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A River of Energy Solutions

Steam, Water, and Wastewater Savings Opportunities and Tools

Thomas Wenning – Oak Ridge National Laboratory

Overview

1. Background
2. Energy Saving Opportunities
3. Other Opportunities
4. Useful Tools

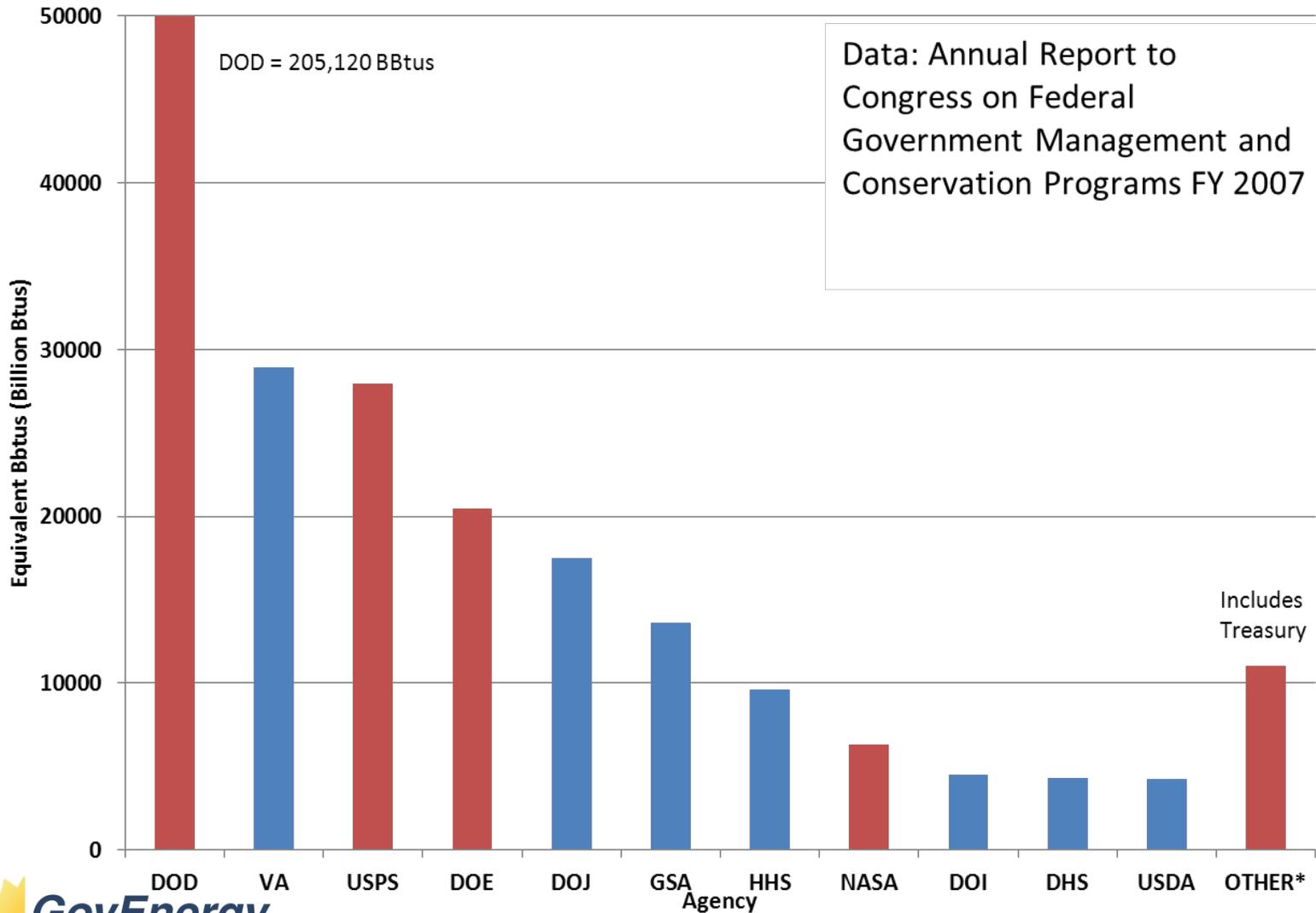


Federal Energy Management Program (FEMP)

“facilitates the Federal Government’s implementation of sound, cost-effective energy management and investment practices to enhance the nation’s energy security and environmental stewardship.”

