

# INDOOR AIR QUALITY: PRACTICAL SOLUTIONS

Katy Hollbacher, PE + Kara Rousselle, PE  
Beyond Efficiency | 11 March 2021



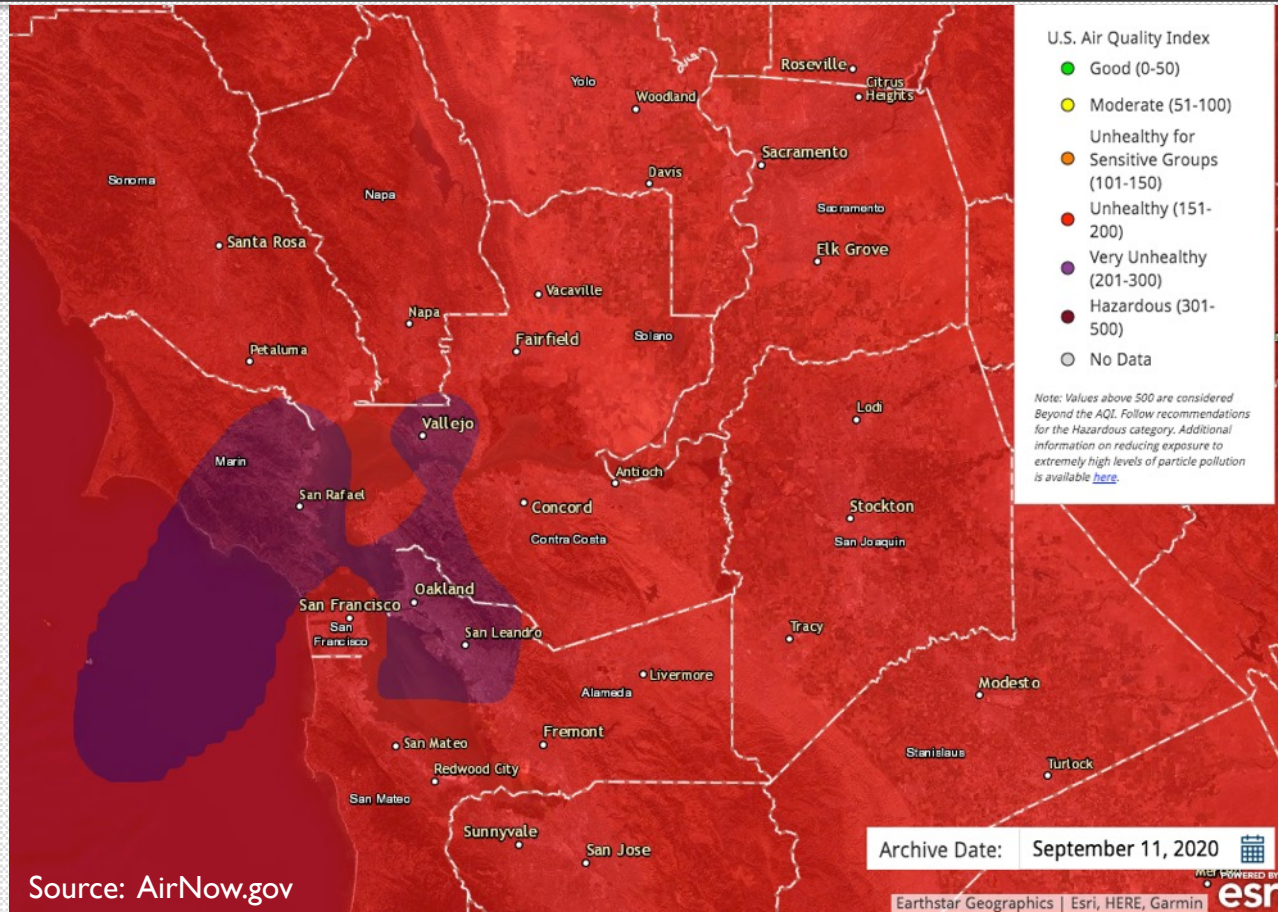
**AIA**  
East Bay

10:43 AM – SEPTEMBER 9, 2020

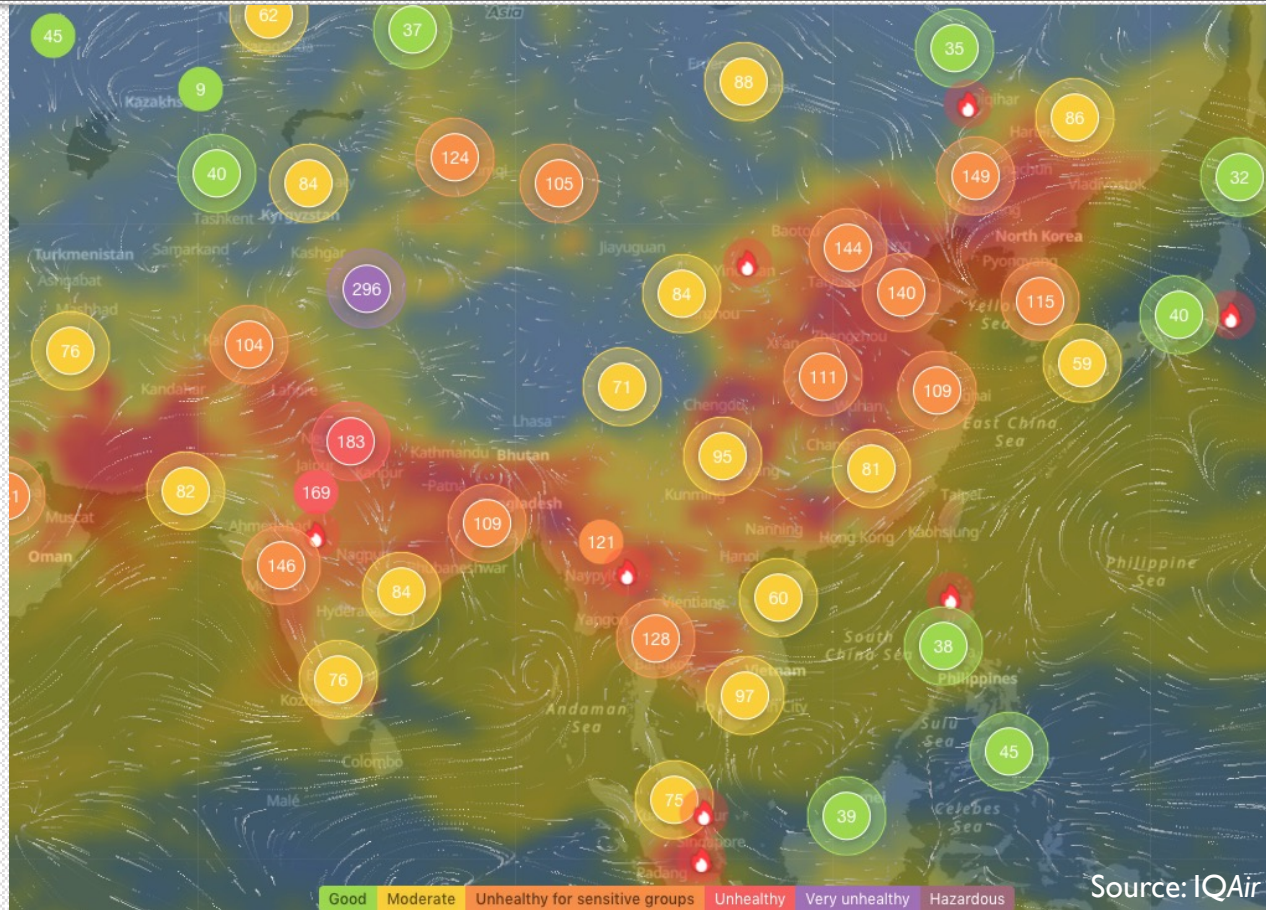




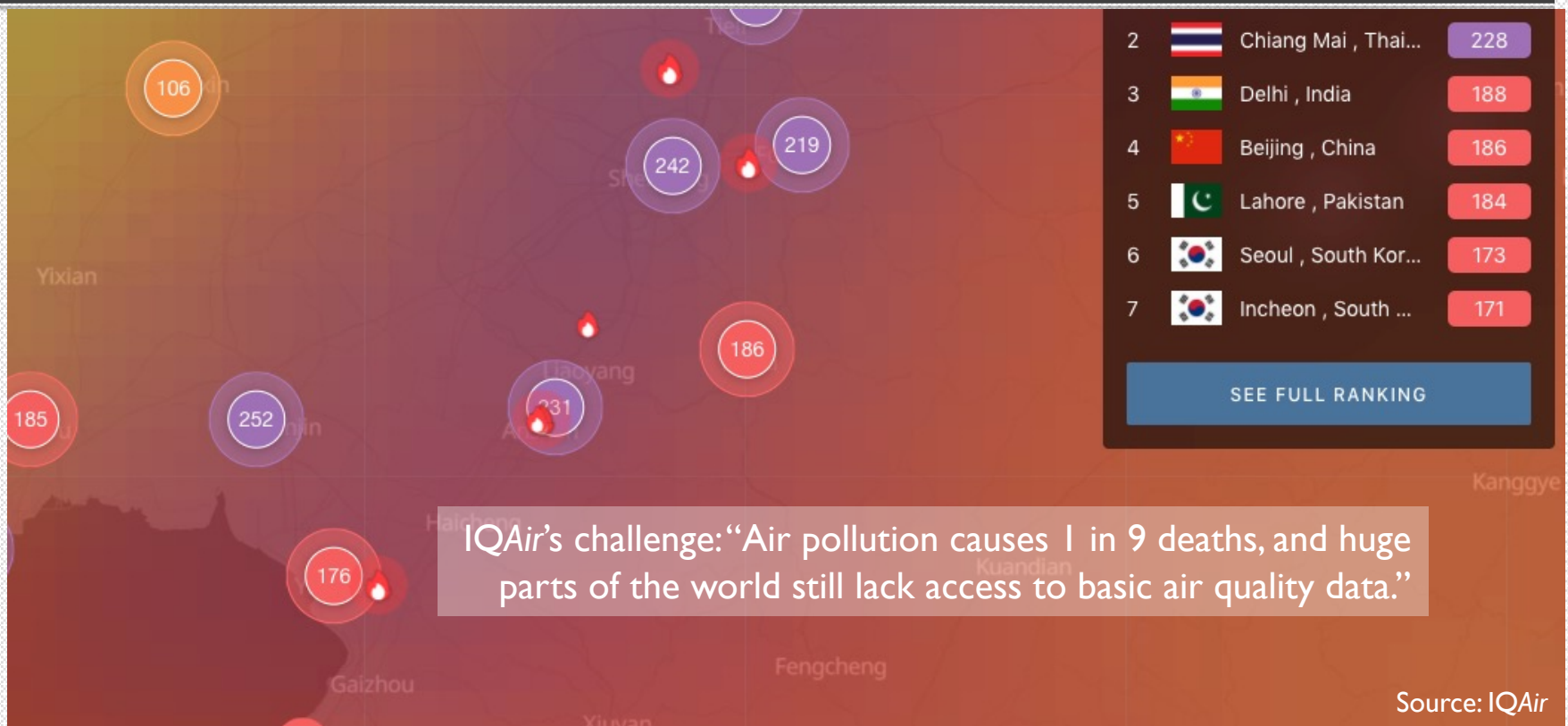
# SEPTEMBER 11, 2020: BAY AREA



# YESTERDAY: INDIA + CHINA



# YESTERDAY: NORTHEAST CHINA





# AIR QUALITY = SOCIAL EQUITY ISSUE

## USC researchers link asthma in children to highway proximity

BY **Monika Guttman** • MAY 5, 2006

