Improving Indoor Air Quality Through Better Buildings

3C-REN Spring/Summer Regional Forum

June 15, 2021

Welcome and Introduction

Mindy Craig, BluePoint Planning

Zoom Orientation

- Please “**Mute**" yourself upon joining.
- Under "**Reactions**" select "**Raise Hand**" to ask a question or comment verbally.
- Use the "**Chat**" to share questions.
- Breakout rooms will be used today.

Mute Video Chat Reactions

3C-REN Staff Online

Today's Learning Objectives

- **Explore** the relationship between energy efficiency, improved indoor air quality (IAQ), and occupant health.
- **Investigate** the causes of indoor air pollution and technology used to improve IAQ.
- **Identify** opportunities for installers to market better building upgrades and ventilation.
- **Connect** with industry professionals supporting the improvement of energy efficiency and IAQ.
- **Apply** practical energy code knowledge in the field.

Agenda

- Introductions and Meeting Orientation
- Context Setting: Sara Hayes
- Breakout: Perceptions vs Reality
- Is your house making you sick?: Joe Medosch
- Break
- IAQ Measures and Energy Code Compliance: Judy Rachel
- Equity and Health-Focused Indoor Air Quality in Practice: Brett Bishop and Cindy Edwards
- Funding, Resources, and Training: 3C-REN
- Meeting Wrap: Ian Logan, 3C-REN
- Speaker Meet and Greet

Presenters

Brett Bishop

Director of Contract Services, Franklin Energy

Cindy Edwards

Founder & President, Efficiency First Solutions; Founder, CK Builders

Sara Hayes

Director of Health and Environment, American Council for an Energy Efficient Economy

Presenters

Joe Medosch

Healthy Building Scientist; Director of Partner Development, Hayward Score

Judy Rachel

Home Performance Specialist & Technical Consultant

Sara Hayes

American Council for an Energy Efficient Economy

Energy Efficiency can Protect Californians from the Health Threats of Climate Change

Improving Indoor Air Quality through Better Buildings
3C-REN

Sara Hayes, Director of Health and Environment

Tuesday, June 15, 2021

ACEEE
American Council for an Energy-Efficient Economy

The American Council for an Energy-Efficient Economy is a nonprofit 501(c)(3) founded in 1980. We act as a catalyst to advance energy efficiency policies, programs, technologies, investments, & behaviors.

Our research explores economic impacts, financing options, behavior changes, program design, and utility planning, as well as US national, state, & local policy.

Our work is made possible by foundation funding, contracts, government grants, and conference revenue.

aceee.org @ACEEEdc

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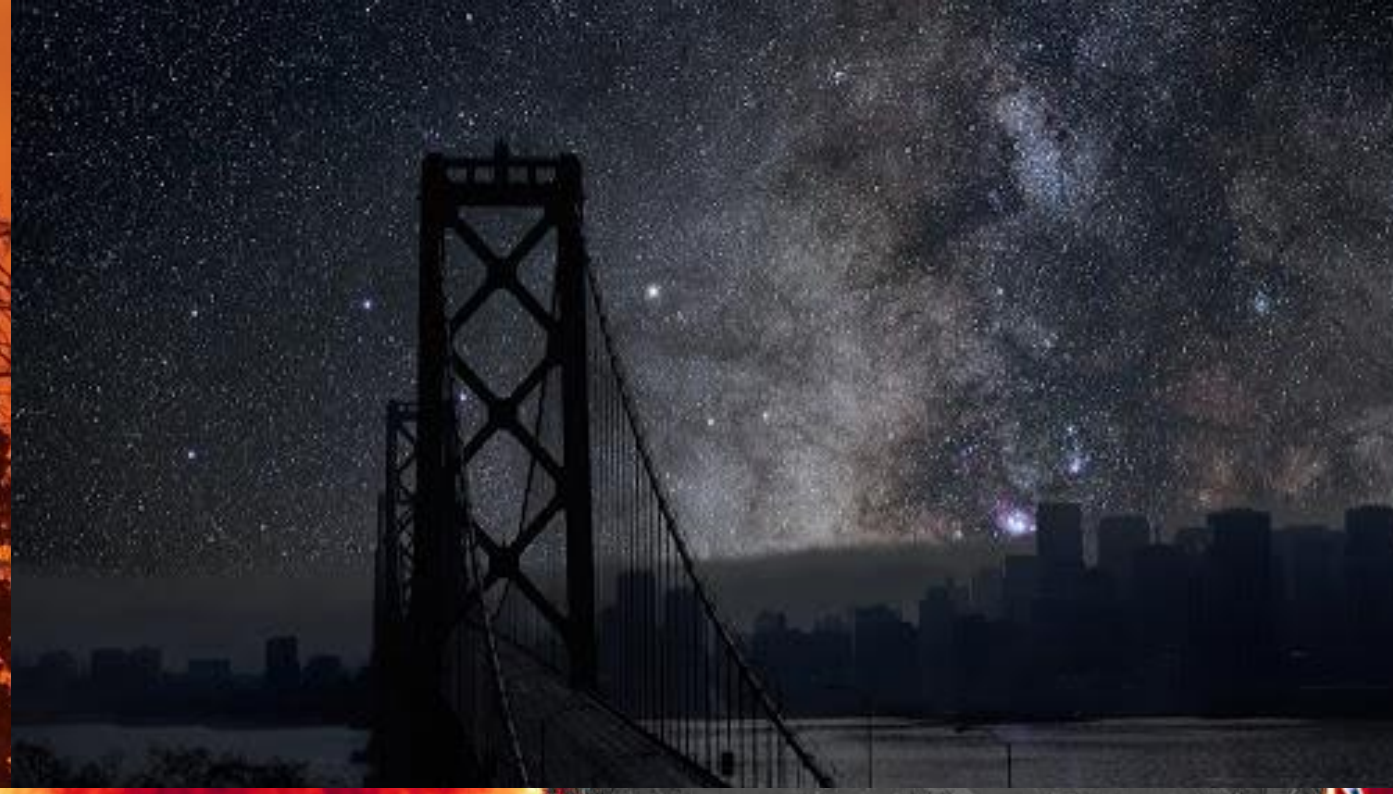
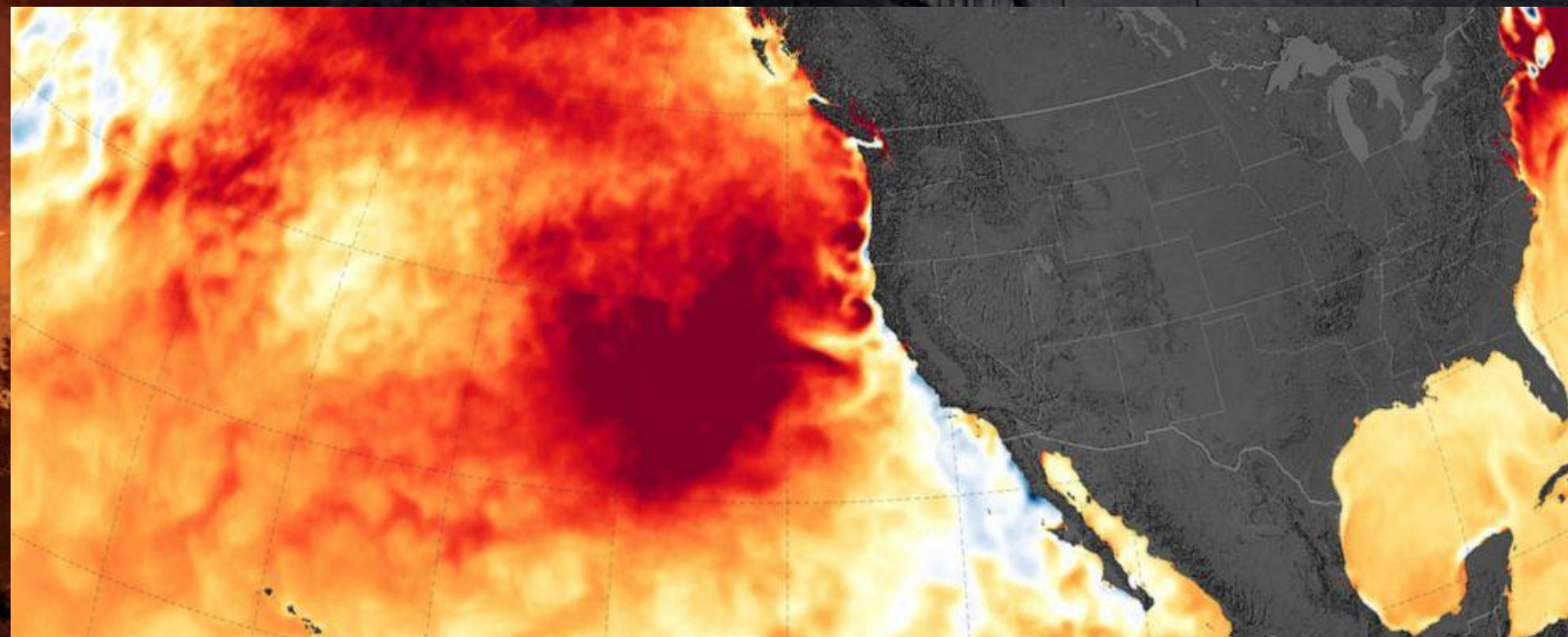


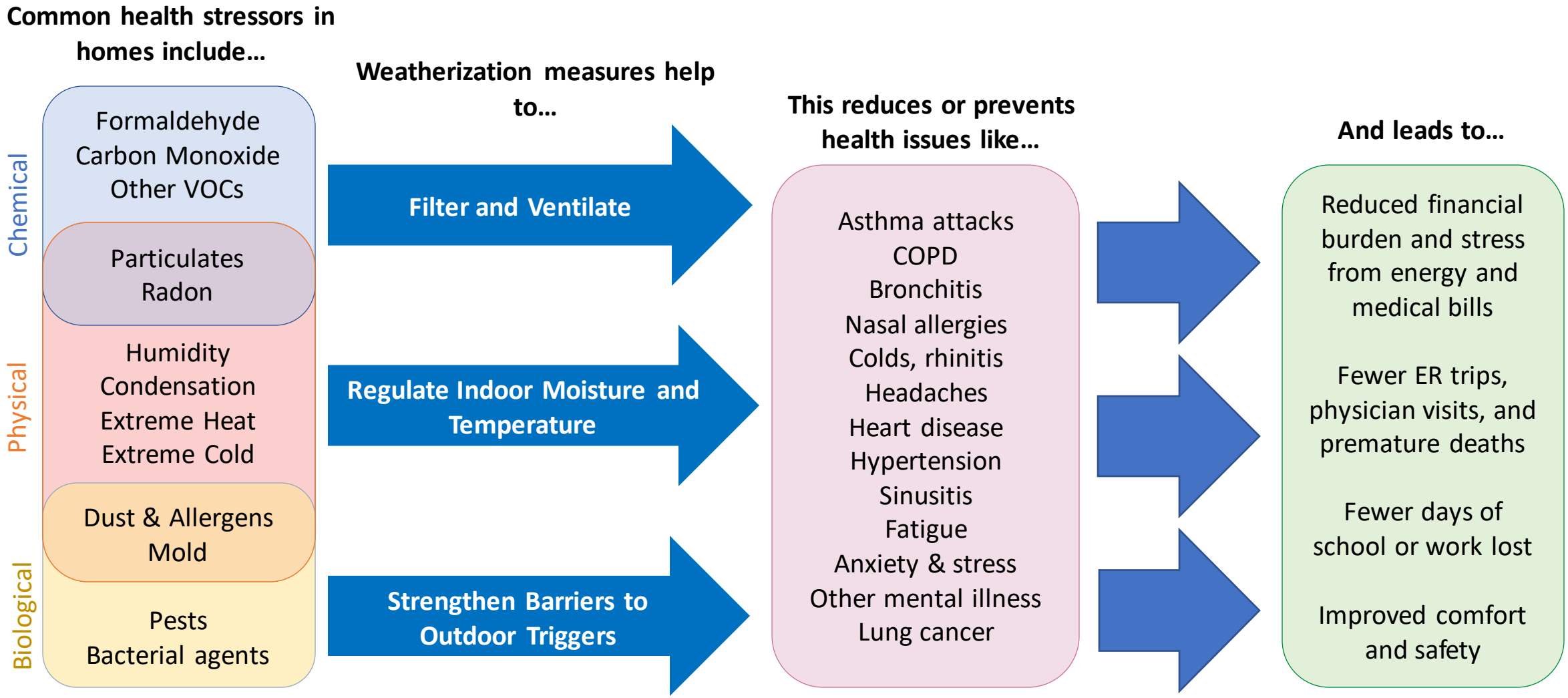


Energy Efficiency is a Strategy to Mitigate the Health Threats of Climate Change

This relationship offers opportunity to

- Protect the health of the most vulnerable Californians
- Attract funding earmarked for health and climate change adaptation
- Expand greenhouse gas reductions through increased program uptake

EE Health Benefits for Building Occupants



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Why Should My Home Energy Program Offer Health Services?

- **Increase program funding:** meet needs to qualify for new sources of funding aimed at preventive public health care
- **Reduce the number of households that are turned away from the program (i.e., deferred):** Pre-existing health and safety issues can lead to deferrals of other program services .
- **Achieve more equitable outcomes:** By improving living conditions in historically underinvested and overburdened communities, we can begin to mitigate the inequitable underlying causes of death and disease.

Why Should My Home Energy Program Offer Health Services?

- **Expand program reach:** People may be motivated to participate in programs that offer improvements to health, comfort, or safety.

- **Better serve the public:** Maximizing the benefits that accrue to customers and reducing the risk of harms is a public good, and benefits customers individually.

Cross-Sector Funding Sources

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aceee.org/research-report/h2002

Categories of In-Home Health Services

- Protection from Outdoor Environment/ Elements
- Building and Electrical Code Compliance
- Ventilation and Filtration of Indoor Air and Pollutants
- Toxic Hazard Remediation
- Technology and Safety Feature Installation
- Other Technology Maintenance, Repair, and Replacement
- Education

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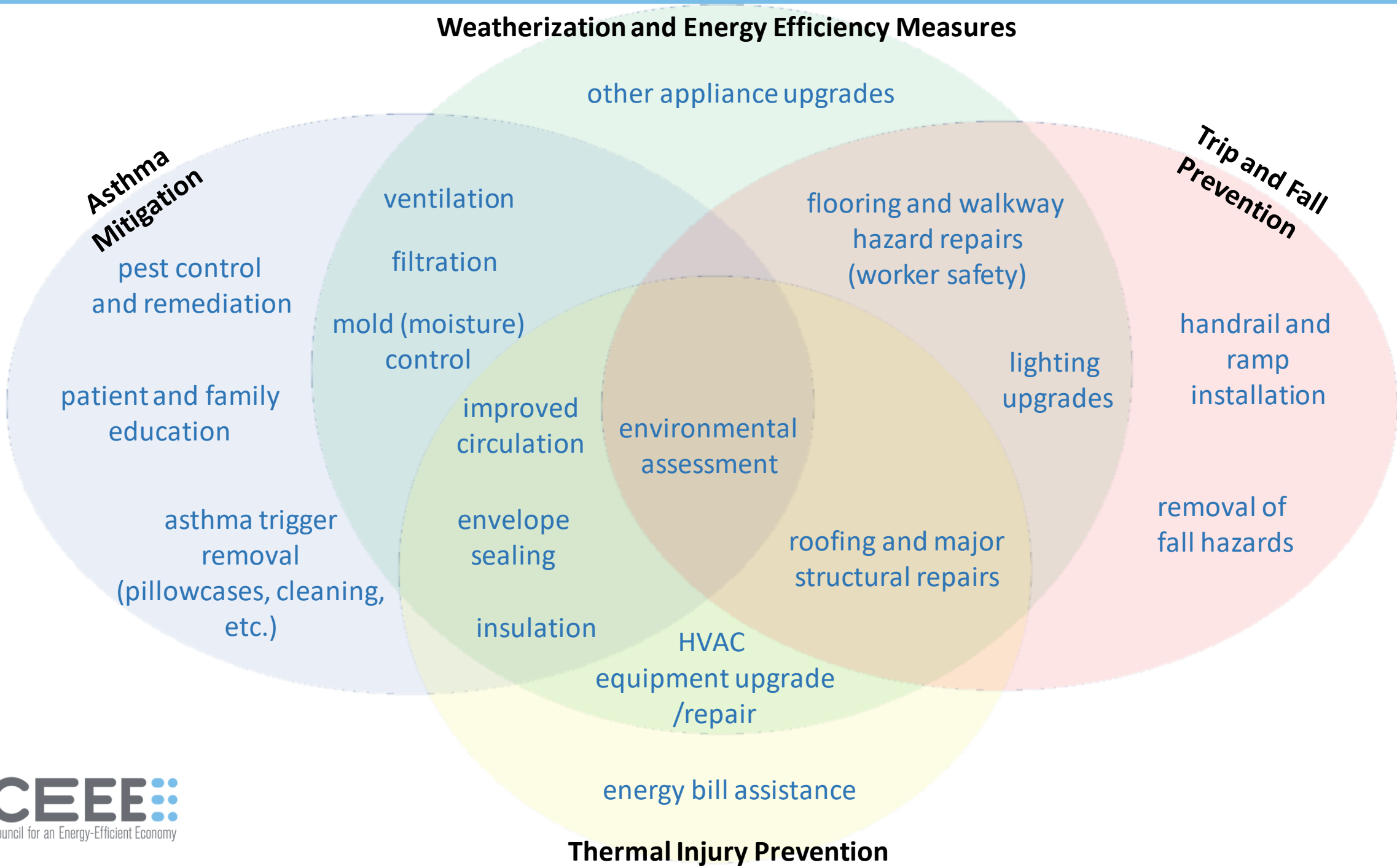

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Asthma Mitigation Service Examples

- Integrated pest management
- Whole house fan/ventilation system
- Kitchen exhaust fan – repair or install
- Bathroom exhaust fan – repair or install
- Dryer venting
- Carpet removal or removal of moldy wet flooring; installation of replacement flooring
- Replacement of forced-air furnace filters and provision of additional filters
- Mold remediation
- Duct cleaning and sealing
- Window air conditioner and installation
- Humidifier or dehumidifier (with built-in pump) and installation
- Dirt floor vapor barrier
- Roof repair
- Gutter/downspouts system replacement
- Cleaning of gutters
- Plumbing repair – water line repair and faucet
- Basement waterproofing
- Repairs to condensate drain and steam system
- Carpet steam cleaning

ACEEE
American Council for an Energy-Efficient Economy

Thank you!

Feel free to send questions, comments, or feedback to Sara Hayes at shayes@aceee.org.

Breakout Room

Perceptions vs. Reality

How do you see energy efficiency impacting indoor air quality?

