



# **Insights from the Low Cost Monitoring Project (LCMP)**

# Reducing Outdoor Contaminants in Indoor Spaces

01

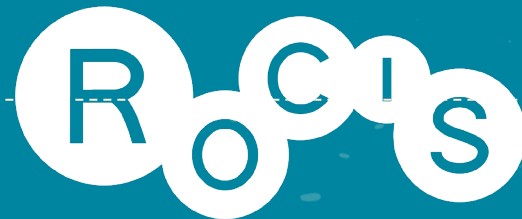


*“Rock-us” or “Raucous”*



**“A Southwestern  
Pennsylvania initiative to  
reduce the impact of exterior  
pollution in indoor spaces”**

[www.ROCIS.org](http://www.ROCIS.org)



# **Most of our exposure to outdoor pollution happens INSIDE buildings**

[www.iaqscience.lbl.gov](http://www.iaqscience.lbl.gov)





02

# Focus on Particles

Also referred to as Particulate Matter (PM)

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## **U.S. Environmental Protection Agency (EPA):**

**Particulate matter (PM), also known as particle pollution, is a complex mixture of extremely small particles & liquid droplets that get into the air. Once inhaled, these particles can affect the heart & lungs & cause serious health effects.**

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# Health Concerns - Particles



- **Particles differ in toxicity.**
- **There can be adverse synergy with other co-pollutants.**
- **Fine and ultra-fine particles can be vehicles to increase exposure of toxic contaminants such as SVOCs and metals.**
- **Our premise: “Precautionary principle” – avoid or minimize your exposure.**

# Pittsburgh's Air Quality is Poor



Rebecca Droke/Post-Gazette

## 9<sup>th</sup>

**People Most at Risk in the U.S.  
from Year-Round Particle Pollution  
(Annual PM<sub>2.5</sub>)**

## 1<sup>st</sup>

**Worst City East of the Rockies for  
Year-Round and Short-Term PM<sub>2.5</sub>**

## 16<sup>th</sup>

**People Most at Risk in the U.S.  
from Short-Term Particle Pollution  
(24-hour PM<sub>2.5</sub>)\***

\*Pittsburgh-New Castle-Weirton (PA-WV-OH)



