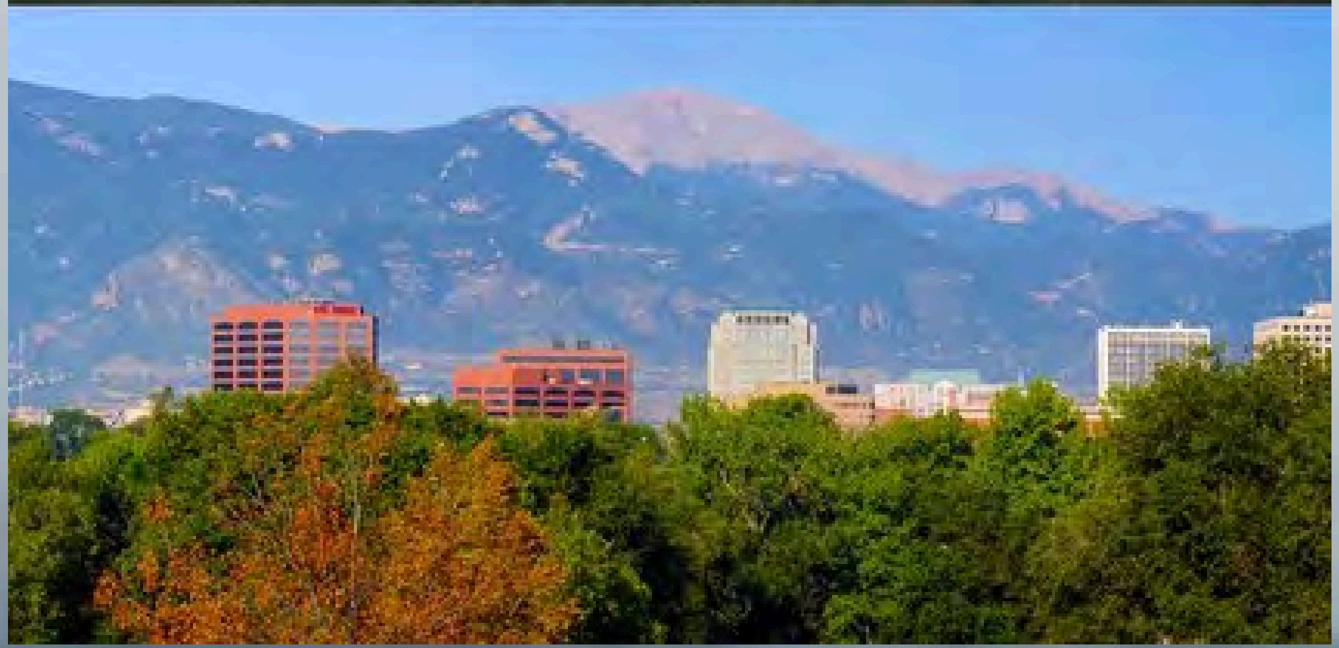
Dust Busters

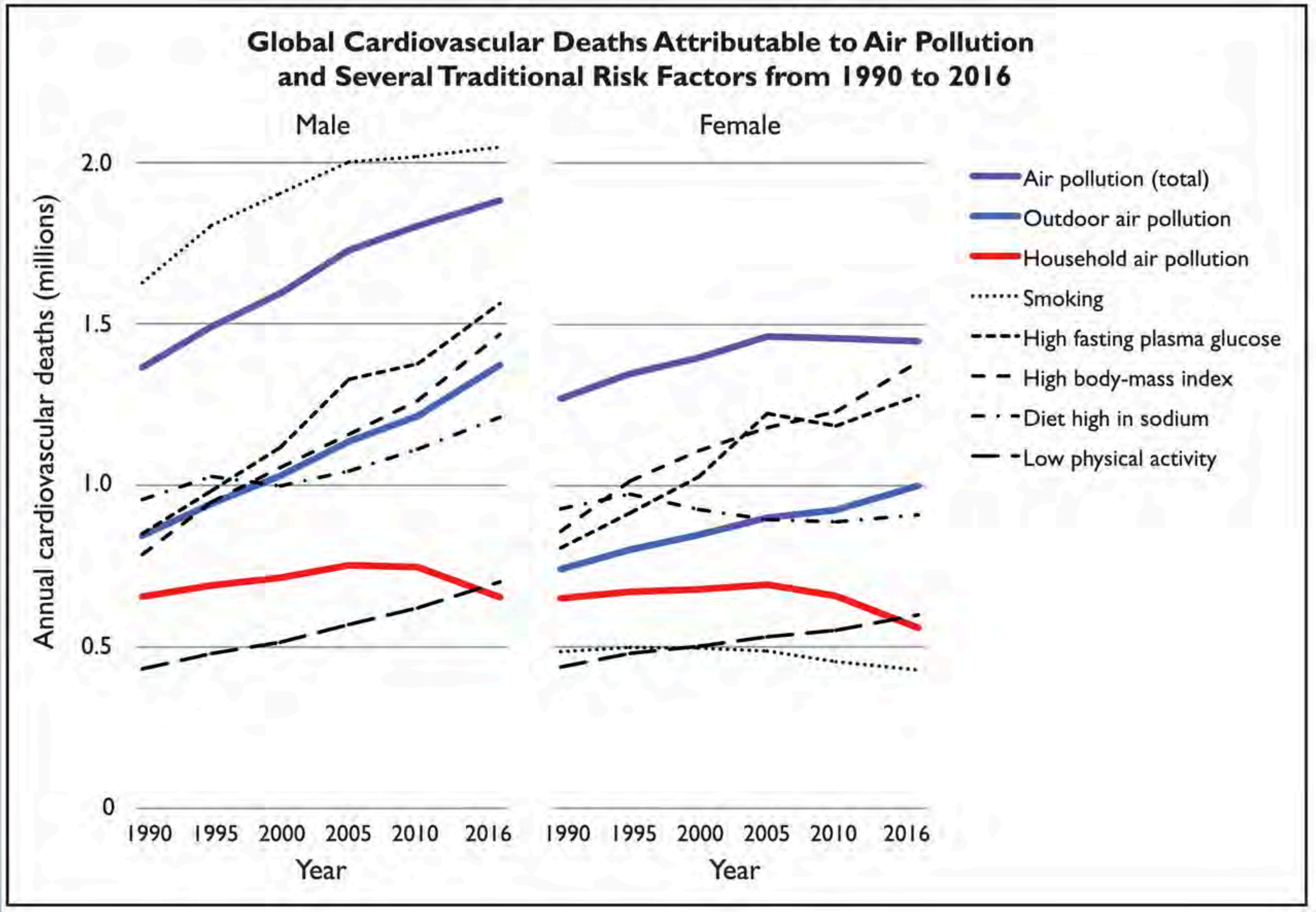
PM 2.5 SENSOR DEVICE FINAL PRESENTATION

BACKGROUND



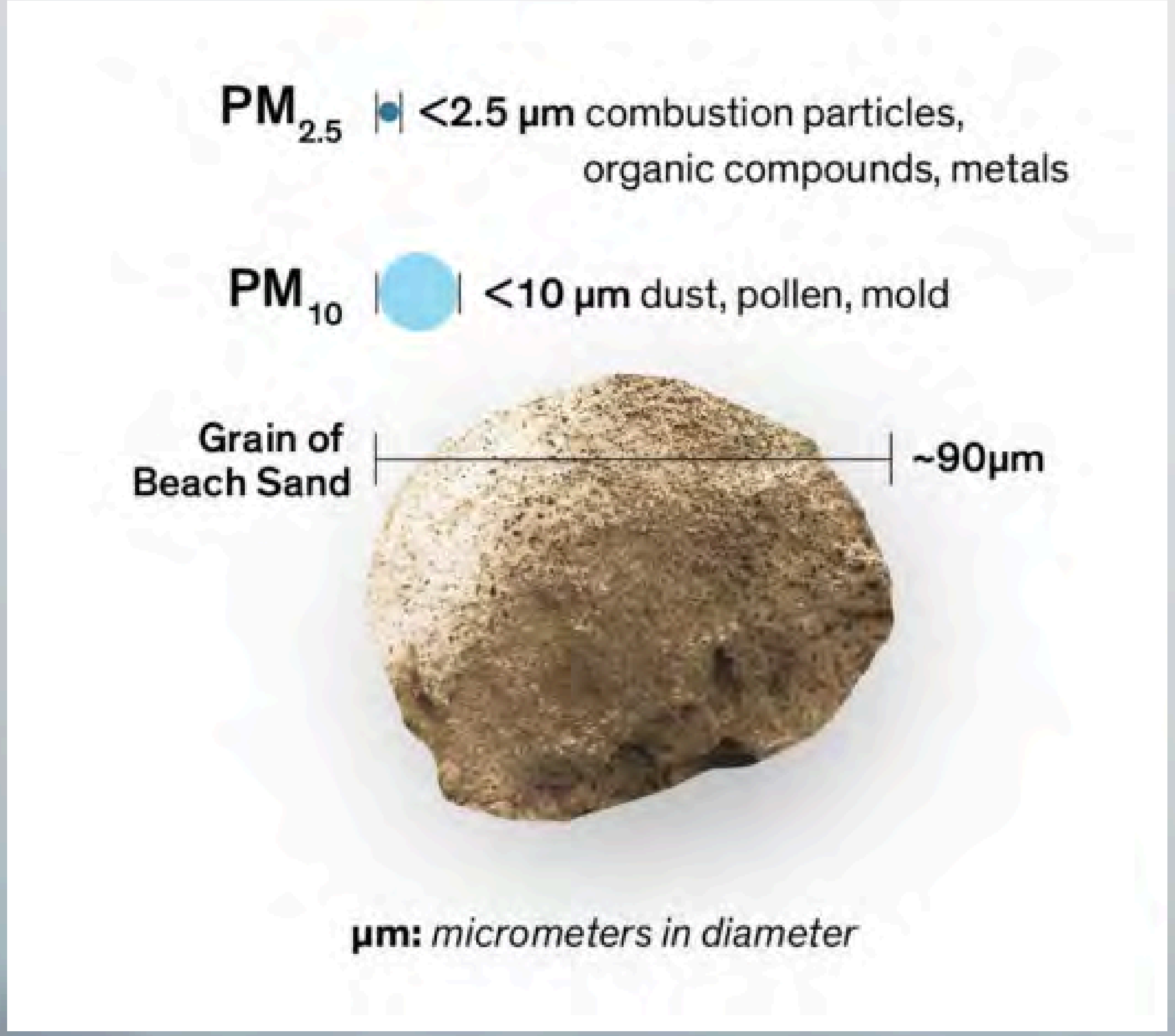
- Rapid urbanization leads to an increase in vehicles and reduction in open spaces
- This causes an increase in airbone particles such as PM2.5, PM10, CO_2 among others
- Which leads an increase in air pollution causing serious health risks
- Most serious particle is PM2.5

