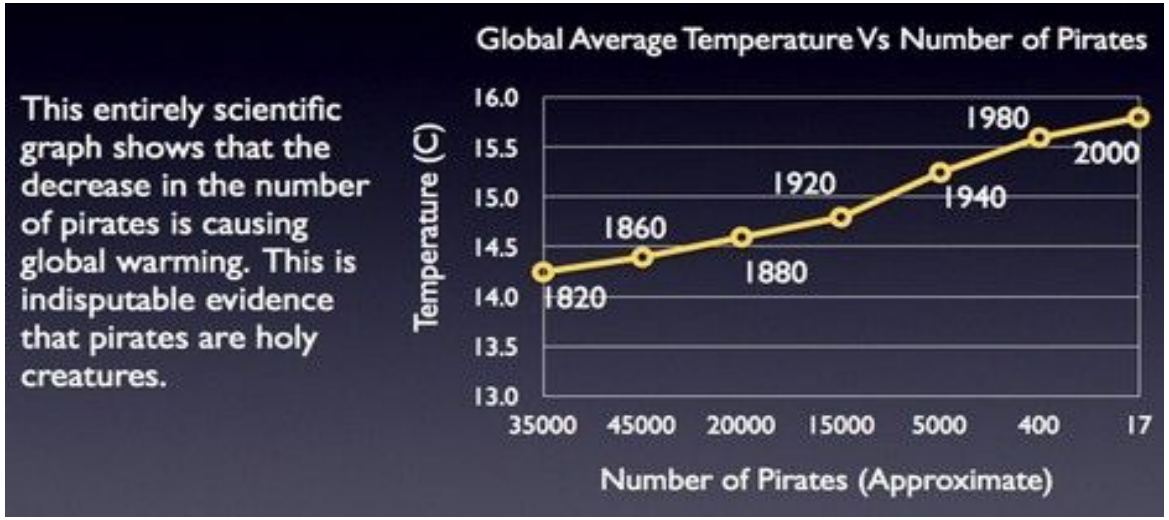
ASHRAE ILLINOIS CHAPTER SPRING CONFERENCE
VENTILATION & INDOOR AIR QUALITY
MARCH 11TH, 2019

RESEARCH AND THE ENVIRONMENT

Amazon Rain Forest – What's it do and how?



- **CORRELATION**
  - A MUTUAL RELATIONSHIP OR CONNECTION BETWEEN TWO OR MORE THINGS.
- **CAUSALITY**
  - THE ACTION OF CAUSING SOMETHING

IAQ and Ventilation in Perspective

- Structures have become tighter with lower infiltration rates.
- In early 1900s, small structures used approximately 50 materials used in construction. By less than100 years later, this list had grown to about?? 55,000![+]
- High moisture can trigger asthma attacks.[++]

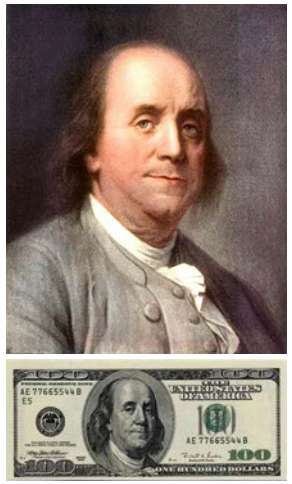
[+] **Raw GJ. *Sick building syndrome: a review of the evidence on causes and solutions*. HSE Contract Research Report no. 42. Building Research Establishment, Garson Watford, 1992.**
[++] **ERT Associates. *Asthma and weatherization in Maine*. National Center for Heathy Housing, 2006.**

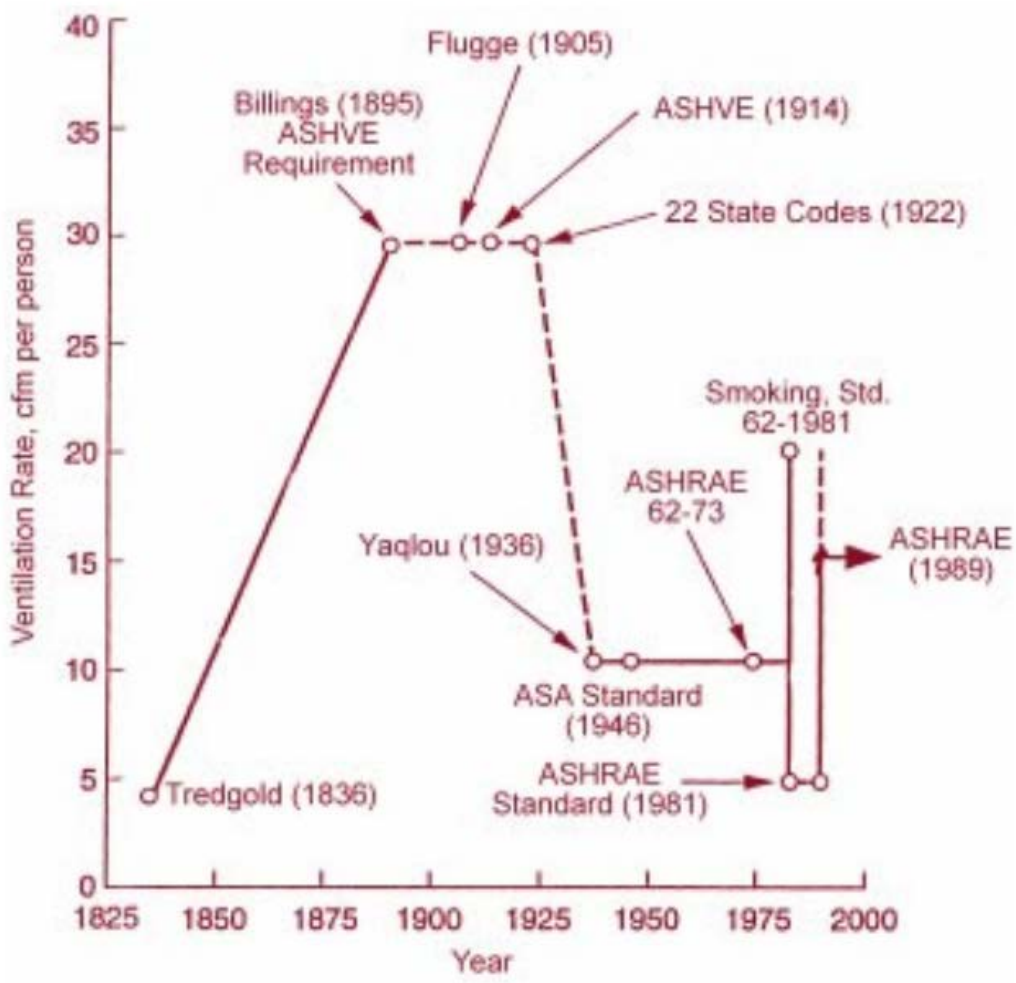
Courtesy of Rick Karg RED

HISTORY OF VENTILATION

- EARLY HUMANS - FIRE AND SMOKE
- EGYPTIAN STONE CARVERS
- MIDDLE AGES – DISEASES
- 1775 – LAVOISIER – CO_2

"I am persuaded that no common air is so unwholesome as the air within a closed room that has been often breathed and not changed."

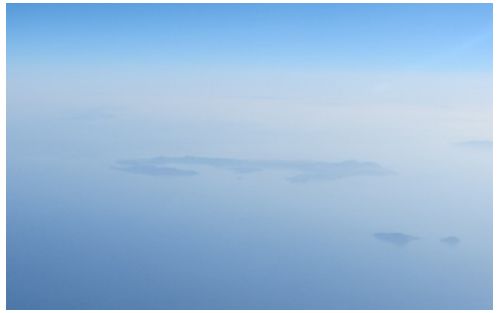




- 1970'S DUE TO THE ENERGY CRISIS, TO CONSERVE ENERGY IN THE US REDUCES VENTILATION RATES
- LED TO "SICK BUILDING SYNDROME"

Trivia

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



WHY VENTILATE - IAQ


Half of U.S. Schools Suffer From
Poor Indoor A
by Sarah Lozanova on Monday, Jan
Share with your netwo
The typical elementary-aged child
spend 940 hours in school this yea
environment of the school can hav
Although it is commonly known th
quality can cause major health iss
asthma and lung cancer, it is a less
it can degrade productivity, the ability to
concentrate, energy levels and even mood.
In fact, mental confusion, reduced mental performance, anxiety and coughin
common responses to indoor air pollution. Longer exposure can lead to pers
changes, impaired memory and slower motor responses -- which can all imp
educational experience and achievement.
There are numerous workplace studies related to indoor air quality. The Nat
Institutes of Health found the impact of poor indoor air quality on work perf
be as high as 6 to 9 percent in resulting loss of productivity. A series of studie
Lawrence Berkeley Laboratory found that the presence of carpeting and less
lowered typing speed, typing accuracy and proofreading accuracy by 4 percent for each
variable.

