Mass Producing Industrial Energy Efficiency through Building Energy Codes

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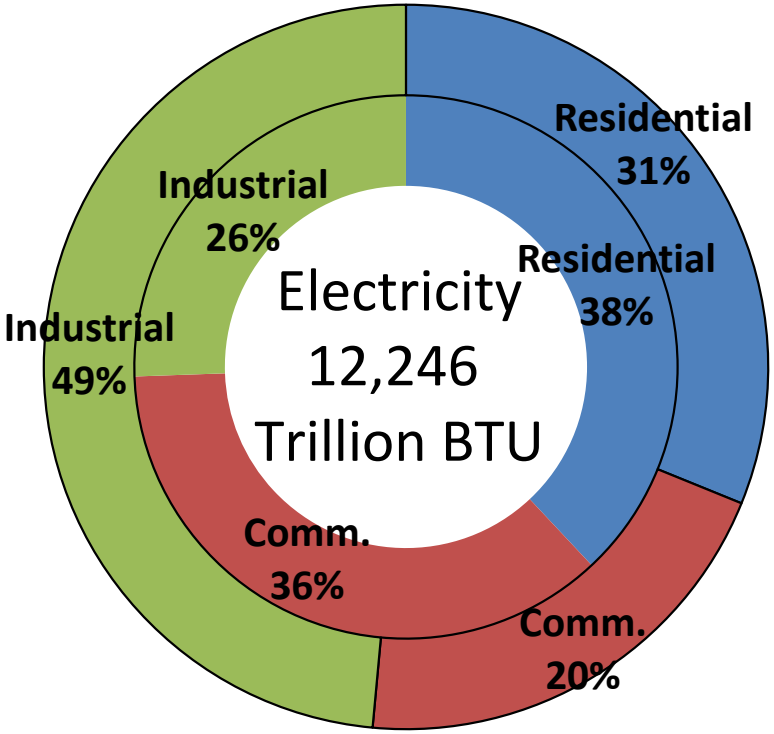
ACEEE 2013 Summer Study
Thursday July 25, 2010 10:30 am

US Industrial Sector Energy Consumption



Natural Gas
15,679 Trillion Btu

~½ total US gas use

~1/4 total US elec use

Only 1-3% of production value

- Thus manuf often ignores high ROI EE opportunities
- EE not core competency

High Interest in Industrial EE

- Government
  - Global competitiveness, employment impacts
  - GHG and indirect emissions from energy
- Energy Utilities
  - High value (hi load factor) large consumers
  - EE program - opportunity to better understand customers
  - Industrial EE program – very cost-effective
    - high savings relative to cost

High Interest in Industrial EE

- Consultants and Equipment suppliers
  - $$ from selling consulting and design services
  - $$ selling the products in efficiency upgrade
- Manufacturers
  - energy management program increases competitiveness and profitability
  - reduced maintenance
  - reduced environmental compliance costs

Industrial Energy Assessments

Combination of :

1. common repeatable EE measures and
2. particular measures for specific plant

Plant specific measures often from facility staff and they need help to evaluate.

- Separate the home runs from the hare-brained
- Provide engineering and financial analysis methodology

Repeatable Industrial EE Measures

- Reducing utility rates
  - fuel switching, special rates, primary service, wellhead gas
  - demand response, power factor adjustment etc.
- Common measures that apply to the operation of any building
  - lighting and HVAC measures.
- Measures for general support services to the process
  - compressed air, steam, chilled water
- Process measures specific to a class of industries
  - improved coating technologies,
  - improved clean-room operation,
  - insulating injection molding barrels etc.

Energy Analysis and Diagnostic Center (EADC) and Industrial Assessment Centers (IAC)

- 1976 EADC funded by Dept of Commerce
- 1978 EADC taken over by USDOE
- 1988 WMAC (Waste Minimization Assessment Center) pilot by USEPA
- 1993 EADC + WMAC = IAC funded by DOE
- 1996 Productivity added to Waste and Energy Assessments provided by IACs

24 Schools Participating in IAC Program

Oregon State
San Diego State
San Francisco State
Boise State
Colorado State
Oklahoma State
Texas A&M
Bradley U
Purdue
U Indianapolis
Iowa State
U Dayton
U Wisconsin Milwaukee

