CEC PIER Integrated Design of Small HVAC Sytems

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Scope of Project

- New Commercial Buildings
  - 4 yr. or newer
- Single package AC and heat pump
  - 10 ton and smaller targeted
- Identify problems with small HVAC systems that prevent them from reaching their full efficiency potential
- Suggest potential solutions and develop market connections

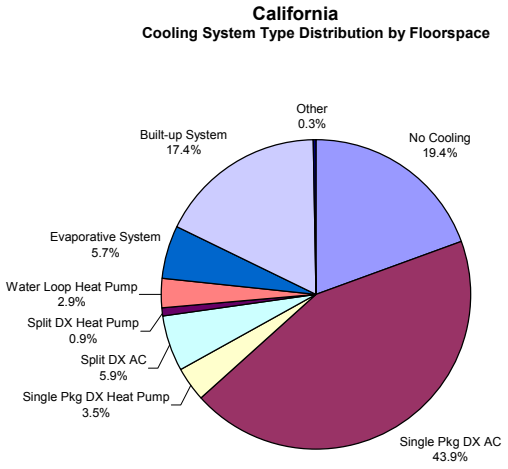
Scope of Project

- Visited 75 sites throughout California
- Tested 215 HVAC units
- Created calibrated DOE-2 models
- Estimated savings from fixing problems

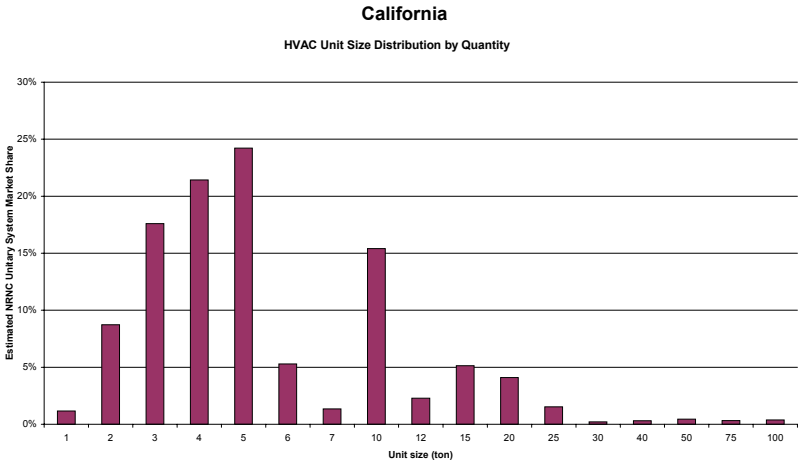
Data collection

- Building survey
  - Packaged RTUs
  - Spaces served (for DOE-2 model)
- One-time tests
  - Economizer functional testing
  - Fan flow rate and power
  - Refrigerant charge
- Short-term monitoring (2-3 wk)
  - Fan controls
  - Economizer operation
  - Model Calibration

Why Packaged HVAC Systems?



Why Small Packaged HVAC?



Economizer Testing

- Mechanical function
  - Will it move?
- System response to simulated economizer cooling
  - Jump unit into 1st stage call for cooling
  - Cool outdoor sensor with "tech spray"
  - Observe operation
- Short term monitoring

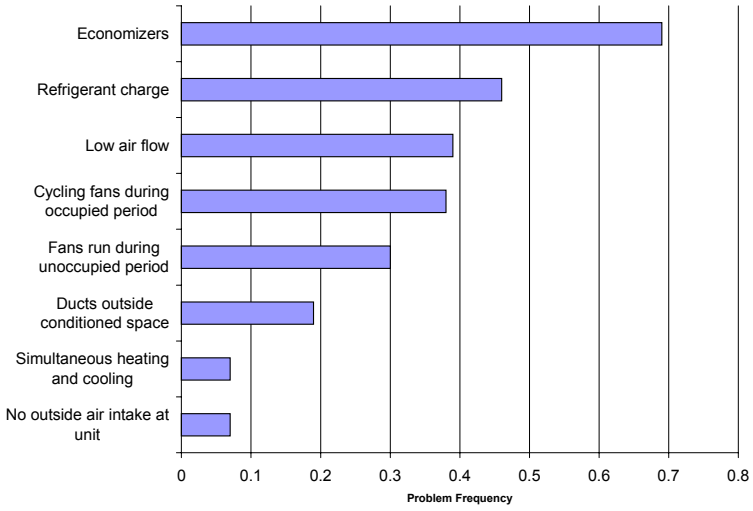
Refrigerant Charge Testing

- Used CheckMe! Procedure
- Test superheat on non-TXV systems
- Test subcooling on TXV systems
- Identify "targets" based on outdoor db temperature, entering db and wb temp
- Unit fails screen if actual value is > 5 degrees F from target