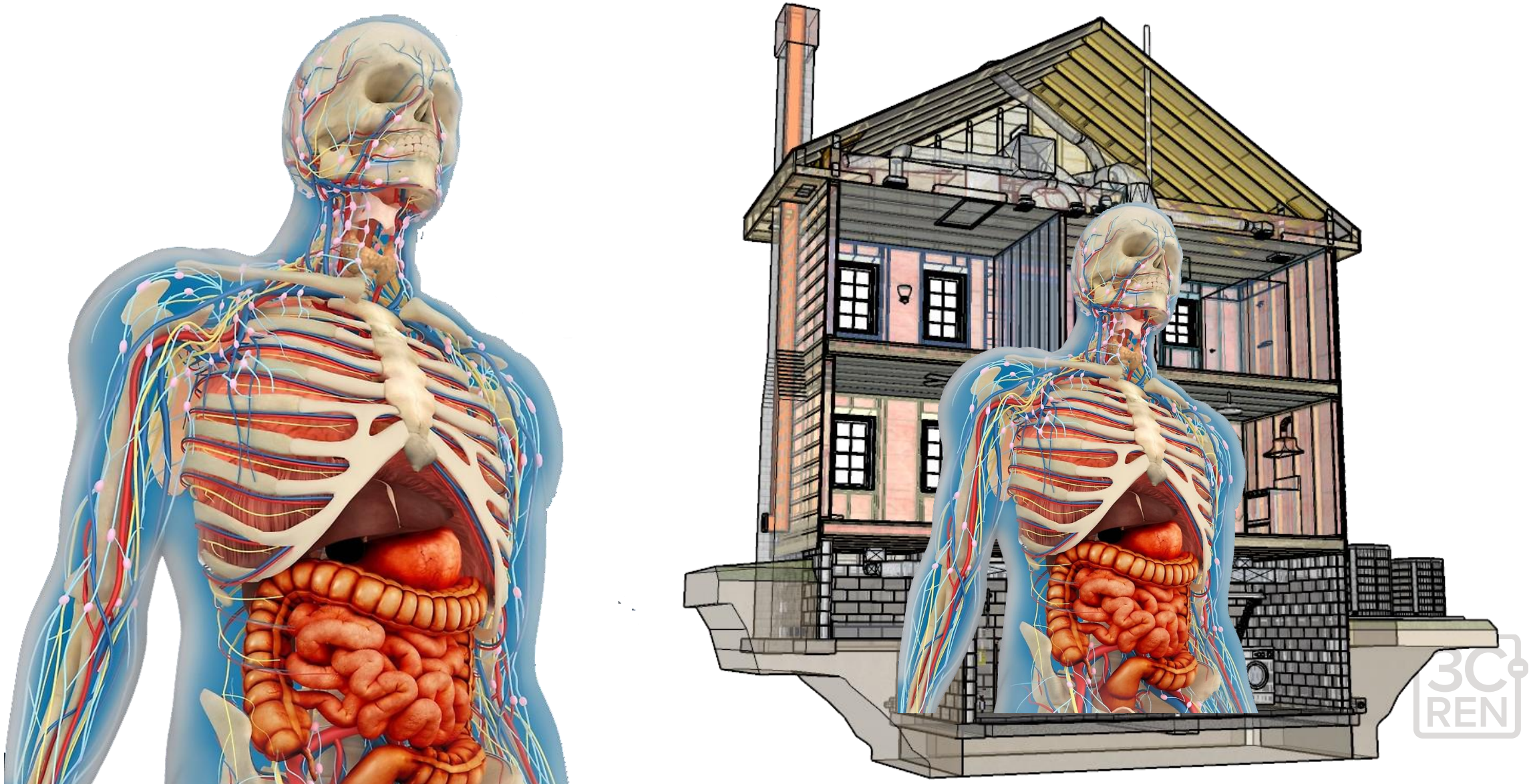
What do you see as the biggest barrier to improving indoor air quality?

Joe Medosch

Healthy Building Scientist; Director of Partner Development, Hayward Score

Health Improvements Through Energy Upgrades

Occupants are more complicated than the indoor environment.



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Occupant is the IAQ Receptor

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Housing is Health Care

- People don't manage their health problems in a hospital, they manage their health in their home
- All homes are supposed to be designed and built for people to occupy
- People's activities and daily behavior have a major impact on the indoor environmental quality of their home
- Many people have unique health issues that can be impacted by their home

source: Kevin Kennedy

Children's Mercy

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HAYWARD™ SCORE

SO YOU CAN FEEL BETTER

FREE Tool for Occupants

~80,000 Individual Scores

www.HaywardScore.com

House Type

Occupant Behaviors

Occupant Health Symptoms

Determine if your home is impacting your health!

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Hayward Score calculates a proprietary “Score” based on the occupants answers

Higher Score = Healthier Home = Less symptoms

Healthier

Hayward Score	# of Symptoms
92	3.9
79	4.7
58	6.2
28	8.2

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Impact of Maintenance - Conditions

Expertly / Well

Somewhat

Deferred

1/13/20	Overall	Expert	Some	Def'd
N	***60725***	*15715*	*29224*	*15786*
Odors	**58%**	32%	59%	84%
Surface dust	**69%**	52%	71%	84%
Sill dust	**51%**	28%	51%	74%
Water stains	**38%**	13%	36%	67%
Visible mold	**32%**	11%	28%	58%
Think mold	**34%**	15%	34%	65%

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Post Hayward Score Follow up Responses

	Made Changes	No Changes	Moved	n
Owner	199	125	2	326
Renter	102	70	28	200
	301	195	30	**526**

57% Made Changes

61% Owners Made Changes

51% Renters Made Changes

6% Moved

1% Owner Moved

14% Renters Moved

Roughly half of the respondents took action and made changes. Owners were a little more likely to make changes.

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What did they do?

57% of Follow up respondents indicated they made a change.

Replaced Furnace Filters	45%
Did Testing	**29%**
Added Air Purifiers	24%
Fixed Leaks	23%
Removed Mold	21%
Replaced Vacuum	21%
Added E/HRV	**17%**
Removed Carpets	16%
Reduced Chemical Exposure	15%
Cleaned Ducts	**14%**
Added Humidifiers	**12%**
Added Dehumidifier	**11%**
Installed Exhaust Fans	**9%**
Completed Maintenance	8%
Sealed Crawlspace	**5%**

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Post Hayward Score Follow up Responses

Respiratory Symptoms Improved

Sinus Congestion	67%
Coughing	50%
Allergies	48%
Trouble Sleeping	38%
Other	16%

Non- Respiratory Symptoms Improved

Feeling Sick	50%
Sore Throat	33%
Freq Headaches	26%
Infrequent Headaches	26%
Depressed	24%
Nausea	22%
Dry Eyes	22%
Extreme Fatigue	22%
Night Sweats	20%

Self-reported Improved Symptoms

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NEW

UPGRADE TO A HEALTHIER HOME: NEW CONSTRUCTION

HAYWARD™ SCORE
SO YOU CAN FEEL BETTER

UPGRADE TO A HEALTHIER HOME: NEW CONSTRUCTION

A healthier, high-performance home is possible. With minimal investment, you can add features that improve air quality, reduce energy bills, increase durability, and add to resale value, while improving comfort and decreasing health risks.

Upgrades to your home can deliver an indoor environment that is peacefully quiet, less prone to dust, odor, allergens, and pollutants, and, most importantly, healthier for your family. A healthier home can help improve sleep, productivity, and cognition. In addition, improving home performance will reduce short-term costs and add long-term value.

From the tables below, choose the upgrades that are right for your build and enjoy an improved lifestyle with healthier home construction.

KEY OCCUPANT BENEFITS & ACTIONS [1]

- Health Savings ($-$$$)
- Peacefully Quiet
- Less Dust/Dirt
- Fewer Odors
- Energy Savings ($-$$$)
- Fewer Sick Days
- Better Sleep
- Improved Cognition
- Fewer Pests

Benefit	Affordable $	Workforce $$	Market Rate $$$	High End $$$$
Peacefully Quiet	• Air tightness of building envelope <2 ACH@50 Pascal		• Air tightness of building envelope <1 ACH@50 Pascal	• Air tightness of building envelope <0.6ACH@50 Pascal
Minimized Dust, Fewer Odors	• Mechanical Ventilation meets ASHRAE 62.2-10 • Continuous low sone integrated bath fan(s) and independent supply ventilation	• ERV / HRV Ventilation Rate of 0.4 ACH to 0.6 ACH *Note: 0.4 ACH (air changes per hour) means the air in the house is exchanged every 135 to 90 min. The higher the number the more air is exchanged.* • Independent ERV / HRV ventilation system not integrated with heating or cooling system.		
	• Cooking ventilation with low sone (quiet) and conditioned makeup air • Cooking ventilation has rated capture efficiency or is field-tested • 4" MERV 13 Air Handler (heating / cooling) Air Filters or equivalent. • HEPA Vacuum			
Healthy Indoor Air	• Sealed combustion or electric appliances • Hayward dust removal protocol[3] should be implemented after construction (pre-drywall) and prior to occupancy.			
	…er has makeup air damper or is ventless …garage present, 100% air sealed with exhaust ventilation			
	…tile paints, foam insulation, or wall-to-wall carpet			

Action Category	Affordable $	Workforce $$	Market Rate $$$	High End $$$$
Clean Tap Water	• Test water to determine contaminants • Filtered water pitchers	• Under-sink filtration system		• Whole house and under-sink filtration
Exterior Wall Assembly and Moisture Management	• Rain screens (drainage plane) behind cladding (climate-specific) • Whole-house dehumidifier (in moderate and high humid climates) • Crawlspace: sealed with mechanical ventilation • Basement: insulation and exterior moisture barrier • Insulated slab and basement floor (minimum 4' perimeter)			
3rd Party Commissioning	• Code compliant • Energy Rating Index (ERI) of 57 to 62[4]	• Certified EPA: EnergyStar, Indoor airPLUS and WaterSense • ERV / HRV commissioned (balanced and flows measured)		
	• Manual "J" and "S" calculation on the heating and cooling equipment • Heating and cooling system is commissioned and balanced • Heating and cooling ducts must be in conditioned space • Return ducts in all bedrooms and rooms that can be separated by a door • Blower door testing and zonal pressure diagnostics			
Other Healthy Upgrades	• Smooth surface low VOC flooring • Passive Radon Mitigation System • Perform long term radon test (91+ days) • CO (carbon monoxide) detector that alarms at 6 ppm • Consumer IAQ Monitor with PM 2.5, TVOC, CO2, RH, temperature, NO2 and ozone • Off-gas appliances before installation • No panels or multiple electrical runs within 5 feet of beds, favorite chair, or desk (EMF) • Zonable WiFi & router that can be turned off at night • Smart Meter EMF shield/cover for EMF mitigation • No WiFi transmitter within 10 feet of beds, favorite chair, or desk • Security door(s) with screens for natural ventilation • Homeowner education and user manual and maintenance reminders			

INCREMENTAL COSTS & HAYWARD SCORE ESTIMATE FOR NEW BUILD

(Calculated using California construction costs on 2,000 sq ft home)

	Affordable $	Workforce $$	Market Rate $$$	High End $$$$
Net Cost	$13K	$23K[5]		

https://www.haywardscore.com/upgradenewconstruction/

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NEW - BPI's Healthy Housing Principles Reference Guide

- Clean
- Dry
- Pest-Free
- Contaminant-Free
- Safe
- Ventilated
- Comfortable
- Maintained

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You can do EE and HH at the same time.

Healthy Outcomes

- Reduce Contaminant pathways
- Reduce Allergen & asthma triggers
- Reduce Pest entry points
- Reduces moisture
- Improves comfort
- Improves ventilation
- Improved durability

Energy Efficient Measures

Air Sealing

Air Sealing

Air Sealing

Air Sealing

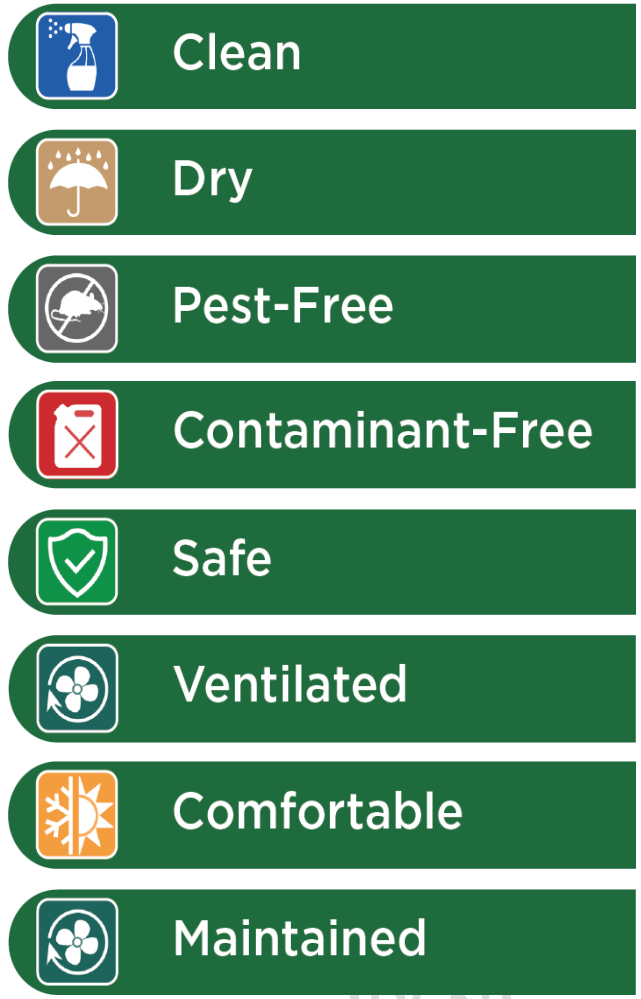
Greatest health savings opportunity

Exhaust fans Air Sealing

Insulation Air Sealing

Repairs & Homeowner education

Keep It Principles



Makes for happy, healthy comfortable users

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Energy

- Combustion safety
- Spillage test
- Carbon Monoxide tests
- CAZ testing
- Bathroom exhaust fan
- Kitchen exhaust fan
- Ventilation 62.2
- Mechanical ventilation
- Moisture damage
- Visible moisture growth
- Dryer vent
- And more …

Non-Energy Efficient Measurements

Healthy Home

- Combustion safety
- Spillage test
- Carbon Monoxide tests
- CAZ testing
- Bathroom exhaust fan
- Kitchen exhaust fan
- Ventilation 62.2
- Mechanical ventilation
- Moisture damage
- Visible moisture growth
- Dryer vent
- And more …

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Energy Audit

- Determine infiltration / air leakage
- Used to calculate SIR
- Find air leakage location
- Measure Zonal Pressure Diagnostics
- Air leakage = heat transfer
- Tighter homes can contain moisture
- Tight homes require enhanced ventilation
- See air sealing

Blower Door Test

Healthy Home Assessment

- Exposure pathway measurement device
- Measure connectivity between locations with contaminants like garage, attic and crawlspace
- Tighter homes can reduce or contain moisture
- Tight homes require enhanced ventilation

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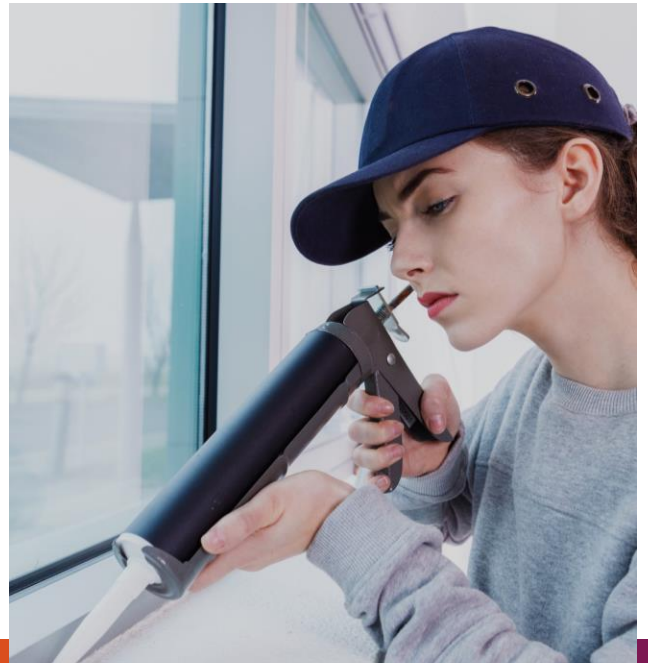
Air Sealing Thermal Comfort

Energy

- Comfortable indoor temperatures
- Reduced energy cost
- Lower indoor relative humidity
- Thermal comfort



Healthy Home

- Reduce exposure pathways
- Comfortable indoor temperatures
- Lower indoor relative humidity
- Reduced allergens
- Reduced deaths due to temperature extremes
- Reduced symptoms of respiratory disease

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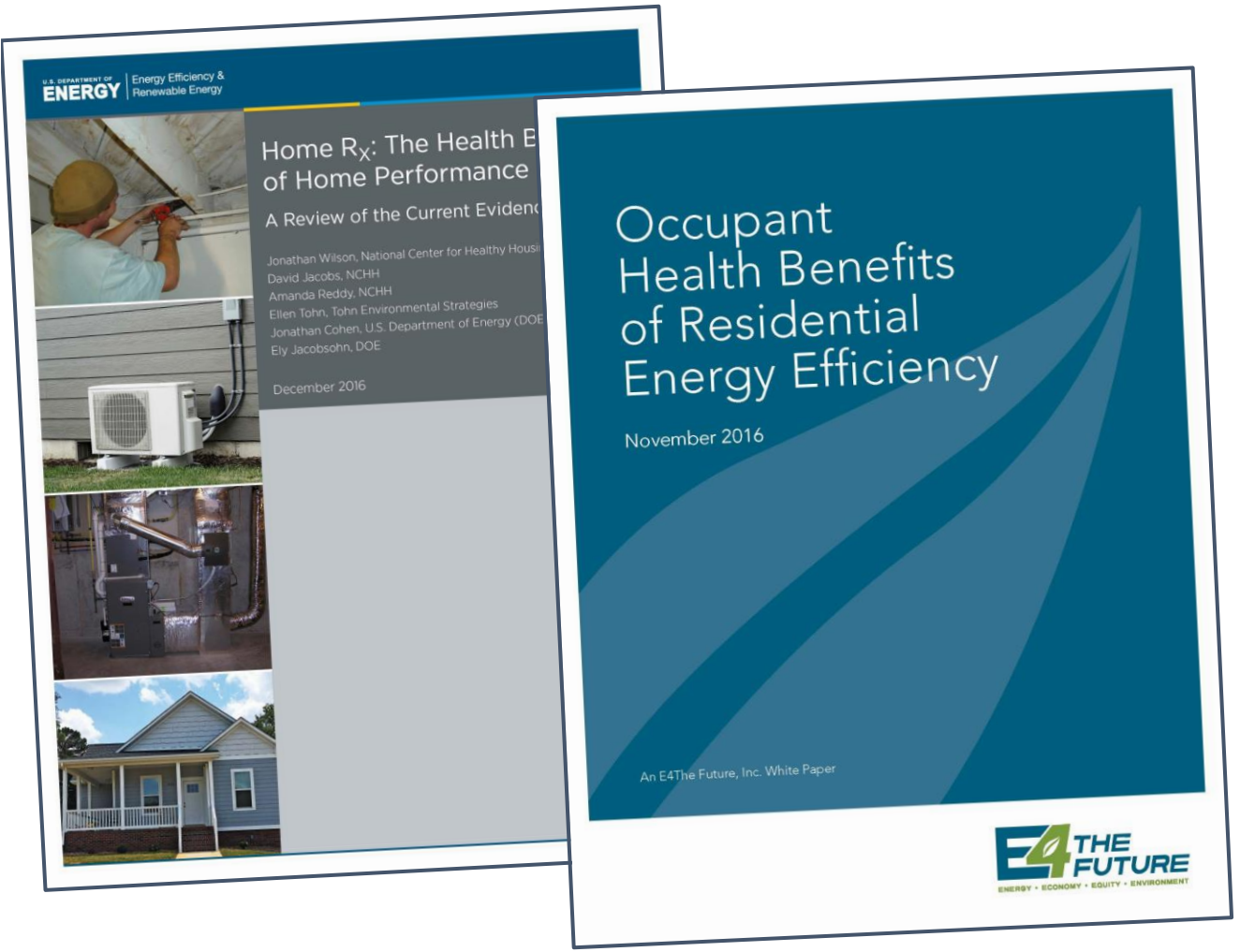
Home Performance is Health Performance



https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/Home%20Rx%20The%20Health%20Benefits%20of%20Home%20Performance%20-%20A%20Review%20of%20the%20Current%20Evidence.pdf

https://e4thefuture.org/wp-content/uploads/2016/11/Occupant-Health-Benefits-Residential-EE.pdf

http://ma-eeac.org/wordpress/wp-content/uploads/TXC50-Low-Income-Multfamily-Health-and-Safety-NEI-Preliminary-Findings-Report_15OCT2018.pdf

https://weatherization.ornl.gov/wp-content/uploads/pdf/WAPRetroEvalFinalReports/ORNL_TM-2014_345.pdf