# Particles (PM)



**Dylos 1700**  
**Our work horse!**

**PM<sub>2.5</sub>: Particulate matter**  
**<2.5  $\mu\text{m}$  in diameter**

**ROCIS LCMP Dylos:**  
**Particles > 0.5  $\mu\text{m}$**   
**(1/100 of human hair!)**

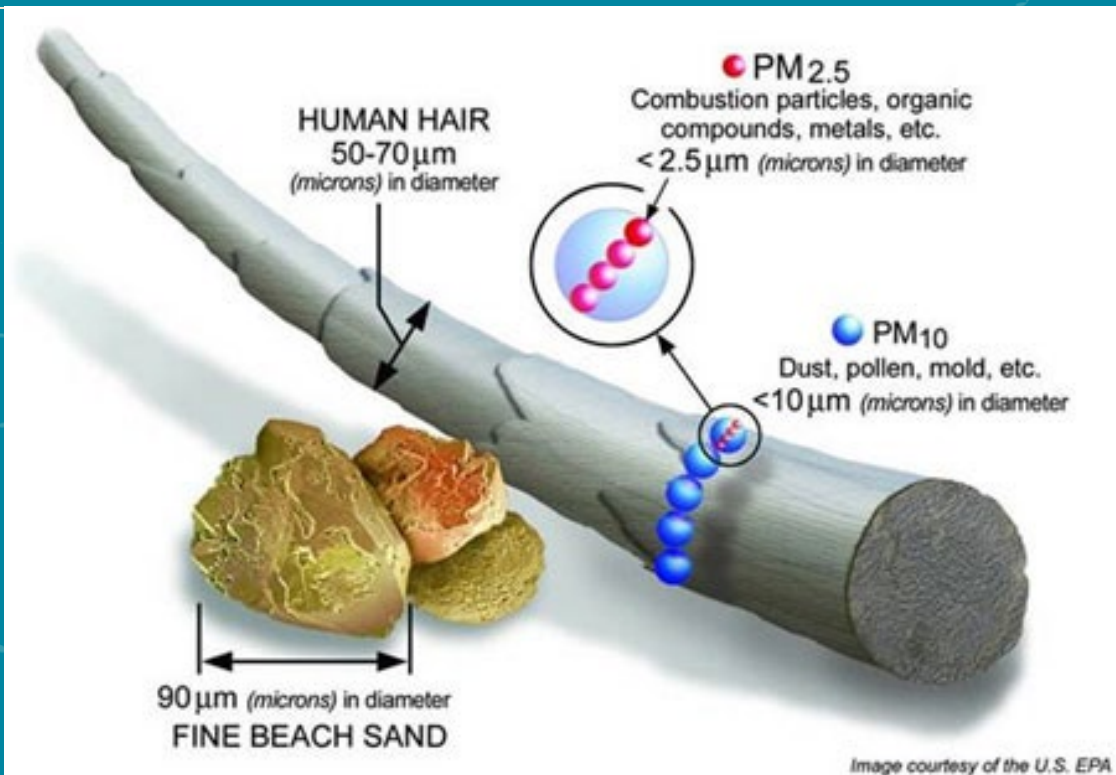


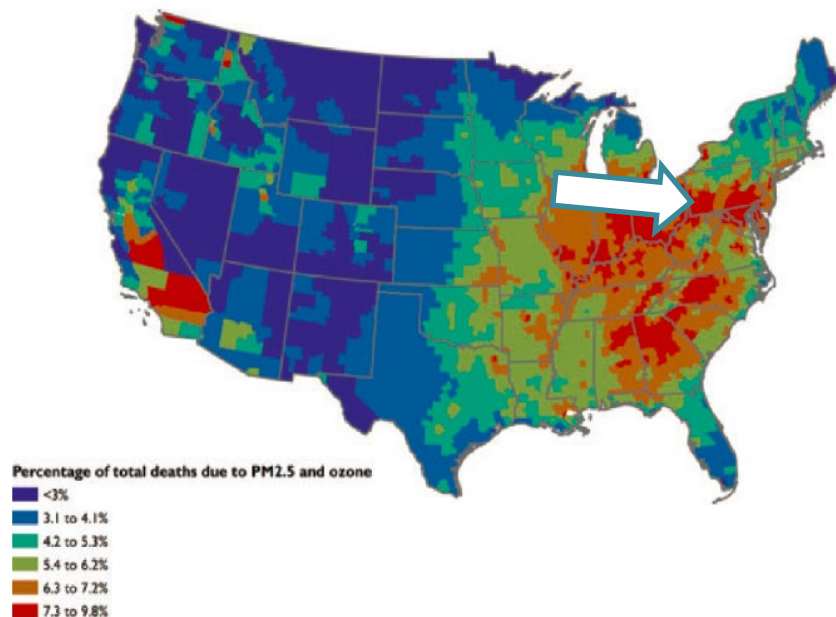
Image courtesy of the U.S. EPA

# Outdoor Particles (PM) & Human Health

**“Our best estimates of the US mortality burden associated with total PM<sub>2.5</sub> exposure in 2012 range from ~230,000 to ~300,000 deaths.”**

Azimi, P., & Stephens, B. (2020). *Journal of exposure science & environmental epidemiology*.

## Outdoor particulate matter and human health



03

# **The Low Cost Monitoring Project (LCMP)**

# LCMP Objectives

1. **Learn how low-cost monitors empower occupants (the Cohort is *FREE*)**
2. **Examine the impacts of outdoor on indoor air**
3. **Explore Interventions to improve indoor air quality**
4. **Develop champions!**



# LCMP Cohorts



- **Participants borrow monitoring equipment to measure:**

- **Particles (0.5+ & 2.5+  $\mu\text{m}$ )**
- **Carbon dioxide ( $\text{CO}_2$ )**
- **Carbon monoxide ( $\text{CO}$ )**
- **Radon**
- **Temperature**
- **Relative humidity**



- **During the course of the 4-week cohort, participants:**

- **Learn from the ROCIS team**
- **Benefit from each other's experiences**
- **Receive weekly individualized feedback in response to their data, observations, & questions**



# **LCMP Design**

## **Not a Regulatory Focus**

- **Measuring particle count, not mass; 1-min. resolution**
- **Focus on indoor / outdoor comparison**
- **Proof of concept – exploration of interventions**



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# **Good Readings ≠ Good Indoor Air Quality**

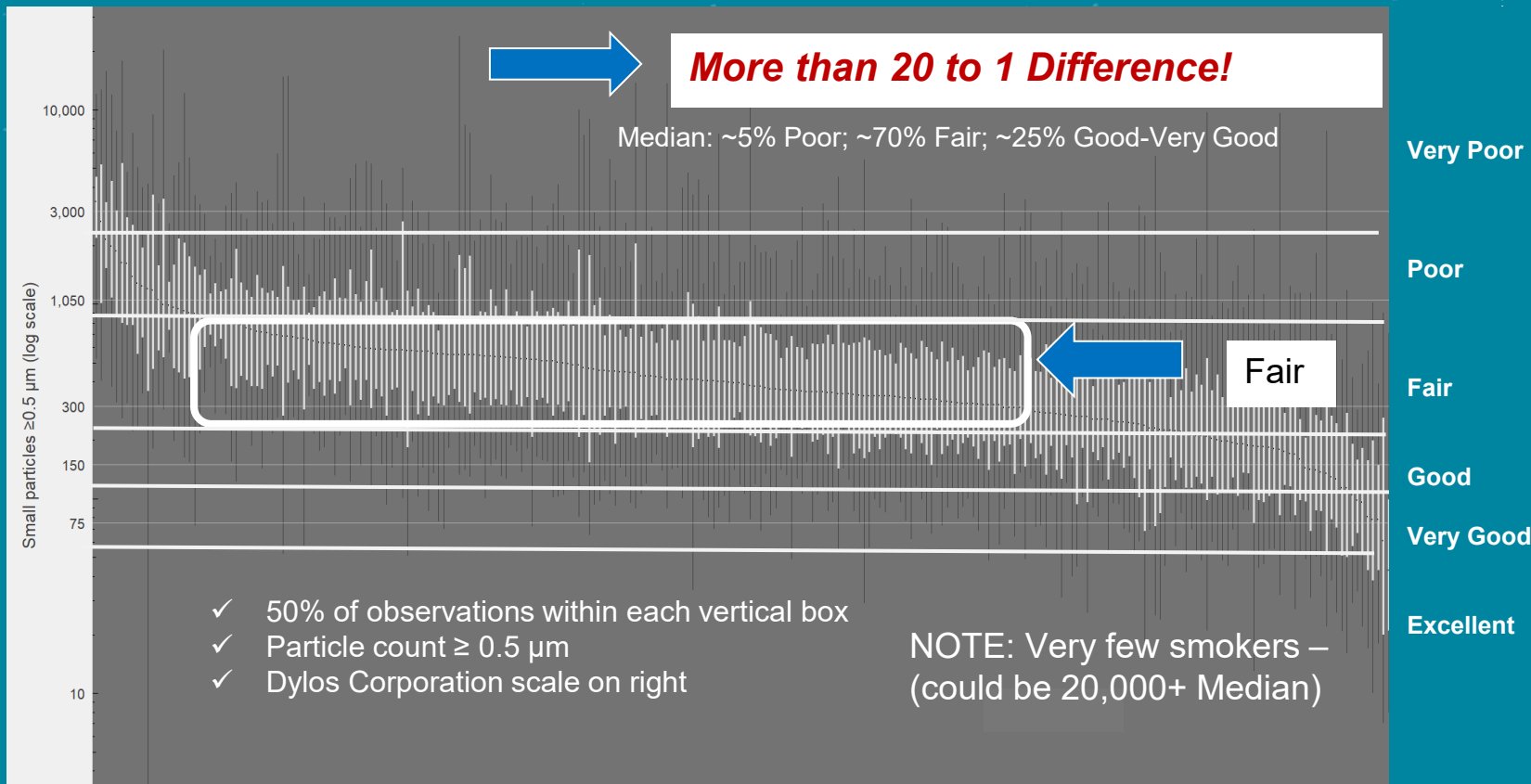
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**Know the limitations of our particle monitoring.  
What we cannot easily monitor could be important!**

