Energy Management Opportunities for Industrial Customers
Meet Your Panelists:

Mike Carter

Justin Kale
NEEA Northwest Industrial Training

- **Provided by:**
  Northwest Regional Industrial Training Center:
  (888) 720-6823
  industrial-training@industrial.neea.org

- **Co-sponsored by your utility and:**
  Washington State University Extension Energy Program
  Bonneville Power Administration
  Northwest Food Processors Association

- **Utility incentives and programs:**
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Upcoming In-Class Trainings

Go to the NEEA calendar at [http://neea.org/get-involved/calendar](http://neea.org/get-involved/calendar) for trainings and events scheduled around the Northwest region.

To register for a training, look for it by date and title. Once you find the training you want to register for, click on the title and you will find a description and registration information. Trainings are posted to the calendar as dates are finalized, so please check the calendar regularly or contact the training team at 888-720-6823.

- **Lighting:**
  
  **Efficient and Effective Industrial Lighting**
  
  December 12, 2013: Moses Lake, WA

[http://neea.org/get-involved/calendar](http://neea.org/get-involved/calendar)
Upcoming In-Class Trainings

- **Pumps:**
  - **Pumping System Optimization**
  - December 10-15, 2014: Bend, OR

- **Special Event:**
  - **NW Energy Efficiency Summit**
  - January 15, 2014: Portland, OR

http://neea.org/get-involved/calendar
Upcoming Webinars

To register for a webinar, go to the NEEA calendar http://neea.org/get-involved/calendar and look for it by date and title. Once you find the webinar you want to register for, click on the title and you will find a description and registration information. All webinars are free!

- **Power Factor:**
  
  **Improve Power Factor and Your Facility**
  December 17: 9-10am PST
  
  http://neea.org/get-involved/calendar
Energy Management Benefits

- Bottom line cost savings today!
  - Energy
  - Maintenance
- Reduced noise levels
- Better indoor air quality
- Reduced air emissions

Source: stock.xchng
Topics

- Basics
- Insulation
- Motors
- Heating Systems
- Compressed Air
- Lighting
- HVAC

![Electric Intensity Pie Chart - Fabricated Metal Products](chart1)

Electric Intensity (kWh/sqft) -- Fabricated Metal Products

- Motors/Machine Drive: 16.26 kWh/sqft (44.05%)
- Process Heating: 8.52 kWh/sqft (23.08%)
- HVAC: 3.73 kWh/sqft (10.11%)
- Lighting: 3.48 kWh/sqft (9.43%)
- Other: 3.43 kWh/sqft (9.29%)
- Process Cooling/Refrigeration: 1.28 kWh/sqft (3.47%)
- Electro-Chemical Processes: 0.21 kWh/sqft (0.57%)

Total: 36.91 kWh/sqft

![Electric Intensity Pie Chart - Food Industry](chart2)

Electric Intensity (kWh/sqft) -- Food Industry

- Motors/Machine Drive: 42.86 kWh/sqft (48.20%)
- Process Cooling/Refrigeration: 23.76 kWh/sqft (26.72%)
- Other: 6.99 kWh/sqft (7.86%)
- HVAC: 6.33 kWh/sqft (7.12%)
- Lighting: 6.03 kWh/sqft (6.78%)
- Process Heating: 2.96 kWh/sqft (3.33%)

Total: 88.93 kWh/sqft
Energy Basics

- **Peak Demand Curtailment**
  - Separate loads into three categories:
    - Life, health, and safety-driven
    - Mission critical
    - Non-critical
  - Start by considering curtailment of non-critical loads.
    - Non-safety lighting
    - HVAC
  - Consider installing sub-metering to identify high intensity loads.
Energy Basics

- **Power Factor**
  - Real/active power (kW) does real work.
  - Reactive power (kVAR) bound up in magnetic fields.
  - Apparent power (kVA) must be supplied by the utility to accommodate the reactive component.
What is Power Factor?

