



Air Handler Interventions



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- 2:45 - 3:45 PDT
- Wednesday, August 3, 2022
- Energy OutWest, August 1-5, 2022
- Denver, CO
- Find this presentation here:
- <http://rocis.org/past-rocis-events>

- Time for a
ROCIS video



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

<https://www.iaqscience.lbl.gov>



Health Concerns - $\text{PM}_{2.5}$



Established PM-associated diseases:
cardiovascular disease, asthma, & lung cancer

Recent associations with PM exposure include:
idiopathic pulmonary fibrosis, type 2 diabetes, Alzheimer's disease, & decreased cognitive function as well as premature birth

Filtration Resources

- EPA Guidelines - Air Cleaners & Air Filters in the Home

<https://www.epa.gov/indoor-air-quality-iaq/air-cleaners-and-air-filters-home-0>

- ROCIS website

<http://rocis.org/air-handler-inquiry>

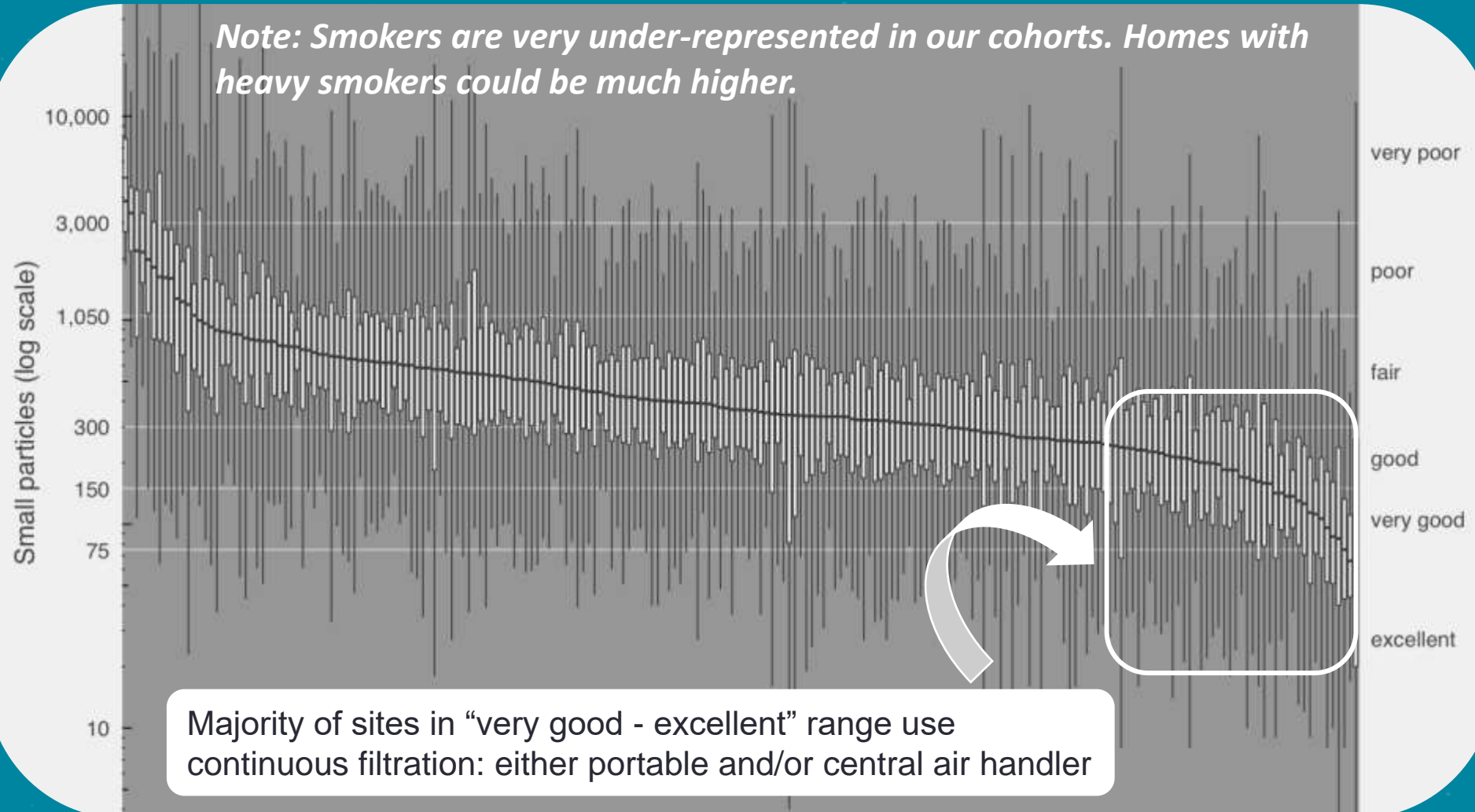
<http://rocis.org/clairton-air-filter-project>

4 Strategies to Reduce Indoor Particles

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

Indoor Particle Distribution: All Sites

Note: Smokers are very under-represented in our cohorts. Homes with heavy smokers could be much higher.



More than 30 to 1
difference!
Median:
~2/3 Fair
~1/3 Good / Very Good

50% of observations are within
each vertical box
Particles 0.5+ μm (Dylos small)
Dylos Corporation scale (on right)

**Filtration only
works when
it is ON!**

YOU ONLY
GET OUT
WHAT YOU
PUT IN

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”



High MERV Filter - Air Handler (Filter/AHU) Inquiry

Initial Question...

Is there an **easy way** to determine if I can use a high MERV filter with a **longer air handler run-time** without causing problems (\$, equipment durability, performance, or GHG emissions)?

NO !!