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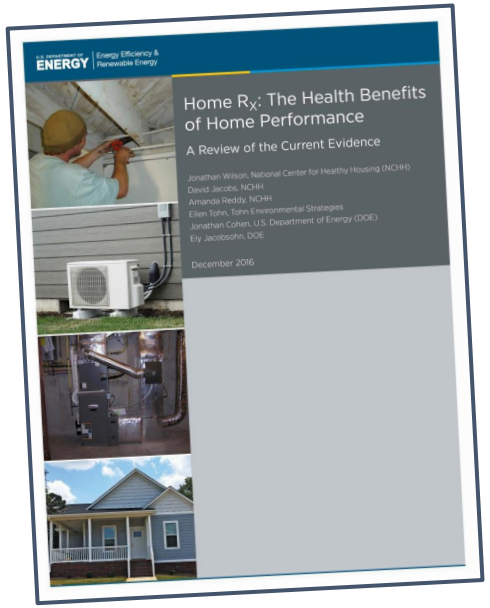
Air Sealing, Thermal upgrades and Heating Tune-Up

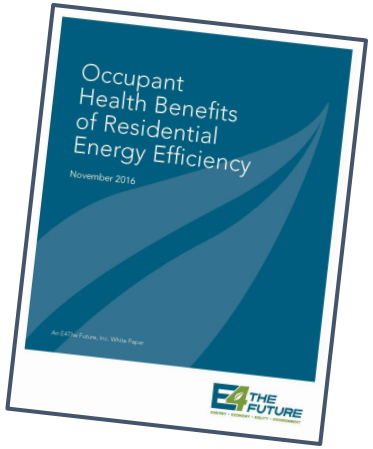
Contaminants Reduced through assessment, education and interventions

gases and particulates
less medications
dampness
mold
risk of cancer
arthritis
depression
energy bill
pollutants
days off work / school
cardiovascular issues
dust mites that are known to cause asthma
exposure to particulate and
contaminants that cause symptoms
use of chemicals



Improvements

savings / more income
general health
mental health
lower respiratory symptoms
blood pressure/hypertension or other
upper respiratory symptoms and headaches.
cooler climates improve comfort with less humidity
human health by reducing thermal stress
daily exposure to cleaner air
less stress and worry about “unknown” indoor air



most studies recommended IAQ Testing

Better quality of life

Remember for these health impacts it’s about long-term health impact and long-term costs in health care $$ and quality of life.

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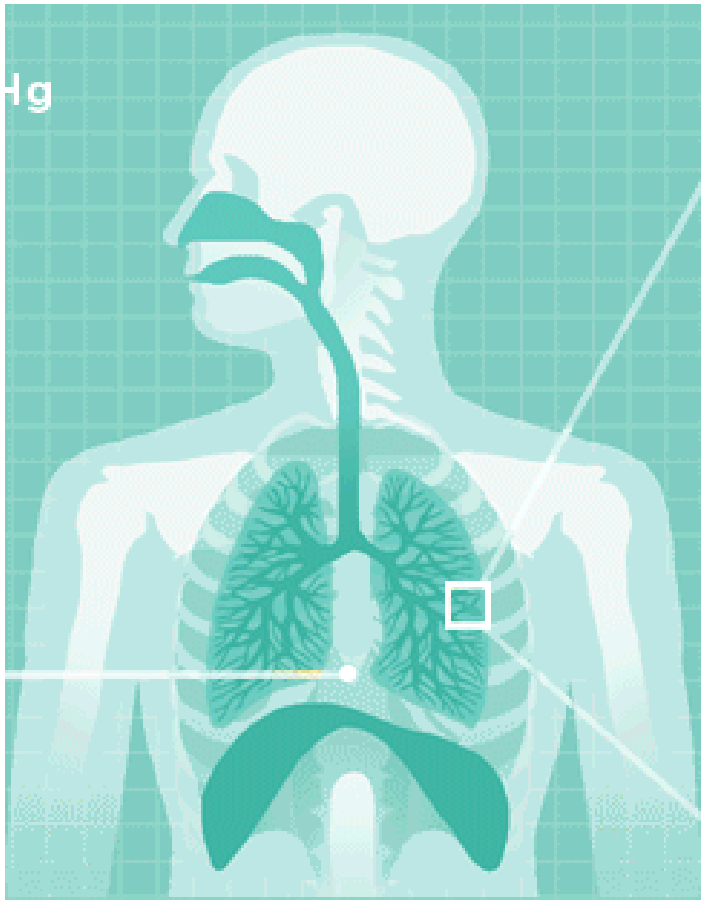
What are you breathing?

10’ x 10’ x 4’



3000 gallons of air every day.

Animation source: http://noticing.co/how-insects-breathe/#

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What are you breathing?

*Lawrence Berkley Labs (LBL) MERV 8-13

Air Leakage / Infiltration = Exposure pathway

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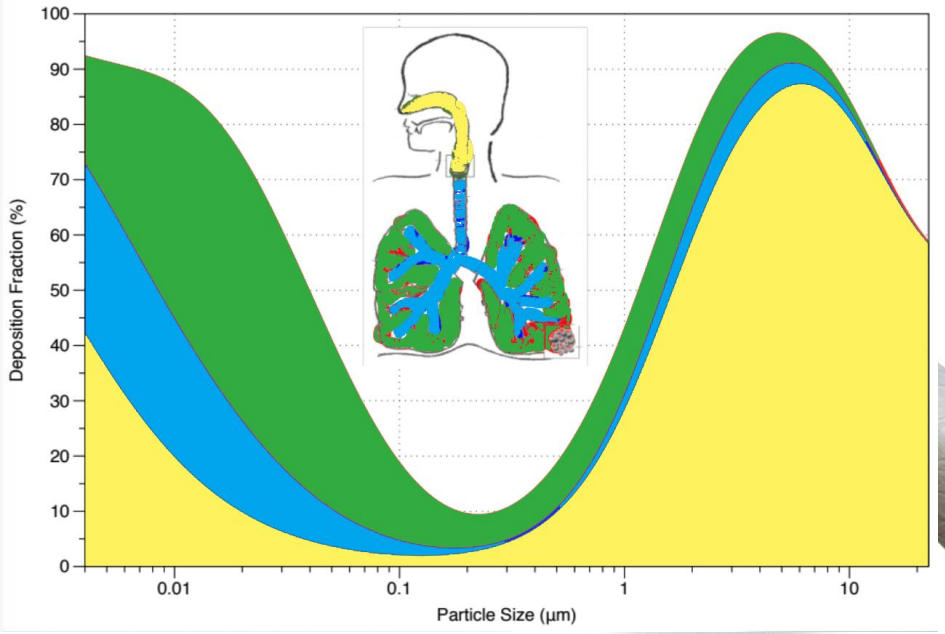
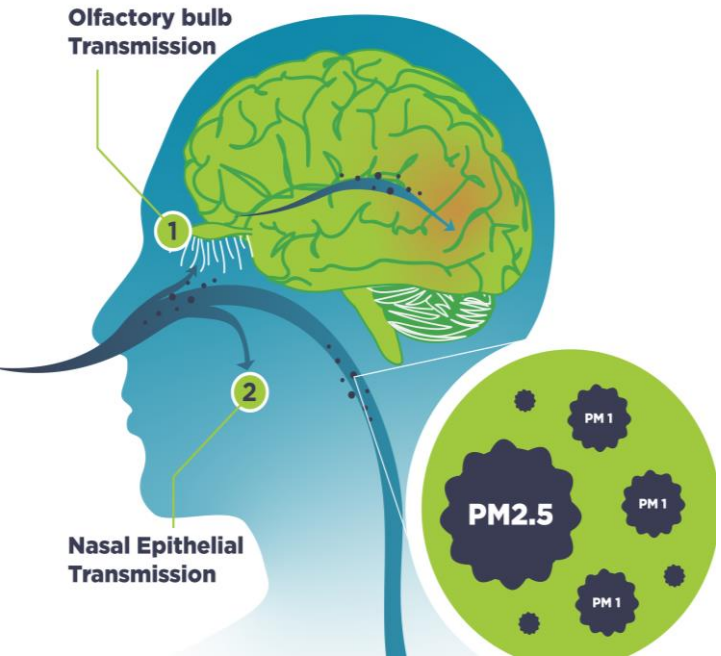


HUMAN HAIR
50-70 µm
(microns) in diameter

PM2.5
Combustion particles, organic compounds, metals, etc.
< 2.5 µm *(microns)* in diameter

← SARS-CoV-2 0.06-0.14 µm
← Bacteria 0.5-2 µm
← Blood cell 7.5 µm

PM10
Dust, pollen, mold, etc.
<10 µm *(microns)* in diameter



90 µm *(microns)* in diameter
FINE BEACH SAND

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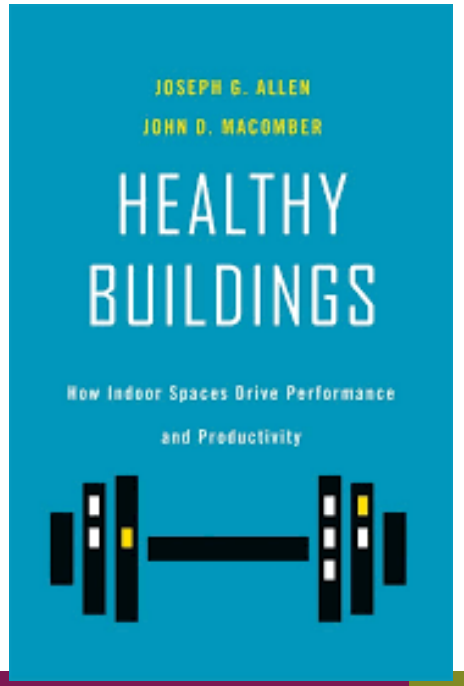
Joseph Allen states:

Director of the Healthy Buildings program and an Associate Professor at Harvard's T. H. Chan School of Public Health.

Building engineers and facilities managers are the true heroes of our health. (As you'll see, they are the reason why I often say, "The people who manage your building have a greater impact on your health than your doctor. ")



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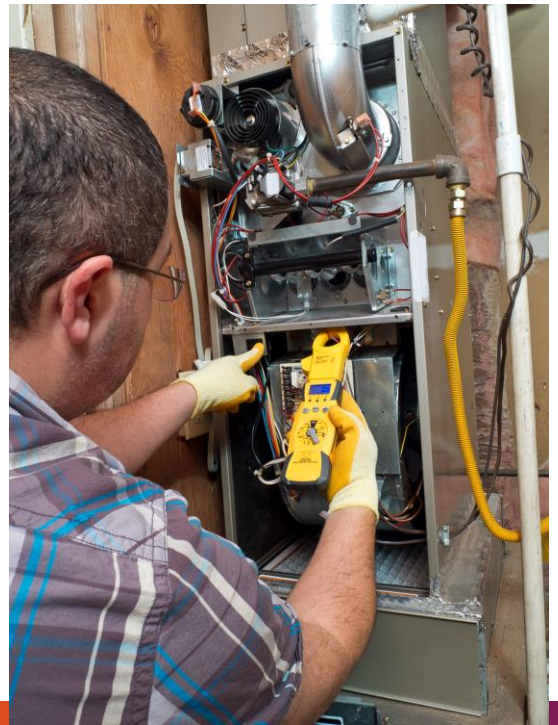
Joseph Medosch states:

Healthy Building Scientist at Hayward Score

The people who manage your H/AC system can have a greater impact on your health than your doctor.



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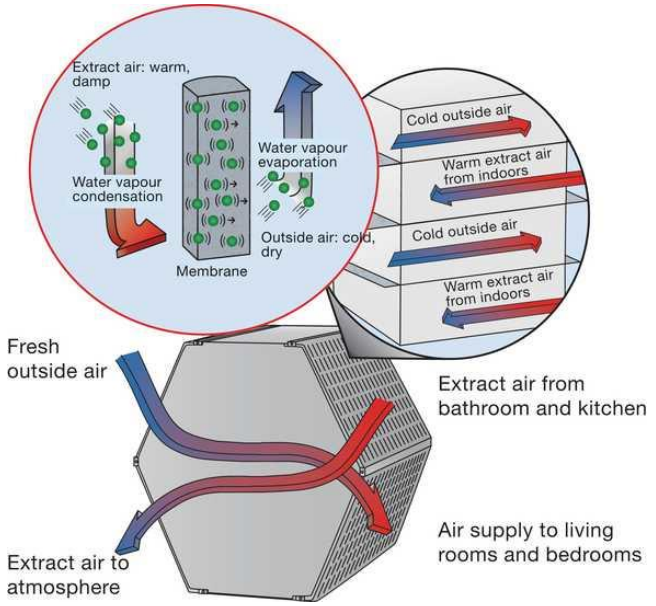
H/AC Contractors are the… Healthy Home Contractor



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Air Handler Intervention

16x25x1 MERV 12

20x25x4 MERV 13

CASE STUDY: Indoor Air Quality Interventions

Chris Guignon, evolveEA

Source: Linda Wigington

Reducing Outdoor Contaminants in Indoor Spaces

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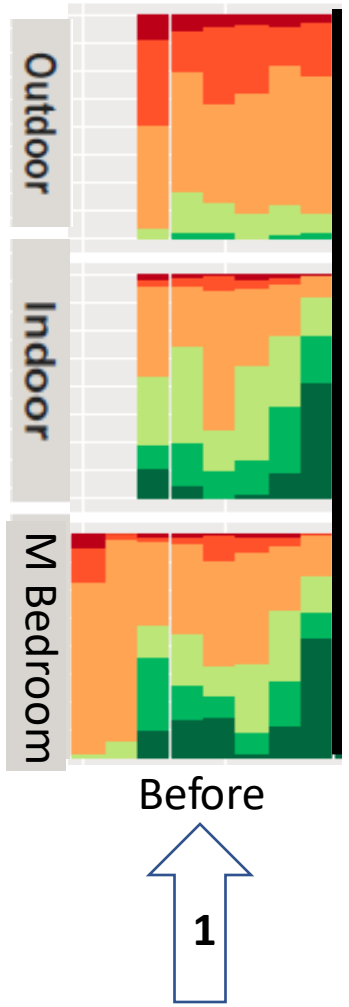
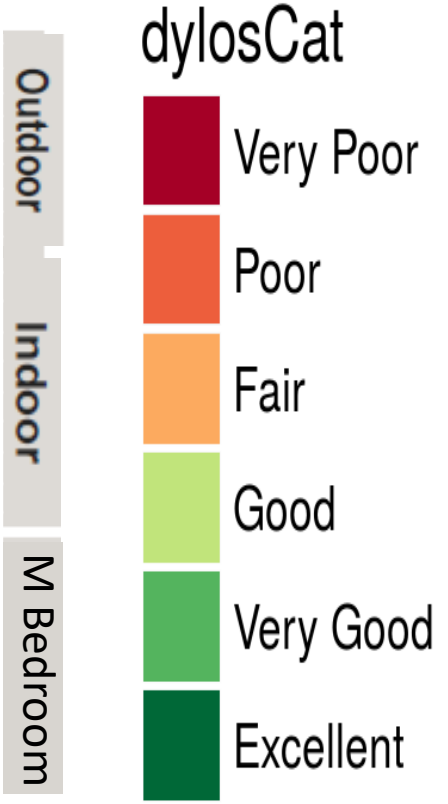
24/7 Air Handler w High MERV Filter

1) Using existing 1” pleated filter





Dylos particles ≥0.5 µm

CASE STUDY: Indoor Air Quality Interventions
Chris Guignon, evolveEA

Source: Linda Wigington

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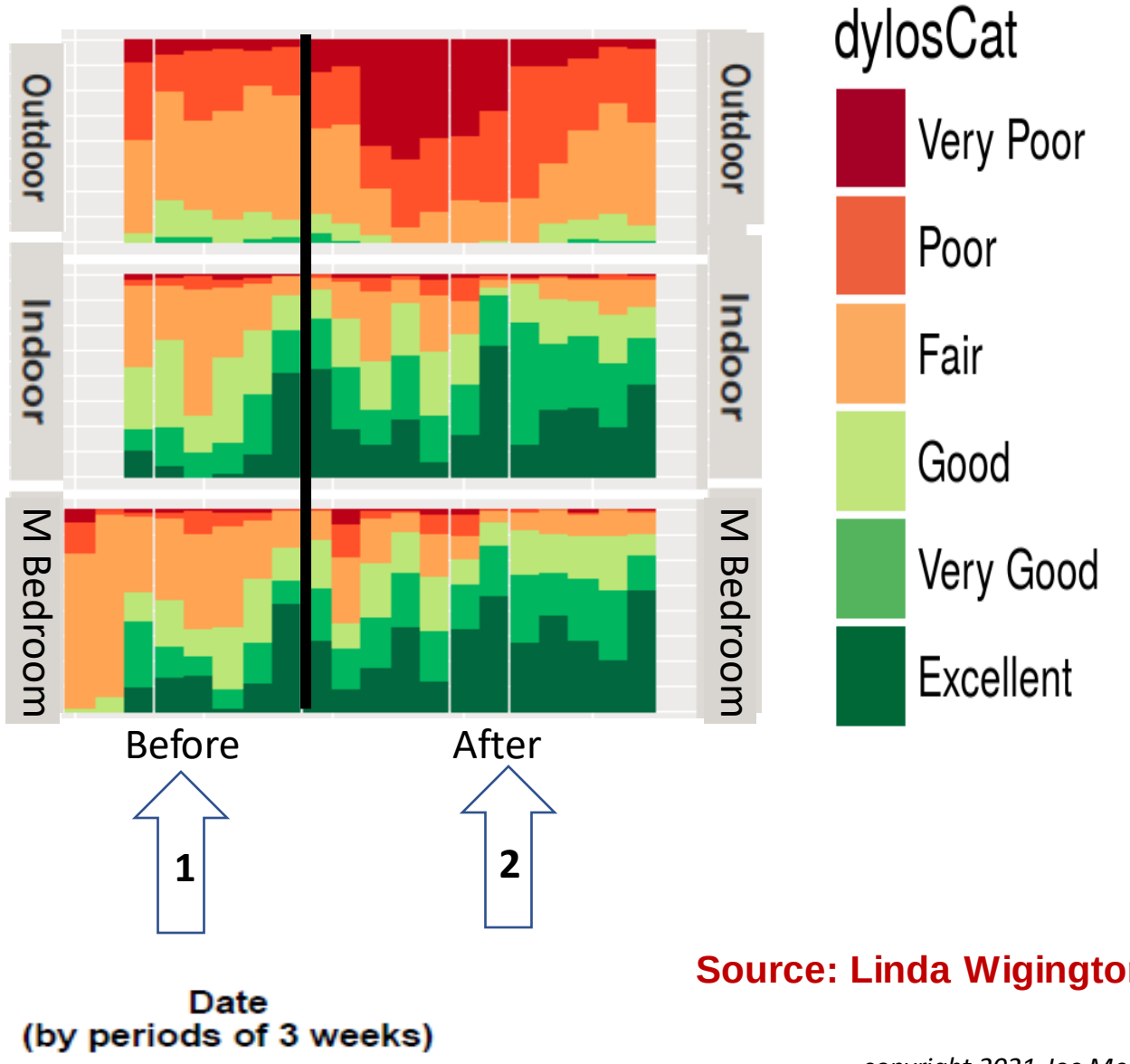
24/7 Air Handler w High MERV Filter

1) Using existing 1” pleated filter

2) Return drop modification
w/ turning vanes
4”, 20”x 25” MERV 13 filter



Dylos particles ≥0.5 µm

CASE STUDY: Indoor Air Quality Interventions
Chris Guignon, evolveEA

Source: Linda Wigington

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Conclusion:

Energy Efficient measures can have a significant impact on occupant health.

