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**Nasim Ildiri**

PhD Candidate in  
Civil & Environmental Engineering

MS Energy Engineering

BS Aerospace Engineering

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**DISCLAIMER**

- ✓ This presentation is not intended to be a comprehensive program covering all aspects of this topic.
- ✓ All participants are encouraged to read and follow applicable standards, codes and regulations related to this topic.
- ✓ The views and opinions following are the presenter's opinions and not necessarily the official position of the National Air Duct Cleaners Association.

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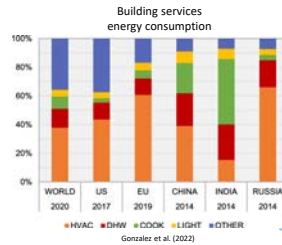
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## MOTIVATION

### ENERGY CONSUMPTION BY HVAC

- Buildings contribute to 1/3 of the world's total energy consumption.
- Buildings account for 1/4 of global CO<sub>2</sub> emissions.
- Commercial and residential buildings are responsible for 40% of the U.S. energy consumption.
- Heating and cooling account for 50% of a typical home's energy usage in the US.
- Electricity demand for cooling is significantly affected by climate and weather.
- Buildings has **high potential** for improving energy efficiency.



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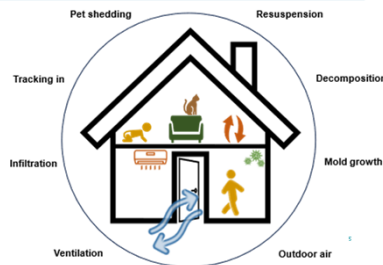
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## MOTIVATION

### HVAC AND INDOOR AIR QUALITY

- People spend approximately 90% of their time in urban dwellers.
- Building environments can have a significant impact on **quality of life**.
- Effects on thermal comfort, respiratory exposures, productivity, cognitive performance
- Sources of PM<sup>\*</sup> and indoor pollutants
- Concentrations of some pollutants are often **2 to 5 times higher** than typical outdoor concentrations.



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## MOTIVATION

### WHY SHOULD NADCA CARE?

**NADCA members are the people to solve this problem!**

- HVAC system moves PM particles and other pollutants around.
- HVAC system becomes a reservoir for pollution.
- HVAC systems spend energy.



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**MOTIVATION**  
RESEARCH HYPOTHESIS

**Primary hypothesis:**

- Cleaned HVAC systems can have a **reduction in energy** consumption compared to their uncleaned counterparts.

**Secondary hypothesis:**

- Cleaned HVAC systems can provide **better indoor air quality** to occupants compared to their uncleaned counterparts.

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**STUDY DESIGN**  
CONTROL VS. INTERVENTION

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**MOTIVATION**  
SENSORS

Energy is consumed in HVAC system by:

- Heating, cooling (heat exchangers, compressor, etc.)
- Ventilation, air filtration, distribution (fans, blowers, etc.)
- Auxiliary components (chillers, boilers, etc.)

The new generation of sensors provide us with:

- Real-time visibility
- Reliable, practical, affordable data

*"You can't manage what you don't measure."*

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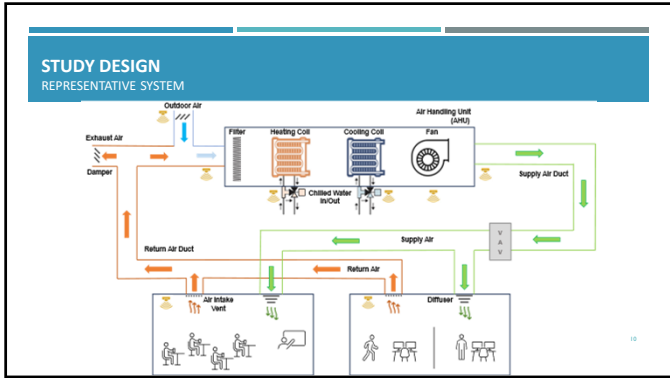
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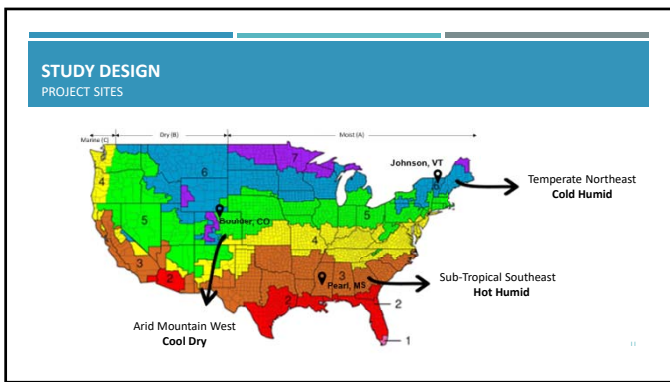
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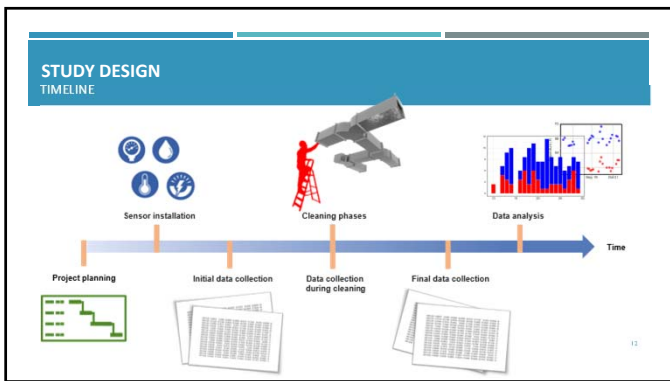
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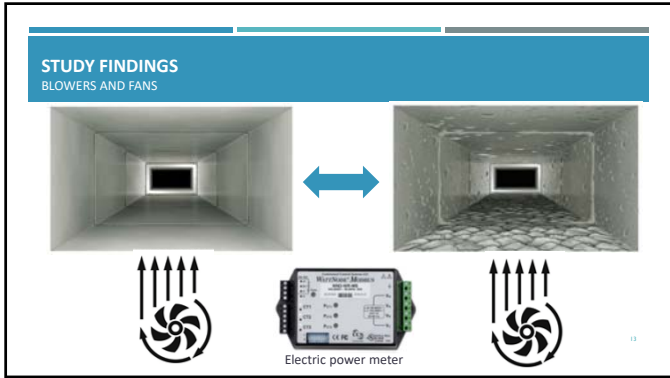
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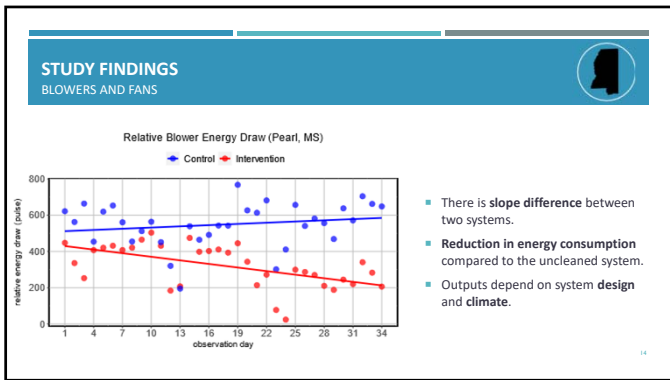
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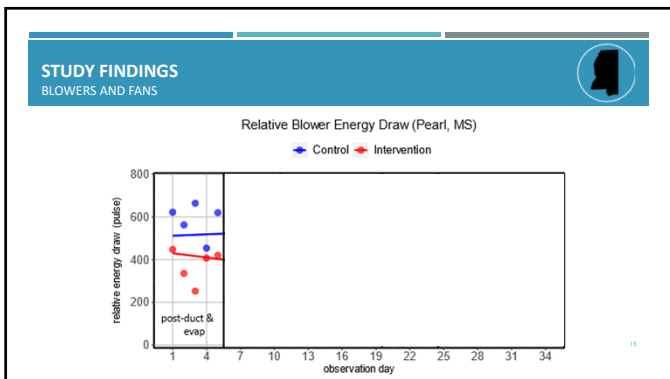
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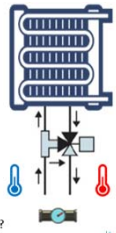
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### STUDY FINDINGS

#### COOLING ENERGY

Energy = mass flow rate × specific heat × temperature difference



The associated cooling/heating energy is proportional with:

- How much **water flow** through the coil tubes?
- How much **temperature increases/decreases** when water passes through the coil tubes?

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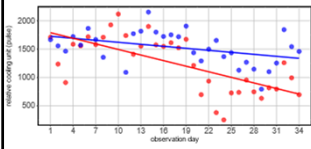
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### STUDY FINDINGS

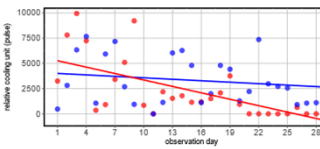
#### COOLING ENERGY



Relative Cooling Energy Draw (Pearl, MS)



Relative Cooling Energy Draw (Johnson, VT)  
Backup Compressor



- Energy consumed by **chilled water or compressor**.
- Energy savings were evident in the cleaned systems in **every scenario**.
- Energy-saving patterns can also be observed in the **backup equipment**.