Displacement Power Factor

\[ PF = \frac{kW}{kVA} \]
\[ = \cos \theta = \cos (45^\circ) = 0.70 \]

\[ kVA^2 = kW^2 + kVAR^2 \]
\[ (kVA)^2 = (75)^2 + (75)^2 = 11,250 \]

Apparent Power (kVA) = \(\sqrt{11,250} = 106 \text{ kVA}\)

Then: Power Factor = \(\frac{kW}{kVA} = \frac{75}{106} = 70.8\%\)
Power Factor

- Add capacitance to correct power factor.
- Does not change demand (kW) or save much energy (kWh).
- New Power Factor = 75 kW / 83 kVA = 90%

Source: Van Rijn Electric
Energy Basics

- **Carbon Footprint**
  - Metric tons (2,205 lbs or 19,550 ft³) of CO2
    - Natural Gas -> 12 lbs CO2/ccf (500 lbs/MWh)
    - Electricity -> 1.6 lbs CO2/kWh (1,600 lbs/MWh)
    - Carbon = \(\frac{CO2}{3.67}\) (100 tons CO2 = 27 tons C)
      - Pine trees can absorb roughly 1 metric ton of carbon per acre per year.
  - **Direct** emissions from company-owned stacks
  - **Indirect** emissions from travel
Insulation

- Insulation has diminishing returns
  - **R-value** is resistance to heat flow (additive)
    - \( R-7 + R-21 = R-28 \) (4 times R-7, and 75% better than R-7)
    - \( R-7 + R-49 = R-56 \) (8 times R-7, but only 12% better than R-28!)
  - **U-value** is conductance of heat; inverse of R-value
    - \( U(R-7) = \frac{1}{7} = 0.143 \)
    - \( U(R-21) = \frac{1}{21} = 0.048 \)
    - \( U(R-56) = \frac{1}{56} = 0.018 \) (87% less than R-7)
    - \( U(R-28) = \frac{1}{28} = 0.036 \) (75% less than R-7)
Energy Basics

- **Insulate steam pipes** with at least ½" insulation
  - For a 350°F process steam pipe (100 ft), savings are $5,000 for 2" diameter and $10,000 for 4" diameter pipe
  - Diminishing returns for insulation thickness >1/2"

<table>
<thead>
<tr>
<th>Type</th>
<th>R-value per inch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fiberglass</td>
<td>2.2-3.1</td>
</tr>
<tr>
<td>Vermiculite/perlite</td>
<td>2.4-2.8</td>
</tr>
<tr>
<td>Polystyrene</td>
<td>4.0-5.0</td>
</tr>
<tr>
<td>Polyurethane</td>
<td>6.0</td>
</tr>
<tr>
<td>Polyisocyanurate</td>
<td>6.0-7.1</td>
</tr>
</tbody>
</table>
# Motors and Transformers

<table>
<thead>
<tr>
<th>Implementation</th>
<th>Load (kWh)</th>
<th>Peak (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replace motors</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Use variable speed drives</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Right size the motor</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Disconnect unused transformers</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
Motors

- **Variable Speed Drives** / Adjustable Speed Drives

![Graph showing the relationship between flow rate and input power for different control methods.](image)

Source: Emerson Industrial Automation
VFD Energy Savings

Power Input

HP ≈ rpm^3

Example: speed reduction to 50%

HP_{0.5} = HP_1 \times (0.5)^3
= HP_1 \times 0.125

<table>
<thead>
<tr>
<th>Speed</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>90%</td>
<td>73%</td>
</tr>
<tr>
<td>80%</td>
<td>51%</td>
</tr>
<tr>
<td>70%</td>
<td>34%</td>
</tr>
<tr>
<td>60%</td>
<td>22%</td>
</tr>
<tr>
<td>50%</td>
<td>13%</td>
</tr>
<tr>
<td>40%</td>
<td>6%</td>
</tr>
<tr>
<td>30%</td>
<td>3%</td>
</tr>
<tr>
<td>20%</td>
<td>1%</td>
</tr>
<tr>
<td>10%</td>
<td>0.1%</td>
</tr>
</tbody>
</table>

*VT/VH = Variable Torque/Variable Horsepower
VFD Energy Savings

- At 50% speed, VFD saves 75-85% versus output throttling and variable inlet speed control.

<table>
<thead>
<tr>
<th>Control</th>
<th>Motor HP Input vs Speed (100 HP)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>25%</td>
</tr>
<tr>
<td>Damper</td>
<td>75</td>
</tr>
<tr>
<td>Inlet Vane</td>
<td>55</td>
</tr>
<tr>
<td>VFD</td>
<td>3.6</td>
</tr>
</tbody>
</table>
Motors

- **Repair or Replace Motors**
  - Replace motors <40 HP.
  - Replace if cost of rewind >65% of new motor.
  - Replace motors last rewound before 1980.

