School of Engineering

Diploma in AI & Data Engineering

EGT209

Data Engineering Project

Final Report

AY2023S1

1. Project Team Members

This Data Engineering Project Team consists of:

S/N	Module Group	Name	Admin Number	Role and Responsibilities
1	EGT209 – T1	Harish Kanna	230268R	Team Leader
2		Leong Jun Hoe	230633N	Member
3		Ng Yik Heng	234622M	Member
4		Lee Ying Ray	233466E	Member

2. Executive Summary

The executive summary is a summary of the entire report. It should include the objectives, scope, and outcomes of the project, as well as any significant findings or recommendations. The executive summary should be concise and to the point and should provide a clear idea of what the report is about.

This project aimed to develop a data-driven approach to identify and analyse the factory shop floor to identify the areas where indoor air parameters such as temperature, humidity and air quality were unsuitable for worker safety and comfort and the when this occurs for further analysis. The goal of this was to derive insights from the analysed data to deliver recommendations that were both sustainable and energy-efficient in maintaining optimal indoor environmental conditions.

Our approach in collecting data involved monitoring the environment with temperature, humidity and air quality sensors connected to an Arduino. Data was collected and sent to a MySQL table in 15 minute intervals and was compared against the Singaporean Standard SS 554:2016 for the analysis. Our analysis showed us that while the air quality was consistently good, temperature was often suboptimal especially near the shutter door and during the afternoons while humidity was very inconsistent throughout the room and is suboptimal a significant amount of the time too.

Based on our findings, we recommended four measures: planting trees outside the factory shop floor to provide shade, applying thermal insulation coating on the shutter door, installing a single-way pressure relief vent to prevent hot air from entering the room, and using an industrial-grade dehumidifier connected to a humidity sensor to control humidity.

These recommendations are sustainable and energy-efficient approaches to maintaining worker safety and comfort.

This project highlights the importance of a data-driven approach to monitoring the environment on a factory shop floor. Our insights can be further explored, especially the spike in air quality. Our insights can also be further enhanced by comparing them to the optimal temperature and humidity needed for the best performance of machines in the area.

3. Introduction

Project objectives: The main objective of the project was to create a data-driven approach to identify areas on the factory shop floor where indoor air parameters, namely temperature, humidity and air quality, became unsuitable for worker safety and comfort and to note down the timings where this occurs. After collection of data, we then intended to derive insights from this data to deliver recommendations as to how a sustainable, energy-efficient approach could be employed to ensure that the indoor air parameters are suitable throughout the factory shop floor while workers are present.

Scope:

What is included in the project?	What is NOT included in the project?
Environmental monitoring system: We will collect and analyse data on the environment.	After analysing data: We will not use existing or create new systems to change the environmental conditions after analysis.
Data analysis during the project: We will constantly update our analysis as we collect new data throughout the duration of our project.	After the project duration is over: We will not continue to analyse or collect data. We will not maintain the systems we used to analyse or collect data.
Report: We will give a detailed report on our findings and recommendations at the end of the project duration.	After the report: We will not create systems to implement the recommendations we give, and we will not continue reporting findings.

Constraints and limitations:

Limited data: The data we can collect is limited to the sensors provided to us and the timeframe of the project. We will be unable to collect data outside of it, for example, we cannot find out the exact percentage of harmful gases such as carbon monoxide in the air of the factory shop floor. We will only be able to know the temperature, humidity and the air quality as determined by the Grove - Air Quality Sensor v1.3.

Determining of 'optimal' indoor air parameters: We were not provided any information on what temperature, humidity or air quality range would be considered suitable for worker safety and comfort on the factory shop floor. As such, we will do our own research into what values of these parameters would be considered suitable in general, but this may be slightly inaccurate as the factory shop floor we are collecting data on may have different needs than other buildings.

