Systems Research on Residential Ventilation

ACEEE Summer Study on
Energy Efficiency in Buildings

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Overview

- Phase I: How we got to Central Fan Integrated Ventilation Systems
- Phase II: The evolution of CFIS
- Phase III: CFIS & ASHRAE 62.2
- Ventilation system cost comparison
- System performance simulations (operating costs & performance of systems in five climates)

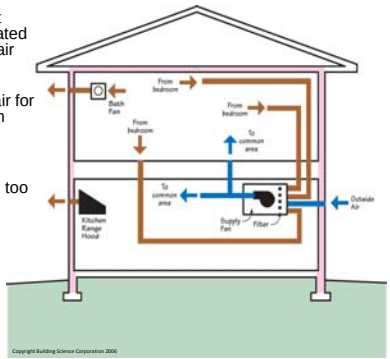
Phase I: Why Supply?

- Supply ventilation was identified as being a preferred whole-house ventilation strategy
- Outside air comes from a known source, can be filtered and conditioned
- Pressurizes rather than depressurizes interior of building with respect to outdoors
  - Helps rather than hinders combustion appliance drafting
  - Avoids drawing polluted air from garage, crawl space, attic
  - Avoids airflow related moisture/mold problems in humid climates under cooling conditions
  - Applicable in cold climates with airtight enclosure and insulated sheathing, or cavity spray foam insulation
- Less expensive than balanced ventilation

Supply ventilation system

(multi-point, with 3:1 recirculation air for tempering)

- Separate duct system dedicated to ventilation air distribution
- Use 3:1 recirculation air for tempering (fan efficiency)
- Continuous-running fan
- Initial cost still too high



Phase I: What about exhaust?

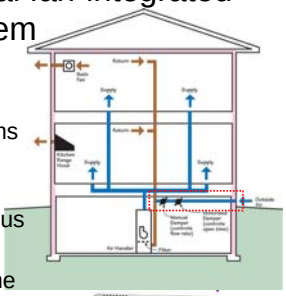
- Some builders chose single-point exhaust-only despite our reservations (cost issues)
- New problems arose:
- Carbon monoxide alarms
- Lack of filtration
  - Dust marking on light carpets
  - Dirt/grit particles settling on horizontal surfaces
- Lack of distribution
  - Moisture accumulation and odor buildup in rooms remote from exhaust fan
- Objections to fan noise

Phase I: High-performance houses

- Building America: Systems engineered high performance building enclosures
- Longer periods between HVAC runtimes for high performance houses
- Improved comfort → increased homeowner expectations?
- Air mixing needed for thermal comfort?
- Part load periods (low thermostat demand)

Phase 2: Central fan-integrated ventilation system

- Outside air duct to return side of AHU
- Timer-based systems (problems)
- "Smart" controller (accounts for previous runtime)
- Set minimum runtime (e.g., 20 min/hour)



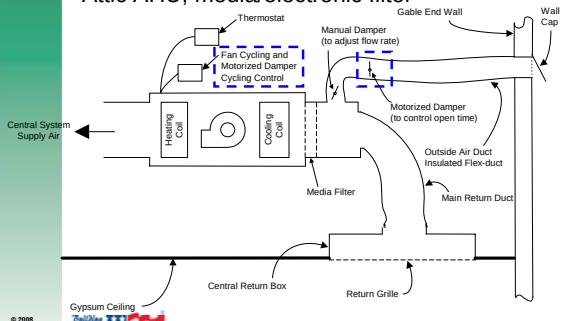
Phase 2: Central fan-integrated ventilation system: tuning

- Chicago-area circa 1996
- 8" duct / 33% duty cycle → ~10 CFM/person
- Overventilation (comfort complaints, 20% RH)
- Change to include infiltration for 66% off cycle
- 6" duct / 33% duty cycle → ~7 CFM/person
- Occupants satisfied

Phase 2: Central fan-integrated ventilation system: deployment

- Las Vegas & Tucson BA developments
- Builders could guarantee 3°F maximum room-to-room
- Under-ventilation trouble-shooting (design, operation)
- Many Building America projects, Environments for Living™
- ~150,000 houses w. CFIS

Central-fan-integrated supply ventilation
Attic AHU, media/electronic filter



Phase 3: ASHRAE 62.2

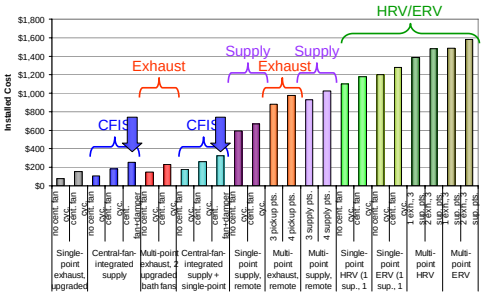
- Doubling of ventilation rates used at the time—how to address change?
- Increase duty cycle from 33%?
  - 33% matches typically duty cycle for heating/cooling (i.e., "free" ventilation)
  - Re-evaporation of moisture from cooling coil in humid climates
- Increase duct size to 8"?
  - Cooling equipment sizing increase possible
  - Larger/more wall penetrations