AIR POLLUTION



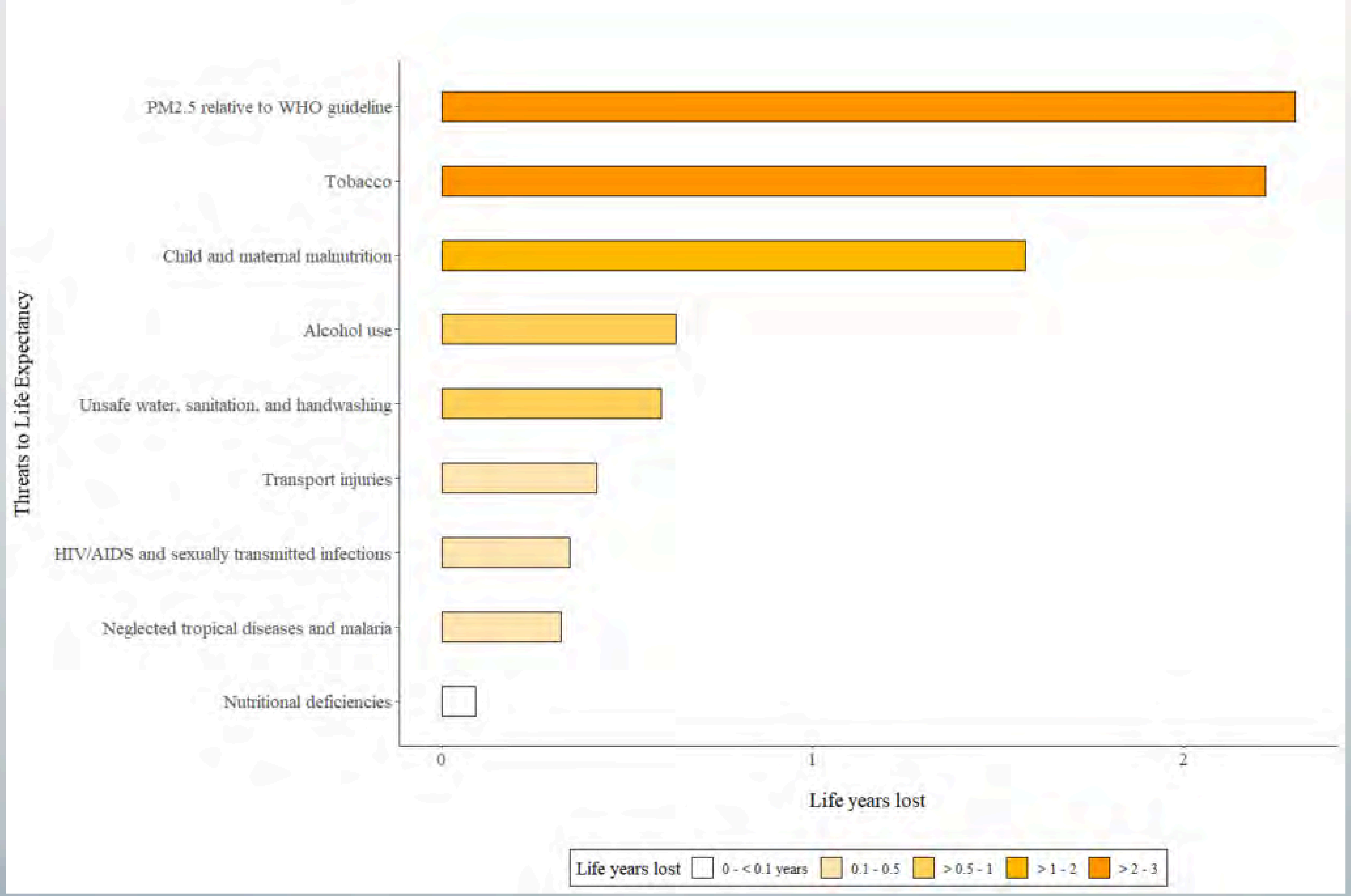
- Air pollution responsible for 19% of all CVD deaths
- Over 3.3 million deaths exceeding smoking at 2.48 million and elevated BMI at 2.85 million

PARTICULATE MATTER



- Particulate matter (PM) are small dust particles in the air
- 2 sizes - 10 microns (PM10) and 2.5 microns (PM 2.5)
- PM2.5 can enter bloodstream and lungs causing serious complications
- Children, elderly people and people with existing health problems most susceptible

AIR POLLUTION



Exposure to PM 2.5 can reduce life expectancy significantly

PROBLEM

01

Current air quality measurement devices are sparsely located and only update hourly, leading to unreliable readings for specific locations.

02

There are no air quality monitors at HM, despite the recent surge in PM2.5 levels making them necessary.

03

Existing air quality monitors are expensive
(IQAir costs 10,000 THB)

OBJECTIVES AND SCOPE

01 Accurately measure PM 2.5 levels indoors and outdoors

- Calibrate by testing in controlled environments such as rooms with air purifiers
- Compare with online air quality data to verify accuracy.

02 Test in controlled and outdoor environments

- Deploy the device in various outdoor and indoor locations at KMITL
- Test in areas of around 10-20m^2

OBJECTIVES AND SCOPE

03 Provide wireless data transmission

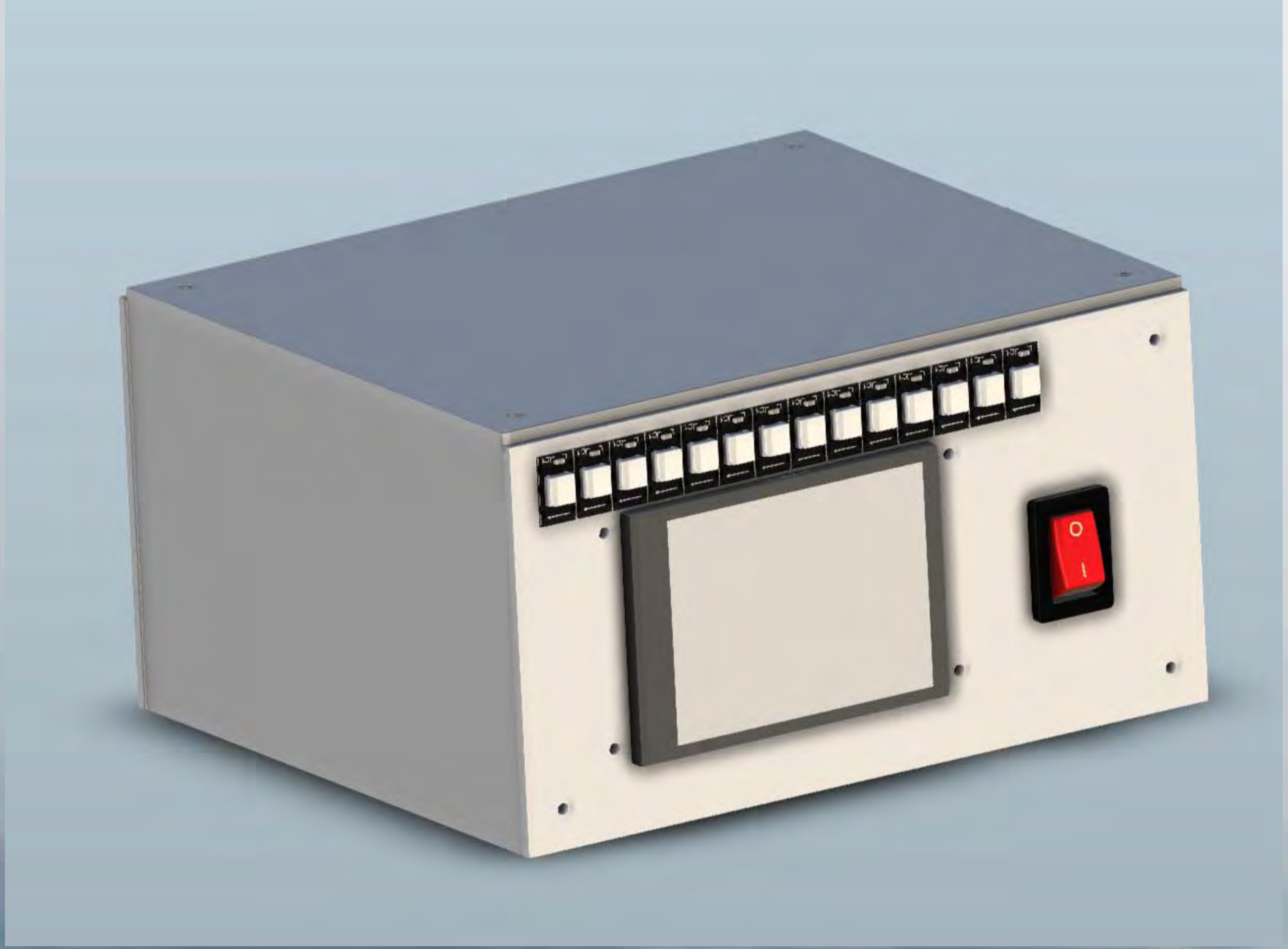
- Transmit the data wirelessly to a laptop or computer at a range of 100m
- Transmit results from the sensor to monitor at a range of 300m

04 Power through solar and rechargeable batteries

- Run the Air Sensor 24/7 using solar and rechargeable batteries
- Run the Air Monitor 2-3 hours on rechargeable batteries

DESIGN

AIR MONITOR



- LEDs to indicate PM 2.5 level
- Display to show real time information
- Simple and Intuitive display UI

