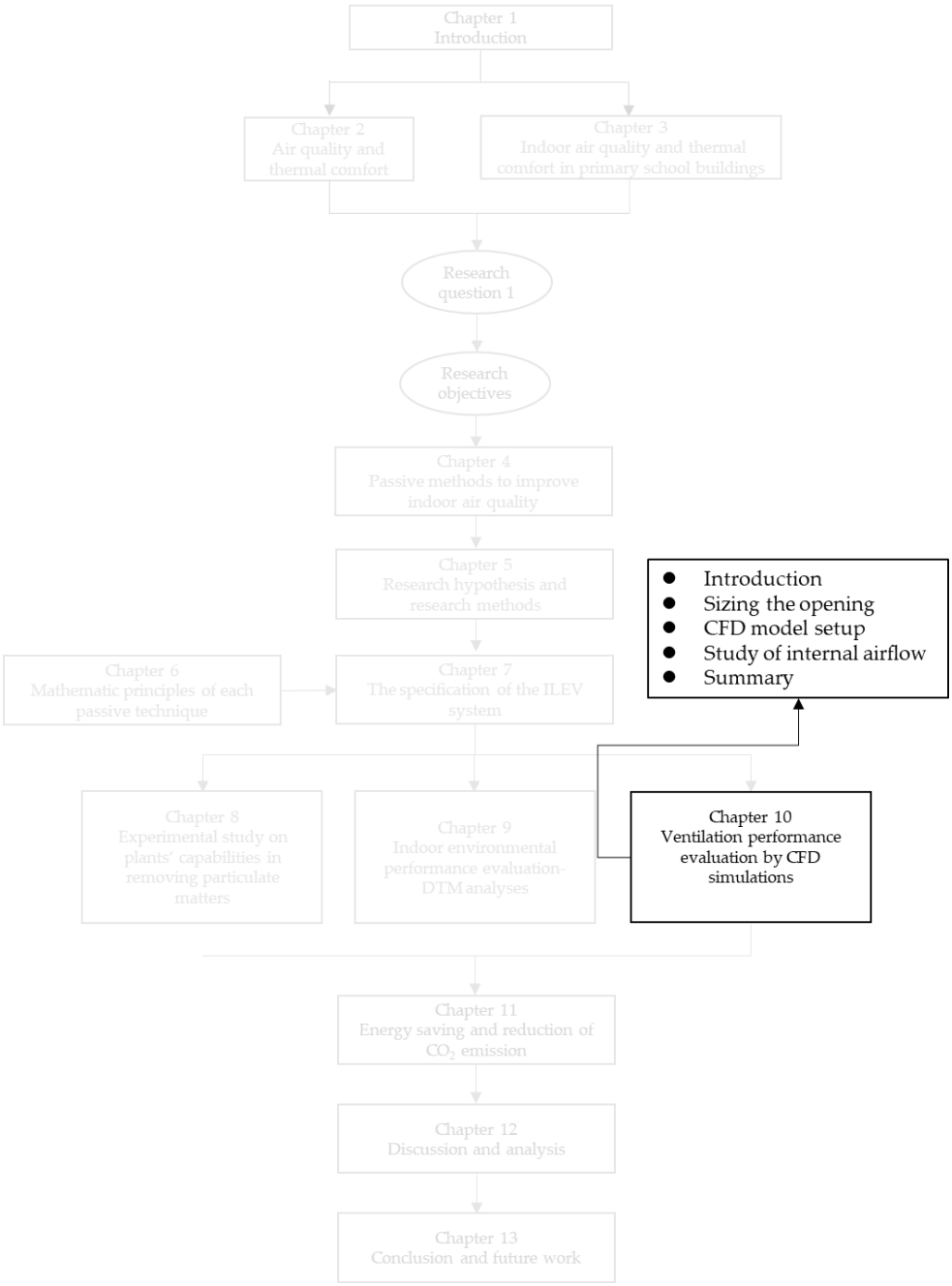
- The DTM analyses of the solar chimney indicated that triple glazing with a higher solar shading coefficient (increased from 0.15 to 0.75) can significantly increase the solar heat gains and further improve the efficiency of stack ventilation. Notably, the minimum and the maximum air temperature

differences between the solar chimney and the sunspace were 3.71°C in January and 10.71°C in August, respectively. In March, April, and November, the air temperature difference was greater than 6°C. In June, July, September, and October, the air temperature differences were greater than 8°C. Therefore, buoyancy effects are successfully achieved between the sunspace and the solar chimney to ensure that air flows into the classrooms from the sunspace and is exhausted from the solar chimney.

- However, in winter months, Fan C (Figure 5.1, Chapter 5) should be in operation to supply air from the sunspace to the classrooms during the first and second hours of the teaching day because the air temperature difference between the solar chimney and the sunspace was only approximately 1.2°C.

This chapter has presented an indoor thermal evaluation over a calendar year and investigated the performance of the ILEV system considering the ambient environment and temporally varying parameters. However, the DTM cannot predict the specific airflow distribution (temperature and velocity fields) inside the classrooms. Accordingly, further investigation of the ILEV system is needed using CFD simulations, as presented in Chapter 10. In the next chapter, the temperature distribution, PMV value distribution, and air velocity distribution are described for the selected school building. The CFD simulations verify the fluidity of the ILEV system, as the air successfully flows from the sunspace to the solar chimney.

Chapter 10: FLUIDITY OF THE ILEV SYSTEM AND THE THERMAL PERFORMANCE INSIDE THE CLASSROOMS



The content of Chapter 10

10.1. Introduction

In this chapter, CFD simulations are conducted to validate the fluidity of the ILEV system and investigate the thermal performance inside the classrooms. The CFD simulations provide a visualisation of the airflow distribution throughout the classrooms. The followings list summarises the crucial issues addressed in this chapter:

- Size the openings of the ILEV systems based on the buoyancy effects;
- Create a CFD model of the case study building in MICROFLO and use the DTM analyses results as inputs for the CFD simulations;
- Conduct a computational mesh study in MICROFLO to ensure that the simulation results are independent of the mesh resolution; and
- Perform CFD simulations of each season and analyse the simulation results.

The chapter concludes with evaluations of the fluidity and ventilation performance of the ILEV system, and the advantages and limitations are discussed.

10.2. Sizing the openings

The pressure differences between the solar chimney and the sunspace result in buoyancy effects. Equation 6.3.1.3, introduced in section 6.3.1, can be used to directly estimate these pressure differences.

$$\Delta P_s = \rho_{ext} g h T_{ext} \left(\frac{1}{T_{ext}} - \frac{1}{T_{int}}\right) \quad (6.3.1.3)$$

The NPL of the ILEV system was positioned 0.25 m above the roof (Eng.harran.edu, n.d.). Therefore, the height differences between the inlet and NPL for classrooms from the first floor to the fourth floor were 14.35 m, 10.71 m, 7.1 m, and 3.5 m. Moreover, the height difference between the outlet and NPL was 4.75 m (Figure 10.1).

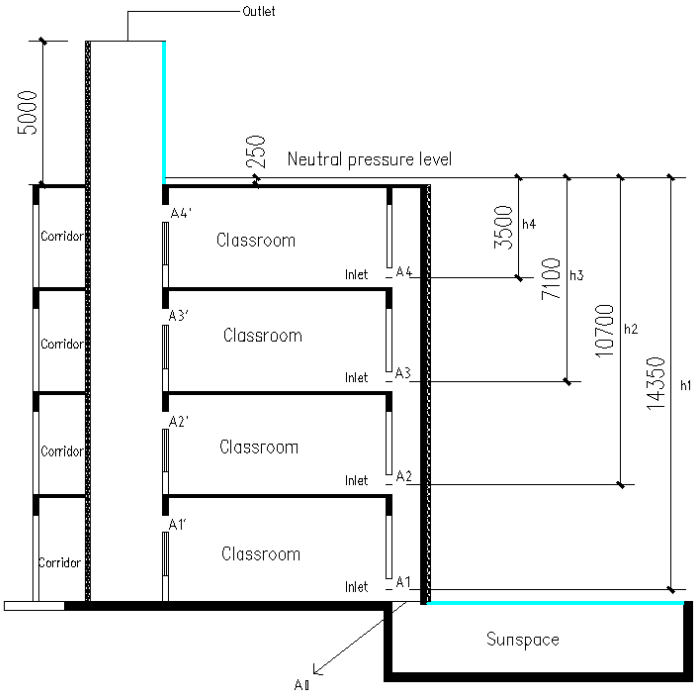


Figure 10.1. *Height differences between the inlets and the outlet of the ILEV system (unit: mm)*

Tables 10.1 and 10.2 summarise the pressure differences between the inlet of the classrooms and the outlet of the solar chimney calculated based on the equation above.

Table 10.1. Total pressure difference for the classrooms (Pa)

	First=floor classroom												Second-floor classroom											
	Ma	Ap	Ma	Jun	Jul	Au	Sep	Oct	No	Dec	Jan	Feb	Ma	Ap	Ma	Jun	Jul	Au	Sep	Oct	No	Dec	Jan	Feb
8:00-9:00	2.7	4.6	4.5	4.8	5.6	5.9	4.8	5.8	2.6	0.8	0.3	1.2	2.0	3.4	3.4	3.6	4.2	4.4	3.6	4.3	2.0	0.6	0.2	0.9
9:00-10:00	3.0	4.2	4.5	4.7	5.6	5.9	4.8	5.5	3.0	1.7	1.3	1.9	2.2	3.1	3.4	3.5	4.2	4.4	3.5	4.1	2.2	1.3	1.0	1.4
10:00-11:00	3.4	4.0	4.5	4.7	5.5	5.9	4.9	5.5	3.3	2.3	2.0	2.4	2.6	3.0	3.4	3.5	4.1	4.4	3.6	4.1	2.5	1.7	1.5	1.8
11:00-12:00	3.8	3.9	4.7	4.8	5.6	6.1	5.1	5.6	3.8	2.9	2.4	2.9	2.8	2.9	3.5	3.6	4.2	4.5	3.8	4.2	2.8	2.1	1.8	2.2
12:00-13:00	4.2	3.9	4.9	4.8	5.7	6.2	5.3	5.7	4.2	3.1	2.7	3.4	3.1	2.9	3.6	3.6	4.3	4.6	3.9	4.2	3.1	2.3	2.0	2.6
13:00-14:00	4.2	3.7	4.9	4.8	5.7	6.2	5.5	5.5	4.3	3.2	2.8	3.7	3.2	2.8	3.6	3.6	4.3	4.6	4.1	4.1	3.2	2.4	2.1	2.7
14:00-15:00	4.2	3.4	4.8	4.8	5.7	6.1	5.5	5.2	4.3	3.5	2.9	3.6	3.1	2.5	3.6	3.6	4.2	4.5	4.1	3.9	3.2	2.6	2.1	2.7
15:00-16:00	4.0	3.0	4.7	4.8	5.6	6.1	5.2	4.7	4.1	3.3	2.8	3.5	3.0	2.3	3.5	3.5	4.2	4.6	3.9	3.5	3.0	2.4	2.1	2.6
16:00-17:00	3.7	2.9	4.8	4.8	5.6	6.3	5.0	4.2	3.6	2.7	2.5	2.9	2.7	2.2	3.6	3.6	4.2	4.7	3.7	3.1	2.7	2.0	1.9	2.2
	Third-floor classroom												Fourth-floor classroom											
	Ma	Ap	Ma	Jun	Jul	Au	Sep	Oct	No	Dec	Jan	Feb	Ma	Ap	Ma	Jun	Jul	Au	Sep	Oct	No	Dec	Jan	Feb
8:00-9:00	1.3	2.3	2.2	2.4	2.8	2.9	2.4	2.9	1.3	0.4	0.1	0.6	0.6	1.1	1.1	1.2	1.4	1.4	1.2	1.4	0.6	0.2	0.1	0.3
9:00-10:00	1.5	2.1	2.2	2.3	2.8	2.9	2.4	2.7	1.5	0.8	0.6	0.9	0.7	1.0	1.1	1.2	1.4	1.4	1.2	1.3	0.7	0.4	0.3	0.5
10:00-11:00	1.7	2.0	2.2	2.3	2.7	2.9	2.4	2.7	1.6	1.2	1.0	1.2	0.8	1.0	1.1	1.1	1.3	1.4	1.2	1.3	0.8	0.6	0.5	0.6
11:00-12:00	1.9	2.0	2.3	2.4	2.8	3.0	2.5	2.8	1.9	1.4	1.2	1.5	0.9	1.0	1.2	1.2	1.4	1.5	1.2	1.4	0.9	0.7	0.6	0.7
12:00-13:00	2.1	2.0	2.4	2.4	2.8	3.1	2.6	2.8	2.1	1.5	1.3	1.7	1.0	1.0	1.2	1.2	1.4	1.5	1.3	1.4	1.0	0.8	0.7	0.8
13:00-14:00	2.1	1.8	2.4	2.4	2.8	3.1	2.7	2.7	2.1	1.6	1.4	1.8	1.0	0.9	1.2	1.2	1.4	1.5	1.3	1.4	1.0	0.8	0.7	0.9
14:00-15:00	2.1	1.7	2.4	2.4	2.8	3.0	2.7	2.6	2.1	1.7	1.4	1.8	1.0	0.8	1.2	1.2	1.4	1.5	1.3	1.3	1.0	0.8	0.7	0.9
15:00-16:00	2.0	1.5	2.3	2.4	2.8	3.0	2.6	2.3	2.0	1.6	1.4	1.7	1.0	0.7	1.2	1.2	1.4	1.5	1.3	1.2	1.0	0.8	0.7	0.8
16:00-17:00	1.8	1.5	2.4	2.4	2.8	3.1	2.5	2.1	1.8	1.3	1.2	1.5	0.9	0.7	1.2	1.2	1.4	1.5	1.2	1.0	0.9	0.7	0.6	0.7

Table 10.2. Total pressure difference at the outlet of the solar chimney (Pa)

	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb
8:00-9:00	0.9	1.5	1.5	1.6	1.9	2.0	1.6	1.9	0.9	0.3	0.1	0.4
9:00-10:00	1.0	1.4	1.5	1.6	1.8	1.9	1.6	1.8	1.0	0.6	0.4	0.6
10:00-11:00	1.1	1.3	1.5	1.6	1.8	2.0	1.6	1.8	1.1	0.8	0.6	0.8
11:00-12:00	1.3	1.3	1.6	1.6	1.8	2.0	1.7	1.8	1.3	1.0	0.8	1.0
12:00-13:00	1.4	1.3	1.6	1.6	1.9	2.0	1.7	1.9	1.4	1.0	0.9	1.1
13:00-14:00	1.4	1.2	1.6	1.6	1.9	2.0	1.8	1.8	1.4	1.1	0.9	1.2
14:00-15:00	1.4	1.1	1.6	1.6	1.9	2.0	1.8	1.7	1.4	1.1	0.9	1.2
15:00-16:00	1.3	1.0	1.6	1.6	1.9	2.0	1.7	1.6	1.4	1.1	0.9	1.1
16:00-17:00	1.2	1.0	1.6	1.6	1.8	2.1	1.7	1.4	1.2	0.9	0.8	1.0

Equation 6.3.1.6 was used to estimate the area of the effective opening, i.e., A_{eff}. Q_s is the volumetric airflow rate in each classroom (0.46 m^3/s), and C_d is a constant equal to 0.61 (experimentally derived parameter, CIBSE Guide A). Tables 10.3 and 10.4 provide the estimates of the effective opening.

$$Q_s = C_d A_{eff} \left(\frac{2\Delta P}{\rho}\right)^{0.5} \quad (6.3.1.6)$$

Table 10.3. The effective openings of the classrooms (A^1_{eff}, A^2_{eff}, A^3_{eff}, and A^4_{eff}) (m^2)

	First=floor classroom												Second-floor classroom											
	Ma	Ap	Ma	Jun	Jul	Au	Sep	Oct	No	Dec	Jan	Feb	Ma	Ap	Ma	Jun	Jul	Au	Sep	Oct	No	Dec	Jan	Feb
8:00-9:00	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.6	1.1	0.5	0.4	0.3	0.3	0.3	0.2	0.2	0.3	0.2	0.4	0.7	1.3	0.6
9:00-10:00	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.4	0.5	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.3	0.2	0.3	0.5	0.6	0.5
10:00-11:00	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.3	0.2	0.3	0.4	0.4	0.4
11:00-12:00	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.3	0.2	0.3	0.4	0.4	0.4
12:00-13:00	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.3	0.2	0.3	0.3	0.4	0.3
13:00-14:00	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.3
14:00-15:00	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.3
15:00-16:00	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.3
16:00-17:00	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.4	0.3	0.3	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4
	Third-floor classroom												Fourth-floor classroom											
	Ma	Ap	Ma	Jun	Jul	Au	Sep	Oct	No	Dec	Jan	Feb	Ma	Ap	Ma	Jun	Jul	Au	Sep	Oct	No	Dec	Jan	Feb
8:00-9:00	0.7	0.5	0.5	0.5	0.5	0.4	0.5	0.5	0.7	1.3	2.3	1.1	0.7	0.5	0.5	0.5	0.5	0.4	0.5	0.5	0.7	1.3	2.3	1.1
9:00-10:00	0.6	0.5	0.5	0.5	0.5	0.4	0.5	0.5	0.6	0.9	1.0	0.8	0.6	0.5	0.5	0.5	0.5	0.4	0.5	0.5	0.6	0.9	1.0	0.8
10:00-11:00	0.6	0.5	0.5	0.5	0.5	0.4	0.5	0.5	0.6	0.7	0.8	0.7	0.6	0.5	0.5	0.5	0.5	0.4	0.5	0.5	0.6	0.7	0.8	0.7
11:00-12:00	0.6	0.6	0.5	0.5	0.5	0.4	0.5	0.5	0.6	0.7	0.7	0.6	0.6	0.6	0.5	0.5	0.5	0.4	0.5	0.5	0.6	0.7	0.7	0.6
12:00-13:00	0.5	0.6	0.5	0.5	0.5	0.4	0.5	0.5	0.5	0.6	0.7	0.6	0.5	0.6	0.5	0.5	0.5	0.4	0.5	0.5	0.5	0.6	0.7	0.6
13:00-14:00	0.5	0.6	0.5	0.5	0.5	0.4	0.5	0.5	0.5	0.6	0.7	0.6	0.5	0.6	0.5	0.5	0.5	0.4	0.5	0.5	0.5	0.6	0.7	0.6
14:00-15:00	0.5	0.6	0.5	0.5	0.5	0.4	0.5	0.5	0.5	0.6	0.7	0.6	0.5	0.6	0.5	0.5	0.5	0.4	0.5	0.5	0.5	0.6	0.7	0.6
15:00-16:00	0.5	0.6	0.5	0.5	0.5	0.4	0.5	0.5	0.5	0.6	0.7	0.6	0.5	0.6	0.5	0.5	0.5	0.4	0.5	0.5	0.5	0.6	0.7	0.6
16:00-17:00	0.6	0.7	0.5	0.5	0.5	0.4	0.5	0.5	0.6	0.7	0.7	0.7	0.6	0.7	0.5	0.5	0.5	0.4	0.5	0.5	0.6	0.7	0.7	0.7

Table 10.4. The effective outlet opening (A_{outlet}) (m^2)

	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb
8:00-9:00	2.52	1.92	1.93	1.87	1.73	1.69	1.87	1.70	2.53	4.65	7.99	3.79
9:00-10:00	2.36	2.01	1.93	1.88	1.74	1.69	1.88	1.74	2.36	3.16	3.61	2.99
10:00-11:00	2.21	2.04	1.92	1.89	1.74	1.68	1.85	1.74	2.24	2.67	2.92	2.64
11:00-12:00	2.09	2.06	1.88	1.87	1.73	1.66	1.81	1.73	2.09	2.41	2.63	2.38
12:00-13:00	2.00	2.06	1.85	1.87	1.71	1.64	1.78	1.72	1.99	2.31	2.49	2.21
13:00-14:00	1.99	2.12	1.85	1.86	1.71	1.64	1.74	1.73	1.98	2.27	2.43	2.13
14:00-15:00	2.00	2.23	1.86	1.87	1.72	1.66	1.75	1.79	1.98	2.19	2.42	2.15
15:00-16:00	2.04	2.35	1.88	1.88	1.73	1.65	1.79	1.89	2.03	2.27	2.45	2.20
16:00-17:00	2.15	2.39	1.88	1.87	1.74	1.64	1.83	2.01	2.17	2.50	2.60	2.39

In the ILEV system, three openings (A_0, A and A') were connected in series. The openings can be sized according to equations 6.3.1.9 and 6.3.1.10. A_0 was 6.3 m^2, as presented in section 7.5. Moreover, A was equal to the A'. Tables 10.5 and 10.6 summarise the sizes of the openings A and A'.

$$1/\left(A_{eff}^2\right) = 1/\left(A_1^2\right) + 1/\left(A_2^2\right) + \cdots 1/\left(A_n^2\right) \quad (6.3.1.9)$$

$$\text{Assuming } A_1 = A_2 = \cdots A_n \quad (6.3.1.10)$$

Table 10.5. Opening areas of the classrooms (A1 = A1′, A2 = A2′, A3 = A3′, A4 = A4′) (m^2)

	First=floor classroom												Second-floor classroom											
	Ma	Ap	Ma	Jun	Jul	Au	Sep	Oct	No	Dec	Jan	Feb	Ma	Ap	Ma	Jun	Jul	Au	Sep	Oct	No	Dec	Jan	Feb
8:00-9:00	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.5	0.9	1.6	0.7	0.6	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.6	1.1	2.2	0.9
9:00-10:00	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.6	0.7	0.6	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.7	0.8	0.7
10:00-11:00	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.5	0.6	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.6	0.7	0.6
11:00-12:00	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.4	0.5	0.4	0.4	0.4	0.4	0.3	0.4	0.4	0.5	0.5	0.6	0.5
12:00-13:00	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.4	0.4	0.5	0.5	0.5
13:00-14:00	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.5	0.4	0.4	0.4	0.3	0.4	0.4	0.4	0.5	0.5	0.5
14:00-15:00	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.5	0.4	0.4	0.4	0.3	0.4	0.4	0.4	0.5	0.5	0.5
15:00-16:00	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.4	0.4	0.5	0.4	0.4	0.4	0.3	0.4	0.4	0.4	0.5	0.5	0.5
16:00-17:00	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.4	0.5	0.5	0.4	0.4	0.4	0.3	0.4	0.4	0.5	0.6	0.6	0.5
	Third-floor classroom												Fourth-floor classroom											
	Ma	Ap	Ma	Jun	Jul	Au	Sep	Oct	No	Dec	Jan	Feb	Ma	Ap	Ma	Jun	Jul	Au	Sep	Oct	No	Dec	Jan	Feb
8:00-9:00	0.7	0.5	0.5	0.5	0.5	0.4	0.5	0.5	0.7	1.4	3.0	1.1	1.0	0.8	0.8	0.7	0.7	0.7	0.7	0.7	1.0	2.2	8.7	1.7
9:00-10:00	0.7	0.5	0.5	0.5	0.5	0.4	0.5	0.5	0.7	0.9	1.0	0.8	1.0	0.8	0.8	0.7	0.7	0.7	0.7	0.7	1.0	1.4	1.6	1.3
10:00-11:00	0.6	0.6	0.5	0.5	0.5	0.4	0.5	0.5	0.6	0.7	0.8	0.7	0.9	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.9	1.1	1.2	1.1
11:00-12:00	0.6	0.6	0.5	0.5	0.5	0.4	0.5	0.5	0.6	0.7	0.7	0.7	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.8	1.0	1.1	1.0
12:00-13:00	0.5	0.6	0.5	0.5	0.5	0.4	0.5	0.5	0.5	0.6	0.7	0.6	0.8	0.8	0.7	0.7	0.7	0.6	0.7	0.7	0.8	0.9	1.0	0.9
13:00-14:00	0.5	0.6	0.5	0.5	0.5	0.4	0.5	0.5	0.5	0.6	0.7	0.6	0.8	0.9	0.7	0.7	0.7	0.6	0.7	0.7	0.8	0.9	1.0	0.9
14:00-15:00	0.5	0.6	0.5	0.5	0.5	0.4	0.5	0.5	0.5	0.6	0.7	0.6	0.8	0.9	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.9	1.0	0.9
15:00-16:00	0.6	0.6	0.5	0.5	0.5	0.4	0.5	0.5	0.5	0.6	0.7	0.6	0.8	1.0	0.7	0.7	0.7	0.6	0.7	0.8	0.8	0.9	1.0	0.9
16:00-17:00	0.6	0.7	0.5	0.5	0.5	0.4	0.5	0.5	0.6	0.7	0.7	0.7	0.9	1.0	0.7	0.7	0.7	0.6	0.7	0.8	0.9	1.0	1.1	1.0

Table 10.6. Opening areas of the outlet (A_{outlet}) (m^2)

	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb
8:00-9:00	2.52	1.92	1.93	1.87	1.73	1.69	1.87	1.70	2.53	4.65	7.99	3.79
9:00-10:00	2.36	2.01	1.93	1.88	1.74	1.69	1.88	1.74	2.36	3.16	3.61	2.99
10:00-11:00	2.21	2.04	1.92	1.89	1.74	1.68	1.85	1.74	2.24	2.67	2.92	2.64
11:00-12:00	2.09	2.06	1.88	1.87	1.73	1.66	1.81	1.73	2.09	2.41	2.63	2.38
12:00-13:00	2.00	2.06	1.85	1.87	1.71	1.64	1.78	1.72	1.99	2.31	2.49	2.21
13:00-14:00	1.99	2.12	1.85	1.86	1.71	1.64	1.74	1.73	1.98	2.27	2.43	2.13
14:00-15:00	2.00	2.23	1.86	1.87	1.72	1.66	1.75	1.79	1.98	2.19	2.42	2.15
15:00-16:00	2.04	2.35	1.88	1.88	1.73	1.65	1.79	1.89	2.03	2.27	2.45	2.20
16:00-17:00	2.15	2.39	1.88	1.87	1.74	1.64	1.83	2.01	2.17	2.50	2.60	2.39

10.3. CFD model setup

The CFD simulations have the same indoor thermal conditions as the DTM analyses. For example, the internal heat gain was 4183 W for each classroom. Moreover, the solar heat gain inputs were based on the DTM results for the classrooms. MICROFLOW in IESVE included a model of the selected primary school building established for DTM simulations (Figure 10.2). Because of computational time and computer memory limitations, objects such as desks, chairs, and occupants were excluded from the three-dimensional model. The inclusion of these variables would significantly increase the number of cells in the mesh and the difficulty of convergence. Moreover, the detailed airflow patterns around desks, chairs and occupants were not essential, as these patterns were highly variable in practical situations. In steady state CFD simulations, heat gains can only be represented in spaces with a certain probability. Therefore, a volumetric heat source was centred in each classroom to represent the internal heat gains (e.g., occupants, solar gains, and equipment) to provide similar steady state results considering internal air parameters. Tables 10.7 and 10.8 summarise the solar heat gains for classrooms and the solar chimney based on the DTM results.

All the surfaces, including the internal floors, were assumed to be plates, which made the simulation procedure more efficient by ignoring the thickness of these materials. The walls, ceilings and ground floor were assumed to be adiabatic. In addition, the k–ε model was used to simulate the flow characteristics of turbulent flow inside the classrooms.

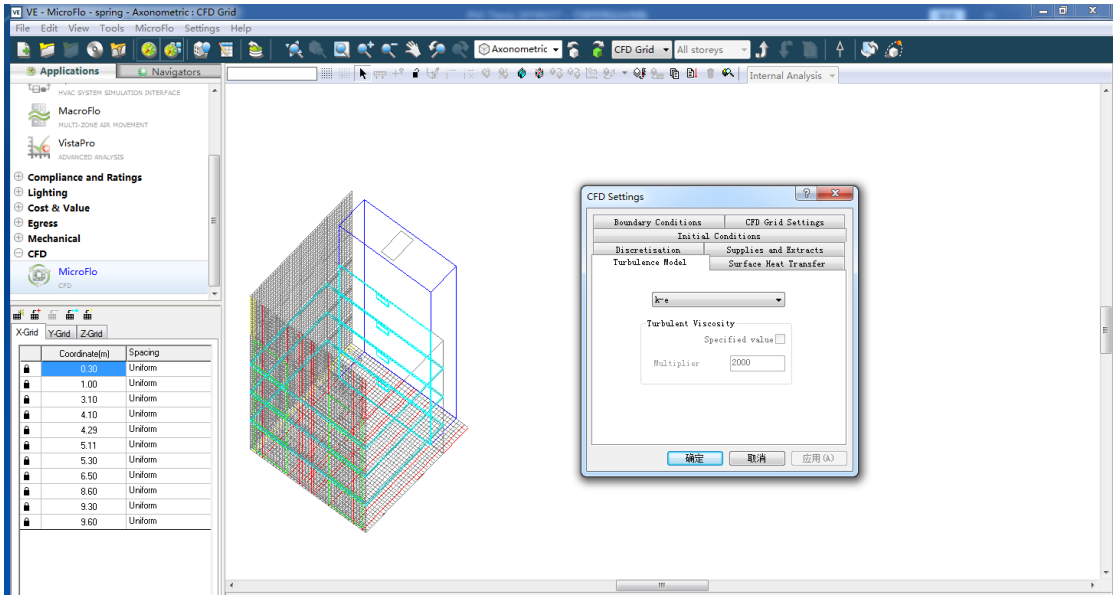


Figure 10.2. *CFD model built in MICROFLO*

Table 10.7. Solar heat gains of the classrooms (W)

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
8:00-9:00	185	29	114	135	140	180	215	187	175	175	181	180
9:00-10:00	337	67	197	195	205	279	345	414	315	315	386	304
10:00-11:00	517	129	301	265	274	394	472	643	462	462	592	489
11:00-12:00	684	335	378	321	337	492	563	747	742	742	641	720
12:00-13:00	734	419	387	343	351	514	703	840	806	807	720	818
13:00-14:00	655	330	342	313	345	529	702	830	714	714	642	774
14:00-15:00	531	249	257	254	270	435	497	660	615	615	568	563
15:00-16:00	353	96	178	193	193	284	290	416	377	377	402	431
16:00-17:00	230	48	128	141	150	177	202	171	95	95	130	257

Table 10.8. Solar heat gains of the solar chimney (W)

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
8:00-9:00	2447	1930	1416	1630	1697	2131	2596	2325	2419	2464	2413	2446
9:00-10:00	4442	3658	2507	2324	2484	3375	4237	5102	4054	4495	4986	3940
10:00-11:00	6707	4849	3941	3144	3309	4852	5723	7737	5853	7752	7417	6150
11:00-12:00	8778	7161	5076	3853	4073	6115	6836	9064	9320	8455	7931	8982
12:00-13:00	9370	7413	5155	4096	4290	6478	8385	10649	9537	8180	8812	10240
13:00-14:00	8374	6151	4522	3719	4160	6569	8659	10158	8897	8239	7968	9704
14:00-15:00	7110	5010	3322	3103	3315	5467	6198	8784	8155	9313	7240	7346
15:00-16:00	4907	3288	2300	2444	2463	3605	3699	5615	5171	4286	5433	5954
16:00-17:00	3079	1982	1672	1788	1920	2246	2563	2229	1166	853	1769	3591

10.4. Study of the internal airflow

Simulations based on hourly data can provide comprehensive results regarding the ventilation performance of the ILEV system. However, using a full yearly input is not practical (e.g., there are 8760 hours in a year). Moreover, during occupied periods, the ventilation rate is constant. Hence, simulations based on average seasonal data are adequate for accessing the ventilation performance of the ILEV system. Four simulations were conducted to investigate the performance of the ILEV system in each season. The average values of the DTM simulation results in each season are used as examples, as summarised in Table 10.9.

Table 10.9. Data used for the CFD simulations in each season

		Spring	Summer	Autumn	Winter
Average air temperatures of the solar chimney (℃)		24.5	28.2	25.7	19.2
Average solar heat gains of the solar chimney (w)		4688	3506	6116	6161
Average air temperatures of the sunspace (℃)		17.5	18.6	17.3	14.9
Average solar heat gains of the classrooms (W)		304	286	489	485
Average pressure difference between the inlet and the outlet (Pa)	A1	4.0	5.5	4.8	2.5
	A2	3.0	4.1	3.6	1.9
	A3	2.0	2.7	2.4	1.3
	A4	1.0	1.3	1.2	0.6
	A_{outlet}	1.3	1.8	1.6	0.8
Areas of the openings (m^2)	A1, A1'	0.41	0.36	0.38	0.52
	A2, A2'	0.48	0.42	0.44	0.62
	A3, A3'	0.60	0.51	0.55	0.76
	A4, A4'	0.86	0.74	0.79	1.11
	A_{outlet}	2.04	1.75	1.86	2.58

10.4.1. Mesh independency study

In MICROFLO, the cell aspect ratio (CAR) of a grid is used to ensure the adequacy of the simulation results (IESVE, 2017). The CAR is defined as the ratio of the length of the longest edge to that of the shortest edge of any of the cells in the computational mesh (Figure 10.3). The IESVE (2017) recommends that the CAR should be less than 10:1 for optimal results. Therefore, to ensure that the meshes

had a smaller CAR than 10:1, the cell widths were set equal to the lengths of the openings, as indicated in Table 10.10.

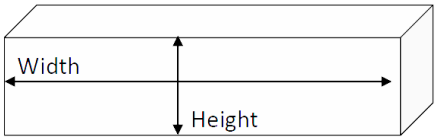


Figure 10.3. *Cell aspect ratio (CAR) in IESVE (IESVE, 2017)*

Table 10.10. Data used for the CFD simulations in each season

		Spring	Summer	Autumn	Winter
	Openings	Lengths of edges (m)			
Areas of the openings (m^2)	A1, A1'	0.60	0.60	0.60	0.90
	A2, A2'	0.70	0.60	0.70	0.80
	A3, A3'	0.80	0.70	0.70	0.90
	A4, A4'	0.90	0.90	0.90	1.00
	A_{outlet}	1.40	1.30	1.40	1.60

To ensure that the simulation results were independent of the mesh resolution, six meshes in different sizes were studied, as listed in Table 10.11. The CFD simulations in spring were used as the basis for the mesh investigation.

Table 10.11. Domain sizes, number of cells and the convergence iterations of the meshes used to study the internal flow of the classrooms

Type	Domain size (x, y, z)	Quantity of cells	Convergence iterations	Running hours (Around)
Mesh 1	40 × 44 × 91	160160	5500	7 hours
Mesh 2	45 × 49 × 100	220500	11000	7 hours
Mesh 3	47 × 53 × 108	269028	5000	6 hours
Mesh 4	52 × 56 × 110	320320	4300	8 hours
Mesh 5	53 × 59 × 119	372113	4500	9 hours
Mesh 6	56 × 61 × 121	413336	5600	12 hours

As Figure 10.4 shows, all the six meshes have an acceptable level of convergence and provided similar results. The temperatures at a user-specified monitor location in all six meshes investigated varied below 0.12°C (Figure 10.5). Mesh 3 was selected because it provides the appropriate results based on the reduction of residual error and the shortest running time.

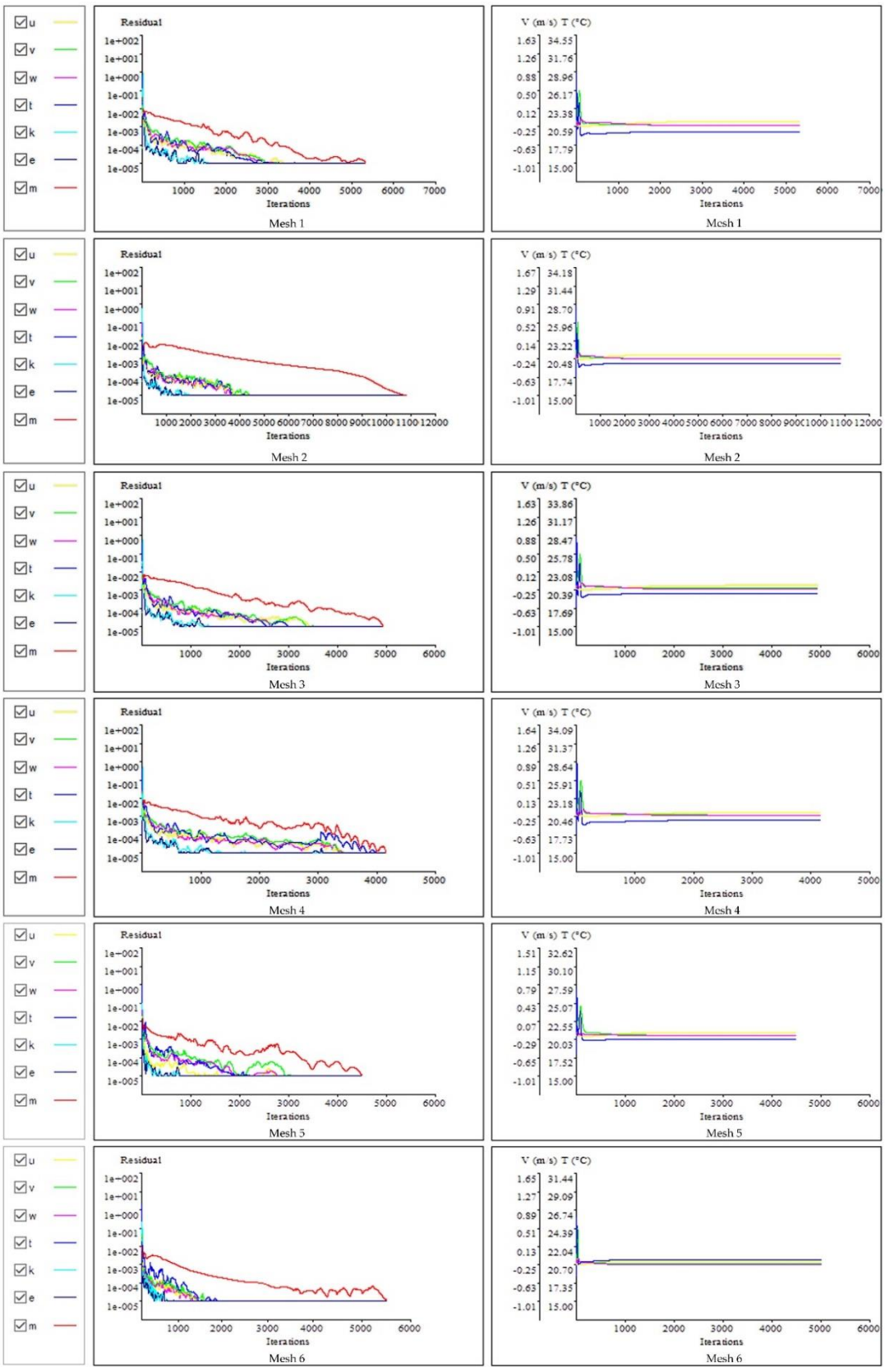


Figure 10.4. *Convergence plots (Left) showing the residual for each solved variable and the values of these variables at a user-defined location in the grid (Right)*

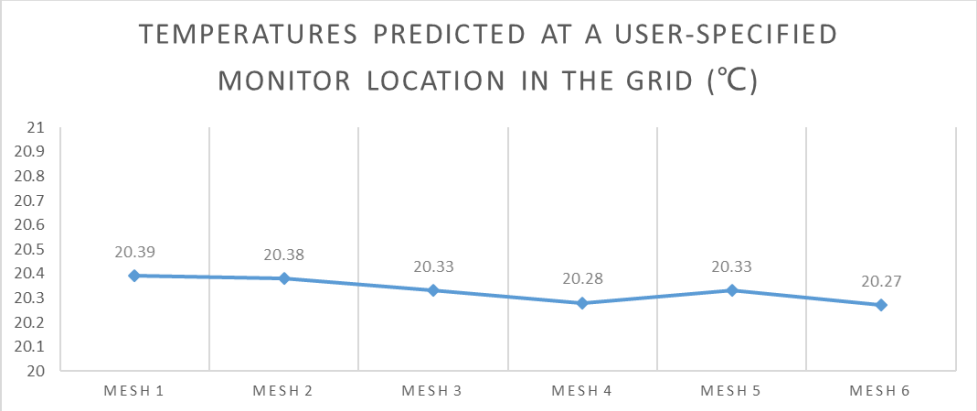


Figure 10.5. *Temperature predicted at a specified monitor point in the grid*

10.4.2. Internal airflow in winter

Figure 10.6 indicates the airflow pattern inside the classrooms in winter months. Air supplied from the sunspace was successfully exhausted through the solar chimney. The highest airflow velocity was approximately 0.69 m/s, and the lowest airflow velocity was approximately 0.09 m/s. Clearly, most areas have airflow velocities approximately between 0.17 m/s and 0.26 m/s; these values are within the ranges recommended by the UK and Chinese standards (0.1-0.3 m/s, Tables 2.6 and 2.7, Chapter 2).

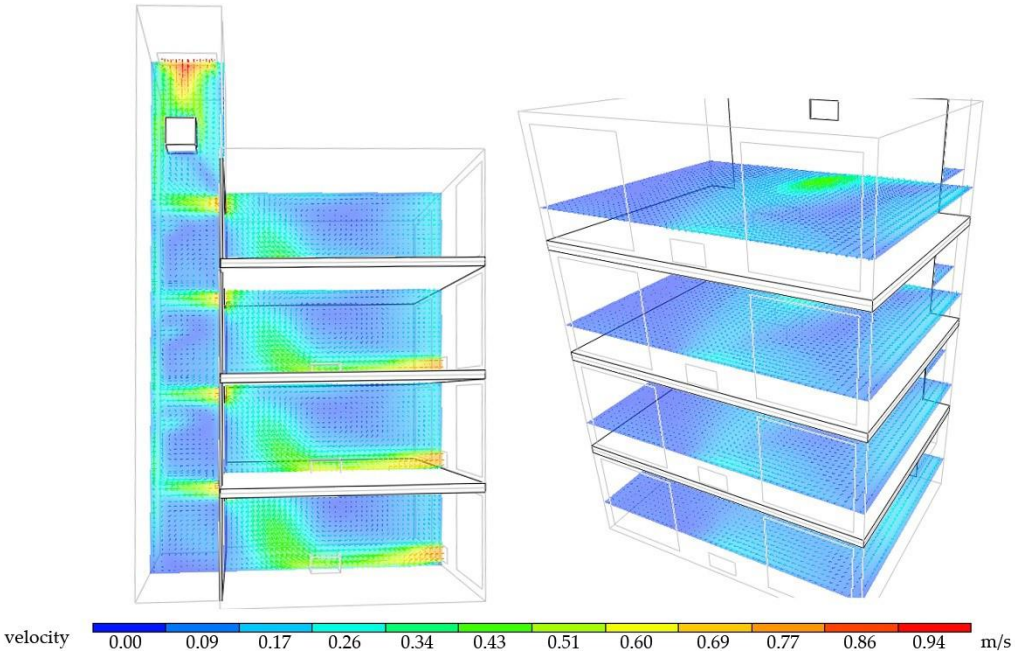


Figure 10.6. *Airflow distribution inside the classrooms in winter*

Figure 10.7 shows that the average air temperature inside the classrooms was approximately 19°C in winter, as most areas are shown in green. Areas around the internal heat sources exhibited the highest air temperatures, and the areas closed to the openings displayed the lowest air temperatures. The average air temperature was 1°C higher than the predicted indoor air temperature based on the DTM (18°C, section 9.5.4).

The PMV performance reflected a slightly cold thermal environment, as illustrated by the many green areas in Figure 10.8. These areas represent PMV values approximately -0.728. The CFD simulations provided PMV values similar to those based on the DTM analyses (-0.763 on average, section 9.5.4)

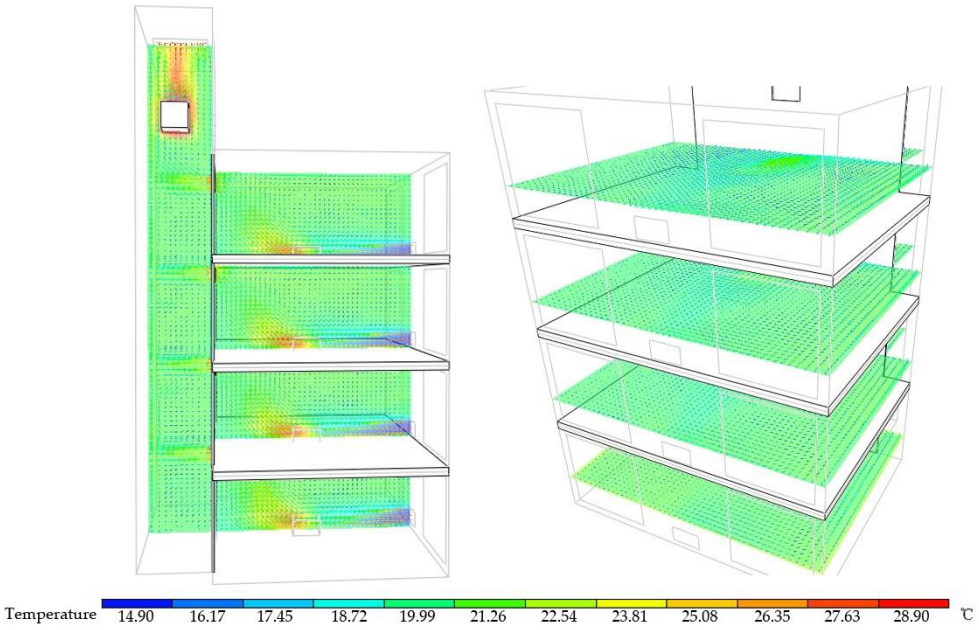


Figure 10.7. *Air temperature distribution inside the classrooms in winter*

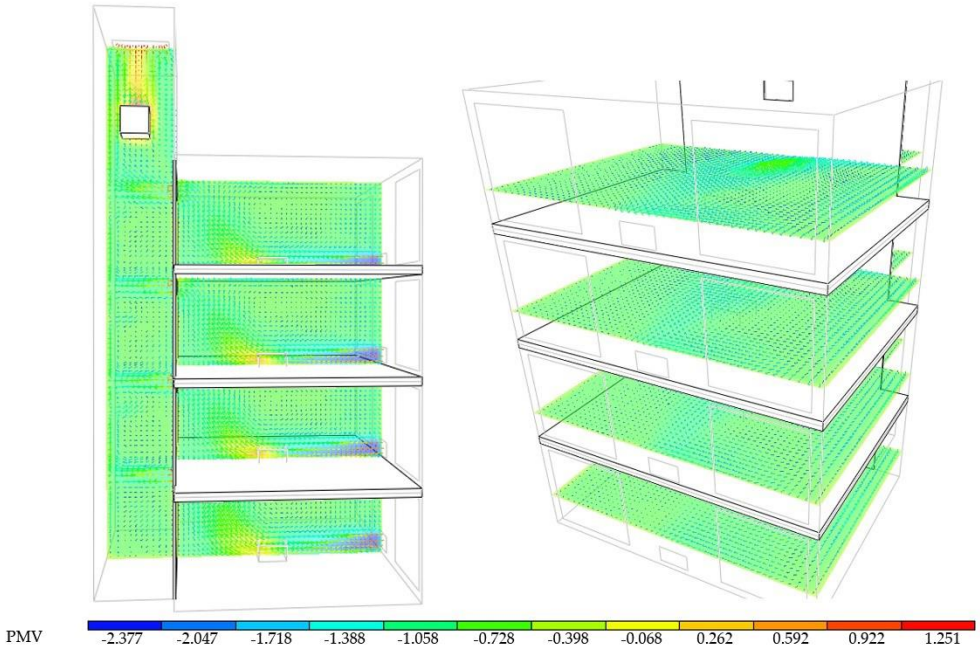


Figure 10.8. *PMV performance inside the classrooms in winter*

10.4.3. Internal airflow in summer

In summer, airflow velocities inside the classrooms were maintained between 0.17 m/s and 0.77 m/s on average (Figure 10.9). The highest airflow velocity was approximately 0.77 m/s at the inlet areas. In the horizontal plane (1.5 m above the floor), the airflow velocity was approximately 0.26 m/s. Generally, the velocities inside the space were within the recommended ranges set by the UK and Chinese standards (0.1-0.3 m/s, Tables 2.6 and 2.7, Chapter 2).

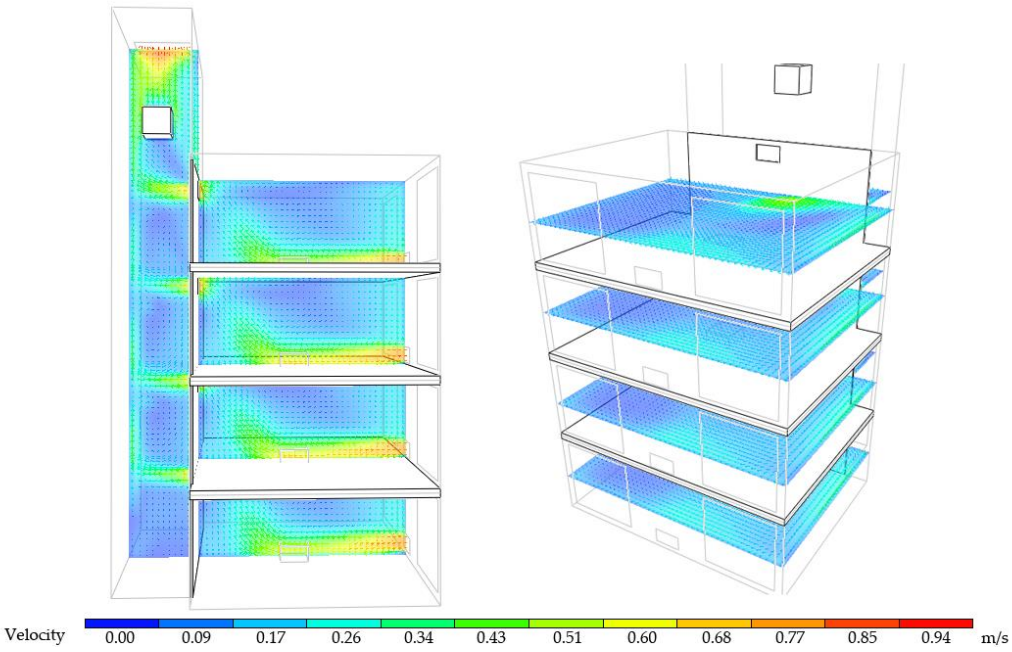


Figure 10.9. *Airflow distribution inside the classrooms in summer*

In summer, the air temperature inside the classrooms was 24°C on average, as highlighted by the many green areas in Figure 10.10. In these areas, the air temperature varies between 22.75°C and 24.82°C. The air temperatures predicted by the CFD simulations were approximately 2°C lower than those based on the DTM results (26°C, section 9.5.4).

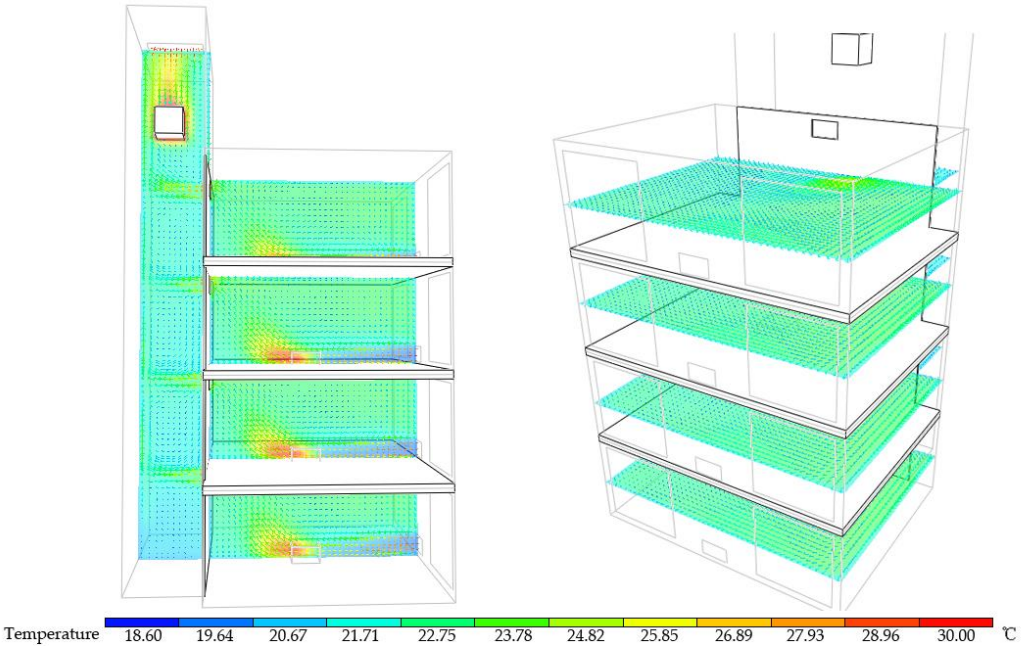


Figure 10.10. *Air temperature distribution inside the classrooms in summer*

The PMV values inside the classrooms reflected an acceptable indoor thermal environment, with the values ranging from -0.886 to -0.500 on average (Figure 10.11). The results of the CFD simulations indicated a different thermal indoor environment compared to that based on the DTM results in section 9.5.4. The DTM results depicted a slightly warm indoor thermal environment, and the PMV values were approximately 1.36 on average.

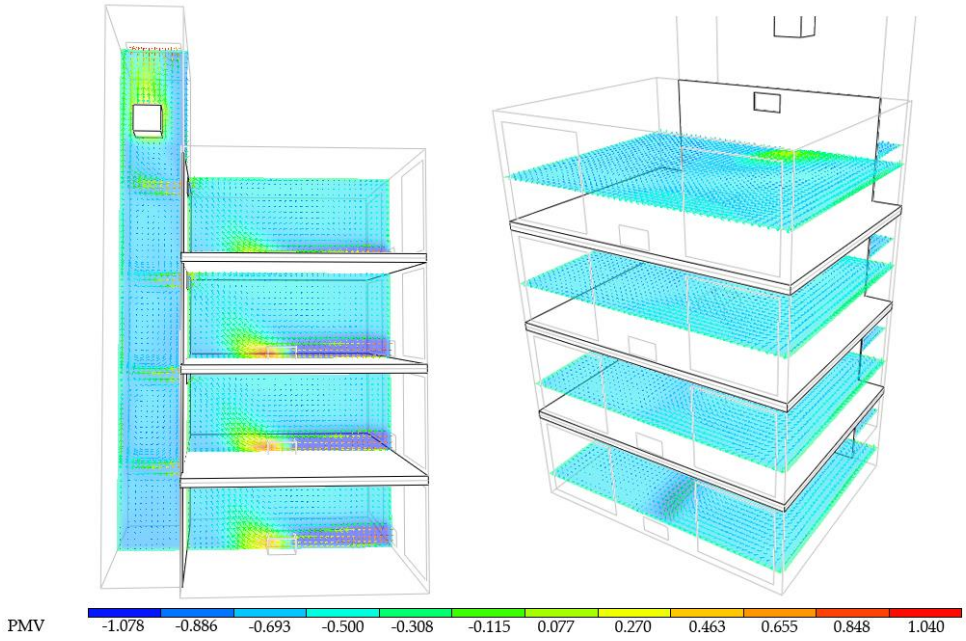


Figure 10.11 *PMV performance inside the classrooms in summer*

10.4.4. Internal airflow in transition seasons

Figures 10.12 and 10.13 show the airflow velocities inside the classrooms in spring and autumn, with values between 0.17 m/s and 0.76 m/s on average. Most areas displayed airflow velocities of approximately 0.25 m/s and met the requirements established by the UK and Chinese standards.

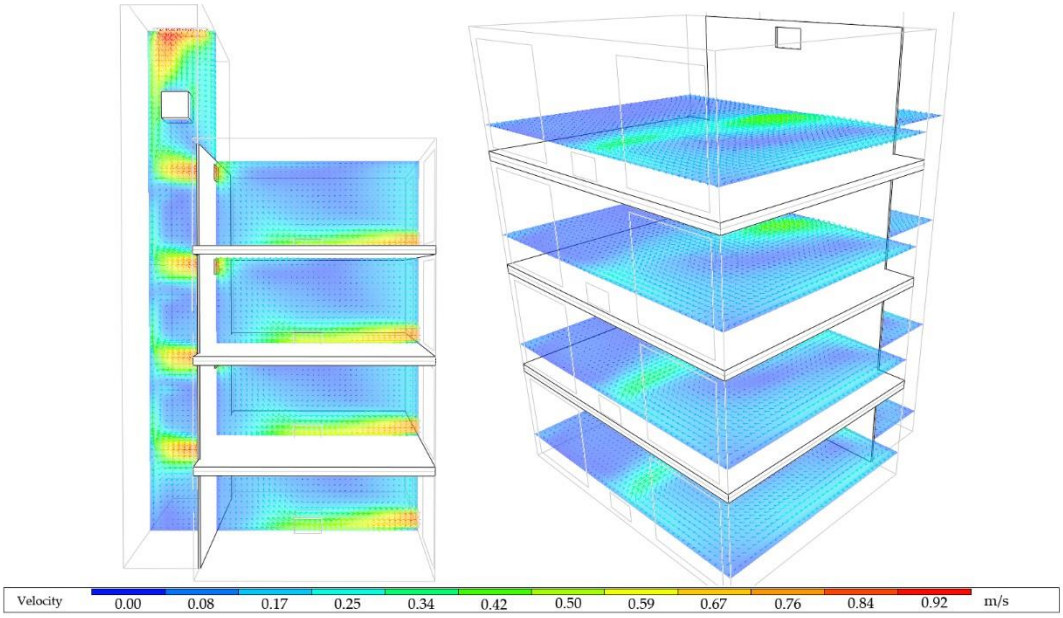


Figure 10.12. *Airflow distribution inside the classrooms in spring*

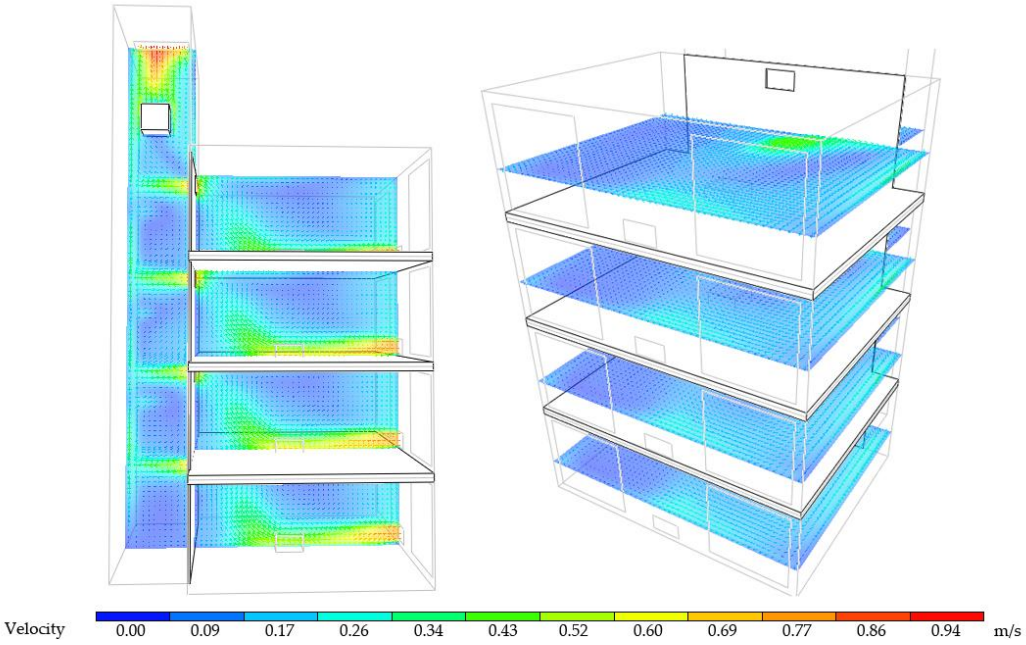


Figure 10.13. *Airflow distribution inside the classrooms in autumn*

Figures 10.14 and 10.15 show that the air temperature performance in spring and autumn was approximately 22°C on average. Only the areas close to the inlet and the internal heat sources exhibited lower and higher temperatures than the average value. The temperature predicted by the CFD simulations was 1°C lower than that based on the DTM results (23°C, section 9.5.4).

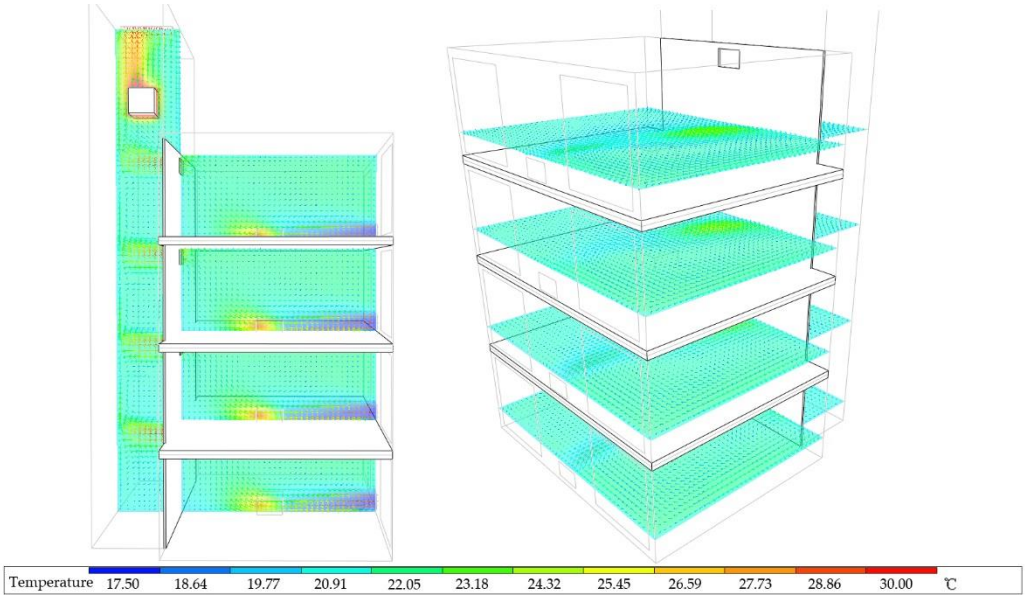


Figure 10.14. *Air temperature distribution inside the classrooms in spring*

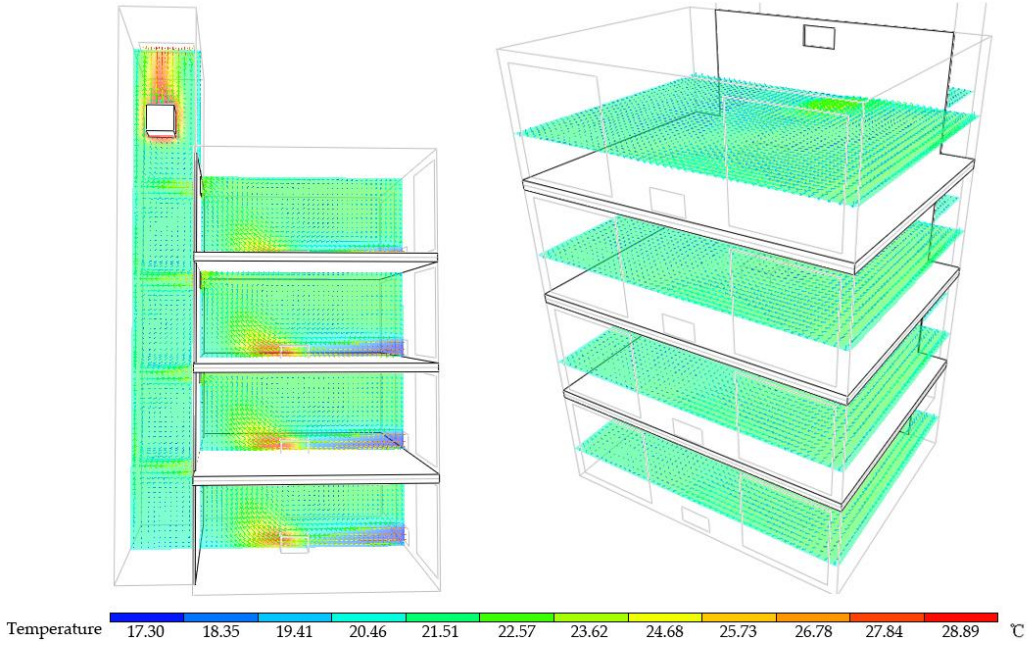


Figure 10.15. *Air temperature distribution inside the classrooms in autumn*

Figures 10.16 and 10.17 indicate that in spring and autumn, an acceptable indoor thermal environment was provided, as most areas displayed a PMV value of approximately 0.7. This number was very close to that in the DTM results (0.5 on average, section 9.5.4).

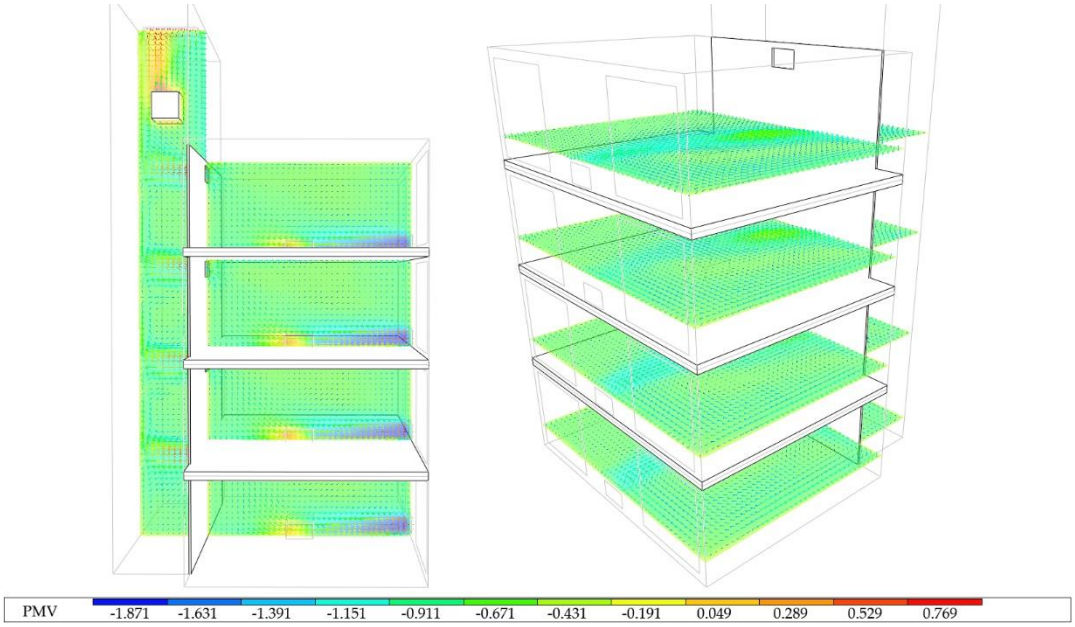


Figure 10.16. *PMV performance inside the classrooms in spring*

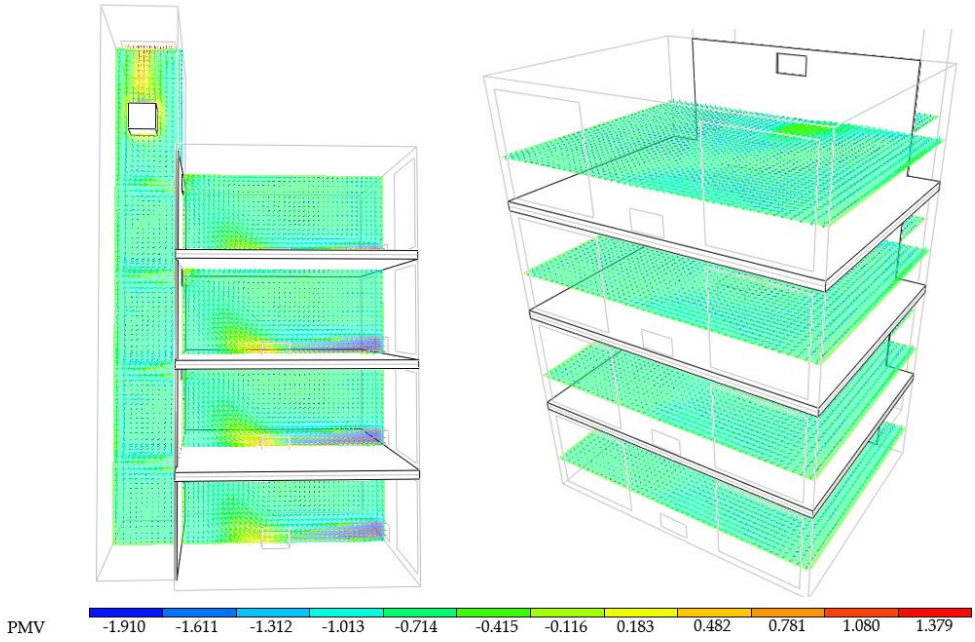


Figure 10.17. *PMV performance inside the classrooms in autumn*

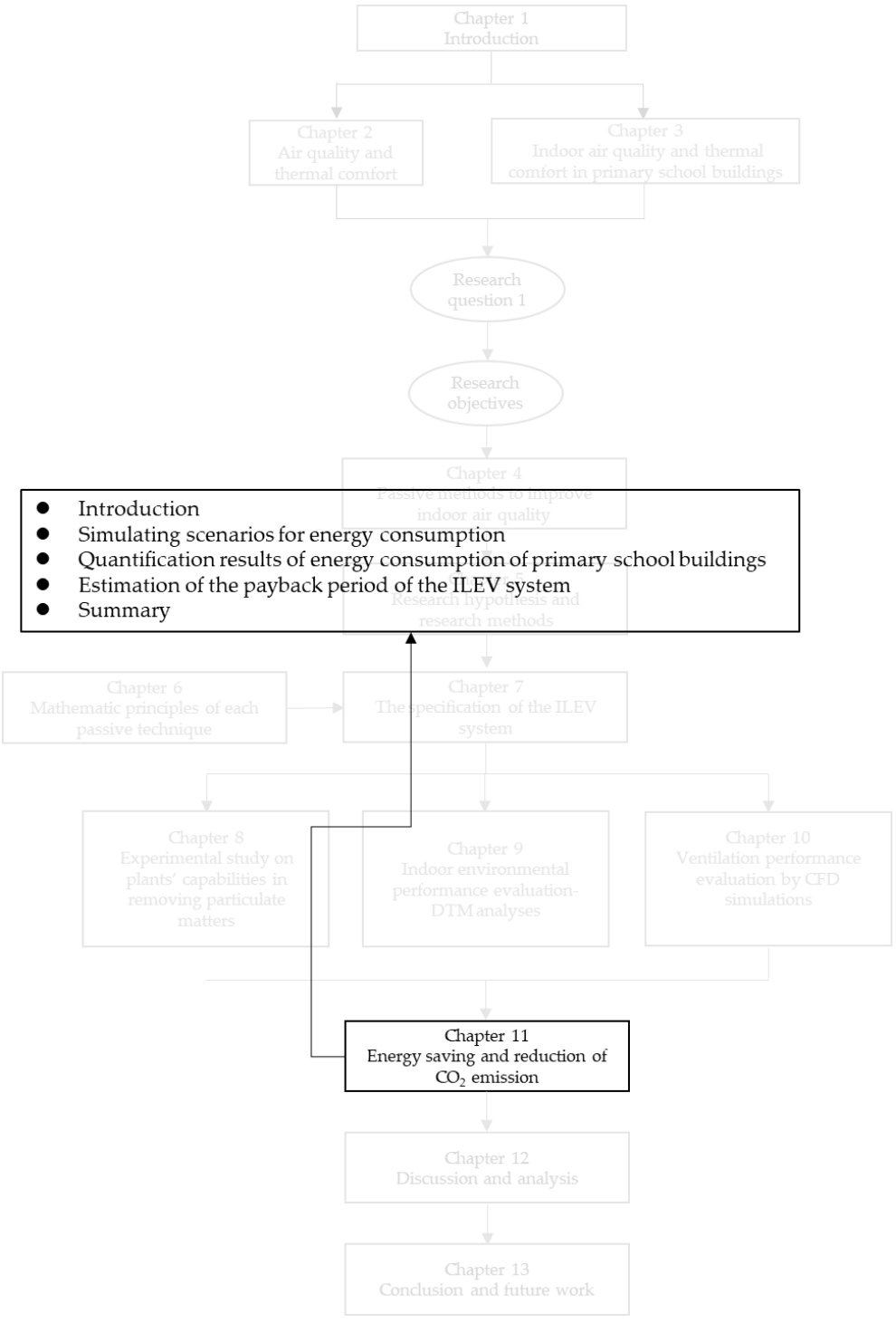
10.5. Summary

In Chapter 10, the flow patterns and thermal comfort levels of the ILEV system in each season were investigated for the selected school building using CFD simulations. The investigated parameters included the air velocity distribution, air temperature distribution, and PMV values. The following list summarises the critical findings of this chapter:

- On average, the indoor air temperature mainly ranged from 19°C to 25°C, and the PMV values were between -1 and 1. The airflow velocity in most areas of the classrooms was approximately 0.3 m/s.
- A similar thermal comfort indoor environment was indicated by the DTM analyses (section 9.5.6, Chapter 9) and CFD simulations (section 10.4). For example, the CFD simulation results showed that in spring and autumn, the PMV values ranged from -1 to 1, which were similar to the DTM results. However, in summer, slight differences were observed between the two sets of simulation results. The DTM yielded a slightly warm indoor thermal environment, and the CFD simulation results reflected an acceptable indoor thermal environment. It is reasonable to have differences between these two sets of simulation results because the calculation methods involved, and input data were different.

The CFD simulation results successfully verified the fluidity of the ILEV system, i.e., air from the sunspace flowed into the classrooms and was exhausted from the outlet of the solar chimney. In the next chapter, the potential energy savings and economic benefits, e.g., the payback period, of the ILEV system will be estimated.

Chapter 11: ENERGY SAVINGS, REDUCTION OF CO2 EMISSIONS AND ESTIMATION OF THE PAYBACK PERIOD FOR THE ILEV SYSTEM



The content of Chapter 11

11.1. Introduction

The earlier chapters provided detailed information with regard to the indoor air temperature, relative humidity and IAQ of the ILEV system designed for the selected primary school building. This system can provide indoor thermal comfort and reduce indoor air pollution. Additionally, the system can promote energy savings and economic benefits for the primary school buildings in the cold climate zone of China. This chapter will investigate the energy savings potential of the ILEV system. An energy model created in GBSWARE will be employed to quantify the case study building's energy consumption. Revit models of the case study building are then used to generate material take-off sheets. These sheets indicate the additional incremental material costs and can be used to directly estimate of the payback period of the ILEV system.

11.2. Simulating model setup for energy consumption

In section 5.4.6, Table 5.3 summarises the two scenarios established to quantify the primary school building energy consumption. The heating service and cooling service for scenario 1 are provided by the urban central heating system and air conditioners. Scenario 2 is serviced by the ILEV system.

In China, the school heating period starts in the middle of November and ends in the middle of March. Air conditioners only operate during summer months. Figures 11.1 and 11.2 indicate the energy model created in GBSWARE and the construction specifications for this model.

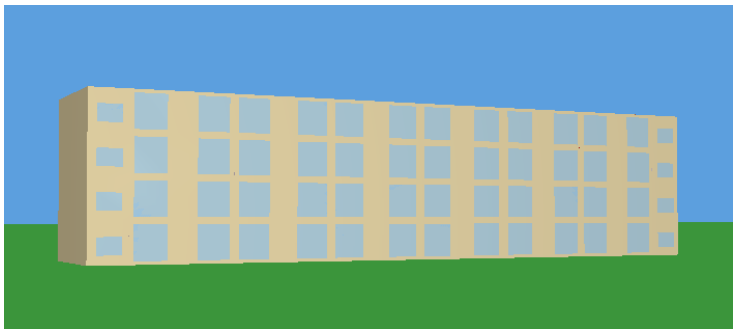


Figure 11.1. *Energy model created in GBSWARE*

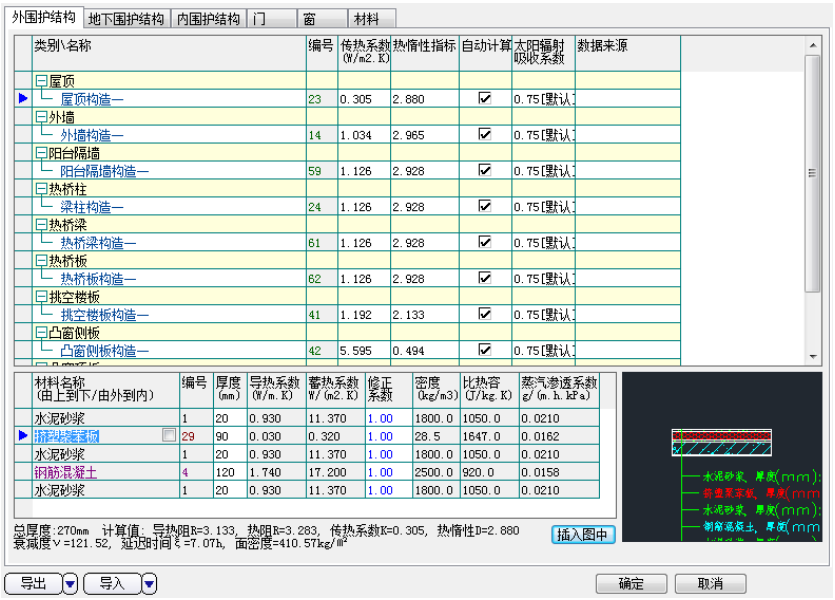


Figure 11.2. *Construction input panel*

Figures 11. 3 and 11.4 present the heating and cooling settings. The energy sources for heating and cooling services are coal and electricity, respectively.

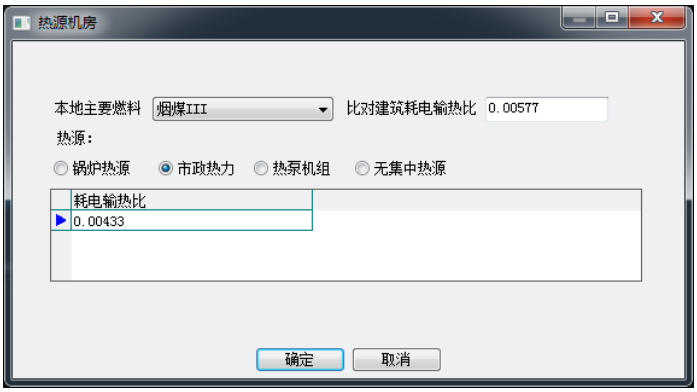


Figure 11.3. *Settings for the urban central heating system*

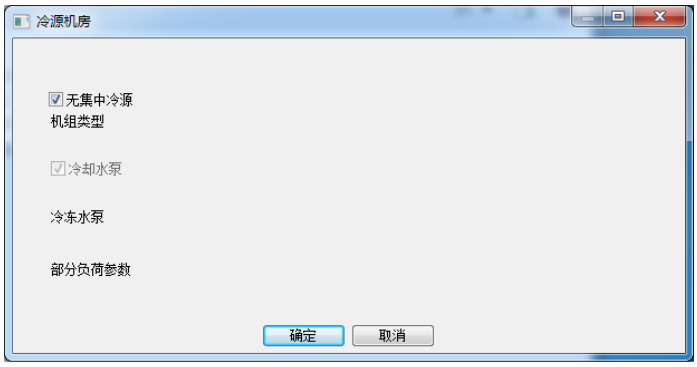


Figure 11.4. *Settings for the cooling system*

School days normally start at 8:00 and end before 17:00. The operation of the heating and cooling services is consistent with the occupancy profile (Figure 11.5).



Figure 11.5. *Occupancy profile*

In the ILEV system, only electricity is required to run the fans and humidifiers. The hours of operation for fans and humidifiers are summarised in Table 11.1 according to the analyses in Chapter 9. The rated power of the fan used in Chapter 8 is 50 W. In addition, for a sunspace with a 100 m^2 floor areas, a humidifier with a rated power of 200 W is enough to wet the air (Taobao, 2018).

Table 11.1. Hours of operation of the fans and humidifiers in the ILEV system

<table>
<tr><th></th><th>Fan A</th><th>Fan B</th><th>Fan C</th><th>Humidifiers</th></tr>
<tr><td>March</td><td rowspan="2"></td><td>Always on (24 hours per day)</td><td rowspan="10"></td><td rowspan="2">8 hours per day (Occupied period)</td></tr>
<tr><td>April</td><td>8 hours per day (Occupied period)</td></tr>
<tr><td>May</td><td rowspan="5"></td><td>8 hours per day (Occupied period)</td><td rowspan="6"></td></tr>
<tr><td>June</td><td rowspan="3">Always on (24 hours per day)</td></tr>
<tr><td>July</td></tr>
<tr><td>August</td></tr>
<tr><td>September</td><td>8 hours per day (Occupied period)</td></tr>
<tr><td>October</td><td>8 hours per day (Occupied period)</td><td></td></tr>
<tr><td>November</td><td rowspan="4"></td><td>Always on (24 hours per day)</td><td rowspan="4">8 hours per day (Occupied period)</td></tr>
<tr><td>December</td><td rowspan="3">Always on (24 hours per day)</td><td rowspan="3">2 hours per day (First two occupied hours during teaching day)</td></tr>
<tr><td>January</td></tr>
<tr><td>February</td></tr>
</table>

Primary school students usually have a one-and-a-half-month summer holiday that starts in the middle of July and extends to the end of August. The winter holiday starts typically in the middle of January and ends in the middle of February. Therefore, the following equation can be used to directly estimate the energy consumption in scenario 2.

$$\text{Energy consumption} = \text{rated power} \times \text{operating hours}$$

Table 11.2 summarises the calculation process for fans and humidifiers.

Table 11.2. Calculation process of energy consumption for the ILEV system (Wh)

	Fan A	Fan B	Fan C	Humidifiers
March		31×24×50×6=223200		44×200×8×6=422400
April	19×8×50×6=45600			
May		21×8×50×6=50400		
June		77×24×50×6=338400		
July				
August				
September		22×8×50×6=52800		
October	23×8×50×6=55200			
November		31×24×50×6=223200		57×200×8×6=547200
December		61×24×50×6=439200	91×2×50×6=54600	
January				
February				
In total	100,800	1,327,200	54,600	969,600

11.3. Estimation of energy savings, the reduction of CO_2 emissions and savings of operation cost

11.3.1. Energy consumption

Table 11.3 summarises the energy consumption results in terms of electricity. Scenario 1 consumed 106,026.3 kWh of electricity per year, and scenario 2 only consumed 2,452 kWh of electricity per year. The case study building with the ILEV system only consumed 2% of the energy currently consumed by scenario 1 to meet the same indoor thermal comfort standards.

Table 11.3. Energy consumption in scenarios 1 and 2

Energy consumption in terms of electricity (kWh)	Scenario 1	Scenario 2
Cooling energy consumption per square meter of floor area	9.74	
Heating energy consumption per square meter of floor area	35.80	
Total energy consumption for cooling	22676.7	
Total energy consumption for heating	83349.6	
Total energy consumption	**106026.3**	**2452**

11.3.2. The reduction in CO_2 emissions and the operational cost

In Tai'an city, electricity is generated by the combustion of coal. According to the Annual Development Report of China Electric Power 2017, 1 kWh of electricity generation requires the consumption of 0.323 kg of standard coal in China (CEPPEI, 2017). Therefore, coal consumption can be quantified based on the electricity consumption of primary school buildings. Moreover, the National Development and Reform Commission (NDRC, 2014) recommends 0.67 as the carbon intensity of coal and 3.67 as the transfer coefficient between carbon and carbon dioxide. Additionally, the price of electricity is 0.5 RMB/kWh in Shandong Province. Therefore, the following equations can be used to estimate the coal consumption, CO_2 emissions and the operational cost for the cooling service (indicated in Figure 11.6)

$$\boldsymbol{Coal\ consumption\ = Total\ energy\ consumption\ in\ electricity\ \times 0.323}$$

$$\boldsymbol{CO_2\ emissions\ = Total\ energy\ consumption\ in\ electricity\ \times 0.323 \times 0.67 \times 3.67}$$

$$\boldsymbol{Operation\ cost\ for\ \ cooling = Cooling\ energy\ consumption\ in\ electricity\ \times 0.5}$$

In the case study city of Tai'an, the price of the heating service is 33.6 RMB per square metre of floor area in non-domestic buildings (TSHP, 2019). Therefore, for the case study building, which has a 2328.2 m² floor area (Figure 5.7, Chapter 5), the heating cost is approximately 78227.5 RMB per year.

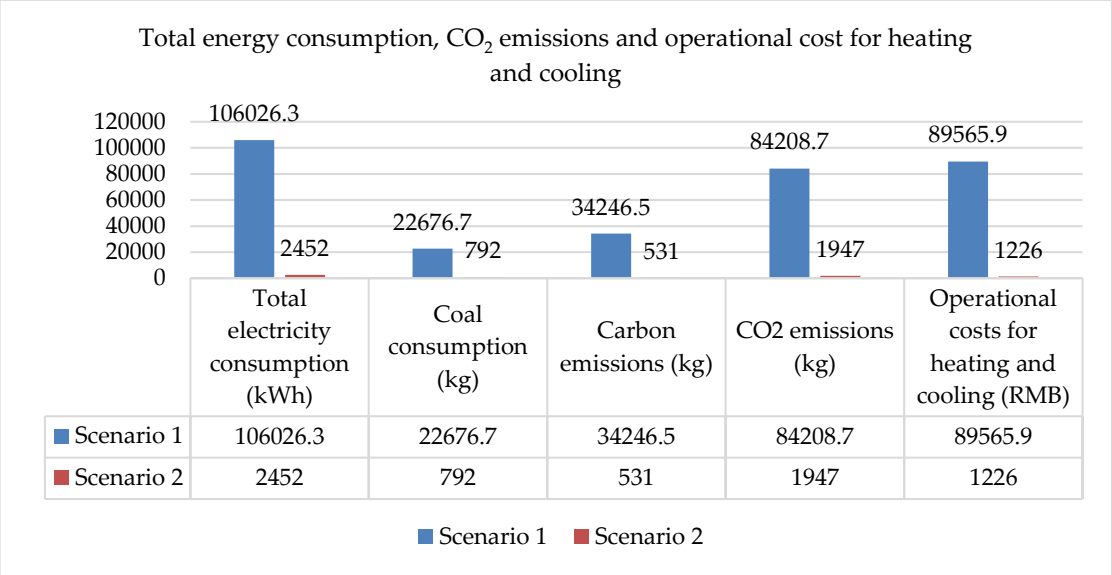


Figure 11.6. *Total energy consumption, CO_2 emissions and operational costs for heating and cooling*

In section 3.7.1, the top-five air-polluted provinces in China are discussed, and these provinces include Beijing, Tianjin, Hebei, Henan, and Shandong. In addition, according to the most recent China National Statistical Yearbook (CNBS, 2018), the number of primary school students in these five areas totals 24.8 million. Assuming that every primary school has 24 classrooms, and the number of students in each classroom is 45; hence, the total number of primary schools is 22,964. Thus, the total energy savings in the primary school sector can be estimated as follows.

(106026.3 – 2452) × 22964 = 2,378,480,225kWh, which is equal to 768,249 tons of coal

and 1,889,047 tons of CO_2 emissions.

Therefore, the ILEV system can reduce CO_2 emissions by 1.89 million tons in the heavy air-polluted provinces in the cold climate zone of China.

11.4. Estimation of the payback period of the ILEV system

To estimate the payback time of the ILEV system, two variables need to be calculated based on the following equation. These are the incremental costs of the ILEV system in terms of material consumption and annual fuel savings. According to the energy simulation results in section 11.3.2, the annual fuel savings were 88,339.9 RMB (Figure 11.6, 59,565.9-1,226=88,339.9 RMB).

Payback time = Additional Cost / Annual Fuel Savings

The incremental cost of the ILEV system in terms of material consumption can be estimated based on the material take-off sheets from the Revit model. As noted in the introduction of the redesigned floor plan in section 7.5, the width of the floor plan was expanded to install the ILEV system. Moreover, the vertical airflow channel and sunspaces increases the building material requirements. To estimate the incremental cost of this system, Revit model was used to quantify the materials consumption, the construction costs of the current primary school buildings, and the construction costs of primary school buildings equipped with the ILEV system (Figures 11.7 - 11.11).

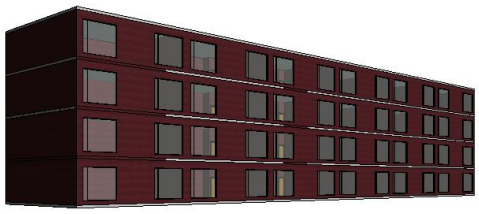


Figure 11.7. *Revit model for current case study primary school building*



Figure 11.8. *Revit model for the case study school building equipped with the ILEV system*

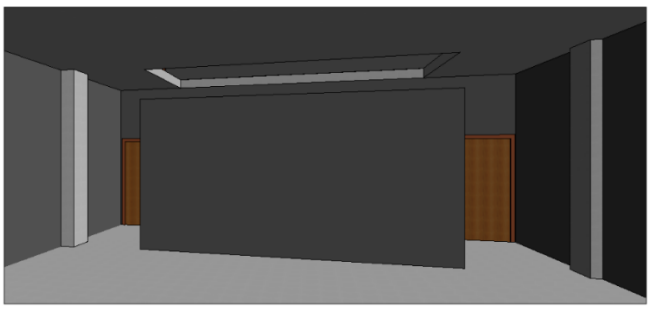


Figure 11.9. *Internal view of a classroom equipped with the ILEV system*

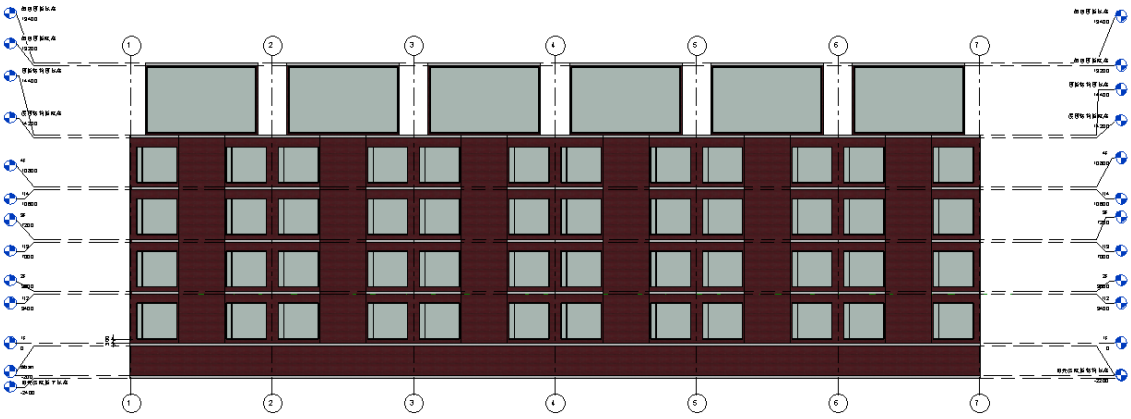


Figure 11.10. *Southern facing facade of the case study school building equipped with the ILEV system*

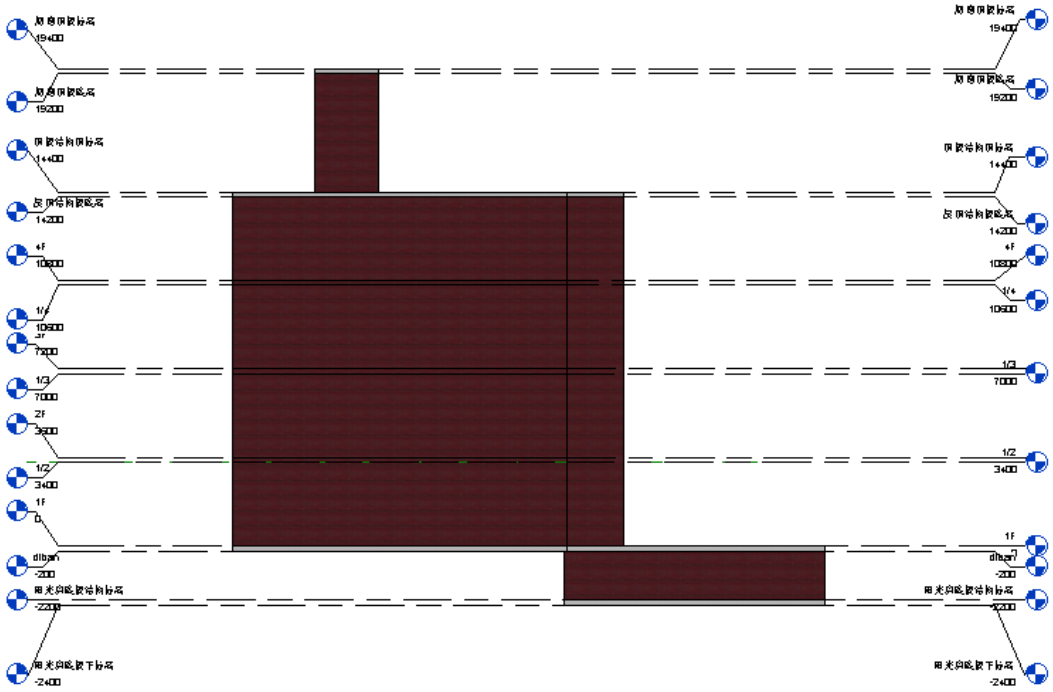


Figure 11.11. *Western facing facade of the case study school building equipped with the ILEV system*

Revit models were created to generate material take-off sheets. These sheets include the quantity (volume: m^3) of each material, which can then be converted to a weight (kg). This study only considered the incremental cost of materials and the fittings of the ILEV system. Other costs, such as labour, transportation, and interior decoration costs were excluded from the payback estimation.

Table 11.4 summarises the materials cost for the ILEV system, and Table 11.5 provides the equipment cost for the ILEV system. The material costs of the 6 solar chimneys, 6 sunspaces, and 6 vertical airflow channels were quantified, and the total equipment cost included the costs of 108 fans, 6 humidifiers, and 42 buried pipes. The total costs for the material consumption and equipment inputs were calculated as 823,107 RMB and 30,499 RMB, respectively.

Table 11.4. Materials cost for the ILEV system

Component		Total surface areas (m^2)	Materials	Thickness (mm)	Volume (m^3)	Price (RMB/m^3)	Total cost (CNY)
Solar chimney (6 in total)	External walls	351	Cement mortar	40	14.04	250	3510
			Concrete block	200	70.2	400	28080
			Rock wool board	80	28.08	200	5616
			Polished tile	10	3.51	65 (RMB /m^2)	22815
	Roof	122	Cement mortar	40	4.88	250	1220
			Extruded polystyrene board	120	14.64	210	3074.4
			Concrete slab	120	14.64	500	7320
	Glazing	225	Triple glazing			600	135000
Sunspace (6 in total)	External walls	278	Cement mortar	40	11.12	250	2780
			Concrete block	200	55.6	400	22240
			Rock wool board	80	22.24	200	4448
			Polished tile	10	2.78	65 (RMB /m^2)	18070
	Floor	625	Cement mortar	40	25	250	6250
			Extruded polystyrene board	120	75	210	15750
			Concrete slab	120	75	500	37500
	Glazing	581	Triple glazing			600	348600
Vertical airflow channel (6 in total)	External walls	666	Cement mortar	40	26.64	250	6660
			Concrete block	200	133.2	400	53280
			Rock wool board	80	53.28	200	10656
			Polished tile	10	6.66	65 (RMB /m^2)	43290

	Roof	44	Cement mortar	40	1.76	250	440
			Extruded polystyrene board	120	5.28	210	1108.8
			Concrete slab	120	5.28	500	2640
Case study building	Increased floor areas	244	Cement mortar	40	9.76	250	2440
			Concrete slab	120	29.28	500	14640
	Increased roof	81	Cement mortar	40	3.24	250	810
			Extruded polystyrene board	120	9.72	210	2041.2
			Concrete slab	120	9.72	500	4860
	Increased ground floor	100	Cement mortar	40	4	250	1000
			Extruded polystyrene board	120	12	230	2760
			Concrete slab	120	12	500	6000
	Increased external walls	48	Cement mortar	40	1.92	250	480
			Concrete block	200	9.6	400	3840
			Rock wool board	80	3.84	200	768
			Polished tile	10	0.48	65 (RMB /m²)	3120
Total cost: 823,107							

Note: prices of the materials were from the local market.

Table 11.5. Equipment cost for the ILEV system

	Amount	Price (CNY/per one)	Total cost
Fan A	42	150	6300
Fan B	42	150	6300
Fan C	24	150	3600
Humidifier	6	1000	6000
Pipes	42	3 .8yuan/m, 2184m in total	8299
Total cost: 30,499			

Note: the price of the equipment was from the local market.

For scenario 2, the main incremental cost (853,606 RMB) of the ILEV system was attributed to the materials and equipment inputs. Thus, according to the Tables 11.4.1 to 11.4.3, and the equation introduced in section 5.4.7, Chapter 5, the payback period for scenario 2 is as follows.

$$853{,}606 \div (89{,}565.9 - 1{,}226) = 9.7 \text{ years};$$

Therefore, it requires less than 10 years for a primary school building to offset the initial costs of an ILEV system.

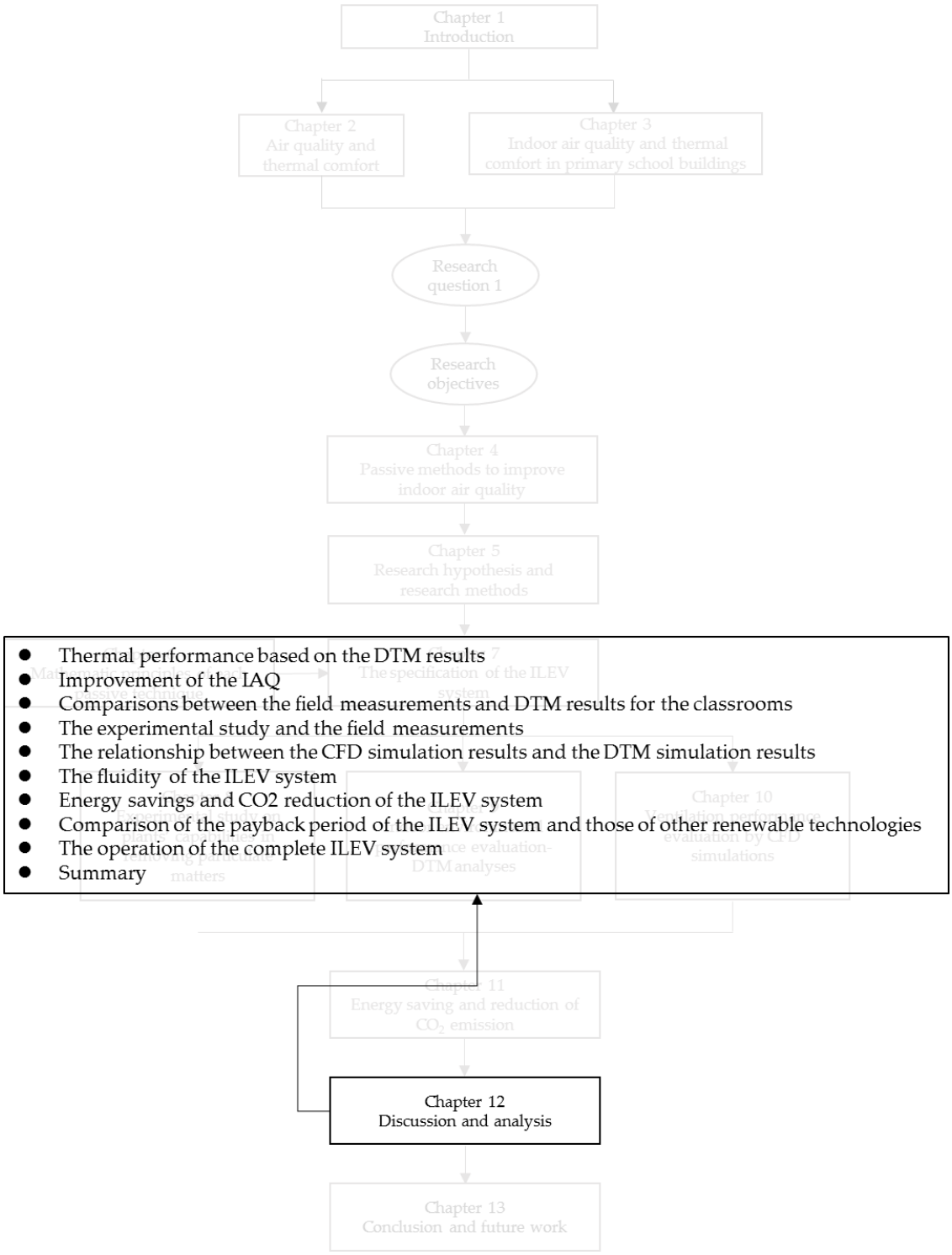
11.5. Summary

This chapter investigated the energy consumption of the studied primary school building and estimated the payback period based on the incremental material costs and equipment inputs. The following list summarises the most significant findings of this chapter.

- Primary school building equipped with the ILEV system consumes approximately 2% of the energy currently consumed by the case study primary school building.
- The ILEV system could reduce CO_2 emissions by 90% based on the case study of the selected primary school building.
- For the top-five most polluted areas, the ILEV system could reduce coal consumption by 768,249 tons, which equates to 1,889,047 tons of CO_2 emissions annually.
- The payback period of the ILEV system is 9.7 years on average based on the incremental material costs and equipment inputs.

These findings suggest that the ILEV system can significantly improve the building energy savings and increase the reduction of CO_2 emissions of the primary school building investigated. Additionally, the payback period was approximately 9.7 years. The following chapter will further justify and discuss the economic feasibility of the ILEV system.

Chapter 12: DISCUSSION AND ANALYSIS



The content of Chapter 12

12.1. Thermal performance based on the DTM results

12.1.1. Winter performance

Figure 12.1 indicates the air temperature performance inside the classrooms in winter. The air temperatures inside the classroom between 9:00 am and 17:00 pm were between 16.72°C and 18.66°C and met the thermal requirements of the CIAQS-2002 (16°C-24°C). However, during the first school hour in winter, the average air temperature was 15.32°C, which was lower than the minimum required value of 16°C.

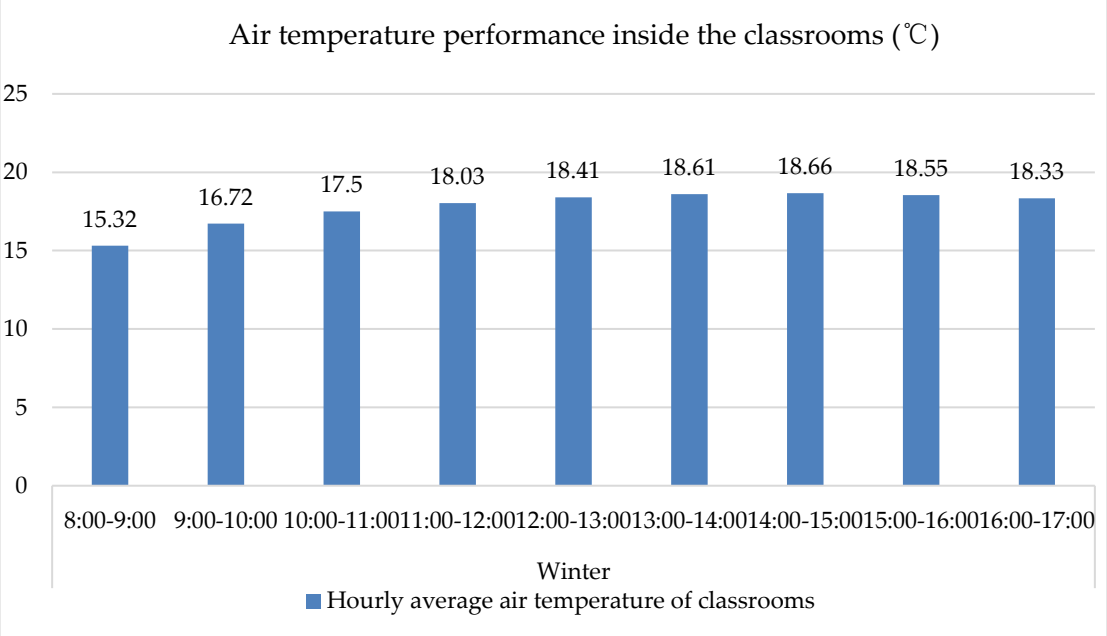


Figure 12.1. *DTM results for air temperatures inside classrooms in winter*

Compared to the recommended air temperatures from the CIBSE Guide A, the air temperatures inside the classrooms were still 1.5°C lower than the minimum recommended value of 19°C.

The PMV values in winter also reflected a slightly cold indoor environment, and the average PMV values ranged from -0.5 to -1 (Figure 12.2). Moreover, during the first and second school hours in January and the first school hour in December and

February, the PMV values were even below -1, representing a cold indoor environment.

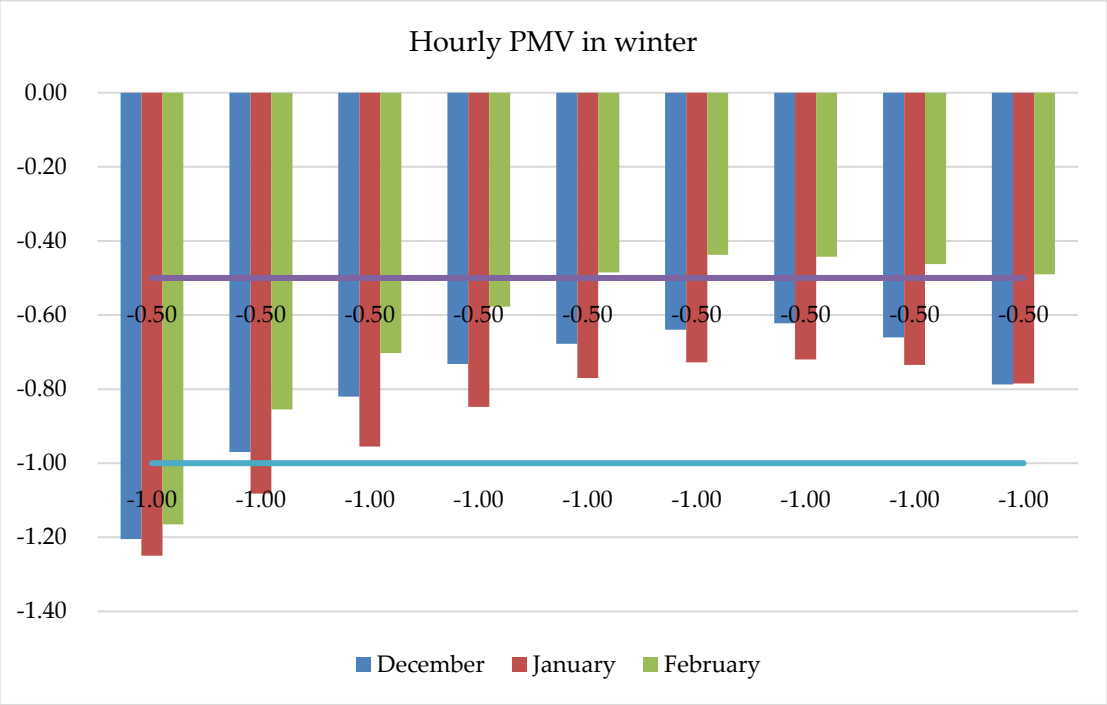


Figure 12.2. *The average PMV values of classrooms in winter*

Therefore, although the average inside air temperature in classrooms in winter months met the CIAQS-2002, some stricter recommendations, such as those in CIBSE Guide A, were not met. The primary reason for this result was the low air temperature inside the sunspace.

