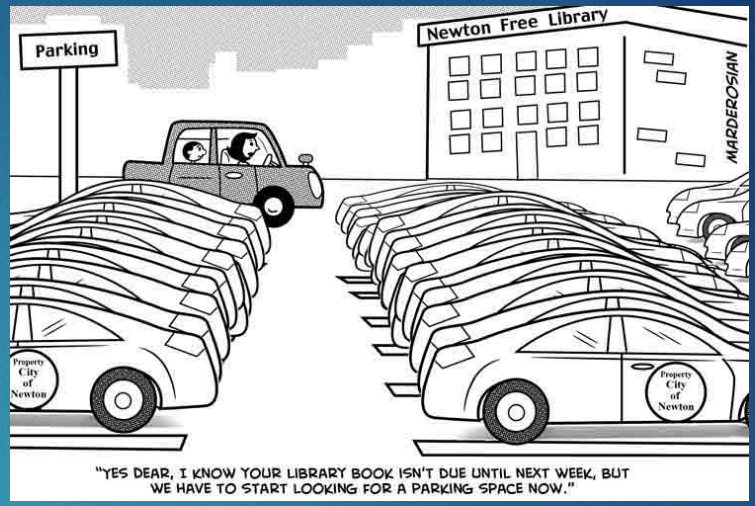
PASSIVE HOUSE INSTITUTE US

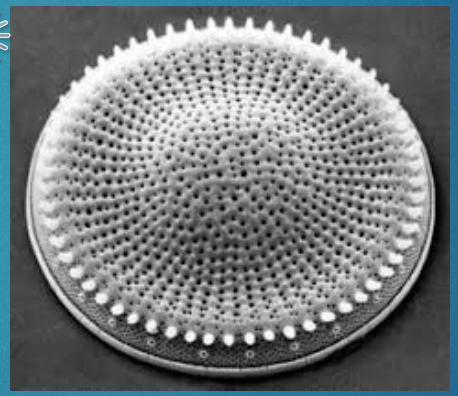
RENEWAIRE ENERGY RECOVERY VENTILATION & IAQ

Can we justify more mechanical ventilation?
If so, why, how & what's next?

What we don't know! We can always learn!



- 40% of cars in cities are looking for parking spots.
- Rainforest O2 used for what?
- Diatoms is what produces Oxygen for the world!



- **Side note;** 2/3's of kids today will do jobs we don't have today!
- 90 – Latitude = Ground Temperature!

IAQ & Ventilation in Perspective

- Structures have become tighter with lower infiltration
  - In early 1900s, there were approximately 50 materials used for construction. By less than100 years later, this list had grown to about?
    - **55,000 materials!**

[+] Raw GJ. *Sick building syndrome: a review of the evidence on causes and solutions*. HSE Contract Research Report no. 42. Building Research Establishment, Garson Watford, 1992.

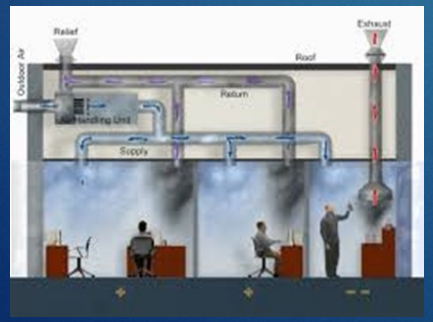
[++] ERT Associates. *Asthma and weatherization in Maine*. National Center for Heathy Housing, 2006.

Trivia

- How much water do we drink daily?
  - 4 lbs.
- How much food do we eat daily?
  - 4 lbs.
- How much air do we breathe daily?
  - 31 lbs.

79 70 89

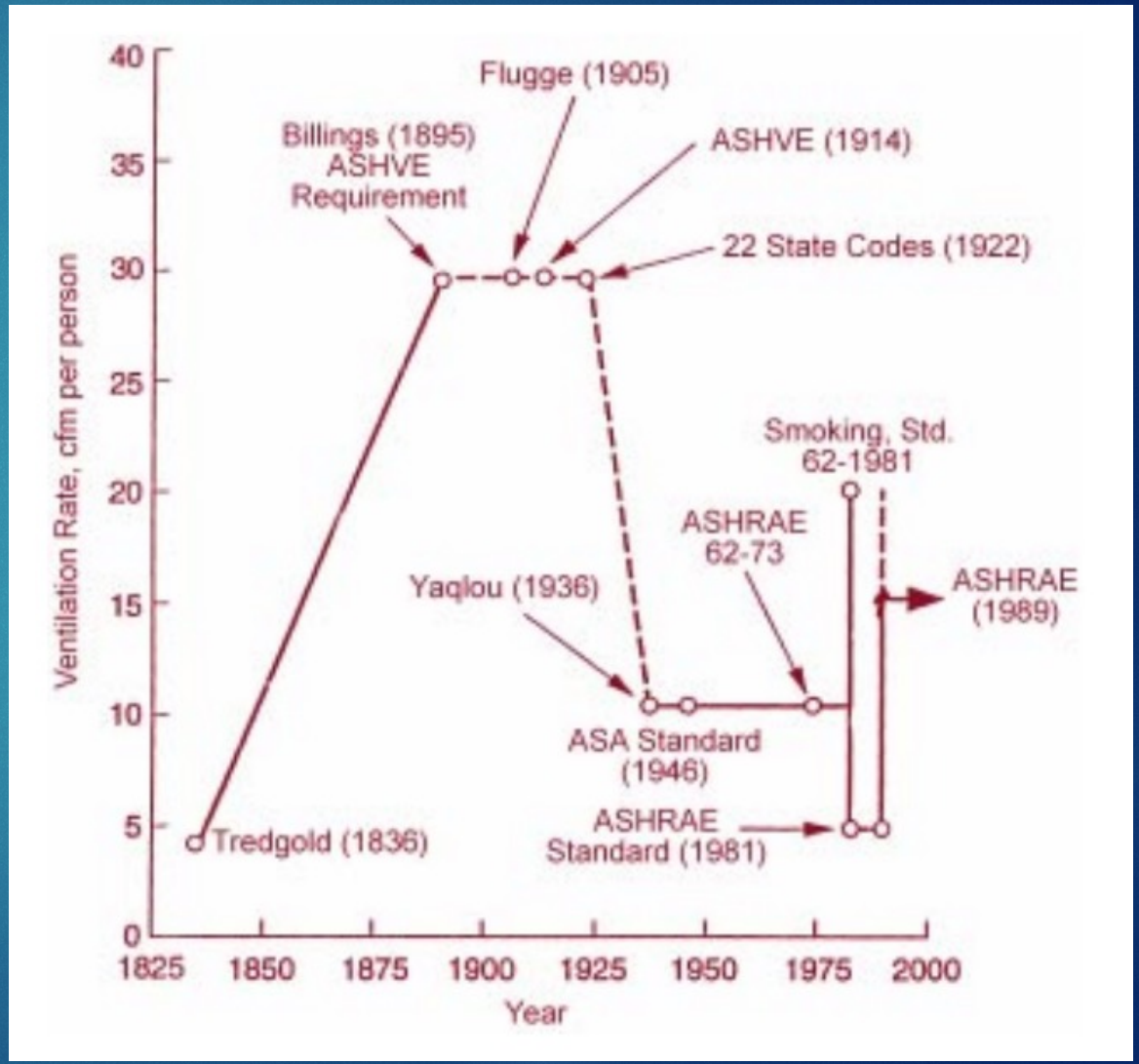
- Average life?
  - 79 years
- 20 years in nonresidential buildings
- 50 years in homes (Residential)
- 89% of an average life is inside the built environment



INDOOR AIR IS 2X-5X AND AS MUCH AS 100X MORE POLLUTED (EPA)

HISTORY OF VENTILATION

- EARLY HUMANS - FIRE AND SMOKE
- EGYPTIAN STONE CARVERS
- MIDDLE AGES – DISEASES
- 1775 – LAVOISIER – CO_2
- 1970'S DUE TO THE ENERGY CRISIS, TO CONSERVE ENERGY IN THE US REDUCES VENTILATION RATES
- LED TO "SICK BUILDING SYNDROME"



Why Ventilate – Contaminates

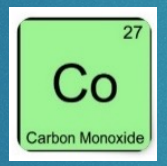
What Always Comes to Mind

- Moisture and Mold
- Odor



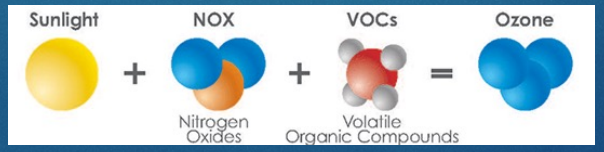
What Often Comes to Mind

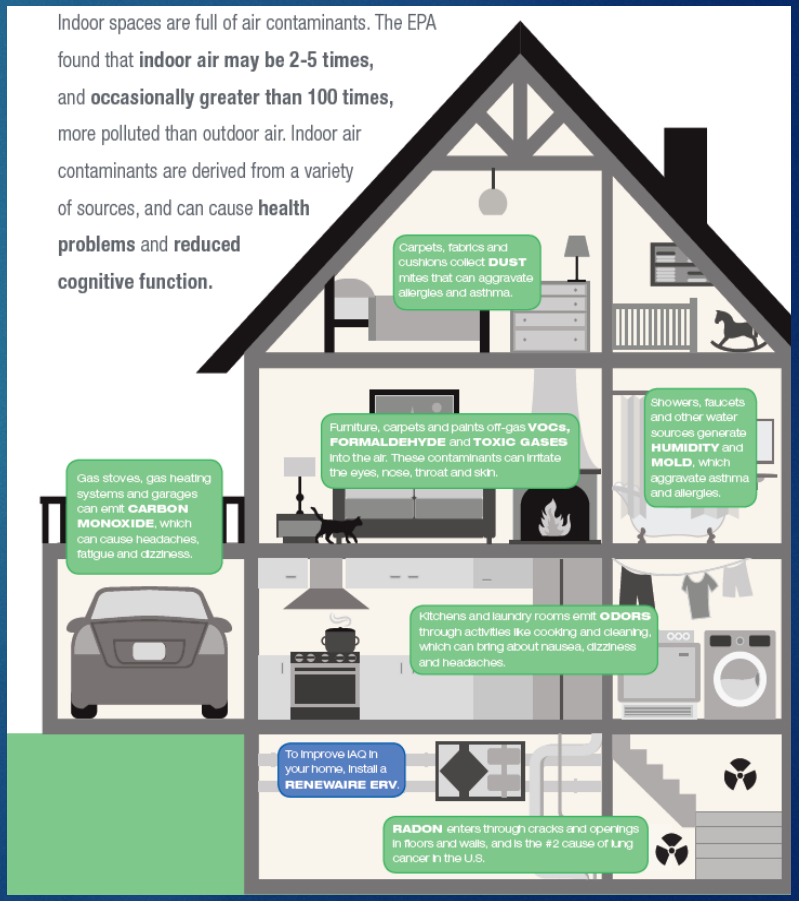
- Carbon Monoxide
- Carbon Dioxide
- Radon



