



Kristin Heinemeier, Ph.D., P.E.
University of California, Davis
Western Cooling Efficiency Center
kheinemeier@ucdavis.edu

Is Your Economizer Just Blowing A Lot of Hot Air?

Acknowledgements

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- Program Managers: Jerine Ahmed, Brian James

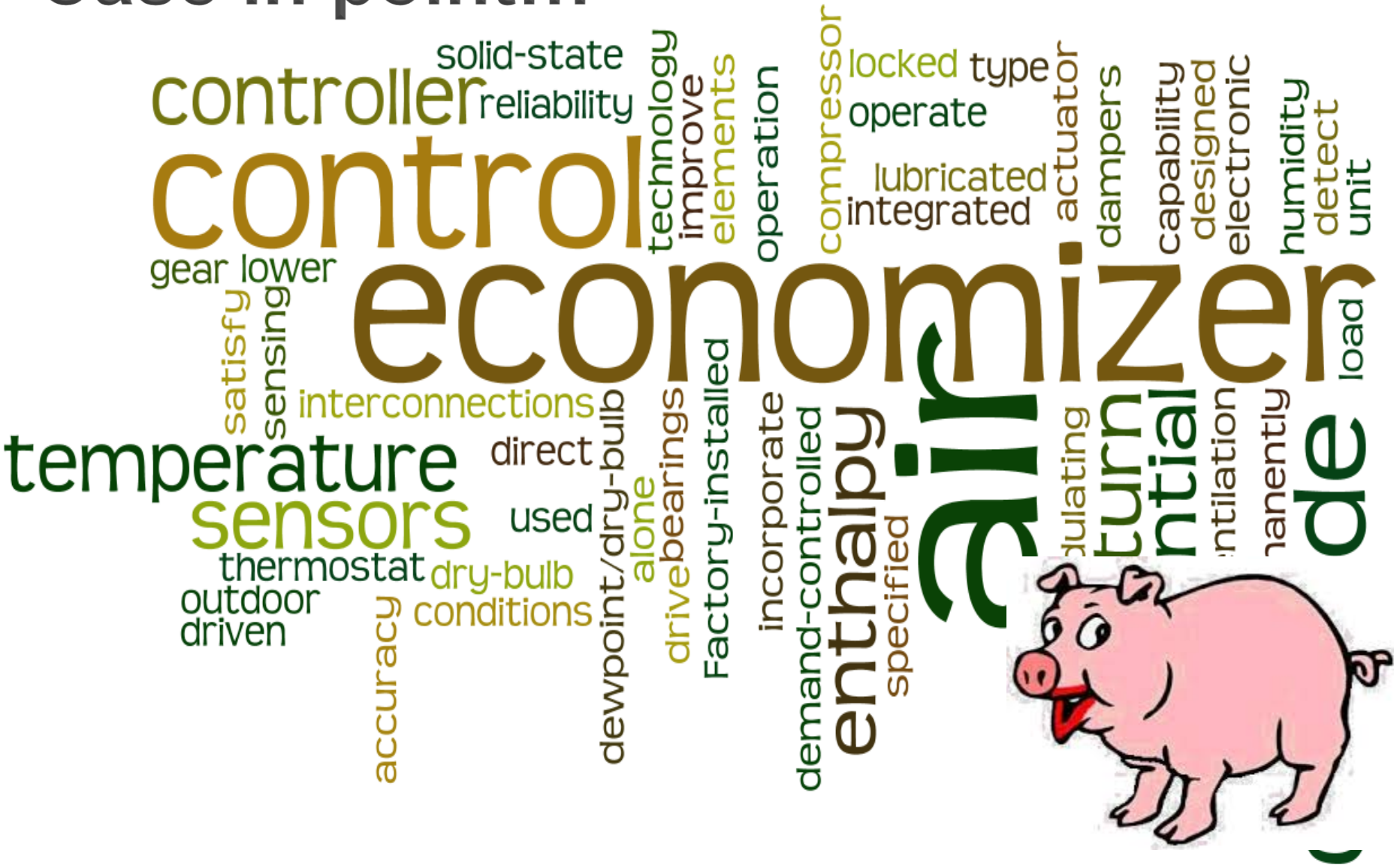
Human Factors Play an Important Role in Adoption and Utilization of Emerging Technologies