Figure 12.3 shows the average air temperature performance inside the sunspace in winter. The air temperatures inside the sunspace were all below the undisturbed temperature of the soil (15.7°C). At the start and finish of the occupied period, the air temperature was below 15°C. Thus, the sunspace loses more heat than is absorbed from the solar energy. The main factors that led to this phenomenon were the small solar shading coefficient of the glazed roof (0.15), the low solar radiation level and the cold ambient environment. The low level of solar radiation and the small solar shading coefficient decreased the solar heat absorbed by the sunspace, and the cold ambient environment accelerated the conductive heat loss.

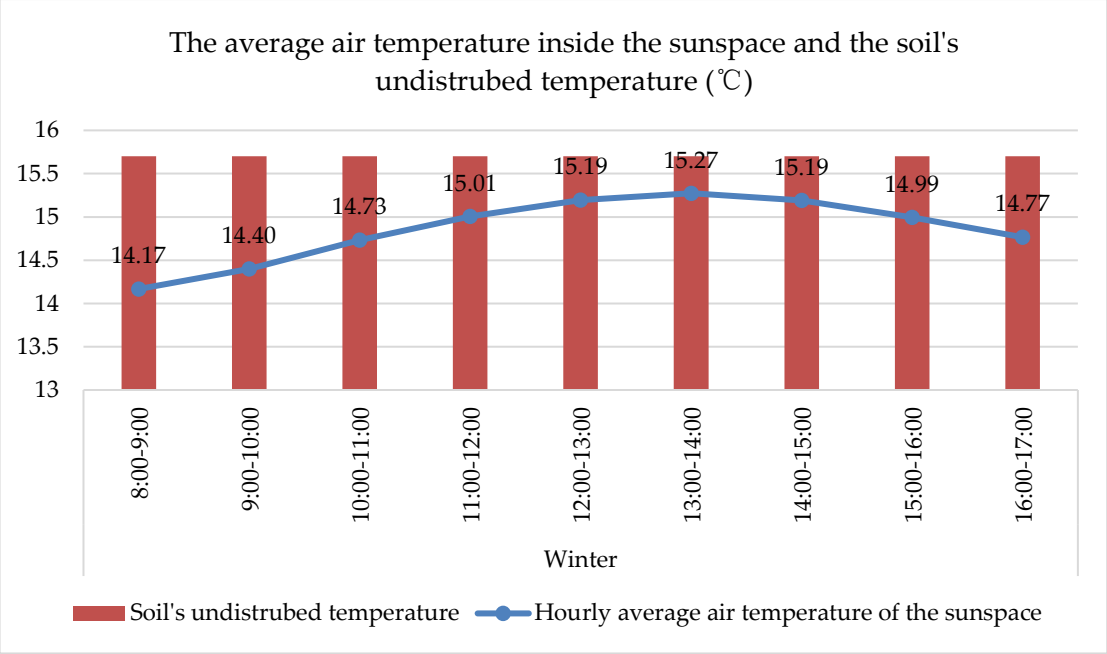


Figure 12.3. *The average air temperatures in the sunspace and the undisturbed soil temperature in winter*

Thus, the ILEV system's thermal performance can be further improved to meet stricter recommendations, such as those in CIBSE Guide A. The preferred method of increasing the air temperature inside the sunspace is increasing the solar shading coefficient of the glazed roof of the sunspace.

As introduced in section 9.7.3, the highest solar shading coefficient for a triple-glazed window is 0.75, as set by the Chinese Thermal Design Code of Civil Building. Therefore, the DTM analyses of the sunspace were conducted again to identify the effects of the increased solar shading coefficient; Figure 12.4 presents these results.

A comparison of Figure 12.3 and Figure 12.4 suggests that the largest improvement in the air temperature inside the sunspace was 1.79°C. This improvement was observed between 13:00 pm and 14:00 pm. Except during the first two hours of the school day, the air temperature inside the sunspace increased by 1.4°C on average.

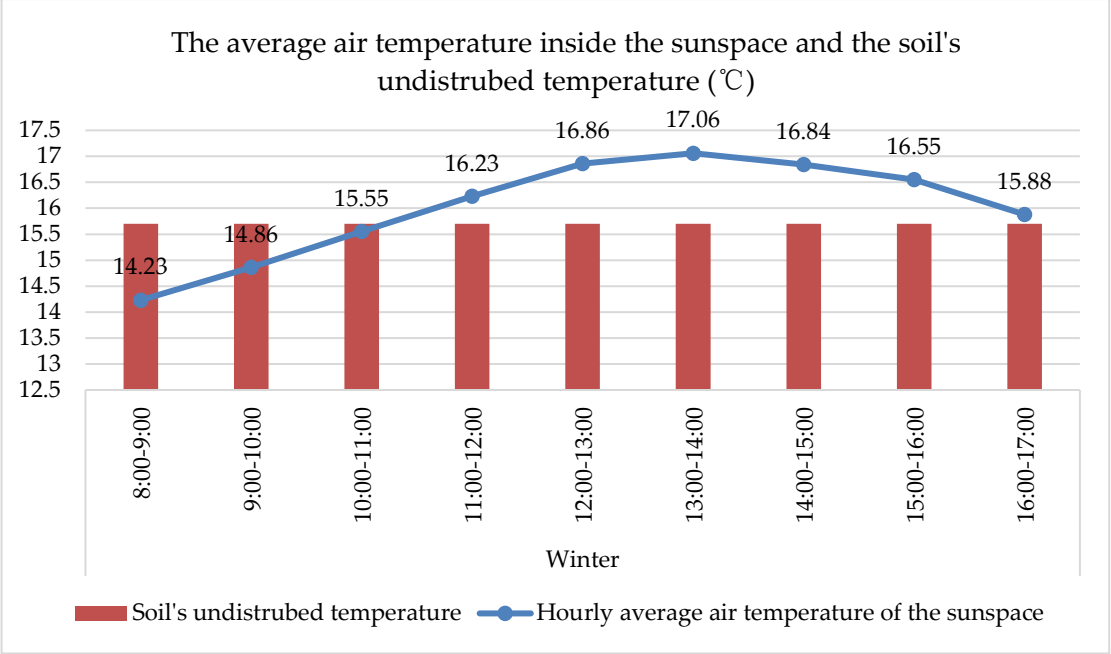


Figure 12.4. *The average air temperature in the sunspace and the undisturbed soil temperature in winter (solar shading coefficient increased from 0.15 to 0.75)*

However, in the first and second hours of the occupied period, the air temperatures inside the sunspace exhibited only slight improvements of 0.06°C and 0.46°C, respectively. Therefore, increasing the solar shading coefficient was not an effective method of increasing the air temperature inside the sunspace in the early morning during winter because the solar radiation level was low.

Based on the analyses above, the following list summarises two design implications for the sunspace.

- First, increasing the solar shading coefficient of the glazed roof improved the air temperature performance inside the sunspace between 10:00 am and 17:00 pm in winter. However, during the first two hours of the school day in winter, increasing the solar shading coefficient did not significantly improve the inside air temperature because the solar radiation level in the early morning was low.

- Second, artificial heating systems, such as a boiler heating system with radiators or space heaters and fans, could be an option for the sunspace to increase the air temperature. However, these types of systems consume electricity, which reduces some of the benefits of the ILEV system. Thus, artificial heating systems should only be used in the sunspace to increase the air temperature during the first and second hours of the school day in winter.

In summary, the thermal performance in classrooms in winter meets the CIAQS-2002 during most school hours. However, the thermal performance can be further improved to meet stricter standards by increasing the solar shading coefficient of the sunspace and using an artificial heating system during the early morning period when the ambient environment has a low-level of solar radiation.

12.1.2. Summer performance

Figure 12.5 illustrates the air temperature performance inside the classrooms in summer. The air temperatures inside the classrooms met the requirements of the CIAQS-2002 (22°C -28°C), as the values ranged from 26.51°C to 27.14°C. The school design standard in the UK, namely, Building Bulletin 101, provides the following evaluation criteria for overheating problems in summer:

a) "There should be no more than 120 hours when the air temperature in the classroom rises above 28°C."

b) "The average internal to external temperature difference should not exceed 5°C (i.e., the internal air temperature should be no more than 5℃ above the external air temperature on average)."

c) "The internal air temperature should not exceed 32°C."

Building Bulletin 101 states that to ensure the teaching areas are not overheated, the indoor environment should meet at least two of these criteria. The DTM results

in summer fully meet these criteria. Therefore, the indoor thermal environment of the case study building will not suffer from overheating problems in summer.

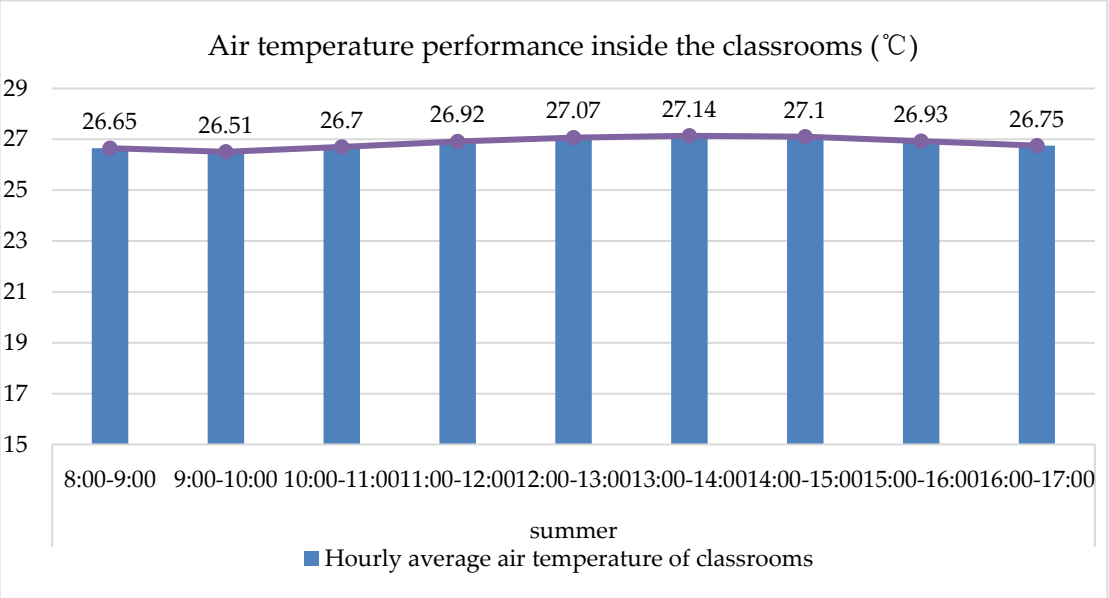


Figure 12.5. *DTM results for the air temperatures inside classrooms in summer*

However, the air temperature in the classrooms remained approximately 3°C higher than the value recommended in CIBSE Guide A of 23°C. Moreover, the average PMV values in the classrooms revealed a warm indoor thermal environment, as the values ranged between 1.32 and 1.42 (Figure 12.6).

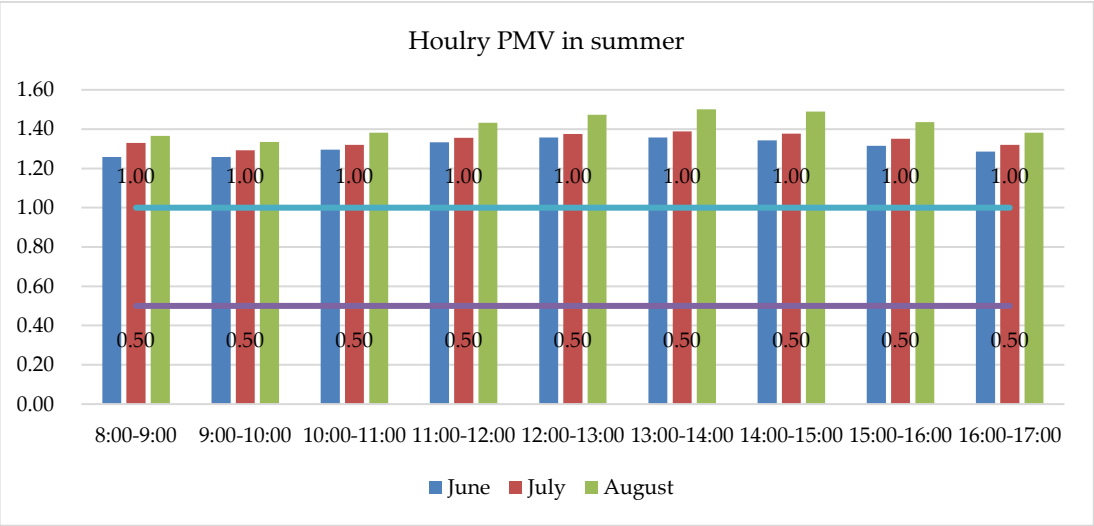


Figure 12.6. *Hourly PMV values in summer*

Thus, there are two possible ways to reduce the indoor air temperature in classrooms and meet the stricter recommendations of CIBSE Guide A.

- First, adding a shading system to the glazed roof of the sunspace could reduce the solar heat gains. As a result, the air temperatures in both the sunspace and the classrooms would decrease.
- Second, a shading system could be added to the external windows of the classrooms. This measure would reduce the air temperature inside the classrooms due to the decrease in the solar heat gains of the classrooms. However, the natural light availability in the classrooms would also decline.

In practice, adding a shading system to the glazed roof of the sunspace is the preferred option because it has no effects on the daylight performance of the classrooms.

Moreover, considering the discussion in section 12.1.1, adding a shading system to the glazed roof of the sunspace can offset the effects of the increased solar shading coefficient on the air temperature performance of the sunspace in summer.

As discussed in section 12.1.1, in winter months, the solar shading coefficient of the glazed roof should be increased to increase the air temperature in the sunspace. However, this change can lead to excessive solar heat gains in the sunspace in summer months. Therefore, there is a conflict regarding the solar shading coefficient of the roof in summer and winter. In winter, the sunspace requires more solar heat gains, and in summer, lower solar heat gains are needed to avoid the overheating problems in classrooms. Overall, adding solar shading systems to the glazed roof of the sunspace is more feasible. In winter, the solar shading system can be turned off to increase the absorption of solar heat.

In summer, although the roof has a higher solar shading coefficient, and the solar shading system can be turned on to reduce the solar heat gains of the sunspace and keep the inside air temperature relatively low.

In summary, the thermal performance of the classrooms in summer met the requirements of the CIAQS-2002. Moreover, the ILEV system avoided overheating problems in the classrooms according to the criteria from the Building Bulletin 101. However, the thermal performance can be further improved to meet stricter recommendations, such as those in CIBSE Guide A, by adding a shading system to the glazed roof of the sunspace. This approach can also solve the conflict between winter and summer heating and cooling strategies.

12.1.3. Performance in spring and autumn

In March and November, the air temperature inside the classrooms was 20.5°C on average (Figure 12.7). The highest and the lowest hourly average air temperatures were 18.4°C and 21.3°C, respectively.

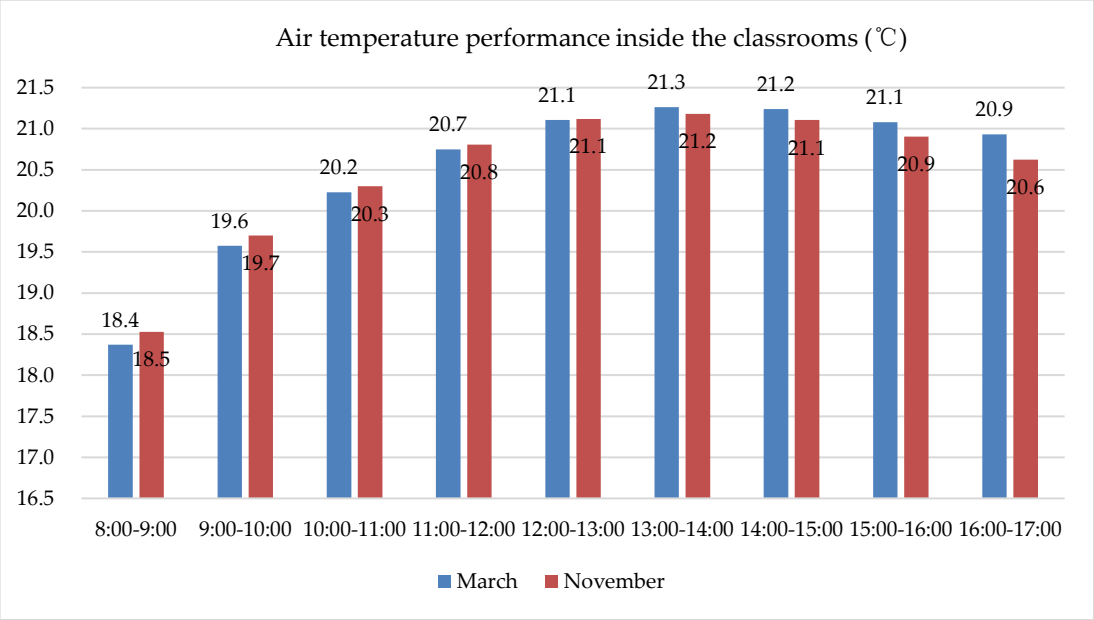


Figure 12.7. *DTM results for the air temperatures inside classrooms in March and November*

Figure 12.8 shows that the ILEV system achieves a thermally comfortable indoor environment in the classrooms, and the PMV values ranged between -0.5 and 0, except during the first school hour. The PMV values for the first school hour were -0.60 and -0.56 in March and November, respectively, reflecting an acceptable indoor thermal environment.

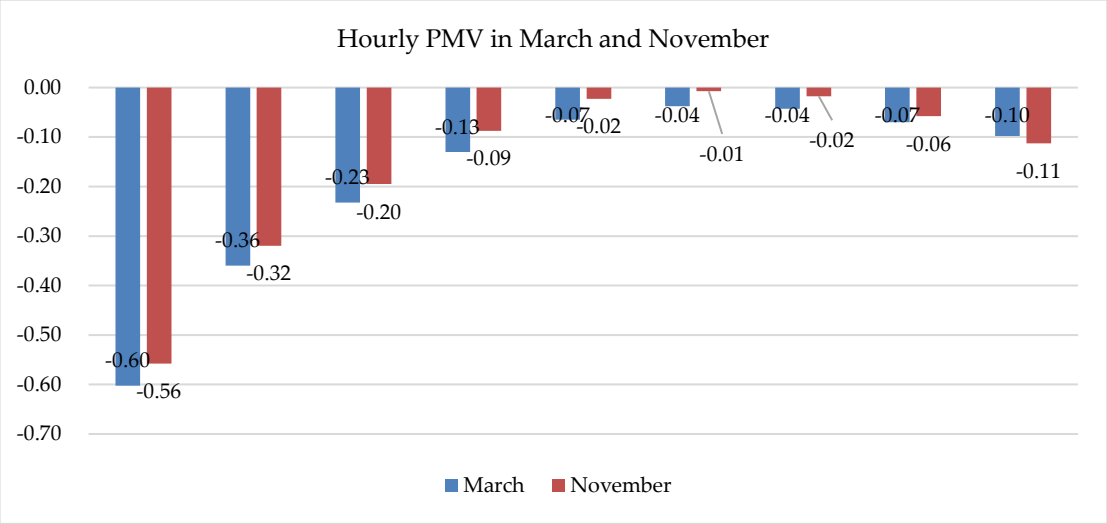


Figure 12.8. *Hourly PMV values in March and November*

Figure 12.9 and Figure 12.10 show the thermal performance of the classroom in April and October. The air temperatures inside the classrooms ranged from 21.56°C to 25.62°C on average. The PMV values in April between 8:00 am and 11:00 am reflected a thermally comfortable indoor environment in classrooms. Additionally, during other school hours, the ILEV system achieved a slightly warm indoor environment. In October, only the first school hour was characterised by a thermally comfortable indoor environment, and during other school hours, the indoor thermal environment was slightly warm.

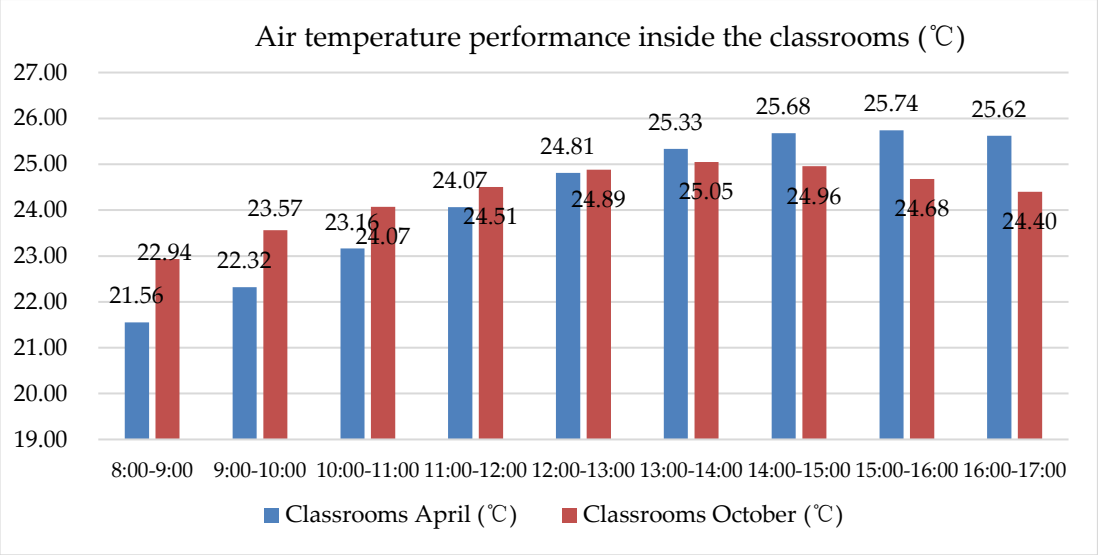


Figure 12.9. *DTM results for the air temperatures inside the classrooms in April and October*

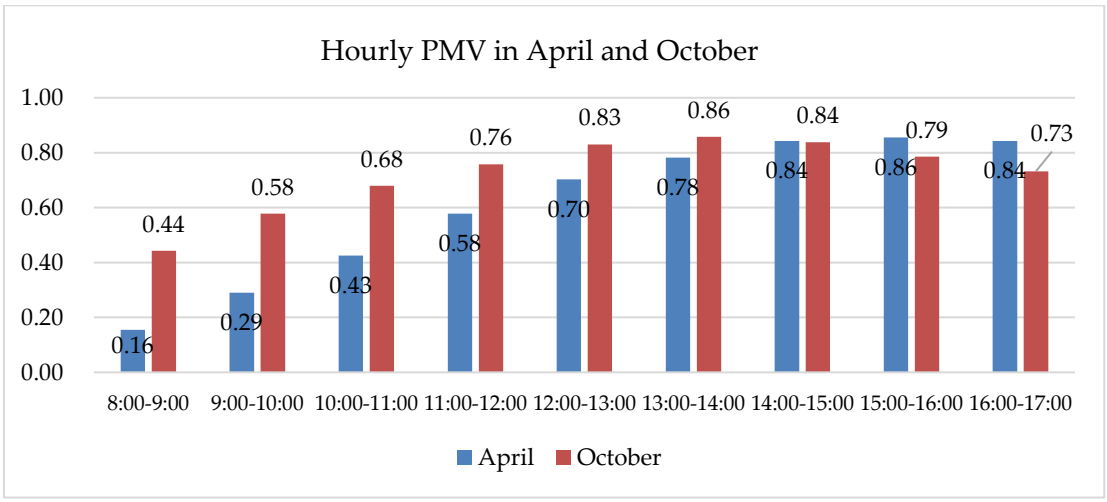


Figure 12.10. *Hourly PMV values in April and October*

Figure 12.11 and Figure 12.12 illustrate the air temperature performance and the PMV values of the classrooms in May and September. The air temperature inside the classrooms was between 23.85°C and 26.19°C. The PMV value in May indicated a slightly warm indoor thermal environment and varied between 0.5 and 1. In September, classrooms had a slightly warm indoor environment during the first two school hours, as the PMV values were below 1. Then, the indoor thermal environment became slightly warmer, and the PMV values were all above 1.

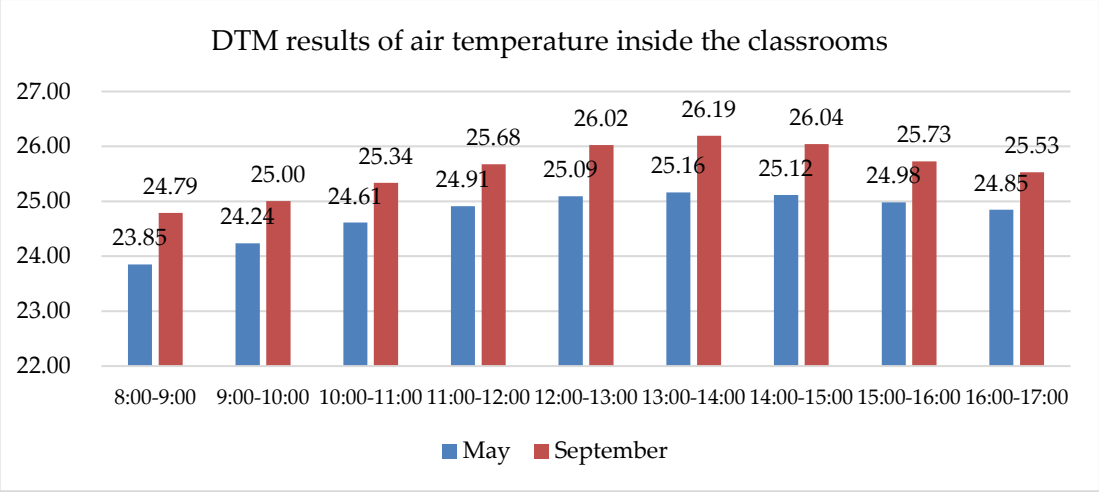


Figure 12.11. *DTM results for air temperatures inside the classrooms in May and September*

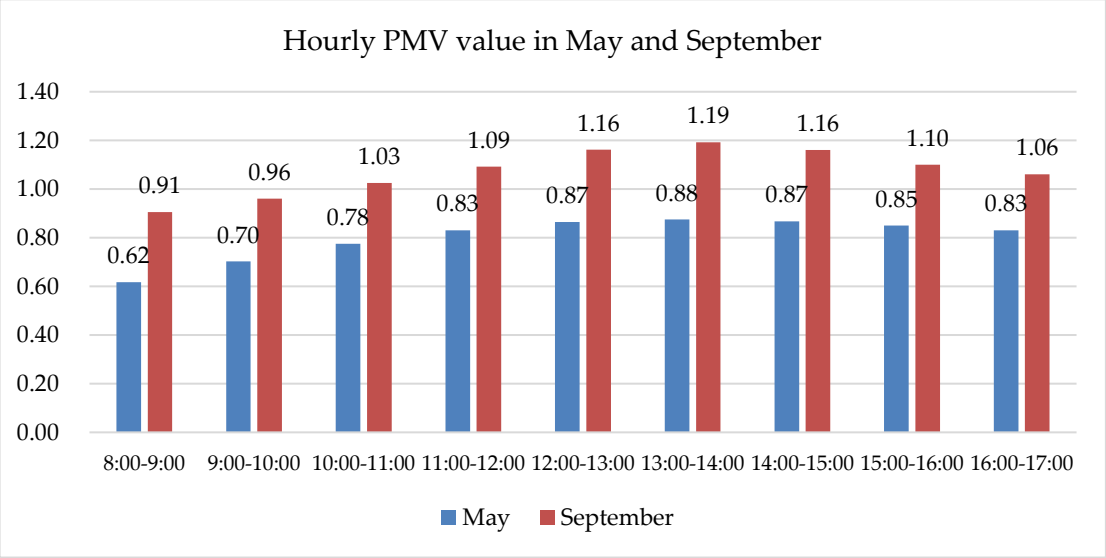


Figure 12.12. *Hourly PMV values in May and September*

Generally, in transition seasons, March and November exhibited the best performance, and a thermally comfortable indoor environment was achieved (PMV values were within the range of -0.5 to 0.5). In April, May, and October, the indoor thermal environment of classrooms was slightly warm, as the PMV values were between +0.5 and 1. In September, the classrooms were also characterised by a warm indoor thermal environment with PMV values above 1.

The indoor thermal performance in April, May, September, and October was similar to the indoor thermal performance in the summer months. For example, the air temperatures in classrooms between 12:00 and 14:00 in September were above 26°C (Figure 12.11). This trend was almost the same as that for the air temperature in the summer months (Figure 12.5). In May, the average air temperature in the classrooms was 25°C, only approximately 1.5°C lower than the average air temperature in the summer months.

As discussed in section 12.3.2, adding a shading system to the glazed roof of the sunspace could be a selection to further improve the thermal comfort of classrooms in the summer months. In transition seasons, this method is also feasible. Solar heat gains can be reduced by covering the roof of the sunspace, and as a result, the air temperature inside the sunspace and classrooms will also decrease. The only difference between the operation of the roof shading system in the summer months and that during the transition seasons would be the coverage strategy for the roof. In the summer months, the solar shading system should cover more areas of the roof; in transition seasons, the coverage area should be smaller.

In summary, the ILEV system achieved optimal thermal comfort or acceptable thermal comfort in classrooms during most school hours in the studied classrooms. Adding a shading system to the glazed roof of the sunspace could reduce the air temperature in the classrooms, mainly, in April, May, September, and October, and further improve the thermal comfort.

12.2. Improvement of the IAQ

12.2.1. Indoor CO_2 concentrations

The DTM results illustrated a stable indoor CO_2 concentration throughout the investigated year. Figure 12.13 shows that the concentrations was approximately 902 ppm in all months. This level meets the requirements of the CIAQS-2002 and the WHO Air Guidelines (1000 ppm presented in Table 2.1 and Table 2.3, Chapter 2) since the CO_2 generated by the occupants can be quickly removed by the supplied air at a rate of 10 L/s per person.

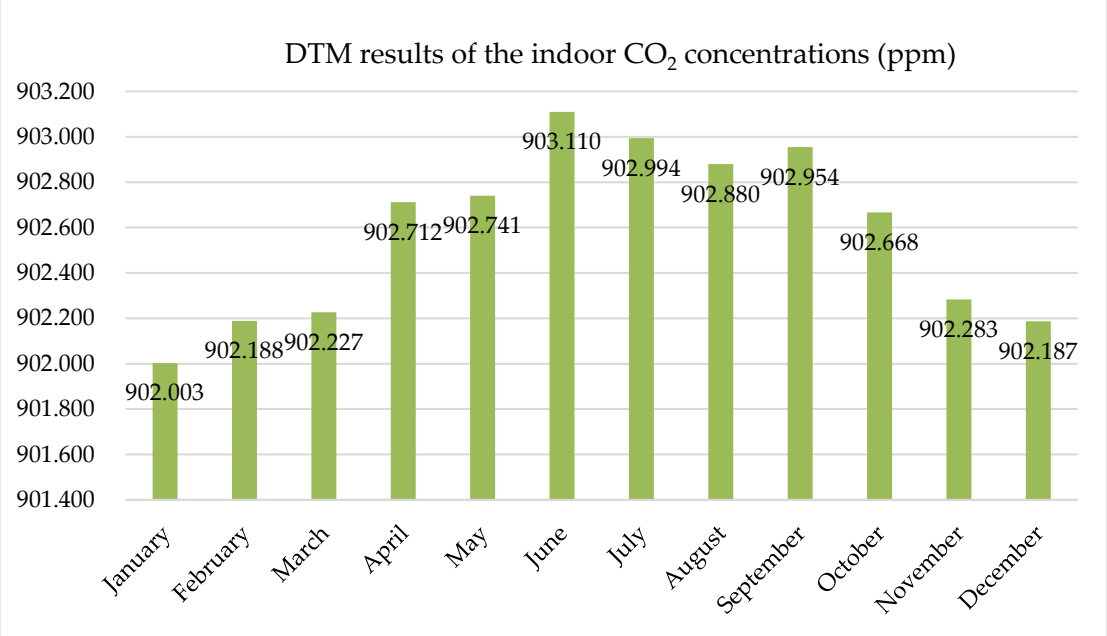


Figure 12.13. *The average indoor CO_2 concentrations predicted based on the DTM results*

However, the concentrations predicted in the DTM analyses are still above the acceptable level of 600 ppm recommended by the CIBSE Guide A (presented in Table 2.2., Chapter 2). Thus, a higher ventilation rate (>10 L/s per person) for the ILEV system might reduce the indoor CO_2 concentrations further.

Increasing the ventilation rate of the ILEV system will lead to significant changes in the design of EAHEs (presented in section 7.3). For example, to maintain a stable

indoor environment in the sunspace, more pipes are needed to supply a high volume of air into the sunspace at a low speed.

Moreover, increasing the ventilation rate in the sunspace will also reduce the air temperature inside the classrooms in the summer months and further reduce the PMV values to achieve a thermally comfortable indoor environment, as discussed in section 12.1.2.

In winter months, increasing the ventilation rate in the sunspace will not decrease the air temperature inside the sunspace and the classrooms. The air temperatures inside the sunspace will be infinitely approach the undisturbed soil temperature (15.7°C). The sunspace can also absorb more solar heat by replacing the glazed roof with a roof with a higher solar shading coefficient. Additionally, artificial heating system can be used to increase the air temperature inside the sunspace during the early morning hours in winter. Thus, increasing the ventilation rate is beneficial for the thermal performance of the ILEV system in winter.

In summary, the ILEV system achieves stable indoor CO_2 concentrations that meet the CIAQS-2002 and the WHO requirements. However, a larger ventilation rate could be an option to reduce the indoor CO_2 concentrations further and meet the stricter guidelines in CIBSE Guide A without affecting the indoor thermal performance of the classrooms.

12.2.2. Indoor PM concentrations

In section 8.4, the ratio of the inside PM concentrations to the outside PM concentrations was 0.55 on average when the air flowed into the sunspace at a speed of 1.3 m/s. Therefore, the ratio of 0.55 was used to quantify the potential reduction in PMs inside the classrooms. In section 7.2, Table 7.1 summarises the average PM concentrations of the ambient environment in the past three years.

The following equation can be used to estimate the indoor PM concentration inside the classrooms.

Potential indoor PM concentrations = I/O ratio x average ambient PM concentrations

Figure 12.14 shows the potential indoor PM concentrations inside the classrooms of the case study building based on the PM data from the past three years. The overall annually average indoor PM_{10} concentrations have significantly improved and meet the Grade II requirement of the NAAQS-2012 (annual mean: 70μg/m^3). The annual average $PM_{2.5}$ concentrations in 2017 and 2015 meet the Grade II requirement, with values below 35 μg/m^3 (annual mean: 35μg/m^3). In 2016, the annual average $PM_{2.5}$ concentration was only 1 μg/m^3 higher than the Grade II requirement at 36 μg/m^3.

However, the average PM concentration only meets the Grade I requirements and WHO requirements in certain months. For example, in 2017, the monthly average indoor PM concentration meets the 24-hour mean Grade I requirement of the NAAQS-2012, except in winter months. Moreover, the monthly average indoor PM_{10} concentrations in the summer months, October and November meet the 24-hour mean Grade I requirement. Similar results can be observed in 2015 and 2016.

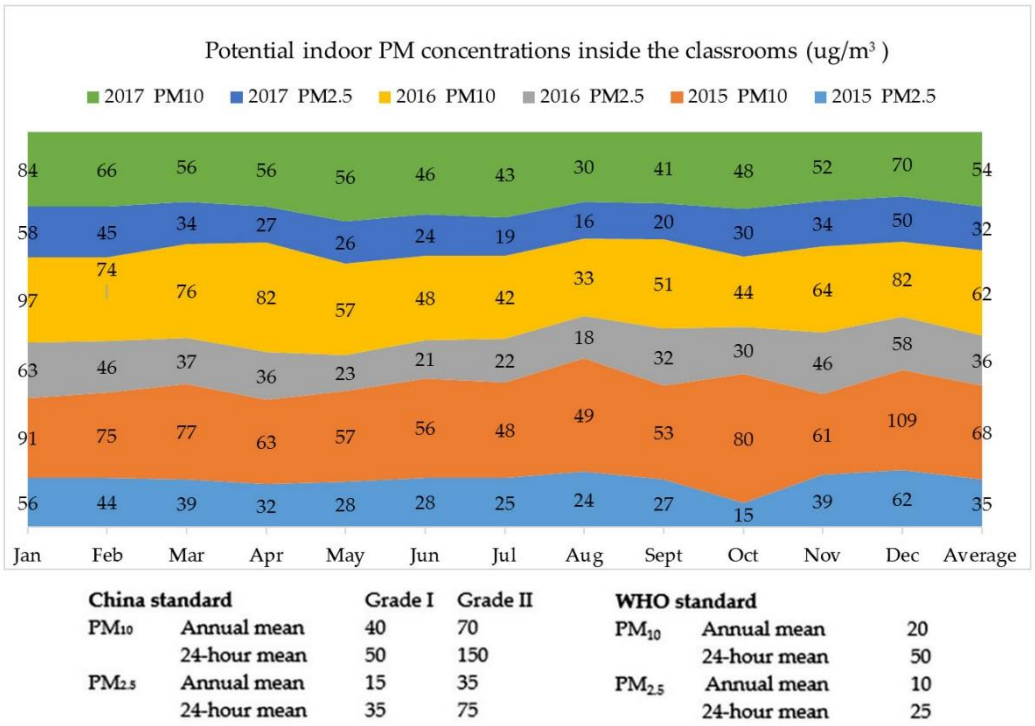


Figure 12.14. *Potential indoor PM concentrations in classrooms*

Compared with the results of the field measurements in Chapter 3, the potential indoor PM concentrations obtained with the ILEV system are lower, representing a significant improved IAQ. Because the field measurements were performed in November and December of 2016, the data from these two months in unoccupied periods were compared with the estimated average indoor PM concentrations in the case study building with the ILEV system. As Figure 12.15 shows, the estimated average indoor PM concentrations in case study building were lower than the PM concentrations based on the field measurements. Specifically, the values with the ILEV system were 48% and 64% of the field-measured values of $PM_{2.5}$ and PM_{10}, respectively.

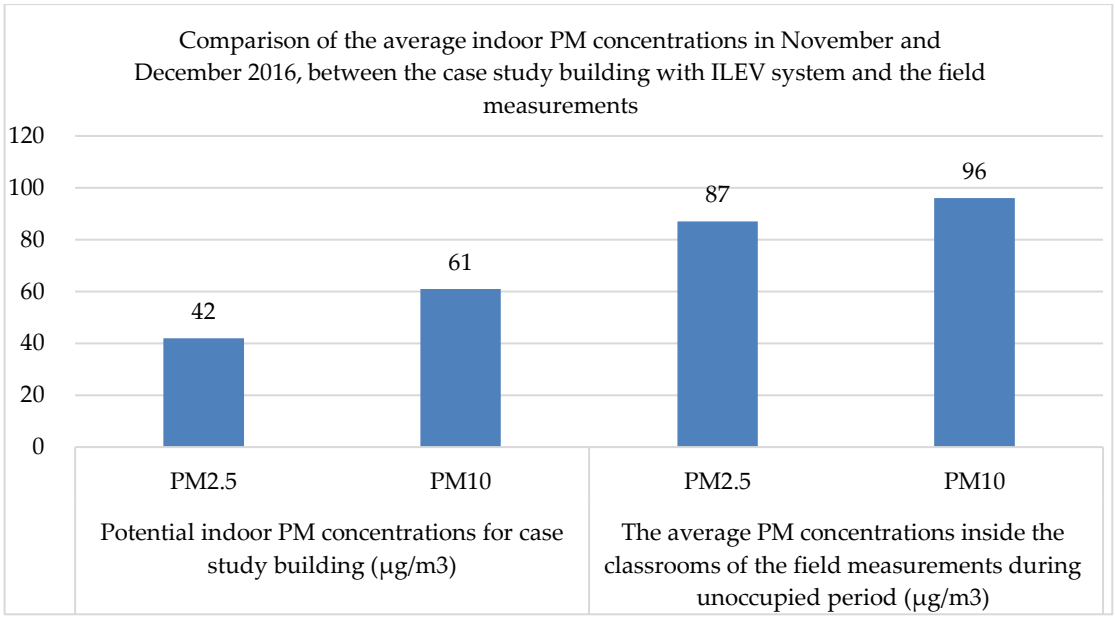


Figure 12.15. *Comparison of the average indoor PM concentrations in November and December 2016, between the case study building with the ILEV system and the field measurements during the unoccupied periods*

The output of Chapter 8 provides a basis for the estimation of the indoor PM concentrations in the case study building with the ILEV system. The I/O ratio used was 0.55. As discussed earlier in section 8.5, the experiment designed in this study was not airtight. Therefore, the I/O ratio could be reduced in practice by increasing the airtightness level of the sunspace.

Moreover, for a real sunspace, more plants or plants with higher absorption efficiencies could be used. These plants could further decrease the inside PM concentrations in the sunspace and supply cleaner air to the classrooms.

In summary, the indoor PM concentrations in the classrooms ventilated by the ILEV system were significantly lower than those based on the field measurements. The estimated potential PM concentrations meet the Grade II requirements of the NAAQS-2012. Further improvements could be achieved by increasing the airtightness level of the sunspace and the number of plants inside the sunspace.

12.3. Comparisons between the field measurements and DTM results for the classrooms

The DTM was used for a thermal modelling analysis (Chapter 9) of the case study building throughout a calendar year. Field measurements (Chapter 3) were obtained to evaluate the thermal performance and the IAQ of classrooms in November and December 2017. The indoor air temperature, indoor relative humidity, and indoor CO_2 concentration were studied in the DTM analyses and based on field measurements.

The only one difference between the DTM analyses in Chapter 9 and the field measurements in Chapter 3 was the ventilation rate. The DTM analyses used a regularly supplied airflow rate of 10 L/s • person, and the classrooms in the field measurements relied on infiltration.

Figures 12.16 and 12.17 show the comparisons of the indoor air temperatures and indoor CO_2 concentrations in November and December based on the DTM analyses and the field measurements. The DTM analyses indicated better thermal performances than observed in the field for the indoor air temperature and the indoor CO_2 concentration. In this case, the classrooms with ILEV systems not only have a constant ventilation rate (10 L/s • person) but also have preheated air from the EAHEs and the sunspace. In the field measurements, the ventilation of primary schools only relied on the infiltration, and some schools lacked external insulation. Therefore, high internal CO_2 concentrations and low levels of thermal comfort were observed.

Thus, based on the comparisons above, the superiority of the ILEV system is demonstrated. This system can create a comfortable indoor air temperature with a low indoor CO_2 concentration in November and December.

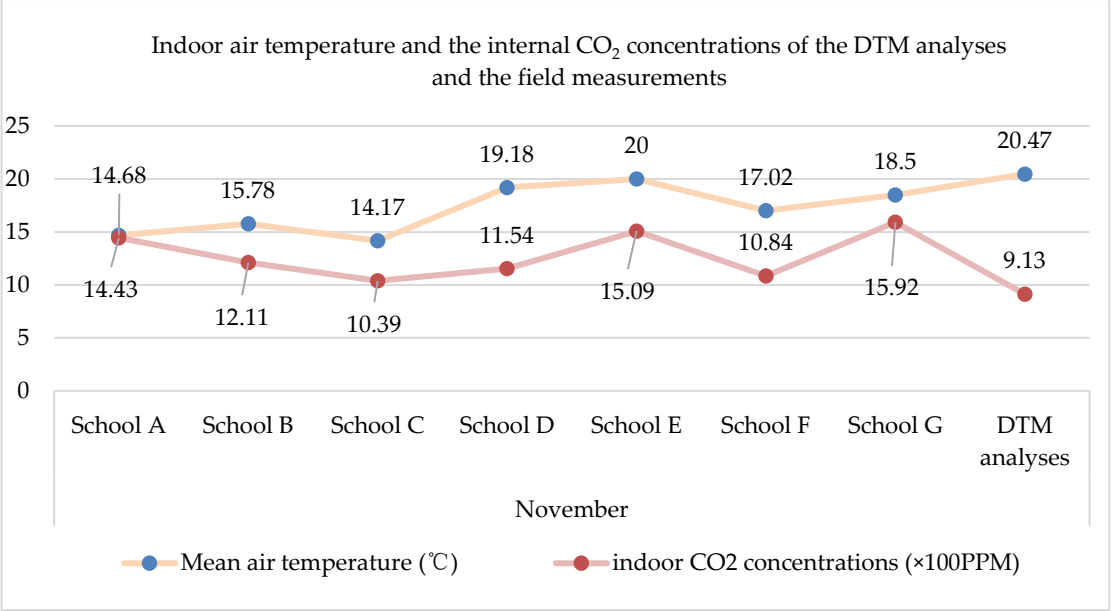


Figure 12.16. *A comparison of the average indoor air temperature and the average indoor CO_2 concentration between the DTM analyses and the field measurements in November*

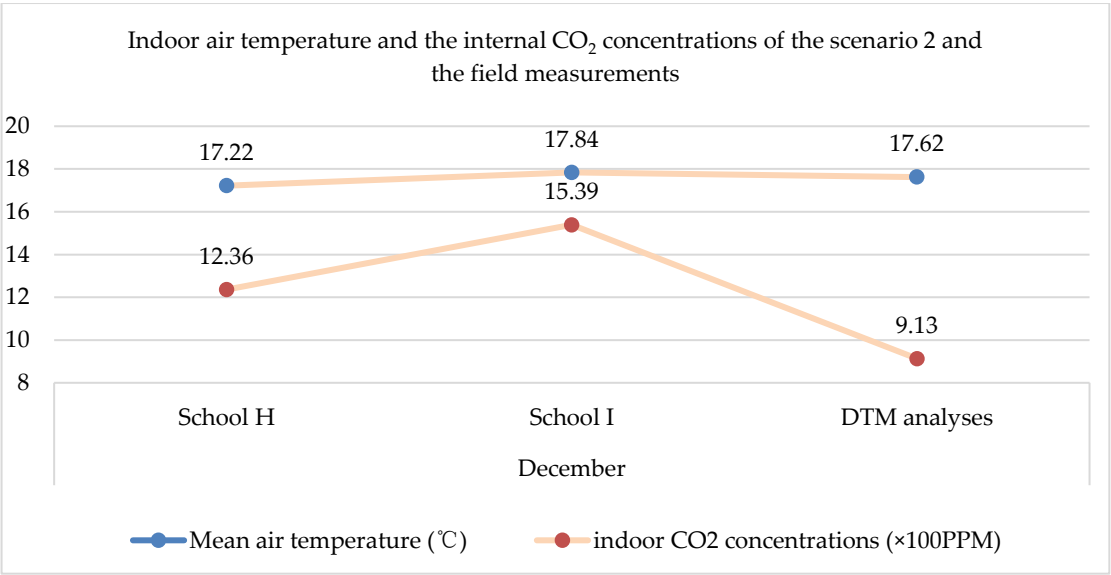


Figure 12.17. *A comparison of the average indoor air temperature and the average indoor CO_2 concentration between the DTM results and the field measurements in December*

12.4. The experimental study and the field measurements

The experiment in Chapter 8 explored the capability of plants to remove PMs. This experiment was designed based on the financial and material resources available for this Ph.D. work. The sunspace, which was made of a steel framework and polyethylene, was not airtight because transparent adhesive tape was used to adjoin the polyethylene films. The key determinants that affect the I/O ratios between the indoor PM concentrations and the outdoor PM concentrations are the airtightness level and plant selection (e.g., number of plants and plant species).

In Chapter 3, actual field measurements were obtained during occupied and unoccupied periods in the classrooms, and the influential factors that affect the I/O ratio include occupancy activities, airtightness levels, and the ambient environment.

Although, the experiment and the field measurements were affected by different factors, some consistent findings were observed.

- PMs in the ambient environment contributed to a significant proportion of the inside PM concentration in both classrooms and the sunspace. For an empty classroom or a sunspace, at least 40% to 70% of the indoor PMs were from the outside environment.
- Field measurements in the occupied period indicated that the occupancy activities disrupted the stable indoor environment of the classrooms. Student activities, such as walking, running, and cleaning the blackboard, increased the resuspension of PM. A similar situation was also observed in the experimental study. When air was supplied at 8 m/s, the indoor PM concentration rapidly increased to the same level as the outdoor PM concentration. Therefore, for an enclosed space, keeping a stable indoor environment is essential for maintaining low inside PM concentrations.

- Both the results based on the field measurements and the experimental study indicates that spaces with low airtightness levels tend to have more PMs that originate from the outside environment.

Moreover, the results of the field measurements provided design implications for the construction of the sunspace.

- Glass should be used to replace the materials of the sunspace (polyethlene and tape) to achieve a high airtightness level.
- During the actual use of the sunspace, the airtightness level should be tested to predict the potential indoor PM trends.

Overall, by comparing the results of the field measurements and the experimental study, it can be concluded that the airtightness level is one of the most important factors that influences the indoor PM performance of the sunspace. Assuming the airtightness level of the sunspace is the same as that in School E (airtightness level is 6), the indoor PM concentration can be reduced by 30% based on the results of the experimental study in Chapter 8.

12.5. The relationship between the CFD simulation results and the DTM simulation results

Both the DTM analyses and CFD simulations evaluated the indoor environment of the case study building. The DTM analyses considered the surrounding environment and provided bulk values of indoor air properties over a calendar year, and the CFD simulations predicted the airflow patterns, velocity, and temperature distribution at numerous locations throughout the classrooms based on specific circumstances.

In this study, the DTM analyses and CFD simulations were both used to assess the ILEV system's ventilation performance. The simulation results indicated that the ILEV system significantly improved the indoor thermal comfort level in classrooms. A consistent trend was observed based on both simulation techniques. For example, in winter, the inside air temperature was predicted to be approximately 19°C based on both types of simulations. Moreover, in March and November, the DTM analyses yielded PMV values similar to those for the CFD simulations in spring and autumn.

However, slight differences between these simulation results can be observed. For example, in summer, the DTM results reflected a slightly warm indoor thermal environment (PMV values ranged from +1 to -1), and the CFD simulations indicated that an acceptable level of thermal comfort was attained in the indoor environment (PMV values ranged from +0.5 to -0.5). These differences were largely caused by the different calculation approaches involved and the input parameters used of the DTM and CFD simulations. Moreover, the relationship between these two methods was complementary, rather than contradictory. Designers or engineers could use this relationship to predict the internal air properties under complicated climate conditions and in various surrounding environments.

12.6. The fluidity of the ILEV system

The ILEV system has 4 parts: the EAHEs, sunspace, classrooms and solar chimney. Air flows into the sunspace from the inlet of the buried pipes and further enters the classrooms. The fluidity of the ILEV system is achieved through two mechanisms: fans and buoyancy effects.

Due to the inertia and bends in the buried pipes, fan B, presented in Figure 5.1 (Chapter 5), was installed to supply air from the inlet of the buried pipes. Moreover, the CFD simulations in section 7.5 indicated that air successfully entered the sunspace and then flowed to the vertical airflow channel. In section 7.5, the CFD simulations provided the airflow and pressure distributions inside the sunspace and the vertical airflow channel. The airflow speed slightly decreased to 0.28 m/s inside the sunspace. Then the air continuously flows to the vertical channel at a speed of 0.1 m/s. Although the airflow speed decreased, it was evident that air filled the sunspace and vertical airflow channel based on the simulation results. Thus, air can successfully enter the sunspace and reach the vertical airflow channel.

From the sunspace to the classrooms and the solar chimney, the driving force was buoyancy generated by the temperature differences. The DTM analyses in Chapter 9 indicated that the air temperature difference between the solar chimney and the sunspace was 7°C on average. Additionally, the CFD simulations in section 7.5 showed that the air supplied by the fans at 1.3 m/s had no effects on the buoyancy-based ventilation of the classrooms, as the pressure at the opening of the classrooms was only -0.001 Pa, which is negligible. The CFD simulations based on the average air temperature differences in each season produced the entire airflow distribution throughout the classrooms and the solar chimney. Thus, the air clearly flows from the sunspace to the solar chimney.

However, during the early morning hours of winter, i.e., from 8:00 am to 10:00 am, the air temperature difference between the solar chimney and the sunspace was only 2.6°C on average. Theoretically, a difference of 2.6°C can lead to buoyancy ventilation. However, larger opening areas may be needed to achieve an adequate ventilation rate. Thus, fan C should be used under such conditions.

In summary, the CFD simulations indicated that the ILEV system results in a complete airflow pathway from the sunspace to the solar chimney. The fluidity of the system is theoretically and experimentally validated based on a theoretical study and CFD techniques.

12.7. Energy savings and CO_2 reduction of the ILEV system

The majority of energy consumption in the current primary school buildings in the cold climate zone of China is associated with the heating demand in cold months and also the cooling demand in hot days. Chapter 11 investigated the energy consumption in primary school buildings based on two scenarios: the case study building with heating and cooling provided by the urban central heating system and air conditioners and the case study building with the ILEV system. The simulation results indicated that the case study building equipped with the ILEV system only consumed 2% of the energy currently consumed by the case study building. Moreover, the ILEV system can reduce CO_2 emissions by 1.89 million tons annually in the 5 most air-polluted provinces in the cold climate zone of China.

Table 12.1 summarises the energy consumption of primary schools in China and other countries (derived from a literature review). Compared with the values from other countries, the ILEV system can significantly decrease the primary school building energy consumption, as it accounts for less than 1% of energy consumption per square metre of floor area in primary school buildings in Greece, Luxemburg, Australia, UK, and Sweden.

Table 12.1. Energy consumption in primary school buildings in China and in around the world

Primary schools	Energy consumption (Heating and cooling) ($kWh/m^2 \cdot year$)	References
China	45.5	Chapter 11
Greece	68	Santamouris et al. (1994)
Luxemburg	93k	Thewes et al. (2014)
Australia	>100, <150	Dias Pereira et al. (2014)
UK	>150, <200	
Sweden	>100, < 150	
ILEV system	1.1	Chapter 11

12.8. Comparison of the payback period of the ILEV system and those of other renewable technologies

The incremental costs of the ILEV system are mainly from the construction of the EAHEs, vertical airflow channel, sunspace, and solar chimney and the expansion of the floor plan. The incremental costs were estimated based on the material consumption, and the payback period was quantified using Revit models. For the case study building, the ILEV system reduced energy consumption by over 90% compared with replying on the urban central heating system and air conditioners. In addition, the payback period of the ILEV system was 9.7 years.

Table 12.2 summarises the payback period and lifespan of some renewable technologies and the ILEV system.

Table 12.2. Payback period and lifespan of renewable technologies and the ILEV system

Technologies	The average payback (years)	The average lifespan (years)	Sources
Wind turbine	6	23	Carbon Trust (2018); GREBE Project (2018)
Anaerobic digestion (AD)	10	20	
Solar thermal	10	25	
Solar photovoltaics (PV)	8	25	
Ground source heat pump (GSHP)	6	20	
The ILEV system	9.7	50	

The lifespan of the main structure (excluded, buried pipes, fans and humidifiers)[3] of the ILEV system is estimated to equal that of the primary school building (50 years). Other renewable technologies typically have a lifespan of approximately 20 years. Additionally, the payback period for the ILEV system is 9.7 years (presented in Chapter 11), and for other technologies, the payback period ranges from 6 to 10 years.

[3] Buried pipes, fans and humidifiers normally have a lifespan less than 50 years. However, the costs of these equipment only occupy 3.4% of the total costs of the ILEV system.

Figure 12.18 illustrates the ratio of the payback period to the lifespan (P/L ratios) for these technologies and the ILEV system. The AD and solar thermal have relatively high P/L ratios, and it will take almost 40% to 50% of the lifetime of these technologies to recoup the initial cost. For PV and GHSP, the P/L ratios are 0.32 and 0.30, respectively. The wind turbine has a relatively low P/L ratio of 0.26. The ILEV system has the samllest P/L ratio due to its longer lifespan than other renewable technologies.

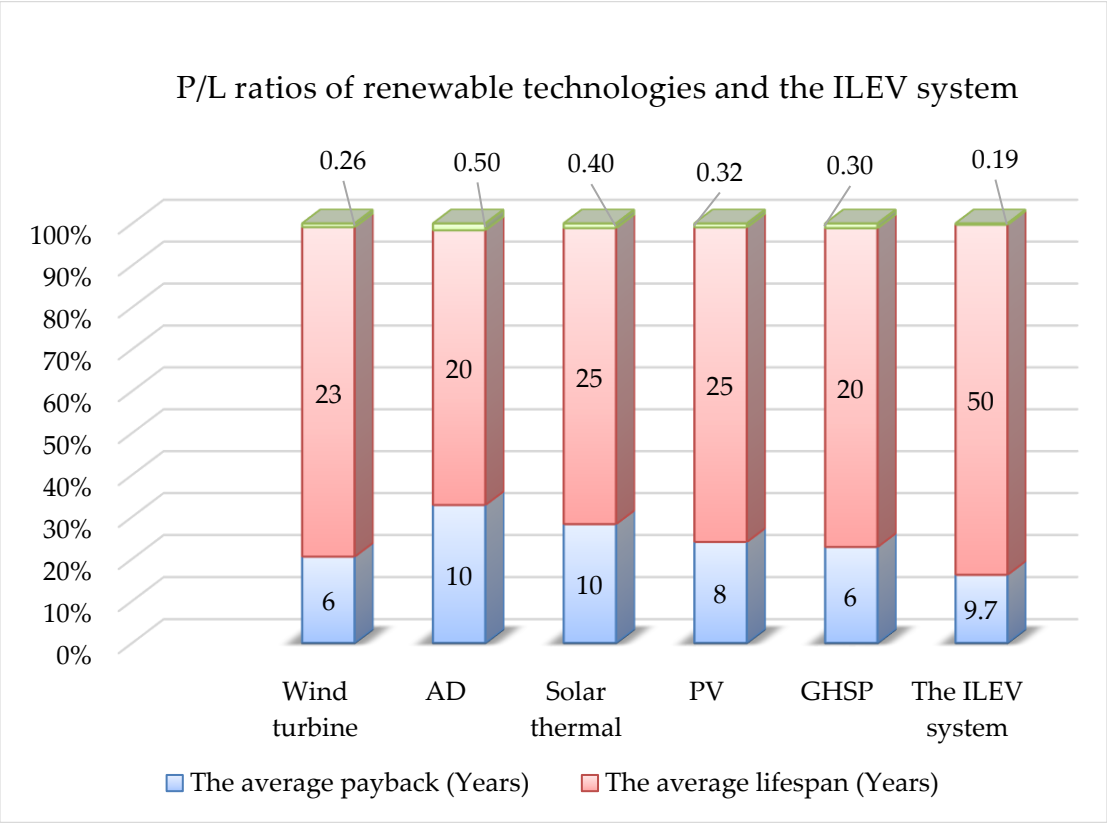


Figure 12.18. *The P/L ratios of renewable technologies and the ILEV system*

Thus, although the ILEV system has a similar payback period as the wind turbine and GHSP, the ILEV system only requires 19% of its lifespan to recoup the initial cost and provides economic benefits over 40 years.

Taking the GHSP as an example, the initial cost for a small commercial-scale installation is usually between 430,000 and 503,000 RMB (Carbon Trust, 2018). For a lifespan of 50 years, the total initial cost would be between 860,000 RMB

and1,006,000 RMB, which is higher than the initial cost of the maintain structure of the ILEV system (823,107 RMB). Therefore, from an economic perspective, the ILEV system has a higher economic efficiency.

Additionally, all the renewable technologies listed in Table 12.8.1 cannot clean indoor air in a passive way. Therefore, the ILEV system has more advantages than traditional renewable technologies in terms of energy use reductions and improving the IAQ.

12.9. The functionality and applicability of the ILEV system

The functionality of the ILEV system was achieved by achieving the functions of each component of the ILEV system. The ILEV system consists of four main components: the EAHEs, a sunspace with plants, classrooms (natural ventilation) and a solar chimney. Each component has its own inherent functions.

For example, the EAHEs were used not only to preheat or precool the supplied air, but also to maintain a suitable indoor environment for plant survival and growth inside the sunspace. This function has been validated by DTM analysis in Chapter 9. The DTM simulations of the sunspace showed that the EAHEs successfully provided a thermally comfortable environment for plant growth and survival and that the average air temperature in the sunspace ranged between 10°C and 30°C throughout the calendar year. Additionally, the DTM results of classrooms have shown that the air temperature inside classrooms was maintained between 15°C and 27°C on average. In summer, the indoor air temperature ranged from approximately 26°C to 27°C. In winter, the indoor air temperature was between 15°C and 20°C during most school hours. In spring and autumn, the indoor air temperature was maintained between these ranges. During the most occupied hours, the indoor air temperature met the requirements of the Chinese standard (CIAQS-2012). The PMV values and PPD values indicated a consistent performance with the indoor air temperature. Undoubtedly, the ILEV system successfully achieves a comfortable indoor thermal environment in primary school classrooms located in the cold climate zone of China.

The sunspace with plants acts as a passive air cleaner. This function was validated by an experimental study presented in Chapter 8. The results indicated that plants can reduce the inside PM concentrations because they increase the surface area of the greenhouse. Moreover, a relatively slow air supply speed (0.9 m/s and 1.3 m/s)

is beneficial for creating a stable indoor environment and increasing the efficiency of plants to reduce PM concentrations.

The solar chimney was mainly used to enhance the ventilation rate of classrooms. This function was validated based on the DTM results in section 9.7, Chapter 9. The results showed that a solar chimney with a high solar shading coefficient (0.75) can significantly strengthen the buoyancy effects. Air temperature differences between the solar chimney and sunspace ranged from 3.71°C to 10°C on average. As a result, air could successfully flow into the classrooms and the solar chimney from the sunspace.

In summary, the functionality of the ILEV system was influenced significantly by each component, and the function of the ILEV system can only be achieved when the functions of each component are fully realized.

To ensure that the ILEV system has a high level of applicability, the functions of each component can be fully realized by complying with the following suggestions.

- EAHEs

EAHEs are used to preheat or precool supplied air. Therefore, the soil must have an undisturbed temperature that is suitable for the plants to grow in and survive. In this research, the undisturbed soil temperature in the cold climate zone of China was identified as 15.7°C based on literature review results. This temperature is within the range that is required for the plants' living activities. Additionally, many studies have validated that EAHEs are effective in the cold climate zone of China. Therefore, this study selected EAHEs as preheating and precooling sources. In other climate zones, such as the temperate zone in South China, the undisturbed soil temperature may not be suitable for the plants' living activities. Moreover, EAHEs might not be as efficient as in the cold climate zone. Thus, other preheating and precooling techniques should be considered.

Another important issue that should be considered is the site space for the application of EAHEs. For example, in this study, seven pipes were used to supply air at a relatively low speed to the sunspace to maintain a stable inside environment. Moreover, the pipes were separately placed 1 metre apart to reduce co-effects. As a result, this required a large site space to install the EAHEs. Figure 12.19 indicates that EAHEs in this research occupied approximately 1964 m2 ground areas of the site. Normally, primary schools located in urban or rural regions of China have a large site space because standards in China require them to install at least a standard 200-metre playground for students to perform activities. Additionally, one standard 200-meter playground normally has a site area of approximately 5000 m2. Thus, pipes can be buried below the surface of the playground.

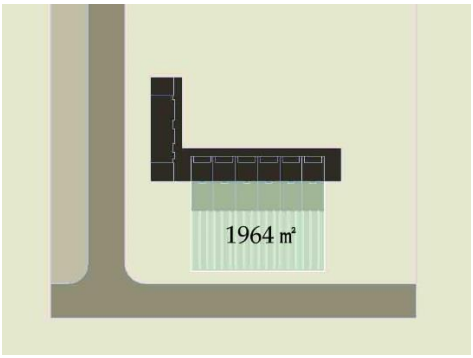


Figure 12.19. *Site areas occupied by the EAHEs*

Even if the site has limited space, several methods are also available to reduce the required site space. For example, pipes can be wrapped with insulating materials to reduce the distance between each other. Thus, more pipes can be installed for one sunspace, and the length of the pipes can be reduced because the air can be supplied at a slower speed. As a result, the site space needed for the EAHEs will decrease. Another method is to increase the diameter of the pipes. Thus, the inner heat exchange surface areas will become larger. As a result, the length of the buried pipes and the site space needed for the EAHEs can be reduced.

- Plants

Plants should have a high level of cleaning efficiency in terms of pollutant removal. More plants or different types of plants could be introduced into the sunspace to remove air pollutants. Additionally, plants should be locally available to reduce the cost of cultivation and regular maintenance.

- Solar chimney

Triple glazing should be used to minimize the conductivity heat loss of the solar chimney and maintain a high ventilation rate in winter. Moreover, the inner surfaces of the solar chimney can be painted black to increase the absorption efficiency.

- Airtightness level of primary school building and the sunspace

Currently, many primary school buildings have a low level of airtightness due to various reasons, such as low construction quality and lack of regular maintenance. However, airtightness levels have a significant impact on the transportation of pollutants from ambient environment to the inside environment. Thus, cracks and gaps in building fabrics should be sealed. Additionally, the related building airtightness requirements should also be improved in China.

In practice, the airtightness of a sunspace could also be significantly improved if glass were used to replace the polyethylene films, and the reductions in PM levels inside the sunspace could differ accordingly.

On the other hand, improved airtightness may cause an increase in CO_2 concentration in an enclosed classroom. Thus, the ILEV system should provide a constant ventilation rate for timely removal of CO_2 during school hours.

12.10. The operation of the complete ILEV system

The ILEV system proposed in this study includes four components: the EAHEs, sunspace with plants, classrooms (natural ventilation) and solar chimney.

EAHEs have been widely used around the world because they have relatively low operating expenses and a high energy conservation efficiency. The advantages of the EAHEs designed in the ILEV system are fully utilised to provide preheated or precooled air for the sunspace. Moreover, the EAHEs provide the foundation for the design of the ILEV system.

The sunspace with plants acts as an air regulator for the classrooms. In this space, the air is cleaned, reheated and stored. The sunspace refreshes the ambient environment in the classrooms. Plants act passive air cleaners and have been widely studied globally in similar contexts. The sunspace with plants in the ILEV system has the same features as those investigated in lab studies, as reviewed in section 4.2, Chapter 4. The sunspace creates a stable indoor environment for the plants and provides a large space for placing as many plants as possible. This approach overcomes the major limitation of field studies: "randomly installing a plant or two in a large space makes no difference regarding air quality." The experimental study in Chapter 8 verified that plants can significantly reduce the inside PM concentration.

The air temperature difference between the solar chimney and the sunspace result in the natural ventilation of the classrooms. The DTM analyses provided results regarding the air temperature performance of the sunspace and the solar chimney over a calendar year. The results indicated the existence of air temperature differences between the sunspace and the solar chimney. Moreover, the CFD simulation results further illustrated the entire airflow path throughout the classrooms and solar chimney, which was induced by buoyancy effects.

The DTM results and CFD simulation results indicated that a thermally comfortable indoor environment was created in the classrooms during most school hours throughout the year. Moreover, the IAQ improved after the ILEV system was installed, and the internal CO_2 concentrations were below 1000 ppm. The estimated indoor PM concentrations met the Chinese standard.

The ILEV system also creates significant economic and environmental benefits for society. For example, for the studied primary school building in the cold climate zone of China, the ILEV system only consumed 2% of the energy currently consumed by the current primary school buildings. Moreover, taking the top-five air-polluted provinces in China as an example, the ILEV system can reduce CO_2 emissions by 1.89 million tons.

In summary, the ILEV system proposed in this research is an integrated ventilation system that combines several passive techniques to create a thermally comfortable indoor environment and good IAQ. This system overcomes the drawbacks of traditional natural ventilation systems and improves the performance of the indoor environment under complicated weather conditions. The performance of this system was validated in a step-by-step method from the EAHEs to the sunspace, the classrooms and the solar chimney. The system also has the potential to further increase the indoor thermal performance of the building if a solar shading system is added and the IAQ by increasing the cleaning efficiency of the sunspace.

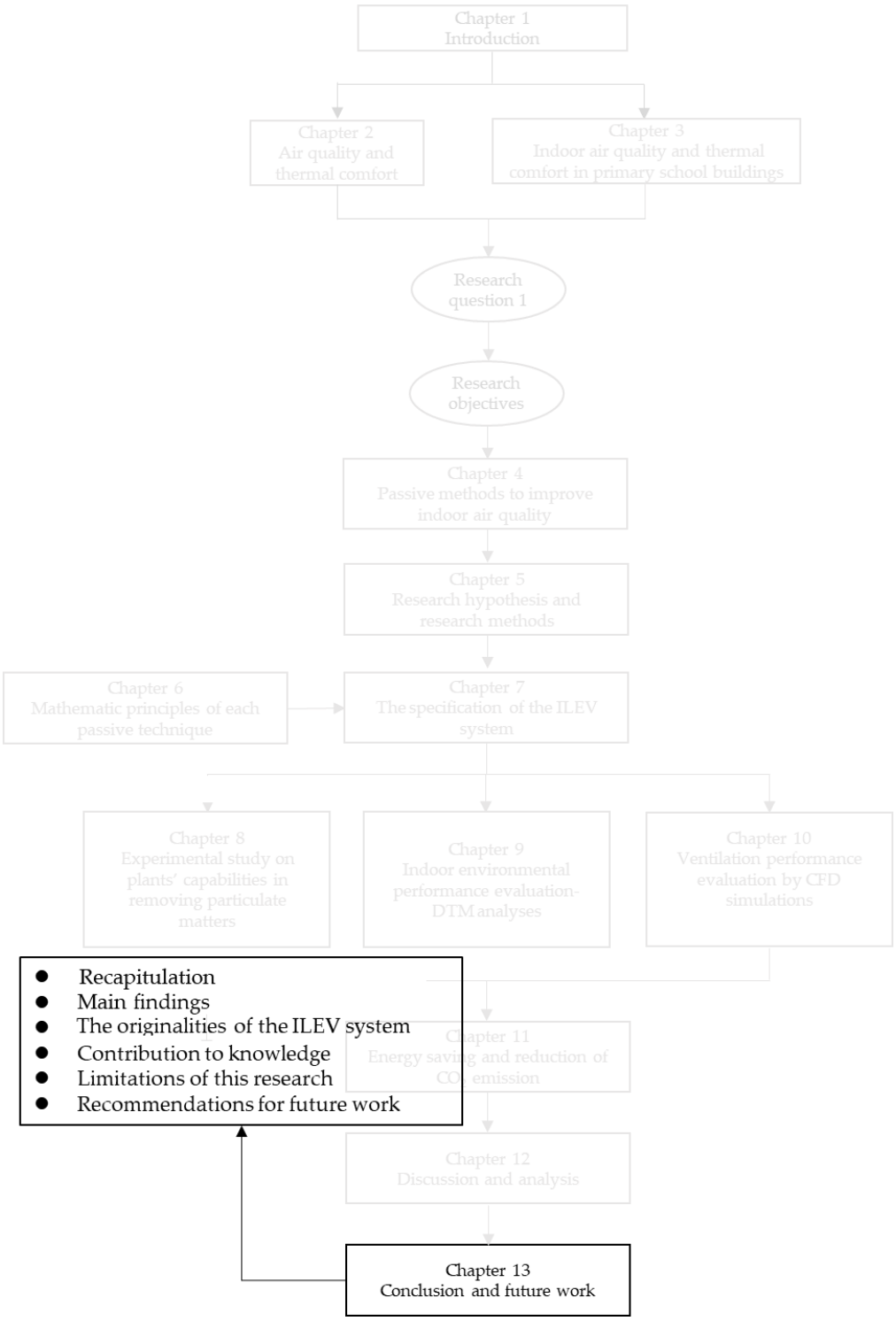
12.11. Summary

In this chapter, an overall analysis of the designed ILEV system was provided. The analysis results made contributions to the design of new buildings or renovation projects. Engineers and designers could utilise the characteristics of the ILEV system to achieve thermally comfortable indoor environments and deliver acceptable IAQ based on the climate features of the cold climate zone of China.

Overall, an ILEV system was proposed to achieve a thermal comfortable indoor environment and provide a new way of cleaning the air in primary school buildings located in the cold climate zone of China. The critical characteristics of this new ventilation system have been summarised, and combined with the analysis results, could be used in the design of similar buildings or renovation projects.

Conclusions of this research presented in Chapters 8, 9 10 and 11 will be summarised in the following chapter.

Chapter 13: CONCLUSIONS AND FUTURE WORK



The content of Chapter 13

13.1. Recapitulation

The goal of this research was to investigate the IAQ and thermal comfort in primary school buildings in the cold climate zone of China and determine the capability of a designed ILEV system to improve the IAQ and thermal comfort and reduce building energy consumption. Four research questions were posed to meet this goal. The first focused on what the air quality in China is currently. In Chapters 2 and 3, ambient air quality in China and the indoor air pollution in primary school buildings were reviewed. In these chapters, it was concluded that severe air pollution and thermal discomfort issues exist in classrooms. In addition, current measures (e.g., air purifiers) are not effective in mitigating the issues. The chapters concluded with suggestions for a new integrated system to address these issues, and one research question stemmed from each of these chapters. These questions established the structural basis for the newly proposed system.

Research question 2 raised in Chapters 2 and 3 was "can low-energy technologies be combined to develop an ILEV system?" The proposed system demonstrated that several techniques can be effectively combined into a single system. The foundation of this system was not based on the characteristics of each low-energy technology, but on the integration of these characteristics. Chapter 4 reviewed the low-energy technologies and analysed their characteristics and advantages in detail. The conclusions of Chapter 4 was used to develop a new framework for the proposed system. In the proposed system, each technology has a unique objective that contributes to maximising the overall goals of solving air pollution issues and creating a comfortable indoor environment. For example, EAHEs were used to supply air to the sunspace rather than the classrooms. Plants were treated as a part of the ventilation system rather than randomly placed inside the classrooms. These concepts gradually shaped the structure of the proposed system, which was finalised in Chapter 5.

Research question 3 was "how efficient is the ILEV system in mitigating indoor air pollution and thermal discomfort problems?" This question was raised in the context of the proposed system, and addressed with various research methods, as described in Chapter 5. The selection of research methods directly determined the steps implemented to answer research question 3. Four steps were identified: the establishment of a coupled mathematical model establishment, experiments involving the ability of plants to clean air, DTM analyses of indoor parameters and CFD simulations of ventilation performance.

The mathematical models of low-energy technologies were reviewed in Chapter 6. The findings of Chapter 6 provided the foundation for the establishment of the coupled mathematical model of the ILEV system. For the studied primary school building, Chapter 7 presented the coupled mathematical model of the ILEV system in detail.

The experimental work in Chapter 8 indicated that plants can significantly reduce the indoor PM concentration. Chapter 8 concluded with implications for the future design of the sunspace. For example, the sunspace should have a high airtightness level, and as many plants as possible can be placed in the space to reduce the indoor PM concentration.

The DTM analyses in Chapter 9 explored the thermal comfort of the ILEV system over a calendar year. The analyses include three components: the DTM of the sunspace, the DTM of the classrooms and the DTM of the solar chimney. The operation of the EAHEs plays an important role in determining the air temperatures inside the sunspace. The DTM analyses of the sunspace provided indoor air temperatures at the hourly scale, and the temperatures were used as inputs in the DTM analyses of the classrooms. Then, the DTM results for the classrooms were used in the DTM analyses of the solar chimney. Chapter 9

concluded that the ILEV system successfully achieves a thermally comfortable indoor environment in classrooms.

The CFD simulations in Chapter 10 were conducted according to the outputs of Chapter 9. The parameters of the air inside the sunspace and solar chimney were input as boundary conditions. The results reflected a level of thermal comfort in the indoor environment of classrooms similar to that based on the DTM analyses. In addition, the fluidity of the ILEV system, i.e., the air flows from the sunspace into the classrooms and to the outlet of the solar chimney, was successfully validated.

Research question 4 was "what are the environmental and the economic benefits of the proposed ILEV system?" Chapter 11 explored this research question by estimating the energy consumption, CO_2 emissions and the payback period of the ILEV system. The ILEV system was verified to be practical from an economic perspective.

The conclusions of this research were based on the results and findings of Chapters 8, 9, 10 and 11. However, those conclusions only represent the results for the case study building. It is important to recognise that modelling the performance of the ILEV system was not the target of this research. The design of the ILEV system was the main goal. The work performed in this research was to determine if the ILEV system was practical and effective. The success of this investigation has implications for the future design of primary school buildings in the cold climate zone of China.

13.2. Main findings

The earlier discussions suggest that the proposed ILEV system is able to improve indoor thermal comfort and IAQ simultaneously in the case study school building. The following points summarise the main findings of this research.

- **Findings identified from the literature review**

A literature review of the IAQ and internal thermal comfort of primary school buildings indicated that indoor air properties and the thermal environment are serious concerns in China since the dominant ventilation system in most primary school buildings involves opening windows and doors. The primary indoor air pollutants are $PM_{2.5}$ and PM_{10}, and the key influential factors are ambient air pollution, internal activities, and building defects. Currently, there are no effective measures for occupants to combat indoor air pollution problems.

Field measurements of the IAQ and thermal comfort obtained in 9 studied primary school buildings in Tai'an city, Shandong Province, indicated that primary school classrooms are characterised by severe levels of indoor air pollution and thermal discomfort issues. The average indoor PM and CO_2 concentrations were over 100 $\mu g/m^3$ and 1000 ppm, respectively. The indoor air temperatures were lower than the minimum values required by the CIAQS-2002. The measurement results were consistent with the findings of the literature review conducted in Chapters 2 and 3.

The findings of the literature review of low-energy technologies in Chapter 4 created the foundation for the ILEV system. Notably, the review suggested that plants have higher cleaning efficiencies in enclosed spaces with stable inside environments compared to being placed randomly inside classrooms. A review of EAHEs indicated that an open-loop system is more effective in cold areas and can avoid the circulation of air contaminants. Double glazing and triple glazing should

be used for solar chimneys to reduce the conductive heat loss. In addition, the review of solar chimneys suggested that the optimum width ot height ratio of roof-mounted vertical solar chimneys is 0.5.

- **Improvement of the IAQ**

The experiment in Chapter 8 demonstrated the capabilities of plants in removing air pollutants. The enclosed sunspace without plants typically displayed PM levels that were 70% of the ambient level. This percentage decreased to 30% after plants were placed inside the sunspace. The airflow speed has an adverse effect on the efficiency of plants in removing PM. For example, the I/O ratio of the PM concentration reached 1 when the airflow speed was 8 m/s. Additionally, the sunspace displayed I/O ratios between 0.46 and 0.55 when the airflow speed was between 0.5 m/s and 1.2 m/s; therefore, a relatively slow air supply speed was more ideal for maintaining a stable inside environment and reducing the internal PM concentration. By using the sunspace, the estimated average indoor PM concentrations in the case study building were 48% and 64% of the current $PM_{2.5}$ and PM_{10} concentrations based on the field measurements, respectively (section 12.2). In addition, the system could potentially further reduce the indoor PM levels by increasing the airtightness level of the sunspace and introducing more plants.

The DTM analyses in Chapter 9 suggested that the indoor CO_2 concentration for an air supply rate of 10 litres per second per person was consistently approximately 902 ppm. This level meets the requirement of the CIAQS-2002 and the WHO Air Guidelines (1000 ppm, presented in Table 2.1 and Table 2.3, Chapter 2). Compared with the field measurements, the average indoor CO_2 concentration was decreased by approximately 31% (from 1312 ppm to 902 ppm on average). In addition, based on the feasibility of the ILEV system (discussed in section 12.2.1), a higher ventilation rate could further reduce the indoor CO_2 concentration to meet

stricter guideline values from CIBSE Guide A (600 ppm), without affecting the indoor thermal performance of the classrooms.

- **Improvement of indoor thermal comfort**

The ILEV system created a thermally comfortable indoor environment based on the DTM results, presented in section 9.6, Chapter 9. For example, in winter, the air temperatures inside the classrooms could be maintained between 16°C and 20°C in most occupied periods. Only the first occupied hour displayed an internal air temperature above 15°C, which is still close to the minimum guideline value of the CIAQS-2002 (16°C). In summer, the internal air temperature was approximately 26°C on average. This level met requirements of the CIAQS-2002 (28°C). Additionally, in spring and autumn, the internal thermal performance was maintained between the levels in summer and winter.

Chapter 10 investigated the ventilation performance of the ILEV system in each season using CFD modelling techniques. The CFD simulations yielded ventilation performance results similar to those based on the DTM analyses.

In addition, the thermal performance can be further improved to meet stricter standards, by increasing the solar shading coefficient of the sunspace and using an artificial heating system during the early morning periods when the ambient environment is characterised by low levels of solar radiation.

- **Operation of EAHEs**

The operation of EAHEs largely relies on the local weather conditions. In March, November, and winter months, EAHEs should be in operation throughout the day to ensure that plants survive and grow in both occupied and unoccupied periods. The DTM analyses indicated that the sunspace air temperature can be maintained between 14.44°C and 15.52°C on average.

In May, September and summer months, the EAHEs were in operation only during occupied periods, and the inside air temperature of the sunspace was approximately 18.3°C on average.

In April and October, ambient air directly flowed into the sunspace, and the internal air temperature ranged from 14.56°C to 20.71°C during occupied periods. In unoccupied periods, the inside air temperature was approximately 17°C on average.

In winter months and transition months, i.e., March, April, October, and November, the relative humidity inside the sunspace was relatively low (below or slightly higher than 30%) due to the dry ambient air; therefore, a humidifier was recommended to increase this value to at least 60%. In September and the summer months, the relative humidity at the outlet of the EAHEs was 100%. This number decreased to approximately 80% on average due to the solar heat gains of the sunspace.

- **Operation of the solar chimney**

The DTM simulation results of the solar chimney verified that the solar chimney was more effective in summer months than in winter months since solar radiation is more intense in summer than in winter. Additionally, triple glazing with a high solar shading coefficient (0.75) significantly increased the solar heat gains and further improved the efficiency of the solar chimney. However, in winter months, the increase in the solar shading coefficient from 0.15 to 0.75 made no significant difference regarding the air temperature difference between the solar chimney and the sunspace during the first occupied hour of the teaching day because of the relatively low level of solar heat gains. Therefore, the fan should be used to supply the air from the sunspace to the classrooms since the small air temperature difference reduces the stack ventilation efficiency.

- **Environment impacts and economic benefits**

The primary school building equipped with the ILEV system consumed approximately 2% of the energy currently consumed by the case study primary school building. Over 90% of the CO_2 emissions in the studied primary school building were eliminated by the ILEV system. By implementing the ILEV system in the top-five most polluted areas in China (Beijing, Tianjin, Hebei, Henan and Shandong), coal consumption and CO_2 emissions can be decreased by approximately 768,249 tons and 1,889,047 tons, respectively.

The payback period of the main structure of the ILEV system was 9.7 years on average, ranking in the middle among popular renewable technologies. However, the ILEV system has shortest payback time based on the system lifespan (19% of its lifespan) compared to other renewable technologies (40% to 50% of their lifespan) and provides economic benefits over 40 years. In addition, the ILEV system not only reduces building energy consumption but also improves IAQ, which other renewable technologies cannot achieve.

13.3. The originalities of the ILEV system

The originality of this Ph.D. work included developing a low-energy method to tackle the current issues that exist in primary school buildings located in the cold climate zone of China. These issues, as presented in Figure 13.1, were identified based on the literature reviews and field measurements (Chapter 2 and Chapter 3).

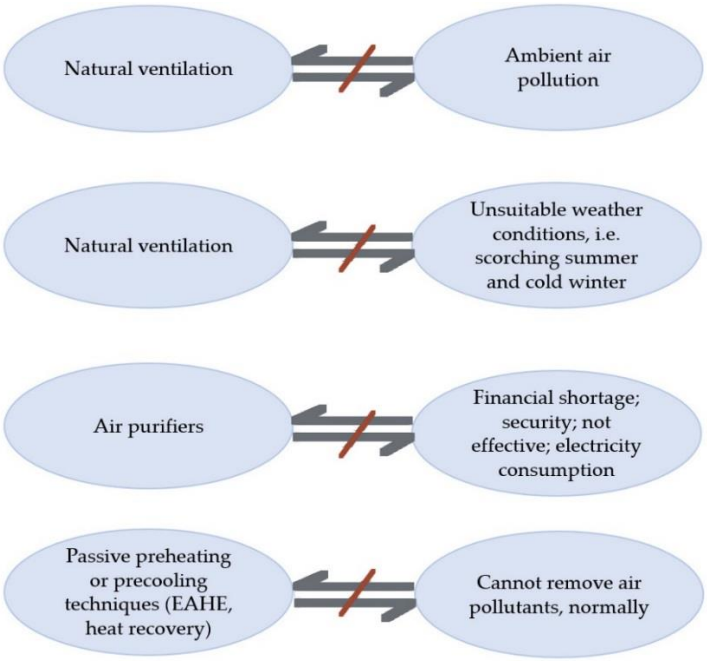


Figure 13.1. *Current issues regarding the thermal indoor environment of primary school buildings*

To tackle these issues, passive techniques, such as EAHEs, a solar chimney, plants, and natural ventilation, were critically reviewed, and an entirely new integrated system was invented, i.e., the ILEV system. The ILEV system is entirely different from other ventilation systems. This system overcomes the limitations of traditional natural ventilation systems and is broadly applicable under various weather conditions. Notably, such system provides clean air without consuming more energy. The following list details the originalities of this study.

- The concept of the sunspace with plants in the ILEV system originated from laboratory studies involving small sealed chambers with many plants. The

literature review in section 4.2 indicated that laboratory studies (chambers with plants) could yield higher air cleaning efficiencies than the field studies. Therefore, the sunspace in this study acts as an enlarged air storage chamber. The designers centrally placed the plants inside the sunspace rather than scattering them randomly inside the classrooms. Therefore, the use of plants eliminated many factors that affect the plant cleaning efficiency, such as wind and occupant activities. Moreover, the sunspace provided a stable indoor environment for plants to remove air pollutants.

- Plants, as an essential biological resource on Earth, have been widely used in building design. For example, plants have been used to cover walls or roofs (living green walls or living green roofs) and minimise heat losses, thereby reducing building energy consumption. Plants are also used in the indoor landscape to improve occupant health. However, this study is the first case in which plants act as a part of the ventilation system.

- EAHEs are indirectly connected to school buildings. In many existing studies, air was directly supplied from the buried pipes of EAHEs. However, in this Ph.D. work, EAHEs are preheaters or precoolers for the sunspace. Combined with the sunspace, air from the buried pipes can be further processed to remove air pollutants and adjust the relative humidity before entering the classrooms. Moreover, fans are used to supply air to the buried pipes at a very slow speed to reduce the effects of wind on the performance of the EAHEs and maximise the plant cleaning efficiency inside the sunspace.

- The ILEV system is the first system in which natural ventilation (buoyancy effects) can overcome the limitations of the outside weather conditions and ambient air pollution levels.

In summary, the most significant original objective of this Ph.D. work was to propose a low-energy solution for buildings, in this case, primary school buildings in the cold climate zone of China that improved the IAQ and simultaneously ensured thermal comfort. The ILEV system has significant implications for future building design. For example, architects and engineers should reconsider the roles of plants in the building environment. Moreover, passive techniques should be combined to overcome the limitations that cannot be overcome with a single technique.

13.4. Contributions to knowledge

This Ph.D. work concentrated on an evaluation of the proposed ILEV system, which combined natural ventilation, EAHEs, a solar chimney and plants to improve the thermal comfort and IAQ in a primary school building located in the cold climate zone of China. By predicting the ventilation and thermal comfort performance, the proposed ILEV system provides valuable guidance for the future construction and renovation of primary school buildings.

The studied primary school is a typical representative of primary school buildings located in the cold climate zone of China. Therefore, the potential exists to implement the ILEV system on a large scale and acquire important energy savings and the reductions of greenhouse gas emission. Therefore, the ILEV system will contribute to reducing the operating costs of school building and, in a broader context, combat global warming. Thus, this research provides a new way of designing and renovating primary school buildings to provide a sustainable development approach for the second largest energy consumer and the CO_2 emitter.

The ILEV system evaluated showed the potential to reduce the heating and cooling loads in the primary school building studied. Moreover, this system was assessed using computational tools with a typical "physical" context regarding the operation and local climate characteristics of the cold climate zone of China. The assessment results provide a representative overview of the performance of the ILEV system, which significantly improves the thermal comfort and IAQ levels relative to those of current primary school buildings.

The analyses of the ILEV system provide new insight into the ventilation practices in primary school buildings in cold climate zone.

13.5. Limitations of this research

This research proposed an integrated ventilation system and evaluated its performance using a typical primary school building located in the cold climatic zone in China. Some assumptions were made to facilitate the simulations and field measurements, e.g. PM absorption efficiency of plants, leaf areas, heat gains, and thermal mass. Though these assumptions were made based on an investigation of earlier studies, it would be more accurate to further explore these parameters in the future. The limitations of this research were listed as follows.

- PM absorption efficiency of the plants

The PM adsorption efficiency of plants is affected by various factors, such as the leaf area, surface texture, hair density, and moisture content. This research did not investigate the effects of these factors on the cleaning performance in the experimental study due to equipment and financial limitations, as discussed in Chapter 8. The value used to identify the optimal number of plants in the sunspace was from similar published studies of plants in China (Section 7.3, Chapter 7). Plants in different surrounding environments may exhibit different absorption efficiencies. Therefore, a more specific value in the context of this research should be determined.

- Photosynthesis of the plants inside the sunspace

This research focused on the cleaning abilities of plants for PMs ($PM_{2.5}$ and PM_{10}). The changes in the concentrations of other air pollutants inside the sunspace were beyond the scope of this research. For example, plants can reduce CO_2 concentrations and increase oxygen levels via photosynthesis. Other air pollutants, such as VOCs, NOx, and SOx, can also be removed from the air by plants. Future work could focus on the potential cleaning performance of plants regarding CO_2 and other air pollutants.

- The number of leaves per plant and the leaf surface area calculation

Due to the lack of professional botany equipment, the number of leaves and the total leaf surface areas per plant were calculated based on manual measurements. A more accurate way method, such as using a professional leaf area metre or scanner, could provide a more accurate result.

- Construction of the sunspace

Due to financial restrictions, the construction materials used for the sunspace in the experiment included a steel framework and polyethylene films. The airtightness level could be significantly improved if glass is used to replace the materials, and the reductions in PM levels inside the sunspace could differ accordingly.

- CFD simulation

In the CFD simulation, simplifications regarding the building fabric, internal heat gains, and solar heat gains were essential due to the computational time required to evaluate the airflow in the studied primary school classrooms. The construction specifications of the building fabric were replaced with a simple "plate", and the obstacles in classrooms, such as desks and chairs, were all excluded from the computational model. These simplifications significantly decreased the quantity of the cells in meshes needed to model detailed airflow around desks, chairs, and students, thereby limiting the computational power required. All CFD simulations used volumetric heat sources to represent the internal heat gains (occupants, computers, and solar heat gains). These sources were centred in each occupied classroom to provide comparable results. The distribution of the heat sources in the classrooms in practice will result in different and non-optimal airflow distributions; however, because occupants behave differently, the heat gains in the classrooms can only be represented with a certain probability.

13.6. Recommendations for future work

The results presented in this thesis provide significant contributions to the knowledgebase regarding indoor air pollution and thermal discomfort in classrooms of primary school buildings and have the potential for applications involving other similar buildings. Several future directions arising from this research have been identified to improve the validity of this research.

First, to improve the cleaning ability of the sunspace, more plants or different types of plants could be introduced into the sunspace to remove air pollutants. Moreover, the number of plants needed should be identified based on a more reliable and scientific approach with the support of a botany specialist.

Second, adding external insulation to the pipes can minimise the distance between the pipes. Therefore, for a site with limited space, more pipes could supply air at a lower speed, which would benefit the stability of the sunspace environment and increase the cleaning efficiency of the plants.

Third, the effects of the back wall of the solar chimney and the vertical airflow channel require more specific analyses in the future. Theoretically, adding more insulation can reduce the conductive heat losses from the solar chimney and the vertical airflow channel.

Finally, to extensively apply the ILEV system in large primary school buildings, future research should focus on in incorporating this ventilation system and other popular design elements. For example, the sunspace could be a part of a green roof or a vertical greening scheme for a façade. This approach can also be combined with the campus agricultural systems.