ASHRAE STANDARD
Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings

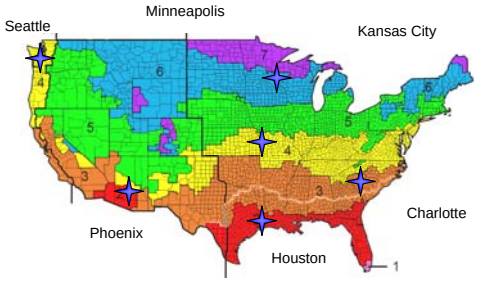
Phase 3: ASHRAE 62.2

- Solution: Upgrade bathroom fan to meet ASHRAE 62.2 (1 sone or less)
- Run at occupant's discretion
- Retain CFIS ventilation system
- Adds $50-75 cost

Ventilation System Costs

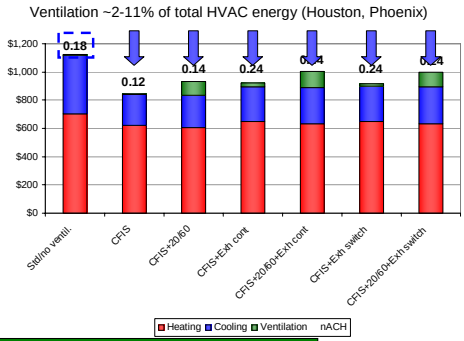


System Performance Simulations



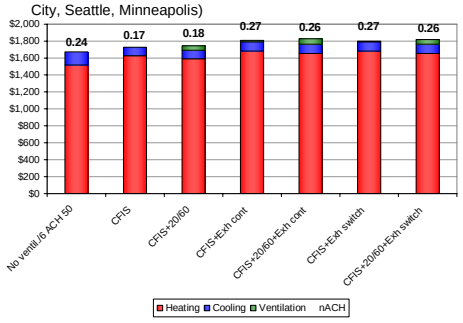
HVAC Costs: Houston (Zone 2A)

Ventilation ~2-11% of total HVAC energy (Houston, Phoenix)

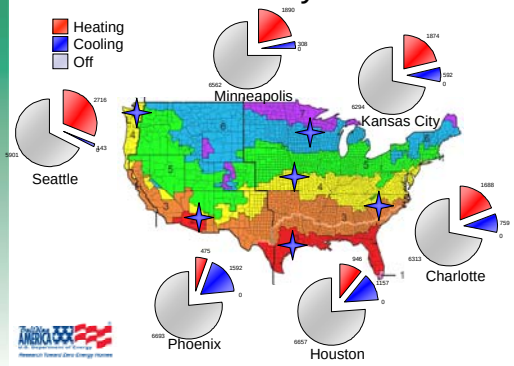


HVAC Costs: Kansas City (Zone 4A)

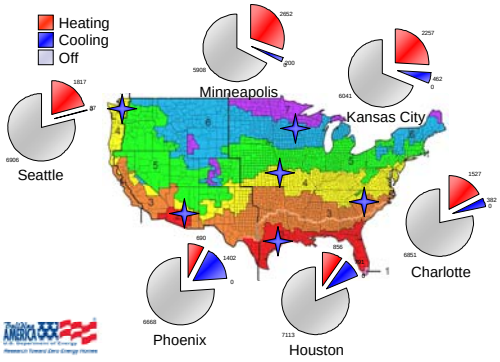
Ventilation ~1-6% of total HVAC energy (Charlotte, Kansas City, Seattle, Minneapolis)



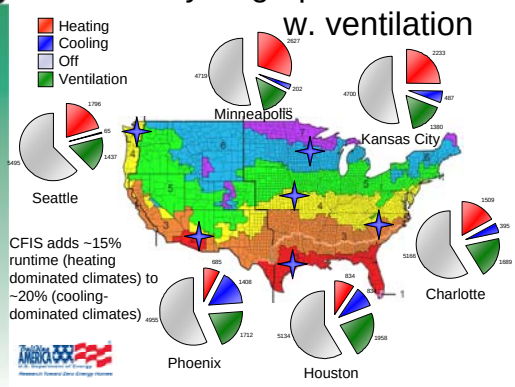
Central AHU Activity: Standard



AHU Activity: High-performance



AHU Activity: High-performance w. ventilation



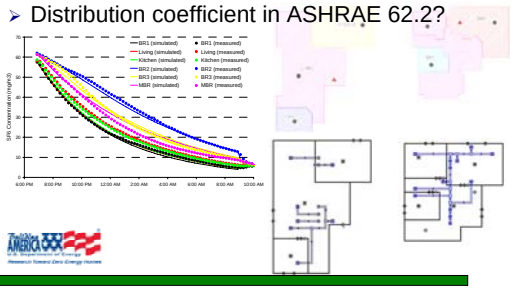
CFIS adds ~15% runtime (heating dominated climates) to ~20% (cooling-dominated climates)

Conclusions

- Central fan integrated ventilation (w. motorized damper): effective distributed ventilation, affordable cost, operating cost
- Electrical energy: ~2-11% of HVAC system energy (Houston, Phoenix); ~1-6% (Charlotte, Kansas City, Seattle, Minneapolis)
- For 33% fan operation (20 minutes/hour)
  - 15-20% of annual hours
  - $0-20 (Minneapolis, Seattle, Kansas City)
  - $50 (Charlotte)
  - $85 (Phoenix, Houston)

Continuing Work

- Ventilation distribution effectiveness (tracer gas measurements + computer modeling)
- Distribution coefficient in ASHRAE 62.2?



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Questions & Comments