World Health Organization

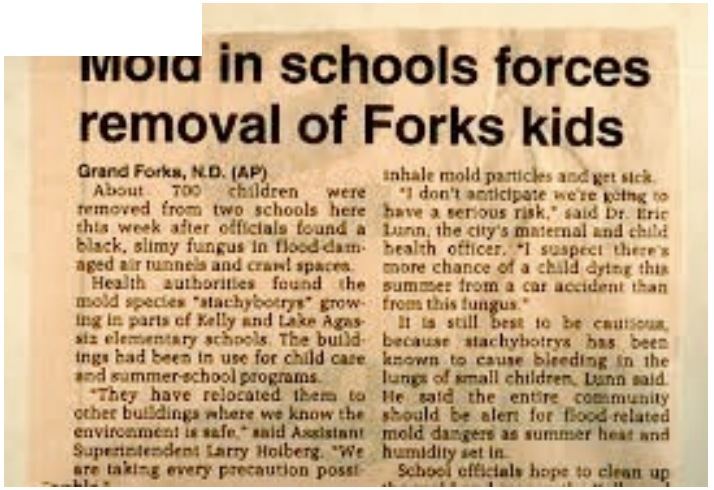
AIRMD
HEALTHY AIR FOR A HEALTHY ENVIRONMENT

household air pollution

Poor indoor air quality has a tremendous impact on the health and comfort of office workers. It is estimated that IAQ problems cost the US economy as much as $168 billion per year.

largest environmental contributor to ill health.
The importance of household air pollution as a public health threat varies drastically according to the level of development: in low- and middle-income countries, household air pollution is responsible for almost 10% of the mortality, while the same risk factor is only responsible for 0.2% of deaths in high-income countries.


SERVING THE HUDSON VALLEY AND THE CATSKILLS
TIMES HERALD-RECORD
HEALTH HAZARD
Town sued for approving 451-home development
HOLIDAY
mold causing pattern
in Liberty schools
PAGE 3


Mold in schools forces removal of Forks kids
Grand Forks, N.D. (AP)
About 700 children were removed from two schools here this week after officials found a black, slimy fungus in flood-damaged air tunnels and crawl spaces.
Health authorities found the mold species "stachybotrys" growing in parts of Kelly and Lake Agassiz elementary schools. The buildings had been in use for child care and summer-school programs.
"They have relocated them to other buildings where we know the environment is safe," said Assistant Superintendent Larry Holberg. "We are taking every precaution possi
inhale mold particles and get sick.
"I don't anticipate we're going to have a serious risk," said Dr. Eric Lunn, the city's maternal and child health officer. "I suspect there's more chance of a child dying this summer from a car accident than from this fungus."
It is still best to be cautious, because stachybotrys has been known to cause bleeding in the lungs of small children, Lunn said.
He said the entire community should be alert for flood-related mold dangers as summer heat and humidity set in.
School officials hope to clean up

WHY VENTILATE - IAQ

WHO'S AT RISK?

Everyone. However, **children are the most vulnerable**. Due to their physiology, children inhale more pollutants per pound of body weight than adults, and because children's airways are narrower, irritation means greater obstruction, according to the WHO. What's more, children's immune systems are less developed than adults.

DID YOU KNOW?

During sleep, people breathe more deeply, allowing more contaminants to enter their body. The results are aggravated asthma and allergies, stuffy noses, headaches, scratchy throats, coughs, sleep interruptions and general sickness. Additionally, contaminants are off-gassed from foams, plastics and flame-retardants found in most new beds and mattresses.

WHY VENTILATE - CONTAMINANTS

AMERICANS SPEND 90% OF THEIR TIME INDOORS

- INDOOR AIR IS **2X-5X** AND AS MUCH AS **100X** MORE POLLUTED (EPA)
- **30%** OF COMMERCIAL BUILDINGS AFFECTED BY INDOOR AIR POLLUTION (EPA)
- POOR IAQ LEADS TO REDUCED EMPLOYEE PRODUCTIVITY, POOR STUDENT PERFORMANCE AND DISCOMFORT.
- POOR IAQ COST THE U.S ECONOMY **$168 BILLION/YR** (AIR MD)

WHY VENTILATE - CONTAMINANTS

ACCORDING TO STUDY OF 75,000 HIGH SCHOOL STUDENTS IN NYC

- STUDENTS WERE **12.3%** MORE LIKELY TO FAIL AN EXAM ON A 90°F DAY VERSUS A 75°F DAY

- POOR VENTILATION IN SCHOOLS WAS ASSOCIATED WITH STUDENT FATIGUE, LOWER ATTENTION SPAN, AND LOSS OF CONCENTRATION

- **MORE THAN 60,000, OR 46%,** OF ALL U.S. PUBLIC SCHOOLS HAVE CONDITIONS THAT CONTRIBUTE TO POOR INDOOR ENVIRONMENTAL QUALITY (EPA)

HARVARD T.H. CHAN SCHOOL OF PUBLIC HEALTH

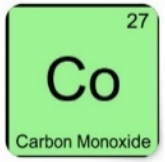
Powerful ideas for a healthier world

WHY VENTILATE - CONTAMINANTS

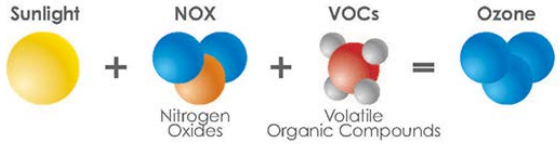
- What Always Comes to Mind
  - Moisture and Mold
  - Odor

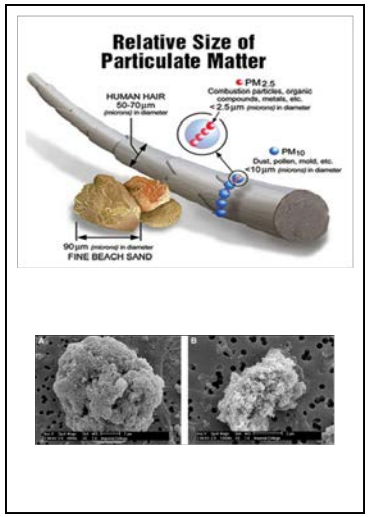


- What Often Comes to Mind
  - Carbon Monoxide
  - Carbon Dioxide
  - Radon



- What Occasionally Comes to Mind
  - Particles (PM2.5)
  - Nitrogen Dioxide
  - Formaldehyde
  - Ozone
  - VOC





IAQ – IT DOES NOT STOP THERE

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 emissions. Top selling products were used in the research p detergent and dryer sheets. The main researcher who found sheets also led the dryer vent study.

Cancer Causing Concerns

Air pollution can affect child's brain development: Experts

26 days ago · 27-07-2016 · IANS · XML

New Delhi, July 27 : Air pollution can affect a child's brain development, create abnormalities, and lower the IQ, health experts have claimed.

The health experts, whose claim is based on several studies, said that the difference between the working memory capacity of children living in urban areas is 4-5 per cent lower than children living in rural areas due to the effects of pollution.

"The findings are disturbing as optimal brain development is crucial in setting the foundation of children's future. Children are most vulnerable to negative effects of air pollution due to their higher breathing rate to body size ratio, and less developed natural barriers in the lungs," explained S.P. Byotra, Head of Department of Internal Medicine at Sir Ganga Ram Hospital.

Byotra claimed that even indoor environment cannot be termed as safe since exposure to many common everyday pollutants in our homes, including tobacco smoke, lead in paint and toys, emissions from cooking stoves, mycotoxins among others, can affect a child's brain development.

A study published in PLOS Medicine, a peer-reviewed weekly medical journal, said that air pollution not only causes respiratory problems but can also affect the brain development of children of all ages including in the womb.

According to medical experts, millions of children exposed to toxic levels of indoor and outdoor pollution were showing brain detrimental effects exhibiting brain abnormalities. Tobacco dust, indoor air pollution, and airborne polycyclic aromatic hydrocarbons were contributing the most.

ases found more than twenty-five
mbinations which included seven
s. Two of the chemicals,
zene are grouped as carcinogens
rotection Agency.

no regulations on dryer emission.
rch study, emission from the dryer
e brands of laundry soap
e (Washington) area alone would
6%) of automobile emission of

2016 author: Dr. Don Colbert

COMMERCIAL VENTILATION – ASHRAE min.?