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APPENDIXES

Appendix I: IAQ Measurement Data- taking School B as an example

Occupied period, outdoor $PM_{2.5}$ concentration

Instrument Name	DustTrak II
Model Number	8530
Serial Number	8530114601
Firmware Version	2.8
Calibration Date	2016/6/20
Test Name	MANUAL 057
Test Start Time	8:45:55
Test Start Date	2016/11/16
Test Length [D:H:M]	0:03:00
Test Interval [M:S]	0:01
Mass Average [mg/m3]	0.018
Mass Minimum [mg/m3]	0.01
Mass Maximum [mg/m3]	0.05
Mass TWA [mg/m3]	0.007
Photometric User Cal	0.38
Flow User Cal	0.38
Errors	
Number of Samples	10800

Elapsed Time [s]	Mass [mg/m3]	Elapsed Time [s]	Mass [mg/m3]	Elapsed Time [s]	Mass [mg/m3]	Elapsed Time [s]	Mass [mg/m3]	Elapsed Time [s]	Mass [mg/m3]
1	0.036	2162	0.042	4319	0.044	6480	0.034	8640	0.028
2	0.036	2163	0.044	4320	0.044	6481	0.034	8641	0.028
3	0.038	2164	0.044	4321	0.044	6482	0.032	8642	0.028
4	0.04	2165	0.04	4322	0.044	6483	0.032	8643	0.026
5	0.038	2166	0.042	4323	0.042	6484	0.034	8644	0.026
6	0.038	2167	0.044	4324	0.044	6485	0.034	8645	0.028
7	0.038	2168	0.044	4325	0.044	6486	0.032	8646	0.026
8	0.036	2169	0.042	4326	0.044	6487	0.032	8647	0.026
9	0.038	2170	0.044	4327	0.042	6488	0.034	8648	0.028
10	0.036	2171	0.044	4328	0.042	6489	0.032	8649	0.028
11	0.036	2172	0.046	4329	0.044	6490	0.03	8650	0.028
12	0.036	2173	0.044	4330	0.046	6491	0.03	8651	0.028
13	0.034	2174	0.044	4331	0.046	6492	0.032	8652	0.028
14	0.036	2175	0.044	4332	0.044	6493	0.032	8653	0.028
15	0.038	2176	0.044	4333	0.044	6494	0.032	8654	0.028
16	0.04	2177	0.044	4334	0.044	6495	0.032	8655	0.03
17	0.036	2178	0.044	4335	0.044	6496	0.032	8656	0.03
18	0.036	2179	0.044	4336	0.044	6497	0.034	8657	0.028
19	0.036	2180	0.044	4337	0.048	6498	0.032	8658	0.028
20	0.036	2181	0.044	4338	0.046	6499	0.032	8659	0.028
21	0.036	2182	0.044	4339	0.044	6500	0.032	8660	0.028
22	0.036	2183	0.042	4340	0.044	6501	0.032	8661	0.026
23	0.036	2184	0.04	4341	0.044	6502	0.032	8662	0.026
24	0.038	2185	0.042	4342	0.044	6503	0.03	8663	0.026
25	0.038	2186	0.044	4343	0.044	6504	0.03	8664	0.028
26	0.036	2187	0.044	4344	0.044	6505	0.03	8665	0.026
27	0.038	2188	0.042	4345	0.044	6506	0.03	8666	0.026
28	0.04	2189	0.044	4346	0.044	6507	0.032	8667	0.028
29	0.04	2190	0.042	4347	0.044	6508	0.032	8668	0.028
30	0.038	2191	0.042	4348	0.042	6509	0.032	8669	0.028
31	0.036	2192	0.044	4349	0.042	6510	0.032	8670	0.028
32	0.036	2193	0.042	4350	0.044	6511	0.034	8671	0.026
33	0.036	2194	0.044	4351	0.048	6512	0.034	8672	0.026
34	0.036	2195	0.046	4352	0.048	6513	0.03	8673	0.028
35	0.036	2196	0.046	4353	0.046	6514	0.03	8674	0.028
36	0.036	2197	0.046	4354	0.048	6515	0.032	8675	0.028
37	0.036	2198	0.046	4355	0.046	6516	0.032	8676	0.028
38	0.036	2199	0.046	4356	0.046	6517	0.032	8677	0.026
39	0.036	2200	0.048	4357	0.048	6518	0.034	8678	0.028
40	0.036	2201	0.048	4358	0.048	6519	0.034	8679	0.028
41	0.034	2202	0.048	4359	0.046	6520	0.034	8680	0.028
42	0.036	2203	0.048	4360	0.046	6521	0.032	8681	0.028
43	0.038	2204	0.048	4361	0.048	6522	0.032	8682	0.028
44	0.036	2205	0.048	4362	0.048	6523	0.032	8683	0.028
45	0.034	2206	0.048	4363	0.048	6524	0.032	8684	0.028
46	0.034	2207	0.048	4364	0.048	6525	0.032	8685	0.028
47	0.036	2208	0.048	4365	0.048	6526	0.032	8686	0.026
48	0.036	2209	0.048	4366	0.048	6527	0.032	8687	0.028
49	0.036	2210	0.046	4367	0.046	6528	0.03	8688	0.028
50	0.036	2211	0.048	4368	0.048	6529	0.03	8689	0.028
51	0.036	2212	0.048	4369	0.05	6530	0.03	8690	0.028
52	0.036	2213	0.048	4370	0.05	6531	0.032	8691	0.028
53	0.036	2214	0.048	4371	0.048	6532	0.034	8692	0.028
54	0.036	2215	0.05	4372	0.048	6533	0.034	8693	0.028
55	0.038	2216	0.048	4373	0.05	6534	0.032	8694	0.028
56	0.038	2217	0.046	4374	0.048	6535	0.032	8695	0.028
57	0.036	2218	0.046	4375	0.048	6536	0.03	8696	0.028
58	0.04	2219	0.046	4376	0.05	6537	0.03	8697	0.03
59	0.04	2220	0.046	4377	0.048	6538	0.032	8698	0.03
60	0.038	2221	0.044	4378	0.05	6539	0.032	8699	0.03
61	0.038	2222	0.044	4379	0.05	6540	0.032	8700	0.028
62	0.036	2223	0.044	4380	0.048	6541	0.032	8701	0.028
63	0.036	2224	0.044	4381	0.05	6542	0.03	8702	0.028
64	0.036	2225	0.044	4382	0.05	6543	0.03	8703	0.03
65	0.038	2226	0.044	4383	0.052	6544	0.032	8704	0.032
66	0.038	2227	0.048	4384	0.054	6545	0.032	8705	0.034
67	0.036	2228	0.048	4385	0.054	6546	0.03	8706	0.048
68	0.036	2229	0.044	4386	0.052	6547	0.03	8707	0.052
69	0.036	2230	0.042	4387	0.054	6548	0.03	8708	0.042
70	0.036	2231	0.044	4388	0.054	6549	0.032	8709	0.038
71	0.036	2232	0.046	4389	0.052	6550	0.032	8710	0.038
72	0.036	2233	0.044	4390	0.054	6551	0.03	8711	0.034

1282	0.034	3443	0.05	5600	0.036	7761	0.028	9921	0.028
1283	0.034	3444	0.052	5601	0.034	7762	0.028	9922	0.026
1284	0.036	3445	0.054	5602	0.036	7763	0.03	9923	0.028
1285	0.032	3446	0.054	5603	0.036	7764	0.028	9924	0.026
1286	0.032	3447	0.054	5604	0.034	7765	0.028	9925	0.028
1287	0.032	3448	0.052	5605	0.034	7766	0.03	9926	0.026
1288	0.032	3449	0.05	5606	0.036	7767	0.028	9927	0.026
1289	0.032	3450	0.05	5607	0.036	7768	0.028	9928	0.026
1290	0.032	3451	0.05	5608	0.036	7769	0.028	9929	0.026
1291	0.032	3452	0.05	5609	0.036	7770	0.026	9930	0.026
1292	0.032	3453	0.05	5610	0.036	7771	0.026	9931	0.026
1293	0.032	3454	0.048	5611	0.034	7772	0.028	9932	0.028
1294	0.032	3455	0.05	5612	0.036	7773	0.028	9933	0.028
1295	0.032	3456	0.052	5613	0.036	7774	0.028	9934	0.026
1296	0.032	3457	0.05	5614	0.036	7775	0.026	9935	0.026
1297	0.034	3458	0.048	5615	0.036	7776	0.026	9936	0.026
1298	0.032	3459	0.048	5616	0.036	7777	0.026	9937	0.026
1299	0.032	3460	0.052	5617	0.036	7778	0.026	9938	0.026
1300	0.032	3461	0.05	5618	0.036	7779	0.026	9939	0.028
1301	0.032	3462	0.05	5619	0.036	7780	0.026	9940	0.026
1302	0.032	3463	0.05	5620	0.038	7781	0.026	9941	0.026
1303	0.032	3464	0.052	5621	0.04	7782	0.026	9942	0.026
1304	0.032	3465	0.048	5622	0.034	7783	0.026	9943	0.026
1305	0.032	3466	0.05	5623	0.036	7784	0.026	9944	0.024
1306	0.034	3467	0.052	5624	0.038	7785	0.026	9945	0.028
1307	0.034	3468	0.05	5625	0.038	7786	0.026	9946	0.028
1308	0.034	3469	0.05	5626	0.034	7787	0.028	9947	0.026
1309	0.032	3470	0.052	5627	0.034	7788	0.028	9948	0.026
1310	0.034	3471	0.052	5628	0.034	7789	0.026	9949	0.026
1311	0.034	3472	0.052	5629	0.034	7790	0.026	9950	0.028
1312	0.032	3473	0.052	5630	0.036	7791	0.026	9951	0.03
1313	0.034	3474	0.052	5631	0.034	7792	0.026	9952	0.03
1314	0.034	3475	0.052	5632	0.036	7793	0.026	9953	0.028
1315	0.034	3476	0.05	5633	0.036	7794	0.024	9954	0.028
1316	0.034	3477	0.048	5634	0.036	7795	0.026	9955	0.026
1317	0.034	3478	0.05	5635	0.036	7796	0.026	9956	0.026
1318	0.032	3479	0.052	5636	0.036	7797	0.026	9957	0.028
1319	0.032	3480	0.05	5637	0.036	7798	0.026	9958	0.026
1320	0.032	3481	0.052	5638	0.036	7799	0.026	9959	0.026
1321	0.034	3482	0.052	5639	0.038	7800	0.026	9960	0.028
1322	0.034	3483	0.05	5640	0.038	7801	0.026	9961	0.028
1323	0.034	3484	0.048	5641	0.036	7802	0.026	9962	0.028
1324	0.032	3485	0.05	5642	0.036	7803	0.026	9963	0.028
1325	0.032	3486	0.05	5643	0.034	7804	0.028	9964	0.026
1326	0.032	3487	0.05	5644	0.034	7805	0.026	9965	0.026
1327	0.032	3488	0.05	5645	0.036	7806	0.026	9966	0.026
1328	0.032	3489	0.05	5646	0.036	7807	0.026	9967	0.026
1329	0.034	3490	0.05	5647	0.036	7808	0.026	9968	0.026
1330	0.036	3491	0.05	5648	0.036	7809	0.026	9969	0.026
1331	0.034	3492	0.05	5649	0.038	7810	0.026	9970	0.026
1332	0.034	3493	0.052	5650	0.036	7811	0.026	9971	0.026
1333	0.032	3494	0.05	5651	0.034	7812	0.024	9972	0.026
1334	0.032	3495	0.048	5652	0.034	7813	0.024	9973	0.026
1335	0.032	3496	0.05	5653	0.034	7814	0.024	9974	0.026
1336	0.034	3497	0.05	5654	0.034	7815	0.024	9975	0.026
1337	0.034	3498	0.05	5655	0.034	7816	0.024	9976	0.026
1338	0.036	3499	0.05	5656	0.036	7817	0.026	9977	0.028
1339	0.036	3500	0.052	5657	0.034	7818	0.024	9978	0.028
1340	0.036	3501	0.052	5658	0.034	7819	0.024	9979	0.028
1341	0.034	3502	0.048	5659	0.036	7820	0.022	9980	0.028
1342	0.032	3503	0.05	5660	0.036	7821	0.022	9981	0.026
1343	0.034	3504	0.048	5661	0.034	7822	0.022	9982	0.026
1344	0.036	3505	0.048	5662	0.034	7823	0.02	9983	0.028
1345	0.034	3506	0.05	5663	0.034	7824	0.022	9984	0.026
1346	0.034	3507	0.05	5664	0.034	7825	0.022	9985	0.026
1347	0.034	3508	0.052	5665	0.032	7826	0.024	9986	0.026
1348	0.034	3509	0.052	5666	0.034	7827	0.024	9987	0.026
1349	0.036	3510	0.048	5667	0.034	7828	0.022	9988	0.026
1350	0.034	3511	0.048	5668	0.036	7829	0.022	9989	0.026
1351	0.036	3512	0.048	5669	0.036	7830	0.024	9990	0.026
1352	0.036	3513	0.048	5670	0.034	7831	0.024	9991	0.026
1353	0.034	3514	0.048	5671	0.036	7832	0.024	9992	0.026
1354	0.032	3515	0.048	5672	0.034	7833	0.022	9993	0.028
1355	0.032	3516	0.048	5673	0.034	7834	0.024	9994	0.026
1356	0.032	3517	0.046	5674	0.034	7835	0.022	9995	0.026
1357	0.032	3518	0.044	5675	0.032	7836	0.022	9996	0.026
1358	0.032	3519	0.044	5676	0.032	7837	0.024	9997	0.026
1359	0.034	3520	0.046	5677	0.034	7838	0.024	9998	0.026
1360	0.036	3521	0.046	5678	0.036	7839	0.022	9999	0.028
1361	0.038	3522	0.044	5679	0.034	7840	0.024	10000	0.028
1362	0.036	3523	0.046	5680	0.034	7841	0.022	10001	0.028
1363	0.034	3524	0.046	5681	0.034	7842	0.022	10002	0.028
1364	0.034	3525	0.046	5682	0.034	7843	0.024	10003	0.026
1365	0.034	3526	0.046	5683	0.034	7844	0.024	10004	0.026
1366	0.034	3527	0.044	5684	0.032	7845	0.026	10005	0.026
1367	0.034	3528	0.046	5685	0.032	7846	0.024	10006	0.026
1368	0.034	3529	0.046	5686	0.034	7847	0.022	10007	0.028
1369	0.034	3530	0.044	5687	0.036	7848	0.024	10008	0.028
1370	0.034	3531	0.044	5688	0.036	7849	0.022	10009	0.026
1371	0.034	3532	0.044	5689	0.036	7850	0.022	10010	0.026
1372	0.036	3533	0.046	5690	0.032	7851	0.022	10011	0.026
1373	0.036	3534	0.046	5691	0.034	7852	0.022	10012	0.026
1374	0.034	3535	0.044	5692	0.034	7853	0.022	10013	0.028

1375	0.034	3536	0.046	5693	0.034	7854	0.024	10014	0.028
1376	0.034	3537	0.046	5694	0.034	7855	0.024	10015	0.026
1377	0.034	3538	0.046	5695	0.034	7856	0.022	10016	0.026
1378	0.036	3539	0.044	5696	0.034	7857	0.022	10017	0.026
1379	0.036	3540	0.044	5697	0.034	7858	0.024	10018	0.026
1380	0.036	3541	0.044	5698	0.034	7859	0.024	10019	0.026
1381	0.034	3542	0.044	5699	0.034	7860	0.022	10020	0.028
1382	0.034	3543	0.044	5700	0.034	7861	0.022	10021	0.028
1383	0.034	3544	0.046	5701	0.032	7862	0.022	10022	0.028
1384	0.032	3545	0.044	5702	0.032	7863	0.022	10023	0.026
1385	0.032	3546	0.042	5703	0.034	7864	0.024	10024	0.026
1386	0.034	3547	0.042	5704	0.034	7865	0.024	10025	0.028
1387	0.036	3548	0.046	5705	0.034	7866	0.024	10026	0.028
1388	0.034	3549	0.046	5706	0.032	7867	0.024	10027	0.026
1389	0.034	3550	0.042	5707	0.034	7868	0.024	10028	0.026
1390	0.036	3551	0.042	5708	0.032	7869	0.024	10029	0.026
1391	0.036	3552	0.044	5709	0.032	7870	0.024	10030	0.028
1392	0.036	3553	0.042	5710	0.032	7871	0.024	10031	0.028
1393	0.036	3554	0.044	5711	0.032	7872	0.024	10032	0.026
1394	0.034	3555	0.044	5712	0.032	7873	0.022	10033	0.026
1395	0.034	3556	0.044	5713	0.034	7874	0.022	10034	0.028
1396	0.034	3557	0.044	5714	0.036	7875	0.024	10035	0.028
1397	0.034	3558	0.044	5715	0.034	7876	0.024	10036	0.026
1398	0.034	3559	0.044	5716	0.034	7877	0.024	10037	0.026
1399	0.034	3560	0.044	5717	0.034	7878	0.024	10038	0.026
1400	0.036	3561	0.044	5718	0.034	7879	0.024	10039	0.026
1401	0.034	3562	0.044	5719	0.036	7880	0.022	10040	0.026
1402	0.034	3563	0.044	5720	0.036	7881	0.024	10041	0.026
1403	0.036	3564	0.046	5721	0.038	7882	0.024	10042	0.026
1404	0.036	3565	0.044	5722	0.04	7883	0.024	10043	0.026
1405	0.034	3566	0.042	5723	0.04	7884	0.022	10044	0.028
1406	0.036	3567	0.042	5724	0.04	7885	0.024	10045	0.026
1407	0.036	3568	0.044	5725	0.042	7886	0.024	10046	0.028
1408	0.036	3569	0.042	5726	0.042	7887	0.024	10047	0.028
1409	0.036	3570	0.042	5727	0.038	7888	0.024	10048	0.028
1410	0.036	3571	0.042	5728	0.036	7889	0.022	10049	0.026
1411	0.036	3572	0.042	5729	0.04	7890	0.024	10050	0.028
1412	0.034	3573	0.04	5730	0.038	7891	0.022	10051	0.026
1413	0.034	3574	0.042	5731	0.036	7892	0.024	10052	0.026
1414	0.036	3575	0.042	5732	0.036	7893	0.024	10053	0.028
1415	0.036	3576	0.04	5733	0.036	7894	0.024	10054	0.026
1416	0.034	3577	0.042	5734	0.034	7895	0.022	10055	0.026
1417	0.034	3578	0.044	5735	0.036	7896	0.022	10056	0.026
1418	0.034	3579	0.044	5736	0.034	7897	0.022	10057	0.028
1419	0.034	3580	0.042	5737	0.036	7898	0.024	10058	0.026
1420	0.034	3581	0.042	5738	0.036	7899	0.022	10059	0.028
1421	0.034	3582	0.042	5739	0.036	7900	0.024	10060	0.028
1422	0.036	3583	0.044	5740	0.036	7901	0.024	10061	0.026
1423	0.038	3584	0.044	5741	0.036	7902	0.024	10062	0.026
1424	0.034	3585	0.044	5742	0.036	7903	0.024	10063	0.026
1425	0.034	3586	0.044	5743	0.036	7904	0.024	10064	0.026
1426	0.034	3587	0.044	5744	0.034	7905	0.028	10065	0.028
1427	0.034	3588	0.042	5745	0.034	7906	0.03	10066	0.028
1428	0.034	3589	0.04	5746	0.036	7907	0.032	10067	0.026
1429	0.034	3590	0.04	5747	0.036	7908	0.034	10068	0.026
1430	0.034	3591	0.042	5748	0.036	7909	0.032	10069	0.028
1431	0.036	3592	0.042	5749	0.038	7910	0.026	10070	0.028
1432	0.038	3593	0.04	5750	0.038	7911	0.026	10071	0.028
1433	0.034	3594	0.042	5751	0.038	7912	0.026	10072	0.026
1434	0.038	3595	0.042	5752	0.04	7913	0.026	10073	0.026
1435	0.038	3596	0.042	5753	0.042	7914	0.024	10074	0.026
1436	0.034	3597	0.044	5754	0.046	7915	0.024	10075	0.026
1437	0.034	3598	0.044	5755	0.046	7916	0.026	10076	0.028
1438	0.034	3599	0.044	5756	0.048	7917	0.026	10077	0.028
1439	0.034	3600	0.042	5757	0.05	7918	0.026	10078	0.028
1440	0.034	3601	0.04	5758	0.05	7919	0.026	10079	0.026
1441	0.034	3602	0.04	5759	0.05	7920	0.028	10080	0.026
1442	0.036	3603	0.042	5760	0.048	7921	0.028	10081	0.026
1443	0.036	3604	0.042	5761	0.048	7922	0.026	10082	0.028
1444	0.034	3605	0.04	5762	0.046	7923	0.024	10083	0.026
1445	0.034	3606	0.042	5763	0.044	7924	0.024	10084	0.026
1446	0.034	3607	0.042	5764	0.044	7925	0.024	10085	0.028
1447	0.034	3608	0.042	5765	0.044	7926	0.024	10086	0.03
1448	0.034	3609	0.042	5766	0.042	7927	0.026	10087	0.026
1449	0.034	3610	0.042	5767	0.042	7928	0.026	10088	0.026
1450	0.034	3611	0.042	5768	0.04	7929	0.028	10089	0.026
1451	0.034	3612	0.042	5769	0.042	7930	0.026	10090	0.026
1452	0.034	3613	0.04	5770	0.038	7931	0.026	10091	0.026
1453	0.036	3614	0.04	5771	0.04	7932	0.026	10092	0.028
1454	0.036	3615	0.04	5772	0.04	7933	0.026	10093	0.028
1455	0.034	3616	0.042	5773	0.04	7934	0.026	10094	0.026
1456	0.036	3617	0.042	5774	0.04	7935	0.026	10095	0.028
1457	0.038	3618	0.042	5775	0.04	7936	0.026	10096	0.028
1458	0.036	3619	0.042	5776	0.042	7937	0.024	10097	0.028
1459	0.038	3620	0.042	5777	0.042	7938	0.026	10098	0.026
1460	0.038	3621	0.042	5778	0.04	7939	0.026	10099	0.028
1461	0.036	3622	0.042	5779	0.04	7940	0.026	10100	0.028
1462	0.036	3623	0.042	5780	0.038	7941	0.026	10101	0.026
1463	0.036	3624	0.042	5781	0.038	7942	0.026	10102	0.026
1464	0.034	3625	0.042	5782	0.036	7943	0.026	10103	0.026
1465	0.034	3626	0.042	5783	0.036	7944	0.026	10104	0.026
1466	0.036	3627	0.042	5784	0.036	7945	0.026	10105	0.026
1467	0.036	3628	0.042	5785	0.036	7946	0.026	10106	0.026

1468	0.038	3629	0.042	5786	0.036	7947	0.026	10107	0.024
1469	0.038	3630	0.04	5787	0.036	7948	0.026	10108	0.026
1470	0.036	3631	0.042	5788	0.036	7949	0.024	10109	0.028
1471	0.038	3632	0.04	5789	0.038	7950	0.026	10110	0.028
1472	0.038	3633	0.042	5790	0.036	7951	0.026	10111	0.026
1473	0.04	3634	0.042	5791	0.036	7952	0.024	10112	0.026
1474	0.038	3635	0.042	5792	0.036	7953	0.024	10113	0.028
1475	0.038	3636	0.042	5793	0.036	7954	0.024	10114	0.028
1476	0.036	3637	0.044	5794	0.038	7955	0.024	10115	0.028
1477	0.038	3638	0.042	5795	0.038	7956	0.026	10116	0.026
1478	0.038	3639	0.042	5796	0.036	7957	0.026	10117	0.026
1479	0.038	3640	0.044	5797	0.036	7958	0.024	10118	0.026
1480	0.04	3641	0.044	5798	0.036	7959	0.026	10119	0.026
1481	0.04	3642	0.044	5799	0.036	7960	0.026	10120	0.026
1482	0.04	3643	0.044	5800	0.036	7961	0.026	10121	0.026
1483	0.042	3644	0.044	5801	0.036	7962	0.024	10122	0.026
1484	0.04	3645	0.042	5802	0.036	7963	0.024	10123	0.026
1485	0.042	3646	0.044	5803	0.036	7964	0.026	10124	0.026
1486	0.042	3647	0.044	5804	0.034	7965	0.024	10125	0.028
1487	0.042	3648	0.044	5805	0.034	7966	0.028	10126	0.028
1488	0.042	3649	0.044	5806	0.036	7967	0.028	10127	0.028
1489	0.042	3650	0.044	5807	0.034	7968	0.024	10128	0.028
1490	0.042	3651	0.044	5808	0.032	7969	0.022	10129	0.028
1491	0.042	3652	0.042	5809	0.032	7970	0.022	10130	0.028
1492	0.042	3653	0.042	5810	0.032	7971	0.022	10131	0.03
1493	0.042	3654	0.044	5811	0.032	7972	0.022	10132	0.028
1494	0.042	3655	0.042	5812	0.032	7973	0.022	10133	0.028
1495	0.04	3656	0.042	5813	0.032	7974	0.022	10134	0.028
1496	0.038	3657	0.042	5814	0.034	7975	0.02	10135	0.028
1497	0.038	3658	0.044	5815	0.034	7976	0.022	10136	0.028
1498	0.04	3659	0.046	5816	0.032	7977	0.022	10137	0.028
1499	0.038	3660	0.044	5817	0.032	7978	0.02	10138	0.028
1500	0.038	3661	0.044	5818	0.032	7979	0.022	10139	0.026
1501	0.036	3662	0.044	5819	0.034	7980	0.022	10140	0.028
1502	0.038	3663	0.044	5820	0.034	7981	0.022	10141	0.028
1503	0.038	3664	0.046	5821	0.032	7982	0.022	10142	0.028
1504	0.038	3665	0.044	5822	0.032	7983	0.022	10143	0.028
1505	0.04	3666	0.044	5823	0.03	7984	0.022	10144	0.03
1506	0.038	3667	0.044	5824	0.032	7985	0.022	10145	0.026
1507	0.038	3668	0.044	5825	0.034	7986	0.022	10146	0.026
1508	0.04	3669	0.044	5826	0.032	7987	0.022	10147	0.028
1509	0.038	3670	0.044	5827	0.032	7988	0.022	10148	0.028
1510	0.038	3671	0.044	5828	0.032	7989	0.022	10149	0.028
1511	0.038	3672	0.046	5829	0.034	7990	0.022	10150	0.028
1512	0.038	3673	0.044	5830	0.036	7991	0.022	10151	0.026
1513	0.04	3674	0.046	5831	0.042	7992	0.02	10152	0.026
1514	0.04	3675	0.048	5832	0.054	7993	0.022	10153	0.028
1515	0.04	3676	0.046	5833	0.054	7994	0.022	10154	0.028
1516	0.038	3677	0.046	5834	0.048	7995	0.024	10155	0.028
1517	0.04	3678	0.046	5835	0.048	7996	0.024	10156	0.028
1518	0.038	3679	0.046	5836	0.046	7997	0.024	10157	0.028
1519	0.038	3680	0.046	5837	0.046	7998	0.024	10158	0.028
1520	0.038	3681	0.044	5838	0.042	7999	0.024	10159	0.026
1521	0.04	3682	0.046	5839	0.04	8000	0.024	10160	0.026
1522	0.04	3683	0.046	5840	0.036	8001	0.024	10161	0.026
1523	0.038	3684	0.046	5841	0.034	8002	0.024	10162	0.026
1524	0.038	3685	0.046	5842	0.034	8003	0.024	10163	0.028
1525	0.038	3686	0.046	5843	0.036	8004	0.024	10164	0.03
1526	0.036	3687	0.046	5844	0.034	8005	0.026	10165	0.028
1527	0.038	3688	0.044	5845	0.032	8006	0.024	10166	0.028
1528	0.038	3689	0.044	5846	0.032	8007	0.024	10167	0.028
1529	0.038	3690	0.046	5847	0.032	8008	0.024	10168	0.028
1530	0.038	3691	0.046	5848	0.032	8009	0.024	10169	0.028
1531	0.036	3692	0.046	5849	0.03	8010	0.024	10170	0.028
1532	0.038	3693	0.046	5850	0.032	8011	0.024	10171	0.028
1533	0.038	3694	0.046	5851	0.032	8012	0.026	10172	0.028
1534	0.038	3695	0.044	5852	0.032	8013	0.026	10173	0.028
1535	0.038	3696	0.044	5853	0.032	8014	0.024	10174	0.028
1536	0.038	3697	0.048	5854	0.032	8015	0.026	10175	0.03
1537	0.038	3698	0.046	5855	0.032	8016	0.026	10176	0.028
1538	0.036	3699	0.046	5856	0.032	8017	0.024	10177	0.028
1539	0.036	3700	0.048	5857	0.034	8018	0.024	10178	0.03
1540	0.036	3701	0.046	5858	0.032	8019	0.024	10179	0.028
1541	0.036	3702	0.046	5859	0.032	8020	0.024	10180	0.028
1542	0.036	3703	0.046	5860	0.034	8021	0.024	10181	0.028
1543	0.036	3704	0.046	5861	0.034	8022	0.024	10182	0.028
1544	0.036	3705	0.046	5862	0.032	8023	0.024	10183	0.028
1545	0.036	3706	0.046	5863	0.032	8024	0.026	10184	0.028
1546	0.036	3707	0.046	5864	0.032	8025	0.024	10185	0.03
1547	0.036	3708	0.046	5865	0.032	8026	0.022	10186	0.03
1548	0.036	3709	0.048	5866	0.03	8027	0.024	10187	0.03
1549	0.036	3710	0.044	5867	0.03	8028	0.024	10188	0.028
1550	0.036	3711	0.044	5868	0.032	8029	0.024	10189	0.028
1551	0.038	3712	0.044	5869	0.032	8030	0.026	10190	0.026
1552	0.036	3713	0.048	5870	0.032	8031	0.026	10191	0.028
1553	0.036	3714	0.05	5871	0.032	8032	0.026	10192	0.028
1554	0.034	3715	0.048	5872	0.032	8033	0.024	10193	0.028
1555	0.036	3716	0.046	5873	0.034	8034	0.024	10194	0.028
1556	0.036	3717	0.044	5874	0.032	8035	0.026	10195	0.028
1557	0.038	3718	0.046	5875	0.032	8036	0.026	10196	0.028
1558	0.038	3719	0.048	5876	0.032	8037	0.024	10197	0.028
1559	0.036	3720	0.05	5877	0.032	8038	0.026	10198	0.028
1560	0.036	3721	0.05	5878	0.03	8039	0.026	10199	0.03

1561	0.038	3722	0.048	5879	0.032	8040	0.024	10200	0.03
1562	0.036	3723	0.048	5880	0.034	8041	0.024	10201	0.028
1563	0.036	3724	0.05	5881	0.032	8042	0.024	10202	0.028
1564	0.036	3725	0.05	5882	0.034	8043	0.026	10203	0.028
1565	0.038	3726	0.048	5883	0.036	8044	0.024	10204	0.028
1566	0.038	3727	0.048	5884	0.036	8045	0.024	10205	0.028
1567	0.038	3728	0.048	5885	0.034	8046	0.024	10206	0.028
1568	0.036	3729	0.048	5886	0.032	8047	0.024	10207	0.028
1569	0.038	3730	0.048	5887	0.032	8048	0.024	10208	0.028
1570	0.04	3731	0.048	5888	0.034	8049	0.024	10209	0.03
1571	0.038	3732	0.048	5889	0.032	8050	0.024	10210	0.03
1572	0.04	3733	0.05	5890	0.032	8051	0.026	10211	0.028
1573	0.038	3734	0.048	5891	0.034	8052	0.024	10212	0.028
1574	0.04	3735	0.046	5892	0.034	8053	0.024	10213	0.03
1575	0.04	3736	0.048	5893	0.032	8054	0.026	10214	0.03
1576	0.042	3737	0.046	5894	0.034	8055	0.026	10215	0.028
1577	0.038	3738	0.046	5895	0.034	8056	0.026	10216	0.03
1578	0.038	3739	0.046	5896	0.034	8057	0.024	10217	0.03
1579	0.042	3740	0.048	5897	0.032	8058	0.026	10218	0.03
1580	0.04	3741	0.048	5898	0.034	8059	0.024	10219	0.03
1581	0.04	3742	0.05	5899	0.032	8060	0.024	10220	0.028
1582	0.04	3743	0.048	5900	0.032	8061	0.024	10221	0.028
1583	0.04	3744	0.048	5901	0.03	8062	0.026	10222	0.028
1584	0.04	3745	0.046	5902	0.032	8063	0.028	10223	0.028
1585	0.04	3746	0.046	5903	0.032	8064	0.026	10224	0.028
1586	0.04	3747	0.046	5904	0.032	8065	0.026	10225	0.03
1587	0.04	3748	0.046	5905	0.032	8066	0.026	10226	0.03
1588	0.04	3749	0.048	5906	0.034	8067	0.026	10227	0.03
1589	0.04	3750	0.048	5907	0.036	8068	0.026	10228	0.028
1590	0.042	3751	0.046	5908	0.04	8069	0.028	10229	0.028
1591	0.044	3752	0.046	5909	0.044	8070	0.028	10230	0.028
1592	0.042	3753	0.048	5910	0.044	8071	0.026	10231	0.028
1593	0.04	3754	0.046	5911	0.036	8072	0.026	10232	0.028
1594	0.042	3755	0.046	5912	0.034	8073	0.026	10233	0.028
1595	0.042	3756	0.046	5913	0.034	8074	0.026	10234	0.028
1596	0.042	3757	0.046	5914	0.032	8075	0.026	10235	0.03
1597	0.042	3758	0.046	5915	0.034	8076	0.026	10236	0.028
1598	0.042	3759	0.046	5916	0.034	8077	0.026	10237	0.028
1599	0.042	3760	0.048	5917	0.04	8078	0.028	10238	0.034
1600	0.042	3761	0.046	5918	0.052	8079	0.026	10239	0.038
1601	0.04	3762	0.046	5919	0.062	8080	0.026	10240	0.028
1602	0.038	3763	0.046	5920	0.078	8081	0.028	10241	0.028
1603	0.038	3764	0.046	5921	0.086	8082	0.026	10242	0.03
1604	0.04	3765	0.048	5922	0.068	8083	0.028	10243	0.03
1605	0.04	3766	0.048	5923	0.054	8084	0.028	10244	0.03
1606	0.042	3767	0.046	5924	0.036	8085	0.026	10245	0.028
1607	0.042	3768	0.046	5925	0.036	8086	0.026	10246	0.028
1608	0.044	3769	0.048	5926	0.038	8087	0.026	10247	0.028
1609	0.042	3770	0.048	5927	0.038	8088	0.026	10248	0.028
1610	0.038	3771	0.048	5928	0.038	8089	0.028	10249	0.026
1611	0.04	3772	0.046	5929	0.038	8090	0.03	10250	0.028
1612	0.042	3773	0.046	5930	0.036	8091	0.028	10251	0.028
1613	0.042	3774	0.046	5931	0.036	8092	0.026	10252	0.028
1614	0.038	3775	0.046	5932	0.034	8093	0.026	10253	0.028
1615	0.04	3776	0.046	5933	0.034	8094	0.026	10254	0.026
1616	0.042	3777	0.044	5934	0.034	8095	0.026	10255	0.026
1617	0.04	3778	0.042	5935	0.032	8096	0.026	10256	0.028
1618	0.04	3779	0.044	5936	0.032	8097	0.026	10257	0.028
1619	0.04	3780	0.044	5937	0.03	8098	0.026	10258	0.03
1620	0.042	3781	0.044	5938	0.032	8099	0.026	10259	0.028
1621	0.042	3782	0.044	5939	0.032	8100	0.026	10260	0.028
1622	0.04	3783	0.044	5940	0.03	8101	0.024	10261	0.03
1623	0.038	3784	0.044	5941	0.03	8102	0.026	10262	0.028
1624	0.04	3785	0.044	5942	0.03	8103	0.028	10263	0.028
1625	0.04	3786	0.044	5943	0.032	8104	0.028	10264	0.03
1626	0.038	3787	0.048	5944	0.034	8105	0.026	10265	0.028
1627	0.04	3788	0.048	5945	0.034	8106	0.026	10266	0.028
1628	0.038	3789	0.044	5946	0.032	8107	0.026	10267	0.028
1629	0.038	3790	0.044	5947	0.032	8108	0.028	10268	0.028
1630	0.04	3791	0.048	5948	0.034	8109	0.028	10269	0.028
1631	0.038	3792	0.048	5949	0.036	8110	0.028	10270	0.028
1632	0.036	3793	0.044	5950	0.036	8111	0.028	10271	0.028
1633	0.038	3794	0.044	5951	0.04	8112	0.026	10272	0.028
1634	0.038	3795	0.044	5952	0.046	8113	0.028	10273	0.028
1635	0.038	3796	0.044	5953	0.04	8114	0.026	10274	0.026
1636	0.04	3797	0.048	5954	0.038	8115	0.028	10275	0.028
1637	0.038	3798	0.048	5955	0.038	8116	0.028	10276	0.028
1638	0.038	3799	0.046	5956	0.038	8117	0.028	10277	0.028
1639	0.038	3800	0.046	5957	0.038	8118	0.03	10278	0.03
1640	0.04	3801	0.046	5958	0.036	8119	0.028	10279	0.03
1641	0.04	3802	0.044	5959	0.036	8120	0.028	10280	0.028
1642	0.038	3803	0.042	5960	0.038	8121	0.028	10281	0.028
1643	0.038	3804	0.044	5961	0.036	8122	0.028	10282	0.028
1644	0.038	3805	0.046	5962	0.034	8123	0.028	10283	0.028
1645	0.04	3806	0.044	5963	0.038	8124	0.028	10284	0.028
1646	0.038	3807	0.044	5964	0.036	8125	0.03	10285	0.028
1647	0.036	3808	0.042	5965	0.036	8126	0.028	10286	0.028
1648	0.036	3809	0.042	5966	0.034	8127	0.028	10287	0.028
1649	0.036	3810	0.042	5967	0.034	8128	0.026	10288	0.026
1650	0.036	3811	0.044	5968	0.034	8129	0.026	10289	0.026
1651	0.036	3812	0.042	5969	0.034	8130	0.026	10290	0.028
1652	0.038	3813	0.042	5970	0.034	8131	0.028	10291	0.028
1653	0.038	3814	0.044	5971	0.032	8132	0.028	10292	0.028

1654	0.038	3815	0.042	5972	0.032	8133	0.028	10293	0.026
1655	0.04	3816	0.042	5973	0.032	8134	0.028	10294	0.028
1656	0.038	3817	0.044	5974	0.03	8135	0.028	10295	0.028
1657	0.038	3818	0.044	5975	0.03	8136	0.026	10296	0.028
1658	0.038	3819	0.046	5976	0.032	8137	0.026	10297	0.028
1659	0.038	3820	0.044	5977	0.032	8138	0.026	10298	0.028
1660	0.038	3821	0.044	5978	0.032	8139	0.026	10299	0.028
1661	0.038	3822	0.042	5979	0.032	8140	0.028	10300	0.028
1662	0.04	3823	0.042	5980	0.032	8141	0.028	10301	0.028
1663	0.038	3824	0.042	5981	0.032	8142	0.026	10302	0.028
1664	0.038	3825	0.042	5982	0.03	8143	0.028	10303	0.03
1665	0.038	3826	0.042	5983	0.032	8144	0.028	10304	0.03
1666	0.038	3827	0.042	5984	0.032	8145	0.028	10305	0.028
1667	0.038	3828	0.042	5985	0.032	8146	0.028	10306	0.028
1668	0.038	3829	0.042	5986	0.032	8147	0.026	10307	0.028
1669	0.036	3830	0.042	5987	0.032	8148	0.028	10308	0.028
1670	0.036	3831	0.044	5988	0.032	8149	0.028	10309	0.028
1671	0.038	3832	0.044	5989	0.034	8150	0.026	10310	0.03
1672	0.036	3833	0.044	5990	0.032	8151	0.026	10311	0.03
1673	0.036	3834	0.044	5991	0.032	8152	0.028	10312	0.028
1674	0.038	3835	0.044	5992	0.034	8153	0.028	10313	0.028
1675	0.038	3836	0.044	5993	0.034	8154	0.026	10314	0.028
1676	0.038	3837	0.044	5994	0.034	8155	0.026	10315	0.028
1677	0.036	3838	0.044	5995	0.032	8156	0.026	10316	0.028
1678	0.038	3839	0.042	5996	0.032	8157	0.026	10317	0.03
1679	0.04	3840	0.042	5997	0.034	8158	0.028	10318	0.03
1680	0.04	3841	0.042	5998	0.034	8159	0.026	10319	0.03
1681	0.038	3842	0.044	5999	0.034	8160	0.028	10320	0.03
1682	0.04	3843	0.044	6000	0.034	8161	0.028	10321	0.028
1683	0.04	3844	0.044	6001	0.034	8162	0.028	10322	0.028
1684	0.04	3845	0.044	6002	0.034	8163	0.028	10323	0.028
1685	0.038	3846	0.044	6003	0.034	8164	0.026	10324	0.028
1686	0.038	3847	0.044	6004	0.034	8165	0.026	10325	0.03
1687	0.038	3848	0.044	6005	0.034	8166	0.028	10326	0.03
1688	0.038	3849	0.046	6006	0.034	8167	0.026	10327	0.03
1689	0.04	3850	0.046	6007	0.034	8168	0.026	10328	0.028
1690	0.04	3851	0.042	6008	0.036	8169	0.026	10329	0.028
1691	0.04	3852	0.044	6009	0.036	8170	0.026	10330	0.03
1692	0.04	3853	0.044	6010	0.036	8171	0.024	10331	0.03
1693	0.04	3854	0.044	6011	0.036	8172	0.026	10332	0.03
1694	0.038	3855	0.046	6012	0.036	8173	0.026	10333	0.03
1695	0.038	3856	0.046	6013	0.038	8174	0.024	10334	0.03
1696	0.038	3857	0.046	6014	0.038	8175	0.024	10335	0.03
1697	0.038	3858	0.044	6015	0.038	8176	0.028	10336	0.028
1698	0.04	3859	0.044	6016	0.036	8177	0.026	10337	0.03
1699	0.042	3860	0.046	6017	0.038	8178	0.026	10338	0.03
1700	0.038	3861	0.046	6018	0.038	8179	0.028	10339	0.03
1701	0.038	3862	0.046	6019	0.038	8180	0.026	10340	0.03
1702	0.038	3863	0.046	6020	0.036	8181	0.026	10341	0.03
1703	0.04	3864	0.046	6021	0.038	8182	0.026	10342	0.028
1704	0.038	3865	0.044	6022	0.038	8183	0.026	10343	0.028
1705	0.038	3866	0.044	6023	0.038	8184	0.026	10344	0.03
1706	0.04	3867	0.044	6024	0.038	8185	0.026	10345	0.03
1707	0.04	3868	0.046	6025	0.038	8186	0.026	10346	0.03
1708	0.038	3869	0.046	6026	0.038	8187	0.028	10347	0.028
1709	0.036	3870	0.044	6027	0.04	8188	0.028	10348	0.028
1710	0.036	3871	0.044	6028	0.04	8189	0.026	10349	0.028
1711	0.038	3872	0.042	6029	0.036	8190	0.026	10350	0.03
1712	0.038	3873	0.042	6030	0.038	8191	0.026	10351	0.03
1713	0.038	3874	0.044	6031	0.038	8192	0.026	10352	0.03
1714	0.04	3875	0.046	6032	0.038	8193	0.026	10353	0.03
1715	0.044	3876	0.046	6033	0.04	8194	0.026	10354	0.028
1716	0.04	3877	0.048	6034	0.04	8195	0.026	10355	0.03
1717	0.038	3878	0.046	6035	0.04	8196	0.026	10356	0.03
1718	0.04	3879	0.046	6036	0.042	8197	0.026	10357	0.03
1719	0.038	3880	0.044	6037	0.04	8198	0.026	10358	0.032
1720	0.038	3881	0.046	6038	0.04	8199	0.026	10359	0.03
1721	0.038	3882	0.046	6039	0.04	8200	0.024	10360	0.03
1722	0.038	3883	0.044	6040	0.04	8201	0.026	10361	0.028
1723	0.04	3884	0.046	6041	0.038	8202	0.024	10362	0.03
1724	0.038	3885	0.046	6042	0.04	8203	0.026	10363	0.03
1725	0.038	3886	0.046	6043	0.04	8204	0.026	10364	0.03
1726	0.038	3887	0.046	6044	0.038	8205	0.028	10365	0.03
1727	0.038	3888	0.046	6045	0.038	8206	0.026	10366	0.03
1728	0.04	3889	0.046	6046	0.038	8207	0.024	10367	0.028
1729	0.038	3890	0.048	6047	0.04	8208	0.024	10368	0.028
1730	0.038	3891	0.048	6048	0.042	8209	0.026	10369	0.03
1731	0.04	3892	0.046	6049	0.04	8210	0.024	10370	0.03
1732	0.04	3893	0.044	6050	0.038	8211	0.026	10371	0.028
1733	0.038	3894	0.044	6051	0.038	8212	0.026	10372	0.028
1734	0.038	3895	0.046	6052	0.038	8213	0.026	10373	0.028
1735	0.038	3896	0.044	6053	0.04	8214	0.028	10374	0.032
1736	0.038	3897	0.046	6054	0.04	8215	0.026	10375	0.032
1737	0.038	3898	0.048	6055	0.04	8216	0.026	10376	0.03
1738	0.04	3899	0.046	6056	0.04	8217	0.026	10377	0.03
1739	0.04	3900	0.044	6057	0.04	8218	0.024	10378	0.028
1740	0.038	3901	0.046	6058	0.038	8219	0.026	10379	0.03
1741	0.04	3902	0.046	6059	0.036	8220	0.024	10380	0.03
1742	0.042	3903	0.046	6060	0.036	8221	0.026	10381	0.028
1743	0.044	3904	0.046	6061	0.036	8222	0.028	10382	0.028
1744	0.046	3905	0.046	6062	0.036	8223	0.028	10383	0.028
1745	0.04	3906	0.048	6063	0.036	8224	0.028	10384	0.032
1746	0.042	3907	0.046	6064	0.036	8225	0.026	10385	0.032

1747	0.042	3908	0.044	6065	0.034	8226	0.026	10386	0.028
1748	0.042	3909	0.046	6066	0.034	8227	0.026	10387	0.028
1749	0.042	3910	0.046	6067	0.034	8228	0.026	10388	0.028
1750	0.042	3911	0.046	6068	0.034	8229	0.026	10389	0.028
1751	0.042	3912	0.046	6069	0.036	8230	0.026	10390	0.028
1752	0.044	3913	0.044	6070	0.038	8231	0.026	10391	0.03
1753	0.044	3914	0.046	6071	0.04	8232	0.026	10392	0.028
1754	0.044	3915	0.048	6072	0.038	8233	0.026	10393	0.028
1755	0.046	3916	0.046	6073	0.036	8234	0.026	10394	0.028
1756	0.044	3917	0.048	6074	0.036	8235	0.028	10395	0.03
1757	0.044	3918	0.046	6075	0.036	8236	0.026	10396	0.03
1758	0.042	3919	0.044	6076	0.036	8237	0.028	10397	0.028
1759	0.042	3920	0.046	6077	0.036	8238	0.03	10398	0.03
1760	0.042	3921	0.046	6078	0.034	8239	0.028	10399	0.03
1761	0.044	3922	0.046	6079	0.036	8240	0.026	10400	0.03
1762	0.046	3923	0.044	6080	0.034	8241	0.028	10401	0.03
1763	0.048	3924	0.044	6081	0.034	8242	0.028	10402	0.03
1764	0.048	3925	0.044	6082	0.034	8243	0.03	10403	0.03
1765	0.048	3926	0.044	6083	0.034	8244	0.028	10404	0.03
1766	0.046	3927	0.044	6084	0.034	8245	0.028	10405	0.028
1767	0.046	3928	0.044	6085	0.032	8246	0.03	10406	0.03
1768	0.046	3929	0.044	6086	0.032	8247	0.03	10407	0.034
1769	0.046	3930	0.044	6087	0.032	8248	0.03	10408	0.034
1770	0.048	3931	0.044	6088	0.032	8249	0.028	10409	0.03
1771	0.046	3932	0.046	6089	0.03	8250	0.026	10410	0.03
1772	0.048	3933	0.046	6090	0.03	8251	0.028	10411	0.028
1773	0.048	3934	0.046	6091	0.032	8252	0.028	10412	0.03
1774	0.05	3935	0.044	6092	0.032	8253	0.03	10413	0.03
1775	0.05	3936	0.044	6093	0.032	8254	0.028	10414	0.03
1776	0.046	3937	0.044	6094	0.034	8255	0.028	10415	0.03
1777	0.046	3938	0.044	6095	0.032	8256	0.028	10416	0.03
1778	0.044	3939	0.044	6096	0.032	8257	0.028	10417	0.03
1779	0.046	3940	0.044	6097	0.032	8258	0.03	10418	0.032
1780	0.046	3941	0.042	6098	0.032	8259	0.03	10419	0.03
1781	0.044	3942	0.044	6099	0.032	8260	0.028	10420	0.03
1782	0.044	3943	0.046	6100	0.032	8261	0.028	10421	0.03
1783	0.042	3944	0.046	6101	0.03	8262	0.03	10422	0.03
1784	0.044	3945	0.044	6102	0.032	8263	0.03	10423	0.03
1785	0.046	3946	0.044	6103	0.034	8264	0.028	10424	0.028
1786	0.042	3947	0.044	6104	0.032	8265	0.03	10425	0.03
1787	0.042	3948	0.044	6105	0.032	8266	0.028	10426	0.03
1788	0.042	3949	0.044	6106	0.032	8267	0.028	10427	0.03
1789	0.042	3950	0.044	6107	0.03	8268	0.03	10428	0.028
1790	0.042	3951	0.046	6108	0.03	8269	0.03	10429	0.028
1791	0.042	3952	0.046	6109	0.03	8270	0.03	10430	0.03
1792	0.042	3953	0.046	6110	0.03	8271	0.03	10431	0.03
1793	0.042	3954	0.046	6111	0.03	8272	0.03	10432	0.028
1794	0.042	3955	0.044	6112	0.03	8273	0.03	10433	0.028
1795	0.044	3956	0.046	6113	0.03	8274	0.03	10434	0.028
1796	0.046	3957	0.046	6114	0.03	8275	0.03	10435	0.03
1797	0.046	3958	0.044	6115	0.03	8276	0.032	10436	0.03
1798	0.046	3959	0.044	6116	0.03	8277	0.03	10437	0.028
1799	0.048	3960	0.044	6117	0.028	8278	0.028	10438	0.028
1800	0.05	3961	0.044	6118	0.028	8279	0.03	10439	0.028
1801	0.05	3962	0.044	6119	0.03	8280	0.032	10440	0.028
1802	0.05	3963	0.046	6120	0.03	8281	0.03	10441	0.028
1803	0.05	3964	0.044	6121	0.03	8282	0.03	10442	0.028
1804	0.05	3965	0.046	6122	0.028	8283	0.03	10443	0.03
1805	0.05	3966	0.044	6123	0.028	8284	0.03	10444	0.03
1806	0.048	3967	0.044	6124	0.028	8285	0.03	10445	0.028
1807	0.046	3968	0.044	6125	0.03	8286	0.03	10446	0.028
1808	0.048	3969	0.044	6126	0.03	8287	0.03	10447	0.028
1809	0.048	3970	0.044	6127	0.03	8288	0.028	10448	0.028
1810	0.046	3971	0.044	6128	0.03	8289	0.028	10449	0.028
1811	0.046	3972	0.046	6129	0.03	8290	0.028	10450	0.028
1812	0.046	3973	0.044	6130	0.028	8291	0.03	10451	0.026
1813	0.046	3974	0.044	6131	0.03	8292	0.03	10452	0.028
1814	0.046	3975	0.044	6132	0.03	8293	0.028	10453	0.028
1815	0.046	3976	0.044	6133	0.03	8294	0.028	10454	0.028
1816	0.046	3977	0.044	6134	0.03	8295	0.03	10455	0.026
1817	0.046	3978	0.044	6135	0.03	8296	0.03	10456	0.03
1818	0.048	3979	0.042	6136	0.028	8297	0.03	10457	0.028
1819	0.046	3980	0.044	6137	0.03	8298	0.03	10458	0.026
1820	0.046	3981	0.044	6138	0.03	8299	0.028	10459	0.028
1821	0.048	3982	0.044	6139	0.03	8300	0.03	10460	0.028
1822	0.048	3983	0.042	6140	0.03	8301	0.03	10461	0.028
1823	0.046	3984	0.042	6141	0.03	8302	0.028	10462	0.032
1824	0.046	3985	0.042	6142	0.03	8303	0.028	10463	0.028
1825	0.044	3986	0.042	6143	0.032	8304	0.03	10464	0.028
1826	0.046	3987	0.042	6144	0.03	8305	0.03	10465	0.028
1827	0.048	3988	0.042	6145	0.03	8306	0.028	10466	0.028
1828	0.044	3989	0.044	6146	0.032	8307	0.028	10467	0.028
1829	0.046	3990	0.042	6147	0.03	8308	0.026	10468	0.028
1830	0.046	3991	0.042	6148	0.03	8309	0.028	10469	0.028
1831	0.046	3992	0.042	6149	0.03	8310	0.028	10470	0.028
1832	0.046	3993	0.044	6150	0.03	8311	0.03	10471	0.028
1833	0.044	3994	0.042	6151	0.028	8312	0.028	10472	0.028
1834	0.046	3995	0.042	6152	0.03	8313	0.028	10473	0.03
1835	0.046	3996	0.042	6153	0.032	8314	0.03	10474	0.03
1836	0.044	3997	0.044	6154	0.03	8315	0.03	10475	0.032
1837	0.044	3998	0.042	6155	0.03	8316	0.03	10476	0.03
1838	0.044	3999	0.04	6156	0.032	8317	0.028	10477	0.03
1839	0.046	4000	0.042	6157	0.032	8318	0.028	10478	0.032

1840	0.048	4001	0.042	6158	0.03	8319	0.028	10479	0.032
1841	0.044	4002	0.04	6159	0.03	8320	0.028	10480	0.03
1842	0.044	4003	0.042	6160	0.03	8321	0.03	10481	0.028
1843	0.044	4004	0.04	6161	0.03	8322	0.03	10482	0.03
1844	0.044	4005	0.04	6162	0.03	8323	0.03	10483	0.03
1845	0.044	4006	0.042	6163	0.03	8324	0.026	10484	0.03
1846	0.046	4007	0.042	6164	0.032	8325	0.028	10485	0.03
1847	0.044	4008	0.04	6165	0.032	8326	0.028	10486	0.03
1848	0.044	4009	0.04	6166	0.032	8327	0.028	10487	0.03
1849	0.046	4010	0.04	6167	0.032	8328	0.028	10488	0.028
1850	0.046	4011	0.038	6168	0.03	8329	0.028	10489	0.028
1851	0.046	4012	0.04	6169	0.03	8330	0.028	10490	0.03
1852	0.048	4013	0.04	6170	0.03	8331	0.028	10491	0.03
1853	0.048	4014	0.04	6171	0.03	8332	0.026	10492	0.028
1854	0.048	4015	0.04	6172	0.032	8333	0.026	10493	0.028
1855	0.048	4016	0.04	6173	0.03	8334	0.028	10494	0.028
1856	0.048	4017	0.038	6174	0.03	8335	0.026	10495	0.028
1857	0.048	4018	0.04	6175	0.032	8336	0.026	10496	0.028
1858	0.048	4019	0.042	6176	0.032	8337	0.028	10497	0.028
1859	0.048	4020	0.042	6177	0.032	8338	0.026	10498	0.028
1860	0.046	4021	0.038	6178	0.03	8339	0.026	10499	0.03
1861	0.046	4022	0.04	6179	0.028	8340	0.024	10500	0.03
1862	0.046	4023	0.04	6180	0.028	8341	0.026	10501	0.03
1863	0.046	4024	0.04	6181	0.03	8342	0.028	10502	0.028
1864	0.046	4025	0.042	6182	0.03	8343	0.028	10503	0.028
1865	0.048	4026	0.042	6183	0.03	8344	0.028	10504	0.028
1866	0.048	4027	0.04	6184	0.03	8345	0.028	10505	0.028
1867	0.046	4028	0.038	6185	0.03	8346	0.026	10506	0.03
1868	0.05	4029	0.04	6186	0.03	8347	0.026	10507	0.028
1869	0.048	4030	0.04	6187	0.032	8348	0.026	10508	0.028
1870	0.048	4031	0.04	6188	0.032	8349	0.026	10509	0.028
1871	0.048	4032	0.04	6189	0.032	8350	0.028	10510	0.03
1872	0.048	4033	0.04	6190	0.032	8351	0.026	10511	0.03
1873	0.052	4034	0.042	6191	0.032	8352	0.028	10512	0.028
1874	0.052	4035	0.04	6192	0.03	8353	0.028	10513	0.028
1875	0.052	4036	0.04	6193	0.032	8354	0.026	10514	0.028
1876	0.05	4037	0.04	6194	0.032	8355	0.026	10515	0.03
1877	0.05	4038	0.042	6195	0.03	8356	0.026	10516	0.03
1878	0.048	4039	0.04	6196	0.032	8357	0.028	10517	0.03
1879	0.048	4040	0.04	6197	0.032	8358	0.026	10518	0.03
1880	0.048	4041	0.04	6198	0.03	8359	0.026	10519	0.03
1881	0.052	4042	0.042	6199	0.03	8360	0.024	10520	0.028
1882	0.052	4043	0.042	6200	0.03	8361	0.026	10521	0.028
1883	0.05	4044	0.042	6201	0.032	8362	0.026	10522	0.028
1884	0.052	4045	0.044	6202	0.03	8363	0.026	10523	0.03
1885	0.05	4046	0.042	6203	0.032	8364	0.026	10524	0.028
1886	0.052	4047	0.044	6204	0.032	8365	0.026	10525	0.028
1887	0.052	4048	0.042	6205	0.032	8366	0.026	10526	0.03
1888	0.052	4049	0.042	6206	0.032	8367	0.026	10527	0.028
1889	0.05	4050	0.044	6207	0.028	8368	0.026	10528	0.028
1890	0.048	4051	0.044	6208	0.03	8369	0.026	10529	0.028
1891	0.05	4052	0.042	6209	0.03	8370	0.028	10530	0.028
1892	0.052	4053	0.042	6210	0.03	8371	0.026	10531	0.03
1893	0.054	4054	0.044	6211	0.03	8372	0.026	10532	0.028
1894	0.052	4055	0.042	6212	0.03	8373	0.026	10533	0.03
1895	0.05	4056	0.042	6213	0.03	8374	0.026	10534	0.03
1896	0.05	4057	0.042	6214	0.03	8375	0.026	10535	0.03
1897	0.05	4058	0.044	6215	0.03	8376	0.026	10536	0.03
1898	0.05	4059	0.042	6216	0.03	8377	0.026	10537	0.03
1899	0.048	4060	0.042	6217	0.03	8378	0.026	10538	0.028
1900	0.05	4061	0.042	6218	0.032	8379	0.026	10539	0.028
1901	0.054	4062	0.044	6219	0.032	8380	0.028	10540	0.028
1902	0.05	4063	0.044	6220	0.03	8381	0.026	10541	0.028
1903	0.05	4064	0.042	6221	0.03	8382	0.026	10542	0.028
1904	0.05	4065	0.044	6222	0.028	8383	0.026	10543	0.028
1905	0.052	4066	0.044	6223	0.03	8384	0.026	10544	0.028
1906	0.05	4067	0.044	6224	0.03	8385	0.026	10545	0.028
1907	0.05	4068	0.046	6225	0.03	8386	0.026	10546	0.028
1908	0.052	4069	0.044	6226	0.032	8387	0.026	10547	0.028
1909	0.052	4070	0.042	6227	0.032	8388	0.026	10548	0.028
1910	0.05	4071	0.044	6228	0.03	8389	0.028	10549	0.028
1911	0.05	4072	0.044	6229	0.03	8390	0.024	10550	0.028
1912	0.05	4073	0.044	6230	0.03	8391	0.024	10551	0.03
1913	0.052	4074	0.046	6231	0.03	8392	0.026	10552	0.032
1914	0.052	4075	0.044	6232	0.03	8393	0.026	10553	0.032
1915	0.052	4076	0.044	6233	0.03	8394	0.028	10554	0.032
1916	0.052	4077	0.044	6234	0.03	8395	0.028	10555	0.032
1917	0.052	4078	0.046	6235	0.032	8396	0.026	10556	0.032
1918	0.05	4079	0.046	6236	0.032	8397	0.026	10557	0.03
1919	0.052	4080	0.046	6237	0.03	8398	0.026	10558	0.03
1920	0.05	4081	0.044	6238	0.03	8399	0.026	10559	0.03
1921	0.048	4082	0.048	6239	0.03	8400	0.026	10560	0.03
1922	0.05	4083	0.05	6240	0.03	8401	0.026	10561	0.03
1923	0.05	4084	0.046	6241	0.03	8402	0.026	10562	0.03
1924	0.048	4085	0.046	6242	0.03	8403	0.026	10563	0.03
1925	0.05	4086	0.044	6243	0.032	8404	0.028	10564	0.028
1926	0.052	4087	0.044	6244	0.032	8405	0.028	10565	0.028
1927	0.05	4088	0.046	6245	0.032	8406	0.028	10566	0.028
1928	0.05	4089	0.044	6246	0.032	8407	0.026	10567	0.03
1929	0.052	4090	0.044	6247	0.032	8408	0.026	10568	0.03
1930	0.052	4091	0.046	6248	0.032	8409	0.028	10569	0.03
1931	0.05	4092	0.044	6249	0.032	8410	0.026	10570	0.03
1932	0.052	4093	0.044	6250	0.032	8411	0.026	10571	0.03

1933	0.05	4094	0.044	6251	0.032	8412	0.026	10572	0.032
1934	0.05	4095	0.044	6252	0.032	8413	0.028	10573	0.03
1935	0.05	4096	0.042	6253	0.032	8414	0.026	10574	0.03
1936	0.052	4097	0.044	6254	0.032	8415	0.026	10575	0.028
1937	0.052	4098	0.042	6255	0.034	8416	0.026	10576	0.03
1938	0.05	4099	0.042	6256	0.034	8417	0.026	10577	0.03
1939	0.052	4100	0.042	6257	0.034	8418	0.026	10578	0.028
1940	0.05	4101	0.044	6258	0.034	8419	0.026	10579	0.03
1941	0.05	4102	0.042	6259	0.034	8420	0.028	10580	0.03
1942	0.052	4103	0.042	6260	0.032	8421	0.026	10581	0.03
1943	0.05	4104	0.042	6261	0.032	8422	0.028	10582	0.03
1944	0.05	4105	0.042	6262	0.034	8423	0.026	10583	0.03
1945	0.048	4106	0.044	6263	0.032	8424	0.028	10584	0.028
1946	0.05	4107	0.042	6264	0.032	8425	0.026	10585	0.03
1947	0.052	4108	0.044	6265	0.032	8426	0.024	10586	0.03
1948	0.05	4109	0.042	6266	0.034	8427	0.024	10587	0.03
1949	0.05	4110	0.044	6267	0.032	8428	0.026	10588	0.03
1950	0.048	4111	0.044	6268	0.032	8429	0.026	10589	0.03
1951	0.05	4112	0.044	6269	0.032	8430	0.026	10590	0.03
1952	0.05	4113	0.042	6270	0.032	8431	0.026	10591	0.028
1953	0.05	4114	0.042	6271	0.032	8432	0.026	10592	0.03
1954	0.05	4115	0.044	6272	0.032	8433	0.026	10593	0.032
1955	0.05	4116	0.042	6273	0.03	8434	0.026	10594	0.032
1956	0.05	4117	0.044	6274	0.03	8435	0.026	10595	0.032
1957	0.05	4118	0.044	6275	0.032	8436	0.026	10596	0.032
1958	0.052	4119	0.044	6276	0.032	8437	0.026	10597	0.032
1959	0.05	4120	0.046	6277	0.032	8438	0.026	10598	0.032
1960	0.05	4121	0.046	6278	0.032	8439	0.026	10599	0.034
1961	0.052	4122	0.046	6279	0.032	8440	0.026	10600	0.032
1962	0.052	4123	0.044	6280	0.032	8441	0.026	10601	0.032
1963	0.05	4124	0.046	6281	0.032	8442	0.026	10602	0.034
1964	0.052	4125	0.048	6282	0.03	8443	0.026	10603	0.034
1965	0.054	4126	0.048	6283	0.032	8444	0.026	10604	0.034
1966	0.054	4127	0.048	6284	0.032	8445	0.026	10605	0.034
1967	0.052	4128	0.046	6285	0.03	8446	0.026	10606	0.032
1968	0.052	4129	0.046	6286	0.032	8447	0.026	10607	0.032
1969	0.054	4130	0.046	6287	0.034	8448	0.026	10608	0.032
1970	0.052	4131	0.046	6288	0.032	8449	0.026	10609	0.032
1971	0.052	4132	0.046	6289	0.034	8450	0.028	10610	0.034
1972	0.054	4133	0.046	6290	0.034	8451	0.028	10611	0.034
1973	0.056	4134	0.046	6291	0.032	8452	0.028	10612	0.032
1974	0.054	4135	0.046	6292	0.032	8453	0.028	10613	0.034
1975	0.054	4136	0.048	6293	0.032	8454	0.026	10614	0.034
1976	0.052	4137	0.046	6294	0.034	8455	0.026	10615	0.034
1977	0.054	4138	0.046	6295	0.034	8456	0.028	10616	0.032
1978	0.054	4139	0.044	6296	0.034	8457	0.028	10617	0.032
1979	0.054	4140	0.048	6297	0.034	8458	0.028	10618	0.036
1980	0.056	4141	0.046	6298	0.032	8459	0.026	10619	0.038
1981	0.054	4142	0.046	6299	0.034	8460	0.026	10620	0.038
1982	0.054	4143	0.046	6300	0.034	8461	0.026	10621	0.038
1983	0.054	4144	0.044	6301	0.032	8462	0.026	10622	0.038
1984	0.054	4145	0.044	6302	0.034	8463	0.028	10623	0.038
1985	0.052	4146	0.046	6303	0.036	8464	0.026	10624	0.038
1986	0.052	4147	0.048	6304	0.034	8465	0.026	10625	0.038
1987	0.052	4148	0.044	6305	0.034	8466	0.026	10626	0.038
1988	0.052	4149	0.046	6306	0.034	8467	0.026	10627	0.04
1989	0.054	4150	0.048	6307	0.034	8468	0.028	10628	0.038
1990	0.054	4151	0.046	6308	0.036	8469	0.03	10629	0.04
1991	0.054	4152	0.046	6309	0.038	8470	0.026	10630	0.04
1992	0.052	4153	0.046	6310	0.038	8471	0.028	10631	0.038
1993	0.052	4154	0.046	6311	0.036	8472	0.028	10632	0.04
1994	0.05	4155	0.046	6312	0.038	8473	0.026	10633	0.04
1995	0.052	4156	0.048	6313	0.038	8474	0.026	10634	0.038
1996	0.056	4157	0.048	6314	0.036	8475	0.03	10635	0.038
1997	0.052	4158	0.048	6315	0.038	8476	0.028	10636	0.038
1998	0.052	4159	0.048	6316	0.036	8477	0.026	10637	0.036
1999	0.052	4160	0.048	6317	0.034	8478	0.026	10638	0.038
2000	0.052	4161	0.048	6318	0.034	8479	0.026	10639	0.04
2001	0.054	4162	0.048	6319	0.036	8480	0.026	10640	0.038
2002	0.052	4163	0.048	6320	0.036	8481	0.028	10641	0.036
2003	0.052	4164	0.05	6321	0.038	8482	0.026	10642	0.038
2004	0.052	4165	0.048	6322	0.038	8483	0.026	10643	0.038
2005	0.052	4166	0.048	6323	0.038	8484	0.026	10644	0.036
2006	0.05	4167	0.048	6324	0.038	8485	0.028	10645	0.036
2007	0.05	4168	0.048	6325	0.04	8486	0.028	10646	0.038
2008	0.05	4169	0.048	6326	0.04	8487	0.028	10647	0.038
2009	0.048	4170	0.048	6327	0.04	8488	0.028	10648	0.04
2010	0.048	4171	0.046	6328	0.038	8489	0.026	10649	0.04
2011	0.048	4172	0.048	6329	0.038	8490	0.026	10650	0.04
2012	0.046	4173	0.048	6330	0.04	8491	0.026	10651	0.042
2013	0.048	4174	0.048	6331	0.042	8492	0.028	10652	0.042
2014	0.048	4175	0.05	6332	0.038	8493	0.028	10653	0.04
2015	0.048	4176	0.05	6333	0.038	8494	0.028	10654	0.04
2016	0.048	4177	0.05	6334	0.04	8495	0.03	10655	0.042
2017	0.046	4178	0.05	6335	0.042	8496	0.028	10656	0.042
2018	0.05	4179	0.054	6336	0.04	8497	0.028	10657	0.042
2019	0.05	4180	0.052	6337	0.04	8498	0.028	10658	0.042
2020	0.048	4181	0.048	6338	0.042	8499	0.03	10659	0.042
2021	0.046	4182	0.05	6339	0.042	8500	0.028	10660	0.042
2022	0.046	4183	0.048	6340	0.04	8501	0.028	10661	0.044
2023	0.046	4184	0.048	6341	0.04	8502	0.03	10662	0.046
2024	0.048	4185	0.05	6342	0.04	8503	0.028	10663	0.046
2025	0.048	4186	0.052	6343	0.042	8504	0.026	10664	0.046

2026	0.048	4187	0.05	6344	0.042	8505	0.028	10665	0.044
2027	0.048	4188	0.05	6345	0.04	8506	0.028	10666	0.044
2028	0.048	4189	0.052	6346	0.04	8507	0.028	10667	0.044
2029	0.05	4190	0.05	6347	0.04	8508	0.028	10668	0.044
2030	0.05	4191	0.05	6348	0.04	8509	0.028	10669	0.042
2031	0.05	4192	0.05	6349	0.042	8510	0.028	10670	0.044
2032	0.048	4193	0.05	6350	0.04	8511	0.028	10671	0.044
2033	0.048	4194	0.052	6351	0.04	8512	0.03	10672	0.042
2034	0.048	4195	0.054	6352	0.042	8513	0.03	10673	0.044
2035	0.048	4196	0.052	6353	0.04	8514	0.03	10674	0.044
2036	0.046	4197	0.052	6354	0.042	8515	0.028	10675	0.046
2037	0.048	4198	0.052	6355	0.042	8516	0.03	10676	0.044
2038	0.048	4199	0.052	6356	0.04	8517	0.028	10677	0.044
2039	0.048	4200	0.052	6357	0.04	8518	0.028	10678	0.044
2040	0.05	4201	0.052	6358	0.04	8519	0.028	10679	0.044
2041	0.048	4202	0.052	6359	0.04	8520	0.028	10680	0.044
2042	0.044	4203	0.05	6360	0.04	8521	0.028	10681	0.042
2043	0.044	4204	0.05	6361	0.04	8522	0.028	10682	0.044
2044	0.044	4205	0.05	6362	0.04	8523	0.028	10683	0.044
2045	0.046	4206	0.05	6363	0.038	8524	0.028	10684	0.044
2046	0.048	4207	0.052	6364	0.04	8525	0.028	10685	0.044
2047	0.05	4208	0.052	6365	0.042	8526	0.03	10686	0.044
2048	0.048	4209	0.054	6366	0.04	8527	0.028	10687	0.044
2049	0.046	4210	0.052	6367	0.04	8528	0.028	10688	0.042
2050	0.044	4211	0.052	6368	0.04	8529	0.028	10689	0.042
2051	0.044	4212	0.052	6369	0.042	8530	0.028	10690	0.042
2052	0.046	4213	0.052	6370	0.042	8531	0.028	10691	0.042
2053	0.046	4214	0.052	6371	0.042	8532	0.03	10692	0.042
2054	0.046	4215	0.052	6372	0.04	8533	0.028	10693	0.04
2055	0.046	4216	0.052	6373	0.042	8534	0.028	10694	0.04
2056	0.048	4217	0.052	6374	0.042	8535	0.03	10695	0.038
2057	0.046	4218	0.052	6375	0.04	8536	0.028	10696	0.038
2058	0.048	4219	0.05	6376	0.04	8537	0.028	10697	0.04
2059	0.046	4220	0.05	6377	0.04	8538	0.028	10698	0.04
2060	0.046	4221	0.052	6378	0.04	8539	0.03	10699	0.04
2061	0.046	4222	0.052	6379	0.038	8540	0.026	10700	0.038
2062	0.046	4223	0.05	6380	0.04	8541	0.026	10701	0.036
2063	0.046	4224	0.052	6381	0.04	8542	0.028	10702	0.036
2064	0.046	4225	0.052	6382	0.038	8543	0.03	10703	0.038
2065	0.044	4226	0.052	6383	0.038	8544	0.028	10704	0.04
2066	0.046	4227	0.052	6384	0.038	8545	0.028	10705	0.04
2067	0.044	4228	0.052	6385	0.038	8546	0.03	10706	0.042
2068	0.044	4229	0.05	6386	0.036	8547	0.03	10707	0.04
2069	0.046	4230	0.05	6387	0.036	8548	0.03	10708	0.034
2070	0.046	4231	0.05	6388	0.038	8549	0.03	10709	0.038
2071	0.046	4232	0.052	6389	0.036	8550	0.03	10710	0.038
2072	0.048	4233	0.052	6390	0.038	8551	0.028	10711	0.038
2073	0.046	4234	0.05	6391	0.038	8552	0.03	10712	0.04
2074	0.046	4235	0.052	6392	0.038	8553	0.028	10713	0.04
2075	0.044	4236	0.05	6393	0.036	8554	0.028	10714	0.04
2076	0.044	4237	0.052	6394	0.038	8555	0.028	10715	0.04
2077	0.044	4238	0.052	6395	0.036	8556	0.03	10716	0.04
2078	0.044	4239	0.052	6396	0.036	8557	0.03	10717	0.04
2079	0.046	4240	0.05	6397	0.036	8558	0.03	10718	0.04
2080	0.046	4241	0.05	6398	0.034	8559	0.03	10719	0.04
2081	0.046	4242	0.05	6399	0.036	8560	0.028	10720	0.038
2082	0.044	4243	0.05	6400	0.036	8561	0.03	10721	0.04
2083	0.044	4244	0.05	6401	0.034	8562	0.032	10722	0.04
2084	0.044	4245	0.052	6402	0.034	8563	0.03	10723	0.04
2085	0.046	4246	0.048	6403	0.036	8564	0.03	10724	0.042
2086	0.044	4247	0.05	6404	0.038	8565	0.028	10725	0.04
2087	0.046	4248	0.05	6405	0.038	8566	0.028	10726	0.038
2088	0.046	4249	0.048	6406	0.036	8567	0.028	10727	0.038
2089	0.044	4250	0.048	6407	0.036	8568	0.028	10728	0.04
2090	0.044	4251	0.048	6408	0.036	8569	0.028	10729	0.038
2091	0.046	4252	0.048	6409	0.036	8570	0.028	10730	0.038
2092	0.048	4253	0.048	6410	0.038	8571	0.028	10731	0.038
2093	0.046	4254	0.046	6411	0.036	8572	0.028	10732	0.038
2094	0.044	4255	0.046	6412	0.036	8573	0.03	10733	0.04
2095	0.046	4256	0.046	6413	0.036	8574	0.028	10734	0.038
2096	0.046	4257	0.046	6414	0.036	8575	0.028	10735	0.038
2097	0.046	4258	0.05	6415	0.036	8576	0.028	10736	0.04
2098	0.046	4259	0.05	6416	0.036	8577	0.028	10737	0.038
2099	0.046	4260	0.048	6417	0.036	8578	0.028	10738	0.036
2100	0.042	4261	0.05	6418	0.036	8579	0.028	10739	0.036
2101	0.044	4262	0.048	6419	0.036	8580	0.026	10740	0.038
2102	0.042	4263	0.048	6420	0.034	8581	0.026	10741	0.038
2103	0.042	4264	0.05	6421	0.036	8582	0.026	10742	0.036
2104	0.044	4265	0.048	6422	0.036	8583	0.026	10743	0.036
2105	0.044	4266	0.046	6423	0.034	8584	0.026	10744	0.036
2106	0.042	4267	0.046	6424	0.036	8585	0.026	10745	0.034
2107	0.042	4268	0.048	6425	0.034	8586	0.028	10746	0.036
2108	0.044	4269	0.048	6426	0.032	8587	0.026	10747	0.036
2109	0.044	4270	0.048	6427	0.032	8588	0.026	10748	0.036
2110	0.044	4271	0.048	6428	0.034	8589	0.028	10749	0.038
2111	0.044	4272	0.048	6429	0.034	8590	0.026	10750	0.038
2112	0.044	4273	0.05	6430	0.034	8591	0.026	10751	0.036
2113	0.044	4274	0.05	6431	0.034	8592	0.026	10752	0.036
2114	0.042	4275	0.05	6432	0.036	8593	0.024	10753	0.04
2115	0.044	4276	0.048	6433	0.036	8594	0.026	10754	0.038
2116	0.044	4277	0.048	6434	0.034	8595	0.026	10755	0.038
2117	0.044	4278	0.048	6435	0.034	8596	0.026	10756	0.036
2118	0.044	4279	0.048	6436	0.03	8597	0.026	10757	0.036

73	0.036	2234	0.046	4391	0.054	6552	0.032	8712	0.028
74	0.034	2235	0.046	4392	0.054	6553	0.032	8713	0.03
75	0.036	2236	0.042	4393	0.052	6554	0.03	8714	0.03
76	0.036	2237	0.044	4394	0.054	6555	0.032	8715	0.03
77	0.036	2238	0.044	4395	0.052	6556	0.034	8716	0.03
78	0.038	2239	0.044	4396	0.052	6557	0.034	8717	0.026
79	0.038	2240	0.046	4397	0.054	6558	0.032	8718	0.028
80	0.038	2241	0.044	4398	0.056	6559	0.032	8719	0.03
81	0.036	2242	0.044	4399	0.054	6560	0.032	8720	0.03
82	0.036	2243	0.044	4400	0.054	6561	0.032	8721	0.03
83	0.036	2244	0.044	4401	0.054	6562	0.032	8722	0.03
84	0.034	2245	0.044	4402	0.054	6563	0.034	8723	0.028
85	0.034	2246	0.044	4403	0.052	6564	0.032	8724	0.028
86	0.038	2247	0.042	4404	0.054	6565	0.032	8725	0.028
87	0.038	2248	0.044	4405	0.054	6566	0.034	8726	0.03
88	0.038	2249	0.044	4406	0.052	6567	0.032	8727	0.03
89	0.038	2250	0.044	4407	0.054	6568	0.032	8728	0.03
90	0.036	2251	0.044	4408	0.054	6569	0.032	8729	0.028
91	0.034	2252	0.04	4409	0.052	6570	0.03	8730	0.03
92	0.034	2253	0.042	4410	0.054	6571	0.032	8731	0.03
93	0.034	2254	0.042	4411	0.054	6572	0.034	8732	0.032
94	0.036	2255	0.038	4412	0.052	6573	0.032	8733	0.034
95	0.036	2256	0.04	4413	0.054	6574	0.032	8734	0.034
96	0.036	2257	0.038	4414	0.054	6575	0.032	8735	0.034
97	0.036	2258	0.038	4415	0.054	6576	0.032	8736	0.034
98	0.036	2259	0.038	4416	0.054	6577	0.032	8737	0.036
99	0.036	2260	0.038	4417	0.054	6578	0.032	8738	0.034
100	0.036	2261	0.034	4418	0.054	6579	0.032	8739	0.034
101	0.038	2262	0.036	4419	0.052	6580	0.032	8740	0.032
102	0.036	2263	0.036	4420	0.052	6581	0.032	8741	0.032
103	0.036	2264	0.036	4421	0.052	6582	0.032	8742	0.032
104	0.036	2265	0.036	4422	0.05	6583	0.034	8743	0.032
105	0.036	2266	0.034	4423	0.052	6584	0.034	8744	0.032
106	0.034	2267	0.036	4424	0.052	6585	0.034	8745	0.03
107	0.036	2268	0.036	4425	0.05	6586	0.032	8746	0.03
108	0.036	2269	0.034	4426	0.052	6587	0.032	8747	0.028
109	0.038	2270	0.034	4427	0.05	6588	0.034	8748	0.028
110	0.036	2271	0.034	4428	0.05	6589	0.034	8749	0.028
111	0.036	2272	0.036	4429	0.05	6590	0.034	8750	0.03
112	0.036	2273	0.036	4430	0.052	6591	0.032	8751	0.028
113	0.034	2274	0.038	4431	0.048	6592	0.034	8752	0.03
114	0.034	2275	0.038	4432	0.05	6593	0.036	8753	0.028
115	0.034	2276	0.036	4433	0.056	6594	0.034	8754	0.026
116	0.036	2277	0.038	4434	0.056	6595	0.034	8755	0.028
117	0.036	2278	0.036	4435	0.054	6596	0.036	8756	0.028
118	0.036	2279	0.036	4436	0.052	6597	0.036	8757	0.026
119	0.036	2280	0.038	4437	0.05	6598	0.034	8758	0.026
120	0.034	2281	0.038	4438	0.05	6599	0.036	8759	0.026
121	0.036	2282	0.038	4439	0.052	6600	0.036	8760	0.026
122	0.04	2283	0.036	4440	0.052	6601	0.036	8761	0.026
123	0.034	2284	0.036	4441	0.052	6602	0.038	8762	0.026
124	0.036	2285	0.038	4442	0.052	6603	0.036	8763	0.026
125	0.036	2286	0.038	4443	0.052	6604	0.036	8764	0.028
126	0.034	2287	0.038	4444	0.052	6605	0.034	8765	0.026
127	0.032	2288	0.038	4445	0.054	6606	0.034	8766	0.026
128	0.032	2289	0.04	4446	0.054	6607	0.036	8767	0.028
129	0.034	2290	0.04	4447	0.05	6608	0.036	8768	0.028
130	0.034	2291	0.04	4448	0.05	6609	0.036	8769	0.028
131	0.036	2292	0.038	4449	0.05	6610	0.036	8770	0.026
132	0.034	2293	0.038	4450	0.05	6611	0.036	8771	0.026
133	0.032	2294	0.04	4451	0.052	6612	0.034	8772	0.026
134	0.034	2295	0.04	4452	0.052	6613	0.036	8773	0.028
135	0.034	2296	0.036	4453	0.05	6614	0.034	8774	0.026
136	0.034	2297	0.038	4454	0.05	6615	0.034	8775	0.028
137	0.034	2298	0.038	4455	0.052	6616	0.034	8776	0.028
138	0.034	2299	0.038	4456	0.052	6617	0.032	8777	0.026
139	0.034	2300	0.038	4457	0.05	6618	0.032	8778	0.026
140	0.034	2301	0.038	4458	0.05	6619	0.034	8779	0.028
141	0.034	2302	0.038	4459	0.046	6620	0.034	8780	0.026
142	0.034	2303	0.04	4460	0.046	6621	0.034	8781	0.026
143	0.034	2304	0.04	4461	0.046	6622	0.032	8782	0.026
144	0.034	2305	0.038	4462	0.046	6623	0.034	8783	0.028
145	0.036	2306	0.038	4463	0.046	6624	0.034	8784	0.028
146	0.036	2307	0.038	4464	0.048	6625	0.034	8785	0.026
147	0.034	2308	0.038	4465	0.048	6626	0.034	8786	0.026
148	0.034	2309	0.04	4466	0.048	6627	0.032	8787	0.028
149	0.034	2310	0.038	4467	0.046	6628	0.032	8788	0.028
150	0.034	2311	0.036	4468	0.048	6629	0.032	8789	0.026
151	0.034	2312	0.038	4469	0.05	6630	0.032	8790	0.026
152	0.034	2313	0.038	4470	0.048	6631	0.032	8791	0.028
153	0.034	2314	0.04	4471	0.044	6632	0.032	8792	0.028
154	0.034	2315	0.04	4472	0.046	6633	0.032	8793	0.026
155	0.034	2316	0.04	4473	0.048	6634	0.032	8794	0.026
156	0.034	2317	0.04	4474	0.046	6635	0.034	8795	0.026
157	0.032	2318	0.04	4475	0.046	6636	0.036	8796	0.028
158	0.034	2319	0.04	4476	0.046	6637	0.034	8797	0.028
159	0.036	2320	0.042	4477	0.046	6638	0.034	8798	0.026
160	0.034	2321	0.044	4478	0.048	6639	0.032	8799	0.026
161	0.034	2322	0.042	4479	0.048	6640	0.034	8800	0.026
162	0.034	2323	0.042	4480	0.046	6641	0.034	8801	0.026
163	0.032	2324	0.042	4481	0.046	6642	0.034	8802	0.026
164	0.034	2325	0.042	4482	0.046	6643	0.032	8803	0.026
165	0.036	2326	0.044	4483	0.048	6644	0.034	8804	0.026

166	0.034	2327	0.042	4484	0.048	6645	0.034	8805	0.028
167	0.032	2328	0.042	4485	0.046	6646	0.036	8806	0.028
168	0.036	2329	0.042	4486	0.048	6647	0.036	8807	0.028
169	0.036	2330	0.042	4487	0.048	6648	0.036	8808	0.028
170	0.032	2331	0.042	4488	0.048	6649	0.036	8809	0.026
171	0.034	2332	0.044	4489	0.05	6650	0.036	8810	0.026
172	0.034	2333	0.044	4490	0.048	6651	0.038	8811	0.028
173	0.034	2334	0.042	4491	0.048	6652	0.036	8812	0.026
174	0.034	2335	0.042	4492	0.048	6653	0.036	8813	0.026
175	0.034	2336	0.042	4493	0.048	6654	0.036	8814	0.03
176	0.034	2337	0.042	4494	0.046	6655	0.038	8815	0.028
177	0.034	2338	0.042	4495	0.046	6656	0.038	8816	0.026
178	0.034	2339	0.042	4496	0.048	6657	0.036	8817	0.026
179	0.036	2340	0.042	4497	0.05	6658	0.036	8818	0.026
180	0.034	2341	0.042	4498	0.05	6659	0.034	8819	0.026
181	0.032	2342	0.042	4499	0.048	6660	0.036	8820	0.026
182	0.034	2343	0.044	4500	0.048	6661	0.036	8821	0.026
183	0.034	2344	0.042	4501	0.048	6662	0.036	8822	0.026
184	0.036	2345	0.042	4502	0.048	6663	0.036	8823	0.028
185	0.036	2346	0.04	4503	0.046	6664	0.036	8824	0.028
186	0.034	2347	0.042	4504	0.046	6665	0.038	8825	0.028
187	0.036	2348	0.042	4505	0.048	6666	0.038	8826	0.028
188	0.036	2349	0.044	4506	0.046	6667	0.036	8827	0.026
189	0.034	2350	0.042	4507	0.046	6668	0.038	8828	0.026
190	0.032	2351	0.042	4508	0.046	6669	0.038	8829	0.026
191	0.034	2352	0.042	4509	0.046	6670	0.036	8830	0.026
192	0.032	2353	0.04	4510	0.046	6671	0.036	8831	0.026
193	0.034	2354	0.04	4511	0.046	6672	0.036	8832	0.026
194	0.034	2355	0.04	4512	0.046	6673	0.036	8833	0.028
195	0.034	2356	0.04	4513	0.048	6674	0.036	8834	0.028
196	0.032	2357	0.04	4514	0.048	6675	0.036	8835	0.028
197	0.034	2358	0.04	4515	0.046	6676	0.036	8836	0.026
198	0.032	2359	0.04	4516	0.048	6677	0.036	8837	0.028
199	0.034	2360	0.04	4517	0.048	6678	0.038	8838	0.028
200	0.032	2361	0.038	4518	0.048	6679	0.038	8839	0.03
201	0.032	2362	0.038	4519	0.048	6680	0.038	8840	0.028
202	0.032	2363	0.04	4520	0.046	6681	0.038	8841	0.028
203	0.032	2364	0.04	4521	0.048	6682	0.036	8842	0.026
204	0.032	2365	0.038	4522	0.048	6683	0.034	8843	0.026
205	0.034	2366	0.04	4523	0.046	6684	0.036	8844	0.028
206	0.034	2367	0.04	4524	0.046	6685	0.036	8845	0.026
207	0.034	2368	0.04	4525	0.046	6686	0.038	8846	0.026
208	0.034	2369	0.038	4526	0.046	6687	0.036	8847	0.026
209	0.034	2370	0.04	4527	0.048	6688	0.036	8848	0.026
210	0.032	2371	0.04	4528	0.046	6689	0.036	8849	0.028
211	0.032	2372	0.04	4529	0.046	6690	0.034	8850	0.028
212	0.032	2373	0.042	4530	0.046	6691	0.036	8851	0.028
213	0.032	2374	0.038	4531	0.046	6692	0.036	8852	0.026
214	0.032	2375	0.04	4532	0.046	6693	0.036	8853	0.026
215	0.034	2376	0.04	4533	0.048	6694	0.036	8854	0.028
216	0.034	2377	0.04	4534	0.048	6695	0.038	8855	0.028
217	0.032	2378	0.04	4535	0.05	6696	0.036	8856	0.028
218	0.032	2379	0.04	4536	0.048	6697	0.038	8857	0.028
219	0.034	2380	0.04	4537	0.046	6698	0.038	8858	0.028
220	0.034	2381	0.038	4538	0.044	6699	0.038	8859	0.026
221	0.032	2382	0.038	4539	0.046	6700	0.036	8860	0.028
222	0.03	2383	0.04	4540	0.046	6701	0.036	8861	0.028
223	0.03	2384	0.042	4541	0.046	6702	0.038	8862	0.026
224	0.032	2385	0.044	4542	0.046	6703	0.038	8863	0.028
225	0.032	2386	0.042	4543	0.048	6704	0.038	8864	0.028
226	0.03	2387	0.042	4544	0.048	6705	0.038	8865	0.026
227	0.032	2388	0.042	4545	0.048	6706	0.036	8866	0.026
228	0.032	2389	0.042	4546	0.048	6707	0.036	8867	0.026
229	0.034	2390	0.042	4547	0.048	6708	0.036	8868	0.026
230	0.034	2391	0.042	4548	0.048	6709	0.036	8869	0.026
231	0.034	2392	0.04	4549	0.048	6710	0.036	8870	0.028
232	0.032	2393	0.04	4550	0.048	6711	0.036	8871	0.028
233	0.032	2394	0.04	4551	0.046	6712	0.036	8872	0.028
234	0.032	2395	0.04	4552	0.048	6713	0.036	8873	0.028
235	0.032	2396	0.042	4553	0.048	6714	0.036	8874	0.026
236	0.032	2397	0.04	4554	0.046	6715	0.036	8875	0.026
237	0.034	2398	0.04	4555	0.046	6716	0.036	8876	0.028
238	0.032	2399	0.04	4556	0.048	6717	0.038	8877	0.028
239	0.032	2400	0.042	4557	0.048	6718	0.038	8878	0.026
240	0.032	2401	0.042	4558	0.048	6719	0.038	8879	0.028
241	0.032	2402	0.04	4559	0.05	6720	0.038	8880	0.028
242	0.032	2403	0.04	4560	0.052	6721	0.038	8881	0.028
243	0.03	2404	0.04	4561	0.052	6722	0.036	8882	0.026
244	0.03	2405	0.04	4562	0.052	6723	0.036	8883	0.026
245	0.03	2406	0.038	4563	0.05	6724	0.038	8884	0.028
246	0.032	2407	0.038	4564	0.05	6725	0.036	8885	0.028
247	0.032	2408	0.04	4565	0.052	6726	0.036	8886	0.028
248	0.032	2409	0.042	4566	0.05	6727	0.036	8887	0.028
249	0.032	2410	0.04	4567	0.052	6728	0.038	8888	0.028
250	0.032	2411	0.04	4568	0.054	6729	0.036	8889	0.028
251	0.032	2412	0.04	4569	0.054	6730	0.036	8890	0.026
252	0.032	2413	0.04	4570	0.052	6731	0.036	8891	0.028
253	0.03	2414	0.038	4571	0.054	6732	0.036	8892	0.03
254	0.03	2415	0.038	4572	0.052	6733	0.038	8893	0.03
255	0.03	2416	0.038	4573	0.05	6734	0.036	8894	0.028
256	0.03	2417	0.04	4574	0.048	6735	0.038	8895	0.028
257	0.03	2418	0.04	4575	0.05	6736	0.04	8896	0.028
258	0.03	2419	0.038	4576	0.05	6737	0.036	8897	0.028

259	0.03	2420	0.04	4577	0.05	6738	0.036	8898	0.028
260	0.03	2421	0.042	4578	0.048	6739	0.036	8899	0.028
261	0.03	2422	0.04	4579	0.046	6740	0.034	8900	0.028
262	0.034	2423	0.038	4580	0.048	6741	0.034	8901	0.028
263	0.032	2424	0.04	4581	0.05	6742	0.034	8902	0.03
264	0.03	2425	0.04	4582	0.05	6743	0.034	8903	0.028
265	0.03	2426	0.04	4583	0.048	6744	0.034	8904	0.028
266	0.03	2427	0.036	4584	0.054	6745	0.034	8905	0.028
267	0.032	2428	0.038	4585	0.056	6746	0.036	8906	0.028
268	0.032	2429	0.038	4586	0.052	6747	0.036	8907	0.03
269	0.032	2430	0.038	4587	0.048	6748	0.034	8908	0.022
270	0.032	2431	0.038	4588	0.048	6749	0.036	8909	0.026
271	0.034	2432	0.04	4589	0.05	6750	0.036	8910	0.026
272	0.036	2433	0.042	4590	0.05	6751	0.036	8911	0.026
273	0.036	2434	0.038	4591	0.05	6752	0.036	8912	0.028
274	0.034	2435	0.038	4592	0.05	6753	0.036	8913	0.028
275	0.034	2436	0.038	4593	0.05	6754	0.034	8914	0.026
276	0.038	2437	0.038	4594	0.05	6755	0.036	8915	0.028
277	0.036	2438	0.036	4595	0.05	6756	0.038	8916	0.026
278	0.034	2439	0.038	4596	0.05	6757	0.036	8917	0.028
279	0.034	2440	0.038	4597	0.05	6758	0.036	8918	0.028
280	0.034	2441	0.04	4598	0.05	6759	0.034	8919	0.026
281	0.034	2442	0.04	4599	0.052	6760	0.034	8920	0.026
282	0.032	2443	0.04	4600	0.052	6761	0.034	8921	0.026
283	0.034	2444	0.038	4601	0.052	6762	0.036	8922	0.028
284	0.034	2445	0.038	4602	0.052	6763	0.036	8923	0.028
285	0.034	2446	0.04	4603	0.05	6764	0.036	8924	0.028
286	0.036	2447	0.042	4604	0.052	6765	0.034	8925	0.028
287	0.034	2448	0.044	4605	0.052	6766	0.036	8926	0.026
288	0.032	2449	0.046	4606	0.05	6767	0.034	8927	0.028
289	0.034	2450	0.044	4607	0.05	6768	0.036	8928	0.028
290	0.034	2451	0.044	4608	0.054	6769	0.036	8929	0.028
291	0.034	2452	0.046	4609	0.052	6770	0.034	8930	0.028
292	0.034	2453	0.048	4610	0.052	6771	0.032	8931	0.028
293	0.032	2454	0.048	4611	0.054	6772	0.032	8932	0.028
294	0.032	2455	0.05	4612	0.052	6773	0.034	8933	0.028
295	0.032	2456	0.048	4613	0.052	6774	0.036	8934	0.026
296	0.034	2457	0.048	4614	0.054	6775	0.034	8935	0.028
297	0.036	2458	0.046	4615	0.052	6776	0.032	8936	0.028
298	0.032	2459	0.046	4616	0.052	6777	0.034	8937	0.028
299	0.032	2460	0.048	4617	0.054	6778	0.036	8938	0.026
300	0.032	2461	0.048	4618	0.054	6779	0.034	8939	0.026
301	0.032	2462	0.048	4619	0.052	6780	0.034	8940	0.028
302	0.032	2463	0.048	4620	0.052	6781	0.036	8941	0.026
303	0.032	2464	0.046	4621	0.052	6782	0.034	8942	0.028
304	0.032	2465	0.048	4622	0.054	6783	0.032	8943	0.028
305	0.032	2466	0.05	4623	0.054	6784	0.034	8944	0.026
306	0.034	2467	0.048	4624	0.052	6785	0.032	8945	0.026
307	0.034	2468	0.05	4625	0.052	6786	0.032	8946	0.028
308	0.032	2469	0.05	4626	0.056	6787	0.034	8947	0.028
309	0.032	2470	0.05	4627	0.056	6788	0.034	8948	0.028
310	0.032	2471	0.046	4628	0.056	6789	0.034	8949	0.028
311	0.034	2472	0.048	4629	0.056	6790	0.034	8950	0.028
312	0.034	2473	0.05	4630	0.054	6791	0.034	8951	0.028
313	0.034	2474	0.05	4631	0.054	6792	0.034	8952	0.03
314	0.052	2475	0.052	4632	0.058	6793	0.034	8953	0.03
315	0.076	2476	0.05	4633	0.056	6794	0.034	8954	0.028
316	0.07	2477	0.05	4634	0.054	6795	0.034	8955	0.028
317	0.07	2478	0.052	4635	0.054	6796	0.034	8956	0.028
318	0.058	2479	0.052	4636	0.054	6797	0.032	8957	0.026
319	0.056	2480	0.05	4637	0.052	6798	0.034	8958	0.028
320	0.046	2481	0.052	4638	0.054	6799	0.034	8959	0.028
321	0.046	2482	0.052	4639	0.056	6800	0.034	8960	0.03
322	0.05	2483	0.054	4640	0.054	6801	0.034	8961	0.03
323	0.052	2484	0.052	4641	0.054	6802	0.032	8962	0.03
324	0.048	2485	0.052	4642	0.054	6803	0.032	8963	0.028
325	0.044	2486	0.052	4643	0.054	6804	0.03	8964	0.028
326	0.04	2487	0.05	4644	0.056	6805	0.032	8965	0.028
327	0.036	2488	0.05	4645	0.054	6806	0.034	8966	0.028
328	0.038	2489	0.05	4646	0.056	6807	0.034	8967	0.03
329	0.038	2490	0.048	4647	0.054	6808	0.034	8968	0.028
330	0.038	2491	0.048	4648	0.052	6809	0.032	8969	0.028
331	0.042	2492	0.046	4649	0.054	6810	0.032	8970	0.03
332	0.038	2493	0.046	4650	0.054	6811	0.034	8971	0.03
333	0.038	2494	0.048	4651	0.054	6812	0.034	8972	0.028
334	0.034	2495	0.048	4652	0.054	6813	0.034	8973	0.028
335	0.032	2496	0.046	4653	0.056	6814	0.034	8974	0.026
336	0.032	2497	0.048	4654	0.056	6815	0.032	8975	0.028
337	0.032	2498	0.046	4655	0.054	6816	0.032	8976	0.028
338	0.032	2499	0.046	4656	0.052	6817	0.032	8977	0.03
339	0.032	2500	0.048	4657	0.052	6818	0.034	8978	0.028
340	0.032	2501	0.044	4658	0.054	6819	0.032	8979	0.028
341	0.034	2502	0.044	4659	0.054	6820	0.034	8980	0.03
342	0.036	2503	0.046	4660	0.054	6821	0.032	8981	0.03
343	0.038	2504	0.046	4661	0.054	6822	0.034	8982	0.03
344	0.038	2505	0.046	4662	0.056	6823	0.034	8983	0.028
345	0.036	2506	0.046	4663	0.058	6824	0.034	8984	0.026
346	0.036	2507	0.046	4664	0.056	6825	0.034	8985	0.028
347	0.038	2508	0.05	4665	0.052	6826	0.034	8986	0.028
348	0.038	2509	0.05	4666	0.052	6827	0.036	8987	0.026
349	0.038	2510	0.048	4667	0.056	6828	0.036	8988	0.026
350	0.04	2511	0.048	4668	0.054	6829	0.038	8989	0.026
351	0.04	2512	0.05	4669	0.054	6830	0.036	8990	0.026

352	0.04	2513	0.046	4670	0.056	6831	0.036	8991	0.028
353	0.042	2514	0.046	4671	0.054	6832	0.036	8992	0.026
354	0.042	2515	0.046	4672	0.054	6833	0.038	8993	0.028
355	0.044	2516	0.046	4673	0.052	6834	0.036	8994	0.026
356	0.042	2517	0.046	4674	0.052	6835	0.036	8995	0.026
357	0.04	2518	0.048	4675	0.054	6836	0.036	8996	0.026
358	0.04	2519	0.048	4676	0.052	6837	0.036	8997	0.026
359	0.042	2520	0.048	4677	0.05	6838	0.034	8998	0.024
360	0.044	2521	0.05	4678	0.052	6839	0.036	8999	0.024
361	0.046	2522	0.05	4679	0.05	6840	0.036	9000	0.026
362	0.054	2523	0.046	4680	0.052	6841	0.04	9001	0.026
363	0.058	2524	0.046	4681	0.052	6842	0.038	9002	0.026
364	0.054	2525	0.046	4682	0.052	6843	0.036	9003	0.026
365	0.052	2526	0.048	4683	0.052	6844	0.038	9004	0.024
366	0.048	2527	0.048	4684	0.052	6845	0.038	9005	0.026
367	0.044	2528	0.048	4685	0.052	6846	0.036	9006	0.026
368	0.046	2529	0.046	4686	0.052	6847	0.036	9007	0.026
369	0.042	2530	0.048	4687	0.05	6848	0.036	9008	0.026
370	0.038	2531	0.05	4688	0.05	6849	0.038	9009	0.026
371	0.034	2532	0.05	4689	0.052	6850	0.038	9010	0.026
372	0.034	2533	0.054	4690	0.052	6851	0.036	9011	0.028
373	0.034	2534	0.052	4691	0.052	6852	0.034	9012	0.026
374	0.032	2535	0.05	4692	0.048	6853	0.036	9013	0.024
375	0.034	2536	0.052	4693	0.05	6854	0.036	9014	0.024
376	0.034	2537	0.052	4694	0.05	6855	0.036	9015	0.024
377	0.032	2538	0.054	4695	0.048	6856	0.036	9016	0.024
378	0.032	2539	0.054	4696	0.05	6857	0.036	9017	0.024
379	0.032	2540	0.054	4697	0.052	6858	0.036	9018	0.024
380	0.032	2541	0.054	4698	0.05	6859	0.038	9019	0.026
381	0.03	2542	0.054	4699	0.05	6860	0.036	9020	0.026
382	0.032	2543	0.054	4700	0.05	6861	0.036	9021	0.026
383	0.032	2544	0.054	4701	0.048	6862	0.036	9022	0.026
384	0.032	2545	0.052	4702	0.05	6863	0.036	9023	0.024
385	0.032	2546	0.054	4703	0.05	6864	0.036	9024	0.024
386	0.034	2547	0.054	4704	0.048	6865	0.036	9025	0.024
387	0.036	2548	0.052	4705	0.05	6866	0.036	9026	0.026
388	0.038	2549	0.052	4706	0.05	6867	0.034	9027	0.026
389	0.038	2550	0.05	4707	0.048	6868	0.034	9028	0.026
390	0.038	2551	0.052	4708	0.046	6869	0.036	9029	0.026
391	0.038	2552	0.054	4709	0.048	6870	0.036	9030	0.026
392	0.036	2553	0.054	4710	0.048	6871	0.036	9031	0.026
393	0.034	2554	0.054	4711	0.046	6872	0.034	9032	0.024
394	0.036	2555	0.054	4712	0.048	6873	0.034	9033	0.024
395	0.034	2556	0.054	4713	0.048	6874	0.034	9034	0.024
396	0.04	2557	0.052	4714	0.048	6875	0.034	9035	0.024
397	0.07	2558	0.052	4715	0.046	6876	0.034	9036	0.024
398	0.1	2559	0.052	4716	0.048	6877	0.034	9037	0.024
399	0.086	2560	0.05	4717	0.05	6878	0.034	9038	0.026
400	0.09	2561	0.05	4718	0.046	6879	0.036	9039	0.026
401	0.086	2562	0.05	4719	0.048	6880	0.034	9040	0.024
402	0.074	2563	0.052	4720	0.05	6881	0.032	9041	0.024
403	0.06	2564	0.054	4721	0.048	6882	0.032	9042	0.024
404	0.05	2565	0.05	4722	0.048	6883	0.034	9043	0.024
405	0.044	2566	0.05	4723	0.05	6884	0.034	9044	0.024
406	0.042	2567	0.052	4724	0.05	6885	0.034	9045	0.024
407	0.04	2568	0.054	4725	0.05	6886	0.034	9046	0.024
408	0.038	2569	0.052	4726	0.05	6887	0.034	9047	0.026
409	0.036	2570	0.05	4727	0.05	6888	0.034	9048	0.026
410	0.038	2571	0.05	4728	0.052	6889	0.034	9049	0.024
411	0.038	2572	0.05	4729	0.052	6890	0.034	9050	0.024
412	0.04	2573	0.05	4730	0.052	6891	0.034	9051	0.024
413	0.038	2574	0.05	4731	0.052	6892	0.034	9052	0.024
414	0.036	2575	0.048	4732	0.052	6893	0.034	9053	0.024
415	0.036	2576	0.046	4733	0.052	6894	0.034	9054	0.024
416	0.036	2577	0.048	4734	0.052	6895	0.034	9055	0.024
417	0.036	2578	0.048	4735	0.054	6896	0.034	9056	0.024
418	0.036	2579	0.048	4736	0.056	6897	0.032	9057	0.024
419	0.036	2580	0.048	4737	0.054	6898	0.034	9058	0.026
420	0.036	2581	0.048	4738	0.056	6899	0.034	9059	0.024
421	0.034	2582	0.048	4739	0.054	6900	0.032	9060	0.024
422	0.03	2583	0.046	4740	0.054	6901	0.034	9061	0.024
423	0.028	2584	0.046	4741	0.054	6902	0.034	9062	0.024
424	0.03	2585	0.046	4742	0.054	6903	0.032	9063	0.026
425	0.032	2586	0.046	4743	0.054	6904	0.032	9064	0.024
426	0.032	2587	0.044	4744	0.054	6905	0.036	9065	0.022
427	0.032	2588	0.044	4745	0.054	6906	0.034	9066	0.024
428	0.032	2589	0.044	4746	0.052	6907	0.034	9067	0.024
429	0.032	2590	0.046	4747	0.054	6908	0.034	9068	0.024
430	0.032	2591	0.048	4748	0.056	6909	0.034	9069	0.024
431	0.032	2592	0.052	4749	0.054	6910	0.034	9070	0.024
432	0.032	2593	0.05	4750	0.052	6911	0.032	9071	0.024
433	0.038	2594	0.048	4751	0.054	6912	0.032	9072	0.024
434	0.04	2595	0.046	4752	0.056	6913	0.032	9073	0.024
435	0.036	2596	0.046	4753	0.056	6914	0.032	9074	0.024
436	0.032	2597	0.046	4754	0.052	6915	0.034	9075	0.024
437	0.032	2598	0.046	4755	0.052	6916	0.034	9076	0.024
438	0.03	2599	0.048	4756	0.052	6917	0.034	9077	0.024
439	0.032	2600	0.046	4757	0.054	6918	0.032	9078	0.024
440	0.032	2601	0.046	4758	0.056	6919	0.032	9079	0.024
441	0.03	2602	0.048	4759	0.054	6920	0.032	9080	0.024
442	0.03	2603	0.05	4760	0.052	6921	0.032	9081	0.024
443	0.032	2604	0.048	4761	0.054	6922	0.032	9082	0.024
444	0.03	2605	0.046	4762	0.054	6923	0.034	9083	0.026

445	0.03	2606	0.046	4763	0.052	6924	0.034	9084	0.024
446	0.03	2607	0.048	4764	0.052	6925	0.034	9085	0.024
447	0.03	2608	0.048	4765	0.054	6926	0.032	9086	0.024
448	0.03	2609	0.048	4766	0.052	6927	0.032	9087	0.024
449	0.03	2610	0.046	4767	0.054	6928	0.032	9088	0.026
450	0.03	2611	0.046	4768	0.054	6929	0.032	9089	0.026
451	0.03	2612	0.046	4769	0.052	6930	0.032	9090	0.024
452	0.03	2613	0.046	4770	0.05	6931	0.032	9091	0.024
453	0.03	2614	0.046	4771	0.052	6932	0.032	9092	0.022
454	0.032	2615	0.046	4772	0.052	6933	0.032	9093	0.022
455	0.032	2616	0.048	4773	0.052	6934	0.032	9094	0.024
456	0.03	2617	0.046	4774	0.052	6935	0.03	9095	0.024
457	0.03	2618	0.048	4775	0.054	6936	0.032	9096	0.024
458	0.03	2619	0.048	4776	0.052	6937	0.034	9097	0.024
459	0.03	2620	0.046	4777	0.052	6938	0.034	9098	0.024
460	0.03	2621	0.048	4778	0.052	6939	0.032	9099	0.024
461	0.03	2622	0.052	4779	0.052	6940	0.032	9100	0.022
462	0.03	2623	0.052	4780	0.052	6941	0.032	9101	0.024
463	0.032	2624	0.052	4781	0.052	6942	0.034	9102	0.026
464	0.03	2625	0.056	4782	0.052	6943	0.034	9103	0.026
465	0.03	2626	0.06	4783	0.052	6944	0.032	9104	0.024
466	0.03	2627	0.058	4784	0.054	6945	0.032	9105	0.024
467	0.032	2628	0.06	4785	0.054	6946	0.032	9106	0.024
468	0.028	2629	0.058	4786	0.05	6947	0.032	9107	0.026
469	0.026	2630	0.058	4787	0.048	6948	0.032	9108	0.026
470	0.026	2631	0.056	4788	0.05	6949	0.032	9109	0.024
471	0.026	2632	0.056	4789	0.05	6950	0.032	9110	0.024
472	0.028	2633	0.056	4790	0.05	6951	0.034	9111	0.024
473	0.028	2634	0.056	4791	0.05	6952	0.034	9112	0.024
474	0.026	2635	0.054	4792	0.052	6953	0.034	9113	0.024
475	0.026	2636	0.054	4793	0.052	6954	0.03	9114	0.024
476	0.026	2637	0.056	4794	0.052	6955	0.032	9115	0.022
477	0.028	2638	0.054	4795	0.052	6956	0.032	9116	0.022
478	0.028	2639	0.052	4796	0.05	6957	0.032	9117	0.024
479	0.028	2640	0.052	4797	0.05	6958	0.032	9118	0.024
480	0.028	2641	0.052	4798	0.05	6959	0.032	9119	0.024
481	0.028	2642	0.052	4799	0.052	6960	0.034	9120	0.024
482	0.03	2643	0.052	4800	0.05	6961	0.032	9121	0.024
483	0.03	2644	0.054	4801	0.05	6962	0.03	9122	0.024
484	0.028	2645	0.052	4802	0.05	6963	0.032	9123	0.024
485	0.028	2646	0.052	4803	0.05	6964	0.034	9124	0.024
486	0.032	2647	0.054	4804	0.05	6965	0.034	9125	0.024
487	0.034	2648	0.052	4805	0.05	6966	0.032	9126	0.024
488	0.034	2649	0.052	4806	0.05	6967	0.032	9127	0.022
489	0.034	2650	0.05	4807	0.05	6968	0.034	9128	0.024
490	0.036	2651	0.05	4808	0.046	6969	0.034	9129	0.024
491	0.032	2652	0.052	4809	0.048	6970	0.032	9130	0.024
492	0.032	2653	0.052	4810	0.046	6971	0.032	9131	0.024
493	0.03	2654	0.052	4811	0.046	6972	0.032	9132	0.024
494	0.032	2655	0.052	4812	0.046	6973	0.032	9133	0.024
495	0.034	2656	0.054	4813	0.046	6974	0.034	9134	0.024
496	0.032	2657	0.054	4814	0.046	6975	0.032	9135	0.024
497	0.032	2658	0.052	4815	0.048	6976	0.032	9136	0.024
498	0.034	2659	0.052	4816	0.048	6977	0.032	9137	0.024
499	0.032	2660	0.05	4817	0.048	6978	0.032	9138	0.024
500	0.03	2661	0.05	4818	0.05	6979	0.032	9139	0.024
501	0.03	2662	0.05	4819	0.048	6980	0.032	9140	0.024
502	0.03	2663	0.048	4820	0.046	6981	0.032	9141	0.024
503	0.03	2664	0.046	4821	0.048	6982	0.032	9142	0.024
504	0.032	2665	0.046	4822	0.048	6983	0.034	9143	0.024
505	0.03	2666	0.048	4823	0.05	6984	0.034	9144	0.024
506	0.03	2667	0.046	4824	0.05	6985	0.032	9145	0.024
507	0.028	2668	0.046	4825	0.046	6986	0.032	9146	0.024
508	0.028	2669	0.046	4826	0.048	6987	0.032	9147	0.024
509	0.028	2670	0.046	4827	0.048	6988	0.032	9148	0.024
510	0.028	2671	0.046	4828	0.048	6989	0.03	9149	0.024
511	0.028	2672	0.044	4829	0.048	6990	0.032	9150	0.024
512	0.028	2673	0.044	4830	0.048	6991	0.03	9151	0.024
513	0.028	2674	0.044	4831	0.048	6992	0.03	9152	0.024
514	0.028	2675	0.042	4832	0.046	6993	0.03	9153	0.026
515	0.028	2676	0.044	4833	0.048	6994	0.03	9154	0.024
516	0.028	2677	0.048	4834	0.046	6995	0.03	9155	0.026
517	0.03	2678	0.046	4835	0.044	6996	0.032	9156	0.026
518	0.032	2679	0.044	4836	0.046	6997	0.032	9157	0.026
519	0.03	2680	0.044	4837	0.048	6998	0.032	9158	0.024
520	0.03	2681	0.044	4838	0.048	6999	0.03	9159	0.024
521	0.032	2682	0.044	4839	0.048	7000	0.03	9160	0.024
522	0.032	2683	0.044	4840	0.048	7001	0.032	9161	0.024
523	0.03	2684	0.044	4841	0.046	7002	0.032	9162	0.024
524	0.028	2685	0.042	4842	0.044	7003	0.032	9163	0.024
525	0.028	2686	0.042	4843	0.046	7004	0.034	9164	0.026
526	0.028	2687	0.044	4844	0.046	7005	0.03	9165	0.026
527	0.028	2688	0.044	4845	0.046	7006	0.032	9166	0.024
528	0.03	2689	0.044	4846	0.046	7007	0.032	9167	0.024
529	0.028	2690	0.042	4847	0.044	7008	0.032	9168	0.024
530	0.028	2691	0.044	4848	0.046	7009	0.034	9169	0.024
531	0.03	2692	0.044	4849	0.044	7010	0.034	9170	0.024
532	0.03	2693	0.042	4850	0.044	7011	0.032	9171	0.024
533	0.028	2694	0.044	4851	0.046	7012	0.032	9172	0.026
534	0.026	2695	0.044	4852	0.046	7013	0.034	9173	0.026
535	0.028	2696	0.042	4853	0.046	7014	0.032	9174	0.026
536	0.028	2697	0.042	4854	0.046	7015	0.032	9175	0.026
537	0.028	2698	0.044	4855	0.048	7016	0.032	9176	0.026

538	0.028	2699	0.046	4856	0.05	7017	0.032	9177	0.026
539	0.026	2700	0.046	4857	0.046	7018	0.032	9178	0.024
540	0.028	2701	0.044	4858	0.044	7019	0.032	9179	0.024
541	0.03	2702	0.044	4859	0.046	7020	0.032	9180	0.024
542	0.03	2703	0.044	4860	0.046	7021	0.034	9181	0.024
543	0.028	2704	0.042	4861	0.046	7022	0.034	9182	0.024
544	0.028	2705	0.042	4862	0.046	7023	0.034	9183	0.024
545	0.028	2706	0.044	4863	0.048	7024	0.034	9184	0.024
546	0.03	2707	0.042	4864	0.048	7025	0.034	9185	0.024
547	0.03	2708	0.044	4865	0.046	7026	0.034	9186	0.026
548	0.038	2709	0.044	4866	0.044	7027	0.032	9187	0.024
549	0.038	2710	0.044	4867	0.046	7028	0.032	9188	0.024
550	0.036	2711	0.044	4868	0.046	7029	0.036	9189	0.026
551	0.04	2712	0.046	4869	0.046	7030	0.036	9190	0.026
552	0.034	2713	0.044	4870	0.046	7031	0.034	9191	0.024
553	0.03	2714	0.042	4871	0.044	7032	0.036	9192	0.026
554	0.032	2715	0.042	4872	0.046	7033	0.036	9193	0.026
555	0.03	2716	0.044	4873	0.046	7034	0.034	9194	0.024
556	0.03	2717	0.044	4874	0.046	7035	0.036	9195	0.024
557	0.032	2718	0.042	4875	0.048	7036	0.036	9196	0.024
558	0.032	2719	0.042	4876	0.05	7037	0.034	9197	0.024
559	0.03	2720	0.042	4877	0.046	7038	0.034	9198	0.026
560	0.03	2721	0.042	4878	0.044	7039	0.034	9199	0.024
561	0.032	2722	0.042	4879	0.044	7040	0.036	9200	0.024
562	0.03	2723	0.042	4880	0.044	7041	0.036	9201	0.026
563	0.03	2724	0.042	4881	0.046	7042	0.036	9202	0.026
564	0.032	2725	0.042	4882	0.046	7043	0.036	9203	0.024
565	0.03	2726	0.042	4883	0.046	7044	0.036	9204	0.024
566	0.03	2727	0.042	4884	0.048	7045	0.036	9205	0.026
567	0.03	2728	0.042	4885	0.048	7046	0.034	9206	0.028
568	0.03	2729	0.038	4886	0.046	7047	0.036	9207	0.026
569	0.032	2730	0.038	4887	0.044	7048	0.036	9208	0.024
570	0.03	2731	0.04	4888	0.044	7049	0.036	9209	0.024
571	0.03	2732	0.038	4889	0.042	7050	0.034	9210	0.024
572	0.032	2733	0.04	4890	0.044	7051	0.034	9211	0.024
573	0.03	2734	0.04	4891	0.044	7052	0.034	9212	0.024
574	0.03	2735	0.04	4892	0.044	7053	0.034	9213	0.024
575	0.03	2736	0.038	4893	0.044	7054	0.036	9214	0.024
576	0.028	2737	0.038	4894	0.042	7055	0.038	9215	0.024
577	0.028	2738	0.04	4895	0.044	7056	0.036	9216	0.024
578	0.03	2739	0.04	4896	0.046	7057	0.036	9217	0.026
579	0.032	2740	0.038	4897	0.044	7058	0.036	9218	0.026
580	0.03	2741	0.038	4898	0.044	7059	0.038	9219	0.026
581	0.03	2742	0.04	4899	0.042	7060	0.036	9220	0.024
582	0.032	2743	0.04	4900	0.044	7061	0.038	9221	0.026
583	0.032	2744	0.04	4901	0.046	7062	0.038	9222	0.026
584	0.03	2745	0.04	4902	0.044	7063	0.036	9223	0.026
585	0.03	2746	0.04	4903	0.044	7064	0.038	9224	0.026
586	0.028	2747	0.04	4904	0.044	7065	0.038	9225	0.024
587	0.03	2748	0.038	4905	0.044	7066	0.038	9226	0.024
588	0.03	2749	0.04	4906	0.044	7067	0.04	9227	0.026
589	0.03	2750	0.04	4907	0.044	7068	0.038	9228	0.026
590	0.03	2751	0.04	4908	0.042	7069	0.036	9229	0.026
591	0.03	2752	0.04	4909	0.042	7070	0.036	9230	0.024
592	0.03	2753	0.038	4910	0.042	7071	0.036	9231	0.024
593	0.028	2754	0.038	4911	0.042	7072	0.038	9232	0.024
594	0.028	2755	0.038	4912	0.042	7073	0.038	9233	0.026
595	0.03	2756	0.038	4913	0.044	7074	0.036	9234	0.026
596	0.03	2757	0.038	4914	0.044	7075	0.032	9235	0.024
597	0.03	2758	0.038	4915	0.044	7076	0.032	9236	0.024
598	0.03	2759	0.038	4916	0.042	7077	0.032	9237	0.026
599	0.03	2760	0.04	4917	0.042	7078	0.032	9238	0.026
600	0.03	2761	0.04	4918	0.042	7079	0.032	9239	0.024
601	0.03	2762	0.04	4919	0.04	7080	0.032	9240	0.024
602	0.03	2763	0.04	4920	0.04	7081	0.032	9241	0.026
603	0.032	2764	0.038	4921	0.04	7082	0.032	9242	0.024
604	0.03	2765	0.038	4922	0.042	7083	0.032	9243	0.024
605	0.03	2766	0.038	4923	0.04	7084	0.032	9244	0.024
606	0.03	2767	0.04	4924	0.04	7085	0.032	9245	0.024
607	0.03	2768	0.038	4925	0.04	7086	0.032	9246	0.024
608	0.03	2769	0.04	4926	0.042	7087	0.032	9247	0.024
609	0.03	2770	0.038	4927	0.042	7088	0.032	9248	0.026
610	0.03	2771	0.038	4928	0.042	7089	0.032	9249	0.026
611	0.032	2772	0.038	4929	0.042	7090	0.034	9250	0.028
612	0.032	2773	0.038	4930	0.04	7091	0.032	9251	0.026
613	0.032	2774	0.038	4931	0.042	7092	0.03	9252	0.026
614	0.032	2775	0.038	4932	0.042	7093	0.034	9253	0.024
615	0.03	2776	0.04	4933	0.04	7094	0.034	9254	0.026
616	0.03	2777	0.04	4934	0.04	7095	0.034	9255	0.024
617	0.03	2778	0.038	4935	0.04	7096	0.034	9256	0.026
618	0.03	2779	0.038	4936	0.04	7097	0.036	9257	0.026
619	0.032	2780	0.038	4937	0.04	7098	0.034	9258	0.026
620	0.032	2781	0.04	4938	0.042	7099	0.034	9259	0.026
621	0.032	2782	0.038	4939	0.042	7100	0.034	9260	0.026
622	0.034	2783	0.036	4940	0.042	7101	0.034	9261	0.026
623	0.034	2784	0.038	4941	0.04	7102	0.036	9262	0.026
624	0.034	2785	0.04	4942	0.04	7103	0.036	9263	0.026
625	0.034	2786	0.038	4943	0.04	7104	0.034	9264	0.026
626	0.03	2787	0.038	4944	0.038	7105	0.034	9265	0.026
627	0.032	2788	0.038	4945	0.038	7106	0.036	9266	0.026
628	0.032	2789	0.038	4946	0.04	7107	0.034	9267	0.026
629	0.03	2790	0.038	4947	0.038	7108	0.03	9268	0.026
630	0.03	2791	0.04	4948	0.04	7109	0.034	9269	0.026