Earlier proposal to expand to 40 schools

Lehigh University
U Delaware
U Massachusetts
Syracuse U
West Virginia U
N. Carolina State
Tennessee Tech
U Alabama
U Kentucky
U Miami
U Michigan
U Missouri-Columbia

IAC Program

- IAC program - hands-on training of energy efficiency engineers
- Free energy assessments to small and medium sized manufacturers
- Public domain methods of calculating savings from industrial EE measures
- Mapping of EE measures to industry types.
  - (IAC) Database contains assessment and recommendations from 15,000+ site assessments including:
    - facility size, SIC or NAICS industry type code
    - description of over 119,000 energy efficiency, pollution prevention and process efficiency recommendations
      - on average approximately 8 recommendations per site

IAC Database Top 20 (out of 900) Recommended Measures - Candidates for Code Inclusion

Description	Times Rec'd	Average Payback	Imp Rate	Code Commentary
utilize higher efficiency lamps and/or ballasts	11,321	2.9	56.34%	Fed appliance stds. CA T-24
eliminate leaks in inert gas and compressed air lines/ valves	7,337	0.4	81.14%	CA 2016 T-24 proposal
use most efficient type of electric motors	5,071	4.1	64.25%	Fed appliance stds
install compressor air intakes in coolest locations	4,881	0.9	47.90%	Climate dependent
utilize energy-efficient belts and other improved mechanisms	3,990	0.8	55.62%	Equipment dependent
reduce the pressure of compressed air to the minimum required	3,863	0.5	49.47%	Application specific
install occupancy sensors	3,514	1.4	35.68%	Building standards
use more efficient light source	3,388	1.9	53.24%	Building standards
insulate bare equipment	3,356	1.2	47.73%	Equipment specific. Opportunity
analyze flue gas for proper air/fuel ratio	2,275	0.6	68.57%	CA 2013 T-24. Parallel positioning and O2 trim control
install timers and/or thermostats	1,904	0.7	55.16%	Building standards
reduce illumination to minimum necessary levels	1,736	0.4	50.79%	Building standards
use multiple speed motors or VFD for variable pump, blower and compressor loads	1,704	2.1	29.34%	CA 2013 T-24
turn off equipment when not in use	1,486	0.4	59.32%	Operations
recover heat from air compressor	1,444	1.1	32.58%	CA 2013 T-24 supermarket refrigeration
replace electrically-operated equipment with fossil fuel equipment	1,430	2.0	27.68%	Fuel switching. T-24 space heating no elec resistance
optimize plant power factor	1,396	2.0	38.67%	Appliance efficiency Standards
insulate steam / hot water lines	1,276	2.4	61.07%	CA 2013 T-24
reschedule plant operations or reduce load to avoid peaks	1,248	0.4	40.68%	Operations.
eliminate or reduce compressed air used for cooling, agitating liquids, moving product, or drying	1,178	0.8	45.98%	Equipment selection

Top 20 selected from http://iac.rutgers.edu/database/topten/

DOE Industrial Technologies Program: Other Repeatable Industrial EE Opportunities