- **Right Size the Motor**
  - Motor efficiency plummets at <40% rated load.

- **Premium Efficiency Motors**
  - Good motor efficiency varies from about 85% (1 HP) to 95% (>75 HP).
  - NEMA Premium Efficiency motors are 1% to 3% basis points more efficient than baseline (EPACT 1992).
Transformers

- **Transformer Losses**

  - Remove power from unused transformers.
    - No load losses (NL)
      - Caused by the magnetizing current to energize the core.
      - <0.5% of rating (for example, roughly 125 watts on a 50 kVA transformer).
    - Full load losses (FL)
      - Heat losses, or $I^2R$ losses, in the winding materials.
      - Roughly 5x NL losses (600 watts on a 50 kVA transformer).
  - High-Efficiency Transformer
    - Paying a little more upfront ($400 to $4,000) leads to long term savings (>20,000 for a 1500 kVA transformer).
# Heating Systems

<table>
<thead>
<tr>
<th>Implementation</th>
<th>Load (Btu)</th>
<th>Load (kWh)</th>
<th>Peak (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Burner Air: Fuel Ratio</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modern Gas Burners/Controls</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steam Traps</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stack Heat Recovery</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infrared Booster Heaters</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste Heat Absorption Chillers</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Industrial Heat Pumps for Drying/Heating</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Radio Frequency/Microwave Drying/Heating</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Induction Process Heating</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Heating Systems

- Measuring Boiler Efficiency
  - **Fuel-to-steam efficiency** is the best efficiency metric.
    - Boiler output (Btu)/boiler input (Btu)
  - Efficiency mainly influenced by boiler design.
    - Number of passes
    - Burner/boiler compatibility
    - Burner controls
    - Heating surface (square feet/boiler HP)
      - $\geq 5 \text{ ft}^2/\text{HP}$ is desired
  - Other factors
    - Flue gas temperature
    - Fuel hydrogen/carbon ratio
    - Excess air (10% to 12%)
    - Ambient temperature
      - Every $40^\circ\text{F} \sim 1\%$ efficiency change

Image courtesy of Cleaver Brooks
Heating Systems

- Proper Boiler **Air:Fuel Ratio**

<table>
<thead>
<tr>
<th>Excess %</th>
<th>Temp. °F (Flue-Comb.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>200°F</td>
</tr>
<tr>
<td>Air 9.5</td>
<td>85.4%</td>
</tr>
<tr>
<td>Oxy 2.0</td>
<td></td>
</tr>
<tr>
<td>Air 28.1</td>
<td>84.7%</td>
</tr>
<tr>
<td>Oxy 4.0</td>
<td></td>
</tr>
<tr>
<td>Air 81.6</td>
<td>82.8%</td>
</tr>
<tr>
<td>Oxy 6.0</td>
<td></td>
</tr>
</tbody>
</table>

- Efficiency improvements
  - 82.8% → 85.4% = 2.6%
  - 68.2% → 76.0% = 7.8%

Source: EPA
Heating Systems

- Upgrade to **Modern Burners**
  - Motor-controlled flue gas recirculation dampers
  - Swirl vanes
  - Turbulence enhancement
  - Premixing chambers
  - Leak-tight modulating air dampers
Heating Systems

- Upgrade to Modern Burners (cont’d)
  - Tangential diluent injection
  - Rotating concentric blade air registers
  - Fuel atomizers
  - Venturi tube air registers
  - Tapered burner tiles with baffles

Ultraclean, Low-Swirl Burner (UCLSB) developed by Berkeley Lab
Heating Systems

- **Use** [Electronic Burner Controls](#) *(typical savings)*
  - Linkless burners have no backlash (1%)
  - Increased turndown (5%)
    - Burner on/off cycles and their associated cold air purges also will be reduced.
  - A second PID control (10%)
    - A second PID control’s setpoint can be used to switch the boiler to a lower steam pressure or hot water temperature during periods of reduced activity.
  - Adaptive oxygen trim (2% to 3%)
    - Large boilers only ($>100,000 fuel per year)
Use Electronic Burner Controls (cont’d)

- Fan speed control
  - Burner turn-down can be increased without compromising efficiency.