<http://www1.eere.energy.gov/femp/>

Federal Energy Use by Agency



Industrial Facilities Initiative (IFI)

- Partnership between DOE's FEMP and Industrial Technologies Program (ITP) began in 2000
- Federal facilities received assessments using the same methodology developed under the Save Energy Now program
- Provided technical expertise from:
 - Oak Ridge National Laboratory
 - Industrial Assessment Centers
 - ITP BestPractices Qualified Specialists



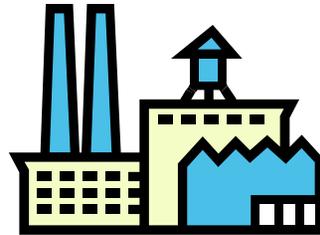
Industrial Energy Assessments

- Provided entire industrial process assessments
- Targeted system assessments
 - Steam
 - Process Heating
 - Compressed Air
 - Pumps/Fans/Motors
(direct drive equipment)
 - Chilled Water
 - Service Water



Common System Opportunities...

What are the typical Energy and Cost Saving Opportunities?



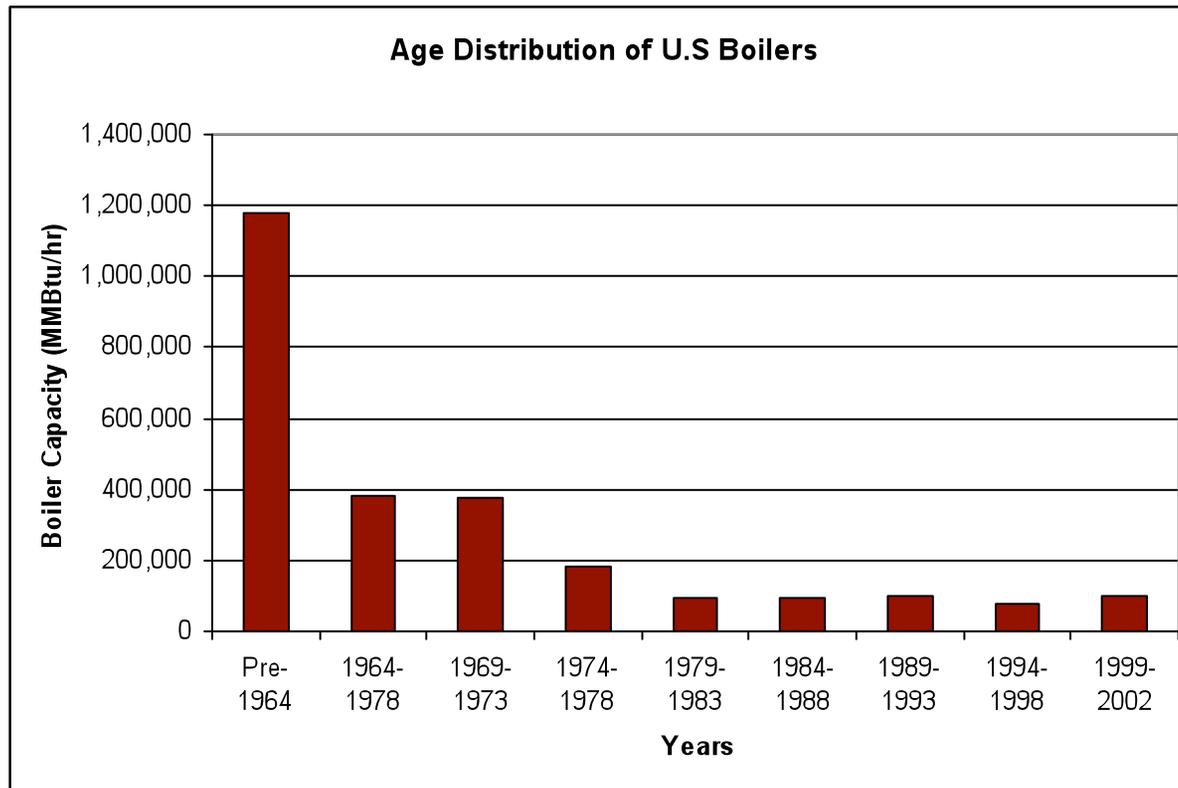
Heating (Steam) Improvements

- Change in Steam Consumption/Conditions
 - Steam Demand Reduction (End Use)
 - Temperature, Pressure
- Dedicated Boiler / Seasonal Shutdown
- Steam Leak and Trap Repair
- Boiler Combustion Control
- Boiler Blowdown
- Condensate Recovery/Return
- Heat Recovery
- Co-generation
- Equipment Upgrades
- Configuration Improvements