**Y**oung children who live near a major road are significantly more likely to have asthma than children who live further away, according to a study that appears in the May 1 issue of Environmental Health Perspectives.

The study found that children living within 75 meters (about 82 yards) of a major road had a 50 percent greater risk of exhibiting asthma symptoms in the past year than were children who lived more than 300 meters (about 328 yards) away.

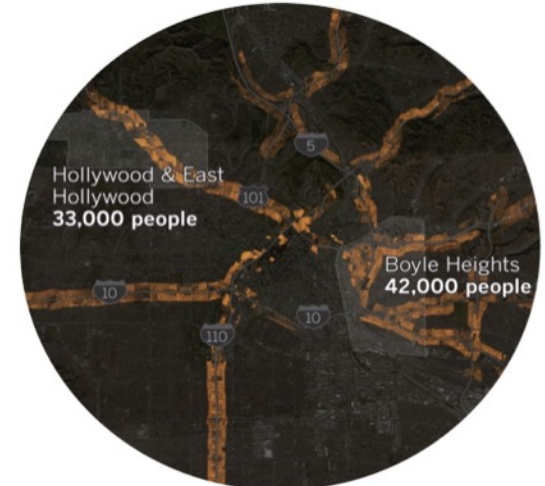
## L.A. keeps building near freeways, even though living there makes people sick

Are you one of the 2.5 million Southern Californians already living in the pollution zone?

