

BUILDINGENERGY BOSTON

Indoor Air Quality: Monitoring Strategies and Results for a Multifamily Passive House Project

**Thomas Chase (New Ecology)
Eleni Macrakis (HRI)**

Curated by Kurt Roth (Fraunhofer USA)

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NESEA
BuildingEnergy Boston
2022

Indoor Air Quality: Monitoring Strategies for a Multifamily Passive House Project

NEW ECOLOGY
Community-Based Sustainable Development

HRI Creating and Preserving
Affordable Housing
Opportunities





Who we are.

As a mission-driven nonprofit, New Ecology works nationally to bring the benefits of sustainable development to the community level, with a concerted emphasis on underserved populations.

We seek to make the built environment more efficient, healthy, durable, and resilient.





Who we are.

HRI is a local non-profit affordable housing organization that develops and preserves affordable, high-quality rental housing, with robust resident services for individuals and families throughout our portfolio.

We have a strong focus on responsible and sustainable practices through deliberate energy efficiency and material selection practices to both reduce our carbon footprint and to create healthy and comfortable homes for our residents.





Agenda

1. IAQ Monitoring Program Design
2. Finch Cambridge IAQ Monitoring Results
3. Finch Cambridge IAQ Monitoring Uses
4. Future Work
5. Q&A



Providing Good IAQ

Source Control

- Materials selection
- Behavior (e.g. pesticide use, cooking)

Ventilation

- 100% outdoor air
- Energy recovery
- Exhaust and supply locations

Filtration

- MERV Rating

Monitoring and Corrective Action



IAQ Monitoring Program Design

Common IAQ Metrics

- ASHRAE Ventilation Rate Guidance (CO₂)
- EPA Radon Guidance
- RESET Air for Residential v1.0

Ventilation and Resultant CO₂ Concentrations

Carbon Dioxide	Outside Air (cfm per person)	CO ₂ Differential (inside/outside)
800 ppm suggests about	20 cfm (or less)	500 ppm
1,000 ppm suggests about	15 cfm (or less)	650 ppm
1,400 ppm suggests about	10 cfm (or less)	1,050 ppm
2,400 ppm suggests about	5 cfm (or less)	2,050 ppm

Note: The CO₂ values in this table are approximate, and based on a constant number of sedentary adult occupants, a constant ventilation rate, an outdoor air CO₂ concentration of about 380 ppm, and good mixing of the indoor air.*

*current atmospheric CO₂ concentration > 410ppm: <https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide>



IAQ Monitoring Program Design

Metrics: RESET Standard

- Monitors
- Buildings



PM2.5 Particulate Matter	TVOC Total Volatile Organic Compounds	CO ₂ Carbon Dioxide	Temp Temperature	RH Relative Humidity	CO** Carbon Monoxide
Acceptable < 35 µg/m ³	Acceptable < 500 µg/m ³	Acceptable < 1000 ppm	Monitored	Monitored	Acceptable < 9 ppm
High Performance < 12 µg/m ³	High Performance < 400 µg/m ³	High Performance < 600 ppm	Although there are no requirements for temperature and humidity under RESET™ Air, both must be monitored given their impact on sensor readings for PM2.5 and TVOC.		CO monitors are only required in spaces with combustion.



IAQ Monitoring Equipment



IAQ Case Study



FINCH
CAMBRIDGE



Finch Cambridge Passive House

Green Building Certification Requirements

PHIUS+ 2015

ASHRAE 62.2-2010
Outside air to bedrooms

EPA Indoor airPLUS

ENERGY STAR
Low-CH₂O plywood and composite wood
Low-VOC paints, finishes, carpet, carpet adhesives
MERV 8 filtration for forced air space conditioning

ENERGY STAR

ASHRAE 62.2-2010 or 2013 (residential)
ASHRAE 62.1-2010 or 2013 (common space)
<50% more than 62.1-2013