Thank you!

Questions?

Joe Medosch
Healthy Building Scientist

HAYWARD™ SCORE
SO YOU CAN FEEL BETTER

www.HaywardScore.com

Break

Breakout Room #	Speakers
1	Sara Hayes
2	Joe Medosch
3	Judy Rachel
4	Brett Bishop & Cindy Edwards

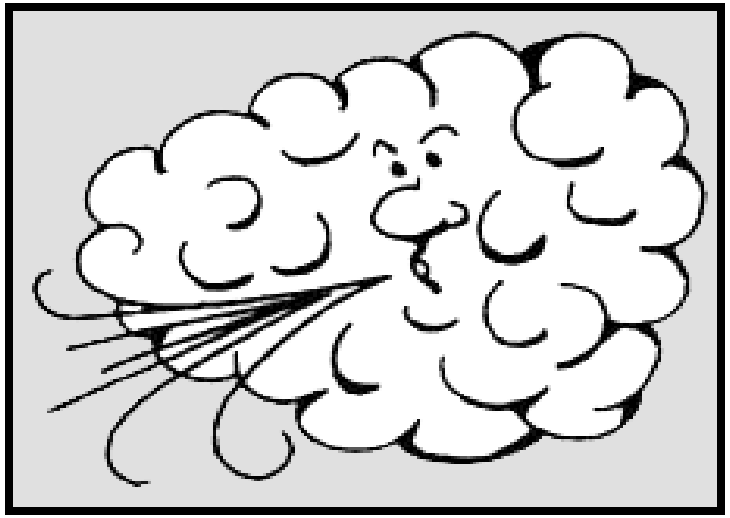
Judy Rachel

Home Performance Specialist & Technical Consultant

High-performance homes require that ventilation energy demands and IAQ be simultaneously optimized.

Judy Rachel – Home Performance Specialist and Technical Consultant

Ventilation



Definition:

- Controlled amount of air
- Derived from clean, dry sources
- Moving as designed through building zones
- Contributing to the health and comfort of the occupants

Indoor Air Changes and Potential Implications for SARS-CoV-2 Transmission – JAMA Insights

To reduce far-field airborne transmission of SARS-CoV-2 in small-volume indoor spaces (eg, classrooms, retail shops, homes if guests are visiting), target 4 to 6 air changes per hour, through any combination of the following: outdoor air ventilation; recirculated air that passes through a filter with at least a MERV 13 rating; or passage of air through portable air cleaners with HEPA (high-efficiency particulate air) filters.

https://jamanetwork.com/journals/jama/fullarticle/2779062

Portable Air Cleaners - Stick with standalone ≥ MERV 13 or HEPA air cleaners

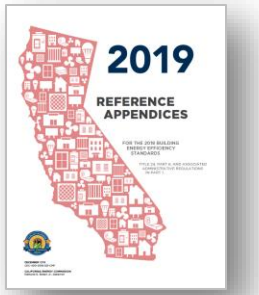
Choose one that does only filtration. One that doesn't add ions, hydrogen peroxide, or any of the other things that electronic air cleaners do.

Stay away from:
Photocatalytic Oxidation - PCO
Ultraviolet Germicidal Irradiation - UVGI
Electrostatic Precipitators - ESP
Ionization - Ionizers or ion generators
Ozone generators

Independent researchers haven't been able to reproduce the high effectiveness rates claimed by the manufacturers.

A number of these technologies produce unsafe by-products that get released into the air.

QII – Quality Insulation Installation Reference Residential Appendix RA3.5



- Is supposed to ensure the existence of a continuous air barrier.
- Is supposed to ensure insulation is installed in contact with the air barrier with no compression, gaps or voids.

The air barrier establishes an enclosure within which:

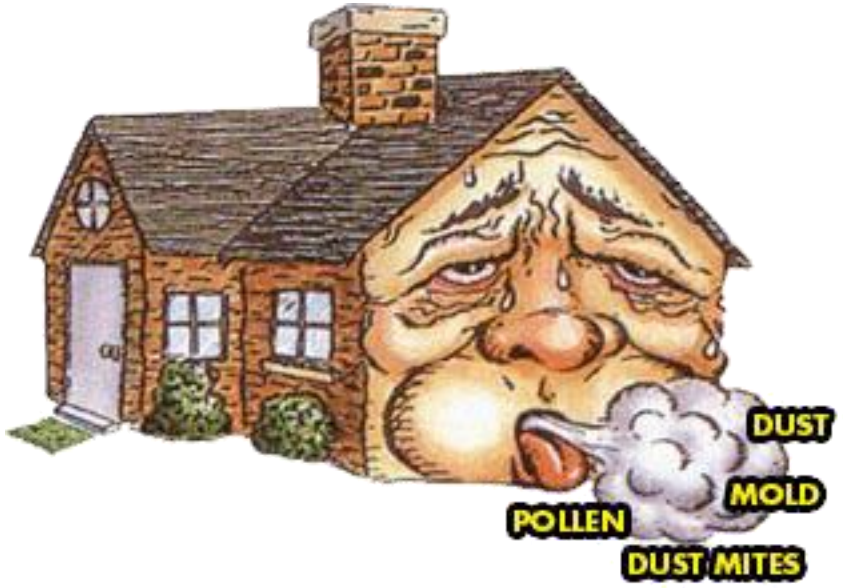
✓ The amount of air into and out of the enclosure can be controlled

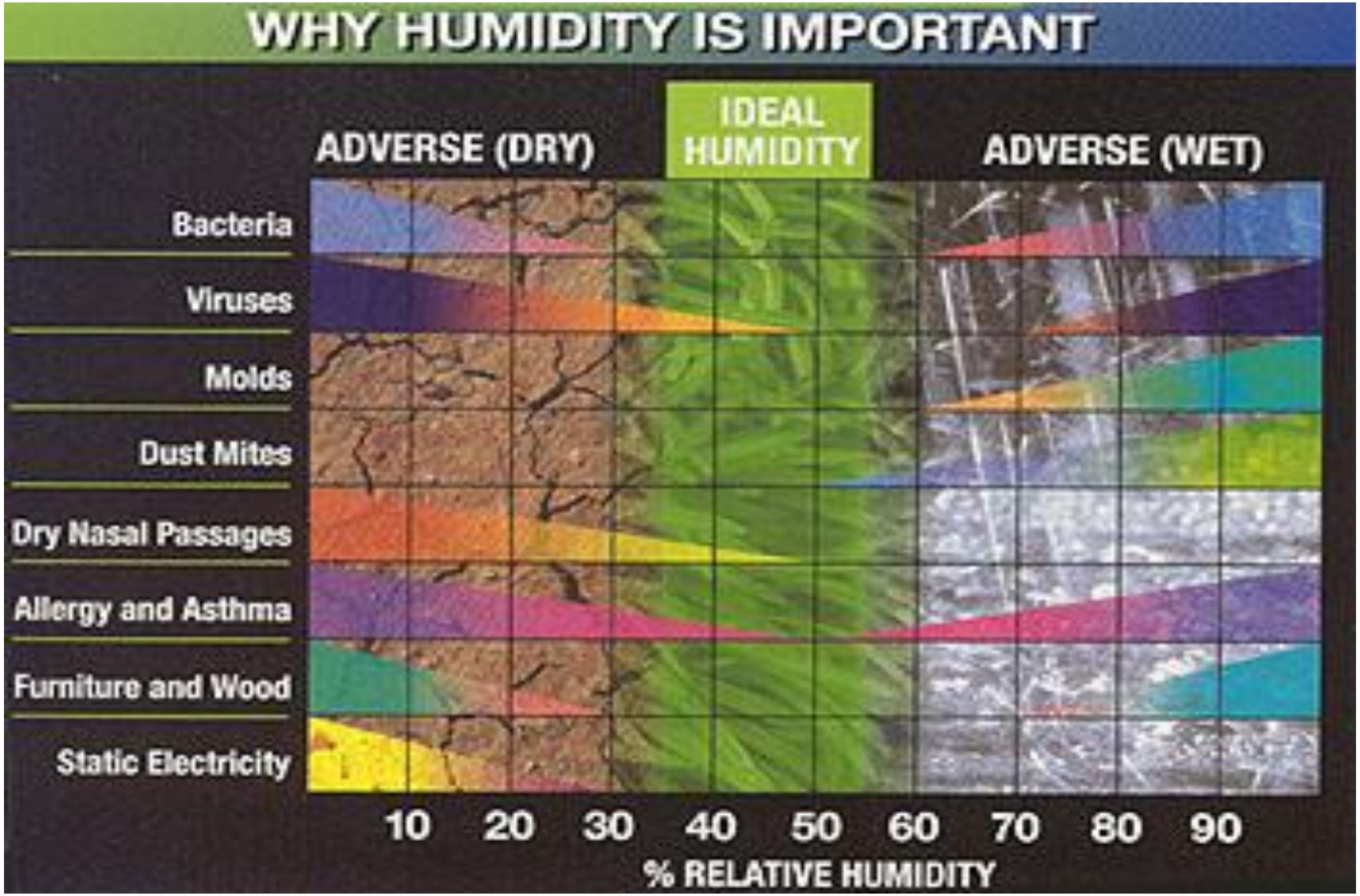
✓ The air can move as designed through the building

✓ Ventilation systems must be integrated into the air barrier.

Why Ventilate

- ❑ Control Moisture
- ❑ Dilute Contaminants / Pollutants
- ❑ Dilute Odors
- ❑ Exchange Stale Air
- ❑ Provide Filtration Opportunity
- ❑ Codes and Standards

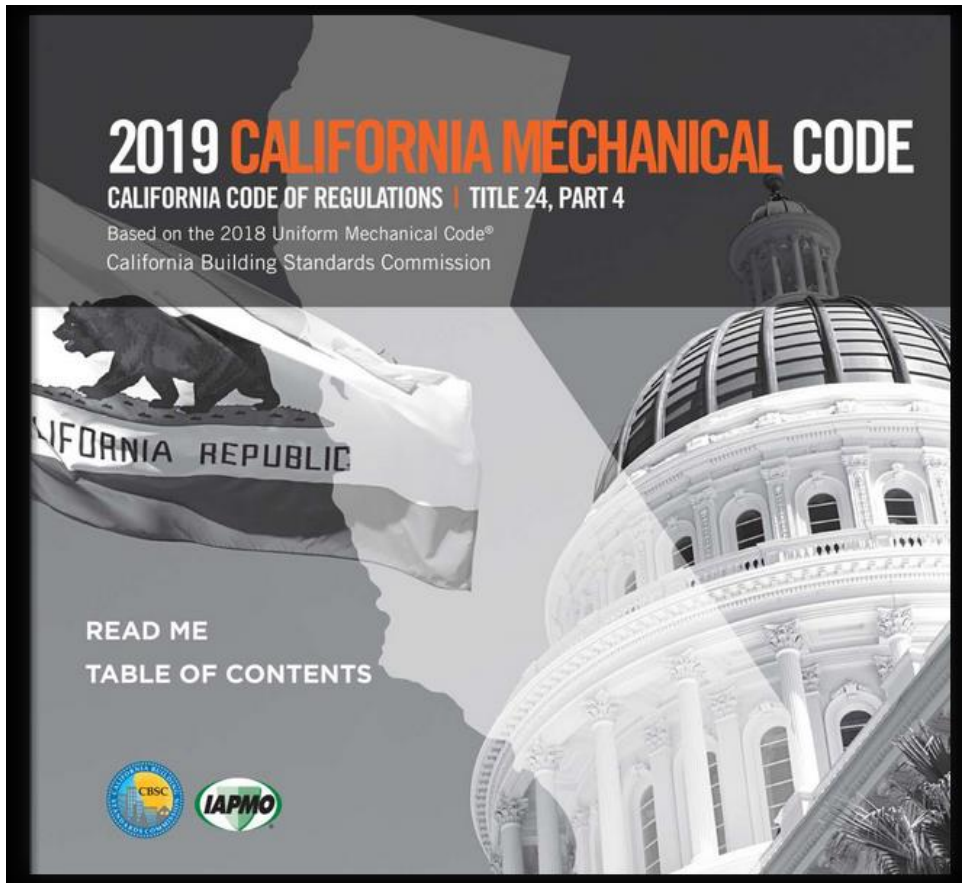




Ideal indoor humidity is between about 35% to 55%

2019 California Mechanical Code

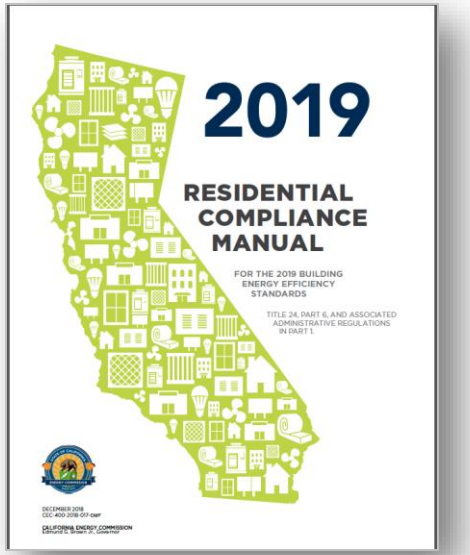
Chapter 4 - Ventilation Air



http://epubs.iapmo.org/2019/CMC/index.html#p=108

2019 Residential Compliance Manual

Chapter 4



4.6 Indoor Air Quality and Mechanical Ventilation

Energy Commission sponsored research has revealed that concentration of pollutants such as formaldehyde are higher than expected, and that many occupants do not open windows regularly for ventilation. The 2019 Energy Standards include requirements for mandatory mechanical ventilation intended to improve indoor air quality (IAQ) in homes, and requirements for MERV 13 air filtration on space conditioning systems, and ventilation systems that provide outside air to the occupiable space of a dwelling

How Much is Required?

That Depends on Lots of Factors:

- Occupant use of the building
- Pollutant sources and strengths
- Size of the building
- Types of combustion appliances
- General relative humidity levels (inside and out)
- Occupant Health Level

CA Building Code has adopted with exceptions ASHRAE 62.2-2016

2019 BUILDING ENERGY EFFICIENCY STANDARDS Section 150.0 (o)
Requirements for Ventilation and Indoor Air Quality. All dwelling units shall meet the requirements of ASHRAE Standard 62.2, Ventilation and Acceptable Indoor Air Quality in Residential Buildings subject to the amendments specified in Section 150.0(o)1 below. All dwelling units shall comply with Section 150.0(o)2 below.

150.0 (0) 1: Amendments to ASHRAE 62.2 requirements

A. Window operation is not a permissible method of providing the dwelling unit ventilation airflow specified in subsections C, E, or F below.

A. Continuous operation of central forced air system air handlers used in central fan integrated ventilation systems is not a permissible method of providing the dwelling unit ventilation airflow required in Section 4 of ASHRAE Standard 62.2.

A. Single family detached dwelling units, and attached dwelling units not sharing ceilings or floors with other dwelling units, occupiable spaces, public garages, or commercial spaces shall have mechanical ventilation airflow provided at rates determined in accordance with ASHRAE 62.2 Sections 4.1.1 and 4.1.2 as specified in subsections i, ii, and iii below.

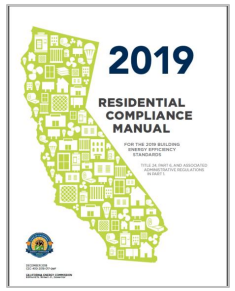
Total Required Ventilation Rate [ASHRAE 62.2:4.1.1]

- $Ventilation\ Rate$ **(**cfm**) = .**03 Conditioned Floor Area(CFA) + (7.5 x (Number of Bedrooms + 1))

- Example: A 2000 square foot house with 3 Bedrooms.

  (2000 x 0.03) + (7.5 x 4) = 90 cfm

- The delivered airflow of the whole house ventilation fan must be greater than or equal to the required ventilation rate (cfm)

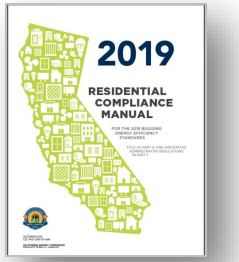


2019 Residential Compliance Manual 4.1.2.1 Mandatory Features and Devices

6. Air filtration is now required on supply and balanced mechanical ventilation systems.

7. With the adoption of ASHRAE Standard 62.2-2016, higher mechanical ventilation rates will be required for single family units which vary by climate zone.

