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2016 Purdue Conferences
Compressor Engineering
Refrigeration and Air Conditioning
High Performance Buildings

Demand Controlled Heat Recovery for Residential Applications

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July 11 -14, 2016

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AeL Applied Energy Laboratory

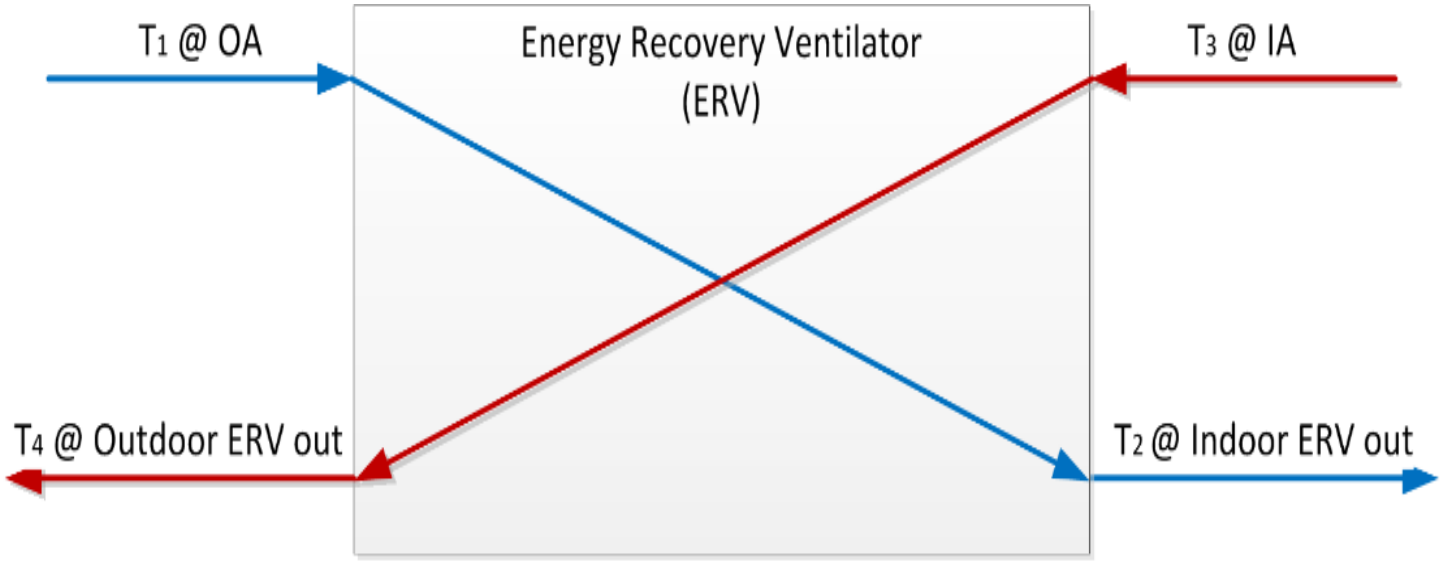
Introduction

- EIA shows about 20% primary energy used for residential building and ½ of that is for Heating, Ventilating, and Air Conditioning (HVAC)

- Airtight building leads to negative effect to Indoor air quality (IAQ)