# Indoor Particle Distribution



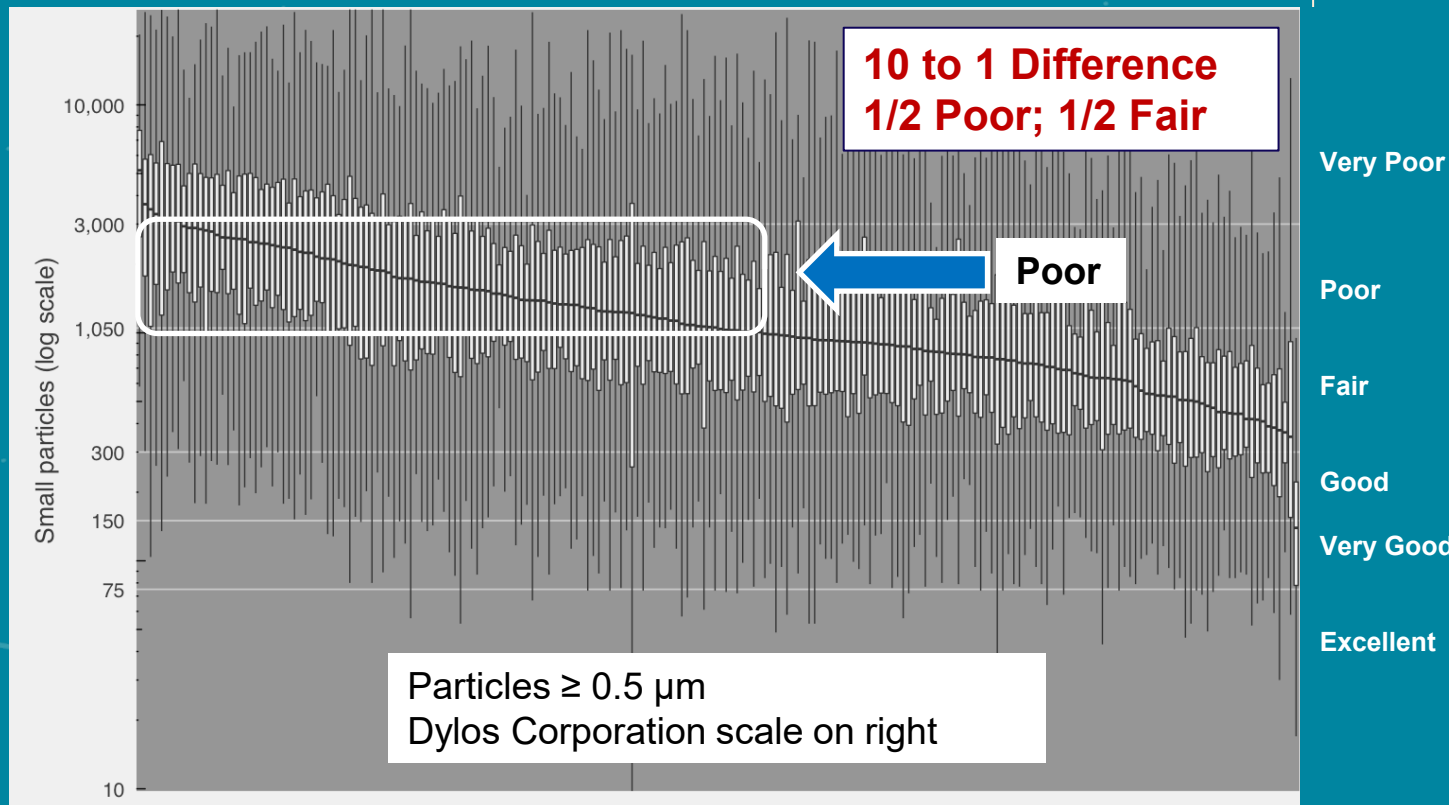
## 250 LCMP Residential Sites





# Outdoor Particle Distribution

## All Sites



# Aha's from past participants

- ✓ Wow! Bad outdoor air quality all over the region. It is the same air shed)
- ✓ Outdoor air often worse at night & early AM
- ✓ Things I do indoors can have big adverse impact
- ✓ The way we cook makes a big difference
- ✓ I need to close windows more
- ✓ There are many ways I can improve my family's air quality
- ✓ There are many simple & relatively inexpensive solutions
- ✓ Filtration can have a big impact
- ✓ Don't trust radon readings from real estate transactions

# 04

## **Reducing Exposure to Indoor Particles**

# 4 Strategies to Reduce Indoor Particles

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- **A) Reduce air exchange from outside**
  - Close windows
  - Tighten home or building
- **B) Reduce indoor sources**
  - Use an effective ducted kitchen hood!
  - Use induction cook top & other good practices w/ cooking
- **C) Reduce resuspension**
  - HEPA vacuum; thoroughly clean hard surfaces
  - Walk-off mats
  - Get rid of carpets, old upholstered furniture
- **D) Filter the air**
  - Portable air cleaners
  - DIY Fan Filters
  - Central air handler (furnace, AC, or ventilation)

# 4 Strategies to Reduce Indoor Particles

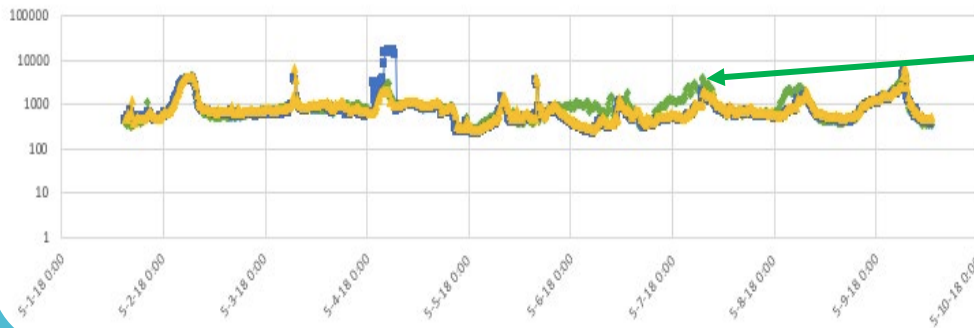
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# House with Wide Open Windows