STALE AIR IS MAKING YOU LESS PRODUCTIVE

- MARCH 2017 ISSUE OF HARVARD BUSINESS REVIEW
- BASED ON RESEARCH AT HARVARD, SYRACUSE UNIVERSITY, SUNY MEDICAL – DOUBLE BLIND STUDY
- STUDIED EFFECT OF DOUBLING VENTILATION ABOVE STANDARD 62, LOW VOC AND LOW CO2

CONCLUSIONS OF FINDINGS

- COST OF DOUBLING VENTILATION:
  - $10 - $40 PER PERSON /YEAR
- PRDUCTIVITY BENEFITS - $6,500 PER PERSON / YEAR (NOT INCLUDING POTENTIAL HEALTH BENEFITS, REDUCED SICK BUILDING SYNDROME AND ABSENTEESIM

Harvard Business Review

WORKSPACES

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.

CO2! Surrogate or COC?

The effects of bedroom air quality on sleep and next-day performance

P. Strøm-Tejsen, D. Zukowska, P. Wargocki and D.P. Wyon.

International Centre for Indoor Environment and Energy, Department of Civil Engineering, Technical University of Denmark

Corresponding author mail id: peterstromtejsen@gmail.com

Abstract

The effects of bedroom air quality on sleep and next-day performance were examined in two field intervention experiments in single-occupancy student dormitory rooms. The occupants, half of them women, could adjust an electric heater to maintain thermal comfort but they experienced two bedroom ventilation conditions, each maintained for one week, in balanced order. In the initial pilot experiment (N=14) bedroom ventilation was changed by opening a window (the resulting average CO_2 level was 2585 or 660 ppm). In the second experiment (N=16) an inaudible fan in the air intake vent was either disabled or

Pawel Wargocki
>20 years of experience in research & monitoring of human requirements in buildin...
2w

Interview in ASHRAE Newsletter

ASHRAE JOURNAL Newsletter

Connecting Today's To Peer-Reviewed C

Volume 1, Number 18, October 10, 2017

Indoor Air Quality

Adjust Your Thermostat, Sleep Better

How Indoor Air Quality Tactics Help You Sleep Better at Night

A study revealed how increasing the clean outdoor air supply rate in bedrooms can improve sleep quality. Pawel Wargocki, Ph.D., Associate Member ASHRAE, of Denmark, discusses the study and how people can manipulate bedrooms' indoor air quality to help them get to sleep faster, stay asleep and be more productive the next day. In a *Journal* article from March 2013, Wargocki and David P. Wyon, Ph.D., Member ASHRAE, answer 40 questions about the effects of thermal comfort and indoor air quality on performance.

In this study, Wargocki and other researchers studied how well college students slept in different ventilation conditions.

NASA STUDY CO_2 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 (Kidney Stones)

Source: Chronic Exposure to Moderately Elevated CO2 during Long-Duration Space Flights

NASA/TP-2012-217358

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

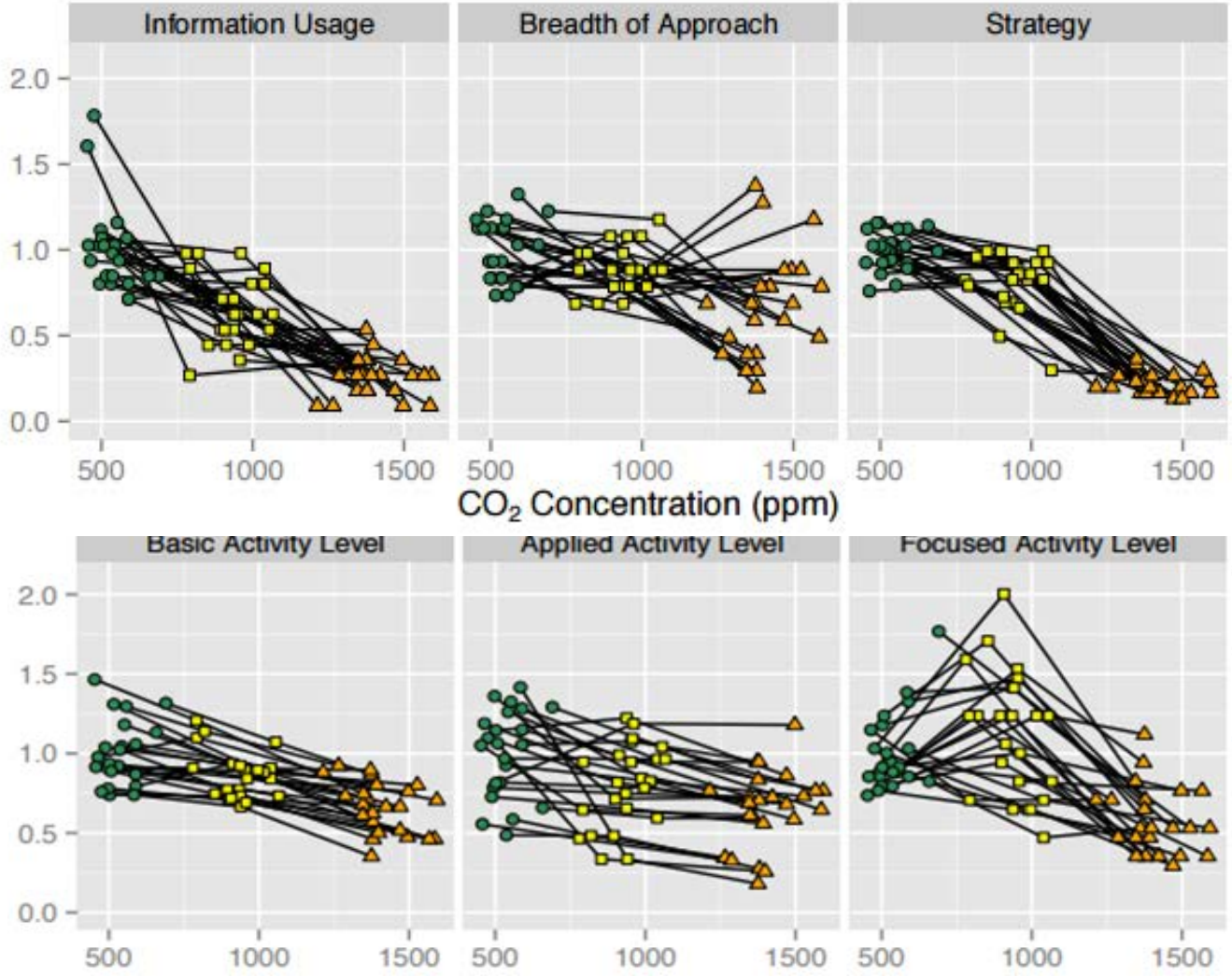
IAQ and Ventilation in Perspective – LBNL Study

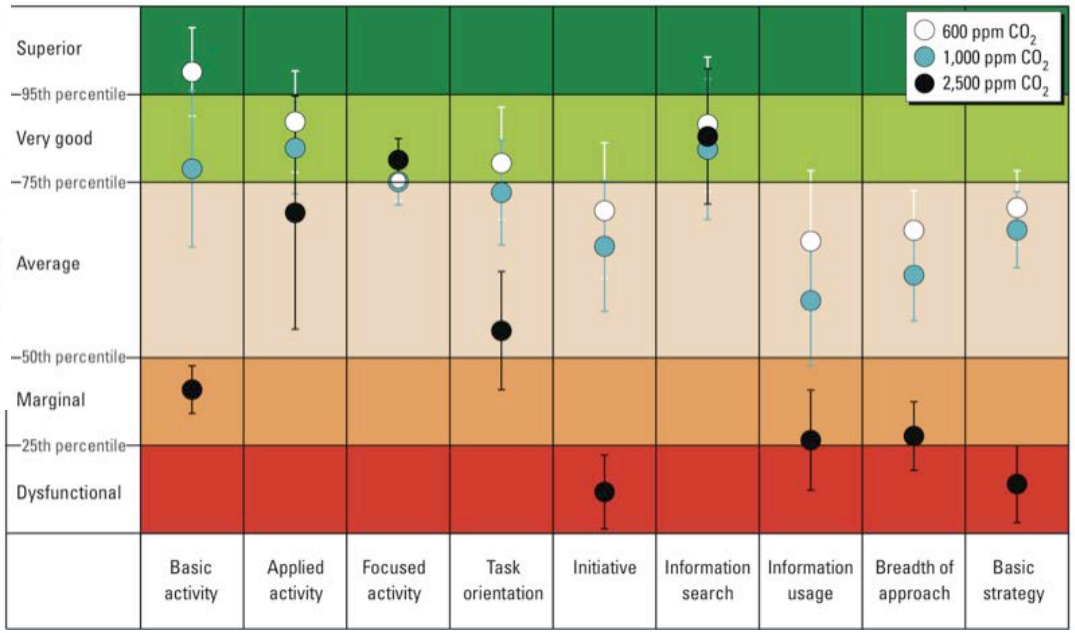
- Significant declines in cognitive functions when CO_2 concentrations were increased to 950 ppm or higher.[+]
- Lack of mechanical ventilation has adverse human impacts; DALYs increase.[++]