US Boiler Age Distribution

Short Term Savings of 11 TBtu/yr

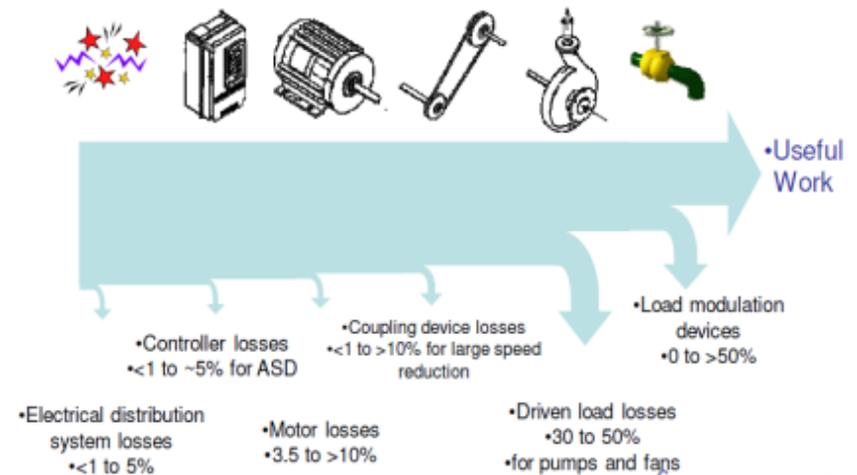


Data: Super Boiler Potential at Federal Sites
(Interim Report) - John Shonder

Pumping and Fan Improvements

- “Pump long and pump slow”
 - Reduce pressure
 - Reduce flow
- Utilize most efficient control
 - Variable Frequency Drive (VFD)
 - Inlet Vanes, Outlet Dampers, Throttling Valves
- Optimize System Configuration
 - Right-size pump/fan
 - “System effect”
 - Reduce friction & avoid “T’s”
- Use appropriate drive coupling
- Utilize most efficient motors

Typical Motor System Losses



General Improvements

- Shut off equipment when not needed
- Preventative maintenance programs
- Insulation
 - Walls
 - Pipes
- Geothermal & River Water



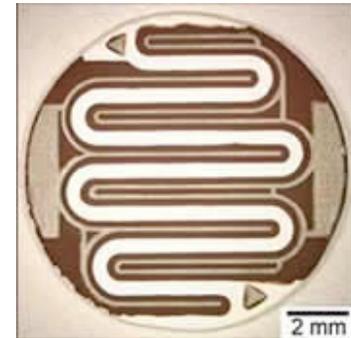
Other Areas to Investigate

Investigating process and other, more advanced components may provide additional opportunities in industrial areas.



Wireless Sensor Technology

- Reduced installation costs– no wires!
 - \$50-\$2,000 per foot wiring cost
- Increase Productivity
 - Real-time monitoring of performance
 - Identification of repair needs
- Reduction in Maintenance Costs
 - Easily replaced
 - Remote sensing for hazardous environments
 - Reduces need for manual inspections
- Energy Tracking