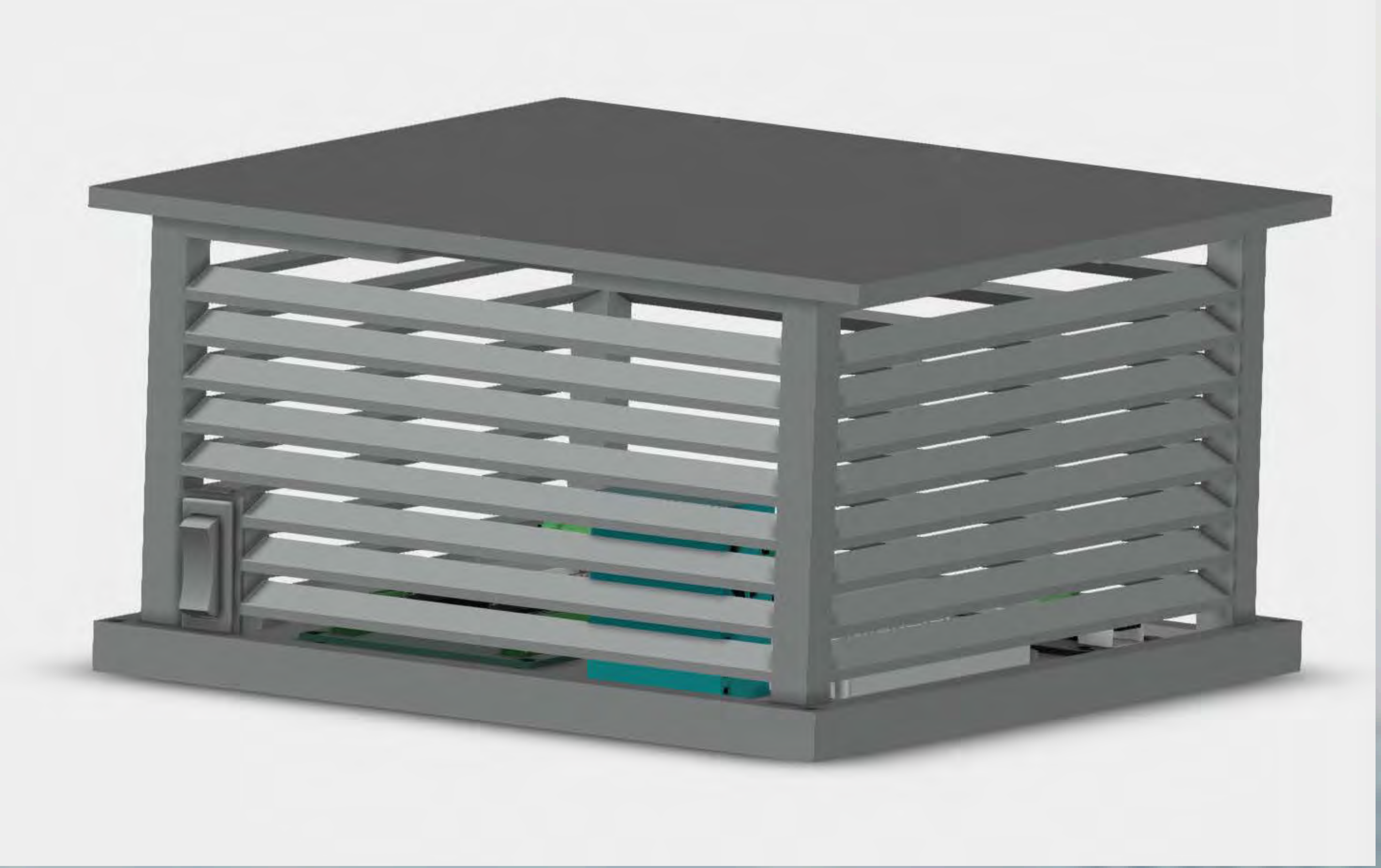
Size: 133 x 116 x 72mm

DESIGN

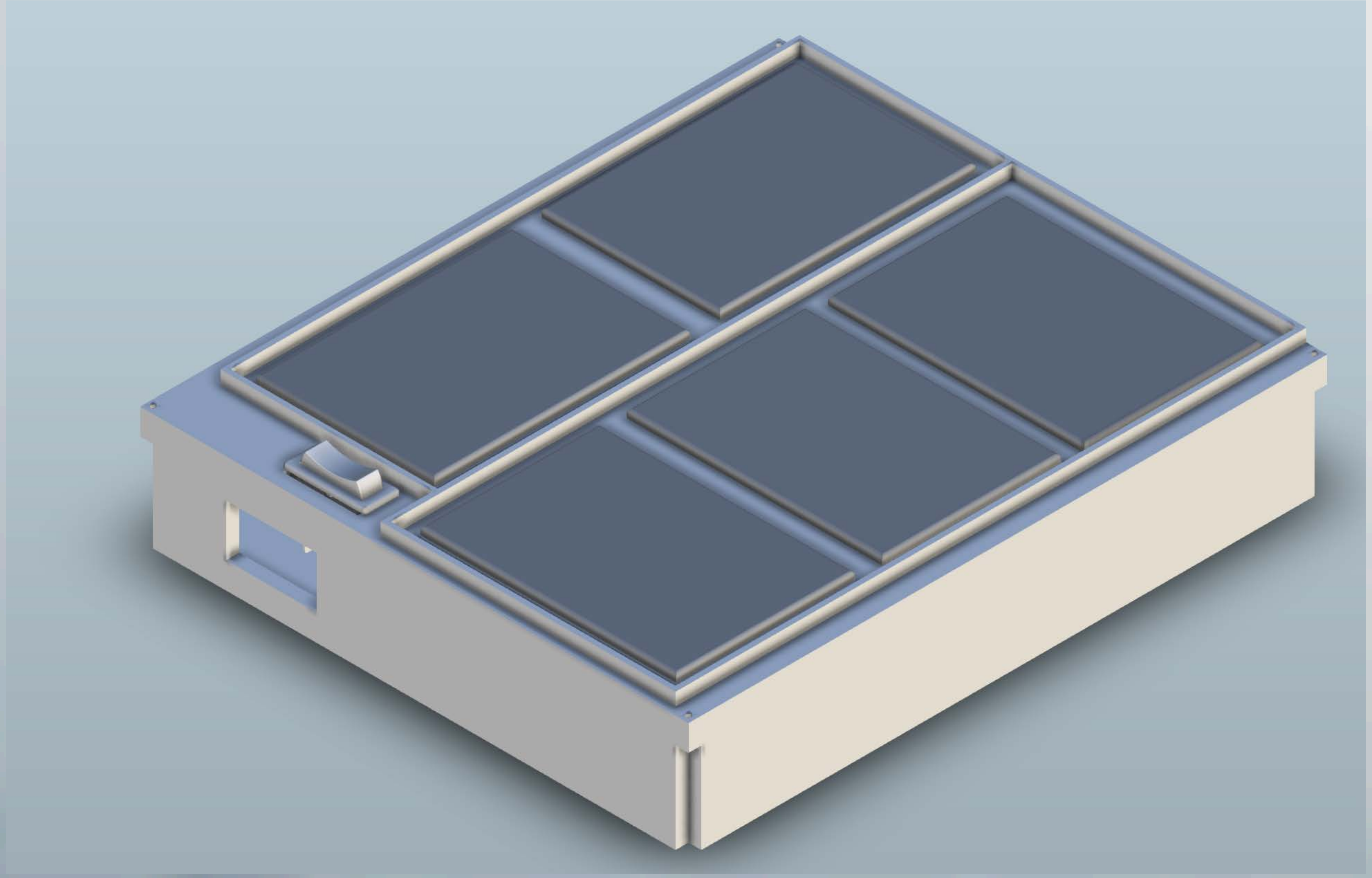
AIR SENSOR

- Louvers to help with ventilation and prevent water and debris from entering
- Overhangs roof prevents rain from directly entering.

Size: 206 x 206 x 115 mm



SOLAR BOX



Size: 247 x 212 x 50 mm

WHY USE PARALLEL PANELS

- Easily available compared to a 5V 1A Panel
- More reliable as if one fails the rest can power
- Can be placed at different places to maximize power
- Easier to adjust the power

