



STATE OF RHODE ISLAND

**ENERGY EFFICIENCY &
RESOURCE MANAGEMENT COUNCIL**

CONSULTANT TEAM

Deep Dive: HVAC Market Transformation

Presented By: EERMC Consultant Team

Date: November 8, 2021





Presentation Outline

This presentation will discuss the challenges and opportunities of transforming the HVAC Market

Key questions that will be explored

- What do we need from an HVAC system?
- What does a transformed market look like?
- What are challenges to transforming the market?
- What are some of the solutions?

Keep in mind the questions below as we go through this presentation. We'll be coming back to these at the conclusion!

Questions for you to consider:

- How does this information relate to:
 - Your role as a Councilor?
 - Your work professionally?
 - Your personal life?
- What is something you learned today?
- Is there something you were hoping to learn that we didn't talk about?



Question 1

- What do we need from an HVAC system?
- What does a transformed market look like?
- What are challenges to transforming the market?
- What are some of the solutions?



What Do We Need From an HVAC System?

Space Conditioning – provide a comfortable space to work, learn, live, and do business

Indoor Environmental Quality – provide a safe, clean, and healthy indoor environment for occupants

Cost Competitive Operation – deliver space conditioning and indoor air quality at a reasonable cost



Space Conditioning

Being a cold climate, New England's dominant space conditioning needs are heating