- End users:
  - choice of technologies, use of technologies, cost/benefit, non-energy benefits, goals and motivations, enforcing spec, user interface usability, risk tolerance, willingness to trust…
- Technicians and contractors:
  - perception of sophistication/ethics, contractor business models, training, maintaining trust, efficiency of service, code compliance, acceptance testing, call-backs, documentation, smart system vs. smart contractor …
- Consulting and specifying engineers:
  - customer project requirements, maintenance needs, risk tolerance…
- Distributors:
  - upstream programs and early retirement, stocking efficient equipment, just in time inventory, training…
- Manufacturers:
  - product design, efficiency at off-peak conditions, marketing, customer project requirements, warrantee calls…
- Utilities:
  - Emerging Technology and program evaluation criteria, market intelligence, market transformation, savings credit, program trade allies…

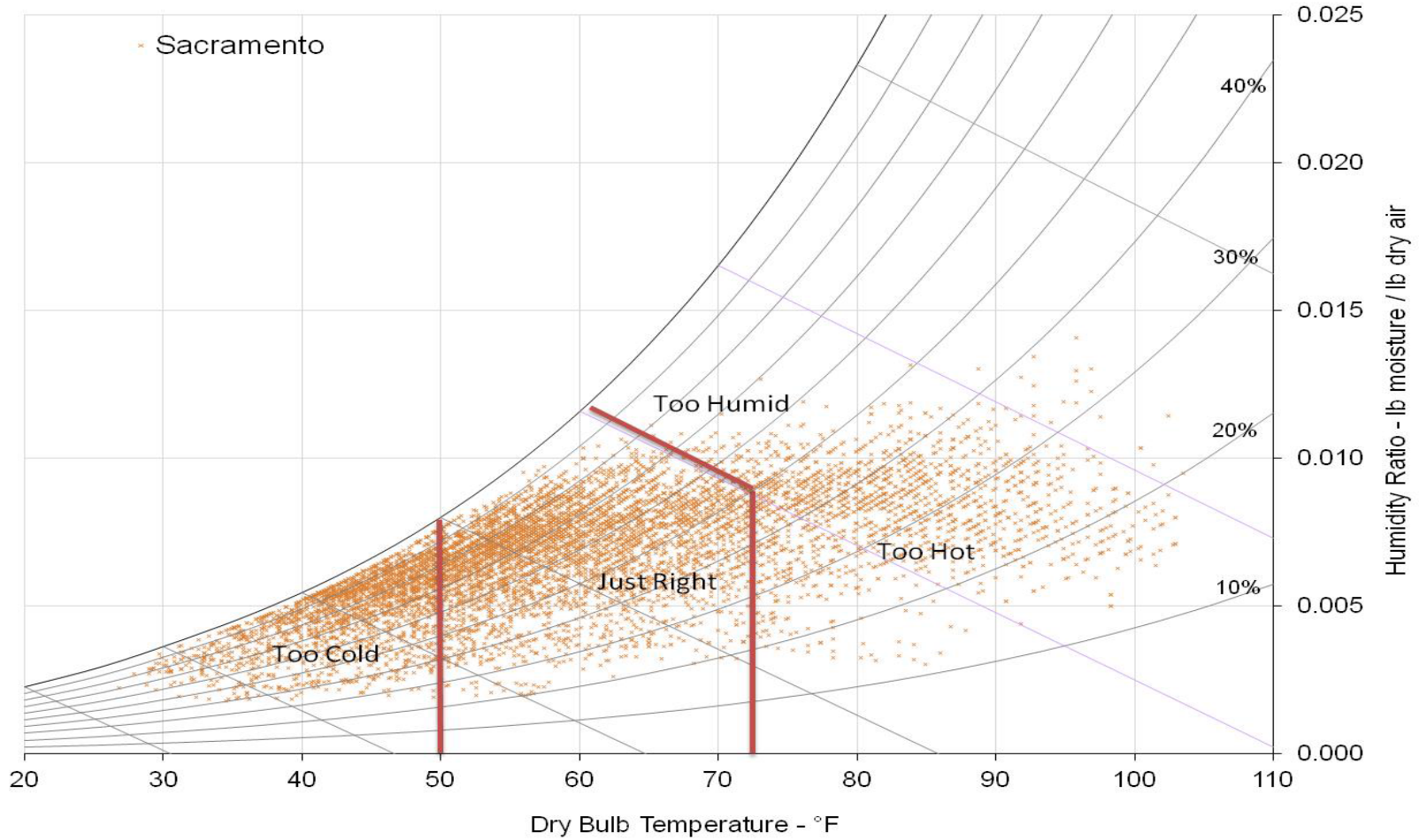
Understanding Human Factors, We Can Improve Technologies and Programs