EQUIPMENTS

x2 ESP32

x1 Laser Dust sensor

x1 led strip lights

x3 Switch

x1 LCD

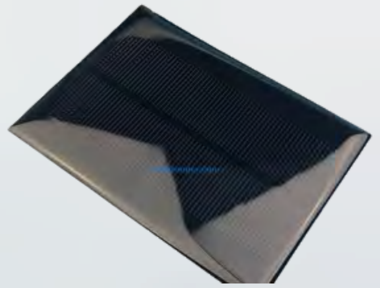
x1 Co2 sensor

DC Step Up Charger

x1 Solar Charger

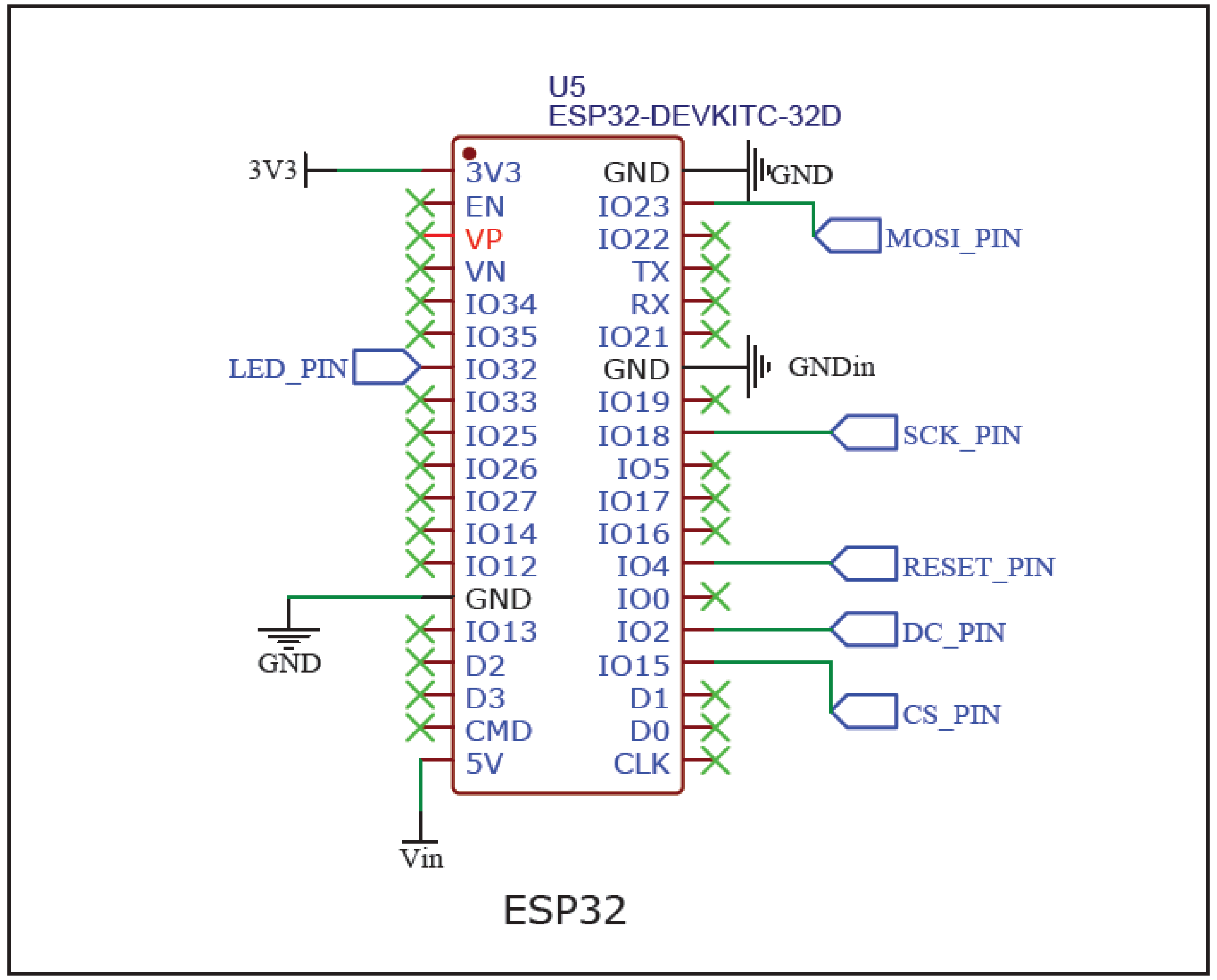
x2 Li-on Battery

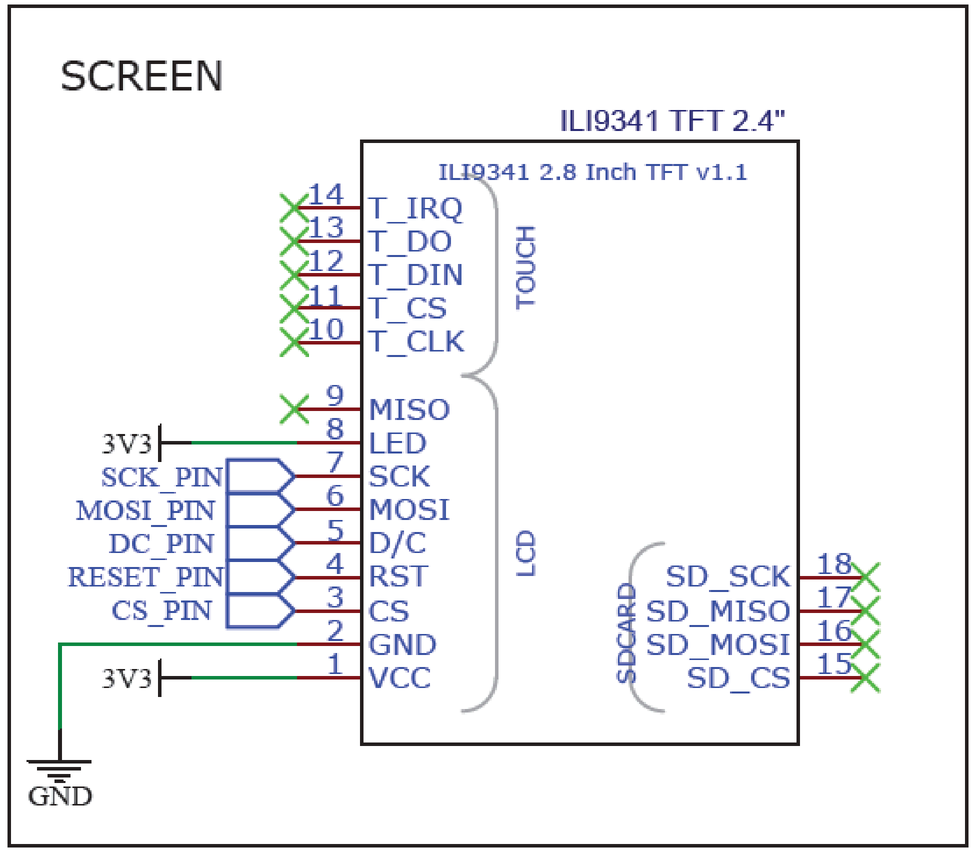
x1 Temperature and humidity sensor

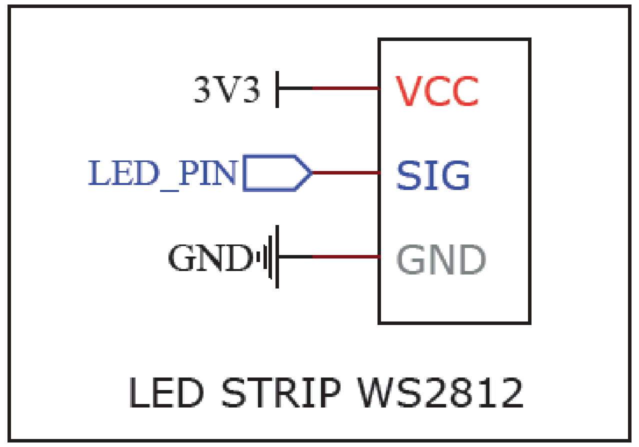


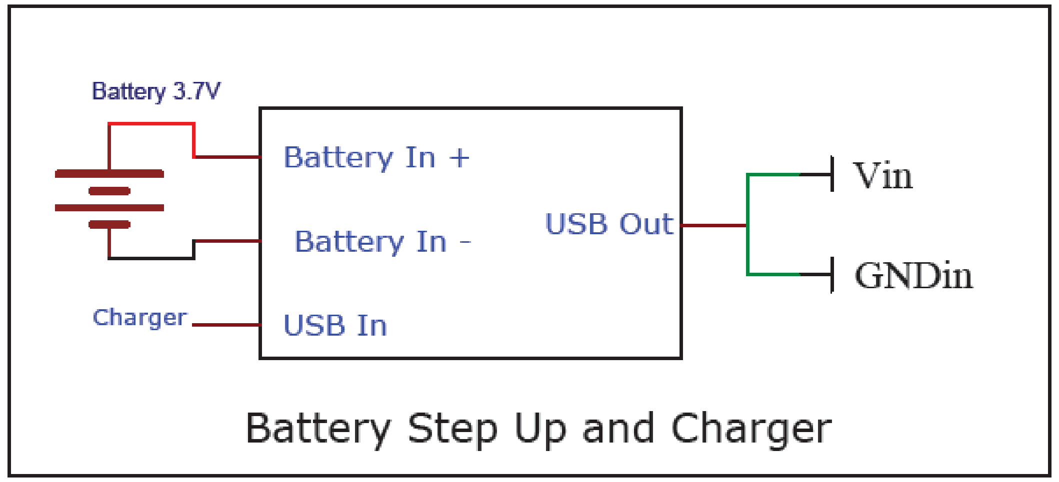
x5 Solar Panel 5v 200ma

AIR MONITOR CIRCUIT

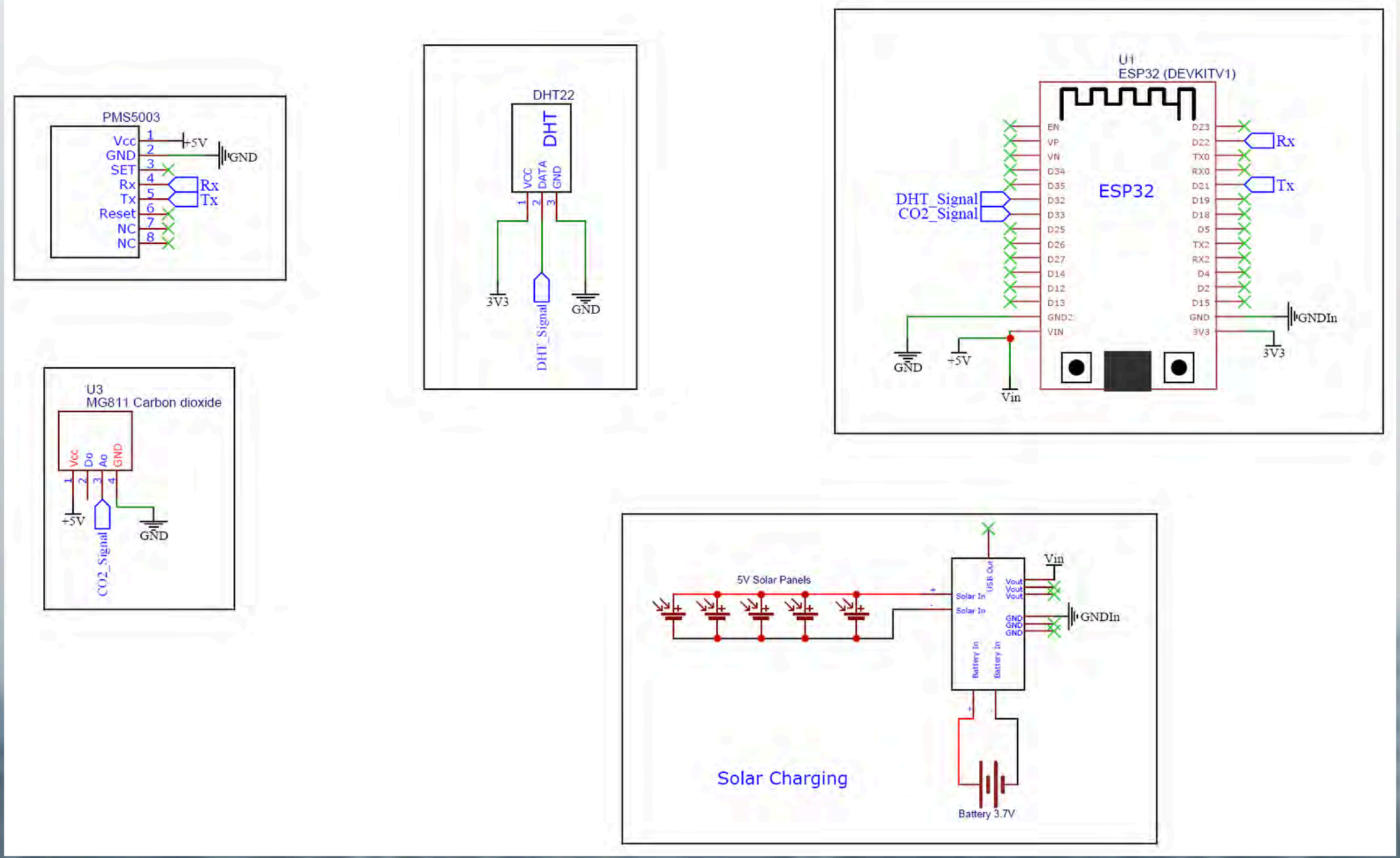








AIR SENSOR CIRCUIT



BATTERY CALCULATIONS

AIR SENSOR CHARGE TIME

Solar Panel Output

5V 1A = 5W *

Efficiency** = 73% --> 5 * 0.73 = 3.65W

Total = 3.65W

Battery Capacity

3.7V 3.1A = 11.47Wh

Average Charging Time

11.47/ 3.65 = 3.14 hours

* Under ideal sunlight
** Efficiency value from datasheet

BATTERY CALCULATIONS

AIR SENSOR RUN TIME

Power Drawn From Components :