Diagnostic
Screen is
Required

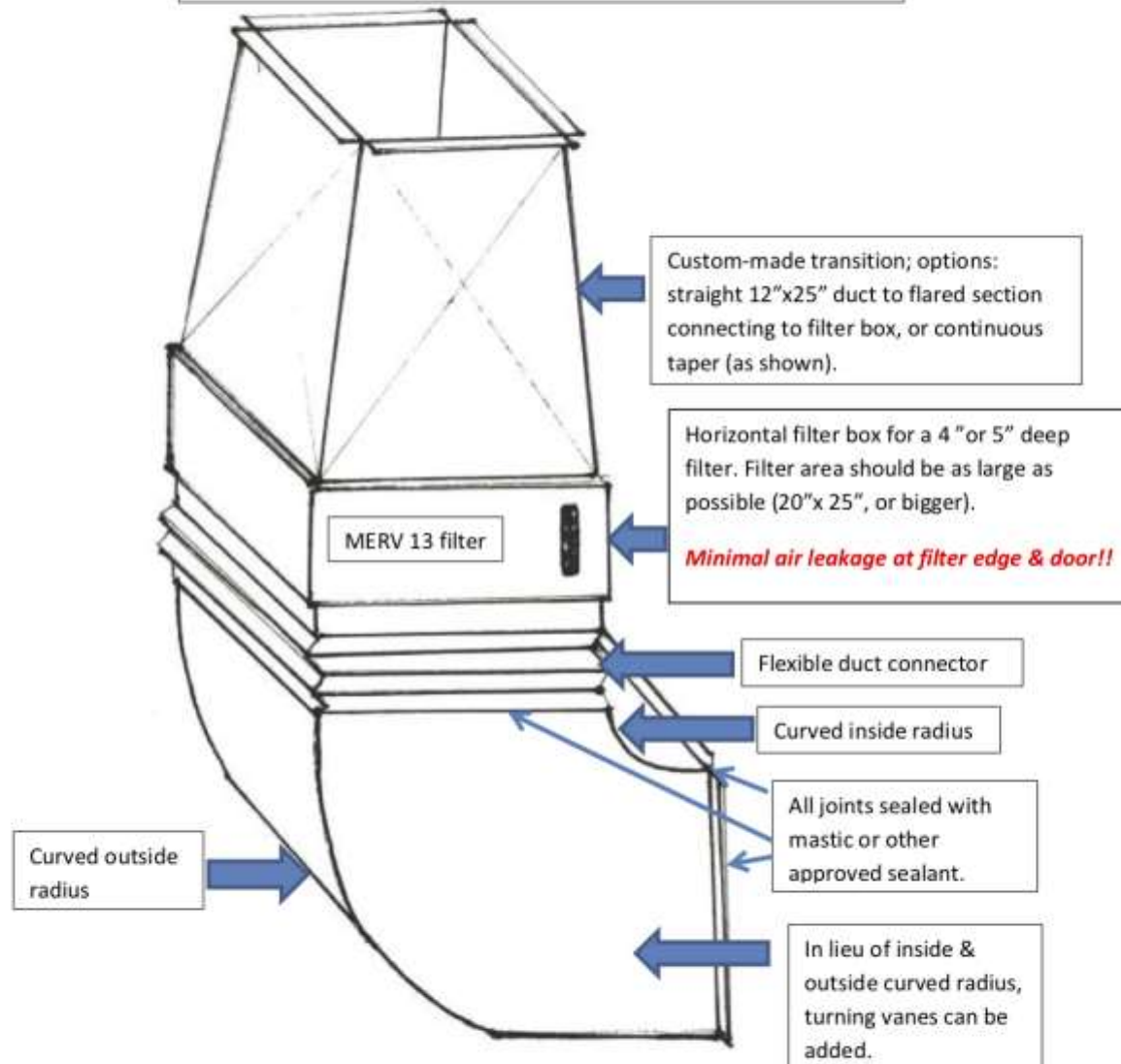
ROCIS 24/7 Air Handler Checklist



Basement Return Drop Modification

This modification allows for:

- 1) a larger & deeper MERV 13 filter;
- 2) more even flow/loading over the full filter;
- and 3) lower static pressure across both the filter & return side of the ductwork.



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/year¹)

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)

¹ \$0.12/kWh

Air Handlers 24/7 w High MERV Filtration

- 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

Measuring Watt Draw



- Clamp-on style Current Transformer (CT) (OWL, Energy Detective, Sense)
- Converts magnetic field to Wattage
- Wireless monitor display

Clamp-on style Current Sensor (CT)

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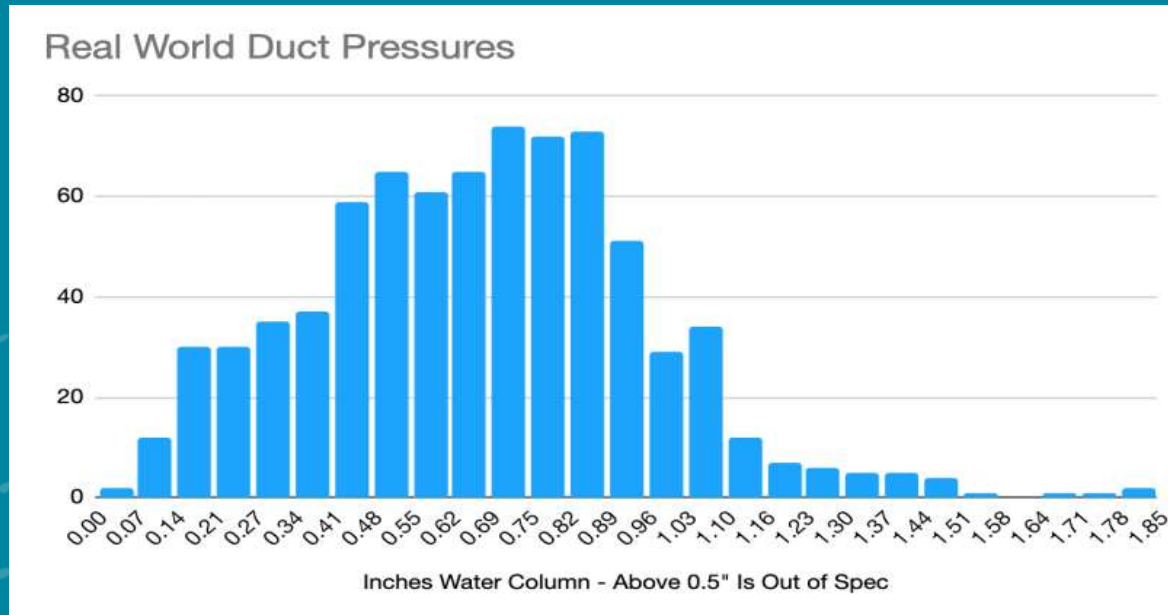
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Why Should I Care About Static Pressure?

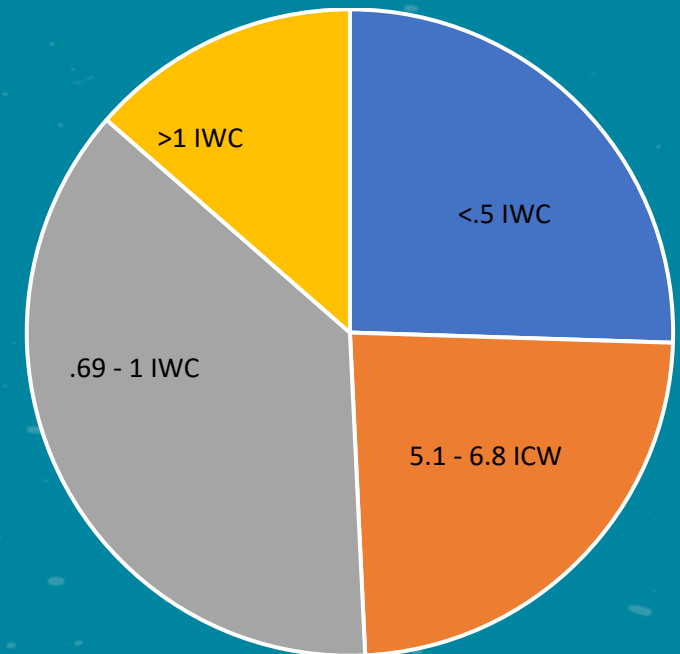
- *High static pressure may cause:*
 - **High amp draw on ECM & variable speed motors**
 - High energy usage
 - Blower motor and/or compressor failure

Total External Static Pressure

- TESP - AKA - External Static Pressure
- Combined highest Positive and Negative pressure External to the air handler - created by the total resistance in the entire furnace/ AC/ duct system.
- The greater the TESP, the more restricted the airflow.

