Tools and Training for Industrial Energy Efficiency

Office of Industrial Technologies
Energy Efficiency and Renewable Energy
U.S. Department of Energy

Texas Technology Showcase
March 2003
Tools Available on Our Web Site

- **Motor Master** + – Assists in energy-efficient motor selection and management.

- **Pumping System Assessment Tool** – Helps industrial users assess the efficiency of pumping system operations.

- **Steam System Scoping Tool** – Profiles and grades steam system operations and management.

- **Steam System Assessment Tool** – Assists users in assessing potential benefits of specific steam-system improvements.

- **Air Master** + – Provides comprehensive information on assessing compressed air systems.

- **3EPlus Insulation Assessment Tool** – Helps to evaluate the thickness of insulation on steam lines.

- **ASDMaster** – Helps users determine the economic feasibility of an ASD application.

- **PHAST** – Helps users assess how much energy is used and model ways to improve performance.

*Coming Soon!*
# Tools and Training Impacts

## Average Annual Savings Identified
*(in Thousands of Dollars)*

<table>
<thead>
<tr>
<th></th>
<th>Forest Products</th>
<th>Refining</th>
<th>Mining</th>
<th>Steel</th>
<th>Aluminum</th>
<th>Chemicals</th>
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<tbody>
<tr>
<td>Pumps</td>
<td>186.5</td>
<td>46.0</td>
<td>410.7</td>
<td>231.5</td>
<td>74.4</td>
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<tr>
<td>Compressed Air</td>
<td>128.9</td>
<td>118.6</td>
<td>235.6</td>
<td></td>
<td>107.0</td>
<td>127.0</td>
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<td>Process Heating</td>
<td>1,112.5</td>
<td>1,231.9</td>
<td>1,500.0</td>
<td></td>
<td></td>
<td>945.0</td>
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<tr>
<td>Steam</td>
<td>365.9</td>
<td>365.9</td>
<td>102.5</td>
<td>1,010.0</td>
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<td>1,565.0</td>
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Systems Management: MotorMaster+ Main Menu
MotorMaster+ Purpose and Scope

- Supports improved management and efficient operation of motor systems
  - Productivity gains
  - Reduced downtime
- Evaluates cost of purchasing and operating new motors
  - Dollar and utility savings
- Provides ability to evaluate conservation opportunities and log maintenance actions
  - System reliability improvements
MotorMaster+ Features

- Motor price and performance database
- Motor selection tool
- Inventory management
- Maintenance logs
- Utility module, including motor rebate program support
- Life cycle cost analysis
- Tracks energy, cost savings, and other benefits
MotorMaster+ Motor Comparisons

- New, energy-efficient motor vs. new standard motor
- Repair vs. new energy-efficient motor
- Replacement with new, energy-efficient motor vs. continued operation of standard motor
Systems Management:

Pumping System Assessment Tool (PSAT)
PSAT: Purpose and Scope

• Help end users identify systems worthy of further consideration (extension of prescreening process)

• Generate “what if” assessments, following the system head-capacity curve

• System loss shedding opportunity assessment

• Limitations:
  – Only 2 through 8 pole motors included in database
  – Several common pump styles are not included, for example:
    • "Plain" vertical turbine
    • Submersible
  – No explicit provision for adjustable speed drives
PSAT: General Methodology

- Uses measured fluid, electrical data.
- Extracts average motor performance characteristics from the MotorMaster+ database.
- Employs Hydraulic Institute algorithms for achievable pump efficiency.
- Estimates existing, "optimal" pump and motor efficiencies and associated operating costs.
PSAT Results: Alcoa NA Extrusions

**Pumping System Assessment**

*Cressona Extrusion Plant*

- Estimated annual savings range from $26,000 to $55,000
- Assessment cost: $10,000

**Opportunities Identified**

- Trimming of pump impellers
- Installation of adjustable speed drives
- Checking lift settings
- Determining if a single pump will suffice where two are currently used

- Oak Ridge National Laboratory
- ALCOA North American Extrusions
Systems Management:

Steam System Scoping Tool
Steam System Scoping Tool: Purpose and Scope

The Steam System Scoping Tool was developed to help industrial users do the following:

- Evaluate their steam operations against identified best practices
- Develop greater awareness of energy efficiency, productivity improvements
- Compare tool results with those obtained by other users
Steam systems have four basic components.

Generation, Distribution, End Use, Recovery
Boiler Plant Operating Practices

Boiler Efficiency

**What To Do:**
Measure, trend, and look for opportunities to improve the efficiency of your boilers.

**Why Important:**
One of the key boiler plant functions is to generate steam at the highest possible efficiency. Major sources of boiler efficiency losses include: a) combustion and flue gas energy losses (typically the largest), b) blowdown losses, and c) refractory insulation losses. It is important to measure and trend boiler efficiency, flue gas temperature, flue gas oxygen content, and flue gas carbon monoxide content on a regular basis. Measurement and control of excess oxygen is critical to minimizing boiler combustion energy losses. Trending flue gas temperature can provide indications of other potential boiler problems, such as waterside or fireside fouling problems.

