

# **Indoor Air Quality: How ventilation is critical to improving the human condition in the built environment**

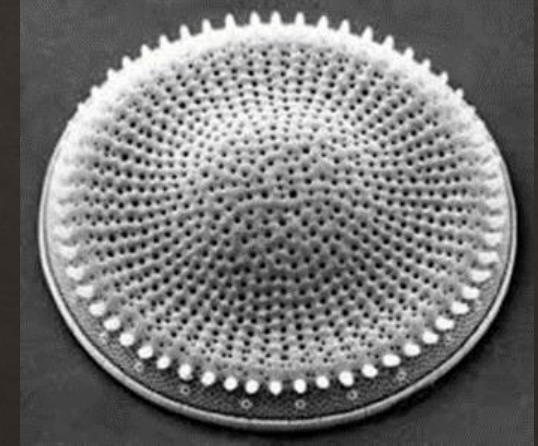
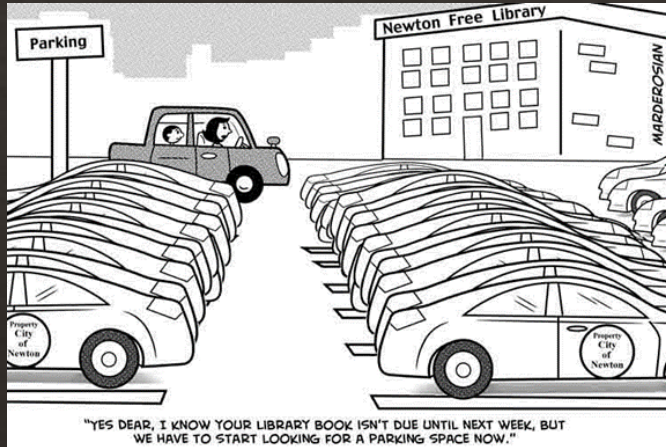
Nick Agopian

# Outline of the content

- Understanding the built environment!
  - What causes deficient indoor air quality “Who – What – How”?
    - Can we justify more outdoor air?

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

- City Traffic
  - 40% of cars in cities are looking for parking spots
- Oxygen come from?
  - Rainforest?
  - Diatoms is what produces Oxygen



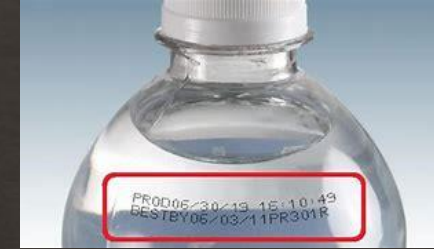
# IAQ & Ventilation in Perspective

- Structures have become tighter with lower infiltration
  - In early 1900s, there were approximately 50 materials used for construction. By less than 100 years later, this list had grown to about?
    - **55,000 materials!**



# Well Known Trivia

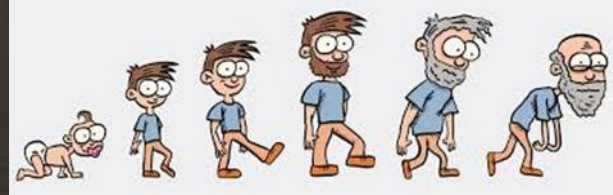
- How much water do we drink daily?
  - 4 Pounds
- How much food do we eat daily?
  - 4 Pounds
- How much air do we breathe daily?
  - 31 Pounds



79 70 89

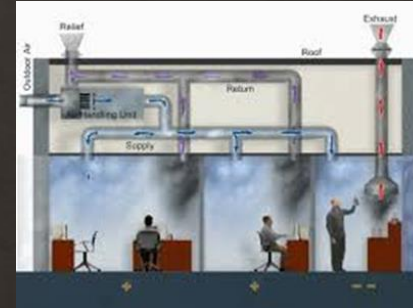
- Average life?

- 79 years



- 20 years in buildings

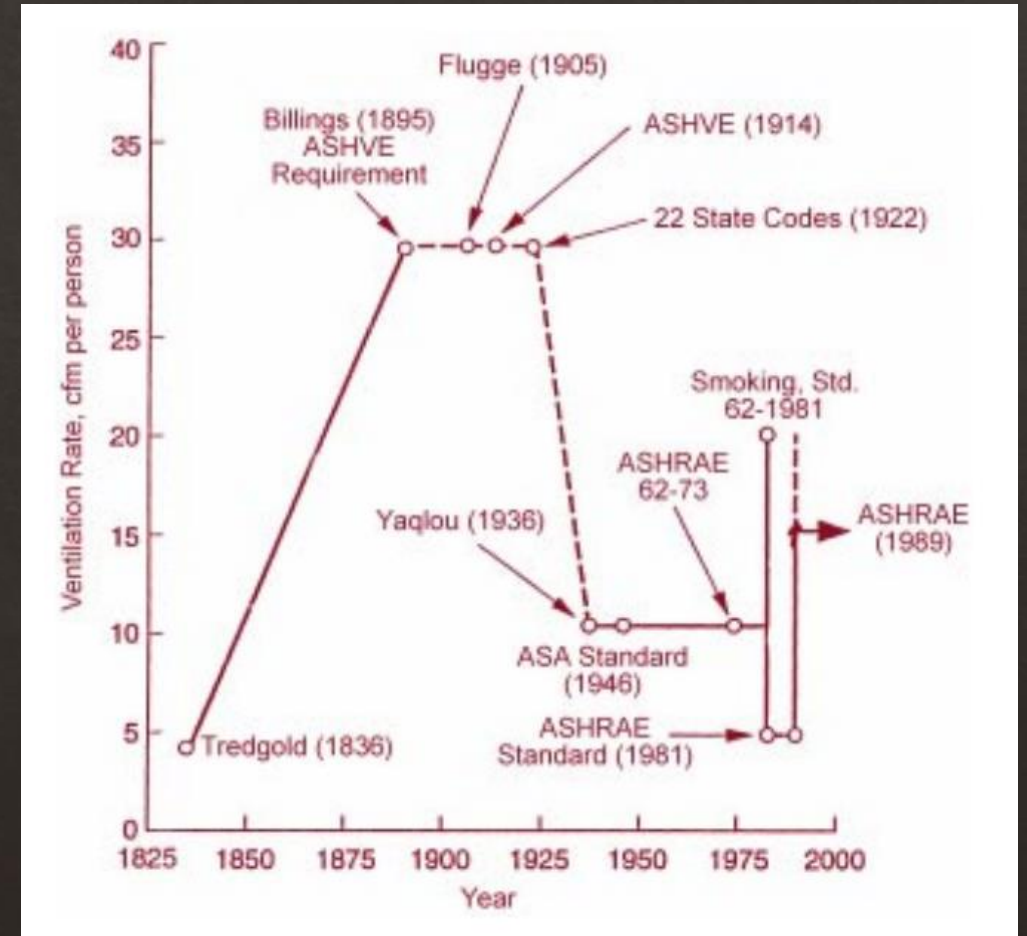
- 50 years in homes



- 89% of an average life is inside the built environment

# HISTORY OF VENTILATION

- EARLY HUMANS - FIRE AND SMOKE
- EGYPTIAN STONE CARVERS
- MIDDLE AGES – DISEASES
- 1775 – LAVOISIER – CO<sub>2</sub>
- 1970'S DUE TO THE ENERGY CRISIS, TO CONSERVE ENERGY IN THE US REDUCES VENTILATION RATES
- LED TO “SICK BUILDING SYNDROME”