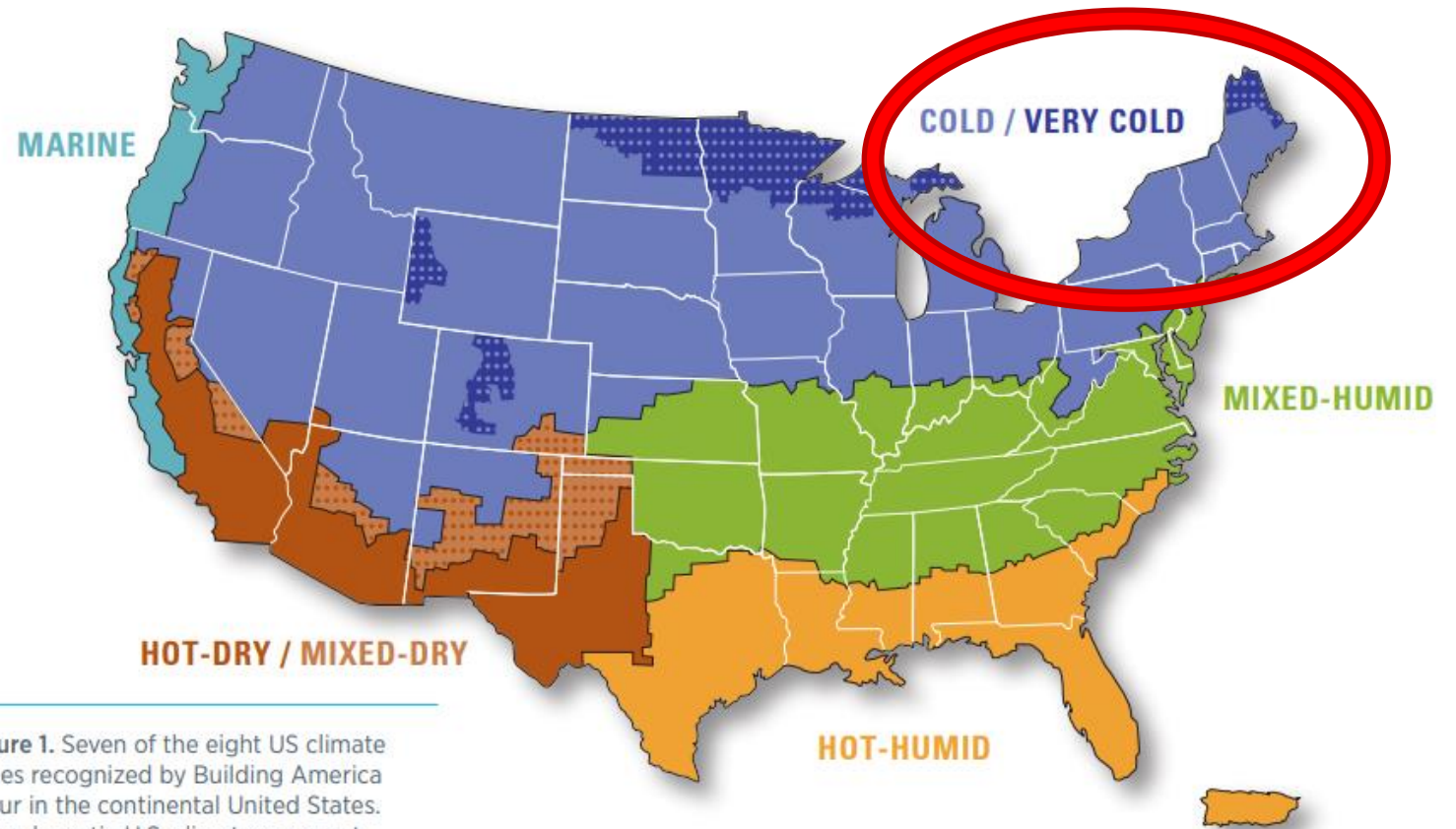


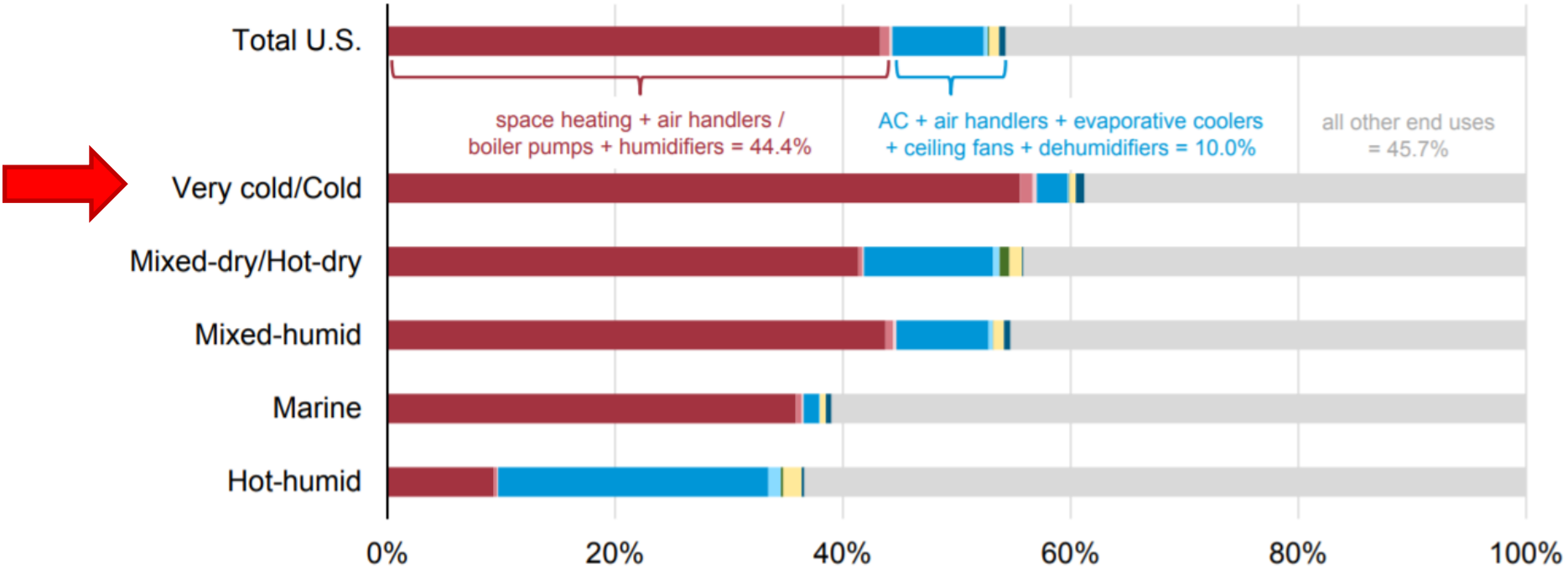
Figure 1. Seven of the eight US climate zones recognized by Building America occur in the continental United States. The sub-arctic U.S. climate zone, not shown on the map, appears only in Alaska.



Space Conditioning

Being a cold climate, New England's dominant space conditioning needs are heating

Share of home energy use, 2015





Indoor Environmental Quality

Provide fresh outdoor air and exhaust stale indoor air

- Prescribed volume of fresh outdoor air and/or allowable level of CO₂ based on occupancy, size and use of space
- Code Requirements = ASHRAE 62.1 (C&I), ASHRAE 62.2 (Res)

**Mechanical
Ventilation**



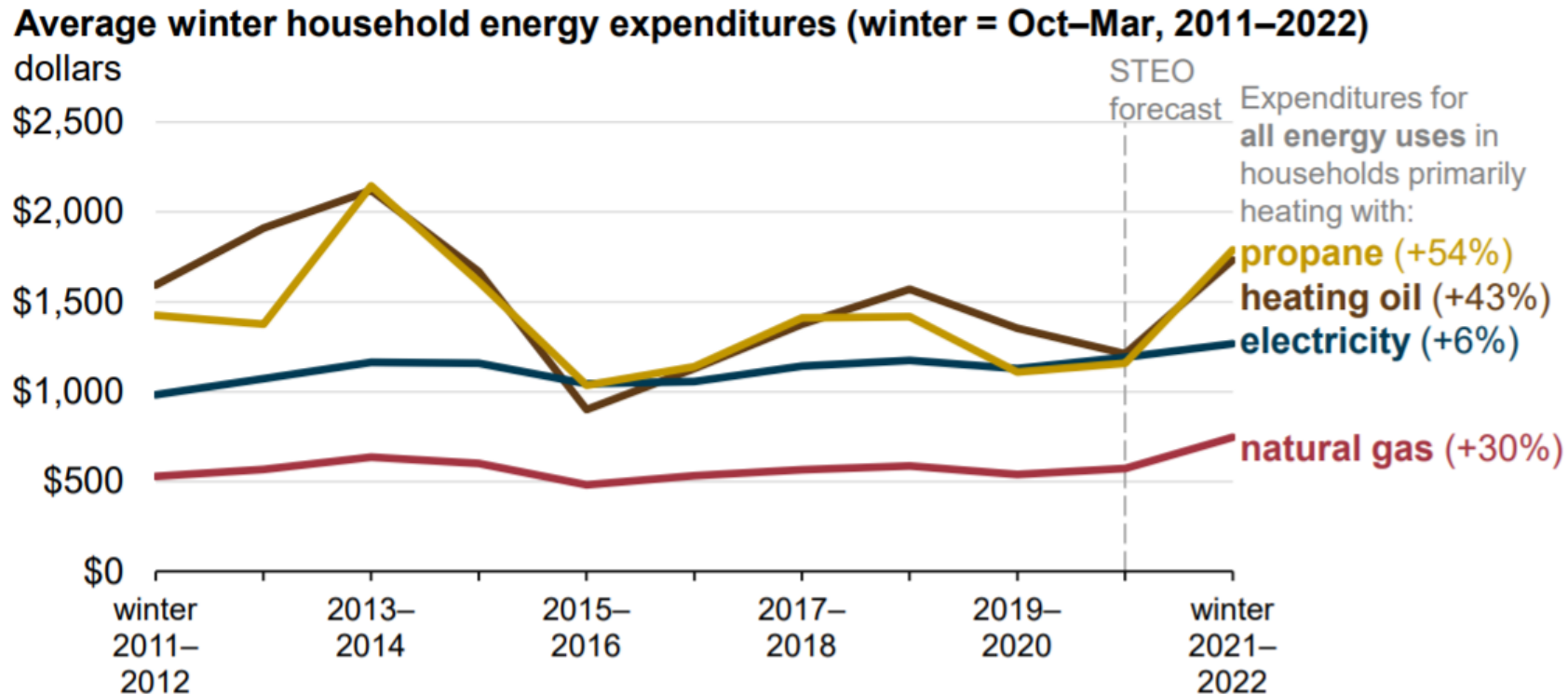
**Natural
Ventilation**





Cost Competitive

All heating fuel prices expected to increase this winter, especially for delivered fuels