631	0.03	2792	0.038	4949	0.04	7110	0.034	9270	0.024
632	0.03	2793	0.04	4950	0.04	7111	0.034	9271	0.026
633	0.03	2794	0.04	4951	0.04	7112	0.034	9272	0.024
634	0.03	2795	0.04	4952	0.04	7113	0.032	9273	0.024
635	0.03	2796	0.04	4953	0.038	7114	0.032	9274	0.026
636	0.032	2797	0.038	4954	0.038	7115	0.032	9275	0.026
637	0.03	2798	0.038	4955	0.04	7116	0.032	9276	0.026
638	0.03	2799	0.04	4956	0.04	7117	0.032	9277	0.028
639	0.032	2800	0.04	4957	0.04	7118	0.034	9278	0.026
640	0.032	2801	0.04	4958	0.04	7119	0.032	9279	0.024
641	0.03	2802	0.038	4959	0.04	7120	0.032	9280	0.026
642	0.032	2803	0.04	4960	0.038	7121	0.032	9281	0.024
643	0.032	2804	0.04	4961	0.04	7122	0.034	9282	0.024
644	0.03	2805	0.04	4962	0.04	7123	0.032	9283	0.026
645	0.03	2806	0.04	4963	0.038	7124	0.03	9284	0.024
646	0.028	2807	0.038	4964	0.04	7125	0.028	9285	0.024
647	0.028	2808	0.04	4965	0.04	7126	0.028	9286	0.024
648	0.028	2809	0.04	4966	0.04	7127	0.032	9287	0.026
649	0.028	2810	0.04	4967	0.038	7128	0.034	9288	0.026
650	0.028	2811	0.04	4968	0.038	7129	0.03	9289	0.024
651	0.028	2812	0.038	4969	0.038	7130	0.028	9290	0.024
652	0.03	2813	0.038	4970	0.038	7131	0.03	9291	0.024
653	0.03	2814	0.038	4971	0.038	7132	0.03	9292	0.026
654	0.028	2815	0.04	4972	0.038	7133	0.03	9293	0.026
655	0.03	2816	0.04	4973	0.038	7134	0.028	9294	0.022
656	0.03	2817	0.038	4974	0.04	7135	0.03	9295	0.024
657	0.028	2818	0.038	4975	0.04	7136	0.03	9296	0.024
658	0.028	2819	0.04	4976	0.038	7137	0.028	9297	0.026
659	0.028	2820	0.04	4977	0.038	7138	0.03	9298	0.026
660	0.026	2821	0.04	4978	0.04	7139	0.03	9299	0.026
661	0.028	2822	0.038	4979	0.038	7140	0.03	9300	0.024
662	0.028	2823	0.04	4980	0.038	7141	0.03	9301	0.024
663	0.028	2824	0.04	4981	0.04	7142	0.03	9302	0.026
664	0.028	2825	0.038	4982	0.038	7143	0.032	9303	0.026
665	0.028	2826	0.038	4983	0.04	7144	0.03	9304	0.026
666	0.028	2827	0.038	4984	0.038	7145	0.03	9305	0.026
667	0.028	2828	0.038	4985	0.038	7146	0.03	9306	0.024
668	0.03	2829	0.04	4986	0.04	7147	0.028	9307	0.024
669	0.028	2830	0.042	4987	0.04	7148	0.028	9308	0.024
670	0.028	2831	0.04	4988	0.038	7149	0.028	9309	0.024
671	0.03	2832	0.04	4989	0.038	7150	0.028	9310	0.026
672	0.03	2833	0.04	4990	0.038	7151	0.028	9311	0.026
673	0.028	2834	0.038	4991	0.038	7152	0.028	9312	0.026
674	0.028	2835	0.038	4992	0.04	7153	0.03	9313	0.026
675	0.028	2836	0.038	4993	0.038	7154	0.03	9314	0.026
676	0.03	2837	0.038	4994	0.038	7155	0.028	9315	0.026
677	0.03	2838	0.04	4995	0.04	7156	0.028	9316	0.024
678	0.028	2839	0.04	4996	0.04	7157	0.028	9317	0.024
679	0.028	2840	0.04	4997	0.04	7158	0.028	9318	0.026
680	0.03	2841	0.04	4998	0.038	7159	0.028	9319	0.024
681	0.028	2842	0.04	4999	0.038	7160	0.028	9320	0.024
682	0.028	2843	0.04	5000	0.038	7161	0.028	9321	0.024
683	0.028	2844	0.04	5001	0.038	7162	0.03	9322	0.024
684	0.028	2845	0.04	5002	0.038	7163	0.03	9323	0.026
685	0.026	2846	0.04	5003	0.04	7164	0.03	9324	0.024
686	0.026	2847	0.04	5004	0.038	7165	0.03	9325	0.024
687	0.028	2848	0.042	5005	0.038	7166	0.03	9326	0.024
688	0.028	2849	0.042	5006	0.038	7167	0.028	9327	0.024
689	0.026	2850	0.042	5007	0.036	7168	0.03	9328	0.026
690	0.028	2851	0.044	5008	0.038	7169	0.03	9329	0.024
691	0.028	2852	0.042	5009	0.038	7170	0.03	9330	0.024
692	0.028	2853	0.042	5010	0.038	7171	0.03	9331	0.026
693	0.028	2854	0.042	5011	0.038	7172	0.032	9332	0.024
694	0.026	2855	0.042	5012	0.038	7173	0.032	9333	0.024
695	0.028	2856	0.044	5013	0.038	7174	0.03	9334	0.024
696	0.028	2857	0.042	5014	0.038	7175	0.03	9335	0.024
697	0.028	2858	0.042	5015	0.038	7176	0.03	9336	0.024
698	0.028	2859	0.04	5016	0.038	7177	0.028	9337	0.026
699	0.026	2860	0.04	5017	0.038	7178	0.028	9338	0.026
700	0.028	2861	0.04	5018	0.038	7179	0.03	9339	0.024
701	0.028	2862	0.04	5019	0.038	7180	0.028	9340	0.026
702	0.026	2863	0.04	5020	0.038	7181	0.028	9341	0.024
703	0.026	2864	0.04	5021	0.038	7182	0.03	9342	0.024
704	0.026	2865	0.04	5022	0.038	7183	0.03	9343	0.026
705	0.026	2866	0.04	5023	0.04	7184	0.032	9344	0.026
706	0.026	2867	0.04	5024	0.038	7185	0.032	9345	0.024
707	0.028	2868	0.04	5025	0.038	7186	0.032	9346	0.024
708	0.028	2869	0.04	5026	0.04	7187	0.032	9347	0.024
709	0.028	2870	0.042	5027	0.038	7188	0.032	9348	0.024
710	0.028	2871	0.042	5028	0.038	7189	0.034	9349	0.024
711	0.028	2872	0.044	5029	0.04	7190	0.034	9350	0.024
712	0.028	2873	0.042	5030	0.04	7191	0.032	9351	0.024
713	0.03	2874	0.042	5031	0.04	7192	0.034	9352	0.024
714	0.032	2875	0.042	5032	0.038	7193	0.034	9353	0.026
715	0.028	2876	0.04	5033	0.038	7194	0.034	9354	0.026
716	0.028	2877	0.042	5034	0.04	7195	0.036	9355	0.024
717	0.026	2878	0.042	5035	0.04	7196	0.036	9356	0.024
718	0.026	2879	0.042	5036	0.04	7197	0.034	9357	0.024
719	0.026	2880	0.042	5037	0.038	7198	0.034	9358	0.026
720	0.028	2881	0.044	5038	0.04	7199	0.036	9359	0.024
721	0.028	2882	0.044	5039	0.04	7200	0.036	9360	0.024
722	0.03	2883	0.044	5040	0.038	7201	0.036	9361	0.024
723	0.034	2884	0.042	5041	0.038	7202	0.034	9362	0.024

724	0.03	2885	0.042	5042	0.038	7203	0.034	9363	0.024
725	0.028	2886	0.044	5043	0.038	7204	0.036	9364	0.026
726	0.028	2887	0.044	5044	0.04	7205	0.036	9365	0.026
727	0.03	2888	0.042	5045	0.038	7206	0.036	9366	0.026
728	0.028	2889	0.042	5046	0.038	7207	0.038	9367	0.024
729	0.028	2890	0.042	5047	0.04	7208	0.038	9368	0.024
730	0.028	2891	0.044	5048	0.04	7209	0.038	9369	0.024
731	0.028	2892	0.044	5049	0.04	7210	0.038	9370	0.024
732	0.028	2893	0.042	5050	0.038	7211	0.038	9371	0.024
733	0.028	2894	0.044	5051	0.038	7212	0.036	9372	0.026
734	0.028	2895	0.044	5052	0.038	7213	0.036	9373	0.026
735	0.028	2896	0.042	5053	0.038	7214	0.036	9374	0.024
736	0.028	2897	0.042	5054	0.038	7215	0.038	9375	0.024
737	0.03	2898	0.046	5055	0.04	7216	0.036	9376	0.024
738	0.03	2899	0.044	5056	0.04	7217	0.036	9377	0.024
739	0.03	2900	0.044	5057	0.04	7218	0.036	9378	0.024
740	0.03	2901	0.044	5058	0.04	7219	0.038	9379	0.024
741	0.03	2902	0.044	5059	0.038	7220	0.038	9380	0.024
742	0.032	2903	0.044	5060	0.038	7221	0.036	9381	0.026
743	0.03	2904	0.044	5061	0.038	7222	0.036	9382	0.024
744	0.03	2905	0.044	5062	0.04	7223	0.036	9383	0.022
745	0.03	2906	0.044	5063	0.042	7224	0.036	9384	0.024
746	0.03	2907	0.044	5064	0.038	7225	0.036	9385	0.024
747	0.03	2908	0.044	5065	0.038	7226	0.038	9386	0.024
748	0.028	2909	0.044	5066	0.038	7227	0.038	9387	0.022
749	0.026	2910	0.044	5067	0.038	7228	0.036	9388	0.022
750	0.028	2911	0.042	5068	0.04	7229	0.036	9389	0.024
751	0.028	2912	0.044	5069	0.038	7230	0.038	9390	0.024
752	0.028	2913	0.044	5070	0.038	7231	0.038	9391	0.022
753	0.03	2914	0.044	5071	0.038	7232	0.038	9392	0.022
754	0.028	2915	0.046	5072	0.038	7233	0.036	9393	0.022
755	0.03	2916	0.044	5073	0.04	7234	0.034	9394	0.022
756	0.03	2917	0.046	5074	0.038	7235	0.036	9395	0.022
757	0.028	2918	0.046	5075	0.038	7236	0.036	9396	0.022
758	0.028	2919	0.046	5076	0.038	7237	0.036	9397	0.022
759	0.028	2920	0.046	5077	0.038	7238	0.038	9398	0.022
760	0.03	2921	0.044	5078	0.038	7239	0.036	9399	0.022
761	0.032	2922	0.046	5079	0.038	7240	0.036	9400	0.02
762	0.03	2923	0.046	5080	0.038	7241	0.034	9401	0.022
763	0.03	2924	0.046	5081	0.036	7242	0.034	9402	0.022
764	0.03	2925	0.044	5082	0.038	7243	0.034	9403	0.022
765	0.028	2926	0.044	5083	0.038	7244	0.034	9404	0.022
766	0.028	2927	0.046	5084	0.038	7245	0.034	9405	0.024
767	0.028	2928	0.044	5085	0.036	7246	0.034	9406	0.024
768	0.03	2929	0.046	5086	0.038	7247	0.034	9407	0.024
769	0.03	2930	0.048	5087	0.04	7248	0.036	9408	0.024
770	0.028	2931	0.046	5088	0.038	7249	0.036	9409	0.024
771	0.03	2932	0.046	5089	0.04	7250	0.034	9410	0.024
772	0.03	2933	0.044	5090	0.04	7251	0.036	9411	0.024
773	0.03	2934	0.046	5091	0.04	7252	0.036	9412	0.024
774	0.03	2935	0.046	5092	0.04	7253	0.036	9413	0.024
775	0.032	2936	0.046	5093	0.038	7254	0.034	9414	0.024
776	0.032	2937	0.046	5094	0.038	7255	0.034	9415	0.024
777	0.03	2938	0.046	5095	0.04	7256	0.036	9416	0.024
778	0.03	2939	0.046	5096	0.04	7257	0.034	9417	0.022
779	0.032	2940	0.046	5097	0.04	7258	0.036	9418	0.024
780	0.032	2941	0.046	5098	0.038	7259	0.034	9419	0.026
781	0.032	2942	0.046	5099	0.038	7260	0.032	9420	0.024
782	0.03	2943	0.046	5100	0.038	7261	0.032	9421	0.024
783	0.032	2944	0.046	5101	0.038	7262	0.034	9422	0.024
784	0.032	2945	0.044	5102	0.038	7263	0.034	9423	0.024
785	0.03	2946	0.046	5103	0.038	7264	0.032	9424	0.024
786	0.032	2947	0.048	5104	0.038	7265	0.032	9425	0.024
787	0.036	2948	0.048	5105	0.036	7266	0.034	9426	0.026
788	0.036	2949	0.046	5106	0.04	7267	0.034	9427	0.024
789	0.036	2950	0.046	5107	0.038	7268	0.034	9428	0.024
790	0.036	2951	0.044	5108	0.034	7269	0.036	9429	0.024
791	0.034	2952	0.044	5109	0.034	7270	0.034	9430	0.024
792	0.032	2953	0.044	5110	0.036	7271	0.032	9431	0.024
793	0.034	2954	0.044	5111	0.036	7272	0.032	9432	0.022
794	0.032	2955	0.044	5112	0.036	7273	0.032	9433	0.024
795	0.032	2956	0.046	5113	0.036	7274	0.032	9434	0.024
796	0.034	2957	0.05	5114	0.036	7275	0.034	9435	0.026
797	0.032	2958	0.05	5115	0.036	7276	0.032	9436	0.024
798	0.032	2959	0.05	5116	0.036	7277	0.032	9437	0.024
799	0.036	2960	0.048	5117	0.036	7278	0.032	9438	0.024
800	0.034	2961	0.048	5118	0.036	7279	0.034	9439	0.024
801	0.032	2962	0.05	5119	0.036	7280	0.032	9440	0.024
802	0.034	2963	0.048	5120	0.036	7281	0.03	9441	0.024
803	0.034	2964	0.048	5121	0.036	7282	0.032	9442	0.024
804	0.034	2965	0.05	5122	0.036	7283	0.032	9443	0.024
805	0.032	2966	0.048	5123	0.036	7284	0.032	9444	0.026
806	0.032	2967	0.048	5124	0.036	7285	0.032	9445	0.026
807	0.03	2968	0.05	5125	0.036	7286	0.032	9446	0.026
808	0.032	2969	0.048	5126	0.036	7287	0.03	9447	0.024
809	0.032	2970	0.046	5127	0.036	7288	0.028	9448	0.026
810	0.032	2971	0.046	5128	0.038	7289	0.03	9449	0.026
811	0.032	2972	0.046	5129	0.036	7290	0.028	9450	0.026
812	0.032	2973	0.048	5130	0.036	7291	0.028	9451	0.024
813	0.032	2974	0.046	5131	0.038	7292	0.028	9452	0.026
814	0.03	2975	0.048	5132	0.036	7293	0.028	9453	0.026
815	0.03	2976	0.05	5133	0.036	7294	0.03	9454	0.024
816	0.032	2977	0.05	5134	0.036	7295	0.028	9455	0.024

817	0.032	2978	0.048	5135	0.036	7296	0.028	9456	0.026
818	0.032	2979	0.046	5136	0.036	7297	0.03	9457	0.026
819	0.032	2980	0.046	5137	0.036	7298	0.03	9458	0.026
820	0.032	2981	0.048	5138	0.038	7299	0.03	9459	0.026
821	0.028	2982	0.05	5139	0.04	7300	0.028	9460	0.026
822	0.03	2983	0.048	5140	0.04	7301	0.03	9461	0.026
823	0.03	2984	0.046	5141	0.038	7302	0.03	9462	0.026
824	0.03	2985	0.046	5142	0.038	7303	0.03	9463	0.024
825	0.03	2986	0.048	5143	0.038	7304	0.028	9464	0.024
826	0.03	2987	0.05	5144	0.038	7305	0.03	9465	0.026
827	0.028	2988	0.05	5145	0.04	7306	0.03	9466	0.026
828	0.03	2989	0.048	5146	0.036	7307	0.03	9467	0.026
829	0.03	2990	0.048	5147	0.036	7308	0.03	9468	0.028
830	0.03	2991	0.048	5148	0.036	7309	0.03	9469	0.028
831	0.03	2992	0.048	5149	0.036	7310	0.028	9470	0.026
832	0.03	2993	0.046	5150	0.036	7311	0.03	9471	0.026
833	0.03	2994	0.05	5151	0.038	7312	0.03	9472	0.024
834	0.03	2995	0.05	5152	0.04	7313	0.03	9473	0.026
835	0.028	2996	0.05	5153	0.04	7314	0.03	9474	0.028
836	0.028	2997	0.046	5154	0.038	7315	0.03	9475	0.026
837	0.03	2998	0.046	5155	0.038	7316	0.028	9476	0.026
838	0.028	2999	0.048	5156	0.038	7317	0.028	9477	0.026
839	0.028	3000	0.05	5157	0.036	7318	0.028	9478	0.026
840	0.03	3001	0.05	5158	0.036	7319	0.03	9479	0.024
841	0.03	3002	0.05	5159	0.036	7320	0.032	9480	0.026
842	0.03	3003	0.048	5160	0.036	7321	0.028	9481	0.026
843	0.032	3004	0.046	5161	0.036	7322	0.026	9482	0.026
844	0.032	3005	0.048	5162	0.036	7323	0.028	9483	0.026
845	0.03	3006	0.048	5163	0.038	7324	0.03	9484	0.026
846	0.03	3007	0.046	5164	0.038	7325	0.03	9485	0.026
847	0.03	3008	0.046	5165	0.038	7326	0.028	9486	0.026
848	0.03	3009	0.046	5166	0.038	7327	0.028	9487	0.026
849	0.03	3010	0.05	5167	0.038	7328	0.026	9488	0.026
850	0.03	3011	0.048	5168	0.038	7329	0.026	9489	0.026
851	0.028	3012	0.048	5169	0.038	7330	0.026	9490	0.026
852	0.028	3013	0.048	5170	0.038	7331	0.026	9491	0.026
853	0.03	3014	0.048	5171	0.038	7332	0.026	9492	0.028
854	0.028	3015	0.046	5172	0.038	7333	0.028	9493	0.028
855	0.028	3016	0.046	5173	0.04	7334	0.026	9494	0.026
856	0.03	3017	0.048	5174	0.038	7335	0.026	9495	0.026
857	0.03	3018	0.048	5175	0.038	7336	0.026	9496	0.026
858	0.028	3019	0.046	5176	0.04	7337	0.026	9497	0.026
859	0.03	3020	0.046	5177	0.04	7338	0.028	9498	0.026
860	0.03	3021	0.044	5178	0.04	7339	0.028	9499	0.026
861	0.028	3022	0.046	5179	0.038	7340	0.026	9500	0.026
862	0.028	3023	0.046	5180	0.038	7341	0.028	9501	0.026
863	0.03	3024	0.044	5181	0.038	7342	0.028	9502	0.028
864	0.03	3025	0.044	5182	0.038	7343	0.028	9503	0.028
865	0.03	3026	0.044	5183	0.038	7344	0.026	9504	0.026
866	0.03	3027	0.044	5184	0.038	7345	0.026	9505	0.026
867	0.03	3028	0.042	5185	0.038	7346	0.026	9506	0.026
868	0.032	3029	0.042	5186	0.038	7347	0.026	9507	0.028
869	0.03	3030	0.042	5187	0.038	7348	0.026	9508	0.028
870	0.028	3031	0.044	5188	0.04	7349	0.026	9509	0.026
871	0.03	3032	0.042	5189	0.04	7350	0.026	9510	0.026
872	0.03	3033	0.04	5190	0.04	7351	0.028	9511	0.026
873	0.028	3034	0.044	5191	0.038	7352	0.026	9512	0.026
874	0.028	3035	0.044	5192	0.038	7353	0.026	9513	0.026
875	0.03	3036	0.044	5193	0.038	7354	0.028	9514	0.03
876	0.03	3037	0.042	5194	0.038	7355	0.028	9515	0.028
877	0.03	3038	0.042	5195	0.038	7356	0.028	9516	0.026
878	0.03	3039	0.042	5196	0.04	7357	0.028	9517	0.026
879	0.03	3040	0.042	5197	0.04	7358	0.028	9518	0.028
880	0.03	3041	0.042	5198	0.038	7359	0.028	9519	0.028
881	0.03	3042	0.042	5199	0.038	7360	0.028	9520	0.026
882	0.03	3043	0.042	5200	0.038	7361	0.026	9521	0.026
883	0.028	3044	0.042	5201	0.038	7362	0.028	9522	0.024
884	0.03	3045	0.044	5202	0.04	7363	0.028	9523	0.026
885	0.028	3046	0.046	5203	0.038	7364	0.028	9524	0.026
886	0.026	3047	0.044	5204	0.04	7365	0.028	9525	0.028
887	0.03	3048	0.042	5205	0.038	7366	0.028	9526	0.028
888	0.032	3049	0.044	5206	0.04	7367	0.028	9527	0.028
889	0.03	3050	0.042	5207	0.044	7368	0.028	9528	0.026
890	0.028	3051	0.044	5208	0.046	7369	0.028	9529	0.026
891	0.028	3052	0.044	5209	0.046	7370	0.028	9530	0.028
892	0.028	3053	0.046	5210	0.048	7371	0.026	9531	0.028
893	0.028	3054	0.046	5211	0.046	7372	0.026	9532	0.026
894	0.028	3055	0.044	5212	0.042	7373	0.026	9533	0.028
895	0.026	3056	0.044	5213	0.046	7374	0.026	9534	0.026
896	0.028	3057	0.044	5214	0.048	7375	0.024	9535	0.026
897	0.03	3058	0.044	5215	0.044	7376	0.026	9536	0.026
898	0.03	3059	0.044	5216	0.042	7377	0.026	9537	0.026
899	0.03	3060	0.044	5217	0.042	7378	0.026	9538	0.028
900	0.028	3061	0.044	5218	0.042	7379	0.026	9539	0.026
901	0.028	3062	0.046	5219	0.04	7380	0.026	9540	0.028
902	0.03	3063	0.046	5220	0.042	7381	0.026	9541	0.03
903	0.028	3064	0.044	5221	0.04	7382	0.024	9542	0.028
904	0.028	3065	0.044	5222	0.042	7383	0.026	9543	0.026
905	0.03	3066	0.044	5223	0.042	7384	0.026	9544	0.026
906	0.028	3067	0.042	5224	0.04	7385	0.026	9545	0.028
907	0.028	3068	0.044	5225	0.042	7386	0.026	9546	0.028
908	0.028	3069	0.044	5226	0.042	7387	0.026	9547	0.028
909	0.028	3070	0.044	5227	0.042	7388	0.028	9548	0.026

910	0.028	3071	0.044	5228	0.042	7389	0.028	9549	0.028
911	0.028	3072	0.044	5229	0.04	7390	0.026	9550	0.028
912	0.028	3073	0.042	5230	0.04	7391	0.026	9551	0.028
913	0.026	3074	0.04	5231	0.04	7392	0.028	9552	0.026
914	0.028	3075	0.04	5232	0.042	7393	0.028	9553	0.028
915	0.028	3076	0.042	5233	0.044	7394	0.024	9554	0.026
916	0.03	3077	0.042	5234	0.042	7395	0.026	9555	0.028
917	0.03	3078	0.042	5235	0.042	7396	0.026	9556	0.028
918	0.028	3079	0.042	5236	0.042	7397	0.024	9557	0.028
919	0.028	3080	0.044	5237	0.042	7398	0.026	9558	0.026
920	0.028	3081	0.042	5238	0.042	7399	0.026	9559	0.026
921	0.028	3082	0.042	5239	0.04	7400	0.024	9560	0.026
922	0.028	3083	0.04	5240	0.04	7401	0.024	9561	0.026
923	0.028	3084	0.042	5241	0.04	7402	0.026	9562	0.026
924	0.028	3085	0.042	5242	0.04	7403	0.026	9563	0.026
925	0.028	3086	0.04	5243	0.04	7404	0.026	9564	0.028
926	0.028	3087	0.044	5244	0.04	7405	0.026	9565	0.026
927	0.028	3088	0.042	5245	0.04	7406	0.026	9566	0.026
928	0.03	3089	0.042	5246	0.04	7407	0.026	9567	0.026
929	0.028	3090	0.042	5247	0.04	7408	0.026	9568	0.026
930	0.026	3091	0.04	5248	0.04	7409	0.026	9569	0.026
931	0.028	3092	0.042	5249	0.04	7410	0.026	9570	0.026
932	0.028	3093	0.044	5250	0.04	7411	0.028	9571	0.026
933	0.028	3094	0.044	5251	0.042	7412	0.028	9572	0.026
934	0.028	3095	0.044	5252	0.04	7413	0.026	9573	0.026
935	0.028	3096	0.042	5253	0.038	7414	0.024	9574	0.026
936	0.03	3097	0.042	5254	0.038	7415	0.026	9575	0.028
937	0.028	3098	0.042	5255	0.04	7416	0.026	9576	0.028
938	0.028	3099	0.042	5256	0.04	7417	0.026	9577	0.024
939	0.028	3100	0.044	5257	0.04	7418	0.026	9578	0.024
940	0.028	3101	0.044	5258	0.04	7419	0.024	9579	0.026
941	0.028	3102	0.042	5259	0.04	7420	0.026	9580	0.026
942	0.03	3103	0.042	5260	0.04	7421	0.024	9581	0.026
943	0.028	3104	0.042	5261	0.04	7422	0.024	9582	0.026
944	0.026	3105	0.044	5262	0.04	7423	0.026	9583	0.026
945	0.026	3106	0.044	5263	0.04	7424	0.026	9584	0.026
946	0.028	3107	0.044	5264	0.04	7425	0.024	9585	0.028
947	0.028	3108	0.042	5265	0.042	7426	0.024	9586	0.026
948	0.028	3109	0.046	5266	0.042	7427	0.024	9587	0.026
949	0.028	3110	0.048	5267	0.04	7428	0.026	9588	0.026
950	0.03	3111	0.044	5268	0.04	7429	0.028	9589	0.026
951	0.028	3112	0.046	5269	0.04	7430	0.026	9590	0.026
952	0.036	3113	0.046	5270	0.04	7431	0.026	9591	0.028
953	0.056	3114	0.048	5271	0.04	7432	0.026	9592	0.028
954	0.066	3115	0.044	5272	0.042	7433	0.028	9593	0.028
955	0.062	3116	0.044	5273	0.04	7434	0.026	9594	0.026
956	0.058	3117	0.044	5274	0.04	7435	0.026	9595	0.026
957	0.056	3118	0.044	5275	0.04	7436	0.028	9596	0.026
958	0.054	3119	0.044	5276	0.04	7437	0.028	9597	0.028
959	0.048	3120	0.044	5277	0.04	7438	0.026	9598	0.028
960	0.044	3121	0.046	5278	0.04	7439	0.026	9599	0.028
961	0.042	3122	0.046	5279	0.042	7440	0.026	9600	0.028
962	0.042	3123	0.048	5280	0.042	7441	0.028	9601	0.026
963	0.042	3124	0.046	5281	0.042	7442	0.028	9602	0.026
964	0.04	3125	0.046	5282	0.042	7443	0.026	9603	0.026
965	0.042	3126	0.046	5283	0.042	7444	0.026	9604	0.026
966	0.044	3127	0.044	5284	0.042	7445	0.026	9605	0.026
967	0.042	3128	0.044	5285	0.04	7446	0.024	9606	0.024
968	0.046	3129	0.044	5286	0.04	7447	0.026	9607	0.026
969	0.046	3130	0.044	5287	0.042	7448	0.028	9608	0.026
970	0.048	3131	0.044	5288	0.042	7449	0.026	9609	0.026
971	0.044	3132	0.048	5289	0.04	7450	0.026	9610	0.026
972	0.038	3133	0.05	5290	0.04	7451	0.026	9611	0.026
973	0.032	3134	0.048	5291	0.042	7452	0.026	9612	0.028
974	0.034	3135	0.05	5292	0.042	7453	0.026	9613	0.026
975	0.034	3136	0.048	5293	0.04	7454	0.026	9614	0.026
976	0.032	3137	0.05	5294	0.04	7455	0.028	9615	0.026
977	0.032	3138	0.05	5295	0.04	7456	0.028	9616	0.026
978	0.034	3139	0.048	5296	0.04	7457	0.026	9617	0.026
979	0.032	3140	0.05	5297	0.038	7458	0.026	9618	0.026
980	0.032	3141	0.048	5298	0.038	7459	0.026	9619	0.028
981	0.032	3142	0.05	5299	0.038	7460	0.026	9620	0.028
982	0.032	3143	0.05	5300	0.038	7461	0.026	9621	0.026
983	0.032	3144	0.05	5301	0.038	7462	0.026	9622	0.026
984	0.032	3145	0.05	5302	0.038	7463	0.028	9623	0.026
985	0.036	3146	0.05	5303	0.038	7464	0.028	9624	0.026
986	0.04	3147	0.048	5304	0.04	7465	0.026	9625	0.026
987	0.04	3148	0.05	5305	0.038	7466	0.026	9626	0.028
988	0.04	3149	0.052	5306	0.04	7467	0.028	9627	0.026
989	0.038	3150	0.05	5307	0.04	7468	0.026	9628	0.026
990	0.04	3151	0.048	5308	0.036	7469	0.028	9629	0.026
991	0.036	3152	0.05	5309	0.038	7470	0.028	9630	0.026
992	0.036	3153	0.052	5310	0.038	7471	0.026	9631	0.028
993	0.036	3154	0.05	5311	0.038	7472	0.026	9632	0.028
994	0.036	3155	0.05	5312	0.036	7473	0.028	9633	0.026
995	0.034	3156	0.048	5313	0.038	7474	0.028	9634	0.026
996	0.034	3157	0.048	5314	0.04	7475	0.026	9635	0.026
997	0.034	3158	0.048	5315	0.038	7476	0.028	9636	0.026
998	0.036	3159	0.048	5316	0.036	7477	0.026	9637	0.028
999	0.036	3160	0.048	5317	0.038	7478	0.028	9638	0.028
1000	0.036	3161	0.048	5318	0.04	7479	0.028	9639	0.028
1001	0.036	3162	0.048	5319	0.038	7480	0.026	9640	0.026
1002	0.036	3163	0.048	5320	0.038	7481	0.026	9641	0.028

1003	0.038	3164	0.044	5321	0.038	7482	0.028	9642	0.028
1004	0.036	3165	0.046	5322	0.038	7483	0.026	9643	0.026
1005	0.034	3166	0.046	5323	0.038	7484	0.028	9644	0.026
1006	0.036	3167	0.046	5324	0.038	7485	0.026	9645	0.026
1007	0.036	3168	0.044	5325	0.04	7486	0.026	9646	0.028
1008	0.034	3169	0.044	5326	0.038	7487	0.028	9647	0.028
1009	0.034	3170	0.044	5327	0.04	7488	0.028	9648	0.028
1010	0.034	3171	0.044	5328	0.038	7489	0.028	9649	0.028
1011	0.034	3172	0.042	5329	0.038	7490	0.026	9650	0.028
1012	0.036	3173	0.042	5330	0.038	7491	0.026	9651	0.026
1013	0.034	3174	0.042	5331	0.038	7492	0.026	9652	0.028
1014	0.034	3175	0.042	5332	0.038	7493	0.026	9653	0.028
1015	0.036	3176	0.04	5333	0.036	7494	0.026	9654	0.026
1016	0.036	3177	0.04	5334	0.036	7495	0.026	9655	0.026
1017	0.034	3178	0.04	5335	0.036	7496	0.028	9656	0.026
1018	0.036	3179	0.04	5336	0.038	7497	0.026	9657	0.026
1019	0.036	3180	0.04	5337	0.038	7498	0.026	9658	0.026
1020	0.036	3181	0.042	5338	0.038	7499	0.026	9659	0.026
1021	0.034	3182	0.04	5339	0.038	7500	0.026	9660	0.028
1022	0.034	3183	0.04	5340	0.038	7501	0.026	9661	0.028
1023	0.034	3184	0.038	5341	0.036	7502	0.028	9662	0.026
1024	0.034	3185	0.04	5342	0.038	7503	0.028	9663	0.026
1025	0.034	3186	0.04	5343	0.036	7504	0.026	9664	0.026
1026	0.034	3187	0.038	5344	0.038	7505	0.026	9665	0.028
1027	0.036	3188	0.04	5345	0.038	7506	0.026	9666	0.028
1028	0.036	3189	0.038	5346	0.038	7507	0.028	9667	0.028
1029	0.034	3190	0.038	5347	0.04	7508	0.026	9668	0.026
1030	0.034	3191	0.04	5348	0.038	7509	0.026	9669	0.026
1031	0.034	3192	0.04	5349	0.038	7510	0.028	9670	0.026
1032	0.034	3193	0.042	5350	0.038	7511	0.028	9671	0.026
1033	0.034	3194	0.042	5351	0.04	7512	0.026	9672	0.028
1034	0.036	3195	0.042	5352	0.038	7513	0.026	9673	0.026
1035	0.034	3196	0.04	5353	0.038	7514	0.026	9674	0.026
1036	0.032	3197	0.042	5354	0.038	7515	0.028	9675	0.026
1037	0.034	3198	0.04	5355	0.038	7516	0.026	9676	0.026
1038	0.034	3199	0.04	5356	0.038	7517	0.026	9677	0.026
1039	0.032	3200	0.042	5357	0.036	7518	0.026	9678	0.026
1040	0.032	3201	0.042	5358	0.038	7519	0.028	9679	0.026
1041	0.032	3202	0.04	5359	0.038	7520	0.026	9680	0.026
1042	0.034	3203	0.042	5360	0.036	7521	0.026	9681	0.028
1043	0.036	3204	0.04	5361	0.038	7522	0.026	9682	0.028
1044	0.034	3205	0.04	5362	0.038	7523	0.026	9683	0.028
1045	0.034	3206	0.04	5363	0.038	7524	0.026	9684	0.03
1046	0.034	3207	0.04	5364	0.04	7525	0.026	9685	0.028
1047	0.034	3208	0.04	5365	0.038	7526	0.026	9686	0.028
1048	0.034	3209	0.04	5366	0.04	7527	0.026	9687	0.03
1049	0.032	3210	0.042	5367	0.038	7528	0.028	9688	0.03
1050	0.034	3211	0.042	5368	0.038	7529	0.028	9689	0.028
1051	0.034	3212	0.042	5369	0.038	7530	0.028	9690	0.028
1052	0.032	3213	0.04	5370	0.038	7531	0.026	9691	0.028
1053	0.032	3214	0.04	5371	0.038	7532	0.028	9692	0.028
1054	0.032	3215	0.04	5372	0.038	7533	0.028	9693	0.028
1055	0.032	3216	0.042	5373	0.038	7534	0.028	9694	0.028
1056	0.032	3217	0.042	5374	0.038	7535	0.028	9695	0.028
1057	0.032	3218	0.042	5375	0.038	7536	0.028	9696	0.026
1058	0.032	3219	0.042	5376	0.04	7537	0.028	9697	0.028
1059	0.034	3220	0.042	5377	0.04	7538	0.028	9698	0.028
1060	0.032	3221	0.042	5378	0.042	7539	0.028	9699	0.028
1061	0.032	3222	0.042	5379	0.038	7540	0.028	9700	0.028
1062	0.032	3223	0.04	5380	0.038	7541	0.028	9701	0.026
1063	0.032	3224	0.04	5381	0.036	7542	0.028	9702	0.028
1064	0.03	3225	0.04	5382	0.038	7543	0.028	9703	0.028
1065	0.03	3226	0.042	5383	0.04	7544	0.028	9704	0.028
1066	0.03	3227	0.04	5384	0.04	7545	0.026	9705	0.028
1067	0.032	3228	0.04	5385	0.04	7546	0.028	9706	0.026
1068	0.032	3229	0.04	5386	0.036	7547	0.028	9707	0.028
1069	0.032	3230	0.038	5387	0.036	7548	0.028	9708	0.026
1070	0.032	3231	0.04	5388	0.036	7549	0.028	9709	0.028
1071	0.03	3232	0.04	5389	0.036	7550	0.028	9710	0.028
1072	0.032	3233	0.04	5390	0.036	7551	0.03	9711	0.028
1073	0.032	3234	0.04	5391	0.036	7552	0.028	9712	0.028
1074	0.03	3235	0.038	5392	0.034	7553	0.028	9713	0.028
1075	0.03	3236	0.04	5393	0.036	7554	0.028	9714	0.028
1076	0.03	3237	0.038	5394	0.036	7555	0.028	9715	0.026
1077	0.032	3238	0.038	5395	0.038	7556	0.03	9716	0.028
1078	0.032	3239	0.04	5396	0.04	7557	0.03	9717	0.028
1079	0.03	3240	0.04	5397	0.036	7558	0.032	9718	0.028
1080	0.03	3241	0.042	5398	0.036	7559	0.03	9719	0.03
1081	0.03	3242	0.04	5399	0.036	7560	0.03	9720	0.028
1082	0.03	3243	0.04	5400	0.036	7561	0.03	9721	0.026
1083	0.03	3244	0.04	5401	0.036	7562	0.03	9722	0.026
1084	0.03	3245	0.038	5402	0.036	7563	0.03	9723	0.026
1085	0.032	3246	0.038	5403	0.034	7564	0.03	9724	0.026
1086	0.03	3247	0.042	5404	0.034	7565	0.03	9725	0.026
1087	0.03	3248	0.04	5405	0.036	7566	0.03	9726	0.026
1088	0.03	3249	0.04	5406	0.036	7567	0.028	9727	0.026
1089	0.032	3250	0.04	5407	0.036	7568	0.032	9728	0.026
1090	0.03	3251	0.04	5408	0.036	7569	0.032	9729	0.024
1091	0.032	3252	0.04	5409	0.036	7570	0.03	9730	0.024
1092	0.032	3253	0.04	5410	0.036	7571	0.03	9731	0.026
1093	0.032	3254	0.04	5411	0.036	7572	0.03	9732	0.026
1094	0.032	3255	0.04	5412	0.036	7573	0.028	9733	0.024
1095	0.032	3256	0.038	5413	0.036	7574	0.028	9734	0.024

73	0.036	2234	0.046	4391	0.054	6552	0.032	8712	0.028
74	0.034	2235	0.046	4392	0.054	6553	0.032	8713	0.03
75	0.036	2236	0.042	4393	0.052	6554	0.03	8714	0.03
76	0.036	2237	0.044	4394	0.054	6555	0.032	8715	0.03
77	0.036	2238	0.044	4395	0.052	6556	0.034	8716	0.03
78	0.038	2239	0.044	4396	0.052	6557	0.034	8717	0.026
79	0.038	2240	0.046	4397	0.054	6558	0.032	8718	0.028
80	0.038	2241	0.044	4398	0.056	6559	0.032	8719	0.03
81	0.036	2242	0.044	4399	0.054	6560	0.032	8720	0.03
82	0.036	2243	0.044	4400	0.054	6561	0.032	8721	0.03
83	0.036	2244	0.044	4401	0.054	6562	0.032	8722	0.03
84	0.034	2245	0.044	4402	0.054	6563	0.034	8723	0.028
85	0.034	2246	0.044	4403	0.052	6564	0.032	8724	0.028
86	0.038	2247	0.042	4404	0.054	6565	0.032	8725	0.028
87	0.038	2248	0.044	4405	0.054	6566	0.034	8726	0.03
88	0.038	2249	0.044	4406	0.052	6567	0.032	8727	0.03
89	0.038	2250	0.044	4407	0.054	6568	0.032	8728	0.03
90	0.036	2251	0.044	4408	0.054	6569	0.032	8729	0.028
91	0.034	2252	0.04	4409	0.052	6570	0.03	8730	0.03
92	0.034	2253	0.042	4410	0.054	6571	0.032	8731	0.03
93	0.034	2254	0.042	4411	0.054	6572	0.034	8732	0.032
94	0.036	2255	0.038	4412	0.052	6573	0.032	8733	0.034
95	0.036	2256	0.04	4413	0.054	6574	0.032	8734	0.034
96	0.036	2257	0.038	4414	0.054	6575	0.032	8735	0.034
97	0.036	2258	0.038	4415	0.054	6576	0.032	8736	0.034
98	0.036	2259	0.038	4416	0.054	6577	0.032	8737	0.036
99	0.036	2260	0.038	4417	0.054	6578	0.032	8738	0.034
100	0.036	2261	0.034	4418	0.054	6579	0.032	8739	0.034
101	0.038	2262	0.036	4419	0.052	6580	0.032	8740	0.032
102	0.036	2263	0.036	4420	0.052	6581	0.032	8741	0.032
103	0.036	2264	0.036	4421	0.052	6582	0.032	8742	0.032
104	0.036	2265	0.036	4422	0.05	6583	0.034	8743	0.032
105	0.036	2266	0.034	4423	0.052	6584	0.034	8744	0.032
106	0.034	2267	0.036	4424	0.052	6585	0.034	8745	0.03
107	0.036	2268	0.036	4425	0.05	6586	0.032	8746	0.03
108	0.036	2269	0.034	4426	0.052	6587	0.032	8747	0.028
109	0.038	2270	0.034	4427	0.05	6588	0.034	8748	0.028
110	0.036	2271	0.034	4428	0.05	6589	0.034	8749	0.028
111	0.036	2272	0.036	4429	0.05	6590	0.034	8750	0.03
112	0.036	2273	0.036	4430	0.052	6591	0.032	8751	0.028
113	0.034	2274	0.038	4431	0.048	6592	0.034	8752	0.03
114	0.034	2275	0.038	4432	0.05	6593	0.036	8753	0.028
115	0.034	2276	0.036	4433	0.056	6594	0.034	8754	0.026
116	0.036	2277	0.038	4434	0.056	6595	0.034	8755	0.028
117	0.036	2278	0.036	4435	0.054	6596	0.036	8756	0.028
118	0.036	2279	0.036	4436	0.052	6597	0.036	8757	0.026
119	0.036	2280	0.038	4437	0.05	6598	0.034	8758	0.026
120	0.034	2281	0.038	4438	0.05	6599	0.036	8759	0.026
121	0.036	2282	0.038	4439	0.052	6600	0.036	8760	0.026
122	0.04	2283	0.036	4440	0.052	6601	0.036	8761	0.026
123	0.034	2284	0.036	4441	0.052	6602	0.038	8762	0.026
124	0.036	2285	0.038	4442	0.052	6603	0.036	8763	0.026
125	0.036	2286	0.038	4443	0.052	6604	0.036	8764	0.028
126	0.034	2287	0.038	4444	0.052	6605	0.034	8765	0.026
127	0.032	2288	0.038	4445	0.054	6606	0.034	8766	0.026
128	0.032	2289	0.04	4446	0.054	6607	0.036	8767	0.028
129	0.034	2290	0.04	4447	0.05	6608	0.036	8768	0.028
130	0.034	2291	0.04	4448	0.05	6609	0.036	8769	0.028
131	0.036	2292	0.038	4449	0.05	6610	0.036	8770	0.026
132	0.034	2293	0.038	4450	0.05	6611	0.036	8771	0.026
133	0.032	2294	0.04	4451	0.052	6612	0.034	8772	0.026
134	0.034	2295	0.04	4452	0.052	6613	0.036	8773	0.028
135	0.034	2296	0.036	4453	0.05	6614	0.034	8774	0.026
136	0.034	2297	0.038	4454	0.05	6615	0.034	8775	0.028
137	0.034	2298	0.038	4455	0.052	6616	0.034	8776	0.028
138	0.034	2299	0.038	4456	0.052	6617	0.032	8777	0.026
139	0.034	2300	0.038	4457	0.05	6618	0.032	8778	0.026
140	0.034	2301	0.038	4458	0.05	6619	0.034	8779	0.028
141	0.034	2302	0.038	4459	0.046	6620	0.034	8780	0.026
142	0.034	2303	0.04	4460	0.046	6621	0.034	8781	0.026
143	0.034	2304	0.04	4461	0.046	6622	0.032	8782	0.026
144	0.034	2305	0.038	4462	0.046	6623	0.034	8783	0.028
145	0.036	2306	0.038	4463	0.046	6624	0.034	8784	0.028
146	0.036	2307	0.038	4464	0.048	6625	0.034	8785	0.026
147	0.034	2308	0.038	4465	0.048	6626	0.034	8786	0.026
148	0.034	2309	0.04	4466	0.048	6627	0.032	8787	0.028
149	0.034	2310	0.038	4467	0.046	6628	0.032	8788	0.028
150	0.034	2311	0.036	4468	0.048	6629	0.032	8789	0.026
151	0.034	2312	0.038	4469	0.05	6630	0.032	8790	0.026
152	0.034	2313	0.038	4470	0.048	6631	0.032	8791	0.028
153	0.034	2314	0.04	4471	0.044	6632	0.032	8792	0.028
154	0.034	2315	0.04	4472	0.046	6633	0.032	8793	0.026
155	0.034	2316	0.04	4473	0.048	6634	0.032	8794	0.026
156	0.034	2317	0.04	4474	0.046	6635	0.034	8795	0.026
157	0.032	2318	0.04	4475	0.046	6636	0.036	8796	0.028
158	0.034	2319	0.04	4476	0.046	6637	0.034	8797	0.028
159	0.036	2320	0.042	4477	0.046	6638	0.034	8798	0.026
160	0.034	2321	0.044	4478	0.048	6639	0.032	8799	0.026
161	0.034	2322	0.042	4479	0.048	6640	0.034	8800	0.026
162	0.034	2323	0.042	4480	0.046	6641	0.034	8801	0.026
163	0.032	2324	0.042	4481	0.046	6642	0.034	8802	0.026
164	0.034	2325	0.042	4482	0.046	6643	0.032	8803	0.026
165	0.036	2326	0.044	4483	0.048	6644	0.034	8804	0.026

166	0.034	2327	0.042	4484	0.048	6645	0.034	8805	0.028
167	0.032	2328	0.042	4485	0.046	6646	0.036	8806	0.028
168	0.036	2329	0.042	4486	0.048	6647	0.036	8807	0.028
169	0.036	2330	0.042	4487	0.048	6648	0.036	8808	0.028
170	0.032	2331	0.042	4488	0.048	6649	0.036	8809	0.026
171	0.034	2332	0.044	4489	0.05	6650	0.036	8810	0.026
172	0.034	2333	0.044	4490	0.048	6651	0.038	8811	0.028
173	0.034	2334	0.042	4491	0.048	6652	0.036	8812	0.026
174	0.034	2335	0.042	4492	0.048	6653	0.036	8813	0.026
175	0.034	2336	0.042	4493	0.048	6654	0.036	8814	0.03
176	0.034	2337	0.042	4494	0.046	6655	0.038	8815	0.028
177	0.034	2338	0.042	4495	0.046	6656	0.038	8816	0.026
178	0.034	2339	0.042	4496	0.048	6657	0.036	8817	0.026
179	0.036	2340	0.042	4497	0.05	6658	0.036	8818	0.026
180	0.034	2341	0.042	4498	0.05	6659	0.034	8819	0.026
181	0.032	2342	0.042	4499	0.048	6660	0.036	8820	0.026
182	0.034	2343	0.044	4500	0.048	6661	0.036	8821	0.026
183	0.034	2344	0.042	4501	0.048	6662	0.036	8822	0.026
184	0.036	2345	0.042	4502	0.048	6663	0.036	8823	0.028
185	0.036	2346	0.04	4503	0.046	6664	0.036	8824	0.028
186	0.034	2347	0.042	4504	0.046	6665	0.038	8825	0.028
187	0.036	2348	0.042	4505	0.048	6666	0.038	8826	0.028
188	0.036	2349	0.044	4506	0.046	6667	0.036	8827	0.026
189	0.034	2350	0.042	4507	0.046	6668	0.038	8828	0.026
190	0.032	2351	0.042	4508	0.046	6669	0.038	8829	0.026
191	0.034	2352	0.042	4509	0.046	6670	0.036	8830	0.026
192	0.032	2353	0.04	4510	0.046	6671	0.036	8831	0.026
193	0.034	2354	0.04	4511	0.046	6672	0.036	8832	0.026
194	0.034	2355	0.04	4512	0.046	6673	0.036	8833	0.028
195	0.034	2356	0.04	4513	0.048	6674	0.036	8834	0.028
196	0.032	2357	0.04	4514	0.048	6675	0.036	8835	0.028
197	0.034	2358	0.04	4515	0.046	6676	0.036	8836	0.026
198	0.032	2359	0.04	4516	0.048	6677	0.036	8837	0.028
199	0.034	2360	0.04	4517	0.048	6678	0.038	8838	0.028
200	0.032	2361	0.038	4518	0.048	6679	0.038	8839	0.03
201	0.032	2362	0.038	4519	0.048	6680	0.038	8840	0.028
202	0.032	2363	0.04	4520	0.046	6681	0.038	8841	0.028
203	0.032	2364	0.04	4521	0.048	6682	0.036	8842	0.026
204	0.032	2365	0.038	4522	0.048	6683	0.034	8843	0.026
205	0.034	2366	0.04	4523	0.046	6684	0.036	8844	0.028
206	0.034	2367	0.04	4524	0.046	6685	0.036	8845	0.026
207	0.034	2368	0.04	4525	0.046	6686	0.038	8846	0.026
208	0.034	2369	0.038	4526	0.046	6687	0.036	8847	0.026
209	0.034	2370	0.04	4527	0.048	6688	0.036	8848	0.026
210	0.032	2371	0.04	4528	0.046	6689	0.036	8849	0.028
211	0.032	2372	0.04	4529	0.046	6690	0.034	8850	0.028
212	0.032	2373	0.042	4530	0.046	6691	0.036	8851	0.028
213	0.032	2374	0.038	4531	0.046	6692	0.036	8852	0.026
214	0.032	2375	0.04	4532	0.046	6693	0.036	8853	0.026
215	0.034	2376	0.04	4533	0.048	6694	0.036	8854	0.028
216	0.034	2377	0.04	4534	0.048	6695	0.038	8855	0.028
217	0.032	2378	0.04	4535	0.05	6696	0.036	8856	0.028
218	0.032	2379	0.04	4536	0.048	6697	0.038	8857	0.028
219	0.034	2380	0.04	4537	0.046	6698	0.038	8858	0.028
220	0.034	2381	0.038	4538	0.044	6699	0.038	8859	0.026
221	0.032	2382	0.038	4539	0.046	6700	0.036	8860	0.028
222	0.03	2383	0.04	4540	0.046	6701	0.036	8861	0.028
223	0.03	2384	0.042	4541	0.046	6702	0.038	8862	0.026
224	0.032	2385	0.044	4542	0.046	6703	0.038	8863	0.028
225	0.032	2386	0.042	4543	0.048	6704	0.038	8864	0.028
226	0.03	2387	0.042	4544	0.048	6705	0.038	8865	0.026
227	0.032	2388	0.042	4545	0.048	6706	0.036	8866	0.026
228	0.032	2389	0.042	4546	0.048	6707	0.036	8867	0.026
229	0.034	2390	0.042	4547	0.048	6708	0.036	8868	0.026
230	0.034	2391	0.042	4548	0.048	6709	0.036	8869	0.026
231	0.034	2392	0.04	4549	0.048	6710	0.036	8870	0.028
232	0.032	2393	0.04	4550	0.048	6711	0.036	8871	0.028
233	0.032	2394	0.04	4551	0.046	6712	0.036	8872	0.028
234	0.032	2395	0.04	4552	0.048	6713	0.036	8873	0.028
235	0.032	2396	0.042	4553	0.048	6714	0.036	8874	0.026
236	0.032	2397	0.04	4554	0.046	6715	0.036	8875	0.026
237	0.034	2398	0.04	4555	0.046	6716	0.036	8876	0.028
238	0.032	2399	0.04	4556	0.048	6717	0.038	8877	0.028
239	0.032	2400	0.042	4557	0.048	6718	0.038	8878	0.026
240	0.032	2401	0.042	4558	0.048	6719	0.038	8879	0.028
241	0.032	2402	0.04	4559	0.05	6720	0.038	8880	0.028
242	0.032	2403	0.04	4560	0.052	6721	0.038	8881	0.028
243	0.03	2404	0.04	4561	0.052	6722	0.036	8882	0.026
244	0.03	2405	0.04	4562	0.052	6723	0.036	8883	0.026
245	0.03	2406	0.038	4563	0.05	6724	0.038	8884	0.028
246	0.032	2407	0.038	4564	0.05	6725	0.036	8885	0.028
247	0.032	2408	0.04	4565	0.052	6726	0.036	8886	0.028
248	0.032	2409	0.042	4566	0.05	6727	0.036	8887	0.028
249	0.032	2410	0.04	4567	0.052	6728	0.038	8888	0.028
250	0.032	2411	0.04	4568	0.054	6729	0.036	8889	0.028
251	0.032	2412	0.04	4569	0.054	6730	0.036	8890	0.026
252	0.032	2413	0.04	4570	0.052	6731	0.036	8891	0.028
253	0.03	2414	0.038	4571	0.054	6732	0.036	8892	0.03
254	0.03	2415	0.038	4572	0.052	6733	0.038	8893	0.03
255	0.03	2416	0.038	4573	0.05	6734	0.036	8894	0.028
256	0.03	2417	0.04	4574	0.048	6735	0.038	8895	0.028
257	0.03	2418	0.04	4575	0.05	6736	0.04	8896	0.028
258	0.03	2419	0.038	4576	0.05	6737	0.036	8897	0.028

259	0.03	2420	0.04	4577	0.05	6738	0.036	8898	0.028
260	0.03	2421	0.042	4578	0.048	6739	0.036	8899	0.028
261	0.03	2422	0.04	4579	0.046	6740	0.034	8900	0.028
262	0.034	2423	0.038	4580	0.048	6741	0.034	8901	0.028
263	0.032	2424	0.04	4581	0.05	6742	0.034	8902	0.03
264	0.03	2425	0.04	4582	0.05	6743	0.034	8903	0.028
265	0.03	2426	0.04	4583	0.048	6744	0.034	8904	0.028
266	0.03	2427	0.036	4584	0.054	6745	0.034	8905	0.028
267	0.032	2428	0.038	4585	0.056	6746	0.036	8906	0.028
268	0.032	2429	0.038	4586	0.052	6747	0.036	8907	0.03
269	0.032	2430	0.038	4587	0.048	6748	0.034	8908	0.022
270	0.032	2431	0.038	4588	0.048	6749	0.036	8909	0.026
271	0.034	2432	0.04	4589	0.05	6750	0.036	8910	0.026
272	0.036	2433	0.042	4590	0.05	6751	0.036	8911	0.026
273	0.036	2434	0.038	4591	0.05	6752	0.036	8912	0.028
274	0.034	2435	0.038	4592	0.05	6753	0.036	8913	0.028
275	0.034	2436	0.038	4593	0.05	6754	0.034	8914	0.026
276	0.038	2437	0.038	4594	0.05	6755	0.036	8915	0.028
277	0.036	2438	0.036	4595	0.05	6756	0.038	8916	0.026
278	0.034	2439	0.038	4596	0.05	6757	0.036	8917	0.028
279	0.034	2440	0.038	4597	0.05	6758	0.036	8918	0.028
280	0.034	2441	0.04	4598	0.05	6759	0.034	8919	0.026
281	0.034	2442	0.04	4599	0.052	6760	0.034	8920	0.026
282	0.032	2443	0.04	4600	0.052	6761	0.034	8921	0.026
283	0.034	2444	0.038	4601	0.052	6762	0.036	8922	0.028
284	0.034	2445	0.038	4602	0.052	6763	0.036	8923	0.028
285	0.034	2446	0.04	4603	0.05	6764	0.036	8924	0.028
286	0.036	2447	0.042	4604	0.052	6765	0.034	8925	0.028
287	0.034	2448	0.044	4605	0.052	6766	0.036	8926	0.026
288	0.032	2449	0.046	4606	0.05	6767	0.034	8927	0.028
289	0.034	2450	0.044	4607	0.05	6768	0.036	8928	0.028
290	0.034	2451	0.044	4608	0.054	6769	0.036	8929	0.028
291	0.034	2452	0.046	4609	0.052	6770	0.034	8930	0.028
292	0.034	2453	0.048	4610	0.052	6771	0.032	8931	0.028
293	0.032	2454	0.048	4611	0.054	6772	0.032	8932	0.028
294	0.032	2455	0.05	4612	0.052	6773	0.034	8933	0.028
295	0.032	2456	0.048	4613	0.052	6774	0.036	8934	0.026
296	0.034	2457	0.048	4614	0.054	6775	0.034	8935	0.028
297	0.036	2458	0.046	4615	0.052	6776	0.032	8936	0.028
298	0.032	2459	0.046	4616	0.052	6777	0.034	8937	0.028
299	0.032	2460	0.048	4617	0.054	6778	0.036	8938	0.026
300	0.032	2461	0.048	4618	0.054	6779	0.034	8939	0.026
301	0.032	2462	0.048	4619	0.052	6780	0.034	8940	0.028
302	0.032	2463	0.048	4620	0.052	6781	0.036	8941	0.026
303	0.032	2464	0.046	4621	0.052	6782	0.034	8942	0.028
304	0.032	2465	0.048	4622	0.054	6783	0.032	8943	0.028
305	0.032	2466	0.05	4623	0.054	6784	0.034	8944	0.026
306	0.034	2467	0.048	4624	0.052	6785	0.032	8945	0.026
307	0.034	2468	0.05	4625	0.052	6786	0.032	8946	0.028
308	0.032	2469	0.05	4626	0.056	6787	0.034	8947	0.028
309	0.032	2470	0.05	4627	0.056	6788	0.034	8948	0.028
310	0.032	2471	0.046	4628	0.056	6789	0.034	8949	0.028
311	0.034	2472	0.048	4629	0.056	6790	0.034	8950	0.028
312	0.034	2473	0.05	4630	0.054	6791	0.034	8951	0.028
313	0.034	2474	0.05	4631	0.054	6792	0.034	8952	0.03
314	0.052	2475	0.052	4632	0.058	6793	0.034	8953	0.03
315	0.076	2476	0.05	4633	0.056	6794	0.034	8954	0.028
316	0.07	2477	0.05	4634	0.054	6795	0.034	8955	0.028
317	0.07	2478	0.052	4635	0.054	6796	0.034	8956	0.028
318	0.058	2479	0.052	4636	0.054	6797	0.032	8957	0.026
319	0.056	2480	0.05	4637	0.052	6798	0.034	8958	0.028
320	0.046	2481	0.052	4638	0.054	6799	0.034	8959	0.028
321	0.046	2482	0.052	4639	0.056	6800	0.034	8960	0.03
322	0.05	2483	0.054	4640	0.054	6801	0.034	8961	0.03
323	0.052	2484	0.052	4641	0.054	6802	0.032	8962	0.03
324	0.048	2485	0.052	4642	0.054	6803	0.032	8963	0.028
325	0.044	2486	0.052	4643	0.054	6804	0.03	8964	0.028
326	0.04	2487	0.05	4644	0.056	6805	0.032	8965	0.028
327	0.036	2488	0.05	4645	0.054	6806	0.034	8966	0.028
328	0.038	2489	0.05	4646	0.056	6807	0.034	8967	0.03
329	0.038	2490	0.048	4647	0.054	6808	0.034	8968	0.028
330	0.038	2491	0.048	4648	0.052	6809	0.032	8969	0.028
331	0.042	2492	0.046	4649	0.054	6810	0.032	8970	0.03
332	0.038	2493	0.046	4650	0.054	6811	0.034	8971	0.03
333	0.038	2494	0.048	4651	0.054	6812	0.034	8972	0.028
334	0.034	2495	0.048	4652	0.054	6813	0.034	8973	0.028
335	0.032	2496	0.046	4653	0.056	6814	0.034	8974	0.026
336	0.032	2497	0.048	4654	0.056	6815	0.032	8975	0.028
337	0.032	2498	0.046	4655	0.054	6816	0.032	8976	0.028
338	0.032	2499	0.046	4656	0.052	6817	0.032	8977	0.03
339	0.032	2500	0.048	4657	0.052	6818	0.034	8978	0.028
340	0.032	2501	0.044	4658	0.054	6819	0.032	8979	0.028
341	0.034	2502	0.044	4659	0.054	6820	0.034	8980	0.03
342	0.036	2503	0.046	4660	0.054	6821	0.032	8981	0.03
343	0.038	2504	0.046	4661	0.054	6822	0.034	8982	0.03
344	0.038	2505	0.046	4662	0.056	6823	0.034	8983	0.028
345	0.036	2506	0.046	4663	0.058	6824	0.034	8984	0.026
346	0.036	2507	0.046	4664	0.056	6825	0.034	8985	0.028
347	0.038	2508	0.05	4665	0.052	6826	0.034	8986	0.028
348	0.038	2509	0.05	4666	0.052	6827	0.036	8987	0.026
349	0.038	2510	0.048	4667	0.056	6828	0.036	8988	0.026
350	0.04	2511	0.048	4668	0.054	6829	0.038	8989	0.026
351	0.04	2512	0.05	4669	0.054	6830	0.036	8990	0.026

352	0.04	2513	0.046	4670	0.056	6831	0.036	8991	0.028
353	0.042	2514	0.046	4671	0.054	6832	0.036	8992	0.026
354	0.042	2515	0.046	4672	0.054	6833	0.038	8993	0.028
355	0.044	2516	0.046	4673	0.052	6834	0.036	8994	0.026
356	0.042	2517	0.046	4674	0.052	6835	0.036	8995	0.026
357	0.04	2518	0.048	4675	0.054	6836	0.036	8996	0.026
358	0.04	2519	0.048	4676	0.052	6837	0.036	8997	0.026
359	0.042	2520	0.048	4677	0.05	6838	0.034	8998	0.024
360	0.044	2521	0.05	4678	0.052	6839	0.036	8999	0.024
361	0.046	2522	0.05	4679	0.05	6840	0.036	9000	0.026
362	0.054	2523	0.046	4680	0.052	6841	0.04	9001	0.026
363	0.058	2524	0.046	4681	0.052	6842	0.038	9002	0.026
364	0.054	2525	0.046	4682	0.052	6843	0.036	9003	0.026
365	0.052	2526	0.048	4683	0.052	6844	0.038	9004	0.024
366	0.048	2527	0.048	4684	0.052	6845	0.038	9005	0.026
367	0.044	2528	0.048	4685	0.052	6846	0.036	9006	0.026
368	0.046	2529	0.046	4686	0.052	6847	0.036	9007	0.026
369	0.042	2530	0.048	4687	0.05	6848	0.036	9008	0.026
370	0.038	2531	0.05	4688	0.05	6849	0.038	9009	0.026
371	0.034	2532	0.05	4689	0.052	6850	0.038	9010	0.026
372	0.034	2533	0.054	4690	0.052	6851	0.036	9011	0.028
373	0.034	2534	0.052	4691	0.052	6852	0.034	9012	0.026
374	0.032	2535	0.05	4692	0.048	6853	0.036	9013	0.024
375	0.034	2536	0.052	4693	0.05	6854	0.036	9014	0.024
376	0.034	2537	0.052	4694	0.05	6855	0.036	9015	0.024
377	0.032	2538	0.054	4695	0.048	6856	0.036	9016	0.024
378	0.032	2539	0.054	4696	0.05	6857	0.036	9017	0.024
379	0.032	2540	0.054	4697	0.052	6858	0.036	9018	0.024
380	0.032	2541	0.054	4698	0.05	6859	0.038	9019	0.026
381	0.03	2542	0.054	4699	0.05	6860	0.036	9020	0.026
382	0.032	2543	0.054	4700	0.05	6861	0.036	9021	0.026
383	0.032	2544	0.054	4701	0.048	6862	0.036	9022	0.026
384	0.032	2545	0.052	4702	0.05	6863	0.036	9023	0.024
385	0.032	2546	0.054	4703	0.05	6864	0.036	9024	0.024
386	0.034	2547	0.054	4704	0.048	6865	0.036	9025	0.024
387	0.036	2548	0.052	4705	0.05	6866	0.036	9026	0.026
388	0.038	2549	0.052	4706	0.05	6867	0.034	9027	0.026
389	0.038	2550	0.05	4707	0.048	6868	0.034	9028	0.026
390	0.038	2551	0.052	4708	0.046	6869	0.036	9029	0.026
391	0.038	2552	0.054	4709	0.048	6870	0.036	9030	0.026
392	0.036	2553	0.054	4710	0.048	6871	0.036	9031	0.026
393	0.034	2554	0.054	4711	0.046	6872	0.034	9032	0.024
394	0.036	2555	0.054	4712	0.048	6873	0.034	9033	0.024
395	0.034	2556	0.054	4713	0.048	6874	0.034	9034	0.024
396	0.04	2557	0.052	4714	0.048	6875	0.034	9035	0.024
397	0.07	2558	0.052	4715	0.046	6876	0.034	9036	0.024
398	0.1	2559	0.052	4716	0.048	6877	0.034	9037	0.024
399	0.086	2560	0.05	4717	0.05	6878	0.034	9038	0.026
400	0.09	2561	0.05	4718	0.046	6879	0.036	9039	0.026
401	0.086	2562	0.05	4719	0.048	6880	0.034	9040	0.024
402	0.074	2563	0.052	4720	0.05	6881	0.032	9041	0.024
403	0.06	2564	0.054	4721	0.048	6882	0.032	9042	0.024
404	0.05	2565	0.05	4722	0.048	6883	0.034	9043	0.024
405	0.044	2566	0.05	4723	0.05	6884	0.034	9044	0.024
406	0.042	2567	0.052	4724	0.05	6885	0.034	9045	0.024
407	0.04	2568	0.054	4725	0.05	6886	0.034	9046	0.024
408	0.038	2569	0.052	4726	0.05	6887	0.034	9047	0.026
409	0.036	2570	0.05	4727	0.05	6888	0.034	9048	0.026
410	0.038	2571	0.05	4728	0.052	6889	0.034	9049	0.024
411	0.038	2572	0.05	4729	0.052	6890	0.034	9050	0.024
412	0.04	2573	0.05	4730	0.052	6891	0.034	9051	0.024
413	0.038	2574	0.05	4731	0.052	6892	0.034	9052	0.024
414	0.036	2575	0.048	4732	0.052	6893	0.034	9053	0.024
415	0.036	2576	0.046	4733	0.052	6894	0.034	9054	0.024
416	0.036	2577	0.048	4734	0.052	6895	0.034	9055	0.024
417	0.036	2578	0.048	4735	0.054	6896	0.034	9056	0.024
418	0.036	2579	0.048	4736	0.056	6897	0.032	9057	0.024
419	0.036	2580	0.048	4737	0.054	6898	0.034	9058	0.026
420	0.036	2581	0.048	4738	0.056	6899	0.034	9059	0.024
421	0.034	2582	0.048	4739	0.054	6900	0.032	9060	0.024
422	0.03	2583	0.046	4740	0.054	6901	0.034	9061	0.024
423	0.028	2584	0.046	4741	0.054	6902	0.034	9062	0.024
424	0.03	2585	0.046	4742	0.054	6903	0.032	9063	0.026
425	0.032	2586	0.046	4743	0.054	6904	0.032	9064	0.024
426	0.032	2587	0.044	4744	0.054	6905	0.036	9065	0.022
427	0.032	2588	0.044	4745	0.054	6906	0.034	9066	0.024
428	0.032	2589	0.044	4746	0.052	6907	0.034	9067	0.024
429	0.032	2590	0.046	4747	0.054	6908	0.034	9068	0.024
430	0.032	2591	0.048	4748	0.056	6909	0.034	9069	0.024
431	0.032	2592	0.052	4749	0.054	6910	0.034	9070	0.024
432	0.032	2593	0.05	4750	0.052	6911	0.032	9071	0.024
433	0.038	2594	0.048	4751	0.054	6912	0.032	9072	0.024
434	0.04	2595	0.046	4752	0.056	6913	0.032	9073	0.024
435	0.036	2596	0.046	4753	0.056	6914	0.032	9074	0.024
436	0.032	2597	0.046	4754	0.052	6915	0.034	9075	0.024
437	0.032	2598	0.046	4755	0.052	6916	0.034	9076	0.024
438	0.03	2599	0.048	4756	0.052	6917	0.034	9077	0.024
439	0.032	2600	0.046	4757	0.054	6918	0.032	9078	0.024
440	0.032	2601	0.046	4758	0.056	6919	0.032	9079	0.024
441	0.03	2602	0.048	4759	0.054	6920	0.032	9080	0.024
442	0.03	2603	0.05	4760	0.052	6921	0.032	9081	0.024
443	0.032	2604	0.048	4761	0.054	6922	0.032	9082	0.024
444	0.03	2605	0.046	4762	0.054	6923	0.034	9083	0.026

445	0.03	2606	0.046	4763	0.052	6924	0.034	9084	0.024
446	0.03	2607	0.048	4764	0.052	6925	0.034	9085	0.024
447	0.03	2608	0.048	4765	0.054	6926	0.032	9086	0.024
448	0.03	2609	0.048	4766	0.052	6927	0.032	9087	0.024
449	0.03	2610	0.046	4767	0.054	6928	0.032	9088	0.026
450	0.03	2611	0.046	4768	0.054	6929	0.032	9089	0.026
451	0.03	2612	0.046	4769	0.052	6930	0.032	9090	0.024
452	0.03	2613	0.046	4770	0.05	6931	0.032	9091	0.024
453	0.03	2614	0.046	4771	0.052	6932	0.032	9092	0.022
454	0.032	2615	0.046	4772	0.052	6933	0.032	9093	0.022
455	0.032	2616	0.048	4773	0.052	6934	0.032	9094	0.024
456	0.03	2617	0.046	4774	0.052	6935	0.03	9095	0.024
457	0.03	2618	0.048	4775	0.054	6936	0.032	9096	0.024
458	0.03	2619	0.048	4776	0.052	6937	0.034	9097	0.024
459	0.03	2620	0.046	4777	0.052	6938	0.034	9098	0.024
460	0.03	2621	0.048	4778	0.052	6939	0.032	9099	0.024
461	0.03	2622	0.052	4779	0.052	6940	0.032	9100	0.022
462	0.03	2623	0.052	4780	0.052	6941	0.032	9101	0.024
463	0.032	2624	0.052	4781	0.052	6942	0.034	9102	0.026
464	0.03	2625	0.056	4782	0.052	6943	0.034	9103	0.026
465	0.03	2626	0.06	4783	0.052	6944	0.032	9104	0.024
466	0.03	2627	0.058	4784	0.054	6945	0.032	9105	0.024
467	0.032	2628	0.06	4785	0.054	6946	0.032	9106	0.024
468	0.028	2629	0.058	4786	0.05	6947	0.032	9107	0.026
469	0.026	2630	0.058	4787	0.048	6948	0.032	9108	0.026
470	0.026	2631	0.056	4788	0.05	6949	0.032	9109	0.024
471	0.026	2632	0.056	4789	0.05	6950	0.032	9110	0.024
472	0.028	2633	0.056	4790	0.05	6951	0.034	9111	0.024
473	0.028	2634	0.056	4791	0.05	6952	0.034	9112	0.024
474	0.026	2635	0.054	4792	0.052	6953	0.034	9113	0.024
475	0.026	2636	0.054	4793	0.052	6954	0.03	9114	0.024
476	0.026	2637	0.056	4794	0.052	6955	0.032	9115	0.022
477	0.028	2638	0.054	4795	0.052	6956	0.032	9116	0.022
478	0.028	2639	0.052	4796	0.05	6957	0.032	9117	0.024
479	0.028	2640	0.052	4797	0.05	6958	0.032	9118	0.024
480	0.028	2641	0.052	4798	0.05	6959	0.032	9119	0.024
481	0.028	2642	0.052	4799	0.052	6960	0.034	9120	0.024
482	0.03	2643	0.052	4800	0.05	6961	0.032	9121	0.024
483	0.03	2644	0.054	4801	0.05	6962	0.03	9122	0.024
484	0.028	2645	0.052	4802	0.05	6963	0.032	9123	0.024
485	0.028	2646	0.052	4803	0.05	6964	0.034	9124	0.024
486	0.032	2647	0.054	4804	0.05	6965	0.034	9125	0.024
487	0.034	2648	0.052	4805	0.05	6966	0.032	9126	0.024
488	0.034	2649	0.052	4806	0.05	6967	0.032	9127	0.022
489	0.034	2650	0.05	4807	0.05	6968	0.034	9128	0.024
490	0.036	2651	0.05	4808	0.046	6969	0.034	9129	0.024
491	0.032	2652	0.052	4809	0.048	6970	0.032	9130	0.024
492	0.032	2653	0.052	4810	0.046	6971	0.032	9131	0.024
493	0.03	2654	0.052	4811	0.046	6972	0.032	9132	0.024
494	0.032	2655	0.052	4812	0.046	6973	0.032	9133	0.024
495	0.034	2656	0.054	4813	0.046	6974	0.034	9134	0.024
496	0.032	2657	0.054	4814	0.046	6975	0.032	9135	0.024
497	0.032	2658	0.052	4815	0.048	6976	0.032	9136	0.024
498	0.034	2659	0.052	4816	0.048	6977	0.032	9137	0.024
499	0.032	2660	0.05	4817	0.048	6978	0.032	9138	0.024
500	0.03	2661	0.05	4818	0.05	6979	0.032	9139	0.024
501	0.03	2662	0.05	4819	0.048	6980	0.032	9140	0.024
502	0.03	2663	0.048	4820	0.046	6981	0.032	9141	0.024
503	0.03	2664	0.046	4821	0.048	6982	0.032	9142	0.024
504	0.032	2665	0.046	4822	0.048	6983	0.034	9143	0.024
505	0.03	2666	0.048	4823	0.05	6984	0.034	9144	0.024
506	0.03	2667	0.046	4824	0.05	6985	0.032	9145	0.024
507	0.028	2668	0.046	4825	0.046	6986	0.032	9146	0.024
508	0.028	2669	0.046	4826	0.048	6987	0.032	9147	0.024
509	0.028	2670	0.046	4827	0.048	6988	0.032	9148	0.024
510	0.028	2671	0.046	4828	0.048	6989	0.03	9149	0.024
511	0.028	2672	0.044	4829	0.048	6990	0.032	9150	0.024
512	0.028	2673	0.044	4830	0.048	6991	0.03	9151	0.024
513	0.028	2674	0.044	4831	0.048	6992	0.03	9152	0.024
514	0.028	2675	0.042	4832	0.046	6993	0.03	9153	0.026
515	0.028	2676	0.044	4833	0.048	6994	0.03	9154	0.024
516	0.028	2677	0.048	4834	0.046	6995	0.03	9155	0.026
517	0.03	2678	0.046	4835	0.044	6996	0.032	9156	0.026
518	0.032	2679	0.044	4836	0.046	6997	0.032	9157	0.026
519	0.03	2680	0.044	4837	0.048	6998	0.032	9158	0.024
520	0.03	2681	0.044	4838	0.048	6999	0.03	9159	0.024
521	0.032	2682	0.044	4839	0.048	7000	0.03	9160	0.024
522	0.032	2683	0.044	4840	0.048	7001	0.032	9161	0.024
523	0.03	2684	0.044	4841	0.046	7002	0.032	9162	0.024
524	0.028	2685	0.042	4842	0.044	7003	0.032	9163	0.024
525	0.028	2686	0.042	4843	0.046	7004	0.034	9164	0.026
526	0.028	2687	0.044	4844	0.046	7005	0.03	9165	0.026
527	0.028	2688	0.044	4845	0.046	7006	0.032	9166	0.024
528	0.03	2689	0.044	4846	0.046	7007	0.032	9167	0.024
529	0.028	2690	0.042	4847	0.044	7008	0.032	9168	0.024
530	0.028	2691	0.044	4848	0.046	7009	0.034	9169	0.024
531	0.03	2692	0.044	4849	0.044	7010	0.034	9170	0.024
532	0.03	2693	0.042	4850	0.044	7011	0.032	9171	0.024
533	0.028	2694	0.044	4851	0.046	7012	0.032	9172	0.026
534	0.026	2695	0.044	4852	0.046	7013	0.034	9173	0.026
535	0.028	2696	0.042	4853	0.046	7014	0.032	9174	0.026
536	0.028	2697	0.042	4854	0.046	7015	0.032	9175	0.026
537	0.028	2698	0.044	4855	0.048	7016	0.032	9176	0.026

538	0.028	2699	0.046	4856	0.05	7017	0.032	9177	0.026
539	0.026	2700	0.046	4857	0.046	7018	0.032	9178	0.024
540	0.028	2701	0.044	4858	0.044	7019	0.032	9179	0.024
541	0.03	2702	0.044	4859	0.046	7020	0.032	9180	0.024
542	0.03	2703	0.044	4860	0.046	7021	0.034	9181	0.024
543	0.028	2704	0.042	4861	0.046	7022	0.034	9182	0.024
544	0.028	2705	0.042	4862	0.046	7023	0.034	9183	0.024
545	0.028	2706	0.044	4863	0.048	7024	0.034	9184	0.024
546	0.03	2707	0.042	4864	0.048	7025	0.034	9185	0.024
547	0.03	2708	0.044	4865	0.046	7026	0.034	9186	0.026
548	0.038	2709	0.044	4866	0.044	7027	0.032	9187	0.024
549	0.038	2710	0.044	4867	0.046	7028	0.032	9188	0.024
550	0.036	2711	0.044	4868	0.046	7029	0.036	9189	0.026
551	0.04	2712	0.046	4869	0.046	7030	0.036	9190	0.026
552	0.034	2713	0.044	4870	0.046	7031	0.034	9191	0.024
553	0.03	2714	0.042	4871	0.044	7032	0.036	9192	0.026
554	0.032	2715	0.042	4872	0.046	7033	0.036	9193	0.026
555	0.03	2716	0.044	4873	0.046	7034	0.034	9194	0.024
556	0.03	2717	0.044	4874	0.046	7035	0.036	9195	0.024
557	0.032	2718	0.042	4875	0.048	7036	0.036	9196	0.024
558	0.032	2719	0.042	4876	0.05	7037	0.034	9197	0.024
559	0.03	2720	0.042	4877	0.046	7038	0.034	9198	0.026
560	0.03	2721	0.042	4878	0.044	7039	0.034	9199	0.024
561	0.032	2722	0.042	4879	0.044	7040	0.036	9200	0.024
562	0.03	2723	0.042	4880	0.044	7041	0.036	9201	0.026
563	0.03	2724	0.042	4881	0.046	7042	0.036	9202	0.026
564	0.032	2725	0.042	4882	0.046	7043	0.036	9203	0.024
565	0.03	2726	0.042	4883	0.046	7044	0.036	9204	0.024
566	0.03	2727	0.042	4884	0.048	7045	0.036	9205	0.026
567	0.03	2728	0.042	4885	0.048	7046	0.034	9206	0.028
568	0.03	2729	0.038	4886	0.046	7047	0.036	9207	0.026
569	0.032	2730	0.038	4887	0.044	7048	0.036	9208	0.024
570	0.03	2731	0.04	4888	0.044	7049	0.036	9209	0.024
571	0.03	2732	0.038	4889	0.042	7050	0.034	9210	0.024
572	0.032	2733	0.04	4890	0.044	7051	0.034	9211	0.024
573	0.03	2734	0.04	4891	0.044	7052	0.034	9212	0.024
574	0.03	2735	0.04	4892	0.044	7053	0.034	9213	0.024
575	0.03	2736	0.038	4893	0.044	7054	0.036	9214	0.024
576	0.028	2737	0.038	4894	0.042	7055	0.038	9215	0.024
577	0.028	2738	0.04	4895	0.044	7056	0.036	9216	0.024
578	0.03	2739	0.04	4896	0.046	7057	0.036	9217	0.026
579	0.032	2740	0.038	4897	0.044	7058	0.036	9218	0.026
580	0.03	2741	0.038	4898	0.044	7059	0.038	9219	0.026
581	0.03	2742	0.04	4899	0.042	7060	0.036	9220	0.024
582	0.032	2743	0.04	4900	0.044	7061	0.038	9221	0.026
583	0.032	2744	0.04	4901	0.046	7062	0.038	9222	0.026
584	0.03	2745	0.04	4902	0.044	7063	0.036	9223	0.026
585	0.03	2746	0.04	4903	0.044	7064	0.038	9224	0.026
586	0.028	2747	0.04	4904	0.044	7065	0.038	9225	0.024
587	0.03	2748	0.038	4905	0.044	7066	0.038	9226	0.024
588	0.03	2749	0.04	4906	0.044	7067	0.04	9227	0.026
589	0.03	2750	0.04	4907	0.044	7068	0.038	9228	0.026
590	0.03	2751	0.04	4908	0.042	7069	0.036	9229	0.026
591	0.03	2752	0.04	4909	0.042	7070	0.036	9230	0.024
592	0.03	2753	0.038	4910	0.042	7071	0.036	9231	0.024
593	0.028	2754	0.038	4911	0.042	7072	0.038	9232	0.024
594	0.028	2755	0.038	4912	0.042	7073	0.038	9233	0.026
595	0.03	2756	0.038	4913	0.044	7074	0.036	9234	0.026
596	0.03	2757	0.038	4914	0.044	7075	0.032	9235	0.024
597	0.03	2758	0.038	4915	0.044	7076	0.032	9236	0.024
598	0.03	2759	0.038	4916	0.042	7077	0.032	9237	0.026
599	0.03	2760	0.04	4917	0.042	7078	0.032	9238	0.026
600	0.03	2761	0.04	4918	0.042	7079	0.032	9239	0.024
601	0.03	2762	0.04	4919	0.04	7080	0.032	9240	0.024
602	0.03	2763	0.04	4920	0.04	7081	0.032	9241	0.026
603	0.032	2764	0.038	4921	0.04	7082	0.032	9242	0.024
604	0.03	2765	0.038	4922	0.042	7083	0.032	9243	0.024
605	0.03	2766	0.038	4923	0.04	7084	0.032	9244	0.024
606	0.03	2767	0.04	4924	0.04	7085	0.032	9245	0.024
607	0.03	2768	0.038	4925	0.04	7086	0.032	9246	0.024
608	0.03	2769	0.04	4926	0.042	7087	0.032	9247	0.024
609	0.03	2770	0.038	4927	0.042	7088	0.032	9248	0.026
610	0.03	2771	0.038	4928	0.042	7089	0.032	9249	0.026
611	0.032	2772	0.038	4929	0.042	7090	0.034	9250	0.028
612	0.032	2773	0.038	4930	0.04	7091	0.032	9251	0.026
613	0.032	2774	0.038	4931	0.042	7092	0.03	9252	0.026
614	0.032	2775	0.038	4932	0.042	7093	0.034	9253	0.024
615	0.03	2776	0.04	4933	0.04	7094	0.034	9254	0.026
616	0.03	2777	0.04	4934	0.04	7095	0.034	9255	0.024
617	0.03	2778	0.038	4935	0.04	7096	0.034	9256	0.026
618	0.03	2779	0.038	4936	0.04	7097	0.036	9257	0.026
619	0.032	2780	0.038	4937	0.04	7098	0.034	9258	0.026
620	0.032	2781	0.04	4938	0.042	7099	0.034	9259	0.026
621	0.032	2782	0.038	4939	0.042	7100	0.034	9260	0.026
622	0.034	2783	0.036	4940	0.042	7101	0.034	9261	0.026
623	0.034	2784	0.038	4941	0.04	7102	0.036	9262	0.026
624	0.034	2785	0.04	4942	0.04	7103	0.036	9263	0.026
625	0.034	2786	0.038	4943	0.04	7104	0.034	9264	0.026
626	0.03	2787	0.038	4944	0.038	7105	0.034	9265	0.026
627	0.032	2788	0.038	4945	0.038	7106	0.036	9266	0.026
628	0.032	2789	0.038	4946	0.04	7107	0.034	9267	0.026
629	0.03	2790	0.038	4947	0.038	7108	0.03	9268	0.026
630	0.03	2791	0.04	4948	0.04	7109	0.034	9269	0.026

631	0.03	2792	0.038	4949	0.04	7110	0.034	9270	0.024
632	0.03	2793	0.04	4950	0.04	7111	0.034	9271	0.026
633	0.03	2794	0.04	4951	0.04	7112	0.034	9272	0.024
634	0.03	2795	0.04	4952	0.04	7113	0.032	9273	0.024
635	0.03	2796	0.04	4953	0.038	7114	0.032	9274	0.026
636	0.032	2797	0.038	4954	0.038	7115	0.032	9275	0.026
637	0.03	2798	0.038	4955	0.04	7116	0.032	9276	0.026
638	0.03	2799	0.04	4956	0.04	7117	0.032	9277	0.028
639	0.032	2800	0.04	4957	0.04	7118	0.034	9278	0.026
640	0.032	2801	0.04	4958	0.04	7119	0.032	9279	0.024
641	0.03	2802	0.038	4959	0.04	7120	0.032	9280	0.026
642	0.032	2803	0.04	4960	0.038	7121	0.032	9281	0.024
643	0.032	2804	0.04	4961	0.04	7122	0.034	9282	0.024
644	0.03	2805	0.04	4962	0.04	7123	0.032	9283	0.026
645	0.03	2806	0.04	4963	0.038	7124	0.03	9284	0.024
646	0.028	2807	0.038	4964	0.04	7125	0.028	9285	0.024
647	0.028	2808	0.04	4965	0.04	7126	0.028	9286	0.024
648	0.028	2809	0.04	4966	0.04	7127	0.032	9287	0.026
649	0.028	2810	0.04	4967	0.038	7128	0.034	9288	0.026
650	0.028	2811	0.04	4968	0.038	7129	0.03	9289	0.024
651	0.028	2812	0.038	4969	0.038	7130	0.028	9290	0.024
652	0.03	2813	0.038	4970	0.038	7131	0.03	9291	0.024
653	0.03	2814	0.038	4971	0.038	7132	0.03	9292	0.026
654	0.028	2815	0.04	4972	0.038	7133	0.03	9293	0.026
655	0.03	2816	0.04	4973	0.038	7134	0.028	9294	0.022
656	0.03	2817	0.038	4974	0.04	7135	0.03	9295	0.024
657	0.028	2818	0.038	4975	0.04	7136	0.03	9296	0.024
658	0.028	2819	0.04	4976	0.038	7137	0.028	9297	0.026
659	0.028	2820	0.04	4977	0.038	7138	0.03	9298	0.026
660	0.026	2821	0.04	4978	0.04	7139	0.03	9299	0.026
661	0.028	2822	0.038	4979	0.038	7140	0.03	9300	0.024
662	0.028	2823	0.04	4980	0.038	7141	0.03	9301	0.024
663	0.028	2824	0.04	4981	0.04	7142	0.03	9302	0.026
664	0.028	2825	0.038	4982	0.038	7143	0.032	9303	0.026
665	0.028	2826	0.038	4983	0.04	7144	0.03	9304	0.026
666	0.028	2827	0.038	4984	0.038	7145	0.03	9305	0.026
667	0.028	2828	0.038	4985	0.038	7146	0.03	9306	0.024
668	0.03	2829	0.04	4986	0.04	7147	0.028	9307	0.024
669	0.028	2830	0.042	4987	0.04	7148	0.028	9308	0.024
670	0.028	2831	0.04	4988	0.038	7149	0.028	9309	0.024
671	0.03	2832	0.04	4989	0.038	7150	0.028	9310	0.026
672	0.03	2833	0.04	4990	0.038	7151	0.028	9311	0.026
673	0.028	2834	0.038	4991	0.038	7152	0.028	9312	0.026
674	0.028	2835	0.038	4992	0.04	7153	0.03	9313	0.026
675	0.028	2836	0.038	4993	0.038	7154	0.03	9314	0.026
676	0.03	2837	0.038	4994	0.038	7155	0.028	9315	0.026
677	0.03	2838	0.04	4995	0.04	7156	0.028	9316	0.024
678	0.028	2839	0.04	4996	0.04	7157	0.028	9317	0.024
679	0.028	2840	0.04	4997	0.04	7158	0.028	9318	0.026
680	0.03	2841	0.04	4998	0.038	7159	0.028	9319	0.024
681	0.028	2842	0.04	4999	0.038	7160	0.028	9320	0.024
682	0.028	2843	0.04	5000	0.038	7161	0.028	9321	0.024
683	0.028	2844	0.04	5001	0.038	7162	0.03	9322	0.024
684	0.028	2845	0.04	5002	0.038	7163	0.03	9323	0.026
685	0.026	2846	0.04	5003	0.04	7164	0.03	9324	0.024
686	0.026	2847	0.04	5004	0.038	7165	0.03	9325	0.024
687	0.028	2848	0.042	5005	0.038	7166	0.03	9326	0.024
688	0.028	2849	0.042	5006	0.038	7167	0.028	9327	0.024
689	0.026	2850	0.042	5007	0.036	7168	0.03	9328	0.026
690	0.028	2851	0.044	5008	0.038	7169	0.03	9329	0.024
691	0.028	2852	0.042	5009	0.038	7170	0.03	9330	0.024
692	0.028	2853	0.042	5010	0.038	7171	0.03	9331	0.026
693	0.028	2854	0.042	5011	0.038	7172	0.032	9332	0.024
694	0.026	2855	0.042	5012	0.038	7173	0.032	9333	0.024
695	0.028	2856	0.044	5013	0.038	7174	0.03	9334	0.024
696	0.028	2857	0.042	5014	0.038	7175	0.03	9335	0.024
697	0.028	2858	0.042	5015	0.038	7176	0.03	9336	0.024
698	0.028	2859	0.04	5016	0.038	7177	0.028	9337	0.026
699	0.026	2860	0.04	5017	0.038	7178	0.028	9338	0.026
700	0.028	2861	0.04	5018	0.038	7179	0.03	9339	0.024
701	0.028	2862	0.04	5019	0.038	7180	0.028	9340	0.026
702	0.026	2863	0.04	5020	0.038	7181	0.028	9341	0.024
703	0.026	2864	0.04	5021	0.038	7182	0.03	9342	0.024
704	0.026	2865	0.04	5022	0.038	7183	0.03	9343	0.026
705	0.026	2866	0.04	5023	0.04	7184	0.032	9344	0.026
706	0.026	2867	0.04	5024	0.038	7185	0.032	9345	0.024
707	0.028	2868	0.04	5025	0.038	7186	0.032	9346	0.024
708	0.028	2869	0.04	5026	0.04	7187	0.032	9347	0.024
709	0.028	2870	0.042	5027	0.038	7188	0.032	9348	0.024
710	0.028	2871	0.042	5028	0.038	7189	0.034	9349	0.024
711	0.028	2872	0.044	5029	0.04	7190	0.034	9350	0.024
712	0.028	2873	0.042	5030	0.04	7191	0.032	9351	0.024
713	0.03	2874	0.042	5031	0.04	7192	0.034	9352	0.024
714	0.032	2875	0.042	5032	0.038	7193	0.034	9353	0.026
715	0.028	2876	0.04	5033	0.038	7194	0.034	9354	0.026
716	0.028	2877	0.042	5034	0.04	7195	0.036	9355	0.024
717	0.026	2878	0.042	5035	0.04	7196	0.036	9356	0.024
718	0.026	2879	0.042	5036	0.04	7197	0.034	9357	0.024
719	0.026	2880	0.042	5037	0.038	7198	0.034	9358	0.026
720	0.028	2881	0.044	5038	0.04	7199	0.036	9359	0.024
721	0.028	2882	0.044	5039	0.04	7200	0.036	9360	0.024
722	0.03	2883	0.044	5040	0.038	7201	0.036	9361	0.024
723	0.034	2884	0.042	5041	0.038	7202	0.034	9362	0.024

724	0.03	2885	0.042	5042	0.038	7203	0.034	9363	0.024
725	0.028	2886	0.044	5043	0.038	7204	0.036	9364	0.026
726	0.028	2887	0.044	5044	0.04	7205	0.036	9365	0.026
727	0.03	2888	0.042	5045	0.038	7206	0.036	9366	0.026
728	0.028	2889	0.042	5046	0.038	7207	0.038	9367	0.024
729	0.028	2890	0.042	5047	0.04	7208	0.038	9368	0.024
730	0.028	2891	0.044	5048	0.04	7209	0.038	9369	0.024
731	0.028	2892	0.044	5049	0.04	7210	0.038	9370	0.024
732	0.028	2893	0.042	5050	0.038	7211	0.038	9371	0.024
733	0.028	2894	0.044	5051	0.038	7212	0.036	9372	0.026
734	0.028	2895	0.044	5052	0.038	7213	0.036	9373	0.026
735	0.028	2896	0.042	5053	0.038	7214	0.036	9374	0.024
736	0.028	2897	0.042	5054	0.038	7215	0.038	9375	0.024
737	0.03	2898	0.046	5055	0.04	7216	0.036	9376	0.024
738	0.03	2899	0.044	5056	0.04	7217	0.036	9377	0.024
739	0.03	2900	0.044	5057	0.04	7218	0.036	9378	0.024
740	0.03	2901	0.044	5058	0.04	7219	0.038	9379	0.024
741	0.03	2902	0.044	5059	0.038	7220	0.038	9380	0.024
742	0.032	2903	0.044	5060	0.038	7221	0.036	9381	0.026
743	0.03	2904	0.044	5061	0.038	7222	0.036	9382	0.024
744	0.03	2905	0.044	5062	0.04	7223	0.036	9383	0.022
745	0.03	2906	0.044	5063	0.042	7224	0.036	9384	0.024
746	0.03	2907	0.044	5064	0.038	7225	0.036	9385	0.024
747	0.03	2908	0.044	5065	0.038	7226	0.038	9386	0.024
748	0.028	2909	0.044	5066	0.038	7227	0.038	9387	0.022
749	0.026	2910	0.044	5067	0.038	7228	0.036	9388	0.022
750	0.028	2911	0.042	5068	0.04	7229	0.036	9389	0.024
751	0.028	2912	0.044	5069	0.038	7230	0.038	9390	0.024
752	0.028	2913	0.044	5070	0.038	7231	0.038	9391	0.022
753	0.03	2914	0.044	5071	0.038	7232	0.038	9392	0.022
754	0.028	2915	0.046	5072	0.038	7233	0.036	9393	0.022
755	0.03	2916	0.044	5073	0.04	7234	0.034	9394	0.022
756	0.03	2917	0.046	5074	0.038	7235	0.036	9395	0.022
757	0.028	2918	0.046	5075	0.038	7236	0.036	9396	0.022
758	0.028	2919	0.046	5076	0.038	7237	0.036	9397	0.022
759	0.028	2920	0.046	5077	0.038	7238	0.038	9398	0.022
760	0.03	2921	0.044	5078	0.038	7239	0.036	9399	0.022
761	0.032	2922	0.046	5079	0.038	7240	0.036	9400	0.02
762	0.03	2923	0.046	5080	0.038	7241	0.034	9401	0.022
763	0.03	2924	0.046	5081	0.036	7242	0.034	9402	0.022
764	0.03	2925	0.044	5082	0.038	7243	0.034	9403	0.022
765	0.028	2926	0.044	5083	0.038	7244	0.034	9404	0.022
766	0.028	2927	0.046	5084	0.038	7245	0.034	9405	0.024
767	0.028	2928	0.044	5085	0.036	7246	0.034	9406	0.024
768	0.03	2929	0.046	5086	0.038	7247	0.034	9407	0.024
769	0.03	2930	0.048	5087	0.04	7248	0.036	9408	0.024
770	0.028	2931	0.046	5088	0.038	7249	0.036	9409	0.024
771	0.03	2932	0.046	5089	0.04	7250	0.034	9410	0.024
772	0.03	2933	0.044	5090	0.04	7251	0.036	9411	0.024
773	0.03	2934	0.046	5091	0.04	7252	0.036	9412	0.024
774	0.03	2935	0.046	5092	0.04	7253	0.036	9413	0.024
775	0.032	2936	0.046	5093	0.038	7254	0.034	9414	0.024
776	0.032	2937	0.046	5094	0.038	7255	0.034	9415	0.024
777	0.03	2938	0.046	5095	0.04	7256	0.036	9416	0.024
778	0.03	2939	0.046	5096	0.04	7257	0.034	9417	0.022
779	0.032	2940	0.046	5097	0.04	7258	0.036	9418	0.024
780	0.032	2941	0.046	5098	0.038	7259	0.034	9419	0.026
781	0.032	2942	0.046	5099	0.038	7260	0.032	9420	0.024
782	0.03	2943	0.046	5100	0.038	7261	0.032	9421	0.024
783	0.032	2944	0.046	5101	0.038	7262	0.034	9422	0.024
784	0.032	2945	0.044	5102	0.038	7263	0.034	9423	0.024
785	0.03	2946	0.046	5103	0.038	7264	0.032	9424	0.024
786	0.032	2947	0.048	5104	0.038	7265	0.032	9425	0.024
787	0.036	2948	0.048	5105	0.036	7266	0.034	9426	0.026
788	0.036	2949	0.046	5106	0.04	7267	0.034	9427	0.024
789	0.036	2950	0.046	5107	0.038	7268	0.034	9428	0.024
790	0.036	2951	0.044	5108	0.034	7269	0.036	9429	0.024
791	0.034	2952	0.044	5109	0.034	7270	0.034	9430	0.024
792	0.032	2953	0.044	5110	0.036	7271	0.032	9431	0.024
793	0.034	2954	0.044	5111	0.036	7272	0.032	9432	0.022
794	0.032	2955	0.044	5112	0.036	7273	0.032	9433	0.024
795	0.032	2956	0.046	5113	0.036	7274	0.032	9434	0.024
796	0.034	2957	0.05	5114	0.036	7275	0.034	9435	0.026
797	0.032	2958	0.05	5115	0.036	7276	0.032	9436	0.024
798	0.032	2959	0.05	5116	0.036	7277	0.032	9437	0.024
799	0.036	2960	0.048	5117	0.036	7278	0.032	9438	0.024
800	0.034	2961	0.048	5118	0.036	7279	0.034	9439	0.024
801	0.032	2962	0.05	5119	0.036	7280	0.032	9440	0.024
802	0.034	2963	0.048	5120	0.036	7281	0.03	9441	0.024
803	0.034	2964	0.048	5121	0.036	7282	0.032	9442	0.024
804	0.034	2965	0.05	5122	0.036	7283	0.032	9443	0.024
805	0.032	2966	0.048	5123	0.036	7284	0.032	9444	0.026
806	0.032	2967	0.048	5124	0.036	7285	0.032	9445	0.026
807	0.03	2968	0.05	5125	0.036	7286	0.032	9446	0.026
808	0.032	2969	0.048	5126	0.036	7287	0.03	9447	0.024
809	0.032	2970	0.046	5127	0.036	7288	0.028	9448	0.026
810	0.032	2971	0.046	5128	0.038	7289	0.03	9449	0.026
811	0.032	2972	0.046	5129	0.036	7290	0.028	9450	0.026
812	0.032	2973	0.048	5130	0.036	7291	0.028	9451	0.024
813	0.032	2974	0.046	5131	0.038	7292	0.028	9452	0.026
814	0.03	2975	0.048	5132	0.036	7293	0.028	9453	0.026
815	0.03	2976	0.05	5133	0.036	7294	0.03	9454	0.024
816	0.032	2977	0.05	5134	0.036	7295	0.028	9455	0.024

817	0.032	2978	0.048	5135	0.036	7296	0.028	9456	0.026
818	0.032	2979	0.046	5136	0.036	7297	0.03	9457	0.026
819	0.032	2980	0.046	5137	0.036	7298	0.03	9458	0.026
820	0.032	2981	0.048	5138	0.038	7299	0.03	9459	0.026
821	0.028	2982	0.05	5139	0.04	7300	0.028	9460	0.026
822	0.03	2983	0.048	5140	0.04	7301	0.03	9461	0.026
823	0.03	2984	0.046	5141	0.038	7302	0.03	9462	0.026
824	0.03	2985	0.046	5142	0.038	7303	0.03	9463	0.024
825	0.03	2986	0.048	5143	0.038	7304	0.028	9464	0.024
826	0.03	2987	0.05	5144	0.038	7305	0.03	9465	0.026
827	0.028	2988	0.05	5145	0.04	7306	0.03	9466	0.026
828	0.03	2989	0.048	5146	0.036	7307	0.03	9467	0.026
829	0.03	2990	0.048	5147	0.036	7308	0.03	9468	0.028
830	0.03	2991	0.048	5148	0.036	7309	0.03	9469	0.028
831	0.03	2992	0.048	5149	0.036	7310	0.028	9470	0.026
832	0.03	2993	0.046	5150	0.036	7311	0.03	9471	0.026
833	0.03	2994	0.05	5151	0.038	7312	0.03	9472	0.024
834	0.03	2995	0.05	5152	0.04	7313	0.03	9473	0.026
835	0.028	2996	0.05	5153	0.04	7314	0.03	9474	0.028
836	0.028	2997	0.046	5154	0.038	7315	0.03	9475	0.026
837	0.03	2998	0.046	5155	0.038	7316	0.028	9476	0.026
838	0.028	2999	0.048	5156	0.038	7317	0.028	9477	0.026
839	0.028	3000	0.05	5157	0.036	7318	0.028	9478	0.026
840	0.03	3001	0.05	5158	0.036	7319	0.03	9479	0.024
841	0.03	3002	0.05	5159	0.036	7320	0.032	9480	0.026
842	0.03	3003	0.048	5160	0.036	7321	0.028	9481	0.026
843	0.032	3004	0.046	5161	0.036	7322	0.026	9482	0.026
844	0.032	3005	0.048	5162	0.036	7323	0.028	9483	0.026
845	0.03	3006	0.048	5163	0.038	7324	0.03	9484	0.026
846	0.03	3007	0.046	5164	0.038	7325	0.03	9485	0.026
847	0.03	3008	0.046	5165	0.038	7326	0.028	9486	0.026
848	0.03	3009	0.046	5166	0.038	7327	0.028	9487	0.026
849	0.03	3010	0.05	5167	0.038	7328	0.026	9488	0.026
850	0.03	3011	0.048	5168	0.038	7329	0.026	9489	0.026
851	0.028	3012	0.048	5169	0.038	7330	0.026	9490	0.026
852	0.028	3013	0.048	5170	0.038	7331	0.026	9491	0.026
853	0.03	3014	0.048	5171	0.038	7332	0.026	9492	0.028
854	0.028	3015	0.046	5172	0.038	7333	0.028	9493	0.028
855	0.028	3016	0.046	5173	0.04	7334	0.026	9494	0.026
856	0.03	3017	0.048	5174	0.038	7335	0.026	9495	0.026
857	0.03	3018	0.048	5175	0.038	7336	0.026	9496	0.026
858	0.028	3019	0.046	5176	0.04	7337	0.026	9497	0.026
859	0.03	3020	0.046	5177	0.04	7338	0.028	9498	0.026
860	0.03	3021	0.044	5178	0.04	7339	0.028	9499	0.026
861	0.028	3022	0.046	5179	0.038	7340	0.026	9500	0.026
862	0.028	3023	0.046	5180	0.038	7341	0.028	9501	0.026
863	0.03	3024	0.044	5181	0.038	7342	0.028	9502	0.028
864	0.03	3025	0.044	5182	0.038	7343	0.028	9503	0.028
865	0.03	3026	0.044	5183	0.038	7344	0.026	9504	0.026
866	0.03	3027	0.044	5184	0.038	7345	0.026	9505	0.026
867	0.03	3028	0.042	5185	0.038	7346	0.026	9506	0.026
868	0.032	3029	0.042	5186	0.038	7347	0.026	9507	0.028
869	0.03	3030	0.042	5187	0.038	7348	0.026	9508	0.028
870	0.028	3031	0.044	5188	0.04	7349	0.026	9509	0.026
871	0.03	3032	0.042	5189	0.04	7350	0.026	9510	0.026
872	0.03	3033	0.04	5190	0.04	7351	0.028	9511	0.026
873	0.028	3034	0.044	5191	0.038	7352	0.026	9512	0.026
874	0.028	3035	0.044	5192	0.038	7353	0.026	9513	0.026
875	0.03	3036	0.044	5193	0.038	7354	0.028	9514	0.03
876	0.03	3037	0.042	5194	0.038	7355	0.028	9515	0.028
877	0.03	3038	0.042	5195	0.038	7356	0.028	9516	0.026
878	0.03	3039	0.042	5196	0.04	7357	0.028	9517	0.026
879	0.03	3040	0.042	5197	0.04	7358	0.028	9518	0.028
880	0.03	3041	0.042	5198	0.038	7359	0.028	9519	0.028
881	0.03	3042	0.042	5199	0.038	7360	0.028	9520	0.026
882	0.03	3043	0.042	5200	0.038	7361	0.026	9521	0.026
883	0.028	3044	0.042	5201	0.038	7362	0.028	9522	0.024
884	0.03	3045	0.044	5202	0.04	7363	0.028	9523	0.026
885	0.028	3046	0.046	5203	0.038	7364	0.028	9524	0.026
886	0.026	3047	0.044	5204	0.04	7365	0.028	9525	0.028
887	0.03	3048	0.042	5205	0.038	7366	0.028	9526	0.028
888	0.032	3049	0.044	5206	0.04	7367	0.028	9527	0.028
889	0.03	3050	0.042	5207	0.044	7368	0.028	9528	0.026
890	0.028	3051	0.044	5208	0.046	7369	0.028	9529	0.026
891	0.028	3052	0.044	5209	0.046	7370	0.028	9530	0.028
892	0.028	3053	0.046	5210	0.048	7371	0.026	9531	0.028
893	0.028	3054	0.046	5211	0.046	7372	0.026	9532	0.026
894	0.028	3055	0.044	5212	0.042	7373	0.026	9533	0.028
895	0.026	3056	0.044	5213	0.046	7374	0.026	9534	0.026
896	0.028	3057	0.044	5214	0.048	7375	0.024	9535	0.026
897	0.03	3058	0.044	5215	0.044	7376	0.026	9536	0.026
898	0.03	3059	0.044	5216	0.042	7377	0.026	9537	0.026
899	0.03	3060	0.044	5217	0.042	7378	0.026	9538	0.028
900	0.028	3061	0.044	5218	0.042	7379	0.026	9539	0.026
901	0.028	3062	0.046	5219	0.04	7380	0.026	9540	0.028
902	0.03	3063	0.046	5220	0.042	7381	0.026	9541	0.03
903	0.028	3064	0.044	5221	0.04	7382	0.024	9542	0.028
904	0.028	3065	0.044	5222	0.042	7383	0.026	9543	0.026
905	0.03	3066	0.044	5223	0.042	7384	0.026	9544	0.026
906	0.028	3067	0.042	5224	0.04	7385	0.026	9545	0.028
907	0.028	3068	0.044	5225	0.042	7386	0.026	9546	0.028
908	0.028	3069	0.044	5226	0.042	7387	0.026	9547	0.028
909	0.028	3070	0.044	5227	0.042	7388	0.028	9548	0.026