# Why Ventilate – Contaminates

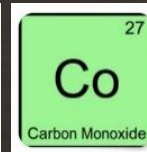
## What Always Comes to Mind

- ◆ Moisture and Mold
- ◆ Odor



## What Often Comes to Mind

- ◆ Carbon Monoxide
- ◆ Carbon Dioxide
- ◆ Radon

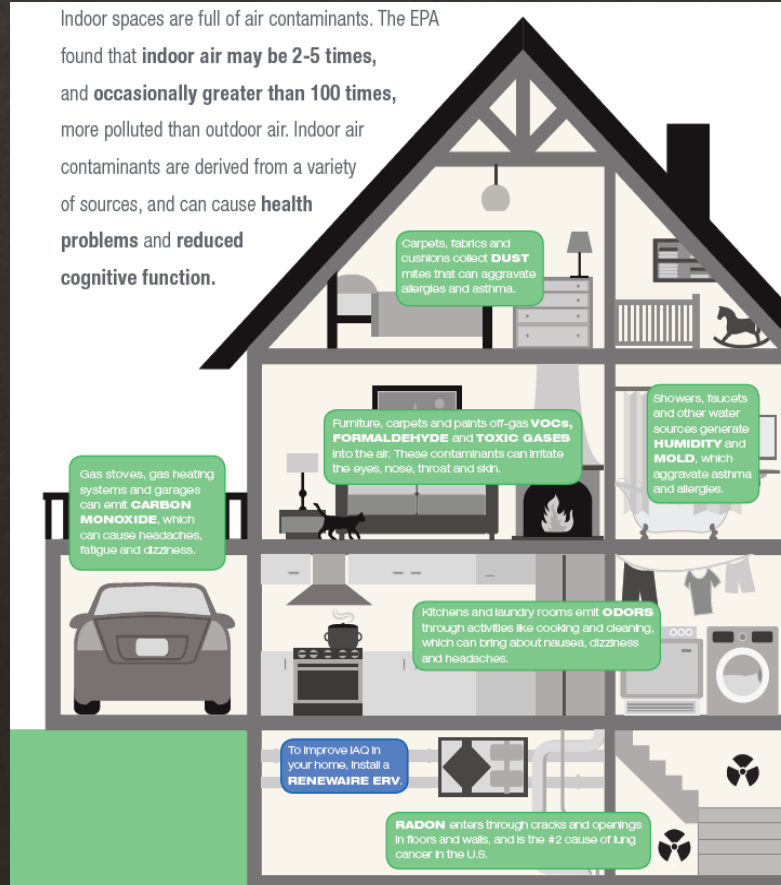


## What Occasionally Comes to Mind

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



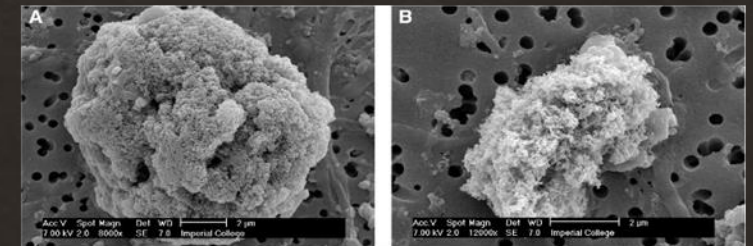
Indoor spaces are full of air contaminants. The EPA found that indoor air may be 2-5 times, and occasionally greater than 100 times, more polluted than outdoor air. Indoor air contaminants are derived from a variety of sources, and can cause health problems and reduced cognitive function.





# 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 DEFICIENCY




## STUDY: ALARMING RESULTS FOUND IN SCENTED LAUNDRY DETERGENTS

11 APRIL 2016 2407 AUTHOR: DR. DON COLBERT 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

Search...

 Divine Health

### Dr. Colbert's Story

I suffered with Chronic Psoriasis for over 15 years. It was a humiliating condition that left my knees, elbows, and neck with a bright red rash that would scab up and bleed. Through a tremendous amount of research, I identified the foods that were inflaming my body, eliminated them, reduced my stress, and began consuming fermented foods and probiotic supplements. Today, I am completely healed of psoriasis. My story is like so many others. God created our body to heal itself if we give it what it needs and remove what it doesn't.

*Don Colbert*

**ORDER NOW!**

It's not your typical **SUPERFOOD**

Fermented is just

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/tunedin/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/>