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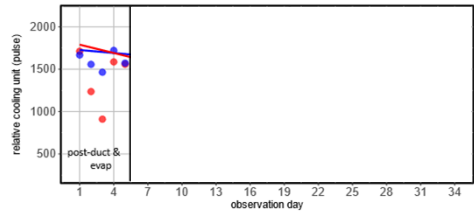
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### STUDY FINDINGS

#### COOLING ENERGY



Relative Cooling Energy Draw (Pearl, MS)



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### STUDY FINDINGS

#### DIFFERENTIAL PRESSURE

Return Duct Pressure

Filter Pressure Drop (Subtracted)

Total External Static Pressure

Coil Pressure Drop (Subtracted)

Supply Duct Pressure

Differential pressure

Source: The Air Conditioning, Heating and Refrigeration NEWS

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### STUDY FINDINGS

#### DIFFERENTIAL PRESSURE

Differential Pressure (Pearl, MS)

Control Intervention

differential pressure (Pa)

observation day

- Starting points are relatively similar in control and intervention.
- A reduction in differential pressure in cleaned systems compared to the uncleaned one.
- More flow resistance in the dirty systems.
- More fan energy and potential air leakage in dirty systems.

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### STUDY FINDINGS

#### AIR FLOW THROUGH DUCTS

Air flow meter

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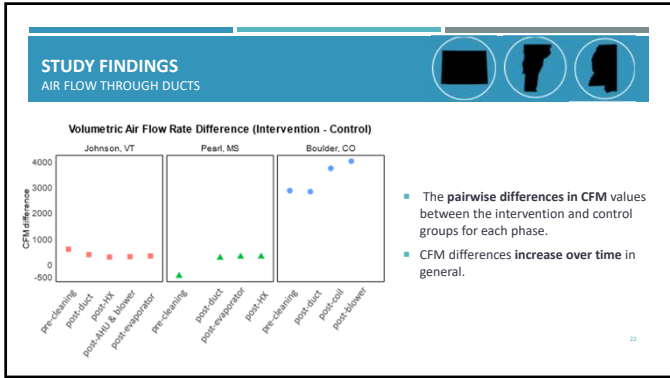
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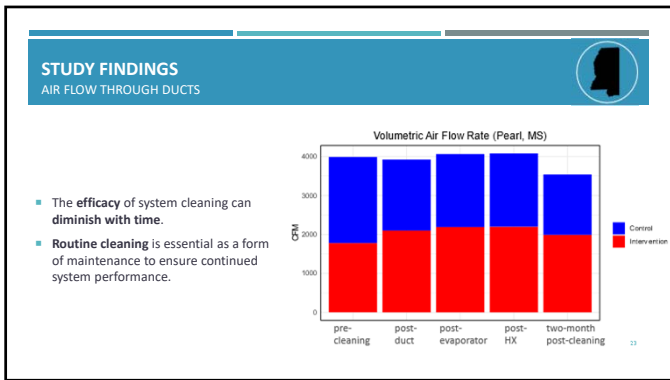
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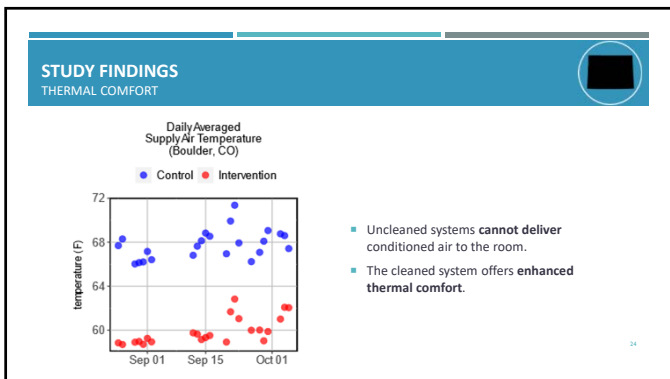
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**ADDITIONAL STUDY FINDINGS**  
SURPRISING DISCOVERIES

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**ADDITIONAL STUDY FINDINGS**  
EQUIPMENT START-UPS

Backup Compressor Start-Ups (Johnson, VT)

Observation Day	Control (Blue)	Intervention (Red)
10	0	1
11	3	3
12	6	3
13	9	3
14	10	2
15	4	5
16	4	5
17	4	5
18	5	5
19	6	5
20	6	5
21	6	5
22	6	5
23	6	5
24	6	5
25	6	5
26	6	5
27	6	5
28	6	5
29	6	5
30	6	5

- Dominant color: Blue (control)
- Reduced startup frequency for backup equipment
- Increased equipment lifetime and lower maintenance costs

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**ADDITIONAL STUDY FINDINGS**  
VAV SYSTEM

- Variable Air Volume (VAV)
- Type of ventilation system
- Supply air temperature is constant.
- Supply air volume can be varied.
- Different zones can operate at different temperatures depending on the load.