EIA 2021 Winter Fuel Outlook: https://www.eia.gov/outlooks/steo/special/winter/2021_Winter_Fuels.pdf



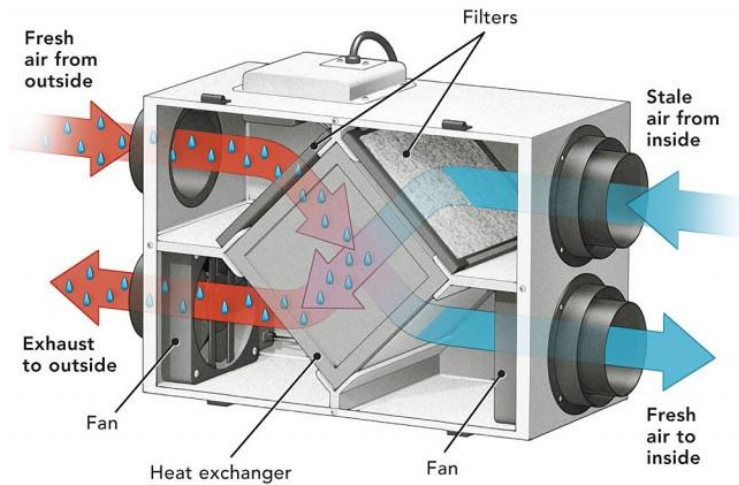
Question 2

- What do we need from an HVAC system?
- What does a transformed market look like?**
- What are challenges to transforming the market?
- What are some of the solutions?

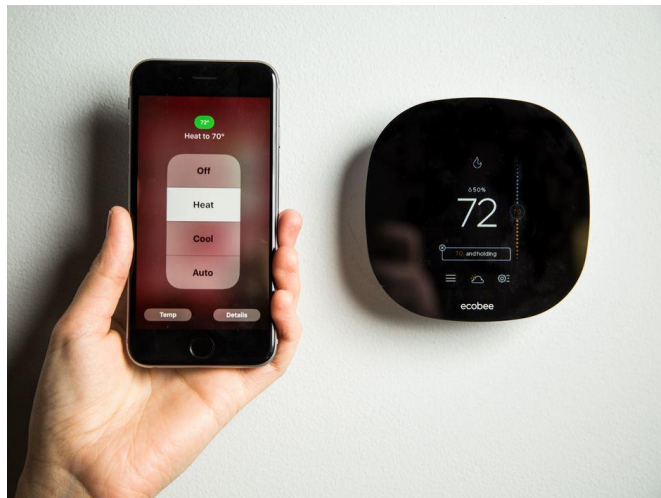


What Does a Transformed Market Look Like?