- Boiler sequencing (lead/lag) control and communication software
  - Enables the plant operator to achieve better utilization and additional energy savings are possible.
Heating Systems

- Fix Broken Steam Traps
  - One 1/8" diameter stuck-open steam trap orifice on a large boiler can cost $1,000 (15 psig) to $5,000 (140 psig) per year in increased natural gas consumption.
  - 1 lb/hr ~ 1,000 Btu/hr

- There are Several Ways to Test Steam Traps
  - Non-contact, infrared thermometer
  - Acoustic testing
  - Electronic stethoscope
### Heating Systems

- **Stack Heat Recovery**
  - Each 40°F reduction in stack temperature results in a 1% improvement in efficiency.
    - Preheating combustion air
    - A 200°F air preheat saves 5%
  - Best applications >900°F stack temperature
    - 1,000°F → 800°F results in 5% savings
  - **Recuperators, regenerators, and heat exchangers**

- **Infrared Booster Heaters**
  - Reduces coating curing times by 25% to 40%.
  - Best *in conjunction with convection* and for thin simple shapes.
Absorption Chillers

- Fueled by waste heat **but** high capital costs.
  - High peak demand charges
  - Capacity >500 tons
  - Waste heat temperature >270°F
  - CFC or HCFC environmental concerns

- Yazaki Energy Systems (Plano, TX) and Thermax (Piscataway, NJ)
  - Low temperature (185°F to 203°F) absorption chillers (20 to 30 ton max capacity)
# Heating Systems

## Industrial Heat Pumps

<table>
<thead>
<tr>
<th>Process</th>
<th>Key Enabler</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Separation</td>
<td>Reduced column pressure enables distillation at low temperatures</td>
<td>Propane/propylene, butane/butylenes</td>
</tr>
<tr>
<td>Concentration</td>
<td>Low (&lt;50°F) temperature lift results in gentle evaporation cycle</td>
<td>Beer, sugar solutions, milk and whey, juice, steep water, syrup and radioactive waste.</td>
</tr>
<tr>
<td>Drying</td>
<td>Upper temperature limit; Slow dry time desired; Continuous operation</td>
<td>Lumber and paper</td>
</tr>
<tr>
<td>Dehumidification</td>
<td>High temperature air used for drying; Slow dry time desired</td>
<td>Brick, ceramics</td>
</tr>
<tr>
<td>Space Heating</td>
<td>Higher thermal efficiency than other furnaces</td>
<td>Shop, warehouse</td>
</tr>
</tbody>
</table>
Heating Systems

Vilter Industrial Ammonia Scavenging Heat Pump System

Heat Source:
160°F / 100 to 150 psig superheated ammonia vapor

Desuperheater

Condenser

Subcooler

Oil Cooler

VSSH-341
500 HP Heat Pump Compressor

Heat Load:
110 GPM Potable Water

85°F / 100 to 150 psig saturated ammonia liquid/vapor

85°F / 485 psig subcooled ammonia liquid

Source: Emerson Climate Technologies
Boiler cost estimate
- Energy saved = \([110 \text{ gal/min} \times 60 \text{ min/hr} \times 90^\circ F \text{ rise}] \times [8.34 \text{ lb/gal} \times 1 \text{ Btu/lbF}] \div 0.80\] = 6,100 kBtuh
- Boiler cost = \([6,100 \text{ kBtu/h} \times 5,840 \text{ hrs}] \times [1 \text{ therm/100kBtu} \times $0.90/\text{therm}]\] = $320,000 per year

Heat pump cost estimate
- HP Cost = energy cost + demand charge
  - \([228 \text{ kW} \times 5,840 \text{ hrs} \times $0.06/\text{kWh}] + [228 \text{ kW} \times $10/\text{kW} \times 12 \text{ mth}]\] = $107,000 per year ($80,000 + $27,000)

Boiler savings of $210,000 per year
- + condenser annual water savings of 12 million gallons per year ($70,000)
- + reduced power draw on source refrigeration compressors (50-80 HP or $13,000)

< 3-year payback
- Estimated capital costs = $570,000 (equipment) + $200,000 (install) = $770,000
Heating Systems