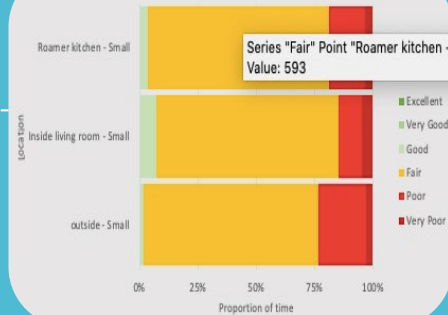
DYLOS SMALL PARTICLES

— outside — Inside living room — Roamer kitchen



Outdoor  
(green)

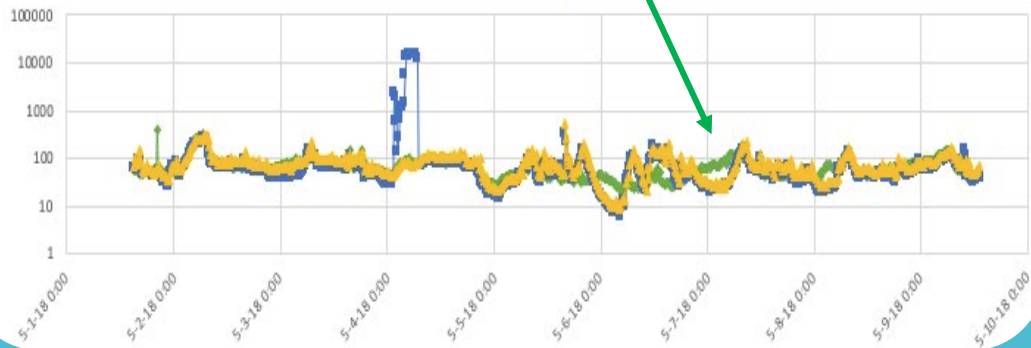
PARTICLE LEVELS IN AND AROUND YOUR HOUSE



Dylos Large

DYLOS LARGE PARTICLES

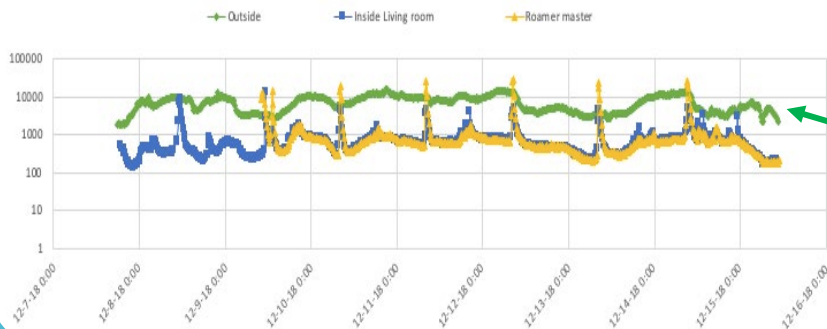
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Green (O), Blue (I), Yellow (R)

# 1941 House in Winter with High Outside Particle Counts

DYLOS SMALL PARTICLES



Dylos Small

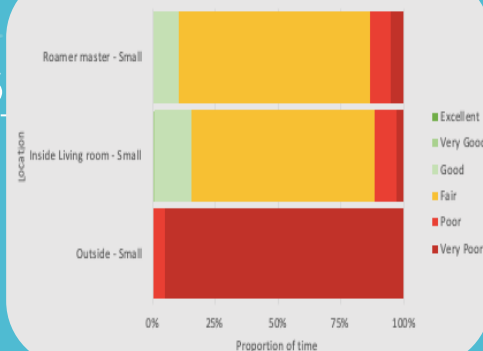
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# Reduce Cooking Emissions

Check out ROCIS guidance document & webpage

<http://rocis.org/kitchen-range-hoods>

- ROCIS ISSUE BRIEF, *Ducted Range Hoods: Recommendations for New and Existing Homes*
- Webinar - *Keep a Lid On It: Practices to Reduce Cooking Pollution in Homes*

[Keep a Lid On It](#)



# More Cooking Considerations!



## Particle generation during cooking:

- Range hood?
- Cooking style (fry vs. steam or bake)
- Use of lids
- Heat: Lower is better
- Impact of different oils & butter
- Add salt & pepper first to oil



## COOKING OIL SMOKE POINT CHART

KNOWYOURPRODUCE.COM

### 450°F+

AVOCADO OIL 520  
RICE BRAN OIL 490  
ALGAE OIL 485  
CLARIFIED BUTTER (GHEE) 485  
SOY BEAN OIL 450  
PEANUT OIL 450

### 400°F

SUNFLOWER OIL 440  
CORN OIL 440  
OLIVE OIL 410  
VEGETABLE OIL 400  
CANOLA OIL 400  
GRAPESSEED OIL 392

### 350°F

LARD 370  
VEGETABLE SHORTENING 360  
EXTRA VIRGIN OLIVE OIL 350  
COCONUT OIL 350  
BUTTER 350  
SESAME OIL (REFINED) 350

## DON'T COOK WITH

TOASTED OILS AND SOME SEED OILS  
These oils have a very low smoke point,  
it's best to add these oils once you  
remove the food from the heat.