Background Information and significance: Environmental monitoring in factories involves sampling and analysing multiple parameters such as temperature, humidity and air quality. This is done for multiple reasons: Safety, efficiency and compliance with industry standards and regulations. Environmental monitoring can identify fluctuations that may signify dangerous events occurring and can identify where and when the parameters are unsuitable for a long period of time which could be dangerous as workers may be constantly exposed to unsafe conditions. Our project not only is significant in protecting the health and safety of workers, but also ensuring that the maintenance of environmental parameters on the factory shop floor can be both sustainable and energy efficient.

4. Methodology

Data collection techniques: A simple set up was created using an Arduino, a temperature sensor, a humidity sensor and an air quality sensor. This Arduino would be placed in a corner of the factory shop floor over the course of a few weeks to collect a wide range of data for analysis. The data would be collected in 15 minute intervals and sent via MQTT to a MySQL server which could be queried at any time to obtain all the data collected so far. The data would be sent as a message in the format <temperature>;<humidity>;<air quality>, and the MySQL server would add a timestamp to the row in a new column when it receives the data.

Data analysis techniques: After collecting enough data, we began our analysis. We started off by doing simple data cleaning in Python, which was to drop the data that was not in the format <temperature>;<humidity>;<air quality> as this data was sent to the MySQL table during our testing. We then had to split the message into three columns for temperature, humidity and air quality. We discovered that from 17th to 22nd July, there was missing data that would affect our analysis. Hence, we dropped the data before 22nd July and kept the time range as 22nd to 31st July. In order to improve our data analysis, we used not only the data collected by our own Arduino but also the data of an Arduino that was attached to the shutter door of the factory shop floor and the Arduino of another team doing the same project whose Arduino was in the opposite corner of the factory shop floor than ours. Once we had narrowed down all the data that we would be analysing and done the appropriate cleaning and pre-processing, we had to consider what we would be comparing the data we collected to. In our research, we discovered the SS 554:2016 (enviresearch, 2016), also known as the Singaporean Standard for the Code of practice for indoor air quality for air-conditioned buildings. Since this code is used to ensure the safety and comfort of workers in the buildings, it aligns with our goal and hence we used the information in this code to guide our analysis. The code states that the acceptable limit of temperature is 23 to 25 degrees Celsius and that the acceptable limit of humidity is below 65%, and we will be using these two ranges in our analysis to determine if where and what time is the factory shop floor unsuitable for workers.

Limitations and challenges: Limited time range of data: We discovered a spike in air quality on the 26th of July that we further analysed later on. There could have been more spikes like this that might have been valuable to analyse, but we would not be able to do so as the time range where we collected data was rather limited. Determining optimal environmental parameters: While we discovered the SS 554:2016 in the end, we struggled a lot to find any standards or industry regulations that stated what temperature or humidity ranges were acceptable. Furthermore, since the SS 554:2016 is for air-conditioned buildings in general instead of for specifically factory shop floors, this standard might not be fully accurate to what is actually needed.

5. Results and Findings

Precursor

Besides the data we collected, we also used data from another team and the data collected from an Arduino on the shutter door. This can be seen in Appendix A. T1G2 is our Arduino which will be labelled as ‘Our Device’, and T1G4 is the data from another team’s Arduino which will be labelled as ‘Reference Device’. device01 refers to the location of the Arduino on the shutter door.

Temperature

As we can see from Appendix B, the temperature at the shutter door is far above the optimal range of 23 – 25 degrees Celsius 100% of the time. However, our device and the reference device does enter the 23 to 25 degrees Celsius range, but its very hard to tell from the graph. Hence we’ll move on to Appendix C, which shows us the temperature of our device and the reference device only. We can see from the graph that the temperature only enters the optimal range of 23 to 25 degrees Celsius only around 8 to 10 am on weekdays. On weekends, the temperature never enters to optimal temperature range. This can be attributed to the fact that the air-conditioning of the room is not on all the time, and even when it is on it may not be enough in the afternoons due to the heat from outside.