RCM 4.4.1.14.1 Air Filter Pressure Drop



Standards Section 150.0(m)12Bii requires all systems to be designed to accommodate the clean-filter pressure drop imposed by the system air filter device(s).

Clean minimum efficiency filter with

155 Pa = 0.62 iwc

This does not comply.

My advice:
Design filter grilles at 200 fpm to 250 fpm face velocity with minimum 2” thick pleated filters. This will provide a large return with plenty of filter surface area resulting in about a 0.1 iwc pressure drop.

3C REN

Ventilation manufacturer's filters are often inadequate

They become dirty quickly and there is often filter bypass issues.

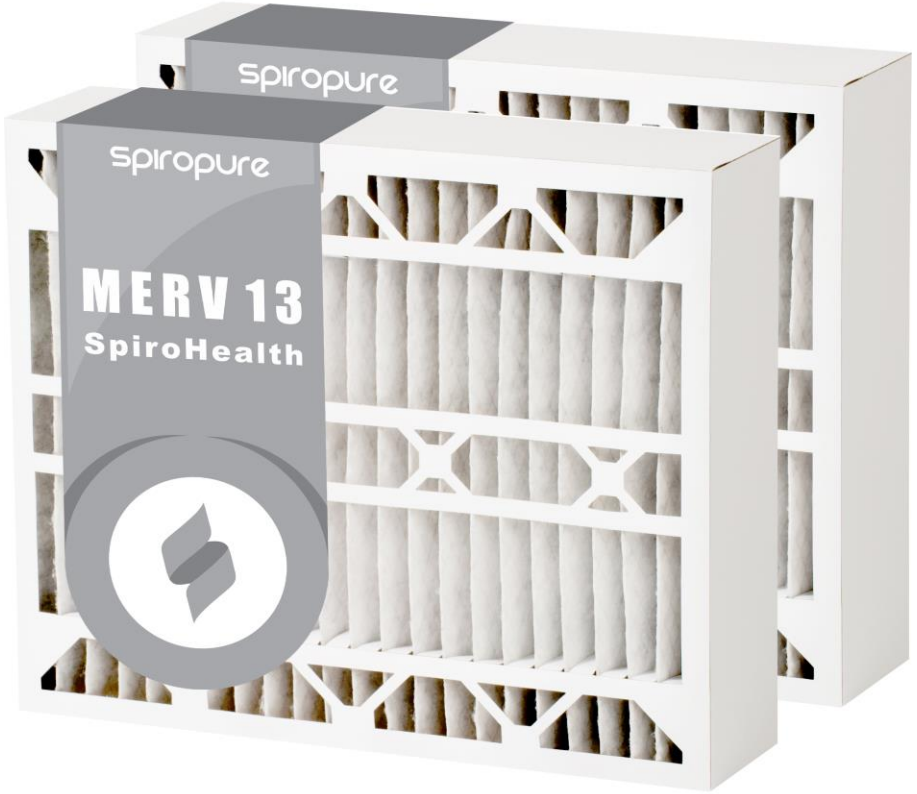
150.0(m)12C Air Filter Efficiency – Equal to or Greater than MERV 13

Do better than Code minimum work

Use deep pleated filters – Minimum 2”, push for 4” to 5” pleated filters

Size for a maximum clean-filter pressure drop of 0.1 iwc

To accomplish this install a filter box in the supply side of the ventilation system upstream of the ventilation fan.



Effective Filtration

Custom 16x25 filter box for 2” pleated filter creating large surface area which will result in a low pressure drop.

MERV Std 52.2	Average Arrestance	Particle Size Ranges	Typical Applications	Typical Filter Type
1 - 4	60 to 80%	> 10.0 μm	Residential/Minimum Light Commercial/ Minimum Minimum Equipment Protection	Permanent/Self Charging(passive) Washable/Metal, Foam/Synthetics Disposable Panels Fiberglass/Synthetics
5 - 8	80 to 95%	3.0-10.0 μm	Industrial Workplaces Commercial Better/Residential Paint Booth/Finishing	Pleated Filters Extended Surface Filters Media Panel Filters
9 - 12	>90 to 98%	1.0-3.0 μm	Superior/Residential Better/Industrial Workplaces Better/Commercial Buildings	Non-Supported/Pocket Filter/Rigid Box Rigid Cell/Cartridge V-Cells
13 - 16	>95 to 99%	0.30-1.0 μm	Smoke Removal General Surgery Hospitals & Health Care Superior/Commercial Buildings	Rigid Cell / Cartridge Rigid Box / Non-Supported / Pocket Filter V-cells
MERV Std 52.2	Efficiency		Typical Applications	Typical Filter Type
17 - 20	99.97% - 99.9999%		Hospital Surgery Suites Cleanrooms Hazardous Biological Contaminants Nuclear Material	HEPA ULPA

Filter Rating Comparison

Rating System	Best	Good	Special Use
MERV (general industry standard)	MERV 12 or better	MERV 9 – 11	MERV 16 or HEPA
FPR (Honeywell)	FPR 8-10	FPR 7	
MPR (3M Filtrete)	MPR 2200 or better	MPR 1000 - 1900	

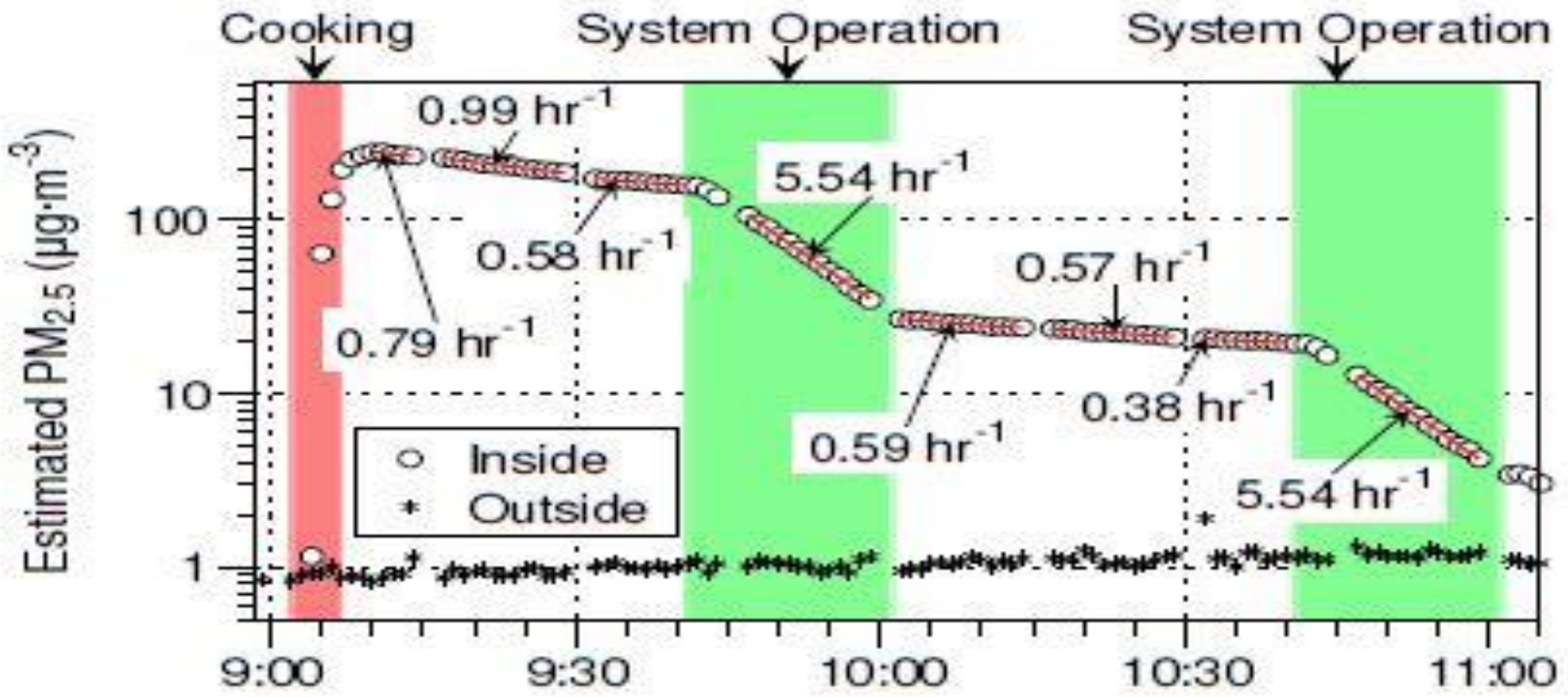


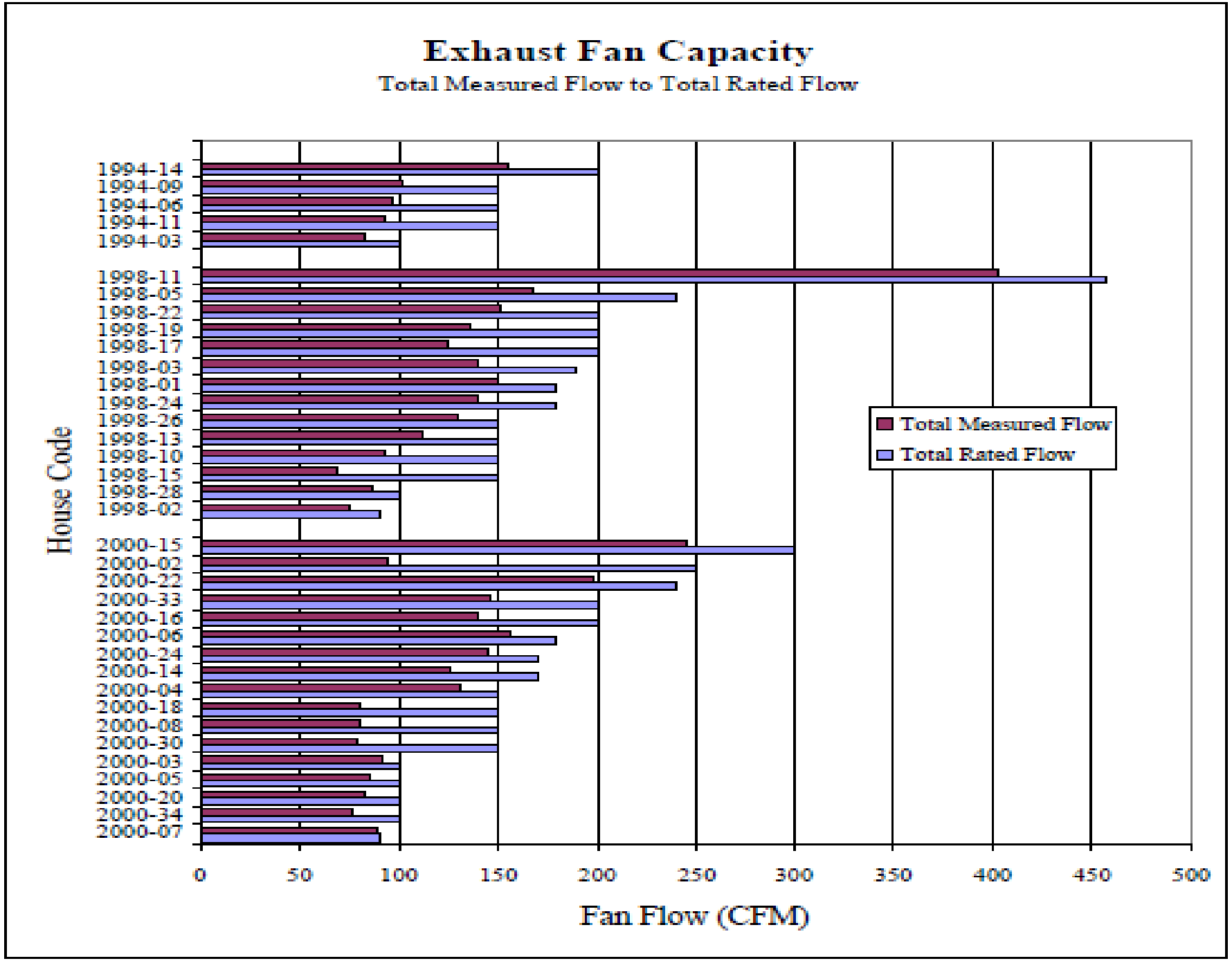
Figure 3.35. Time series of estimated $PM_{2.5}$ concentration calculated from size-resolved particle number concentrations during cooking experiment with System D on July 16, 2014.
Refer to Methods section for details on this calculation. Fitted decay rates during each period reflect sum of all particle transformation and removal mechanisms including growth, ventilation, deposition and filtration.

Weatherization Assistance Programs

- Are meant to reduce energy costs for low-income households by increasing the energy efficiency of their homes, while ensuring their health and safety.

- Installing mechanical ventilation to ensure indoor air quality is listed as one health and safety measure.

https://www.energy.gov/eere/wap/about-weatherization-assistance-program/whole-house-weatherization


Exhaust Fan Capacity
Total Measured Flow to Total Rated Flow
House Code
1994-14
1994-09
1994-06
1994-11
1994-03
1998-11
1998-05
1998-22
1998-19
1998-17
1998-03
1998-01
1998-24
1998-26
1998-13
1998-10
1998-15
1998-28
1998-02
2000-15
2000-02
2000-22
2000-33
2000-16
2000-06
2000-24
2000-14
2000-04
2000-18
2000-08
2000-30
2000-03
2000-05
2000-20
2000-34
2000-07
Total Measured Flow
Total Rated Flow
0
50
100
150
200
250
300
350
400
450
500
Fan Flow (CFM)

Don’t duct fans like this

2019 RCM 4.6.2 Typical Solutions for Single-Family Dwelling Unit Ventilation

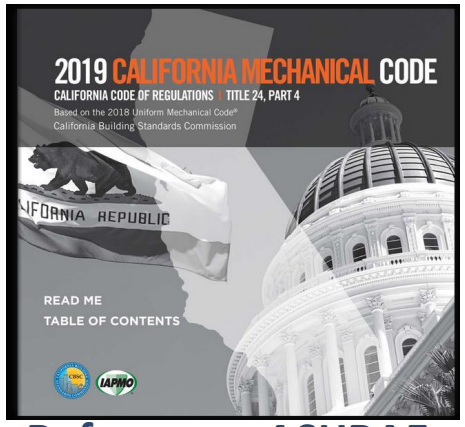
1. **Exhaust ventilation** - air is exhausted from the dwelling unit and replaced by infiltration.
2. **Supply ventilation** - outdoor air is supplied directly to the dwelling unit after being filtered.
3. **Central fan-integrated ventilation** - outdoor air is ducted to the return plenum of the central space conditioner air handler. Both return air and outdoor air must be filtered. (Uses too much energy. Continuous operation prohibited)
4. **Balanced ventilation –** may be a single packaged unit containing supply and exhaust fans that move approximately the same airflow through a heat or energy recovery core, or may use separate fans without heat exchange. In both cases, air supplied from outdoors must be filtered. (See Section 4.4.1.14 for filter requirements.)

Standards Section 150.0(o)1I & RCM 4.6.5.4 Control and Operation

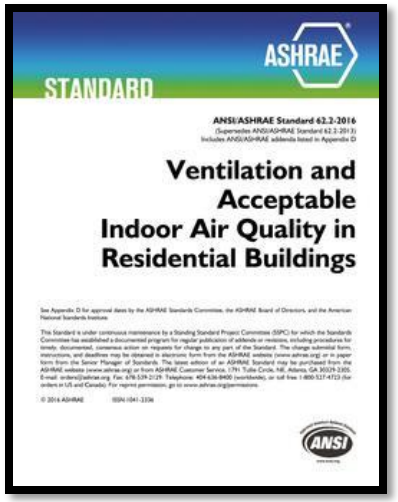
Compliance with ASHRAE 62.2 Section 4.4 (Control and Operation) shall require manual switches associated with dwelling unit ventilation systems to have a label clearly displaying the following text, or equivalent text: "*This switch controls the indoor air quality ventilation for the home. Leave it on unless the outdoor air quality is very poor.*"

Codes and Standards
Prescriptive Methods of Calculating Ventilation Rates

Prescriptive attempts to determine effective ventilation rates will improve some homes, over-ventilate some homes, under ventilate some homes and make the air quality in some homes worse. If the end goal is to have better air quality in a house, testing the air quality is a better metric for success than achieving a particular volume of air movement. The question should be did it work or didn't it?



References ASHRAE STANDARD 62-2-2016



References ASHRAE STANDARD 62-2-2013

Anecdotal Evidence

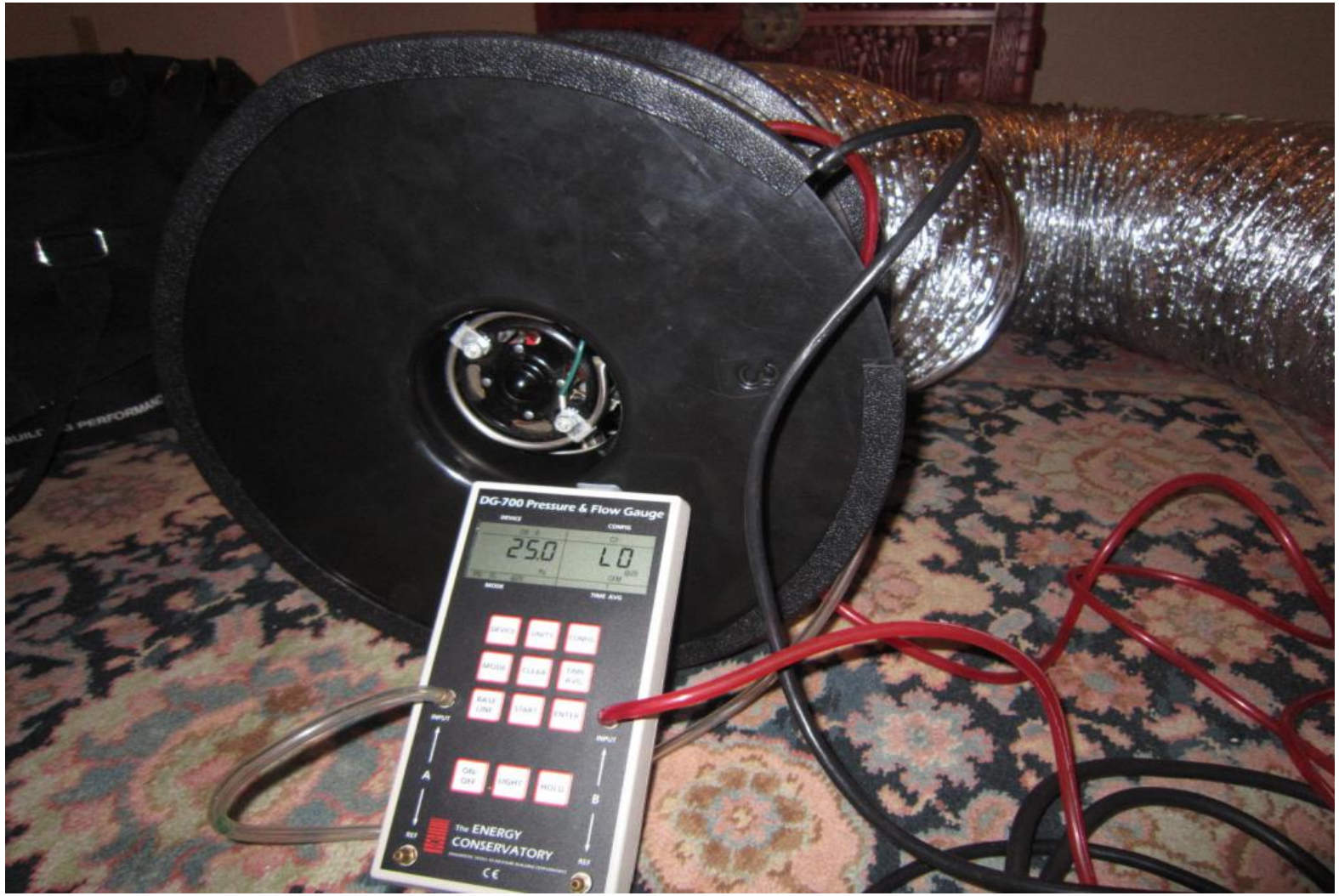
LOVE OUR HOME!!! There just aren't enough good words to express what Energy Docs has done for us! For the first time since owning this home we have a PG&E bill that is less than $1500, even less than $300!!! and for the first time in 12 years our son has made it through his first December without a trip to the hospital because our air quality is so much better! This project has improved our lives in more ways than we could have imagined. Thank You So Much

Unlike · Comment · Tuesday at 9:42pm

You like this.