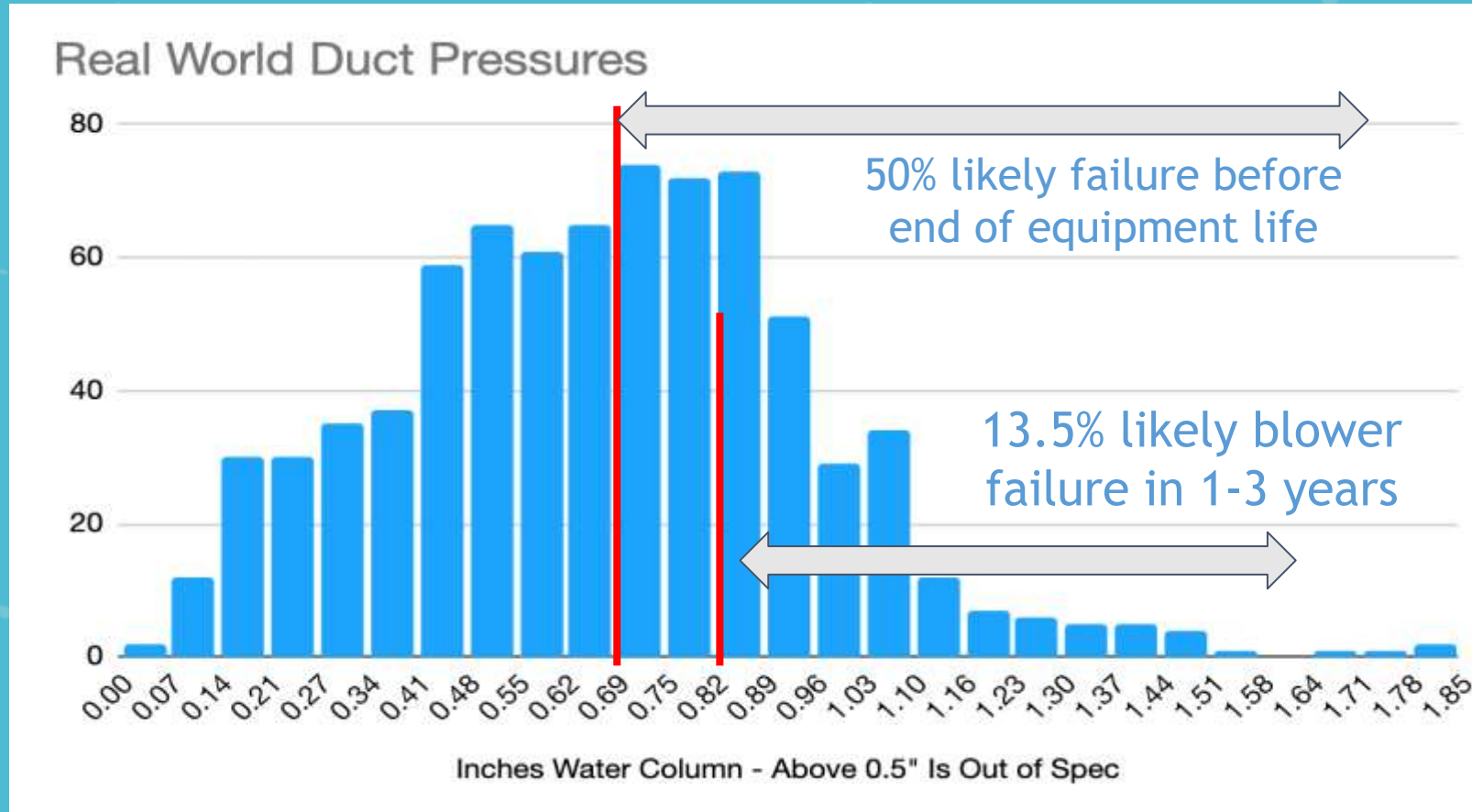


Measured TESP of 796 HVAC Systems



Thanks to measureQuick (<https://measurequick.com/>) for permission to share their nationwide data set from 796 HVAC systems. The majority of these are retrofit.

TESP in Reality - 796 Systems



Measuring External Static Pressure

Equipment Needed

- Standard Manometer/Magnehelic or Digital
- 1 or 2 Static Pressure Probes
- Tubing
- Other equipment
 - Drill with 1/4 inch bit
 - Step Drill bit



Measure Static Pressure with manometer

- Drill $\frac{1}{4}$ inch ports, insert static tip

Return Plenum



After Filter



Before Coil



Supply Plenum



Three types of blowers



PSC



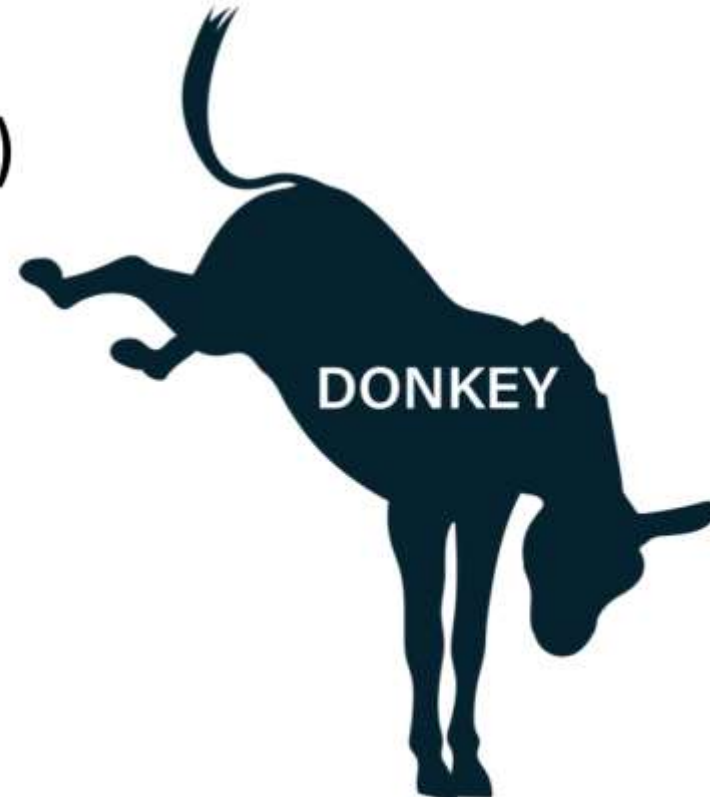
ECM
Constant-Airflow



ECM
Constant-Torque

Permanent-split Capacitor (PSC)