- **Radio Frequency/Microwave**

<table>
<thead>
<tr>
<th>Process</th>
<th>Key Enabler</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-drying</td>
<td>Selective heating (water only) to avoid product damage; Speed</td>
<td>Fiberglass packaging and mats; Dyed yarn spools; Ceramic fiberboard, powder, and extrusions</td>
</tr>
<tr>
<td>Post-drying</td>
<td>Low final moisture content; Uniform (small temperature gradient) heating; No surface crust</td>
<td>Foods such as cookies, potato chips, and pasta; Dry pet foods; Polyurethane foam</td>
</tr>
<tr>
<td>Tempering</td>
<td>Volumetric heating; Speed</td>
<td>Frozen meats; Room temperature bacon; Chocolate</td>
</tr>
<tr>
<td>Cooking</td>
<td>Reduce drip loss (water, fat, nutrients, and flavor)</td>
<td>Sausage, bacon</td>
</tr>
<tr>
<td>Curing</td>
<td>Uniform heating; Precise temperature control; Speed</td>
<td>Adhesives for wood and laminates</td>
</tr>
</tbody>
</table>
### Heating Systems

- **Induction**

<table>
<thead>
<tr>
<th>Process</th>
<th>Key Enabler</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metallurgical processing (Hardening, Tempering, Annealing)</td>
<td>Selective heating; Speed; In-line continuous process</td>
<td>Gear teeth; Cutting blades; Pulleys; Axles; Camshafts; Galvanized sheet</td>
</tr>
<tr>
<td>Preheating prior to deformation (Forging; Swaging; Upsetting; Bending; and Piercing)</td>
<td>Reduced scale formation; Speed</td>
<td>Turbine engine blades; Billets; Mill rolling of slabs and strips</td>
</tr>
<tr>
<td>Melting</td>
<td>Speed; Flexibility</td>
<td>Steel; Iron; Copper alloys; Aluminum; Zinc</td>
</tr>
<tr>
<td>Brazing and Soldering</td>
<td>Localized heating; Precise temperature control and uniformity</td>
<td>Dissimilar materials; Carbide tips; Turbine blades; Eyeglass frames</td>
</tr>
</tbody>
</table>
## Compressed Air

<table>
<thead>
<tr>
<th>Implementation</th>
<th>Load (kWh)</th>
<th>Peak (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Only use when there is no other option</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Fix leaks</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Right size</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Use variable speed compressor motor drives</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Implement heat recovery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use two-stage, lubricated or centrifugal</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>
Compressed Air

Air Compressor Efficiency Benchmarks

<table>
<thead>
<tr>
<th></th>
<th>Reciprocal</th>
<th>Rotary Screw</th>
<th>Centrifugal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Air cooled</td>
<td>Water cooled</td>
<td>Lubricated</td>
</tr>
<tr>
<td>Units</td>
<td>Single-Stage</td>
<td>Single-Stage</td>
<td>Two-Stage</td>
</tr>
<tr>
<td>BHP per 100 CFM</td>
<td>26-32</td>
<td>25</td>
<td>19-22</td>
</tr>
<tr>
<td>kW per 100 CFM</td>
<td>22-27</td>
<td>21</td>
<td>16-18</td>
</tr>
</tbody>
</table>

Source: Research Associates
Compressed Air

- **Compressed Air** energy cost for 6,000 hrs at $0.10/kWh = $125/CFM
  - At 4 CFM/HP, a 250 HP compressor costs about $125,000 annually.

- Only use compressed air when it is absolutely necessary!
  - If possible, switch to motors, mechanical actuators, and other means to accomplish the same function.

-Leaks often account for 20% to 30% of compressor output.
  - A 1/32" leak in a 90 psi compressed air system would cost approximately $185 annually.
Compressed Air

Lubricant Cooled Rotary Screw Compressor Capacity Control Comparison

40 Second Blow Down

% Full Load Average BHP vs. % of Compressor Capacity

- IV Mod No BD
- 2-Step Control 1 gal/cfm storage
- IV Mod 60% BD
- 2-Step Control 5 gal/cfm storage
- Covventional VSD
- VSD Compared to Constant Speed Control

All data taken from the Compressed Air Challenge 1999, sponsored by the U.S. DOE.

Abbreviations:
- IV: Inlet Valve
- Mod: Modulation
- BD: Blow Down
- VSD: Variable Speed Drive

NOTE: All percentages are stated as a percent of full load horsepower at a specific discharge pressure (i.e. 100 psig) on a specific machine.