Enterprise Green Communities 2015

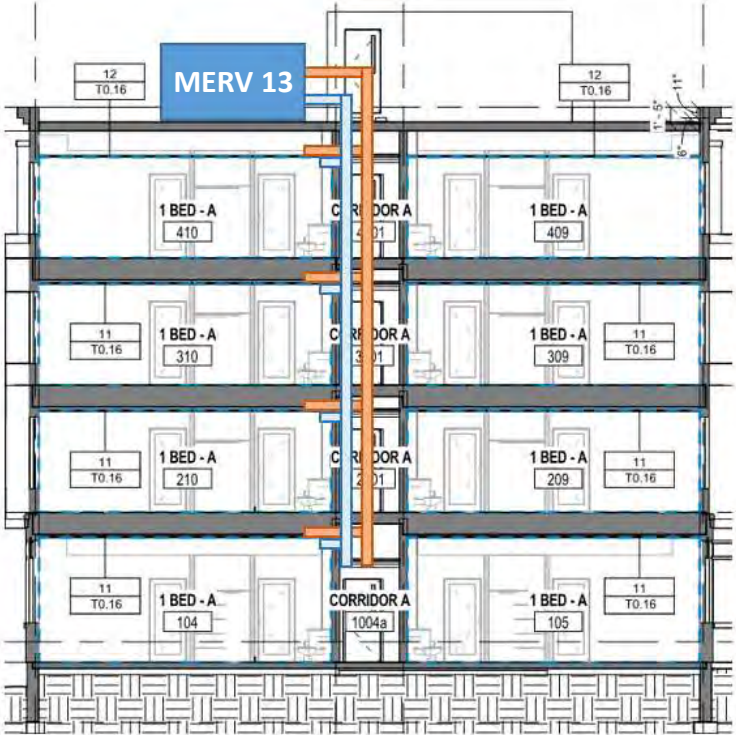
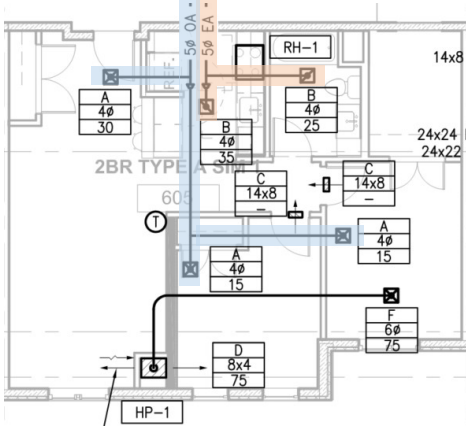
ENERGY STAR
Radon mitigation
Low-VOC paints, coatings, primers, adhesives, sealants



Finch Cambridge Passive House

Ventilation Systems

- Design
- Commissioning



IAQ Monitoring Program Design

Space Type	Radon	CO2	TVOC	Temp	RH	Pressure
Lobby, Conference Room, Community Room, Lounge	✓	✓	✓	✓	✓	✓
Apartments (Sample of 20)	✓	✓	✓	✓	✓	✓
Apartments (All 98)			✓	✓	✓	✓



IAQ Monitoring Program Design



Airthings Wave Plus Air Quality Monitor

Lobby, Conference Room, Community Room, Lounge, 20 Apartment Units

- Indoor Air Quality**
- Radon
 - CO2
 - TVOC
 - Temperature
 - Humidity
 - Pressure
 - Light



IAQ Monitoring Program Design



Airthings Wave
Mini Air Quality
Monitor

78 Apartment
Units

Indoor Air Quality
TVOC
Temperature
Humidity
Pressure
Light



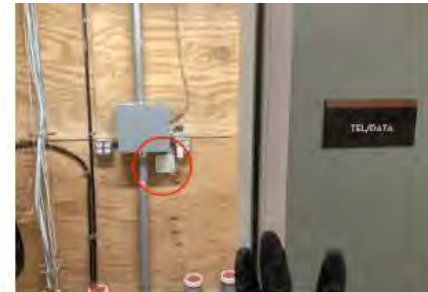
IAQ Monitoring Program Design



Airthings
Communication
Hub

Ground Floor
Offices
3rd Floor Tel/Data
Room
4th Floor Storage
Room (STO 09)
5th Floor Tel-Data
Room
Community Room

N/A



IAQ Monitoring Program Design

<p>Sensor sampling interval: 5 minutes</p> <p>Sensor Resolution: Temperature $\pm 0.1^{\circ}\text{C} / \pm 0.1^{\circ}\text{F}$ Humidity $\pm 1\%$ Pressure $\pm 0.15\text{hPa}$</p> <p>Settling time: TVOC ~ 7 days CO₂ ~ 7 days</p> <p>CO₂ details: NDIR Sensor (Non-Dispersive Infra-Red): Measurement range 400-5000 ppm Non condensing 0 - 85%RH Optimum Accuracy $\pm 30\text{ppm} \pm 3\%$ within 15 - 35°C / 60 - 95°F and 0 - 80%RH</p>	<p>Radon sampling: Passive diffusion chamber</p> <p>Detection method: Alpha spectrometry</p> <p>Measurement range: 0 - 500 pCi/L / 0 - 20,000 Bq/m³</p> <p>Accuracy/precision at 5.4 pCi/L / 200 Bq/m³ : After 7 days ~ 10 % After 2 months ~ 5 %</p>
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Property IAQ Policies



- Smoke-Free Policy
- Green Guide
- IAQ Monitoring
- Integrated Pest Management
- Robust Resident Services

GREEN CLEANING

THE RIGHT PRODUCTS FOR YOU

How can you tell if a product is sustainable and healthy?