- Widely used for furnace blowers
- AC induction motor
- Runs at constant speed; 3-4 selections
- Limited airflow range
- Not very efficient (60-65%)
- Low cost
- Commodity replacement

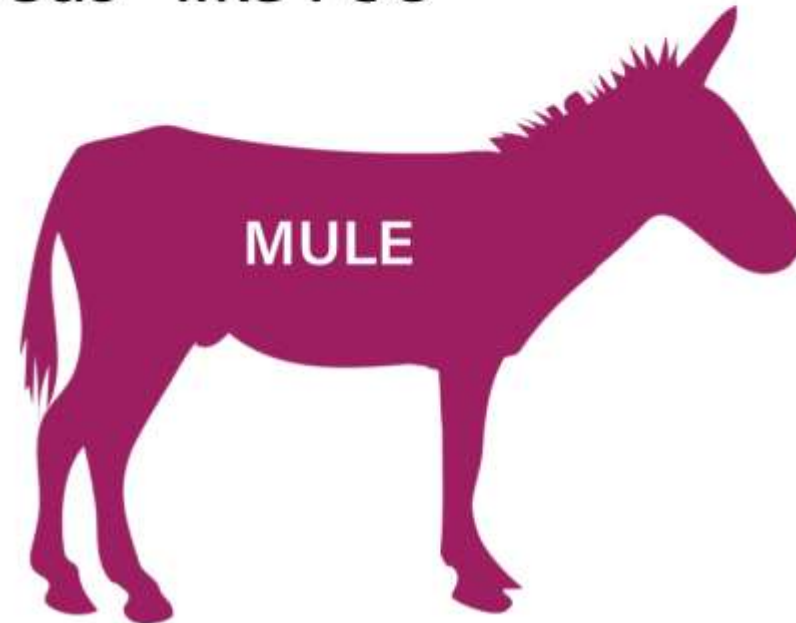


Electronically-commutated Motor (ECM)

Constant Torque

Original trade name "X13"

- Introduced around 2006
- ECM efficiency
- Maintains constant torque (not airflow)
- Limited to discrete "speeds" like PSC
- Has start/stop ramping
- Middle cost
- Can be retrofit





After Improving air flow, we are able to change out the inefficient permanent split capacitor motor (PSC) with a replacement ECM (Constant Torque). The drop in wattage (same airflow) is often very significant.



This model also allows us to set up a very low continuous movement of air for filtration, ~400 - 700 CFM, @120 - 180 Watts of power.

Electronically-commutated Motor (ECM), *Constant Airflow*

Aka “brushless permanent magnet (BPM)”

- Introduced in late 1980s for high-end, “variable-speed” furnaces
- DC motor
- Maintains constant airflow
- Wide airflow range
- More efficient
- Has start/stop ramping
- High cost
- Mfr specific



Airflow Control Tips For Constant Volume ECM™

- **Low static**, high quality ducted applications will run slowly, quietly and efficiently.....
while delivering the correct airflow.

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Use good duct design practices and hold static pressure to less than .8", ideally less than .5"

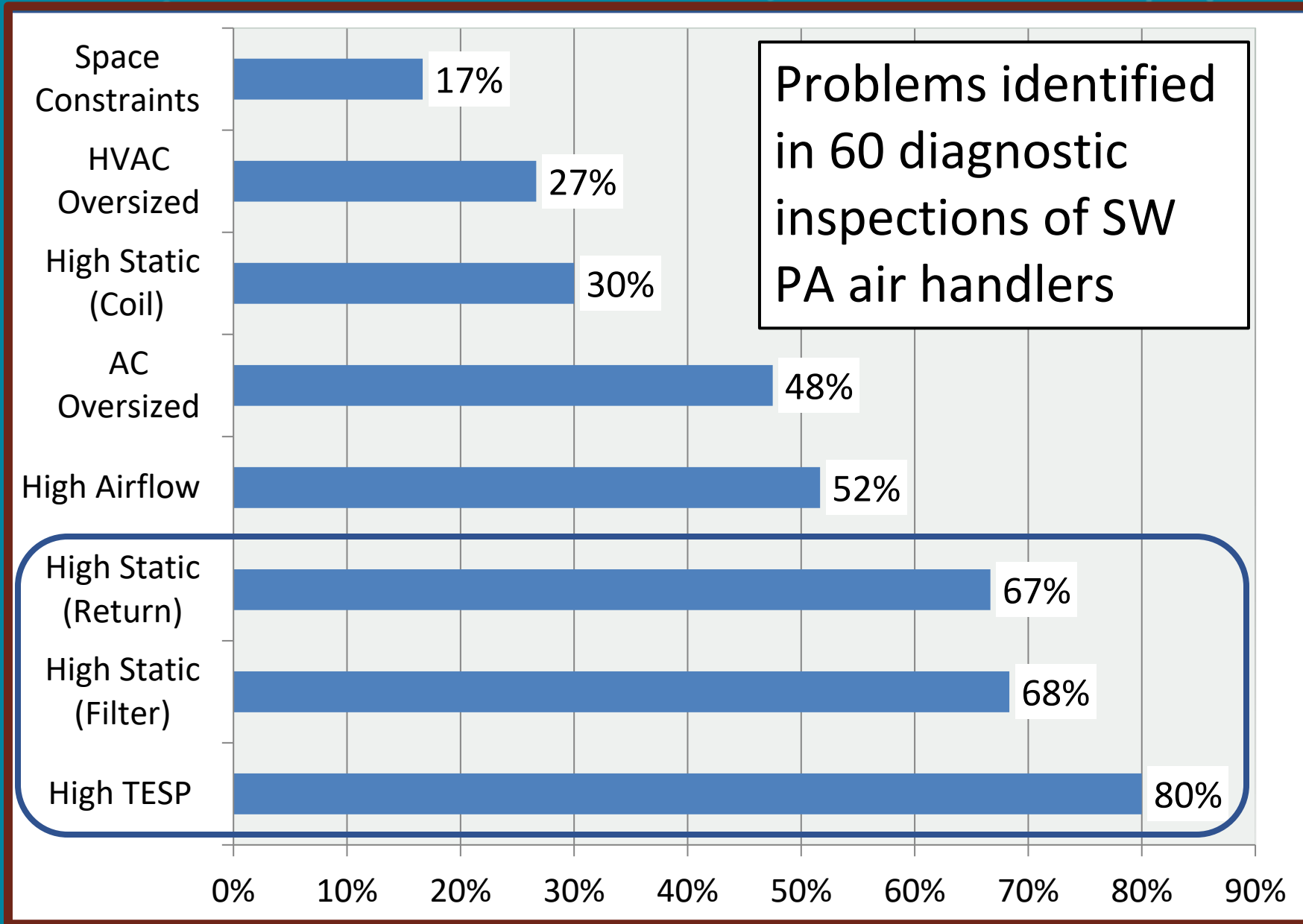
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This is a measurement - not a setting!