910	0.028	3071	0.044	5228	0.042	7389	0.028	9549	0.028
911	0.028	3072	0.044	5229	0.04	7390	0.026	9550	0.028
912	0.028	3073	0.042	5230	0.04	7391	0.026	9551	0.028
913	0.026	3074	0.04	5231	0.04	7392	0.028	9552	0.026
914	0.028	3075	0.04	5232	0.042	7393	0.028	9553	0.028
915	0.028	3076	0.042	5233	0.044	7394	0.024	9554	0.026
916	0.03	3077	0.042	5234	0.042	7395	0.026	9555	0.028
917	0.03	3078	0.042	5235	0.042	7396	0.026	9556	0.028
918	0.028	3079	0.042	5236	0.042	7397	0.024	9557	0.028
919	0.028	3080	0.044	5237	0.042	7398	0.026	9558	0.026
920	0.028	3081	0.042	5238	0.042	7399	0.026	9559	0.026
921	0.028	3082	0.042	5239	0.04	7400	0.024	9560	0.026
922	0.028	3083	0.04	5240	0.04	7401	0.024	9561	0.026
923	0.028	3084	0.042	5241	0.04	7402	0.026	9562	0.026
924	0.028	3085	0.042	5242	0.04	7403	0.026	9563	0.026
925	0.028	3086	0.04	5243	0.04	7404	0.026	9564	0.028
926	0.028	3087	0.044	5244	0.04	7405	0.026	9565	0.026
927	0.028	3088	0.042	5245	0.04	7406	0.026	9566	0.026
928	0.03	3089	0.042	5246	0.04	7407	0.026	9567	0.026
929	0.028	3090	0.042	5247	0.04	7408	0.026	9568	0.026
930	0.026	3091	0.04	5248	0.04	7409	0.026	9569	0.026
931	0.028	3092	0.042	5249	0.04	7410	0.026	9570	0.026
932	0.028	3093	0.044	5250	0.04	7411	0.028	9571	0.026
933	0.028	3094	0.044	5251	0.042	7412	0.028	9572	0.026
934	0.028	3095	0.044	5252	0.04	7413	0.026	9573	0.026
935	0.028	3096	0.042	5253	0.038	7414	0.024	9574	0.026
936	0.03	3097	0.042	5254	0.038	7415	0.026	9575	0.028
937	0.028	3098	0.042	5255	0.04	7416	0.026	9576	0.028
938	0.028	3099	0.042	5256	0.04	7417	0.026	9577	0.024
939	0.028	3100	0.044	5257	0.04	7418	0.026	9578	0.024
940	0.028	3101	0.044	5258	0.04	7419	0.024	9579	0.026
941	0.028	3102	0.042	5259	0.04	7420	0.026	9580	0.026
942	0.03	3103	0.042	5260	0.04	7421	0.024	9581	0.026
943	0.028	3104	0.042	5261	0.04	7422	0.024	9582	0.026
944	0.026	3105	0.044	5262	0.04	7423	0.026	9583	0.026
945	0.026	3106	0.044	5263	0.04	7424	0.026	9584	0.026
946	0.028	3107	0.044	5264	0.04	7425	0.024	9585	0.028
947	0.028	3108	0.042	5265	0.042	7426	0.024	9586	0.026
948	0.028	3109	0.046	5266	0.042	7427	0.024	9587	0.026
949	0.028	3110	0.048	5267	0.04	7428	0.026	9588	0.026
950	0.03	3111	0.044	5268	0.04	7429	0.028	9589	0.026
951	0.028	3112	0.046	5269	0.04	7430	0.026	9590	0.026
952	0.036	3113	0.046	5270	0.04	7431	0.026	9591	0.028
953	0.056	3114	0.048	5271	0.04	7432	0.026	9592	0.028
954	0.066	3115	0.044	5272	0.042	7433	0.028	9593	0.028
955	0.062	3116	0.044	5273	0.04	7434	0.026	9594	0.026
956	0.058	3117	0.044	5274	0.04	7435	0.026	9595	0.026
957	0.056	3118	0.044	5275	0.04	7436	0.028	9596	0.026
958	0.054	3119	0.044	5276	0.04	7437	0.028	9597	0.028
959	0.048	3120	0.044	5277	0.04	7438	0.026	9598	0.028
960	0.044	3121	0.046	5278	0.04	7439	0.026	9599	0.028
961	0.042	3122	0.046	5279	0.042	7440	0.026	9600	0.028
962	0.042	3123	0.048	5280	0.042	7441	0.028	9601	0.026
963	0.042	3124	0.046	5281	0.042	7442	0.028	9602	0.026
964	0.04	3125	0.046	5282	0.042	7443	0.026	9603	0.026
965	0.042	3126	0.046	5283	0.042	7444	0.026	9604	0.026
966	0.044	3127	0.044	5284	0.042	7445	0.026	9605	0.026
967	0.042	3128	0.044	5285	0.04	7446	0.024	9606	0.024
968	0.046	3129	0.044	5286	0.04	7447	0.026	9607	0.026
969	0.046	3130	0.044	5287	0.042	7448	0.028	9608	0.026
970	0.048	3131	0.044	5288	0.042	7449	0.026	9609	0.026
971	0.044	3132	0.048	5289	0.04	7450	0.026	9610	0.026
972	0.038	3133	0.05	5290	0.04	7451	0.026	9611	0.026
973	0.032	3134	0.048	5291	0.042	7452	0.026	9612	0.028
974	0.034	3135	0.05	5292	0.042	7453	0.026	9613	0.026
975	0.034	3136	0.048	5293	0.04	7454	0.026	9614	0.026
976	0.032	3137	0.05	5294	0.04	7455	0.028	9615	0.026
977	0.032	3138	0.05	5295	0.04	7456	0.028	9616	0.026
978	0.034	3139	0.048	5296	0.04	7457	0.026	9617	0.026
979	0.032	3140	0.05	5297	0.038	7458	0.026	9618	0.026
980	0.032	3141	0.048	5298	0.038	7459	0.026	9619	0.028
981	0.032	3142	0.05	5299	0.038	7460	0.026	9620	0.028
982	0.032	3143	0.05	5300	0.038	7461	0.026	9621	0.026
983	0.032	3144	0.05	5301	0.038	7462	0.026	9622	0.026
984	0.032	3145	0.05	5302	0.038	7463	0.028	9623	0.026
985	0.036	3146	0.05	5303	0.038	7464	0.028	9624	0.026
986	0.04	3147	0.048	5304	0.04	7465	0.026	9625	0.026
987	0.04	3148	0.05	5305	0.038	7466	0.026	9626	0.028
988	0.04	3149	0.052	5306	0.04	7467	0.028	9627	0.026
989	0.038	3150	0.05	5307	0.04	7468	0.026	9628	0.026
990	0.04	3151	0.048	5308	0.036	7469	0.028	9629	0.026
991	0.036	3152	0.05	5309	0.038	7470	0.028	9630	0.026
992	0.036	3153	0.052	5310	0.038	7471	0.026	9631	0.028
993	0.036	3154	0.05	5311	0.038	7472	0.026	9632	0.028
994	0.036	3155	0.05	5312	0.036	7473	0.028	9633	0.026
995	0.034	3156	0.048	5313	0.038	7474	0.028	9634	0.026
996	0.034	3157	0.048	5314	0.04	7475	0.026	9635	0.026
997	0.034	3158	0.048	5315	0.038	7476	0.028	9636	0.026
998	0.036	3159	0.048	5316	0.036	7477	0.026	9637	0.028
999	0.036	3160	0.048	5317	0.038	7478	0.028	9638	0.028
1000	0.036	3161	0.048	5318	0.04	7479	0.028	9639	0.028
1001	0.036	3162	0.048	5319	0.038	7480	0.026	9640	0.026
1002	0.036	3163	0.048	5320	0.038	7481	0.026	9641	0.028

1003	0.038	3164	0.044	5321	0.038	7482	0.028	9642	0.028
1004	0.036	3165	0.046	5322	0.038	7483	0.026	9643	0.026
1005	0.034	3166	0.046	5323	0.038	7484	0.028	9644	0.026
1006	0.036	3167	0.046	5324	0.038	7485	0.026	9645	0.026
1007	0.036	3168	0.044	5325	0.04	7486	0.026	9646	0.028
1008	0.034	3169	0.044	5326	0.038	7487	0.028	9647	0.028
1009	0.034	3170	0.044	5327	0.04	7488	0.028	9648	0.028
1010	0.034	3171	0.044	5328	0.038	7489	0.028	9649	0.028
1011	0.034	3172	0.042	5329	0.038	7490	0.026	9650	0.028
1012	0.036	3173	0.042	5330	0.038	7491	0.026	9651	0.026
1013	0.034	3174	0.042	5331	0.038	7492	0.026	9652	0.028
1014	0.034	3175	0.042	5332	0.038	7493	0.026	9653	0.028
1015	0.036	3176	0.04	5333	0.036	7494	0.026	9654	0.026
1016	0.036	3177	0.04	5334	0.036	7495	0.026	9655	0.026
1017	0.034	3178	0.04	5335	0.036	7496	0.028	9656	0.026
1018	0.036	3179	0.04	5336	0.038	7497	0.026	9657	0.026
1019	0.036	3180	0.04	5337	0.038	7498	0.026	9658	0.026
1020	0.036	3181	0.042	5338	0.038	7499	0.026	9659	0.026
1021	0.034	3182	0.04	5339	0.038	7500	0.026	9660	0.028
1022	0.034	3183	0.04	5340	0.038	7501	0.026	9661	0.028
1023	0.034	3184	0.038	5341	0.036	7502	0.028	9662	0.026
1024	0.034	3185	0.04	5342	0.038	7503	0.028	9663	0.026
1025	0.034	3186	0.04	5343	0.036	7504	0.026	9664	0.026
1026	0.034	3187	0.038	5344	0.038	7505	0.026	9665	0.028
1027	0.036	3188	0.04	5345	0.038	7506	0.026	9666	0.028
1028	0.036	3189	0.038	5346	0.038	7507	0.028	9667	0.028
1029	0.034	3190	0.038	5347	0.04	7508	0.026	9668	0.026
1030	0.034	3191	0.04	5348	0.038	7509	0.026	9669	0.026
1031	0.034	3192	0.04	5349	0.038	7510	0.028	9670	0.026
1032	0.034	3193	0.042	5350	0.038	7511	0.028	9671	0.026
1033	0.034	3194	0.042	5351	0.04	7512	0.026	9672	0.028
1034	0.036	3195	0.042	5352	0.038	7513	0.026	9673	0.026
1035	0.034	3196	0.04	5353	0.038	7514	0.026	9674	0.026
1036	0.032	3197	0.042	5354	0.038	7515	0.028	9675	0.026
1037	0.034	3198	0.04	5355	0.038	7516	0.026	9676	0.026
1038	0.034	3199	0.04	5356	0.038	7517	0.026	9677	0.026
1039	0.032	3200	0.042	5357	0.036	7518	0.026	9678	0.026
1040	0.032	3201	0.042	5358	0.038	7519	0.028	9679	0.026
1041	0.032	3202	0.04	5359	0.038	7520	0.026	9680	0.026
1042	0.034	3203	0.042	5360	0.036	7521	0.026	9681	0.028
1043	0.036	3204	0.04	5361	0.038	7522	0.026	9682	0.028
1044	0.034	3205	0.04	5362	0.038	7523	0.026	9683	0.028
1045	0.034	3206	0.04	5363	0.038	7524	0.026	9684	0.03
1046	0.034	3207	0.04	5364	0.04	7525	0.026	9685	0.028
1047	0.034	3208	0.04	5365	0.038	7526	0.026	9686	0.028
1048	0.034	3209	0.04	5366	0.04	7527	0.026	9687	0.03
1049	0.032	3210	0.042	5367	0.038	7528	0.028	9688	0.03
1050	0.034	3211	0.042	5368	0.038	7529	0.028	9689	0.028
1051	0.034	3212	0.042	5369	0.038	7530	0.028	9690	0.028
1052	0.032	3213	0.04	5370	0.038	7531	0.026	9691	0.028
1053	0.032	3214	0.04	5371	0.038	7532	0.028	9692	0.028
1054	0.032	3215	0.04	5372	0.038	7533	0.028	9693	0.028
1055	0.032	3216	0.042	5373	0.038	7534	0.028	9694	0.028
1056	0.032	3217	0.042	5374	0.038	7535	0.028	9695	0.028
1057	0.032	3218	0.042	5375	0.038	7536	0.028	9696	0.026
1058	0.032	3219	0.042	5376	0.04	7537	0.028	9697	0.028
1059	0.034	3220	0.042	5377	0.04	7538	0.028	9698	0.028
1060	0.032	3221	0.042	5378	0.042	7539	0.028	9699	0.028
1061	0.032	3222	0.042	5379	0.038	7540	0.028	9700	0.028
1062	0.032	3223	0.04	5380	0.038	7541	0.028	9701	0.026
1063	0.032	3224	0.04	5381	0.036	7542	0.028	9702	0.028
1064	0.03	3225	0.04	5382	0.038	7543	0.028	9703	0.028
1065	0.03	3226	0.042	5383	0.04	7544	0.028	9704	0.028
1066	0.03	3227	0.04	5384	0.04	7545	0.026	9705	0.028
1067	0.032	3228	0.04	5385	0.04	7546	0.028	9706	0.026
1068	0.032	3229	0.04	5386	0.036	7547	0.028	9707	0.028
1069	0.032	3230	0.038	5387	0.036	7548	0.028	9708	0.026
1070	0.032	3231	0.04	5388	0.036	7549	0.028	9709	0.028
1071	0.03	3232	0.04	5389	0.036	7550	0.028	9710	0.028
1072	0.032	3233	0.04	5390	0.036	7551	0.03	9711	0.028
1073	0.032	3234	0.04	5391	0.036	7552	0.028	9712	0.028
1074	0.03	3235	0.038	5392	0.034	7553	0.028	9713	0.028
1075	0.03	3236	0.04	5393	0.036	7554	0.028	9714	0.028
1076	0.03	3237	0.038	5394	0.036	7555	0.028	9715	0.026
1077	0.032	3238	0.038	5395	0.038	7556	0.03	9716	0.028
1078	0.032	3239	0.04	5396	0.04	7557	0.03	9717	0.028
1079	0.03	3240	0.04	5397	0.036	7558	0.032	9718	0.028
1080	0.03	3241	0.042	5398	0.036	7559	0.03	9719	0.03
1081	0.03	3242	0.04	5399	0.036	7560	0.03	9720	0.028
1082	0.03	3243	0.04	5400	0.036	7561	0.03	9721	0.026
1083	0.03	3244	0.04	5401	0.036	7562	0.03	9722	0.026
1084	0.03	3245	0.038	5402	0.036	7563	0.03	9723	0.026
1085	0.032	3246	0.038	5403	0.034	7564	0.03	9724	0.026
1086	0.03	3247	0.042	5404	0.034	7565	0.03	9725	0.026
1087	0.03	3248	0.04	5405	0.036	7566	0.03	9726	0.026
1088	0.03	3249	0.04	5406	0.036	7567	0.028	9727	0.026
1089	0.032	3250	0.04	5407	0.036	7568	0.032	9728	0.026
1090	0.03	3251	0.04	5408	0.036	7569	0.032	9729	0.024
1091	0.032	3252	0.04	5409	0.036	7570	0.03	9730	0.024
1092	0.032	3253	0.04	5410	0.036	7571	0.03	9731	0.026
1093	0.032	3254	0.04	5411	0.036	7572	0.03	9732	0.026
1094	0.032	3255	0.04	5412	0.036	7573	0.028	9733	0.024
1095	0.032	3256	0.038	5413	0.036	7574	0.028	9734	0.024

1096	0.032	3257	0.04	5414	0.036	7575	0.028	9735	0.024
1097	0.032	3258	0.04	5415	0.036	7576	0.028	9736	0.024
1098	0.032	3259	0.04	5416	0.036	7577	0.03	9737	0.026
1099	0.032	3260	0.04	5417	0.036	7578	0.03	9738	0.026
1100	0.034	3261	0.04	5418	0.036	7579	0.03	9739	0.026
1101	0.036	3262	0.04	5419	0.036	7580	0.032	9740	0.024
1102	0.034	3263	0.042	5420	0.036	7581	0.03	9741	0.026
1103	0.032	3264	0.04	5421	0.036	7582	0.03	9742	0.026
1104	0.032	3265	0.04	5422	0.036	7583	0.03	9743	0.024
1105	0.034	3266	0.04	5423	0.038	7584	0.03	9744	0.024
1106	0.034	3267	0.04	5424	0.038	7585	0.03	9745	0.024
1107	0.032	3268	0.042	5425	0.036	7586	0.028	9746	0.026
1108	0.032	3269	0.042	5426	0.036	7587	0.028	9747	0.024
1109	0.032	3270	0.04	5427	0.036	7588	0.03	9748	0.024
1110	0.034	3271	0.04	5428	0.036	7589	0.03	9749	0.024
1111	0.034	3272	0.038	5429	0.034	7590	0.028	9750	0.024
1112	0.034	3273	0.04	5430	0.036	7591	0.028	9751	0.024
1113	0.032	3274	0.04	5431	0.036	7592	0.028	9752	0.024
1114	0.032	3275	0.04	5432	0.036	7593	0.028	9753	0.024
1115	0.032	3276	0.04	5433	0.036	7594	0.03	9754	0.024
1116	0.032	3277	0.04	5434	0.036	7595	0.03	9755	0.024
1117	0.034	3278	0.038	5435	0.038	7596	0.03	9756	0.026
1118	0.032	3279	0.038	5436	0.04	7597	0.03	9757	0.024
1119	0.032	3280	0.038	5437	0.04	7598	0.03	9758	0.024
1120	0.034	3281	0.04	5438	0.036	7599	0.03	9759	0.026
1121	0.034	3282	0.04	5439	0.036	7600	0.03	9760	0.024
1122	0.036	3283	0.04	5440	0.036	7601	0.03	9761	0.024
1123	0.038	3284	0.04	5441	0.038	7602	0.03	9762	0.026
1124	0.036	3285	0.04	5442	0.038	7603	0.03	9763	0.026
1125	0.034	3286	0.04	5443	0.038	7604	0.03	9764	0.024
1126	0.034	3287	0.04	5444	0.038	7605	0.032	9765	0.024
1127	0.034	3288	0.04	5445	0.036	7606	0.03	9766	0.024
1128	0.034	3289	0.04	5446	0.036	7607	0.032	9767	0.026
1129	0.034	3290	0.04	5447	0.038	7608	0.032	9768	0.026
1130	0.034	3291	0.04	5448	0.038	7609	0.03	9769	0.026
1131	0.034	3292	0.04	5449	0.036	7610	0.03	9770	0.028
1132	0.034	3293	0.04	5450	0.036	7611	0.03	9771	0.028
1133	0.034	3294	0.04	5451	0.036	7612	0.028	9772	0.028
1134	0.034	3295	0.038	5452	0.036	7613	0.03	9773	0.026
1135	0.034	3296	0.042	5453	0.038	7614	0.032	9774	0.026
1136	0.034	3297	0.042	5454	0.038	7615	0.032	9775	0.028
1137	0.034	3298	0.042	5455	0.036	7616	0.03	9776	0.026
1138	0.034	3299	0.042	5456	0.036	7617	0.03	9777	0.026
1139	0.034	3300	0.04	5457	0.036	7618	0.032	9778	0.028
1140	0.034	3301	0.04	5458	0.036	7619	0.032	9779	0.028
1141	0.034	3302	0.042	5459	0.038	7620	0.032	9780	0.028
1142	0.034	3303	0.042	5460	0.036	7621	0.03	9781	0.028
1143	0.034	3304	0.042	5461	0.036	7622	0.03	9782	0.028
1144	0.034	3305	0.042	5462	0.036	7623	0.032	9783	0.028
1145	0.034	3306	0.04	5463	0.036	7624	0.032	9784	0.026
1146	0.034	3307	0.038	5464	0.036	7625	0.03	9785	0.028
1147	0.034	3308	0.04	5465	0.036	7626	0.03	9786	0.03
1148	0.036	3309	0.04	5466	0.034	7627	0.03	9787	0.03
1149	0.036	3310	0.042	5467	0.034	7628	0.03	9788	0.028
1150	0.034	3311	0.044	5468	0.034	7629	0.03	9789	0.03
1151	0.034	3312	0.042	5469	0.034	7630	0.03	9790	0.032
1152	0.034	3313	0.04	5470	0.032	7631	0.032	9791	0.036
1153	0.032	3314	0.042	5471	0.034	7632	0.03	9792	0.042
1154	0.032	3315	0.042	5472	0.034	7633	0.03	9793	0.04
1155	0.034	3316	0.042	5473	0.034	7634	0.03	9794	0.04
1156	0.034	3317	0.042	5474	0.036	7635	0.03	9795	0.038
1157	0.034	3318	0.04	5475	0.034	7636	0.03	9796	0.04
1158	0.034	3319	0.042	5476	0.034	7637	0.03	9797	0.04
1159	0.034	3320	0.042	5477	0.036	7638	0.03	9798	0.04
1160	0.032	3321	0.04	5478	0.036	7639	0.03	9799	0.038
1161	0.032	3322	0.04	5479	0.034	7640	0.03	9800	0.036
1162	0.032	3323	0.04	5480	0.034	7641	0.03	9801	0.032
1163	0.032	3324	0.042	5481	0.036	7642	0.03	9802	0.034
1164	0.03	3325	0.042	5482	0.036	7643	0.03	9803	0.034
1165	0.03	3326	0.042	5483	0.036	7644	0.03	9804	0.032
1166	0.032	3327	0.042	5484	0.034	7645	0.03	9805	0.03
1167	0.03	3328	0.044	5485	0.036	7646	0.03	9806	0.03
1168	0.032	3329	0.044	5486	0.036	7647	0.03	9807	0.03
1169	0.032	3330	0.044	5487	0.036	7648	0.03	9808	0.03
1170	0.032	3331	0.042	5488	0.036	7649	0.03	9809	0.03
1171	0.03	3332	0.044	5489	0.036	7650	0.03	9810	0.03
1172	0.032	3333	0.044	5490	0.036	7651	0.03	9811	0.028
1173	0.032	3334	0.042	5491	0.036	7652	0.03	9812	0.028
1174	0.032	3335	0.044	5492	0.034	7653	0.03	9813	0.028
1175	0.03	3336	0.044	5493	0.036	7654	0.03	9814	0.03
1176	0.032	3337	0.044	5494	0.036	7655	0.03	9815	0.032
1177	0.032	3338	0.044	5495	0.036	7656	0.028	9816	0.03
1178	0.032	3339	0.046	5496	0.036	7657	0.028	9817	0.028
1179	0.034	3340	0.044	5497	0.036	7658	0.028	9818	0.03
1180	0.032	3341	0.044	5498	0.036	7659	0.03	9819	0.03
1181	0.032	3342	0.046	5499	0.034	7660	0.03	9820	0.03
1182	0.032	3343	0.046	5500	0.034	7661	0.028	9821	0.028
1183	0.032	3344	0.046	5501	0.036	7662	0.028	9822	0.03
1184	0.034	3345	0.044	5502	0.036	7663	0.028	9823	0.03
1185	0.032	3346	0.044	5503	0.036	7664	0.028	9824	0.028
1186	0.032	3347	0.044	5504	0.036	7665	0.028	9825	0.03
1187	0.034	3348	0.044	5505	0.036	7666	0.028	9826	0.03
1188	0.036	3349	0.044	5506	0.038	7667	0.028	9827	0.03

1189	0.034	3350	0.044	5507	0.038	7668	0.026	9828	0.028
1190	0.036	3351	0.042	5508	0.034	7669	0.028	9829	0.028
1191	0.036	3352	0.044	5509	0.034	7670	0.026	9830	0.03
1192	0.038	3353	0.044	5510	0.036	7671	0.028	9831	0.03
1193	0.038	3354	0.044	5511	0.036	7672	0.028	9832	0.03
1194	0.038	3355	0.044	5512	0.036	7673	0.026	9833	0.03
1195	0.036	3356	0.044	5513	0.036	7674	0.026	9834	0.03
1196	0.036	3357	0.044	5514	0.034	7675	0.026	9835	0.028
1197	0.04	3358	0.044	5515	0.036	7676	0.026	9836	0.028
1198	0.042	3359	0.044	5516	0.034	7677	0.028	9837	0.028
1199	0.044	3360	0.044	5517	0.034	7678	0.028	9838	0.03
1200	0.046	3361	0.042	5518	0.036	7679	0.028	9839	0.03
1201	0.048	3362	0.042	5519	0.036	7680	0.028	9840	0.028
1202	0.044	3363	0.042	5520	0.036	7681	0.028	9841	0.028
1203	0.044	3364	0.042	5521	0.038	7682	0.026	9842	0.028
1204	0.046	3365	0.044	5522	0.038	7683	0.026	9843	0.028
1205	0.044	3366	0.046	5523	0.036	7684	0.026	9844	0.028
1206	0.04	3367	0.046	5524	0.034	7685	0.028	9845	0.028
1207	0.042	3368	0.044	5525	0.036	7686	0.028	9846	0.028
1208	0.042	3369	0.046	5526	0.034	7687	0.028	9847	0.028
1209	0.044	3370	0.046	5527	0.036	7688	0.026	9848	0.03
1210	0.044	3371	0.044	5528	0.036	7689	0.026	9849	0.03
1211	0.044	3372	0.044	5529	0.034	7690	0.026	9850	0.028
1212	0.042	3373	0.046	5530	0.036	7691	0.026	9851	0.028
1213	0.042	3374	0.046	5531	0.036	7692	0.028	9852	0.028
1214	0.038	3375	0.046	5532	0.036	7693	0.028	9853	0.028
1215	0.04	3376	0.048	5533	0.034	7694	0.028	9854	0.028
1216	0.04	3377	0.046	5534	0.036	7695	0.03	9855	0.03
1217	0.04	3378	0.046	5535	0.036	7696	0.028	9856	0.028
1218	0.036	3379	0.046	5536	0.034	7697	0.028	9857	0.028
1219	0.036	3380	0.046	5537	0.036	7698	0.028	9858	0.028
1220	0.036	3381	0.048	5538	0.038	7699	0.028	9859	0.03
1221	0.038	3382	0.048	5539	0.038	7700	0.028	9860	0.03
1222	0.036	3383	0.046	5540	0.036	7701	0.028	9861	0.026
1223	0.036	3384	0.046	5541	0.036	7702	0.028	9862	0.028
1224	0.036	3385	0.046	5542	0.036	7703	0.03	9863	0.028
1225	0.034	3386	0.05	5543	0.034	7704	0.028	9864	0.028
1226	0.036	3387	0.05	5544	0.036	7705	0.028	9865	0.028
1227	0.036	3388	0.05	5545	0.034	7706	0.028	9866	0.028
1228	0.036	3389	0.05	5546	0.036	7707	0.028	9867	0.028
1229	0.036	3390	0.05	5547	0.036	7708	0.028	9868	0.028
1230	0.036	3391	0.048	5548	0.038	7709	0.028	9869	0.028
1231	0.038	3392	0.048	5549	0.036	7710	0.026	9870	0.03
1232	0.036	3393	0.05	5550	0.036	7711	0.028	9871	0.03
1233	0.038	3394	0.048	5551	0.038	7712	0.026	9872	0.03
1234	0.04	3395	0.048	5552	0.036	7713	0.026	9873	0.03
1235	0.04	3396	0.048	5553	0.036	7714	0.026	9874	0.028
1236	0.038	3397	0.046	5554	0.036	7715	0.026	9875	0.028
1237	0.038	3398	0.048	5555	0.036	7716	0.028	9876	0.03
1238	0.042	3399	0.046	5556	0.038	7717	0.028	9877	0.028
1239	0.04	3400	0.048	5557	0.038	7718	0.026	9878	0.026
1240	0.04	3401	0.048	5558	0.038	7719	0.026	9879	0.026
1241	0.04	3402	0.048	5559	0.038	7720	0.026	9880	0.028
1242	0.038	3403	0.05	5560	0.036	7721	0.024	9881	0.028
1243	0.04	3404	0.052	5561	0.036	7722	0.026	9882	0.028
1244	0.04	3405	0.05	5562	0.034	7723	0.026	9883	0.028
1245	0.042	3406	0.048	5563	0.034	7724	0.026	9884	0.028
1246	0.042	3407	0.05	5564	0.036	7725	0.026	9885	0.028
1247	0.038	3408	0.05	5565	0.038	7726	0.028	9886	0.028
1248	0.038	3409	0.05	5566	0.036	7727	0.028	9887	0.026
1249	0.038	3410	0.048	5567	0.038	7728	0.026	9888	0.026
1250	0.034	3411	0.052	5568	0.038	7729	0.028	9889	0.028
1251	0.034	3412	0.052	5569	0.036	7730	0.026	9890	0.028
1252	0.034	3413	0.052	5570	0.036	7731	0.026	9891	0.028
1253	0.034	3414	0.052	5571	0.036	7732	0.026	9892	0.028
1254	0.034	3415	0.052	5572	0.036	7733	0.026	9893	0.028
1255	0.034	3416	0.05	5573	0.038	7734	0.026	9894	0.028
1256	0.034	3417	0.052	5574	0.038	7735	0.028	9895	0.028
1257	0.034	3418	0.052	5575	0.036	7736	0.028	9896	0.028
1258	0.032	3419	0.05	5576	0.036	7737	0.028	9897	0.026
1259	0.034	3420	0.052	5577	0.038	7738	0.028	9898	0.026
1260	0.034	3421	0.052	5578	0.038	7739	0.03	9899	0.028
1261	0.036	3422	0.052	5579	0.038	7740	0.028	9900	0.026
1262	0.036	3423	0.052	5580	0.038	7741	0.028	9901	0.026
1263	0.034	3424	0.052	5581	0.038	7742	0.028	9902	0.028
1264	0.034	3425	0.054	5582	0.036	7743	0.03	9903	0.028
1265	0.036	3426	0.054	5583	0.036	7744	0.028	9904	0.026
1266	0.038	3427	0.052	5584	0.036	7745	0.026	9905	0.026
1267	0.038	3428	0.05	5585	0.034	7746	0.03	9906	0.028
1268	0.036	3429	0.05	5586	0.034	7747	0.03	9907	0.028
1269	0.034	3430	0.05	5587	0.036	7748	0.028	9908	0.028
1270	0.036	3431	0.052	5588	0.034	7749	0.028	9909	0.028
1271	0.034	3432	0.05	5589	0.036	7750	0.028	9910	0.026
1272	0.034	3433	0.05	5590	0.036	7751	0.028	9911	0.026
1273	0.034	3434	0.052	5591	0.036	7752	0.03	9912	0.028
1274	0.034	3435	0.052	5592	0.036	7753	0.028	9913	0.028
1275	0.034	3436	0.052	5593	0.036	7754	0.026	9914	0.028
1276	0.034	3437	0.052	5594	0.036	7755	0.028	9915	0.026
1277	0.034	3438	0.052	5595	0.036	7756	0.028	9916	0.026
1278	0.032	3439	0.05	5596	0.036	7757	0.028	9917	0.026
1279	0.032	3440	0.05	5597	0.036	7758	0.028	9918	0.024
1280	0.036	3441	0.05	5598	0.034	7759	0.028	9919	0.028
1281	0.034	3442	0.05	5599	0.036	7760	0.028	9920	0.028

1282	0.034	3443	0.05	5600	0.036	7761	0.028	9921	0.028
1283	0.034	3444	0.052	5601	0.034	7762	0.028	9922	0.026
1284	0.036	3445	0.054	5602	0.036	7763	0.03	9923	0.028
1285	0.032	3446	0.054	5603	0.036	7764	0.028	9924	0.026
1286	0.032	3447	0.054	5604	0.034	7765	0.028	9925	0.028
1287	0.032	3448	0.052	5605	0.034	7766	0.03	9926	0.026
1288	0.032	3449	0.05	5606	0.036	7767	0.028	9927	0.026
1289	0.032	3450	0.05	5607	0.036	7768	0.028	9928	0.026
1290	0.032	3451	0.05	5608	0.036	7769	0.028	9929	0.026
1291	0.032	3452	0.05	5609	0.036	7770	0.026	9930	0.026
1292	0.032	3453	0.05	5610	0.036	7771	0.026	9931	0.026
1293	0.032	3454	0.048	5611	0.034	7772	0.028	9932	0.028
1294	0.032	3455	0.05	5612	0.036	7773	0.028	9933	0.028
1295	0.032	3456	0.052	5613	0.036	7774	0.028	9934	0.026
1296	0.032	3457	0.05	5614	0.036	7775	0.026	9935	0.026
1297	0.034	3458	0.048	5615	0.036	7776	0.026	9936	0.026
1298	0.032	3459	0.048	5616	0.036	7777	0.026	9937	0.026
1299	0.032	3460	0.052	5617	0.036	7778	0.026	9938	0.026
1300	0.032	3461	0.05	5618	0.036	7779	0.026	9939	0.028
1301	0.032	3462	0.05	5619	0.036	7780	0.026	9940	0.026
1302	0.032	3463	0.05	5620	0.038	7781	0.026	9941	0.026
1303	0.032	3464	0.052	5621	0.04	7782	0.026	9942	0.026
1304	0.032	3465	0.048	5622	0.034	7783	0.026	9943	0.026
1305	0.032	3466	0.05	5623	0.036	7784	0.026	9944	0.024
1306	0.034	3467	0.052	5624	0.038	7785	0.026	9945	0.028
1307	0.034	3468	0.05	5625	0.038	7786	0.026	9946	0.028
1308	0.034	3469	0.05	5626	0.034	7787	0.028	9947	0.026
1309	0.032	3470	0.052	5627	0.034	7788	0.028	9948	0.026
1310	0.034	3471	0.052	5628	0.034	7789	0.026	9949	0.026
1311	0.034	3472	0.052	5629	0.034	7790	0.026	9950	0.028
1312	0.032	3473	0.052	5630	0.036	7791	0.026	9951	0.03
1313	0.034	3474	0.052	5631	0.034	7792	0.026	9952	0.03
1314	0.034	3475	0.052	5632	0.036	7793	0.026	9953	0.028
1315	0.034	3476	0.05	5633	0.036	7794	0.024	9954	0.028
1316	0.034	3477	0.048	5634	0.036	7795	0.026	9955	0.026
1317	0.034	3478	0.05	5635	0.036	7796	0.026	9956	0.026
1318	0.032	3479	0.052	5636	0.036	7797	0.026	9957	0.028
1319	0.032	3480	0.05	5637	0.036	7798	0.026	9958	0.026
1320	0.032	3481	0.052	5638	0.036	7799	0.026	9959	0.026
1321	0.034	3482	0.052	5639	0.038	7800	0.026	9960	0.028
1322	0.034	3483	0.05	5640	0.038	7801	0.026	9961	0.028
1323	0.034	3484	0.048	5641	0.036	7802	0.026	9962	0.028
1324	0.032	3485	0.05	5642	0.036	7803	0.026	9963	0.028
1325	0.032	3486	0.05	5643	0.034	7804	0.028	9964	0.026
1326	0.032	3487	0.05	5644	0.034	7805	0.026	9965	0.026
1327	0.032	3488	0.05	5645	0.036	7806	0.026	9966	0.026
1328	0.032	3489	0.05	5646	0.036	7807	0.026	9967	0.026
1329	0.034	3490	0.05	5647	0.036	7808	0.026	9968	0.026
1330	0.036	3491	0.05	5648	0.036	7809	0.026	9969	0.026
1331	0.034	3492	0.05	5649	0.038	7810	0.026	9970	0.026
1332	0.034	3493	0.052	5650	0.036	7811	0.026	9971	0.026
1333	0.032	3494	0.05	5651	0.034	7812	0.024	9972	0.026
1334	0.032	3495	0.048	5652	0.034	7813	0.024	9973	0.026
1335	0.032	3496	0.05	5653	0.034	7814	0.024	9974	0.026
1336	0.034	3497	0.05	5654	0.034	7815	0.024	9975	0.026
1337	0.034	3498	0.05	5655	0.034	7816	0.024	9976	0.026
1338	0.036	3499	0.05	5656	0.036	7817	0.026	9977	0.028
1339	0.036	3500	0.052	5657	0.034	7818	0.024	9978	0.028
1340	0.036	3501	0.052	5658	0.034	7819	0.024	9979	0.028
1341	0.034	3502	0.048	5659	0.036	7820	0.022	9980	0.028
1342	0.032	3503	0.05	5660	0.036	7821	0.022	9981	0.026
1343	0.034	3504	0.048	5661	0.034	7822	0.022	9982	0.026
1344	0.036	3505	0.048	5662	0.034	7823	0.02	9983	0.028
1345	0.034	3506	0.05	5663	0.034	7824	0.022	9984	0.026
1346	0.034	3507	0.05	5664	0.034	7825	0.022	9985	0.026
1347	0.034	3508	0.052	5665	0.032	7826	0.024	9986	0.026
1348	0.034	3509	0.052	5666	0.034	7827	0.024	9987	0.026
1349	0.036	3510	0.048	5667	0.034	7828	0.022	9988	0.026
1350	0.034	3511	0.048	5668	0.036	7829	0.022	9989	0.026
1351	0.036	3512	0.048	5669	0.036	7830	0.024	9990	0.026
1352	0.036	3513	0.048	5670	0.034	7831	0.024	9991	0.026
1353	0.034	3514	0.048	5671	0.036	7832	0.024	9992	0.026
1354	0.032	3515	0.048	5672	0.034	7833	0.022	9993	0.028
1355	0.032	3516	0.048	5673	0.034	7834	0.024	9994	0.026
1356	0.032	3517	0.046	5674	0.034	7835	0.022	9995	0.026
1357	0.032	3518	0.044	5675	0.032	7836	0.022	9996	0.026
1358	0.032	3519	0.044	5676	0.032	7837	0.024	9997	0.026
1359	0.034	3520	0.046	5677	0.034	7838	0.024	9998	0.026
1360	0.036	3521	0.046	5678	0.036	7839	0.022	9999	0.028
1361	0.038	3522	0.044	5679	0.034	7840	0.024	10000	0.028
1362	0.036	3523	0.046	5680	0.034	7841	0.022	10001	0.028
1363	0.034	3524	0.046	5681	0.034	7842	0.022	10002	0.028
1364	0.034	3525	0.046	5682	0.034	7843	0.024	10003	0.026
1365	0.034	3526	0.046	5683	0.034	7844	0.024	10004	0.026
1366	0.034	3527	0.044	5684	0.032	7845	0.026	10005	0.026
1367	0.034	3528	0.046	5685	0.032	7846	0.024	10006	0.026
1368	0.034	3529	0.046	5686	0.034	7847	0.022	10007	0.028
1369	0.034	3530	0.044	5687	0.036	7848	0.024	10008	0.028
1370	0.034	3531	0.044	5688	0.036	7849	0.022	10009	0.026
1371	0.034	3532	0.044	5689	0.036	7850	0.022	10010	0.026
1372	0.036	3533	0.046	5690	0.032	7851	0.022	10011	0.026
1373	0.036	3534	0.046	5691	0.034	7852	0.022	10012	0.026
1374	0.034	3535	0.044	5692	0.034	7853	0.022	10013	0.028

1375	0.034	3536	0.046	5693	0.034	7854	0.024	10014	0.028
1376	0.034	3537	0.046	5694	0.034	7855	0.024	10015	0.026
1377	0.034	3538	0.046	5695	0.034	7856	0.022	10016	0.026
1378	0.036	3539	0.044	5696	0.034	7857	0.022	10017	0.026
1379	0.036	3540	0.044	5697	0.034	7858	0.024	10018	0.026
1380	0.036	3541	0.044	5698	0.034	7859	0.024	10019	0.026
1381	0.034	3542	0.044	5699	0.034	7860	0.022	10020	0.028
1382	0.034	3543	0.044	5700	0.034	7861	0.022	10021	0.028
1383	0.034	3544	0.046	5701	0.032	7862	0.022	10022	0.028
1384	0.032	3545	0.044	5702	0.032	7863	0.022	10023	0.026
1385	0.032	3546	0.042	5703	0.034	7864	0.024	10024	0.026
1386	0.034	3547	0.042	5704	0.034	7865	0.024	10025	0.028
1387	0.036	3548	0.046	5705	0.034	7866	0.024	10026	0.028
1388	0.034	3549	0.046	5706	0.032	7867	0.024	10027	0.026
1389	0.034	3550	0.042	5707	0.034	7868	0.024	10028	0.026
1390	0.036	3551	0.042	5708	0.032	7869	0.024	10029	0.026
1391	0.036	3552	0.044	5709	0.032	7870	0.024	10030	0.028
1392	0.036	3553	0.042	5710	0.032	7871	0.024	10031	0.028
1393	0.036	3554	0.044	5711	0.032	7872	0.024	10032	0.026
1394	0.034	3555	0.044	5712	0.032	7873	0.022	10033	0.026
1395	0.034	3556	0.044	5713	0.034	7874	0.022	10034	0.028
1396	0.034	3557	0.044	5714	0.036	7875	0.024	10035	0.028
1397	0.034	3558	0.044	5715	0.034	7876	0.024	10036	0.026
1398	0.034	3559	0.044	5716	0.034	7877	0.024	10037	0.026
1399	0.034	3560	0.044	5717	0.034	7878	0.024	10038	0.026
1400	0.036	3561	0.044	5718	0.034	7879	0.024	10039	0.026
1401	0.034	3562	0.044	5719	0.036	7880	0.022	10040	0.026
1402	0.034	3563	0.044	5720	0.036	7881	0.024	10041	0.026
1403	0.036	3564	0.046	5721	0.038	7882	0.024	10042	0.026
1404	0.036	3565	0.044	5722	0.04	7883	0.024	10043	0.026
1405	0.034	3566	0.042	5723	0.04	7884	0.022	10044	0.028
1406	0.036	3567	0.042	5724	0.04	7885	0.024	10045	0.026
1407	0.036	3568	0.044	5725	0.042	7886	0.024	10046	0.028
1408	0.036	3569	0.042	5726	0.042	7887	0.024	10047	0.028
1409	0.036	3570	0.042	5727	0.038	7888	0.024	10048	0.028
1410	0.036	3571	0.042	5728	0.036	7889	0.022	10049	0.026
1411	0.036	3572	0.042	5729	0.04	7890	0.024	10050	0.028
1412	0.034	3573	0.04	5730	0.038	7891	0.022	10051	0.026
1413	0.034	3574	0.042	5731	0.036	7892	0.024	10052	0.026
1414	0.036	3575	0.042	5732	0.036	7893	0.024	10053	0.028
1415	0.036	3576	0.04	5733	0.036	7894	0.024	10054	0.026
1416	0.034	3577	0.042	5734	0.034	7895	0.022	10055	0.026
1417	0.034	3578	0.044	5735	0.036	7896	0.022	10056	0.026
1418	0.034	3579	0.044	5736	0.034	7897	0.022	10057	0.028
1419	0.034	3580	0.042	5737	0.036	7898	0.024	10058	0.026
1420	0.034	3581	0.042	5738	0.036	7899	0.022	10059	0.028
1421	0.034	3582	0.042	5739	0.036	7900	0.024	10060	0.028
1422	0.036	3583	0.044	5740	0.036	7901	0.024	10061	0.026
1423	0.038	3584	0.044	5741	0.036	7902	0.024	10062	0.026
1424	0.034	3585	0.044	5742	0.036	7903	0.024	10063	0.026
1425	0.034	3586	0.044	5743	0.036	7904	0.024	10064	0.026
1426	0.034	3587	0.044	5744	0.034	7905	0.028	10065	0.028
1427	0.034	3588	0.042	5745	0.034	7906	0.03	10066	0.028
1428	0.034	3589	0.04	5746	0.036	7907	0.032	10067	0.026
1429	0.034	3590	0.04	5747	0.036	7908	0.034	10068	0.026
1430	0.034	3591	0.042	5748	0.036	7909	0.032	10069	0.028
1431	0.036	3592	0.042	5749	0.038	7910	0.026	10070	0.028
1432	0.038	3593	0.04	5750	0.038	7911	0.026	10071	0.028
1433	0.034	3594	0.042	5751	0.038	7912	0.026	10072	0.026
1434	0.038	3595	0.042	5752	0.04	7913	0.026	10073	0.026
1435	0.038	3596	0.042	5753	0.042	7914	0.024	10074	0.026
1436	0.034	3597	0.044	5754	0.046	7915	0.024	10075	0.026
1437	0.034	3598	0.044	5755	0.046	7916	0.026	10076	0.028
1438	0.034	3599	0.044	5756	0.048	7917	0.026	10077	0.028
1439	0.034	3600	0.042	5757	0.05	7918	0.026	10078	0.028
1440	0.034	3601	0.04	5758	0.05	7919	0.026	10079	0.026
1441	0.034	3602	0.04	5759	0.05	7920	0.028	10080	0.026
1442	0.036	3603	0.042	5760	0.048	7921	0.028	10081	0.026
1443	0.036	3604	0.042	5761	0.048	7922	0.026	10082	0.028
1444	0.034	3605	0.04	5762	0.046	7923	0.024	10083	0.026
1445	0.034	3606	0.042	5763	0.044	7924	0.024	10084	0.026
1446	0.034	3607	0.042	5764	0.044	7925	0.024	10085	0.028
1447	0.034	3608	0.042	5765	0.044	7926	0.024	10086	0.03
1448	0.034	3609	0.042	5766	0.042	7927	0.026	10087	0.026
1449	0.034	3610	0.042	5767	0.042	7928	0.026	10088	0.026
1450	0.034	3611	0.042	5768	0.04	7929	0.028	10089	0.026
1451	0.034	3612	0.042	5769	0.042	7930	0.026	10090	0.026
1452	0.034	3613	0.04	5770	0.038	7931	0.026	10091	0.026
1453	0.036	3614	0.04	5771	0.04	7932	0.026	10092	0.028
1454	0.036	3615	0.04	5772	0.04	7933	0.026	10093	0.028
1455	0.034	3616	0.042	5773	0.04	7934	0.026	10094	0.026
1456	0.036	3617	0.042	5774	0.04	7935	0.026	10095	0.028
1457	0.038	3618	0.042	5775	0.04	7936	0.026	10096	0.028
1458	0.036	3619	0.042	5776	0.042	7937	0.024	10097	0.028
1459	0.038	3620	0.042	5777	0.042	7938	0.026	10098	0.026
1460	0.038	3621	0.042	5778	0.04	7939	0.026	10099	0.028
1461	0.036	3622	0.042	5779	0.04	7940	0.026	10100	0.028
1462	0.036	3623	0.042	5780	0.038	7941	0.026	10101	0.026
1463	0.036	3624	0.042	5781	0.038	7942	0.026	10102	0.026
1464	0.034	3625	0.042	5782	0.036	7943	0.026	10103	0.026
1465	0.034	3626	0.042	5783	0.036	7944	0.026	10104	0.026
1466	0.036	3627	0.042	5784	0.036	7945	0.026	10105	0.026
1467	0.036	3628	0.042	5785	0.036	7946	0.026	10106	0.026

1468	0.038	3629	0.042	5786	0.036	7947	0.026	10107	0.024
1469	0.038	3630	0.04	5787	0.036	7948	0.026	10108	0.026
1470	0.036	3631	0.042	5788	0.036	7949	0.024	10109	0.028
1471	0.038	3632	0.04	5789	0.038	7950	0.026	10110	0.028
1472	0.038	3633	0.042	5790	0.036	7951	0.026	10111	0.026
1473	0.04	3634	0.042	5791	0.036	7952	0.024	10112	0.026
1474	0.038	3635	0.042	5792	0.036	7953	0.024	10113	0.028
1475	0.038	3636	0.042	5793	0.036	7954	0.024	10114	0.028
1476	0.036	3637	0.044	5794	0.038	7955	0.024	10115	0.028
1477	0.038	3638	0.042	5795	0.038	7956	0.026	10116	0.026
1478	0.038	3639	0.042	5796	0.036	7957	0.026	10117	0.026
1479	0.038	3640	0.044	5797	0.036	7958	0.024	10118	0.026
1480	0.04	3641	0.044	5798	0.036	7959	0.026	10119	0.026
1481	0.04	3642	0.044	5799	0.036	7960	0.026	10120	0.026
1482	0.04	3643	0.044	5800	0.036	7961	0.026	10121	0.026
1483	0.042	3644	0.044	5801	0.036	7962	0.024	10122	0.026
1484	0.04	3645	0.042	5802	0.036	7963	0.024	10123	0.026
1485	0.042	3646	0.044	5803	0.036	7964	0.026	10124	0.026
1486	0.042	3647	0.044	5804	0.034	7965	0.024	10125	0.028
1487	0.042	3648	0.044	5805	0.034	7966	0.028	10126	0.028
1488	0.042	3649	0.044	5806	0.036	7967	0.028	10127	0.028
1489	0.042	3650	0.044	5807	0.034	7968	0.024	10128	0.028
1490	0.042	3651	0.044	5808	0.032	7969	0.022	10129	0.028
1491	0.042	3652	0.042	5809	0.032	7970	0.022	10130	0.028
1492	0.042	3653	0.042	5810	0.032	7971	0.022	10131	0.03
1493	0.042	3654	0.044	5811	0.032	7972	0.022	10132	0.028
1494	0.042	3655	0.042	5812	0.032	7973	0.022	10133	0.028
1495	0.04	3656	0.042	5813	0.032	7974	0.022	10134	0.028
1496	0.038	3657	0.042	5814	0.034	7975	0.02	10135	0.028
1497	0.038	3658	0.044	5815	0.034	7976	0.022	10136	0.028
1498	0.04	3659	0.046	5816	0.032	7977	0.022	10137	0.028
1499	0.038	3660	0.044	5817	0.032	7978	0.02	10138	0.028
1500	0.038	3661	0.044	5818	0.032	7979	0.022	10139	0.026
1501	0.036	3662	0.044	5819	0.034	7980	0.022	10140	0.028
1502	0.038	3663	0.044	5820	0.034	7981	0.022	10141	0.028
1503	0.038	3664	0.046	5821	0.032	7982	0.022	10142	0.028
1504	0.038	3665	0.044	5822	0.032	7983	0.022	10143	0.028
1505	0.04	3666	0.044	5823	0.03	7984	0.022	10144	0.03
1506	0.038	3667	0.044	5824	0.032	7985	0.022	10145	0.026
1507	0.038	3668	0.044	5825	0.034	7986	0.022	10146	0.026
1508	0.04	3669	0.044	5826	0.032	7987	0.022	10147	0.028
1509	0.038	3670	0.044	5827	0.032	7988	0.022	10148	0.028
1510	0.038	3671	0.044	5828	0.032	7989	0.022	10149	0.028
1511	0.038	3672	0.046	5829	0.034	7990	0.022	10150	0.028
1512	0.038	3673	0.044	5830	0.036	7991	0.022	10151	0.026
1513	0.04	3674	0.046	5831	0.042	7992	0.02	10152	0.026
1514	0.04	3675	0.048	5832	0.054	7993	0.022	10153	0.028
1515	0.04	3676	0.046	5833	0.054	7994	0.022	10154	0.028
1516	0.038	3677	0.046	5834	0.048	7995	0.024	10155	0.028
1517	0.04	3678	0.046	5835	0.048	7996	0.024	10156	0.028
1518	0.038	3679	0.046	5836	0.046	7997	0.024	10157	0.028
1519	0.038	3680	0.046	5837	0.046	7998	0.024	10158	0.028
1520	0.038	3681	0.044	5838	0.042	7999	0.024	10159	0.026
1521	0.04	3682	0.046	5839	0.04	8000	0.024	10160	0.026
1522	0.04	3683	0.046	5840	0.036	8001	0.024	10161	0.026
1523	0.038	3684	0.046	5841	0.034	8002	0.024	10162	0.026
1524	0.038	3685	0.046	5842	0.034	8003	0.024	10163	0.028
1525	0.038	3686	0.046	5843	0.036	8004	0.024	10164	0.03
1526	0.036	3687	0.046	5844	0.034	8005	0.026	10165	0.028
1527	0.038	3688	0.044	5845	0.032	8006	0.024	10166	0.028
1528	0.038	3689	0.044	5846	0.032	8007	0.024	10167	0.028
1529	0.038	3690	0.046	5847	0.032	8008	0.024	10168	0.028
1530	0.038	3691	0.046	5848	0.032	8009	0.024	10169	0.028
1531	0.036	3692	0.046	5849	0.03	8010	0.024	10170	0.028
1532	0.038	3693	0.046	5850	0.032	8011	0.024	10171	0.028
1533	0.038	3694	0.046	5851	0.032	8012	0.026	10172	0.028
1534	0.038	3695	0.044	5852	0.032	8013	0.026	10173	0.028
1535	0.038	3696	0.044	5853	0.032	8014	0.024	10174	0.028
1536	0.038	3697	0.048	5854	0.032	8015	0.026	10175	0.03
1537	0.038	3698	0.046	5855	0.032	8016	0.026	10176	0.028
1538	0.036	3699	0.046	5856	0.032	8017	0.024	10177	0.028
1539	0.036	3700	0.048	5857	0.034	8018	0.024	10178	0.03
1540	0.036	3701	0.046	5858	0.032	8019	0.024	10179	0.028
1541	0.036	3702	0.046	5859	0.032	8020	0.024	10180	0.028
1542	0.036	3703	0.046	5860	0.034	8021	0.024	10181	0.028
1543	0.036	3704	0.046	5861	0.034	8022	0.024	10182	0.028
1544	0.036	3705	0.046	5862	0.032	8023	0.024	10183	0.028
1545	0.036	3706	0.046	5863	0.032	8024	0.026	10184	0.028
1546	0.036	3707	0.046	5864	0.032	8025	0.024	10185	0.03
1547	0.036	3708	0.046	5865	0.032	8026	0.022	10186	0.03
1548	0.036	3709	0.048	5866	0.03	8027	0.024	10187	0.03
1549	0.036	3710	0.044	5867	0.03	8028	0.024	10188	0.028
1550	0.036	3711	0.044	5868	0.032	8029	0.024	10189	0.028
1551	0.038	3712	0.044	5869	0.032	8030	0.026	10190	0.026
1552	0.036	3713	0.048	5870	0.032	8031	0.026	10191	0.028
1553	0.036	3714	0.05	5871	0.032	8032	0.026	10192	0.028
1554	0.034	3715	0.048	5872	0.032	8033	0.024	10193	0.028
1555	0.036	3716	0.046	5873	0.034	8034	0.024	10194	0.028
1556	0.036	3717	0.044	5874	0.032	8035	0.026	10195	0.028
1557	0.038	3718	0.046	5875	0.032	8036	0.026	10196	0.028
1558	0.038	3719	0.048	5876	0.032	8037	0.024	10197	0.028
1559	0.036	3720	0.05	5877	0.032	8038	0.026	10198	0.028
1560	0.036	3721	0.05	5878	0.03	8039	0.026	10199	0.03

1561	0.038	3722	0.048	5879	0.032	8040	0.024	10200	0.03
1562	0.036	3723	0.048	5880	0.034	8041	0.024	10201	0.028
1563	0.036	3724	0.05	5881	0.032	8042	0.024	10202	0.028
1564	0.036	3725	0.05	5882	0.034	8043	0.026	10203	0.028
1565	0.038	3726	0.048	5883	0.036	8044	0.024	10204	0.028
1566	0.038	3727	0.048	5884	0.036	8045	0.024	10205	0.028
1567	0.038	3728	0.048	5885	0.034	8046	0.024	10206	0.028
1568	0.036	3729	0.048	5886	0.032	8047	0.024	10207	0.028
1569	0.038	3730	0.048	5887	0.032	8048	0.024	10208	0.028
1570	0.04	3731	0.048	5888	0.034	8049	0.024	10209	0.03
1571	0.038	3732	0.048	5889	0.032	8050	0.024	10210	0.03
1572	0.04	3733	0.05	5890	0.032	8051	0.026	10211	0.028
1573	0.038	3734	0.048	5891	0.034	8052	0.024	10212	0.028
1574	0.04	3735	0.046	5892	0.034	8053	0.024	10213	0.03
1575	0.04	3736	0.048	5893	0.032	8054	0.026	10214	0.03
1576	0.042	3737	0.046	5894	0.034	8055	0.026	10215	0.028
1577	0.038	3738	0.046	5895	0.034	8056	0.026	10216	0.03
1578	0.038	3739	0.046	5896	0.034	8057	0.024	10217	0.03
1579	0.042	3740	0.048	5897	0.032	8058	0.026	10218	0.03
1580	0.04	3741	0.048	5898	0.034	8059	0.024	10219	0.03
1581	0.04	3742	0.05	5899	0.032	8060	0.024	10220	0.028
1582	0.04	3743	0.048	5900	0.032	8061	0.024	10221	0.028
1583	0.04	3744	0.048	5901	0.03	8062	0.026	10222	0.028
1584	0.04	3745	0.046	5902	0.032	8063	0.028	10223	0.028
1585	0.04	3746	0.046	5903	0.032	8064	0.026	10224	0.028
1586	0.04	3747	0.046	5904	0.032	8065	0.026	10225	0.03
1587	0.04	3748	0.046	5905	0.032	8066	0.026	10226	0.03
1588	0.04	3749	0.048	5906	0.034	8067	0.026	10227	0.03
1589	0.04	3750	0.048	5907	0.036	8068	0.026	10228	0.028
1590	0.042	3751	0.046	5908	0.04	8069	0.028	10229	0.028
1591	0.044	3752	0.046	5909	0.044	8070	0.028	10230	0.028
1592	0.042	3753	0.048	5910	0.044	8071	0.026	10231	0.028
1593	0.04	3754	0.046	5911	0.036	8072	0.026	10232	0.028
1594	0.042	3755	0.046	5912	0.034	8073	0.026	10233	0.028
1595	0.042	3756	0.046	5913	0.034	8074	0.026	10234	0.028
1596	0.042	3757	0.046	5914	0.032	8075	0.026	10235	0.03
1597	0.042	3758	0.046	5915	0.034	8076	0.026	10236	0.028
1598	0.042	3759	0.046	5916	0.034	8077	0.026	10237	0.028
1599	0.042	3760	0.048	5917	0.04	8078	0.028	10238	0.034
1600	0.042	3761	0.046	5918	0.052	8079	0.026	10239	0.038
1601	0.04	3762	0.046	5919	0.062	8080	0.026	10240	0.028
1602	0.038	3763	0.046	5920	0.078	8081	0.028	10241	0.028
1603	0.038	3764	0.046	5921	0.086	8082	0.026	10242	0.03
1604	0.04	3765	0.048	5922	0.068	8083	0.028	10243	0.03
1605	0.04	3766	0.048	5923	0.054	8084	0.028	10244	0.03
1606	0.042	3767	0.046	5924	0.036	8085	0.026	10245	0.028
1607	0.042	3768	0.046	5925	0.036	8086	0.026	10246	0.028
1608	0.044	3769	0.048	5926	0.038	8087	0.026	10247	0.028
1609	0.042	3770	0.048	5927	0.038	8088	0.026	10248	0.028
1610	0.038	3771	0.048	5928	0.038	8089	0.028	10249	0.026
1611	0.04	3772	0.046	5929	0.038	8090	0.03	10250	0.028
1612	0.042	3773	0.046	5930	0.036	8091	0.028	10251	0.028
1613	0.042	3774	0.046	5931	0.036	8092	0.026	10252	0.028
1614	0.038	3775	0.046	5932	0.034	8093	0.026	10253	0.028
1615	0.04	3776	0.046	5933	0.034	8094	0.026	10254	0.026
1616	0.042	3777	0.044	5934	0.034	8095	0.026	10255	0.026
1617	0.04	3778	0.042	5935	0.032	8096	0.026	10256	0.028
1618	0.04	3779	0.044	5936	0.032	8097	0.026	10257	0.028
1619	0.04	3780	0.044	5937	0.03	8098	0.026	10258	0.03
1620	0.042	3781	0.044	5938	0.032	8099	0.026	10259	0.028
1621	0.042	3782	0.044	5939	0.032	8100	0.026	10260	0.028
1622	0.04	3783	0.044	5940	0.03	8101	0.024	10261	0.03
1623	0.038	3784	0.044	5941	0.03	8102	0.026	10262	0.028
1624	0.04	3785	0.044	5942	0.03	8103	0.028	10263	0.028
1625	0.04	3786	0.044	5943	0.032	8104	0.028	10264	0.03
1626	0.038	3787	0.048	5944	0.034	8105	0.026	10265	0.028
1627	0.04	3788	0.048	5945	0.034	8106	0.026	10266	0.028
1628	0.038	3789	0.044	5946	0.032	8107	0.026	10267	0.028
1629	0.038	3790	0.044	5947	0.032	8108	0.028	10268	0.028
1630	0.04	3791	0.048	5948	0.034	8109	0.028	10269	0.028
1631	0.038	3792	0.048	5949	0.036	8110	0.028	10270	0.028
1632	0.036	3793	0.044	5950	0.036	8111	0.028	10271	0.028
1633	0.038	3794	0.044	5951	0.04	8112	0.026	10272	0.028
1634	0.038	3795	0.044	5952	0.046	8113	0.028	10273	0.028
1635	0.038	3796	0.044	5953	0.04	8114	0.026	10274	0.026
1636	0.04	3797	0.048	5954	0.038	8115	0.028	10275	0.028
1637	0.038	3798	0.048	5955	0.038	8116	0.028	10276	0.028
1638	0.038	3799	0.046	5956	0.038	8117	0.028	10277	0.028
1639	0.038	3800	0.046	5957	0.038	8118	0.03	10278	0.03
1640	0.04	3801	0.046	5958	0.036	8119	0.028	10279	0.03
1641	0.04	3802	0.044	5959	0.036	8120	0.028	10280	0.028
1642	0.038	3803	0.042	5960	0.038	8121	0.028	10281	0.028
1643	0.038	3804	0.044	5961	0.036	8122	0.028	10282	0.028
1644	0.038	3805	0.046	5962	0.034	8123	0.028	10283	0.028
1645	0.04	3806	0.044	5963	0.038	8124	0.028	10284	0.028
1646	0.038	3807	0.044	5964	0.036	8125	0.03	10285	0.028
1647	0.036	3808	0.042	5965	0.036	8126	0.028	10286	0.028
1648	0.036	3809	0.042	5966	0.034	8127	0.028	10287	0.028
1649	0.036	3810	0.042	5967	0.034	8128	0.026	10288	0.026
1650	0.036	3811	0.044	5968	0.034	8129	0.026	10289	0.026
1651	0.036	3812	0.042	5969	0.034	8130	0.026	10290	0.028
1652	0.038	3813	0.042	5970	0.034	8131	0.028	10291	0.028
1653	0.038	3814	0.044	5971	0.032	8132	0.028	10292	0.028

1654	0.038	3815	0.042	5972	0.032	8133	0.028	10293	0.026
1655	0.04	3816	0.042	5973	0.032	8134	0.028	10294	0.028
1656	0.038	3817	0.044	5974	0.03	8135	0.028	10295	0.028
1657	0.038	3818	0.044	5975	0.03	8136	0.026	10296	0.028
1658	0.038	3819	0.046	5976	0.032	8137	0.026	10297	0.028
1659	0.038	3820	0.044	5977	0.032	8138	0.026	10298	0.028
1660	0.038	3821	0.044	5978	0.032	8139	0.026	10299	0.028
1661	0.038	3822	0.042	5979	0.032	8140	0.028	10300	0.028
1662	0.04	3823	0.042	5980	0.032	8141	0.028	10301	0.028
1663	0.038	3824	0.042	5981	0.032	8142	0.026	10302	0.028
1664	0.038	3825	0.042	5982	0.03	8143	0.028	10303	0.03
1665	0.038	3826	0.042	5983	0.032	8144	0.028	10304	0.03
1666	0.038	3827	0.042	5984	0.032	8145	0.028	10305	0.028
1667	0.038	3828	0.042	5985	0.032	8146	0.028	10306	0.028
1668	0.038	3829	0.042	5986	0.032	8147	0.026	10307	0.028
1669	0.036	3830	0.042	5987	0.032	8148	0.028	10308	0.028
1670	0.036	3831	0.044	5988	0.032	8149	0.028	10309	0.028
1671	0.038	3832	0.044	5989	0.034	8150	0.026	10310	0.03
1672	0.036	3833	0.044	5990	0.032	8151	0.026	10311	0.03
1673	0.036	3834	0.044	5991	0.032	8152	0.028	10312	0.028
1674	0.038	3835	0.044	5992	0.034	8153	0.028	10313	0.028
1675	0.038	3836	0.044	5993	0.034	8154	0.026	10314	0.028
1676	0.038	3837	0.044	5994	0.034	8155	0.026	10315	0.028
1677	0.036	3838	0.044	5995	0.032	8156	0.026	10316	0.028
1678	0.038	3839	0.042	5996	0.032	8157	0.026	10317	0.03
1679	0.04	3840	0.042	5997	0.034	8158	0.028	10318	0.03
1680	0.04	3841	0.042	5998	0.034	8159	0.026	10319	0.03
1681	0.038	3842	0.044	5999	0.034	8160	0.028	10320	0.03
1682	0.04	3843	0.044	6000	0.034	8161	0.028	10321	0.028
1683	0.04	3844	0.044	6001	0.034	8162	0.028	10322	0.028
1684	0.04	3845	0.044	6002	0.034	8163	0.028	10323	0.028
1685	0.038	3846	0.044	6003	0.034	8164	0.026	10324	0.028
1686	0.038	3847	0.044	6004	0.034	8165	0.026	10325	0.03
1687	0.038	3848	0.044	6005	0.034	8166	0.028	10326	0.03
1688	0.038	3849	0.046	6006	0.034	8167	0.026	10327	0.03
1689	0.04	3850	0.046	6007	0.034	8168	0.026	10328	0.028
1690	0.04	3851	0.042	6008	0.036	8169	0.026	10329	0.028
1691	0.04	3852	0.044	6009	0.036	8170	0.026	10330	0.03
1692	0.04	3853	0.044	6010	0.036	8171	0.024	10331	0.03
1693	0.04	3854	0.044	6011	0.036	8172	0.026	10332	0.03
1694	0.038	3855	0.046	6012	0.036	8173	0.026	10333	0.03
1695	0.038	3856	0.046	6013	0.038	8174	0.024	10334	0.03
1696	0.038	3857	0.046	6014	0.038	8175	0.024	10335	0.03
1697	0.038	3858	0.044	6015	0.038	8176	0.028	10336	0.028
1698	0.04	3859	0.044	6016	0.036	8177	0.026	10337	0.03
1699	0.042	3860	0.046	6017	0.038	8178	0.026	10338	0.03
1700	0.038	3861	0.046	6018	0.038	8179	0.028	10339	0.03
1701	0.038	3862	0.046	6019	0.038	8180	0.026	10340	0.03
1702	0.038	3863	0.046	6020	0.036	8181	0.026	10341	0.03
1703	0.04	3864	0.046	6021	0.038	8182	0.026	10342	0.028
1704	0.038	3865	0.044	6022	0.038	8183	0.026	10343	0.028
1705	0.038	3866	0.044	6023	0.038	8184	0.026	10344	0.03
1706	0.04	3867	0.044	6024	0.038	8185	0.026	10345	0.03
1707	0.04	3868	0.046	6025	0.038	8186	0.026	10346	0.03
1708	0.038	3869	0.046	6026	0.038	8187	0.028	10347	0.028
1709	0.036	3870	0.044	6027	0.04	8188	0.028	10348	0.028
1710	0.036	3871	0.044	6028	0.04	8189	0.026	10349	0.028
1711	0.038	3872	0.042	6029	0.036	8190	0.026	10350	0.03
1712	0.038	3873	0.042	6030	0.038	8191	0.026	10351	0.03
1713	0.038	3874	0.044	6031	0.038	8192	0.026	10352	0.03
1714	0.04	3875	0.046	6032	0.038	8193	0.026	10353	0.03
1715	0.044	3876	0.046	6033	0.04	8194	0.026	10354	0.028
1716	0.04	3877	0.048	6034	0.04	8195	0.026	10355	0.03
1717	0.038	3878	0.046	6035	0.04	8196	0.026	10356	0.03
1718	0.04	3879	0.046	6036	0.042	8197	0.026	10357	0.03
1719	0.038	3880	0.044	6037	0.04	8198	0.026	10358	0.032
1720	0.038	3881	0.046	6038	0.04	8199	0.026	10359	0.03
1721	0.038	3882	0.046	6039	0.04	8200	0.024	10360	0.03
1722	0.038	3883	0.044	6040	0.04	8201	0.026	10361	0.028
1723	0.04	3884	0.046	6041	0.038	8202	0.024	10362	0.03
1724	0.038	3885	0.046	6042	0.04	8203	0.026	10363	0.03
1725	0.038	3886	0.046	6043	0.04	8204	0.026	10364	0.03
1726	0.038	3887	0.046	6044	0.038	8205	0.028	10365	0.03
1727	0.038	3888	0.046	6045	0.038	8206	0.026	10366	0.03
1728	0.04	3889	0.046	6046	0.038	8207	0.024	10367	0.028
1729	0.038	3890	0.048	6047	0.04	8208	0.024	10368	0.028
1730	0.038	3891	0.048	6048	0.042	8209	0.026	10369	0.03
1731	0.04	3892	0.046	6049	0.04	8210	0.024	10370	0.03
1732	0.04	3893	0.044	6050	0.038	8211	0.026	10371	0.028
1733	0.038	3894	0.044	6051	0.038	8212	0.026	10372	0.028
1734	0.038	3895	0.046	6052	0.038	8213	0.026	10373	0.028
1735	0.038	3896	0.044	6053	0.04	8214	0.028	10374	0.032
1736	0.038	3897	0.046	6054	0.04	8215	0.026	10375	0.032
1737	0.038	3898	0.048	6055	0.04	8216	0.026	10376	0.03
1738	0.04	3899	0.046	6056	0.04	8217	0.026	10377	0.03
1739	0.04	3900	0.044	6057	0.04	8218	0.024	10378	0.028
1740	0.038	3901	0.046	6058	0.038	8219	0.026	10379	0.03
1741	0.04	3902	0.046	6059	0.036	8220	0.024	10380	0.03
1742	0.042	3903	0.046	6060	0.036	8221	0.026	10381	0.028
1743	0.044	3904	0.046	6061	0.036	8222	0.028	10382	0.028
1744	0.046	3905	0.046	6062	0.036	8223	0.028	10383	0.028
1745	0.04	3906	0.048	6063	0.036	8224	0.028	10384	0.032
1746	0.042	3907	0.046	6064	0.036	8225	0.026	10385	0.032

1747	0.042	3908	0.044	6065	0.034	8226	0.026	10386	0.028
1748	0.042	3909	0.046	6066	0.034	8227	0.026	10387	0.028
1749	0.042	3910	0.046	6067	0.034	8228	0.026	10388	0.028
1750	0.042	3911	0.046	6068	0.034	8229	0.026	10389	0.028
1751	0.042	3912	0.046	6069	0.036	8230	0.026	10390	0.028
1752	0.044	3913	0.044	6070	0.038	8231	0.026	10391	0.03
1753	0.044	3914	0.046	6071	0.04	8232	0.026	10392	0.028
1754	0.044	3915	0.048	6072	0.038	8233	0.026	10393	0.028
1755	0.046	3916	0.046	6073	0.036	8234	0.026	10394	0.028
1756	0.044	3917	0.048	6074	0.036	8235	0.028	10395	0.03
1757	0.044	3918	0.046	6075	0.036	8236	0.026	10396	0.03
1758	0.042	3919	0.044	6076	0.036	8237	0.028	10397	0.028
1759	0.042	3920	0.046	6077	0.036	8238	0.03	10398	0.03
1760	0.042	3921	0.046	6078	0.034	8239	0.028	10399	0.03
1761	0.044	3922	0.046	6079	0.036	8240	0.026	10400	0.03
1762	0.046	3923	0.044	6080	0.034	8241	0.028	10401	0.03
1763	0.048	3924	0.044	6081	0.034	8242	0.028	10402	0.03
1764	0.048	3925	0.044	6082	0.034	8243	0.03	10403	0.03
1765	0.048	3926	0.044	6083	0.034	8244	0.028	10404	0.03
1766	0.046	3927	0.044	6084	0.034	8245	0.028	10405	0.028
1767	0.046	3928	0.044	6085	0.032	8246	0.03	10406	0.03
1768	0.046	3929	0.044	6086	0.032	8247	0.03	10407	0.034
1769	0.046	3930	0.044	6087	0.032	8248	0.03	10408	0.034
1770	0.048	3931	0.044	6088	0.032	8249	0.028	10409	0.03
1771	0.046	3932	0.046	6089	0.03	8250	0.026	10410	0.03
1772	0.048	3933	0.046	6090	0.03	8251	0.028	10411	0.028
1773	0.048	3934	0.046	6091	0.032	8252	0.028	10412	0.03
1774	0.05	3935	0.044	6092	0.032	8253	0.03	10413	0.03
1775	0.05	3936	0.044	6093	0.032	8254	0.028	10414	0.03
1776	0.046	3937	0.044	6094	0.034	8255	0.028	10415	0.03
1777	0.046	3938	0.044	6095	0.032	8256	0.028	10416	0.03
1778	0.044	3939	0.044	6096	0.032	8257	0.028	10417	0.03
1779	0.046	3940	0.044	6097	0.032	8258	0.03	10418	0.032
1780	0.046	3941	0.042	6098	0.032	8259	0.03	10419	0.03
1781	0.044	3942	0.044	6099	0.032	8260	0.028	10420	0.03
1782	0.044	3943	0.046	6100	0.032	8261	0.028	10421	0.03
1783	0.042	3944	0.046	6101	0.03	8262	0.03	10422	0.03
1784	0.044	3945	0.044	6102	0.032	8263	0.03	10423	0.03
1785	0.046	3946	0.044	6103	0.034	8264	0.028	10424	0.028
1786	0.042	3947	0.044	6104	0.032	8265	0.03	10425	0.03
1787	0.042	3948	0.044	6105	0.032	8266	0.028	10426	0.03
1788	0.042	3949	0.044	6106	0.032	8267	0.028	10427	0.03
1789	0.042	3950	0.044	6107	0.03	8268	0.03	10428	0.028
1790	0.042	3951	0.046	6108	0.03	8269	0.03	10429	0.028
1791	0.042	3952	0.046	6109	0.03	8270	0.03	10430	0.03
1792	0.042	3953	0.046	6110	0.03	8271	0.03	10431	0.03
1793	0.042	3954	0.046	6111	0.03	8272	0.03	10432	0.028
1794	0.042	3955	0.044	6112	0.03	8273	0.03	10433	0.028
1795	0.044	3956	0.046	6113	0.03	8274	0.03	10434	0.028
1796	0.046	3957	0.046	6114	0.03	8275	0.03	10435	0.03
1797	0.046	3958	0.044	6115	0.03	8276	0.032	10436	0.03
1798	0.046	3959	0.044	6116	0.03	8277	0.03	10437	0.028
1799	0.048	3960	0.044	6117	0.028	8278	0.028	10438	0.028
1800	0.05	3961	0.044	6118	0.028	8279	0.03	10439	0.028
1801	0.05	3962	0.044	6119	0.03	8280	0.032	10440	0.028
1802	0.05	3963	0.046	6120	0.03	8281	0.03	10441	0.028
1803	0.05	3964	0.044	6121	0.03	8282	0.03	10442	0.028
1804	0.05	3965	0.046	6122	0.028	8283	0.03	10443	0.03
1805	0.05	3966	0.044	6123	0.028	8284	0.03	10444	0.03
1806	0.048	3967	0.044	6124	0.028	8285	0.03	10445	0.028
1807	0.046	3968	0.044	6125	0.03	8286	0.03	10446	0.028
1808	0.048	3969	0.044	6126	0.03	8287	0.03	10447	0.028
1809	0.048	3970	0.044	6127	0.03	8288	0.028	10448	0.028
1810	0.046	3971	0.044	6128	0.03	8289	0.028	10449	0.028
1811	0.046	3972	0.046	6129	0.03	8290	0.028	10450	0.028
1812	0.046	3973	0.044	6130	0.028	8291	0.03	10451	0.026
1813	0.046	3974	0.044	6131	0.03	8292	0.03	10452	0.028
1814	0.046	3975	0.044	6132	0.03	8293	0.028	10453	0.028
1815	0.046	3976	0.044	6133	0.03	8294	0.028	10454	0.028
1816	0.046	3977	0.044	6134	0.03	8295	0.03	10455	0.026
1817	0.046	3978	0.044	6135	0.03	8296	0.03	10456	0.03
1818	0.048	3979	0.042	6136	0.028	8297	0.03	10457	0.028
1819	0.046	3980	0.044	6137	0.03	8298	0.03	10458	0.026
1820	0.046	3981	0.044	6138	0.03	8299	0.028	10459	0.028
1821	0.048	3982	0.044	6139	0.03	8300	0.03	10460	0.028
1822	0.048	3983	0.042	6140	0.03	8301	0.03	10461	0.028
1823	0.046	3984	0.042	6141	0.03	8302	0.028	10462	0.032
1824	0.046	3985	0.042	6142	0.03	8303	0.028	10463	0.028
1825	0.044	3986	0.042	6143	0.032	8304	0.03	10464	0.028
1826	0.046	3987	0.042	6144	0.03	8305	0.03	10465	0.028
1827	0.048	3988	0.042	6145	0.03	8306	0.028	10466	0.028
1828	0.044	3989	0.044	6146	0.032	8307	0.028	10467	0.028
1829	0.046	3990	0.042	6147	0.03	8308	0.026	10468	0.028
1830	0.046	3991	0.042	6148	0.03	8309	0.028	10469	0.028
1831	0.046	3992	0.042	6149	0.03	8310	0.028	10470	0.028
1832	0.046	3993	0.044	6150	0.03	8311	0.03	10471	0.028
1833	0.044	3994	0.042	6151	0.028	8312	0.028	10472	0.028
1834	0.046	3995	0.042	6152	0.03	8313	0.028	10473	0.03
1835	0.046	3996	0.042	6153	0.032	8314	0.03	10474	0.03
1836	0.044	3997	0.044	6154	0.03	8315	0.03	10475	0.032
1837	0.044	3998	0.042	6155	0.03	8316	0.03	10476	0.03
1838	0.044	3999	0.04	6156	0.032	8317	0.028	10477	0.03
1839	0.046	4000	0.042	6157	0.032	8318	0.028	10478	0.032

1840	0.048	4001	0.042	6158	0.03	8319	0.028	10479	0.032
1841	0.044	4002	0.04	6159	0.03	8320	0.028	10480	0.03
1842	0.044	4003	0.042	6160	0.03	8321	0.03	10481	0.028
1843	0.044	4004	0.04	6161	0.03	8322	0.03	10482	0.03
1844	0.044	4005	0.04	6162	0.03	8323	0.03	10483	0.03
1845	0.044	4006	0.042	6163	0.03	8324	0.026	10484	0.03
1846	0.046	4007	0.042	6164	0.032	8325	0.028	10485	0.03
1847	0.044	4008	0.04	6165	0.032	8326	0.028	10486	0.03
1848	0.044	4009	0.04	6166	0.032	8327	0.028	10487	0.03
1849	0.046	4010	0.04	6167	0.032	8328	0.028	10488	0.028
1850	0.046	4011	0.038	6168	0.03	8329	0.028	10489	0.028
1851	0.046	4012	0.04	6169	0.03	8330	0.028	10490	0.03
1852	0.048	4013	0.04	6170	0.03	8331	0.028	10491	0.03
1853	0.048	4014	0.04	6171	0.03	8332	0.026	10492	0.028
1854	0.048	4015	0.04	6172	0.032	8333	0.026	10493	0.028
1855	0.048	4016	0.04	6173	0.03	8334	0.028	10494	0.028
1856	0.048	4017	0.038	6174	0.03	8335	0.026	10495	0.028
1857	0.048	4018	0.04	6175	0.032	8336	0.026	10496	0.028
1858	0.048	4019	0.042	6176	0.032	8337	0.028	10497	0.028
1859	0.048	4020	0.042	6177	0.032	8338	0.026	10498	0.028
1860	0.046	4021	0.038	6178	0.03	8339	0.026	10499	0.03
1861	0.046	4022	0.04	6179	0.028	8340	0.024	10500	0.03
1862	0.046	4023	0.04	6180	0.028	8341	0.026	10501	0.03
1863	0.046	4024	0.04	6181	0.03	8342	0.028	10502	0.028
1864	0.046	4025	0.042	6182	0.03	8343	0.028	10503	0.028
1865	0.048	4026	0.042	6183	0.03	8344	0.028	10504	0.028
1866	0.048	4027	0.04	6184	0.03	8345	0.028	10505	0.028
1867	0.046	4028	0.038	6185	0.03	8346	0.026	10506	0.03
1868	0.05	4029	0.04	6186	0.03	8347	0.026	10507	0.028
1869	0.048	4030	0.04	6187	0.032	8348	0.026	10508	0.028
1870	0.048	4031	0.04	6188	0.032	8349	0.026	10509	0.028
1871	0.048	4032	0.04	6189	0.032	8350	0.028	10510	0.03
1872	0.048	4033	0.04	6190	0.032	8351	0.026	10511	0.03
1873	0.052	4034	0.042	6191	0.032	8352	0.028	10512	0.028
1874	0.052	4035	0.04	6192	0.03	8353	0.028	10513	0.028
1875	0.052	4036	0.04	6193	0.032	8354	0.026	10514	0.028
1876	0.05	4037	0.04	6194	0.032	8355	0.026	10515	0.03
1877	0.05	4038	0.042	6195	0.03	8356	0.026	10516	0.03
1878	0.048	4039	0.04	6196	0.032	8357	0.028	10517	0.03
1879	0.048	4040	0.04	6197	0.032	8358	0.026	10518	0.03
1880	0.048	4041	0.04	6198	0.03	8359	0.026	10519	0.03
1881	0.052	4042	0.042	6199	0.03	8360	0.024	10520	0.028
1882	0.052	4043	0.042	6200	0.03	8361	0.026	10521	0.028
1883	0.05	4044	0.042	6201	0.032	8362	0.026	10522	0.028
1884	0.052	4045	0.044	6202	0.03	8363	0.026	10523	0.03
1885	0.05	4046	0.042	6203	0.032	8364	0.026	10524	0.028
1886	0.052	4047	0.044	6204	0.032	8365	0.026	10525	0.028
1887	0.052	4048	0.042	6205	0.032	8366	0.026	10526	0.03
1888	0.052	4049	0.042	6206	0.032	8367	0.026	10527	0.028
1889	0.05	4050	0.044	6207	0.028	8368	0.026	10528	0.028
1890	0.048	4051	0.044	6208	0.03	8369	0.026	10529	0.028
1891	0.05	4052	0.042	6209	0.03	8370	0.028	10530	0.028
1892	0.052	4053	0.042	6210	0.03	8371	0.026	10531	0.03
1893	0.054	4054	0.044	6211	0.03	8372	0.026	10532	0.028
1894	0.052	4055	0.042	6212	0.03	8373	0.026	10533	0.03
1895	0.05	4056	0.042	6213	0.03	8374	0.026	10534	0.03
1896	0.05	4057	0.042	6214	0.03	8375	0.026	10535	0.03
1897	0.05	4058	0.044	6215	0.03	8376	0.026	10536	0.03
1898	0.05	4059	0.042	6216	0.03	8377	0.026	10537	0.03
1899	0.048	4060	0.042	6217	0.03	8378	0.026	10538	0.028
1900	0.05	4061	0.042	6218	0.032	8379	0.026	10539	0.028
1901	0.054	4062	0.044	6219	0.032	8380	0.028	10540	0.028
1902	0.05	4063	0.044	6220	0.03	8381	0.026	10541	0.028
1903	0.05	4064	0.042	6221	0.03	8382	0.026	10542	0.028
1904	0.05	4065	0.044	6222	0.028	8383	0.026	10543	0.028
1905	0.052	4066	0.044	6223	0.03	8384	0.026	10544	0.028
1906	0.05	4067	0.044	6224	0.03	8385	0.026	10545	0.028
1907	0.05	4068	0.046	6225	0.03	8386	0.026	10546	0.028
1908	0.052	4069	0.044	6226	0.032	8387	0.026	10547	0.028
1909	0.052	4070	0.042	6227	0.032	8388	0.026	10548	0.028
1910	0.05	4071	0.044	6228	0.03	8389	0.028	10549	0.028
1911	0.05	4072	0.044	6229	0.03	8390	0.024	10550	0.028
1912	0.05	4073	0.044	6230	0.03	8391	0.024	10551	0.03
1913	0.052	4074	0.046	6231	0.03	8392	0.026	10552	0.032
1914	0.052	4075	0.044	6232	0.03	8393	0.026	10553	0.032
1915	0.052	4076	0.044	6233	0.03	8394	0.028	10554	0.032
1916	0.052	4077	0.044	6234	0.03	8395	0.028	10555	0.032
1917	0.052	4078	0.046	6235	0.032	8396	0.026	10556	0.032
1918	0.05	4079	0.046	6236	0.032	8397	0.026	10557	0.03
1919	0.052	4080	0.046	6237	0.03	8398	0.026	10558	0.03
1920	0.05	4081	0.044	6238	0.03	8399	0.026	10559	0.03
1921	0.048	4082	0.048	6239	0.03	8400	0.026	10560	0.03
1922	0.05	4083	0.05	6240	0.03	8401	0.026	10561	0.03
1923	0.05	4084	0.046	6241	0.03	8402	0.026	10562	0.03
1924	0.048	4085	0.046	6242	0.03	8403	0.026	10563	0.03
1925	0.05	4086	0.044	6243	0.032	8404	0.028	10564	0.028
1926	0.052	4087	0.044	6244	0.032	8405	0.028	10565	0.028
1927	0.05	4088	0.046	6245	0.032	8406	0.028	10566	0.028
1928	0.05	4089	0.044	6246	0.032	8407	0.026	10567	0.03
1929	0.052	4090	0.044	6247	0.032	8408	0.026	10568	0.03
1930	0.052	4091	0.046	6248	0.032	8409	0.028	10569	0.03
1931	0.05	4092	0.044	6249	0.032	8410	0.026	10570	0.03
1932	0.052	4093	0.044	6250	0.032	8411	0.026	10571	0.03

1933	0.05	4094	0.044	6251	0.032	8412	0.026	10572	0.032
1934	0.05	4095	0.044	6252	0.032	8413	0.028	10573	0.03
1935	0.05	4096	0.042	6253	0.032	8414	0.026	10574	0.03
1936	0.052	4097	0.044	6254	0.032	8415	0.026	10575	0.028
1937	0.052	4098	0.042	6255	0.034	8416	0.026	10576	0.03
1938	0.05	4099	0.042	6256	0.034	8417	0.026	10577	0.03
1939	0.052	4100	0.042	6257	0.034	8418	0.026	10578	0.028
1940	0.05	4101	0.044	6258	0.034	8419	0.026	10579	0.03
1941	0.05	4102	0.042	6259	0.034	8420	0.028	10580	0.03
1942	0.052	4103	0.042	6260	0.032	8421	0.026	10581	0.03
1943	0.05	4104	0.042	6261	0.032	8422	0.028	10582	0.03
1944	0.05	4105	0.042	6262	0.034	8423	0.026	10583	0.03
1945	0.048	4106	0.044	6263	0.032	8424	0.028	10584	0.028
1946	0.05	4107	0.042	6264	0.032	8425	0.026	10585	0.03
1947	0.052	4108	0.044	6265	0.032	8426	0.024	10586	0.03
1948	0.05	4109	0.042	6266	0.034	8427	0.024	10587	0.03
1949	0.05	4110	0.044	6267	0.032	8428	0.026	10588	0.03
1950	0.048	4111	0.044	6268	0.032	8429	0.026	10589	0.03
1951	0.05	4112	0.044	6269	0.032	8430	0.026	10590	0.03
1952	0.05	4113	0.042	6270	0.032	8431	0.026	10591	0.028
1953	0.05	4114	0.042	6271	0.032	8432	0.026	10592	0.03
1954	0.05	4115	0.044	6272	0.032	8433	0.026	10593	0.032
1955	0.05	4116	0.042	6273	0.03	8434	0.026	10594	0.032
1956	0.05	4117	0.044	6274	0.03	8435	0.026	10595	0.032
1957	0.05	4118	0.044	6275	0.032	8436	0.026	10596	0.032
1958	0.052	4119	0.044	6276	0.032	8437	0.026	10597	0.032
1959	0.05	4120	0.046	6277	0.032	8438	0.026	10598	0.032
1960	0.05	4121	0.046	6278	0.032	8439	0.026	10599	0.034
1961	0.052	4122	0.046	6279	0.032	8440	0.026	10600	0.032
1962	0.052	4123	0.044	6280	0.032	8441	0.026	10601	0.032
1963	0.05	4124	0.046	6281	0.032	8442	0.026	10602	0.034
1964	0.052	4125	0.048	6282	0.03	8443	0.026	10603	0.034
1965	0.054	4126	0.048	6283	0.032	8444	0.026	10604	0.034
1966	0.054	4127	0.048	6284	0.032	8445	0.026	10605	0.034
1967	0.052	4128	0.046	6285	0.03	8446	0.026	10606	0.032
1968	0.052	4129	0.046	6286	0.032	8447	0.026	10607	0.032
1969	0.054	4130	0.046	6287	0.034	8448	0.026	10608	0.032
1970	0.052	4131	0.046	6288	0.032	8449	0.026	10609	0.032
1971	0.052	4132	0.046	6289	0.034	8450	0.028	10610	0.034
1972	0.054	4133	0.046	6290	0.034	8451	0.028	10611	0.034
1973	0.056	4134	0.046	6291	0.032	8452	0.028	10612	0.032
1974	0.054	4135	0.046	6292	0.032	8453	0.028	10613	0.034
1975	0.054	4136	0.048	6293	0.032	8454	0.026	10614	0.034
1976	0.052	4137	0.046	6294	0.034	8455	0.026	10615	0.034
1977	0.054	4138	0.046	6295	0.034	8456	0.028	10616	0.032
1978	0.054	4139	0.044	6296	0.034	8457	0.028	10617	0.032
1979	0.054	4140	0.048	6297	0.034	8458	0.028	10618	0.036
1980	0.056	4141	0.046	6298	0.032	8459	0.026	10619	0.038
1981	0.054	4142	0.046	6299	0.034	8460	0.026	10620	0.038
1982	0.054	4143	0.046	6300	0.034	8461	0.026	10621	0.038
1983	0.054	4144	0.044	6301	0.032	8462	0.026	10622	0.038
1984	0.054	4145	0.044	6302	0.034	8463	0.028	10623	0.038
1985	0.052	4146	0.046	6303	0.036	8464	0.026	10624	0.038
1986	0.052	4147	0.048	6304	0.034	8465	0.026	10625	0.038
1987	0.052	4148	0.044	6305	0.034	8466	0.026	10626	0.038
1988	0.052	4149	0.046	6306	0.034	8467	0.026	10627	0.04
1989	0.054	4150	0.048	6307	0.034	8468	0.028	10628	0.038
1990	0.054	4151	0.046	6308	0.036	8469	0.03	10629	0.04
1991	0.054	4152	0.046	6309	0.038	8470	0.026	10630	0.04
1992	0.052	4153	0.046	6310	0.038	8471	0.028	10631	0.038
1993	0.052	4154	0.046	6311	0.036	8472	0.028	10632	0.04
1994	0.05	4155	0.046	6312	0.038	8473	0.026	10633	0.04
1995	0.052	4156	0.048	6313	0.038	8474	0.026	10634	0.038
1996	0.056	4157	0.048	6314	0.036	8475	0.03	10635	0.038
1997	0.052	4158	0.048	6315	0.038	8476	0.028	10636	0.038
1998	0.052	4159	0.048	6316	0.036	8477	0.026	10637	0.036
1999	0.052	4160	0.048	6317	0.034	8478	0.026	10638	0.038
2000	0.052	4161	0.048	6318	0.034	8479	0.026	10639	0.04
2001	0.054	4162	0.048	6319	0.036	8480	0.026	10640	0.038
2002	0.052	4163	0.048	6320	0.036	8481	0.028	10641	0.036
2003	0.052	4164	0.05	6321	0.038	8482	0.026	10642	0.038
2004	0.052	4165	0.048	6322	0.038	8483	0.026	10643	0.038
2005	0.052	4166	0.048	6323	0.038	8484	0.026	10644	0.036
2006	0.05	4167	0.048	6324	0.038	8485	0.028	10645	0.036
2007	0.05	4168	0.048	6325	0.04	8486	0.028	10646	0.038
2008	0.05	4169	0.048	6326	0.04	8487	0.028	10647	0.038
2009	0.048	4170	0.048	6327	0.04	8488	0.028	10648	0.04
2010	0.048	4171	0.046	6328	0.038	8489	0.026	10649	0.04
2011	0.048	4172	0.048	6329	0.038	8490	0.026	10650	0.04
2012	0.046	4173	0.048	6330	0.04	8491	0.026	10651	0.042
2013	0.048	4174	0.048	6331	0.042	8492	0.028	10652	0.042
2014	0.048	4175	0.05	6332	0.038	8493	0.028	10653	0.04
2015	0.048	4176	0.05	6333	0.038	8494	0.028	10654	0.04
2016	0.048	4177	0.05	6334	0.04	8495	0.03	10655	0.042
2017	0.046	4178	0.05	6335	0.042	8496	0.028	10656	0.042
2018	0.05	4179	0.054	6336	0.04	8497	0.028	10657	0.042
2019	0.05	4180	0.052	6337	0.04	8498	0.028	10658	0.042
2020	0.048	4181	0.048	6338	0.042	8499	0.03	10659	0.042
2021	0.046	4182	0.05	6339	0.042	8500	0.028	10660	0.042
2022	0.046	4183	0.048	6340	0.04	8501	0.028	10661	0.044
2023	0.046	4184	0.048	6341	0.04	8502	0.03	10662	0.046
2024	0.048	4185	0.05	6342	0.04	8503	0.028	10663	0.046
2025	0.048	4186	0.052	6343	0.042	8504	0.026	10664	0.046

2026	0.048	4187	0.05	6344	0.042	8505	0.028	10665	0.044
2027	0.048	4188	0.05	6345	0.04	8506	0.028	10666	0.044
2028	0.048	4189	0.052	6346	0.04	8507	0.028	10667	0.044
2029	0.05	4190	0.05	6347	0.04	8508	0.028	10668	0.044
2030	0.05	4191	0.05	6348	0.04	8509	0.028	10669	0.042
2031	0.05	4192	0.05	6349	0.042	8510	0.028	10670	0.044
2032	0.048	4193	0.05	6350	0.04	8511	0.028	10671	0.044
2033	0.048	4194	0.052	6351	0.04	8512	0.03	10672	0.042
2034	0.048	4195	0.054	6352	0.042	8513	0.03	10673	0.044
2035	0.048	4196	0.052	6353	0.04	8514	0.03	10674	0.044
2036	0.046	4197	0.052	6354	0.042	8515	0.028	10675	0.046
2037	0.048	4198	0.052	6355	0.042	8516	0.03	10676	0.044
2038	0.048	4199	0.052	6356	0.04	8517	0.028	10677	0.044
2039	0.048	4200	0.052	6357	0.04	8518	0.028	10678	0.044
2040	0.05	4201	0.052	6358	0.04	8519	0.028	10679	0.044
2041	0.048	4202	0.052	6359	0.04	8520	0.028	10680	0.044
2042	0.044	4203	0.05	6360	0.04	8521	0.028	10681	0.042
2043	0.044	4204	0.05	6361	0.04	8522	0.028	10682	0.044
2044	0.044	4205	0.05	6362	0.04	8523	0.028	10683	0.044
2045	0.046	4206	0.05	6363	0.038	8524	0.028	10684	0.044
2046	0.048	4207	0.052	6364	0.04	8525	0.028	10685	0.044
2047	0.05	4208	0.052	6365	0.042	8526	0.03	10686	0.044
2048	0.048	4209	0.054	6366	0.04	8527	0.028	10687	0.044
2049	0.046	4210	0.052	6367	0.04	8528	0.028	10688	0.042
2050	0.044	4211	0.052	6368	0.04	8529	0.028	10689	0.042
2051	0.044	4212	0.052	6369	0.042	8530	0.028	10690	0.042
2052	0.046	4213	0.052	6370	0.042	8531	0.028	10691	0.042
2053	0.046	4214	0.052	6371	0.042	8532	0.03	10692	0.042
2054	0.046	4215	0.052	6372	0.04	8533	0.028	10693	0.04
2055	0.046	4216	0.052	6373	0.042	8534	0.028	10694	0.04
2056	0.048	4217	0.052	6374	0.042	8535	0.03	10695	0.038
2057	0.046	4218	0.052	6375	0.04	8536	0.028	10696	0.038
2058	0.048	4219	0.05	6376	0.04	8537	0.028	10697	0.04
2059	0.046	4220	0.05	6377	0.04	8538	0.028	10698	0.04
2060	0.046	4221	0.052	6378	0.04	8539	0.03	10699	0.04
2061	0.046	4222	0.052	6379	0.038	8540	0.026	10700	0.038
2062	0.046	4223	0.05	6380	0.04	8541	0.026	10701	0.036
2063	0.046	4224	0.052	6381	0.04	8542	0.028	10702	0.036
2064	0.046	4225	0.052	6382	0.038	8543	0.03	10703	0.038
2065	0.044	4226	0.052	6383	0.038	8544	0.028	10704	0.04
2066	0.046	4227	0.052	6384	0.038	8545	0.028	10705	0.04
2067	0.044	4228	0.052	6385	0.038	8546	0.03	10706	0.042
2068	0.044	4229	0.05	6386	0.036	8547	0.03	10707	0.04
2069	0.046	4230	0.05	6387	0.036	8548	0.03	10708	0.034
2070	0.046	4231	0.05	6388	0.038	8549	0.03	10709	0.038
2071	0.046	4232	0.052	6389	0.036	8550	0.03	10710	0.038
2072	0.048	4233	0.052	6390	0.038	8551	0.028	10711	0.038
2073	0.046	4234	0.05	6391	0.038	8552	0.03	10712	0.04
2074	0.046	4235	0.052	6392	0.038	8553	0.028	10713	0.04
2075	0.044	4236	0.05	6393	0.036	8554	0.028	10714	0.04
2076	0.044	4237	0.052	6394	0.038	8555	0.028	10715	0.04
2077	0.044	4238	0.052	6395	0.036	8556	0.03	10716	0.04
2078	0.044	4239	0.052	6396	0.036	8557	0.03	10717	0.04
2079	0.046	4240	0.05	6397	0.036	8558	0.03	10718	0.04
2080	0.046	4241	0.05	6398	0.034	8559	0.03	10719	0.04
2081	0.046	4242	0.05	6399	0.036	8560	0.028	10720	0.038
2082	0.044	4243	0.05	6400	0.036	8561	0.03	10721	0.04
2083	0.044	4244	0.05	6401	0.034	8562	0.032	10722	0.04
2084	0.044	4245	0.052	6402	0.034	8563	0.03	10723	0.04
2085	0.046	4246	0.048	6403	0.036	8564	0.03	10724	0.042
2086	0.044	4247	0.05	6404	0.038	8565	0.028	10725	0.04
2087	0.046	4248	0.05	6405	0.038	8566	0.028	10726	0.038
2088	0.046	4249	0.048	6406	0.036	8567	0.028	10727	0.038
2089	0.044	4250	0.048	6407	0.036	8568	0.028	10728	0.04
2090	0.044	4251	0.048	6408	0.036	8569	0.028	10729	0.038
2091	0.046	4252	0.048	6409	0.036	8570	0.028	10730	0.038
2092	0.048	4253	0.048	6410	0.038	8571	0.028	10731	0.038
2093	0.046	4254	0.046	6411	0.036	8572	0.028	10732	0.038
2094	0.044	4255	0.046	6412	0.036	8573	0.03	10733	0.04
2095	0.046	4256	0.046	6413	0.036	8574	0.028	10734	0.038
2096	0.046	4257	0.046	6414	0.036	8575	0.028	10735	0.038
2097	0.046	4258	0.05	6415	0.036	8576	0.028	10736	0.04
2098	0.046	4259	0.05	6416	0.036	8577	0.028	10737	0.038
2099	0.046	4260	0.048	6417	0.036	8578	0.028	10738	0.036
2100	0.042	4261	0.05	6418	0.036	8579	0.028	10739	0.036
2101	0.044	4262	0.048	6419	0.036	8580	0.026	10740	0.038
2102	0.042	4263	0.048	6420	0.034	8581	0.026	10741	0.038
2103	0.042	4264	0.05	6421	0.036	8582	0.026	10742	0.036
2104	0.044	4265	0.048	6422	0.036	8583	0.026	10743	0.036
2105	0.044	4266	0.046	6423	0.034	8584	0.026	10744	0.036
2106	0.042	4267	0.046	6424	0.036	8585	0.026	10745	0.034
2107	0.042	4268	0.048	6425	0.034	8586	0.028	10746	0.036
2108	0.044	4269	0.048	6426	0.032	8587	0.026	10747	0.036
2109	0.044	4270	0.048	6427	0.032	8588	0.026	10748	0.036
2110	0.044	4271	0.048	6428	0.034	8589	0.028	10749	0.038
2111	0.044	4272	0.048	6429	0.034	8590	0.026	10750	0.038
2112	0.044	4273	0.05	6430	0.034	8591	0.026	10751	0.036
2113	0.044	4274	0.05	6431	0.034	8592	0.026	10752	0.036
2114	0.042	4275	0.05	6432	0.036	8593	0.024	10753	0.04
2115	0.044	4276	0.048	6433	0.036	8594	0.026	10754	0.038
2116	0.044	4277	0.048	6434	0.034	8595	0.026	10755	0.038
2117	0.044	4278	0.048	6435	0.034	8596	0.026	10756	0.036
2118	0.044	4279	0.048	6436	0.03	8597	0.026	10757	0.036

2119	0.042	4280	0.05	6437	0.03	8598	0.028	10758	0.036
2120	0.044	4281	0.05	6438	0.03	8599	0.028	10759	0.036
2121	0.044	4282	0.048	6439	0.03	8600	0.028	10760	0.036
2122	0.042	4283	0.05	6440	0.032	8601	0.026	10761	0.038
2123	0.042	4284	0.05	6441	0.032	8602	0.028	10762	0.036
2124	0.04	4285	0.05	6442	0.032	8603	0.028	10763	0.034
2125	0.042	4286	0.048	6443	0.032	8604	0.028	10764	0.036
2126	0.042	4287	0.048	6444	0.032	8605	0.026	10765	0.036
2127	0.042	4288	0.048	6445	0.032	8606	0.026	10766	0.036
2128	0.044	4289	0.048	6446	0.032	8607	0.028	10767	0.036
2129	0.046	4290	0.048	6447	0.032	8608	0.028	10768	0.034
2130	0.046	4291	0.05	6448	0.032	8609	0.026	10769	0.038
2131	0.046	4292	0.048	6449	0.032	8610	0.026	10770	0.04
2132	0.046	4293	0.046	6450	0.032	8611	0.026	10771	0.036
2133	0.044	4294	0.048	6451	0.032	8612	0.026	10772	0.034
2134	0.042	4295	0.048	6452	0.034	8613	0.026	10773	0.036
2135	0.044	4296	0.046	6453	0.034	8614	0.028	10774	0.038
2136	0.046	4297	0.046	6454	0.034	8615	0.026	10775	0.036
2137	0.048	4298	0.048	6455	0.034	8616	0.026	10776	0.036
2138	0.048	4299	0.048	6456	0.032	8617	0.026	10777	0.038
2139	0.048	4300	0.048	6457	0.032	8618	0.028	10778	0.036
2140	0.048	4301	0.048	6458	0.032	8619	0.026	10779	0.034
2141	0.046	4302	0.048	6459	0.032	8620	0.028	10780	0.036
2142	0.046	4303	0.05	6460	0.032	8621	0.028	10781	0.036
2143	0.046	4304	0.05	6461	0.032	8622	0.028	10782	0.036
2144	0.048	4305	0.048	6462	0.032	8623	0.026	10783	0.036
2145	0.046	4306	0.048	6463	0.032	8624	0.026	10784	0.036
2146	0.048	4307	0.05	6464	0.034	8625	0.028	10785	0.036
2147	0.048	4308	0.048	6465	0.032	8626	0.028	10786	0.036
2148	0.048	4309	0.046	6466	0.032	8627	0.028	10787	0.036
2149	0.05	4310	0.048	6467	0.034	8628	0.028	10788	0.036
2150	0.05	4311	0.048	6468	0.032	8629	0.026	10789	0.036
2151	0.048	4312	0.044	6469	0.032	8630	0.026	10790	0.038
2152	0.048	4313	0.046	6470	0.032	8631	0.028	10791	0.038
2153	0.048	4314	0.048	6471	0.034	8632	0.028	10792	0.038
2154	0.046	4315	0.046	6472	0.034	8633	0.026	10793	0.036
2155	0.046	4316	0.046	6473	0.032	8634	0.026	10794	0.034
2156	0.046	4317	0.044	6474	0.032	8635	0.026	10795	0.036
2157	0.044	4318	0.044	6475	0.032	8636	0.028	10796	0.036
2158	0.044			6476	0.032	8637	0.03	10797	0.034
2159	0.044			6477	0.03	8638	0.026	10798	0.036
2160	0.046			6478	0.032	8639	0.028	10799	0.036
2161	0.046			6479	0.034			10800	0.036

Occupied period, outdoor PM_{10} concentration

Instrument Name	DustTrak II
Model Number	8530
Serial Number	8530114601
Firmware Version	2.8
Calibration Date	2016/6/20
Test Name	MANUAL 058
Test Start Time	13:08:36
Test Start Date	2016/11/16
Test Length [D:H:M]	0:02:51
Test Interval [M:S]	0:01
Mass Average [mg/m3]	0.027
Mass Minimum [mg/m3]	0.019
Mass Maximum [mg/m3]	0.123
Mass TWA [mg/m3]	0.01
Photometric User Cal	0.38
Flow User Cal	0.38
Errors	
Number of Samples	10280

Elapsed Time [s]	Mass [mg/m3]	Elapsed Time [s]	Mass [mg/m3]	Elapsed Time [s]	Mass [mg/m3]	Elapsed Time [s]	Mass [mg/m3]	Elapsed Time [s]	Mass [mg/m3]
1	0.0424	2054	0.0584	4110	0.056	6167	0.052	8224	0.0504
2	0.0424	2055	0.0584	4111	0.052	6168	0.0504	8225	0.0504
3	0.044	2056	0.056	4112	0.0544	6169	0.0504	8226	0.0504
4	0.0464	2057	0.0584	4113	0.0544	6170	0.052	8227	0.048
5	0.044	2058	0.0544	4114	0.06	6171	0.048	8228	0.048
6	0.0424	2059	0.052	4115	0.056	6172	0.0464	8229	0.048
7	0.0424	2060	0.0504	4116	0.0544	6173	0.0464	8230	0.0464
8	0.044	2061	0.052	4117	0.0544	6174	0.0464	8231	0.0504
9	0.044	2062	0.052	4118	0.056	6175	0.0464	8232	0.0504
10	0.044	2063	0.0504	4119	0.0544	6176	0.044	8233	0.0504
11	0.04	2064	0.0544	4120	0.0584	6177	0.056	8234	0.0464
12	0.044	2065	0.056	4121	0.056	6178	0.0584	8235	0.044
13	0.0464	2066	0.0504	4122	0.056	6179	0.048	8236	0.0464
14	0.048	2067	0.056	4123	0.056	6180	0.0464	8237	0.048
15	0.0464	2068	0.06	4124	0.052	6181	0.052	8238	0.0544
16	0.0464	2069	0.06	4125	0.056	6182	0.0504	8239	0.052
17	0.048	2070	0.0584	4126	0.056	6183	0.048	8240	0.0464
18	0.0464	2071	0.0504	4127	0.0544	6184	0.0464	8241	0.044
19	0.044	2072	0.052	4128	0.0544	6185	0.0464	8242	0.044
20	0.044	2073	0.052	4129	0.056	6186	0.0504	8243	0.0464
21	0.044	2074	0.06	4130	0.0584	6187	0.0544	8244	0.044
22	0.048	2075	0.056	4131	0.0624	6188	0.0504	8245	0.044
23	0.0424	2076	0.0544	4132	0.064	6189	0.048	8246	0.0464
24	0.044	2077	0.0584	4133	0.056	6190	0.048	8247	0.0464
25	0.048	2078	0.0544	4134	0.0544	6191	0.0464	8248	0.0464
26	0.0504	2079	0.0544	4135	0.056	6192	0.0464	8249	0.0464
27	0.0504	2080	0.056	4136	0.06	6193	0.0464	8250	0.0464
28	0.0504	2081	0.052	4137	0.0544	6194	0.044	8251	0.0504
29	0.0504	2082	0.0504	4138	0.052	6195	0.044	8252	0.0504
30	0.0504	2083	0.0504	4139	0.052	6196	0.048	8253	0.0504
31	0.0504	2084	0.052	4140	0.052	6197	0.0504	8254	0.0504
32	0.0464	2085	0.0544	4141	0.052	6198	0.0464	8255	0.0504
33	0.044	2086	0.0544	4142	0.052	6199	0.0464	8256	0.048
34	0.0464	2087	0.0504	4143	0.0544	6200	0.048	8257	0.0464
35	0.048	2088	0.0504	4144	0.0544	6201	0.0504	8258	0.0464
36	0.0464	2089	0.0504	4145	0.052	6202	0.048	8259	0.044
37	0.0464	2090	0.052	4146	0.056	6203	0.0504	8260	0.044
38	0.0504	2091	0.0544	4147	0.0544	6204	0.0504	8261	0.0424
39	0.056	2092	0.056	4148	0.052	6205	0.048	8262	0.044
40	0.056	2093	0.0544	4149	0.056	6206	0.0504	8263	0.0464
41	0.0504	2094	0.0544	4150	0.052	6207	0.048	8264	0.0464
42	0.048	2095	0.052	4151	0.0544	6208	0.052	8265	0.0464
43	0.048	2096	0.0504	4152	0.0544	6209	0.052	8266	0.0464
44	0.0504	2097	0.0504	4153	0.052	6210	0.048	8267	0.048
45	0.048	2098	0.052	4154	0.052	6211	0.048	8268	0.048
46	0.048	2099	0.0584	4155	0.0584	6212	0.0464	8269	0.0464
47	0.0464	2100	0.064	4156	0.06	6213	0.0464	8270	0.0464
48	0.0464	2101	0.0584	4157	0.0544	6214	0.0464	8271	0.0504
49	0.0424	2102	0.052	4158	0.056	6215	0.0464	8272	0.048
50	0.0464	2103	0.0544	4159	0.056	6216	0.0464	8273	0.0464
51	0.0464	2104	0.052	4160	0.056	6217	0.048	8274	0.0504
52	0.0464	2105	0.052	4161	0.056	6218	0.0464	8275	0.0504
53	0.0544	2106	0.052	4162	0.056	6219	0.048	8276	0.052
54	0.0504	2107	0.052	4163	0.056	6220	0.048	8277	0.0504
55	0.0424	2108	0.052	4164	0.0544	6221	0.044	8278	0.0504
56	0.044	2109	0.0544	4165	0.0544	6222	0.044	8279	0.0504
57	0.0464	2110	0.052	4166	0.056	6223	0.0464	8280	0.0504
58	0.0464	2111	0.0504	4167	0.0544	6224	0.0464	8281	0.048
59	0.044	2112	0.052	4168	0.052	6225	0.0464	8282	0.052
60	0.048	2113	0.0504	4169	0.0544	6226	0.044	8283	0.0464
61	0.0504	2114	0.048	4170	0.056	6227	0.0464	8284	0.048
62	0.048	2115	0.0504	4171	0.06	6228	0.0464	8285	0.0504
63	0.044	2116	0.056	4172	0.068	6229	0.0464	8286	0.048
64	0.0504	2117	0.0544	4173	0.064	6230	0.044	8287	0.0504
65	0.048	2118	0.056	4174	0.056	6231	0.0464	8288	0.048
66	0.044	2119	0.0544	4175	0.056	6232	0.0504	8289	0.0504
67	0.044	2120	0.052	4176	0.0504	6233	0.048	8290	0.0464
68	0.0464	2121	0.0504	4177	0.056	6234	0.044	8291	0.048
69	0.0464	2122	0.052	4178	0.0584	6235	0.044	8292	0.048
70	0.0424	2123	0.052	4179	0.0584	6236	0.044	8293	0.048
71	0.0464	2124	0.0504	4180	0.056	6237	0.044	8294	0.048