Humidity

For humidity, we only have the data from our device and the reference device as can be seen from Appendix D. It is interesting to note that the reference device, which is on the opposite side of the room, has its humidity stay within the optimal range around 50% of the time while our device shows the humidity rarely every dipping into the optimal range. This shows us that the humidity throughout the room is not the same, which will be explored when giving our recommendations.

Air Quality

From Appendix E, we can see that the air quality is fine most of the time and shows that there is no air pollution in the room. However, on the 26th of July, there is a spike which may indicate a spike in pollution in the room. Both our device and the reference device shows this spike, further confirming that this is not a bug and rather something that happened. Despite the spike, we still believe that this is no cause for concern. Appendix F shows us that the device on the shutter door constantly gives an air quality rating of 3, even on 26th July. Since an air quality rating of 3 signifies no pollution, the spike may not actually be something to worry about. However, this could be looked into further as this may have been caused by some illegal substance usage or issues with the machines. We do not have the capacity to look further into this and hence will not do so.

Recommendations

Our first recommendation is to plant trees outside the factory shop floor, as can be seen from Appendix G. This will help provide shade to reduce the amount of sunlight hitting the room, which can help reduce the very high temperatures in the room during the afternoon. Trees not only provide shade, but also release water vapour which will help further cool down the surrounding air and reduce the local temperature in the area. Trees such as the Batoko Plum as shown in Appendix H can be used as these are very leafy trees which will do a good job in providing shade and releasing water vapour.

Our second recommendation is to apply a thermal insulation coating on the metal shutter door as shown in Appendix I. From our analysis, we noted that the temperature near the shutter door is always above the optimal range which could be very dangerous for workers working near the shutter door. Thermal Insulation coating reflects the sun's visible light and energy, therefore minimising thermal conductivity of the shutter. This will not only help reduce the overall temperature of the room but also significantly reduce the ambient and surface temperature of the surface door, minimising the risks of working near there.

Our third recommendation is to install a single-way pressure relief vent as shown in Appendix J in the room. Since air flows from high to low pressure, if the temperature of the room is higher than the outside, hot air will flow from the room to outside. However, the opposite is usually true where the temperature outside is hotter than the inside of the room and hence hot air will flow from outside the room into the inside. This can be circumvented by installing a single-way pressure relief vent, which only allows air from the inside to the outside. Hence, hot air from outside the room will not flow in and heat up the room.

Our fourth and final recommendation is to install an industrial-grade dehumidifier as shown in Appendix K. This dehumidifier should be connected to a humidity sensor, and will only turn on when the humidity of the room exceeds the optimal percentage. This will help lower the humidity of the room only when needed, saving energy during the times it is not needed.

6. Conclusion

Key findings: Temperature near the shutter door is extremely high and far above optimal range. Temperature throughout the rest of the room is high, and only enters the optimal range before the afternoon and when the air conditioning is turned on. Humidity is under control 50% of the time on one side of the room, but is nearly always suboptimal on the other side. Air quality is good all the time. Spike in air quality is not a cause for concern, but could be investigated further.

Outcomes: Delivered four recommendations- Plant trees outside the factory shop floor, apply a thermal insulation coating on the metal shutter door, install a single-way pressure relief vent and use an industrial-grade dehumidifier when needed. All of these are sustainable and energy-efficient approaches to keeping indoor air parameters at optimal levels for worker safety and comfort.

Impact of the project: Our project will have a high impact on creating a cost-effective and environmentally friendly approach for ensuring worker safety and comfort on the factory shop floor. In our project, we were able to identify the timings and areas where indoor air parameters were unsuitable, and discover specific recommendations to solve these issues. Our data-driven approach will also allow the client to do further research, such as the spike in air quality which they may be interested in finding the cause of.

Limitations and areas for further research: Not all parts of the factory shop floor may have the same temperature and humidity requirements due to the various machines around the area. Since we were not given this information, we did not consider the requirements of the machines on the factory shop floor. Further research can be done into this to not only maintain worker safety and comfort, but ensure that machines are in their most optimal environment for use.