“Oversized”
in response
to ducts,
not home:
many more
systems are
oversized



Filter Bypass: Relatively Common in Homes



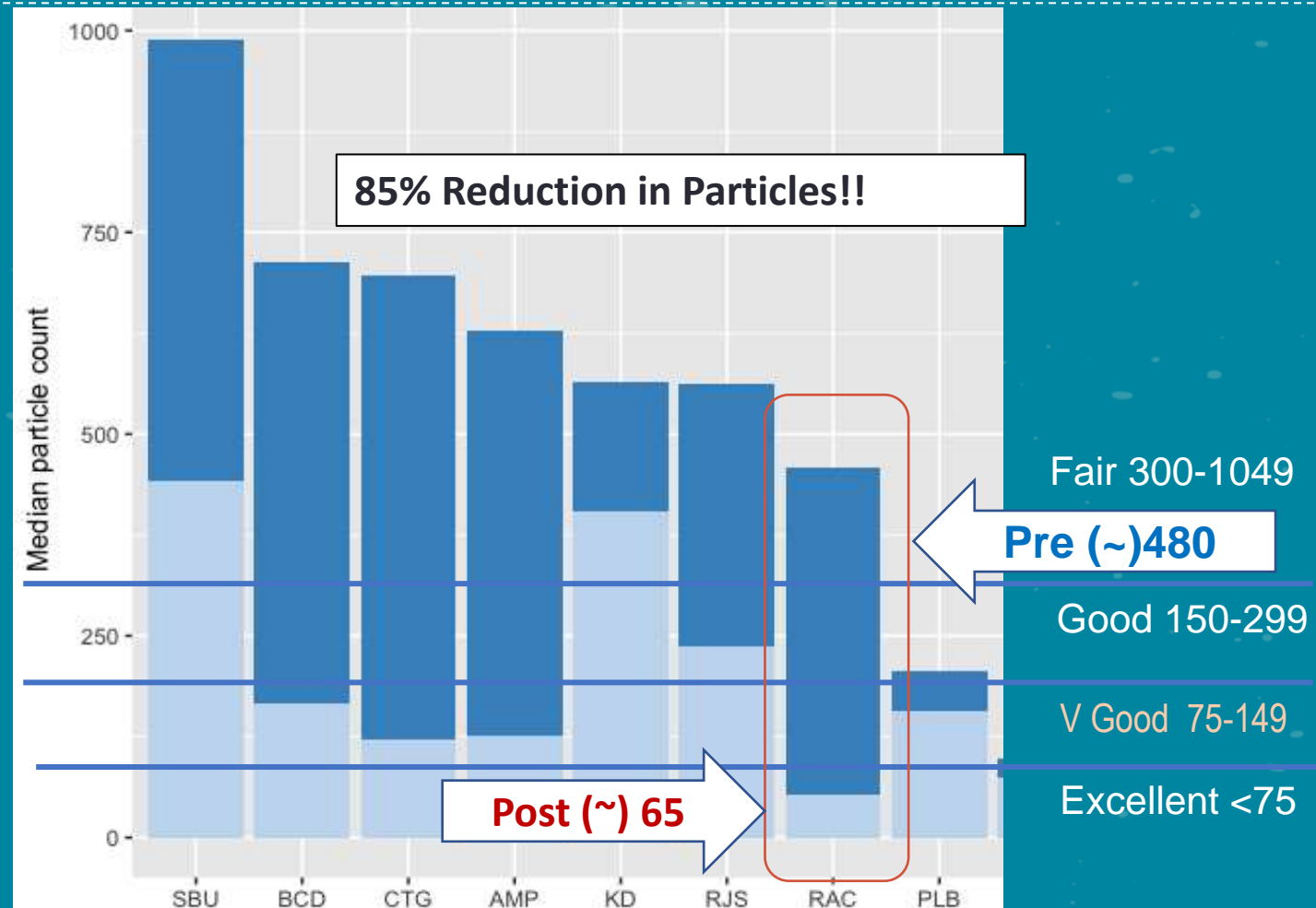
Elements for 24/7 Operation of AHU

- **ECM (electronically commutated motor) Blower**
 - Increase control to optimize (& lower) air flow
 - Drops electricity use, **but only if static pressure** is low/correct
- **4" Pleated MERV 13 filter – ideally also larger area**
 - Lower air flow thru filter increases reduction of smaller particles
 - 4" deep filter longer life without clogging
 - Option for 2nd filter (pre or post)
- **Good Duct System**
 - Minimal leaks to outside
 - Air flow & TESP within name plate specifications

NOT RECOMMENDED:
1" pleated MERV 11 or 13
filter (equivalent) without
performance testing for
TESP, air flow, & watt-draw