Eliminate Filter Bypass

Ventilation ducts in unconditioned spaces need to be airtight and well insulated.



Resources

- Balanced Ventilation Systems For High Performance Homes - Webinars
  https://pge.docebosaas.com/learn/external-ecommerce;view=none?ctldoc-catalog-0=se-%22Dan%20Perunko%22
- Energy Vanguard Blog
  https://www.energyvanguard.com/blog/2-reasons-to-avoid-most-electronic-air-cleaners/
  https://www.energyvanguard.com/blog/how-make-high-merv-diy-portable-air-cleaner
- How to Assemble a Fan/Filter
  https://rocis.org/072318-how-assemble-fanfilter
- Residential Air Cleaners - EPA Guide
  https://www.epa.gov/indoor-air-quality-iaq/air-cleaners-and-air-filters-home
- California Energy Commission – Title 24 Publications
  https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards
- Department of Energy Weatherization Assistance Program https://www.energy.gov/eere/wap/about-weatherization-assistance-program/whole-house-weatherization
- ASHRAE 62.2-2019 – ANSI web store
  https://webstore.ansi.org SearchFindin=1&st=ANSI%2FASHRAE+62.2-2019

Summary

- Building leakage does not mean you have fresh air
- The presence of a ventilation system does not mean you have fresh air.
- Prescriptive targets don't guarantee fresh air.
- Distribution performance is critical to ventilation system performance (air flow, static pressure, watt draw, air balance, conductive losses, duct leakage)
- Test your work and refine your designs, figure out if you've accomplished your goals.
- Ventilation systems must be maintainable and maintained.

Judy Rachel

Home Performance Specialist

jrachel79@gmail.com

Audience Questions?

Brett Bishop

Director of Contract Services, Franklin Energy

Cindy Edwards

Founder & President, Efficiency First Solutions; Founder CK, Builders

INDOOR AIR QUALITY in the Built Environment

An Energy Upgrade California™ Program Authorized Contractor

Presented by:

Cindy Edwards
BPI Certified Building Analyst, General Contractor
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Director of Contract Services for Franklin Energy
BPI Certified Building Analyst, Single & Multi-Family
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An Energy Upgrade California™ Program Authorized Contractor

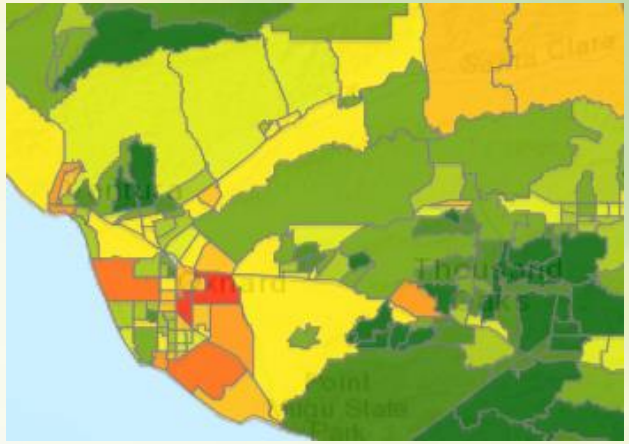
Disclosures:

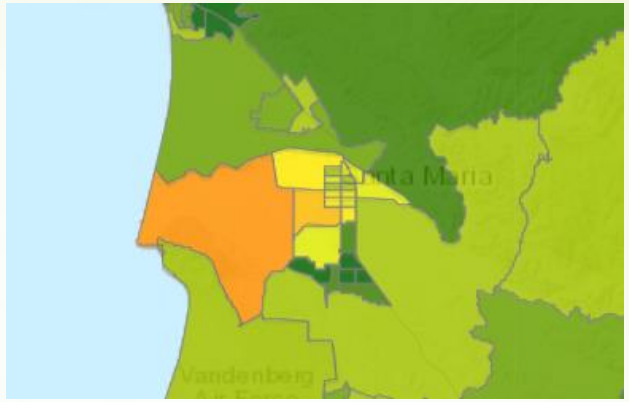
Cindy Edwards is the president of CK Builders Inc. and Efficiency First solutions.

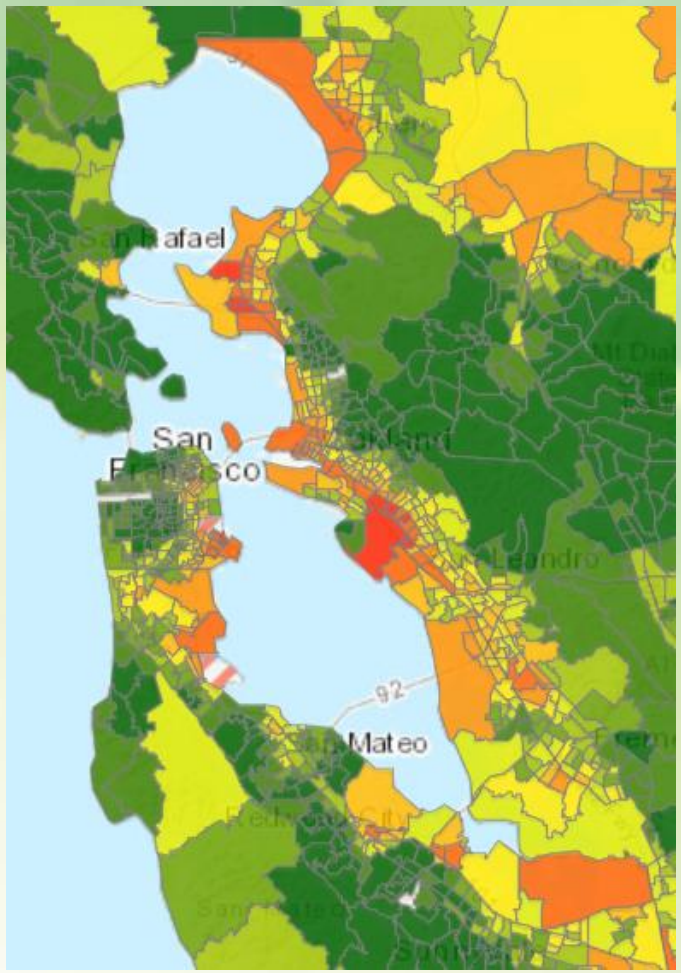
EFS is a home performance energy upgrade company that specializes in air sealing buildings using the AeroBarrier air sealing system.

Brett Bishop is Director of Contract Services for Franklin Energy's Western Region. Franklin Energy administrates energy efficiency programs for utilities within the 3C-REN service area.

Air Quality & Social Equity







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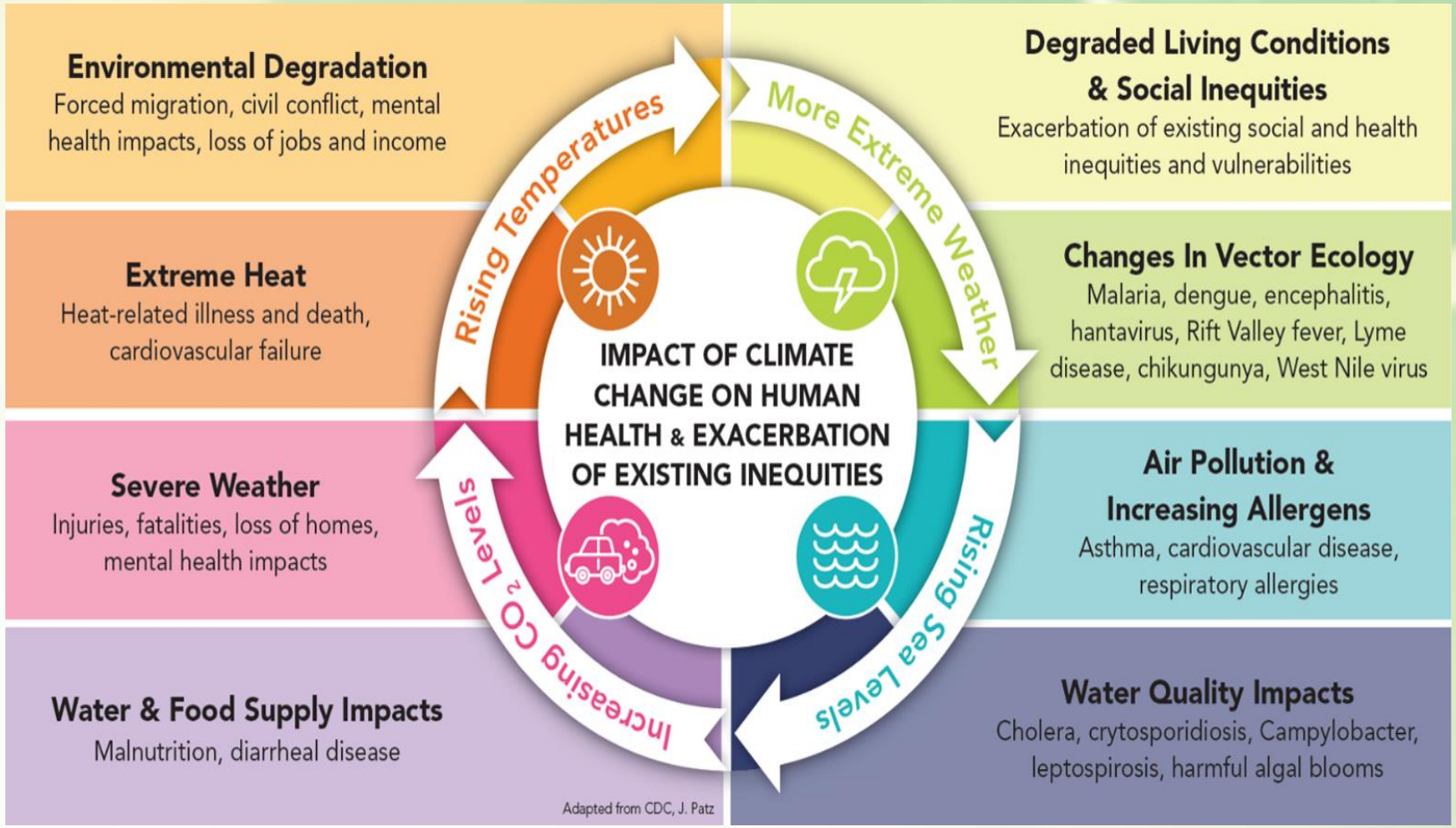
Climate Change: Human Health Impacts



Health Impacts & Air Quality:

- The annual per-person medical cost of asthma was **$3,266**. Of that, $1,830 was for prescriptions, $640 for office visits, $529 for hospitalizations, $176 for hospital outpatient visits and $105 for emergency room care.

In order to reduce asthma-related ER visits, hospitalizations, absenteeism and mortality, **we need to support guidelines-based care, expand self-management education and reduce environmental asthma triggers at homes**."

Dr. Tursynbek Nurmagambetov
CDC's National Asthma Control Program

American Thoracic Society, 2018
https://www.thoracic.org/about/newsroom/press-releases/journal/asthma-costs-the-us-economy-more-than-80-billion-per-year.php

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Stats on Indoor Air Quality:

- People in the U.S. spend about 90% of their time indoors.

  US EPA, (1987). The Total Exposure Assessment Methodology (TEAM) Study

- EPA studies indicate indoor levels of pollutants are up to ten times higher than outdoor levels.

  Environmental Protection Agency (2008). An Introduction to Indoor Air Quality.

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75% Increase in Respiratory Problems Since 1980's

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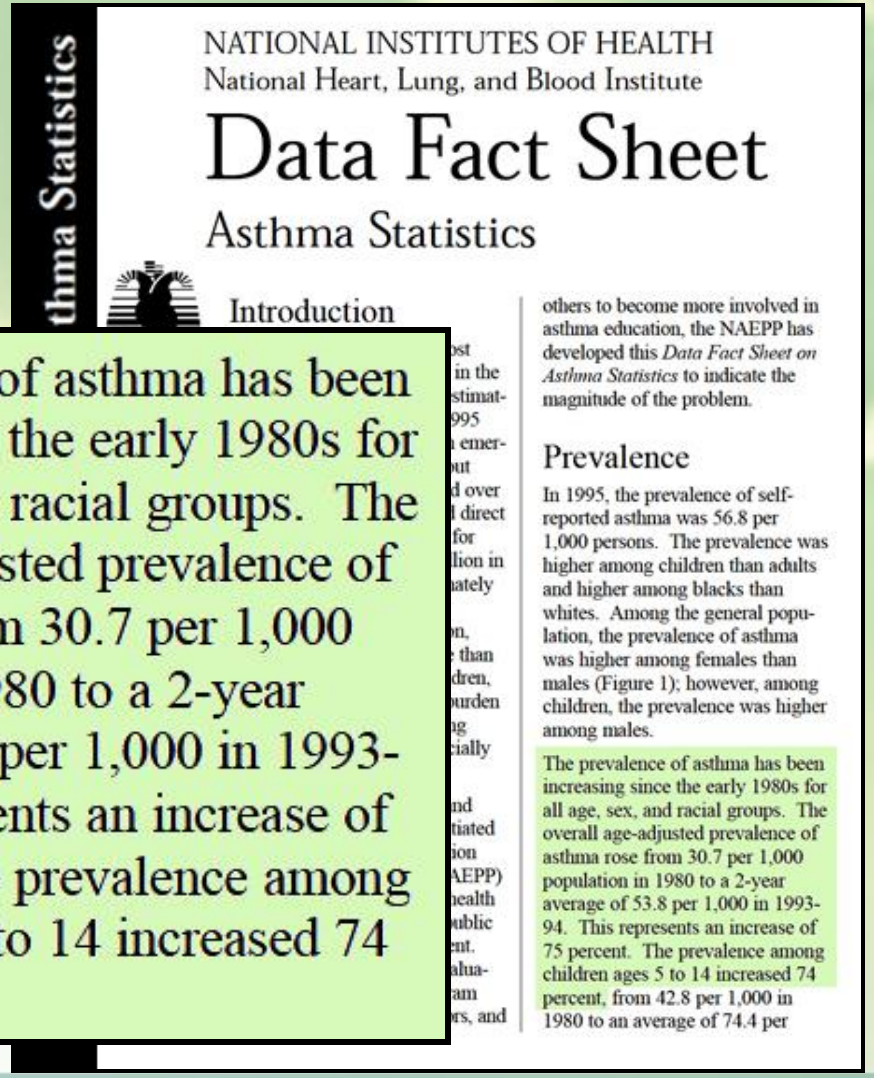

thma Statistics

NATIONAL INSTITUTES OF HEALTH
National Heart, Lung, and Blood Institute

Data Fact Sheet

Asthma Statistics

Introduction

others to become more involved in asthma education, the NAEPP has developed this *Data Fact Sheet on Asthma Statistics* to indicate the magnitude of the problem.

Prevalence

In 1995, the prevalence of self-reported asthma was 56.8 per 1,000 persons. The prevalence was higher among children than adults and higher among blacks than whites. Among the general population, the prevalence of asthma was higher among females than males (Figure 1); however, among children, the prevalence was higher among males.

The prevalence of asthma has been increasing since the early 1980s for all age, sex, and racial groups. The overall age-adjusted prevalence of asthma rose from 30.7 per 1,000 population in 1980 to a 2-year average of 53.8 per 1,000 in 1993-94. This represents an increase of 75 percent. The prevalence among children ages 5 to 14 increased 74 percent, from 42.8 per 1,000 in 1980 to an average of 74.4 per

The prevalence of asthma has been increasing since the early 1980s for all age, sex, and racial groups. The overall age-adjusted prevalence of asthma rose from 30.7 per 1,000 population in 1980 to a 2-year average of 53.8 per 1,000 in 1993-94. This represents an increase of 75 percent. The prevalence among children ages 5 to 14 increased 74 percent.

SOURCE CONTROL

8.3.1 Recommend the removal of indoor air pollutants sources identified in BPI-1100, Section 8.1, or implementation of other source control measures.

8.3.2 Sealing, gasketing, or weatherstripping all leaks between an attached or tuckunder garage and the house shall be recommended, including specific leakage paths as identified in BPI-1100, Section 8.2.

8.3.4 Sealing of air handler units and ducts that are located outside the pressure boundary shall be recommended.

8.3.5 For ducts located outside the pressure boundary, recommend R-8 insulation, at a minimum.

https://exams.bpi.org/site/resources/public/online-testing/ANSI-BPI-1200-S-2015-Standard-Practice-for-Basic-Analysis-of-Buildings.pdf

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Why do Widespread Indoor Air Quality Problems Go Unidentified?

- Causes are complex.
- No “warning light” for many issues
- CO detectors are inadequate
- “People spend more time looking at kitchen counter tops rather than the issues that can cause serious health problems”.
  - Nancy Harvey Steorts, Realtor, Author of Your Home Safe Home

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Home Air Infiltration

The single biggest factor affecting comfort, indoor air quality, and energy efficiency

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Where Does Your Home Leak?