**IAQ & Energy** 2020  
CONFERENCE



- 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

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



# US DOES Ventilation Study

U.S. DEPARTMENT OF  
**ENERGY**

Energy Efficiency &  
Renewable Energy

**BUILDING TECHNOLOGIES PROGRAM**

## Ventilation System Effectiveness and Tested Indoor Air Quality Impacts

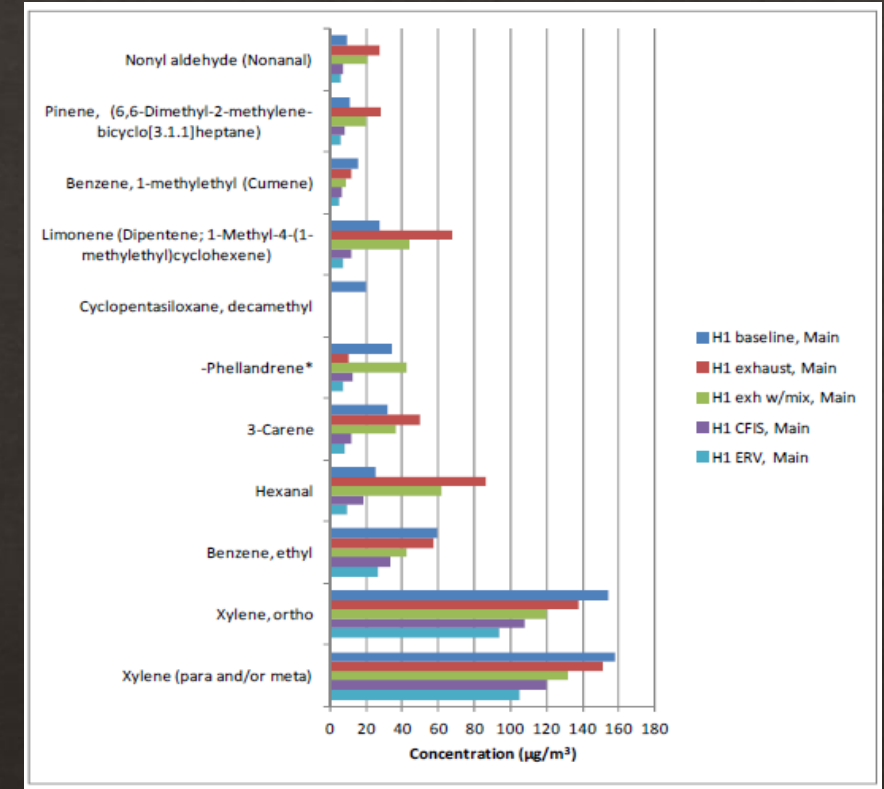
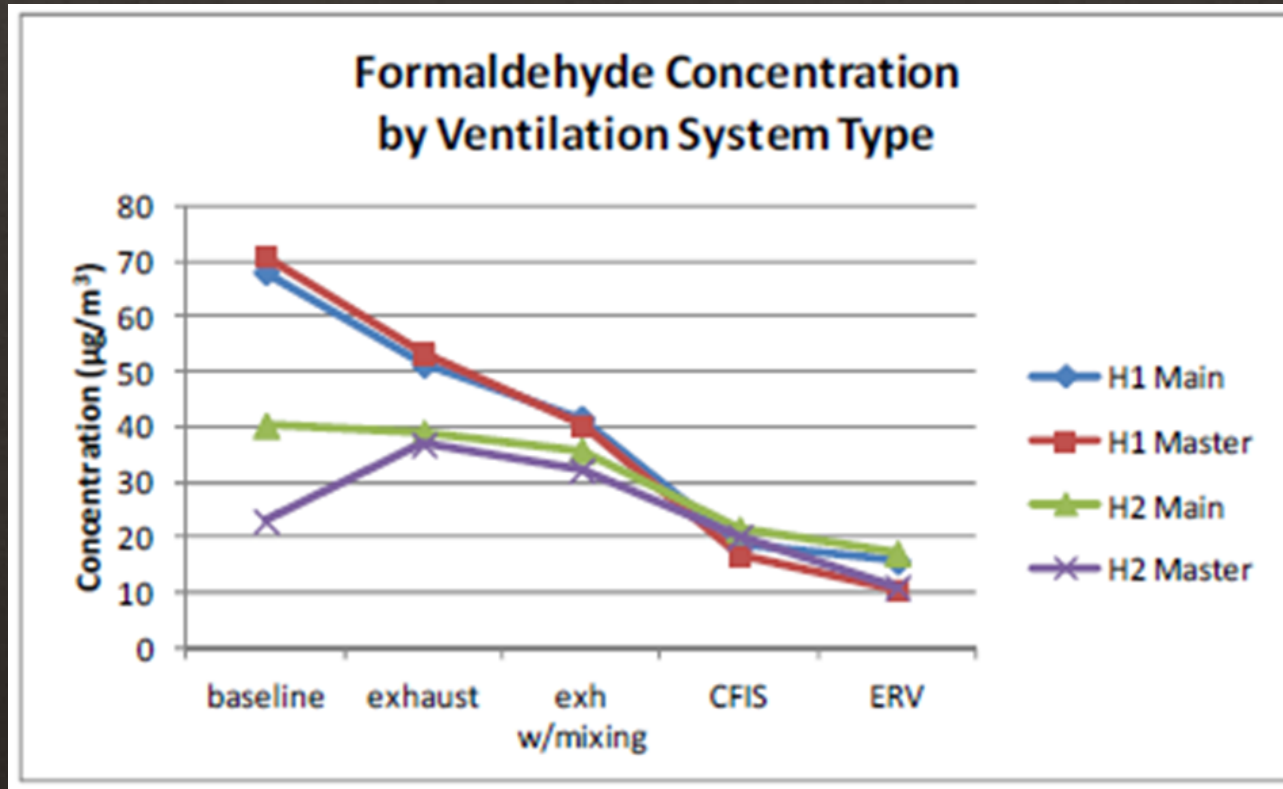
Armin Rudd, Daniel Bergey

March 2013

**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

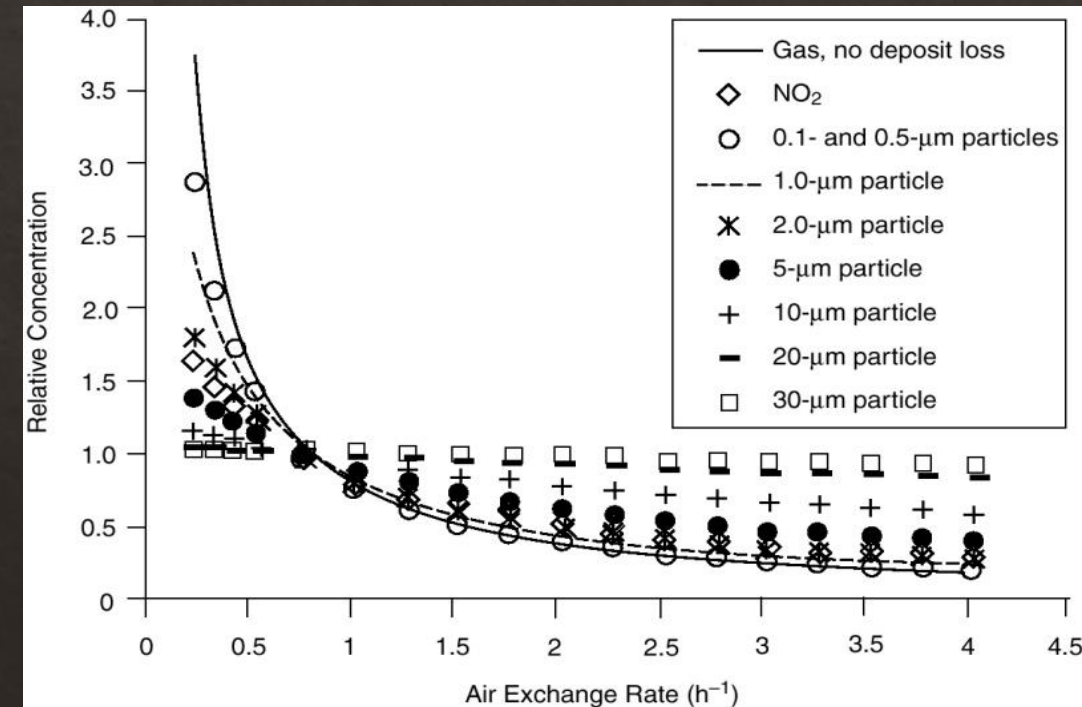


# INSTITUTE OF MEDICINE STUDY

## 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.”*



# NASA STUDY CO<sub>2</sub> STUDY

## EFFECTS OF PROLONGED CO<sub>2</sub> EXPOSURE

- HUMANS GENERATE 200 ML OF CO<sub>2</sub>
- RESPIRATORY ACIDOSIS OCCURS FEW MINS AFTER EXPOSURE TO CO<sub>2</sub>
- LEADS TO PULMONARY RESPONSE
- CO<sub>2</sub> IS A POTENT VASODILATOR OF CEREBRAL BLOOD VESSELS
- ELEVATED CO<sub>2</sub> LEVELS LEAD TO RENAL CALCULI