What Occasionally Comes to Mind

- Particles (PM2.5)
- Nitrogen Dioxide
- Formaldehyde
- Ozone
- **TVOC or SVOC**

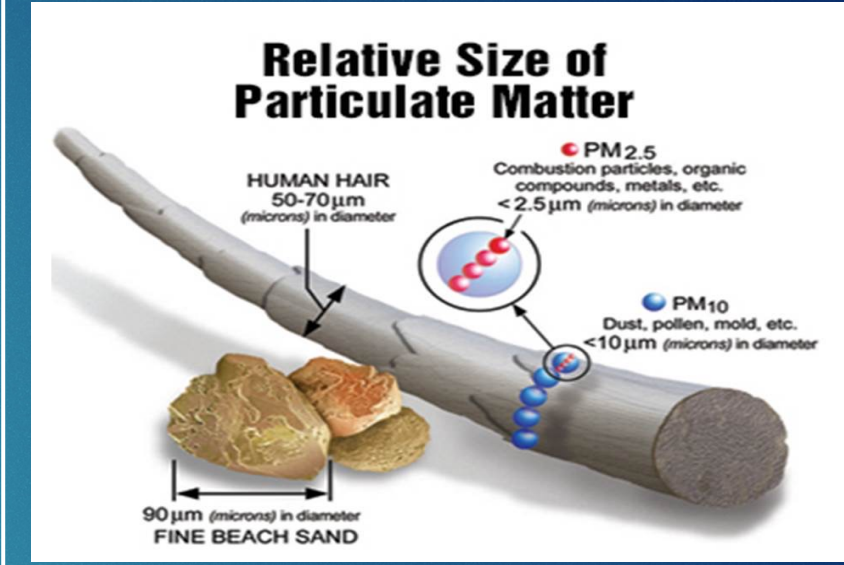


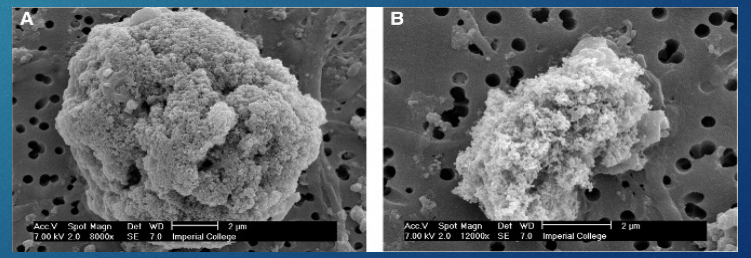
PM 2.5 PARTICULATES

PM 2.5 particulates are receiving increased focus by code influencers

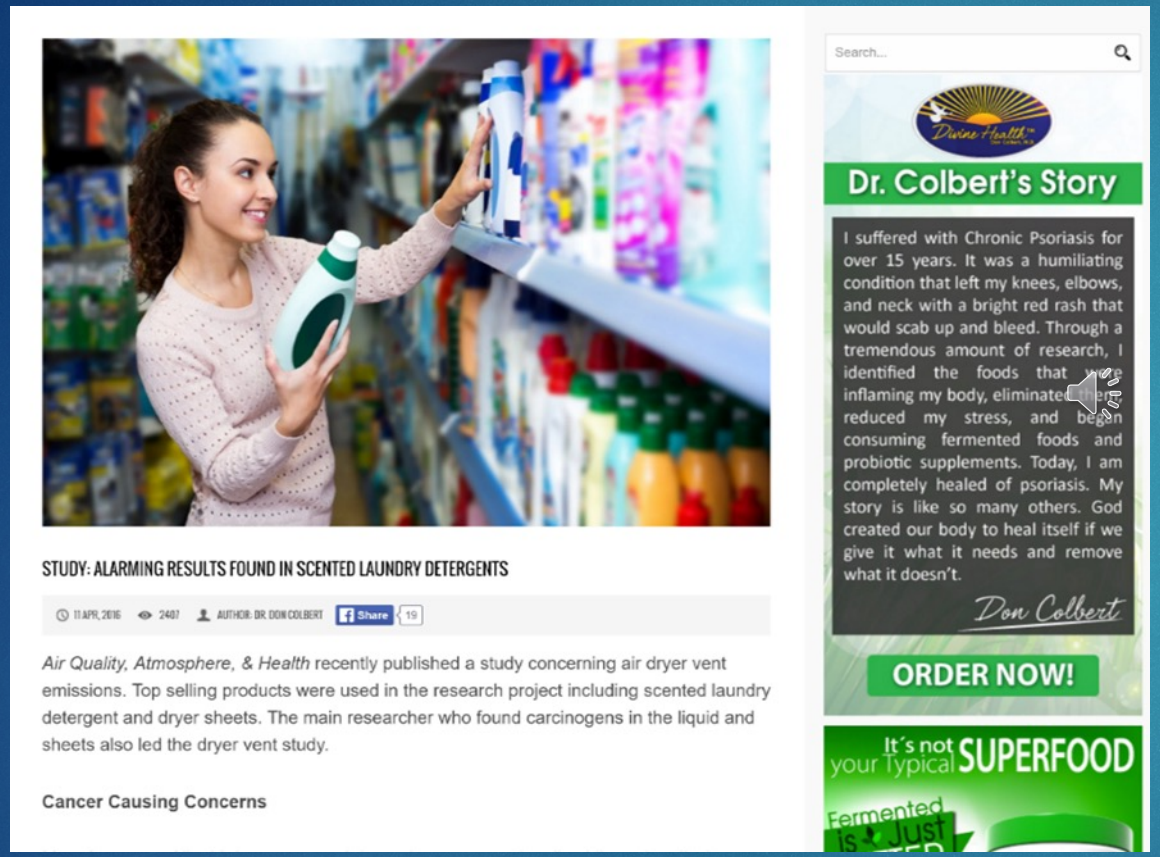
Small size and ability to suspend in the air make them particularly troublesome

Filter effectiveness measures increasingly use PM 2.5 as a measuring stick for particulate removal





IAQ – WHERE IS THE DEFICIENY



STUDY: ALARMING RESULTS FOUND IN SCENTED LAUNDRY DETERGENTS

11 APR, 2016 · 2407 · AUTHOR: DR. DON COLBERT · Share 19

Air Quality, Atmosphere, & Health recently published a study concerning air dryer vent emissions. Top selling products were used in the research project including scented laundry detergent and dryer sheets. The main researcher who found carcinogens in the liquid and sheets also led the dryer vent study.

Cancer Causing Concerns

Analysis of captured gases found more than twenty-five (25) volatile organic combinations which included seven (7) hazardous pollutants. Two of the chemicals, acetaldehyde, and benzene are grouped as carcinogens by the Environmental Protection Agency

Interestingly, there are no regulations on dryer vent emission. According to the research study, emission from the dryer vents (using the top five brands of laundry soap detergent) in the Seattle (Washington) area alone would constitute six percent (6%) of automobile emission of acetaldehyde.

Reference: 11 APR, 2016 author: Dr. Don Colbert

IMPACT OF COVID-19 ON VENTILATION DESIGN

- CODES WILL EVENTUALLY REACT TO THE "NEW NORMAL" OF VIRUS MANAGEMENT
- LOOK FOR STRONGER FILTRATION AND HIGHER MINIMUM VENTILATION REQUIREMENTS
- DECOUPLED VENTILATION IS MOVING TOWARD STANDARD DESIGN PRACTICE
- BUILDING OWNERS WILL CALL FOR PROTECTION FROM LEGAL EXPOSURE
- A WHOLISTIC SYSTEM APPROACH TO HVAC IS MORE IMPORTANT THAN EVER
- https://www.msn.com/en-us/Video/tuneall/how-a-restaurants-ventilation-system-can-affect-the-spread-of-the-coronavirus/vi-BB13Ysxa?ocid=ientp
- https://globalnews.ca/news/6940893/staff-infected-vigi-mont-royal-residence-ventilation/

REHVA
Federation of European Heating, Ventilation and Air Conditioning Associations

ASHRAE

- Increase outdoor air ventilation (use caution in highly polluted areas); with a lower population in the building, this increases the effective dilution ventilation per person.
- Disable demand-controlled ventilation (DCV).
- Further open minimum outdoor air dampers, as high as 100%, thus eliminating recirculation (in the mild

Statement on operation of heating, ventilating, and air-conditioning systems to reduce SARS-CoV-2 transmission: Ventilation and filtration provided by heating, ventilating, and air-conditioning systems can reduce the airborne concentration of SARS-CoV-2 and thus

LATEST CDC GUIDELINES

CDC Centers for Disease Control and Prevention

COVID-19

Ventilation in Buildings

Updated Mar. 23, 2021 Print

Summary of Recent Changes

Updates as of March 23,2021

- Simplified language in the overall list of tools to improve ventilation.
- Added three new Frequently Asked Questions (FAQs) on the usefulness of carbon dioxide monitors to inform ventilation decisions, the useful of temperature and relative humidity to control the spread of COVID-19, and the use of fans indoors.
- Expanded the FAQ on emerging technologies to include more products available on the market.
- Added additional information with simple calculations to the FAQ on portable HEPA air cleaners to help consumers choose appropriate units for their spaces.

CDC recommends a layered approach to reduce exposures to SARS-CoV-2, the virus that causes COVID-19. This approach includes using multiple mitigation strategies, including improvements to building ventilation, to reduce the spread of disease and lower the risk of exposure. In addition to ventilation improvements, the layered approach includes physical distancing, wearing face masks, hand hygiene, and vaccination.

LATEST CDC GUIDELINES

Many new air disinfection devices are marketed for their ability to inactivate SARS-CoV-2. How can I tell if they work as advertised?

CDC does not provide recommendations for, or against, any manufacturer or product. There are numerous technologies being heavily marketed to provide air cleaning during the ongoing COVID-19 pandemic. Common among these are ionization, dry hydrogen peroxide, and chemical fogging disinfection. Some products on the market include combinations of these technologies. These products generate ions, reactive oxidative species (ROS, which are marketed using many names), or chemicals into the air as part of the air cleaning process. People in spaces treated by these products are also exposed to these ions, ROS, or chemicals.

