Energy Conservation
DOE Best Practices Tools

Beka Kosanovic, PhD.
Director, Industrial Assessment Center
Mechanical & Industrial Engineering Department
University of Massachusetts - Amherst

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Outline

• Advanced Manufacturing Office Programs
  Technology Deployment Activities
  – Industrial Assessment Centers
  – Better Plants Program (ISO 50001) – Superior Energy Performance Program
  – Clean Energy Application Centers

• Overview of BestPractices Tools
Beginning in 1984 with four Schools

Currently 24 Centers at 29 Universities Nationwide

For more information on IAC program and participating schools visit: http://iac.rutgers.edu/database/centers/
Industrial Assessment Center at the University of Massachusetts

- Provides assistance to New England Industry since 1984

- US DOE Funding allows the IAC Program to provide no cost energy conservation, waste prevention and productivity assistance to small and medium sized industrial firms within S.I.C. 20 through 39
IAC Program Goals

- Reduce Industrial Energy Use
- Reduce waste and prevent pollution in manufacturing operations
- Raise productivity
- Lower Operating Costs
- Increase Profitability
- Provide Professional Training for Students
Client Criteria

• Have Annual Energy Costs Less Than $ 2.5 Million
• Have Gross Sales Less Than $100 Million
• Have Less Than 500 Employees
• Have No In-house Energy Staff
• Be Within 150 Miles of Amherst, MA
UMASS Clients 1984-2012

- Over 700 plants visited since 1984
- Over $12 billion in gross annual sales
- $310 million in annual energy costs
- Over 82,000 employees
- Over 4,300 recommendations with $62,000 average annual cost savings per assessment
- 51% Implementation Rate; 1.04 years payback period
- $125,000 average savings per assessment in 2010-2011
IDENTIFYING EFFECTIVE ENERGY SAVING OPTIONS

- Major energy users
- Major pieces of equipment
- Motors
- Boilers and Furnaces
- Compressors/Chillers
- Hot exhausts
- Compressed air leaks
- Cooling Towers

- Variable Frequency Drives
- Energy-efficient Motors
- Consider CHP
- Energy Management Systems
- Steam Trap Replacement
- High-efficiency Boiler
- Chiller Water Plant Operation
- Process Heat Recovery

www.ceere.org
TOP $$ SAVERS

- Convert To VSD For Pumps & Blowers
- Process Heat Recovery
- Use High Efficiency Lamps & Ballasts
- Reduce Fluid Flows
- Change Electrical Rates
- Use Energy Efficient Equipment
- Consider Cogeneration
- Preheat Fluids With Waste Heat
- Insulate Equipment
- Switch From Electrical To Fossil Fuels
Superior Energy Performance

• The SEP certification program provides facilities with a pathway for continual energy efficiency improvements

• To earn SEP Certification facilities must:
  – Conform to the ISO 50001 energy management system standard
Clean Energy Application Centers

DOE Clean Energy Application Centers: Locations, Contacts, and Web Sites

NORTHWEST
www.northwestcleanenergy.org
Dave Spindig
Washington State University
Tel: 360-956-2004
spindigd@email.ewu.edu

MIDWEST
www.midwestcleanenergy.org
John Cuttica
University of Illinois at Chicago
Tel: 312-996-4382
cuttica@uic.edu
Cliff Haefke
University of Illinois at Chicago
Tel: 312-355-3476
cptank1@uic.edu

PACIFIC
www.pacificcleanenergy.org
Tim Lipman
University of California, Berkeley
Tel: 510-642-4501
tellman@berkeley.edu
Vince McDonell
University of California, Irvine
Tel: 949-824-7302 x121
mcdonell@apep.uci.edu

INTERMOUNTAIN
www.intermountaincleanenergy.org
Patti Case
enr Group
Tel: 801-278-1927 x 3
pcase@enrgrp.com
Thomas Broderick
Southwest Energy Efficiency Project
Tel: 928-527-8036
thbroderick@swenergy.org

