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Indoor Air Quality (IAQ) Monitoring for Space Farming Institute

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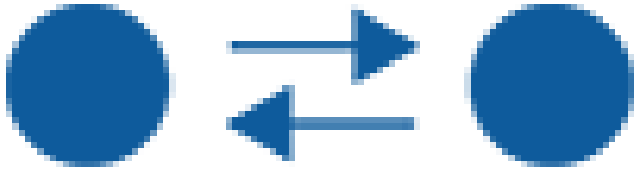
Energy to Communities Expert Match Program

May 2025

Contents

Energy to Communities (E2C) Expert Match

- E2C is a DOE-funded program that provides technical support to communities enhancing energy security and independence.
- The Expert Match offering of E2C provides national lab support on a topic that will assist the community to make an informed energy decision.
- For more information: https://www2.nrel.gov/state-local-tribal/e2c-expert-match



Space Farming Institute

- Non-profit organization based in Anchorage, Alaska.
- Space Farming Institute's mission is to teach students STEM, experience green technologies firsthand, and create food sufficiency for Alaskans.
- Partners include Alaska Tribes, schools, and medical centers.
- Website: https://www.agronauts.org/

Photo credit Space Farming Institute

Objective

- Space Farming Institute is currently working with Tribes to improve indoor air quality in community centers using an algae bioreactor.
- NREL will provide technical input to assist with the bioreactor design:
  - Using existing air quality data from another building, provide a range of indoor carbon dioxide (CO2) concentrations and rate of change.
  - Provide general information on indoor air quality monitoring with sensors that are easy to use.

Indoor Air Quality Basics

- Indoor air quality is important because people spend much of their time indoors, up to 90% [1]
- Healthy indoor air is free of pollutants, such as carbon monoxide, particulate matter, smoke, radon, mold, volatile organic compounds, and more [2]

Photo credit Space Farming Institute

Indoor Air Quality Basics, continued.

- Optimal relative humidity for human health is 40-60% although in cold climates it is better for buildings to have a lower moisture drive through the walls, so for building durability it is optimal to shift this slightly to a goal of 30-50% [3].
- Carbon dioxide levels should be no more than 650 ppm above ambient levels according to the ASTM Standard D6245-12.

Photo credit Space Farming Institute

IAQ Monitoring – Placement Considerations

- Avoid placing near areas that will over-represent fresh air and/or warmer or cooler temperatures such as a door, window that opens, air supply vent, or air filter / cleaner.
- Avoid placing near areas that will over-represent a high carbon dioxide concentration, such as where someone might always be standing or sitting (if the community center has an office, do not place right next to a desk for instance)
- Placing sensors at ‘breathing’ height for a range of people from children to adults will represent the air people are breathing in if the air is stratified. However, it may be advisable to place them higher or lower for other reasons, such as keeping them out of reach/sight.

IAQ Monitoring – Placement Considerations (2)

- Try to place sensors near the middle of a room or wall, not in a corner or behind a piece of furniture. Try to maintain a minimum 2-foot distance from walls, floors, and ceilings so sampling is done in the occupied zone away from surface effects.
- Similarly, if there are places producing a lot of particulates or other chemicals (such as a kitchen area with a lot of cooking activity), sensors will over-represent contaminated air.
- If budget allows, placing multiple sensors can give a complete picture of the building's air quality. This would allow you to place sensors in some of the areas listed here to avoid and provide additional context to where the air quality is improving or worsening.
- For more considerations, visit EPA's Guide to Siting and Installing Air Sensors:

https://www.epa.gov/air-sensor-toolbox/guide-siting-and-installing-air-sensors

IAQ Oxygen Sensor Options

Note: O_2 Sensors are rare in Air Quality Monitors

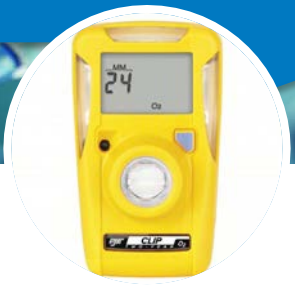
- **Oxygen levels in normal atmospheric conditions are relatively stable** at around 21% [4], so there's less emphasis on tracking it in consumer-level air quality monitoring. Devices usually focus on pollutants or gases that fluctuate and impact human health, such as PM2.5.
- Oxygen sensors in air quality systems are typically **used for monitoring in specific environments like confined spaces, labs, hazardous environments,** or in medical applications [5].