While variations of these technologies have been around for decades, relative to other air cleaning or disinfection methods, they have a less-documented track record when it comes to cleaning/disinfecting large and fast volumes of moving air within heating, ventilation, and air conditioning (HVAC) systems or even inside individual rooms. This does

w.cdc.gov/coronavirus/2019-ncov/community/ventilation.html

Ventilation in Buildings | CDC

not necessarily imply the technologies do not work as advertised. However, in the absence of an established body of peer-reviewed evidence showing proven efficacy and safety under as-used conditions, the technologies are still considered by many to be "emerging."

As with all emerging technologies, consumers are encouraged to exercise caution and to do their homework. Registration alone, with national or local authorities, does not always imply product efficacy or safety. Consumers should research the technology, attempting to match any specific claims against the intended use of the product. Consumers should request testing data that quantitively demonstrates a clear protective benefit and occupant safety under conditions consistent with the intended use. When considering air cleaning technologies that potentially or intentionally expose building occupants, the safety data should be applicable to all occupants, including those with health conditions that could be aggravated by the air treatment. In transient spaces, where average exposures to the public may be temporary, it is important to also consider occupational exposures for workers that must spend prolonged periods in the space.

HOW SUCCESSFUL HAVE WE BEEN IN ACHIEVING HEALTHY INDOOR AIR QUALITY?

US DOE Ventilation Study

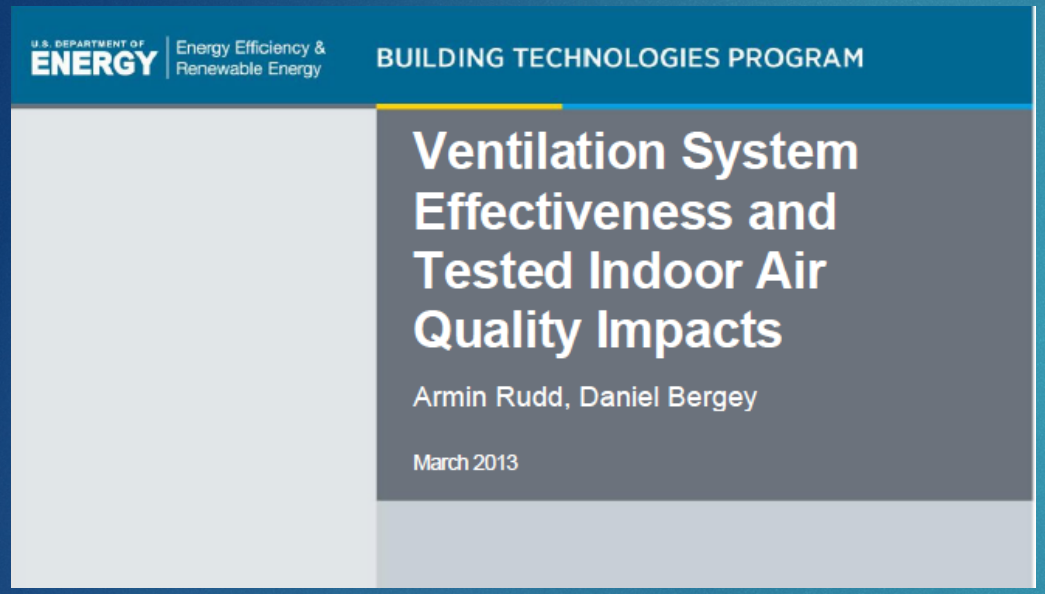
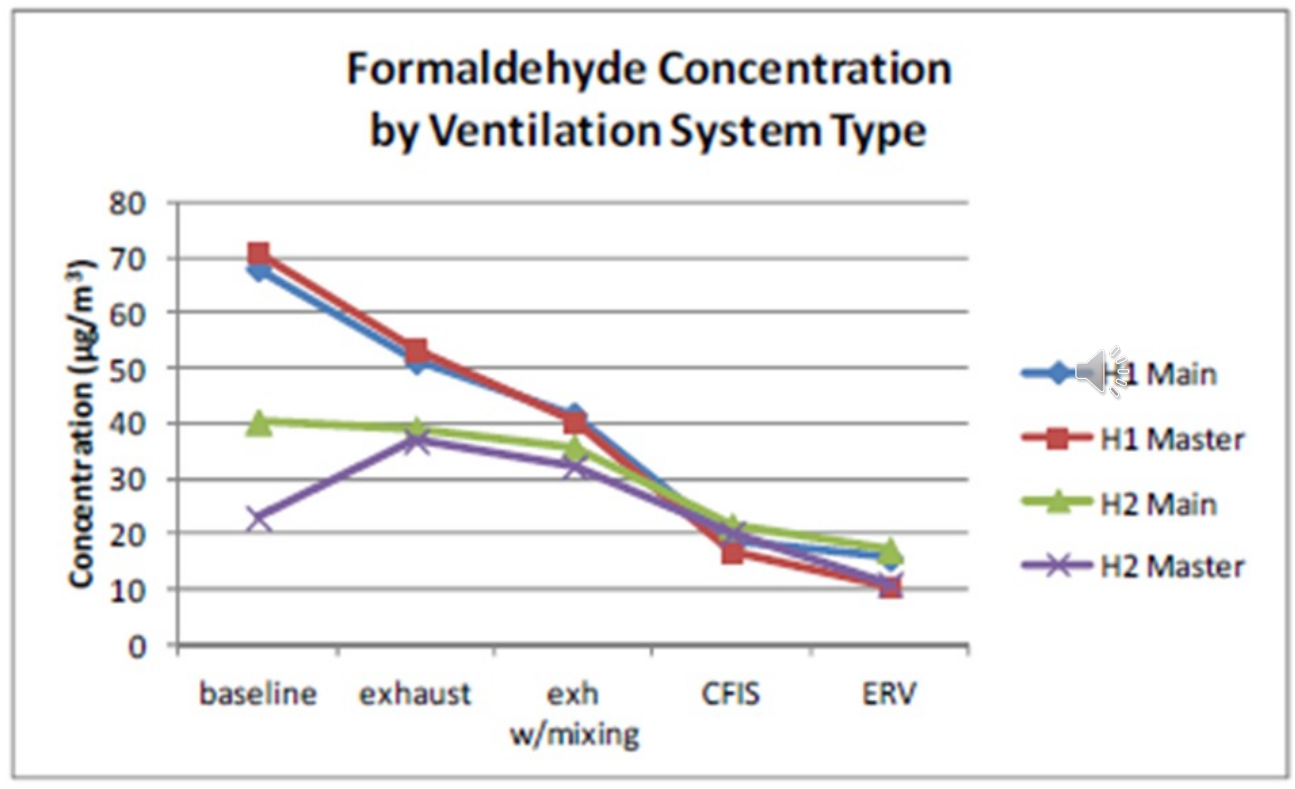
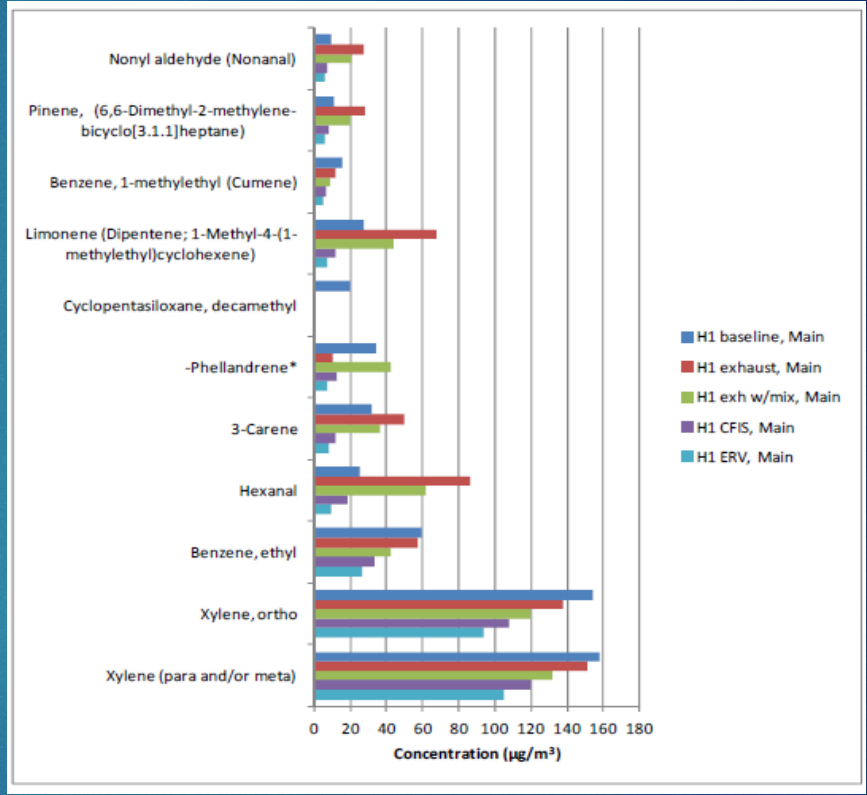


Table 2. Test number, name, and description of the five tests conducted in each house

Test Number	Test Name	Test Description
1	Baseline	No ventilation, bedroom doors closed, no central fan operation
2	Exhaust	Exhaust ventilation from master bathroom, bathroom door open to bedroom, bedroom doors closed, no central fan operation
3	Exh w/mixing	Exhaust ventilation from master bathroom, bathroom door open to bedroom, bedroom doors closed, 20% central fan operation (48 off / 12 on)
4	CFIS	Central-fan-integrated supply (CFIS) ventilation, bedrooms closed, 33% central fan duty cycle (20 off / 10 on)
5	ERV	Balanced (ERV) ventilation, bedrooms closed, no central fan operation