GULF COAST
www.gulfcoastcleanenergy.org
Dan Bullock
Houston Advanced Research Center
Tel: 281-364-6087
dbullock@harc.org

INTERNATIONAL DISTRICT ENERGY ASSOCIATION
www.districtenergy.org
Rob Thornton
President
Tel: 508-364-9339
rob.idas@districtenergy.org

NORTHEAST
www.northeastcleanenergy.org
Tom Bourgeois
Pace University
Tel: 914-674-4013
tbourgeois@faw.pace.edu
Beka Kosarovic
University of Massachusetts Amherst
Tel: 413-545-0684
kosarovic@ecs.umass.edu

MID- ATLANTIC
www.mmacce.psu.edu
Jim Freihaute
Pennsylvania State University
Tel: 814-863-0083
jfreihaute@engr.psu.edu

SOUTHEAST
www.southeastcleanenergy.org
Isaac Panarella
North Carolina State University
Tel: 919-515-6354
ipanarella@ncsu.edu
Pedro Magno
Missippi State University
Tel: 662-325-6402
magno@me.msstate.edu

DOE Clean Energy Application Centers: Program Contacts

Katrina Pielli
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy
Phone: 202-287-5850
E-mail: katrina.pielli@ee.doe.gov

Joe Renk
National Energy Technology Laboratory (NETL)
U.S. Department of Energy
Phone: 412-386-6406
E-mail: joseph.renk@netl.doe.gov

Patti Garland
Oak Ridge National Laboratory (ORNL)
U.S. Department of Energy
Phone: 202-586-3753
E-mail: patricia.garland@ee.doe.gov

Ted Bronson
DOE Clean Energy RAC Coordinator
Power Equipment Associates
Phone: 630-248-8778
E-mail: tbronson@pea@aol.com
AMO BestPractices Tools

- Motor Driven Systems
  - CWSAT (Chilled Water System Assessment Tool)
  - AirMaster + (Compressed air system assessment tool)
  - FSAT (Fan System Assessment Tool)
  - MotorMaster + (Motor management tool)
  - PSAT (Pumping System Assessment Tool)
  - ChemPEP (Plant Energy Profiler for the Chemical Industry)
AMO Best Practices Tools (Continued)

• Process Heating
  – PHAST (Process Heating Assessment and Survey Tool)
  – NxEAT (NOx and Energy Assessment Tool)
  – Combined Heat and Power Application Tool

• Steam Systems
  – SSST (Steam System Scoping Tool)
  – SSAT (Steam System Assessment Tool)
  – 3E Plus – Insulation Assessment Tool
CWSAT Program

Purpose: Reduce the energy consumption of installed chilled water systems

Goal: Create a simple but useful software tool for analyzing potential energy savings in chilled water systems
CWSAT INTRODUCTION

• A central chilled water system may account for a quarter to a third of facility energy consumption.

• ULTIMATE GOAL
  – Provide adequate cooling to process or comfort load.
  – Reduce energy consumption of chilled water SYSTEMS (important to look at it as a SYSTEM and not as a collection of components).

• The Program IS NOT intended to determine system energy use down to the kWh or MMBtu
• Program IS intended to direct analysis effort toward the most promising cost reduction opportunities
CWSAT ECM Capabilities

• New Equipment Specification
  – Chillers, Towers, Pumps
• Variable Speed Drive Installation
  – Centrifugal Chillers, Tower Fans, & Pumps
• Various Chilled and Condenser Water Strategies
• Air-Cooled to Water-Cooled System Conversion
• Use Free Cooling When Possible
• Sequence Chillers
Annual Cooling System Operations

- Chiller
  - 375,100 kWh
  - $23,000

- Tower
  - 105,700 kWh
  - $6,500

- Pumps
  - 653,500 kWh
  - $40,000

- ~1,134,300 kWh
  - $69,500
Install VFD on Tower Pumps

- Potential Annual Savings:
  - 131,216 kWh
  - $8,036
Install VFD on Tower Fan

- Potential Annual Savings:
  - 29,283 kWh
  - $1,794
Vary Tower Water Temperature with Outside Temperature