Green cleaning products have specific ingredients that help to create a healthier indoor environment and reduce outdoor smog by avoiding volatile organic compounds (VOCs).

BREATHE EASY

AVOID ASTHMA AND ALLERGY TRIGGERS

Help keep your home clear of these common asthma and allergy triggers.

1

PERILS

3

MOLD & MOISTURE

2

NO SMOKING

4

DUST MITES

SELECT PRODUCTS WITH THESE LABELS

AVOID PRODUCTS LABELED

The way you clean also matters. Follow these best practices:

- Sweep and mop the floors of your apartment at least 1x/week
- Vacuum any rugs regularly
- Wash dirty dishes and kitchen surfaces daily
- Wipe up spills immediately
- Clean discolored surfaces or cracked grout with baking soda or borax. If discoloration persists or gets worse, contact Management
- Open windows to let fresh air in when the heat and A/C is off
- Clean your stove's range hood and grease filter
- Avoid using bristly cleaning brushes and abrasive products
- Regularly replace sponges and cleaning rags
- Don't mix cleaning products
- Dispose of chemical products properly

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IAQ Monitoring Findings

Temperature

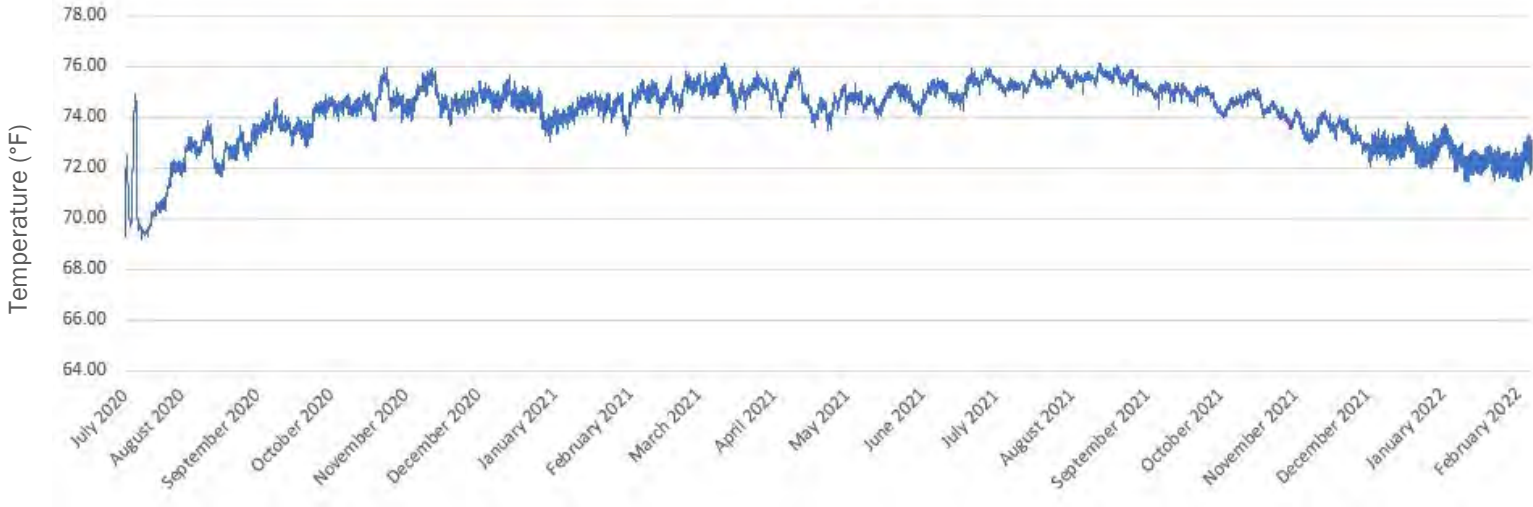
Temp Temperature	RH Relative Humidity
Monitored	Monitored
<i>Although there are no requirements for temperature and humidity under RESET™ Air, both must be monitored given their impact on sensor readings for PM2.5 and TVOC.</i>	