US DOES Ventilation Study



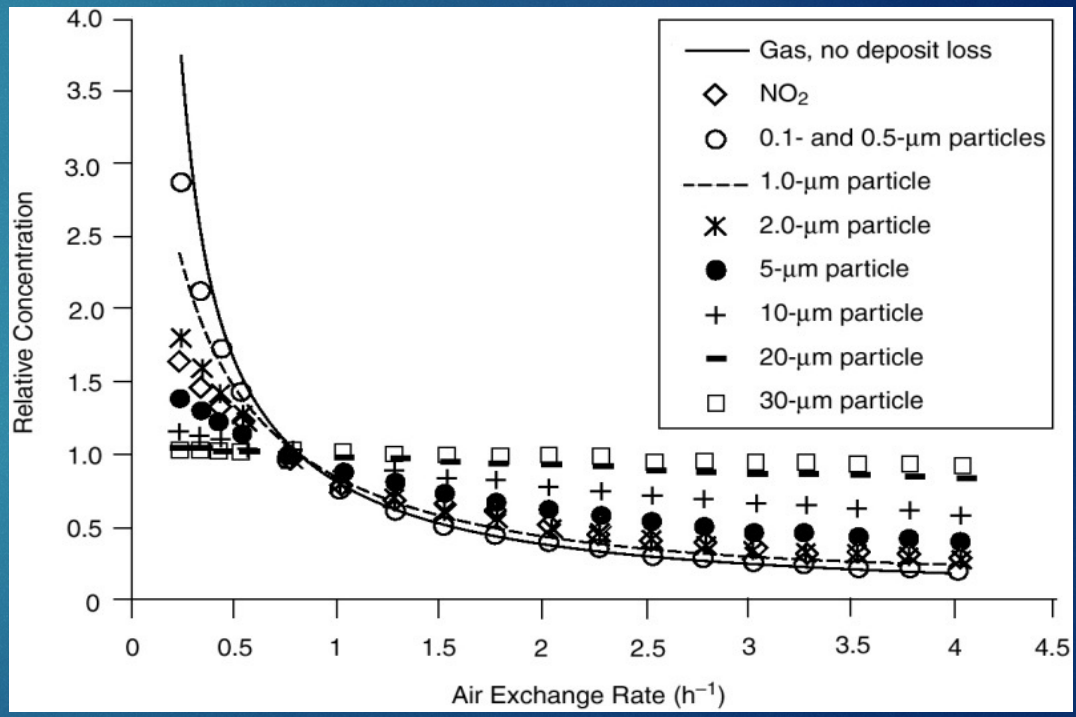


INSTITUTE OF MEDICINE STUDY

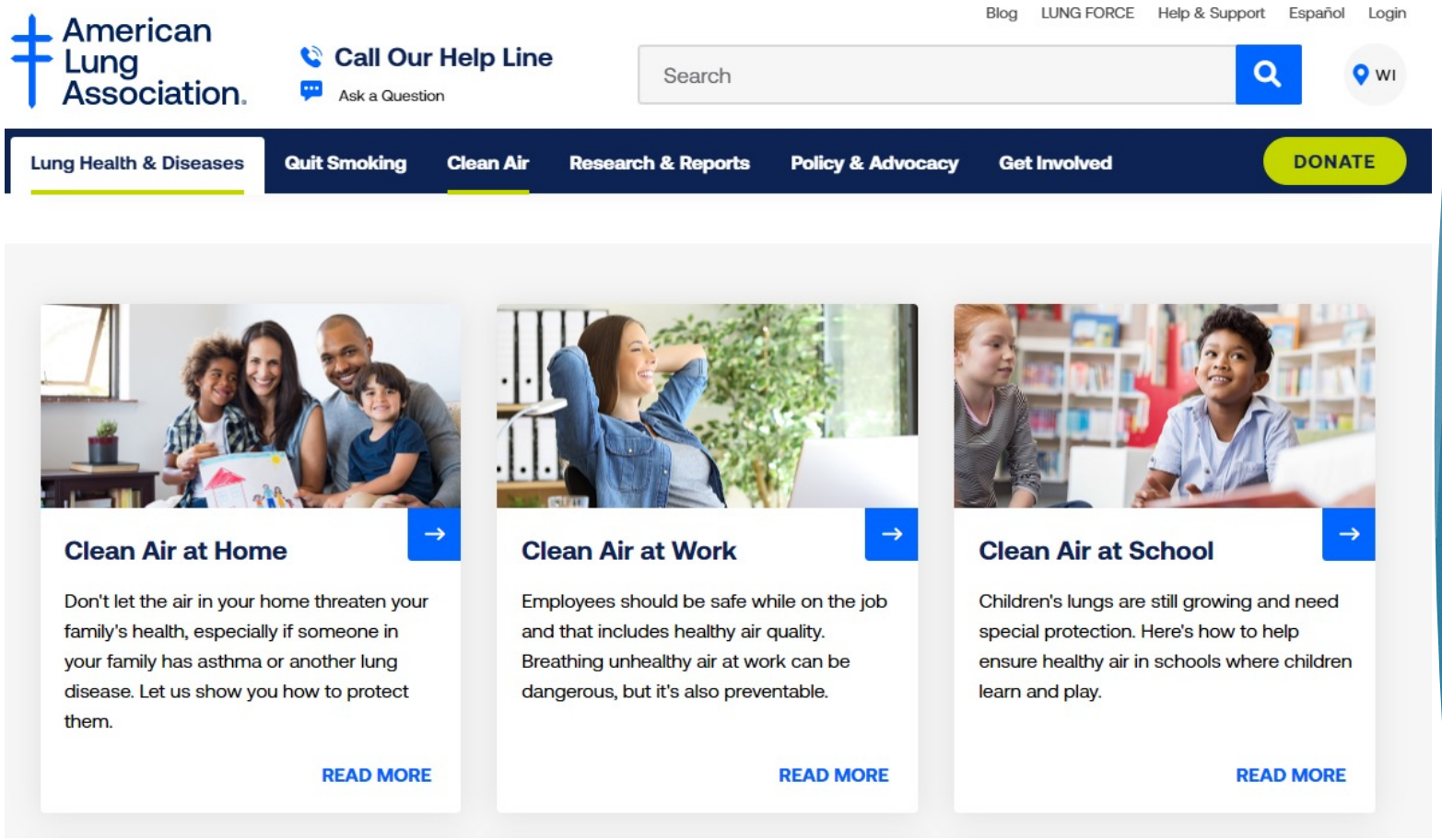
METHODS TO ENHANCE IAQ

- MINIMIZE CHEMICAL POLLUTANTS
- MOISTURE CONTROL
- FILTRATION
- PROPER MAINTENANCE OF HVAC SYSTEMS
- **IMPROVED VENTILATION – SIMPLEST AND MOST COST-EFFECTIVE METHOD**

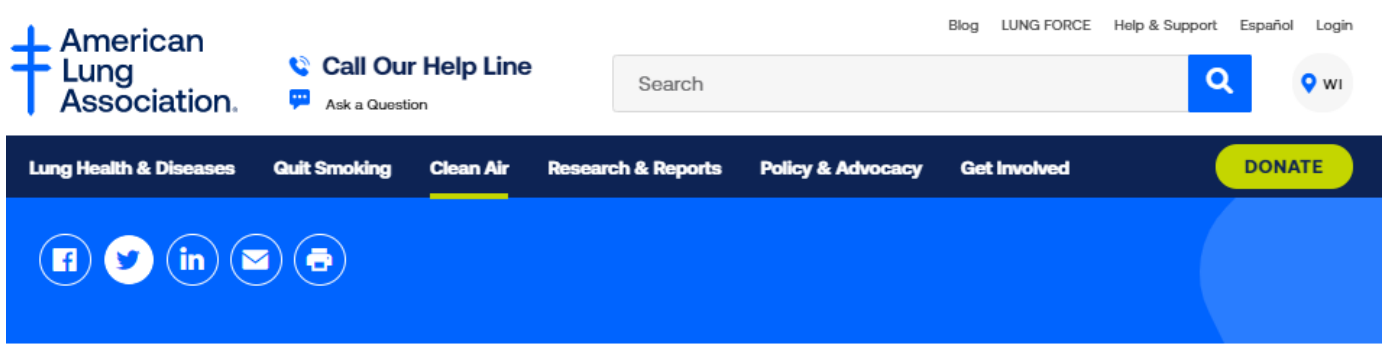
"Ventilation is providing for acceptable IAQ)through the simultaneous exhaust of stale air and supply of fresh outdoor air."



Source: Institute of Medicine (US) Committee on the Assessment of Asthma and Indoor Air.
Washington (DC): National Academies Press (US) ; 2000.



American Lung Association



The key to fixing problems in the indoor air at work are these steps. They take time to work through, but they are core to healthy indoor air.

1. Identify the source(s) of the problem.

Many sources can be removed or kept out of the workspace once identified. However, several sources may combine to become a more serious problem together than they are separately. Are some rooms worse than others or is the problem occur more frequently when some activity occurs?

2. Remove the source of the problem.

Depending on the source, this can be easy (for example, remove the garbage) or may take more work (for example, switch cleaning chemicals). Make sure the workplace is 100 percent tobacco-free. Clean damaged or dirty materials. Remove and replace materials too saturated or damaged to be adequately cleaned. For example, drywall or carpeting that has been flooded will likely need replacing rather than just cleaning.

3. Make sure the ventilation system is working correctly and that air flow is not blocked.

Inadequate ventilation is one of the most common causes of problems with indoor air in a workplace.[1]

For more information about solving indoor air problems, check out these tools available online. They are designed to help building professionals investigate and solve indoor air problems in the workplace.

- Learn more about the steps to create a lung friendly workplace and get access to template policies and proven effective strategies on our Corporate Wellness page.
- Download the free guidance model IAQ Building Education and Assessment Model (I-BEAM) from the U.S. Environmental Protection Agency.
- Get a technical guide to investigating problems from the Occupational Safety and Health Administration, click here.

PHIUS
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American Lung Association

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MENU

Canada.ca > National Research Council Canada > Research and development > Products and services > Software and applications

IA-Quest: indoor air quality emission simulation tool

From: National Research Council Canada

Overview of the tool

Canadians spend 90% of their time indoors, making indoor air quality (IAQ) an important issue. Testing conducted at the National Research Council (NRC) has identified building materials as key sources of indoor pollutants. Controlling these sources is the most effective strategy to improving IAQ.

Experts at the NRC have developed indoor air quality prediction software called IA-Quest (Indoor Air Quality Emission Simulation Tool). IA-Quest provides a database of materials and their measured emissions, allowing materials to be selected based on low emissions. In addition, the tool predicts the emission of volatile organic compounds (VOCs) from building materials and furnishings, helping to quantify the effect of low-emission materials and effective ventilation strategies on IAQ.