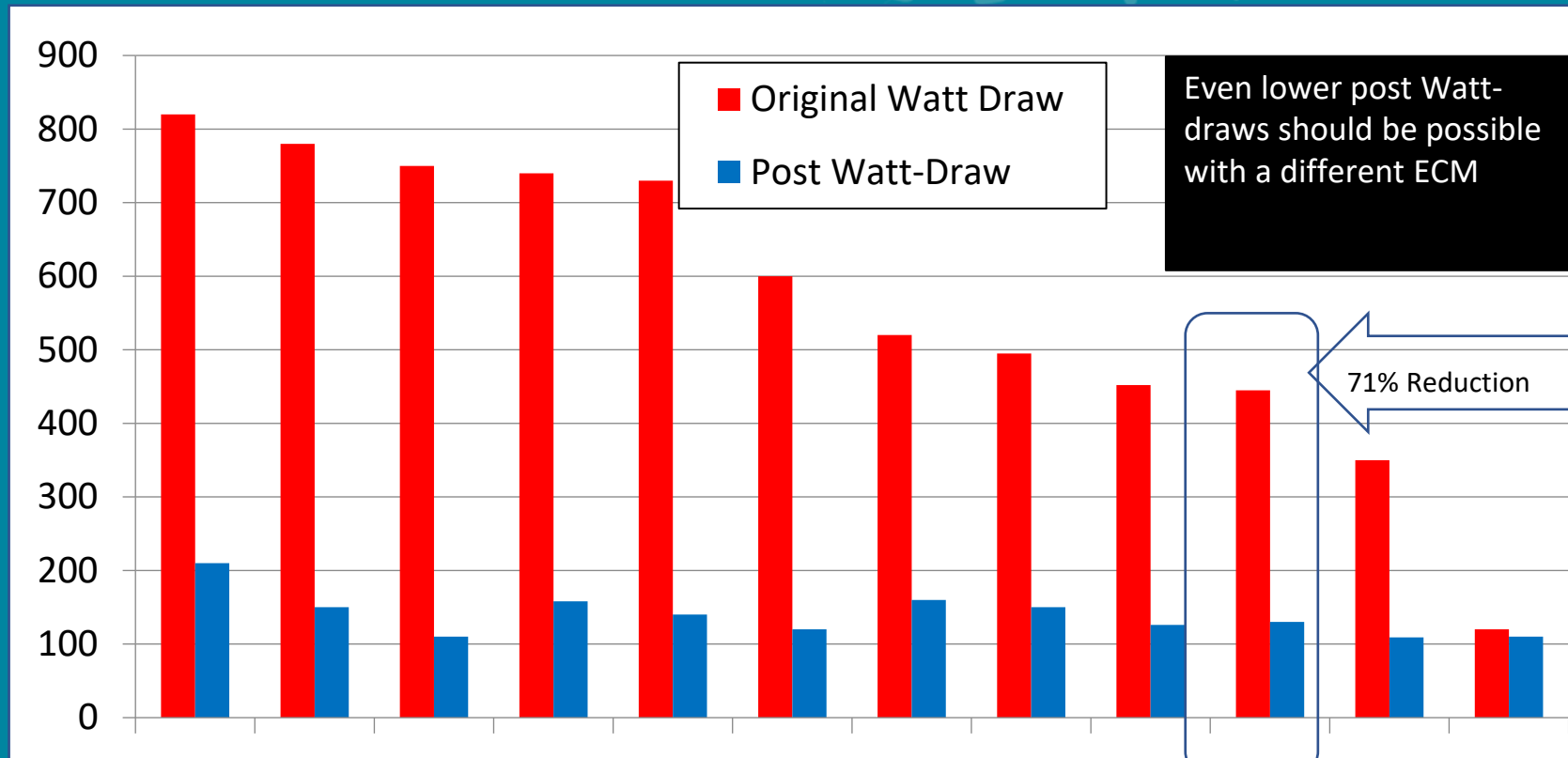
Selected ROCIS Intervention Homes Pre-Post Median Particle Count

Use code **(w2i9)** to
view data on ROCIS
LMCP Data Explorer
<http://rocis.org/rocis-data-explorer>



Air Handler Interventions

Pre-Post Continuous Watt-Draw



1st 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

Air Handler Retrofit

Larger return drop

2-part filter rack
(20" x 25")
Horizontal
(4" MERV 13 +
2" pre or post filter)

90 degree transition
designed for better air
flow (heel & throat);
lower static



RESULTS:

In continuous mode:

- 4.27 CFM/watt
- 120 Watts
- Pressure drop across filter Pre: 93 Pa, Post: 16 Pa
- **Allowable TESP: 125 Pa (total system)**

ECM
replacement

Fan speed adjusted to
optimize heating, cooling,
& continuous
performance.

Brand new Carrier system

INITIALLY:

- 1" filter & return drop too restrictive
- Airflows not adjusted properly
- TESP too high in Stages 2 & 3, & AC

INTERVENTION:

- Carrier tech adjusted airflows
- ROCIS installed new return drop w larger deeper MERV 13 Aprilaire filter

POST:

- Fan only: 42 watts, 317 CFM, TESP 49 Pa
- Stage 2 & AC: 193 watts, 670 CFM; TESP 94 Pa
- Stage 3: 310 watts, 720 CFM, TESP 114 PA

FAN ONLY PERFORMANCE:

7.54 CFM/Watt

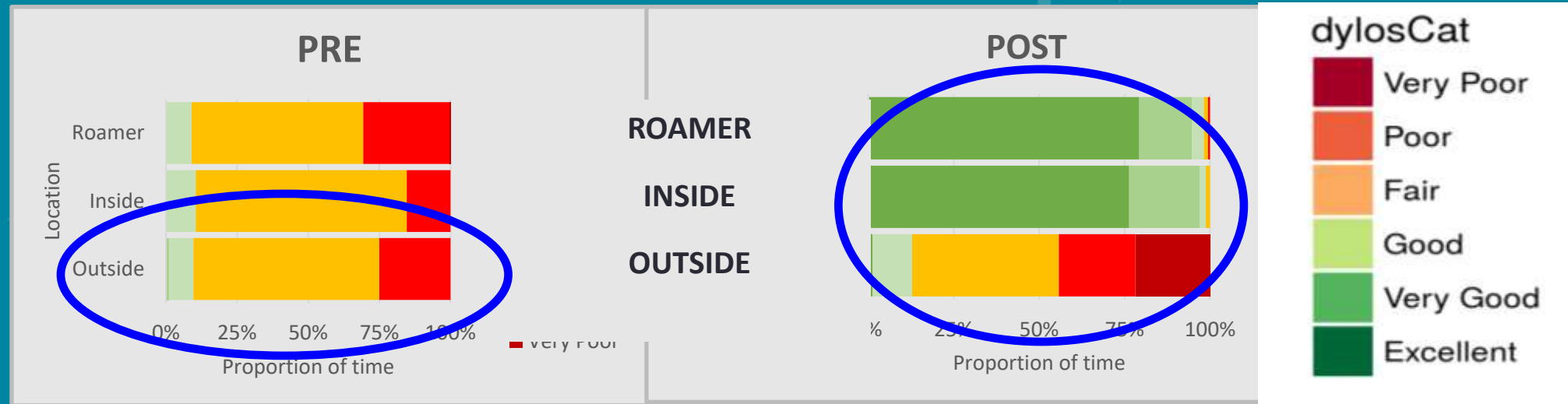
24/7 operation: \$53/year

TESP System Limit: 125 Pa



Results: Pre & Post Particles

Air Handler Retrofit



Week ending 5-24-2017 (**windows open**) vs. 7-31-2017, poorer outdoor counts

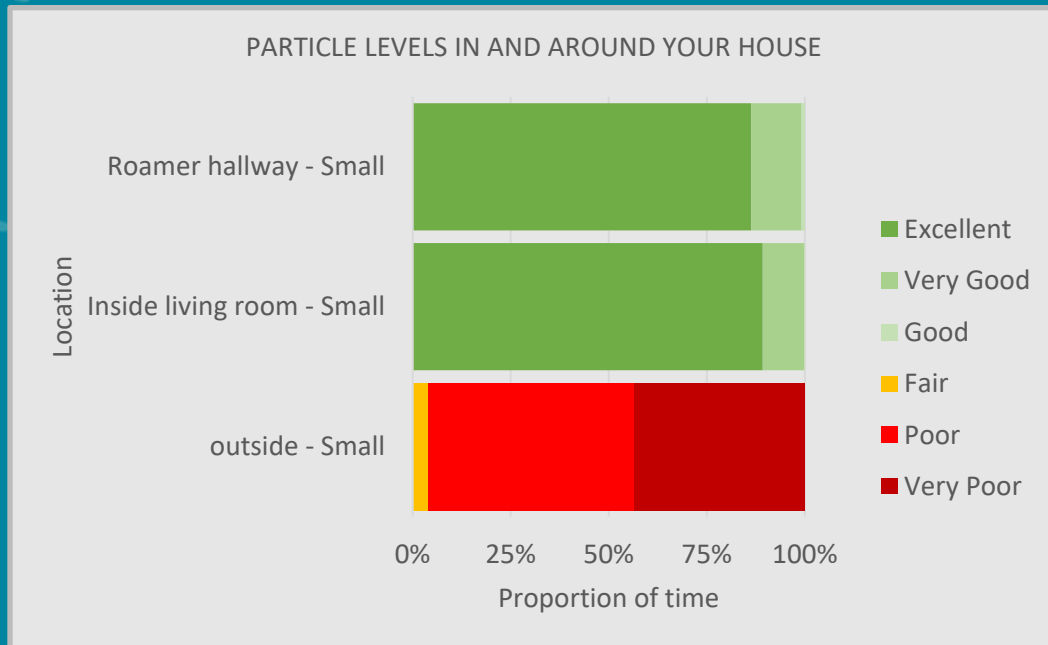
INTERVENTION:

ECM blower (lower air flow & energy cost on continuous setting)

New return (larger 20" x 25" MERV 13 filter & pre-filter)

Cost – labor & materials: \$1,000

RESULTS: Lower CO₂ in bedroom
24/7 annual operating cost: \$131.40



LCMP Top Performer

Air Handler 24/7 – MERV 13 Filter

Indoor tracks outdoor

Indoor uniform – 2 locations

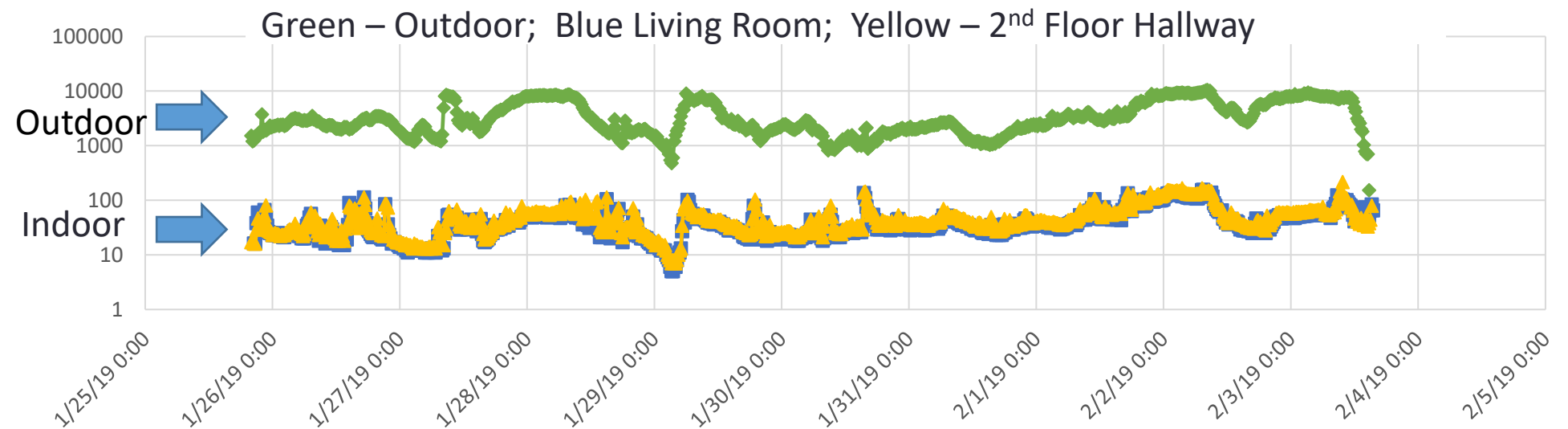
Also – 2nd floor portable air cleaner

Continuous Mode: \$12/month

Post: 110 watts; 500 CFM

(Pre-Post: 400 watt reduction)

Dylos small (0.5+ microns) (#/1/100 ft³)



Filter Essentials

- 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 μm particles (MERV is like R-Value; *performance depends on installation/operation*)
- Adequate run/on time (if system passes diagnostic screening)

Bottom Line – Air Handlers 24/7 w High MERV Filtration

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- NOTE: One-inch pleated filters can be very restrictive

4 Challenges

- 1) **No option for AHU upgrade**
- 2) How to determine optimal fan run-time
- 3) Don't miss the boat – at point of replacement
- 4) Clarify the value proposition

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



EOW August 3, 2022

Fan/Filter Options

20" Box Fan w High MERV Filters

- Use multiple filters for better air flow (2 in V, or 4 in box)



Known as the Corsi-Rosenthal Cube

https://m.box.com/shared_item/https%3A%2F%2Fucdavis.box.com%2Fs%2Fkgo937lk0d02g0k2bxvpxxqbfatd7czu