[+] **Allen, GA, et al. *Associations of cognitive function scores with carbon dioxide, ventilation, and volatile organic compound exposures in office workers: A controlled exposure study of green and conventional office environments*, National Institute of Environmental Health Sciences, 2015.**
[++] **Logue et al., *Hazard assessment of chemical air contaminants measured in residences*, June 2010, LBNL-3650E.**

Courtesy of Rick Karg RED

CO_2 FRIEND OR FOE – LBNL Real World Research



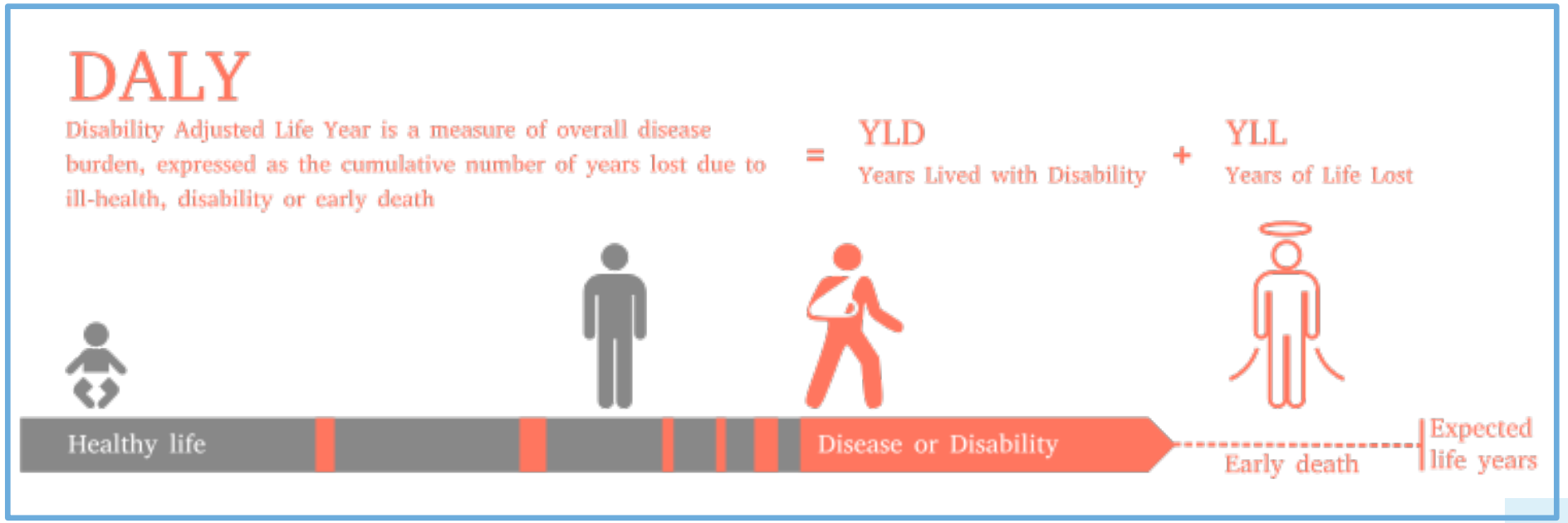


Source: Satish et al. (2012) Is CO2 an Indoor Pollutant? Direct Effects of Low-to-Moderate CO2 Concentrations on Human Decision-Making Performance
Source: Allen et al (2015) Associations of Cognitive Function Scores with Carbon Dioxide, Ventilation, and Volatile Organic Compound Exposures in Office Workers

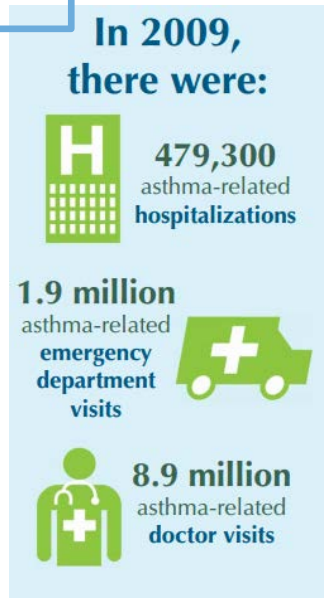
Cost of illness - DALY

1 in 11 children has asthma

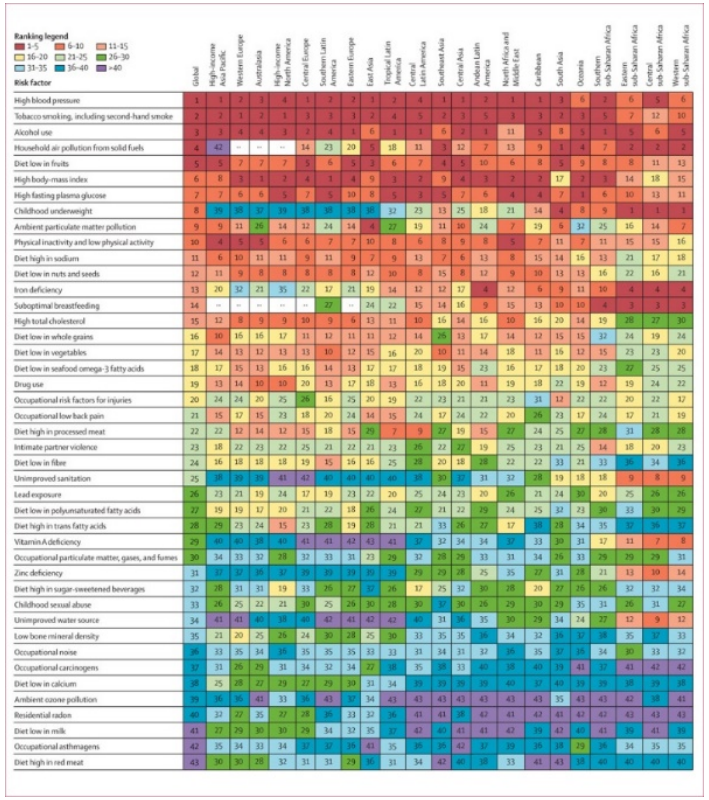
1 in 12 adults has asthma



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



Disease Burden By Various Risks

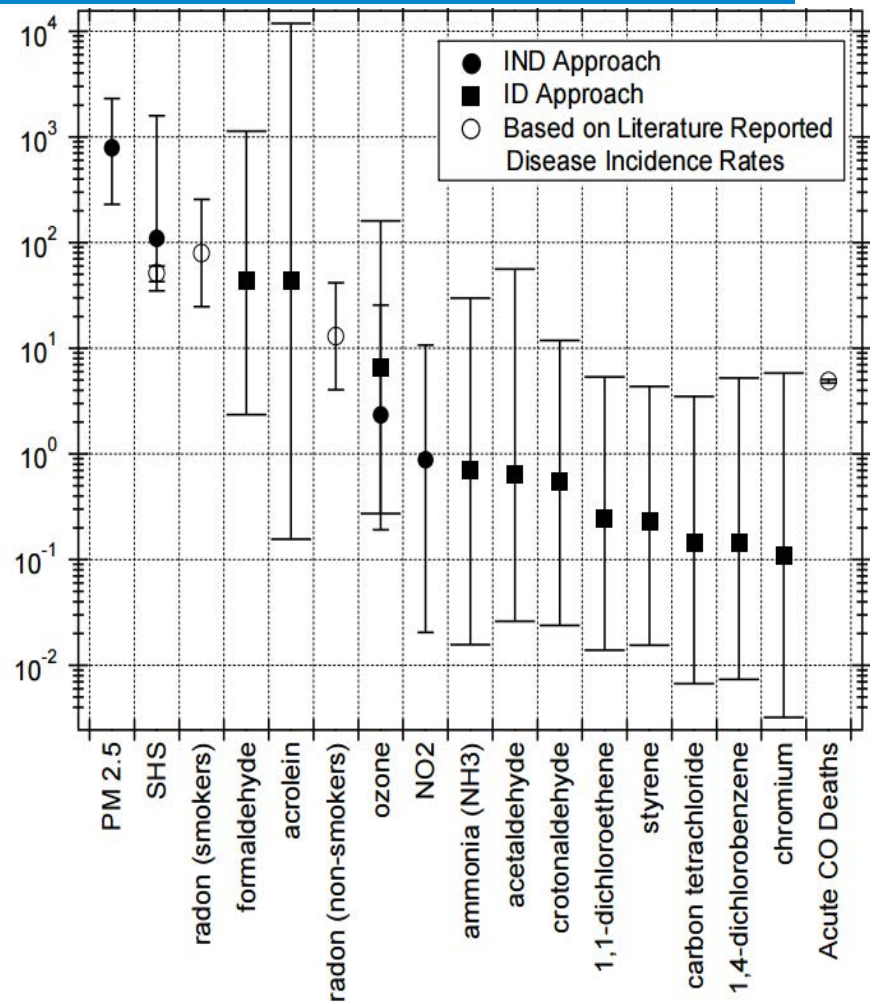


Ranking legend

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	..	..	..	..