# Other Indoor-Generated Sources

## Here's what we have seen:

- Humidifier using tap water (not distilled water)
- Showers – high humidity
- Cleaning products
- Personal hygiene
- Recreational combustion
  - Cigarettes, vaping...
  - Candles, incense, diffusers



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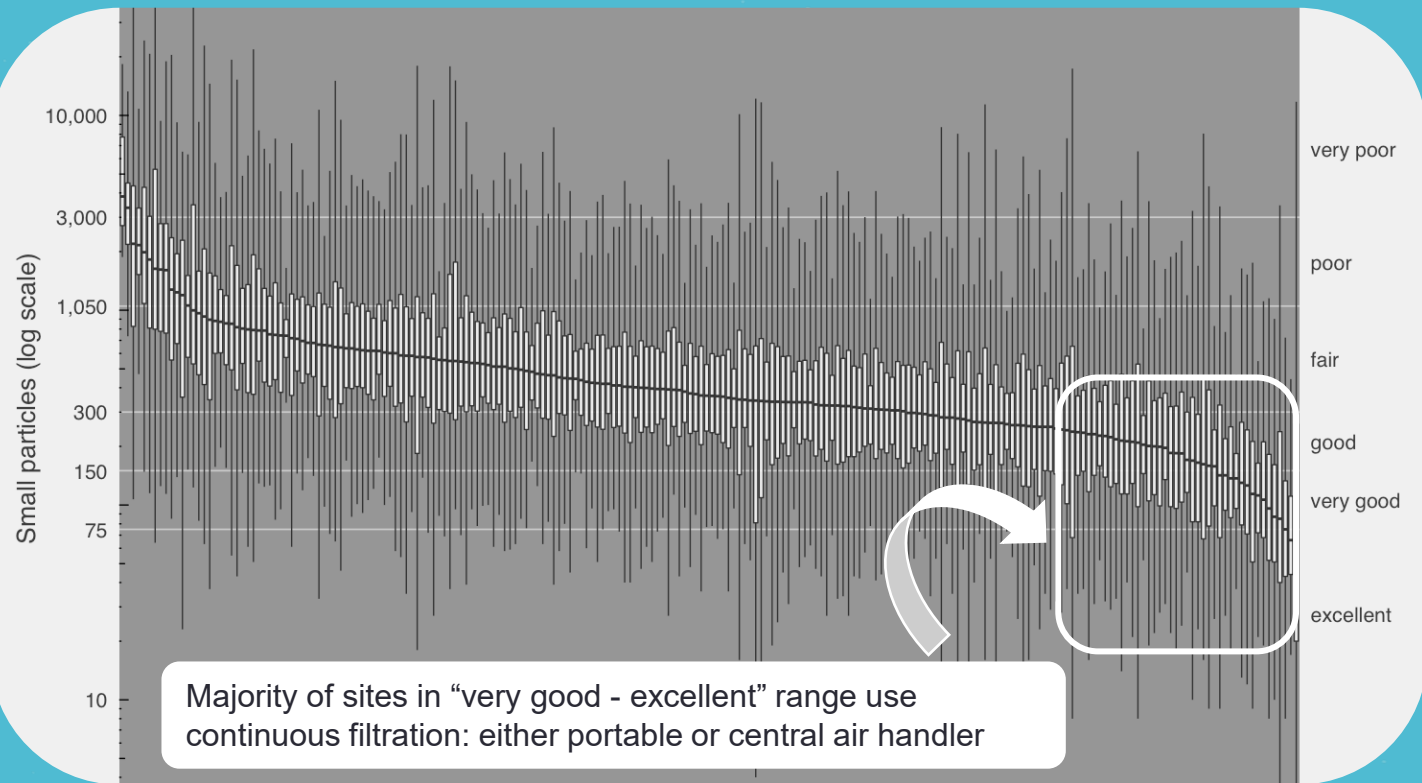
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# Indoor Particle Distribution: All Sites



More than 20 to 1  
difference!

Median:

~5% Poor, 70% Fair

~25% Good / Very  
Good

50% of observations are within  
each vertical box  
Particles 0.5+  $\mu\text{m}$  (Dylos small)  
Dylos Corporation scale (on right)

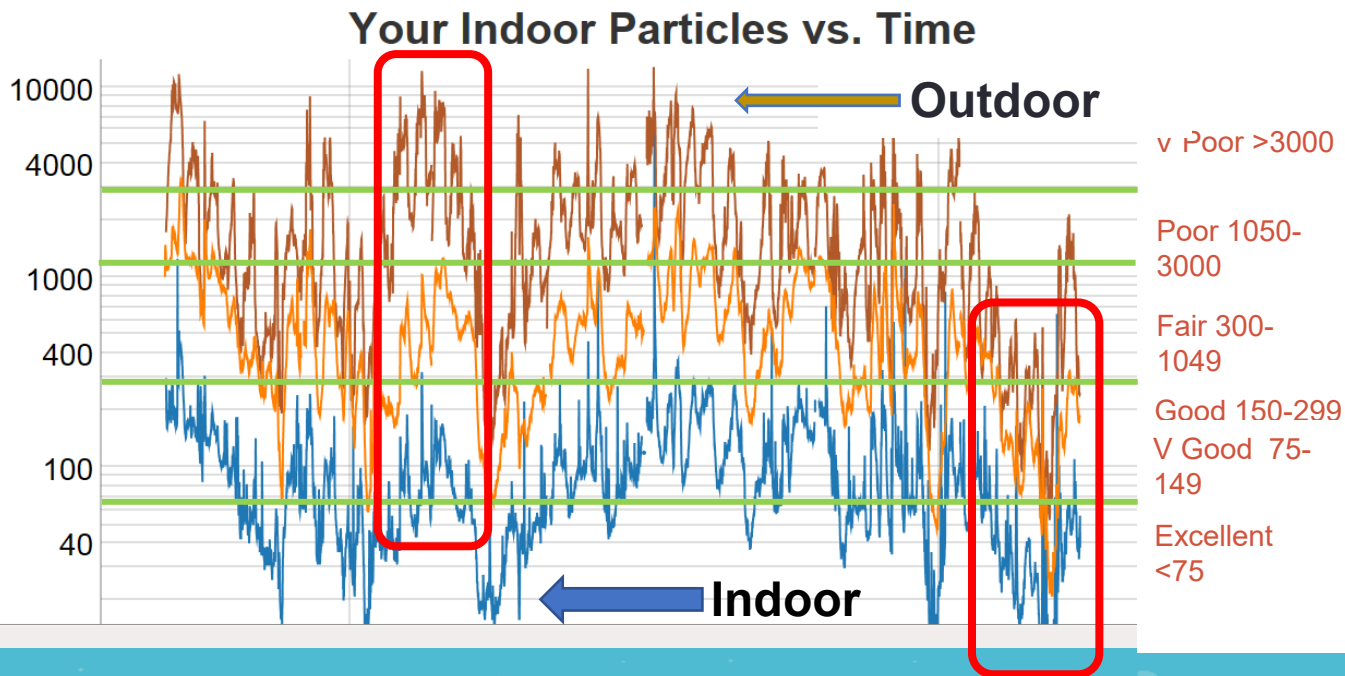
# Impact of Portable Air Cleaner

[http://rocis.org/rocis-data-explorer \(j1t8\)](http://rocis.org/rocis-data-explorer (j1t8))  
0.5+  $\mu\text{m}$  Particles by Time (15-min. avg.)