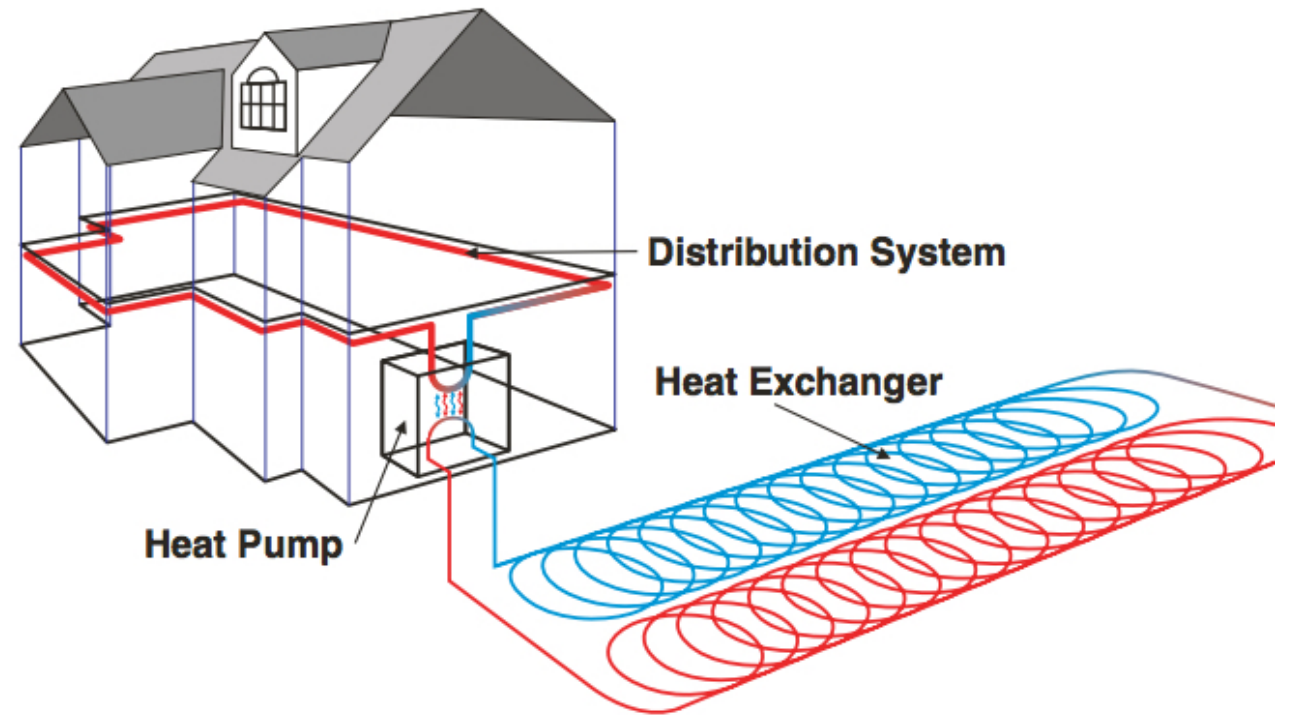
Energy Recovery Ventilation



Smart Controls



High-Efficiency Distribution Medium

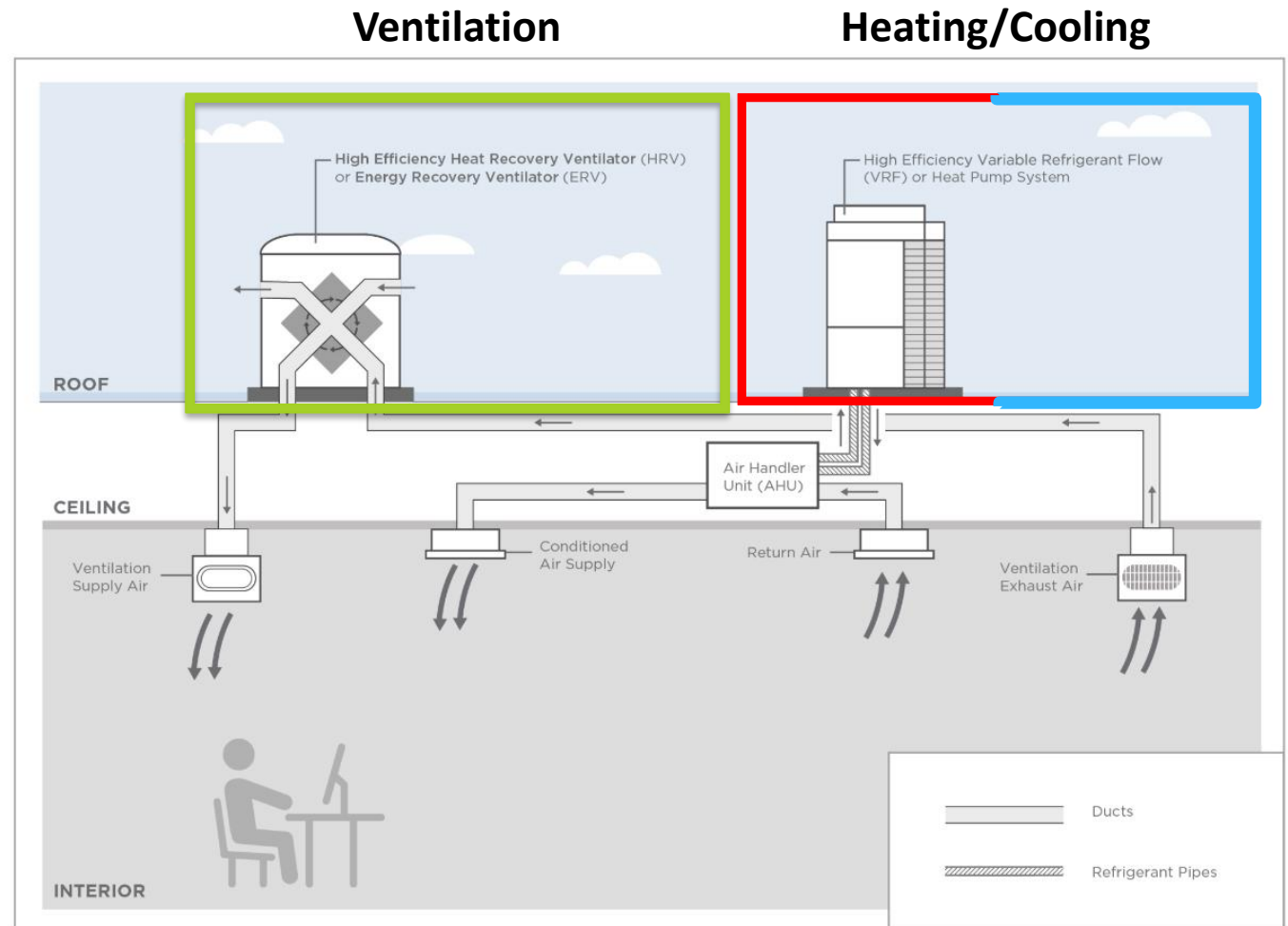




What Does a Transformed Market Look Like?

Example Components

- Highly efficient heating/cooling
- Good indoor environmental quality with adequate air exchange and energy – recovery ventilation
- Comfortable occupants
- Low or no carbon emissions
- Cost competitive



Source: https://betterbricks.com/uploads/resources/VHE-DOAS_SummaryReport.pdf



Question 3

- What do we need from an HVAC system?
- What does a transformed market look like?
- What are challenges to transforming the market?**
- What are some of the solutions?



What Are Challenges to Transforming the Market?

Existing/Legacy Infrastructure

Building Envelopes

Operations & Controls

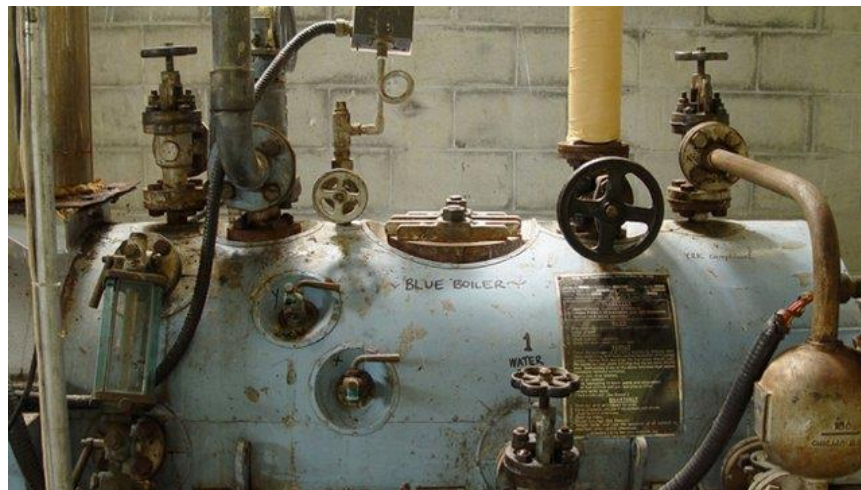
Customer Economics & Climate Goals



Existing/Legacy Infrastructure

Legacy equipment and existing infrastructure make modernizing HVAC systems difficult

- Like-for-like replacements are common
- Overhauling central plant and distribution system is complex and expensive



Most older systems are unable to meet current code minimum outdoor air requirements



Building Envelopes

Leaky windows and walls mean much of the energy consumed to condition a building is wasted

However, older buildings rely on leakiness to meet minimum ventilation





Building Envelopes

Improving insulation without addressing ventilation leads to poor indoor air quality

Indoor CO2 Levels and Associated Health Impacts

250-400ppm	Normal background concentration in outdoor ambient air
400-1,000ppm	Concentrations typical of occupied indoor spaces with good air exchange
1,000-2,000ppm	Complaints of drowsiness and poor air.
2,000-5,000 ppm	Headaches, sleepiness and stagnant, stale, stuffy air. Poor concentration, loss of attention, increased heart rate and slight nausea may also be present.
5,000	Workplace exposure limit (as 8-hour TWA) in most jurisdictions.
>40,000 ppm	Exposure may lead to serious oxygen deprivation resulting in permanent brain damage, coma, even death.