NASA/TP-2012-217358

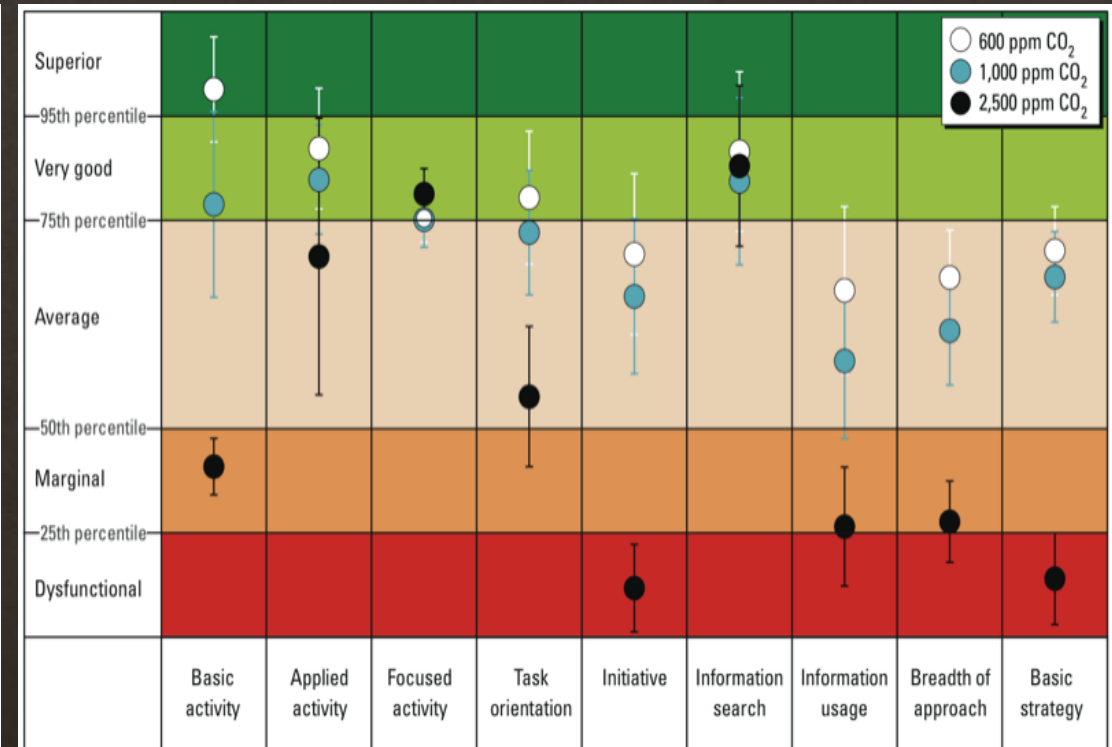
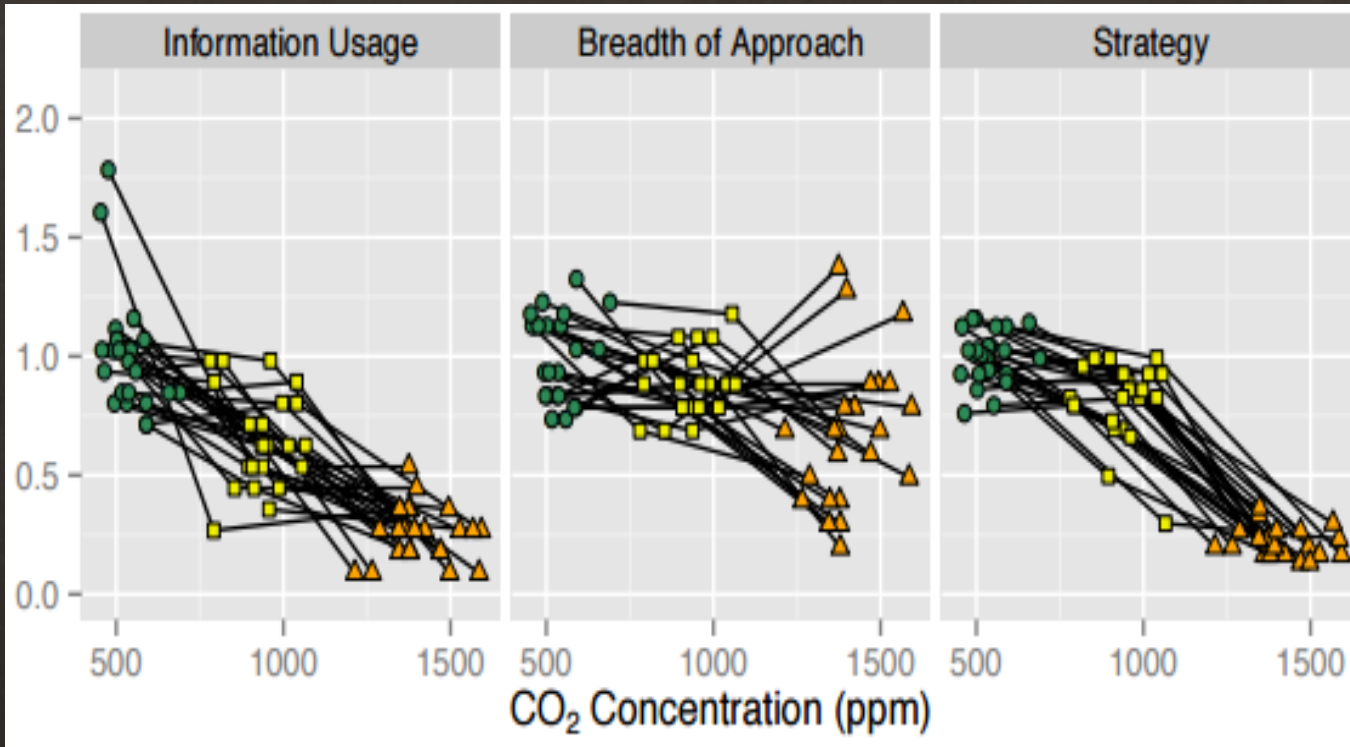