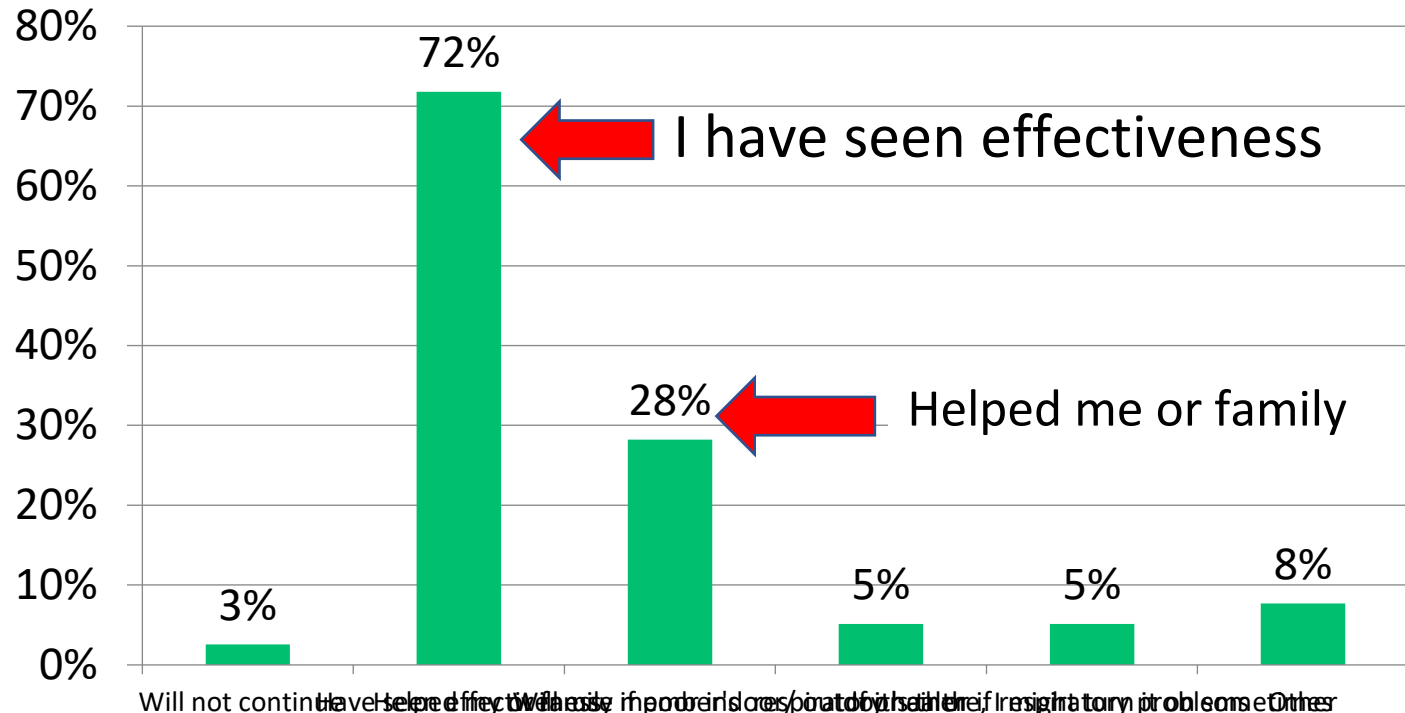


**Brown:** outdoors  
**Orange:** untreated zone  
**Blue:** treated zone with 24/7 air cleaner

Tight, single-family home  
Though order of magnitude lower, Indoor (Blue/orange) tracks Outdoor (brown)



# Why Continue to Use an Air Cleaner or Fan/Filter?





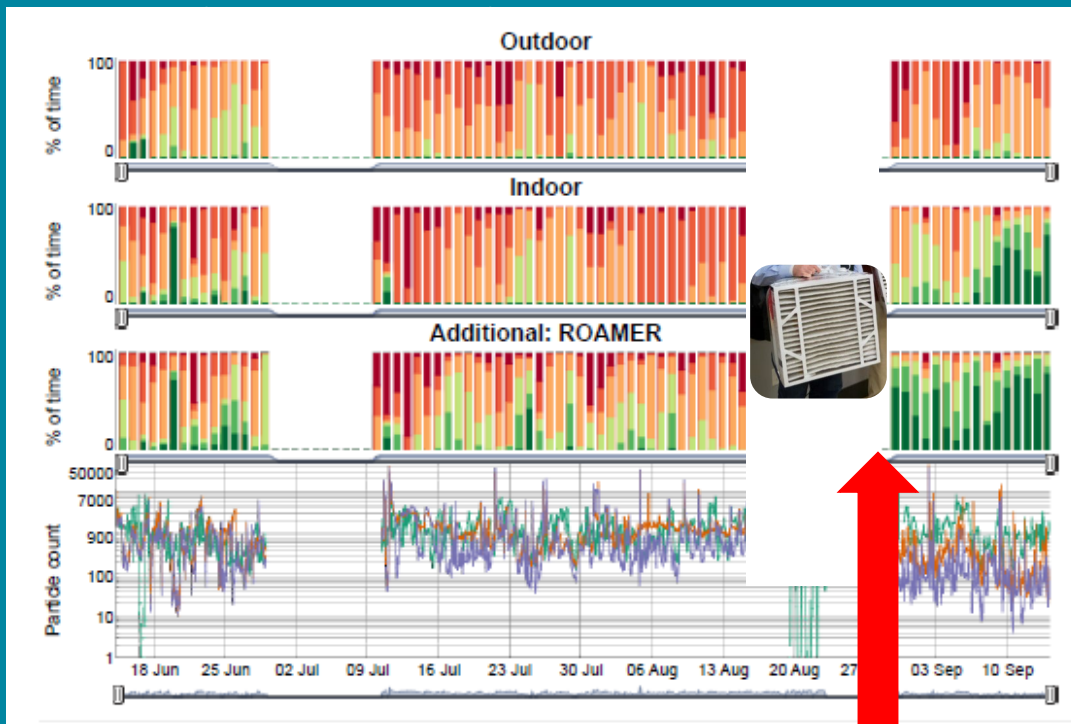
# Fan/Filter Intervention: Low Cost, MERV 13