72	0.0504	2125	0.052	4181	0.056	6238	0.048	8295	0.052
73	0.048	2126	0.052	4182	0.0584	6239	0.048	8296	0.056
74	0.044	2127	0.052	4183	0.056	6240	0.0464	8297	0.048
75	0.04	2128	0.0544	4184	0.052	6241	0.0424	8298	0.048
76	0.0424	2129	0.056	4185	0.0544	6242	0.044	8299	0.0464
77	0.044	2130	0.0584	4186	0.0544	6243	0.048	8300	0.0504
78	0.0424	2131	0.0544	4187	0.0584	6244	0.0504	8301	0.052
79	0.04	2132	0.052	4188	0.0584	6245	0.0504	8302	0.048
80	0.04	2133	0.0504	4189	0.0584	6246	0.0504	8303	0.0504
81	0.0424	2134	0.0504	4190	0.056	6247	0.044	8304	0.052
82	0.0464	2135	0.0504	4191	0.0544	6248	0.044	8305	0.0504
83	0.048	2136	0.0504	4192	0.0544	6249	0.0464	8306	0.048
84	0.048	2137	0.0504	4193	0.0584	6250	0.044	8307	0.048
85	0.0424	2138	0.0504	4194	0.064	6251	0.044	8308	0.052
86	0.0464	2139	0.052	4195	0.0584	6252	0.0464	8309	0.0504
87	0.048	2140	0.0504	4196	0.0584	6253	0.048	8310	0.0504
88	0.048	2141	0.056	4197	0.052	6254	0.048	8311	0.0504
89	0.048	2142	0.0584	4198	0.0544	6255	0.048	8312	0.0464
90	0.0464	2143	0.0584	4199	0.056	6256	0.0504	8313	0.0464
91	0.0464	2144	0.052	4200	0.0544	6257	0.0464	8314	0.0504
92	0.0464	2145	0.0504	4201	0.0544	6258	0.0464	8315	0.0504
93	0.044	2146	0.052	4202	0.0544	6259	0.048	8316	0.048
94	0.044	2147	0.056	4203	0.0544	6260	0.044	8317	0.048
95	0.044	2148	0.052	4204	0.0544	6261	0.048	8318	0.0464
96	0.0464	2149	0.0544	4205	0.0544	6262	0.0504	8319	0.0504
97	0.0464	2150	0.056	4206	0.056	6263	0.0464	8320	0.048
98	0.0424	2151	0.056	4207	0.0544	6264	0.048	8321	0.048
99	0.0424	2152	0.0584	4208	0.052	6265	0.048	8322	0.0464
100	0.044	2153	0.0544	4209	0.0504	6266	0.0464	8323	0.048
101	0.0464	2154	0.0584	4210	0.052	6267	0.0464	8324	0.0504
102	0.044	2155	0.068	4211	0.052	6268	0.044	8325	0.048
103	0.044	2156	0.0664	4212	0.056	6269	0.044	8326	0.0464
104	0.0464	2157	0.056	4213	0.0544	6270	0.0464	8327	0.048
105	0.044	2158	0.06	4214	0.0544	6271	0.0464	8328	0.048
106	0.044	2159	0.0584	4215	0.0544	6272	0.048	8329	0.0504
107	0.044	2160	0.0544	4216	0.052	6273	0.0464	8330	0.0504
108	0.0424	2161	0.056	4217	0.052	6274	0.048	8331	0.048
109	0.044	2162	0.0584	4218	0.0544	6275	0.0464	8332	0.0504
110	0.0464	2163	0.056	4219	0.06	6276	0.04	8333	0.048
111	0.0464	2164	0.052	4220	0.0544	6277	0.044	8334	0.048
112	0.0424	2165	0.0544	4221	0.0504	6278	0.0464	8335	0.048
113	0.0424	2166	0.0584	4222	0.052	6279	0.048	8336	0.0504
114	0.044	2167	0.0584	4223	0.052	6280	0.0464	8337	0.048
115	0.0424	2168	0.0584	4224	0.056	6281	0.044	8338	0.0504
116	0.0504	2169	0.0624	4225	0.056	6282	0.0464	8339	0.0504
117	0.048	2170	0.0544	4226	0.0544	6283	0.0424	8340	0.0544
118	0.044	2171	0.052	4227	0.0544	6284	0.044	8341	0.0544
119	0.0464	2172	0.052	4228	0.0544	6285	0.044	8342	0.0504
120	0.04	2173	0.056	4229	0.0544	6286	0.0424	8343	0.056
121	0.0424	2174	0.0504	4230	0.052	6287	0.048	8344	0.0544
122	0.04	2175	0.0544	4231	0.056	6288	0.0504	8345	0.0504
123	0.0424	2176	0.0544	4232	0.06	6289	0.044	8346	0.0504
124	0.0424	2177	0.0544	4233	0.056	6290	0.0464	8347	0.0504
125	0.044	2178	0.056	4234	0.0544	6291	0.044	8348	0.0464
126	0.0424	2179	0.0584	4235	0.052	6292	0.0464	8349	0.048
127	0.044	2180	0.056	4236	0.052	6293	0.048	8350	0.052
128	0.0424	2181	0.0504	4237	0.056	6294	0.0464	8351	0.0504
129	0.0424	2182	0.052	4238	0.0544	6295	0.0424	8352	0.0504
130	0.0424	2183	0.0504	4239	0.052	6296	0.0424	8353	0.052
131	0.044	2184	0.0504	4240	0.0544	6297	0.044	8354	0.056
132	0.0464	2185	0.0544	4241	0.056	6298	0.044	8355	0.0544
133	0.0464	2186	0.0624	4242	0.056	6299	0.044	8356	0.0504
134	0.04	2187	0.056	4243	0.0584	6300	0.0464	8357	0.0544
135	0.0424	2188	0.0544	4244	0.0584	6301	0.048	8358	0.0584
136	0.0424	2189	0.052	4245	0.0544	6302	0.048	8359	0.056
137	0.0464	2190	0.052	4246	0.0544	6303	0.048	8360	0.0504
138	0.044	2191	0.0544	4247	0.056	6304	0.048	8361	0.052
139	0.0424	2192	0.0544	4248	0.052	6305	0.0464	8362	0.052
140	0.0424	2193	0.0584	4249	0.052	6306	0.048	8363	0.0504
141	0.0464	2194	0.0584	4250	0.0504	6307	0.0504	8364	0.0504
142	0.0464	2195	0.056	4251	0.052	6308	0.0504	8365	0.0504
143	0.044	2196	0.06	4252	0.0544	6309	0.048	8366	0.052
144	0.044	2197	0.06	4253	0.0544	6310	0.044	8367	0.0504
145	0.0424	2198	0.0544	4254	0.052	6311	0.0464	8368	0.048
146	0.0424	2199	0.056	4255	0.0544	6312	0.0504	8369	0.0504
147	0.044	2200	0.0624	4256	0.0544	6313	0.0504	8370	0.0504
148	0.044	2201	0.0584	4257	0.0544	6314	0.044	8371	0.048
149	0.044	2202	0.0544	4258	0.0544	6315	0.0424	8372	0.048
150	0.044	2203	0.0544	4259	0.0544	6316	0.044	8373	0.0504
151	0.04	2204	0.0504	4260	0.056	6317	0.0464	8374	0.0504
152	0.044	2205	0.052	4261	0.0544	6318	0.044	8375	0.0504
153	0.048	2206	0.0544	4262	0.0544	6319	0.048	8376	0.052
154	0.0424	2207	0.052	4263	0.056	6320	0.0504	8377	0.056
155	0.04	2208	0.052	4264	0.0584	6321	0.044	8378	0.0584
156	0.04	2209	0.052	4265	0.056	6322	0.044	8379	0.052
157	0.04	2210	0.0544	4266	0.052	6323	0.0424	8380	0.052
158	0.044	2211	0.052	4267	0.0544	6324	0.0464	8381	0.052
159	0.0424	2212	0.052	4268	0.052	6325	0.0464	8382	0.0464
160	0.0384	2213	0.056	4269	0.052	6326	0.0464	8383	0.048
161	0.0424	2214	0.0584	4270	0.052	6327	0.048	8384	0.048
162	0.044	2215	0.056	4271	0.052	6328	0.048	8385	0.048
163	0.044	2216	0.056	4272	0.0544	6329	0.0504	8386	0.0584
164	0.04	2217	0.0544	4273	0.052	6330	0.0504	8387	0.052

165	0.0424	2218	0.0544	4274	0.0544	6331	0.0464	8388	0.048
166	0.0424	2219	0.052	4275	0.0544	6332	0.0464	8389	0.048
167	0.04	2220	0.052	4276	0.056	6333	0.0464	8390	0.0504
168	0.0464	2221	0.0504	4277	0.052	6334	0.048	8391	0.0544
169	0.044	2222	0.052	4278	0.052	6335	0.0504	8392	0.0584
170	0.0384	2223	0.0584	4279	0.0544	6336	0.048	8393	0.056
171	0.04	2224	0.0624	4280	0.0584	6337	0.048	8394	0.0584
172	0.044	2225	0.06	4281	0.056	6338	0.0464	8395	0.0544
173	0.0464	2226	0.0584	4282	0.052	6339	0.048	8396	0.0544
174	0.044	2227	0.0544	4283	0.0544	6340	0.0504	8397	0.0544
175	0.0424	2228	0.0544	4284	0.0544	6341	0.0504	8398	0.056
176	0.0424	2229	0.0584	4285	0.052	6342	0.048	8399	0.0584
177	0.044	2230	0.0584	4286	0.052	6343	0.0464	8400	0.06
178	0.0424	2231	0.0624	4287	0.056	6344	0.044	8401	0.0584
179	0.0424	2232	0.0584	4288	0.0584	6345	0.0464	8402	0.056
180	0.0424	2233	0.0584	4289	0.0544	6346	0.0464	8403	0.0544
181	0.0424	2234	0.0544	4290	0.056	6347	0.044	8404	0.056
182	0.044	2235	0.056	4291	0.056	6348	0.044	8405	0.0584
183	0.04	2236	0.0584	4292	0.056	6349	0.044	8406	0.0584
184	0.044	2237	0.052	4293	0.0584	6350	0.044	8407	0.06
185	0.0464	2238	0.0584	4294	0.052	6351	0.0504	8408	0.0624
186	0.0424	2239	0.0624	4295	0.048	6352	0.0504	8409	0.06
187	0.0424	2240	0.052	4296	0.0544	6353	0.048	8410	0.06
188	0.0424	2241	0.056	4297	0.0584	6354	0.048	8411	0.056
189	0.0424	2242	0.056	4298	0.06	6355	0.048	8412	0.0544
190	0.0424	2243	0.056	4299	0.052	6356	0.048	8413	0.06
191	0.0424	2244	0.0544	4300	0.052	6357	0.0504	8414	0.056
192	0.0424	2245	0.0544	4301	0.052	6358	0.0504	8415	0.056
193	0.044	2246	0.052	4302	0.052	6359	0.052	8416	0.056
194	0.048	2247	0.0544	4303	0.052	6360	0.052	8417	0.0584
195	0.044	2248	0.056	4304	0.0504	6361	0.052	8418	0.056
196	0.044	2249	0.052	4305	0.0504	6362	0.052	8419	0.0544
197	0.044	2250	0.0544	4306	0.0504	6363	0.0464	8420	0.056
198	0.0424	2251	0.0544	4307	0.052	6364	0.048	8421	0.0624
199	0.04	2252	0.056	4308	0.0544	6365	0.048	8422	0.0624
200	0.0424	2253	0.056	4309	0.0544	6366	0.0504	8423	0.0504
201	0.0424	2254	0.056	4310	0.052	6367	0.052	8424	0.056
202	0.0424	2255	0.0544	4311	0.056	6368	0.056	8425	0.056
203	0.04	2256	0.0544	4312	0.052	6369	0.06	8426	0.056
204	0.0424	2257	0.0504	4313	0.056	6370	0.06	8427	0.056
205	0.0464	2258	0.048	4314	0.056	6371	0.056	8428	0.056
206	0.0464	2259	0.052	4315	0.052	6372	0.052	8429	0.056
207	0.0464	2260	0.052	4316	0.0544	6373	0.056	8430	0.056
208	0.044	2261	0.052	4317	0.0544	6374	0.056	8431	0.0664
209	0.0464	2262	0.056	4318	0.056	6375	0.0544	8432	0.0704
210	0.044	2263	0.0544	4319	0.0584	6376	0.0544	8433	0.0584
211	0.0424	2264	0.052	4320	0.0544	6377	0.0544	8434	0.056
212	0.0504	2265	0.0544	4321	0.052	6378	0.056	8435	0.052
213	0.052	2266	0.052	4322	0.056	6379	0.056	8436	0.0544
214	0.0424	2267	0.0504	4323	0.056	6380	0.056	8437	0.056
215	0.0424	2268	0.0504	4324	0.0544	6381	0.056	8438	0.0544
216	0.044	2269	0.052	4325	0.0544	6382	0.056	8439	0.052
217	0.044	2270	0.052	4326	0.052	6383	0.056	8440	0.056
218	0.044	2271	0.052	4327	0.0544	6384	0.0584	8441	0.056
219	0.04	2272	0.056	4328	0.052	6385	0.0624	8442	0.0584
220	0.04	2273	0.056	4329	0.052	6386	0.0664	8443	0.0584
221	0.0424	2274	0.056	4330	0.056	6387	0.064	8444	0.06
222	0.044	2275	0.0544	4331	0.0544	6388	0.06	8445	0.056
223	0.0464	2276	0.0544	4332	0.056	6389	0.0584	8446	0.056
224	0.0424	2277	0.0584	4333	0.0544	6390	0.056	8447	0.0584
225	0.044	2278	0.0544	4334	0.0584	6391	0.0624	8448	0.06
226	0.0464	2279	0.0544	4335	0.056	6392	0.064	8449	0.06
227	0.0464	2280	0.0584	4336	0.052	6393	0.0624	8450	0.0544
228	0.0464	2281	0.056	4337	0.0544	6394	0.06	8451	0.052
229	0.0464	2282	0.052	4338	0.0584	6395	0.0584	8452	0.048
230	0.044	2283	0.052	4339	0.052	6396	0.0584	8453	0.0504
231	0.0464	2284	0.052	4340	0.056	6397	0.056	8454	0.0504
232	0.044	2285	0.052	4341	0.068	6398	0.06	8455	0.0504
233	0.044	2286	0.056	4342	0.0624	6399	0.0624	8456	0.048
234	0.0424	2287	0.06	4343	0.0544	6400	0.064	8457	0.0504
235	0.0424	2288	0.0544	4344	0.052	6401	0.0624	8458	0.0504
236	0.0424	2289	0.0544	4345	0.056	6402	0.056	8459	0.0504
237	0.044	2290	0.056	4346	0.0544	6403	0.056	8460	0.0544
238	0.048	2291	0.064	4347	0.052	6404	0.06	8461	0.0584
239	0.0464	2292	0.06	4348	0.0544	6405	0.0584	8462	0.048
240	0.044	2293	0.056	4349	0.0544	6406	0.0544	8463	0.0464
241	0.0424	2294	0.056	4350	0.052	6407	0.0504	8464	0.0504
242	0.0424	2295	0.0544	4351	0.0544	6408	0.0544	8465	0.056
243	0.0424	2296	0.0544	4352	0.0584	6409	0.0584	8466	0.0584
244	0.0424	2297	0.0584	4353	0.056	6410	0.0624	8467	0.052
245	0.0424	2298	0.056	4354	0.056	6411	0.0584	8468	0.048
246	0.0464	2299	0.052	4355	0.056	6412	0.052	8469	0.0504
247	0.0464	2300	0.0544	4356	0.0544	6413	0.056	8470	0.052
248	0.044	2301	0.0584	4357	0.0504	6414	0.0624	8471	0.0584
249	0.044	2302	0.056	4358	0.052	6415	0.06	8472	0.0504
250	0.0464	2303	0.052	4359	0.0544	6416	0.06	8473	0.048
251	0.0464	2304	0.056	4360	0.056	6417	0.0624	8474	0.0464
252	0.0464	2305	0.06	4361	0.056	6418	0.0624	8475	0.0464
253	0.0424	2306	0.06	4362	0.0584	6419	0.0584	8476	0.048
254	0.044	2307	0.052	4363	0.0544	6420	0.06	8477	0.0464
255	0.0424	2308	0.056	4364	0.052	6421	0.064	8478	0.048
256	0.04	2309	0.056	4365	0.056	6422	0.064	8479	0.0504
257	0.04	2310	0.052	4366	0.064	6423	0.064	8480	0.0464

258	0.04	2311	0.056	4367	0.064	6424	0.068	8481	0.0464
259	0.044	2312	0.06	4368	0.0584	6425	0.0784	8482	0.0504
260	0.044	2313	0.052	4369	0.06	6426	0.0784	8483	0.0544
261	0.0424	2314	0.0504	4370	0.056	6427	0.0744	8484	0.056
262	0.04	2315	0.056	4371	0.0504	6428	0.072	8485	0.052
263	0.044	2316	0.056	4372	0.052	6429	0.072	8486	0.0544
264	0.0464	2317	0.0544	4373	0.0544	6430	0.072	8487	0.0504
265	0.048	2318	0.0544	4374	0.056	6431	0.0624	8488	0.0504
266	0.0464	2319	0.056	4375	0.056	6432	0.0544	8489	0.0544
267	0.04	2320	0.056	4376	0.0624	6433	0.0544	8490	0.056
268	0.04	2321	0.0544	4377	0.064	6434	0.06	8491	0.048
269	0.0504	2322	0.0544	4378	0.056	6435	0.064	8492	0.048
270	0.052	2323	0.056	4379	0.056	6436	0.06	8493	0.048
271	0.0424	2324	0.0544	4380	0.0584	6437	0.06	8494	0.048
272	0.0424	2325	0.0584	4381	0.0544	6438	0.0584	8495	0.0504
273	0.0424	2326	0.06	4382	0.052	6439	0.052	8496	0.048
274	0.0424	2327	0.0584	4383	0.0544	6440	0.052	8497	0.048
275	0.0424	2328	0.0544	4384	0.056	6441	0.052	8498	0.0464
276	0.0424	2329	0.052	4385	0.0544	6442	0.0504	8499	0.048
277	0.0424	2330	0.0544	4386	0.0584	6443	0.052	8500	0.0464
278	0.0424	2331	0.0544	4387	0.0584	6444	0.0544	8501	0.0504
279	0.0424	2332	0.0544	4388	0.056	6445	0.052	8502	0.052
280	0.0384	2333	0.052	4389	0.056	6446	0.056	8503	0.048
281	0.0424	2334	0.052	4390	0.0584	6447	0.0584	8504	0.0504
282	0.044	2335	0.0544	4391	0.0544	6448	0.0624	8505	0.0544
283	0.0464	2336	0.056	4392	0.056	6449	0.056	8506	0.0544
284	0.0464	2337	0.0584	4393	0.06	6450	0.0544	8507	0.0504
285	0.044	2338	0.0584	4394	0.06	6451	0.0584	8508	0.0504
286	0.044	2339	0.0584	4395	0.056	6452	0.064	8509	0.048
287	0.044	2340	0.0584	4396	0.056	6453	0.064	8510	0.0504
288	0.0424	2341	0.0584	4397	0.0584	6454	0.064	8511	0.0504
289	0.044	2342	0.056	4398	0.056	6455	0.0584	8512	0.048
290	0.044	2343	0.0544	4399	0.0584	6456	0.0624	8513	0.0544
291	0.0464	2344	0.0504	4400	0.0544	6457	0.0664	8514	0.0504
292	0.048	2345	0.0544	4401	0.056	6458	0.072	8515	0.0504
293	0.0464	2346	0.056	4402	0.056	6459	0.076	8516	0.048
294	0.0424	2347	0.056	4403	0.056	6460	0.084	8517	0.0464
295	0.0424	2348	0.056	4404	0.056	6461	0.088	8518	0.0464
296	0.0424	2349	0.0544	4405	0.052	6462	0.08	8519	0.0504
297	0.0424	2350	0.052	4406	0.0544	6463	0.0864	8520	0.0544
298	0.044	2351	0.056	4407	0.0544	6464	0.0864	8521	0.052
299	0.0424	2352	0.056	4408	0.0544	6465	0.0784	8522	0.0544
300	0.044	2353	0.0544	4409	0.0584	6466	0.0824	8523	0.052
301	0.044	2354	0.052	4410	0.0584	6467	0.0824	8524	0.0504
302	0.0464	2355	0.052	4411	0.0544	6468	0.0784	8525	0.0504
303	0.0424	2356	0.0544	4412	0.0584	6469	0.08	8526	0.048
304	0.044	2357	0.056	4413	0.0584	6470	0.076	8527	0.0504
305	0.044	2358	0.0544	4414	0.056	6471	0.076	8528	0.0504
306	0.044	2359	0.052	4415	0.056	6472	0.0784	8529	0.0504
307	0.0424	2360	0.052	4416	0.06	6473	0.0824	8530	0.048
308	0.0424	2361	0.052	4417	0.0624	6474	0.084	8531	0.0504
309	0.044	2362	0.052	4418	0.0584	6475	0.084	8532	0.0504
310	0.044	2363	0.0544	4419	0.056	6476	0.084	8533	0.0504
311	0.0424	2364	0.052	4420	0.0584	6477	0.0944	8534	0.0464
312	0.044	2365	0.052	4421	0.0584	6478	0.1064	8535	0.052
313	0.0504	2366	0.052	4422	0.0544	6479	0.1344	8536	0.0544
314	0.048	2367	0.052	4423	0.0584	6480	0.176	8537	0.052
315	0.0424	2368	0.0544	4424	0.056	6481	0.156	8538	0.0544
316	0.044	2369	0.0584	4425	0.0544	6482	0.1424	8539	0.048
317	0.0464	2370	0.0584	4426	0.0544	6483	0.1344	8540	0.0504
318	0.0464	2371	0.0544	4427	0.056	6484	0.1344	8541	0.0584
319	0.048	2372	0.0544	4428	0.056	6485	0.1344	8542	0.052
320	0.0424	2373	0.052	4429	0.0584	6486	0.1424	8543	0.0504
321	0.044	2374	0.0544	4430	0.06	6487	0.1384	8544	0.0504
322	0.0464	2375	0.056	4431	0.0624	6488	0.132	8545	0.0544
323	0.044	2376	0.0584	4432	0.056	6489	0.1344	8546	0.056
324	0.0504	2377	0.0584	4433	0.0584	6490	0.136	8547	0.052
325	0.0504	2378	0.056	4434	0.0584	6491	0.1224	8548	0.052
326	0.0464	2379	0.0584	4435	0.0584	6492	0.116	8549	0.0504
327	0.044	2380	0.0584	4436	0.0584	6493	0.1144	8550	0.048
328	0.0424	2381	0.056	4437	0.0584	6494	0.108	8551	0.0464
329	0.0424	2382	0.0584	4438	0.0624	6495	0.1104	8552	0.052
330	0.0464	2383	0.06	4439	0.0664	6496	0.112	8553	0.052
331	0.0464	2384	0.0584	4440	0.064	6497	0.104	8554	0.052
332	0.044	2385	0.0584	4441	0.064	6498	0.104	8555	0.052
333	0.044	2386	0.0544	4442	0.0664	6499	0.108	8556	0.0504
334	0.0464	2387	0.056	4443	0.0664	6500	0.1024	8557	0.0544
335	0.0424	2388	0.0584	4444	0.0624	6501	0.1064	8558	0.0544
336	0.0424	2389	0.0544	4445	0.0624	6502	0.1064	8559	0.056
337	0.048	2390	0.056	4446	0.064	6503	0.0984	8560	0.0544
338	0.0464	2391	0.0624	4447	0.0664	6504	0.092	8561	0.0464
339	0.04	2392	0.0624	4448	0.0664	6505	0.092	8562	0.044
340	0.044	2393	0.0624	4449	0.064	6506	0.0864	8563	0.0464
341	0.048	2394	0.0664	4450	0.0664	6507	0.08	8564	0.0464
342	0.044	2395	0.068	4451	0.064	6508	0.0784	8565	0.052
343	0.0424	2396	0.068	4452	0.06	6509	0.0744	8566	0.0504
344	0.0424	2397	0.064	4453	0.0584	6510	0.0704	8567	0.048
345	0.044	2398	0.06	4454	0.0624	6511	0.0744	8568	0.0464
346	0.0464	2399	0.06	4455	0.0624	6512	0.0744	8569	0.048
347	0.044	2400	0.0624	4456	0.0584	6513	0.072	8570	0.052
348	0.044	2401	0.0624	4457	0.0584	6514	0.072	8571	0.0504
349	0.064	2402	0.064	4458	0.056	6515	0.068	8572	0.0504
350	0.0664	2403	0.06	4459	0.06	6516	0.064	8573	0.0544

351	0.0464	2404	0.0624	4460	0.0624	6517	0.068	8574	0.0504
352	0.0464	2405	0.0624	4461	0.064	6518	0.0664	8575	0.052
353	0.044	2406	0.0664	4462	0.0624	6519	0.0664	8576	0.052
354	0.044	2407	0.064	4463	0.064	6520	0.064	8577	0.048
355	0.0464	2408	0.064	4464	0.056	6521	0.0624	8578	0.0464
356	0.0464	2409	0.0624	4465	0.0584	6522	0.06	8579	0.048
357	0.0464	2410	0.06	4466	0.0584	6523	0.0624	8580	0.0504
358	0.0424	2411	0.0624	4467	0.056	6524	0.056	8581	0.0464
359	0.04	2412	0.0584	4468	0.0584	6525	0.056	8582	0.044
360	0.0464	2413	0.0584	4469	0.06	6526	0.0544	8583	0.0504
361	0.044	2414	0.0584	4470	0.056	6527	0.056	8584	0.0504
362	0.0424	2415	0.0584	4471	0.0584	6528	0.06	8585	0.048
363	0.0424	2416	0.0584	4472	0.064	6529	0.06	8586	0.052
364	0.0464	2417	0.0584	4473	0.064	6530	0.0584	8587	0.056
365	0.0464	2418	0.0584	4474	0.0664	6531	0.056	8588	0.052
366	0.0464	2419	0.06	4475	0.06	6532	0.0544	8589	0.0464
367	0.044	2420	0.0624	4476	0.06	6533	0.056	8590	0.048
368	0.0424	2421	0.06	4477	0.06	6534	0.056	8591	0.048
369	0.04	2422	0.06	4478	0.0584	6535	0.056	8592	0.048
370	0.0424	2423	0.064	4479	0.0584	6536	0.0584	8593	0.0504
371	0.0424	2424	0.068	4480	0.0584	6537	0.0584	8594	0.0544
372	0.04	2425	0.06	4481	0.0584	6538	0.06	8595	0.056
373	0.04	2426	0.0624	4482	0.056	6539	0.0624	8596	0.052
374	0.04	2427	0.064	4483	0.06	6540	0.06	8597	0.0504
375	0.04	2428	0.0624	4484	0.0624	6541	0.056	8598	0.0504
376	0.0424	2429	0.0624	4485	0.0664	6542	0.06	8599	0.0504
377	0.0424	2430	0.0624	4486	0.076	6543	0.0584	8600	0.048
378	0.044	2431	0.064	4487	0.0784	6544	0.0584	8601	0.0464
379	0.044	2432	0.0624	4488	0.0744	6545	0.06	8602	0.0544
380	0.04	2433	0.064	4489	0.068	6546	0.0584	8603	0.06
381	0.04	2434	0.0624	4490	0.068	6547	0.056	8604	0.052
382	0.04	2435	0.06	4491	0.08	6548	0.0544	8605	0.052
383	0.048	2436	0.0664	4492	0.084	6549	0.056	8606	0.0544
384	0.048	2437	0.0624	4493	0.068	6550	0.06	8607	0.048
385	0.0464	2438	0.06	4494	0.0624	6551	0.064	8608	0.048
386	0.0424	2439	0.0584	4495	0.0624	6552	0.064	8609	0.052
387	0.048	2440	0.0584	4496	0.0664	6553	0.0624	8610	0.056
388	0.048	2441	0.056	4497	0.064	6554	0.064	8611	0.052
389	0.0504	2442	0.06	4498	0.0664	6555	0.0624	8612	0.0504
390	0.0504	2443	0.0584	4499	0.068	6556	0.06	8613	0.056
391	0.0464	2444	0.0584	4500	0.064	6557	0.0624	8614	0.056
392	0.0424	2445	0.0584	4501	0.064	6558	0.06	8615	0.0504
393	0.04	2446	0.0544	4502	0.0624	6559	0.0624	8616	0.0504
394	0.04	2447	0.056	4503	0.06	6560	0.064	8617	0.052
395	0.044	2448	0.056	4504	0.0624	6561	0.064	8618	0.0504
396	0.0464	2449	0.0584	4505	0.0664	6562	0.064	8619	0.0504
397	0.0504	2450	0.0624	4506	0.0704	6563	0.06	8620	0.052
398	0.0464	2451	0.068	4507	0.064	6564	0.0584	8621	0.0504
399	0.0464	2452	0.0664	4508	0.0624	6565	0.06	8622	0.0544
400	0.048	2453	0.06	4509	0.064	6566	0.0624	8623	0.056
401	0.044	2454	0.06	4510	0.0624	6567	0.0664	8624	0.0544
402	0.044	2455	0.0624	4511	0.06	6568	0.0704	8625	0.0504
403	0.048	2456	0.0624	4512	0.064	6569	0.064	8626	0.0464
404	0.0464	2457	0.06	4513	0.064	6570	0.0664	8627	0.0504
405	0.044	2458	0.06	4514	0.06	6571	0.0624	8628	0.052
406	0.0424	2459	0.0584	4515	0.056	6572	0.0624	8629	0.052
407	0.0424	2460	0.06	4516	0.056	6573	0.0624	8630	0.052
408	0.0464	2461	0.0624	4517	0.0584	6574	0.064	8631	0.048
409	0.0464	2462	0.064	4518	0.0664	6575	0.0664	8632	0.048
410	0.0464	2463	0.06	4519	0.0664	6576	0.0664	8633	0.0544
411	0.044	2464	0.0584	4520	0.056	6577	0.064	8634	0.052
412	0.048	2465	0.056	4521	0.056	6578	0.068	8635	0.052
413	0.0464	2466	0.056	4522	0.056	6579	0.068	8636	0.052
414	0.0424	2467	0.0624	4523	0.06	6580	0.064	8637	0.0584
415	0.048	2468	0.0664	4524	0.06	6581	0.0664	8638	0.056
416	0.0424	2469	0.064	4525	0.0624	6582	0.068	8639	0.048
417	0.044	2470	0.0624	4526	0.064	6583	0.068	8640	0.052
418	0.048	2471	0.0544	4527	0.0584	6584	0.072	8641	0.056
419	0.044	2472	0.068	4528	0.0584	6585	0.064	8642	0.0504
420	0.0424	2473	0.0744	4529	0.056	6586	0.064	8643	0.052
421	0.0424	2474	0.0584	4530	0.056	6587	0.068	8644	0.0544
422	0.0464	2475	0.0584	4531	0.0584	6588	0.064	8645	0.052
423	0.048	2476	0.0584	4532	0.06	6589	0.0704	8646	0.0504
424	0.044	2477	0.056	4533	0.064	6590	0.0704	8647	0.0504
425	0.04	2478	0.0584	4534	0.06	6591	0.064	8648	0.048
426	0.0424	2479	0.06	4535	0.0624	6592	0.0584	8649	0.0504
427	0.044	2480	0.056	4536	0.056	6593	0.0624	8650	0.0584
428	0.0464	2481	0.0544	4537	0.0544	6594	0.06	8651	0.0544
429	0.0504	2482	0.0544	4538	0.056	6595	0.064	8652	0.0544
430	0.0504	2483	0.056	4539	0.0584	6596	0.0664	8653	0.052
431	0.0464	2484	0.056	4540	0.0584	6597	0.0624	8654	0.048
432	0.044	2485	0.0544	4541	0.0584	6598	0.0624	8655	0.0504
433	0.0464	2486	0.0544	4542	0.056	6599	0.06	8656	0.0584
434	0.0464	2487	0.0544	4543	0.056	6600	0.0624	8657	0.0584
435	0.048	2488	0.056	4544	0.0584	6601	0.064	8658	0.0544
436	0.0464	2489	0.056	4545	0.0584	6602	0.06	8659	0.0544
437	0.0504	2490	0.06	4546	0.0584	6603	0.0664	8660	0.0504
438	0.0464	2491	0.056	4547	0.0584	6604	0.064	8661	0.056
439	0.0464	2492	0.056	4548	0.0584	6605	0.06	8662	0.056
440	0.0464	2493	0.06	4549	0.0584	6606	0.06	8663	0.048
441	0.0464	2494	0.06	4550	0.0584	6607	0.0584	8664	0.0504
442	0.0424	2495	0.0584	4551	0.0584	6608	0.06	8665	0.052
443	0.044	2496	0.056	4552	0.0584	6609	0.0624	8666	0.052

444	0.044	2497	0.056	4553	0.0624	6610	0.064	8667	0.0504
445	0.044	2498	0.0544	4554	0.0584	6611	0.0664	8668	0.052
446	0.0424	2499	0.056	4555	0.0584	6612	0.0624	8669	0.052
447	0.044	2500	0.056	4556	0.06	6613	0.064	8670	0.048
448	0.0464	2501	0.0544	4557	0.06	6614	0.0664	8671	0.048
449	0.0544	2502	0.056	4558	0.0584	6615	0.0704	8672	0.0504
450	0.052	2503	0.06	4559	0.06	6616	0.072	8673	0.052
451	0.0464	2504	0.0624	4560	0.056	6617	0.072	8674	0.052
452	0.0464	2505	0.06	4561	0.056	6618	0.072	8675	0.048
453	0.0464	2506	0.056	4562	0.064	6619	0.072	8676	0.0544
454	0.0424	2507	0.0584	4563	0.068	6620	0.072	8677	0.0544
455	0.0464	2508	0.0624	4564	0.064	6621	0.076	8678	0.052
456	0.0504	2509	0.0784	4565	0.0664	6622	0.084	8679	0.052
457	0.048	2510	0.0824	4566	0.0624	6623	0.0824	8680	0.0504
458	0.0464	2511	0.0784	4567	0.06	6624	0.072	8681	0.052
459	0.048	2512	0.072	4568	0.0624	6625	0.068	8682	0.0544
460	0.0464	2513	0.0664	4569	0.064	6626	0.0704	8683	0.052
461	0.048	2514	0.0704	4570	0.06	6627	0.0664	8684	0.0544
462	0.052	2515	0.072	4571	0.06	6628	0.0664	8685	0.048
463	0.0544	2516	0.0664	4572	0.06	6629	0.0704	8686	0.0504
464	0.052	2517	0.064	4573	0.06	6630	0.068	8687	0.0504
465	0.052	2518	0.064	4574	0.064	6631	0.0704	8688	0.0504
466	0.0504	2519	0.064	4575	0.056	6632	0.0744	8689	0.048
467	0.0504	2520	0.064	4576	0.06	6633	0.0744	8690	0.048
468	0.0424	2521	0.068	4577	0.0624	6634	0.064	8691	0.0504
469	0.0464	2522	0.06	4578	0.06	6635	0.064	8692	0.0504
470	0.0504	2523	0.0584	4579	0.0624	6636	0.0664	8693	0.0504
471	0.0464	2524	0.0624	4580	0.06	6637	0.072	8694	0.048
472	0.048	2525	0.064	4581	0.0584	6638	0.0704	8695	0.0504
473	0.048	2526	0.0624	4582	0.0624	6639	0.0664	8696	0.052
474	0.0424	2527	0.0664	4583	0.0584	6640	0.064	8697	0.0504
475	0.0424	2528	0.064	4584	0.0584	6641	0.0624	8698	0.052
476	0.044	2529	0.064	4585	0.0584	6642	0.068	8699	0.056
477	0.0464	2530	0.0664	4586	0.056	6643	0.0704	8700	0.0504
478	0.0464	2531	0.0584	4587	0.056	6644	0.0664	8701	0.052
479	0.0464	2532	0.06	4588	0.0584	6645	0.068	8702	0.048
480	0.048	2533	0.0584	4589	0.0584	6646	0.064	8703	0.048
481	0.0464	2534	0.056	4590	0.056	6647	0.0624	8704	0.052
482	0.0464	2535	0.06	4591	0.0624	6648	0.0624	8705	0.052
483	0.0504	2536	0.0624	4592	0.0584	6649	0.0624	8706	0.048
484	0.0464	2537	0.06	4593	0.056	6650	0.0664	8707	0.0464
485	0.044	2538	0.064	4594	0.0584	6651	0.0624	8708	0.048
486	0.044	2539	0.064	4595	0.056	6652	0.0624	8709	0.052
487	0.052	2540	0.06	4596	0.056	6653	0.0624	8710	0.052
488	0.052	2541	0.06	4597	0.0584	6654	0.0624	8711	0.0504
489	0.048	2542	0.0624	4598	0.06	6655	0.0584	8712	0.048
490	0.048	2543	0.0584	4599	0.0584	6656	0.0664	8713	0.0464
491	0.0504	2544	0.06	4600	0.0584	6657	0.0624	8714	0.044
492	0.0544	2545	0.06	4601	0.0544	6658	0.0624	8715	0.0464
493	0.048	2546	0.056	4602	0.056	6659	0.0664	8716	0.056
494	0.052	2547	0.0624	4603	0.0584	6660	0.0664	8717	0.056
495	0.052	2548	0.06	4604	0.0624	6661	0.0664	8718	0.048
496	0.056	2549	0.056	4605	0.0584	6662	0.0624	8719	0.0504
497	0.06	2550	0.0584	4606	0.056	6663	0.06	8720	0.0504
498	0.056	2551	0.0624	4607	0.056	6664	0.064	8721	0.0504
499	0.06	2552	0.0584	4608	0.056	6665	0.0664	8722	0.052
500	0.0544	2553	0.056	4609	0.0584	6666	0.068	8723	0.048
501	0.0504	2554	0.056	4610	0.06	6667	0.0624	8724	0.0504
502	0.056	2555	0.0544	4611	0.056	6668	0.06	8725	0.048
503	0.0584	2556	0.0544	4612	0.06	6669	0.0624	8726	0.048
504	0.052	2557	0.0544	4613	0.0624	6670	0.068	8727	0.052
505	0.052	2558	0.056	4614	0.0584	6671	0.0664	8728	0.0704
506	0.0584	2559	0.0584	4615	0.0584	6672	0.06	8729	0.068
507	0.0624	2560	0.0544	4616	0.056	6673	0.0584	8730	0.0504
508	0.06	2561	0.056	4617	0.06	6674	0.06	8731	0.052
509	0.0544	2562	0.056	4618	0.06	6675	0.06	8732	0.052
510	0.056	2563	0.056	4619	0.064	6676	0.06	8733	0.0504
511	0.052	2564	0.056	4620	0.06	6677	0.06	8734	0.0464
512	0.0544	2565	0.052	4621	0.0584	6678	0.06	8735	0.048
513	0.0584	2566	0.0544	4622	0.0584	6679	0.06	8736	0.052
514	0.0584	2567	0.0544	4623	0.06	6680	0.064	8737	0.048
515	0.0584	2568	0.056	4624	0.06	6681	0.06	8738	0.048
516	0.056	2569	0.0544	4625	0.0584	6682	0.06	8739	0.056
517	0.0584	2570	0.0544	4626	0.056	6683	0.0624	8740	0.052
518	0.056	2571	0.056	4627	0.0544	6684	0.06	8741	0.0464
519	0.0544	2572	0.056	4628	0.056	6685	0.0584	8742	0.0464
520	0.052	2573	0.0624	4629	0.06	6686	0.0584	8743	0.052
521	0.0544	2574	0.06	4630	0.06	6687	0.0584	8744	0.052
522	0.056	2575	0.06	4631	0.064	6688	0.056	8745	0.048
523	0.06	2576	0.0584	4632	0.0624	6689	0.056	8746	0.052
524	0.0624	2577	0.056	4633	0.056	6690	0.0544	8747	0.0544
525	0.056	2578	0.0544	4634	0.0584	6691	0.06	8748	0.052
526	0.056	2579	0.056	4635	0.056	6692	0.056	8749	0.048
527	0.056	2580	0.056	4636	0.056	6693	0.056	8750	0.0504
528	0.0544	2581	0.056	4637	0.0664	6694	0.0584	8751	0.048
529	0.056	2582	0.0584	4638	0.0664	6695	0.0624	8752	0.048
530	0.0584	2583	0.0584	4639	0.0584	6696	0.0624	8753	0.048
531	0.056	2584	0.0624	4640	0.056	6697	0.0584	8754	0.0504
532	0.0584	2585	0.06	4641	0.06	6698	0.0584	8755	0.0544
533	0.0624	2586	0.0544	4642	0.0664	6699	0.0584	8756	0.052
534	0.06	2587	0.0544	4643	0.0624	6700	0.056	8757	0.0504
535	0.0624	2588	0.06	4644	0.056	6701	0.056	8758	0.0504
536	0.0664	2589	0.0584	4645	0.056	6702	0.056	8759	0.048

537	0.0584	2590	0.0584	4646	0.0624	6703	0.056	8760	0.044
538	0.0584	2591	0.0584	4647	0.064	6704	0.056	8761	0.048
539	0.06	2592	0.0624	4648	0.06	6705	0.052	8762	0.0544
540	0.064	2593	0.0544	4649	0.0584	6706	0.0544	8763	0.052
541	0.0664	2594	0.0584	4650	0.0584	6707	0.06	8764	0.052
542	0.06	2595	0.0584	4651	0.064	6708	0.06	8765	0.048
543	0.0624	2596	0.0544	4652	0.0704	6709	0.056	8766	0.0504
544	0.06	2597	0.06	4653	0.0664	6710	0.0544	8767	0.052
545	0.056	2598	0.06	4654	0.06	6711	0.06	8768	0.0464
546	0.0584	2599	0.0584	4655	0.0664	6712	0.0624	8769	0.048
547	0.0624	2600	0.052	4656	0.0624	6713	0.0584	8770	0.0504
548	0.0624	2601	0.0544	4657	0.0664	6714	0.06	8771	0.0464
549	0.056	2602	0.0544	4658	0.064	6715	0.06	8772	0.048
550	0.0544	2603	0.0544	4659	0.0664	6716	0.064	8773	0.0464
551	0.056	2604	0.052	4660	0.0664	6717	0.064	8774	0.048
552	0.0624	2605	0.056	4661	0.0664	6718	0.0624	8775	0.048
553	0.0584	2606	0.0624	4662	0.0704	6719	0.0624	8776	0.056
554	0.056	2607	0.0584	4663	0.0704	6720	0.0624	8777	0.0584
555	0.0584	2608	0.0584	4664	0.0704	6721	0.0584	8778	0.0464
556	0.056	2609	0.056	4665	0.072	6722	0.0584	8779	0.0464
557	0.06	2610	0.0584	4666	0.068	6723	0.0544	8780	0.0504
558	0.06	2611	0.0544	4667	0.0664	6724	0.0584	8781	0.048
559	0.0544	2612	0.0544	4668	0.0624	6725	0.064	8782	0.048
560	0.0584	2613	0.056	4669	0.064	6726	0.0624	8783	0.0504
561	0.0624	2614	0.0584	4670	0.0664	6727	0.0624	8784	0.0464
562	0.052	2615	0.06	4671	0.068	6728	0.064	8785	0.0464
563	0.056	2616	0.0584	4672	0.0704	6729	0.0584	8786	0.048
564	0.06	2617	0.056	4673	0.072	6730	0.06	8787	0.048
565	0.056	2618	0.0544	4674	0.068	6731	0.06	8788	0.0464
566	0.052	2619	0.0584	4675	0.0624	6732	0.0584	8789	0.0464
567	0.056	2620	0.056	4676	0.0664	6733	0.056	8790	0.0464
568	0.0544	2621	0.06	4677	0.068	6734	0.06	8791	0.048
569	0.0544	2622	0.056	4678	0.0624	6735	0.056	8792	0.048
570	0.056	2623	0.0544	4679	0.0624	6736	0.056	8793	0.048
571	0.0544	2624	0.052	4680	0.0624	6737	0.0584	8794	0.0464
572	0.0544	2625	0.0544	4681	0.0624	6738	0.06	8795	0.048
573	0.0584	2626	0.056	4682	0.06	6739	0.0584	8796	0.048
574	0.052	2627	0.0624	4683	0.0624	6740	0.06	8797	0.044
575	0.0584	2628	0.0624	4684	0.0664	6741	0.0624	8798	0.044
576	0.0584	2629	0.0544	4685	0.068	6742	0.0624	8799	0.044
577	0.056	2630	0.056	4686	0.0664	6743	0.0584	8800	0.0464
578	0.052	2631	0.056	4687	0.0624	6744	0.06	8801	0.0504
579	0.0544	2632	0.052	4688	0.06	6745	0.06	8802	0.0504
580	0.056	2633	0.052	4689	0.064	6746	0.0544	8803	0.048
581	0.056	2634	0.052	4690	0.0664	6747	0.0584	8804	0.052
582	0.052	2635	0.052	4691	0.064	6748	0.06	8805	0.052
583	0.052	2636	0.056	4692	0.064	6749	0.052	8806	0.0464
584	0.056	2637	0.0544	4693	0.0704	6750	0.0544	8807	0.048
585	0.0544	2638	0.052	4694	0.0664	6751	0.0544	8808	0.052
586	0.0544	2639	0.0504	4695	0.0624	6752	0.056	8809	0.0544
587	0.056	2640	0.052	4696	0.0624	6753	0.06	8810	0.052
588	0.06	2641	0.0504	4697	0.0664	6754	0.056	8811	0.048
589	0.0624	2642	0.0504	4698	0.06	6755	0.052	8812	0.0464
590	0.056	2643	0.056	4699	0.0584	6756	0.052	8813	0.048
591	0.056	2644	0.0544	4700	0.0584	6757	0.052	8814	0.052
592	0.0584	2645	0.056	4701	0.056	6758	0.056	8815	0.048
593	0.056	2646	0.0624	4702	0.056	6759	0.0544	8816	0.048
594	0.056	2647	0.064	4703	0.06	6760	0.0544	8817	0.052
595	0.06	2648	0.056	4704	0.0664	6761	0.0544	8818	0.0504
596	0.056	2649	0.0544	4705	0.064	6762	0.052	8819	0.0504
597	0.0544	2650	0.056	4706	0.06	6763	0.052	8820	0.0504
598	0.0544	2651	0.056	4707	0.0624	6764	0.0544	8821	0.0504
599	0.0584	2652	0.0544	4708	0.0624	6765	0.056	8822	0.0504
600	0.056	2653	0.056	4709	0.0624	6766	0.052	8823	0.0504
601	0.0544	2654	0.052	4710	0.0624	6767	0.0544	8824	0.048
602	0.056	2655	0.052	4711	0.064	6768	0.0544	8825	0.0504
603	0.056	2656	0.052	4712	0.06	6769	0.0544	8826	0.0504
604	0.056	2657	0.0544	4713	0.0624	6770	0.0584	8827	0.048
605	0.056	2658	0.0544	4714	0.064	6771	0.0584	8828	0.048
606	0.056	2659	0.0544	4715	0.0664	6772	0.0544	8829	0.052
607	0.056	2660	0.056	4716	0.064	6773	0.0544	8830	0.0544
608	0.0544	2661	0.052	4717	0.06	6774	0.0544	8831	0.0584
609	0.064	2662	0.056	4718	0.064	6775	0.052	8832	0.0504
610	0.068	2663	0.056	4719	0.0664	6776	0.0504	8833	0.048
611	0.056	2664	0.052	4720	0.064	6777	0.0504	8834	0.0464
612	0.056	2665	0.052	4721	0.0664	6778	0.0544	8835	0.044
613	0.056	2666	0.0624	4722	0.064	6779	0.0544	8836	0.0504
614	0.056	2667	0.0624	4723	0.0584	6780	0.0584	8837	0.052
615	0.0544	2668	0.056	4724	0.0584	6781	0.056	8838	0.052
616	0.056	2669	0.0544	4725	0.0584	6782	0.0504	8839	0.0464
617	0.056	2670	0.052	4726	0.06	6783	0.052	8840	0.0464
618	0.056	2671	0.052	4727	0.0584	6784	0.0584	8841	0.0464
619	0.0544	2672	0.06	4728	0.056	6785	0.0584	8842	0.0464
620	0.06	2673	0.064	4729	0.0624	6786	0.06	8843	0.048
621	0.06	2674	0.0624	4730	0.0624	6787	0.056	8844	0.0504
622	0.056	2675	0.0624	4731	0.0584	6788	0.056	8845	0.0504
623	0.0624	2676	0.0624	4732	0.06	6789	0.056	8846	0.048
624	0.06	2677	0.06	4733	0.0664	6790	0.056	8847	0.0464
625	0.056	2678	0.06	4734	0.064	6791	0.0584	8848	0.048
626	0.0584	2679	0.0584	4735	0.0584	6792	0.0584	8849	0.0504
627	0.06	2680	0.0624	4736	0.064	6793	0.0624	8850	0.0504
628	0.0584	2681	0.06	4737	0.0664	6794	0.0664	8851	0.0504
629	0.0584	2682	0.06	4738	0.0664	6795	0.0624	8852	0.0504

630	0.056	2683	0.0624	4739	0.0664	6796	0.0584	8853	0.0464
631	0.056	2684	0.056	4740	0.068	6797	0.0624	8854	0.048
632	0.056	2685	0.056	4741	0.06	6798	0.06	8855	0.048
633	0.06	2686	0.06	4742	0.06	6799	0.056	8856	0.0504
634	0.0584	2687	0.056	4743	0.06	6800	0.0544	8857	0.052
635	0.06	2688	0.0584	4744	0.0584	6801	0.0544	8858	0.048
636	0.0584	2689	0.0584	4745	0.0584	6802	0.056	8859	0.048
637	0.0584	2690	0.056	4746	0.0624	6803	0.0544	8860	0.048
638	0.052	2691	0.056	4747	0.064	6804	0.056	8861	0.0504
639	0.052	2692	0.0584	4748	0.0584	6805	0.0584	8862	0.052
640	0.056	2693	0.056	4749	0.0584	6806	0.0544	8863	0.052
641	0.052	2694	0.06	4750	0.06	6807	0.0544	8864	0.0504
642	0.052	2695	0.056	4751	0.06	6808	0.056	8865	0.044
643	0.0544	2696	0.056	4752	0.0624	6809	0.0544	8866	0.0464
644	0.0504	2697	0.056	4753	0.0624	6810	0.0504	8867	0.0464
645	0.0544	2698	0.056	4754	0.06	6811	0.0544	8868	0.0464
646	0.056	2699	0.056	4755	0.064	6812	0.056	8869	0.048
647	0.0544	2700	0.0544	4756	0.0624	6813	0.0544	8870	0.048
648	0.056	2701	0.052	4757	0.06	6814	0.0504	8871	0.0464
649	0.0544	2702	0.056	4758	0.06	6815	0.056	8872	0.048
650	0.052	2703	0.056	4759	0.06	6816	0.0624	8873	0.0504
651	0.052	2704	0.052	4760	0.064	6817	0.056	8874	0.0504
652	0.0504	2705	0.048	4761	0.064	6818	0.056	8875	0.0504
653	0.052	2706	0.0504	4762	0.0664	6819	0.0584	8876	0.048
654	0.056	2707	0.052	4763	0.064	6820	0.0544	8877	0.0504
655	0.052	2708	0.0544	4764	0.064	6821	0.056	8878	0.052
656	0.0544	2709	0.052	4765	0.0704	6822	0.0584	8879	0.0504
657	0.0544	2710	0.0544	4766	0.064	6823	0.0544	8880	0.0504
658	0.052	2711	0.0504	4767	0.0584	6824	0.052	8881	0.0504
659	0.0504	2712	0.0504	4768	0.0664	6825	0.0544	8882	0.048
660	0.0504	2713	0.056	4769	0.064	6826	0.0544	8883	0.048
661	0.052	2714	0.0584	4770	0.064	6827	0.056	8884	0.0504
662	0.0544	2715	0.056	4771	0.0624	6828	0.056	8885	0.0504
663	0.052	2716	0.056	4772	0.064	6829	0.052	8886	0.052
664	0.048	2717	0.0584	4773	0.0624	6830	0.0544	8887	0.0544
665	0.052	2718	0.056	4774	0.06	6831	0.056	8888	0.0544
666	0.052	2719	0.06	4775	0.056	6832	0.048	8889	0.0464
667	0.0464	2720	0.06	4776	0.056	6833	0.0544	8890	0.0464
668	0.048	2721	0.056	4777	0.06	6834	0.0544	8891	0.0464
669	0.044	2722	0.052	4778	0.06	6835	0.052	8892	0.0504
670	0.0464	2723	0.0544	4779	0.064	6836	0.0544	8893	0.052
671	0.052	2724	0.052	4780	0.076	6837	0.0544	8894	0.0504
672	0.0544	2725	0.052	4781	0.076	6838	0.0504	8895	0.048
673	0.052	2726	0.052	4782	0.0624	6839	0.048	8896	0.0464
674	0.048	2727	0.048	4783	0.0584	6840	0.0504	8897	0.052
675	0.048	2728	0.0504	4784	0.064	6841	0.052	8898	0.0504
676	0.0584	2729	0.0544	4785	0.0624	6842	0.0504	8899	0.0504
677	0.0584	2730	0.0544	4786	0.056	6843	0.052	8900	0.0464
678	0.048	2731	0.056	4787	0.0624	6844	0.052	8901	0.052
679	0.0504	2732	0.056	4788	0.064	6845	0.056	8902	0.0504
680	0.048	2733	0.056	4789	0.0664	6846	0.0584	8903	0.048
681	0.052	2734	0.056	4790	0.0624	6847	0.0504	8904	0.0464
682	0.0544	2735	0.056	4791	0.0584	6848	0.0504	8905	0.048
683	0.0584	2736	0.056	4792	0.064	6849	0.0504	8906	0.048
684	0.052	2737	0.06	4793	0.064	6850	0.048	8907	0.048
685	0.0504	2738	0.0624	4794	0.06	6851	0.048	8908	0.048
686	0.0504	2739	0.056	4795	0.06	6852	0.052	8909	0.0504
687	0.048	2740	0.056	4796	0.0624	6853	0.0544	8910	0.0504
688	0.0504	2741	0.06	4797	0.064	6854	0.0544	8911	0.048
689	0.0544	2742	0.0584	4798	0.0584	6855	0.052	8912	0.048
690	0.052	2743	0.056	4799	0.06	6856	0.052	8913	0.048
691	0.048	2744	0.0584	4800	0.068	6857	0.052	8914	0.052
692	0.048	2745	0.056	4801	0.072	6858	0.0504	8915	0.052
693	0.048	2746	0.0504	4802	0.064	6859	0.0504	8916	0.0504
694	0.048	2747	0.0504	4803	0.0664	6860	0.052	8917	0.0504
695	0.0504	2748	0.052	4804	0.064	6861	0.0544	8918	0.048
696	0.0504	2749	0.0544	4805	0.064	6862	0.0544	8919	0.0504
697	0.048	2750	0.052	4806	0.0664	6863	0.056	8920	0.056
698	0.0464	2751	0.052	4807	0.0624	6864	0.0584	8921	0.056
699	0.0464	2752	0.056	4808	0.0664	6865	0.056	8922	0.056
700	0.0464	2753	0.0544	4809	0.0664	6866	0.0544	8923	0.06
701	0.048	2754	0.0544	4810	0.0624	6867	0.0544	8924	0.056
702	0.048	2755	0.052	4811	0.0624	6868	0.0504	8925	0.052
703	0.0464	2756	0.0504	4812	0.0584	6869	0.0464	8926	0.0504
704	0.048	2757	0.0504	4813	0.056	6870	0.044	8927	0.052
705	0.0504	2758	0.052	4814	0.0584	6871	0.0544	8928	0.0544
706	0.0504	2759	0.0504	4815	0.06	6872	0.0544	8929	0.052
707	0.048	2760	0.0504	4816	0.0624	6873	0.052	8930	0.0544
708	0.044	2761	0.0544	4817	0.0744	6874	0.052	8931	0.052
709	0.044	2762	0.056	4818	0.0784	6875	0.0504	8932	0.0584
710	0.0464	2763	0.0584	4819	0.064	6876	0.0544	8933	0.056
711	0.0464	2764	0.0544	4820	0.0664	6877	0.052	8934	0.052
712	0.0464	2765	0.0504	4821	0.064	6878	0.0504	8935	0.0544
713	0.0464	2766	0.0504	4822	0.06	6879	0.056	8936	0.052
714	0.048	2767	0.0544	4823	0.06	6880	0.056	8937	0.0504
715	0.044	2768	0.052	4824	0.0624	6881	0.048	8938	0.0504
716	0.0464	2769	0.0584	4825	0.06	6882	0.048	8939	0.0504
717	0.048	2770	0.0584	4826	0.06	6883	0.0504	8940	0.0584
718	0.0464	2771	0.0504	4827	0.0664	6884	0.048	8941	0.056
719	0.048	2772	0.0504	4828	0.068	6885	0.048	8942	0.052
720	0.0504	2773	0.048	4829	0.068	6886	0.048	8943	0.052
721	0.0464	2774	0.052	4830	0.064	6887	0.0504	8944	0.048
722	0.0464	2775	0.0504	4831	0.0624	6888	0.048	8945	0.052

723	0.0504	2776	0.0504	4832	0.0624	6889	0.0504	8946	0.052
724	0.0464	2777	0.052	4833	0.06	6890	0.0504	8947	0.052
725	0.0464	2778	0.052	4834	0.064	6891	0.048	8948	0.0544
726	0.048	2779	0.052	4835	0.0664	6892	0.048	8949	0.0504
727	0.048	2780	0.052	4836	0.068	6893	0.048	8950	0.052
728	0.052	2781	0.0544	4837	0.0624	6894	0.0504	8951	0.0504
729	0.0544	2782	0.052	4838	0.0624	6895	0.048	8952	0.052
730	0.0464	2783	0.052	4839	0.06	6896	0.0504	8953	0.0544
731	0.0504	2784	0.052	4840	0.06	6897	0.048	8954	0.0504
732	0.0504	2785	0.052	4841	0.0664	6898	0.0464	8955	0.0464
733	0.052	2786	0.052	4842	0.068	6899	0.048	8956	0.048
734	0.052	2787	0.052	4843	0.072	6900	0.048	8957	0.0544
735	0.0504	2788	0.048	4844	0.0704	6901	0.0504	8958	0.072
736	0.0504	2789	0.052	4845	0.0664	6902	0.052	8959	0.068
737	0.0504	2790	0.0544	4846	0.0704	6903	0.0504	8960	0.0504
738	0.052	2791	0.056	4847	0.064	6904	0.0504	8961	0.0544
739	0.0584	2792	0.0544	4848	0.06	6905	0.0504	8962	0.052
740	0.056	2793	0.052	4849	0.056	6906	0.0464	8963	0.048
741	0.0544	2794	0.0504	4850	0.0584	6907	0.0504	8964	0.0504
742	0.0504	2795	0.0504	4851	0.0624	6908	0.052	8965	0.0504
743	0.0504	2796	0.0504	4852	0.0624	6909	0.048	8966	0.0504
744	0.056	2797	0.0504	4853	0.0624	6910	0.0464	8967	0.0504
745	0.0584	2798	0.0504	4854	0.0624	6911	0.048	8968	0.0464
746	0.0504	2799	0.052	4855	0.056	6912	0.048	8969	0.0584
747	0.0504	2800	0.052	4856	0.0544	6913	0.0464	8970	0.0584
748	0.052	2801	0.0464	4857	0.0584	6914	0.044	8971	0.0504
749	0.0504	2802	0.0504	4858	0.06	6915	0.0464	8972	0.0544
750	0.0504	2803	0.056	4859	0.0584	6916	0.048	8973	0.056
751	0.0504	2804	0.052	4860	0.0584	6917	0.0464	8974	0.056
752	0.0504	2805	0.048	4861	0.0584	6918	0.048	8975	0.0544
753	0.048	2806	0.0504	4862	0.0584	6919	0.052	8976	0.0504
754	0.0464	2807	0.048	4863	0.056	6920	0.052	8977	0.052
755	0.0464	2808	0.0464	4864	0.0624	6921	0.0504	8978	0.052
756	0.0464	2809	0.0504	4865	0.064	6922	0.052	8979	0.052
757	0.0464	2810	0.0504	4866	0.0584	6923	0.0504	8980	0.0544
758	0.0504	2811	0.048	4867	0.06	6924	0.048	8981	0.06
759	0.0504	2812	0.048	4868	0.0584	6925	0.0464	8982	0.0584
760	0.0504	2813	0.0464	4869	0.056	6926	0.048	8983	0.052
761	0.0504	2814	0.0504	4870	0.0584	6927	0.044	8984	0.052
762	0.048	2815	0.052	4871	0.06	6928	0.052	8985	0.056
763	0.0504	2816	0.048	4872	0.068	6929	0.0464	8986	0.0504
764	0.052	2817	0.0504	4873	0.06	6930	0.044	8987	0.0504
765	0.0504	2818	0.0504	4874	0.0584	6931	0.0464	8988	0.0544
766	0.052	2819	0.0504	4875	0.0584	6932	0.0464	8989	0.0544
767	0.0584	2820	0.052	4876	0.0624	6933	0.0464	8990	0.0504
768	0.052	2821	0.052	4877	0.0624	6934	0.048	8991	0.052
769	0.0504	2822	0.0504	4878	0.064	6935	0.048	8992	0.048
770	0.0544	2823	0.048	4879	0.0664	6936	0.0464	8993	0.0504
771	0.052	2824	0.048	4880	0.068	6937	0.048	8994	0.0544
772	0.0504	2825	0.052	4881	0.064	6938	0.048	8995	0.0544
773	0.048	2826	0.0544	4882	0.0624	6939	0.044	8996	0.0544
774	0.0544	2827	0.0504	4883	0.0584	6940	0.0464	8997	0.0504
775	0.052	2828	0.052	4884	0.0584	6941	0.0464	8998	0.052
776	0.048	2829	0.0504	4885	0.0624	6942	0.0464	8999	0.0504
777	0.048	2830	0.0544	4886	0.068	6943	0.0504	9000	0.0504
778	0.052	2831	0.048	4887	0.0664	6944	0.052	9001	0.0504
779	0.0584	2832	0.048	4888	0.0664	6945	0.0504	9002	0.0624
780	0.0584	2833	0.0504	4889	0.06	6946	0.048	9003	0.0624
781	0.056	2834	0.052	4890	0.0624	6947	0.0504	9004	0.052
782	0.0544	2835	0.0504	4891	0.0624	6948	0.0504	9005	0.052
783	0.0584	2836	0.048	4892	0.06	6949	0.048	9006	0.052
784	0.0584	2837	0.0504	4893	0.0584	6950	0.048	9007	0.0504
785	0.056	2838	0.0504	4894	0.0624	6951	0.0464	9008	0.052
786	0.056	2839	0.0504	4895	0.06	6952	0.044	9009	0.052
787	0.0544	2840	0.0504	4896	0.056	6953	0.0464	9010	0.0504
788	0.0544	2841	0.048	4897	0.0584	6954	0.0504	9011	0.052
789	0.064	2842	0.0504	4898	0.0624	6955	0.0584	9012	0.052
790	0.076	2843	0.052	4899	0.0584	6956	0.052	9013	0.048
791	0.0744	2844	0.0544	4900	0.0584	6957	0.0504	9014	0.048
792	0.072	2845	0.0544	4901	0.056	6958	0.0504	9015	0.052
793	0.0704	2846	0.0464	4902	0.06	6959	0.052	9016	0.048
794	0.0704	2847	0.048	4903	0.0624	6960	0.0504	9017	0.048
795	0.0624	2848	0.0504	4904	0.0624	6961	0.0464	9018	0.052
796	0.06	2849	0.0504	4905	0.0624	6962	0.048	9019	0.0504
797	0.056	2850	0.0504	4906	0.06	6963	0.0504	9020	0.0504
798	0.056	2851	0.052	4907	0.0624	6964	0.0464	9021	0.048
799	0.0584	2852	0.052	4908	0.0624	6965	0.0464	9022	0.0504
800	0.06	2853	0.0504	4909	0.0584	6966	0.0504	9023	0.052
801	0.056	2854	0.048	4910	0.0584	6967	0.052	9024	0.0504
802	0.0544	2855	0.0504	4911	0.06	6968	0.0504	9025	0.0504
803	0.056	2856	0.0504	4912	0.0664	6969	0.0464	9026	0.052
804	0.0544	2857	0.0504	4913	0.064	6970	0.0504	9027	0.048
805	0.064	2858	0.0504	4914	0.06	6971	0.0504	9028	0.0504
806	0.0704	2859	0.056	4915	0.0584	6972	0.0504	9029	0.0504
807	0.056	2860	0.0504	4916	0.06	6973	0.056	9030	0.048
808	0.0544	2861	0.0504	4917	0.0584	6974	0.0584	9031	0.0464
809	0.052	2862	0.048	4918	0.06	6975	0.052	9032	0.0464
810	0.0504	2863	0.0464	4919	0.06	6976	0.056	9033	0.0504
811	0.0504	2864	0.0464	4920	0.06	6977	0.0544	9034	0.0504
812	0.052	2865	0.0464	4921	0.0584	6978	0.052	9035	0.0504
813	0.052	2866	0.0464	4922	0.0584	6979	0.052	9036	0.048
814	0.052	2867	0.0464	4923	0.06	6980	0.056	9037	0.048
815	0.052	2868	0.0464	4924	0.056	6981	0.0544	9038	0.048

816	0.048	2869	0.052	4925	0.0584	6982	0.0544	9039	0.052
817	0.048	2870	0.0624	4926	0.0584	6983	0.0584	9040	0.052
818	0.0504	2871	0.0584	4927	0.06	6984	0.0544	9041	0.0464
819	0.0544	2872	0.048	4928	0.056	6985	0.052	9042	0.0504
820	0.052	2873	0.0504	4929	0.056	6986	0.0504	9043	0.0504
821	0.056	2874	0.048	4930	0.0584	6987	0.0504	9044	0.0504
822	0.0544	2875	0.048	4931	0.0584	6988	0.0504	9045	0.0504
823	0.0544	2876	0.0504	4932	0.06	6989	0.0504	9046	0.048
824	0.056	2877	0.052	4933	0.06	6990	0.052	9047	0.0464
825	0.0584	2878	0.0504	4934	0.0584	6991	0.0504	9048	0.052
826	0.0544	2879	0.048	4935	0.0584	6992	0.0504	9049	0.056
827	0.048	2880	0.048	4936	0.0584	6993	0.052	9050	0.052
828	0.048	2881	0.048	4937	0.0624	6994	0.0504	9051	0.052
829	0.0544	2882	0.052	4938	0.06	6995	0.052	9052	0.048
830	0.0504	2883	0.052	4939	0.056	6996	0.052	9053	0.0464
831	0.052	2884	0.0464	4940	0.064	6997	0.052	9054	0.0464
832	0.052	2885	0.048	4941	0.0664	6998	0.052	9055	0.048
833	0.052	2886	0.0504	4942	0.06	6999	0.052	9056	0.048
834	0.0544	2887	0.0504	4943	0.056	7000	0.0544	9057	0.0464
835	0.0544	2888	0.0504	4944	0.0584	7001	0.0504	9058	0.0464
836	0.056	2889	0.048	4945	0.0584	7002	0.048	9059	0.0464
837	0.056	2890	0.0504	4946	0.06	7003	0.0504	9060	0.048
838	0.0544	2891	0.052	4947	0.0584	7004	0.052	9061	0.0504
839	0.0544	2892	0.052	4948	0.056	7005	0.0504	9062	0.052
840	0.056	2893	0.052	4949	0.056	7006	0.052	9063	0.0504
841	0.0544	2894	0.052	4950	0.06	7007	0.0544	9064	0.0464
842	0.0504	2895	0.052	4951	0.06	7008	0.0544	9065	0.048
843	0.0504	2896	0.048	4952	0.0584	7009	0.0584	9066	0.048
844	0.0504	2897	0.0504	4953	0.056	7010	0.0544	9067	0.0504
845	0.0504	2898	0.0544	4954	0.0584	7011	0.056	9068	0.048
846	0.052	2899	0.06	4955	0.0624	7012	0.06	9069	0.048
847	0.052	2900	0.0584	4956	0.06	7013	0.06	9070	0.044
848	0.0504	2901	0.048	4957	0.056	7014	0.052	9071	0.048
849	0.0504	2902	0.048	4958	0.0584	7015	0.0544	9072	0.0504
850	0.052	2903	0.048	4959	0.064	7016	0.056	9073	0.048
851	0.048	2904	0.048	4960	0.064	7017	0.056	9074	0.048
852	0.048	2905	0.0504	4961	0.064	7018	0.056	9075	0.0464
853	0.0464	2906	0.048	4962	0.0664	7019	0.056	9076	0.044
854	0.0504	2907	0.0504	4963	0.064	7020	0.0504	9077	0.0464
855	0.048	2908	0.048	4964	0.0624	7021	0.052	9078	0.0464
856	0.0504	2909	0.0464	4965	0.0584	7022	0.0544	9079	0.0464
857	0.0584	2910	0.0464	4966	0.06	7023	0.0544	9080	0.0464
858	0.0584	2911	0.048	4967	0.0584	7024	0.0544	9081	0.052
859	0.0504	2912	0.0464	4968	0.0584	7025	0.056	9082	0.052
860	0.0504	2913	0.048	4969	0.056	7026	0.0544	9083	0.0504
861	0.048	2914	0.0544	4970	0.0584	7027	0.056	9084	0.048
862	0.048	2915	0.052	4971	0.06	7028	0.056	9085	0.0504
863	0.048	2916	0.048	4972	0.0624	7029	0.052	9086	0.056
864	0.048	2917	0.0504	4973	0.06	7030	0.0504	9087	0.0584
865	0.0464	2918	0.048	4974	0.0624	7031	0.0584	9088	0.0544
866	0.0504	2919	0.048	4975	0.0744	7032	0.0584	9089	0.0504
867	0.048	2920	0.0504	4976	0.0784	7033	0.0504	9090	0.0504
868	0.0504	2921	0.0504	4977	0.0784	7034	0.0544	9091	0.056
869	0.0504	2922	0.0504	4978	0.08	7035	0.052	9092	0.0584
870	0.048	2923	0.0544	4979	0.068	7036	0.052	9093	0.0464
871	0.048	2924	0.048	4980	0.0584	7037	0.0544	9094	0.048
872	0.048	2925	0.0464	4981	0.0624	7038	0.0504	9095	0.048
873	0.052	2926	0.048	4982	0.06	7039	0.0504	9096	0.0464
874	0.052	2927	0.048	4983	0.064	7040	0.0504	9097	0.0504
875	0.048	2928	0.0504	4984	0.0624	7041	0.052	9098	0.0504
876	0.0504	2929	0.0504	4985	0.064	7042	0.052	9099	0.0464
877	0.0504	2930	0.048	4986	0.064	7043	0.052	9100	0.0464
878	0.0504	2931	0.0464	4987	0.0584	7044	0.052	9101	0.0464
879	0.0504	2932	0.052	4988	0.06	7045	0.0504	9102	0.048
880	0.0464	2933	0.052	4989	0.06	7046	0.052	9103	0.0464
881	0.048	2934	0.048	4990	0.0584	7047	0.056	9104	0.048
882	0.0504	2935	0.0504	4991	0.056	7048	0.052	9105	0.0504
883	0.0464	2936	0.0504	4992	0.0584	7049	0.052	9106	0.052
884	0.048	2937	0.052	4993	0.06	7050	0.052	9107	0.048
885	0.0464	2938	0.048	4994	0.064	7051	0.052	9108	0.048
886	0.0464	2939	0.048	4995	0.0584	7052	0.052	9109	0.0504
887	0.048	2940	0.048	4996	0.0584	7053	0.056	9110	0.048
888	0.048	2941	0.0504	4997	0.0624	7054	0.0544	9111	0.048
889	0.048	2942	0.0464	4998	0.0624	7055	0.0584	9112	0.048
890	0.044	2943	0.0464	4999	0.06	7056	0.052	9113	0.0464
891	0.0464	2944	0.048	5000	0.0624	7057	0.0544	9114	0.0464
892	0.0464	2945	0.0464	5001	0.06	7058	0.056	9115	0.048
893	0.0464	2946	0.044	5002	0.06	7059	0.0584	9116	0.048
894	0.048	2947	0.052	5003	0.0624	7060	0.0544	9117	0.048
895	0.048	2948	0.052	5004	0.0664	7061	0.0504	9118	0.048
896	0.044	2949	0.044	5005	0.0624	7062	0.0504	9119	0.0504
897	0.0464	2950	0.044	5006	0.06	7063	0.0504	9120	0.048
898	0.048	2951	0.0464	5007	0.0584	7064	0.052	9121	0.052
899	0.048	2952	0.0464	5008	0.0664	7065	0.0544	9122	0.052
900	0.048	2953	0.0464	5009	0.068	7066	0.052	9123	0.0504
901	0.0504	2954	0.052	5010	0.0584	7067	0.0544	9124	0.056
902	0.052	2955	0.048	5011	0.0584	7068	0.056	9125	0.0504
903	0.048	2956	0.0464	5012	0.06	7069	0.056	9126	0.052
904	0.0544	2957	0.048	5013	0.0624	7070	0.052	9127	0.0544
905	0.056	2958	0.0464	5014	0.0624	7071	0.052	9128	0.048
906	0.052	2959	0.0464	5015	0.064	7072	0.052	9129	0.052
907	0.048	2960	0.0464	5016	0.064	7073	0.06	9130	0.0504
908	0.0464	2961	0.044	5017	0.06	7074	0.064	9131	0.0504

909	0.048	2962	0.048	5018	0.06	7075	0.0584	9132	0.052
910	0.052	2963	0.048	5019	0.06	7076	0.056	9133	0.0584
911	0.0704	2964	0.0464	5020	0.0624	7077	0.0624	9134	0.0624
912	0.0984	2965	0.0464	5021	0.0624	7078	0.064	9135	0.0544
913	0.0824	2966	0.048	5022	0.0624	7079	0.0624	9136	0.0504
914	0.0664	2967	0.048	5023	0.06	7080	0.06	9137	0.048
915	0.0664	2968	0.044	5024	0.0584	7081	0.06	9138	0.0504
916	0.0664	2969	0.044	5025	0.0584	7082	0.0624	9139	0.0544
917	0.06	2970	0.0464	5026	0.056	7083	0.06	9140	0.0504
918	0.064	2971	0.0504	5027	0.0584	7084	0.06	9141	0.048
919	0.0624	2972	0.0504	5028	0.064	7085	0.0584	9142	0.0504
920	0.0624	2973	0.048	5029	0.06	7086	0.06	9143	0.0504
921	0.0624	2974	0.0504	5030	0.0624	7087	0.0584	9144	0.052
922	0.064	2975	0.0504	5031	0.06	7088	0.056	9145	0.0544
923	0.064	2976	0.048	5032	0.06	7089	0.056	9146	0.0544
924	0.06	2977	0.048	5033	0.0624	7090	0.056	9147	0.052
925	0.056	2978	0.0464	5034	0.06	7091	0.056	9148	0.0504
926	0.056	2979	0.0464	5035	0.0624	7092	0.06	9149	0.056
927	0.06	2980	0.0464	5036	0.068	7093	0.064	9150	0.056
928	0.052	2981	0.048	5037	0.0624	7094	0.0624	9151	0.056
929	0.0544	2982	0.048	5038	0.0584	7095	0.0664	9152	0.052
930	0.056	2983	0.044	5039	0.064	7096	0.0584	9153	0.0544
931	0.0584	2984	0.0464	5040	0.0664	7097	0.0544	9154	0.0504
932	0.056	2985	0.048	5041	0.064	7098	0.056	9155	0.0504
933	0.056	2986	0.0464	5042	0.0624	7099	0.056	9156	0.052
934	0.056	2987	0.0464	5043	0.0664	7100	0.0544	9157	0.052
935	0.0504	2988	0.048	5044	0.06	7101	0.052	9158	0.048
936	0.052	2989	0.048	5045	0.0584	7102	0.052	9159	0.0504
937	0.052	2990	0.052	5046	0.0584	7103	0.056	9160	0.0504
938	0.052	2991	0.056	5047	0.0624	7104	0.0544	9161	0.0504
939	0.052	2992	0.06	5048	0.0624	7105	0.0544	9162	0.048
940	0.0504	2993	0.06	5049	0.06	7106	0.0544	9163	0.048
941	0.0464	2994	0.052	5050	0.0624	7107	0.0504	9164	0.0464
942	0.0504	2995	0.048	5051	0.0584	7108	0.052	9165	0.048
943	0.0504	2996	0.0464	5052	0.06	7109	0.0544	9166	0.0504
944	0.056	2997	0.0504	5053	0.06	7110	0.052	9167	0.0464
945	0.0544	2998	0.0504	5054	0.06	7111	0.052	9168	0.048
946	0.0504	2999	0.0504	5055	0.0584	7112	0.052	9169	0.048
947	0.0464	3000	0.048	5056	0.056	7113	0.052	9170	0.048
948	0.048	3001	0.0464	5057	0.0544	7114	0.0504	9171	0.0504
949	0.048	3002	0.0504	5058	0.06	7115	0.056	9172	0.048
950	0.048	3003	0.0544	5059	0.0624	7116	0.056	9173	0.052
951	0.0464	3004	0.0504	5060	0.064	7117	0.0504	9174	0.056
952	0.0504	3005	0.0464	5061	0.0624	7118	0.052	9175	0.052
953	0.052	3006	0.048	5062	0.0584	7119	0.0504	9176	0.048
954	0.052	3007	0.0464	5063	0.0584	7120	0.052	9177	0.0544
955	0.0504	3008	0.044	5064	0.056	7121	0.0504	9178	0.0544
956	0.0504	3009	0.0464	5065	0.052	7122	0.0504	9179	0.052
957	0.0464	3010	0.048	5066	0.056	7123	0.052	9180	0.0504
958	0.0464	3011	0.0464	5067	0.0584	7124	0.0544	9181	0.048
959	0.052	3012	0.048	5068	0.0544	7125	0.0544	9182	0.0504
960	0.056	3013	0.048	5069	0.06	7126	0.0504	9183	0.0544
961	0.052	3014	0.0464	5070	0.0584	7127	0.0544	9184	0.0544
962	0.048	3015	0.044	5071	0.056	7128	0.0544	9185	0.048
963	0.0504	3016	0.0464	5072	0.056	7129	0.056	9186	0.048
964	0.0504	3017	0.0504	5073	0.0544	7130	0.052	9187	0.0504
965	0.0464	3018	0.048	5074	0.0544	7131	0.0504	9188	0.0504
966	0.0464	3019	0.044	5075	0.056	7132	0.052	9189	0.0504
967	0.0464	3020	0.044	5076	0.0584	7133	0.0504	9190	0.0504
968	0.0504	3021	0.044	5077	0.0584	7134	0.0504	9191	0.0504
969	0.048	3022	0.0464	5078	0.06	7135	0.0504	9192	0.0504
970	0.0424	3023	0.048	5079	0.06	7136	0.0544	9193	0.048
971	0.044	3024	0.0464	5080	0.06	7137	0.068	9194	0.0504
972	0.0504	3025	0.0424	5081	0.0584	7138	0.0784	9195	0.052
973	0.0504	3026	0.044	5082	0.056	7139	0.068	9196	0.0504
974	0.0544	3027	0.0464	5083	0.0584	7140	0.0584	9197	0.0504
975	0.0584	3028	0.0464	5084	0.0624	7141	0.0624	9198	0.0504
976	0.052	3029	0.0504	5085	0.06	7142	0.068	9199	0.052
977	0.052	3030	0.0464	5086	0.056	7143	0.072	9200	0.0544
978	0.0584	3031	0.0464	5087	0.056	7144	0.0704	9201	0.048
979	0.0584	3032	0.0504	5088	0.0584	7145	0.0664	9202	0.048
980	0.052	3033	0.0504	5089	0.0544	7146	0.0584	9203	0.0504
981	0.056	3034	0.0464	5090	0.052	7147	0.0624	9204	0.0504
982	0.052	3035	0.048	5091	0.0544	7148	0.0584	9205	0.048
983	0.0464	3036	0.048	5092	0.0584	7149	0.0544	9206	0.048
984	0.044	3037	0.048	5093	0.06	7150	0.052	9207	0.0504
985	0.0464	3038	0.048	5094	0.0624	7151	0.056	9208	0.0504
986	0.0504	3039	0.0504	5095	0.06	7152	0.0624	9209	0.0504
987	0.048	3040	0.048	5096	0.0584	7153	0.0624	9210	0.052
988	0.0464	3041	0.048	5097	0.056	7154	0.0544	9211	0.052
989	0.0504	3042	0.0464	5098	0.056	7155	0.052	9212	0.0504
990	0.052	3043	0.0464	5099	0.056	7156	0.052	9213	0.048
991	0.052	3044	0.048	5100	0.056	7157	0.052	9214	0.048
992	0.052	3045	0.048	5101	0.06	7158	0.0504	9215	0.048
993	0.0504	3046	0.0504	5102	0.0584	7159	0.052	9216	0.0504
994	0.0504	3047	0.0504	5103	0.0544	7160	0.0504	9217	0.052
995	0.0464	3048	0.0504	5104	0.052	7161	0.0544	9218	0.0504
996	0.048	3049	0.0504	5105	0.056	7162	0.0544	9219	0.0504
997	0.0504	3050	0.048	5106	0.06	7163	0.052	9220	0.048
998	0.0504	3051	0.0504	5107	0.06	7164	0.0544	9221	0.0504
999	0.0504	3052	0.048	5108	0.056	7165	0.056	9222	0.0504
1000	0.0504	3053	0.048	5109	0.0584	7166	0.0504	9223	0.048
1001	0.048	3054	0.048	5110	0.0544	7167	0.048	9224	0.052

1002	0.0504	3055	0.0464	5111	0.0544	7168	0.0544	9225	0.0464
1003	0.052	3056	0.0464	5112	0.0584	7169	0.052	9226	0.048
1004	0.052	3057	0.0464	5113	0.06	7170	0.052	9227	0.0504
1005	0.056	3058	0.0464	5114	0.056	7171	0.052	9228	0.052
1006	0.052	3059	0.044	5115	0.0544	7172	0.052	9229	0.0464
1007	0.052	3060	0.044	5116	0.0544	7173	0.052	9230	0.0464
1008	0.048	3061	0.048	5117	0.0544	7174	0.0504	9231	0.0544
1009	0.0504	3062	0.048	5118	0.0544	7175	0.0504	9232	0.0544
1010	0.052	3063	0.0464	5119	0.0584	7176	0.052	9233	0.0504
1011	0.0584	3064	0.044	5120	0.0544	7177	0.0504	9234	0.048
1012	0.0544	3065	0.0504	5121	0.0544	7178	0.0504	9235	0.0504
1013	0.048	3066	0.0584	5122	0.056	7179	0.052	9236	0.0544
1014	0.0504	3067	0.052	5123	0.056	7180	0.0504	9237	0.056
1015	0.0504	3068	0.044	5124	0.0584	7181	0.0504	9238	0.0464
1016	0.0504	3069	0.0464	5125	0.056	7182	0.052	9239	0.048
1017	0.052	3070	0.052	5126	0.056	7183	0.0544	9240	0.0544
1018	0.0504	3071	0.048	5127	0.056	7184	0.0544	9241	0.0544
1019	0.0504	3072	0.0504	5128	0.056	7185	0.0544	9242	0.052
1020	0.052	3073	0.052	5129	0.0584	7186	0.052	9243	0.0504
1021	0.052	3074	0.048	5130	0.0544	7187	0.0544	9244	0.0504
1022	0.0504	3075	0.048	5131	0.0584	7188	0.056	9245	0.0544
1023	0.0504	3076	0.048	5132	0.056	7189	0.0464	9246	0.0504
1024	0.052	3077	0.0464	5133	0.056	7190	0.048	9247	0.048
1025	0.052	3078	0.0464	5134	0.0584	7191	0.048	9248	0.044
1026	0.0504	3079	0.0464	5135	0.0584	7192	0.0584	9249	0.048
1027	0.0504	3080	0.0464	5136	0.0544	7193	0.056	9250	0.048
1028	0.052	3081	0.0464	5137	0.056	7194	0.0544	9251	0.048
1029	0.0504	3082	0.0504	5138	0.056	7195	0.056	9252	0.0464
1030	0.052	3083	0.0504	5139	0.0544	7196	0.056	9253	0.0464
1031	0.048	3084	0.0464	5140	0.0544	7197	0.0584	9254	0.048
1032	0.048	3085	0.0464	5141	0.056	7198	0.0584	9255	0.0464
1033	0.0504	3086	0.0464	5142	0.056	7199	0.0584	9256	0.0464
1034	0.0544	3087	0.0464	5143	0.0584	7200	0.0544	9257	0.048
1035	0.0544	3088	0.0504	5144	0.0544	7201	0.0544	9258	0.0544
1036	0.0544	3089	0.044	5145	0.0544	7202	0.056	9259	0.0544
1037	0.0544	3090	0.044	5146	0.0544	7203	0.06	9260	0.048
1038	0.052	3091	0.048	5147	0.0544	7204	0.0584	9261	0.048
1039	0.0504	3092	0.048	5148	0.0544	7205	0.056	9262	0.048
1040	0.052	3093	0.048	5149	0.0544	7206	0.056	9263	0.0504
1041	0.052	3094	0.048	5150	0.0584	7207	0.0504	9264	0.048
1042	0.0544	3095	0.048	5151	0.0624	7208	0.052	9265	0.048
1043	0.052	3096	0.0464	5152	0.056	7209	0.056	9266	0.0464
1044	0.048	3097	0.044	5153	0.056	7210	0.052	9267	0.0464
1045	0.0504	3098	0.044	5154	0.06	7211	0.0544	9268	0.0464
1046	0.0504	3099	0.044	5155	0.0584	7212	0.0544	9269	0.0504
1047	0.048	3100	0.0464	5156	0.048	7213	0.072	9270	0.048
1048	0.052	3101	0.0464	5157	0.052	7214	0.092	9271	0.048
1049	0.0544	3102	0.0464	5158	0.056	7215	0.0824	9272	0.048
1050	0.0584	3103	0.0504	5159	0.056	7216	0.0744	9273	0.0504
1051	0.052	3104	0.0464	5160	0.0544	7217	0.0664	9274	0.0504
1052	0.052	3105	0.0464	5161	0.0584	7218	0.0584	9275	0.0504
1053	0.0544	3106	0.0464	5162	0.06	7219	0.056	9276	0.048
1054	0.0464	3107	0.044	5163	0.056	7220	0.0584	9277	0.0504
1055	0.048	3108	0.048	5164	0.0544	7221	0.06	9278	0.0504
1056	0.048	3109	0.048	5165	0.056	7222	0.0624	9279	0.0464
1057	0.0464	3110	0.0464	5166	0.056	7223	0.0624	9280	0.0464
1058	0.048	3111	0.048	5167	0.056	7224	0.0624	9281	0.0464
1059	0.0504	3112	0.048	5168	0.056	7225	0.0624	9282	0.0464
1060	0.048	3113	0.0464	5169	0.056	7226	0.064	9283	0.0464
1061	0.0504	3114	0.0464	5170	0.06	7227	0.0584	9284	0.048
1062	0.052	3115	0.044	5171	0.06	7228	0.056	9285	0.048
1063	0.052	3116	0.044	5172	0.0584	7229	0.06	9286	0.048
1064	0.048	3117	0.0464	5173	0.0584	7230	0.06	9287	0.048
1065	0.0504	3118	0.0504	5174	0.0544	7231	0.064	9288	0.0504
1066	0.056	3119	0.0504	5175	0.056	7232	0.0664	9289	0.0504
1067	0.0544	3120	0.0464	5176	0.06	7233	0.068	9290	0.0464
1068	0.048	3121	0.044	5177	0.064	7234	0.068	9291	0.044
1069	0.048	3122	0.0464	5178	0.068	7235	0.0664	9292	0.0464
1070	0.048	3123	0.0464	5179	0.0704	7236	0.0664	9293	0.0464
1071	0.052	3124	0.048	5180	0.056	7237	0.0664	9294	0.0464
1072	0.052	3125	0.0464	5181	0.0584	7238	0.0664	9295	0.048
1073	0.0544	3126	0.0464	5182	0.0584	7239	0.072	9296	0.052
1074	0.048	3127	0.0504	5183	0.06	7240	0.072	9297	0.0504
1075	0.0544	3128	0.048	5184	0.06	7241	0.068	9298	0.0424
1076	0.0584	3129	0.044	5185	0.06	7242	0.072	9299	0.044
1077	0.0504	3130	0.0464	5186	0.06	7243	0.0744	9300	0.048
1078	0.0464	3131	0.048	5187	0.056	7244	0.076	9301	0.0504
1079	0.048	3132	0.044	5188	0.056	7245	0.072	9302	0.0504
1080	0.0504	3133	0.044	5189	0.0624	7246	0.068	9303	0.0504
1081	0.0504	3134	0.0464	5190	0.0624	7247	0.0704	9304	0.0504
1082	0.052	3135	0.044	5191	0.06	7248	0.072	9305	0.0504
1083	0.0544	3136	0.0464	5192	0.0624	7249	0.0784	9306	0.0504
1084	0.0504	3137	0.0464	5193	0.06	7250	0.072	9307	0.0504
1085	0.0504	3138	0.0504	5194	0.0624	7251	0.1304	9308	0.0544
1086	0.052	3139	0.048	5195	0.0584	7252	0.2464	9309	0.06
1087	0.0504	3140	0.048	5196	0.0624	7253	0.176	9310	0.056
1088	0.048	3141	0.048	5197	0.0584	7254	0.124	9311	0.056
1089	0.0464	3142	0.0504	5198	0.056	7255	0.124	9312	0.056
1090	0.0464	3143	0.048	5199	0.06	7256	0.1024	9313	0.052
1091	0.0464	3144	0.048	5200	0.0624	7257	0.0984	9314	0.048
1092	0.048	3145	0.048	5201	0.0584	7258	0.088	9315	0.0504
1093	0.052	3146	0.0464	5202	0.06	7259	0.092	9316	0.052
1094	0.048	3147	0.0504	5203	0.0704	7260	0.0984	9317	0.048

1095	0.0504	3148	0.052	5204	0.064	7261	0.1024	9318	0.048
1096	0.0504	3149	0.0464	5205	0.0664	7262	0.1224	9319	0.0504
1097	0.0504	3150	0.048	5206	0.06	7263	0.1344	9320	0.0504
1098	0.0504	3151	0.0504	5207	0.056	7264	0.108	9321	0.0504
1099	0.0504	3152	0.0504	5208	0.052	7265	0.088	9322	0.048
1100	0.052	3153	0.048	5209	0.052	7266	0.104	9323	0.0504
1101	0.0544	3154	0.0584	5210	0.056	7267	0.08	9324	0.0504
1102	0.052	3155	0.06	5211	0.0584	7268	0.0744	9325	0.0544
1103	0.0504	3156	0.0544	5212	0.0624	7269	0.0664	9326	0.0544
1104	0.0504	3157	0.056	5213	0.0584	7270	0.064	9327	0.048
1105	0.0504	3158	0.0544	5214	0.056	7271	0.076	9328	0.0424
1106	0.0504	3159	0.048	5215	0.0584	7272	0.0864	9329	0.0464
1107	0.048	3160	0.048	5216	0.056	7273	0.088	9330	0.0504
1108	0.048	3161	0.052	5217	0.052	7274	0.0824	9331	0.052
1109	0.0504	3162	0.0504	5218	0.0544	7275	0.092	9332	0.052
1110	0.052	3163	0.0504	5219	0.056	7276	0.0864	9333	0.0504
1111	0.048	3164	0.0464	5220	0.056	7277	0.0704	9334	0.0504
1112	0.0504	3165	0.044	5221	0.0544	7278	0.064	9335	0.0504
1113	0.052	3166	0.0544	5222	0.056	7279	0.0664	9336	0.048
1114	0.0504	3167	0.0544	5223	0.052	7280	0.092	9337	0.0504
1115	0.0504	3168	0.0464	5224	0.052	7281	0.176	9338	0.052
1116	0.052	3169	0.048	5225	0.052	7282	0.1544	9339	0.052
1117	0.0504	3170	0.048	5226	0.052	7283	0.0704	9340	0.048
1118	0.0504	3171	0.048	5227	0.0544	7284	0.0704	9341	0.0504
1119	0.0504	3172	0.0464	5228	0.0544	7285	0.0704	9342	0.0504
1120	0.052	3173	0.044	5229	0.052	7286	0.0664	9343	0.0464
1121	0.0504	3174	0.0464	5230	0.056	7287	0.0624	9344	0.0464
1122	0.0504	3175	0.048	5231	0.056	7288	0.06	9345	0.048
1123	0.052	3176	0.048	5232	0.0544	7289	0.064	9346	0.052
1124	0.0544	3177	0.0464	5233	0.056	7290	0.064	9347	0.0504
1125	0.0504	3178	0.052	5234	0.0544	7291	0.0624	9348	0.0504
1126	0.048	3179	0.0504	5235	0.056	7292	0.0664	9349	0.0464
1127	0.0504	3180	0.0464	5236	0.0584	7293	0.0624	9350	0.0504
1128	0.0504	3181	0.0464	5237	0.056	7294	0.064	9351	0.048
1129	0.0464	3182	0.0504	5238	0.052	7295	0.0664	9352	0.0504
1130	0.0464	3183	0.052	5239	0.056	7296	0.0664	9353	0.0544
1131	0.048	3184	0.048	5240	0.056	7297	0.068	9354	0.0544
1132	0.048	3185	0.048	5241	0.0584	7298	0.0744	9355	0.052
1133	0.052	3186	0.0464	5242	0.06	7299	0.08	9356	0.0504
1134	0.052	3187	0.048	5243	0.056	7300	0.0784	9357	0.0504
1135	0.0504	3188	0.048	5244	0.0544	7301	0.0784	9358	0.0504
1136	0.0504	3189	0.044	5245	0.056	7302	0.0784	9359	0.056
1137	0.052	3190	0.0464	5246	0.056	7303	0.0744	9360	0.06
1138	0.0504	3191	0.044	5247	0.052	7304	0.076	9361	0.0544
1139	0.0544	3192	0.0464	5248	0.0504	7305	0.08	9362	0.0504
1140	0.0544	3193	0.0464	5249	0.056	7306	0.0824	9363	0.0504
1141	0.052	3194	0.044	5250	0.0584	7307	0.0784	9364	0.048
1142	0.048	3195	0.0464	5251	0.056	7308	0.0824	9365	0.048
1143	0.048	3196	0.0504	5252	0.056	7309	0.088	9366	0.0544
1144	0.0464	3197	0.048	5253	0.0544	7310	0.088	9367	0.052
1145	0.048	3198	0.044	5254	0.0584	7311	0.0864	9368	0.048
1146	0.048	3199	0.0424	5255	0.0584	7312	0.084	9369	0.048
1147	0.0464	3200	0.0424	5256	0.056	7313	0.0944	9370	0.056
1148	0.048	3201	0.0464	5257	0.056	7314	0.092	9371	0.056
1149	0.0504	3202	0.052	5258	0.056	7315	0.084	9372	0.052
1150	0.048	3203	0.052	5259	0.0544	7316	0.088	9373	0.052
1151	0.0464	3204	0.0464	5260	0.0504	7317	0.0864	9374	0.052
1152	0.0464	3205	0.044	5261	0.0504	7318	0.088	9375	0.052
1153	0.048	3206	0.048	5262	0.0504	7319	0.0824	9376	0.0504
1154	0.056	3207	0.0504	5263	0.052	7320	0.08	9377	0.052
1155	0.06	3208	0.0464	5264	0.0544	7321	0.0824	9378	0.056
1156	0.056	3209	0.044	5265	0.056	7322	0.084	9379	0.056
1157	0.052	3210	0.044	5266	0.056	7323	0.0864	9380	0.0544
1158	0.0464	3211	0.0464	5267	0.056	7324	0.084	9381	0.0504
1159	0.048	3212	0.048	5268	0.052	7325	0.08	9382	0.052
1160	0.0504	3213	0.044	5269	0.0544	7326	0.0824	9383	0.0504
1161	0.048	3214	0.044	5270	0.056	7327	0.08	9384	0.048
1162	0.048	3215	0.0464	5271	0.0544	7328	0.0784	9385	0.0504
1163	0.048	3216	0.048	5272	0.0544	7329	0.0864	9386	0.0464
1164	0.048	3217	0.0464	5273	0.056	7330	0.0944	9387	0.048
1165	0.0504	3218	0.048	5274	0.052	7331	0.0904	9388	0.052
1166	0.052	3219	0.0464	5275	0.052	7332	0.08	9389	0.056
1167	0.0504	3220	0.048	5276	0.0544	7333	0.0864	9390	0.056
1168	0.0504	3221	0.048	5277	0.0544	7334	0.0904	9391	0.0544
1169	0.048	3222	0.0464	5278	0.052	7335	0.084	9392	0.052
1170	0.0504	3223	0.048	5279	0.052	7336	0.08	9393	0.0584
1171	0.0544	3224	0.0464	5280	0.0544	7337	0.088	9394	0.056
1172	0.052	3225	0.0464	5281	0.052	7338	0.08	9395	0.052
1173	0.052	3226	0.044	5282	0.052	7339	0.076	9396	0.0504
1174	0.052	3227	0.0464	5283	0.052	7340	0.0784	9397	0.052
1175	0.0504	3228	0.0504	5284	0.0544	7341	0.0864	9398	0.0584
1176	0.0504	3229	0.0504	5285	0.0624	7342	0.084	9399	0.056
1177	0.048	3230	0.048	5286	0.06	7343	0.08	9400	0.0504
1178	0.0464	3231	0.052	5287	0.052	7344	0.0824	9401	0.052
1179	0.0464	3232	0.052	5288	0.0544	7345	0.076	9402	0.052
1180	0.0504	3233	0.0504	5289	0.0544	7346	0.0744	9403	0.052
1181	0.0544	3234	0.0464	5290	0.052	7347	0.072	9404	0.056
1182	0.0504	3235	0.0464	5291	0.0544	7348	0.068	9405	0.0584
1183	0.048	3236	0.044	5292	0.0544	7349	0.068	9406	0.052
1184	0.048	3237	0.044	5293	0.0544	7350	0.068	9407	0.052
1185	0.048	3238	0.048	5294	0.056	7351	0.068	9408	0.0584
1186	0.0504	3239	0.048	5295	0.052	7352	0.0664	9409	0.0584
1187	0.0544	3240	0.048	5296	0.052	7353	0.0624	9410	0.0504

1188	0.0504	3241	0.048	5297	0.0544	7354	0.0624	9411	0.0504
1189	0.0504	3242	0.048	5298	0.0664	7355	0.064	9412	0.0544
1190	0.0504	3243	0.0464	5299	0.068	7356	0.06	9413	0.0544
1191	0.0504	3244	0.044	5300	0.0544	7357	0.0584	9414	0.0544
1192	0.048	3245	0.0504	5301	0.052	7358	0.0544	9415	0.052
1193	0.0504	3246	0.0504	5302	0.048	7359	0.0544	9416	0.052
1194	0.048	3247	0.0424	5303	0.052	7360	0.0544	9417	0.0504
1195	0.048	3248	0.044	5304	0.0544	7361	0.056	9418	0.048
1196	0.0464	3249	0.044	5305	0.0544	7362	0.0584	9419	0.052
1197	0.0504	3250	0.0464	5306	0.052	7363	0.056	9420	0.052
1198	0.0504	3251	0.0464	5307	0.0504	7364	0.056	9421	0.0504
1199	0.0504	3252	0.044	5308	0.056	7365	0.064	9422	0.052
1200	0.0504	3253	0.044	5309	0.0544	7366	0.0664	9423	0.0504
1201	0.048	3254	0.044	5310	0.0544	7367	0.0584	9424	0.052
1202	0.048	3255	0.0464	5311	0.0544	7368	0.064	9425	0.0504
1203	0.048	3256	0.0464	5312	0.052	7369	0.068	9426	0.0504
1204	0.048	3257	0.048	5313	0.0504	7370	0.056	9427	0.052
1205	0.048	3258	0.0504	5314	0.0544	7371	0.0584	9428	0.052
1206	0.048	3259	0.044	5315	0.052	7372	0.0624	9429	0.0504
1207	0.048	3260	0.044	5316	0.052	7373	0.0584	9430	0.056
1208	0.048	3261	0.0464	5317	0.0544	7374	0.0544	9431	0.0584
1209	0.052	3262	0.048	5318	0.0544	7375	0.056	9432	0.0584
1210	0.0544	3263	0.0464	5319	0.0544	7376	0.056	9433	0.052
1211	0.052	3264	0.048	5320	0.0544	7377	0.056	9434	0.0504
1212	0.0504	3265	0.0464	5321	0.056	7378	0.0584	9435	0.052
1213	0.052	3266	0.0504	5322	0.06	7379	0.06	9436	0.06
1214	0.0544	3267	0.0544	5323	0.056	7380	0.0544	9437	0.0584
1215	0.0504	3268	0.048	5324	0.0544	7381	0.06	9438	0.0504
1216	0.0504	3269	0.0464	5325	0.0584	7382	0.056	9439	0.052
1217	0.0504	3270	0.044	5326	0.0544	7383	0.0544	9440	0.0504
1218	0.052	3271	0.0424	5327	0.052	7384	0.0544	9441	0.048
1219	0.0504	3272	0.0464	5328	0.056	7385	0.0544	9442	0.0504
1220	0.0504	3273	0.0504	5329	0.0504	7386	0.0544	9443	0.0544
1221	0.052	3274	0.0464	5330	0.0504	7387	0.052	9444	0.056
1222	0.0544	3275	0.0424	5331	0.052	7388	0.0544	9445	0.0504
1223	0.0544	3276	0.044	5332	0.0544	7389	0.0544	9446	0.052
1224	0.052	3277	0.044	5333	0.056	7390	0.056	9447	0.0504
1225	0.052	3278	0.0464	5334	0.0544	7391	0.056	9448	0.052
1226	0.0504	3279	0.0504	5335	0.0504	7392	0.0544	9449	0.0544
1227	0.0504	3280	0.048	5336	0.052	7393	0.0544	9450	0.0544
1228	0.0504	3281	0.0464	5337	0.0544	7394	0.056	9451	0.056
1229	0.052	3282	0.048	5338	0.052	7395	0.0544	9452	0.0504
1230	0.0544	3283	0.048	5339	0.052	7396	0.06	9453	0.0504
1231	0.052	3284	0.048	5340	0.048	7397	0.06	9454	0.0504
1232	0.0504	3285	0.048	5341	0.052	7398	0.0584	9455	0.0504
1233	0.0544	3286	0.048	5342	0.052	7399	0.0584	9456	0.0584
1234	0.0544	3287	0.0464	5343	0.0504	7400	0.052	9457	0.056
1235	0.052	3288	0.044	5344	0.052	7401	0.052	9458	0.056
1236	0.052	3289	0.0464	5345	0.0544	7402	0.056	9459	0.052
1237	0.0504	3290	0.048	5346	0.0544	7403	0.0544	9460	0.052
1238	0.048	3291	0.048	5347	0.0544	7404	0.052	9461	0.048
1239	0.048	3292	0.0464	5348	0.052	7405	0.052	9462	0.0504
1240	0.048	3293	0.0464	5349	0.0544	7406	0.056	9463	0.064
1241	0.048	3294	0.048	5350	0.0544	7407	0.0584	9464	0.064
1242	0.048	3295	0.0464	5351	0.052	7408	0.052	9465	0.052
1243	0.048	3296	0.0464	5352	0.052	7409	0.0504	9466	0.0544
1244	0.048	3297	0.0504	5353	0.0544	7410	0.052	9467	0.056
1245	0.052	3298	0.044	5354	0.052	7411	0.052	9468	0.0584
1246	0.048	3299	0.0424	5355	0.0504	7412	0.0544	9469	0.052
1247	0.048	3300	0.044	5356	0.0504	7413	0.056	9470	0.052
1248	0.048	3301	0.0464	5357	0.0504	7414	0.056	9471	0.0544
1249	0.052	3302	0.0504	5358	0.052	7415	0.0544	9472	0.056
1250	0.048	3303	0.048	5359	0.056	7416	0.052	9473	0.0544
1251	0.052	3304	0.0464	5360	0.0544	7417	0.0544	9474	0.0584
1252	0.0504	3305	0.044	5361	0.0584	7418	0.0544	9475	0.0584
1253	0.048	3306	0.0464	5362	0.0584	7419	0.056	9476	0.0584
1254	0.052	3307	0.0464	5363	0.056	7420	0.0584	9477	0.056
1255	0.052	3308	0.048	5364	0.052	7421	0.056	9478	0.052
1256	0.048	3309	0.048	5365	0.0544	7422	0.052	9479	0.052
1257	0.0504	3310	0.052	5366	0.0584	7423	0.056	9480	0.0504
1258	0.052	3311	0.048	5367	0.06	7424	0.056	9481	0.056
1259	0.048	3312	0.0464	5368	0.056	7425	0.056	9482	0.056
1260	0.0464	3313	0.0504	5369	0.056	7426	0.052	9483	0.0544
1261	0.0504	3314	0.0464	5370	0.0584	7427	0.0504	9484	0.0544
1262	0.052	3315	0.0464	5371	0.06	7428	0.052	9485	0.052
1263	0.048	3316	0.0544	5372	0.0584	7429	0.0544	9486	0.052
1264	0.048	3317	0.0504	5373	0.0584	7430	0.0504	9487	0.0664
1265	0.048	3318	0.0464	5374	0.056	7431	0.0504	9488	0.0664
1266	0.0504	3319	0.0464	5375	0.056	7432	0.0544	9489	0.0504
1267	0.0464	3320	0.044	5376	0.056	7433	0.0544	9490	0.0544
1268	0.048	3321	0.0464	5377	0.0624	7434	0.0504	9491	0.056
1269	0.044	3322	0.0504	5378	0.0624	7435	0.0504	9492	0.052
1270	0.0504	3323	0.0464	5379	0.06	7436	0.052	9493	0.052
1271	0.0464	3324	0.048	5380	0.0584	7437	0.052	9494	0.052
1272	0.0464	3325	0.048	5381	0.06	7438	0.0504	9495	0.0544
1273	0.044	3326	0.0464	5382	0.0584	7439	0.052	9496	0.052
1274	0.0504	3327	0.0504	5383	0.0584	7440	0.052	9497	0.052
1275	0.0464	3328	0.0544	5384	0.0624	7441	0.052	9498	0.052
1276	0.044	3329	0.048	5385	0.0624	7442	0.0544	9499	0.052
1277	0.048	3330	0.0504	5386	0.0624	7443	0.0544	9500	0.052
1278	0.052	3331	0.0464	5387	0.0664	7444	0.052	9501	0.052
1279	0.0464	3332	0.048	5388	0.068	7445	0.056	9502	0.052
1280	0.0464	3333	0.0504	5389	0.0704	7446	0.0584	9503	0.052