**BE1**
How often do you measure your overall Boiler Efficiency \( \text{[(heat absorbed to create steam) / (energy input from fuel)]} \)?

<table>
<thead>
<tr>
<th>Actions</th>
<th>Points</th>
<th>Your Score</th>
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<tr>
<td>at least quarterly</td>
<td>10</td>
<td>0</td>
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<tr>
<td>at least yearly</td>
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<tr>
<td>less than yearly</td>
<td>0</td>
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**BE2**
Which of the following parameters do you measure as a function of boiler load and ambient temperature?

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<tr>
<th>Actions</th>
<th>Points</th>
<th>Your Score</th>
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</thead>
<tbody>
<tr>
<td>Flue gas temperature</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Flue gas oxygen content</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Flue gas CO content</td>
<td>5</td>
<td>0</td>
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</table>

**BE3**
How do you control Excess Air in your Boiler to maximize Boiler Efficiency?

<table>
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<tr>
<th>Actions</th>
<th>Points</th>
<th>Your Score</th>
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<tr>
<td>automatically</td>
<td>10</td>
<td>0</td>
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<tr>
<td>manually</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>not at all</td>
<td>0</td>
<td>0</td>
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### Summary Results

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<tr>
<th>Scoping Tool Questions</th>
<th>Possible Score</th>
<th>Your Score</th>
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<tr>
<td>Steam System Profiling</td>
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<tr>
<td>Steam Costs</td>
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<tr>
<td>SC1: Measure Fuel Cost to Generate Steam</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>SC2: Trend Fuel Cost to Generate Steam</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Steam/Product Benchmarks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BM1: Measure Steam/Product Benchmarks</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>BM2: Trend Steam/Product Benchmarks</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Steam System Measurements</td>
<td></td>
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<tr>
<td>MS1: Measure/Record Steam System Critical Energy Parameters</td>
<td>30</td>
<td>0</td>
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<tr>
<td>MS2: Intensity of Measuring Steam Flows</td>
<td>20</td>
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**Steam System Profiling Score:** 90
Summary of Results

<table>
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<tr>
<th>Summary of Steam System Scoping Tool Results</th>
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<td>Steam System Profiling</td>
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<td>Steam System Operating Practices</td>
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<td>Boiler Plant Operating Practices</td>
<td>80</td>
<td>0</td>
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<tr>
<td>Distribution, End Use, Recovery Operating Practices</td>
<td>30</td>
<td>0</td>
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<tr>
<td>Total Scoping Tool Questionnaire Score</td>
<td>340</td>
<td>0</td>
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<tr>
<td>Total Scoping Tool Questionnaire Score (%)</td>
<td>0.0%</td>
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<tr>
<td>Date That You Completed This Questionnaire</td>
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Steam System Scoping Tool: Results/Trends

<table>
<thead>
<tr>
<th>Category</th>
<th>Possible Score</th>
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<th>Stand. Dev.</th>
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<tr>
<td>Profiling</td>
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<tr>
<td>System OP</td>
<td>140</td>
<td>112</td>
<td>14</td>
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<tr>
<td>Boiler OP</td>
<td>80</td>
<td>50</td>
<td>17</td>
</tr>
<tr>
<td>D/EU/R OP</td>
<td>30</td>
<td>16</td>
<td>5</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td><strong>100%</strong></td>
<td><strong>65%</strong></td>
<td><strong>16%</strong></td>
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</table>
Steam System Assessment Tool (SSAT)

• PURPOSE:
  – Demonstrate magnitude – energy, cost, emission savings – of key steam system improvement opportunities
You Can Use SSAT To Evaluate These Key Steam Improvement Initiatives

- Real Cost Of Steam
- Steam Quality
- Boiler Efficiency
- Alternative Fuels
- Cogeneration Opportunities
- Steam Turbines vs PRVs
- Boiler Blowdown

- Condensate Recovery
- Steam Trap Operating Efficiency
- Heat Recovery
- Vent Steam
- Steam Leaks
- Insulation Efficiency
- Emissions Calculations
Key SSAT Features

- Choice of 1, 2, or 3 Header Pressure Models
- Schematics of Model Steam systems
- Estimates of Site Environmental Emissions

- Major Equipment Simulated:
  - Boiler
  - Back pressure turbines
  - Condensing turbine
  - Deaerator
  - Steam traps, leaks, insulation losses
  - Letdowns
  - Flash vessels
  - Feedwater preheat exchangers
SSAT