By **TONY BARBOZA AND JON SCHLEUSS**

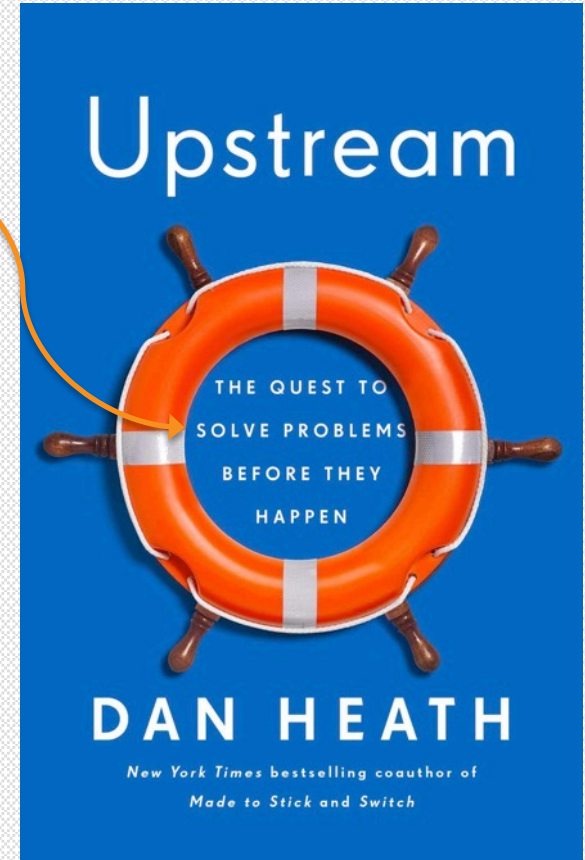
MARCH 2, 2017, 3 A.M.

LA Times



# INDOOR AIR QUALITY STRATEGY

1. SOURCE CONTROL:  
minimize pollutants by design
2. VENTILATION:  
dilute indoor pollutants
3. AIR CLEANING:  
remove pollutants



# IAQ: I. SOURCE CONTROL

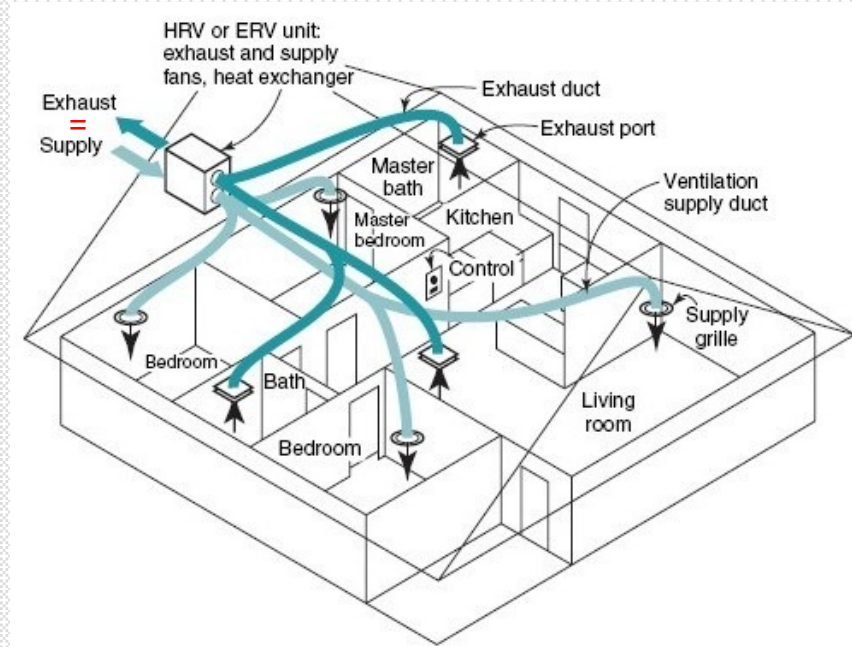
- Minimize pollutants by design
  - Emissions: interior material specifications & product choices (VOCs & SVOCs)
  - Mold: rainwater management, no plumbing leaks, proper building assemblies
  - Wildfire smoke, pollen: highly airtight building enclosure
  - Radon: sealed slab or crawlspace, depressurize underneath vapor barrier





# IAQ: 2. VENTILATION

- Dilute indoor pollutants
  - Mechanical ventilation system w/ balanced supply & exhaust airflows
  - Filtered ventilation supply air
- Why balanced?
  - Minimizes backdrafting (issue for combustion appliances)
  - Most efficient (if using HRV/ERV)
  - Maximizes filtration of supply air



## Key Components

- HRV or ERV unit with exhaust and supply fans, heat exchanger
- Programmable timer with speed switch
- Exhaust and supply ducts and grilles

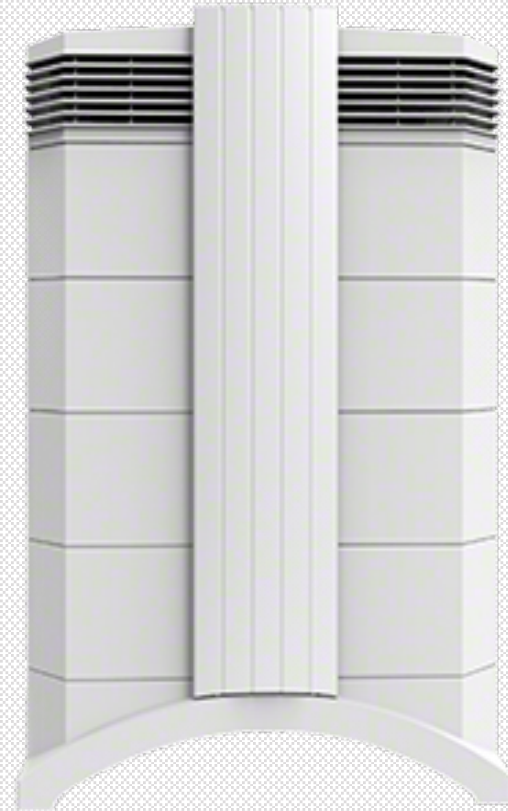
## Operation

- Runs continuously at low speed.
- Air is exhausted from bathrooms, supplied to bedrooms.
- Residents can temporarily boost ventilation rate

(C) 2006 John Wiley & Sons, Best Practices Guide to Residential Construction

# IAQ: 3. AIR CLEANING

- Remove pollutants
  - Plug-in recirculating device
  - Ideal choice for renters or homeowners not able to embark on steps 1. and 2.
  - *Should be last resort otherwise*