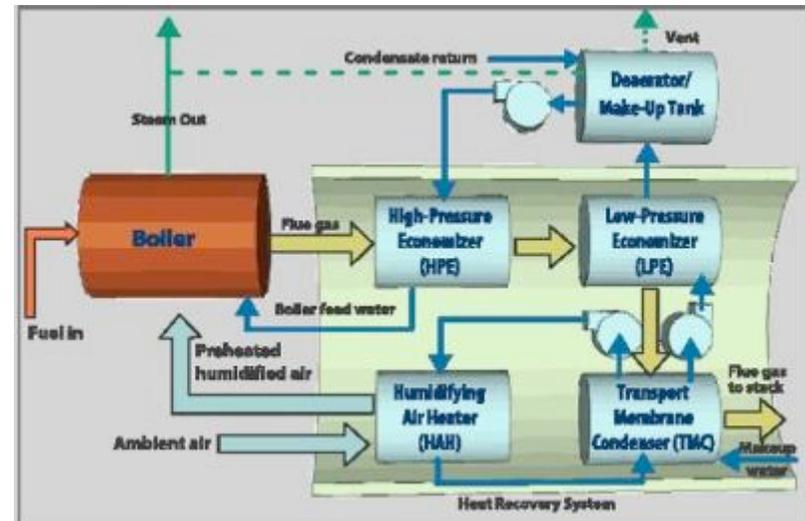


Exhaust Gas Sensor
Courtesy of ORNL

http://www1.eere.energy.gov/industry/sensors_automation/pdfs/transformational_wireless.pdf

Super Boiler Technology

- What makes it 'Super'?
 - Advanced controls
 - Heat Recovery of Flue Gas
 - Staged and intercooled combustion system
 - Ultra-low emissions
- EERE: 25% increase in steam generation efficiency
 - SuperBoiler is reported at 90-94% efficiency
 - Traditional Boilers are typically mid-80's efficiency

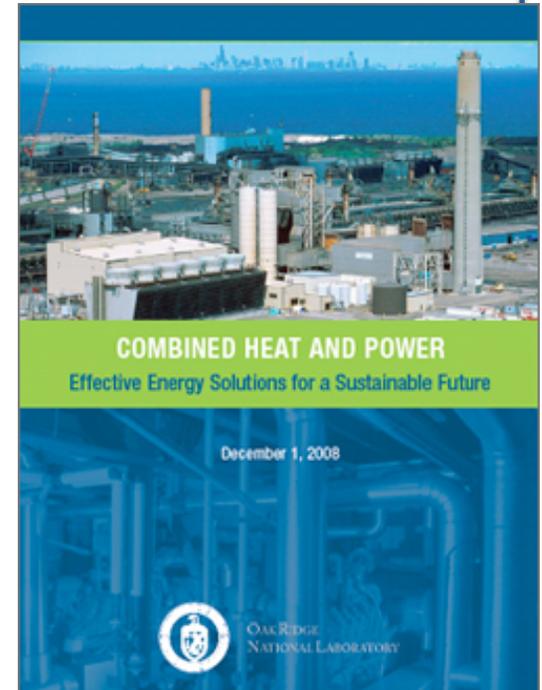


<http://www1.eere.energy.gov/industry/combustion/pdfs/superboiler.pdf>

Combined Heat and Power (CHP)

– On-Site Generation

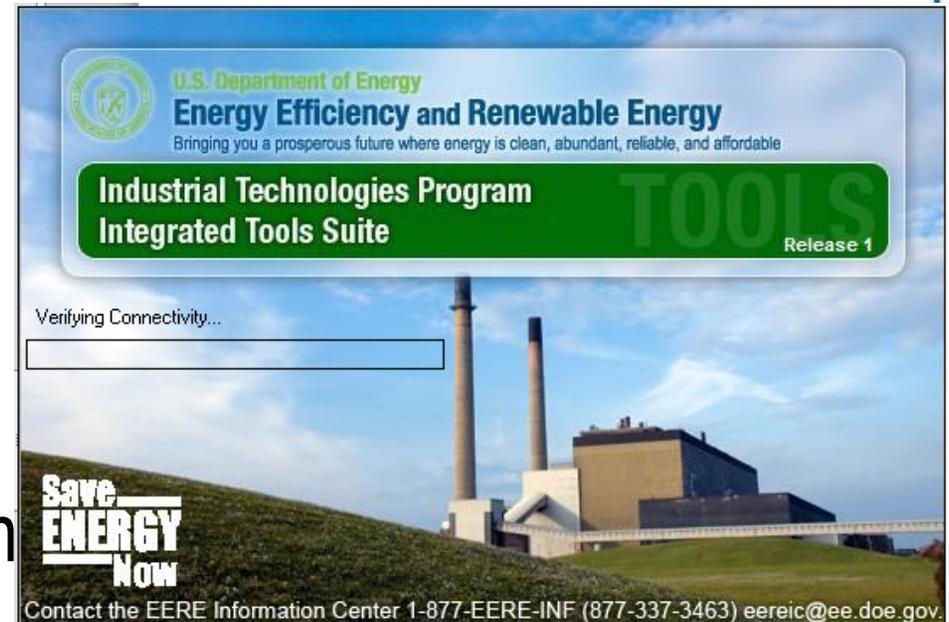
- Grid Independency / Energy Security
- Utilize Waste Heat
 - Absorption Chillers
 - Heat Recovery for Steam/Hot Water
 - Heat Recovery for Process
 - Desiccant Dehumidification
- Excess Steam Generation
- Carbon Dioxide Reduction
- Minimizes Distribution Loss
- Alternative Fuels
 - Biomass, Landfill Gas