NOTE: Curves are based on a lubricant cooled screw with a 40 second blow down, other parameters see miscellaneous section.
Compressed Air

- Variable **speed** is best applied to compressors that operate primarily as trim units, or as single units with loads below 75% to 80% demand.
  - Below 85% loading, variable **displacement** units become less efficient than variable speed, and are very poor at loads below 50%.

- Reduce system pressure
  - 10 psi decrease saves 8% to 10%.

- Use larger diameter hoses
  - ¾" diameter hose for >3 HP tools or >50' lengths.
Compressed Air

**Heat Recovery**

- **Air-cooled** compressors offer recovery efficiencies of 80% to 90% for space heating or water heating.
  - Passes air across the system’s aftercooler and lubricant cooler.
  - 100 cfm ⇒ 50,000 Btuh available heat
  - 30°F to 40°F air temperature rise can be obtained.

- **Water-cooled** compressors offer recovery efficiencies of 50% to 60% for space heating only.
  - Limited to 130°F water temperature

Source: Atlas Copco
**Lighting**

<table>
<thead>
<tr>
<th>Implementation</th>
<th>Load (kWh)</th>
<th>Peak (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replace T12 with T8 or T5</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Replace Metal Halide with T8 or T5HO</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
Lighting

- Replace existing T12 fluorescent lamps with T8 fluorescent lamps (up to 30% savings).

<table>
<thead>
<tr>
<th>Four-lamp T12 versus T8 Fixtures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lamp Type</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>F40T12</td>
</tr>
<tr>
<td>F34T12</td>
</tr>
<tr>
<td>F32T8</td>
</tr>
</tbody>
</table>

- No magnetic ballasts manufactured for replacement after June 2010.

- 2009 DOE Energy Regulations
  - Began July 14, 2012.
  - Effectively eliminates most 4-ft and 8-ft (F96) T12 lamps
    - 700 series (1st generation) T8 lamps exempt until 2014
Lighting

- **T5 versus T8**
  - T5s smaller diameter and shorter.
  - Four F54T5HOs equivalent to six F32T8s.
  - Lower mercury content than T8s.
  - T5 lumen maintenance
    - Better at higher ambient temperatures
    - Worse in cold temperatures
  - High-temperature T5HO available
    - Holophane IntelliBay™ & IntelliVue™
    - Lithonia I-BEAM™ System

Source: RPI Lighting Research Center
Metal Halide (MH) versus Fluorescent for Highbay

- **Probe start (PS) MH** with low lumen maintenance (<65%) is best target for replacement.
  - EISA2007 imparts higher performance standards for PS MH.
  - Lumen maintenance of fluorescents (90% to 95%)

- **Comparison**
  - One PS MH with 20,000 EOL lumens at 320 system watts
  - Six F32T8 with 18,000 EOL lumens at 220 system watts

- Lumen output of fluorescents declines with heat/cold.
### HVAC

<table>
<thead>
<tr>
<th>Implementation</th>
<th>Load (kWh)</th>
<th>Peak (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature Setback</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Economizers</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Heat Recovery Ventilators/Wheels</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Chiller Water Temperature</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>New HVAC Equipment</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Geothermal Heat Pump</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Air Doors/Curtains</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>
**Temperature Setback/Setforward**
- Save 3% per °F per 24 hrs
- 72°F → 68°F (Δ4°F) for 12 hrs saves 6%

**Economizers Bring in Cool Outside Air**
- Typical 2 to 5 year payback for economizers.
- Most appropriate for large systems (>4.5 tons per ASHRAE 90.1-2010).
- Not very effective in high humidity climates.
Heat Recovery Ventilators

- Can recover about 60% to 70% of heat in exhaust air.
- A solution to ASHRAE 62 IAQ requirements.

Photo source: George Retseck Illustrations
Narrow Your Chiller Water Temperature Set Points

- Typical conditions are chilled water temperature of 42°F and condensing water temperature of 80-85°F.
  - 2% savings per °F that chilled water temperature is raised
  - 5 to 10°F increase is possible; more may cause damage and reduce cooling capacity (ton rating)
- Efficiency benefits from lowering condensing water temperature are offset.
  - Increased fan and pump operation
  - Reduced cooling capacity.

Source: stock.xchng
Upgrade Older HVAC (10 to 15 years)

- Chillers: 0.8 kW/ton → 0.5 kW/ton (37% less!)
- Unitary rooftop: 1.5 kW/ton → 1.2 kW/ton (20% less!)