Motors Challenge

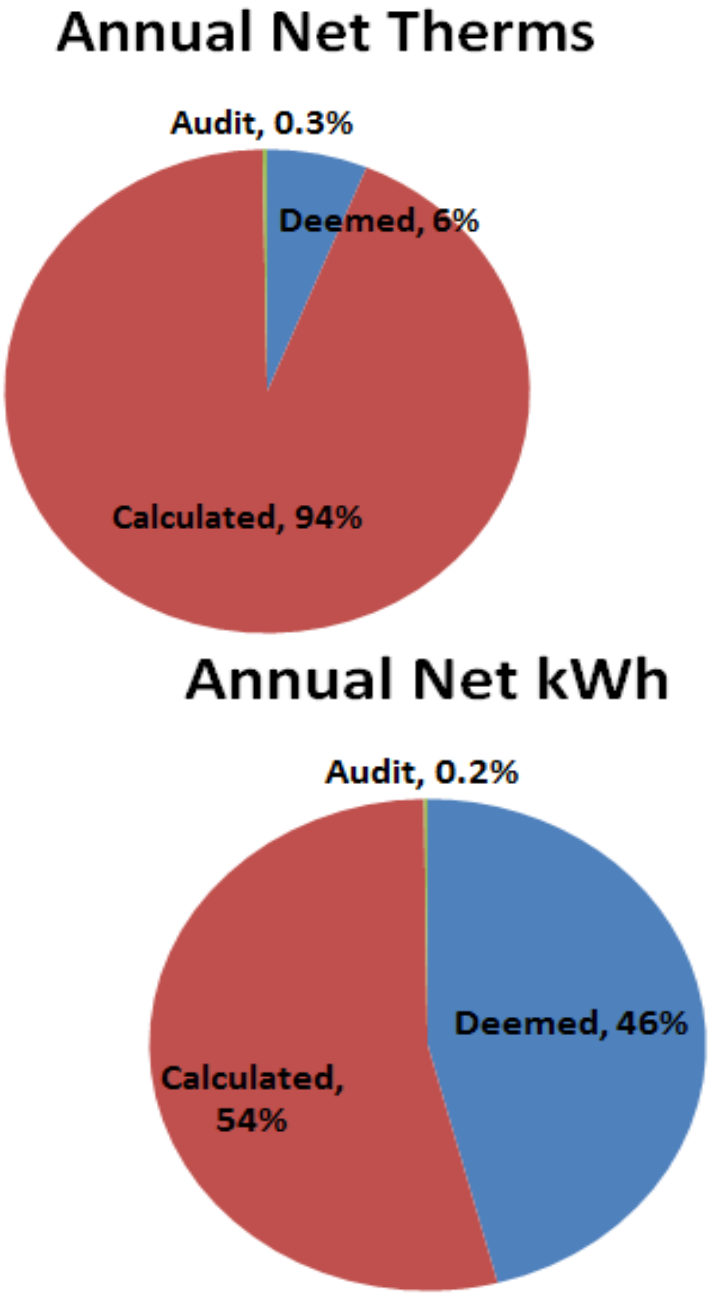
- MotorMaster+, a software tool for motor system optimization
  - Consortium for Energy Efficiency (CEE) used as basis of motors efficiency program
  - basis of DOE Rulemaking on Motors

Compressed Air Challenge (CAC)

- Publication: “Best Practices for Compressed Air Systems”
- Optimization Software: AirMaster
  - Basis of 2013 T-24 compressed air measures

PG&E Industrial Programs

- Deemed programs – prescriptive measures and most code-ready
- Calculated programs – require facility specific detail. Some converted into deemed.
- Audit program – measures not deemed or calculated. Audits used to market deemed and calculated measures



Industrial Programs are Cost-Effective PG&E Experience

Levelized TRC cost

- includes incremental measure cost, program overhead & incentives to free-riders
- $0.076/kWh
- $0.399/therm

Lower than avoided cost and consumer cost

- Avg CA industrial retail rate $0.0991/kWh
- Avg CA industrial retail rate $0.657/therm

California Building Codes: Title 24

- 2001 after California power crisis, Senate Bill SB 5X gave CEC authority over outdoor lighting and unconditioned spaces
- 2008 Title 24 standards, CEC determined no legal barrier to regulating process loads only traditional practice
  - Refrigerated warehouse refrigeration - the first process area regulated
    - First year savings: 10 GWh/yr
    - Based on measures in Savings by Design program
- 2013 significant expansion to industrial and process energy

2013 Title 24 - Energy Savings and Life Cycle Energy Cost Savings for First Year's New Construction in California

Code Measure Description	Elec Savings GWH/yr	Demand Savings MW	Gas Savings Million therms/yr	Life Cycle Cost Savings PV $ (Millions)
Compressed air VSD and optimal staging controls	23.2	4.2		43.0
Industrial Boiler: Flue damper			0.03	0.4
Ind. Boiler VFD combustion air fan	0.7	0.1		1.3
Ind Boiler Parallel Position Controls			0.47	6.8
Ind Boiler O2 Trim Controls			0.61	8.8
Laboratory HVAC Variable Air Volume	TBD	TBD	TBD	TBD
Data Center Cooling Systems	51.7	1.5		98.7
Refrigerated warehouse efficiency	1.1	0.2		2.9
Supermarket refrigeration efficiency and heat recovery	18.0	1.5	1.89	68.5
Parking Garage Ventilation Control	13.9	3.2		25.7
Kitchen Ventilation Control	30.1	5.2	.3	59.7
Total	138.7	16.0	3.28	$315.8