Image Credit: Comparetto Comfort Solutions

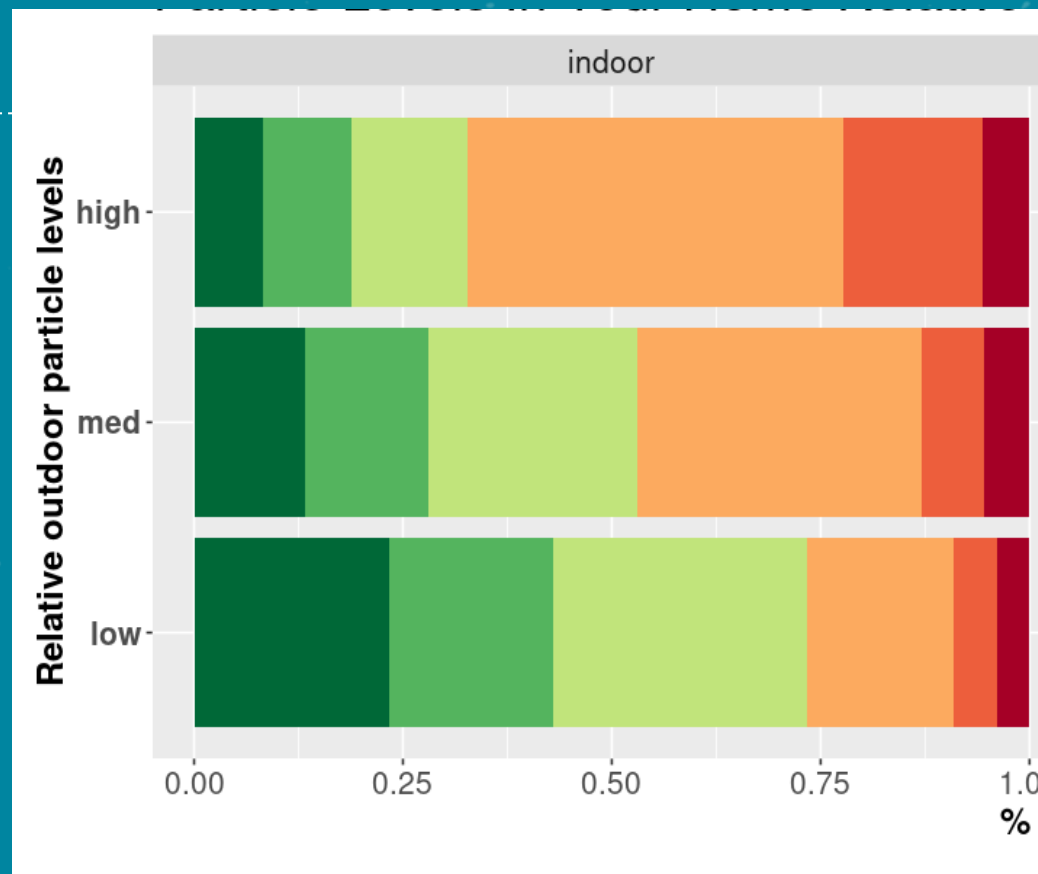
Image Credit: Comparetto Comfort Solutions

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Particle Levels Inside Relative to Outside

Shorter fan run-time
needed when
outdoor air is best



Indoor when Outdoor
air is worst (25%)

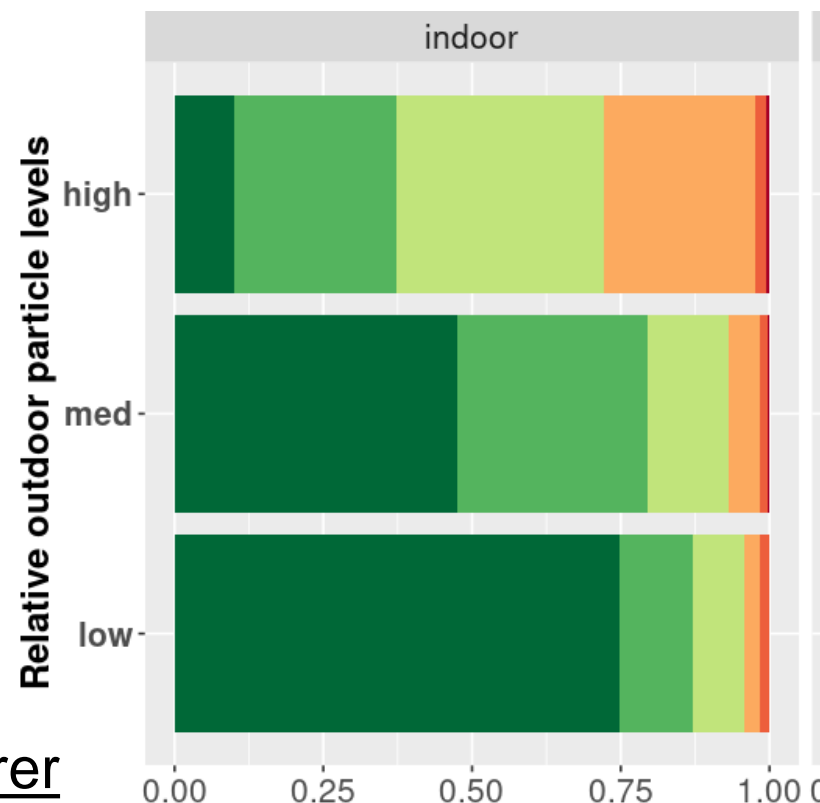
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ROCIS LMCP Data Explorer <http://rocis.org/rocis-data-explorer>

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-

Big Opportunity at HVAC Replacement

- *Downsize HVAC to reduce static pressure!!*
- Incorporate return drop modification & option for larger, deeper filter
- Set blower speeds for optimal performance
- Address duct system shortcomings
- To ponder...
 - Could potential filtration health & comfort benefits add impetus to getting HVAC systems designed & installed correctly?

Performance Tested Comfort Systems (PTCS)

- Great program in the NW that addresses system sizing, air flow, & static pressure:
<https://ptcs.bpa.gov/>

4 Challenges

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Value Proposition

- Longer equipment life; reduce risk of equipment failure
- More resilient if filter is not changed regularly
- Better health for occupants
- Lower peak (kW) & energy (kWh) fan energy use
- Option for better mixing of house air – improved comfort
- Better operation & efficiency in heating & cooling mode & with electrification efforts
- **To ponder...**
 - Could potential filtration, health & comfort benefits add impetus to getting HVAC systems designed & installed correctly?

Implications for:

- Weatherization Assistance Programs?
- Crisis Assistance/Furnace Replacement Programs?
- Affordable Housing?

Thanks!

**Thanks to Phil Johnson & The Heinz Endowments for
support of the ROCIS initiative
(Reducing Outdoor Contaminants in Indoor Spaces)
and our 410+ LCMP participants**



This presentation: <http://rocis.org/past-rocis-events>

Upcoming Cohort (sign up for intro session)

<http://ROCIS.org> (limited slots for out-of-region participants)

Access to resources & research results

- LCMP <http://rocis.org/rocis-low-cost-monitoring-project>
- ROCIS Brief - Ducted Range Hood <http://rocis.org/kitchen-range-hoods>
- Air Handler Inquiry <http://rocis.org/air-handler-inquiry>
- ROCIS Data <http://rocis.org/rocis-data>
- Clairton Air Filter Project
- <http://rocis.org/clairton-air-filter-project>

Stay Tuned!!

- Video Shorts - Telling the Story



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