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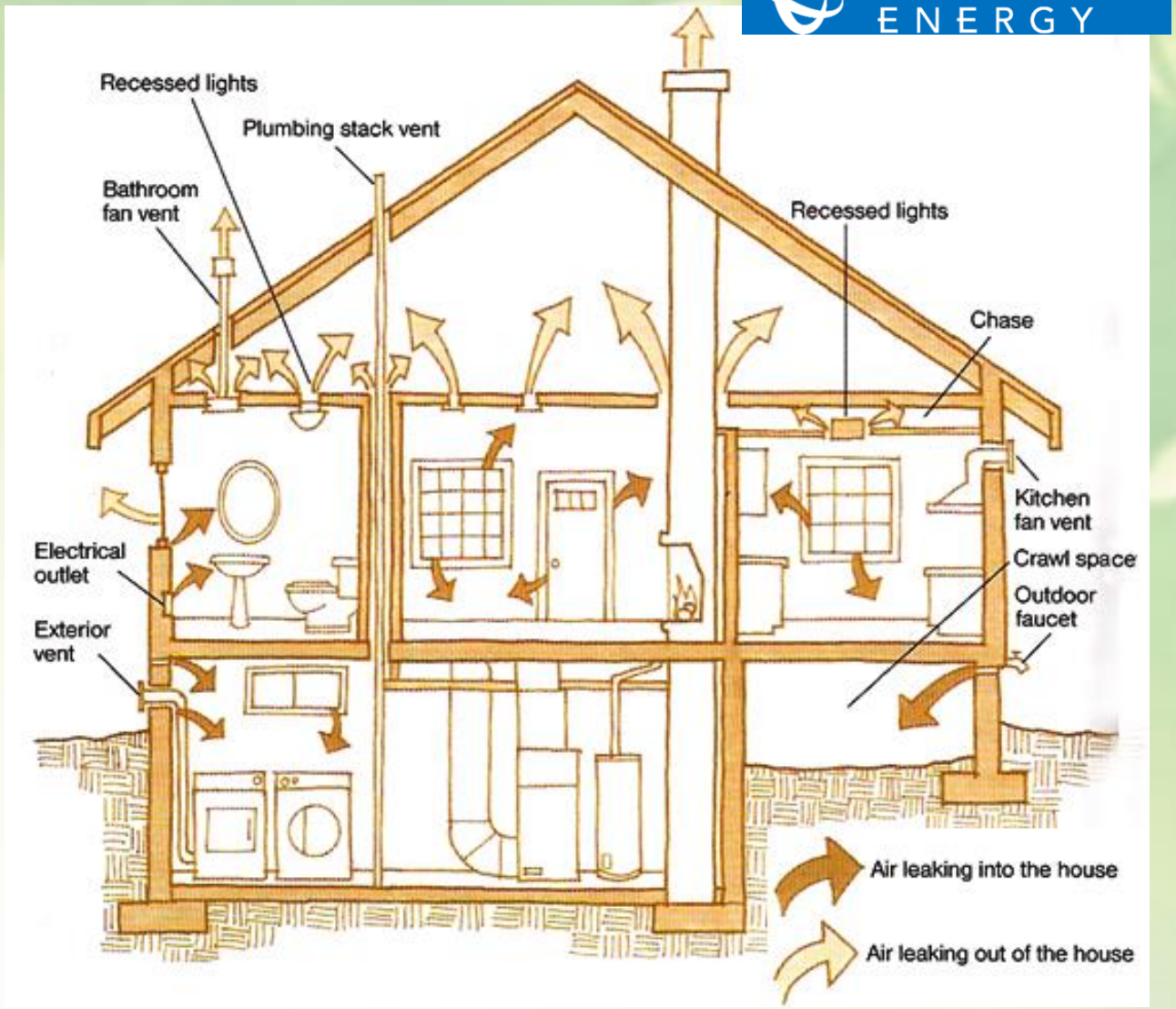

Where are the leaks?

- Electrical and plumbing holes
- Tub access panels in sub floor
- Unsealed sub floor
- Duct leaks in crawlspace

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Are You Breathing CO from Combustion Appliances?

- **25% of SLO County homes tested have combustion appliance safety issues.**
- 85% of homes have “depressurization” due to duct leakage and large fans.
- Can cause standard water heaters to draw flue gasses and CO into home.

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Combustion Safety: This is Dangerous!!!

Dryer in small laundry room depressurizes room and causes water heater flue to “backdraft”

Carbon Monoxide and other combustion gasses commonly enter the living space!

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Combustion Safety: Dangerous Conditions

Water heater flue terminates in attic or is broken in attic.

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Does Your CO Monitor Keep You Safe?

- **UL approved monitors are triggered if:**
  1) exposed to 30ppm for 30 days, or
  2) 70 ppm for four hours, or
  3) 150 ppm for under 50 minutes.
- Harmful effects such as headaches and dizziness flue symptoms are felt at 35 ppm in 6 to 8 hours.
- OSHA allows 50 ppm for 8 hours.

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What is a Safe Level of Carbon Monoxide?

- **UCLA study indicates only 5 ppm is linked to pregnant women having underweight children with smaller heads.**

Concentration	Symptoms
35 ppm (0.0035%)	Headache and dizziness within six to eight hours of constant exposure
100 ppm (0.01%)	Slight headache in two to three hours
200 ppm (0.02%)	Slight headache within two to three hours; loss of judgment
400 ppm (0.04%)	Frontal headache within one to two hours
800 ppm (0.08%)	Dizziness, nausea, and convulsions within 45 min; insensible within 2 hours
1,600 ppm (0.16%)	Headache, tachycardia, dizziness, and nausea within 20 min; death in less than 2 hours
3,200 ppm (0.32%)	Headache, dizziness and nausea in five to ten minutes. Death within 30 minutes.
6,400 ppm (0.64%)	Headache and dizziness in one to two minutes. Convulsions, respiratory arrest, and death in less than 20 minutes.
12,800 ppm (1.28%)	Unconsciousness after 2–3 breaths. Death in less than three minutes.

Chart from Wikipedia.org

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How Dangerous is Radon?

- Naturally occurring odorless gas
- Second leading cause of lung cancer.
- 5.9% of SLO County residents live in homes with radon over EPA action level.
- Radon exposure produces no symptoms.
- Test kits are only about $25
- There are ways to mitigate

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Radon Problems in SLO

- In Templeton, 27.3% of homes are exposed to levels that exceed EPA action level (4 picocuries/liter)
- 18.8% in Atascadero
- In Paso: 8.9%

-Based on 2008 Department of Public Health Indoor Radon Program survey of 918 homes in SLO County. Radon Potential in San Luis Obispo County.

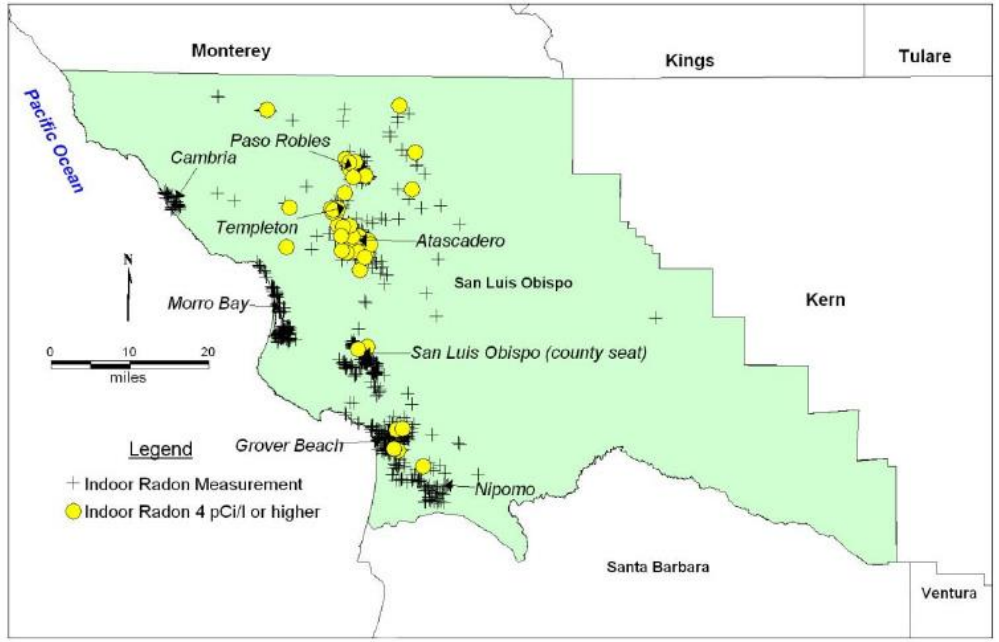

Figure 2. All CDPH Short-Term Radon Test Results for San Luis Obispo County—with 4.0 pCi/l or Greater Sites Shown as Yellow Circles

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Inside Source VOC's

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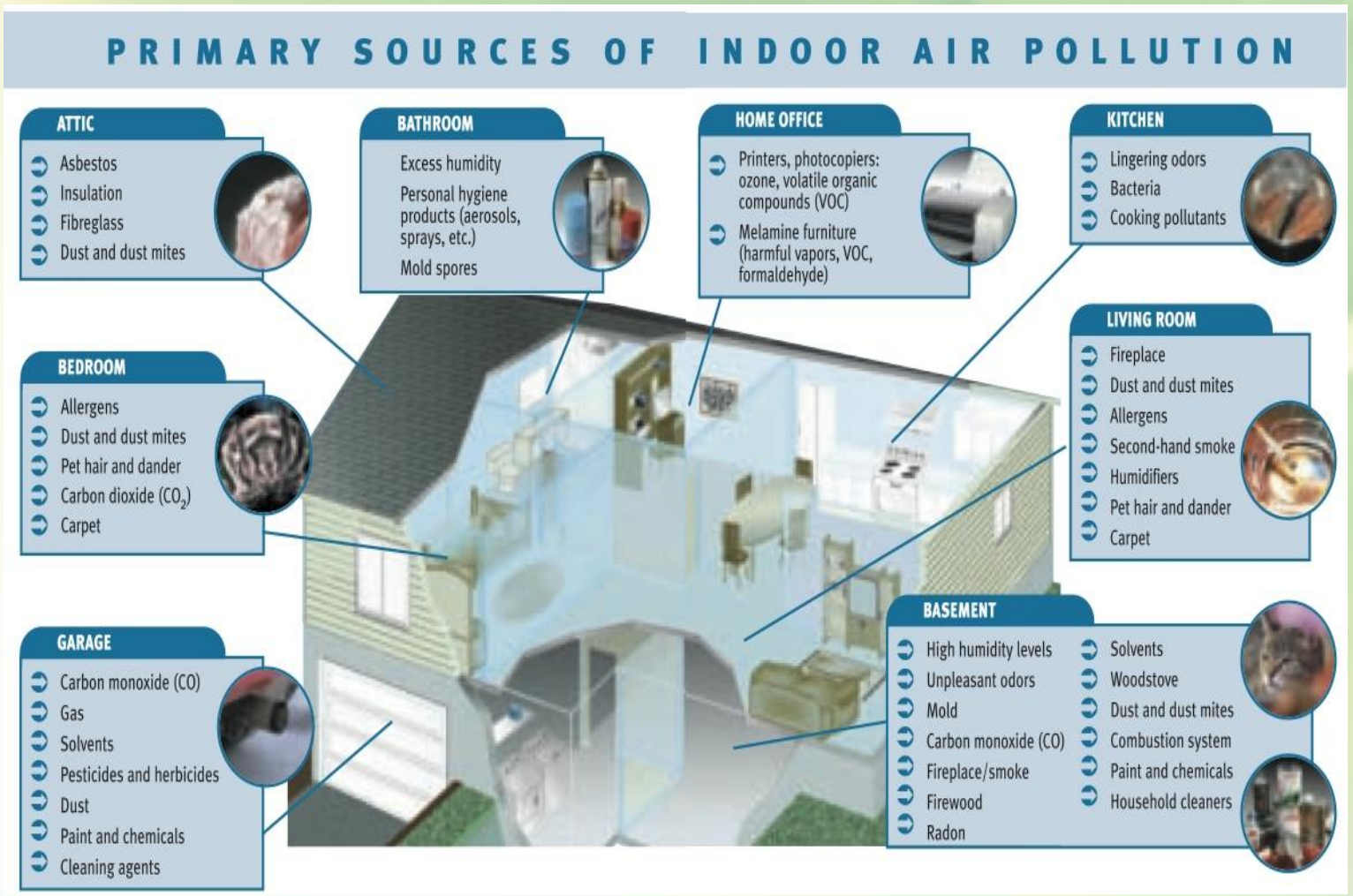
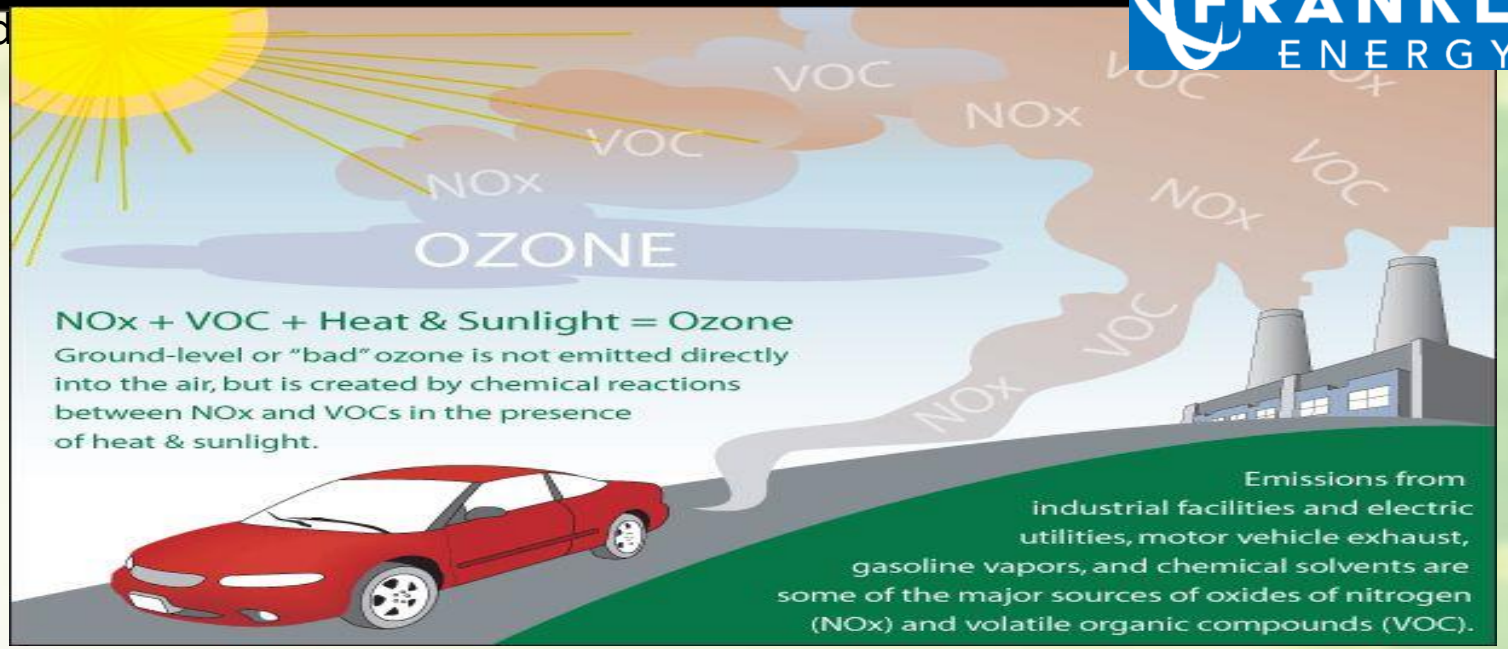


Outsid



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Typical Heating System Problems

- Average home has 30% duct leakage!!!
- Causes toxin infiltration
- All homes before 2004 have issues.
- Use anything but “duct tape”.

See Anything But Duct Tape, by Lawrence Berkeley Labs for the DOE

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Inadequate Venting

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Why Have Dedicated Source of Fresh Air?

- Most homes don't have controlled source of fresh air (required in commercial building).
- HVAC can be designed to continuously draw air from outdoors, but this is not efficient.
- An ERV allows you to bring in fresh air without losing heat and also prevents depressurization.

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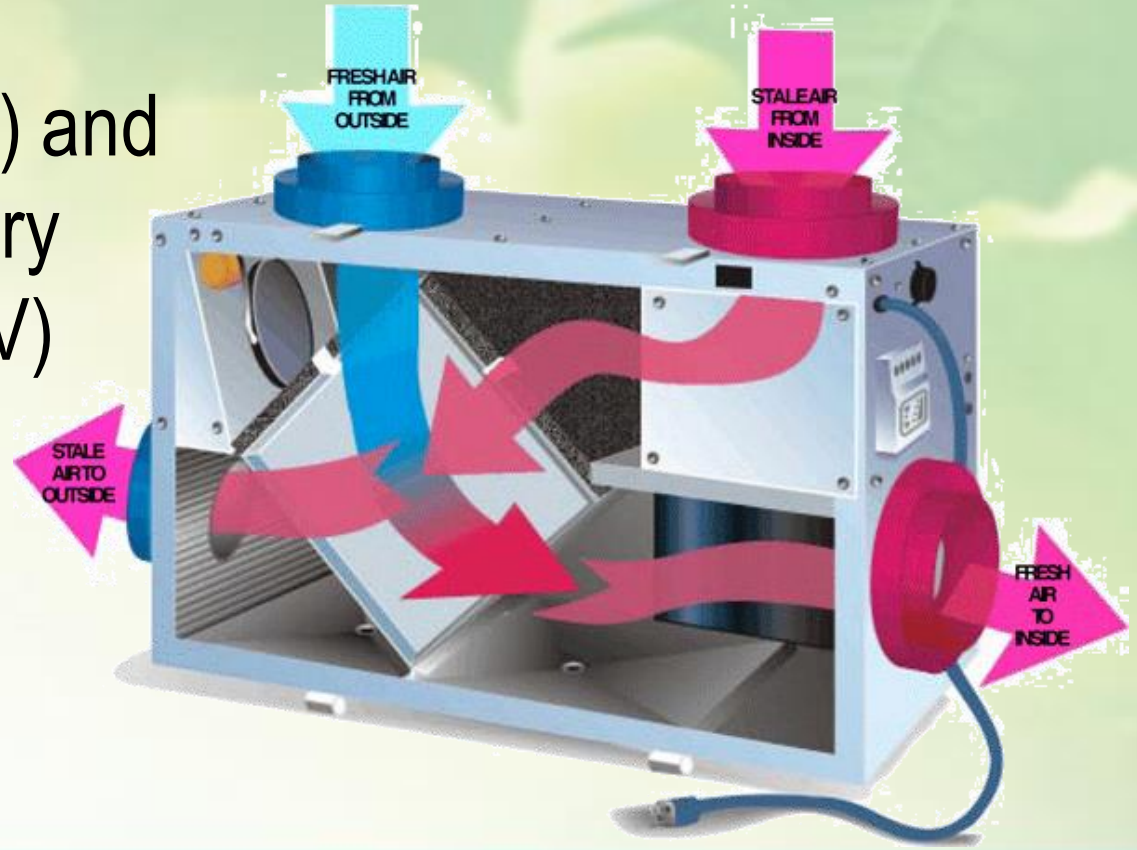
ERV's: Fresh Air without Heat Loss!