National impacts about 10X as large – 1 TWh/yr and growing

Impact of Industrial Building Codes on Industrial Programs

- PG&E Industrial Programs
  - 97% of the natural gas savings of the industrial incentive programs were due to retrofits
- Some code requirements are triggered by a retrofit
  - If the program motivates retrofit rather than responding to an intent to retrofit, code is not an accurate reflection of what would have happened without the program (i.e. not the appropriate baseline)

Opportunity for C&S and Industrial Program Synergies

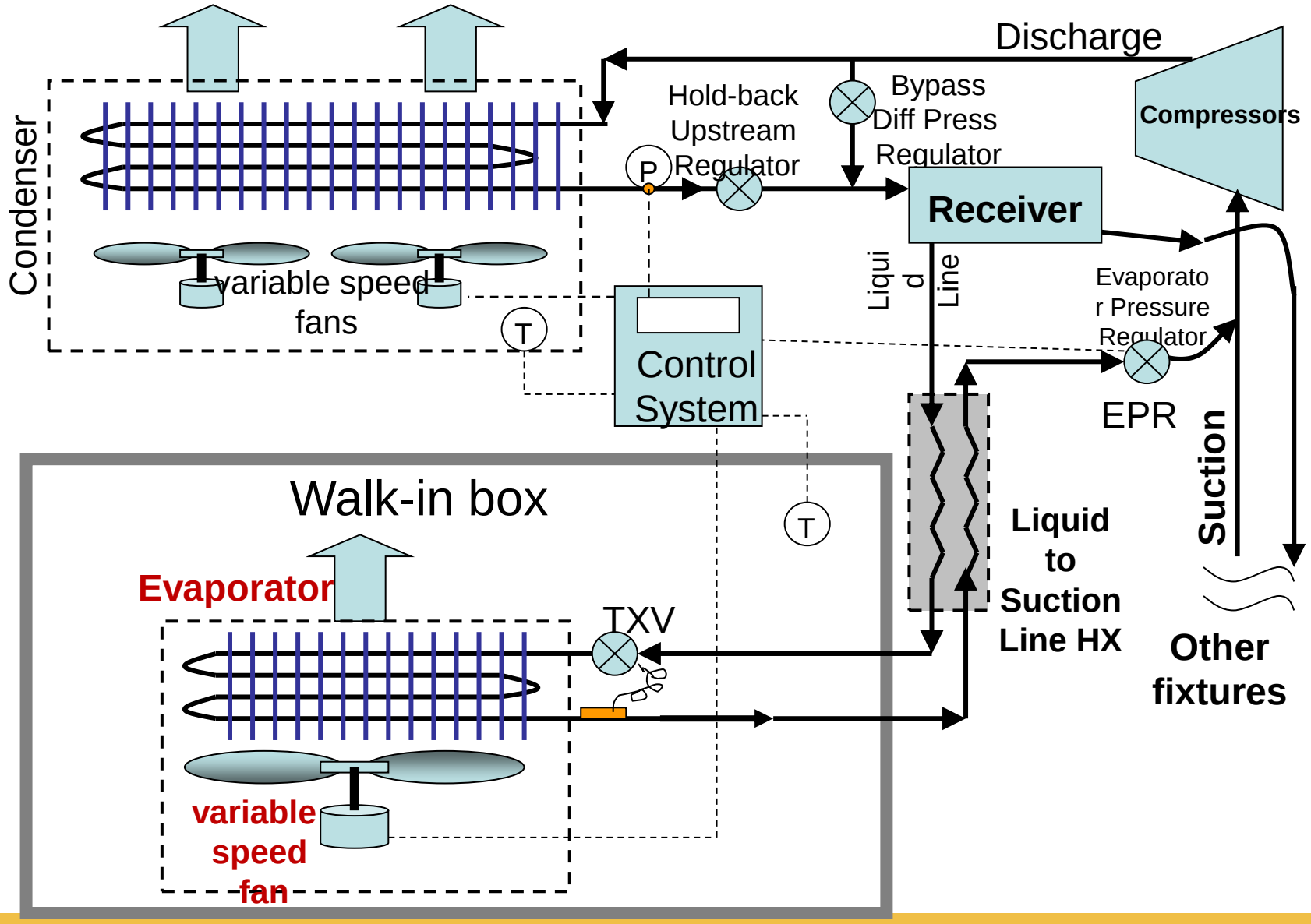
- Industrial programs are well suited to systematically collect the energy, cost, and feasibility information for consideration as a code measure.
- Once adopted in code, credibility of measure enhanced, easier to market measure for retrofits.
- EE program can prepare new construction market in advance of effective code date