- Potential Annual Savings:
  - 12,100 kWh
  - $740
Implementation of All Cooling System Improvements

Potential Annual Savings:
- 147,927 kWh
- $9,060
“Free Cooling”

Operation at 75% Load
(temperatures typical)

Cooling Tower

57 °F

Chiller

54 °F

Condenser

Evaporator

Plate/Frame Heat Exchanger

Cooling Coil

Load

62 °F

Tower Pump
(2,100 gpm)

Chilled Water Pump
(800 - 1,600 gpm)

58 °F
Free Cooling: Case Study

Without Using Free Cooling
• 3,478,900 kWh actual ($296,000 annually)
• 3,436,900 kWh predicted
• Difference: 41,974 kWh (-1.2%)

With Free Cooling
• 489,100 kWh and $41,570 actual savings
• 513,500 kWh and $43,644 predicted savings (+4.9%)
Process Heating Assessment and Survey Tool (PHAST)

What is PHAST?

A tool that can be used to:

- Estimate annual energy use and energy cost for furnaces and boilers in a plant
- Perform detail heat balance and energy use analysis that identifies areas of energy use and energy losses for a furnace or a boiler
- Perform “what-if” analysis for possible energy reduction and efficiency improvements through changes in operation, maintenance and retrofits of components/systems
- Obtain information on energy saving methods and identify additional resources
Areas of Energy Saving Opportunities

1. Heat Generation
2. Heat Transfer
3. Heat Containment
4. Waste Heat Recovery
5. Furnace scheduling, loading, operation
# Heating Systems - Heat Generation

## Energy Saving Opportunities

<table>
<thead>
<tr>
<th>Energy Saving Techniques</th>
<th>Energy Savings (% Range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Air-fuel ratio control</td>
<td>5 to 25</td>
</tr>
<tr>
<td>2 High turndown combustion system</td>
<td>5 to 10</td>
</tr>
<tr>
<td>3 Air Infiltration (Furnace sealing)</td>
<td>5 to 10</td>
</tr>
<tr>
<td>4 Use of Preheated Air</td>
<td>15 to 30</td>
</tr>
<tr>
<td>5 Use of oxygen enrichment or oxy fuel burners</td>
<td>5 to 25</td>
</tr>
</tbody>
</table>
Preheat Furnaces #1

Combustion Air

- Currently Using Room Air for Combustion @ 80-100 °F
- Furnace Exhaust Gas @ 1400 °F
- Preheat air to ~700 °F
- Annual Energy Savings: 4,812 MMBtu/yr
- Potential Cost Savings: $48,120
- Potential Savings for Three Furnaces: ~$145,000
Improve Furnace #2 Combustion Efficiency

- O₂ measured @ 12%
- Should be reduced to 7%
- Annual Energy Savings: 3,996 MMBtu/yr per furnace
- Potential Cost Savings: $39,960
- Potential Savings for Three Furnaces: ~$119,900
## Improve Furnace Insulation

- **Annual Energy Savings:** 1,510 MMBtu/yr
- **Potential Cost Savings:** $15,100
- **Potential Savings for Three Furnaces:** ~$45,300

### Furnace Data

<table>
<thead>
<tr>
<th>Plant Name</th>
<th>Furnace Name</th>
<th>Current</th>
<th>Modified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load/Charge Material</td>
<td>3002</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixtures, Traps, Baskets etc. Losses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Losses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flue Gas Losses/Heating System Efficiency</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atmosphere Losses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heat Storage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wall Losses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water - Cooling Losses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opeing Losses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface Area (ft^2)</td>
<td>620</td>
<td>620</td>
<td></td>
</tr>
<tr>
<td>Average Surface Temp. (Degree F)</td>
<td>250</td>
<td>130</td>
<td></td>
</tr>
<tr>
<td>Ambient Temp. (Degree F)</td>
<td>85</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>Correction Factor</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Heat Required (Btu/hr)</td>
<td>246,063</td>
<td>66,402</td>
<td></td>
</tr>
</tbody>
</table>