- Iterative review and enhancement of technology, in terms of usability, matching of user needs and product attributes
- Understand unique attributes of technology that will impact the program design and implementation.
- Impacts of behavior on activities, outputs, short-term outcomes, intermediate outcomes, and long-term outcomes (program logic model)
- Identify program features that will improve uptake of program and savings within program and market transformation.
- Identify any unique opportunities or challenges in M&V
- Identify unique training requirements
- Identify how behavior affects savings
- Requirements for marketing materials based upon behavioral understanding

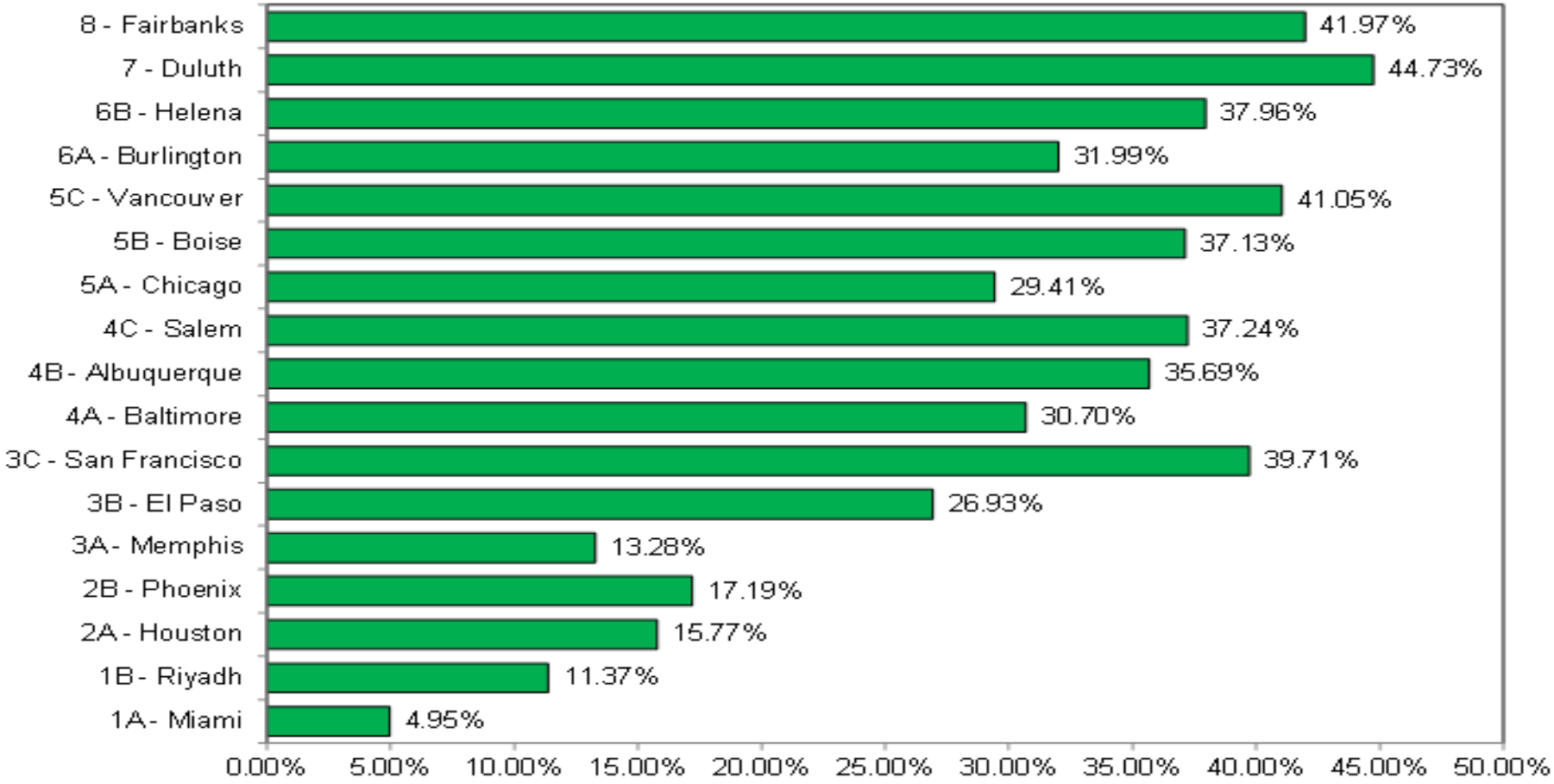
Case in point…



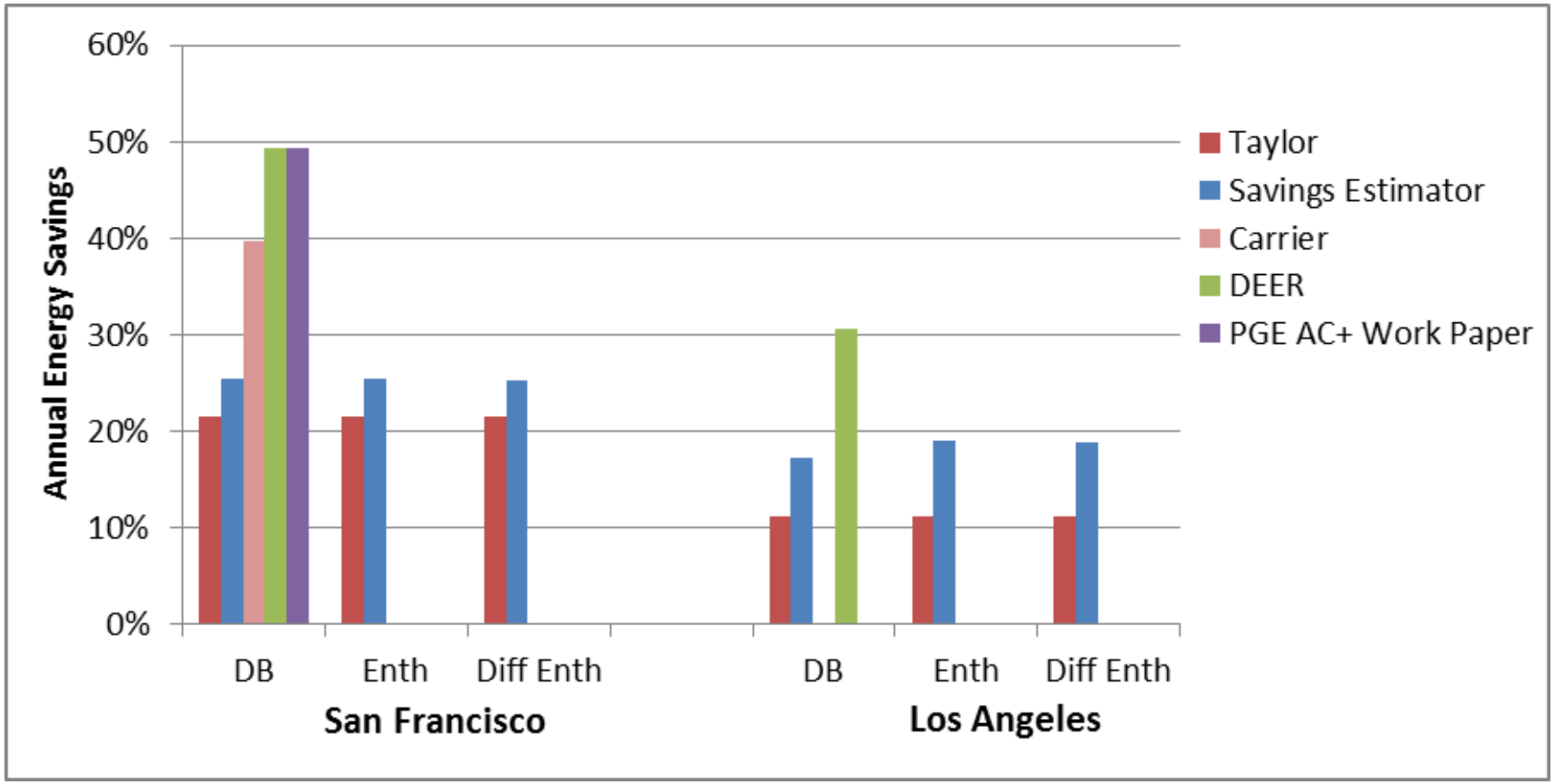
Economizers: The Goldilocks Principle



Annual Energy Savings (Modeled)