Energy Recovery Ventilation

Basic for ERV system



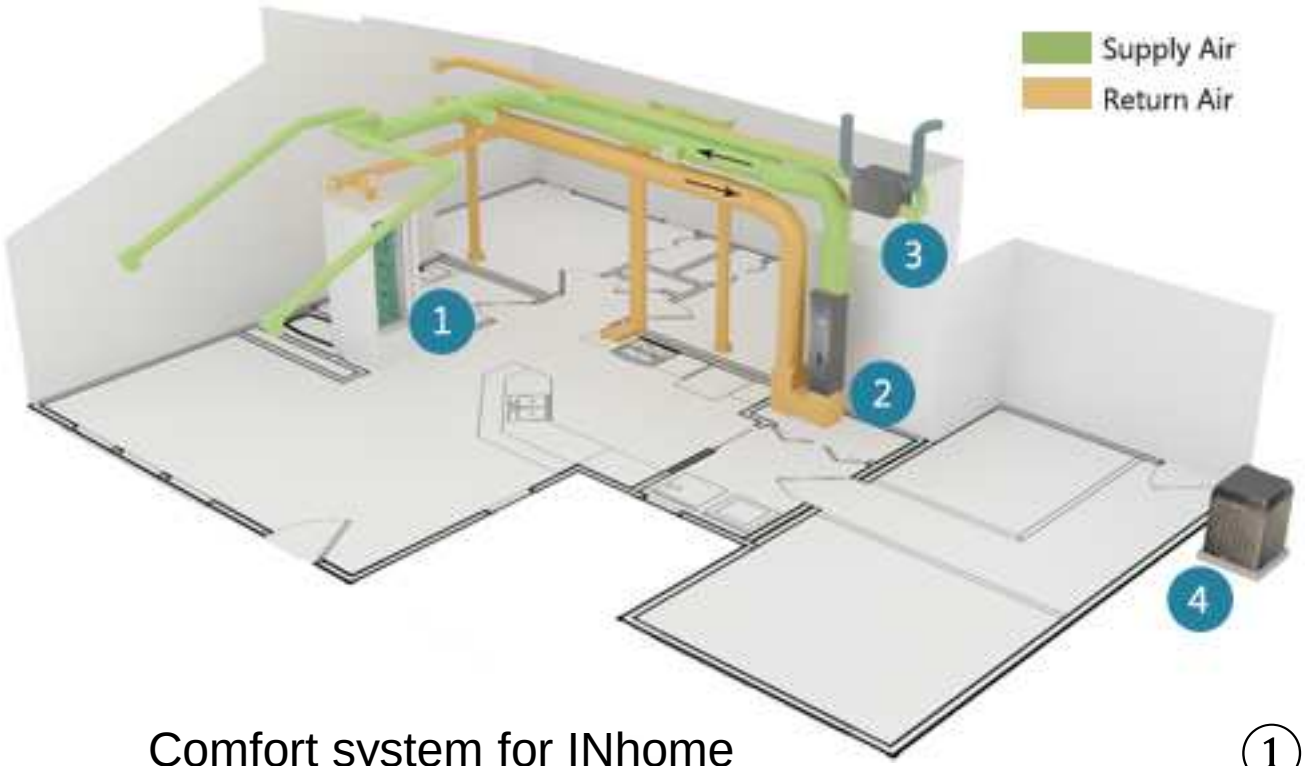
$$\text{effictiveness}: \varepsilon = \frac{T_2 - T_1}{T_3 - T_1}$$

T1: Outside air
T2: Supply air
T3: Return air
T4: Exhaust air

Smart House --INhome

- Design for 2011 Solar Decathlon, new generation of smart house
- Located in Lafayette, IN permanently
- Construction cost: $250,000, 1000 square feet