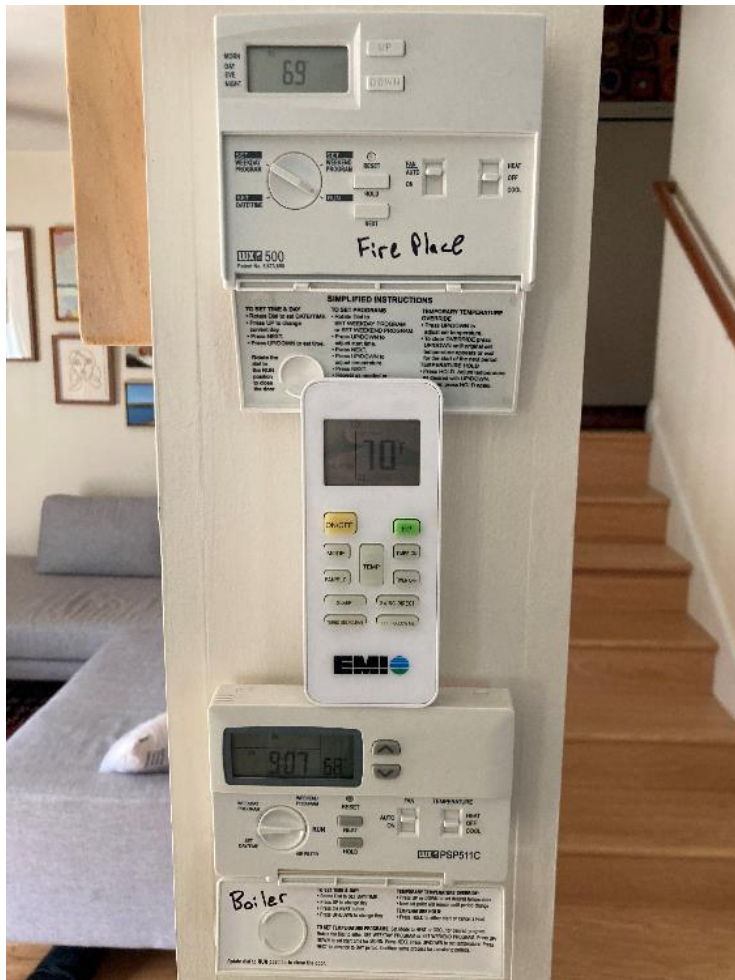
2020 Construction with Energy Recovery Ventilator



2008 Construction with Natural Ventilation



Operations and Control



Controlling legacy systems in concert with new systems is complicated

Optimizing systems for cost and GHG emissions is a moving target

All of this is part of the messy transition to a “transformed market”



Operations and Control

Legacy pneumatic (pressure-based) controls

Unitary controls or thermostats with no overarching system

Modern controls create more data → useful, but can be overwhelming



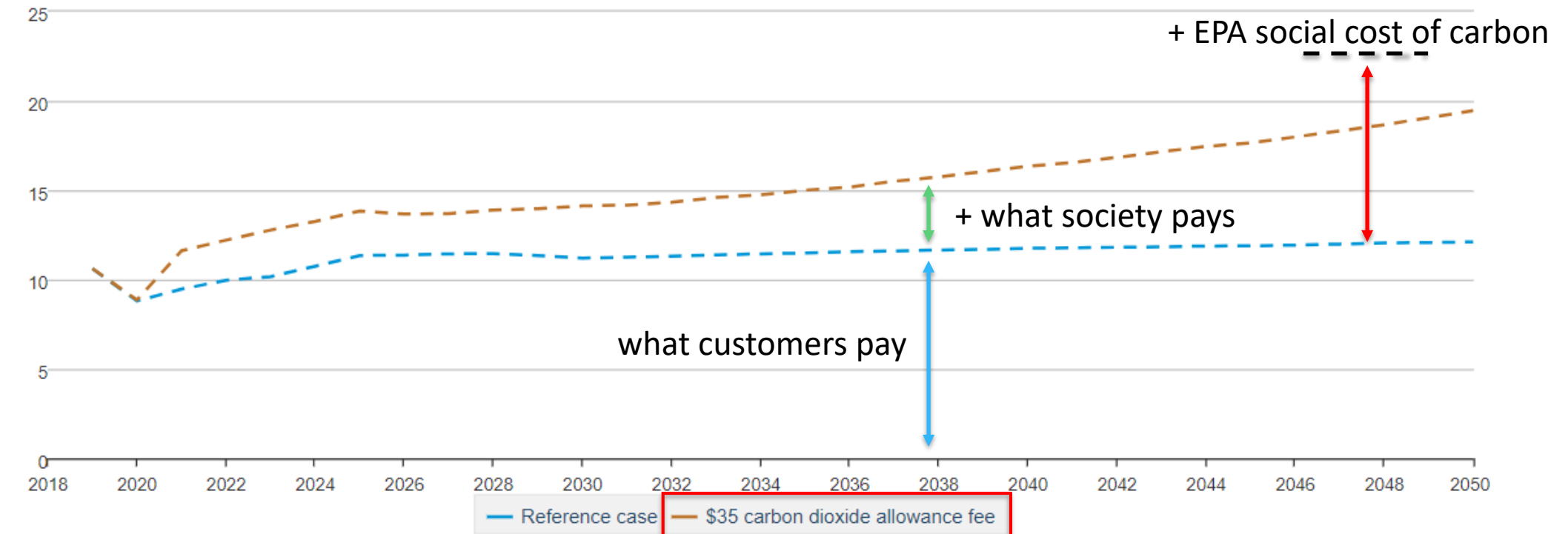


Customer Economics and Climate Goals

Energy prices ignore un-priced “externalities”

Natural Gas Delivered: Commercial: New England

2019 \$/Mcf



Source: U.S. Energy Information Administration

Source: <https://www.eia.gov/outlooks/aeo/>



Question 4

- What do we need from an HVAC system?
- What does a transformed market look like?
- What are challenges to transforming the market?
- What are some of the solutions?