**Chronic Exposure to Moderately Elevated CO<sub>2</sub> during Long-Duration Space Flight**



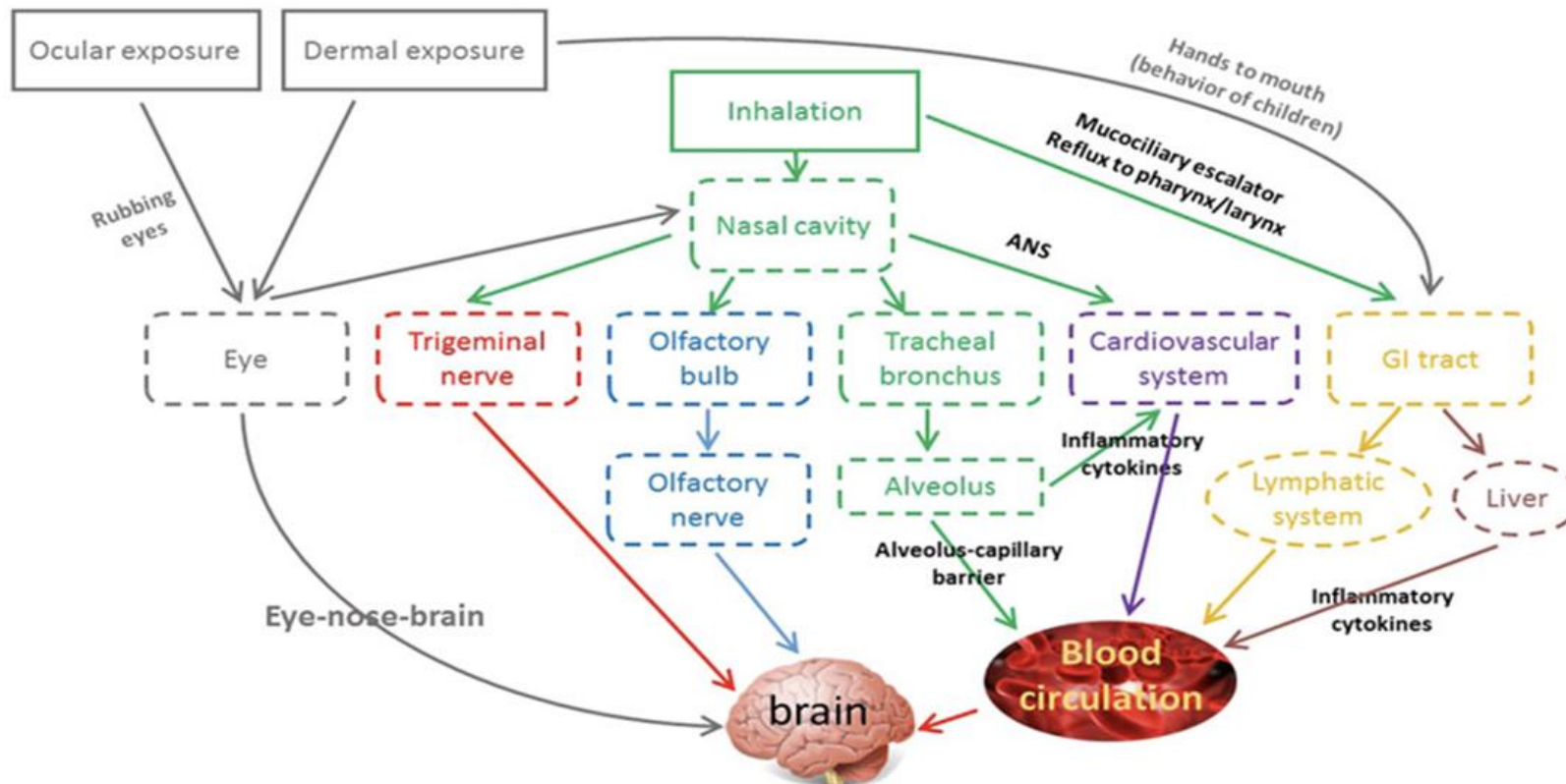


# CO2 AND COGNITIVE FUNCTION



Relatively small increases in CO<sub>2</sub> levels significantly affect cognitive function

# VENTILATION OR INDOOR AIR QUALITY (IAQ) OR HEALTH



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

# COST OF ILLNESS - DALY

## DALY

Disability Adjusted Life Year is a measure of overall disease burden, expressed as the cumulative number of years lost due to ill-health, disability or early death

$$= \text{YLD (Years Lived with Disability)} + \text{YLL (Years of Life Lost)}$$



In 2009,  
there were:

**H** 479,300  
asthma-related  
hospitalizations

1.9 million  
asthma-related  
emergency  
department  
visits



**+** 8.9 million  
asthma-related  
doctor visits



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

Body Nervous And Endocrine System Problems

**1** in **12**  
adults  
has asthma

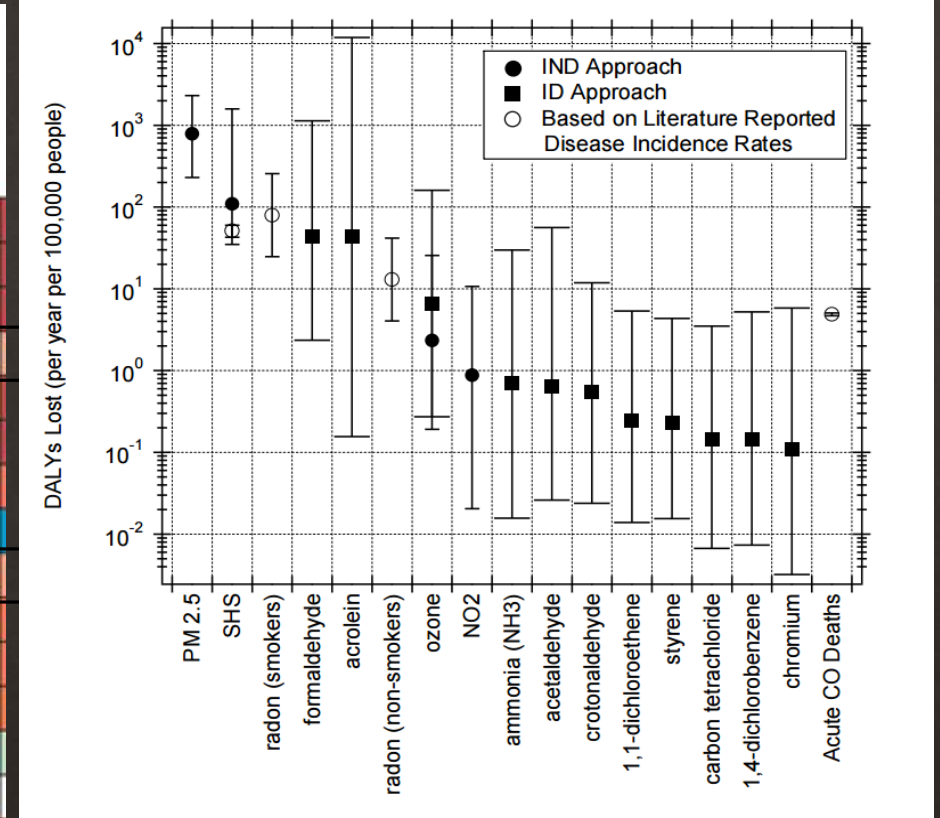
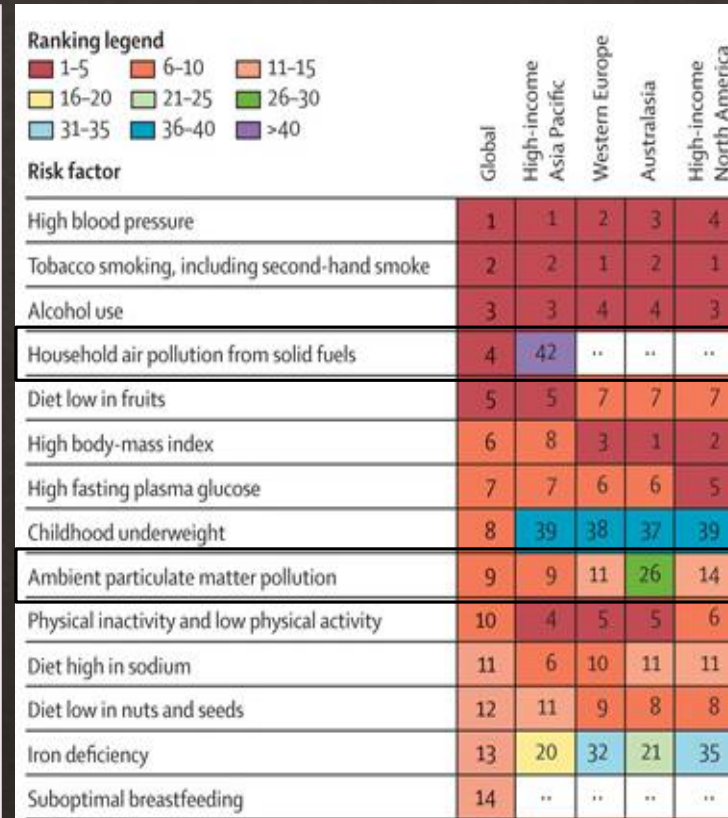
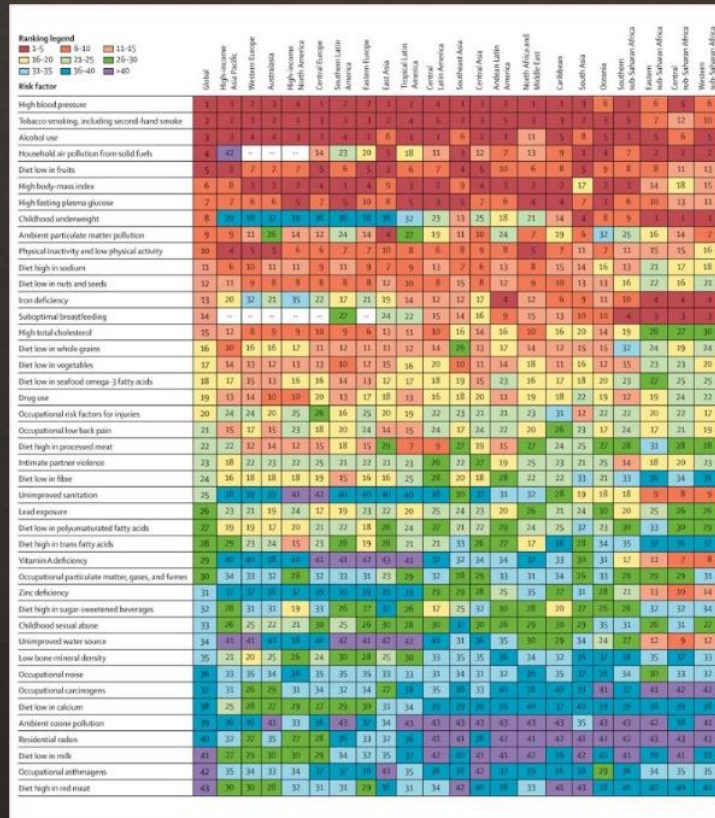
**1** in **11**  
children  
has asthma