HVAC system in INhome

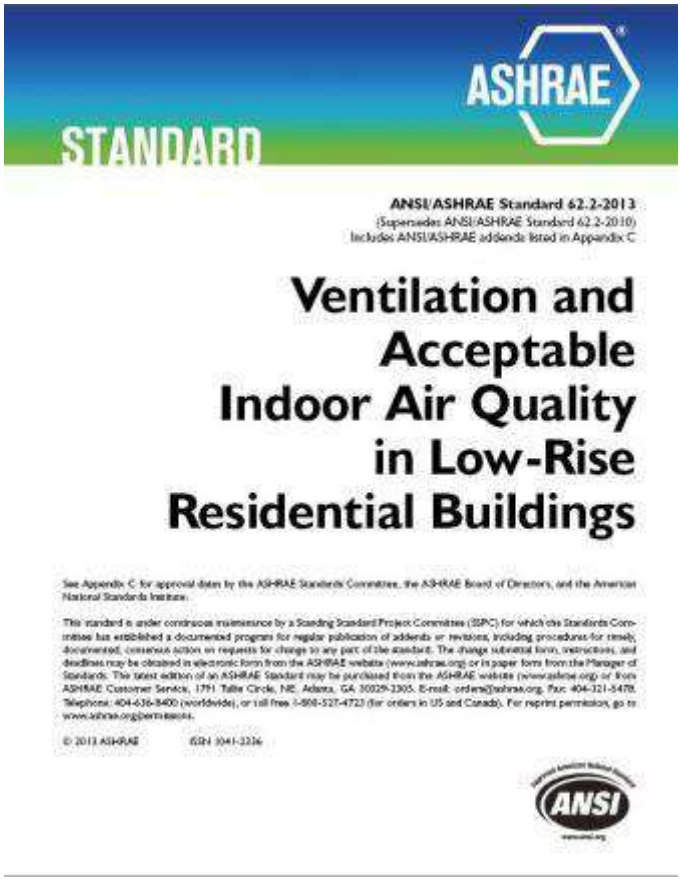


Comfort system for INhome

① Biofilter
② Air Handling Unit
③ ERV
④ Heat pump

ASHRAE 62.2

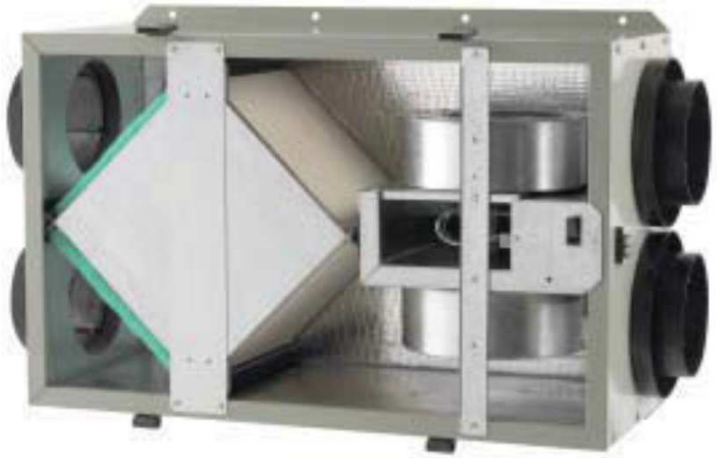
- ASHRAE 62.2 Ventilation and Acceptable Indoor Air Quality in Residential Buildings



- INhome meets the standard
  - Total Ventilation Rate required for INhome is 53 cfm.
  - 2 bedrooms and 1000ft^2

$$Q_{tot} = 0.03A_{floor} + 7.5(N_{br} + 1)$$

ERV in INhome



Controlled by:

- Volatile Organic Compounds (VOC)
- Carbon Dioxide (CO_2)
- Relative humidity (RH)
- Manual control

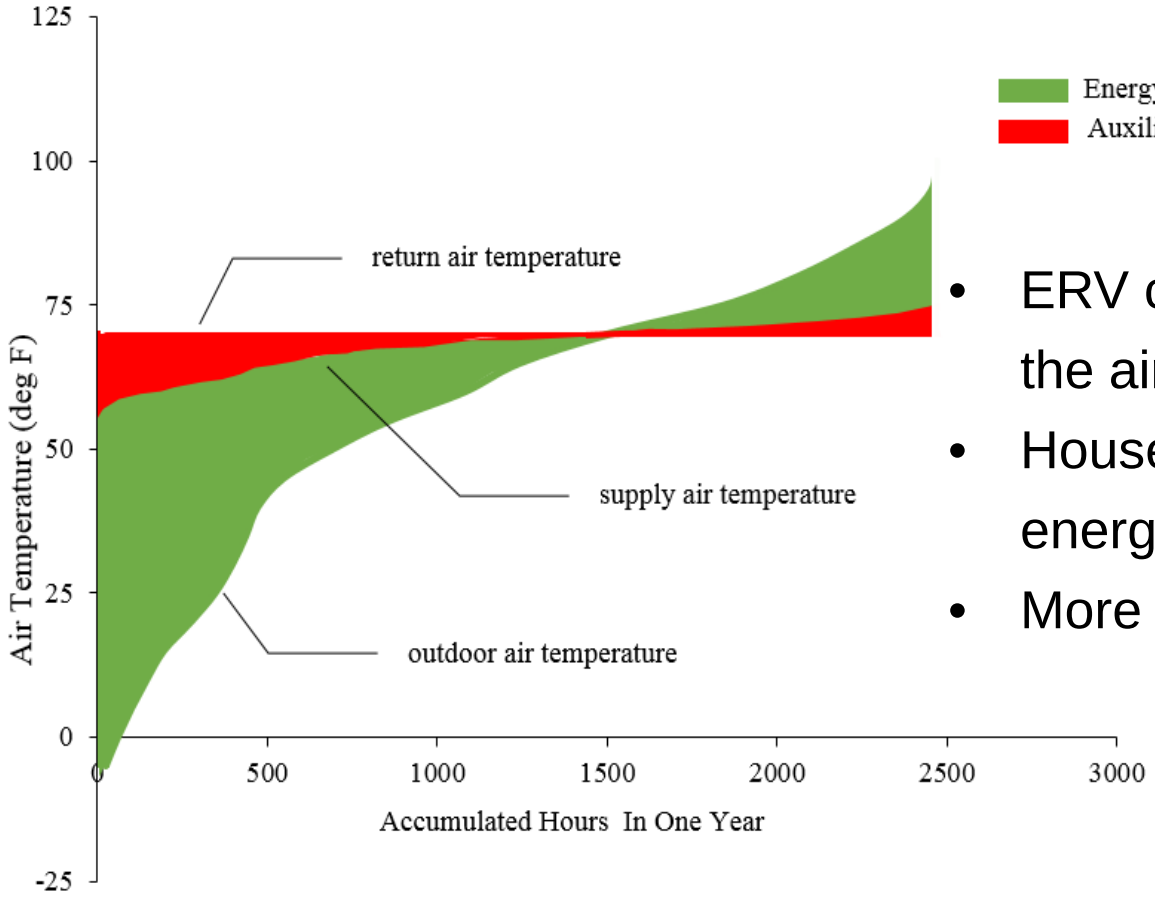
- Effectiveness: 87%
- Runs about 2500 hours per year
- Works as bathroom vent