24" tall

HealthPro Compact: \$799  
HEPA filtration

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# ENCLOSURE AIR TIGHTNESS



# WHY AIR TIGHTNESS?

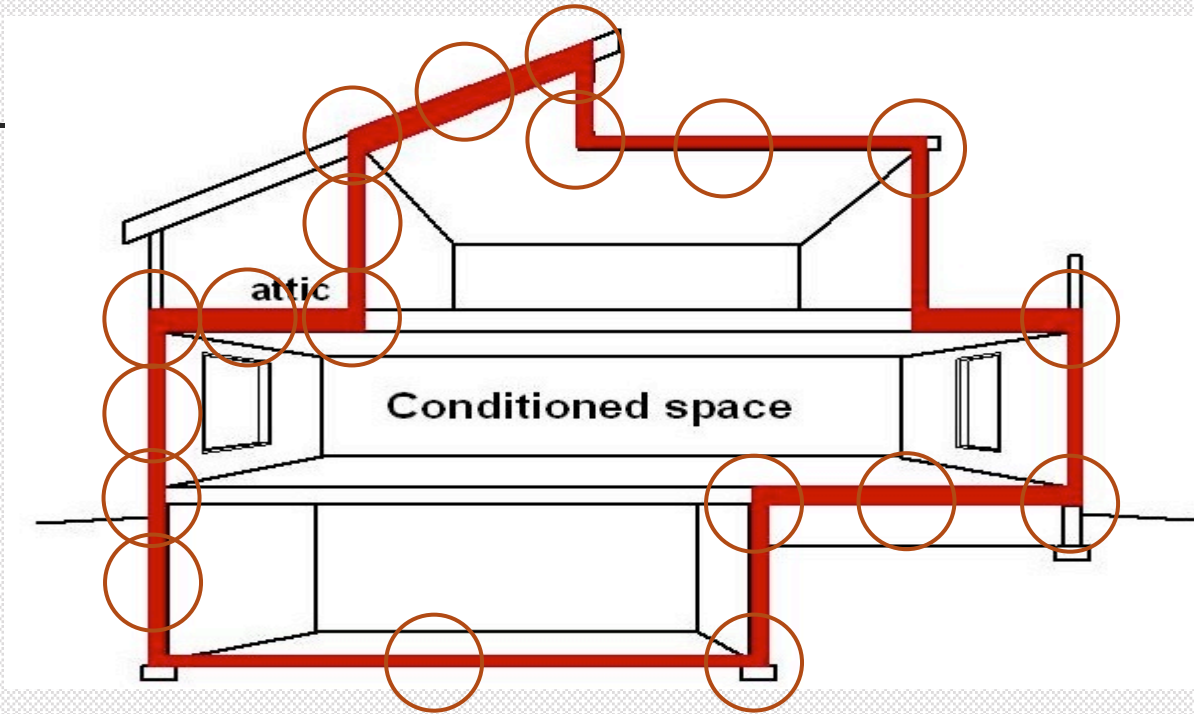
- Energy
- Sound
- Safety (fire & smoke)
- Durability
  - What besides heat does air contain?
  - Water vapor
- Health
  - “Naturally” leaky = “Randomly” leaky
  - Particulates, wildfire smoke, pollen
  - Build Tight, Ventilate Right!



“Carpet filter effect”

# SOURCE CONTROL STRATEGY: AIRTIGHTNESS

- Draw a continuous line:
- Then, detail it.
- Ensure continuity – don't miss any conditions



# BUILDING ENVELOPE: WALLS

- Designate struc. sheathing as primary airtight layer
- Use self-adhered product for premium durability/weather tightness w/ bonus air tightness properties!
  - ZIP System sheathing
  - Self-adhered membrane
  - Roll or spray on product





# BUILDING ENVELOPE: FOUNDATION

- Conditioned (unvented & insulated) crawlspace ideal
  - Space for equipment
  - Keeps ducts warm
  - Futureproofing/  
ease of future  
renovations
  - Facilitates radon  
mitigation (vs. vented  
crawlspace)



# AIR SEALING SUCCESS: DESIGN

- Details & specs aren't sufficient. Supplement with comprehensive summary & incorporate into plans.

**Objectives:** Ensure an uninterrupted airtight boundary that is fully aligned with thermal envelope to achieve final blower test result of  $\leq 1.50$  ACH<sub>50</sub>

**Air Sealing Strategies Planning Matrix**

Location	Description	Product Types*	Product Name**	NOTES
Various	Plate penetrations	Concrete mortar or grout	See options below	See CalGreen requirement
Slab on grade	Plumbing or conduit	Rubber gasket		
Foundation wall (slab edge)	Concrete to sill plate	Sill seal	Wigluv	Min; gasket or pond liner better
Foundation wall	Sheathing to foundation wall	Tape	Wigluv	
Subfloor sheathing	Panel joints, T&G	Construction adhesive	-	
Wall sheathing	Panel joints	Tape	Wigluv	
Roof sheathing	Panel joints	Tape	Wigluv	
Exterior wall, bottom plates	Plate to drywall	Gasket	BG32	
Exterior wall, top plates	Plate to drywall	Gasket	BG32	
Drywall	Typical joints	Mud & tape	-	
Exterior wall	Electrical boxes	Airtight boxes	Airfoil boxes w/ Primur	alt: Lowry pads
Exterior wall	Penetrations	Tape	Wigluv	
Exterior wall, plates	Plumbing or wires	Tape	Wigluv	

# AIR SEALING SUCCESS: DESIGN

- Pull it all together onto a dedicated plan sheet

## EXTERIOR SHEATHING CONTINUITY

1. The plywood exterior sheathing (wall/roof/subfloor) is the home's air barrier. This needs to be taped for continuity across the entire shell of the house: all seams, penetrations, and edges (to adjacent materials) using an acrylic air sealing tape, *SIGA Wigluv* or equal (Refer to Approved Materials below). Tape sheathing: to concrete foundation, at wall-roof transition, to installed windows & doors.
2. Contractor shall perform a leakage test & working session under negative pressure to identify exterior sheathing leaks & correct air leakage defects before the walls are insulated.



Photo 1. Tape wall sheathing to roof sheathing for continuity of air barrier



Photo 2. Tape wall sheathing to concrete foundation for continuity of air barrier



# AIR SEALING SUCCESS: CONSTRUCTION

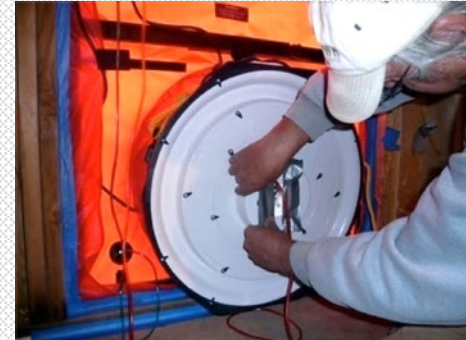
- How will responsibilities be assigned?
  - Typical: each sub expected to seal their own holes/clean up after themselves. This is not going to go well.
  - BETTER: designate an ASS, a.k.a. AIR SEALING SPECIALIST to own & champion this @jobsite
  - Having a single person accountable will maximize results!