7. References

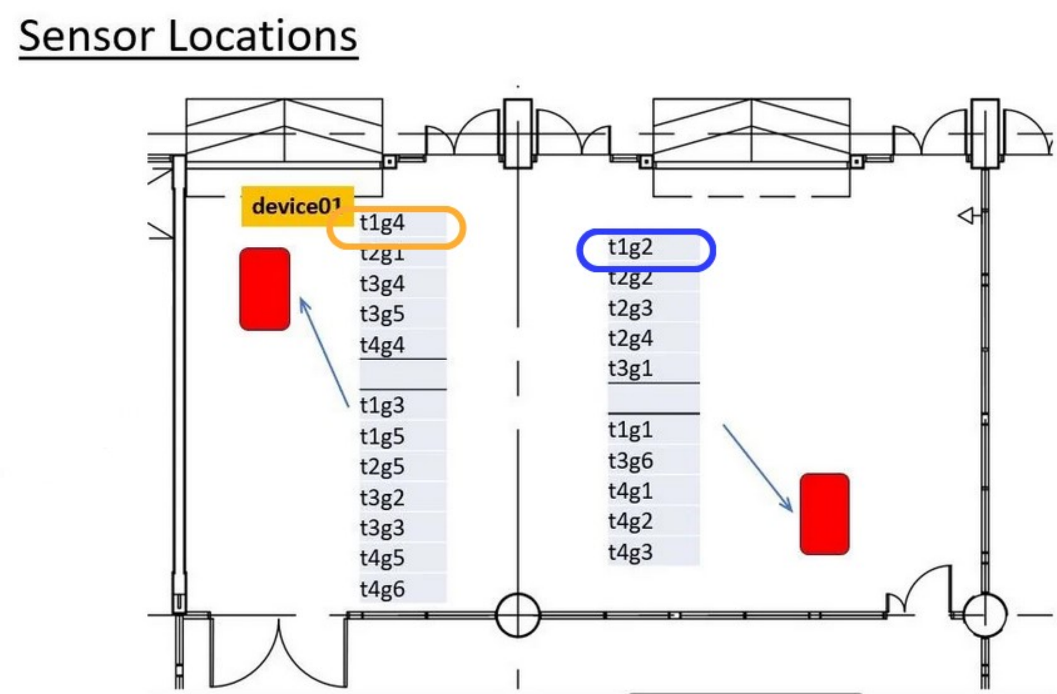
The references/bibliography section should include a list of all the sources used in the project. The list should be organized alphabetically by author's last name and should include all relevant publication information. Proper citation style should be followed according to the guidelines provided by the course or institution.

SS 554 : 2016 - indoor air quality parameters and measurement. (2016). http://www.enviresearch.co.th/wp-content/uploads/2020/01/Indoor-Air-2016.pdf