DALYs Lost (per year per 100,000 people)



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; results for the 15 pollutants with highest mean damage estimates.

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

ASHRAE®

ASHRAE Guideline 42P

Advisory Public Review Draft

Indoor Air Quality in Commercial and Institutional Buildings

Advisory Public Review (April 2018)

(Complete Draft for Full Review)

This draft has been recommended for public review by the responsible project committee. To submit a comment on this proposed guideline, go to the ASHRAE website at www.ashrae.org/standards-research--technology/public-review-drafts and access the online comment database. The draft is subject to modification until it is approved for publication by the Board of Directors. Until this time, the current edition of the guideline (as modified by any published addenda on the ASHRAE website) remains in effect. The current edition of any guideline may be purchased from the ASHRAE Online Store at www.ashrae.org/bookstore or by calling 404-636-8400 or 1-800-727-4723 (for orders in the U.S. or Canada).

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ASHRAE, 1791 Tullie Circle, NE, Atlanta GA 30329-2305

4.2.4 Design aspects to increase the occupant experience

a. Increasing activity – Applicable as IAQ and IEQ
b. Daylight - Applicable as IAQ and IEQ, impact the ability for thermal and moisture control
c. Products and materials selection

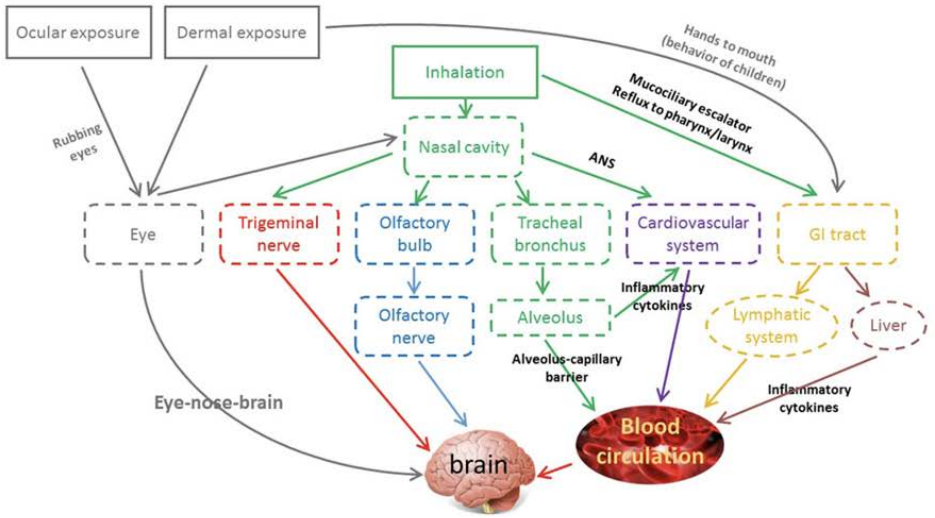
4.3 Environmental Health. Encompasses both indoor and outdoor components of environmental health, awareness of contaminants of concern, controllable and non-controllable pollutants. Discussion will include best practices in design and operation to improve IAQ.

4.3.1 This is part of the "people portion" of people, pathways, pollutants, and pressure

4.3.2 Focus on what is known about environmental impacts on health

a. Ambient particulate matter, in 2010, was ranked as the ninth most hazardous factor of the global burden of disease. The contribution to premature deaths was approximately 3.3 million yearly and premature mortality has been estimated to double by 2050 if ambient PM levels are not significantly reduced. This points out the importance requiring excellent filtration for PM removal prior to occupants' exposure indoors.
b. Also must remember that PM is not just the solid matter, but also is a carrier of other chemicals, which can float in the air as aerosols. These have the potential to deposit in the respiratory tract at all levels from the upper nasal areas to the lower alveoli.

Possible routes for PM to enter the brain (from Wang Y, Xiong L, and Tang M. 2016. Toxicity of inhaled particulate matter on the central nervous system: neuroinflammation, neurodegenerative disease. *J appl toxicology*. Published on-line 3/16/17. DOI 10.1002/jat.3451.

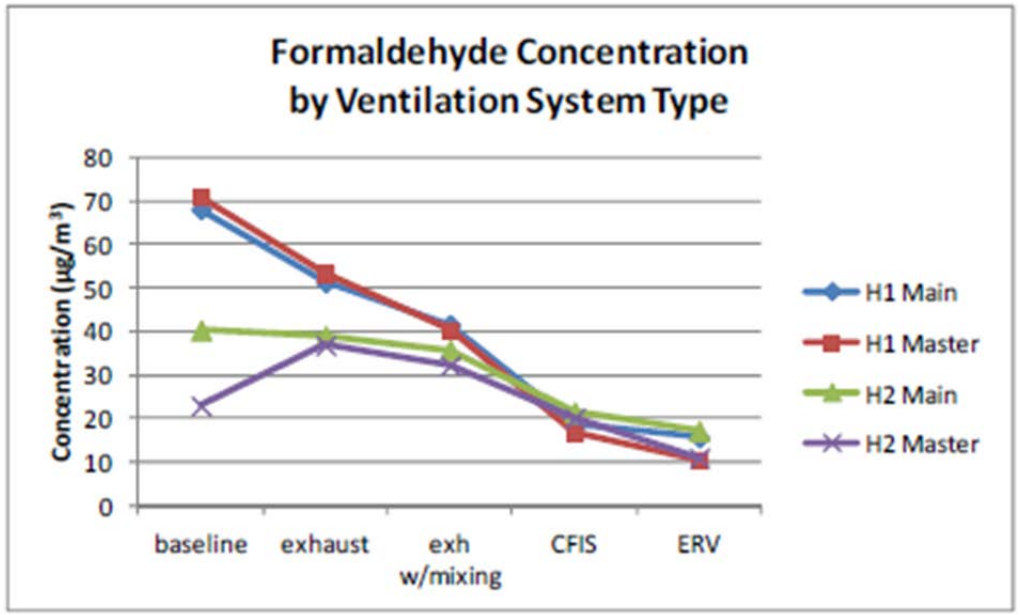


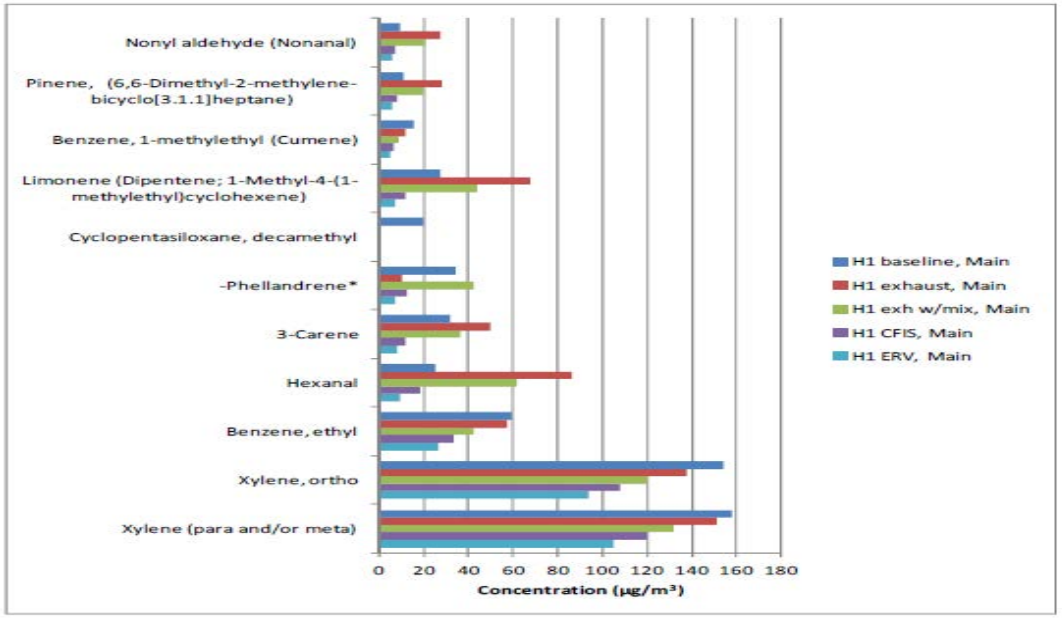
c. PM effects – respiratory (asthma), cardio, neurological, obesity, neurodevelopmental impacts