children with asthma  
went to an **emergency  
department** for asthma-  
related care in 2009.



# DISEASE BURDEN BY VARIOUS RISKS



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

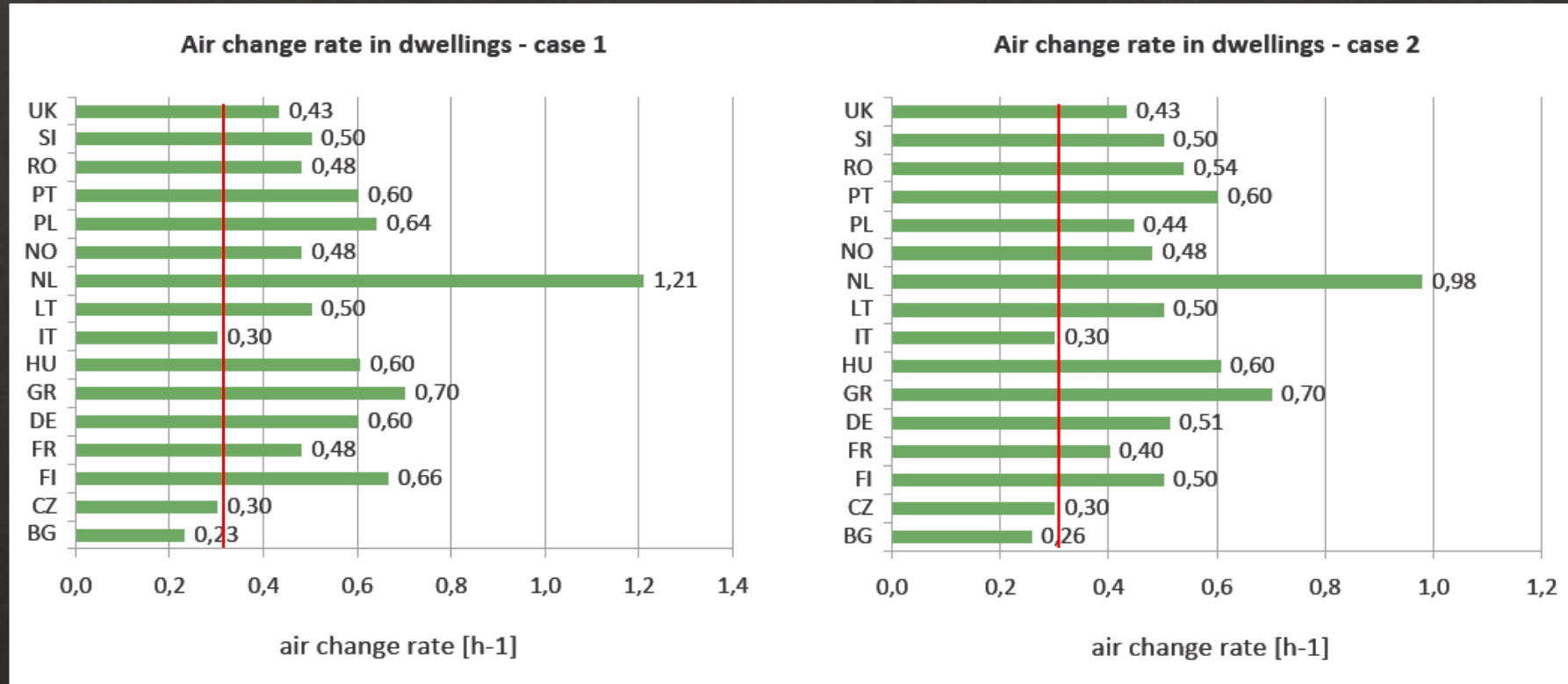
Table 1. Energy use (E) in  $10^{-3}$  quads and DALYs (D) per 100,000 households per year

| <i>Ventilation Cases</i>          | <i>Energy<br/>(quads / <math>10^{-3}</math>)</i> | <i><math>\Delta E</math><br/>(<math>\Delta E/E_{base-case}</math>)</i> | <i>DALYs lost<br/>(years)</i> | <i><math>\Delta D</math><br/>(<math>\Delta D/D_{base-case}</math>)</i> |
|-----------------------------------|--|--|-------------------------------|--|
| 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%)  |

# 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.”

# EUROPEAN VENTILATION RATES



ASHRAE 62 -2016 rate ~ 0.3 - 0.35 ach



# JUSTIFICATION TO INCREASED VENTILATION ABOVE CODE

## CONCLUSIONS OF FINDINGS

- COST OF DOUBLING VENTILATION:
  - \$10 - \$40 PER PERSON /YEAR
- PRODUCTIVITY BENEFITS - \$6,500 PER PERSON / YEAR (NOT INCLUDING POTENTIAL HEALTH BENEFITS, REDUCED SICK BUILDING SYNDROME AND ABSENTEEISM)
- Estimated Annual Savings in the USA = 165 Billion Dollars

## Research: Stale Office Air Is Making You Less Productive

by Joseph G. Allen

MARCH 21, 2017



How often do you consider the air quality in your office and how it affects employees and their productivity? Chances are it's not often.