IA-Quest users can:

- browse a database of measured emission characteristics for various building materials
- query and search the database

Download IA-Quest

Related links

IA-Quest - Frequently asked questions
IA-Quest registration for software update notifications

Contact us

General enquiries

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Email: IAQuest@nrc-cnrc.gc.ca

Business enquiries

Chris Pezoulas, Business Advisor

https://nrc.canada.ca/en/research-development/products-services/software-applications/ia-quest-indoor-air-quality-emission-simulation-tool

PHIUS Passive House Institute US

Government of Canada

NASA STUDY CO2 STUDY

EFFECTS OF PROLONGED CO2 EXPOSURE

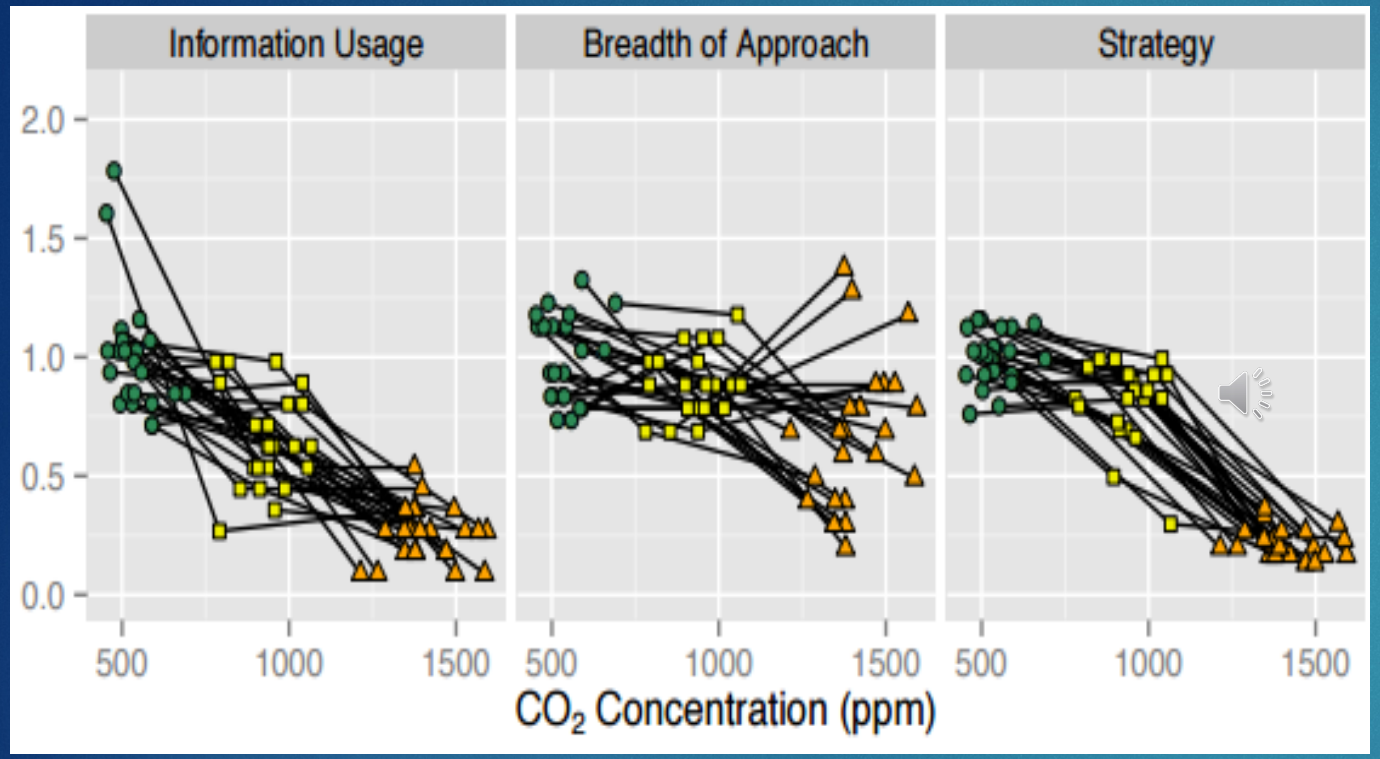
- HUMANS GENERATE 200 ML OF CO_2
- ***RESPIRATORY ACIDOSIS*** OCCURS FEW MINS AFTER EXPOSURE TO CO_2
- LEADS TO ***PULMONARY RESPONSE***
- CO_2 IS A POTENT ***VASODILATOR OF CEREBRAL BLOOD VESSELS***
- ELEVATED CO_2 LEVELS LEAD TO ***RENAL CALCULI***

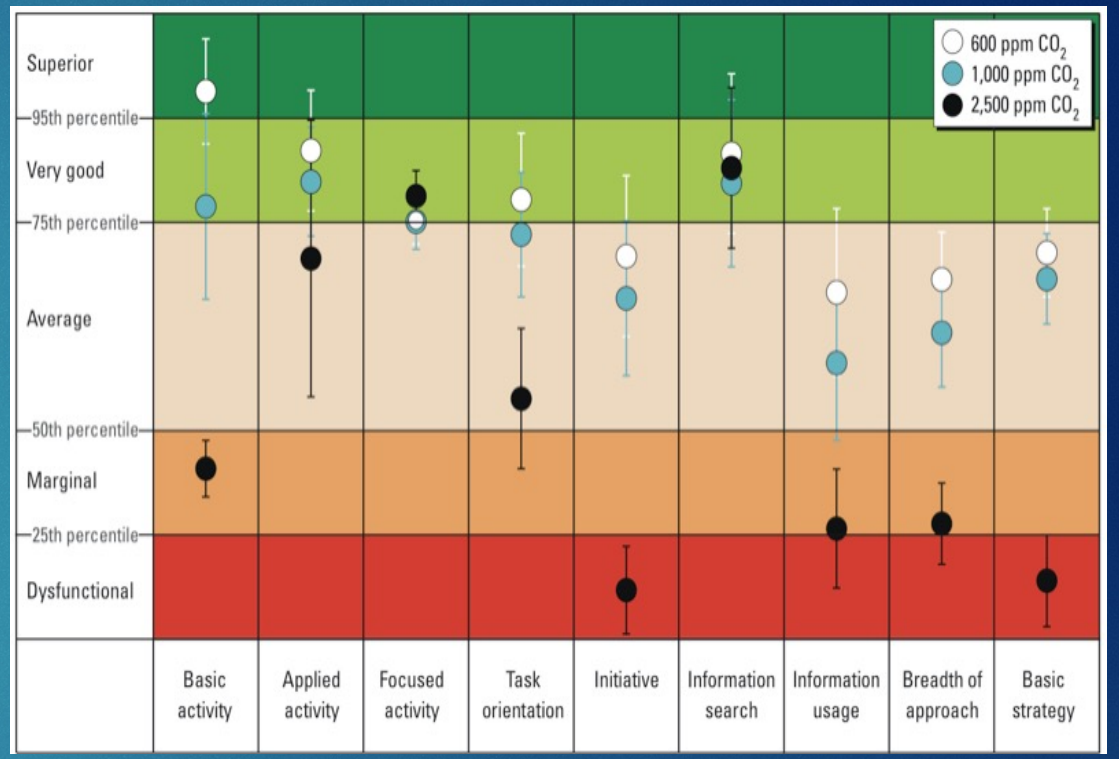
NASA/TP-2012-217358

Chronic Exposure to Moderately Elevated CO_2 during Long-Duration Space Flight

The effects of CO_2 toxicity can include dyspnea, increased respiratory and heart rate, headache, decreased alertness, anxiety, dizziness, muscle twitching, coma, or death. Symptom severity is related to the concentration of CO_2 and the length of the exposure. Headache is the symptom most commonly reported by ISS flight crew, typically when levels reach 0.7% CO_2 (5 mmHg) (Carr 2006). The SMAC for

CO2 AND COGNITIVE FUNCTION





Relatively small increases in CO2 levels significantly affect cognitive function

Source: Satish et al. (2012) Is CO2 an Indoor Pollutant? Direct Effects of Low-to-Moderate CO2 Concentrations on Human Decision-Making Performance

Source: Allen et al (2015) Associations of Cognitive Function Scores with Carbon Dioxide, Ventilation, and Volatile Organic Compound Exposures in Office Workers