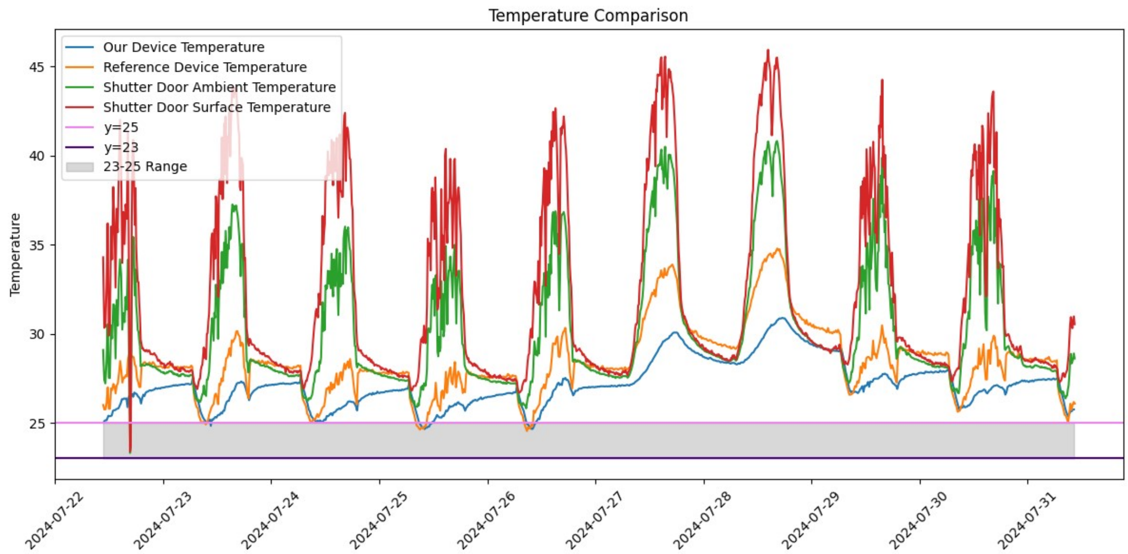
8. Appendices

The appendices section should include any additional documentation or evidence of the project work. This can include project plans, visual aids, data tables, or any other relevant information that supports the analysis in the report. This section should be clearly labelled and organized for easy reference.

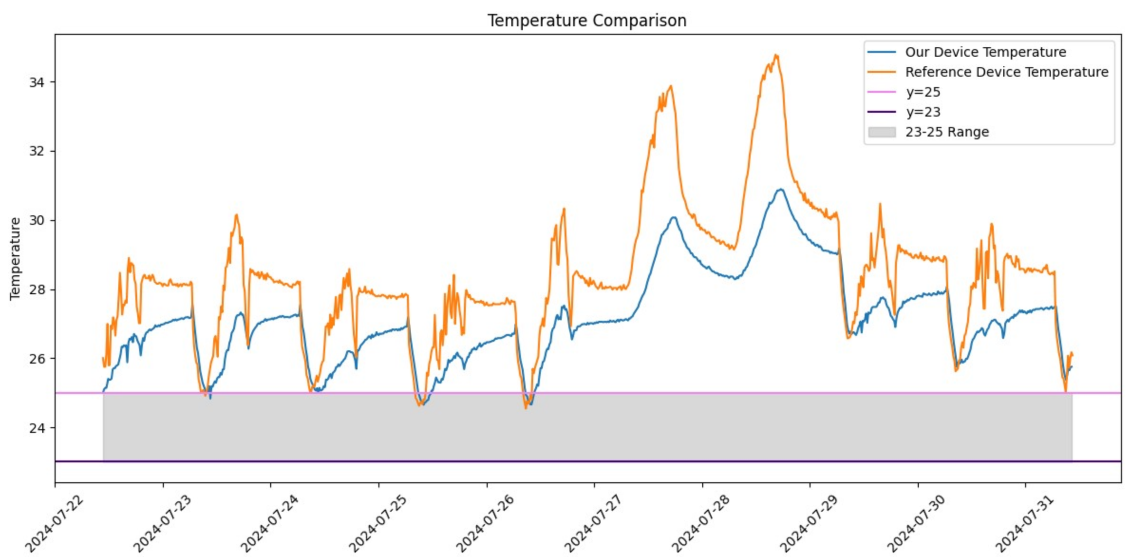
Appendix A:



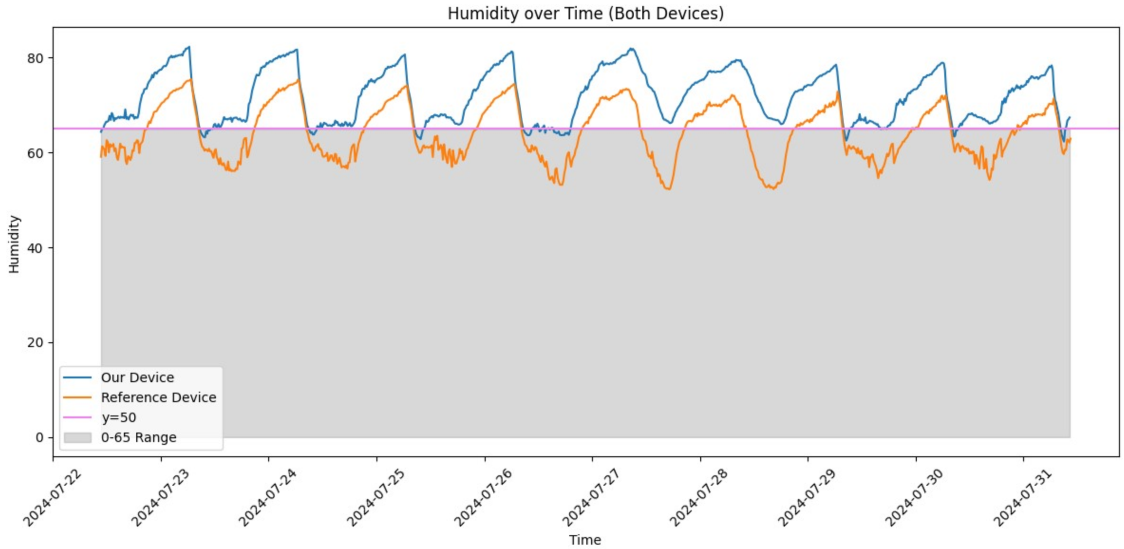
Appendix B:



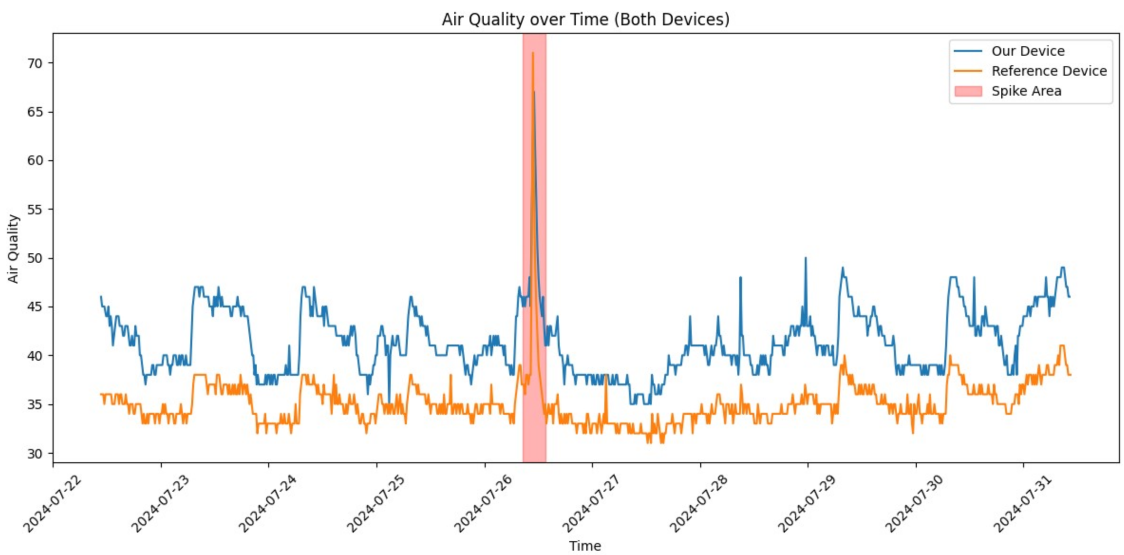
Appendix C:



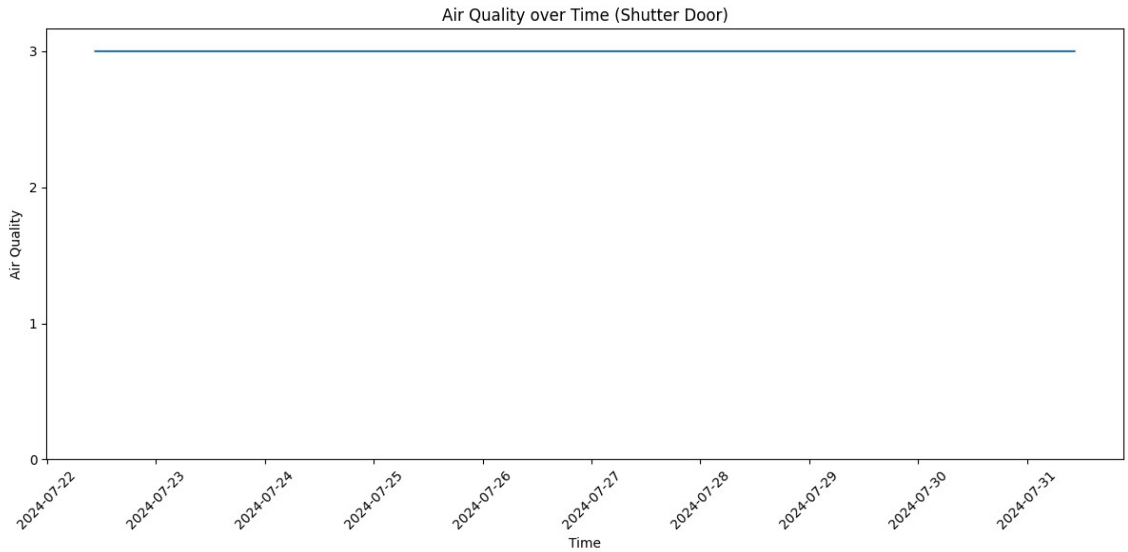
Appendix D:



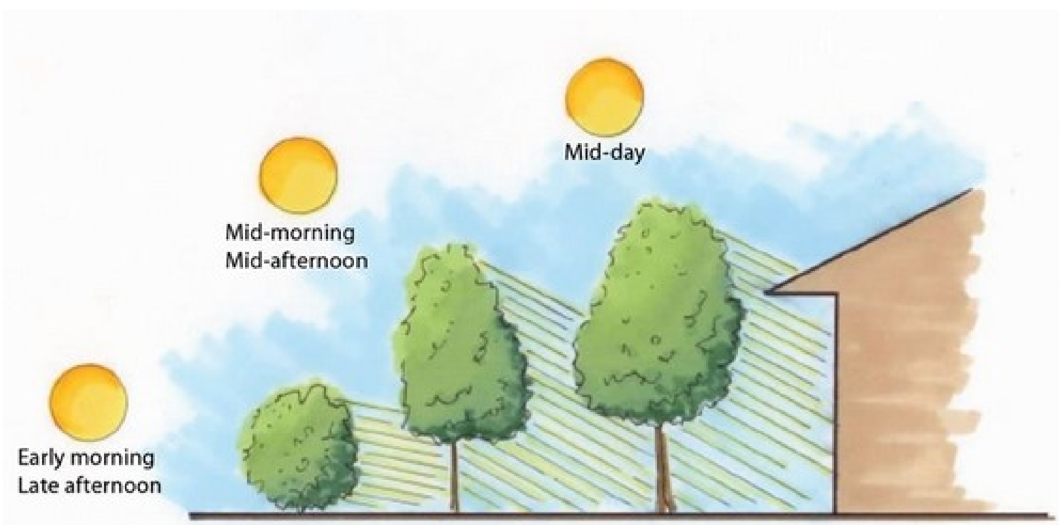
Appendix E:



Appendix F:


Air Quality over Time (Shutter Door)
Air Quality
3
2
1
0
2024-07-22
2024-07-23
2024-07-24
2024-07-25
2024-07-26
2024-07-27
2024-07-28
2024-07-29
2024-07-30
2024-07-31
Time

Appendix G:


Mid-day
Mid-morning
Mid-afternoon
Early morning
Late afternoon

Appendix H:

Appendix I:

Appendix J:

Appendix K:


LGR 6000Li
DEHUMIDIFIER
DRIEAZ