There is a tendency to assume that, as long as commonly used standards for air quality are met, it won't be an issue. But these standards aren't very high. One common international standard that governs how much air is brought in from outside, "Ventilation for Acceptable Indoor Quality," does not even purport to assure "healthy" air quality.



# Presenter Contact Information

Nick Agopian

RenewAire LLC

nagopian@renewaire.com

Renewaire.com

607-512-3807

<https://www.linkedin.com/in/nick-agopian-3454864>



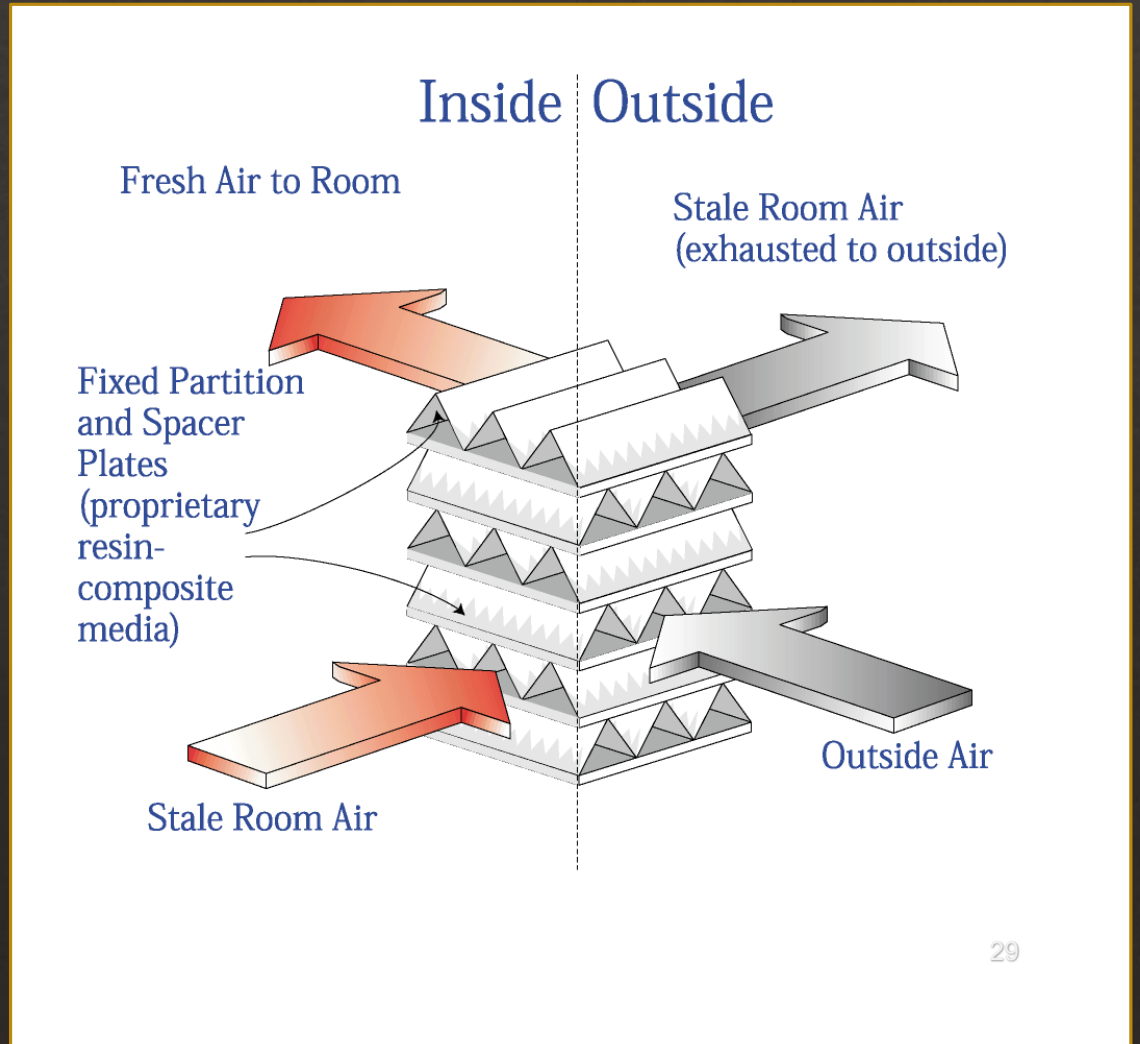
# Disclaimer

- This presentation is not intended to be a comprehensive program covering all aspects of this topic.
- All are participants are encouraged to read and follow applicable standards, codes and regulations related to this topic.
- The views and opinions following are the presenter's opinions and not necessarily the official position of the Maine IAQ Council, IAQnet LLC, or Healthy Indoors.