ESP32 = 3.3V × 150mA = 0.495W   PMS5003 = 5V ×100mA = 0.5W

DHT22 = 3.3V × 2.5mA = 8.25mW   MG811 = 5V × 250mA = 1.25W

Total = 2.25W

Power Drawn From Battery :

P_{in} = P_{out} / Effeciency* = 2.25W / 0.86 = 2.62W

Battery Current Draw :

I_{draw} = P_{in} / Battery’s Voltage = 2.62W/3.7V = 0.708A

Battery Run Time Calculation :

Run Time = Battery’s Current / I_{draw} = 3.1Ah / 0.708A = 4.37 Hours

* Efficiency value from datasheet

BATTERY CALCULATIONS

AIR MONITOR CHARING TIME

USB Charging

3.7 - 5.5V at 1A = 3.7W to 5.5W*

Battery Capacity

3.7V 3.1A = 11.47Wh

Average Charging Time

11.47/3.7 to 11.47/5.5 = 3.1 to 2.1 hours

* Range of supported input voltage is 3.7 - 5.5V from datasheet

BATTERY CALCULATIONS

AIR MONITOR RUN TIME

Power Drawn From Components :

ESP32 = 3.3V × 150mA = 0.495W   2.4" LCD Screen = 3.3V × 100mA = 0.33 W

8 LEDs Strip = 3.3V × 20 mA × 8 = 0.528W

Total = 1.353W

Power Drawn From Battery :

$P_{in} = P_{out}$ / Efficiency* = 1.353W / 0.85 = 1.591W

Battery Current Draw :

$I_{draw} = P_{in}$ / Battery’s Voltage = 2.62W/3.7V = 0.43A

Battery Run Time Calculation :

Run Time = Battery’s Current / I_{draw} = 3.1Ah / 0.43A = 7.2 Hours

* Efficiency value from datasheet

DEMONSTRATION

https://youtube.com/shorts/P0_oIdW7phA?feature=share

RESULTS

Without Load*

Under Load

Current = 1.2A

Voltage = 5.3V

Voltage = 4.3V

* Without load, the open circuit volatge and short circuit current is measured which is always higher than actual values

RESULTS

Charging Air Monitor via USB

Time	Voltage (V)
Start	3.2
30 min	3.6
1 hour	3.7
1:30 hour	3.9
2 hour	4
2.5 hour	4.1 (max)

Total charge time = 2.5 hours
Charge voltage = 5V
Relative error:
2.5 - 2.294 / 2.294 = 8.98%

RESULTS

Time	Voltage
Start	4.1
30 min	3.9
1 hour	3.85
1:30 hour	3.85
2 hour	3.7
2.5 hour	3.6
3 hour	3.55
3.5 hour	3.5
4 hour	3.4

Runtime of Air Monitor

Average rate of discharge = 4.1 - 3.4 / 4 = 0.175 V/hr

Remaning volatge* = 3.4 - 2.9 = 0.5V
Extra time needed = 0.5 / 0.175 = 2.85 hr

Total Runtime = 6.85 hours

Relative error:
6.85 - 7.2 / 7.2 = 4.86%

* Step up stops discharge at 2.9V

RESULTS

Charging Air Sensor via Solar

Time	Voltage
Start	3.0
30 min	3.2
1 hour	3.3
1:30 hour	3.4
2 hour	3.5
2.5 hours	3.55
3 hours	3.6

Average charge rate = 0.6/3 = 0.2V/hr
Remaining Voltage = 4.1 - 3.6 = 0.5V
0.5 / 0.2 = 2.5 hr
Total charge time = 5.5 hr

* Tested in cloudy weather

RESULTS

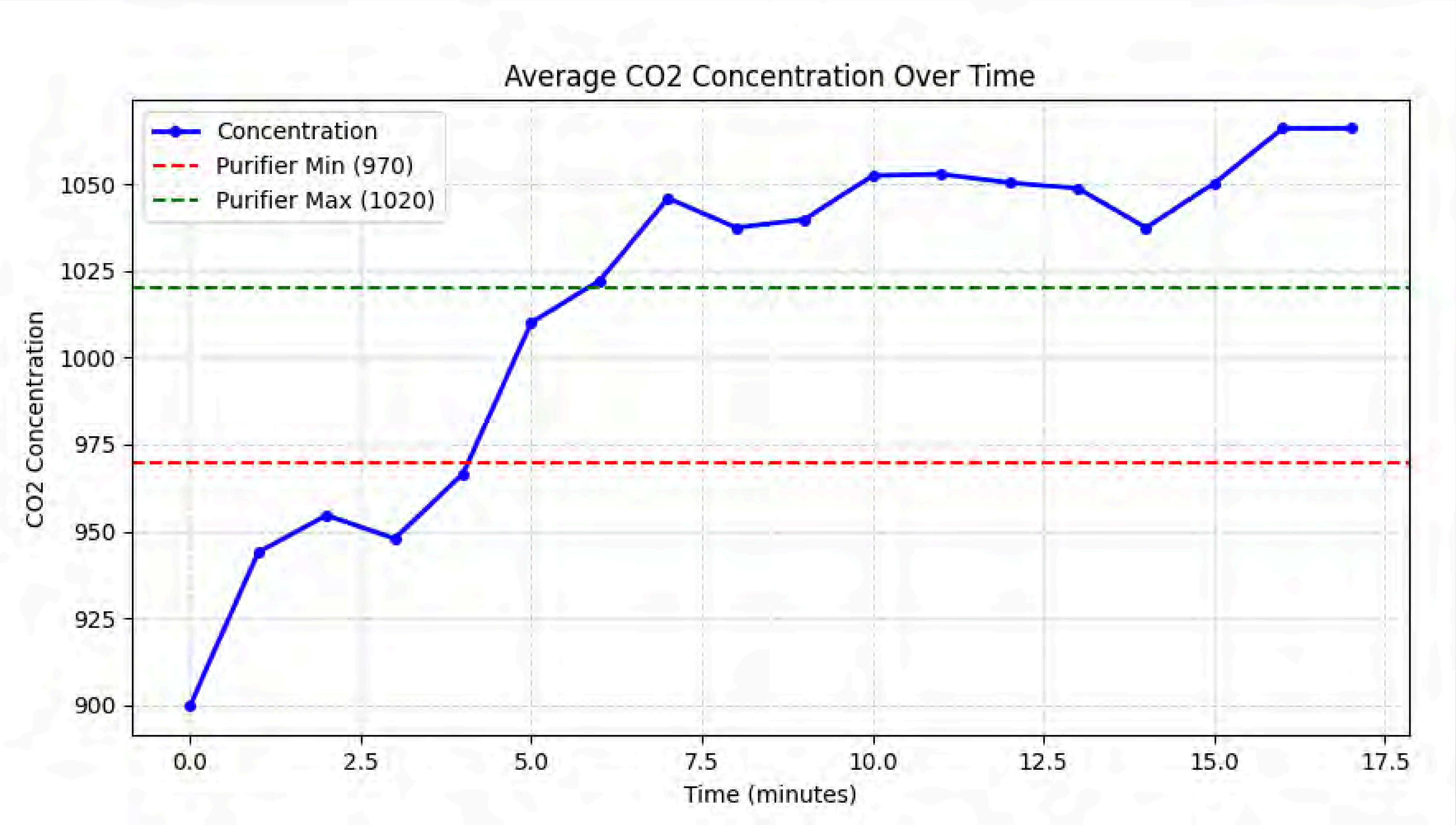
Time	Voltage
Start	4.1
30 min	3.8
1 hour	3.7
1:30 hour	3.6
2 hour	3.5
2.5 hour	3.4
3 hour	3.2
3.5 hour	3.1
4 hour	2.8 (lowest)