Space	Min. Temp.	Max. Temp.	Avg. Min. Temp.	Avg. Max. Temp.	Avg. Temp.
Apartment Average	32.0 °F	94.0 °F	69.1 °F	76.2 °F	74.7 °F
Lobby	n/a	n/a	53.8 °F	80.4 °F	71.2 °F
Conference Room	n/a	n/a	54.5 °F	81.4 °F	73.1 °F
Community Room	n/a	n/a	60.4 °F	89.5 °F	74.7 °F
Lounge	n/a	n/a	56.5 °F	90.4 °F	72.4 °F



IAQ: Temperature

Unit Average Temperature



IAQ: Temperature

Finch Lounge Temperature



IAQ Monitoring Findings

Relative Humidity

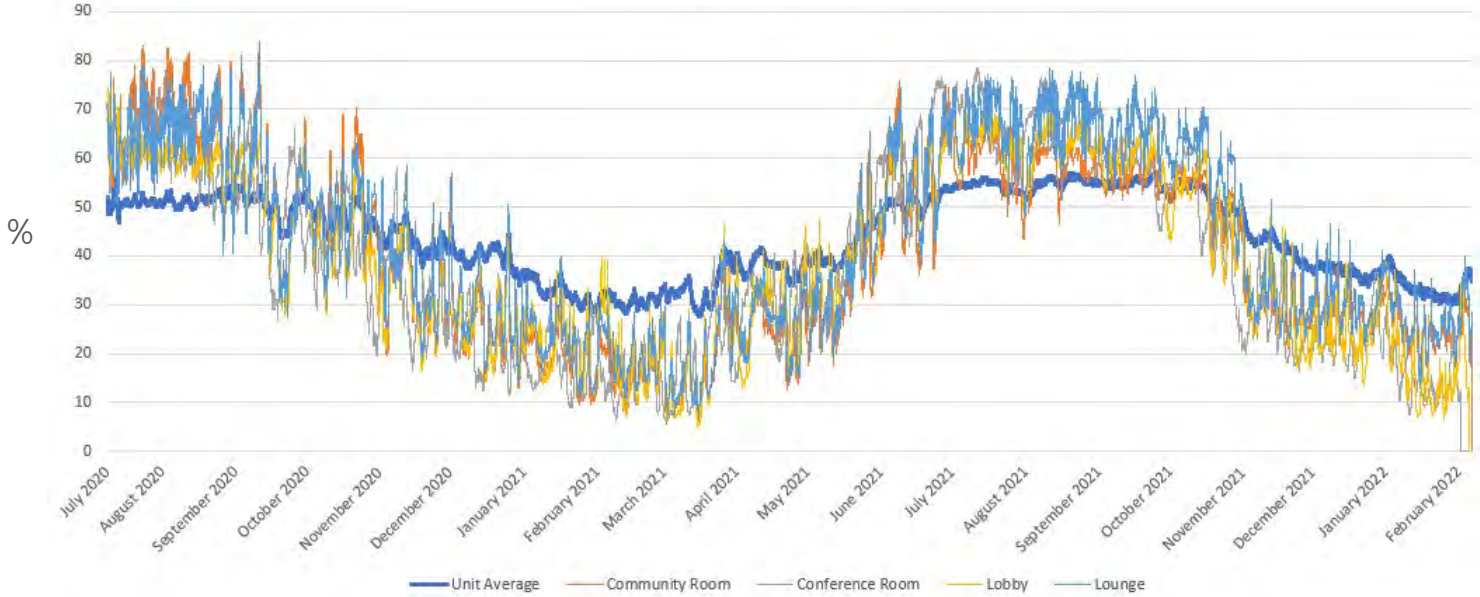
Temp Temperature	RH Relative Humidity
Monitored	Monitored
<i>Although there are no requirements for temperature and humidity under RESET™ Air, both must be monitored given their impact on sensor readings for PM2.5 and TVOC.</i>	

Space	Min. RH	Max. RH	Avg. RH
Apartment Average	27.5%	57.1%	44.0%
Lobby	5.0%	74.5%	38.9%
Conference Room	6.5%	78.5%	39.3%
Community Room	5.5%	84.0%	40.2%
Lounge	7.0%	81.5%	43.2%