- Current Net Heat Required (Btu/hr): **423,753**
- Modified Net Heat Required (Btu/hr): **244,092**
Pumping System Assessment Tool (PSAT)

- An opportunity quantification tool
- Relies on field measured (or estimated) fluid and electrical performance data
- Uses achievable pump efficiency algorithms from the Hydraulic Institute
- Motor performance (efficiency, current, power factor) curves developed from average motor data available in MotorMaster+ (supplemented by manufacturer data for larger size, slower speed motors)
Some symptoms of interest

- Throttle valve-controlled systems
- Bypass (recirculation) line normally open
- Multiple parallel pump system with same number of pumps always operating
- Constant pump operation in a batch environment or frequent cycle batch operation in a continuous process
- Cavitation noise (at pump or elsewhere in the system)
- High system maintenance
- Systems that have undergone change in function
Head calculation

PSAT includes a pump head calculator to support user-measured pressure, flow data.

Type of measurement configuration
Suction tank elevation, gas space pressure, and discharge

\[ K_s \text{ represents all suction losses from the tank to the pump} \]
\[ K_d \text{ represents all discharge losses from the pump to gauge } P_d \]

<table>
<thead>
<tr>
<th>Suction pipe diameter (ID), inches</th>
<th>19.500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suction tank gas overpressure ( P_g ), psig</td>
<td>0.00</td>
</tr>
<tr>
<td>Suction tank fluid surface elevation ( Z_s ), feet</td>
<td>12.00</td>
</tr>
<tr>
<td>Suction line loss coefficients, ( K_s )</td>
<td>0.50</td>
</tr>
<tr>
<td>Discharge pipe diameter (ID), inches</td>
<td>15.500</td>
</tr>
<tr>
<td>Discharge gauge pressure ( P_d ), psig</td>
<td>75.50</td>
</tr>
<tr>
<td>Discharge gauge elevation ( Z_d ), feet</td>
<td>5.00</td>
</tr>
<tr>
<td>Discharge line loss coefficients, ( K_d )</td>
<td>2.50</td>
</tr>
<tr>
<td>Fluid specific gravity</td>
<td>0.990</td>
</tr>
<tr>
<td>Flow rate, gpm</td>
<td>6050</td>
</tr>
<tr>
<td>Differential elevation head, ft</td>
<td>-7.00</td>
</tr>
<tr>
<td>Differential pressure head, ft</td>
<td>176.17</td>
</tr>
<tr>
<td>Differential velocity head, ft</td>
<td>1.64</td>
</tr>
<tr>
<td>Estimated suction friction head, ft</td>
<td>0.33</td>
</tr>
<tr>
<td>Estimated discharge friction head, ft</td>
<td>4.11</td>
</tr>
<tr>
<td>Pump head, ft</td>
<td>175.25</td>
</tr>
</tbody>
</table>

Tank to pipe entrance loss

Check valve, SR elbow
Raw Crude

- Head loss: 358 ft
- Friction loss: 78.7 hp
  83.2 kW
- Annual Cost: $28,000

Optimization Rating: 197.6
\[
\text{Optimization Rating} = \frac{197.6}{242.0} = 0.816 (81.65\%)
\]
Raw Crude

Type of measurement configuration: Suction and discharge line pressures

- $K_s$ represents all suction losses from gauge $P_s$ to the pump.
- $K_d$ represents all discharge losses from the pump to gauge $P_d$.

| Suction pipe diameter (ID), inches | 8.000 | Discharge pipe diameter (ID), inches | 8.000 |
| Suction gauge pressure ($P_s$), psig | 82.00 | Discharge gauge pressure ($P_d$), psig | 422.00 |
| Suction gauge elevation ($Z_s$), feet | 2.50 | Discharge gauge elevation ($Z_d$), feet | 5.50 |
| Suction line loss coefficients, $K_s$ | 0.50 | Discharge line loss coefficients, $K_d$ | 1.00 |

Fluid specific gravity: 0.624
Flow rate, gpm: 913

- Don't update
- Accept and update

- Click to leave the main panel head unchanged
- Click to Accept and return the calculated head

