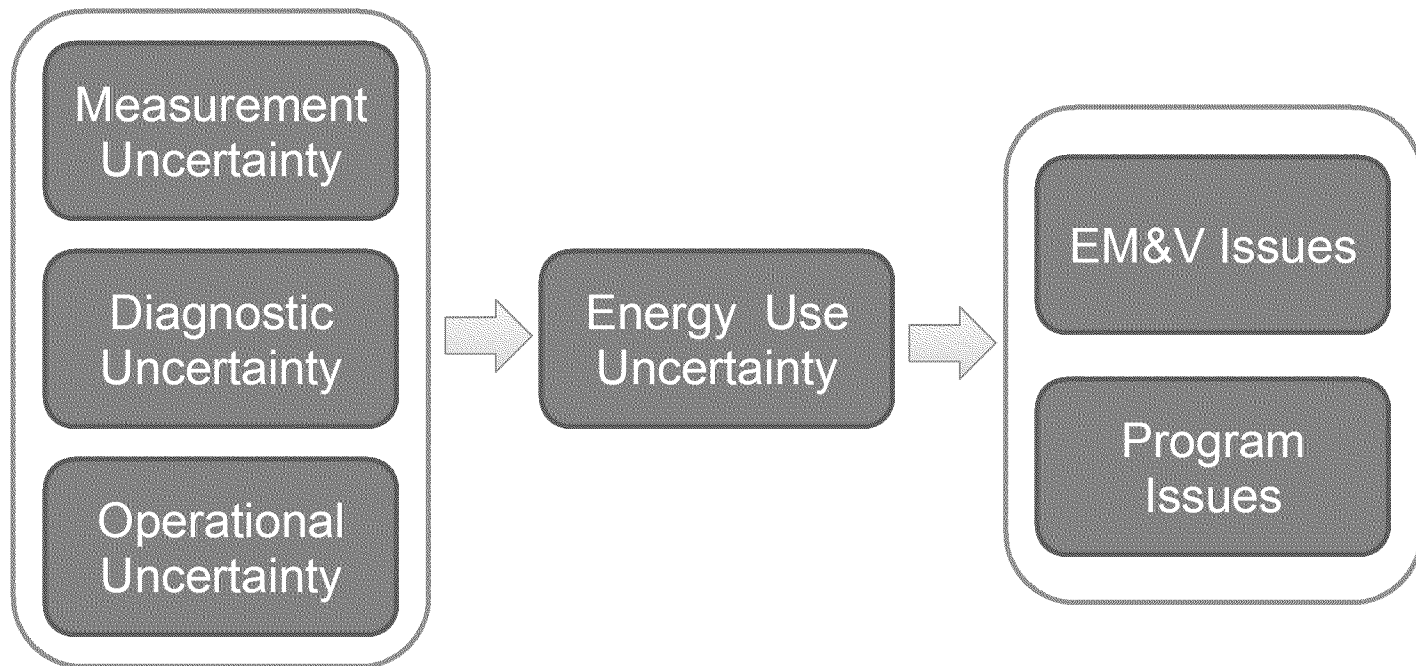# Review of HVAC Maintenance Study

Brett Close

SCE

Tuesday, March 8, 2011

Outline

- Background: what this study is and what it is not
- Measurement uncertainty
- Diagnostic uncertainty
- Operational uncertainty
- Energy use uncertainty
- EM&V-related issues
- Program-related issues
- Key takeaways
- Next steps: phase II

Phase I: Identified Problem Statement

Goals of the study: 3x3

Uncertainty and complexity play a larger role in HVAC programs than other deemed-savings programs