1281	0.0424	3334	0.0464	5390	0.068	7447	0.052	9504	0.0504
1282	0.044	3335	0.048	5391	0.068	7448	0.0504	9505	0.052
1283	0.044	3336	0.0464	5392	0.0704	7449	0.0544	9506	0.052
1284	0.044	3337	0.048	5393	0.072	7450	0.0544	9507	0.056
1285	0.0464	3338	0.0504	5394	0.0704	7451	0.048	9508	0.0584
1286	0.048	3339	0.048	5395	0.0664	7452	0.0504	9509	0.0504
1287	0.0504	3340	0.048	5396	0.0664	7453	0.0544	9510	0.052
1288	0.048	3341	0.0464	5397	0.064	7454	0.056	9511	0.0544
1289	0.0464	3342	0.0464	5398	0.0584	7455	0.052	9512	0.0504
1290	0.0464	3343	0.048	5399	0.0624	7456	0.052	9513	0.0504
1291	0.048	3344	0.0504	5400	0.0664	7457	0.052	9514	0.052
1292	0.048	3345	0.0464	5401	0.068	7458	0.0544	9515	0.0504
1293	0.0464	3346	0.0464	5402	0.0664	7459	0.0544	9516	0.052
1294	0.0424	3347	0.0504	5403	0.0664	7460	0.0544	9517	0.0544
1295	0.044	3348	0.0504	5404	0.068	7461	0.056	9518	0.0544
1296	0.048	3349	0.044	5405	0.0704	7462	0.06	9519	0.052
1297	0.0464	3350	0.044	5406	0.068	7463	0.06	9520	0.0504
1298	0.0464	3351	0.0464	5407	0.0704	7464	0.052	9521	0.052
1299	0.044	3352	0.0464	5408	0.0704	7465	0.052	9522	0.0504
1300	0.044	3353	0.044	5409	0.0664	7466	0.052	9523	0.052
1301	0.044	3354	0.048	5410	0.0664	7467	0.0544	9524	0.052
1302	0.0464	3355	0.0544	5411	0.0704	7468	0.052	9525	0.052
1303	0.044	3356	0.052	5412	0.068	7469	0.052	9526	0.056
1304	0.0464	3357	0.048	5413	0.0664	7470	0.056	9527	0.052
1305	0.044	3358	0.048	5414	0.068	7471	0.0544	9528	0.0584
1306	0.044	3359	0.048	5415	0.064	7472	0.052	9529	0.0664
1307	0.0464	3360	0.0504	5416	0.0624	7473	0.0544	9530	0.064
1308	0.044	3361	0.0544	5417	0.0704	7474	0.052	9531	0.056
1309	0.04	3362	0.0544	5418	0.068	7475	0.052	9532	0.052
1310	0.0424	3363	0.048	5419	0.064	7476	0.0504	9533	0.056
1311	0.0464	3364	0.0464	5420	0.064	7477	0.0544	9534	0.056
1312	0.044	3365	0.0504	5421	0.068	7478	0.056	9535	0.0584
1313	0.0424	3366	0.048	5422	0.068	7479	0.052	9536	0.0624
1314	0.044	3367	0.044	5423	0.072	7480	0.052	9537	0.064
1315	0.0464	3368	0.0424	5424	0.0744	7481	0.0544	9538	0.056
1316	0.048	3369	0.0424	5425	0.0704	7482	0.056	9539	0.0544
1317	0.0504	3370	0.0464	5426	0.064	7483	0.0544	9540	0.0544
1318	0.048	3371	0.0504	5427	0.0664	7484	0.052	9541	0.0544
1319	0.0464	3372	0.048	5428	0.064	7485	0.0504	9542	0.056
1320	0.0424	3373	0.048	5429	0.0664	7486	0.0464	9543	0.0544
1321	0.0504	3374	0.0504	5430	0.0664	7487	0.0464	9544	0.052
1322	0.056	3375	0.0504	5431	0.064	7488	0.048	9545	0.0584
1323	0.048	3376	0.0504	5432	0.068	7489	0.0544	9546	0.06
1324	0.0504	3377	0.052	5433	0.0664	7490	0.0544	9547	0.0624
1325	0.0464	3378	0.052	5434	0.068	7491	0.048	9548	0.0664
1326	0.044	3379	0.0504	5435	0.0704	7492	0.048	9549	0.0584
1327	0.048	3380	0.0504	5436	0.0704	7493	0.048	9550	0.0584
1328	0.0464	3381	0.048	5437	0.0584	7494	0.0464	9551	0.0624
1329	0.0504	3382	0.0464	5438	0.0584	7495	0.048	9552	0.056
1330	0.0504	3383	0.044	5439	0.0624	7496	0.048	9553	0.056
1331	0.048	3384	0.044	5440	0.064	7497	0.048	9554	0.056
1332	0.0504	3385	0.0464	5441	0.068	7498	0.048	9555	0.052
1333	0.044	3386	0.0504	5442	0.0664	7499	0.0464	9556	0.0544
1334	0.044	3387	0.052	5443	0.068	7500	0.0464	9557	0.0624
1335	0.044	3388	0.048	5444	0.0664	7501	0.052	9558	0.0624
1336	0.048	3389	0.0464	5445	0.0664	7502	0.052	9559	0.052
1337	0.048	3390	0.0464	5446	0.064	7503	0.048	9560	0.052
1338	0.048	3391	0.0464	5447	0.0664	7504	0.0544	9561	0.052
1339	0.048	3392	0.0464	5448	0.0664	7505	0.052	9562	0.052
1340	0.048	3393	0.048	5449	0.064	7506	0.0504	9563	0.0544
1341	0.052	3394	0.0464	5450	0.068	7507	0.048	9564	0.052
1342	0.0584	3395	0.0464	5451	0.0664	7508	0.0504	9565	0.0584
1343	0.056	3396	0.0464	5452	0.068	7509	0.052	9566	0.06
1344	0.048	3397	0.048	5453	0.076	7510	0.052	9567	0.06
1345	0.052	3398	0.052	5454	0.076	7511	0.0464	9568	0.0624
1346	0.0504	3399	0.048	5455	0.064	7512	0.0464	9569	0.0584
1347	0.0504	3400	0.048	5456	0.064	7513	0.0464	9570	0.0584
1348	0.0504	3401	0.048	5457	0.064	7514	0.0504	9571	0.0584
1349	0.0504	3402	0.048	5458	0.0624	7515	0.0504	9572	0.0584
1350	0.048	3403	0.048	5459	0.0624	7516	0.0504	9573	0.0584
1351	0.048	3404	0.0464	5460	0.0624	7517	0.0504	9574	0.056
1352	0.048	3405	0.0464	5461	0.0624	7518	0.048	9575	0.056
1353	0.048	3406	0.0504	5462	0.06	7519	0.048	9576	0.0544
1354	0.048	3407	0.048	5463	0.064	7520	0.044	9577	0.0544
1355	0.044	3408	0.048	5464	0.0664	7521	0.0504	9578	0.0544
1356	0.0464	3409	0.048	5465	0.0624	7522	0.052	9579	0.056
1357	0.0504	3410	0.048	5466	0.06	7523	0.056	9580	0.056
1358	0.048	3411	0.0464	5467	0.0624	7524	0.0544	9581	0.0544
1359	0.0464	3412	0.048	5468	0.06	7525	0.0504	9582	0.0584
1360	0.0464	3413	0.0464	5469	0.0624	7526	0.052	9583	0.0584
1361	0.048	3414	0.0464	5470	0.06	7527	0.0504	9584	0.056
1362	0.048	3415	0.0464	5471	0.06	7528	0.0544	9585	0.0544
1363	0.048	3416	0.0464	5472	0.0584	7529	0.052	9586	0.064
1364	0.048	3417	0.0464	5473	0.0624	7530	0.048	9587	0.0624
1365	0.0464	3418	0.044	5474	0.0664	7531	0.048	9588	0.0584
1366	0.044	3419	0.0464	5475	0.064	7532	0.0504	9589	0.0584
1367	0.0504	3420	0.0464	5476	0.064	7533	0.052	9590	0.056
1368	0.048	3421	0.048	5477	0.064	7534	0.0464	9591	0.0584
1369	0.048	3422	0.0504	5478	0.06	7535	0.0464	9592	0.0584
1370	0.0504	3423	0.0504	5479	0.0584	7536	0.048	9593	0.056
1371	0.0504	3424	0.048	5480	0.06	7537	0.0504	9594	0.0584
1372	0.0584	3425	0.0464	5481	0.06	7538	0.0504	9595	0.056
1373	0.052	3426	0.0504	5482	0.0584	7539	0.0464	9596	0.056

1374	0.044	3427	0.0464	5483	0.06	7540	0.048	9597	0.06
1375	0.0464	3428	0.0464	5484	0.0584	7541	0.0504	9598	0.06
1376	0.052	3429	0.0504	5485	0.0544	7542	0.0504	9599	0.056
1377	0.052	3430	0.0464	5486	0.056	7543	0.0504	9600	0.0544
1378	0.0504	3431	0.0464	5487	0.0584	7544	0.0544	9601	0.0624
1379	0.048	3432	0.0464	5488	0.0584	7545	0.0504	9602	0.0624
1380	0.0464	3433	0.0464	5489	0.0584	7546	0.0464	9603	0.0584
1381	0.0464	3434	0.048	5490	0.0624	7547	0.0464	9604	0.0584
1382	0.048	3435	0.0464	5491	0.0624	7548	0.0504	9605	0.06
1383	0.0544	3436	0.0464	5492	0.056	7549	0.0464	9606	0.0624
1384	0.0544	3437	0.044	5493	0.056	7550	0.0504	9607	0.0624
1385	0.0544	3438	0.048	5494	0.0584	7551	0.052	9608	0.06
1386	0.048	3439	0.048	5495	0.0584	7552	0.048	9609	0.0624
1387	0.0464	3440	0.0464	5496	0.056	7553	0.048	9610	0.064
1388	0.044	3441	0.0464	5497	0.0584	7554	0.0464	9611	0.064
1389	0.044	3442	0.0464	5498	0.056	7555	0.0504	9612	0.0624
1390	0.0504	3443	0.048	5499	0.0544	7556	0.048	9613	0.0624
1391	0.052	3444	0.048	5500	0.0584	7557	0.048	9614	0.0624
1392	0.0464	3445	0.0504	5501	0.0624	7558	0.0504	9615	0.06
1393	0.048	3446	0.0464	5502	0.06	7559	0.0464	9616	0.06
1394	0.0464	3447	0.0544	5503	0.0544	7560	0.0504	9617	0.0624
1395	0.044	3448	0.0584	5504	0.0544	7561	0.048	9618	0.0624
1396	0.044	3449	0.052	5505	0.0624	7562	0.0504	9619	0.0624
1397	0.048	3450	0.048	5506	0.0584	7563	0.0504	9620	0.0624
1398	0.048	3451	0.048	5507	0.056	7564	0.0504	9621	0.06
1399	0.0464	3452	0.048	5508	0.056	7565	0.0464	9622	0.0624
1400	0.0464	3453	0.0504	5509	0.0624	7566	0.0464	9623	0.064
1401	0.044	3454	0.048	5510	0.064	7567	0.048	9624	0.06
1402	0.0424	3455	0.048	5511	0.0584	7568	0.048	9625	0.0624
1403	0.048	3456	0.048	5512	0.0544	7569	0.048	9626	0.068
1404	0.052	3457	0.048	5513	0.056	7570	0.0464	9627	0.064
1405	0.0464	3458	0.0464	5514	0.0544	7571	0.048	9628	0.0584
1406	0.048	3459	0.0464	5515	0.0544	7572	0.0464	9629	0.06
1407	0.0504	3460	0.048	5516	0.0544	7573	0.0464	9630	0.06
1408	0.0504	3461	0.048	5517	0.056	7574	0.044	9631	0.0624
1409	0.052	3462	0.0504	5518	0.056	7575	0.048	9632	0.0624
1410	0.0504	3463	0.048	5519	0.0624	7576	0.0504	9633	0.0624
1411	0.048	3464	0.048	5520	0.06	7577	0.0504	9634	0.064
1412	0.048	3465	0.0544	5521	0.06	7578	0.0464	9635	0.064
1413	0.0464	3466	0.0544	5522	0.0584	7579	0.0464	9636	0.06
1414	0.048	3467	0.0464	5523	0.06	7580	0.0504	9637	0.0584
1415	0.0504	3468	0.0504	5524	0.06	7581	0.0544	9638	0.06
1416	0.0464	3469	0.0504	5525	0.0544	7582	0.052	9639	0.0664
1417	0.0464	3470	0.0464	5526	0.0544	7583	0.052	9640	0.068
1418	0.044	3471	0.048	5527	0.0544	7584	0.048	9641	0.0704
1419	0.044	3472	0.048	5528	0.0544	7585	0.044	9642	0.076
1420	0.0464	3473	0.048	5529	0.0584	7586	0.048	9643	0.0664
1421	0.048	3474	0.0464	5530	0.06	7587	0.0504	9644	0.06
1422	0.048	3475	0.0464	5531	0.056	7588	0.048	9645	0.064
1423	0.0464	3476	0.0464	5532	0.056	7589	0.048	9646	0.0624
1424	0.0464	3477	0.0464	5533	0.0544	7590	0.048	9647	0.064
1425	0.044	3478	0.048	5534	0.056	7591	0.0544	9648	0.068
1426	0.0584	3479	0.0464	5535	0.0584	7592	0.052	9649	0.0624
1427	0.064	3480	0.044	5536	0.056	7593	0.048	9650	0.06
1428	0.0464	3481	0.044	5537	0.0544	7594	0.052	9651	0.0624
1429	0.048	3482	0.0504	5538	0.052	7595	0.052	9652	0.064
1430	0.048	3483	0.048	5539	0.056	7596	0.0464	9653	0.0624
1431	0.048	3484	0.0464	5540	0.056	7597	0.0464	9654	0.064
1432	0.044	3485	0.048	5541	0.0544	7598	0.048	9655	0.06
1433	0.0464	3486	0.048	5542	0.052	7599	0.052	9656	0.0624
1434	0.0504	3487	0.0504	5543	0.0544	7600	0.0504	9657	0.064
1435	0.0464	3488	0.0504	5544	0.052	7601	0.052	9658	0.0664
1436	0.044	3489	0.0464	5545	0.056	7602	0.0504	9659	0.064
1437	0.052	3490	0.044	5546	0.0584	7603	0.048	9660	0.064
1438	0.052	3491	0.0464	5547	0.056	7604	0.048	9661	0.0664
1439	0.0504	3492	0.0544	5548	0.052	7605	0.048	9662	0.068
1440	0.048	3493	0.0504	5549	0.052	7606	0.044	9663	0.0664
1441	0.044	3494	0.044	5550	0.0544	7607	0.0464	9664	0.0664
1442	0.044	3495	0.052	5551	0.056	7608	0.0504	9665	0.0624
1443	0.048	3496	0.0624	5552	0.0544	7609	0.048	9666	0.0624
1444	0.0504	3497	0.056	5553	0.052	7610	0.0464	9667	0.0624
1445	0.048	3498	0.0504	5554	0.0504	7611	0.0504	9668	0.06
1446	0.0464	3499	0.0464	5555	0.0544	7612	0.048	9669	0.064
1447	0.048	3500	0.0464	5556	0.056	7613	0.0504	9670	0.064
1448	0.048	3501	0.048	5557	0.06	7614	0.052	9671	0.0624
1449	0.048	3502	0.0504	5558	0.0584	7615	0.048	9672	0.0624
1450	0.052	3503	0.048	5559	0.052	7616	0.048	9673	0.064
1451	0.0544	3504	0.044	5560	0.0544	7617	0.0504	9674	0.064
1452	0.0504	3505	0.044	5561	0.056	7618	0.0544	9675	0.0664
1453	0.0504	3506	0.0464	5562	0.0544	7619	0.0544	9676	0.06
1454	0.048	3507	0.0464	5563	0.0584	7620	0.048	9677	0.064
1455	0.048	3508	0.048	5564	0.0544	7621	0.048	9678	0.0664
1456	0.052	3509	0.0464	5565	0.052	7622	0.0544	9679	0.068
1457	0.0504	3510	0.044	5566	0.052	7623	0.048	9680	0.064
1458	0.0504	3511	0.0464	5567	0.056	7624	0.048	9681	0.0624
1459	0.048	3512	0.0504	5568	0.0584	7625	0.0504	9682	0.0624
1460	0.048	3513	0.0544	5569	0.0544	7626	0.048	9683	0.064
1461	0.0504	3514	0.052	5570	0.0504	7627	0.0504	9684	0.0624
1462	0.052	3515	0.0464	5571	0.0544	7628	0.0504	9685	0.0584
1463	0.048	3516	0.0464	5572	0.0544	7629	0.048	9686	0.0624
1464	0.0504	3517	0.0464	5573	0.0504	7630	0.048	9687	0.0664
1465	0.052	3518	0.0504	5574	0.048	7631	0.0464	9688	0.0624
1466	0.052	3519	0.0504	5575	0.0504	7632	0.0464	9689	0.0624

1467	0.048	3520	0.044	5576	0.0544	7633	0.0464	9690	0.0624
1468	0.052	3521	0.0464	5577	0.052	7634	0.048	9691	0.0664
1469	0.0504	3522	0.0464	5578	0.0544	7635	0.048	9692	0.0704
1470	0.048	3523	0.0504	5579	0.0544	7636	0.048	9693	0.072
1471	0.0544	3524	0.052	5580	0.0544	7637	0.048	9694	0.068
1472	0.0504	3525	0.048	5581	0.056	7638	0.0504	9695	0.0624
1473	0.0504	3526	0.052	5582	0.0544	7639	0.0504	9696	0.06
1474	0.048	3527	0.0504	5583	0.048	7640	0.048	9697	0.06
1475	0.0464	3528	0.048	5584	0.052	7641	0.0504	9698	0.064
1476	0.0464	3529	0.044	5585	0.052	7642	0.048	9699	0.0664
1477	0.048	3530	0.048	5586	0.052	7643	0.048	9700	0.064
1478	0.0544	3531	0.052	5587	0.0544	7644	0.0504	9701	0.0624
1479	0.052	3532	0.0504	5588	0.0544	7645	0.048	9702	0.064
1480	0.052	3533	0.0464	5589	0.0544	7646	0.0504	9703	0.064
1481	0.0544	3534	0.048	5590	0.056	7647	0.052	9704	0.064
1482	0.0544	3535	0.0504	5591	0.052	7648	0.052	9705	0.064
1483	0.0544	3536	0.0464	5592	0.0504	7649	0.0504	9706	0.0664
1484	0.056	3537	0.044	5593	0.052	7650	0.0504	9707	0.06
1485	0.0544	3538	0.044	5594	0.0544	7651	0.0464	9708	0.064
1486	0.052	3539	0.0464	5595	0.052	7652	0.048	9709	0.0664
1487	0.0544	3540	0.0504	5596	0.0544	7653	0.0504	9710	0.068
1488	0.052	3541	0.052	5597	0.052	7654	0.0504	9711	0.0664
1489	0.052	3542	0.048	5598	0.056	7655	0.0504	9712	0.0664
1490	0.0504	3543	0.0464	5599	0.0544	7656	0.0504	9713	0.072
1491	0.048	3544	0.0464	5600	0.052	7657	0.052	9714	0.0664
1492	0.052	3545	0.048	5601	0.052	7658	0.052	9715	0.0664
1493	0.052	3546	0.0504	5602	0.052	7659	0.056	9716	0.068
1494	0.0504	3547	0.044	5603	0.052	7660	0.0584	9717	0.068
1495	0.0544	3548	0.048	5604	0.052	7661	0.0504	9718	0.0704
1496	0.0584	3549	0.044	5605	0.052	7662	0.0504	9719	0.0744
1497	0.052	3550	0.048	5606	0.052	7663	0.052	9720	0.0744
1498	0.048	3551	0.0464	5607	0.052	7664	0.052	9721	0.0704
1499	0.048	3552	0.0464	5608	0.052	7665	0.048	9722	0.0704
1500	0.048	3553	0.0504	5609	0.052	7666	0.0504	9723	0.072
1501	0.0504	3554	0.0504	5610	0.052	7667	0.0544	9724	0.0704
1502	0.0504	3555	0.048	5611	0.0544	7668	0.0544	9725	0.0664
1503	0.052	3556	0.048	5612	0.056	7669	0.0544	9726	0.068
1504	0.048	3557	0.048	5613	0.056	7670	0.052	9727	0.0704
1505	0.0464	3558	0.048	5614	0.0584	7671	0.052	9728	0.068
1506	0.0464	3559	0.044	5615	0.0584	7672	0.052	9729	0.0664
1507	0.048	3560	0.0464	5616	0.0544	7673	0.0504	9730	0.0664
1508	0.052	3561	0.0464	5617	0.0504	7674	0.0504	9731	0.072
1509	0.052	3562	0.0464	5618	0.0504	7675	0.0504	9732	0.068
1510	0.048	3563	0.0504	5619	0.0544	7676	0.0504	9733	0.0664
1511	0.052	3564	0.052	5620	0.0544	7677	0.052	9734	0.068
1512	0.048	3565	0.0504	5621	0.052	7678	0.0504	9735	0.0744
1513	0.0464	3566	0.0464	5622	0.052	7679	0.0504	9736	0.0664
1514	0.048	3567	0.0464	5623	0.0544	7680	0.0504	9737	0.0704
1515	0.048	3568	0.048	5624	0.0544	7681	0.048	9738	0.076
1516	0.052	3569	0.0504	5625	0.0544	7682	0.052	9739	0.0744
1517	0.052	3570	0.0504	5626	0.0544	7683	0.0544	9740	0.0704
1518	0.0504	3571	0.052	5627	0.052	7684	0.0504	9741	0.0664
1519	0.0504	3572	0.0504	5628	0.0544	7685	0.0504	9742	0.064
1520	0.0504	3573	0.0504	5629	0.0544	7686	0.056	9743	0.064
1521	0.052	3574	0.0464	5630	0.052	7687	0.0544	9744	0.068
1522	0.0504	3575	0.048	5631	0.056	7688	0.048	9745	0.0744
1523	0.052	3576	0.0504	5632	0.0584	7689	0.0504	9746	0.0744
1524	0.06	3577	0.0464	5633	0.0544	7690	0.048	9747	0.0704
1525	0.0624	3578	0.044	5634	0.052	7691	0.052	9748	0.0744
1526	0.0464	3579	0.0464	5635	0.0544	7692	0.0504	9749	0.0744
1527	0.0464	3580	0.0464	5636	0.0504	7693	0.052	9750	0.0704
1528	0.048	3581	0.048	5637	0.052	7694	0.056	9751	0.068
1529	0.048	3582	0.052	5638	0.0544	7695	0.0544	9752	0.0704
1530	0.052	3583	0.0504	5639	0.0504	7696	0.056	9753	0.068
1531	0.056	3584	0.0464	5640	0.0544	7697	0.056	9754	0.0664
1532	0.0504	3585	0.048	5641	0.0544	7698	0.056	9755	0.0704
1533	0.0504	3586	0.0504	5642	0.0544	7699	0.056	9756	0.072
1534	0.0504	3587	0.048	5643	0.0504	7700	0.052	9757	0.076
1535	0.0504	3588	0.048	5644	0.0504	7701	0.0504	9758	0.072
1536	0.0504	3589	0.0504	5645	0.0504	7702	0.052	9759	0.068
1537	0.052	3590	0.0504	5646	0.0504	7703	0.052	9760	0.0744
1538	0.056	3591	0.048	5647	0.052	7704	0.052	9761	0.0784
1539	0.0464	3592	0.048	5648	0.0544	7705	0.0504	9762	0.076
1540	0.048	3593	0.048	5649	0.0544	7706	0.052	9763	0.068
1541	0.0504	3594	0.0504	5650	0.056	7707	0.0544	9764	0.072
1542	0.048	3595	0.0464	5651	0.056	7708	0.0544	9765	0.0704
1543	0.0504	3596	0.0504	5652	0.0544	7709	0.052	9766	0.0664
1544	0.052	3597	0.0504	5653	0.052	7710	0.052	9767	0.0704
1545	0.0544	3598	0.048	5654	0.0544	7711	0.052	9768	0.0744
1546	0.056	3599	0.0464	5655	0.056	7712	0.052	9769	0.072
1547	0.0544	3600	0.0464	5656	0.056	7713	0.0544	9770	0.0704
1548	0.056	3601	0.0464	5657	0.0544	7714	0.0544	9771	0.068
1549	0.0544	3602	0.052	5658	0.052	7715	0.052	9772	0.068
1550	0.0504	3603	0.048	5659	0.0544	7716	0.052	9773	0.072
1551	0.0464	3604	0.048	5660	0.0544	7717	0.0544	9774	0.0704
1552	0.048	3605	0.0464	5661	0.0544	7718	0.056	9775	0.068
1553	0.048	3606	0.0504	5662	0.0544	7719	0.0584	9776	0.0704
1554	0.048	3607	0.052	5663	0.0544	7720	0.0544	9777	0.072
1555	0.0504	3608	0.048	5664	0.0584	7721	0.052	9778	0.072
1556	0.0504	3609	0.0464	5665	0.056	7722	0.052	9779	0.072
1557	0.0504	3610	0.0504	5666	0.0504	7723	0.0584	9780	0.0744
1558	0.0504	3611	0.0504	5667	0.052	7724	0.06	9781	0.0744
1559	0.0504	3612	0.048	5668	0.0544	7725	0.052	9782	0.0744

1560	0.048	3613	0.0464	5669	0.052	7726	0.052	9783	0.08
1561	0.0464	3614	0.048	5670	0.052	7727	0.0544	9784	0.084
1562	0.048	3615	0.048	5671	0.0544	7728	0.0544	9785	0.0824
1563	0.052	3616	0.048	5672	0.0544	7729	0.0544	9786	0.072
1564	0.0504	3617	0.048	5673	0.052	7730	0.056	9787	0.072
1565	0.0504	3618	0.048	5674	0.0544	7731	0.056	9788	0.068
1566	0.052	3619	0.048	5675	0.0504	7732	0.0544	9789	0.076
1567	0.048	3620	0.052	5676	0.0504	7733	0.06	9790	0.0744
1568	0.048	3621	0.052	5677	0.052	7734	0.0664	9791	0.0704
1569	0.0504	3622	0.048	5678	0.052	7735	0.064	9792	0.0744
1570	0.0504	3623	0.048	5679	0.056	7736	0.056	9793	0.0744
1571	0.0504	3624	0.0504	5680	0.056	7737	0.056	9794	0.076
1572	0.048	3625	0.048	5681	0.056	7738	0.06	9795	0.0784
1573	0.048	3626	0.048	5682	0.052	7739	0.06	9796	0.0704
1574	0.048	3627	0.052	5683	0.0504	7740	0.0544	9797	0.068
1575	0.052	3628	0.048	5684	0.052	7741	0.0584	9798	0.068
1576	0.052	3629	0.048	5685	0.0544	7742	0.056	9799	0.0704
1577	0.06	3630	0.052	5686	0.0504	7743	0.0584	9800	0.068
1578	0.052	3631	0.056	5687	0.052	7744	0.056	9801	0.068
1579	0.052	3632	0.0544	5688	0.048	7745	0.052	9802	0.0704
1580	0.0504	3633	0.0544	5689	0.052	7746	0.0544	9803	0.0744
1581	0.0464	3634	0.052	5690	0.052	7747	0.0544	9804	0.076
1582	0.048	3635	0.052	5691	0.048	7748	0.052	9805	0.0744
1583	0.052	3636	0.048	5692	0.048	7749	0.052	9806	0.0744
1584	0.048	3637	0.0504	5693	0.048	7750	0.0544	9807	0.0704
1585	0.0504	3638	0.052	5694	0.048	7751	0.056	9808	0.068
1586	0.0504	3639	0.0544	5695	0.048	7752	0.0544	9809	0.0704
1587	0.048	3640	0.0544	5696	0.0504	7753	0.056	9810	0.068
1588	0.0464	3641	0.0464	5697	0.048	7754	0.0584	9811	0.0744
1589	0.0504	3642	0.048	5698	0.0504	7755	0.0584	9812	0.0744
1590	0.048	3643	0.0504	5699	0.052	7756	0.056	9813	0.0704
1591	0.048	3644	0.0504	5700	0.0504	7757	0.056	9814	0.0664
1592	0.0504	3645	0.052	5701	0.052	7758	0.056	9815	0.064
1593	0.0504	3646	0.052	5702	0.0504	7759	0.0544	9816	0.068
1594	0.052	3647	0.0504	5703	0.048	7760	0.0544	9817	0.0704
1595	0.052	3648	0.052	5704	0.0504	7761	0.056	9818	0.0704
1596	0.052	3649	0.052	5705	0.0544	7762	0.056	9819	0.068
1597	0.0544	3650	0.052	5706	0.052	7763	0.0584	9820	0.068
1598	0.052	3651	0.0504	5707	0.048	7764	0.0584	9821	0.0664
1599	0.052	3652	0.052	5708	0.052	7765	0.0624	9822	0.0664
1600	0.0504	3653	0.0504	5709	0.0544	7766	0.068	9823	0.0664
1601	0.0544	3654	0.0464	5710	0.0504	7767	0.076	9824	0.072
1602	0.0544	3655	0.0464	5711	0.048	7768	0.072	9825	0.0704
1603	0.0464	3656	0.0504	5712	0.044	7769	0.0584	9826	0.064
1604	0.0464	3657	0.0504	5713	0.048	7770	0.0584	9827	0.064
1605	0.052	3658	0.0504	5714	0.0504	7771	0.06	9828	0.0664
1606	0.052	3659	0.048	5715	0.052	7772	0.0584	9829	0.068
1607	0.048	3660	0.0504	5716	0.048	7773	0.06	9830	0.0704
1608	0.0584	3661	0.048	5717	0.0464	7774	0.06	9831	0.0704
1609	0.064	3662	0.048	5718	0.0464	7775	0.064	9832	0.0704
1610	0.056	3663	0.048	5719	0.048	7776	0.0584	9833	0.072
1611	0.0504	3664	0.0504	5720	0.0504	7777	0.0584	9834	0.0744
1612	0.056	3665	0.052	5721	0.052	7778	0.0584	9835	0.0704
1613	0.06	3666	0.052	5722	0.052	7779	0.0584	9836	0.0664
1614	0.0624	3667	0.0504	5723	0.0504	7780	0.0624	9837	0.064
1615	0.06	3668	0.0504	5724	0.0504	7781	0.0624	9838	0.072
1616	0.052	3669	0.052	5725	0.048	7782	0.0624	9839	0.0744
1617	0.052	3670	0.052	5726	0.048	7783	0.0624	9840	0.0744
1618	0.0544	3671	0.0544	5727	0.052	7784	0.0624	9841	0.084
1619	0.052	3672	0.0544	5728	0.0504	7785	0.06	9842	0.0784
1620	0.052	3673	0.052	5729	0.048	7786	0.06	9843	0.064
1621	0.052	3674	0.056	5730	0.052	7787	0.0584	9844	0.0624
1622	0.0504	3675	0.056	5731	0.048	7788	0.0624	9845	0.068
1623	0.0504	3676	0.052	5732	0.048	7789	0.06	9846	0.0704
1624	0.0544	3677	0.0504	5733	0.052	7790	0.0624	9847	0.072
1625	0.056	3678	0.052	5734	0.052	7791	0.056	9848	0.068
1626	0.056	3679	0.052	5735	0.048	7792	0.056	9849	0.068
1627	0.0584	3680	0.0504	5736	0.048	7793	0.06	9850	0.064
1628	0.0504	3681	0.0504	5737	0.048	7794	0.056	9851	0.06
1629	0.0504	3682	0.0544	5738	0.048	7795	0.0544	9852	0.0704
1630	0.0504	3683	0.0584	5739	0.0504	7796	0.056	9853	0.072
1631	0.048	3684	0.0544	5740	0.048	7797	0.0624	9854	0.0704
1632	0.052	3685	0.0504	5741	0.048	7798	0.064	9855	0.068
1633	0.048	3686	0.0504	5742	0.0544	7799	0.0584	9856	0.0704
1634	0.052	3687	0.0504	5743	0.052	7800	0.056	9857	0.0704
1635	0.0544	3688	0.048	5744	0.0504	7801	0.0584	9858	0.068
1636	0.0544	3689	0.0504	5745	0.048	7802	0.0584	9859	0.0664
1637	0.056	3690	0.0504	5746	0.0504	7803	0.0544	9860	0.068
1638	0.0504	3691	0.048	5747	0.0544	7804	0.056	9861	0.072
1639	0.048	3692	0.0504	5748	0.048	7805	0.0544	9862	0.0664
1640	0.048	3693	0.0584	5749	0.0504	7806	0.0584	9863	0.0664
1641	0.048	3694	0.06	5750	0.0504	7807	0.064	9864	0.072
1642	0.048	3695	0.0504	5751	0.048	7808	0.0664	9865	0.0744
1643	0.048	3696	0.0544	5752	0.052	7809	0.0624	9866	0.0664
1644	0.048	3697	0.0544	5753	0.0584	7810	0.06	9867	0.064
1645	0.0504	3698	0.06	5754	0.056	7811	0.056	9868	0.0664
1646	0.0504	3699	0.06	5755	0.048	7812	0.056	9869	0.064
1647	0.052	3700	0.0504	5756	0.0544	7813	0.0584	9870	0.068
1648	0.0464	3701	0.0504	5757	0.06	7814	0.056	9871	0.072
1649	0.0504	3702	0.0504	5758	0.0584	7815	0.0544	9872	0.0704
1650	0.0504	3703	0.0544	5759	0.056	7816	0.0544	9873	0.0664
1651	0.0464	3704	0.056	5760	0.0544	7817	0.0544	9874	0.0664
1652	0.048	3705	0.0544	5761	0.048	7818	0.0544	9875	0.072

1653	0.044	3706	0.056	5762	0.048	7819	0.0584	9876	0.072
1654	0.048	3707	0.0544	5763	0.0504	7820	0.0584	9877	0.0624
1655	0.0464	3708	0.0544	5764	0.0464	7821	0.0544	9878	0.0664
1656	0.0504	3709	0.052	5765	0.048	7822	0.0544	9879	0.0704
1657	0.048	3710	0.052	5766	0.0504	7823	0.0544	9880	0.068
1658	0.048	3711	0.052	5767	0.0504	7824	0.0544	9881	0.068
1659	0.048	3712	0.0504	5768	0.0504	7825	0.0544	9882	0.0664
1660	0.0464	3713	0.0504	5769	0.052	7826	0.0544	9883	0.064
1661	0.052	3714	0.0544	5770	0.048	7827	0.052	9884	0.0664
1662	0.0544	3715	0.056	5771	0.0504	7828	0.052	9885	0.0664
1663	0.048	3716	0.0544	5772	0.048	7829	0.052	9886	0.0624
1664	0.0504	3717	0.056	5773	0.0504	7830	0.052	9887	0.0624
1665	0.052	3718	0.052	5774	0.052	7831	0.052	9888	0.064
1666	0.0504	3719	0.0544	5775	0.0544	7832	0.056	9889	0.0624
1667	0.0464	3720	0.056	5776	0.0504	7833	0.0584	9890	0.068
1668	0.0464	3721	0.0624	5777	0.052	7834	0.056	9891	0.0704
1669	0.048	3722	0.0584	5778	0.0504	7835	0.0544	9892	0.064
1670	0.048	3723	0.056	5779	0.0504	7836	0.052	9893	0.0664
1671	0.044	3724	0.0544	5780	0.0544	7837	0.052	9894	0.0704
1672	0.048	3725	0.052	5781	0.052	7838	0.052	9895	0.0704
1673	0.052	3726	0.056	5782	0.052	7839	0.052	9896	0.0744
1674	0.048	3727	0.0544	5783	0.052	7840	0.0504	9897	0.0744
1675	0.0504	3728	0.056	5784	0.0504	7841	0.056	9898	0.068
1676	0.0504	3729	0.06	5785	0.044	7842	0.056	9899	0.068
1677	0.0504	3730	0.064	5786	0.0464	7843	0.052	9900	0.068
1678	0.048	3731	0.06	5787	0.06	7844	0.0544	9901	0.0664
1679	0.0504	3732	0.0584	5788	0.064	7845	0.0544	9902	0.0664
1680	0.0504	3733	0.056	5789	0.048	7846	0.056	9903	0.064
1681	0.048	3734	0.0544	5790	0.048	7847	0.0544	9904	0.0704
1682	0.0504	3735	0.0544	5791	0.0504	7848	0.0544	9905	0.068
1683	0.048	3736	0.0584	5792	0.048	7849	0.0544	9906	0.072
1684	0.0504	3737	0.056	5793	0.044	7850	0.056	9907	0.072
1685	0.048	3738	0.056	5794	0.0464	7851	0.0544	9908	0.072
1686	0.0504	3739	0.052	5795	0.0464	7852	0.052	9909	0.068
1687	0.052	3740	0.052	5796	0.0464	7853	0.0544	9910	0.068
1688	0.052	3741	0.052	5797	0.0504	7854	0.0544	9911	0.0664
1689	0.0504	3742	0.0544	5798	0.0544	7855	0.0544	9912	0.0624
1690	0.0504	3743	0.056	5799	0.052	7856	0.052	9913	0.068
1691	0.0504	3744	0.0584	5800	0.0464	7857	0.052	9914	0.068
1692	0.0504	3745	0.0584	5801	0.0464	7858	0.052	9915	0.0744
1693	0.0504	3746	0.0544	5802	0.044	7859	0.0544	9916	0.08
1694	0.0544	3747	0.056	5803	0.0504	7860	0.0544	9917	0.064
1695	0.048	3748	0.06	5804	0.052	7861	0.0544	9918	0.0664
1696	0.048	3749	0.06	5805	0.048	7862	0.0544	9919	0.064
1697	0.0504	3750	0.056	5806	0.048	7863	0.0584	9920	0.064
1698	0.0544	3751	0.06	5807	0.0464	7864	0.06	9921	0.0624
1699	0.052	3752	0.0584	5808	0.0504	7865	0.0584	9922	0.0664
1700	0.0504	3753	0.0624	5809	0.052	7866	0.0584	9923	0.068
1701	0.052	3754	0.064	5810	0.0504	7867	0.0584	9924	0.0704
1702	0.052	3755	0.06	5811	0.0464	7868	0.0584	9925	0.068
1703	0.052	3756	0.056	5812	0.0464	7869	0.056	9926	0.0704
1704	0.0504	3757	0.06	5813	0.0464	7870	0.0584	9927	0.0704
1705	0.048	3758	0.056	5814	0.048	7871	0.0544	9928	0.0704
1706	0.048	3759	0.056	5815	0.052	7872	0.0504	9929	0.068
1707	0.048	3760	0.06	5816	0.0464	7873	0.052	9930	0.0664
1708	0.048	3761	0.0624	5817	0.0464	7874	0.0544	9931	0.068
1709	0.0504	3762	0.0624	5818	0.048	7875	0.0544	9932	0.068
1710	0.052	3763	0.064	5819	0.048	7876	0.0544	9933	0.0704
1711	0.0504	3764	0.056	5820	0.0504	7877	0.0584	9934	0.0704
1712	0.052	3765	0.0584	5821	0.0504	7878	0.056	9935	0.068
1713	0.052	3766	0.056	5822	0.0544	7879	0.056	9936	0.0664
1714	0.0544	3767	0.056	5823	0.0544	7880	0.056	9937	0.064
1715	0.052	3768	0.0544	5824	0.052	7881	0.056	9938	0.0664
1716	0.052	3769	0.056	5825	0.0504	7882	0.0544	9939	0.068
1717	0.0544	3770	0.0584	5826	0.0504	7883	0.056	9940	0.064
1718	0.0504	3771	0.0584	5827	0.052	7884	0.0584	9941	0.068
1719	0.056	3772	0.06	5828	0.0504	7885	0.0584	9942	0.068
1720	0.052	3773	0.0544	5829	0.048	7886	0.0584	9943	0.0664
1721	0.052	3774	0.0544	5830	0.0504	7887	0.056	9944	0.0664
1722	0.0504	3775	0.06	5831	0.0544	7888	0.052	9945	0.0664
1723	0.0504	3776	0.064	5832	0.0504	7889	0.052	9946	0.064
1724	0.052	3777	0.06	5833	0.0504	7890	0.052	9947	0.064
1725	0.052	3778	0.056	5834	0.048	7891	0.056	9948	0.0704
1726	0.0504	3779	0.056	5835	0.0464	7892	0.0664	9949	0.072
1727	0.0504	3780	0.056	5836	0.0504	7893	0.0664	9950	0.072
1728	0.0544	3781	0.0544	5837	0.0504	7894	0.0544	9951	0.0664
1729	0.056	3782	0.0544	5838	0.048	7895	0.056	9952	0.0664
1730	0.0544	3783	0.0544	5839	0.048	7896	0.0544	9953	0.0704
1731	0.0504	3784	0.0504	5840	0.0504	7897	0.052	9954	0.0704
1732	0.0544	3785	0.052	5841	0.0504	7898	0.052	9955	0.076
1733	0.0584	3786	0.0544	5842	0.048	7899	0.0504	9956	0.072
1734	0.052	3787	0.056	5843	0.0464	7900	0.0504	9957	0.072
1735	0.0504	3788	0.056	5844	0.0504	7901	0.0544	9958	0.0744
1736	0.052	3789	0.056	5845	0.048	7902	0.052	9959	0.0664
1737	0.052	3790	0.052	5846	0.0464	7903	0.0544	9960	0.068
1738	0.0544	3791	0.068	5847	0.044	7904	0.0544	9961	0.0704
1739	0.052	3792	0.0704	5848	0.048	7905	0.0544	9962	0.068
1740	0.0504	3793	0.056	5849	0.048	7906	0.056	9963	0.0704
1741	0.0504	3794	0.056	5850	0.044	7907	0.0584	9964	0.0704
1742	0.048	3795	0.0544	5851	0.0504	7908	0.052	9965	0.0704
1743	0.0504	3796	0.0544	5852	0.048	7909	0.0544	9966	0.0704
1744	0.0544	3797	0.056	5853	0.04	7910	0.056	9967	0.072
1745	0.052	3798	0.056	5854	0.044	7911	0.0544	9968	0.0664

1746	0.0504	3799	0.056	5855	0.044	7912	0.0584	9969	0.0704
1747	0.052	3800	0.056	5856	0.044	7913	0.056	9970	0.0664
1748	0.056	3801	0.0544	5857	0.0464	7914	0.056	9971	0.0624
1749	0.056	3802	0.0584	5858	0.048	7915	0.056	9972	0.064
1750	0.0544	3803	0.056	5859	0.0464	7916	0.0544	9973	0.0704
1751	0.0504	3804	0.0544	5860	0.044	7917	0.052	9974	0.0784
1752	0.052	3805	0.056	5861	0.0464	7918	0.0544	9975	0.076
1753	0.0504	3806	0.0584	5862	0.048	7919	0.056	9976	0.072
1754	0.0544	3807	0.056	5863	0.0504	7920	0.0544	9977	0.072
1755	0.0584	3808	0.06	5864	0.0464	7921	0.056	9978	0.072
1756	0.0504	3809	0.064	5865	0.052	7922	0.0544	9979	0.068
1757	0.0504	3810	0.056	5866	0.0544	7923	0.052	9980	0.064
1758	0.052	3811	0.0584	5867	0.0504	7924	0.056	9981	0.0664
1759	0.052	3812	0.052	5868	0.052	7925	0.06	9982	0.0664
1760	0.0544	3813	0.0544	5869	0.0504	7926	0.0544	9983	0.068
1761	0.056	3814	0.0544	5870	0.052	7927	0.0504	9984	0.068
1762	0.0584	3815	0.056	5871	0.052	7928	0.052	9985	0.072
1763	0.0544	3816	0.056	5872	0.048	7929	0.052	9986	0.0704
1764	0.0504	3817	0.0624	5873	0.0464	7930	0.052	9987	0.0704
1765	0.0504	3818	0.0624	5874	0.0424	7931	0.052	9988	0.0704
1766	0.048	3819	0.056	5875	0.0464	7932	0.0504	9989	0.0704
1767	0.048	3820	0.056	5876	0.048	7933	0.0504	9990	0.0704
1768	0.0504	3821	0.056	5877	0.0464	7934	0.0504	9991	0.072
1769	0.052	3822	0.0544	5878	0.0464	7935	0.052	9992	0.072
1770	0.052	3823	0.056	5879	0.048	7936	0.0544	9993	0.072
1771	0.0504	3824	0.0544	5880	0.0464	7937	0.0544	9994	0.0744
1772	0.0504	3825	0.0544	5881	0.048	7938	0.056	9995	0.076
1773	0.0504	3826	0.0544	5882	0.056	7939	0.0544	9996	0.076
1774	0.052	3827	0.0544	5883	0.0504	7940	0.052	9997	0.0744
1775	0.052	3828	0.056	5884	0.044	7941	0.052	9998	0.0784
1776	0.056	3829	0.056	5885	0.0464	7942	0.0544	9999	0.0784
1777	0.0544	3830	0.0584	5886	0.0464	7943	0.0544	10000	0.076
1778	0.052	3831	0.056	5887	0.0464	7944	0.0544	10001	0.076
1779	0.0544	3832	0.0584	5888	0.048	7945	0.0544	10002	0.0744
1780	0.0544	3833	0.06	5889	0.048	7946	0.052	10003	0.0784
1781	0.0504	3834	0.06	5890	0.048	7947	0.052	10004	0.08
1782	0.052	3835	0.064	5891	0.052	7948	0.0504	10005	0.08
1783	0.052	3836	0.056	5892	0.048	7949	0.052	10006	0.0784
1784	0.0544	3837	0.0584	5893	0.044	7950	0.0544	10007	0.0784
1785	0.0544	3838	0.0584	5894	0.048	7951	0.052	10008	0.0824
1786	0.0544	3839	0.0584	5895	0.0464	7952	0.052	10009	0.084
1787	0.056	3840	0.0584	5896	0.0504	7953	0.056	10010	0.0744
1788	0.0544	3841	0.0544	5897	0.048	7954	0.0584	10011	0.0664
1789	0.0544	3842	0.0544	5898	0.044	7955	0.056	10012	0.0704
1790	0.052	3843	0.056	5899	0.044	7956	0.0504	10013	0.0704
1791	0.06	3844	0.06	5900	0.044	7957	0.052	10014	0.072
1792	0.0624	3845	0.0584	5901	0.048	7958	0.0544	10015	0.0704
1793	0.0504	3846	0.0584	5902	0.0464	7959	0.052	10016	0.0744
1794	0.048	3847	0.06	5903	0.0464	7960	0.0544	10017	0.0744
1795	0.0504	3848	0.0624	5904	0.0464	7961	0.0544	10018	0.0744
1796	0.0504	3849	0.06	5905	0.048	7962	0.0544	10019	0.0744
1797	0.056	3850	0.056	5906	0.048	7963	0.0584	10020	0.072
1798	0.056	3851	0.056	5907	0.044	7964	0.0544	10021	0.072
1799	0.048	3852	0.056	5908	0.044	7965	0.0544	10022	0.0704
1800	0.0504	3853	0.056	5909	0.044	7966	0.0544	10023	0.068
1801	0.052	3854	0.056	5910	0.048	7967	0.0504	10024	0.072
1802	0.052	3855	0.0544	5911	0.0504	7968	0.052	10025	0.072
1803	0.0504	3856	0.056	5912	0.0544	7969	0.0504	10026	0.0744
1804	0.052	3857	0.0584	5913	0.048	7970	0.0464	10027	0.076
1805	0.0504	3858	0.0584	5914	0.0504	7971	0.0464	10028	0.0744
1806	0.052	3859	0.0584	5915	0.052	7972	0.048	10029	0.072
1807	0.052	3860	0.056	5916	0.0504	7973	0.048	10030	0.0704
1808	0.0504	3861	0.0544	5917	0.048	7974	0.052	10031	0.064
1809	0.048	3862	0.0544	5918	0.044	7975	0.052	10032	0.072
1810	0.048	3863	0.0544	5919	0.048	7976	0.048	10033	0.076
1811	0.0504	3864	0.0544	5920	0.0504	7977	0.048	10034	0.0704
1812	0.052	3865	0.052	5921	0.048	7978	0.0504	10035	0.0704
1813	0.048	3866	0.0544	5922	0.048	7979	0.052	10036	0.0744
1814	0.048	3867	0.0544	5923	0.0464	7980	0.052	10037	0.072
1815	0.0504	3868	0.056	5924	0.0464	7981	0.048	10038	0.072
1816	0.0504	3869	0.056	5925	0.044	7982	0.048	10039	0.0744
1817	0.0504	3870	0.056	5926	0.044	7983	0.0504	10040	0.0664
1818	0.0544	3871	0.056	5927	0.044	7984	0.0504	10041	0.0664
1819	0.0544	3872	0.0584	5928	0.048	7985	0.048	10042	0.0664
1820	0.0584	3873	0.056	5929	0.0464	7986	0.0504	10043	0.068
1821	0.056	3874	0.0544	5930	0.048	7987	0.0544	10044	0.0664
1822	0.056	3875	0.052	5931	0.0464	7988	0.052	10045	0.0704
1823	0.056	3876	0.0544	5932	0.0504	7989	0.0504	10046	0.072
1824	0.0544	3877	0.056	5933	0.052	7990	0.048	10047	0.0704
1825	0.0544	3878	0.0584	5934	0.0464	7991	0.048	10048	0.0704
1826	0.056	3879	0.056	5935	0.048	7992	0.0464	10049	0.0744
1827	0.056	3880	0.0544	5936	0.0464	7993	0.0504	10050	0.0704
1828	0.052	3881	0.0544	5937	0.044	7994	0.0504	10051	0.068
1829	0.052	3882	0.056	5938	0.0464	7995	0.048	10052	0.064
1830	0.0504	3883	0.0584	5939	0.056	7996	0.048	10053	0.0664
1831	0.0504	3884	0.056	5940	0.056	7997	0.052	10054	0.068
1832	0.052	3885	0.056	5941	0.044	7998	0.0504	10055	0.072
1833	0.052	3886	0.0544	5942	0.044	7999	0.0504	10056	0.0704
1834	0.052	3887	0.0544	5943	0.0464	8000	0.0504	10057	0.0704
1835	0.0544	3888	0.0544	5944	0.0504	8001	0.048	10058	0.064
1836	0.056	3889	0.0544	5945	0.0504	8002	0.0544	10059	0.064
1837	0.0504	3890	0.052	5946	0.0464	8003	0.056	10060	0.068
1838	0.0544	3891	0.0584	5947	0.048	8004	0.0464	10061	0.068

1839	0.056	3892	0.0584	5948	0.0504	8005	0.048	10062	0.0664
1840	0.0544	3893	0.0544	5949	0.048	8006	0.048	10063	0.0664
1841	0.0544	3894	0.0584	5950	0.048	8007	0.048	10064	0.064
1842	0.052	3895	0.0544	5951	0.0464	8008	0.0464	10065	0.0664
1843	0.056	3896	0.052	5952	0.048	8009	0.048	10066	0.0704
1844	0.0624	3897	0.0544	5953	0.0504	8010	0.0504	10067	0.0664
1845	0.0664	3898	0.0584	5954	0.0464	8011	0.048	10068	0.068
1846	0.056	3899	0.0544	5955	0.0464	8012	0.0464	10069	0.068
1847	0.052	3900	0.052	5956	0.0464	8013	0.0464	10070	0.068
1848	0.052	3901	0.056	5957	0.048	8014	0.048	10071	0.0704
1849	0.052	3902	0.0584	5958	0.0464	8015	0.048	10072	0.0664
1850	0.0544	3903	0.0584	5959	0.044	8016	0.0544	10073	0.072
1851	0.052	3904	0.0584	5960	0.044	8017	0.052	10074	0.0744
1852	0.052	3905	0.0544	5961	0.044	8018	0.0504	10075	0.064
1853	0.0544	3906	0.056	5962	0.044	8019	0.0504	10076	0.0664
1854	0.052	3907	0.0584	5963	0.0424	8020	0.052	10077	0.064
1855	0.056	3908	0.056	5964	0.044	8021	0.052	10078	0.0624
1856	0.056	3909	0.0584	5965	0.0504	8022	0.0504	10079	0.064
1857	0.0544	3910	0.056	5966	0.0544	8023	0.0504	10080	0.0664
1858	0.0544	3911	0.056	5967	0.044	8024	0.048	10081	0.064
1859	0.056	3912	0.0544	5968	0.0424	8025	0.0544	10082	0.064
1860	0.06	3913	0.0544	5969	0.044	8026	0.056	10083	0.0624
1861	0.0544	3914	0.0544	5970	0.044	8027	0.0544	10084	0.064
1862	0.0544	3915	0.0544	5971	0.044	8028	0.0504	10085	0.0664
1863	0.056	3916	0.0544	5972	0.0464	8029	0.048	10086	0.068
1864	0.0584	3917	0.0544	5973	0.0464	8030	0.048	10087	0.0704
1865	0.052	3918	0.052	5974	0.0464	8031	0.048	10088	0.0664
1866	0.052	3919	0.0544	5975	0.048	8032	0.048	10089	0.064
1867	0.0504	3920	0.056	5976	0.052	8033	0.048	10090	0.0744
1868	0.052	3921	0.056	5977	0.0464	8034	0.052	10091	0.0784
1869	0.052	3922	0.056	5978	0.0424	8035	0.052	10092	0.064
1870	0.0584	3923	0.056	5979	0.0464	8036	0.048	10093	0.064
1871	0.0584	3924	0.0544	5980	0.048	8037	0.048	10094	0.064
1872	0.056	3925	0.0504	5981	0.044	8038	0.048	10095	0.0664
1873	0.0544	3926	0.0544	5982	0.044	8039	0.048	10096	0.0624
1874	0.0544	3927	0.056	5983	0.044	8040	0.048	10097	0.064
1875	0.052	3928	0.06	5984	0.044	8041	0.0464	10098	0.0664
1876	0.0544	3929	0.0584	5985	0.044	8042	0.0464	10099	0.0664
1877	0.056	3930	0.0544	5986	0.044	8043	0.0464	10100	0.0664
1878	0.052	3931	0.0544	5987	0.048	8044	0.0464	10101	0.0664
1879	0.056	3932	0.0584	5988	0.048	8045	0.0504	10102	0.064
1880	0.0544	3933	0.056	5989	0.0464	8046	0.048	10103	0.0664
1881	0.0544	3934	0.056	5990	0.044	8047	0.0504	10104	0.0664
1882	0.052	3935	0.0584	5991	0.048	8048	0.0464	10105	0.064
1883	0.0504	3936	0.052	5992	0.048	8049	0.0504	10106	0.064
1884	0.052	3937	0.0544	5993	0.0424	8050	0.0544	10107	0.068
1885	0.052	3938	0.052	5994	0.0424	8051	0.0544	10108	0.0624
1886	0.0544	3939	0.0544	5995	0.044	8052	0.0464	10109	0.0624
1887	0.0584	3940	0.0584	5996	0.048	8053	0.0464	10110	0.0624
1888	0.0584	3941	0.056	5997	0.0464	8054	0.048	10111	0.064
1889	0.0504	3942	0.0544	5998	0.044	8055	0.048	10112	0.0664
1890	0.056	3943	0.0544	5999	0.0424	8056	0.0464	10113	0.068
1891	0.052	3944	0.0584	6000	0.048	8057	0.0464	10114	0.068
1892	0.0544	3945	0.06	6001	0.048	8058	0.0464	10115	0.0624
1893	0.0544	3946	0.0544	6002	0.0464	8059	0.0464	10116	0.0664
1894	0.056	3947	0.0544	6003	0.0464	8060	0.048	10117	0.0664
1895	0.056	3948	0.0504	6004	0.048	8061	0.0544	10118	0.068
1896	0.0544	3949	0.0584	6005	0.0504	8062	0.0544	10119	0.0704
1897	0.06	3950	0.0624	6006	0.0504	8063	0.0504	10120	0.072
1898	0.052	3951	0.0584	6007	0.052	8064	0.048	10121	0.0704
1899	0.0544	3952	0.0584	6008	0.0504	8065	0.0544	10122	0.0664
1900	0.052	3953	0.0544	6009	0.048	8066	0.052	10123	0.072
1901	0.0544	3954	0.0544	6010	0.0544	8067	0.052	10124	0.068
1902	0.052	3955	0.0504	6011	0.0544	8068	0.0504	10125	0.0664
1903	0.056	3956	0.0544	6012	0.044	8069	0.0464	10126	0.0664
1904	0.0544	3957	0.056	6013	0.0464	8070	0.0464	10127	0.0664
1905	0.052	3958	0.052	6014	0.0464	8071	0.0504	10128	0.0704
1906	0.0544	3959	0.052	6015	0.0464	8072	0.048	10129	0.072
1907	0.052	3960	0.0544	6016	0.044	8073	0.0464	10130	0.0704
1908	0.052	3961	0.056	6017	0.044	8074	0.0464	10131	0.0704
1909	0.0504	3962	0.056	6018	0.0464	8075	0.0504	10132	0.068
1910	0.048	3963	0.0544	6019	0.0464	8076	0.0504	10133	0.068
1911	0.056	3964	0.0504	6020	0.044	8077	0.052	10134	0.0664
1912	0.0584	3965	0.048	6021	0.044	8078	0.048	10135	0.068
1913	0.052	3966	0.0504	6022	0.0504	8079	0.0504	10136	0.0664
1914	0.0544	3967	0.0504	6023	0.0464	8080	0.056	10137	0.068
1915	0.0544	3968	0.0544	6024	0.044	8081	0.0584	10138	0.0704
1916	0.0584	3969	0.0504	6025	0.044	8082	0.052	10139	0.0704
1917	0.0584	3970	0.052	6026	0.0464	8083	0.0504	10140	0.0704
1918	0.052	3971	0.0544	6027	0.048	8084	0.0504	10141	0.0664
1919	0.0544	3972	0.0544	6028	0.0504	8085	0.048	10142	0.0664
1920	0.056	3973	0.056	6029	0.0584	8086	0.048	10143	0.068
1921	0.056	3974	0.056	6030	0.06	8087	0.0464	10144	0.0664
1922	0.0544	3975	0.052	6031	0.0464	8088	0.0504	10145	0.0704
1923	0.0544	3976	0.052	6032	0.0464	8089	0.0504	10146	0.0704
1924	0.0544	3977	0.0544	6033	0.0504	8090	0.0504	10147	0.0664
1925	0.0544	3978	0.056	6034	0.052	8091	0.048	10148	0.06
1926	0.0544	3979	0.056	6035	0.048	8092	0.0464	10149	0.0624
1927	0.052	3980	0.0504	6036	0.044	8093	0.052	10150	0.068
1928	0.0544	3981	0.056	6037	0.0464	8094	0.0504	10151	0.0704
1929	0.052	3982	0.056	6038	0.0464	8095	0.0504	10152	0.0664
1930	0.052	3983	0.052	6039	0.048	8096	0.056	10153	0.064
1931	0.0584	3984	0.0544	6040	0.048	8097	0.0544	10154	0.0664

1932	0.056	3985	0.056	6041	0.0424	8098	0.052	10155	0.068
1933	0.0544	3986	0.056	6042	0.0424	8099	0.0544	10156	0.0664
1934	0.048	3987	0.0544	6043	0.0464	8100	0.048	10157	0.064
1935	0.0504	3988	0.0544	6044	0.0464	8101	0.048	10158	0.0704
1936	0.0504	3989	0.0544	6045	0.0464	8102	0.048	10159	0.0704
1937	0.0544	3990	0.052	6046	0.044	8103	0.048	10160	0.0664
1938	0.056	3991	0.052	6047	0.044	8104	0.0504	10161	0.0664
1939	0.0544	3992	0.052	6048	0.0464	8105	0.048	10162	0.068
1940	0.0504	3993	0.0544	6049	0.0464	8106	0.0504	10163	0.068
1941	0.0544	3994	0.052	6050	0.0464	8107	0.048	10164	0.0704
1942	0.052	3995	0.048	6051	0.048	8108	0.048	10165	0.064
1943	0.0504	3996	0.0504	6052	0.044	8109	0.052	10166	0.0664
1944	0.0544	3997	0.0504	6053	0.0424	8110	0.0504	10167	0.0624
1945	0.056	3998	0.052	6054	0.0424	8111	0.0504	10168	0.06
1946	0.056	3999	0.0504	6055	0.0464	8112	0.0504	10169	0.06
1947	0.0544	4000	0.0504	6056	0.048	8113	0.0504	10170	0.0664
1948	0.052	4001	0.052	6057	0.048	8114	0.052	10171	0.064
1949	0.0504	4002	0.056	6058	0.0464	8115	0.0504	10172	0.0664
1950	0.0544	4003	0.052	6059	0.0464	8116	0.048	10173	0.0664
1951	0.0544	4004	0.0504	6060	0.044	8117	0.052	10174	0.064
1952	0.052	4005	0.0504	6061	0.044	8118	0.052	10175	0.0664
1953	0.0504	4006	0.052	6062	0.0424	8119	0.0504	10176	0.0664
1954	0.052	4007	0.052	6063	0.048	8120	0.0504	10177	0.0664
1955	0.0544	4008	0.0544	6064	0.048	8121	0.048	10178	0.0664
1956	0.0544	4009	0.056	6065	0.044	8122	0.048	10179	0.0664
1957	0.0504	4010	0.056	6066	0.044	8123	0.0464	10180	0.0704
1958	0.0504	4011	0.052	6067	0.044	8124	0.048	10181	0.0704
1959	0.052	4012	0.052	6068	0.048	8125	0.052	10182	0.068
1960	0.052	4013	0.056	6069	0.048	8126	0.048	10183	0.064
1961	0.052	4014	0.056	6070	0.0504	8127	0.0544	10184	0.0624
1962	0.0504	4015	0.052	6071	0.0504	8128	0.0504	10185	0.072
1963	0.0504	4016	0.052	6072	0.048	8129	0.0464	10186	0.068
1964	0.0544	4017	0.052	6073	0.0464	8130	0.0464	10187	0.064
1965	0.0584	4018	0.0504	6074	0.044	8131	0.048	10188	0.0664
1966	0.056	4019	0.048	6075	0.0464	8132	0.048	10189	0.0664
1967	0.048	4020	0.0504	6076	0.044	8133	0.0504	10190	0.0624
1968	0.052	4021	0.0504	6077	0.044	8134	0.0544	10191	0.0624
1969	0.052	4022	0.0504	6078	0.0464	8135	0.0544	10192	0.0664
1970	0.052	4023	0.056	6079	0.044	8136	0.0504	10193	0.068
1971	0.0544	4024	0.0584	6080	0.0424	8137	0.048	10194	0.072
1972	0.052	4025	0.052	6081	0.048	8138	0.0504	10195	0.0704
1973	0.0504	4026	0.052	6082	0.0504	8139	0.052	10196	0.068
1974	0.056	4027	0.0504	6083	0.0464	8140	0.052	10197	0.064
1975	0.052	4028	0.0504	6084	0.048	8141	0.048	10198	0.0664
1976	0.052	4029	0.0544	6085	0.048	8142	0.0464	10199	0.072
1977	0.06	4030	0.072	6086	0.048	8143	0.048	10200	0.08
1978	0.0584	4031	0.0584	6087	0.044	8144	0.0504	10201	0.0784
1979	0.052	4032	0.0624	6088	0.044	8145	0.0504	10202	0.068
1980	0.0544	4033	0.052	6089	0.0464	8146	0.0624	10203	0.068
1981	0.052	4034	0.0504	6090	0.048	8147	0.0624	10204	0.072
1982	0.0544	4035	0.0504	6091	0.0464	8148	0.0504	10205	0.068
1983	0.0504	4036	0.056	6092	0.0504	8149	0.048	10206	0.0704
1984	0.0504	4037	0.056	6093	0.056	8150	0.0504	10207	0.068
1985	0.052	4038	0.0544	6094	0.044	8151	0.0464	10208	0.0704
1986	0.0504	4039	0.0544	6095	0.0424	8152	0.0464	10209	0.072
1987	0.0504	4040	0.0544	6096	0.0424	8153	0.048	10210	0.072
1988	0.048	4041	0.0544	6097	0.044	8154	0.0464	10211	0.0704
1989	0.0544	4042	0.0504	6098	0.0464	8155	0.0504	10212	0.076
1990	0.0544	4043	0.0504	6099	0.0464	8156	0.0504	10213	0.076
1991	0.0544	4044	0.0504	6100	0.0464	8157	0.0504	10214	0.072
1992	0.06	4045	0.0504	6101	0.0464	8158	0.0544	10215	0.0704
1993	0.056	4046	0.048	6102	0.0504	8159	0.052	10216	0.0744
1994	0.0544	4047	0.0504	6103	0.0504	8160	0.0504	10217	0.072
1995	0.0544	4048	0.0504	6104	0.0464	8161	0.052	10218	0.0704
1996	0.0544	4049	0.0504	6105	0.048	8162	0.048	10219	0.072
1997	0.056	4050	0.0584	6106	0.0464	8163	0.0464	10220	0.0744
1998	0.0544	4051	0.0544	6107	0.048	8164	0.0464	10221	0.0744
1999	0.0544	4052	0.048	6108	0.048	8165	0.0504	10222	0.0704
2000	0.052	4053	0.048	6109	0.052	8166	0.0504	10223	0.0704
2001	0.0544	4054	0.0504	6110	0.048	8167	0.0504	10224	0.072
2002	0.0544	4055	0.0504	6111	0.0504	8168	0.052	10225	0.072
2003	0.0544	4056	0.052	6112	0.048	8169	0.056	10226	0.072
2004	0.0584	4057	0.0584	6113	0.0464	8170	0.0544	10227	0.0744
2005	0.052	4058	0.0584	6114	0.0464	8171	0.0584	10228	0.0704
2006	0.052	4059	0.0504	6115	0.0464	8172	0.056	10229	0.0704
2007	0.056	4060	0.052	6116	0.0464	8173	0.052	10230	0.0704
2008	0.052	4061	0.052	6117	0.044	8174	0.0544	10231	0.072
2009	0.0544	4062	0.0544	6118	0.044	8175	0.048	10232	0.072
2010	0.052	4063	0.056	6119	0.048	8176	0.052	10233	0.0744
2011	0.0544	4064	0.06	6120	0.0464	8177	0.052	10234	0.0704
2012	0.056	4065	0.056	6121	0.044	8178	0.0504	10235	0.068
2013	0.0544	4066	0.0504	6122	0.0464	8179	0.0504	10236	0.072
2014	0.0544	4067	0.0544	6123	0.048	8180	0.0544	10237	0.0704
2015	0.0544	4068	0.052	6124	0.048	8181	0.052	10238	0.072
2016	0.0504	4069	0.0584	6125	0.048	8182	0.0504	10239	0.072
2017	0.052	4070	0.0584	6126	0.0544	8183	0.048	10240	0.0744
2018	0.0544	4071	0.0544	6127	0.0504	8184	0.0504	10241	0.072
2019	0.0544	4072	0.052	6128	0.0464	8185	0.052	10242	0.0704
2020	0.0584	4073	0.0544	6129	0.044	8186	0.052	10243	0.076
2021	0.056	4074	0.0624	6130	0.0464	8187	0.0544	10244	0.0744
2022	0.0544	4075	0.056	6131	0.048	8188	0.056	10245	0.068
2023	0.052	4076	0.0544	6132	0.0504	8189	0.0544	10246	0.068
2024	0.052	4077	0.0584	6133	0.0464	8190	0.0544	10247	0.0704

2025	0.052	4078	0.0624	6134	0.044	8191	0.052	10248	0.068
2026	0.0544	4079	0.0584	6135	0.044	8192	0.048	10249	0.068
2027	0.052	4080	0.052	6136	0.0464	8193	0.0464	10250	0.08
2028	0.056	4081	0.052	6137	0.0464	8194	0.048	10251	0.08
2029	0.0584	4082	0.052	6138	0.048	8195	0.048	10252	0.068
2030	0.0544	4083	0.052	6139	0.0504	8196	0.0504	10253	0.0744
2031	0.052	4084	0.0504	6140	0.044	8197	0.0504	10254	0.0744
2032	0.056	4085	0.0544	6141	0.044	8198	0.0504	10255	0.072
2033	0.0544	4086	0.0584	6142	0.0464	8199	0.048	10256	0.0704
2034	0.048	4087	0.0544	6143	0.0464	8200	0.0504	10257	0.1
2035	0.048	4088	0.052	6144	0.0464	8201	0.052	10258	0.104
2036	0.052	4089	0.0544	6145	0.0464	8202	0.052	10259	0.0704
2037	0.052	4090	0.056	6146	0.048	8203	0.052	10260	0.076
2038	0.0504	4091	0.056	6147	0.0464	8204	0.052	10261	0.072
2039	0.052	4092	0.052	6148	0.0544	8205	0.0504	10262	0.0744
2040	0.0504	4093	0.0584	6149	0.056	8206	0.0544	10263	0.072
2041	0.0504	4094	0.0624	6150	0.052	8207	0.052	10264	0.072
2042	0.0504	4095	0.0544	6151	0.0464	8208	0.0504	10265	0.0664
2043	0.052	4096	0.052	6152	0.0464	8209	0.052	10266	0.0664
2044	0.052	4097	0.056	6153	0.0464	8210	0.052	10267	0.064
2045	0.052	4098	0.0584	6154	0.0464	8211	0.0464	10268	0.064
2046	0.052	4099	0.052	6155	0.0464	8212	0.048	10269	0.0664
2047	0.0584	4100	0.0584	6156	0.0584	8213	0.0504	10270	0.0704
2048	0.06	4101	0.0584	6157	0.06	8214	0.0504	10271	0.076
2049	0.052	4102	0.052	6158	0.0464	8215	0.048	10272	0.072
2050	0.052	4103	0.052	6159	0.0464	8216	0.0504	10273	0.0744
2051	0.0544	4104	0.0544	6160	0.0464	8217	0.0504	10274	0.076
2052	0.056	4105	0.052	6161	0.0504	8218	0.0464	10275	0.072
2053	0.056	4106	0.052	6162	0.052	8219	0.0504	10276	0.0704
		4107	0.064	6163	0.0584	8220	0.052	10277	0.0704
		4108	0.0544	6164	0.048	8221	0.0504	10278	0.072
		4109	0.0584	6165	0.0464	8222	0.0464	10279	0.0704
				6166	0.0504	8223	0.048	10280	0.076

Occupied period, indoor PM concentrations

日期:201611250759	PM2.5:62	PM10:74	VOC:0.48	日期:201611250912	PM2.5:54	PM10:60	VOC:0.48
日期:201611250800	PM2.5:65	PM10:76	VOC:0.48	日期:201611250913	PM2.5:53	PM10:60	VOC:0.48
日期:201611250801	PM2.5:64	PM10:73	VOC:0.48	日期:201611250914	PM2.5:52	PM10:59	VOC:0.48
日期:201611250802	PM2.5:65	PM10:75	VOC:0.48	日期:201611250915	PM2.5:51	PM10:57	VOC:0.48
日期:201611250803	PM2.5:65	PM10:74	VOC:0.48	日期:201611250916	PM2.5:53	PM10:62	VOC:0.48
日期:201611250804	PM2.5:63	PM10:76	VOC:0.48	日期:201611250917	PM2.5:53	PM10:63	VOC:0.48
日期:201611250805	PM2.5:65	PM10:74	VOC:0.48	日期:201611250918	PM2.5:51	PM10:59	VOC:0.48
日期:201611250806	PM2.5:66	PM10:73	VOC:0.48	日期:201611250919	PM2.5:52	PM10:59	VOC:0.48
日期:201611250807	PM2.5:67	PM10:78	VOC:0.48	日期:201611250920	PM2.5:53	PM10:58	VOC:0.48
日期:201611250808	PM2.5:70	PM10:82	VOC:0.48	日期:201611250921	PM2.5:57	PM10:65	VOC:0.48
日期:201611250809	PM2.5:71	PM10:89	VOC:0.48	日期:201611250922	PM2.5:53	PM10:60	VOC:0.48
日期:201611250810	PM2.5:70	PM10:82	VOC:0.48	日期:201611250923	PM2.5:59	PM10:67	VOC:0.48
日期:201611250811	PM2.5:70	PM10:81	VOC:0.48	日期:201611250924	PM2.5:59	PM10:69	VOC:0.48
日期:201611250812	PM2.5:73	PM10:80	VOC:0.48	日期:201611250925	PM2.5:57	PM10:60	VOC:0.48
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Occupied period, IAQ

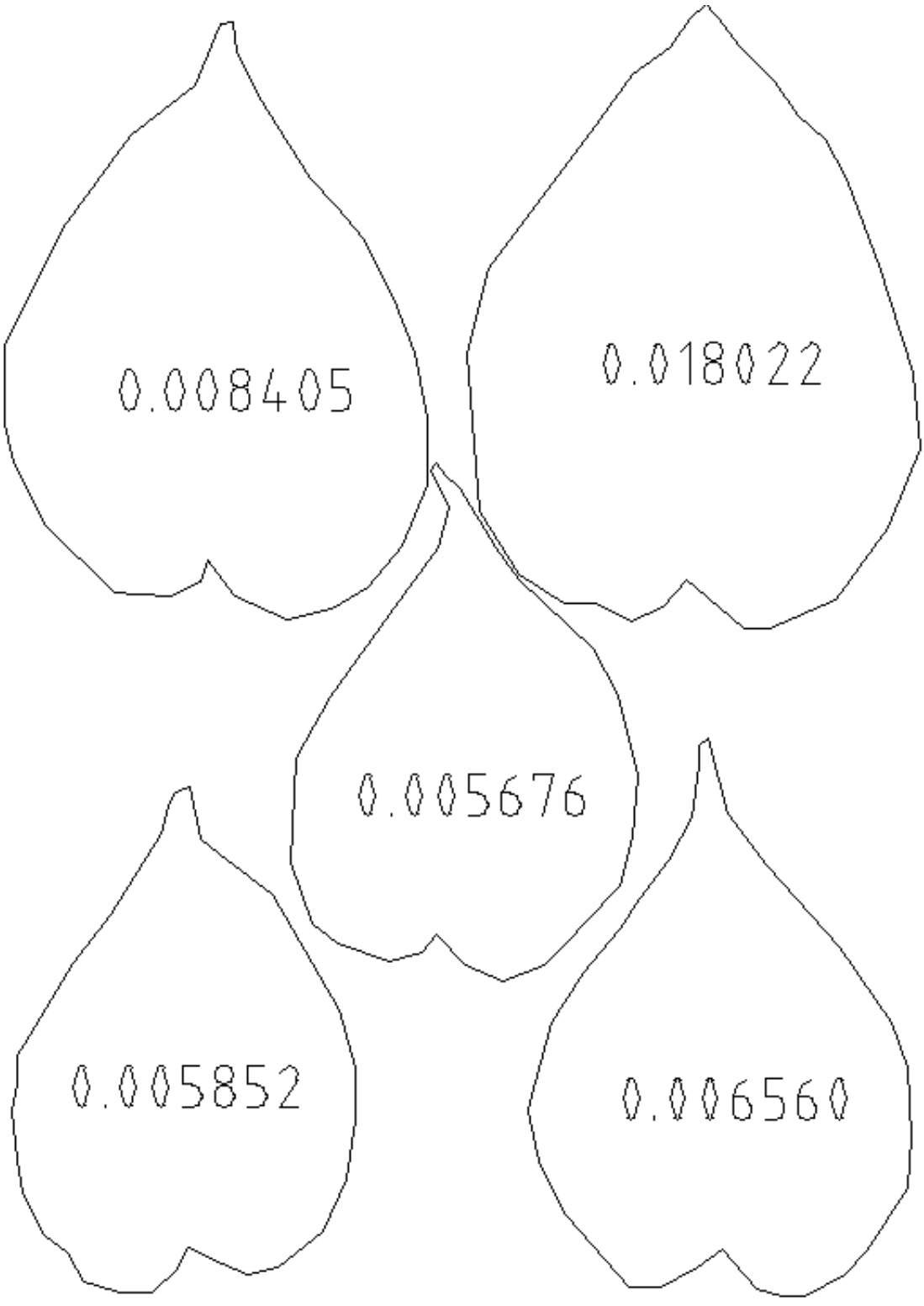
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2016/11/16	08:43:00;	17;	36.4;	907;
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2016/11/16	09:27:00;	14.3;	42.9;	1417;
2016/11/16	09:28:00;	14.2;	43;	1429;
2016/11/16	09:29:00;	14.3;	42.8;	1429;
2016/11/16	09:30:00;	14.2;	43;	1429;
2016/11/16	09:31:00;	14.3;	43.2;	1451;
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2016/11/16	09:40:00;	14.2;	44;	1564;
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2016/11/16	09:56:00;	14.3;	44.2;	1697;
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2016/11/16	09:58:00;	14.4;	41.3;	1436;
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2016/11/16	10:14:00;	15.1;	36.3;	1006;
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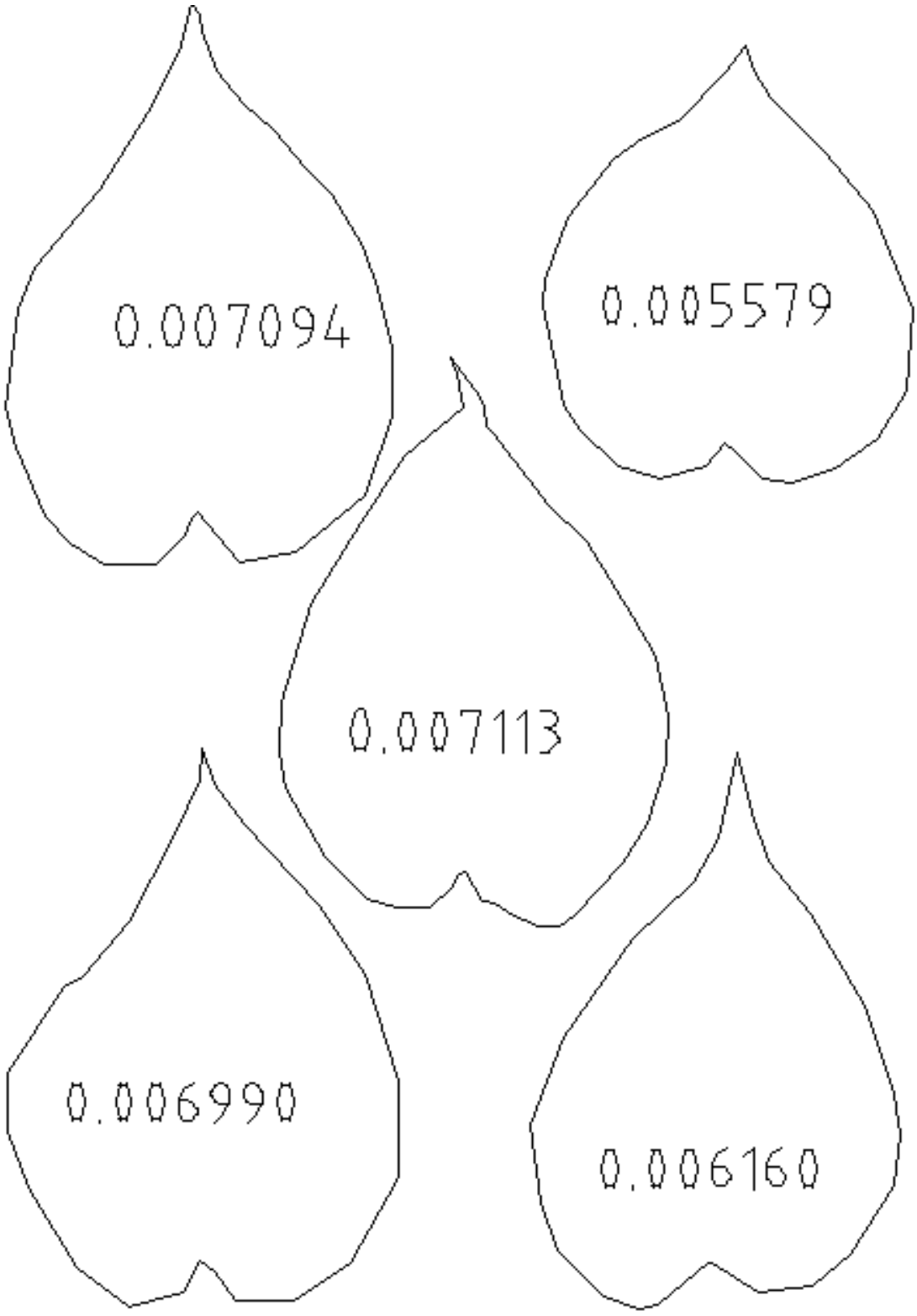
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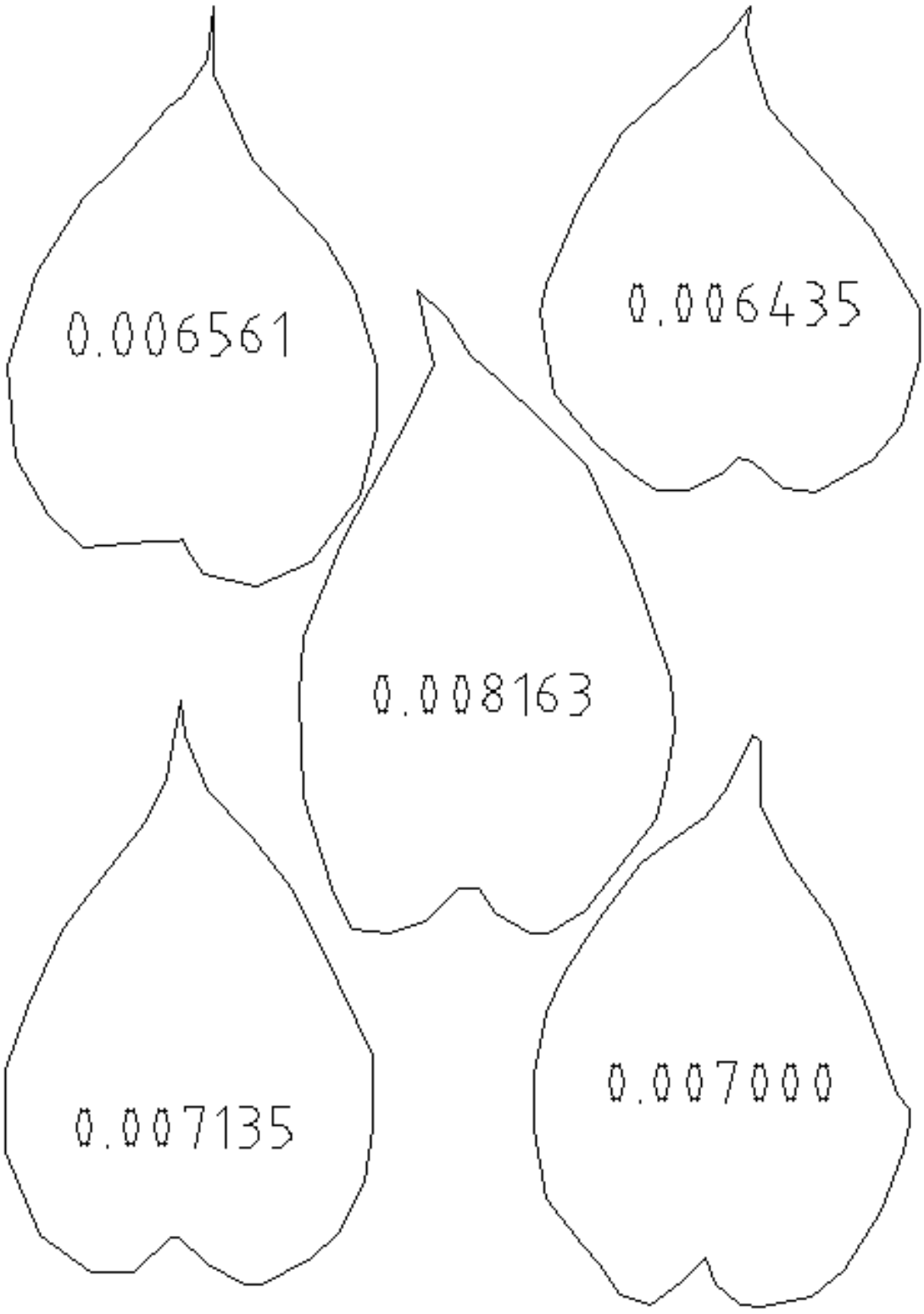
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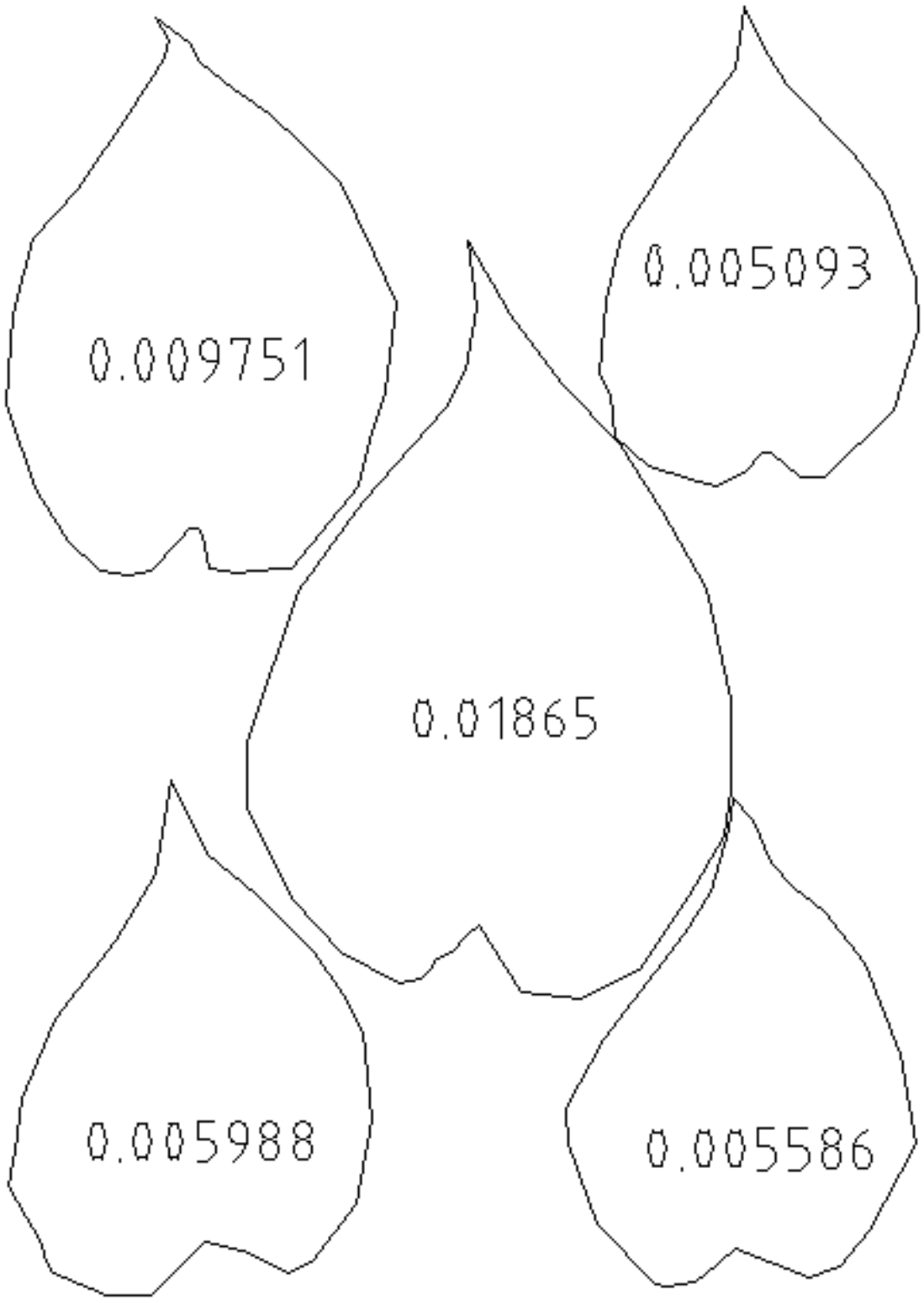
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2016/11/16 15:25:00	15.7	33.7	1232
2016/11/16 15:26:00	15.6	34	1227
2016/11/16 15:27:00	15.7	34	1227
2016/11/16 15:28:00	15.7	34	1220
2016/11/16 15:29:00	15.7	34.2	1212
2016/11/16 15:30:00	15.6	34.2	1220
2016/11/16 15:31:00	15.7	33.9	1222
2016/11/16 15:32:00	15.6	33.9	1215
2016/11/16 15:33:00	15.7	34	1215
2016/11/16 15:34:00	15.6	34	1222
2016/11/16 15:35:00	15.7	34	1222
2016/11/16 15:36:00	15.7	34	1222
2016/11/16 15:37:00	15.7	34	1222
2016/11/16 15:38:00	15.7	33.9	1207
2016/11/16 15:39:00	15.7	33.8	1194
2016/11/16 15:40:00	15.7	34	1194
2016/11/16 15:41:00	15.7	33.9	1192
2016/11/16 15:42:00	15.7	34	1192
2016/11/16 15:43:00	15.7	34	1192
2016/11/16 15:44:00	15.6	34.2	1192
2016/11/16 15:45:00	15.7	34	1192
2016/11/16 15:46:00	15.6	34	1187
2016/11/16 15:47:00	15.7	34.3	1187
2016/11/16 15:48:00	15.6	34.3	1194
2016/11/16 15:49:00	15.6	34.3	1192
2016/11/16 15:50:00	15.6	34.4	1192
2016/11/16 15:51:00	15.7	34.5	1192
2016/11/16 15:52:00	15.6	34.5	1200
2016/11/16 15:53:00	15.6	34.5	1200
2016/11/16 15:54:00	15.6	34.7	1200
2016/11/16 15:55:00	15.6	34.8	1215
2016/11/16 15:56:00	15.5	35	1215
2016/11/16 15:57:00	15.6	34.9	1215
2016/11/16 15:58:00	15.5	35.3	1247
2016/11/16 15:59:00	15.5	35	1257
2016/11/16 16:00:00	15.5	34.8	1227
2016/11/16 16:01:00	15.5	34.8	1222
2016/11/16 16:02:00	15.4	35	1215
2016/11/16 16:03:00	15.5	35	1212
2016/11/16 16:04:00	15.5	35	1237

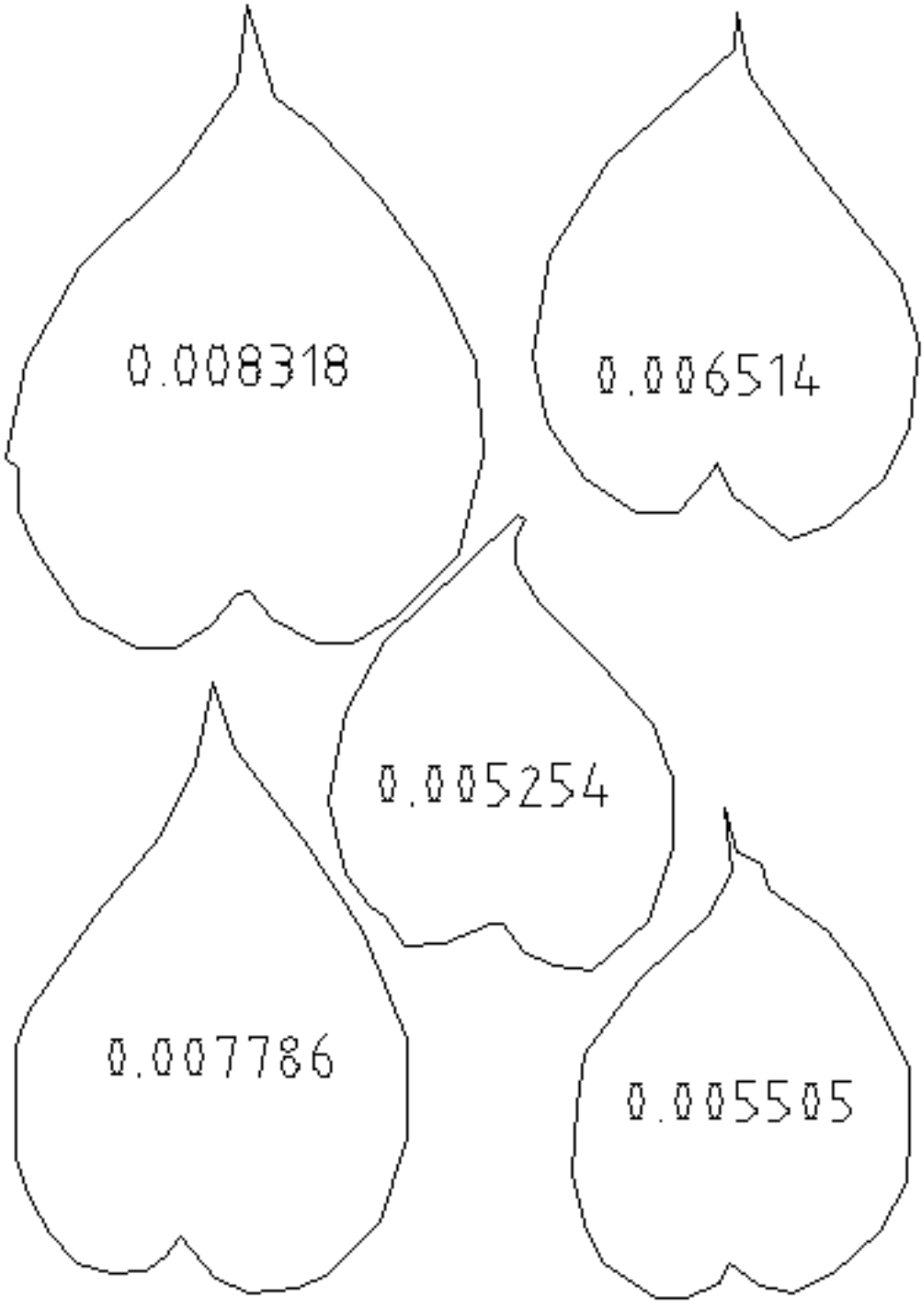
Appendix II: Scanned pictures of leaves- taking plant A as an example

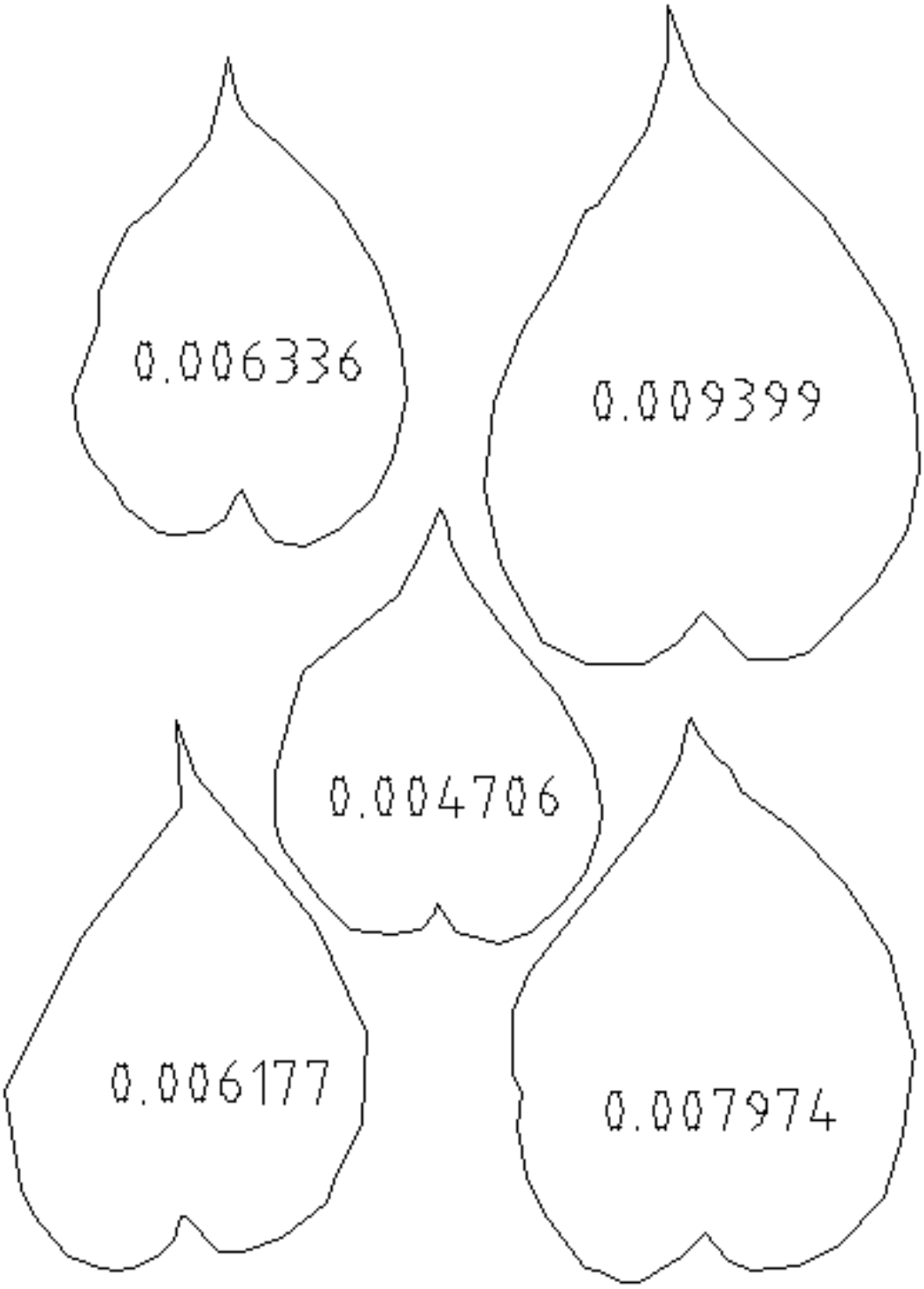


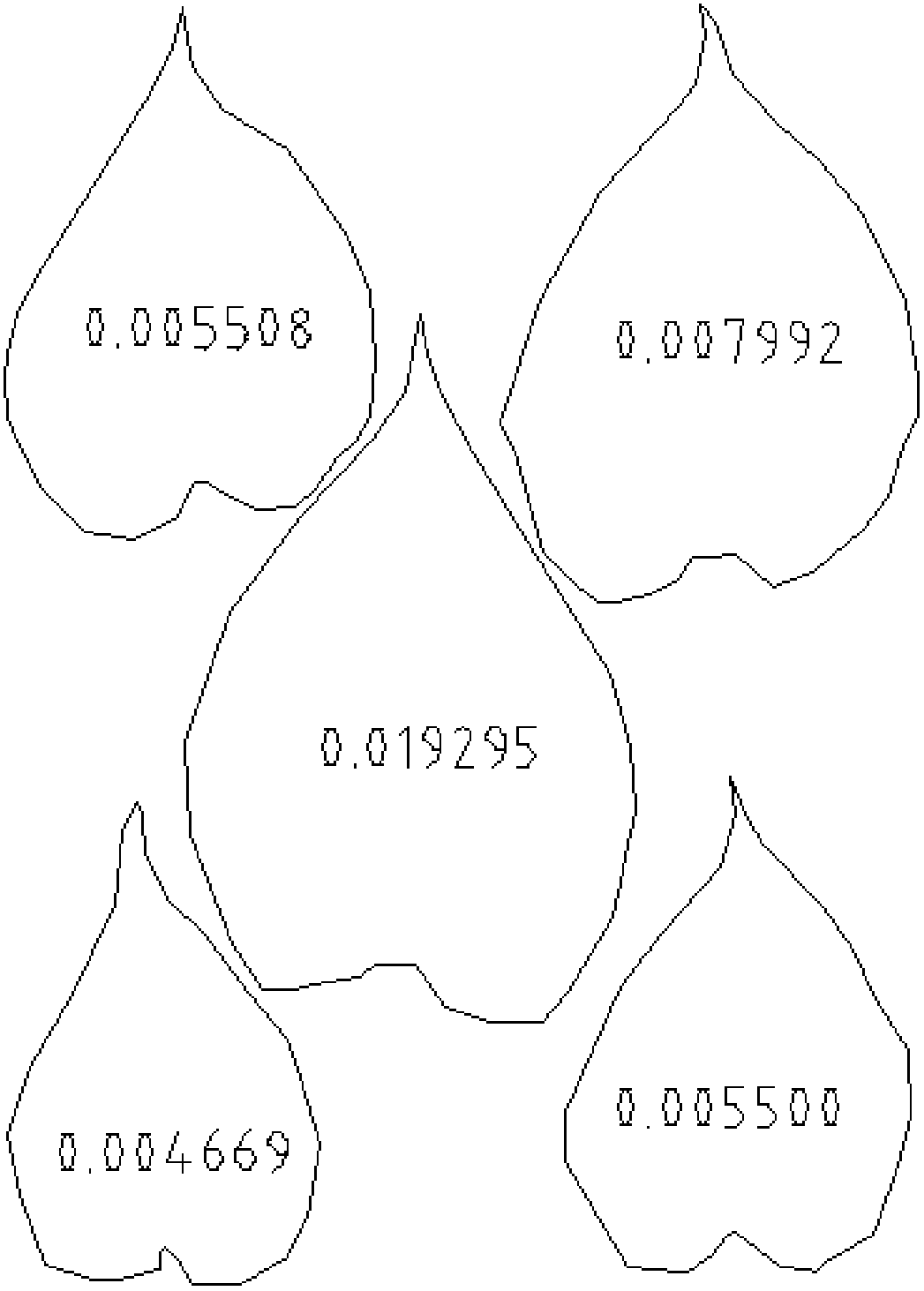

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0.005579
0.007113
0.006990
0.006160