4" MERV 13 filter (\$35) on  
20" x 20" box fan (~\$20)  
Box fan in room or in window  
UL-rated fan with overheat  
protection



# Indoor Fan/Filter 24/7 Impact

<http://rocis.org/rocis-data-explorer> (k4x3)



Added fan/filter here

# Fan/Filter Options

## 20" Box Fan w High MERV Filters

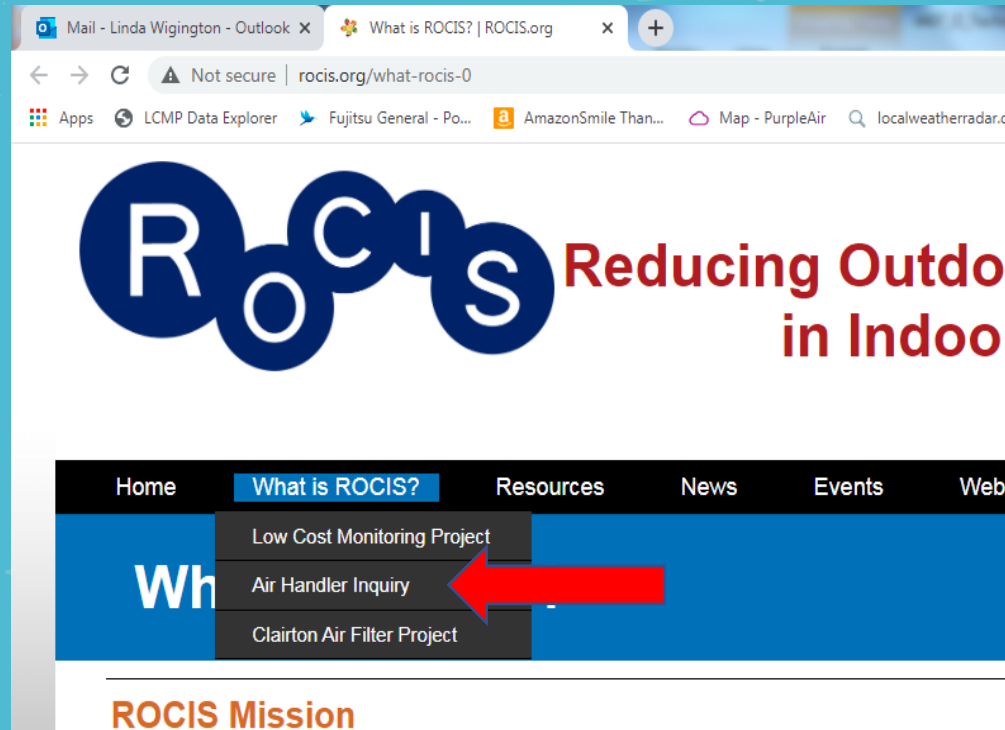
- Some use multiple filters (2 in V, or 4 in box)



[https://m.box.com/shared\\_item/https%3A%2F%2Fucdavis.box.com%2Fs%2Fkgo937Ik0d02g0k2bxvpxxqbfatd7czu](https://m.box.com/shared_item/https%3A%2F%2Fucdavis.box.com%2Fs%2Fkgo937Ik0d02g0k2bxvpxxqbfatd7czu)

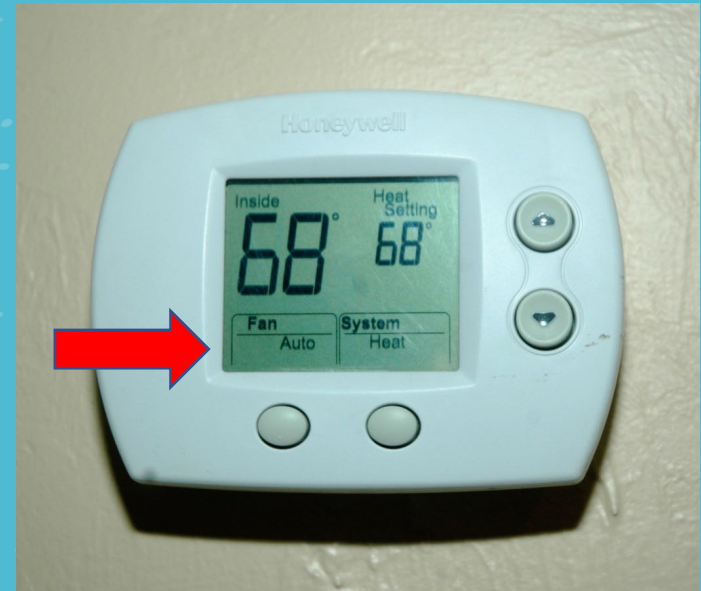
Or use “Corsi-Rosenthal Cube” in search

# ROCIS 24/7 Air Handler Checklist



# Air Handler Operation

- Thermostat usually set to “Auto”, not “On”
- Average annual run-time is ~15%
- Inadequate for filtration
- Call for heat & cool does not align with need for filtration
- With smart thermostats more control of “on time”



# Big Issues with 24/7 High MERV Filter

---

**Air handler (AHU) energy use** can be high due to 500 to 1,500 watt-draw

- High cost of running air handler continuously  
(360 kWh to 1080 kWh/month = ~\$500 to \$1500/year<sup>1</sup>)

## **Wrong blower speed**

- Seldom set in field
- Often defaults to high speed, not low, in continuous mode
- Higher energy cost, less effective filtration

**Ductwork issues** introduce additional problems

- Static pressure too high (can lead to equipment failure)
- Duct leaks (energy waste & pressure-related problems)