Example Screen

Steam System Assessment Tool
Model of Current Operation

Economic Summary based on 7834 hr, $0.90/lb

Power Balance

Generator: 0.0 MW
Export: 1034 MW
Unit Cost: $3.00/MBtu

Fuel Balance

Boiler: 10311 MBtu/h
Unit Cost: $1.20

Make-Up Water

Flow: 384 gpm
Unit Cost: 0.0050/ft

Total Operating Cost: 6.018
Systems Management:

AIRMaster+

Compressed Air Systems
AIRMaster+: Compressed Air System

A. Control Panel
B. Motors
C. Compressor Air End
D. Lubricant / Air Separator
E. Aftercooler and Lubricant Cooler
F. Air Inlet Filter
G. Compressor Package Enclosure
H. Filter, Regulator, and Lubricator
I. Pneumatic Tool
J. Air Filter
K. Distribution System
L. Air Receiver
M. Dryer
N. Supplemental Aftercooler
O. Leaks
AIRMaster+: Purpose and Scope

- Supports short-term, compressed air system assessments based on simple instrumentation
- Identifies low-risk and quick-payback operation and maintenance improvements
- Enables an efficient and systematic approach for objective and repeatable assessments
- Models supply-side airflow and electrical demands, but not dynamic effects of distribution and end use
Compressed Air System: Augusta Newsprint

Compressed Air System Assessment
Augusta, GA

- Estimated annual savings of $59,000 and over 1 million kWh
- Assessment cost: $5,000

Opportunities Identified

- Link the two compressed air systems and add a 10,000-gallon air storage tank to improve system efficiency.
- Identify and repair system leaks.
- Eliminate seldom-used equipment.
- Total cost of $75,000 with simple payback in 1.3 years

Augusta Newsprint Company is part of a joint partnership between Abitibi Consolidated and the Woodbridge Company, Ltd.
Systems Management:

3E-Plus

Insulation Appraisal Software
3E-Plus: Purpose and Scope

Used for performing insulation appraisal calculations:

- Energy
- Environmental
- Economic
3E-Plus: Main Menu

Energy
- Insulation Thickness
  - Surface Temperatures
  - Personnel Protection
  - Condensation Control
- Energy Loss/Gain
  - Bare & Insulated Surfaces
- Cost of Energy
  - Bare & Insulated Surfaces

Environment
- CO2, NOx, CE Reduction w/ Insulation Thickness

Economics
- Economic Thickness Calculations for a New Insulation Project
- Economic Thickness Calculations from a Previous Project

Options
- Thermal Conductivity ("k-Factor")
- External Covering (Jacket)
- Quit Program

Click any button to proceed

Use the F1 key on your keyboard for help on any form
3E-Plus: Energy Loss/Gain

• Inputs
  – Pipe size, material
  – Insulation material
  – Jacket material
  – Surface geometry
  – Operating hours
  – Process, ambient temperatures
  – Max. surface temp.
  – Wind speed

• Outputs (vs. insulation thickness):
  – Surface temp. (F)
  – Heat loss (Btu/ft-yr)
  – Efficiency (%)
3E-Plus Results: Georgia-Pacific

3E+ Insulation Evaluation

Georgia-Pacific plywood mill in Madison, GA

Saves $138,560 in annual energy costs and reduces CO₂ emissions

Opportunity Identified

Install 2-inch mineral pipe insulation on 970 feet of steam lines.

The insulation increased dryer temperatures, reduced processing time, and cut a boiler energy consumption by 63 billion Btu annually.

- Georgia-Pacific Corp.
- NAIMA
- Rock Wool Mfg., Inc.
Systems Management:

Adjustable Speed Drive

(ASDMaster)
Adjustable Speed Drives

The adjustable speed drive, when present, can have an impact on the nature of several elements.
ASDMaster

Provides the end-user with a tool to help with the application of ASDs to control process systems
ASDMaster: Program Goals

• Educate users on ASD technology
• Educate users on analyzing ASDs as part of an overall system.
• Assist users in properly analyzing the energy use of ASDs.
• Assist users in properly specifying and implementing ASDs.
ASD Master can help you to...