[FD-90A-O2]

$160-300
Handheld & Display
No data logging
2-3 year sensor life

MACURCO Single-Gas Detector

$175
Handheld & Display
Data logging - USB
30 day sensor life



HONEYWELL Single-Gas Detector

$240
Handheld & Display
Data logging -BT
2 year battery life

HONEYWELL Sensorpoint XCLL

$600
Paired with Smartphone
Wall Mounted
Data logging - BT

Saurmann AQ Pro-O

$1200-1500
Data logging - BT
Professional quality
Several parameters (6 at a time)

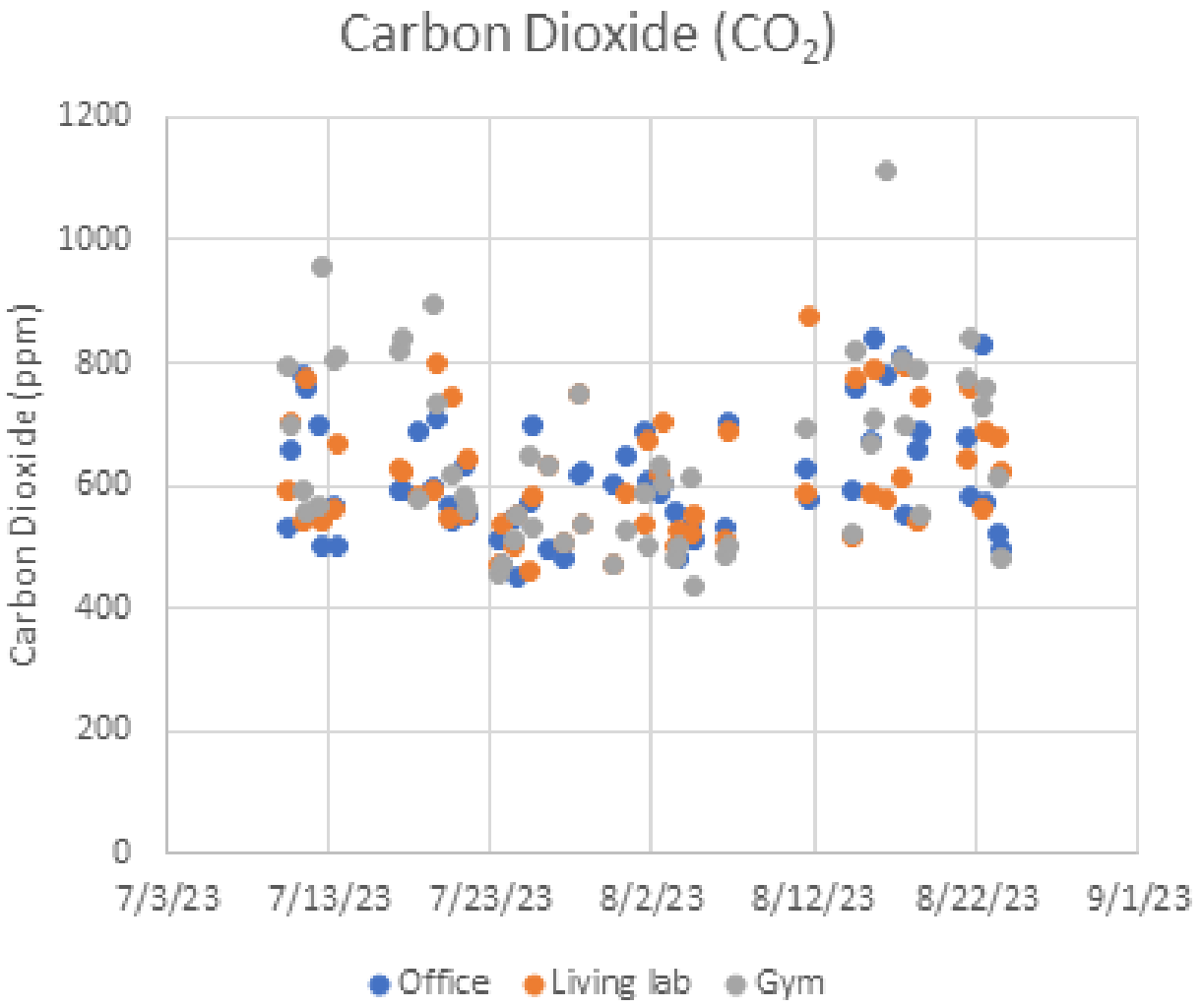
*All prices are best estimations
**These sensors are shown as examples of the range of commercial products available, and this does not constitute an NREL endorsement or recommendation.