VENTILATION OR INDOOR AIR QUALITY (IAQ) OR HEALTH

ASHRAE

ASHRAE Guideline 42P

Advisory Public Review Draft

Indoor Air Quality in

and Institution

Advisor

(Co

This draft has been recommended for public review by the responsible proje
this proposed guideline, go to the ASHRAE website at www.ashrae.org/standa
drafts and access the online comment database. The draft is subject to modi
by the Board of Directors. Until this time, the current edition of the guideline (a
the ASHRAE website) remains in effect. The current edition of any guidelin
Online Store at www.ashrae.org/bookstore or by calling 404-636-8400 or 1-
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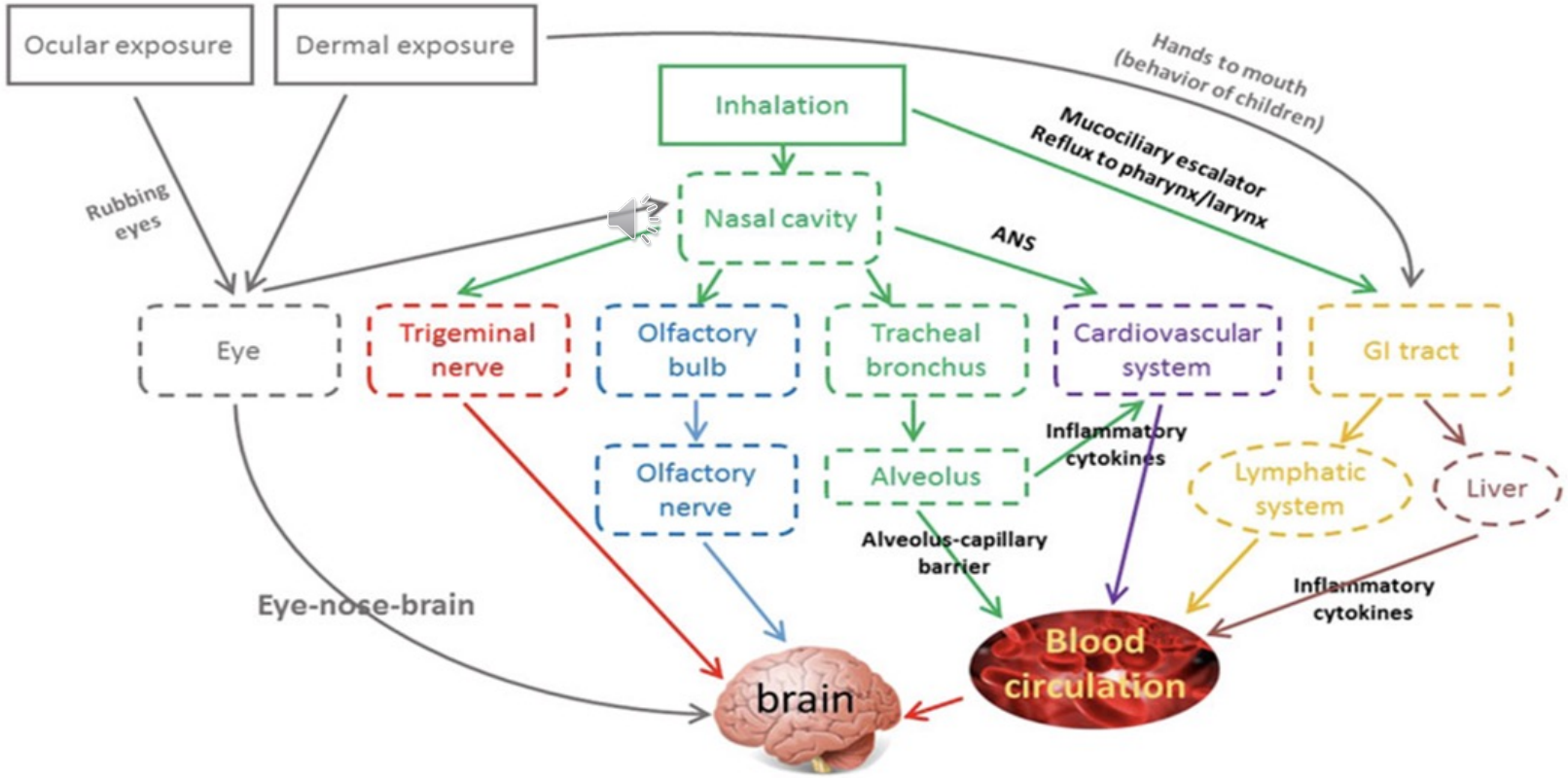
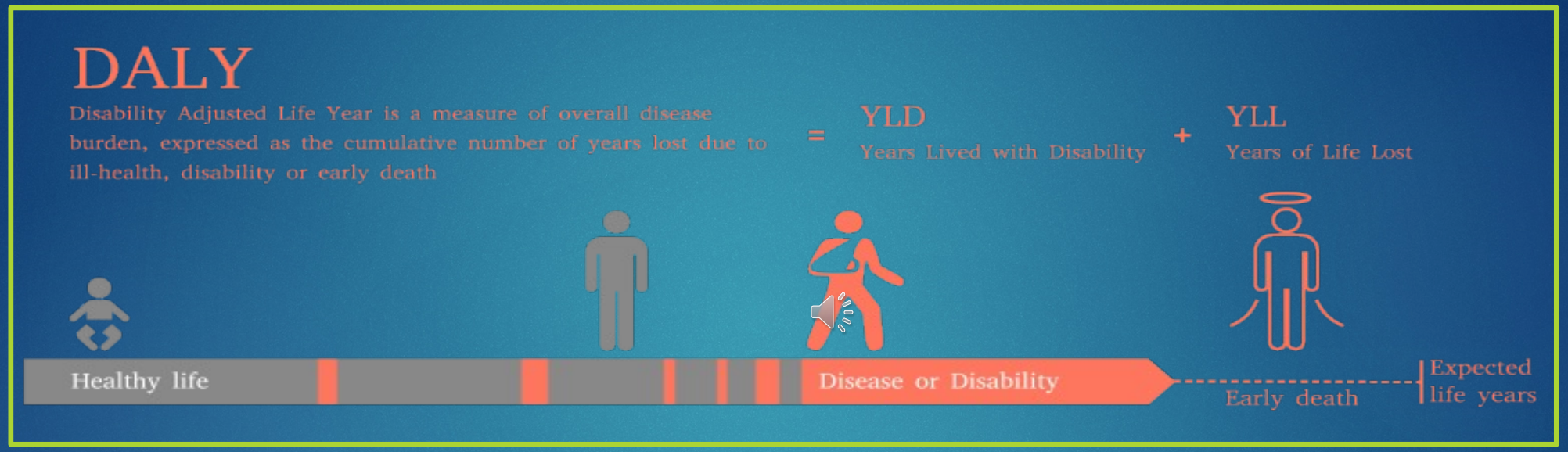
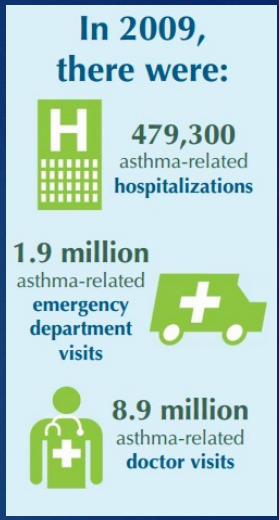
ASHRAE, 1791 Tullie Circle, NE, Atlanta GA 30329-2305



c. PM effects – respiratory (asthma), cardio, neurological, obesity, neurodevelopmental impacts

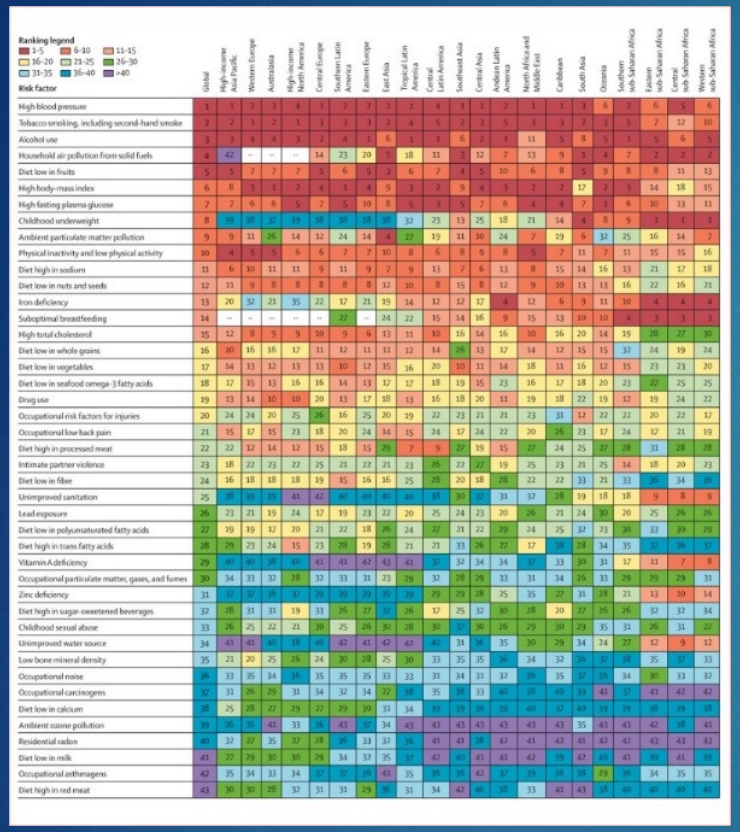
COST OF ILLNESS - DALY





- **Asthma**
- **Damage To Liver Kidneys And Central Nervous System**
- **Spread Of Communicable Diseases (Eg.SARS)**
- **Body Nervous And Endocrine System Problems**

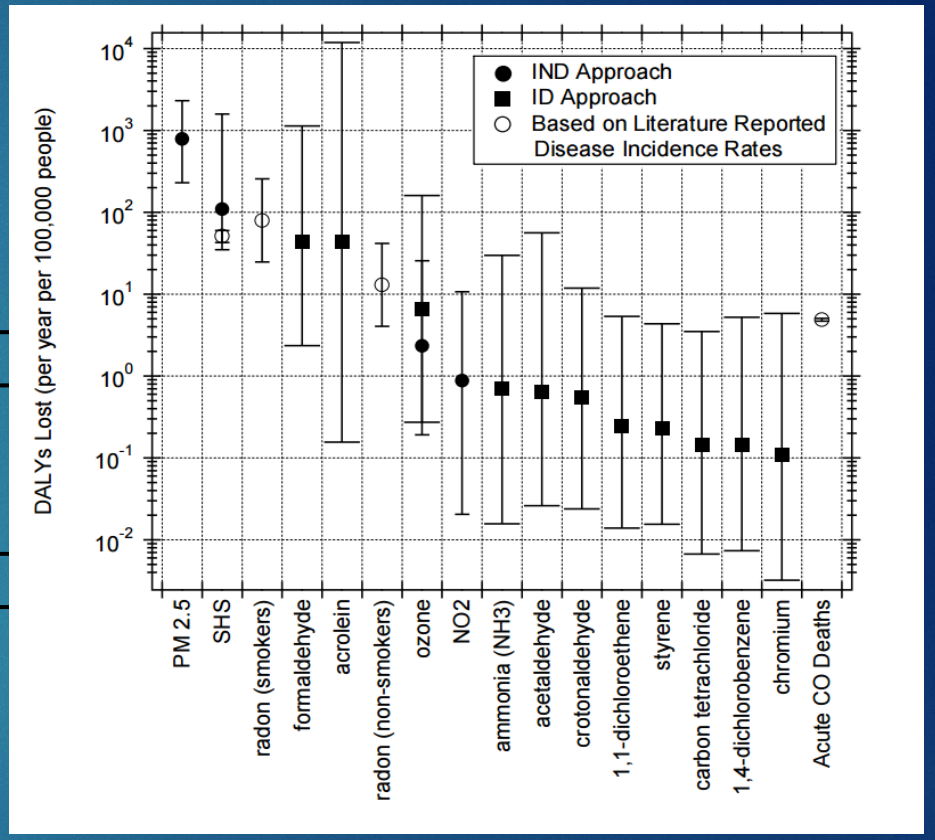
DISEASE BURDEN BY VARIOUS RISKS



Ranking legend

1–5	6–10	11–15
16–20	21–25	26–30
31–35	36–40	>40

Risk factor	Global	High-income Asia Pacific	Western Europe	Australasia	High-income North America
High blood pressure	1	1	2	3	4
Tobacco smoking, including second-hand smoke	2	2	1	2	1
Alcohol use	3	3	4	4	3
Household air pollution from solid fuels	4	42	..	..	..
Diet low in fruits	5	5	7	7	7
High body-mass index	6	8	3	1	2
High fasting plasma glucose	7	7	6	6	5
Childhood underweight	8	39	38	37	39
Ambient particulate matter pollution	9	9	11	26	14
Physical inactivity and low physical activity	10	4	5	5	6
Diet high in sodium	11	6	10	11	11
Diet low in nuts and seeds	12	11	9	8	8
Iron deficiency	13	20	32	21	35
Suboptimal breastfeeding	14	..	..	..	..