# AIR SEALING SUCCESS: CONSTRUCTION

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- Blower door testing for envelope air tightness
  - End of project is only the “rubber stamp”
  - Adequate testing during construction is critical to hunt down leaks & ensure achievement of air tightness goals
- Coordinate w/HERS Rater to test:
  1. After exterior sheathing & windows, pre-insulation
  2. After trades & insulation, pre-drywall
  3. Final final!

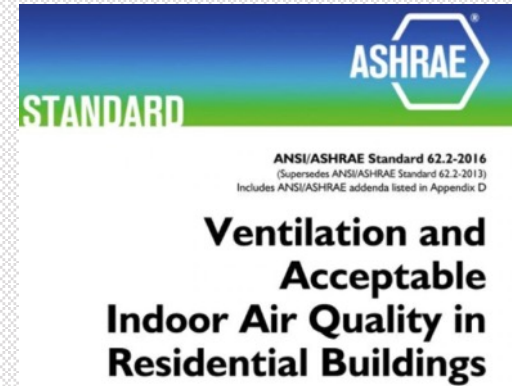


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# MECHANICAL VENTILATION

# MECHANICAL VENTILATION: 2019 CODE

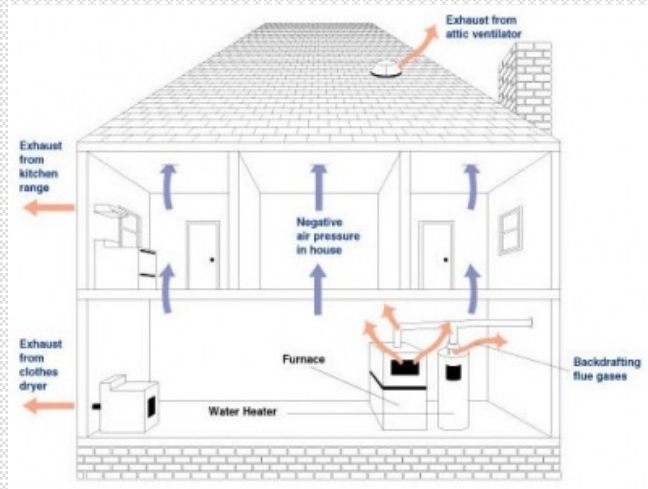
- 2019 Title 24 Energy Code §150.0(o)
- ASHRAE 62.2-2016 fresh air ventilation requirement:
  - $(0.03 \times \text{conditioned floor area, sq.ft.}) + (7.5 \times [\# \text{ bedrooms} + 1]) = \text{continuous (24/7) CFM required}$ 
    - 1-BR 500sq.ft. ADU:  $(.03 \times 500 + 7.5 \times 2) = 30\text{CFM}$
    - 4-BR 2500sq.ft. home:  $(.03 \times 2500 + 7.5 \times 5) = 113\text{CFM}$
- Exhaust, supply or balanced?
  - Doesn't matter for code...
  - DOES matter for air quality!









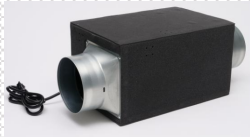
# MECHANICAL VENTILATION: “WHOLE HOUSE”

- “Build Tight, Ventilate Right” → occupant has control
- Best practices
  - Independent from heating/cooling system (dedicated outside air or DOAS) → allows optimization of both systems, no compromises
  - Balanced → doesn’t induce pressurization or depressurization
  - Filtered supply air → don’t bring in what you don’t want to
  - *BONUS: Heat or energy recovery → ventilate with the best efficiency and comfort*



Knoji.com: common causes of depressurization

# “WHOLE HOUSE” VENTILATION MENU: 1 OF 2

Cost	Quality	Exhaust Air	Fresh Air Supply	Comments
\$	Poor	Bath Exhaust Fan 	Leaks & cracks	<i>Panasonic WhisperGreen Select</i> 0-120 CFM, 0.23 W/CFM, 4"-6"Ø duct  <i>Only recommended for sites where doors &amp; windows are usually open, with good outdoor air quality</i>
\$	Fair		Makeup air damper 	Make-up Air damper, delivering outside air to pantry or other zone without a risk of cold drafts. This can be filtered. 8-10" Ø inlet duct, typically through the roof. <i>Only effective with high envelope airtightness ~max 1.5ACH<sub>50</sub></i> Refer to <i>International Residential Code (IRC)</i> requirements for cooking exhaust makeup air
\$\$	Good		Powered supply fan with filter 	<div> <i>Air King QFAM</i>            0-100 CFM            0.24 W/CFM @ 70 CFM            (MERV 8 or 13)  <a href="http://www.airkinglimited.com/m/page/qfam-fresh-air-machine.html">http://www.airkinglimited.com/m/page/qfam-fresh-air-machine.html</a> </div> <div> <i>or Broan FIN 180-P</i>            30-130 CFM            ~0.24 W/CFM            (MERV 8 or 13)   <i>or Panasonic WhisperFresh</i> </div>

# “WHOLE HOUSE” VENTILATION MENU: 2 OF 2

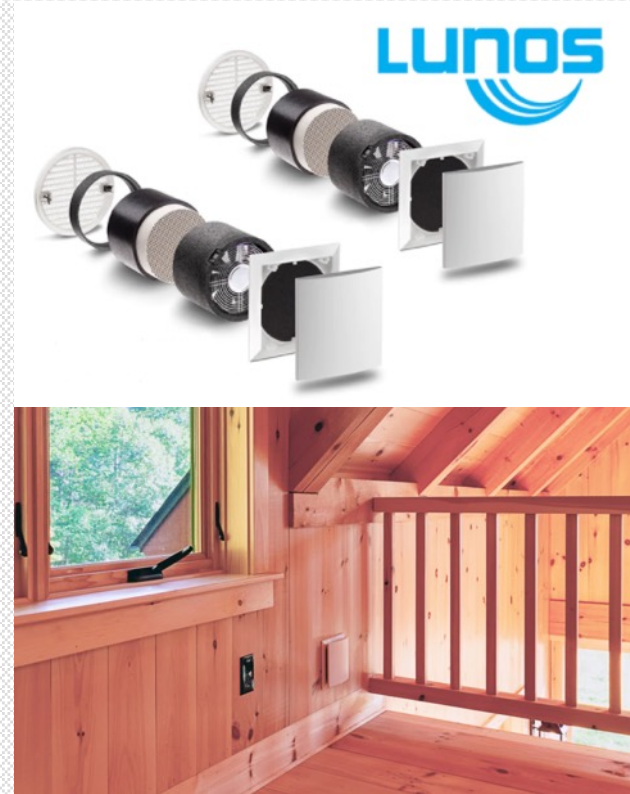
Cost	Quality	Exhaust Air	Fresh Air Supply	Comments
\$\$	Better		Ductless ERV, suitable for ADUs, studios 	<i>Panasonic WhisperComfort</i> \$450 retail 20 CFM without noise 66% heat recovery 0.76 W/CFM  or through-wall HRV or Zehnder ComfoAir 70 
\$\$\$	Better	Simple exhaust (1-2 rooms) 	Simple supply (1-2 rooms) 	<i>Panasonic IntelliBalance 100</i> \$950 retail 0-100 CFM 80% heat recovery 0.6 W/CFM  or <i>Renewaire SL70</i>
\$\$\$\$	Best	Exhaust bathrooms, laundry, wet areas 	Supply bedrooms, living areas 	<i>Zehnder CA350</i> 0-200 CFM 85% heat recovery 0.5 W/CFM