Geothermal or Water-Source Heat Pump

- Roughly 30% savings compared to AC/Boiler or AC/Furnace combination.
- **Geothermal** requires higher capital investment and requires significant amounts of real estate.
  - New construction accommodates verticals and pond loop.
High-Volume Low-Speed (HVLS) Fans

- Up to 24’ diameter
- Mixes striated air
  - 15°F heat gradient from floor to ceiling
- Example: 30,000 sqft warehouse
  - (2) 24’ fans operating 9 hrs/day
  - $11,500 purchase and installation cost
  - 1 HP motors (830 watt)
  - 20% ($2,000) savings on $10,000 winter heating bill
  - Fan energy consumption = Power (kW) x Time (Hr)
    = 1.63 kW x 1,000 hrs (winter)
    = 1,630 kWh
    = $140 (@$0.085/kWh)

- Payback = $11,500/($2,000 - $140)
  = 6 years

### HVAC

<table>
<thead>
<tr>
<th>Size</th>
<th>CFM</th>
<th>Watts</th>
<th>CFM/Watt</th>
</tr>
</thead>
<tbody>
<tr>
<td>24’</td>
<td>375,000</td>
<td>830</td>
<td>450</td>
</tr>
<tr>
<td>16’</td>
<td>125,000</td>
<td>370</td>
<td>340</td>
</tr>
<tr>
<td>30”</td>
<td>5,600</td>
<td>415</td>
<td>13</td>
</tr>
</tbody>
</table>

Source: Macroairtech
- **Use Air Doors/Curtains**
  - Open door energy consumption
    - Loses 600,000 Btu/h at a cost of roughly $7 per hour.
      - 14 feet wide and 11 feet high
      - Indoor temperature of 70°F
      - Outdoor temperature of 20°F
      - Zero wind velocity
    - Any wind at all triples the loss!
  - Air door recovers 75% of heat loss.
  - 1 to 2 year payback possible ($3,500 cap. + $100 op.)
  - Exhaust fans (negative pressure) and wind tunnel effect are potential problems.

Source: www.berner.com
Case Study

Food Processing

- Initiated startup and shutdown schedules for equipment (idle equipment shutoff)
- Reduced excessive temperature of hot water
- Made lighting lumens in line with work being performed
  - Overhead plus station lighting
  - Excessive wattage per fixture
  - Number of fixtures
- Compressed air leak repair programs instituted
- Savings of $610,000 the first year ($11 million/year energy bill)
Case Study

Manufacturer of automotive batteries

- Reduced processing temperatures and times that were in excess of SOPs
- Improved utilization of existing equipment enabling fewer machines
- Implemented procedures/auditing for start-up and shut-down of equipment to reduce unnecessary run-time of equipment
- Implemented energy improvement teams to identify and correct problem areas
- Savings of $600,000
Case Study

Powdered metal manufacturer

- Optimized the performance of the dryers
  - Reduced excess oxygen in the stack gas
  - Damper control
  - Reduced burner minimum fire

- Optimized the performance of the annealing furnaces
  - Changed furnace zone temperature set points
  - Switched to modulated zone firing from on/off cycles

- 17% decrease in natural gas use
- Over a 5% decrease in electricity use
Go to the NEEA calendar at http://neea.org/get-involved/calendar for trainings and events scheduled around the Northwest region.

To register for a training, look for it by date and title. Once you find the training you want to register for, click on the title and you will find a description and registration information. Trainings are posted to the calendar as dates are finalized, so please check the calendar regularly or contact the training team at 888-720-6823.

- **Lighting:**

  **Efficient and Effective Industrial Lighting**

  December 12, 2013: Moses Lake, WA
Upcoming In-Class Trainings

- **Pumps:**
  - Pumping System Optimization
  - December 10 15, 2014: Bend, OR

- **Special Event:**
  - NW Energy Efficiency Summit
  - January 15, 2014: Portland, OR

http://neea.org/get-involved/calendar
Upcoming Webinars

To register for a webinar, go to the NEEA calendar http://neea.org/get-involved/calendar and look for it by date and title. Once you find the webinar you want to register for, click on the title and you will find a description and registration information. All webinars are free!

- **Power Factor:**
  
  Improve Power Factor and Your Facility
  
  December 17: 9-10am PST

  [http://neea.org/get-involved/calendar](http://neea.org/get-involved/calendar)
Thank You

- Please take our online survey