IAQ: Relative Humidity

Relative Humidity at Finch



IAQ Monitoring Findings

Total VOCs

TVOC
Total Volatile
Organic Compounds

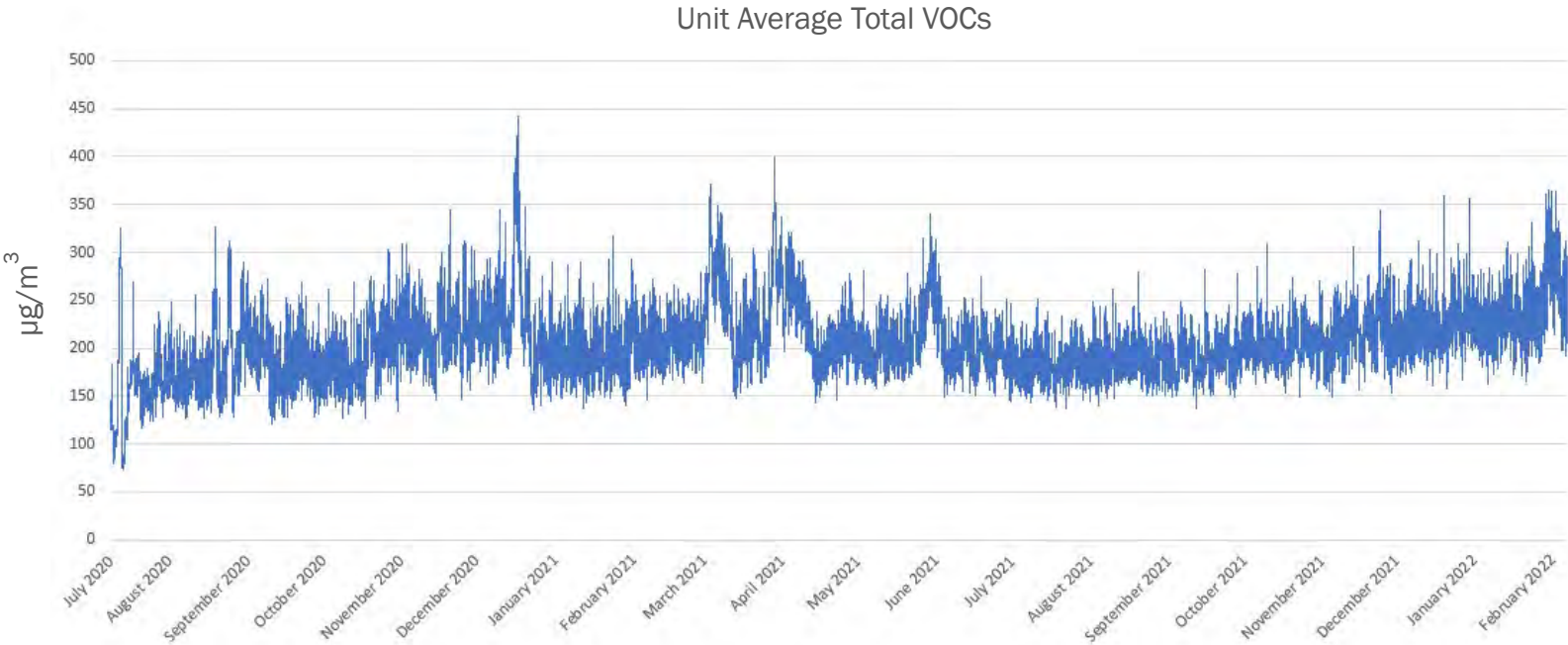
Acceptable
< 500 µg/m³

High Performance
< 400 µg/m³

Space	Min. TVOC	Max. TVOC	Avg. TVOC
Apartment Average	74 µg/m ³	442 µg/m ³	202 µg/m ³
Lobby	0 µg/m ³	8,295 µg/m ³	1,306 µg/m ³
Conference Room	0 µg/m ³	1,311 µg/m ³	155 µg/m ³
Community Room	0 µg/m ³	8,277 µg/m ³	197 µg/m ³
Lounge	0 µg/m ³	8,287 µg/m ³	231 µg/m ³