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**ADDITIONAL STUDY FINDINGS**  
SYSTEM STABILITY

- Reduced variations in differential pressure (supply-return) can contribute to **system stability and durability**.
- This can lead to **decreased maintenance** requirements and other benefits.

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**ADDITIONAL STUDY FINDINGS**  
ADDITIONAL ENERGY SAVINGS

- The energy-saving benefits of cleaning are evident **during non-occupied hours**.
- Some equipment continues to operate outside of business hours.
- The differences in slope between cleaned and uncleaned HVAC systems become **more apparent**.

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**ONGOING WORK**  
NEW CLIMATE

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**ONGOING WORK**  
NEW CLIMATE

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**CLOSING NOTES**

- HVAC cleaning can **reduce** system energy consumption.
- HVAC cleaning can **reduce** maintenance costs and **increase** equipment lifetime.
- HVAC cleaning can **improve** indoor air quality, TOMORROW!

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**ACKNOWLEDGEMENTS**

- Scientific Advisor: Mark Hernandez, PE, PhD
- NADCA (leadership, members, scientific committee)
- Cleaning Contractors
- Facility Managers

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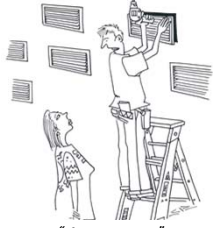
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Questions?



*"I'm venting."*

Source: CartoonStock.com

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**PRESENTER CONTACT INFORMATION**

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**Thank You**  
for participating!

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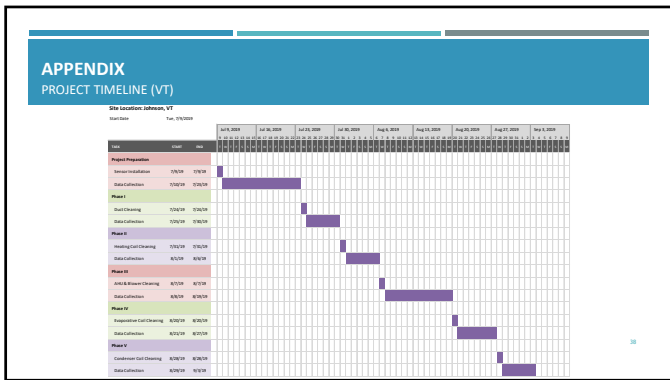
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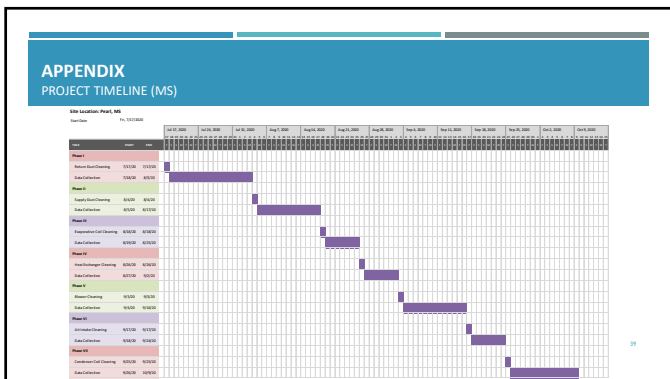
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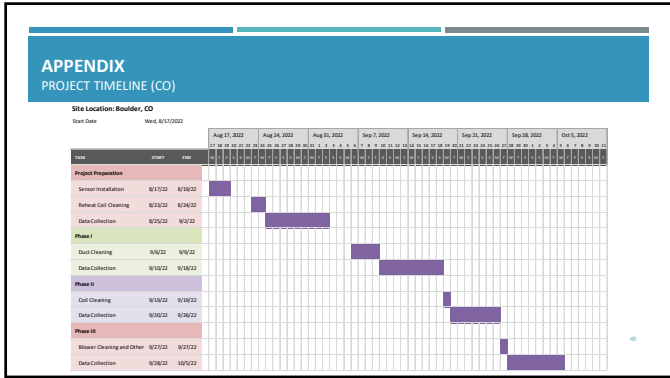
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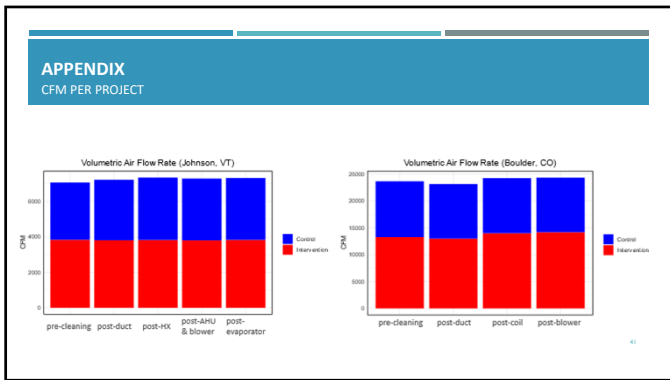
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