# HVAC [BALANCED VENTILATION]

- Heat recovery (HRV) or energy recovery (ERV) ventilation
  - Deliver continuous fresh, filtered air to living areas and bedrooms while exhausting from bathrooms or other areas
  - Help maintain indoor temperature and reduce heating/cooling loads
  - ERVs recover some moisture as well as heat, usually\* an appropriate choice for CA homes, and don't require a condensate drain



\* Higher density space, or higher moisture load: HRV recommended; but with proper controls an ERV can run longer@ higher CFM until humidity is adequately controlled (ERVs do not require condensate drain)



LUNOS e<sup>2</sup> ductless ERV photos: 475 High Performance Building Supply



# HRV DESIGN: I OF 3

## Outdoor Air + Exhaust

Fresh air ventilation is provided for the whole house by a balanced heat-recovery ventilation unit (HRV) located in the Lower Floor Utility space. The unit will continuously exhaust from the bathrooms, laundry, kitchen, and crawlspace and supply outside air to the living and bedroom spaces. Refer to Crawlspace Ventilation section for additional information. 8" round exhaust and intake ducts between the HRV unit and outdoors to be insulated w/ 1.5" (min R-4.2) continuous ductwrap. The intake and exhaust termination locations will need to be confirmed during the site visit. HRV operation to be a minimum 140 CFM continuous outside air. Each bathroom will have a boost switch to increase the CFM for a preset amount of time when energized (20 minutes is recommended). The main controller has four CFM % settings: absent, low, medium, and high. The HRV will operate at the high setting when the boost switch is activated and then revert to the main controller % setting after the boost period. Low setting to correspond with minimum code required CFM and be the default continuous setting of the HRV. Any existing bathroom exhaust fans can remain or be removed depending on owner's preference.

*Excerpts from Beyond Efficiency Basis of Design narrative for single-family home renovation*

### *Basis of Specification:*

- *HRV-1 Zehnder ComfoAir Q450 (29"Wx33"Hx22"D) heat recovery ventilator. Provide Zehnder wired boost switch with default setting of 20 minutes in bathrooms. Main controller Zehnder Comfosense C67 to be located by architect and owner.*

# HRV DESIGN: 2 OF 3

## *Additional information for HRV:*

- ~ 3'x2' area for sound attenuator/manifold boxes required unless there is space available to install above the HRV.
- Manifold box number of tubing connections to be based on number of tubes required in final ventilation system design. Tubing from the manifold box to each supply or exhaust register to be Zehnder Comfoflex.
- Ceiling supply diffusers to be Zehnder Luna.
- Wall supply and exhaust registers to be Zehnder Roma. Ceiling exhaust registers to be Zehnder STB sized for CFM.
- Diffuser boxes to be Zehnder TVA 75 2 port or TVA 75 3 port for ceiling installation and Zehnder CLD75 register box for wall installation.
- There is a MERV 13 filter housing in outside air supply airstream internal to the unit.
- There is a MERV 7/8 filter housing in the exhaust airstream internal to the unit to protect unit.
- HFU-1 Hawk Environmental Airwash Whisper 350  
(14.5"Wx14.5"Dx27.25"H) HEPA filtration system installed on the intake ductwork before the HRV for additional filtration when the outside air quality is poor. There will be an on/off rocker switch located in Utility to turn on the HEPA filtration unit when the outside air quality is poor. When the HEPA filtration unit wall switch is on, the outside air will be filtered through the HEPA filter. When the HEPA filtration unit wall switch is off, the outside air will bypass the HEPA filter.
- The Zehnder Q series will self-balance to the set CFM to compensate for the system pressure difference with and without the HEPA filtration unit operating. Ensure HEPA filter unit is easily accessible to the homeowner for switch out.
- Condensate drain required for HRV.

Excerpts from Beyond Efficiency Basis of Design narrative for single-family home renovation

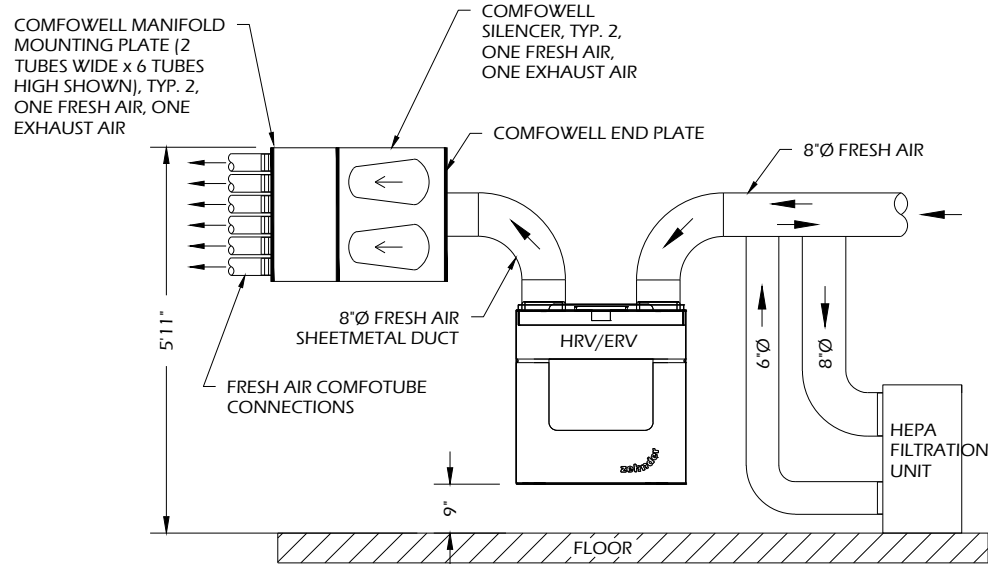


Hawk Environmental HEPA filter

## PERFECT SEAL® HEPA

- Smart 360° cylindrical design
- 99.97% HEPA efficiency
- 100% leak-proof seal
- Washable foam pre-filter
- Activated carbon canister for VOC