- Differential elevation head, ft | 3.00 |
- Differential pressure head, ft | 950.00 |
- Differential velocity head, ft/s | 0.0 |
Estimated suction friction head, ft | 0.28 |
Estimated discharge friction head, ft | 0.56 |
Pump head, ft | 863.84 |
Raw Crude
Hood and Saturation Spray Pumps

- Use VSD to control the flow – reduce flow 50% during off periods

- Potential Savings: 321,000 kWh $19,000
Compressed Air - Air Master

![Diagram of Energy Efficiency Measures]

### Data Entry

<table>
<thead>
<tr>
<th>Description</th>
<th>Energy Savings, kWh</th>
<th>Energy Savings, $</th>
<th>Energy Savings, %</th>
<th>Demand Savings, kW</th>
<th>Demand Savings, $</th>
<th>Installed Cost, $</th>
<th>Total Savings, $</th>
<th>Simple Payback, years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce Air Leaks</td>
<td>77,632</td>
<td>2,948</td>
<td>9.6</td>
<td>14.9</td>
<td>603</td>
<td>1,000</td>
<td>3,551</td>
<td>0.3</td>
</tr>
<tr>
<td>Use Efficient Nozzles for Blow</td>
<td>29,866</td>
<td>1,135</td>
<td>3.7</td>
<td>19.9</td>
<td>806</td>
<td>800</td>
<td>1,941</td>
<td>0.4</td>
</tr>
<tr>
<td>Reduce System Air Pressure</td>
<td>49,055</td>
<td>1,862</td>
<td>6.0</td>
<td>12.9</td>
<td>521</td>
<td>100</td>
<td>2,384</td>
<td>0.0</td>
</tr>
<tr>
<td>Use Unloading Controls</td>
<td>36,463</td>
<td>1,386</td>
<td>4.5</td>
<td>0.0</td>
<td>0</td>
<td>1,200</td>
<td>1,386</td>
<td>0.9</td>
</tr>
<tr>
<td>Adjust Cascading Set Points</td>
<td>14,226</td>
<td>540</td>
<td>1.8</td>
<td>1.5</td>
<td>59</td>
<td>200</td>
<td>600</td>
<td>0.3</td>
</tr>
<tr>
<td>Use Automatic Sequencer</td>
<td>126,020</td>
<td>4,788</td>
<td>15.5</td>
<td>28.3</td>
<td>1,144</td>
<td>8,000</td>
<td>5,932</td>
<td>1.3</td>
</tr>
<tr>
<td>Reduce Run Time</td>
<td>73,168</td>
<td>2,780</td>
<td>9.0</td>
<td>0.0</td>
<td>0</td>
<td>200</td>
<td>2,780</td>
<td>0.1</td>
</tr>
<tr>
<td>Add Primary Receiver Volume</td>
<td>18,709</td>
<td>711</td>
<td>2.3</td>
<td>0.0</td>
<td>0</td>
<td>3,500</td>
<td>711</td>
<td>4.9</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td>425,139</td>
<td>16,150</td>
<td>52.4</td>
<td>77.4</td>
<td>3,134</td>
<td>15,000</td>
<td>19,285</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Double-click row to view corresponding measure input data

Copy To Clipboard
AC – Reduce Air Leaks

- Annual Energy Savings: 77,632 kWh
- Potential Cost Savings: $3,551
- Measure Cost: $1,000
AC – Add Receiver Tank

- **Annual Energy Savings:** 18,709 kWh
- **Potential Cost Savings:** $711
- **Measure Cost:** $3,500
Information, Tools and Training

- Tip sheets, case studies, brochures, technical briefs etc.
- *Energy Matters* newsletter
- Industrial Technologies Monthly e-bulletin
- Software tools
- Training workshops and webcasts
- Web sites
- New:
  - Packets of Information for Plants
Questions?

Contact Information:
Beka Kosanovic
kosanovic@ecs.umass.edu
Ph.: 413-545-0684
Fax: 413-545-1027