More (Modeled) Savings Estimates



But Economizers Don't Do So Well in the Field

Economizer is disabled and dampers are closed	30–40%
Actuator/linkage broken, misaligned, or loose, due to normal wear and tear or lack of lubrication	20–30%
High/low limit setpoints incorrect, set by installing contractor	
Range/action setup incorrectly	
Min Outside Air is not set correctly: too low	
Actuator/linkage broken, misaligned, or loose, due to occupant/operation staff action	10–20%
Min Outside Air is not set correctly: too high	
High/low limit setpoints incorrect, set by factory	
Dampers mechanically forced open	
OA Sensor (db, enthalpy) malfunction	
OA Sensor (db, enthalpy) drift	
High/low limit setpoints incorrect, set by occupants/operating staff	5–10%
OA sensor (db, enthalpy) miscalibration	

Survey of Contractors: What do You Find Out There on RTUs? (2013)

We Aren't the Only Ones Who've Noticed

% Failures	Source	Notes
43%	AEC 2002.	Just damper faults.
50%	Mike Kaplan, Personal Communication with Dave Sellers, 1999.	New construction.
56%	HEC, 1993.	Economizers up to two years old.
64%	Jacobs and Higgins, 2003; and Jacobs et al., 2004.	124 RTUs 10 tons or less, with economizers.
64%	Jonathan Woolley, Personal Communication, 2013.	22 RTUs with economizers.
65%	Goody et al. 2003.	Small commercial RTUs.
66%	NEES, 1993.	Units two years old or newer
70%	Davis, et al. 2002.	Small number of RTUs.
70%	KEMA, 2013a	Economizers that had been fixed up to a year ago.
75%	Craig Hofferber, Personal Communication with Dave Sellers, 2000.	Estimate from interviews with consultants, mechanical contractors, and commissioning agents.
80%	Felts and Bailey, 2000.	Existing RTUs
100%	Pratt, et al., 2000.	Four of four RTUs investigated.

Recommendations

- Improve design or specification
- Conduct quality installation and commissioning
- Conduct quality maintenance including performance checkout
- Conduct research to understand behavioral Issues

Improve Design or Specification: Advanced RTU Specification (AEC 2008)

Factory-installed economizer; direct drive modulating actuator, gear driven interconnections, and permanently lubricated bearings on outside air and return air dampers, or other technology designed to improve economizer reliability; economizer control type differential dry-bulb, differential enthalpy, or dewpoint/dry-bulb temperature control; economizer controller with the capability to operate under demand-controlled ventilation control; compressor operation will be locked out when the outside air temperature is lower than that at which outside air alone can satisfy the cooling load; the thermostat or unit controller will incorporate “integrated economizer control;” sensors that are used to detect outdoor air and return air conditions shall have a specified accuracy; and enthalpy sensors will have solid-state electronic humidity sensing elements; utilize a deadband between economizer enable/disable operation of no greater than 2 deg F in a dry-bulb temperature application, and 2 Btu/lb in an enthalpy application; economizer systems (sensors, dampers, actuators, and controller) shall be factory warranted for parts and labor by the manufacturer for 2 to 5 years; outside and return air dampers will have maximum leakage rates conforming to the requirements of ASH 90.1 2004; controls to adjust the minimum outside air position shall be accessible with air plenum panels in place; sense a non-operating or improperly operating economizer damper and send a fault signal upon detection; Economizers shall be tested for XX open/close cycles according to Standard Test YYY; literature supplied with the unit shall thoroughly explain proper application, installation, operation, and maintenance of: the economizer setup and operating control logic, including setting minimum outdoor airflow; proper sensor installation and location; and sensor calibration procedures and recommended check-out schedule, at the controller, capability to override sensor inputs to allow verification of the sequence of operation shall be provided, economizers and sensors shall have design, materials and construction that provide a mean time before failure of 15 years, provide a readout of the outside air percentage based on air temperature measurement.

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Improve Economizer Design or Specification: ADEC

- More accurate and reliable sensors.
- Solid state digital controls.
- Sophisticated ventilation cycles such as demand-controlled ventilation and variable speed ventilation.
- Commissioning mode.
- Automated Fault Detection and Diagnostics (FDD).