# HRV DESIGN: 3 OF 3



Excerpt from Beyond Efficiency mech design plans for single-family home renovation

NOTE:

1. FRESH AIR SUPPLY DISTRIBUTION SHOWN. EXHAUST AIR IS BEHIND FRESH AIR SUPPLY WITH IDENTICAL LAYOUT. EXHAUST AIR TO OUTSIDE IS BEHIND FRESH AIR.
2. UNIT CAN BE INSTALLED WITH SUPPLY AND EXTRACT AIR TO THE RIGHT OR TO THE LEFT.

# WHAT ARE WE MISSING?

- Kitchen exhaust!
- Code: 100CFM intermittent or 5ACH continuous
- Best practice: direct exhaust via proper range hood
  - Most important with gas
  - Size right!
  - Follow installation specs!
- Do I need makeup air?
  - CA: no requirement
  - Most of US: req'd for  $\geq 400\text{CFM}$
  - Recommended: regardless of hood CFM in very tight homes

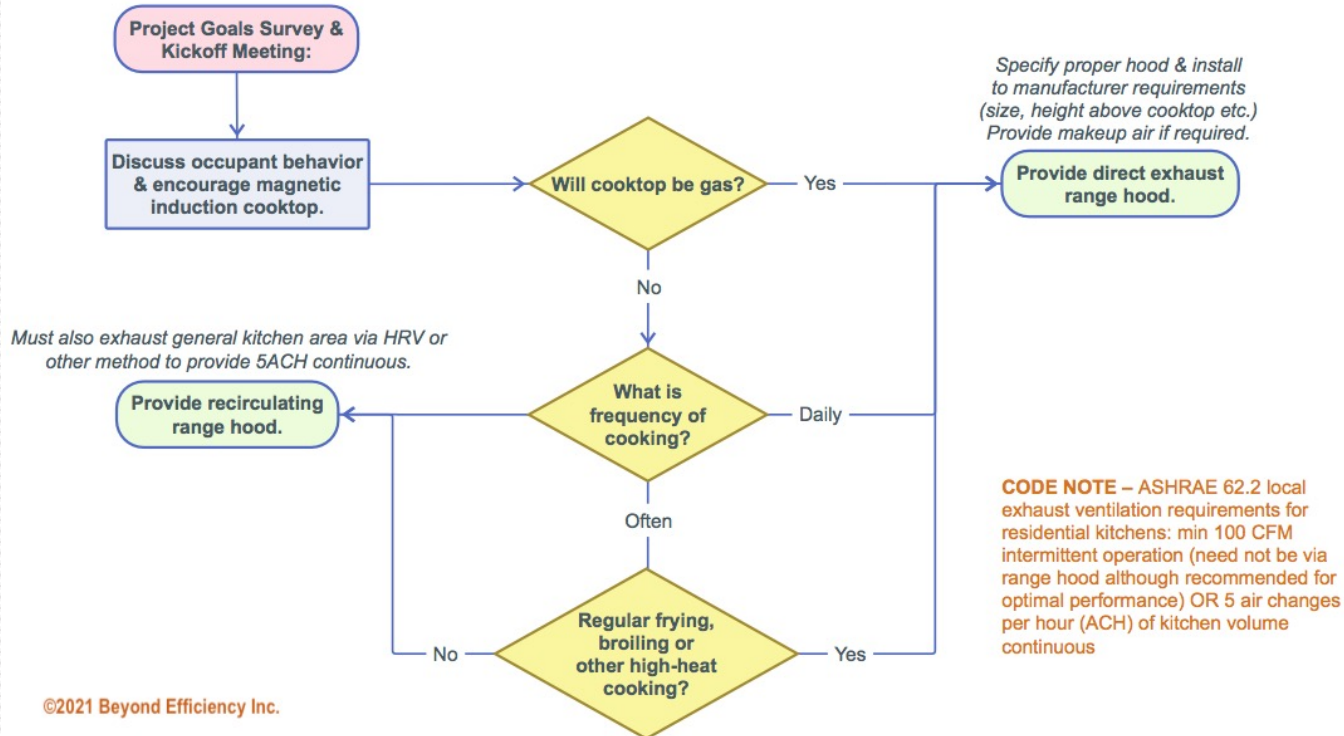




# KITCHEN EXHAUST

## How to Determine Importance of Providing Vented Range Hood for Cooktop

*Vented range hood recommended in all cases when feasible and affordable. This decision chart based on cost:risk evaluation based on objective review of indoor air quality studies.*