What Are Some of the Solutions?

Controls upgrades/optimization and commissioning

Weatherization (with ventilation improvements!)

Vendor and customer training

Financing and making the business case



Controls Upgrades and Integration (Res)



Windows Central



Save energy and money, improve comfort, and make your home better with these energy savings offers for residential electric customers.

- Central Heat Pumps
- Mini-Split Heat Pumps
- **Integrated Controls**

These offers are co-funded by the Rhode Island Office of Energy Resources with proceeds from the Regional Greenhouse Gas Initiative and by National Grid.



Controls Upgrades and Integration (C&I)

Upgrading old pneumatics to direct digital control (DDC) allows for modern sequence of operations

ASHRAE Guideline 36 sets standards for High-Performance Sequences of Operation for HVAC Systems

- Meeting space conditioning and indoor environmental quality performance requirements for the lowest energy input
- Real-time fault detection and diagnostics



ASHRAE Addendum u to
ASHRAE Guideline 36-2018

High Performance Sequences of Operation for HVAC Systems

Approved by ASHRAE on March 30, 2021.

This addendum was approved by a Standing Guideline Project Committee (SGPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the guideline. Instructions for how to submit a change can be found on the ASHRAE® website (<https://www.ashrae.org/continuous-maintenance>).

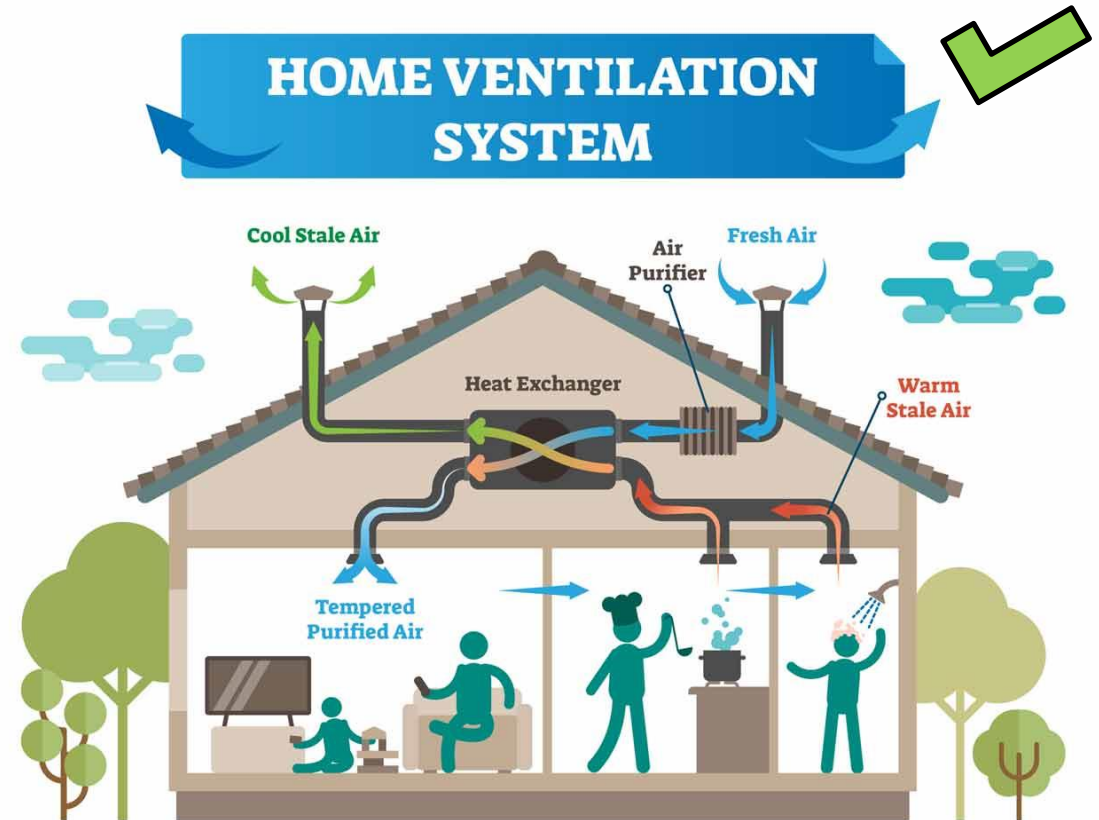
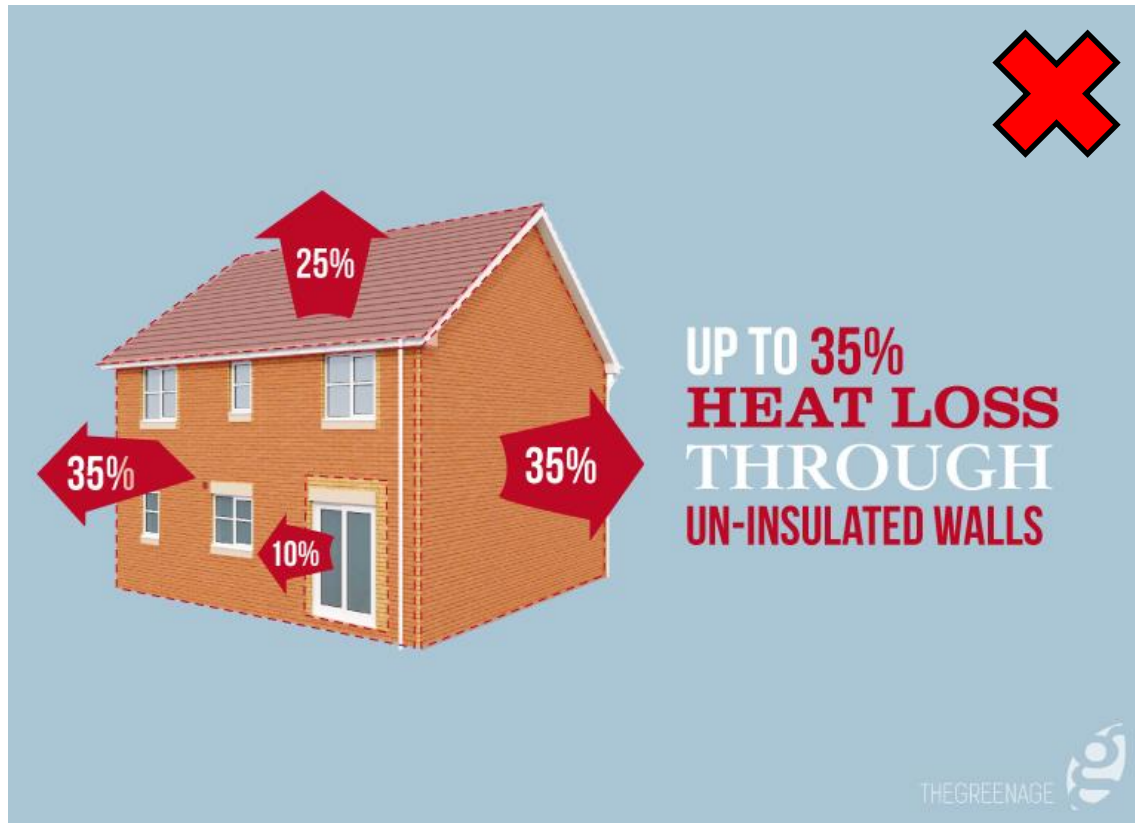
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Weatherization and Ventilation