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



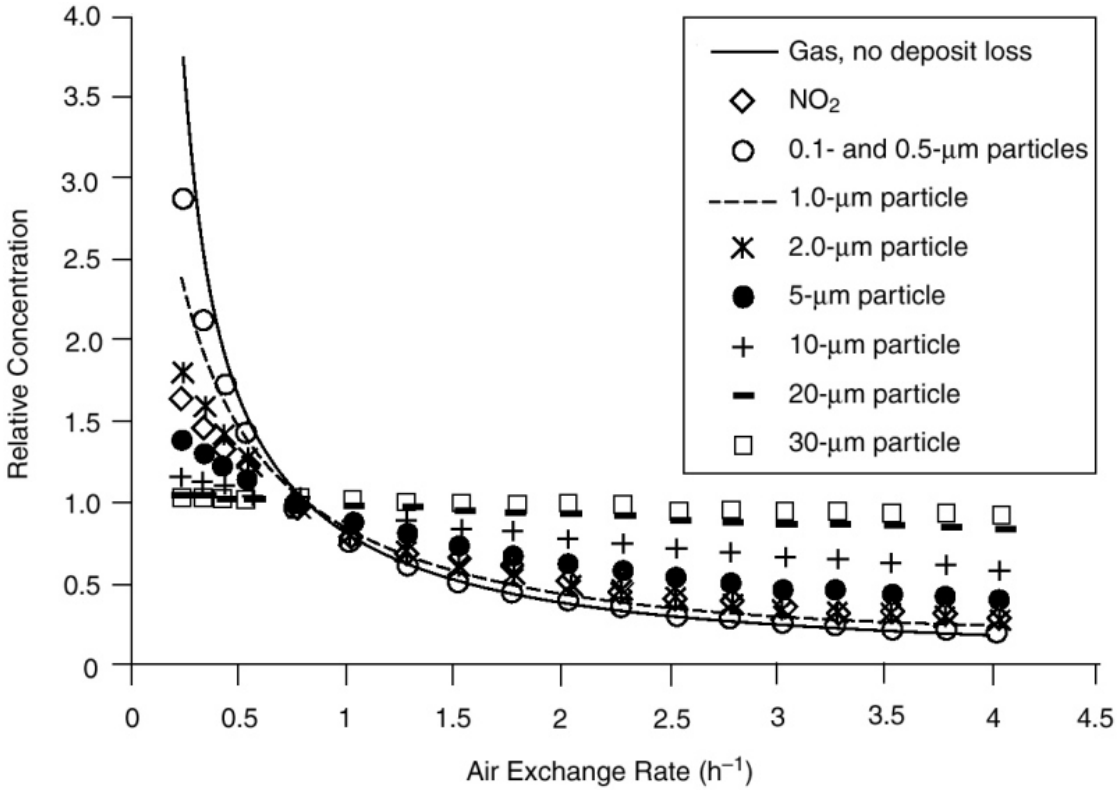


ENHANCING IAQ

METHODS TO ENHANE IAQ

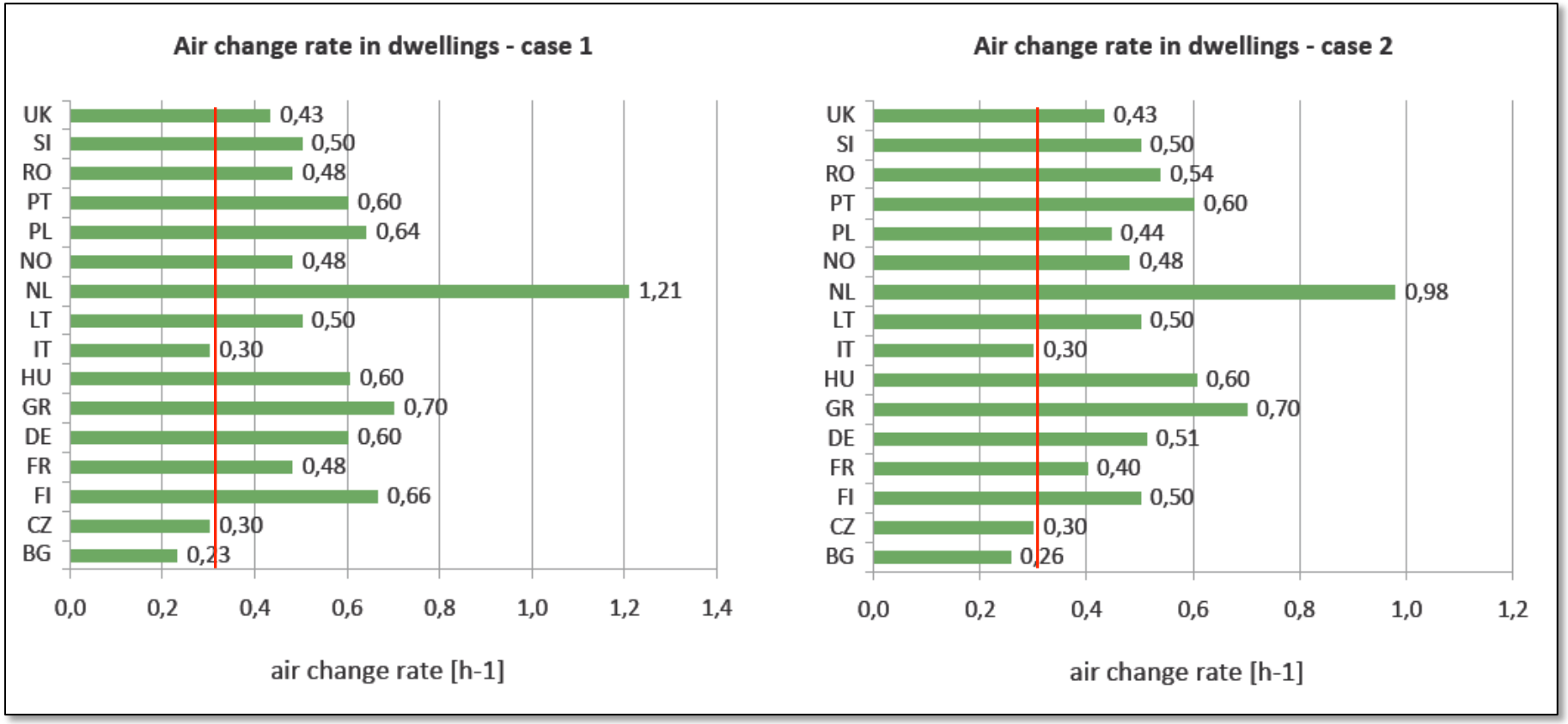
- MINIMIZE CHEMICAL POLLUTANTS
- MOISTURE CONTROL
- FILTRATION
- PROPER MAINTENANCE OF HVAC SYSTEMS
- **IMPROVED VENTILATION – SIMPLEST AND MOST COST EFFECTIVE METHOD**

"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.