Conduct Quality Installation and Commissioning

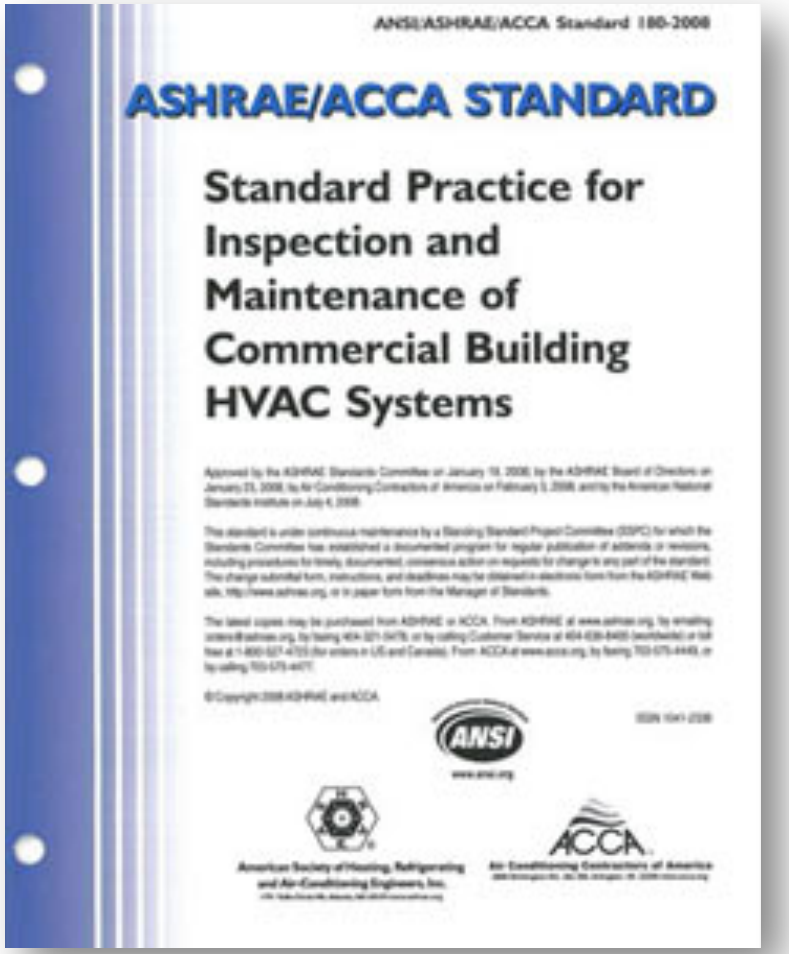
- Does the economizer actuator work? Do the dampers move freely over their full range (full open to full closed)? Are mixed-air sensors correctly installed across the flow area? Is the minimum outdoor air damper setting correct? Are the sensors calibrated? Are the high-limit temperature setpoints set appropriately for the climate? Is the operation proper and capacity of exhaust/relief mechanisms adequate with all doors, windows and other openings closed?

Conduct Quality Installation and Commissioning

- Proper specification
- Manufacturer's installation instructions (Industry-wide installation guidelines?)
- Self configuring and commissioning controllers
- Commissioning:
  - Design review
  - Acceptance tests: Inspections and functional performance tests
  - Training
  - Documentation

Conduct Quality Maintenance, Including Performance Checkout

- Most routine maintenance does not look for performance problems.
- A thorough energy-focused check-out is critical upon initial installation or upon initiating a service contract, but not cost effective on a too-frequent basis.
- Need a two-tier program structure