Sensor Specifcation

- Sensors for ERV system

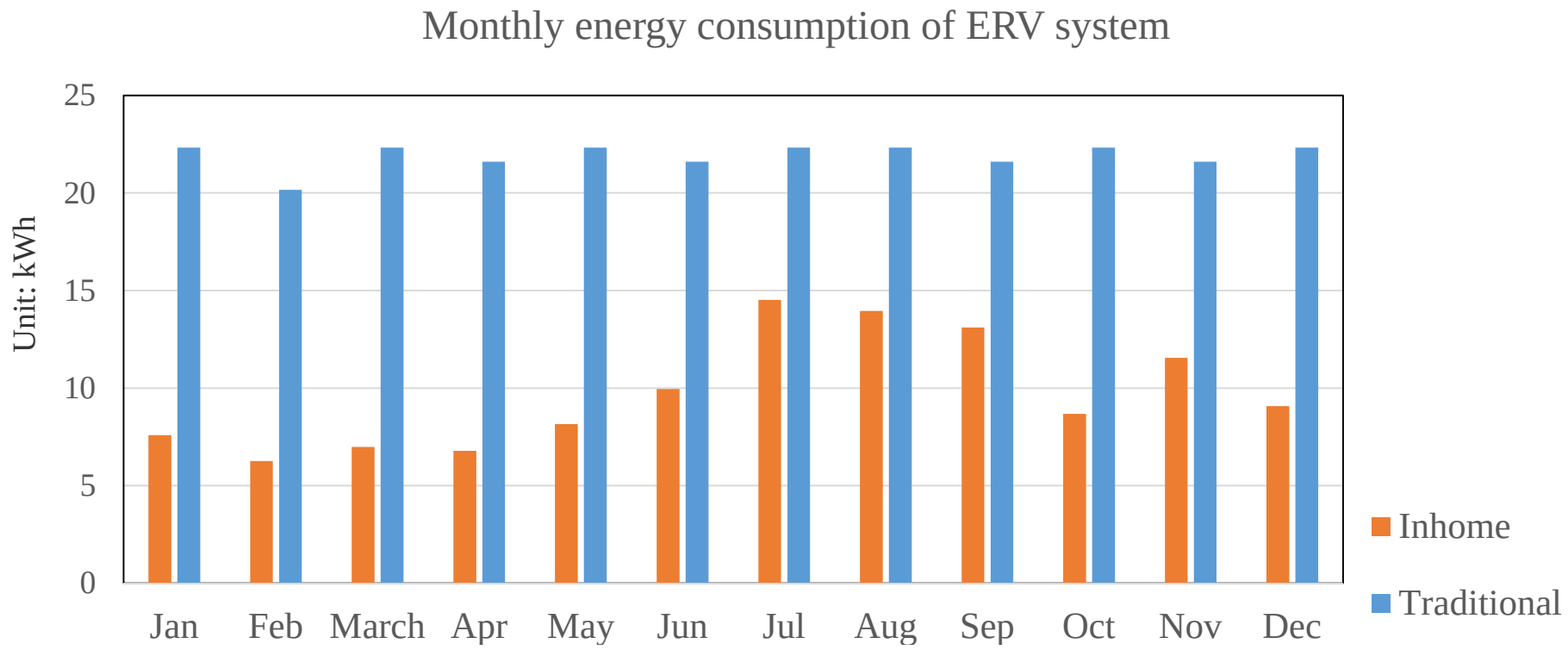
Sensor	Accuracy	Range	On/Off thresholds
VOC	±5% ppm	0-2000 ppm	1000/900 ppm
CO_2	±3% ppm	0-2000 ppm	900/800 ppm
RH	±5% RH	0%-95%	60/55 %