# RANGE HOOD DESIGN + INSTALLATION

## ■ GreenPoint Rated measure H7:

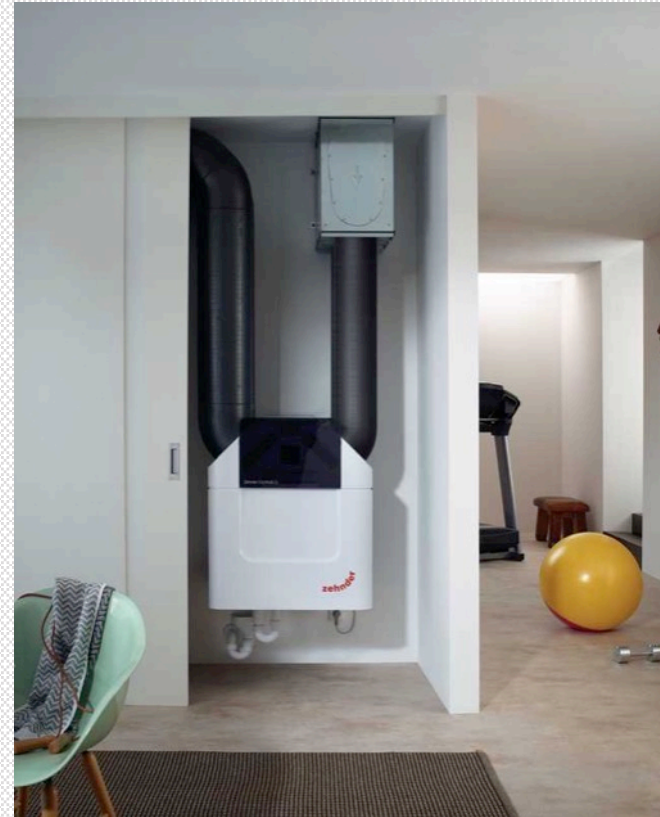


- The kitchen range hood must have a setting with HVI certified airflow of 200 cfm or greater and sone rating of 4 sones or less. If the fan is not HVI certified but meets the sone limit, then the flow rate should be divided by 3 to estimate the certified flow rate.
- The ducting for the range hood must be rigid and smooth.
- Never make the cross-sectional area smaller than the transition originating at the hood.
- Keep duct lengths less than 50 effective linear feet. Elbows are equivalent to 10 feet of duct.
- Install a range hood with an open collection hood that is at least one inch deep at the front edge and deeper at the rear. The range hood must cover 50% of the front burner.
- Install a range hood without a one-inch sump. The depth at the front edge must cover the front burners completely.
- Install a range hood with a setting that moves 300 cfm at 4 sones or less if the front burners are not at least 50% covered.
- If the range hood exhausts air more than 400 cfm, then make up air must be interlocked with the range hood.
- If the dwelling contains natural draft combustion appliances, then the sum of the two largest exhaust fans in the house cannot exceed 15 cfm per square foot of the dwelling areas that communicate with those exhaust fans.

**One IAQ/Health point** is available. Ensure that the range hood is equipped with a control to automatically turn on when the range or oven is used for cooking.

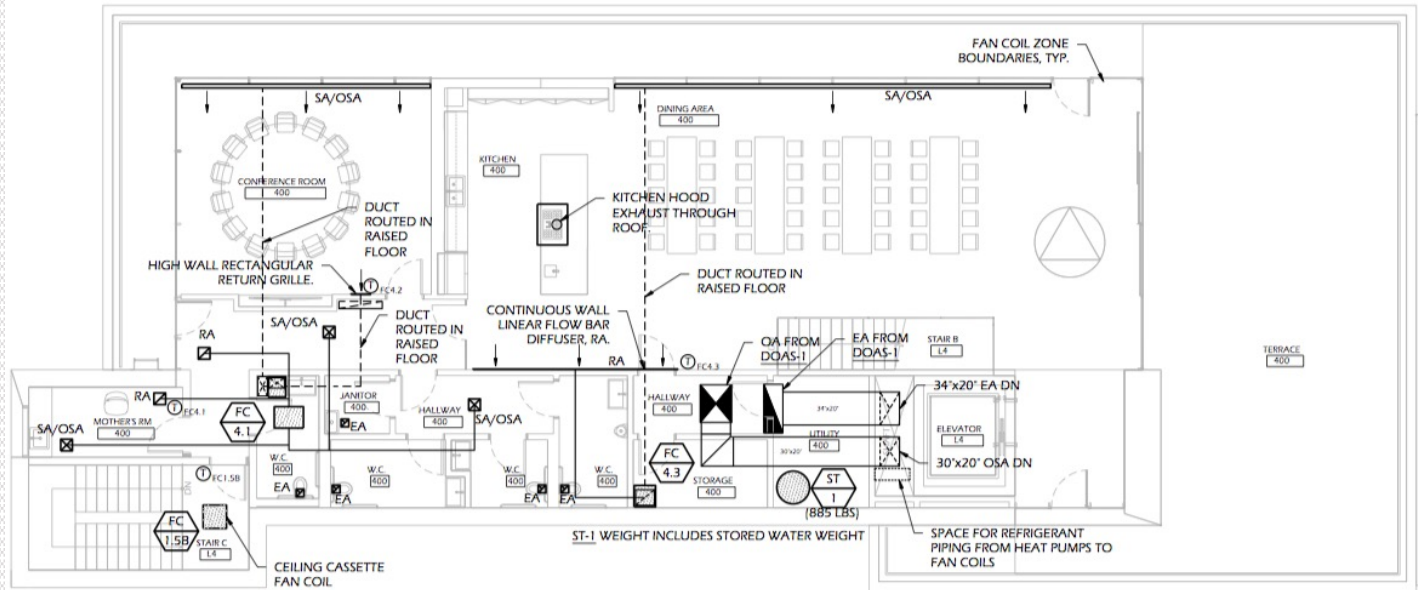
# SELF-BALANCING HRV/ERV

- Zehnder Q series units are “self-balancing”: adjusts exhaust or supply airflows as required to maintain neutral pressure
  - Facilitates initial systems commissioning
  - Addresses temporary depressurization from clothes dryer or other cause
  - Q350 may sometimes be appropriate to provide makeup air for lower CFM kitchen range hoods



Zehnder ComfoAir Q350: 90% SRE, ~\$3000

# OFFICE BUILDINGS + COVID



## NOTES:

SA - SUPPLY AIR  
 RA - RETURN AIR  
 OA - OUTSIDE AIR  
 EA - EXHAUST AIR

1. DUCTWORK, GRILLES, REGISTERS, AND DIFFUSERS ARE NOT SIZED - ONLY SHOWN FOR REFERENCE TO PLANNED LOCATIONS.
2. DOAS-1 OUTSIDE AIR AND EXHAUST AIR NEED DUCTED TO OUTSIDE AIR REGISTERS AND EXHAUST AIR GRILLES.



# OFFICE BUILDINGS + COVID

The following are ASHRAE recommendations that are being implemented in the HVAC system design for this building:

- Ventilation (aerosol): Dedicated outside air/exhaust air system provides outside air (mechanical ventilation) directly to each occupied space, providing dilution of indoor airborne infectious agents during occupied hours.
- Ventilation (aerosol): Operable windows that can be opened to provide cross ventilation of the space during temperate outdoor air conditions will assist in dilution of indoor airborne infectious agents during occupied hours.
- Airborne Transmission (aerosol): Zoned heating and cooling systems reduce airborne infectious agents spread through the whole building that may occur with a single building air handling unit with air recirculation.
- Airborne Transmission (aerosol): Minimum MERV 13 filtration (greater than 90% of particles 3.0-10.0 microns trapped, greater than 85% of particles 1.0-3.0 microns trapped) for all forced air systems to include outside air DOAS and recirculating fan coils to capture airborne infectious agents. Filtration within the space (portable HEPA units) may reduce localized exposure if desired as an additional measure outside of the mechanical system scope.
- Airborne Transmission (aerosol): Elevator lift ventilation fan can be turned on to remove airborne infectious agents within the elevator enclosure.
- Air Distribution (fomite): Air supplied and returned at low velocities to reduce surface disturbances, which can entrain airborne infectious agents that have settled on surfaces.



# QUESTIONS?



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