<sup>1</sup> \$0.12/kWh



# 1<sup>st</sup> Air Handler Retrofit

Pre



Post

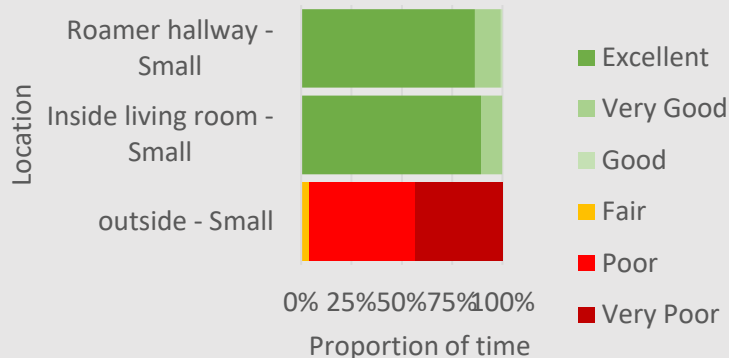


Replaced  
PSC  
motor w/  
ECM  
motor

Labor & material cost: ~\$1,000  
24/7 monthly operating cost: ~\$12.50

CASE STUDY: Indoor Air Quality Interventions  
Chris Guignon, evolveEA

## PARTICLE LEVELS IN AND AROUND YOUR HOUSE



## LCMP Top Performer

### Air Handler 24/7 – MERV 13 Filter

Indoor tracks outdoor

Indoor uniform – 2 locations

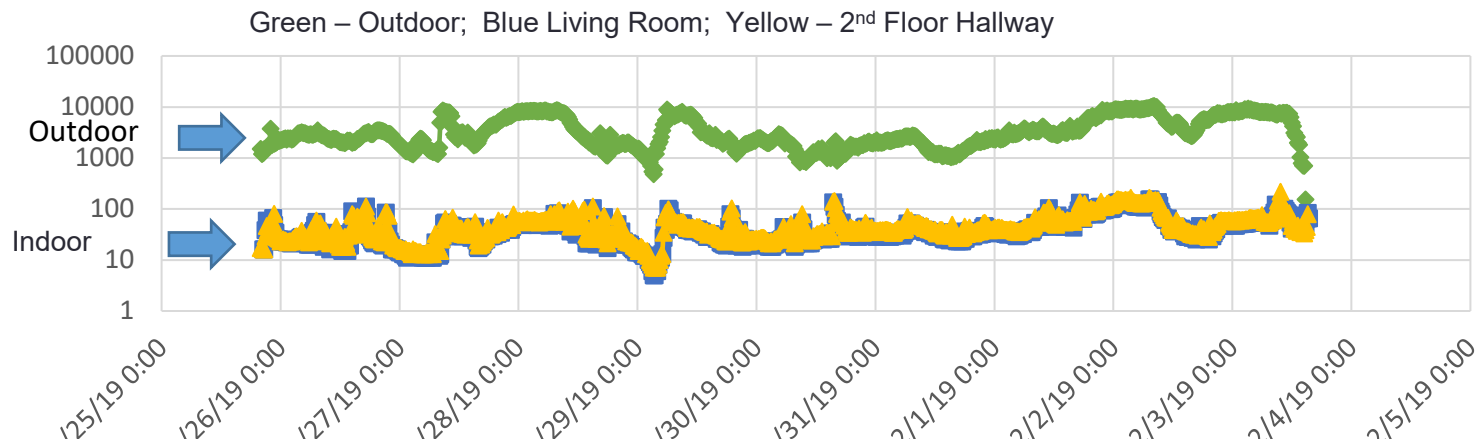
Also – 2<sup>nd</sup> floor portable air cleaner

Continuous Mode: \$12/month

Post: 110 watts; 500 CFM

(Pre-Post: 400 watt reduction)

#### Dylos small (0.5+ microns) (#/100 ft<sup>3</sup>)





# Filter Essentials

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- Deep filter (we prefer 4")
  - Large filter (surface area)
  - Low resistance filter (check label on filter)
  - Minimize filter bypasses
- 
- MERV 13 to reduce 0.3 to 0.5  $\mu\text{m}$  particles (MERV is like R-Value; *performance depends on installation/operation*)
- 
- Adequate run/on time (if system passes diagnostic screening)

# Take Aways:

## Air Handlers 24/7 w High MERV Filtration

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- Can be very effective!
- Do not operate air handler 24/7 without confirming
  - Fan cost (electricity)
  - Minimal duct leakage to outside (big issue w/attic ducts)
  - Static pressure within operating range
- NOTE: One-inch pleated filters can be very restrictive

# Four Conclusions

1. Low cost monitors - Reinforce behavior & investment
2. Lower outdoor particle pollution - Lower indoor levels
3. No magic bullet - Occupants & building systems - significant impact on particle levels
4. *Better outdoor air quality & housing stock/building systems - critical to reduce disparities & to improve health*

# Implications for Climate Change

Integrated on-site solutions are needed to enhance health, resilience, energy efficiency (kWh & kW), comfort, & durability

Easier to make the case for on-site investment with multiple benefits, including job & local economic impact

Reduction of fossil fuel use can improve outdoor (& indoor) air quality

Better air quality lowers energy operating cost of interventions (30% vs. 100% runtime)

On-site solutions also provide capacity to respond to worsening climate incidences (heat events, thermal inversions, wildfire smoke)

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# Thanks!

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**Thanks to Phil Johnson & The Heinz Endowments for  
support of the ROCIS initiative  
(Reducing Outdoor Contaminants in Indoor Spaces)  
and our 400+ LCMP participants**

# QUESTIONS??



Linda Wigington  
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lwigington1@outlook.com

Upcoming Cohort (sign up for intro session)  
Mon. 7 PM Feb.14, or Tue. 10:30 AM Feb. 15

Monitoring Feb. 24 - March 25, 2022  
<http://ROCIS.org>



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**Freepik** .



# Outdoor + Indoor



## Reducing Cooking Emissions:

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  - **ROCIS ISSUE BRIEF, Ducted Range Hoods: Recommendations for New and Existing Homes**
- **And recent ROCIS webinar**
  - **Keep a Lid on It: Best Practices for Reducing Cooking Pollution in Homes**



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