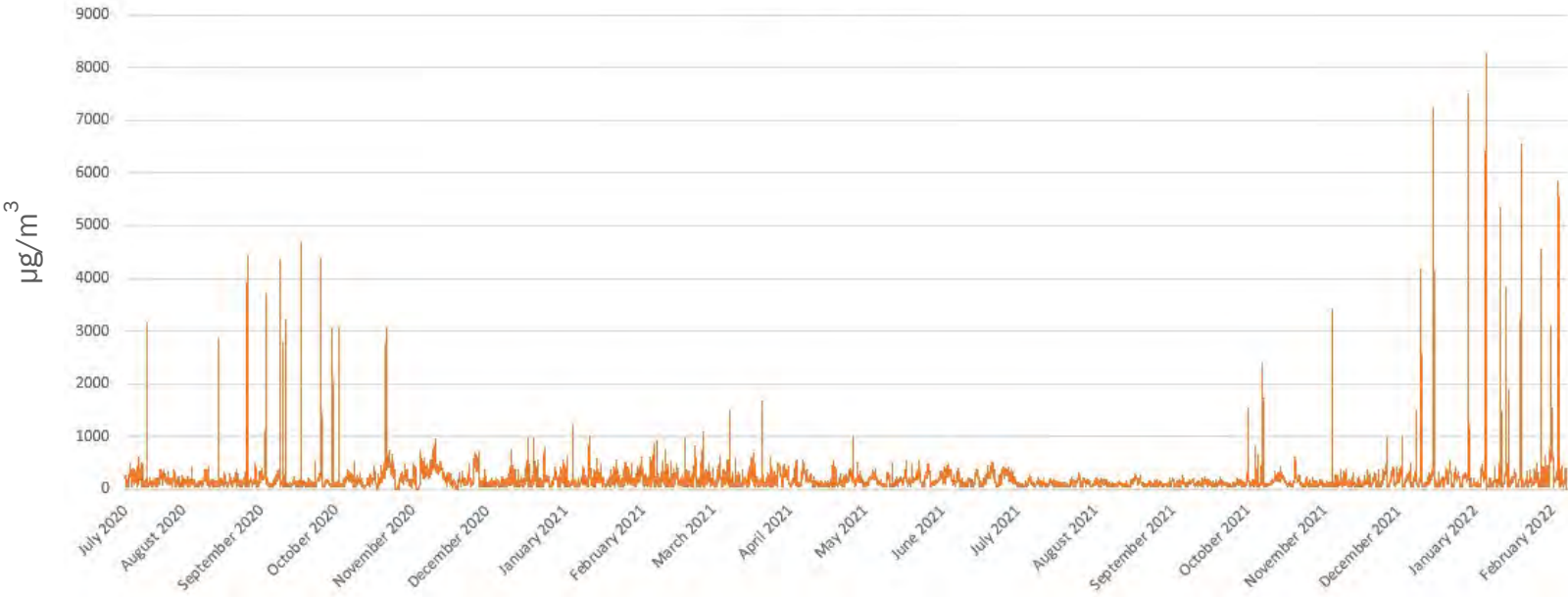


IAQ: Total VOCs



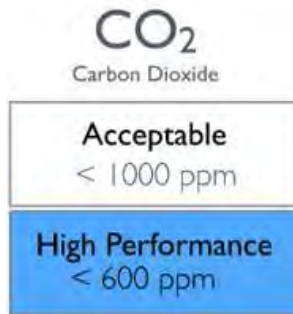
IAQ: Total VOCs

Average Community Room Total VOCs



IAQ Monitoring Findings

Carbon Dioxide (CO₂)