Heat Recovery Ventilator (HRV) and Energy Recovery Ventilators (ERV)



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DOE – Building America Project

Project Goals:

- Integrate aerosol envelope sealing into home building process.
- Determine appropriate time for applying
- Measure performance relative to conventional methods
- Determine existing sealing efforts that could be avoided
- Determine cost-effectiveness

73%
Tighter than baseline homes

79%
Average leakage reduction

56%
Greater building tightness using Aerosols versus open-cell spray foam

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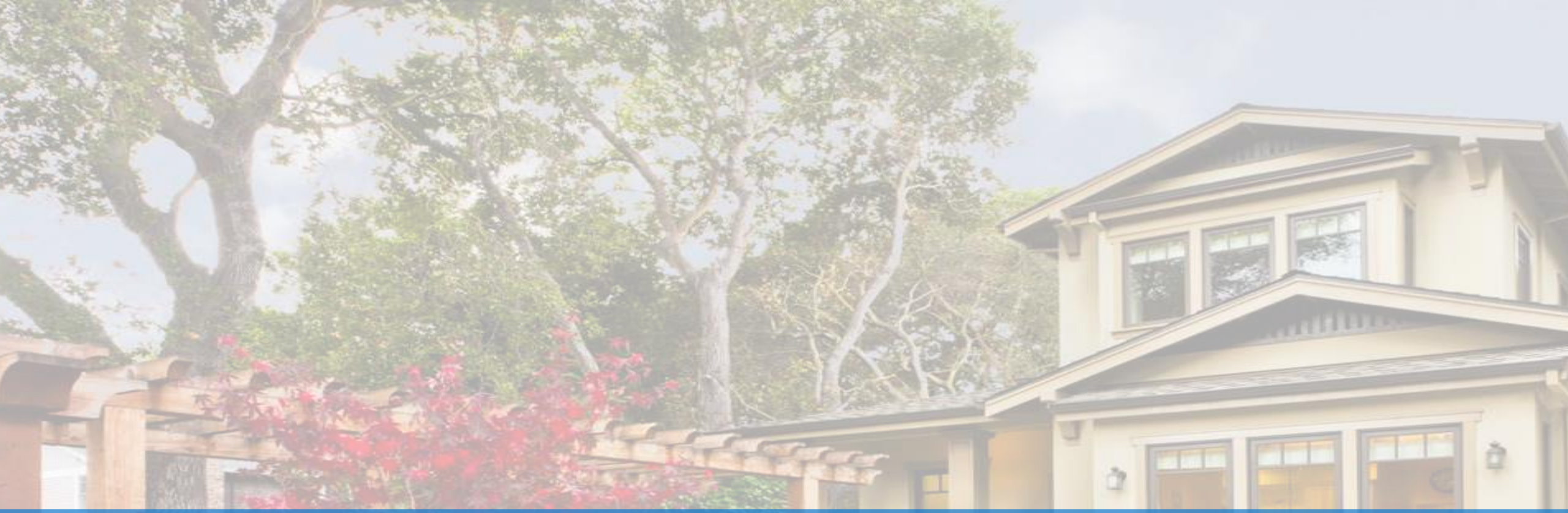
Center for Energy and Environment

Building America U.S. Department of Energy



Build It Green & Franklin Energy Healthy Home Connect

Build It Green®

FRANKLIN ENERGY

Approach

Energy Saving Assistance Program (ESA)

Energy efficiency improvements

Peninsula Minor Home Repair Program + Rebuilding Together

Home repairs with a focus on health & safety

SASH – Single Family Affordable Solar Housing Program

Rooftop solar photovoltaics

Facebook Grant

Gap funding for health remediations + repairs for disqualified homes

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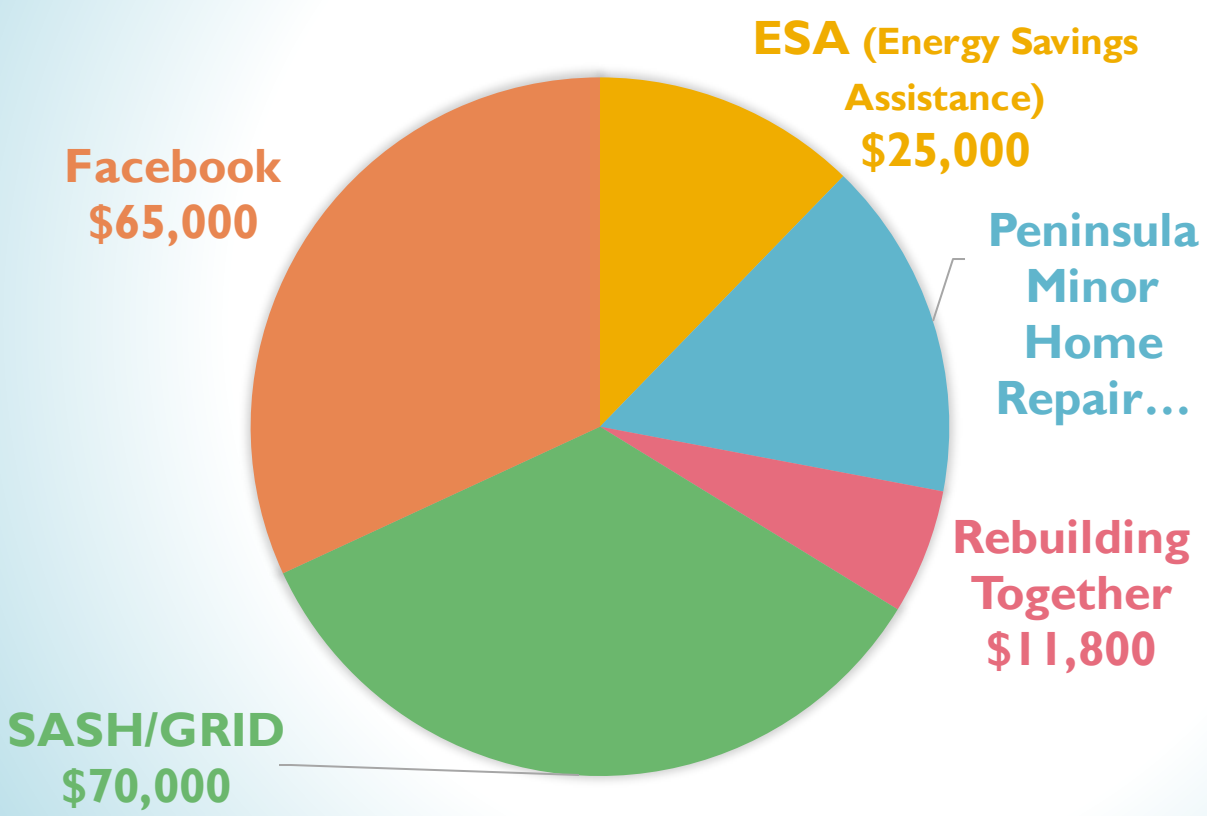
Funds Allocated for Home Improvements: $208,800



"Non-Energy" Measures

Roof repair "for PV"

- Access to roof repair

Sub-floor treatments

- Moisture barrier
- Air sealing
- Radon control

Drainage

- Rain gutters and bulk moisture control

ERV

- Filtered fresh air
- Positive pressure with no energy loss

Build It Green

FRANKLIN ENERGY

Home Snapshot: Belle Haven

Hayward Score of 13

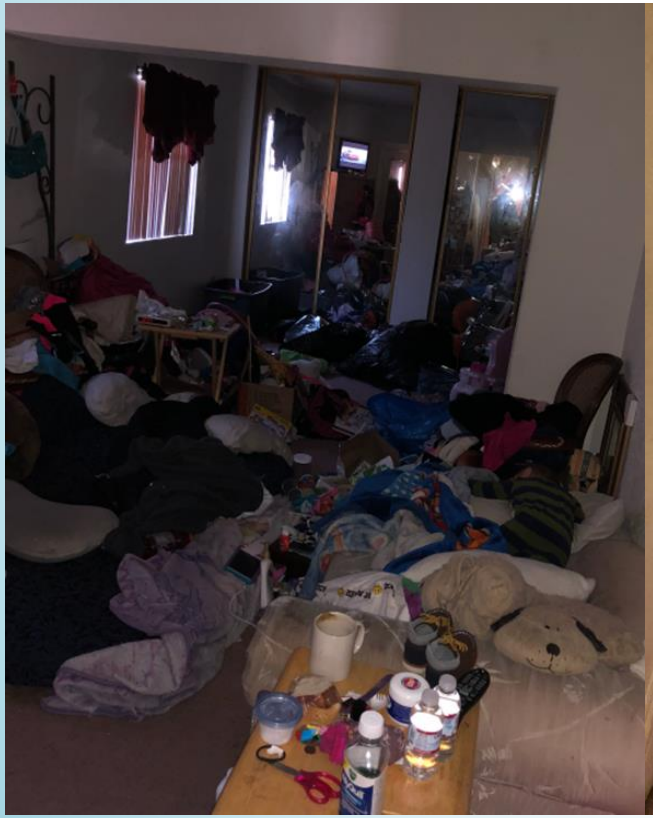
3 People in Household - 3 year old w/ asthma

Build It Green

FRANKLIN ENERGY

Home Snapshot: Belle Haven

Multiple health & safety issues: Dust, mold, pests, clutter, poor IAQ, no vents, no heat, open to attic



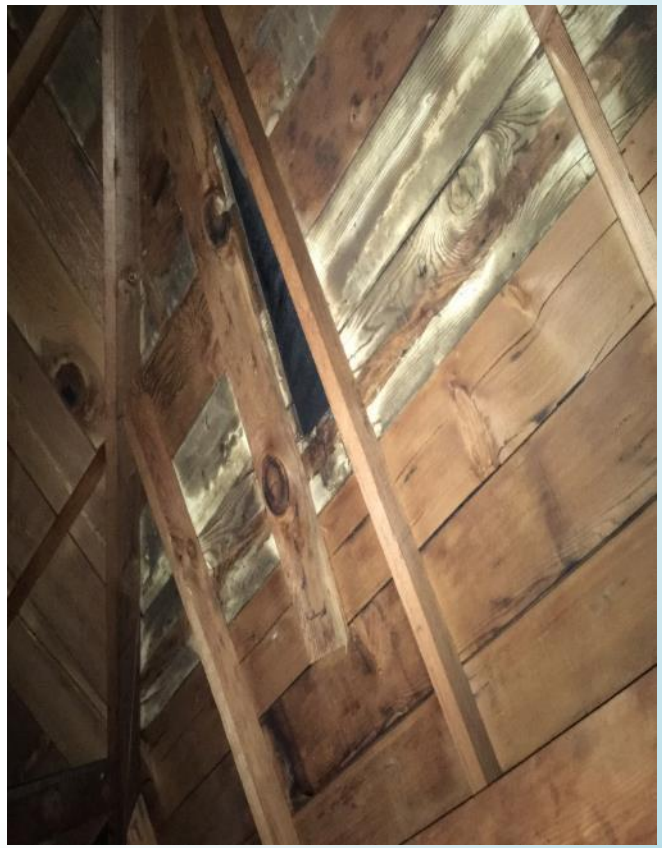
Build It Green

FRANKLIN ENERGY

Home Snapshot: Belle Haven

Hayward Score of 41

1 Person in Household - Elderly



Build It Green

FRANKLIN ENERGY

Home Snapshot: Belle Haven

Multiple health & safety issues: Dust, poor IAQ, poor venting, damaged roof, damaged smoke detector

Build It Green

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Home Snapshot: Belle Haven

Hayward Score of 54

3 People in Household - 6 year old w/ allergies

Build It Green

FRANKLIN ENERGY

Audience Questions?

Meet & Greet

Breakout Room #	Speakers
1	Sara Hayes
2	Joe Medosch
3	Judy Rachel
4	Brett Bishop & Cindy Edwards

Funding, Resources, and Trainings

Jordan Garbayo, 3C-REN

Federal and State Funding for Projects

Financing

- GoGreen Financing offers loans for appliances, insulation, building envelope, and HVAC upgrades.
- The Energy Conservation Assistance Act (ECAA) offers two loan programs through the California Energy Commission for energy efficiency and energy generation projects.

Services

- The Low-Income Weatherization Program (LIWP) provides low-income households with solar PV systems and energy efficiency at no cost.
- The Low-Income Home Energy Assistance Program (LIHEAP) provides free weatherization services to low-income households.

Tax Credits

- ENERGY STAR provides federal income tax credits for building insulation projects for residential and commercial building owners and builders.

IOU Funding for Projects

Comfortable Home Rebates Program

PG&E's Comfortable Home Rebates Program offers rebates for performing energy-saving improvements and air conditioning maintenance to households.

Energy Savings Assistance Program

The Energy Savings Assistance Program (ESA) provides no-cost weatherization services to low-income households who meet the CARE income guidelines. Learn more about this program from PG&E, SCE, and SoCalGas.

Rebates

Both PG&E and SCE below have a marketplace for rebates on air purifiers and ventilation equipment.

Training Resources for Improving IAQ

ASHRAE Learning Institute

Provides a multitude of resources and online trainings on IAQ, IEQ and environmental health.

Building Performance Institute

The Healthy Housing Principles (HHP) Certification program provides an overview of occupant health in homes.

Building Science Corporation

Develops seminars on building science principals and high-performing, energy efficient, and healthy buildings.

Passive House California

Provides training on the application of the International Passive House standard.

PG&E's Pacific Energy Center

Offers and real-time access to professional training, a robust tool-lending library, on-demand courses by industry experts.

SCE's Energy Education Centers

Provides a wide range of trainings on the installation and maintenance of various technologies that improve indoor health.

Small Planet Supply Learning Center

Provides online training on installing, maintaining, and replacing HRV equipment and filters.

WELL AP

The WELL Accredited Professional (WELL AP) offers online courses and certifications on human health, wellness, and building design.

Educational Resources

Berkeley Lab

Houses a resource bank of scientific findings that describe how different building and environmental attributes impact IAQ.

Building Science Corporation

Attic air sealing guide which provides background and approach for adding insulation.

California Air Resources Board

Offers information on how to improve IAQ and reduce your exposure to pollutants.

E4The Future

Whitepaper which provides an overview on the health benefits of residential energy efficiency.

GTI

Guide offering best practices for measuring home performance.

Educational Resources

Hayward Score

Provides a comprehensive list of resources to both learn about and improve the health of your home.

Indoor Chem

Project overview and observations of household microbial and environmental chemistry.

Passive House California

Provides a variety of resources for building professionals interested in incorporating passive house design into their work.

United States Environmental Protection Agency

Provides information on the health benefits of home performance, and the latest science on the performance, operation and use of air sensor monitoring systems.

ROCIS

This checklist enables the identification of deficiencies in the ROCIS Air Handler system and improvements.

Key Takeaways

Mindy Craig, BluePoint Planning

About 3C-REN and Upcoming Offerings

Jordan Garbayo, 3C-REN

Meet & Greet

Breakout Room #	Speakers
1	Sara Hayes
2	Joe Medosch
3	Judy Rachel
4	Brett Bishop & Cindy Edwards

But First…

A Survey!

1. YAY!
2. There's a prize for three lucky individuals!
3. Link in chat

3C
REN

3C
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ENERGY
CODE
CONNECT

3C
REN
BUILDING
PERFORMANCE
TRAINING

3C
REN
HOME
ENERGY
SAVINGS

3C
REN

Learning Units and Upcoming 3C-REN Events

- Continuing Education Units Available
  - Contact spburns@countyofsb.org for AIA LUs
  - Contact jgarbayo@co.slo.ca.us for ICC LUs
- Coming to Your Inbox Soon!
  - Forum Slides, Survey, Recording, and Materials
- Upcoming Courses:
  - Understanding CalGreen Requirements for Res & Non-Res Projects – June 17
  - What Energy Consultants Need to Know About HERS Features – June 24
  - 2021 Q3 – Q4 Course Calendar Coming Soon – Including Several Air Sealing and Ventilation Courses
  - **AND….**

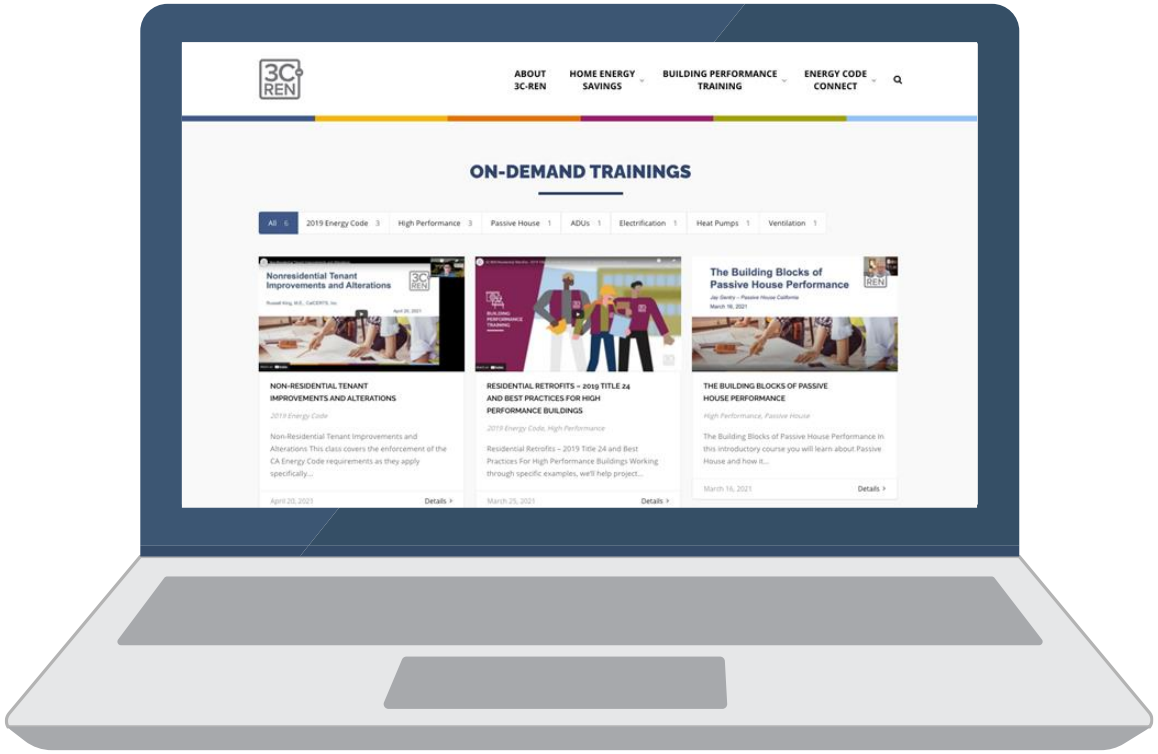
SPECIAL PREVIEW FOR FORUM ATTENDEES

on demand

3C-REN On-Demand Trainings are here!

Get up to speed on electrification, air sealing, ventilation and more—anytime.

Visit **3c-ren.org/on-demand** today



Get Involved!

Visit 3C-REN.org

For questions:
info@3C-REN.org

3C-REN

TRI-COUNTY REGIONAL ENERGY NETWORK

SAN LUIS OBISPO • SANTA BARBARA • VENTURA

Thank You!

Meet & Greet

Breakout Room #	Speakers
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