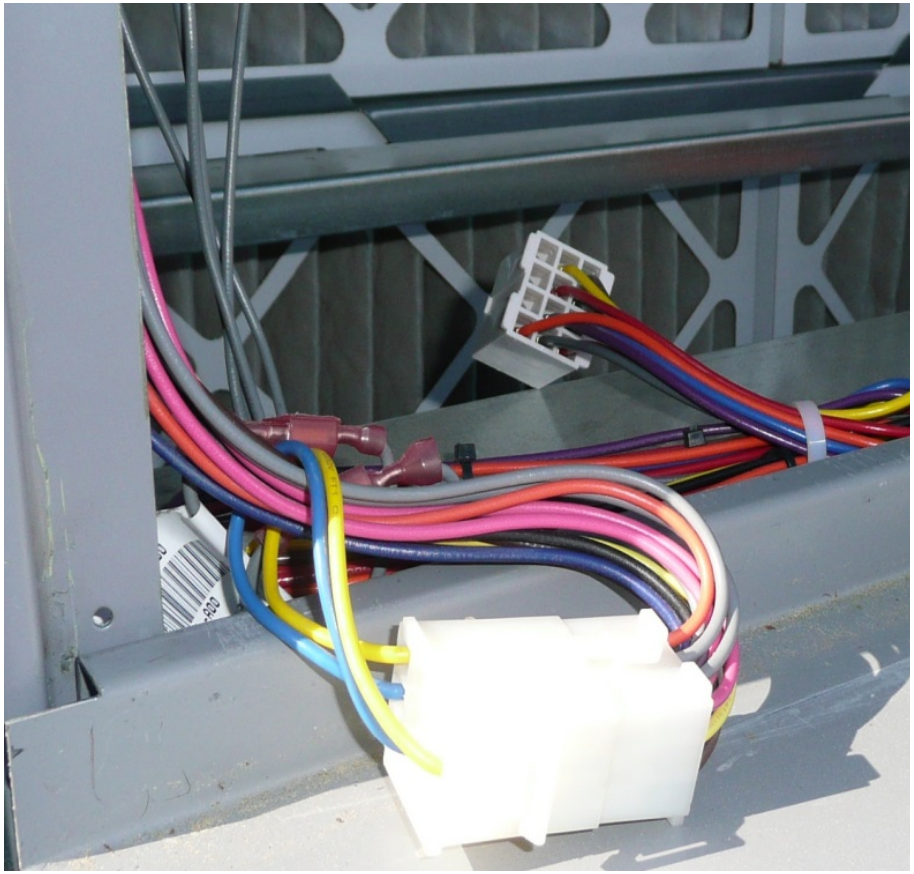
Continue to Pursue Utility Programs

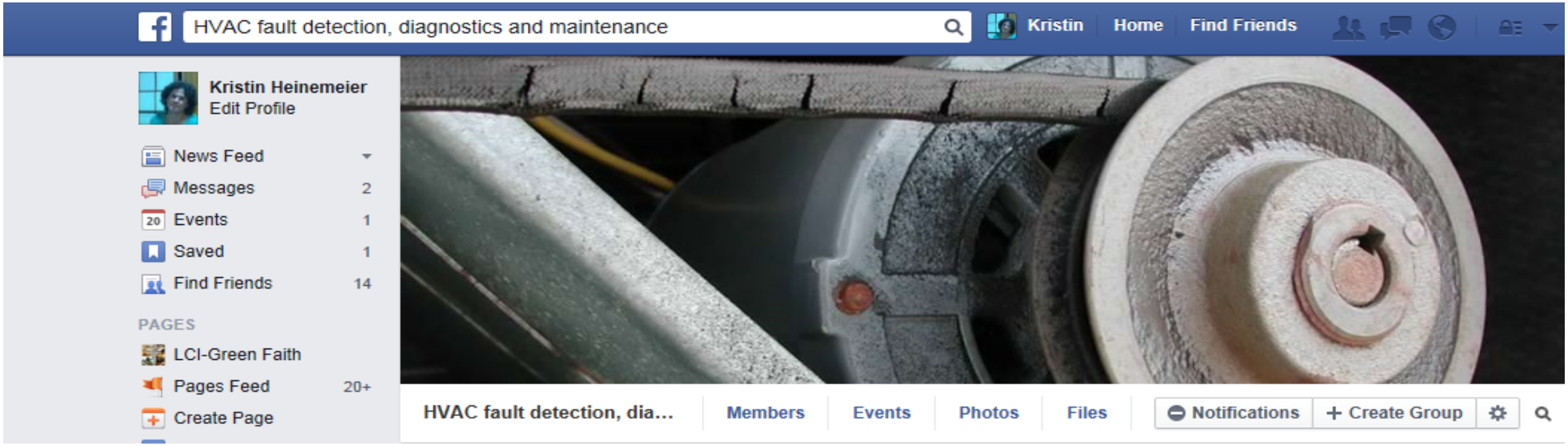
Measure	Notes	Tier 1 less than 6 tons	Tier 2 6 to 12.5 tons	Tier 3 12.5 tons and up
Economizer Repair	Replace existing unqualified dry bulb transmitter (i.e. Honeywell C7650) or snap disc sensor with an adjustable set point dry bulb sensor (i.e. Honeywell C7660) or enthalpy sensor that meets program specifications. Adjust the changeover set points to meet program protocols.	$105	$150	$300
Economizer Changeover Sensor Replacement	Replace existing unqualified dry bulb transmitter (i.e. Honeywell C7650) or snap disc sensor with an adjustable set point dry bulb sensor (i.e. Honeywell C7660) or enthalpy sensor that meets program specifications. Adjust the changeover set points to meet program protocols.	$70	$100	$200
Economizer Adjustment	Optimize economizer control by adjusting to a higher-efficiency changeover set point.	$35	$50	$100

- Economizer improvement Incentives in Air Care Plus Program. *Source*: Air Care Plus, 2014

Conduct Research to Understand Behavioral Issues

- There is no data on what causes failures or what practices or attitudes allow them to stay broken.
- “Out of sight, out of mind”.
- Technicians do not fully understand how they work.
- The failures may exist from Day 1.
- Often “temporarily” disabled, to address complaints about unrelated system problems.