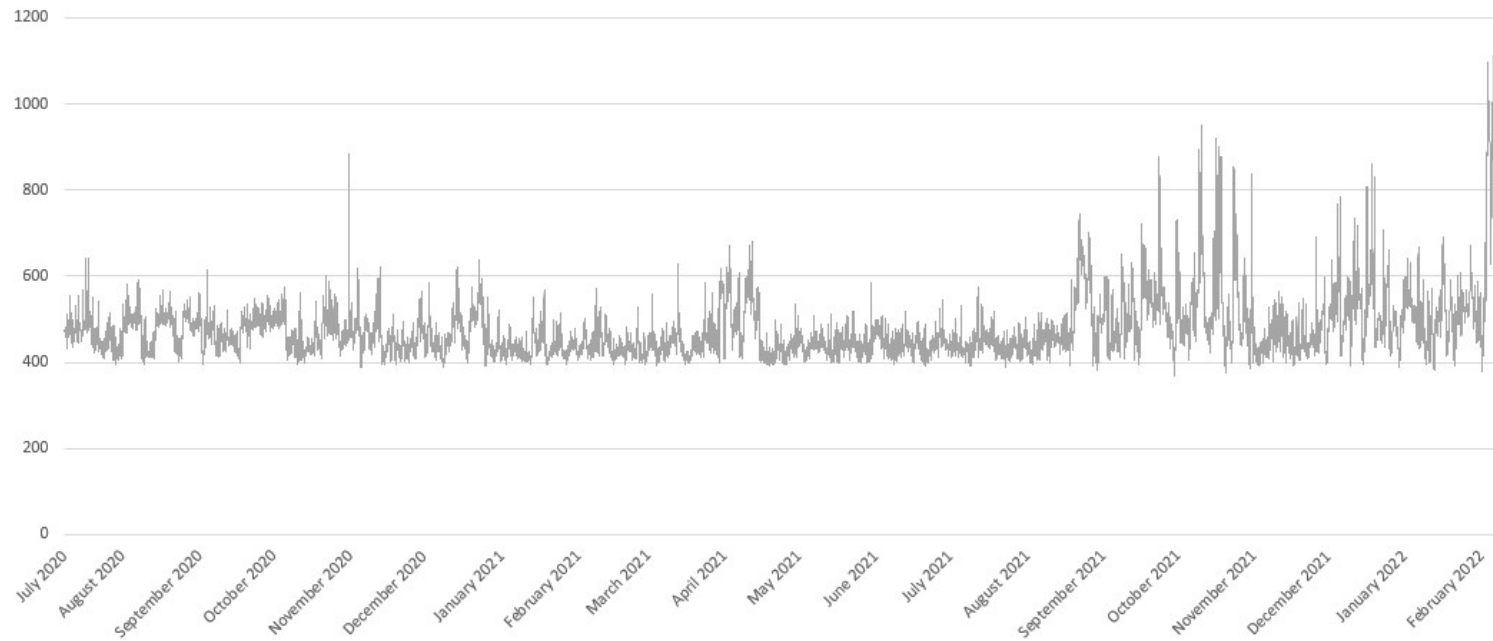


Space	Min. CO ₂	Max. CO ₂	Avg. CO ₂
Apartment Average (ERV 1)	433 ppm	2,596 ppm	783 ppm
Apartment Average (ERV 2)	428 ppm	2,082 ppm	691 ppm
Lobby	385 ppm	954 ppm	486 ppm
Conference Room	382 ppm	2,114 ppm	482 ppm
Community Room	368 ppm	1,114 ppm	474 ppm
Lounge	360 ppm	1,475 ppm	485 ppm