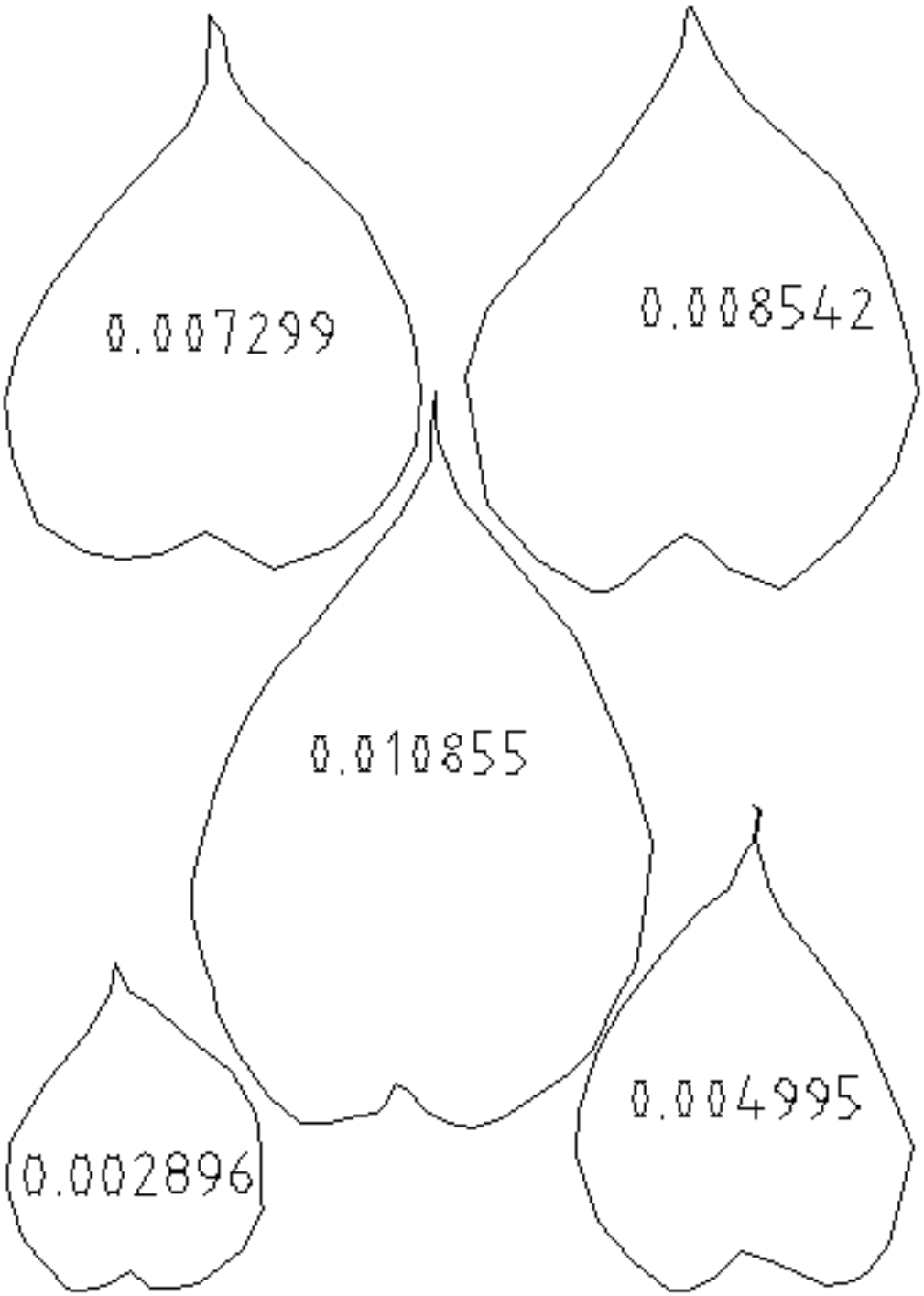

0.006561
0.006435
0.008163
0.007135
0.007000

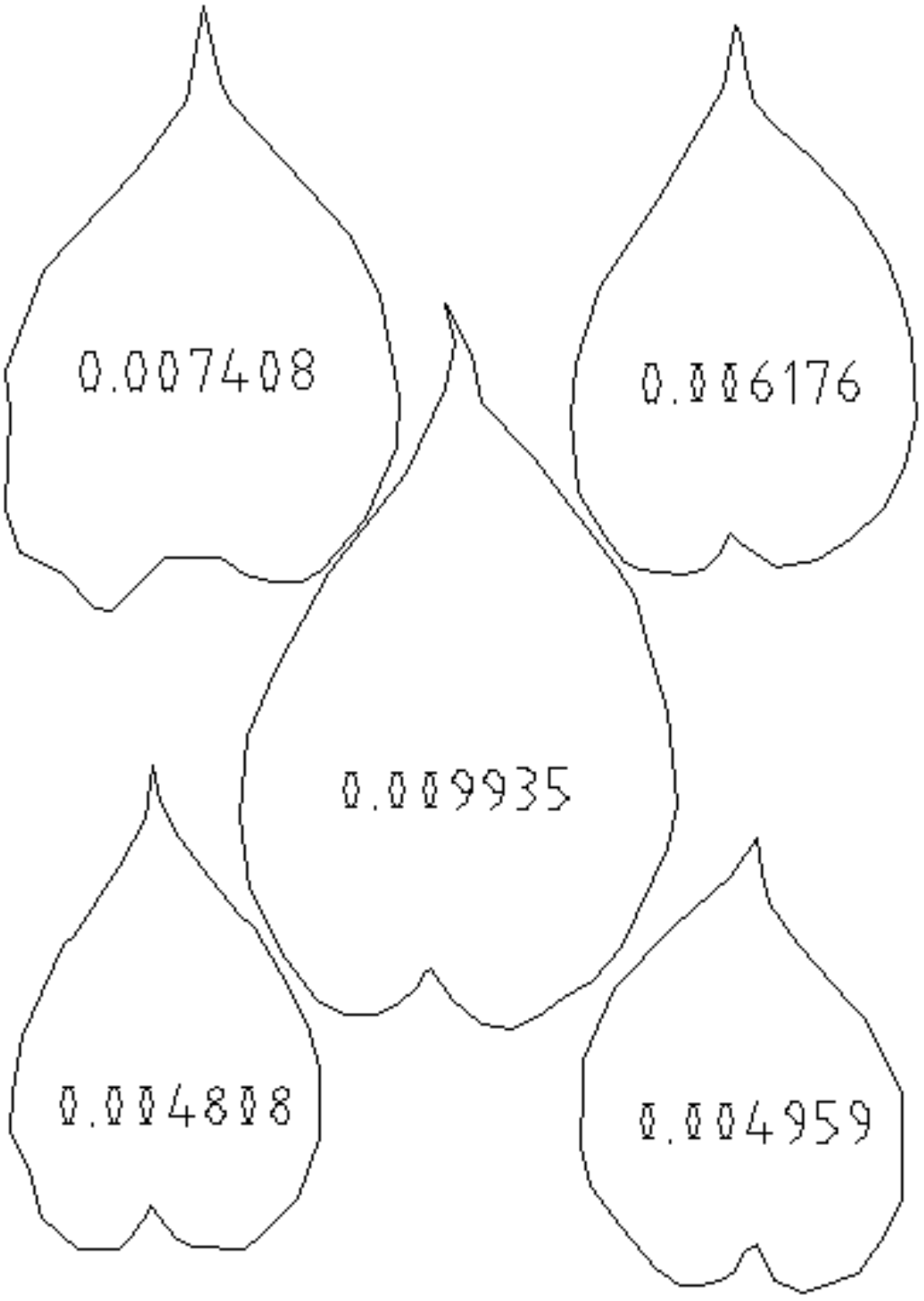

0.009751
0.005093
0.01865
0.005988
0.005586

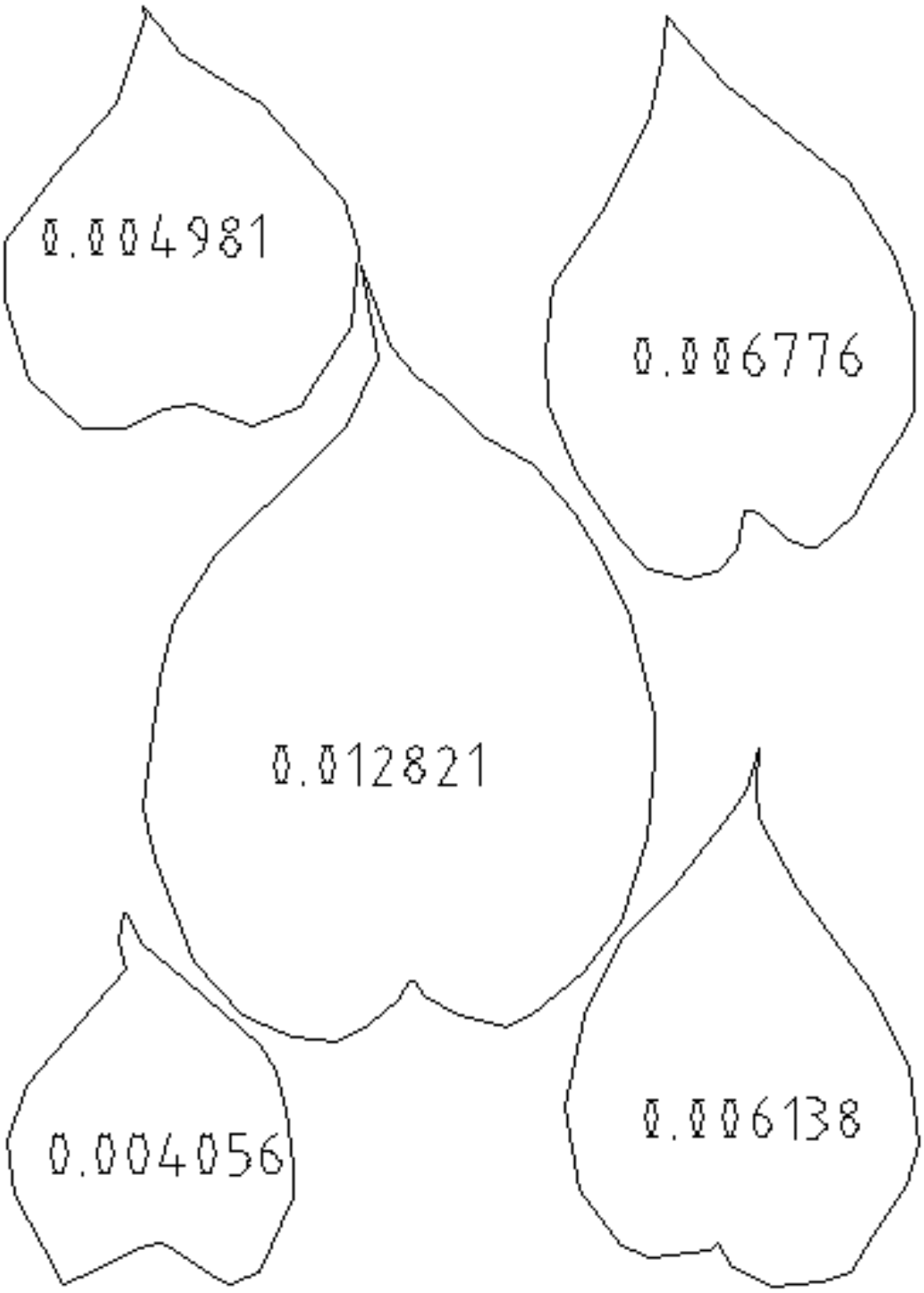

0.008318
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0.005254
0.007786
0.005505


0.006336
0.009399
0.004706
0.006177
0.007974


0.005508
0.007992
0.019295
0.004669
0.005500


0.007299
0.008542
0.010855
0.002896
0.004995


0.007408
0.006176
0.009935
0.004808
0.004959


0.004981
0.006776
0.012821
0.004056
0.006138

Appendix III: Surface areas of sample leaves of the potted plants (m^2)

Numbered leaves	A	B	C	D	E	F	G	H	I	J
1	0.0084	0.0056	0.0063	0.0051	0.0069	0.0082	0.0065	0.0035	0.0062	0.0076
2	0.0180	0.0095	0.0080	0.0066	0.0050	0.0060	0.0062	0.0060	0.0057	0.0057
3	0.0057	0.0103	0.0112	0.0082	0.0078	0.0108	0.0084	0.0109	0.0118	0.0065
4	0.0059	0.0052	0.0096	0.0078	0.0067	0.0049	0.0082	0.0051	0.0097	0.0065
5	0.0066	0.0053	0.0059	0.0058	0.0101	0.0078	0.0071	0.0080	0.0079	0.0075
6	0.0071	0.0047	0.0120	0.0073	0.0071	0.0050	0.0066	0.0062	0.0067	0.0084
7	0.0056	0.0065	0.0079	0.0061	0.0071	0.0080	0.0091	0.0074	0.0061	0.0077
8	0.0071	0.0111	0.0049	0.0097	0.0128	0.0137	0.0076	0.0081	0.0118	0.0086
9	0.0070	0.0048	0.0124	0.0058	0.0076	0.0039	0.0052	0.0083	0.0083	0.0056
10	0.0062	0.0124	0.0065	0.0068	0.0093	0.0091	0.0068	0.0091	0.0071	0.0067
11	0.0066	0.0052	0.0055	0.0057	0.0067	0.0076	0.0110	0.0051	0.0048	0.0073
12	0.0082	0.0061	0.0115	0.0059	0.0092	0.0077	0.0106	0.0064	0.0065	0.0057
13	0.0064	0.0091	0.0081	0.0088	0.0148	0.0118	0.0070	0.0086	0.0108	0.0098
14	0.0070	0.0107	0.0080	0.0075	0.0054	0.0035	0.0073	0.0060	0.0056	0.0056
15	0.0071	0.0090	0.0102	0.0068	0.0059	0.0043	0.0087	0.0069	0.0085	0.0088
16	0.0051	0.0055	0.0136	0.0071	0.0088	0.0078	0.0069	0.0049	0.0041	0.0078
17	0.0187	0.0126	0.0078	0.0045	0.0057	0.0089	0.0086	0.0058	0.0069	0.0060
18	0.0060	0.0109	0.0079	0.0110	0.0108	0.0072	0.0062	0.0126	0.0129	0.0128
19	0.0056	0.0052	0.0053	0.0051	0.0060	0.0085	0.0120	0.0052	0.0073	0.0074
20	0.0098	0.0075	0.0080	0.0049	0.0049	0.0106	0.0094	0.0073	0.0075	0.0053
21	0.0065	0.0116	0.0069	0.0081	0.0081	0.0082	0.0050	0.0053	0.0056	0.0090
22	0.0053	0.0063	0.0089	0.0082	0.0064	0.0092	0.0041	0.0062	0.0051	0.0086
23	0.0078	0.0105	0.0124	0.0110	0.0099	0.0130	0.0122	0.0085	0.0126	0.0075
24	0.0055	0.0053	0.0037	0.0056	0.0076	0.0059	0.0079	0.0044	0.0075	0.0089
25	0.0083	0.0037	0.0066	0.0055	0.0075	0.0043	0.0066	0.0044	0.0066	0.0095
26	0.0047	0.0054	0.0080	0.0059	0.0085	0.0045	0.0072	0.0072	0.0077	0.0073
27	0.0062	0.0061	0.0035	0.0066	0.0086	0.0074	0.0066	0.0061	0.0051	0.0097
28	0.0080	0.0166	0.0066	0.0082	0.0129	0.0111	0.0079	0.0089	0.0116	0.0080
29	0.0094	0.0046	0.0068	0.0083	0.0049	0.0063	0.0071	0.0099	0.0078	0.0081
30	0.0063	0.0061	0.0089	0.0072	0.0036	0.0075	0.0073	0.0069	0.0077	0.0047
31	0.0080	0.0060	0.0042	0.0059	0.0055	0.0038	0.0069	0.0073	0.0036	0.0091
32	0.0193	0.0113	0.0134	0.0077	0.0088	0.0051	0.0089	0.0060	0.0048	0.0067
33	0.0047	0.0083	0.0073	0.0113	0.0115	0.0119	0.0071	0.0103	0.0054	0.0052
34	0.0055	0.0074	0.0055	0.0061	0.0064	0.0059	0.0065	0.0071	0.0139	0.0083
35	0.0055	0.0048	0.0081	0.0092	0.0046	0.0076	0.0087	0.0075	0.0089	0.0080
36	0.0073	0.0056	0.0058	0.0067	0.0082	0.0074	0.0078	0.0077	0.0067	0.0053
37	0.0085	0.0104	0.0046	0.0078	0.0076	0.0065	0.0073	0.0071	0.0052	0.0079
38	0.0109	0.0084	0.0061	0.0090	0.0117	0.0146	0.0098	0.0102	0.0056	0.0091
39	0.0029	0.0074	0.0085	0.0045	0.0056	0.0041	0.0063	0.0078	0.0077	0.0081
40	0.0050	0.0055	0.0088	0.0078	0.0050	0.0041	0.0126	0.0067	0.0093	0.0107
41	0.0074	0.0046	0.0088	0.0098	0.0085	0.0066	0.0058	0.0064	0.0063	0.0049
42	0.0099	0.0048	0.0048	0.0044	0.0053	0.0068	0.0085	0.0072	0.0056	0.0097
43	0.0048	0.0063	0.0087	0.0055	0.0061	0.0085	0.0087	0.0075	0.0114	0.0051
44	0.0050	0.0119	0.0062	0.0044	0.0063	0.0081	0.0095	0.0062	0.0063	0.0071
45	0.0062	0.0099	0.0060	0.0103	0.0114	0.0072	0.0097	0.0114	0.0088	0.0062
46	0.0050	0.0064	0.0071	0.0076	0.0082	0.0069	0.0051	0.0072	0.0070	0.0063
47	0.0128	0.0120	0.0045	0.0053	0.0100	0.0071	0.0045	0.0074	0.0076	0.0064
48	0.0098	0.0058	0.0090	0.0092	0.0060	0.0011	0.0115	0.0110	0.0105	0.0156
49	0.0061	0.0064	0.0065	0.0060	0.0059	0.0057	0.0054	0.0046	0.0055	0.0057
50	0.0050	0.0055	0.0065	0.0076	0.0084	0.0070	0.0140	0.0080	0.0056	0.0052
Mean	0.0074	0.0076	0.0077	0.0071	0.0078	0.0074	0.0079	0.0073	0.0076	0.0076

Numbered leaves	K	L	M	N	O	P	Q	I	S	T
1	0.0085	0.0056	0.0057	0.0111	0.0080	0.0122	0.0057	0.0076	0.0117	0.0087
2	0.0054	0.0067	0.0086	0.0065	0.0044	0.0060	0.0054	0.0058	0.0081	0.0079
3	0.0100	0.0096	0.0066	0.0131	0.0062	0.0056	0.0064	0.0094	0.0092	0.0094
4	0.0057	0.0069	0.0112	0.0060	0.0072	0.0072	0.0060	0.0089	0.0047	0.0059
5	0.0079	0.0045	0.0090	0.0051	0.0111	0.0070	0.0123	0.0079	0.0069	0.0056
6	0.0064	0.0063	0.0100	0.0089	0.0076	0.0059	0.0061	0.0062	0.0059	0.0061
7	0.0069	0.0055	0.0073	0.0068	0.0053	0.0055	0.0060	0.0050	0.0075	0.0060
8	0.0070	0.0078	0.0074	0.0087	0.0053	0.0104	0.0087	0.0095	0.0133	0.0181
9	0.0085	0.0083	0.0072	0.0054	0.0091	0.0064	0.0094	0.0058	0.0034	0.0056
10	0.0088	0.0068	0.0136	0.0070	0.0088	0.0061	0.0080	0.0061	0.0044	0.0071
11	0.0085	0.0073	0.0110	0.0055	0.0063	0.0055	0.0056	0.0086	0.0098	0.0067
12	0.0068	0.0069	0.0087	0.0112	0.0053	0.0074	0.0066	0.0077	0.0075	0.0085
13	0.0012	0.0068	0.0085	0.0065	0.0054	0.0115	0.0134	0.0074	0.0118	0.0053
14	0.0054	0.0087	0.0093	0.0113	0.0083	0.0064	0.0052	0.0087	0.0050	0.0074
15	0.0058	0.0086	0.0080	0.0096	0.0073	0.0093	0.0073	0.0060	0.0041	0.0079
16	0.0069	0.0061	0.0084	0.0131	0.0052	0.0091	0.0081	0.0049	0.0077	0.0101
17	0.0077	0.0061	0.0055	0.0070	0.0036	0.0084	0.0109	0.0067	0.0053	0.0073
18	0.0066	0.0109	0.0055	0.0054	0.0113	0.0085	0.0057	0.0191	0.0078	0.0087
19	0.0088	0.0080	0.0089	0.0092	0.0121	0.0066	0.0055	0.0055	0.0061	0.0065
20	0.0077	0.0073	0.0144	0.0062	0.0080	0.0074	0.0065	0.0075	0.0047	0.0061
21	0.0070	0.0070	0.0078	0.0063	0.0093	0.0066	0.0060	0.0078	0.0054	0.0051
22	0.0073	0.0079	0.0074	0.0034	0.0068	0.0071	0.0083	0.0058	0.0061	0.0060
23	0.0106	0.0075	0.0117	0.0060	0.0070	0.0103	0.0100	0.0091	0.0080	0.0079
24	0.0071	0.0085	0.0063	0.0134	0.0072	0.0061	0.0060	0.0080	0.0047	0.0056
25	0.0078	0.0068	0.0077	0.0093	0.0082	0.0091	0.0075	0.0058	0.0071	0.0083
26	0.0062	0.0061	0.0059	0.0066	0.0084	0.0091	0.0080	0.0055	0.0066	0.0056
27	0.0075	0.0076	0.0064	0.0057	0.0061	0.0101	0.0046	0.0046	0.0072	0.0055
28	0.0075	0.0108	0.0096	0.0108	0.0063	0.0065	0.0084	0.0094	0.0058	0.0096
29	0.0077	0.0074	0.0078	0.0057	0.0059	0.0055	0.0062	0.0050	0.0066	0.0054
30	0.0077	0.0079	0.0089	0.0078	0.0088	0.0083	0.0079	0.0060	0.0090	0.0057
31	0.0080	0.0088	0.0132	0.0068	0.0067	0.0077	0.0095	0.0049	0.0042	0.0075
32	0.0065	0.0073	0.0082	0.0091	0.0080	0.0067	0.0061	0.0048	0.0057	0.0086
33	0.0082	0.0076	0.0050	0.0065	0.0059	0.0085	0.0099	0.0095	0.0123	0.0095
34	0.0081	0.0067	0.0084	0.0078	0.0079	0.0079	0.0050	0.0067	0.0039	0.0056
35	0.0099	0.0080	0.0087	0.0059	0.0050	0.0073	0.0055	0.0088	0.0089	0.0068
36	0.0064	0.0092	0.0065	0.0082	0.0066	0.0076	0.0124	0.0063	0.0079	0.0053
37	0.0086	0.0088	0.0066	0.0059	0.0072	0.0085	0.0050	0.0072	0.0065	0.0077
38	0.0084	0.0071	0.0131	0.0048	0.0043	0.0077	0.0107	0.0198	0.0094	0.0062
39	0.0062	0.0094	0.0095	0.0093	0.0070	0.0067	0.0046	0.0057	0.0059	0.0057
40	0.0078	0.0056	0.0048	0.0067	0.0100	0.0076	0.0045	0.0062	0.0082	0.0071
41	0.0081	0.0057	0.0082	0.0062	0.0065	0.0057	0.0056	0.0048	0.0069	0.0044
42	0.0106	0.0059	0.0100	0.0096	0.0068	0.0097	0.0057	0.0099	0.0074	0.0071
43	0.0083	0.0085	0.0097	0.0077	0.0074	0.0083	0.0124	0.0083	0.0098	0.0194
44	0.0073	0.0092	0.0053	0.0127	0.0086	0.0056	0.0066	0.0066	0.0083	0.0058
45	0.0067	0.0097	0.0082	0.0076	0.0102	0.0069	0.0089	0.0098	0.0058	0.0064
46	0.0063	0.0069	0.0070	0.0058	0.0059	0.0081	0.0053	0.0061	0.0048	0.0045
47	0.0073	0.0081	0.0080	0.0059	0.0064	0.0098	0.0053	0.0095	0.0107	0.0049
48	0.0093	0.0113	0.0132	0.0057	0.0112	0.0131	0.0075	0.0061	0.0054	0.0071
49	0.0082	0.0065	0.0066	0.0111	0.0063	0.0052	0.0091	0.0087	0.0079	0.0107
50	0.0093	0.0082	0.0071	0.0143	0.0007	0.0054	0.0089	0.0075	0.0072	0.0081
Mean	0.0075	0.0076	0.0084	0.0079	0.0072	0.0077	0.0074	0.0076	0.0072	0.0074

Appendix IV: Experimental Study on Plants' Capabilities in Removing PMs-taking scenario 2 as an example

27th December

	Inside		Outside			Inside		Outside	
日期:201712270000	PM2.5:062	PM10:074	PM2.5:142	PM10:154	日期:201712271212	PM2.5:029	PM10:032	PM2.5:109	PM10:124
日期:201712270001	PM2.5:058	PM10:065	PM2.5:143	PM10:155	日期:201712271213	PM2.5:035	PM10:039	PM2.5:111	PM10:125
日期:201712270002	PM2.5:058	PM10:070	PM2.5:131	PM10:155	日期:201712271214	PM2.5:030	PM10:035	PM2.5:112	PM10:134
日期:201712270003	PM2.5:059	PM10:069	PM2.5:139	PM10:160	日期:201712271215	PM2.5:030	PM10:033	PM2.5:103	PM10:116
日期:201712270004	PM2.5:057	PM10:066	PM2.5:144	PM10:159	日期:201712271216	PM2.5:030	PM10:036	PM2.5:108	PM10:123
日期:201712270005	PM2.5:058	PM10:065	PM2.5:144	PM10:156	日期:201712271217	PM2.5:029	PM10:035	PM2.5:100	PM10:111
日期:201712270006	PM2.5:058	PM10:066	PM2.5:147	PM10:168	日期:201712271218	PM2.5:027	PM10:032	PM2.5:110	PM10:128
日期:201712270007	PM2.5:058	PM10:070	PM2.5:143	PM10:168	日期:201712271219	PM2.5:027	PM10:029	PM2.5:107	PM10:124
日期:201712270008	PM2.5:055	PM10:067	PM2.5:142	PM10:166	日期:201712271220	PM2.5:032	PM10:038	PM2.5:116	PM10:127
日期:201712270009	PM2.5:061	PM10:067	PM2.5:148	PM10:170	日期:201712271221	PM2.5:030	PM10:037	PM2.5:110	PM10:130
日期:201712270010	PM2.5:055	PM10:065	PM2.5:141	PM10:168	日期:201712271222	PM2.5:030	PM10:033	PM2.5:112	PM10:123
日期:201712270011	PM2.5:060	PM10:072	PM2.5:138	PM10:159	日期:201712271223	PM2.5:025	PM10:029	PM2.5:116	PM10:137
日期:201712270012	PM2.5:056	PM10:064	PM2.5:137	PM10:169	日期:201712271224	PM2.5:032	PM10:036	PM2.5:113	PM10:129
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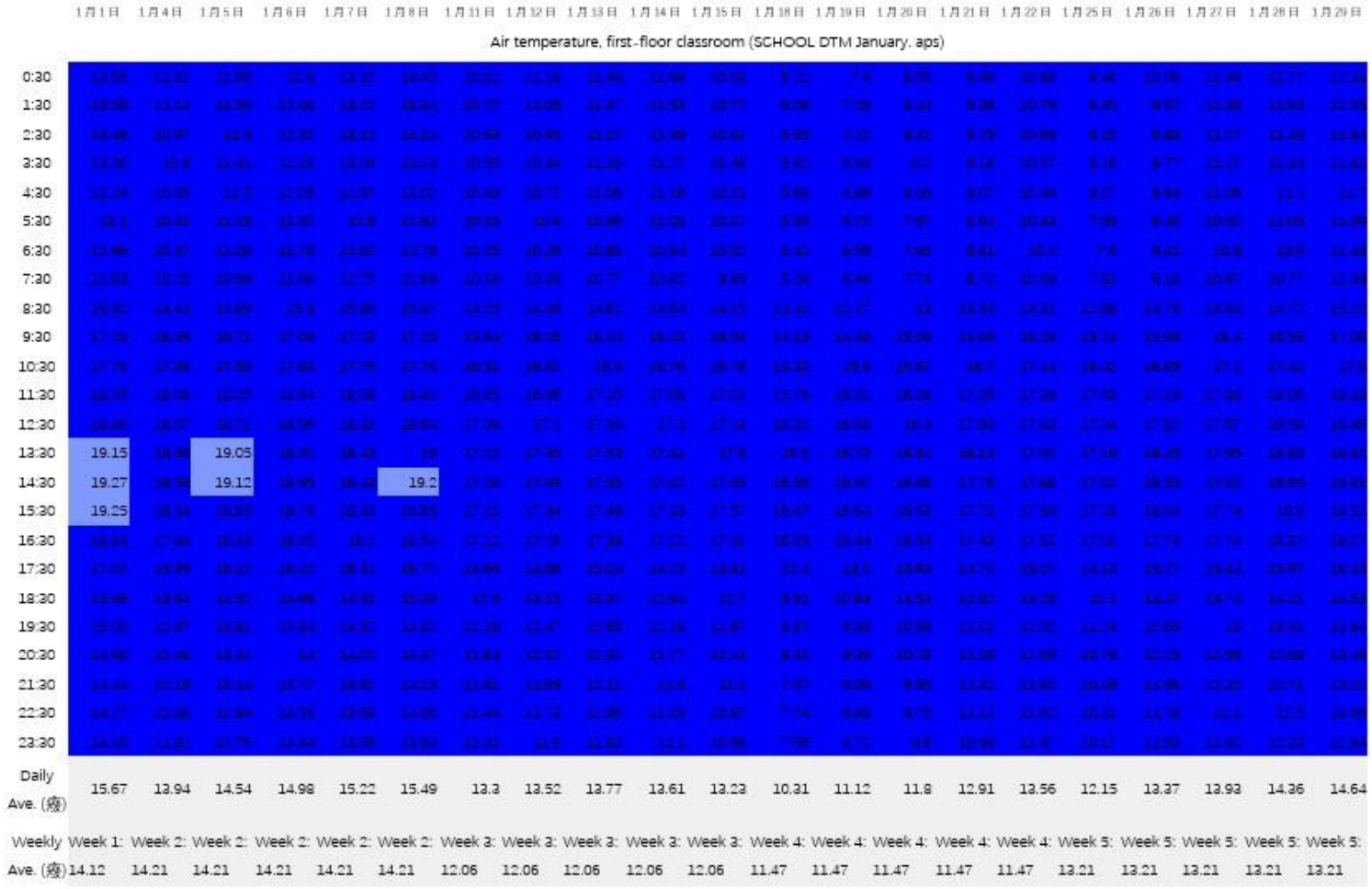
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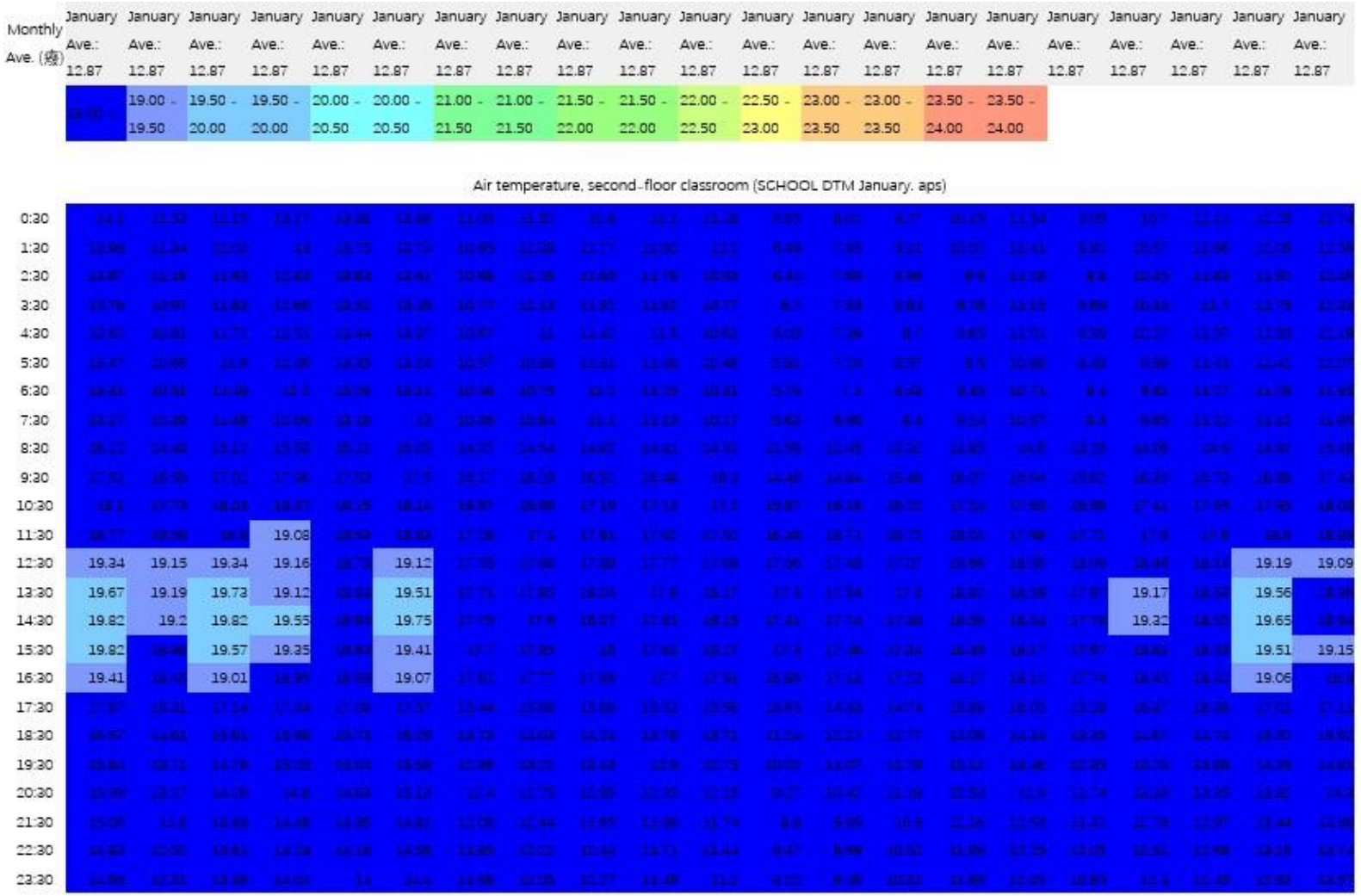
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日期:201712271114 PM2.5:033 PM10:039 PM2.5:096 PM10:106
日期:201712271115 PM2.5:031 PM10:035 PM2.5:091 PM10:107
日期:201712271116 PM2.5:034 PM10:039 PM2.5:097 PM10:111
日期:201712271117 PM2.5:029 PM10:034 PM2.5:097 PM10:112
日期:201712271118 PM2.5:033 PM10:037 PM2.5:094 PM10:111
日期:201712271119 PM2.5:031 PM10:036 PM2.5:097 PM10:115
日期:201712271120 PM2.5:031 PM10:036 PM2.5:100 PM10:112
日期:201712271121 PM2.5:032 PM10:035 PM2.5:093 PM10:103
日期:201712271122 PM2.5:031 PM10:035 PM2.5:090 PM10:104
日期:201712271123 PM2.5:032 PM10:035 PM2.5:104 PM10:119
日期:201712271124 PM2.5:033 PM10:036 PM2.5:101 PM10:117
日期:201712271125 PM2.5:030 PM10:035 PM2.5:100 PM10:114
日期:201712271126 PM2.5:028 PM10:030 PM2.5:097 PM10:104
日期:201712271127 PM2.5:032 PM10:037 PM2.5:098 PM10:111
日期:201712271128 PM2.5:031 PM10:035 PM2.5:096 PM10:110
日期:201712271129 PM2.5:034 PM10:039 PM2.5:097 PM10:109
日期:201712271130 PM2.5:030 PM10:033 PM2.5:103 PM10:116
日期:201712271131 PM2.5:032 PM10:034 PM2.5:104 PM10:121
日期:201712271132 PM2.5:030 PM10:035 PM2.5:104 PM10:114
日期:201712271133 PM2.5:028 PM10:036 PM2.5:099 PM10:109
日期:201712271134 PM2.5:032 PM10:035 PM2.5:096 PM10:107
日期:201712271135 PM2.5:029 PM10:032 PM2.5:103 PM10:115
日期:201712271136 PM2.5:027 PM10:034 PM2.5:101 PM10:116
日期:201712271137 PM2.5:029 PM10:036 PM2.5:100 PM10:115
日期:201712271138 PM2.5:029 PM10:032 PM2.5:106 PM10:120
日期:201712271139 PM2.5:026 PM10:029 PM2.5:105 PM10:120
日期:201712271140 PM2.5:030 PM10:034 PM2.5:103 PM10:119
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日期:201712271143 PM2.5:030 PM10:034 PM2.5:094 PM10:112
日期:201712271144 PM2.5:029 PM10:033 PM2.5:107 PM10:125
日期:201712271145 PM2.5:034 PM10:038 PM2.5:111 PM10:121
日期:201712271146 PM2.5:030 PM10:035 PM2.5:111 PM10:125
日期:201712271147 PM2.5:032 PM10:036 PM2.5:107 PM10:114
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日期:201712271152 PM2.5:031 PM10:034 PM2.5:107 PM10:117
日期:201712271153 PM2.5:029 PM10:033 PM2.5:107 PM10:120
日期:201712271154 PM2.5:027 PM10:031 PM2.5:105 PM10:112
日期:201712271155 PM2.5:030 PM10:032 PM2.5:106 PM10:124
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日期:201712271157 PM2.5:027 PM10:030 PM2.5:111 PM10:120
日期:201712271158 PM2.5:029 PM10:031 PM2.5:108 PM10:125
日期:201712271159 PM2.5:031 PM10:034 PM2.5:108 PM10:124
日期:201712271200 PM2.5:030 PM10:032 PM2.5:108 PM10:131
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日期:201712271203 PM2.5:029 PM10:032 PM2.5:097 PM10:107
日期:201712271204 PM2.5:031 PM10:035 PM2.5:097 PM10:111
日期:201712271205 PM2.5:030 PM10:034 PM2.5:097 PM10:107
日期:201712271206 PM2.5:030 PM10:033 PM2.5:101 PM10:114
日期:201712271207 PM2.5:027 PM10:032 PM2.5:103 PM10:124
日期:201712271208 PM2.5:032 PM10:036 PM2.5:112 PM10:127
日期:201712271209 PM2.5:028 PM10:030 PM2.5:113 PM10:135
日期:201712271210 PM2.5:033 PM10:040 PM2.5:107 PM10:121
日期:201712271211 PM2.5:027 PM10:029 PM2.5:112 PM10:122
日期:201712272318 PM2.5:060 PM10:065 PM2.5:110 PM10:134
日期:201712272319 PM2.5:058 PM10:064 PM2.5:118 PM10:131
日期:201712272320 PM2.5:059 PM10:066 PM2.5:117 PM10:134
日期:201712272321 PM2.5:061 PM10:070 PM2.5:111 PM10:129
日期:201712272322 PM2.5:056 PM10:062 PM2.5:118 PM10:133
日期:201712272323 PM2.5:059 PM10:064 PM2.5:113 PM10:129
日期:201712272324 PM2.5:059 PM10:067 PM2.5:109 PM10:134
日期:201712272325 PM2.5:062 PM10:069 PM2.5:103 PM10:120
日期:201712272326 PM2.5:060 PM10:072 PM2.5:108 PM10:126
日期:201712272327 PM2.5:060 PM10:069 PM2.5:107 PM10:127
日期:201712272328 PM2.5:063 PM10:069 PM2.5:108 PM10:127
日期:201712272329 PM2.5:059 PM10:075 PM2.5:108 PM10:123
日期:201712272330 PM2.5:061 PM10:068 PM2.5:114 PM10:128
日期:201712272331 PM2.5:060 PM10:065 PM2.5:113 PM10:124
日期:201712272332 PM2.5:063 PM10:073 PM2.5:108 PM10:131
日期:201712272333 PM2.5:064 PM10:075 PM2.5:110 PM10:118
日期:201712272334 PM2.5:063 PM10:072 PM2.5:110 PM10:138
日期:201712272335 PM2.5:064 PM10:072 PM2.5:112 PM10:125
日期:201712272336 PM2.5:063 PM10:075 PM2.5:108 PM10:131
日期:201712272337 PM2.5:064 PM10:069 PM2.5:106 PM10:120
日期:201712272338 PM2.5:060 PM10:071 PM2.5:113 PM10:125
日期:201712272339 PM2.5:060 PM10:068 PM2.5:118 PM10:132
日期:201712272340 PM2.5:059 PM10:065 PM2.5:145 PM10:172
日期:201712272341 PM2.5:066 PM10:076 PM2.5:155 PM10:173
日期:201712272342 PM2.5:065 PM10:075 PM2.5:154 PM10:177
日期:201712272343 PM2.5:061 PM10:069 PM2.5:162 PM10:181
日期:201712272344 PM2.5:070 PM10:08 PM2.5:167 PM10:193
日期:201712272345 PM2.5:060 PM10:068 PM2.5:166 PM10:190
日期:201712272346 PM2.5:068 PM10:078 PM2.5:176 PM10:211
日期:201712272347 PM2.5:064 PM10:073 PM2.5:171 PM10:196
日期:201712272348 PM2.5:065 PM10:075 PM2.5:174 PM10:198
日期:201712272349 PM2.5:063 PM10:074 PM2.5:175 PM10:197
日期:201712272350 PM2.5:068 PM10:074 PM2.5:171 PM10:194
日期:201712272351 PM2.5:062 PM10:070 PM2.5:168 PM10:189
日期:201712272352 PM2.5:066 PM10:076 PM2.5:169 PM10:199
日期:201712272353 PM2.5:065 PM10:075 PM2.5:169 PM10:201
日期:201712272354 PM2.5:063 PM10:073 PM2.5:173 PM10:194
日期:201712272355 PM2.5:063 PM10:073 PM2.5:172 PM10:212
日期:201712272356 PM2.5:063 PM10:073
日期:201712272357 PM2.5:063 PM10:073
日期:201712272358 PM2.5:063 PM10:073
日期:201712272359 PM2.5:063 PM10:073

Appendix V: DTM simulation results of classrooms-taking January as an example



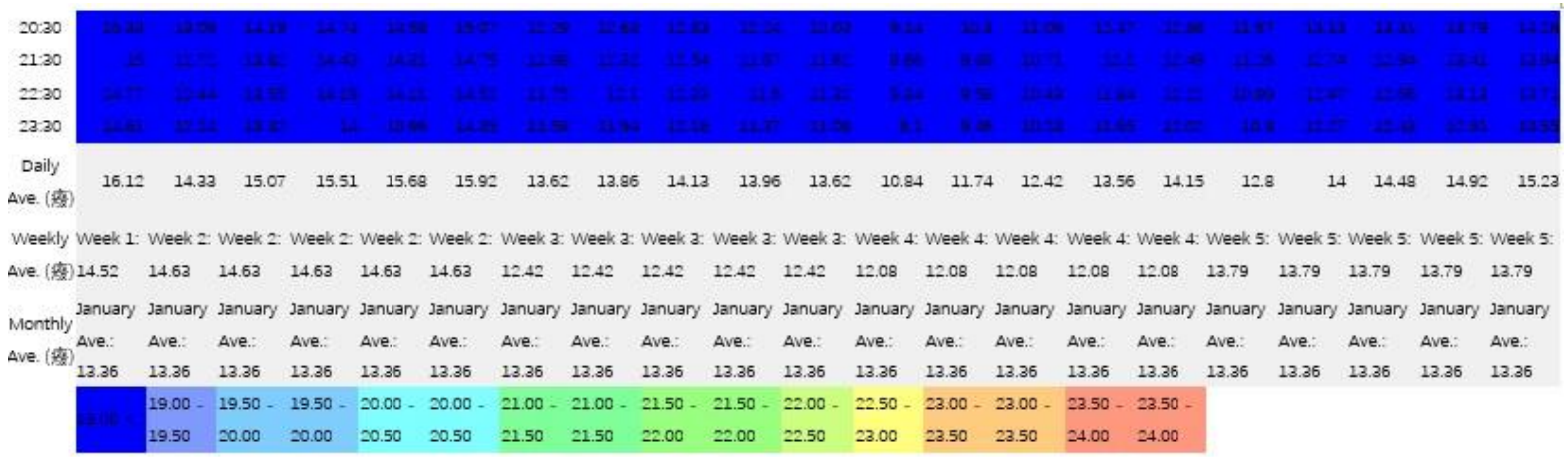

Monthly Ave. (燈)
January Ave.: 12.87
19.00 - 19.50
19.50 - 20.00
20.00 - 20.50
20.50 - 21.00
21.00 - 21.50
21.50 - 22.00
22.00 - 22.50
22.50 - 23.00
23.00 - 23.50
23.50 - 24.00
Air temperature, second-floor classroom (SCHOOL DTM January. aps)
0:30
1:30
2:30
3:30
4:30
5:30
6:30
7:30
8:30
9:30
10:30
11:30
12:30
13:30
14:30
15:30
16:30
17:30
18:30
19:30
20:30
21:30
22:30
23:30
19.34 19.15 19.34 19.16 19.12 19.19 19.09
19.67 19.19 19.73 19.12 19.51 19.17 19.56
19.82 19.2 19.82 19.55 19.75 19.32 19.65
19.82 19.57 19.35 19.41 19.51 19.15
19.41 19.01 19.07 19.06

Daily Ave. (癈)	16.17	14.38	15.13	15.56	15.73	15.97	13.7	13.97	14.24	14.06	13.73	10.96	11.85	12.51	13.62	14.2	12.85	14.05	14.51	14.95	15.26
Weekly Ave. (癈)	Week 1: 14.56	Week 2: 14.68	Week 2: 14.68	Week 2: 14.68	Week 2: 14.68	Week 2: 14.68	Week 3: 12.52	Week 3: 12.52	Week 3: 12.52	Week 3: 12.52	Week 3: 12.52	Week 4: 12.14	Week 4: 12.14	Week 4: 12.14	Week 4: 12.14	Week 4: 12.14	Week 5: 13.82	Week 5: 13.82	Week 5: 13.82	Week 5: 13.82	Week 5: 13.82
Monthly Ave. (癈)	January Ave.: 13.41	January Ave.: 13.41	January Ave.: 13.41	January Ave.: 13.41	January Ave.: 13.41	January Ave.: 13.41	January Ave.: 13.41	January Ave.: 13.41	January Ave.: 13.41	January Ave.: 13.41	January Ave.: 13.41	January Ave.: 13.41	January Ave.: 13.41	January Ave.: 13.41	January Ave.: 13.41	January Ave.: 13.41	January Ave.: 13.41	January Ave.: 13.41	January Ave.: 13.41	January Ave.: 13.41	January Ave.: 13.41

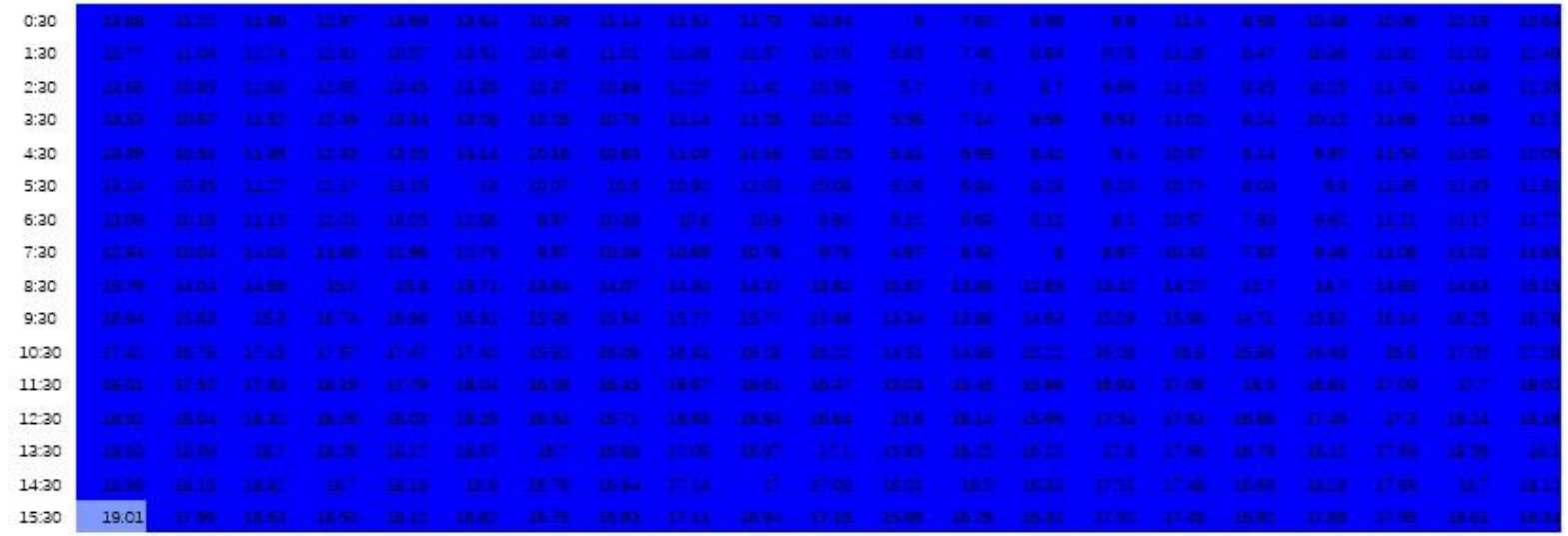
		19.00 - 19.50	19.50 - 20.00	19.50 - 20.00	20.00 - 20.50	20.00 - 20.50	21.00 - 21.50	21.00 - 21.50	21.50 - 22.00	21.50 - 22.00	22.00 - 22.50	22.50 - 23.00	23.00 - 23.50	23.00 - 23.50	23.50 - 24.00	23.50 - 24.00

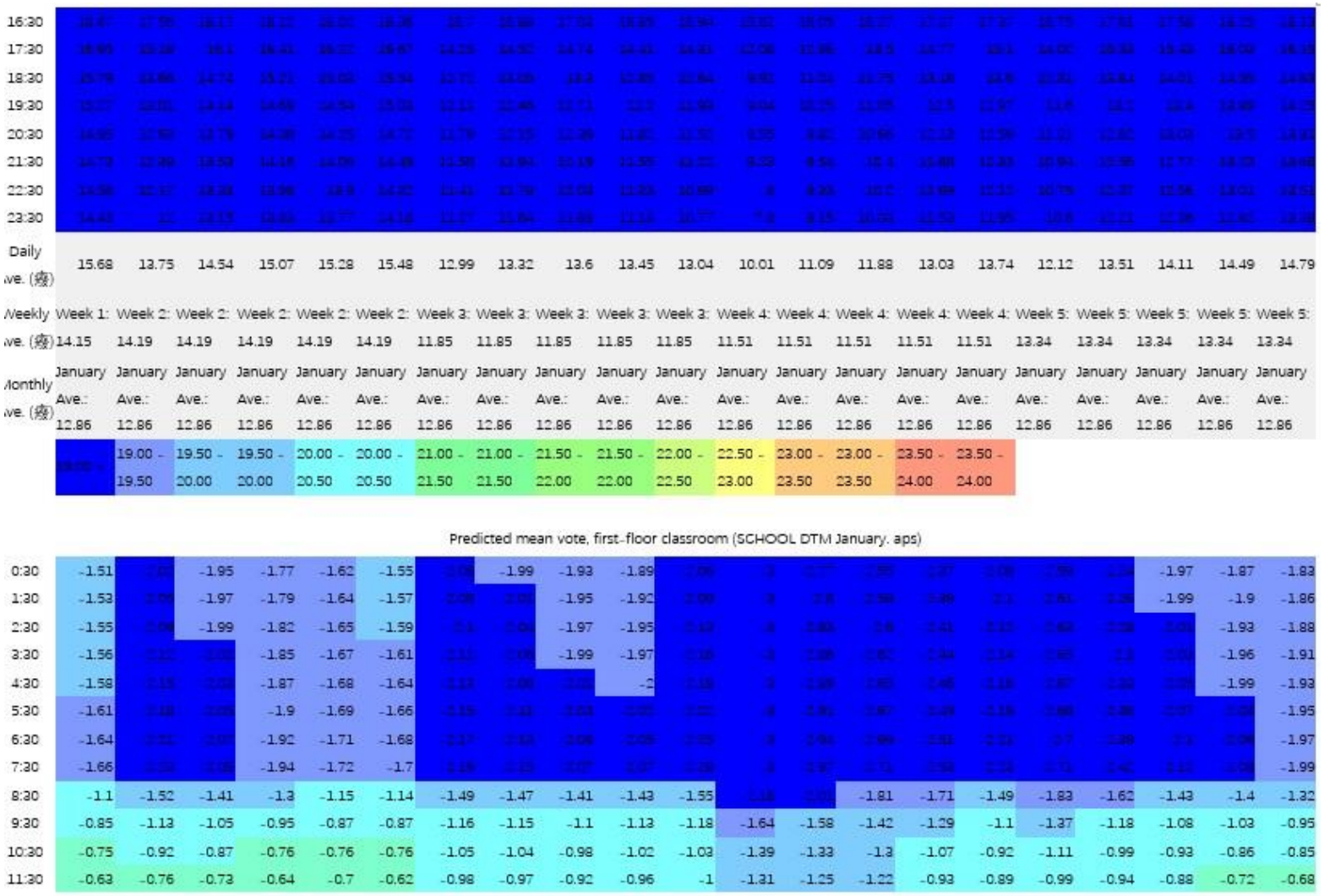
Air temperature, third-floor classroom (SCHOOL DTM January. aps)

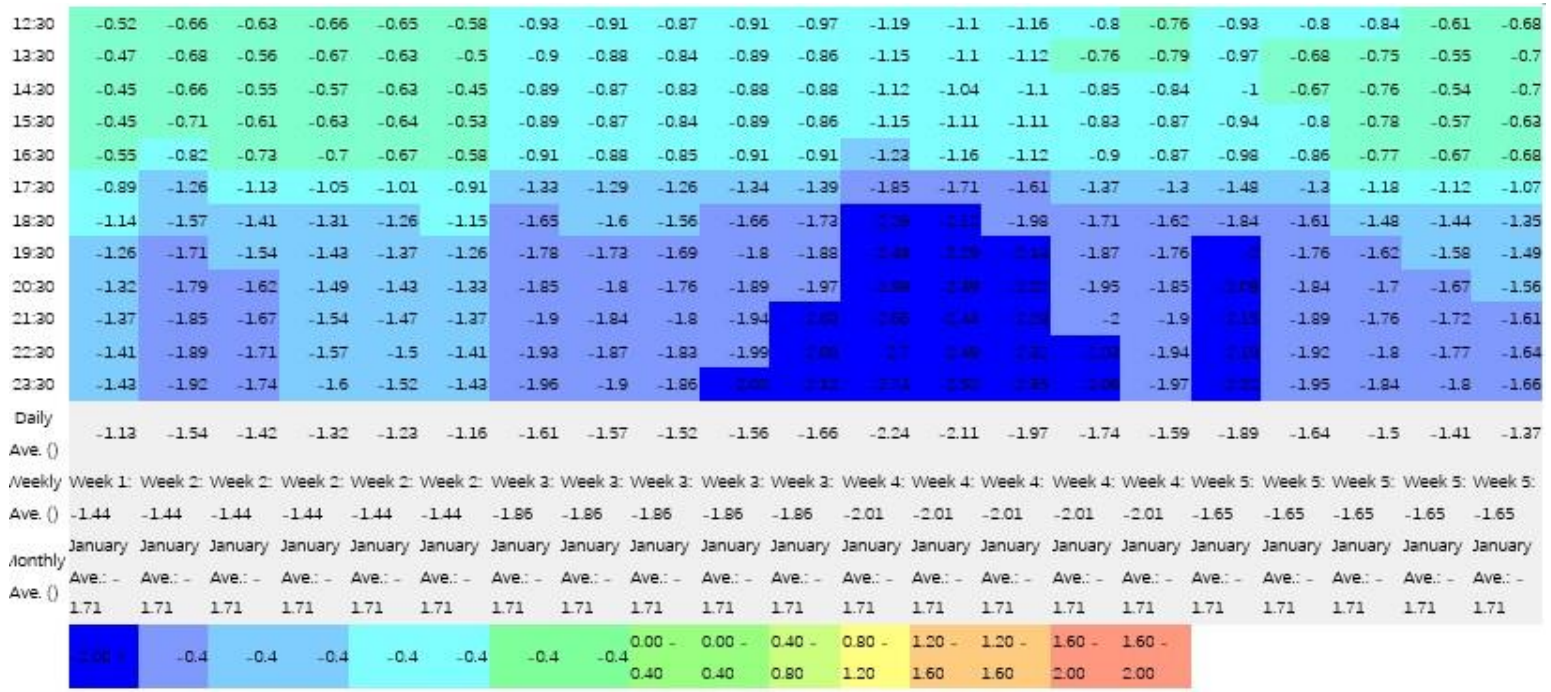
0:30																					
1:30																					
2:30																					
3:30																					
4:30																					
5:30																					
6:30																					
7:30																					
8:30																					
9:30																					
10:30																					
11:30				19.02																	
12:30	19.28	19.09	19.28	19.11		19.06														19.15	19.05
13:30	19.62	19.13	19.67	19.06		19.45												19.12		19.52	
14:30	19.77	19.15	19.77	19.49		19.7												19.28		19.61	
15:30	19.77		19.52	19.2		19.36														19.48	19.1
16:30	19.36					19.02														19.03	
17:30																					
18:30																					
19:30																					



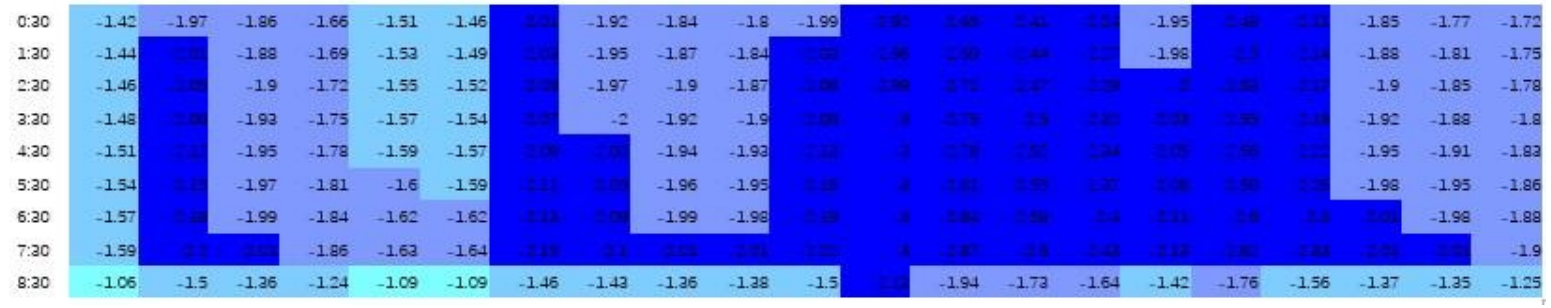
Air temperature, fourth-floor classroom (SCHOOL DTM January. aps)

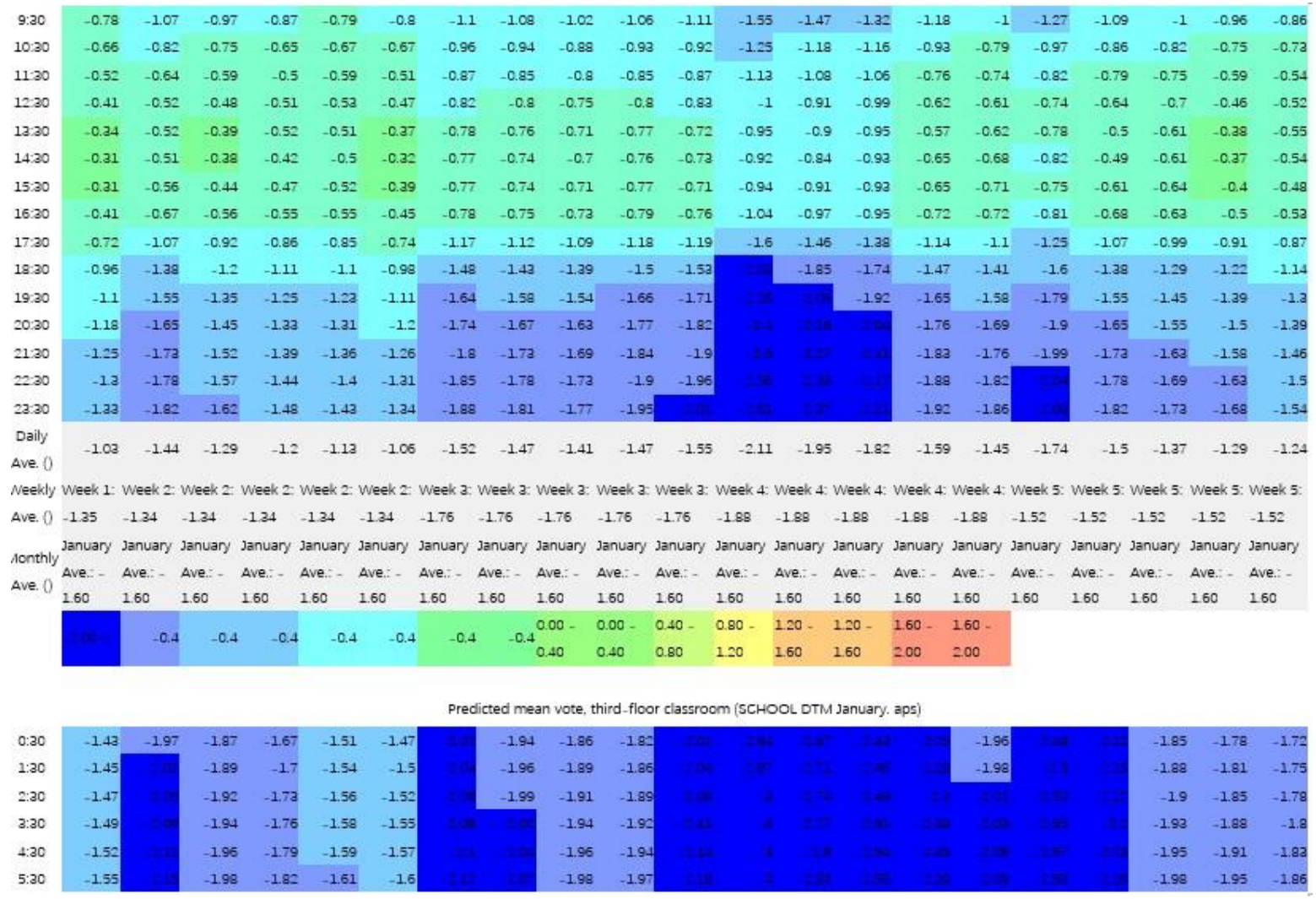



16:30
17:30
18:30
19:30
20:30
21:30
22:30
23:30
Daily ave. (癈)
15.68 13.75 14.54 15.07 15.28 15.48 12.99 13.32 13.6 13.45 13.04 10.01 11.09 11.88 13.03 13.74 12.12 13.51 14.11 14.49 14.79
Weekly ave. (癈)
Week 1: 14.15
Week 2: 14.19
Week 2: 14.19
Week 2: 14.19
Week 2: 14.19
Week 2: 14.19
Week 3: 11.85
Week 3: 11.85
Week 3: 11.85
Week 3: 11.85
Week 3: 11.85
Week 4: 11.51
Week 4: 11.51
Week 4: 11.51
Week 4: 11.51
Week 4: 11.51
Week 5: 13.34
Week 5: 13.34
Week 5: 13.34
Week 5: 13.34
Week 5: 13.34
Monthly ave. (癈)
January Ave.: 12.86
19.00 - 19.50
19.50 - 20.00
19.50 - 20.00
20.00 - 20.50
20.00 - 20.50
21.00 - 21.50
21.00 - 21.50
21.50 - 22.00
21.50 - 22.00
22.00 - 22.50
22.50 - 23.00
23.00 - 23.50
23.00 - 23.50
23.50 - 24.00
23.50 - 24.00
Predicted mean vote, first-floor classroom (SCHOOL DTM January. aps)
0:30 -1.51 -1.95 -1.77 -1.62 -1.55 -1.99 -1.93 -1.89 -1.97 -1.87 -1.83
1:30 -1.53 -1.97 -1.79 -1.64 -1.57 -1.95 -1.92 -1.99 -1.9 -1.86
2:30 -1.55 -1.99 -1.82 -1.65 -1.59 -1.97 -1.95 -1.93 -1.88
3:30 -1.56 -1.85 -1.67 -1.61 -1.99 -1.97 -1.96 -1.91
4:30 -1.58 -1.87 -1.68 -1.64 -2 -1.99 -1.93
5:30 -1.61 -1.9 -1.69 -1.66 -1.95
6:30 -1.64 -1.92 -1.71 -1.68 -1.97
7:30 -1.66 -1.94 -1.72 -1.7 -1.99
8:30 -1.1 -1.52 -1.41 -1.3 -1.15 -1.14 -1.49 -1.47 -1.41 -1.43 -1.55 -1.81 -1.71 -1.49 -1.83 -1.62 -1.43 -1.4 -1.32
9:30 -0.85 -1.13 -1.05 -0.95 -0.87 -0.87 -1.16 -1.15 -1.1 -1.13 -1.18 -1.64 -1.58 -1.42 -1.29 -1.1 -1.37 -1.18 -1.08 -1.03 -0.95
10:30 -0.75 -0.92 -0.87 -0.76 -0.76 -0.76 -1.05 -1.04 -0.98 -1.02 -1.03 -1.39 -1.33 -1.3 -1.07 -0.92 -1.11 -0.99 -0.93 -0.86 -0.85
11:30 -0.63 -0.76 -0.73 -0.64 -0.7 -0.62 -0.98 -0.97 -0.92 -0.96 -1 -1.31 -1.25 -1.22 -0.93 -0.89 -0.99 -0.94 -0.88 -0.72 -0.68

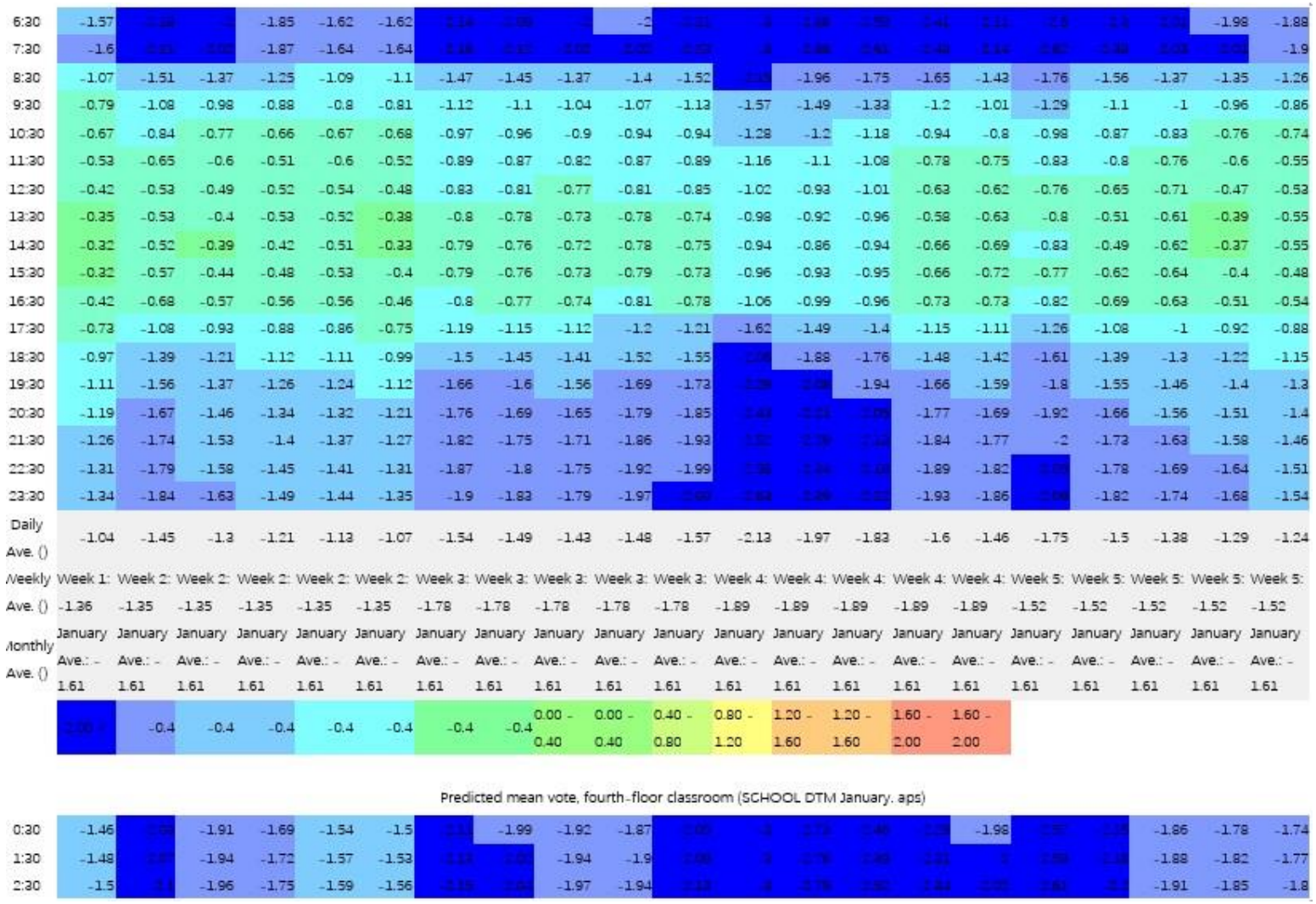


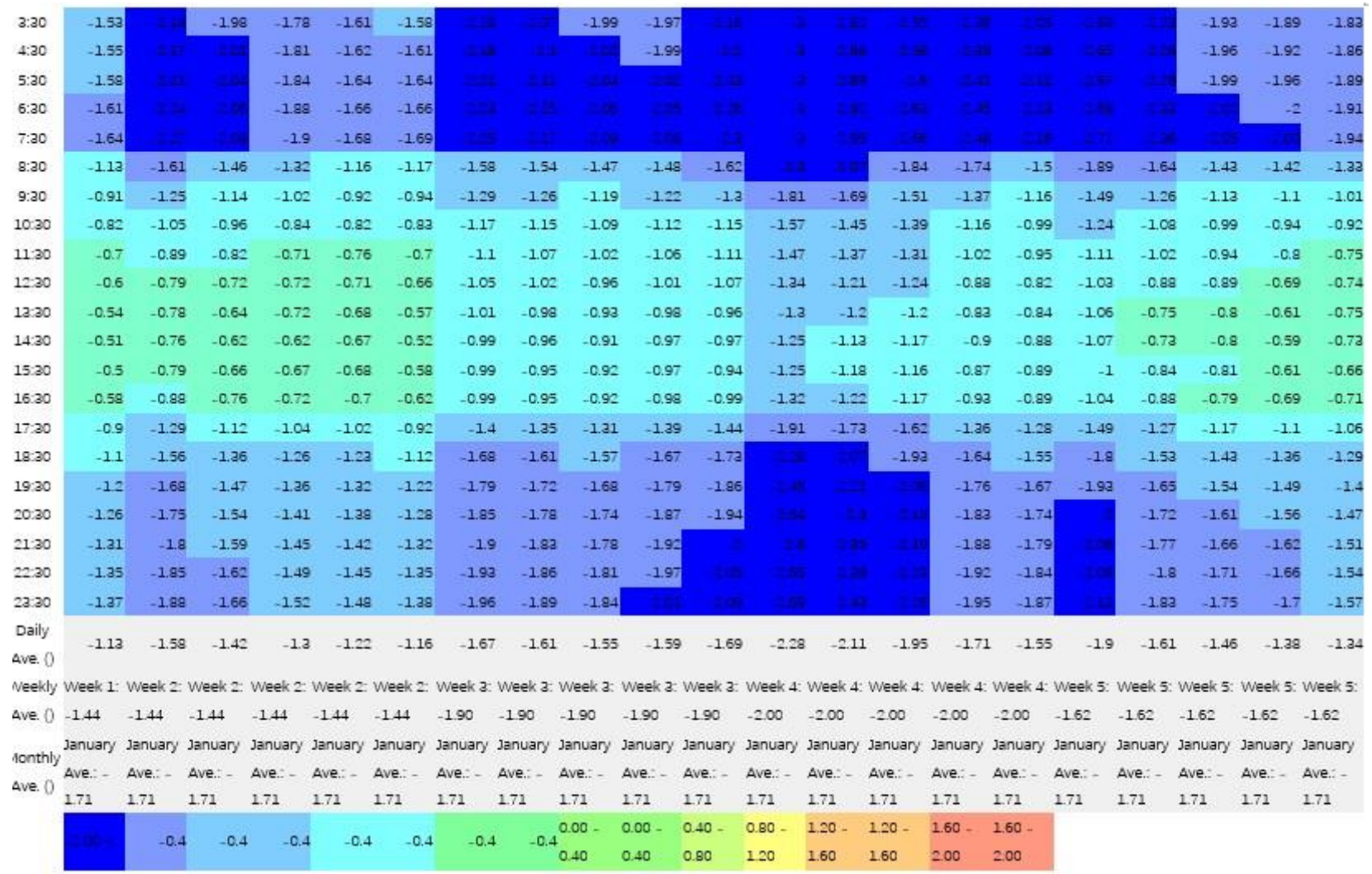
Predicted mean vote, second-floor classroom (SCHOOL DTM January. aps)





Predicted mean vote, third-floor classroom (SCHOOL DTM January. aps)


6:30 -1.57 -1.85 -1.62 -1.62 -1.98 -1.88
7:30 -1.6 -1.87 -1.64 -1.64 -1.9
8:30 -1.07 -1.51 -1.37 -1.25 -1.09 -1.1 -1.47 -1.45 -1.37 -1.4 -1.52 -1.96 -1.75 -1.65 -1.43 -1.76 -1.56 -1.37 -1.35 -1.26
9:30 -0.79 -1.08 -0.98 -0.88 -0.8 -0.81 -1.12 -1.1 -1.04 -1.07 -1.13 -1.57 -1.49 -1.33 -1.2 -1.01 -1.29 -1.1 -1 -0.96 -0.86
10:30 -0.67 -0.84 -0.77 -0.66 -0.67 -0.68 -0.97 -0.96 -0.9 -0.94 -0.94 -1.28 -1.2 -1.18 -0.94 -0.8 -0.98 -0.87 -0.83 -0.76 -0.74
11:30 -0.53 -0.65 -0.6 -0.51 -0.6 -0.52 -0.89 -0.87 -0.82 -0.87 -0.89 -1.16 -1.1 -1.08 -0.78 -0.75 -0.83 -0.8 -0.76 -0.6 -0.55
12:30 -0.42 -0.53 -0.49 -0.52 -0.54 -0.48 -0.83 -0.81 -0.77 -0.81 -0.85 -1.02 -0.93 -1.01 -0.63 -0.62 -0.76 -0.65 -0.71 -0.47 -0.53
13:30 -0.35 -0.53 -0.4 -0.53 -0.52 -0.38 -0.8 -0.78 -0.73 -0.78 -0.74 -0.98 -0.92 -0.96 -0.58 -0.63 -0.8 -0.51 -0.61 -0.39 -0.55
14:30 -0.32 -0.52 -0.39 -0.42 -0.51 -0.33 -0.79 -0.76 -0.72 -0.78 -0.75 -0.94 -0.86 -0.94 -0.66 -0.69 -0.83 -0.49 -0.62 -0.37 -0.55
15:30 -0.32 -0.57 -0.44 -0.48 -0.53 -0.4 -0.79 -0.76 -0.73 -0.79 -0.73 -0.96 -0.93 -0.95 -0.66 -0.72 -0.77 -0.62 -0.64 -0.4 -0.48
16:30 -0.42 -0.68 -0.57 -0.56 -0.56 -0.46 -0.8 -0.77 -0.74 -0.81 -0.78 -1.06 -0.99 -0.96 -0.73 -0.73 -0.82 -0.69 -0.63 -0.51 -0.54
17:30 -0.73 -1.08 -0.93 -0.88 -0.86 -0.75 -1.19 -1.15 -1.12 -1.2 -1.21 -1.62 -1.49 -1.4 -1.15 -1.11 -1.26 -1.08 -1 -0.92 -0.88
18:30 -0.97 -1.39 -1.21 -1.12 -1.11 -0.99 -1.5 -1.45 -1.41 -1.52 -1.55 -1.88 -1.76 -1.48 -1.42 -1.61 -1.39 -1.3 -1.22 -1.15
19:30 -1.11 -1.56 -1.37 -1.26 -1.24 -1.12 -1.66 -1.6 -1.56 -1.69 -1.73 -1.94 -1.66 -1.59 -1.8 -1.55 -1.46 -1.4 -1.3
20:30 -1.19 -1.67 -1.46 -1.34 -1.32 -1.21 -1.76 -1.69 -1.65 -1.79 -1.85 -1.77 -1.69 -1.92 -1.66 -1.56 -1.51 -1.4
21:30 -1.26 -1.74 -1.53 -1.4 -1.37 -1.27 -1.82 -1.75 -1.71 -1.86 -1.93 -1.84 -1.77 -2 -1.73 -1.63 -1.58 -1.46
22:30 -1.31 -1.79 -1.58 -1.45 -1.41 -1.31 -1.87 -1.8 -1.75 -1.92 -1.99 -1.89 -1.82 -1.78 -1.69 -1.64 -1.51
23:30 -1.34 -1.84 -1.63 -1.49 -1.44 -1.35 -1.9 -1.83 -1.79 -1.97 -1.93 -1.86 -1.82 -1.74 -1.68 -1.54
Daily Ave. () -1.04 -1.45 -1.3 -1.21 -1.13 -1.07 -1.54 -1.49 -1.43 -1.48 -1.57 -2.13 -1.97 -1.83 -1.6 -1.46 -1.75 -1.5 -1.38 -1.29 -1.24
Weekly Ave. () Week 1: -1.36 Week 2: -1.35 Week 2: -1.35 Week 2: -1.35 Week 2: -1.35 Week 2: -1.35 Week 3: -1.78 Week 3: -1.78 Week 3: -1.78 Week 3: -1.78 Week 3: -1.78 Week 4: -1.89 Week 4: -1.89 Week 4: -1.89 Week 4: -1.89 Week 4: -1.89 Week 5: -1.52 Week 5: -1.52 Week 5: -1.52 Week 5: -1.52 Week 5: -1.52
Monthly Ave. () January Ave.: - 1.61
-0.4 -0.4 -0.4 -0.4 -0.4 -0.4 -0.4 0.00 - 0.40 0.00 - 0.40 0.40 - 0.80 0.80 - 1.20 1.20 - 1.60 1.60 - 2.00
Predicted mean vote, fourth-floor classroom (SCHOOL DTM January. aps)
0:30 -1.46 -1.91 -1.69 -1.54 -1.5 -1.99 -1.92 -1.87 -1.98 -1.86 -1.78 -1.74
1:30 -1.48 -1.94 -1.72 -1.57 -1.53 -1.94 -1.9 -1.88 -1.82 -1.77
2:30 -1.5 -1.96 -1.75 -1.59 -1.56 -1.97 -1.94 -1.91 -1.85 -1.8



3:30	-1.53		-1.98	-1.78	-1.61	-1.58			-1.99	-1.97									-1.93	-1.89	-1.83
4:30	-1.55			-1.81	-1.62	-1.61				-1.99									-1.96	-1.92	-1.86
5:30	-1.58			-1.84	-1.64	-1.64													-1.99	-1.96	-1.89
6:30	-1.61			-1.88	-1.66	-1.66														-2	-1.91
7:30	-1.64			-1.9	-1.68	-1.69															-1.94
8:30	-1.13	-1.61	-1.46	-1.32	-1.16	-1.17	-1.58	-1.54	-1.47	-1.48	-1.62			-1.84	-1.74	-1.5	-1.89	-1.64	-1.43	-1.42	-1.33
9:30	-0.91	-1.25	-1.14	-1.02	-0.92	-0.94	-1.29	-1.26	-1.19	-1.22	-1.3	-1.81	-1.69	-1.51	-1.37	-1.16	-1.49	-1.26	-1.13	-1.1	-1.01
10:30	-0.82	-1.05	-0.96	-0.84	-0.82	-0.83	-1.17	-1.15	-1.09	-1.12	-1.15	-1.57	-1.45	-1.39	-1.16	-0.99	-1.24	-1.08	-0.99	-0.94	-0.92
11:30	-0.7	-0.89	-0.82	-0.71	-0.76	-0.7	-1.1	-1.07	-1.02	-1.06	-1.11	-1.47	-1.37	-1.31	-1.02	-0.95	-1.11	-1.02	-0.94	-0.8	-0.75
12:30	-0.6	-0.79	-0.72	-0.72	-0.71	-0.66	-1.05	-1.02	-0.96	-1.01	-1.07	-1.34	-1.21	-1.24	-0.88	-0.82	-1.03	-0.88	-0.89	-0.69	-0.74
13:30	-0.54	-0.78	-0.64	-0.72	-0.68	-0.57	-1.01	-0.98	-0.93	-0.98	-0.96	-1.3	-1.2	-1.2	-0.83	-0.84	-1.06	-0.75	-0.8	-0.61	-0.75
14:30	-0.51	-0.76	-0.62	-0.62	-0.67	-0.52	-0.99	-0.96	-0.91	-0.97	-0.97	-1.25	-1.13	-1.17	-0.9	-0.88	-1.07	-0.73	-0.8	-0.59	-0.73
15:30	-0.5	-0.79	-0.66	-0.67	-0.68	-0.58	-0.99	-0.95	-0.92	-0.97	-0.94	-1.25	-1.18	-1.16	-0.87	-0.89	-1	-0.84	-0.81	-0.61	-0.66
16:30	-0.58	-0.88	-0.76	-0.72	-0.7	-0.62	-0.99	-0.95	-0.92	-0.98	-0.99	-1.32	-1.22	-1.17	-0.93	-0.89	-1.04	-0.88	-0.79	-0.69	-0.71
17:30	-0.9	-1.29	-1.12	-1.04	-1.02	-0.92	-1.4	-1.35	-1.31	-1.39	-1.44	-1.91	-1.73	-1.62	-1.36	-1.28	-1.49	-1.27	-1.17	-1.1	-1.06
18:30	-1.1	-1.56	-1.36	-1.26	-1.23	-1.12	-1.68	-1.61	-1.57	-1.67	-1.73			-1.93	-1.64	-1.55	-1.8	-1.53	-1.43	-1.36	-1.29
19:30	-1.2	-1.68	-1.47	-1.36	-1.32	-1.22	-1.79	-1.72	-1.68	-1.79	-1.86				-1.76	-1.67	-1.93	-1.65	-1.54	-1.49	-1.4
20:30	-1.26	-1.75	-1.54	-1.41	-1.38	-1.28	-1.85	-1.78	-1.74	-1.87	-1.94				-1.83	-1.74		-1.72	-1.61	-1.56	-1.47
21:30	-1.31	-1.8	-1.59	-1.45	-1.42	-1.32	-1.9	-1.83	-1.78	-1.92					-1.88	-1.79		-1.77	-1.66	-1.62	-1.51
22:30	-1.35	-1.85	-1.62	-1.49	-1.45	-1.35	-1.93	-1.86	-1.81	-1.97					-1.92	-1.84		-1.8	-1.71	-1.66	-1.54
23:30	-1.37	-1.88	-1.66	-1.52	-1.48	-1.38	-1.96	-1.89	-1.84						-1.95	-1.87		-1.83	-1.75	-1.7	-1.57
Daily Ave. ()	-1.13	-1.58	-1.42	-1.3	-1.22	-1.16	-1.67	-1.61	-1.55	-1.59	-1.69	-2.28	-2.11	-1.95	-1.71	-1.55	-1.9	-1.61	-1.46	-1.38	-1.34
Weekly Ave. ()	Week 1: -1.44	Week 2: -1.44	Week 2: -1.44	Week 2: -1.44	Week 2: -1.44	Week 2: -1.44	Week 3: -1.90	Week 3: -1.90	Week 3: -1.90	Week 3: -1.90	Week 3: -1.90	Week 4: -2.00	Week 4: -2.00	Week 4: -2.00	Week 4: -2.00	Week 4: -2.00	Week 5: -1.62	Week 5: -1.62	Week 5: -1.62	Week 5: -1.62	Week 5: -1.62
Monthly Ave. ()	January Ave.: - 1.71	January Ave.: - 1.71	January Ave.: - 1.71	January Ave.: - 1.71	January Ave.: - 1.71	January Ave.: - 1.71	January Ave.: - 1.71	January Ave.: - 1.71	January Ave.: - 1.71	January Ave.: - 1.71	January Ave.: - 1.71	January Ave.: - 1.71	January Ave.: - 1.71	January Ave.: - 1.71	January Ave.: - 1.71	January Ave.: - 1.71	January Ave.: - 1.71	January Ave.: - 1.71	January Ave.: - 1.71	January Ave.: - 1.71	January Ave.: - 1.71
		-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	0.00 - 0.40	0.00 - 0.40	0.40 - 0.80	0.80 - 1.20	1.20 - 1.60	1.20 - 1.60	1.60 - 2.00	1.60 - 2.00					

Room CO2 concentration, first-floor classroom (SCHOOL DTM January. aps) - ppm

0:30	580.1	400.83	584.12	580.83	581.99	583.11	400.86	586.18	586.83	587.15	588.95	400.93	587.85	586.94	586.54	583.05	400.9	582.17	579.95	583.56	583.63
1:30	559.58	400.75	563.43	560.32	561.12	562.25	400.77	565.33	565.94	566.27	568	400.84	567.21	566.13	565.68	562.38	400.82	561.51	559.43	562.98	563
2:30	541.64	400.67	545.35	542.43	542.92	544.02	400.69	547.05	547.6	547.94	549.6	400.76	549.11	547.89	547.39	544.32	400.74	543.5	541.58	544.99	544.99
3:30	525.9	400.61	529.46	526.76	527	528.01	400.62	530.95	531.46	531.8	533.37	400.68	533.17	531.85	531.31	528.47	400.67	527.71	525.96	529.2	529.19
4:30	512.03	400.55	515.45	512.98	513.01	513.92	400.56	516.75	517.19	517.54	519.03	400.61	519.06	517.68	517.11	514.5	400.61	513.81	512.22	515.29	515.27
5:30	499.79	400.49	503.06	500.82	500.67	501.49	400.5	504.18	504.57	504.92	506.31	400.55	506.54	505.13	504.55	502.16	400.55	501.54	500.12	503	502.97
6:30	488.95	400.45	492.06	490.08	489.77	490.49	400.45	493.04	493.37	493.72	495.02	400.5	495.42	493.98	493.41	491.23	400.5	490.68	489.42	492.11	492.07
7:30	479.35	400.4	482.3	480.55	480.12	480.75	400.4	483.14	483.42	483.77	484.97	400.45	485.51	484.08	483.51	481.53	400.45	481.06	479.95	482.45	482.38
8:30	839.37	823.86	838.82	838.64	839.43	839.45	824.53	838.6	838.65	838.44	838.45	821.69	837.38	837.91	838.03	838.39	823.28	838.1	838.23	837.94	838.55
9:30	907.29	905.7	907.29	907.3	907.5	907.37	905.73	907.15	907.16	907.12	907.14	905.61	907.1	907.17	907.24	907.27	905.75	907.32	907.27	907.18	907.29
10:30	910.71	910.25	910.81	910.78	910.76	910.73	910.25	910.78	910.79	910.77	910.85	910.5	910.95	910.87	910.9	910.84	910.41	910.88	910.79	910.77	910.76
11:30	911.87	911.71	911.93	911.9	911.87	911.88	911.72	911.94	911.94	911.93	911.97	911.87	912.04	912	912	911.94	911.81	911.94	911.9	911.9	911.88
12:30	912.32	912.25	912.35	912.32	912.32	912.33	912.28	912.37	912.36	912.36	912.38	912.35	912.41	912.4	912.39	912.35	912.31	912.36	912.33	912.34	912.32
13:30	912.5	912.46	912.51	912.49	912.5	912.5	912.49	912.52	912.52	912.52	912.53	912.52	912.55	912.54	912.53	912.51	912.49	912.52	912.51	912.5	912.49
14:30	912.57	912.55	912.57	912.57	912.57	912.57	912.57	912.58	912.58	912.58	912.59	912.58	912.59	912.59	912.58	912.58	912.57	912.58	912.58	912.57	912.57
15:30	912.6	912.59	912.6	912.6	912.6	912.6	912.6	912.61	912.61	912.61	912.61	912.61	912.61	912.61	912.6	912.6	912.6	912.6	912.6	912.6	912.6
16:30	912.61	912.6	912.61	912.61	912.61	912.61	912.61	912.62	912.62	912.62	912.62	912.61	912.62	912.62	912.61	912.61	912.61	912.61	912.61	912.61	912.61
17:30	867.48	868.16	867.68	867.94	867.78	867.54	868.24	868.28	868.33	868.57	868.4	868.8	868.67	868.55	868.08	868.15	868.25	867.94	868.14	868.2	868.08
18:30	801.78	803.14	801.9	802.76	802.71	802.05	803.93	804.14	804.27	804.86	804.45	804.83	804.66	804.54	803.08	803.38	803.29	802.4	803.31	803.09	803.14
19:30	747.86	749.49	747.64	749.02	749.29	748.3	751.13	751.57	751.77	752.71	752.15	751.97	751.87	751.84	749.43	749.98	749.36	747.97	749.84	749.31	749.62
20:30	702.86	704.74	702.37	704.03	704.62	703.41	706.93	707.54	707.79	709.03	708.38	707.73	707.6	707.59	704.51	705.24	704.08	702.35	705.03	704.43	704.82
21:30	664.94	667.11	664.33	666.04	666.89	665.54	669.54	670.23	670.51	671.99	671.31	670.45	670.17	670.09	666.62	667.45	665.94	663.96	667.18	666.7	666.99
22:30	632.71	635.19	632.09	633.71	634.72	633.3	637.59	638.31	638.61	640.26	639.58	638.73	638.24	638.05	634.43	635.29	633.61	631.45	634.95	634.7	634.78
23:30	605.09	607.85	604.52	605.99	607.06	605.63	610.07	610.76	611.06	612.85	612.18	611.49	610.78	610.46	606.85	607.69	605.98	603.72	607.32	607.32	607.14
Daily Ave. ()	722.58	681.43	723.63	723.14	723.41	723.41	681.96	725.36	725.58	726.01	726.37	682.15	726.09	725.65	724.72	724	681.23	723.03	723.13	724.07	724.13
Weekly Ave. ()	Week 1: 530.26	Week 2: 634.86	Week 2: 634.86	Week 2: 634.86	Week 2: 634.86	Week 2: 634.86	Week 3: 636.95	Week 3: 636.95	Week 3: 636.95	Week 3: 636.95	Week 3: 636.95	Week 4: 636.10	Week 4: 636.10	Week 4: 636.10	Week 4: 636.10	Week 4: 636.10	Week 5: 635.00	Week 5: 635.00	Week 5: 635.00	Week 5: 635.00	Week 5: 635.00

Monthly Ave. ()	January Ave.: 625.52	January Ave.: 625.52	January Ave.: 625.52	January Ave.: 625.52	January Ave.: 625.52	January Ave.: 625.52	January Ave.: 625.52	January Ave.: 625.52	January Ave.: 625.52	January Ave.: 625.52	January Ave.: 625.52	January Ave.: 625.52	January Ave.: 625.52	January Ave.: 625.52	January Ave.: 625.52	January Ave.: 625.52	January Ave.: 625.52	January Ave.: 625.52	January Ave.: 625.52	January Ave.: 625.52	January Ave.: 625.52
	350.00 - 475.00	475.00 - 600.00	475.00 - 600.00	600.00 - 725.00	600.00 - 725.00	850.00 - 975.00	850.00 - 975.00	975.00 - 1100.00	975.00 - 1100.00	1100.00 - 1225.00	1225.00 - 1350.00	1350.00 - 1475.00	1350.00 - 1475.00	1475.00 - 1600.00	1475.00 - 1600.00						

Room CO2 concentration, second-floor classroom (SCHOOL DTM January. aps) - ppm

0:30	598.13	401.01	603.28	601.42	601.5	600.34	401	602.77	603.26	603.49	604.67	401.1	607.32	606.19	604.95	603.13	401.2	603.58	601.91	602.22	603.78
1:30	576.99	400.91	581.95	580.24	580.09	578.94	400.9	581.37	581.81	582.04	583.13	400.98	585.94	584.7	583.49	581.8	401.07	582.28	580.76	581.07	582.48
2:30	558.19	400.81	562.95	561.37	561.04	559.92	400.8	562.3	562.68	562.92	563.93	400.88	566.83	565.52	564.35	562.79	400.96	563.29	561.92	562.24	563.5
3:30	541.43	400.73	545.99	544.53	544.06	542.97	400.72	545.29	545.62	545.86	546.79	400.79	549.73	548.38	547.25	545.82	400.87	546.33	545.1	545.44	546.55
4:30	526.47	400.66	530.82	529.48	528.91	527.86	400.65	530.1	530.37	530.61	531.48	400.71	534.4	533.04	531.96	530.64	400.78	531.17	530.06	530.42	531.39
5:30	513.12	400.59	517.24	516.03	515.38	514.37	400.58	516.53	516.74	516.99	517.79	400.64	520.66	519.29	518.28	517.06	400.7	517.59	516.61	516.99	517.82
6:30	501.19	400.53	505.08	503.99	503.3	502.32	400.52	504.39	504.56	504.8	505.53	400.58	508.34	506.98	506.03	504.9	400.63	505.44	504.56	504.96	505.67
7:30	490.52	400.48	494.18	493.22	492.48	491.55	400.47	493.52	493.65	493.89	494.57	400.52	497.28	495.95	495.05	494.01	400.56	494.55	493.78	494.19	494.77
8:30	838.05	819.99	837.53	837.54	838.34	838.07	820.59	837.02	837.02	836.8	836.64	817.36	835.83	836.42	836.51	837.14	819.18	837.01	837.29	836.66	837.36
9:30	904.88	902.63	904.91	904.9	905.18	905.02	902.64	904.75	904.74	904.7	904.73	902.54	904.68	904.74	904.84	904.87	902.62	904.96	904.87	904.77	904.88
10:30	909.65	908.95	909.8	909.74	909.73	909.7	908.97	909.8	909.79	909.78	909.89	909.35	910.04	909.91	909.94	909.84	909.17	909.89	909.77	909.74	909.7
11:30	911.45	911.18	911.52	911.47	911.44	911.46	911.23	911.56	911.56	911.55	911.61	911.45	911.71	911.65	911.63	911.54	911.33	911.55	911.49	911.49	911.45
12:30	912.15	912.03	912.17	912.14	912.14	912.15	912.09	912.22	912.22	912.22	912.24	912.19	912.29	912.27	912.25	912.19	912.11	912.2	912.17	912.16	912.14
13:30	912.43	912.36	912.43	912.41	912.43	912.43	912.42	912.47	912.47	912.47	912.48	912.46	912.5	912.5	912.47	912.45	912.41	912.46	912.44	912.43	912.41
14:30	912.54	912.5	912.54	912.53	912.54	912.54	912.54	912.56	912.56	912.56	912.57	912.56	912.57	912.58	912.56	912.55	912.53	912.56	912.55	912.53	912.53
15:30	912.58	912.56	912.58	912.58	912.59	912.59	912.59	912.6	912.6	912.6	912.6	912.6	912.6	912.6	912.59	912.59	912.59	912.59	912.59	912.58	912.58
16:30	912.6	912.59	912.6	912.6	912.61	912.61	912.61	912.61	912.61	912.61	912.61	912.61	912.61	912.61	912.61	912.61	912.61	912.61	912.61	912.6	912.61
17:30	868.95	869.6	869.17	869.4	869.23	869.01	869.71	869.77	869.81	870.04	869.92	870.35	870.23	870.11	869.62	869.64	869.78	869.47	869.62	869.67	869.56
18:30	807.79	809.14	808.22	808.77	808.45	807.94	809.64	809.89	810.03	810.52	810.38	811.17	810.94	810.66	809.44	809.41	809.7	808.85	809.27	809.33	809.24
19:30	758.68	760.49	759.32	759.98	759.48	758.82	761.18	761.66	761.84	762.55	762.52	763.55	763.24	762.77	761.03	760.85	761.25	760.01	760.58	760.83	760.69
20:30	717.42	719.67	718.3	718.91	718.21	717.5	720.24	720.85	721.06	721.95	722.02	723.37	722.89	722.2	720.2	719.89	720.4	718.94	719.51	720.1	719.79
21:30	681.94	684.62	683.07	683.56	682.68	681.94	684.92	685.56	685.78	686.82	686.94	688.64	687.96	687.06	684.99	684.58	685.23	683.63	684.13	685.08	684.53
22:30	651.02	654.08	652.34	652.72	651.69	650.94	654.05	654.67	654.89	656.02	656.17	658.2	657.34	656.26	654.23	653.76	654.54	652.84	653.25	654.54	653.74

23:30	623.85	627.2	625.3	625.58	624.45	623.69	626.85	627.41	627.63	628.84	628.97	631.28	630.27	629.07	627.13	626.63	627.53	625.78	626.11	627.66	626.63
Daily Ave. ()	730.92	684.81	732.64	732.3	732	731.44	684.91	732.99	733.14	733.44	733.76	685.66	734.93	734.31	733.48	732.94	684.99	732.9	732.62	732.9	733.16
Weekly Ave. ()	Week 1: 536.43	Week 2: 641.66	Week 2: 641.66	Week 2: 641.66	Week 2: 641.66	Week 2: 641.66	Week 3: 642.84	Week 3: 642.84	Week 3: 642.84	Week 3: 642.84	Week 3: 642.84	Week 4: 643.24	Week 4: 643.24	Week 4: 643.24	Week 4: 643.24	Week 4: 643.24	Week 5: 642.44	Week 5: 642.44	Week 5: 642.44	Week 5: 642.44	Week 5: 642.44
Monthly Ave. ()	January Ave.: 632.27	January Ave.: 632.27	January Ave.: 632.27	January Ave.: 632.27	January Ave.: 632.27	January Ave.: 632.27	January Ave.: 632.27	January Ave.: 632.27	January Ave.: 632.27	January Ave.: 632.27	January Ave.: 632.27	January Ave.: 632.27	January Ave.: 632.27	January Ave.: 632.27	January Ave.: 632.27	January Ave.: 632.27	January Ave.: 632.27	January Ave.: 632.27	January Ave.: 632.27	January Ave.: 632.27	January Ave.: 632.27

	350.00 - 475.00	475.00 - 600.00	475.00 - 600.00	600.00 - 725.00	600.00 - 725.00	850.00 - 975.00	850.00 - 975.00	975.00 - 1100.00	975.00 - 1100.00	1100.00 - 1225.00	1225.00 - 1350.00	1350.00 - 1475.00	1350.00 - 1475.00	1475.00 - 1600.00	1475.00 - 1600.00

Room CO2 concentration, third-floor classroom (SCHOOL DTM January. aps) - ppm

0:30	608.41	401.09	613.79	612	612.08	610.69	401.07	612.64	612.89	613.11	614.21	401.16	617.08	615.93	614.75	613.5	401.29	614.21	612.8	612.84	614.63
1:30	586.74	400.98	591.96	590.33	590.17	588.77	400.96	590.72	590.89	591.13	592.12	401.04	595.18	593.93	592.76	591.66	401.16	592.44	591.21	591.21	592.82
2:30	567.3	400.88	572.33	570.84	570.5	569.11	400.86	571.05	571.15	571.39	572.28	400.94	575.46	574.13	573	572.03	401.04	572.85	571.78	571.77	573.19
3:30	549.86	400.79	554.67	553.33	552.86	551.47	400.77	553.38	553.43	553.67	554.48	400.84	557.7	556.34	555.25	554.38	400.93	555.23	554.3	554.3	555.52
4:30	534.21	400.71	538.78	537.58	537.02	535.66	400.69	537.53	537.54	537.78	538.5	400.76	541.71	540.34	539.31	538.51	400.83	539.38	538.57	538.6	539.63
5:30	520.18	400.64	524.5	523.44	522.8	521.48	400.62	523.31	523.28	523.52	524.17	400.68	527.33	525.96	524.99	524.26	400.75	525.13	524.43	524.48	525.34
6:30	507.6	400.57	511.66	510.75	510.05	508.79	400.56	510.55	510.49	510.73	511.32	400.61	514.39	513.04	512.14	511.46	400.67	512.32	511.72	511.79	512.49
7:30	496.34	400.51	500.14	499.35	498.61	497.41	400.5	499.11	499.02	499.27	499.79	400.55	502.77	501.45	500.6	499.97	400.6	500.81	500.3	500.39	500.94
8:30	835.74	815.81	835.15	835.26	836.13	835.74	816.37	834.51	834.46	834.23	833.96	812.75	833.11	833.75	833.87	834.69	814.8	834.62	835.04	834.3	835.01
9:30	902.38	899.43	902.45	902.43	902.79	902.57	899.44	902.26	902.25	902.2	902.25	899.4	902.21	902.27	902.39	902.39	899.44	902.53	902.38	902.26	902.39
10:30	908.59	907.64	908.8	908.7	908.69	908.64	907.67	908.8	908.79	908.77	908.93	908.21	909.14	908.96	908.99	908.85	907.95	908.92	908.74	908.7	908.65
11:30	911.02	910.66	911.13	911.05	911.01	911.04	910.73	911.19	911.18	911.17	911.25	911.03	911.39	911.31	911.28	911.15	910.87	911.16	911.08	911.07	911.03
12:30	911.98	911.81	912.01	911.96	911.97	911.99	911.9	912.08	912.08	912.07	912.11	912.04	912.18	912.15	912.11	912.04	911.93	912.06	912	911.99	911.97
13:30	912.36	912.26	912.36	912.33	912.36	912.36	912.35	912.42	912.42	912.41	912.43	912.4	912.46	912.45	912.42	912.39	912.34	912.41	912.38	912.36	912.33
14:30	912.51	912.46	912.51	912.5	912.51	912.51	912.52	912.54	912.54	912.54	912.55	912.54	912.56	912.56	912.54	912.52	912.5	912.53	912.52	912.5	912.5
15:30	912.57	912.54	912.57	912.57	912.58	912.57	912.58	912.59	912.59	912.59	912.59	912.59	912.6	912.6	912.58	912.58	912.57	912.58	912.58	912.57	912.57
16:30	912.6	912.58	912.59	912.6	912.6	912.6	912.61	912.61	912.61	912.61	912.61	912.61	912.61	912.61	912.61	912.6	912.6	912.6	912.6	912.59	912.6
17:30	870.2	870.8	870.38	870.64	870.52	870.29	871.01	871.1	871.14	871.37	871.26	871.64	871.55	871.46	870.91	870.93	871.05	870.71	870.91	870.86	870.83

18:30	812.21	813.36	812.51	813.15	812.95	812.42	814.05	814.36	814.52	814.98	814.89	815.45	815.35	815.16	813.88	813.86	814.06	813.19	813.71	813.62	813.7
19:30	765.94	767.46	766.42	767.17	766.77	766.12	768.25	768.79	768.99	769.68	769.73	770.46	770.31	769.96	768.26	768.1	768.37	767.17	767.84	768	768.01
20:30	726.64	728.62	727.39	728.07	727.41	726.72	729.1	729.71	729.95	730.8	730.93	732.06	731.72	731.15	729.34	729.05	729.47	728.1	728.71	729.33	729.08
21:30	692.29	694.77	693.35	693.86	692.96	692.26	694.77	695.35	695.59	696.57	696.72	698.35	697.76	696.95	695.22	694.85	695.47	694.03	694.47	695.57	694.95
22:30	661.84	664.79	663.15	663.53	662.41	661.7	664.3	664.77	665.01	666.08	666.2	668.31	667.49	666.5	664.92	664.5	665.33	663.83	664.11	665.61	664.64
23:30	634.67	637.98	636.16	636.44	635.14	634.43	637.05	637.41	637.63	638.77	638.84	641.36	640.36	639.23	637.82	637.39	638.4	636.89	637.01	638.8	637.53
Daily Ave. ()	735.59	686.63	737.36	737.08	736.79	736.14	686.7	737.45	737.52	737.81	738.09	687.41	739.35	738.76	738	737.65	686.85	737.74	737.55	737.73	738.01
Weekly Ave. ()	Week 1: 539.67	Week 2: 645.34	Week 2: 645.34	Week 2: 645.34	Week 2: 645.34	Week 2: 645.34	Week 3: 646.21	Week 3: 646.21	Week 3: 646.21	Week 3: 646.21	Week 3: 646.21	Week 4: 646.82	Week 4: 646.82	Week 4: 646.82	Week 4: 646.82	Week 4: 646.82	Week 5: 646.23	Week 5: 646.23	Week 5: 646.23	Week 5: 646.23	Week 5: 646.23
Monthly Ave. ()	January Ave.: 635.85	January Ave.: 635.85	January Ave.: 635.85	January Ave.: 635.85	January Ave.: 635.85	January Ave.: 635.85	January Ave.: 635.85	January Ave.: 635.85	January Ave.: 635.85	January Ave.: 635.85	January Ave.: 635.85	January Ave.: 635.85	January Ave.: 635.85	January Ave.: 635.85	January Ave.: 635.85	January Ave.: 635.85	January Ave.: 635.85	January Ave.: 635.85	January Ave.: 635.85	January Ave.: 635.85	January Ave.: 635.85

	350.00 - 475.00	475.00 - 600.00	600.00 - 725.00	850.00 - 975.00	975.00 - 1100.00	1100.00 - 1225.00	1225.00 - 1350.00	1350.00 - 1475.00	1475.00 - 1600.00

Room CO2 concentration, fourth-floor classroom (SCHOOL DTM January. aps) - ppm

0:30	614.74	401.11	619.19	618.19	618.52	617.15	401.09	617.86	618.43	618.86	620.17	401.17	622.04	621.87	620.88	620.3	401.28	619.98	620.08	620.13	621.77
1:30	592.83	401	597.37	596.47	596.44	594.89	400.98	595.81	596.18	596.59	597.74	401.05	600.17	599.68	598.63	598.23	401.15	598.25	598.44	598.26	599.73
2:30	573	400.9	577.52	576.73	576.44	574.79	400.88	575.86	576.08	576.49	577.47	400.95	580.26	579.56	578.49	578.2	401.04	578.47	578.72	578.41	579.65
3:30	555.1	400.81	559.5	558.85	558.36	556.67	400.79	557.86	557.96	558.36	559.2	400.85	562.19	561.34	560.29	560.07	400.94	560.51	560.8	560.44	561.44
4:30	538.98	400.73	543.19	542.68	542.04	540.36	400.7	541.63	541.65	542.05	542.76	400.77	545.83	544.9	543.88	543.69	400.84	544.26	544.56	544.2	544.96
5:30	524.48	400.65	528.47	528.08	527.33	525.7	400.63	527.03	526.98	527.38	527.98	400.69	531.05	530.07	529.12	528.93	400.76	529.58	529.88	529.54	530.1
6:30	511.47	400.59	515.21	514.94	514.11	512.56	400.57	513.91	513.81	514.19	514.7	400.62	517.74	516.73	515.84	515.66	400.68	516.37	516.63	516.34	516.71
7:30	499.8	400.53	503.29	503.11	502.22	500.77	400.51	502.12	501.99	502.36	502.79	400.56	505.75	504.74	503.91	503.73	400.61	504.48	504.71	504.46	504.67
8:30	833.19	811.9	832.53	832.71	833.67	833.18	812.54	831.76	831.7	831.44	831.08	808.51	830.16	830.87	830.99	831.98	810.8	831.93	832.49	831.66	832.42
9:30	900.17	896.74	900.35	900.27	900.69	900.44	896.77	900.08	900.07	899.98	900.08	896.81	900.07	900.11	900.24	900.21	896.81	900.42	900.16	900.05	900.26
10:30	907.7	906.68	908.03	907.9	907.83	907.79	906.66	907.98	907.97	907.94	908.16	907.38	908.43	908.19	908.25	908.06	907.06	908.17	907.91	907.88	907.84
11:30	910.69	910.34	910.86	910.76	910.67	910.72	910.36	910.89	910.88	910.87	910.98	910.76	911.15	911.05	911.03	910.86	910.57	910.89	910.76	910.78	910.72
12:30	911.86	911.7	911.92	911.85	911.84	911.86	911.76	911.97	911.97	911.96	912	911.95	912.1	912.06	912.03	911.93	911.82	911.95	911.88	911.89	911.85

13:30	912.31	912.22	912.33	912.28	912.3	912.31	912.29	912.38	912.37	912.37	912.39	912.37	912.43	912.42	912.39	912.34	912.29	912.37	912.33	912.32	912.28
14:30	912.49	912.43	912.49	912.48	912.49	912.49	912.49	912.53	912.53	912.53	912.54	912.52	912.55	912.55	912.52	912.5	912.48	912.52	912.5	912.49	912.48
15:30	912.56	912.53	912.56	912.56	912.57	912.57	912.57	912.59	912.59	912.58	912.59	912.58	912.59	912.59	912.58	912.57	912.57	912.57	912.57	912.56	912.56
16:30	912.59	912.58	912.59	912.59	912.6	912.6	912.6	912.61	912.61	912.61	912.61	912.61	912.61	912.61	912.6	912.6	912.6	912.6	912.6	912.59	912.6
17:30	870.75	871.13	870.76	871.24	871.28	870.94	871.64	871.82	871.89	872.15	871.95	871.99	872.13	872.19	871.48	871.64	871.47	871.18	871.59	871.27	871.44
18:30	813.66	813.72	813.27	814.74	815.13	814.23	815.47	816.25	816.55	817.13	816.7	815.7	816.66	817.05	815.34	815.86	814.67	814.21	815.61	814.66	815.37
19:30	768.49	768.15	767.9	769.89	770.36	769.16	770.44	771.77	772.23	773.15	772.66	770.84	772.52	773.01	770.87	771.54	769.35	769.08	771.1	770.21	770.88
20:30	730.5	730.42	730.18	732.08	732.3	731.06	732.28	733.78	734.32	735.47	735	733.45	735.17	735.42	733.41	734.01	731.51	731.5	733.47	733.22	733.32
21:30	697.31	697.94	697.53	699.02	698.83	697.68	698.89	700.27	700.83	702.12	701.67	701.09	702.39	702.24	700.62	701.06	698.88	699	700.49	701.01	700.37
22:30	667.67	669.1	668.42	669.48	668.84	667.84	669.1	670.21	670.74	672.09	671.66	672.2	672.94	672.41	671.22	671.5	669.93	670.05	670.97	672.13	670.82
23:30	640.9	643.04	642.08	642.8	641.72	640.88	642.21	643.03	643.5	644.89	644.46	645.99	646.23	645.4	644.56	644.7	643.79	643.86	644.27	645.86	644.04
Daily Ave. ()	738.05	686.96	739.48	739.65	739.52	738.69	687.26	739.67	739.83	740.23	740.39	687.64	741.46	741.21	740.47	740.51	687.25	740.18	740.61	740.52	740.76
Weekly Ave. ()	Week 1: 541.29	Week 2: 647.17	Week 2: 647.17	Week 2: 647.17	Week 2: 647.17	Week 2: 647.17	Week 3: 647.92	Week 3: 647.92	Week 3: 647.92	Week 3: 647.92	Week 3: 647.92	Week 4: 648.56	Week 4: 648.56	Week 4: 648.56	Week 4: 648.56	Week 4: 648.56	Week 5: 648.19	Week 5: 648.19	Week 5: 648.19	Week 5: 648.19	Week 5: 648.19
Monthly Ave. ()	January Ave.: 637.64	January Ave.: 637.64	January Ave.: 637.64	January Ave.: 637.64	January Ave.: 637.64	January Ave.: 637.64	January Ave.: 637.64	January Ave.: 637.64	January Ave.: 637.64	January Ave.: 637.64	January Ave.: 637.64	January Ave.: 637.64	January Ave.: 637.64	January Ave.: 637.64	January Ave.: 637.64	January Ave.: 637.64	January Ave.: 637.64	January Ave.: 637.64	January Ave.: 637.64	January Ave.: 637.64	January Ave.: 637.64
	350.00	350.00 - 475.00	475.00 - 600.00	475.00 - 600.00	600.00 - 725.00	600.00 - 725.00	850.00 - 975.00	850.00 - 975.00	975.00 - 1100.00	975.00 - 1100.00	1100.00 - 1225.00	1225.00 - 1350.00	1350.00 - 1475.00	1350.00 - 1475.00	1475.00 - 1600.00	1475.00 - 1600.00					