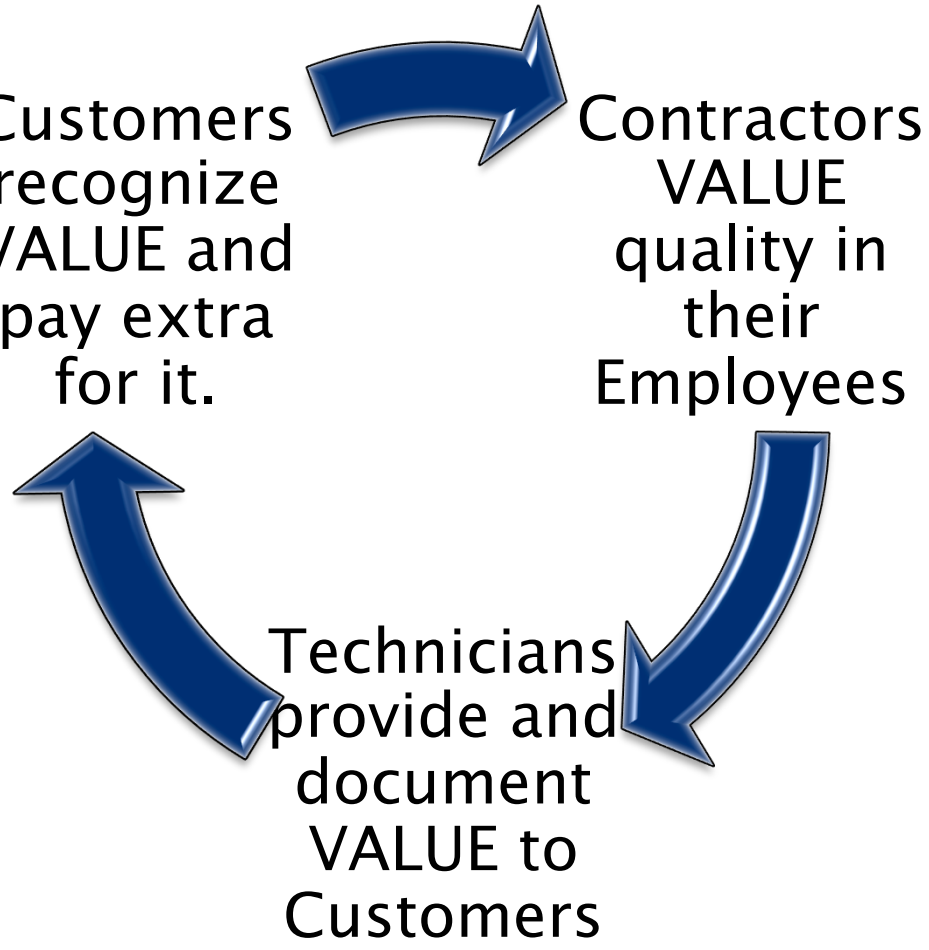




- Comfort complaints: A unit that is undersized and having difficulty meeting load.
- Air quality complaints: Equipment that is in the vicinity of a lot of wood stoves/fireplaces, morning warm-up on gaspacks, fresh air intake is installed directly over a vent stack, truck fumes from units near loading docks, two units installed side by side and the gas exhaust of one is directed towards the economizer of the other.
- Other complaints: too much positive pressure causes doors to not close (esp. day-care centers).

Conclusions

- Technicians want to do a good job, but aren't given the motivation or time.
- Contractors who prioritize quality workmanship could offer a better product to their customers (at a premium), but they perceive there's no market for it.
- Customers want their buildings to work but they don't have enough information about the value to make optimal decisions.
- It's a vicious cycle (or opportunity!)



Next Steps

- Identify human factors in the status quo, as well as Emerging Technologies.
  - *More behavioral research, integrated with technical assessments.*
- Increase technicians' confidence in their ability to provide value and act as qualified and effective energy efficiency communicators and deliverers.
  - *Materials and training*.
- Technicians provide a sophisticated report of maintenance measurements, interventions, and recommendations, with expected savings.
  - *Templates and standards.*
- Customers recognize value and pay for quality services.
  - *Stronger data and analytic tools, and perception of sophistication*.

Questions?