Energy saving from ERV



- ERV can pre-heating/pre-cooling the air
- House still needs additional energy for requirement
- More beneficial during winter

Result: Compare with traditional ERV



- Comparing with **traditional ERV**, it works about 35% per year and can save about $40 while maintaining acceptable IAQ
- In summer and winter, smart ERV works more time

Compare with house without ERV system

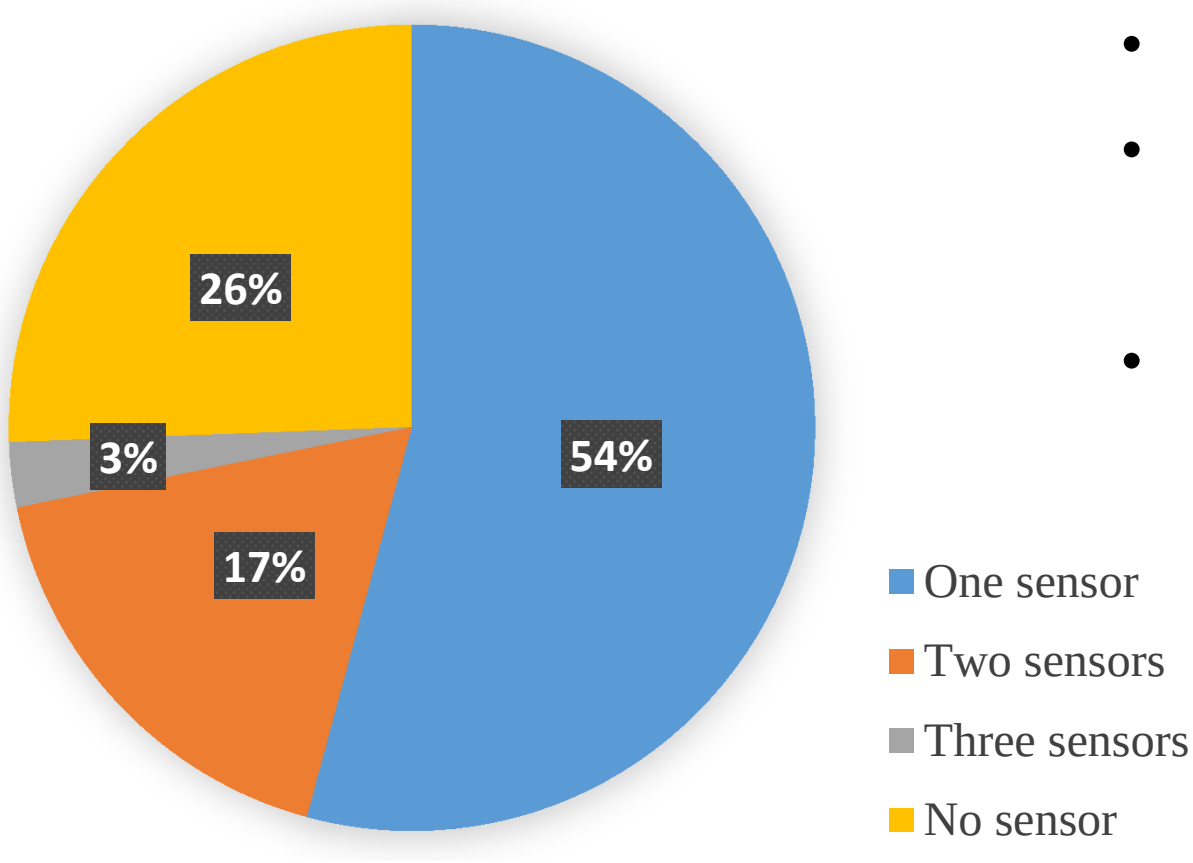
- Information about INhome's ERV
  - Works at 87% efficiency
  - Cost of ERV (including installation) is $1000
  - Maintain house temperature about 70°F
- Cost analysis
  - Total heat **without** ERV: 3996 Mbtu
  - Total heat with ERV: 519 Mbtu
  - Total heat saved by ERV: 3476 Mbtu
  - Annual energy saving: $96