IAQ Monitoring – O2 Sensors

- There are several types of oxygen sensors, each suited to different applications, with **electrochemical oxygen sensors** measuring oxygen levels in ambient air. [6]
  - Compact (handheld) and have low power requirements. [6]
  - Have a lifespan of 1-3 years. [6]
- Remember to regularly calibrate & perform maintenance!
  - Calibrate regularly per manufacturer's instructions. Manufacturers often include calibration instructions or have a service to send the device back for calibration.
  - Follow the manufacturer instructions for installation and maintenance to get the longest lifespan for the device. For instance, the manufacturer might recommend proper storage procedures or how to clean the device regularly.

CO2 Data Analysis

- To obtain a range of indoor carbon dioxide (CO2) concentrations and rate of change as examples of what might be seen in an Alaska building, staff used existing data from air quality sensors that were installed in a gym, office, and the Space Farming Institute's space in 2023.
- The sensors measure temperature, humidity, pressure, and carbon dioxide and are still in place today, in 2025.
- While these data are not from a community center, they do provide insight on how CO2 levels can change inside a building in a cold climate.



IAQ Monitoring – CO2 Data & Analysis

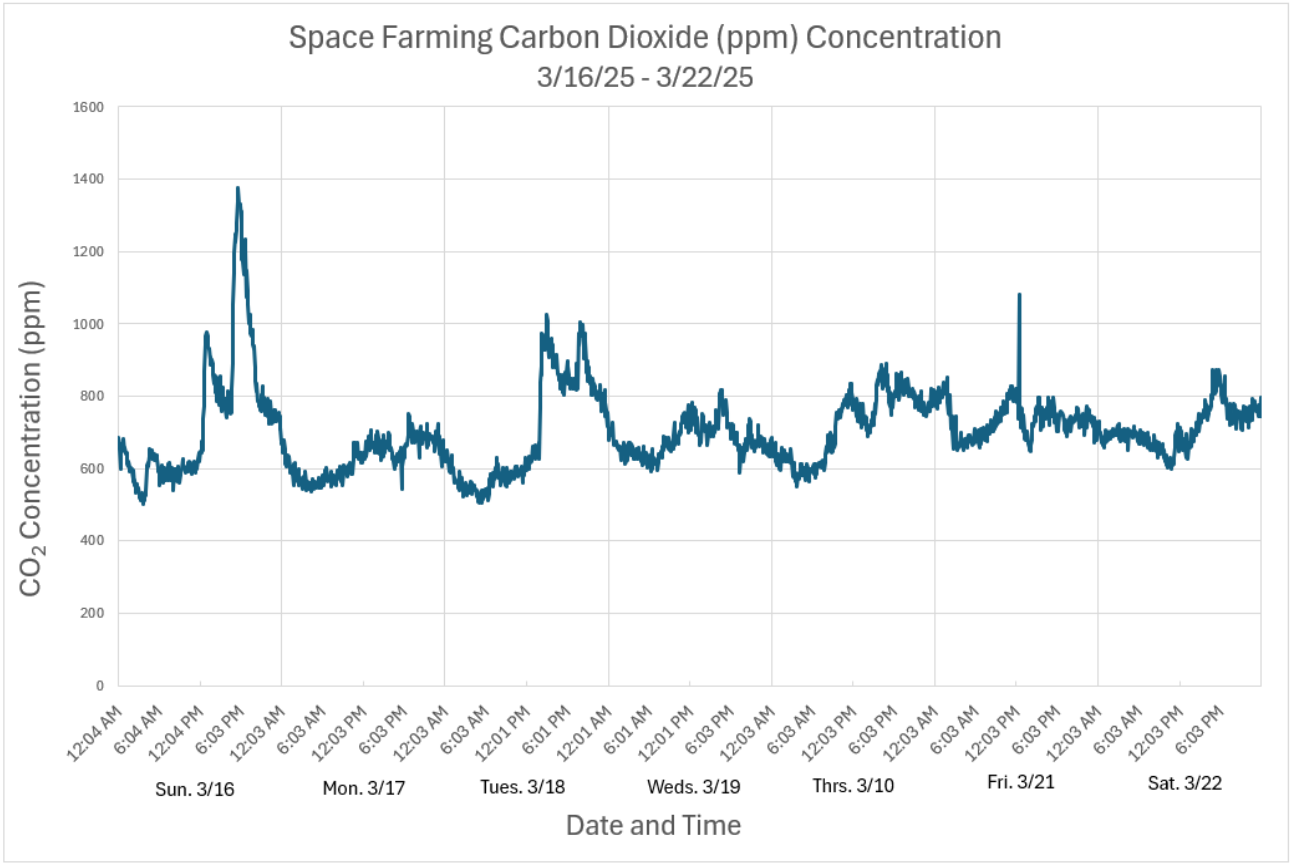
CO_2 concentration data overview (2025), Space Farming Institute					
2025 (1/1/25 – 4/8/25)	**Max CO_2** (ppm)	**Min CO_2** (ppm)	**Max Increase Rate of Change** (ppm/min)	**Max Decrease Rate of Change** (ppm/min)	**Average Rate of Change** (ppm/min)
CO2 concentration	1859	422	106.4	-157.4	-0.0006
Date & Time	Wed, Feb. 19 1:48 PM	Sun, Jan. 26 7:56 AM	Fri, Feb 21 2:23 PM	Sun, Jan 26 7:56 AM	