EUROPEAN VENTILATION RATES

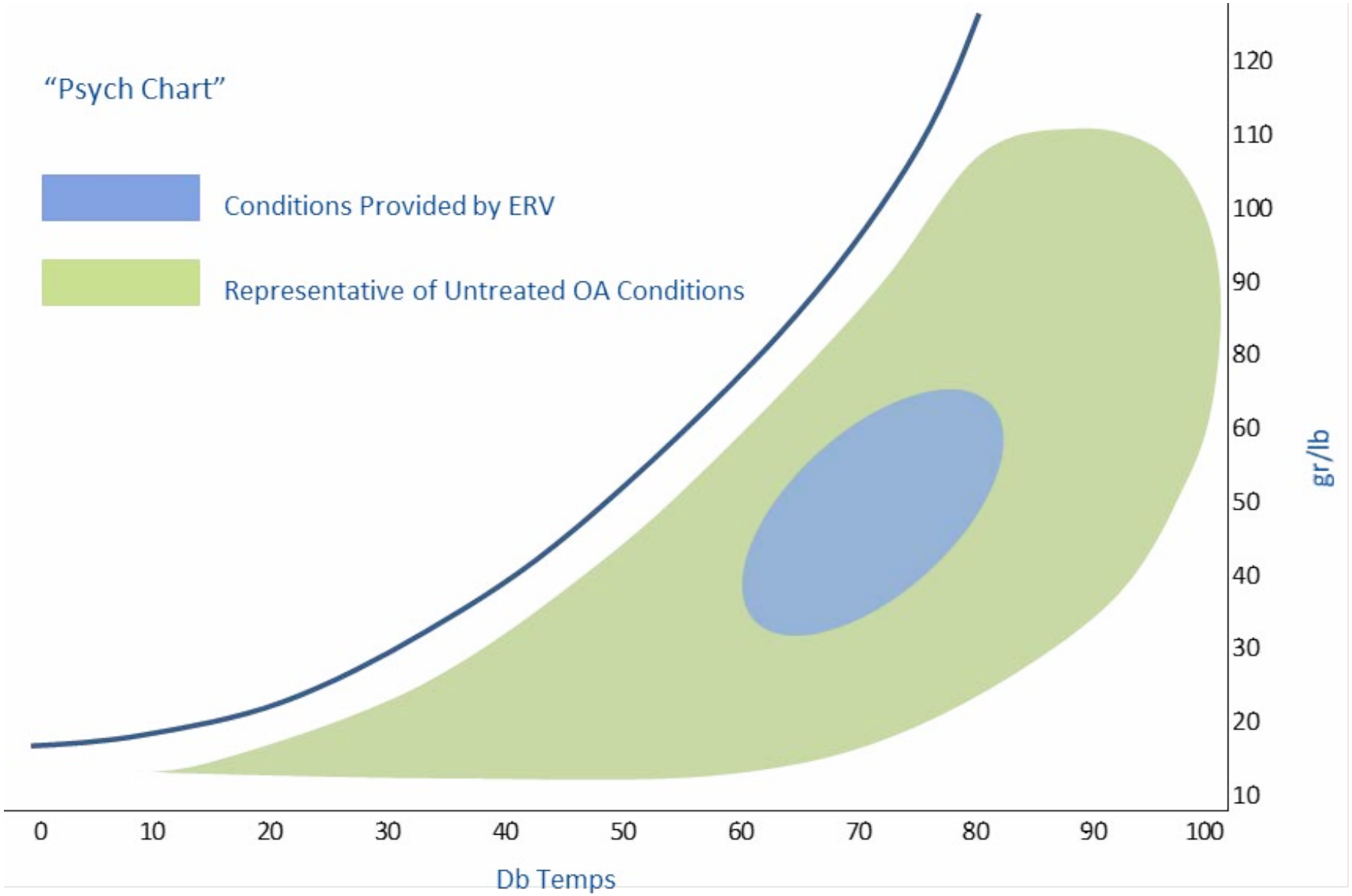


ASHRAE 62.2-2016 rate ~ 0.3 – 0.35 ach

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

Courtesy of Rick Karg RED

ERV AS A SHIELD



COOLING LOAD WITH ERV

COOLING LOAD CONVENTIONAL
SUPPLY AIR = 5000 CFM

OUTSIDE AIR = 1500 CFM

RETURN AIR = 3500 CFM

OA TEMP [DB/WB] – 95/78

RA TEMP (DB/WB) – 75/62.5

MA TEMP (DB/WB) – 81/67

COOLING = 17 TONS

COOLING LOAD WITH ENERGY RECOVERY
SUPPLY AIR = 5000 CFM

OUTSIDE AIR = 1500 CFM

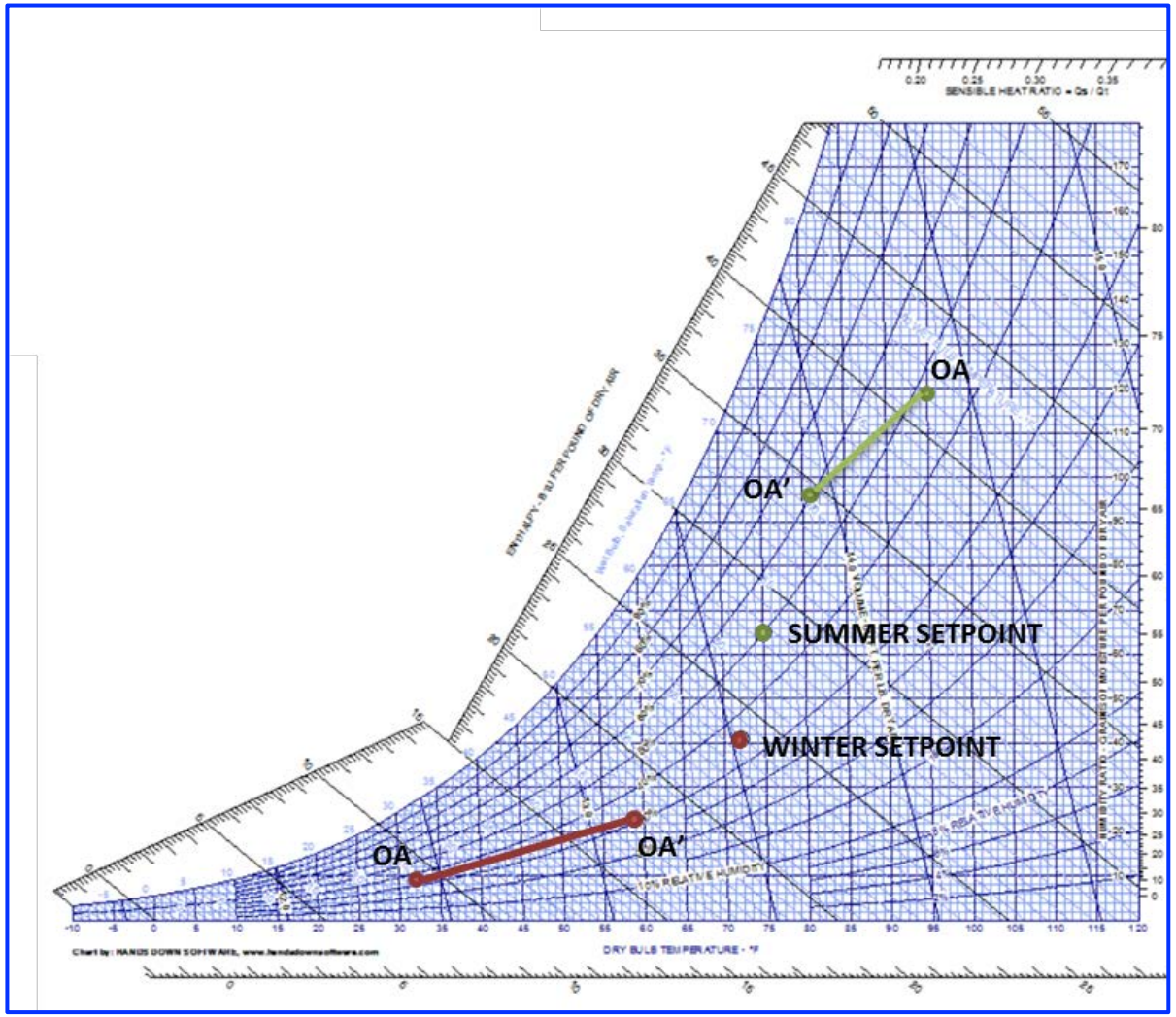
RETURN AIR = 3500 CFM

OA TEMP [DB/WB] – 95/78

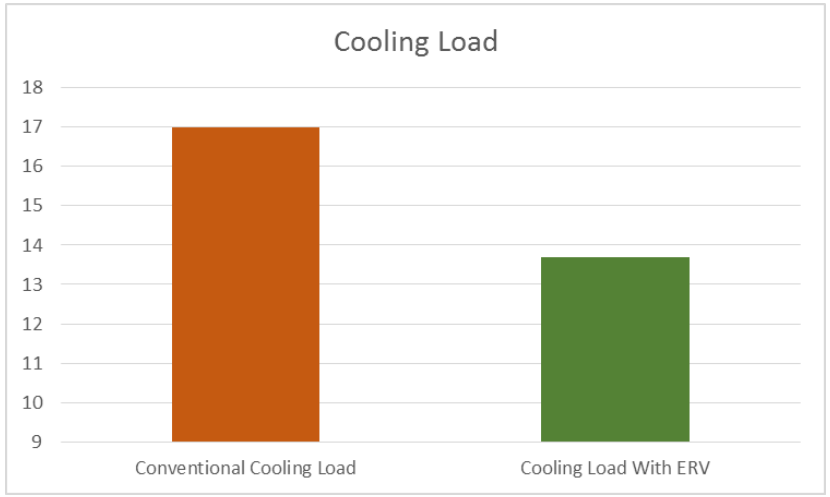
RA TEMP (DB/WB) – 75/62.5

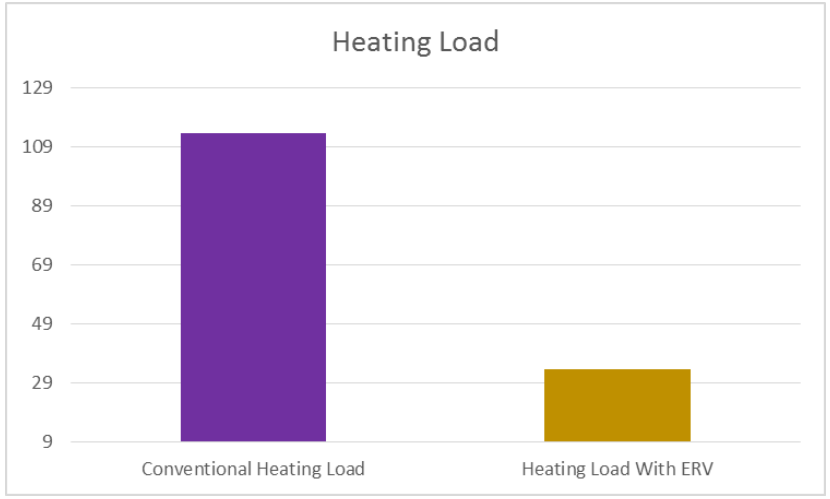
MA TEMP (DB/WB) – 76.8/64.93

COOLING = 13.9 TONS



BUILDING LOADS WITH ERV





20% COOLING LOAD SAVINGS

= $3,600 IN COOLING LOAD SAVINGS

- ***$5,500 Total Equipment Savings***
- ***$2,250 Annual Energy Savings***

Installed Cost for 1,500 cfm ERV ~ $7,550

True Payback = 1 Year !!

70% HEATING LOAD SAVINGS

= $1,900 IN HEATING LOAD SAVINGS

ERV REQUIREMENTS IN CODES

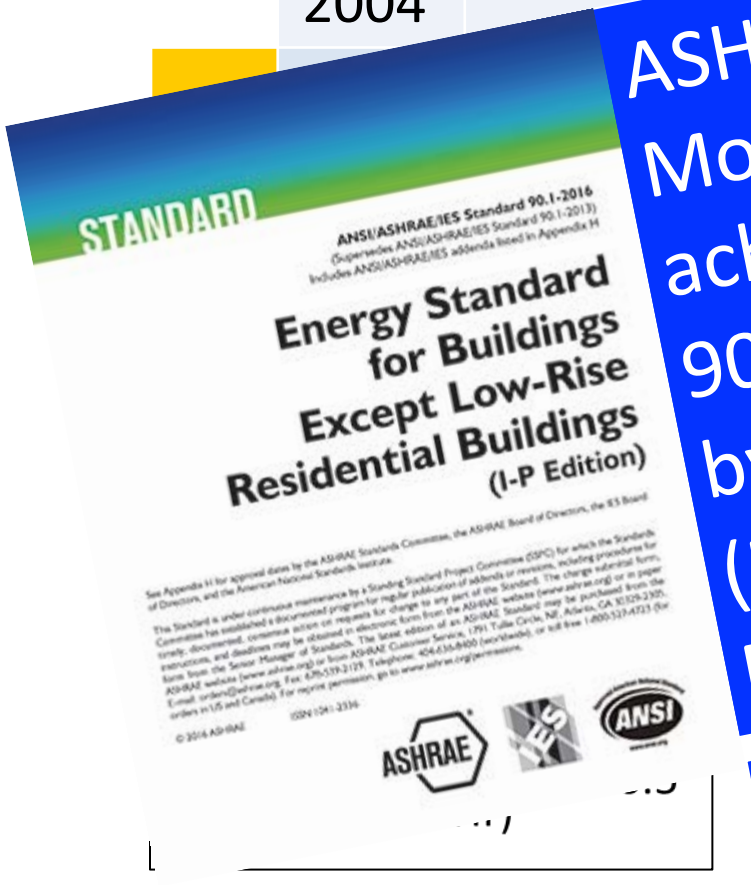
	90.1	IECC	Provisions affecting ERV
	2004		ERV not required