- Perform energy analysis of potential ASD applications.
- Compile an ASD specification and bid list.
- Determine the economic value of an ASD’s non-energy benefits.
- Analyze the economics of an ASD application.
Systems Management:

Process Heating Assessment and Survey Tool (PHAST)
PHAST: Plant Survey

**Step 1**
Survey of plant process heating equipment
Collect energy use data for equipment or estimate of energy consumption and cost using equipment specifications and operating data/experience

**Step 2**
Summary of energy used by the plant process heating equipment using data collected in Step 1 and graphical illustration of energy usage distribution within the plant

(cont’d)
PHAST: Analysis & Assessment

Analysis & Assessment

Step 3
Analysis of energy use pattern and selection of equipment that use top 75% to 80% of the energy used for process heating within the plant

Step 4
For the selected equipment, estimation of current energy distribution and heat balance for the process heating equipment

Step 5
Analysis of effects of possible modifications in the process, operations, and equipment design
PHAST: End Result

Supporting Tools / Guide
End Result

Support
Guidance on method of data collection and instrumentation requirements
Check list for energy saving methods for process heating equipment
A tool to analyze effect of combustion variables on the “available heat” for the process

End result
List of possible activities and Resource Guide for further actions
PHAST Results: Alcoa NA Extrusions

Process Heating Assessment
Plant City Extrusion Plant

- Estimated annual saving of $450,000

Opportunities Identified

- Maintain minimum required free oxygen in combustion
- Eliminate formation of excess carbon monoxide
- Preheat combustion air
- Use of water/air nozzles for accelerated cooling
- Optimize insulation
- Use of high convection or radiation burners
- Operate with full load minimum idle time

- CSGI, Inc.
- ALCOA North American Extrusions
OBJECTIVE

Design a Tool that assists the development of a cost-effective, plant-wide strategy and plan for NOX reduction and energy efficiency improvements.

The scoping tool is meant to be a general guide to assess available options for energy efficiency improvement and NOx reduction.
It will include:

- Information on commonly used methods of energy efficiency improvement and NOx reduction using the available technologies, hardware or systems.
- Information on resources that will enable user to estimate energy reduction for equipment and processes used in chemical – petroleum refining plants.
- Information on NOx reduction through use of currently available combustion systems and other NOx reduction technologies.
- Data on cost of NOx reduction technologies/equipment and “rule-of-thumbs” for implementation cost obtained from the vendors and E&C firms.
- A model for consolidating and summarizing result and summary of the end-effects.
• All data will be presented as “default” data that can be changed by the user to allow for specific situations.

• This is only a scoping tool and not a substitute for detail engineering study that may be required to meet regulatory requirements.
Tool Approach

Step 1 - Divide plant into three major sections
Step 2 – Define plant supply side
Step 3 – Define plant demand side
Step 4 – Define plant distribution network
Step 5 – Define conceptual cost-effective combustion system improvement opportunities in Section 1
Step 6 – Define conceptual cost-effective energy efficiency improvement opportunities in Section 2
Step 7 – Summarize NOx reduction, energy savings and cost resulting from steps 5 and 6 & Identify the “gaps” between what can be achieved vs. the regulatory requirements
Step 8 – Define conceptual cost-effective “tail-pipe” NOx reduction opportunities for selected Sources
Step 9 – Summarize and save the results steps 6, 7, and 8
Step 10 – Review and select select the most cost effective or applicable option for further considerations
Summary Report

Example of the Reported Items for Each Option Considered
(to be revised based on recommendations from the industry advisory committee)

- Total NOx reduction: ** Tons/year
- Total Energy Savings *** MM Btu/year
- Capital Cost : **** $ per annual ton of NOx reduction
- Payback periods (NPV or IRR)
- Risk factor
Report Links

- Links to DOE-OIT Best Practices Tools (Process Heating, Pump System, Compressed Air, Steam System)
- Information and guide to Low NOx burner performance and cost data collected from the vendors and engineering companies
- Information on typical cost-performance data for “tail-pipe” NOx reduction systems
Report References

- List of suppliers and consultants
- Case studies supplied by the industry advisors
- Reference to articles and literature sources related to NOx reduction and energy efficiency improvements
EERE Industrial Energy Efficiency Training Opportunities

- Motor Systems Management
- Steam Systems Improvement
- Pump System Assessment
- Pump System Assessment Tool (PSAT) Specialist Training
- Fundamentals of Compressed Air Systems
- Advanced Management of Compressed Air Systems
- AirMaster+ Specialist Training
- Insulation Assessment
- Optimization of Process Heating Systems
- Process Heating Assessment Tool (PHAST) Specialist Training
Schedule Training

*Contact your state energy office or Regional DOE Office:*

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<tr>
<th>Location</th>
<th>Name</th>
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<tr>
<td>Atlanta</td>
<td>David Godfrey</td>
<td>404-562-0568</td>
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<tr>
<td>Chicago</td>
<td>Brian Olsen</td>
<td>312-886-8579</td>
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<tr>
<td>Seattle</td>
<td>Chris Cockrill</td>
<td>816-873-3299</td>
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<tr>
<td>Boston</td>
<td>Scott Hutchins</td>
<td>617-565-9765</td>
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<tr>
<td>Denver</td>
<td>Jack Jenkins</td>
<td>303-275-4824</td>
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<tr>
<td>Philadelphia</td>
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