# SUPPORTING SLIDES

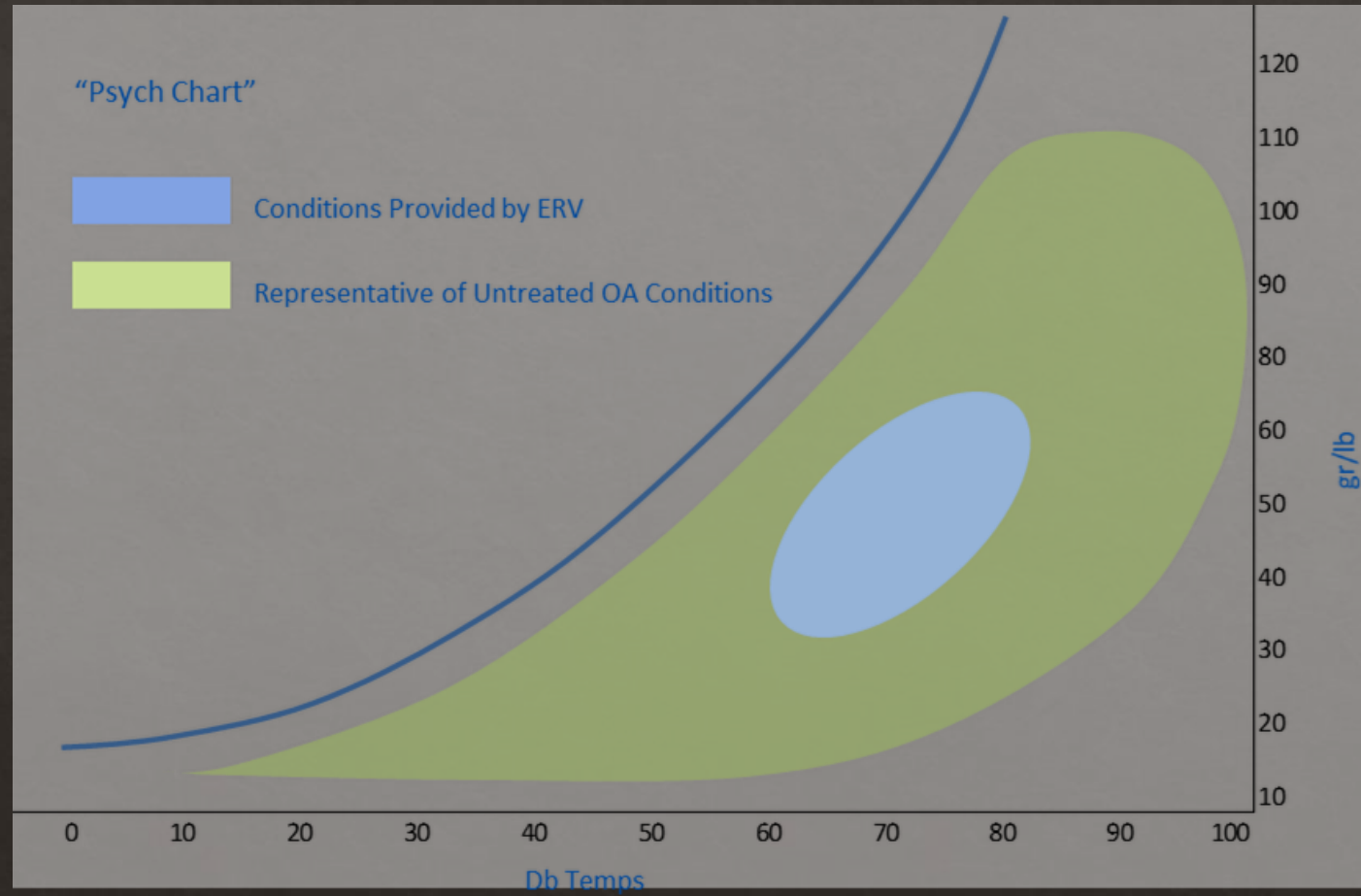
# ENERGY RECOVERY VIA STATIC PLATE

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





# ERV AS A SHIELD





# RENEWAIRE ERV

TRANSFERS ONLY WATER VAPOR





# ECONOMIC ANALYSIS

|   |            |
|---|------------|
| School Type                               | Elementary |
| Average No of Students                    | 500        |
| ASHRAE 62.2 Ventilation Rate [cfm/person] | 15         |
| Outside Air Quantity [cfm]                | 7500       |
| City                                      | Denver     |
| State                                     | Colorado   |
| Electricity Rate [\$ /kwh]                | 0.13       |
| Utility Price Escalation                  | 2.2%       |
| Discount Rate                             | 2.900%     |
| Useful Life                               | 20.00      |

|                                  | Baseline - No ERV<br>and Rooftop Air<br>Conditioning                               | Rooftop With<br>RenewAir Energy<br>Recovery   | Savings from<br>using ERV |
|----------------------------------|--|---|---------------------------|
|                                  |  |  |                           |
| Flow Rate [cfm]                  | 7,500  | 7,500   | -                         |
| Annual Runtime [hrs]             | 4,368  | 4,368   | -                         |
| Cooling Load [Btuh]              | 272,014  | 123,304   | 148,710                   |
| Heating Load [Btuh]              | 853,134  | 305,715   | 547,419                   |
| Cooling Season Consumption [Btu] | 269,341,200  | 80,802,360  | 188,538,840               |
| Heating Season Consumption [Btu] | 531,100,800  | 159,330,240   | 371,770,560               |
| Cooling Energy Cost              | \$ 3,501   | \$ 1,781  | \$ 1,721                  |
| Heating Energy Cost              | \$ 6,639   | \$ 1,992  | \$ 4,647                  |
| Annual Energy Cost               | \$ 10,140  | \$ 3,772  | \$ 6,368                  |

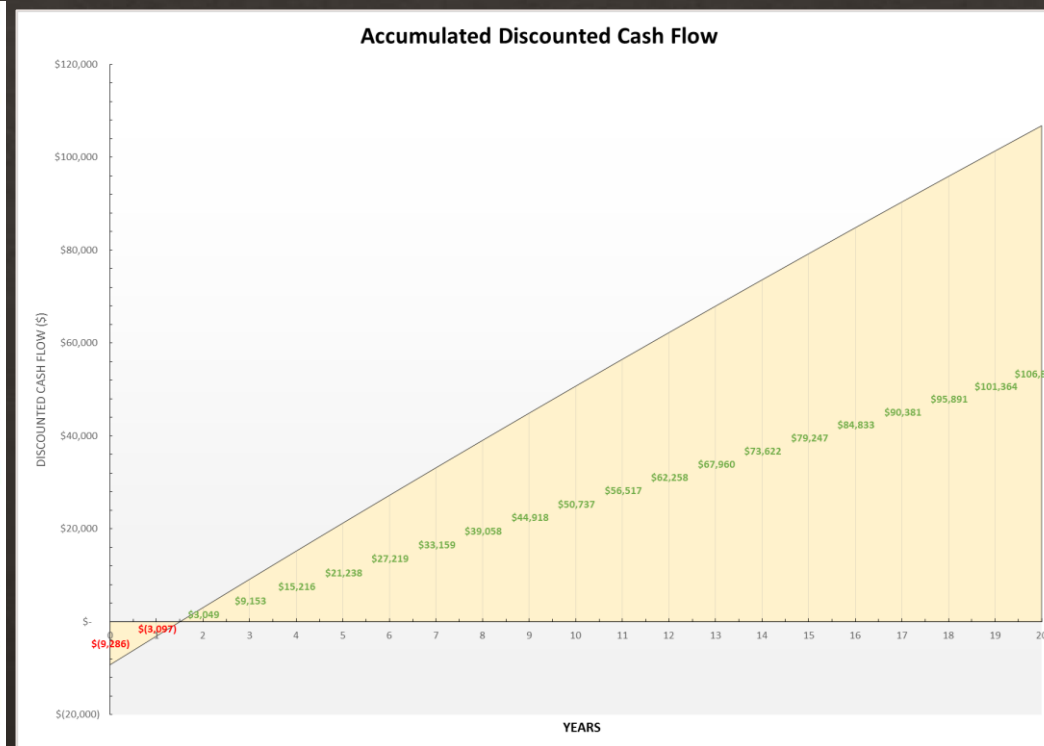


# ECONOMIC ANALYSIS

|   | Baseline - No ERV<br>and Rooftop Air<br>Conditioning                               | With RenewAire<br>Energy Recovery   |
|---|--|---|
|   |  |  |
| Installed ERV Cost  | \$ -   | \$ 48,000   |
| Additional AC Cost (\$1200/Ton)                             | \$ 14,871  | \$ -  |
| Less Avoided Costs Ventilation System (Exhaust Fans)        | \$ 4,200   | \$ (4,200)  |
| Less Cooling Avoided Costs (\$1200/Ton)                     |  | \$ (14,871)   |
| Less Utility Rebate (\$400/KW and \$0.04/Kwh) - Xcel Energy |  | \$ (19,643)   |
| Net System Costs  | \$ 19,071  | \$ 9,286  |
| Simple Payback [yrs]  | No Payback Ever !  | 1.46  |
| Yearly Cashflow towards Operational Exp                     | None !!  | \$ 6,368  |
| Annual Return on Investment (ROI)                           | None !!  | 68.58%  |

|                        |            |
|------------------------|------------|
| NPV                    | \$ 103,790 |
| IRR                    | 70.77%     |
| Yearly Net Cash Inflow | \$ 7,892   |



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