Source: Lancet 2012 Dec 15;380(9859):2224-60. doi: 10.1016/S0140-6736(12)61766-8

Estimated population averaged annual cost, in DALYs, of chronic air pollutant inhalation in U.S residences; results for the 15 pollutants with highest mean damage estimates. [Whiskers indicate aggregate uncertainty (95% confidence)]

LBNL DALY AND DISEASE BURDEN

Table 1. Energy use (E) in 10^{-3} quads and DALYs (D) per 100,000 households per year

Ventilation Cases	*Energy (quads /10^{-3})*	*ΔE ($\Delta E/E_{base\text{-}case}$)*	*DALYs lost (years)*	*ΔD ($\Delta D/ D_{base\text{-}case}$)*
Base Case-Infiltration only	3.5	-----	160	-----
Unbalanced Mechanical Ventilation	4.0	5 (14%)	90	70 (-41%)
Balanced Mechanical Ventilation	4.3	8 (21%)	70	90 (-54%)

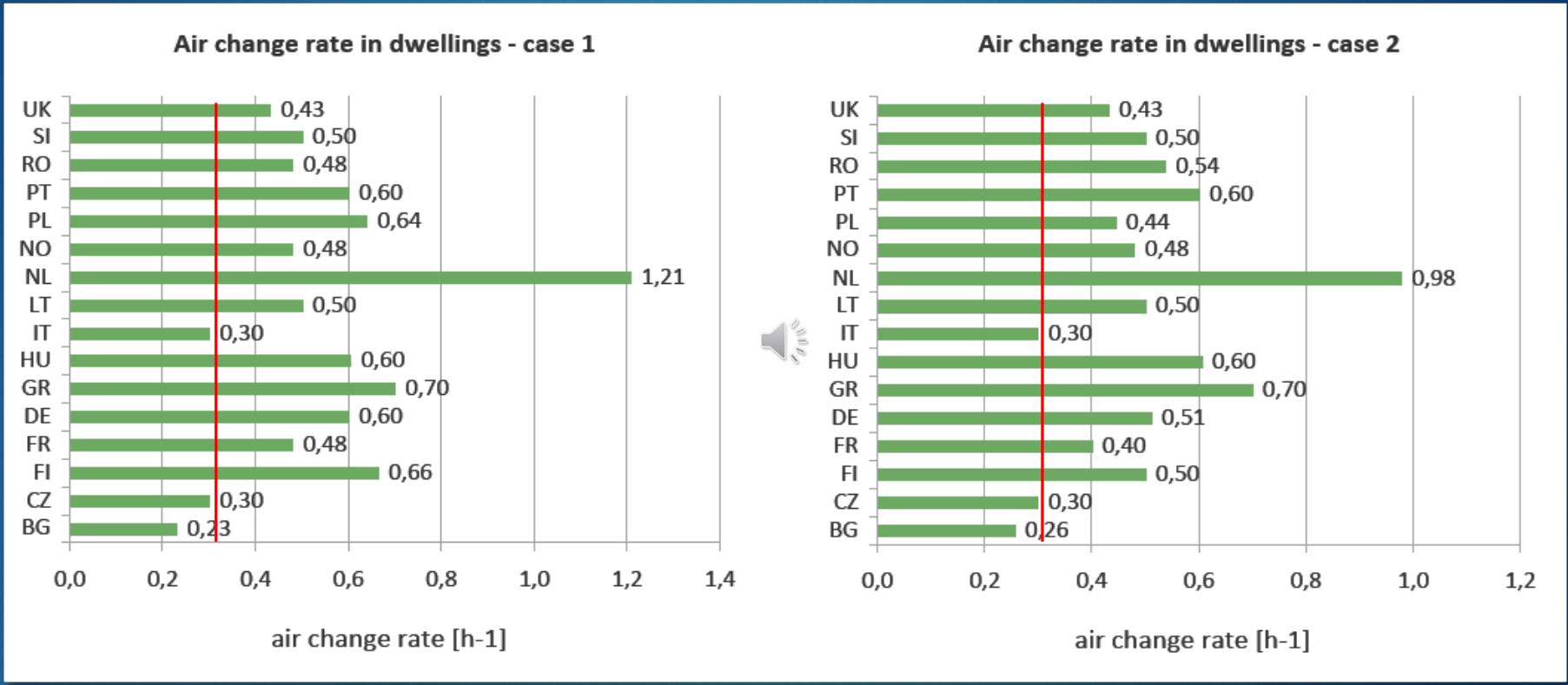
Source: Logue et al., Assessment of Indoor Air Quality Benefits and Energy Costs of Mechanical Ventilation, June 2011, LBNL-4945-E

LBNL STUDY CONCLUSION

“Overall. . .the number of reported statistically significant improvements in health with increased ventilation rates far exceeded the anticipated chance improvements in health.”

***Ventilation Rates and Health in Homes*.**
LBNL Indoor Environment Group, 2019

EUROPEAN VENTILATION RATES



ASHRAE 62 -2016 rate ~ 0.3 – 0.35 ach

Ventilation Rates and IAQ in National Regulations **Nejc Brelih, AIVC Conference, October 2011, Brussels, Belgium**

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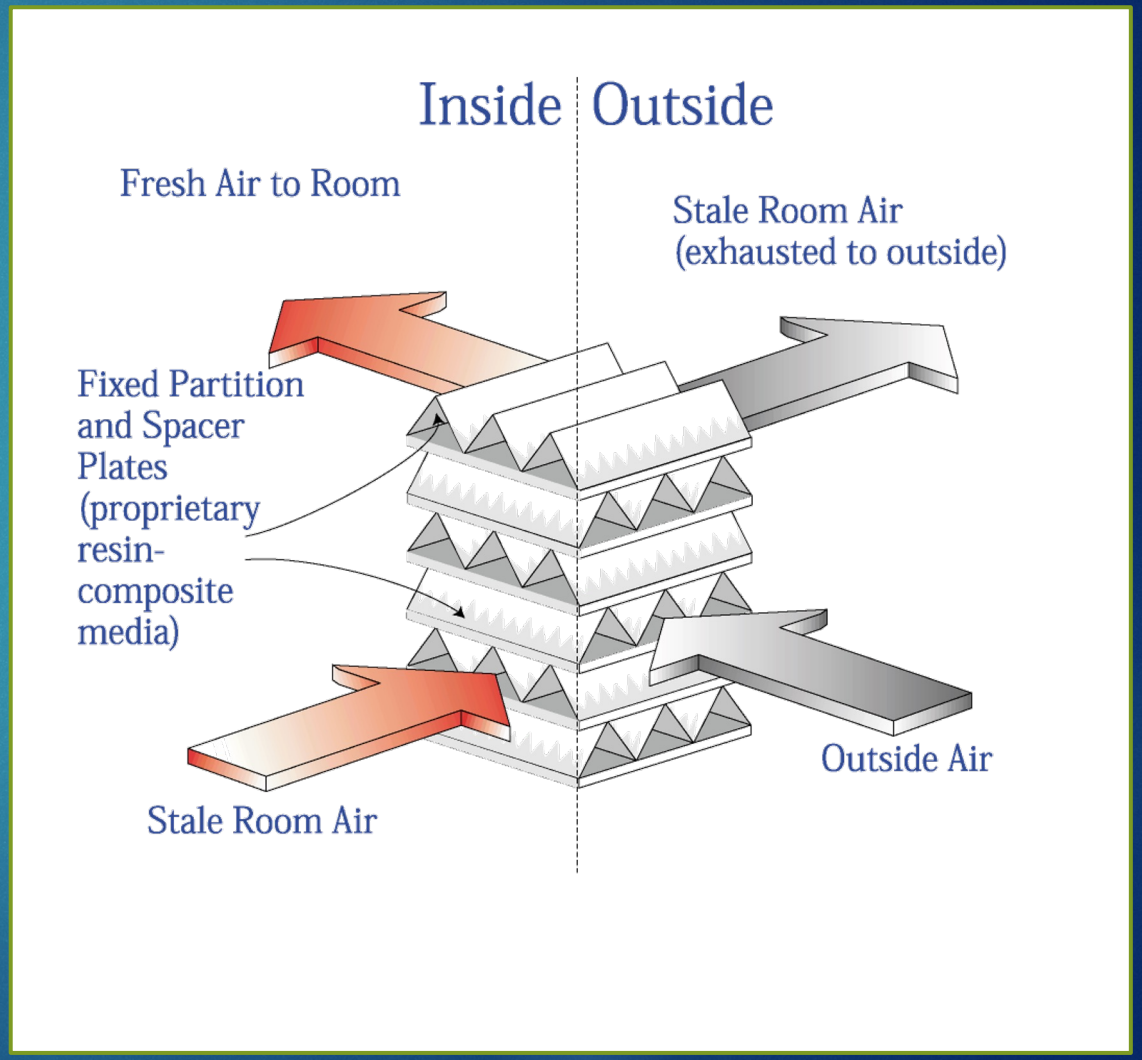
Supporting Slides

Energy Recovery Ventilation

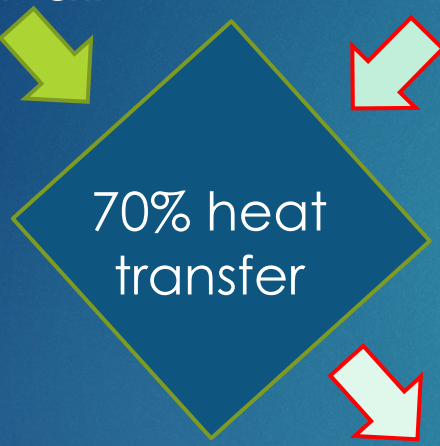
Maintains desired OA ventilation and enhanced IAQ with minimal energy penalty

ENERGY RECOVERY VIA STATIC PLATE

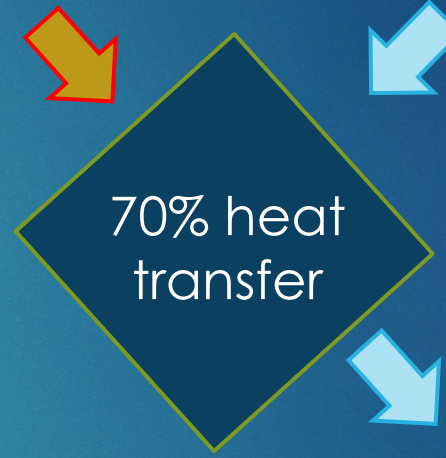
STATIC-PLATE CORE ALLOWS EXHAUST AND OUTSIDE AIR STREAMS TO PASS THROUGH THE CORE, *TRANSFERRING BOTH HEAT AND MOISTURE* IN THE PROCESS.