The study was looking at:
- What do we know about HVAC maintenance?
- What don't we know about HVAC maintenance?
- How will we learn the things we don't know?
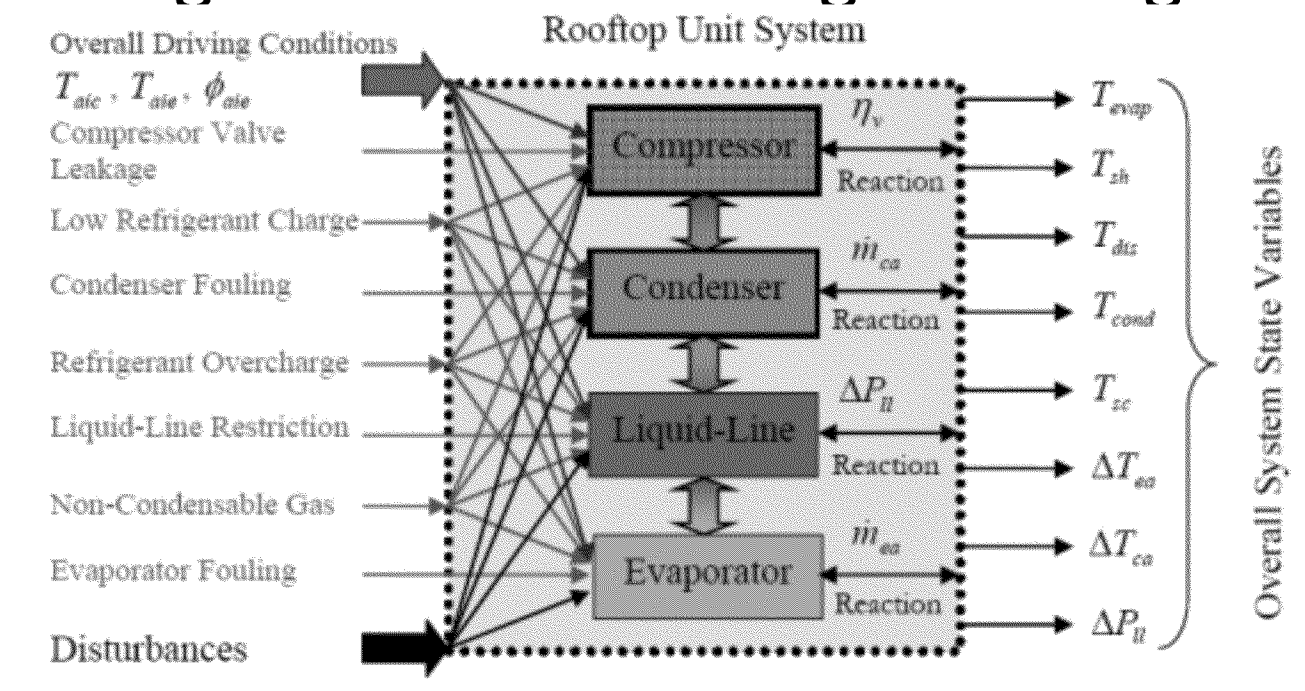
Specific thing we wanted to know about:
- Does HVAC maintenance save energy?
- If so, how do we achieve those savings?
- How do we evaluate the savings?

4

Measurement Uncertainty

- Key idea: **Uncertainty depends non-linearly on individual measurement uncertainties**
- Many important values are calculated and interrelated
- What this means:
  - Uncertainty in measurements affects the correct diagnosis and remediation of system faults
  - Need better instrumentation and smaller tolerances to ensure success maintenance

5

Diagnostic Uncertainty

- System faults are interrelated
- Simple superheat/subcooling measurement may not correctly diagnose charge
- Leakage can affect leakage readings

Rooftop Unit System

Overall Driving Conditions

T_{aic}, T_{aie}, ϕ_{aie}

Compressor Valve Leakage

Low Refrigerant Charge

Condenser Fouling

Refrigerant Overcharge

Liquid-Line Restriction

Non-Condensable Gas

Evaporator Fouling

Disturbances

Compressor — η_v — Reaction
Condenser — $\dot{m}_{ca}$ — Reaction
Liquid-Line — ΔP_{ll} — Reaction
Evaporator — $\dot{m}_{ea}$ — Reaction

T_{evap}
T_{zh}
T_{dis}
T_{cond}
T_{sc}
ΔT_{ea}
ΔT_{ca}
ΔP_{ll}

Overall System State Variables

6

Operational Uncertainty

- Many technicians do not have the training to understand the system correctly
- Many technicians do not have the correct incentives (from their bosses) to do the work correctly
- Even without intervening faults, bringing a system to the minimum target levels only gives 50% confidence it is within target
- Sensor type and placement significantly affects results
- Repeated duct tests are subject to significant variation

7

Energy Use Uncertainty

- All of the above uncertainties converge to affect uncertainty of energy savings

- EER is affected by so many factors, each with their own uncertainty, that uncertainty is high

- Aggregated simulation inputs may not adequately reflect the variety of operating conditions

EM&V Implications

- Time-series measurements, analytical techniques may address some uncertainty

- EM&V should be more integrated into the program

- New technological capabilities may aid EM&V

Program Implications

- Need better RCA diagnostic protocols

- HVAC is more than just RCA and DTS

- Some units would be better replaced than kept up

- Technicians and occupants are important to program outcomes

10

Current Program Changes

- Forthcoming programs are already incorporating many of the findings
  - Revising diagnostic protocols
  - Developing long-term maintenance relationships
  - Expanding beyond refrigerant charge, looking at the system
- Programs are targeted to the whole value chain
- Programs continue to collaborate with the WHPA and EM&V research and findings

11

Key findings

- Uncertainties are inherent in programs such as these must be accounted for

- Improved diagnostic/servicing approaches would benefit future programs

- HVAC is more than just RCA and DTS

- People matter for the programs

- EM&V timing and methods should be improved

12

Next Step: Phase 2 EM&V

- Phase 2 will include data collection
  - Field work
  - Lab work
  - Data analysis
- Other research could be done through other efforts

13

Thank you.

Any question?

The full study is available at calmac.org