	2007	2009	ERV required when for HVAC systems over 5000 CFM and 70% OA. Fan power limits introduced, ERVs exempted
	2010	2012	Table 6.5.6.1 introduced – ERV required in every zone for some systems, sometimes under 5000 CFM. Fan Power Limits apply
	2013	2015	Table 6.5.6.1 – ERV requirements change slightly, and now every climate zone has applications for ERV

In all editions supply air load reduction by the ERV must exceed 50% at the applied air flow

$$ERE = \frac{(Ho - Hsa)}{(Ho - Hr)} >= 0.5$$

ERV REQUIREMENTS IN CODES

	90.1	IECC	Provisions affecting E
	2004		E

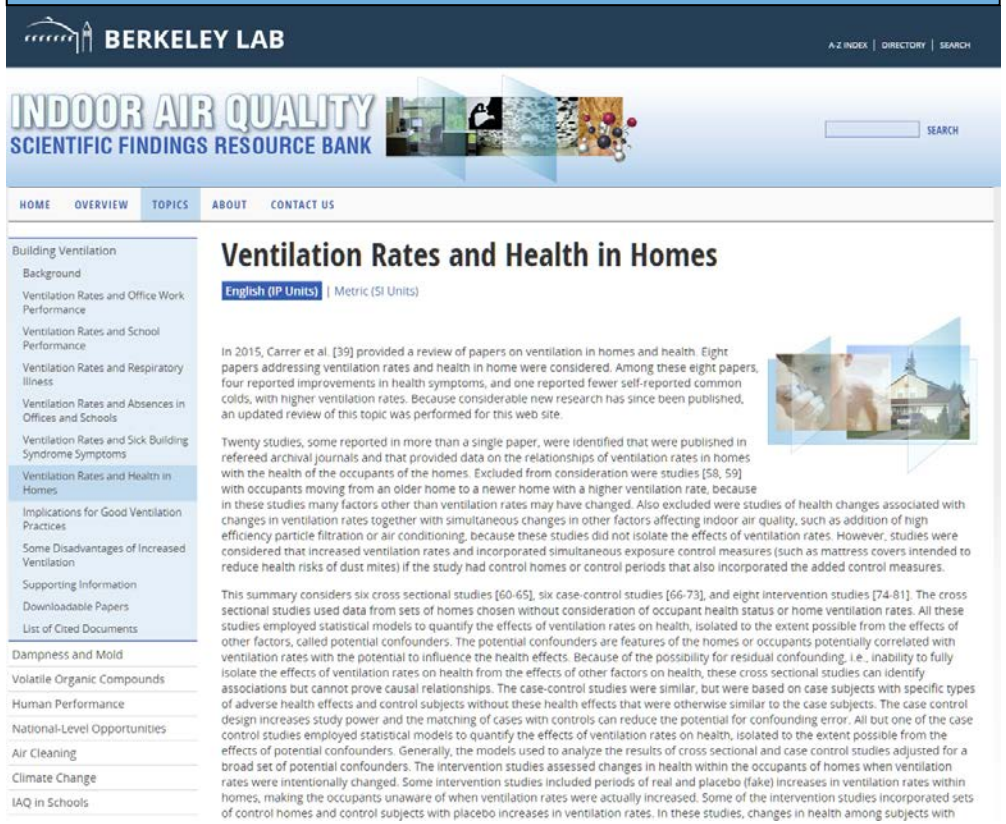


ASHRAE 90.1-2016:
More than 30 percent energy savings can be achieved using the 2016 version of Standard 90.1, according to recent analysis conducted by Pacific Northwest National Laboratories (PNNL) in support of the U.S. Department of Energy (DOE) Building Energy Codes Program

ASHRAE 90.1-2019?

Very Good Resource

www.iaqscience.lbl.gov/vent-home



Based on 118 papers

Courtesy of Rick Karg RED

LBNL Study

"Overall……the number of reported statistically significant improvements in health with increased ventilation rates far exceeded the anticipated chance