Air exchange is a good thing, but needs to be intentional





Vendor and Customer Training

“

If a building's systems are improperly installed, commissioned, or maintained, the building will not function as intended, not only hindering its energy and indoor environmental performance but also dissuading customers from future investments in energy efficiency technologies, thereby slowing their adoption.

”

From: <https://www.aceee.org/research-report/b2003>





Financing and Making the Business Case

Financings especially important for customers motivated by first cost or with shorter term financial decision making



Small Business Customers



Tenant/Landlord Split Incentives



Developers Who Build and Flip Buildings



Homeowners Buying Starter Homes

Contractors need to make the business case based on the full value stack



Energy Savings



Health/Comfort Improvements



Environmental Stewardship

Bottom Line: HVAC projects are not lighting projects



More Capital Intensive



More Complex



Longer Simple Payback

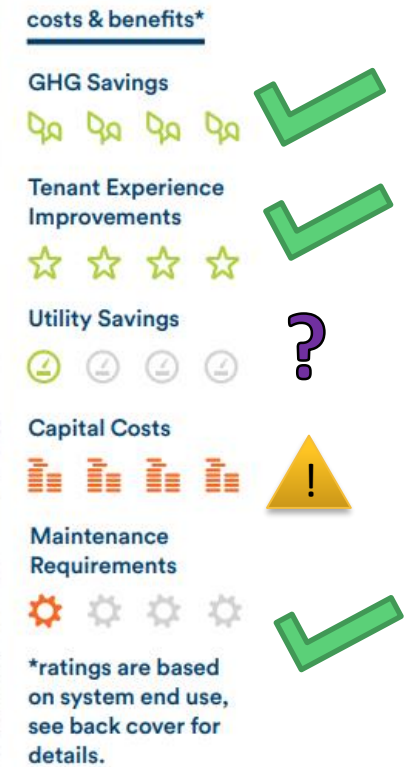


Bringing It All Together

Example: Retrofit NY

NYC Retrofit
Accelerator: VRF +
DOAS with HRV

Not a silver bullet,
but this is where
the market is
heading



Source: https://be-exchange.org/wp-content/uploads/2019/06/HPRT_techprimer_DOAS_.pdf



Key Takeaways

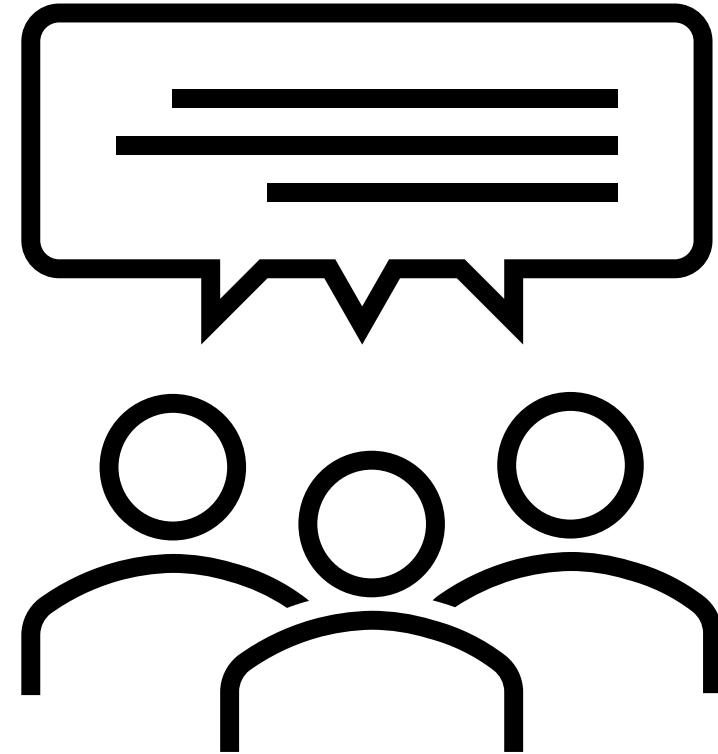
- What do we need from an HVAC system?**
 - Space conditioning and good indoor air quality at a competitive price
- What does a transformed market look like?**
 - A comfortable, healthy, low-carbon built environment
- What are challenges to transforming the market?**
 - Legacy infrastructure, external environmental costs, customer/contractor understanding of new technology
- What are some of the solutions?**
 - Controls, better building envelopes, customer/contractor training and a more wholistic view of costs/benefits of HVAC system modernization



Council Member Discussion

Questions for you to consider:

- How does this information relate to:
 - Your role as a Councilor?
 - Your work professionally?
 - Your personal life?
- What is something you learned today?
- Is there something you were hoping to learn that we didn't talk about?