CO_2 concentration data by month (2025), Space Farming Institute

2025 (1/1/25 – *4/8/25)		Max CO_2 (ppm)	Min CO_2 (ppm)	Max ROC Increase (ppm/min)	Max ROC Decrease (ppm/min)	Average ROC (ppm/min)
Jan 2025	**CO2 concentration**	955	422	16.6	-114.2	**-0.024**
	Date & Time	Wed, Jan, 8 5:59 PM	Sun, Jan 26 7:56 AM	Wed, Jan. 8 11:39 AM	Sun, Jan. 26 7:56 AM	
Feb 2025	**CO2 concentration**	1859	436	106.4	-157.4	**-0.024**
	Date & Time	Wed, Feb. 19 1:48 PM	Thrs, Feb. 20 4: 23 PM	Fri, Feb. 21 2:23 PM	Thrs, Feb. 20 4:23 PM	
Mar 2025	**CO2 concentration**	1458	432	68.2	-158.6	**-0.036**
	Date & Time	Sat, Mar. 8 5:46 PM	Sun, Mar. 30 3:40 PM	Fri, Mar. 21 12:18 PM	Thrs, Mar. 27 5:47 PM	
***April 2025**	**CO2 concentration**	1170	430	26.4	-148.4	**-0.054**
	Date & Time	Fri, Apr. 4 3:34 PM	Thrs, Apr. 3 8:59 PM	Wed, Apr. 2 5:45 PM	Tues, Apr. 8 11:38 AM	

*Two outlier data points removed on March 27th @ 5:52PM & 8:58PM. 3 hour jump in data recording which skewed the rate of change.

IAQ Monitoring – CO2 Weekly Graph



- March selected as a typical week due to spring weather that is not abnormally cold (which might result in reduced occupancy) or hot (when windows and doors would be open).
- Weekly graph shows lower CO2 at night and higher concentrations during periods of high occupancy.

*This week lay entirely within the operating range of the Aranet4 sensor (below 85% relative humidity and within 32-122°F)[7].

Space Farming Institute Future Plans

- Pacific Northwest National Laboratory (PNNL) will provide technical support with a bioreactor design and maintenance through the E2C Expert Match Program.
- Space Farming Institute continues to evaluate different plant cultivation systems in their laboratory.
- The final goal will be to use the information from NREL, PNNL, and Space Farming Institute's experiments to design and build an algae bioreactor inside a community center in Alaska.

Additional Resources for Indoor Air Quality in Alaska

- EPA'S Tribal Indoor Air Quality Training & Resource Directory
- Alaska Tribal Air Toolkit
- ANTHC Air and Healthy Homes
- Institute for Tribal Environmental Professionals (ITEP) Indoor Air Quality Page

Sources

[1] U.S. Environmental Protection Agency. 1989. Report to Congress on indoor air quality: Volume 2. EPA/400/1-89/001C. Washington, D.C.

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[3] Seifert, R., C. Deer, M. George, P. Kaluza, P. Louden, G. Moor, M. Musiuk, R. Musiuk, and J. Woodward. 2007. Alaska residential building manual (HCM-00051). Anchorage, AK: Alaska Housing Finance Corporation.

[4] Bugbee, B. & Blonquist, M. "Absolute and Relative Gas Concentration: Understanding Oxygen in Air." Apogee Instruments. Accessed on May 9, 2025. Available at: https://www.apogeeinstruments.com/content/o2s_correcting.pdf

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[6] CO2Meter: Gas Measurement Specialists. (2024). "How does an oxygen sensor work?" Accessed on May 9, 2025. Available at: https://www.co2meter.com/blogs/news/how-does-an-oxygen-sensor-work

[7] aranet. No date. "Aranet4 PRO – perfect indoor air quality monitor. Features & Technical Specifications." Accessed on May 29, 2025. Available at: https://aranet.com/en/pro/products/aranet4-pro?srsltid=AfmBOooq5DacWQWg2IFjrspInUnWLfV5upc0q_lty2PJpyOCxv7_rG20

Thank you

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