Result: Indoor Air Quality(1)

Sensor	Zone VOCs	Zone CO_2	Bathroom RH
Percentage of Time Above IAQ Threshold	21.1%	6.2%	4.6%

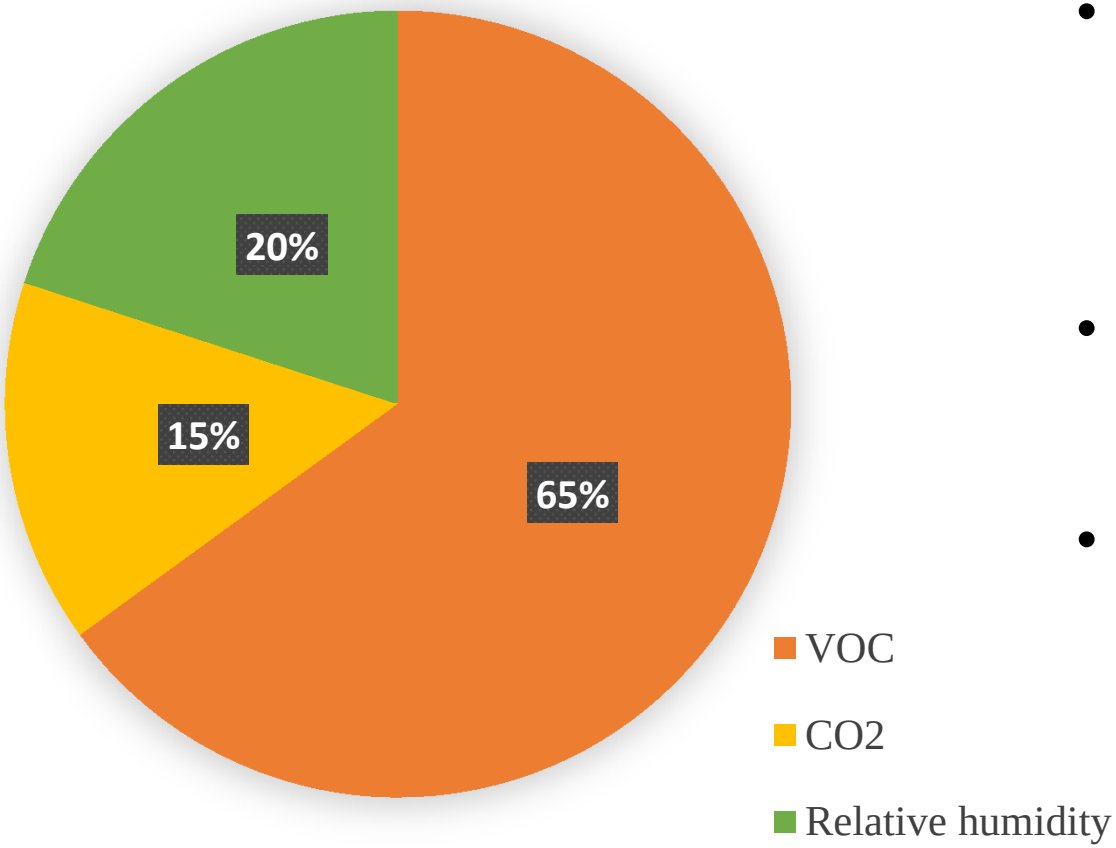
- Analyzed from Jan.2014 to Dec.2015
- Most of the time indoor air quality is acceptable
- VOCs are always the main issue for IAQ

Result: Indoor Air Quality(2)



- Almost smart control
- About ½ time controlled by one sensor
- Residents can control the ERV manually

Result: Indoor Air Quality(3)



- The weighted percentage of a parameter energized ERV
- Runs about 35% time per year
- About 2/3 time controlled by VOC sensor

Survey of homeowner

- From survey of house owner, this ERV system:
  - » This system is reliable, functional, and practical to provide fresh air
  - » Automatically turning on/off
  - » Nearly flawless in functionality

Conclusion

- INhome is a new generation net zero energy residential house
- Demand control ERV is beneficial in INhome
  - Improves indoor air quality
  - Makes system more efficient
  - Fulfills smart control
- Demand control ERV should be considered for more residential houses

Thank You!

QUESTIONS?