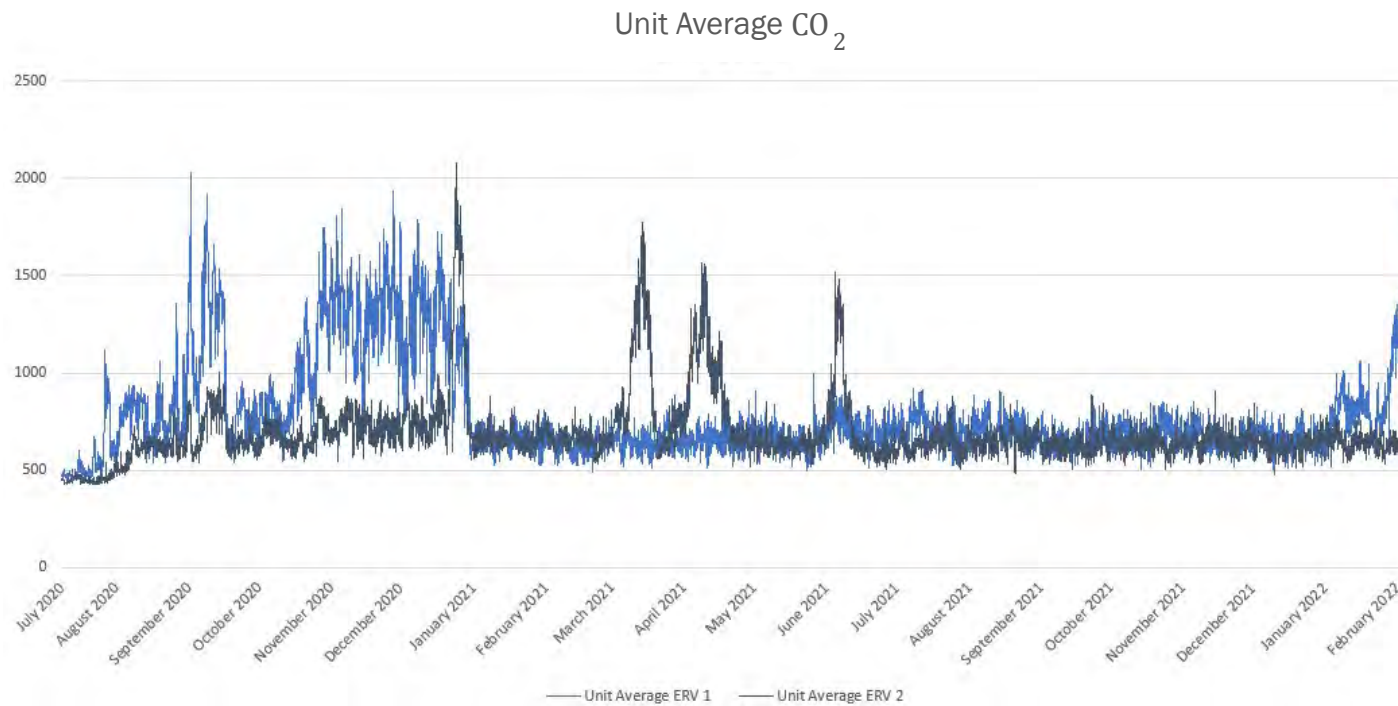


IAQ: CO₂

Average Community Room CO₂



IAQ: CO₂



IAQ Monitoring Findings

Radon

Radon

EPA Action level
= 4 pCi/L

Space	Min. Radon	Max. Radon	Avg. Radon
Apartment Average	0.09 pCi/L	1.29 pCi/L	0.23 pCi/L
Lobby	0.00 pCi/L	2.35 pCi/L	0.53 pCi/L
Conference Room	0.00 pCi/L	3.32 pCi/L	0.71 pCi/L
Community Room	0.00 pCi/L	2.19 pCi/L	0.28 pCi/L
Lounge	0.00 pCi/L	1.97 pCi/L	0.22 pCi/L



IAQ Monitoring Uses by Property Management

Resident Experience

Thermal Comfort

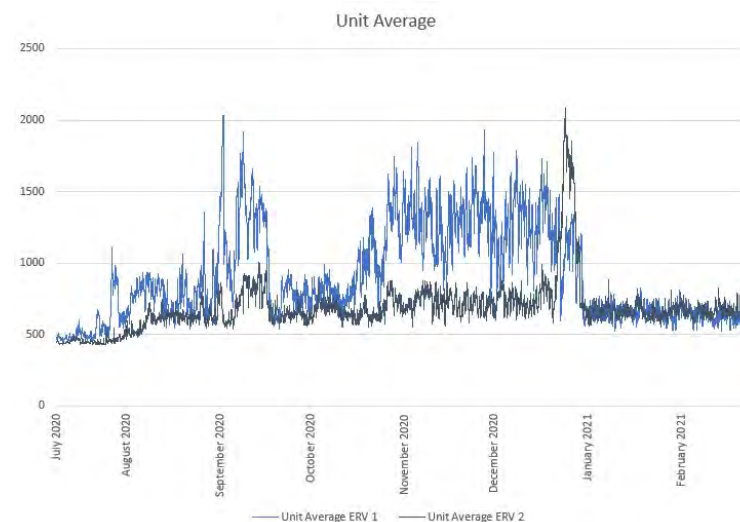
- Limited Thermostats
- Resident Requests for higher heat and lower A/C

Odors in Common Areas

- Troubleshooting malfunctioning ERVs and confirming repairs

Systems Management

IAQ monitors help confirm issues with the ERV systems



IAQ Monitoring Uses by Property Management

Balancing Real Time Data with Resident Privacy

- Provide a healthy comfortable environment for our residents
- Avoid policing resident behavior unless it affects the health and safety of other residents and/or staff
- Examples of disastrous IAQ situations due to misguided resident behavior that we try and avoid
 - *Ex: Resident humidification causing dramatic mold growth*
 - *Ex: Resident use of space heaters, risk of fire*



Future Work

Deployment

- All units, selected units, portable monitors
- Common spaces
- Ventilation air flow monitors
- Wireless hub connectivity in masonry and concrete buildings

PM2.5 monitoring

Too much data, not enough information

HUD-NCHH PM2.5 monitoring in passive house vs. conventional multifamily



Future Work

Too much data,
not enough information.

3. Set rules

Set rules to trigger the alert to be sent if the sensor value exceeds or falls below the threshold for a set timespan.

View Airthings recommended thresholds:

[view thresholds](#)

- RADON (pCi/L) Radon sensor alerts are coming soon.
- VOC (ppb)
- CO₂ (ppm)
Generate alert when above: 1000
For more than: 24:00 hh:mm
- HUMIDITY (%)
Generate alert when outside the range: 30 60
For more than: 08:00 hh:mm
- TEMP (°F)
Generate alert when outside the range: 65 75
For more than: 05:00 hh:mm



Thank You!

Tom Chase

Senior Project Manager

chase@newecology.org

617-557-1700 x7061

Eleni Macrakis

Project Manager

emacrakis@homeownersrehab.org

617-868-4858 x209