Potential NEW 2016 Title 24 Process and Industrial Measures: CA Statewide 1st yr Savings Rough Estimate

Code Measure Description	GWH/yr	Million therms
Evap fan speed control for supermarket walk-ins	2.5	
Lab fume hoods: Occupancy sensing control of sash, occupancy + time control general AC setback, no reheat, system sizing	8.1	1.2
Compressed air: Pipe sizing and leak testing	4.5	
Compressed air: Air dryer efficiency	TBD	
Compressed air: Capacity controls for centrifugal compressors	4.5	
Requirements for steam traps including networked fault detection and diagnostics		2.9
Total	**19.5**	**4.1**

National impacts about 10X as large and growing

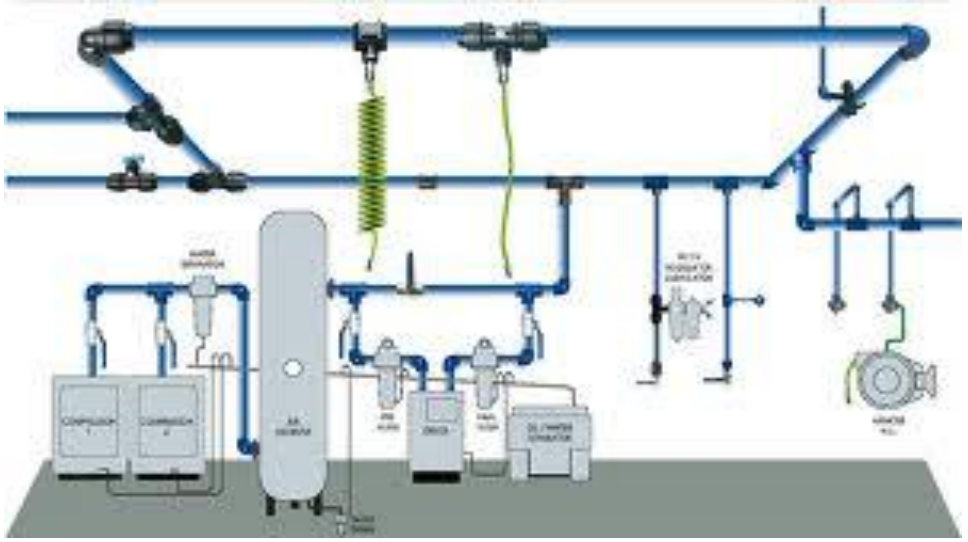
Evaporator Fan Speed Control



Fume Hoods and Lab HVAC

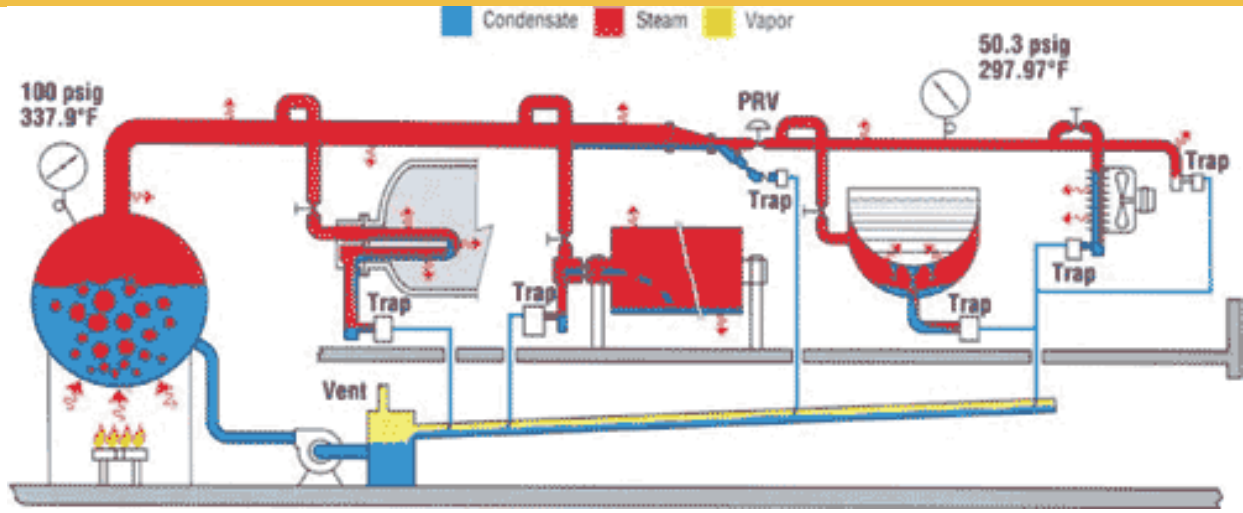
- Lab fume hoods, Occupancy sensing control of sash
  - Evaluate the feasibility and cost-effectiveness of an automatic control of vent hood sashes.
  - Similar to automatic doors at stores
  - Requires VAV fume hood exhaust system
- Lab HVAC measures
  - reset general room airflow rate and setpoint when unoccupied after hours,
  - max W/cfm at peak air flow,
  - no simultaneous heating and cooling (dual duct, chilled beam, 4PFC etc.,),
    - Internal gains in labs can vary widely over time and they become the “rogue” zone
  - sizing calculated,
  - exhaust duct sealing.