Air Flow Testing

- Used TrueFlow grids to measure unit air flow rate
- Used a micro manometer to measure external static pressure drop
- Used a kW meter to measure fan power
  - Subtracted off "standby" power

Findings Summary



Economizer Findings

- 69% of economizers tested failed
  - 43% failed mechanical test
  - Remaining failed response test
- Changeover setpoint rarely set to "A"

Findings - Refrigerant charge

- 46% of units did not pass refrigerant charge screen
- Average energy impacts = 5% of cooling energy (not including "dead" units)
- Increases as units age

Findings -Air flow and fan power

- 39% of units had air flow < 300 cfm/ton
- Average air flow = 325 cfm/ton (400 standard)
- Energy impacts = 8.9% of annual cooling energy
- Average fan power = .18 kW/ton (.15 standard)
- Energy impacts = 20% of annual fan energy
- Increases to .34 kW/ton @ 400 cfm/ton
- Effectively reduces 10.3 EER unit to 9.1 EER

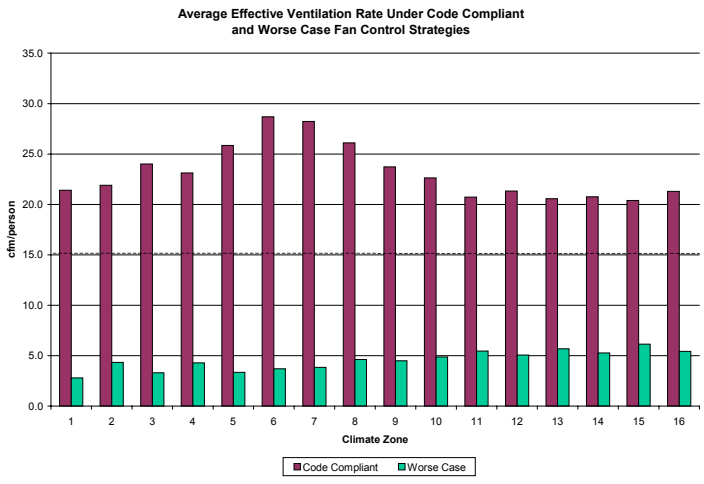
Findings - Air flow and fan power

- Average duct system pressure drop = 0.48 in. W.C.
- ARI efficiency ratings based on 0.1 - 0.25 in. W.C.
- Duct system pressure drop corrected to 400 cfm/ton = 0.625 in. W.C.!!

Cycling Fans

- Most thermostats observed were "commercial" grade
- Can be set up to program fan schedule and mode independent of tstat schedule
- Set-up/operations issue

Ventilation Impact of Cycling Fans



Average Impacts from Correcting Problems

Broken economizers	600 kWh/ton
Excessive fan power	200 kWh/ton
Units running during unoccupied hours	720 kWh/ton
Cycling fans	-700 kWh/ton*
Correct charge	180 kWh/ton
Correct air flow	300 kWh/ton

* Fan power increases, but effective ventilation goes from ~ 5 cfm/person to 20+ with operable economizer

Design Recommendations

- Improved economizer reliability
  - Direct drive gear driven
  - Differential temperature or enthalpy
  - Low temperature compressor cutout
  - Factory installed and run tested
- Commercial grade thermostat
  - Independent fan and thermostat scheduling
  - Defaults appropriate for commercial buildings
- TXV

Commissioning Activities

- Duct leakage test
  - Confirm leakage flow < 6% of fan flow @ ??Pa
- Air flow test
  - Confirm flow rate 400 cfm/ton
  - Target flow rate could be lower in humid climates; higher in dry climates
- Fan power test
  - Confirm specific fan power (365 W/1000 cfm target)
- Check thermostat wiring and setup
- Check economizer function

O&M Issues

- O&M Quality Issues
  - Service tech training/turnover
- Building owner/manager awareness
  - Out of sight/out of mind
  - Need to be educated about the problem
- Role of manufacturer/distributor
  - Primary source of technical information (PECI study)
  - Simplified/standardized service procedures

O&M Issues

- Role of Utility
  - HVAC advanced "tune-up" programs
    - NEEA Small Commercial O&M Pilot
  - Provide customer information and incentives for advanced service offering
  - Pricing and incentive levels tricky
    - Need to convey the value of service

Retro-commissioning Program Elements

- Check and repair economizer operation
- Check and adjust refrigerant charge
- Check and seal duct leaks
- Remove flow restrictions
- Check and replace thermostat

Retrocommissioning Issues

- Test economizer sensor *and* mechanical function
- Refrigerant adjustments are tricky
  - Calibrate meters and gages
  - Use digital gages
  - Use RTDs instead of thermocouples
  - Use expert system to ID bad data
  - Check schrader valves for leakage and replace if necessary

Thank you!!

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