Runtime of Air Sensor

Total Runtime = 4 hours
Relative error:
4.37- 4 / 4.37 = 8.46%

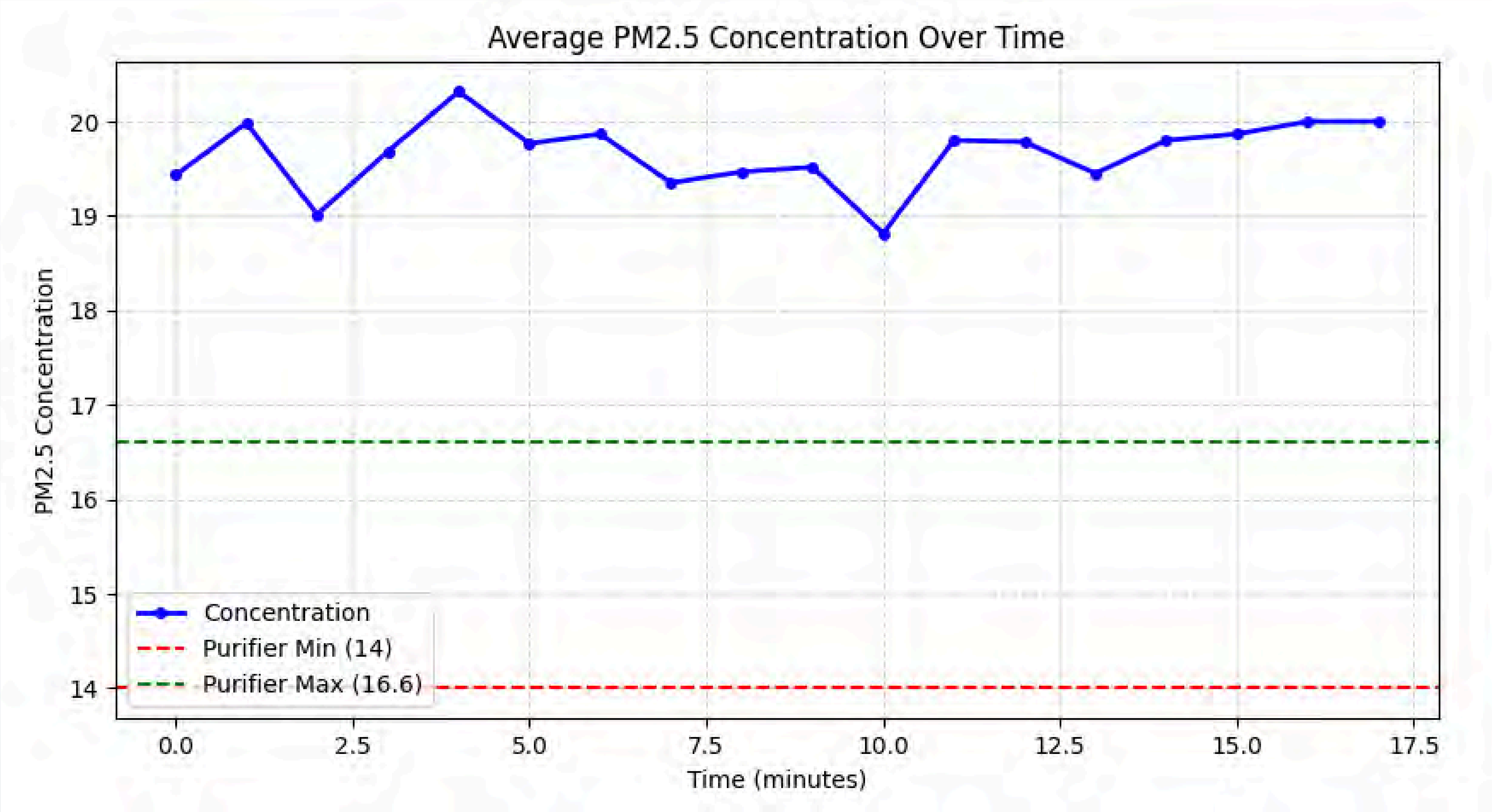
RESULTS

CO2 Variation in HM Lab (Calibration)



RESULTS

PM2.5 Variation in HM Lab (Calibration)