Process Compressed Air

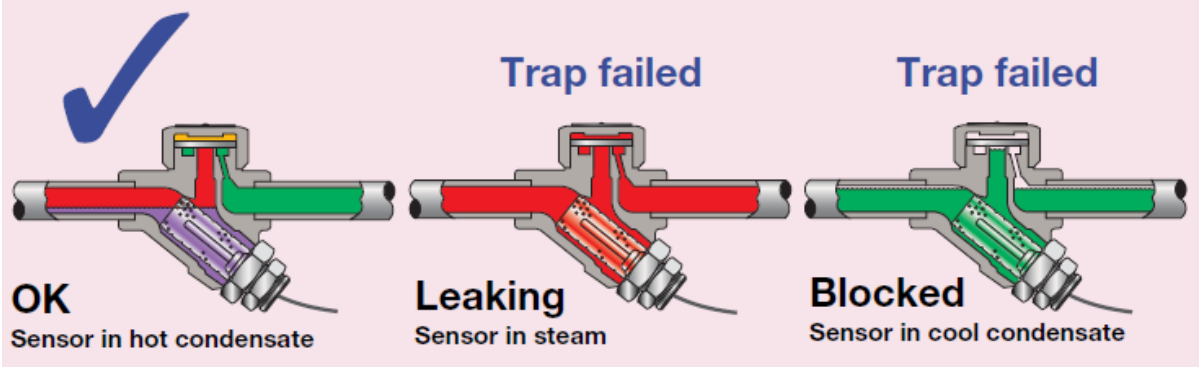


- Pipe sizing and testing for compressed air systems
  - Compressed air piping requirements in either the energy code or other code (e.g. Plumbing or Mechanical Code).
  - Acceptance test for air leaks and pressure drop
- Air dryer efficiency for compressed air
  - Build on SCE research on thermal and variable speed control of air dryers
- Capacity controls for centrifugal compressors
  - VSD's or other capacity controls for centrifugal compressors under different system configurations.

Steam Traps



- Sizing of steam traps (same size as condensate line),
- Strainer and purge valve upstream.
- FDD (fault detection and diagnostics) and remote monitoring of steam traps on large systems (exceeds threshold number of traps or capacity)



Conclusions

- Expansion of scope to process loads increases code savings significantly (~20% of T-24)
- If implemented nationwide would save ~ 1 TWh/yr & 30 Million therms/yr for each year's new construction
- Synergies between Industrial programs and C&S programs
  - EE collect info on cost, savings, applicability and feasibility
  - C&S address repeatable measures so EE can focus on new or factory specific measures
- Program evaluators and managers must develop an energy baseline that estimates …
  - What would have happened without the program
- **Framework for implementing key industrial efficiency measures on a state by state basis rather than on a factory by factory basis**

Acknowledgements

- Thanks to my co-authors:
  - Doug Naaf & Patrick Eilert, Pacific Gas & Electric Company
  - Mike McGaraghan & Amanda Gonzalez, Energy Solutions
- PG&E Codes & Standards Program
- EADC/IAC Program sponsored by USDOE
  - Dr. C. Byron Winn, ME Dept CSU