Appendix





Additional Resources

[Institute for Market Transformation: Very High Efficiency HVAC \(video\)](#)

[Lawrence Berkeley National Laboratory Indoor Air Quality \(research\)](#)

[Efficiency Vermont A guide to home heating systems \(blog\)](#)

[Northwest Energy Efficiency Alliance: Commercial High Performance HVAC Market Characterization \(report\)](#)

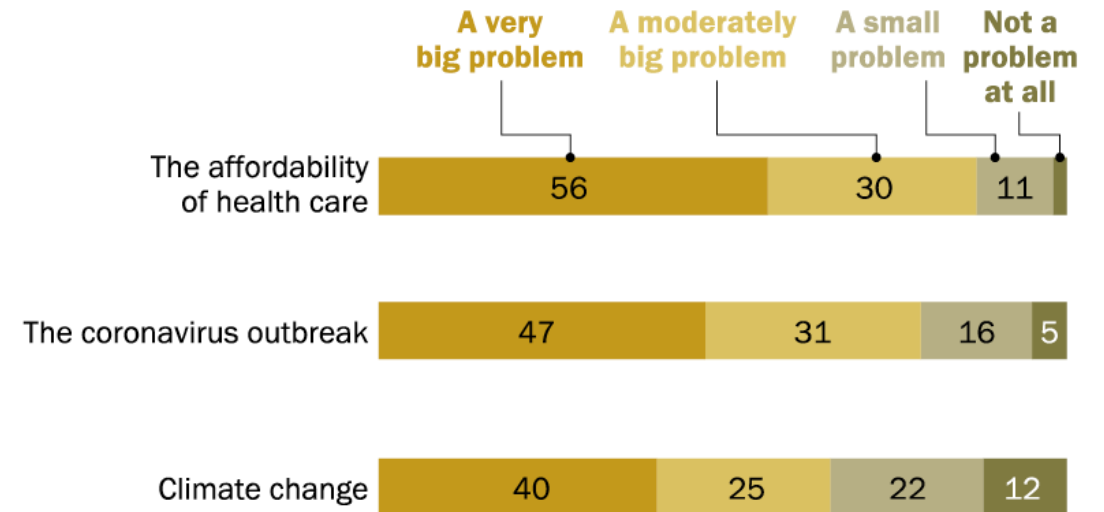


Weatherization and Ventilation

Not everyone can be motivated by climate change, but people really care about their health!

A majority of Americans say the affordability of health care is a very big problem in the country today

% who say each of the following is ___ in the country today



Note: No answer responses not shown.
Source: Survey of U.S. adults conducted April 5-11, 2021.

PEW RESEARCH CENTER



Weatherization and Ventilation

Excellent webinar from 2020 for anyone who did not join.

Energy Efficiency, Human Health, and COVID 19 -

<https://www.youtube.com/watch?v=wAc4xLZhX4E>

THE UNIVERSITY OF RHODE ISLAND COOPERATIVE EXTENSION

PLUGGED INTO ENERGY RESEARCH LECTURE SERIES

The COVID-19 pandemic has highlighted the links between health and the built environment. Adequate ventilation is essential to reducing transmission of the COVID-19 virus [Dai, H., Zhao, B. (2020)] and people living without proper ventilation may be at an increased risk of exposure.

Is energy efficiency an effective solution to increasing health and safety in buildings, and reducing exposure to COVID-19? Join us for this important conversation featuring experts from around the United States.

-  LECTURE 1 - TUESDAY, OCTOBER 7, 2020 @ 6:30 P.M.
ENERGY EFFICIENCY, HUMAN HEALTH, AND COVID-19
-  LECTURE 2 - WEDNESDAY, OCTOBER 28, 2020 @ 6:30 P.M.
ENERGY EFFICIENCY IN SCHOOLS: SAFER BUILDINGS, HEALTHIER STUDENTS
-  LECTURE 3 - NOVEMBER 18, 2020 @ 6:30 P.M.
BARRIERS TO ENERGY EFFICIENCY IN RENTAL AND AFFORDABLE HOUSING

Registration required. For more information and registration please visit web.uri.edu/coopext/plugged-into-energy-research-lecture-series/
Have questions? Please contact Kate Venturini at kate@uri.edu.



Weatherization and Ventilation

Ventilation is a health and productivity benefit

- Study simply assumes increased ventilation, not optimized ventilation

Association of classroom ventilation with reduced illness absence:
a prospective study in California elementary schools

$$\frac{\text{Health Benefits}}{\text{Energy Costs}} = \frac{\$33 \text{ million}}{\$4 \text{ million}} = 8.25 \text{ BCR}$$

Abstract Limited evidence associates inadequate classroom ventilation rates (VRs) with increased illness absence (IA). We investigated relationships between VRs and IA in California elementary schools over two school years in 162 3rd–5th-grade classrooms in 28 schools in three school districts: South Coast (SC), Bay Area (BA), and Central Valley (CV). We estimated relationships between daily IA and VR (estimated from two year daily real-time carbon dioxide in each classroom) in zero-inflated negative binomial models. We also compared IA benefits and energy costs of increased VRs. All school districts had median VRs below the 7.1 l/s-person California standard. For each additional 1 l/s-person of VR, IA was reduced significantly ($p < 0.05$) in models for combined districts (–1.6%) and for SC (–1.2%), and nonsignificantly for districts providing less data: BA (–1.5%) and CV (–1.0%). Assuming associations were causal and generalizable, increasing classroom VRs from the California average (4 l/s-person) to the State standard would decrease IA by 3.4%, increase attendance-linked funding to schools by \$33 million annually, and increase costs by only \$4 million. Further increasing VRs would provide additional benefits. These findings, while requiring confirmation, suggest that increasing classroom VRs above the State standard would substantially decrease illness absence and produce economic benefits.

**M. J. Mendell, E. A. Eliseeva,
M. M. Davies, M. Spears,
A. Lobscheid, W. J. Fisk,
M. G. Apte**

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Key words: Carbon dioxide; Indoor environmental
quality; Schools; Ventilation; Illness absence.

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- When paired with weatherization, it can also be an energy efficiency benefit