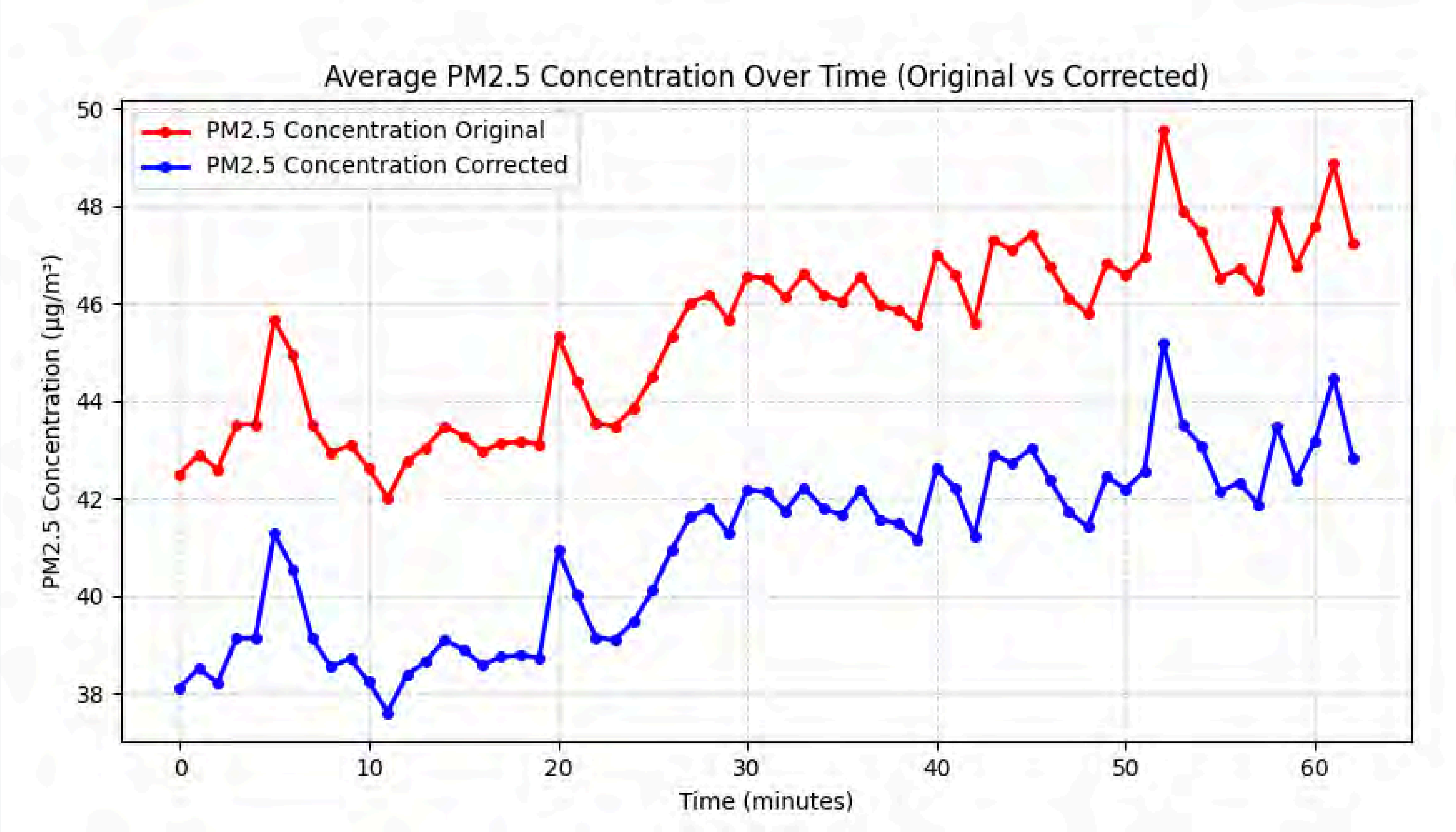
Average of Sensor Readings: 19.67

Average of Purifier Data: 15.3

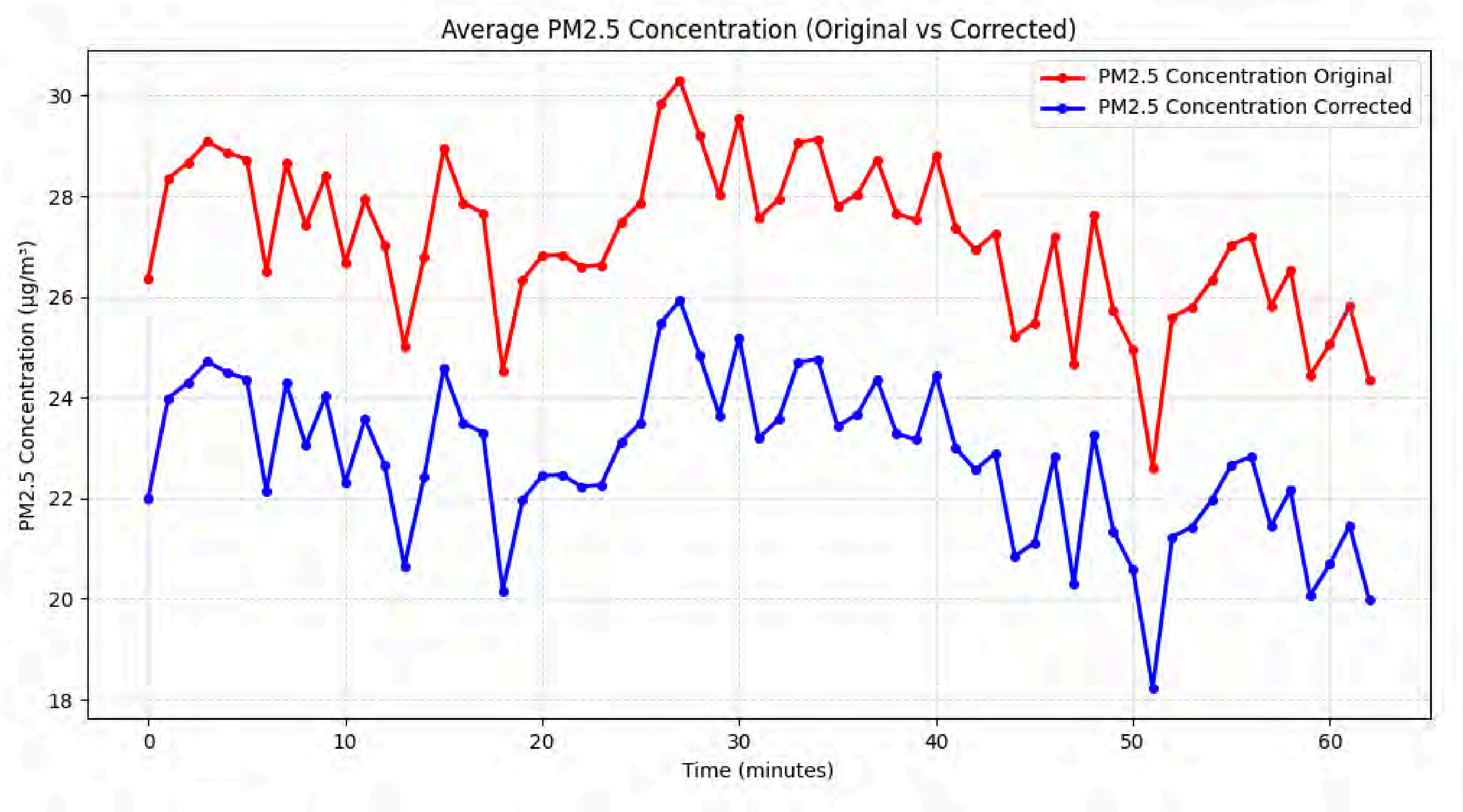
Average offset = 19.67 - 15.3 = 4.37

RESULTS

PM2.5 Variations



Outside HM Lab

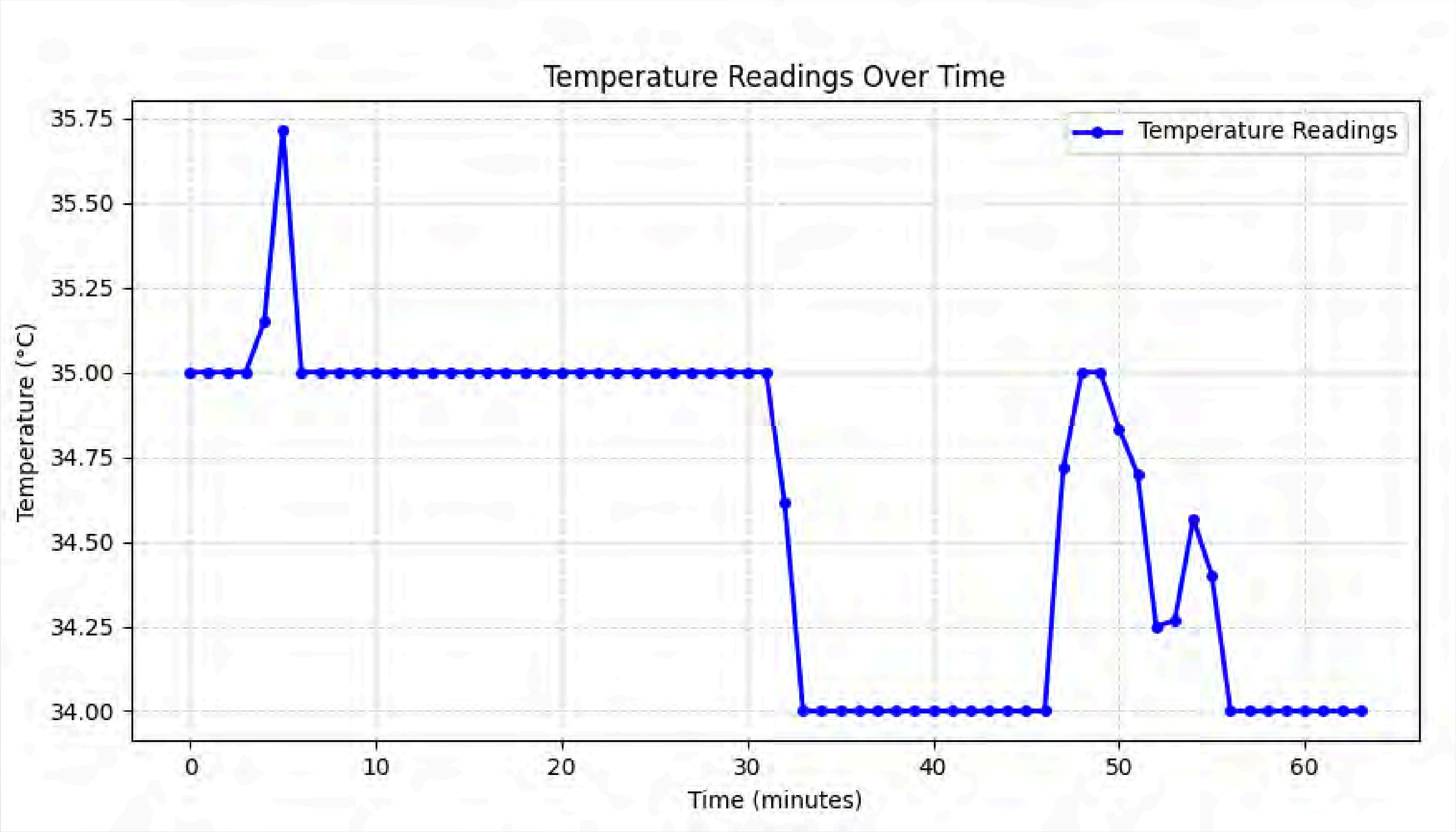


KMITL Dorm

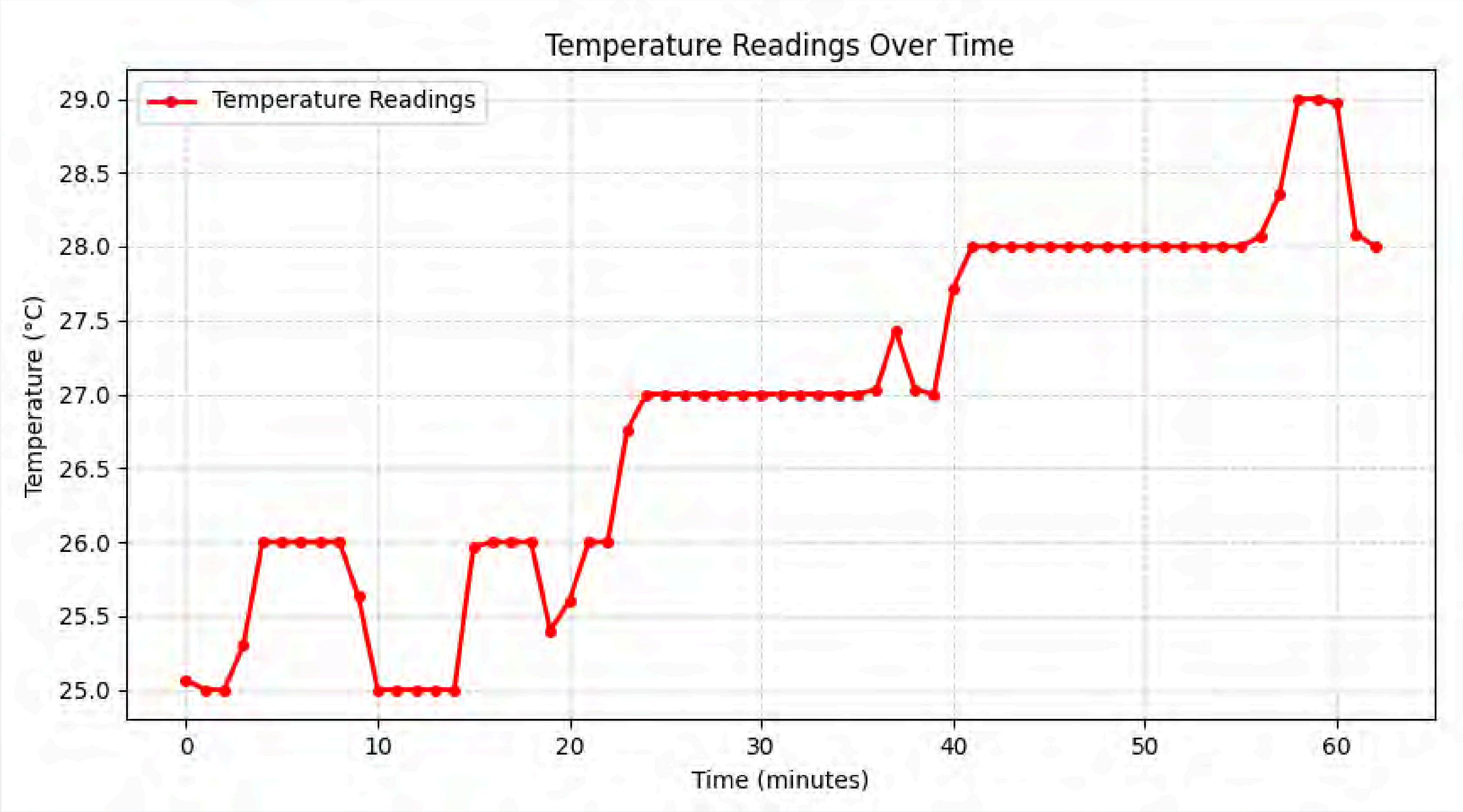
* Taken at different times of the day

RESULTS

PM2.5 Variations



Outside HM Lab



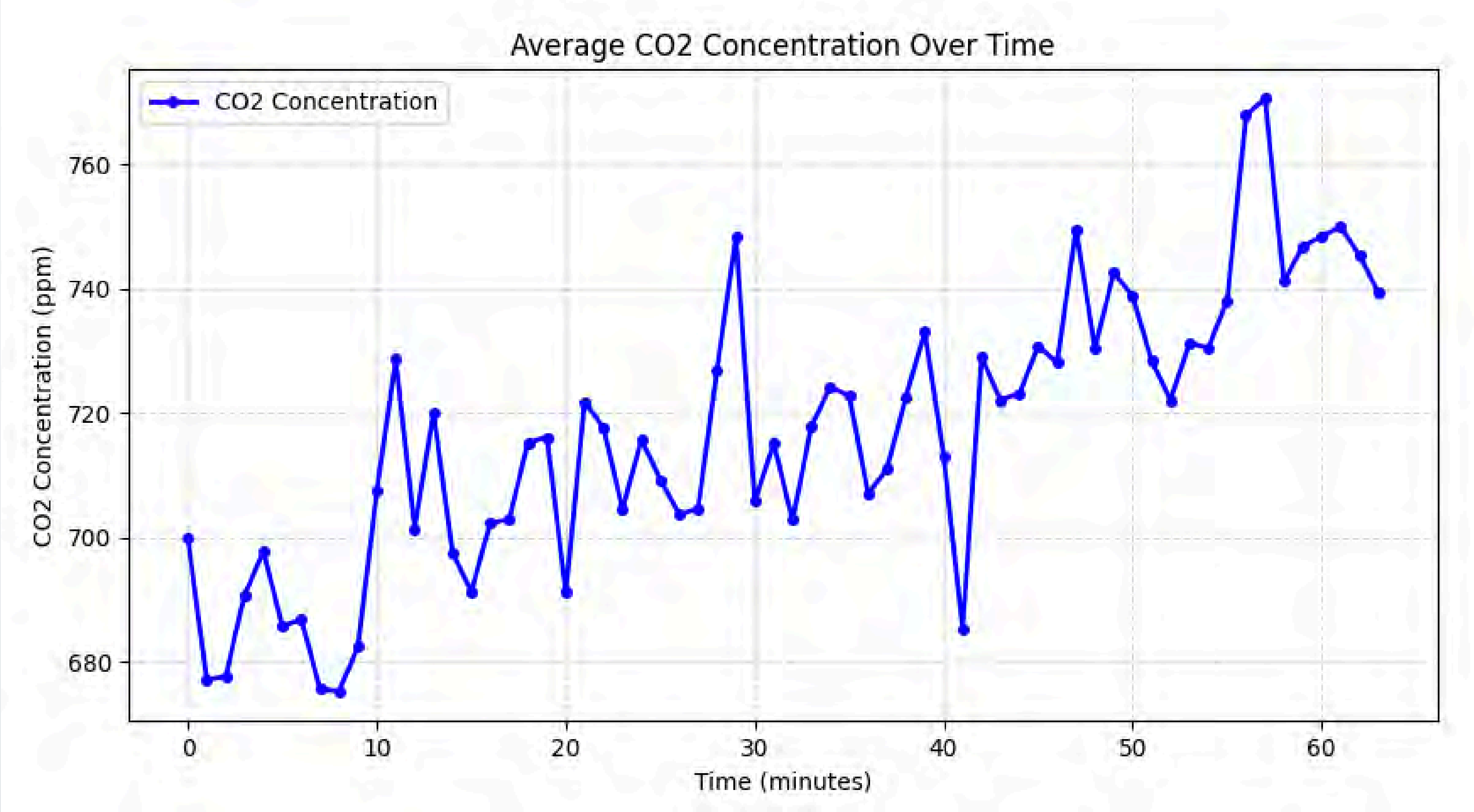
KMITL Dorm**

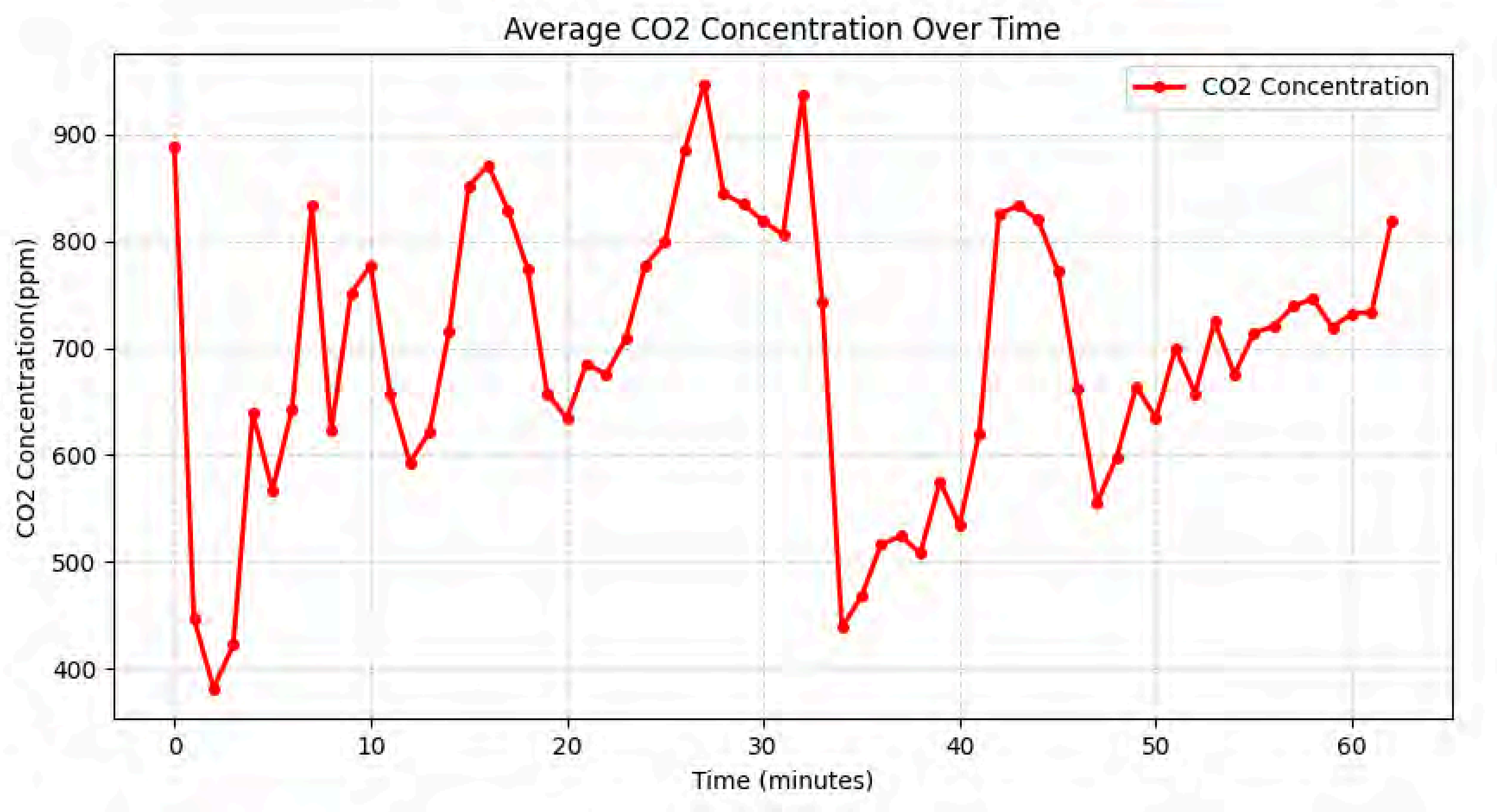
* Taken at different times of the day

** The sensor was initially placed in front of a fan and then moved causing temperature to rise

RESULTS

CO2 Variation





Outside HM Lab

KMITL Dorm

* Taken at different times of the day

LIMITATIONS

Over estimating the range of ESP’s WiFi

Design for Air Sensor could be better

Unstable and slightly inaccurate readings

Cloudy weather: unable to test solar properly

RANGE ISSUES

Too much interference from WiFi usage

Using different ESP versions

Not using external antennas using the IPEX connector

Not using the maximum transmission power settings

FUTURE WORK

IMPROVING RESULTS

- Use a more stable CO_2 and PM sensor
- Use External Antennas on the ESP or Radio Modules to increase range
- Conduct more extensive testing in controlled environments
- Use more efficient step up and solar charger

FUTURE WORK

DEVELOPMENT PLANS

Make a touchscreen UI for the air monitor

Enable solar charging on both devices

Integrate all sensors and ESP32 into a single PCB

Integrate the air sensor on a drone allowing to measure air quality at remote places and different altitudes

Develop a Web UI and store the data in cloud allowing it to be viewed from anywhere

CONCLUSION

Successfully implemented solar charging

Successfully transmitted data between 2 ESPs and a PC

Successfully read data from sensors and displayed on a screen along with controlling and LED based on it