Vancouver Performance Example



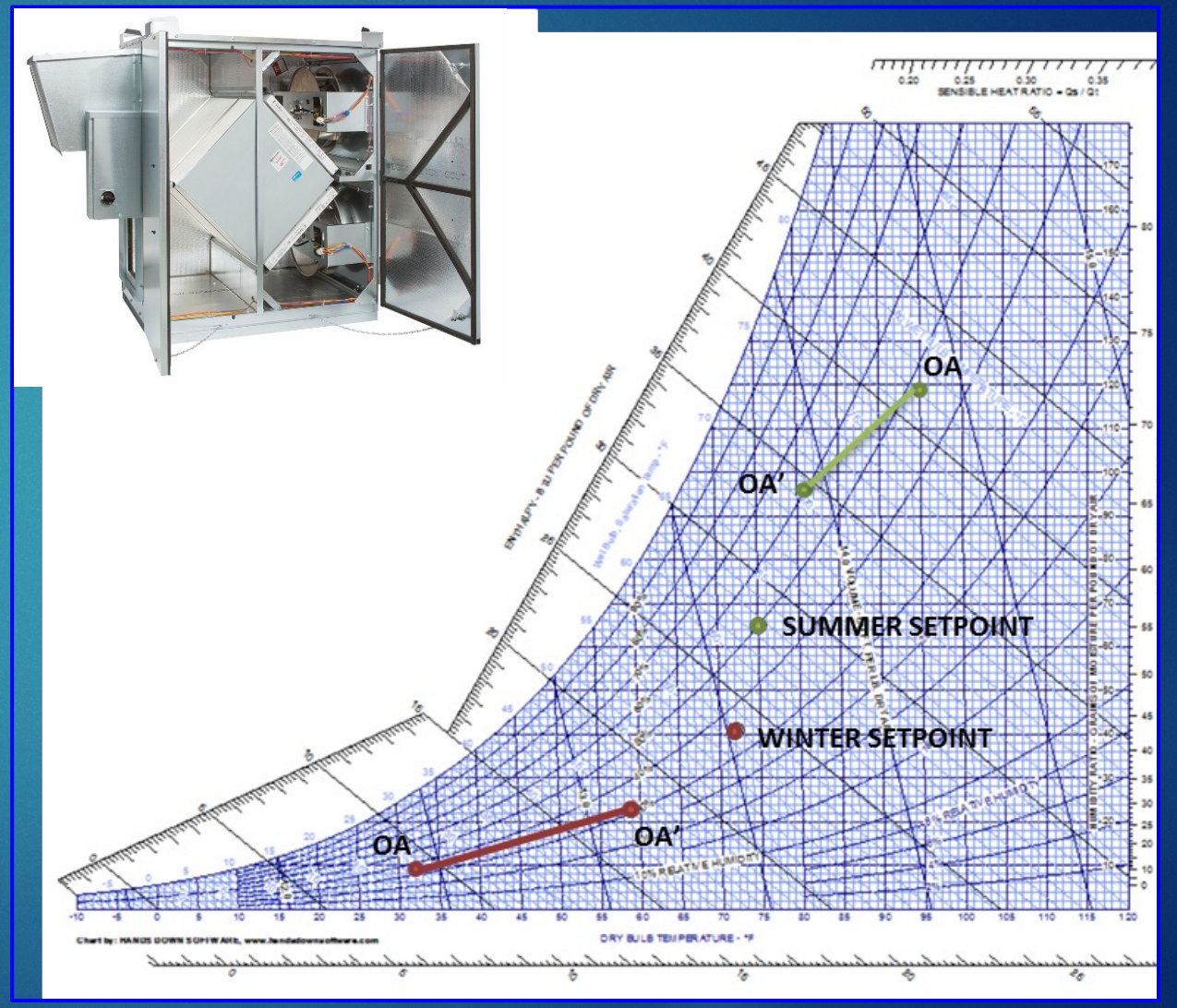
Winter Example



Summer Example

Economics of ERV in Vancouver

- Reduce cooling equipment tonnage
- Replace traditional ventilation equipment
- Lower operating/energy costs
- Reduce liability issues like mold, mildew and IAQ
- Filtration and balanced airflow in one package



LIFE CYCLE COST CONSIDERATIONS

- FIRST COST
- MAINTENANCE COST AND COMPLEXITY
- EFFECTIVENESS (SENSIBLE AND LATENT)
- FAN OPERATING COST
- OTHER ENERGY CONSUMPTION OF THE ERV
- RELIABILITY AND OPERATING LIFE
- LIFETIME PERFORMANCE – PERFORMANCE DEGRADATION
- UTILITY AND GOVERNMENT REBATES

Design Option: decoupled outdoor air

Exhaust

Outdoor Air
90 F

Fresh Air
to space
79.5 F

Return Air
from space to
ERV 75 F

VRF Fan
Coil

Conditioned Air

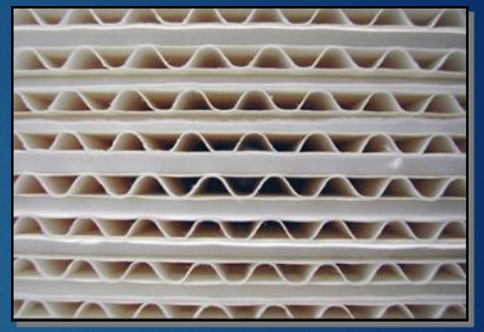
Return Air for
Recirculation

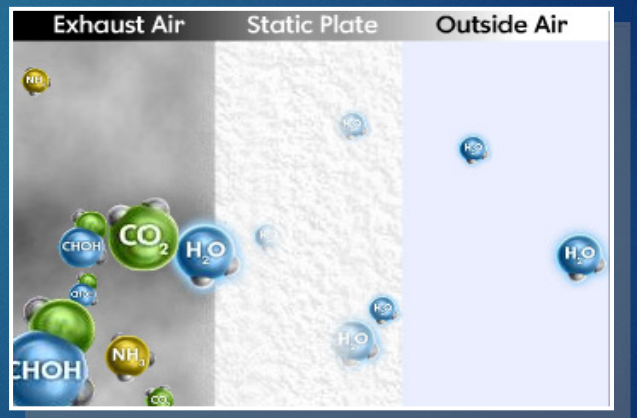
STATIC PLATE SENSIBLE ONLY HRV

- Transfers sensible heat only, no moisture transfer
- Requires condensate drain and humidity sensor
- Usually made of aluminum or plastic
- No moisture reduction

STATIC PLATE TOTAL ENERGY ERV

- RELIABLE PERFORMANCE
- SIMPLE MAINTENANCE
- POSITIVE AIRSTREAM SEPARATION
- LAMINAR FLOW – INTERIOR DOES NOT CLOG
- BOTH SENSIBLE (70-75%) AND LATENT (45-55%) TRANSFER
- AT 500 FPM AIR VELOCITY PRESSURE DROP IS 0.62" W.G.
- CROSS-FLOW AIRSTREAMS PASS NEXT TO EACH OTHER, BUT NEVER MIX – AHRI 0% CROSS CONTAMINATION
- HEAT TRANSFER OCCURS VIA SIMPLE CONDUCTION DUE TO TEMPERATURE DIFFERENTIAL





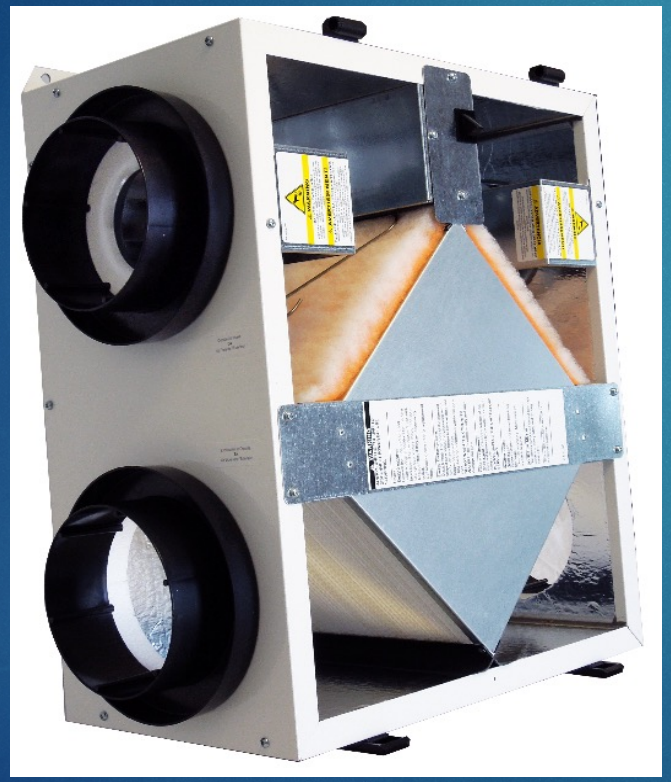
STATIC ENTHALPIC PLATE ERV

- MOISTURE TRANSFER IN VAPOR PHASE THROUGH PLATE MEDIA VIA VAPOR PRESSURE DIFFERENTIAL
- NO CONDENSATE DRAIN, NO FROST CONCERNS
- EASY, LOW COST MAINTENANCE
- DOES NOT SUPPORT BIOLOGICAL GROWTH
- UL-723, NFPA 90A AND 90B WITH LESS THAN 25/50 FLAME SPREAD/SMOKE DEVELOPED RATING
- AUTOMATICALLY MODERATES INDOOR HUMIDITY TO ASHRAE STANDARD 40% - 60% RH
- 0% CROSS CONTAMINATION – AHRI CERTIFIED

RenewAire products

RESIDENTIAL ERV'S COMMERCIAL QUALITY

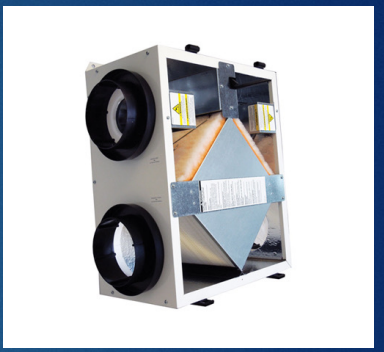
Several Models with
CFM range 70 to 300



- Excellent total heat transfer
- No defrost needed
- No condensate drain needed
- Mount in any orientation
- UL listed for commercial use
- MERV-8 filters
- Continuous insulation

UC SAN FRANCISCO TIDELANDS HOUSING

- 596 apartment project completed in 2019
- Each 1 or 2-bedroom unit has EV90 ERV mounted in ceiling with MERV13 prefilter
- Apartments only HVAC is RenewAire ERV and electric strip heat under window
- Common areas have cooling with RenewAire HE1XIN and HE8XRT serving those areas for ventilation



MULTIFAMILY RESIDENTIAL ERVS

FEATURES AVAILABLE FOR TITLE 24-6 APPLICATIONS:

- ECM
- TWO SPEED OPERATION
- MERV13 FILTER ON OA
- LOW PROFILE MODELS

MERV 13 on Outdoor Air

Pressure Taps in door for faster set-up and balancing

Easily accessible controls

Dial-in balancing of supply & exhaust air streams