Encountered problems in maximizing the transmission range, testing solar due to cloudy weather and getting stable data

REFRENCES

Rozali, S. M., Shari, N. S. M., Ruslan, E., Ramli, R., & Rahmat, M. F. (2024). Development of particulate matter detection and air monitoring system by using Arduino. International Journal of Academic Research in Business and Social Sciences, 14(12). https://doi.org/10.6007/IJARBSS/v14-i12/24398

Jumaah, H. J., Kalantar, B., Halin, A. A., Mansor, S., Ueda, N., & Jumaah, S. J. (2021). Development of UAV-based PM2.5 monitoring system. Drones, 5(60). https://doi.org/10.3390/drones5030060

Li, Z. (2017). Arduino based environmental air monitoring system (Master's thesis, Case Western Reserve University). OhioLINK Electronic Theses & Dissertations Center.https://etd.ohiolink.edu/acprod/odb_etd/ws/send_file/send?accession=case1499093616376284&disposition=inline

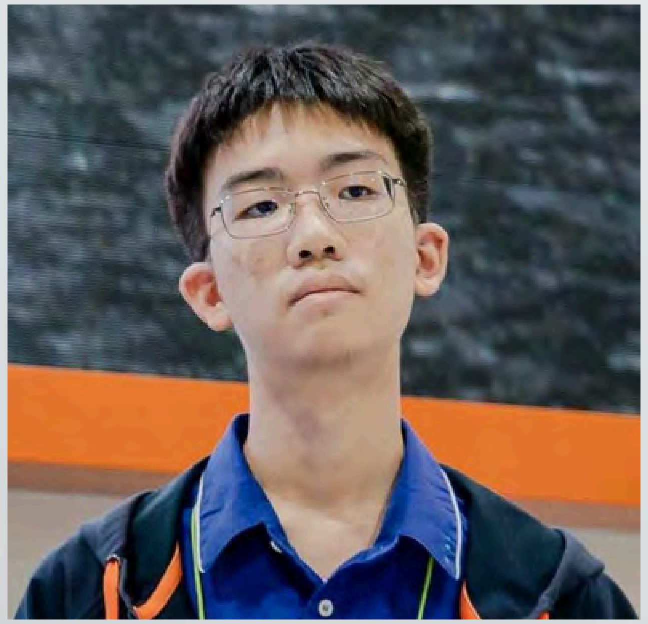
Mullick, I. U., Faisal, K. A., Nishat, T. I., & Bhuyan, M. H. (2024). Portable air quality detector using DSM501A dust sensor and Arduino Uno. Journal of Engineering Research and Reports, 26(5), 163–174. https://doi.org/10.9734/JERR/2024/v26i51143

Rodriguez-Vasquez, K. A., Cole, A. M., Yordanova, D., Smith, R., & Kidwell, N. M. (2020). AIRduino: On-demand atmospheric secondary organic aerosol measurements with a mobile Arduino multisensor. Journal of Chemical Education, 97(3), 838–844. https://doi.org/10.1021/acs.jchemed.9b00744

Hadley, Michael & Baumgartner, Jill & Vedanthan, Rajesh. (2018). Developing a Clinical Approach to Air Pollution and Cardiovascular Health. Circulation. 137. 725-742. 10.1161/CIRCULATIONAHA.117.030377.

The Air Quality Life Index (AQLI). AQLI. (2024, August 27). https://aqli.epic.uchicago.edu/pollution-facts-3/

TEAM MEMBERS



THEECHUTHA SUPHACHITKULCHAI

67011351

LUCKY AGARWAL

67011698

POONNACHOTE KAEWSUWAN

67011649


Dust Busters
THANK YOU