http://www1.eere.energy.gov/industry/distributedenergy/pdfs/chp_report_12-08.pdf

System Level Software Tools

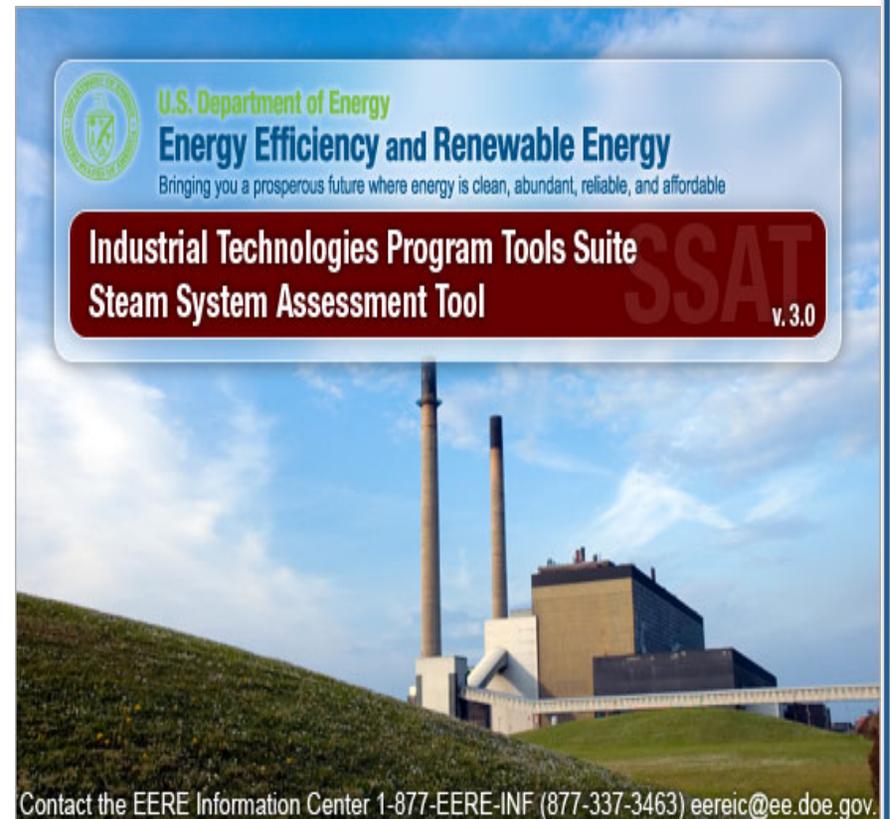
- Steam Systems
- Pumping Systems
- Fan Systems
- Chiller Water Systems
- Compressed Air System
- Motor Systems
- Data Centers



<http://www1.eere.energy.gov/industry/bestpractices/software.html>

The Steam System Tool Suite

- Steam System Tool Suite consists of three downloadable software tools:
 - Steam System Scoping Tool (SSST)
 - Steam System Assessment Tool (SSAT)
 - 3E Plus



SSST & SSAT

Steam System Scoping Tool (SSST)

- A scorecard designed to perform initial self-assessments of steam systems to identify areas of improvement
- Evaluate your steam system operations and management against best practices
- Use SSAT to analyze potential projects to consider

Steam System Assessment Tool (SSAT)

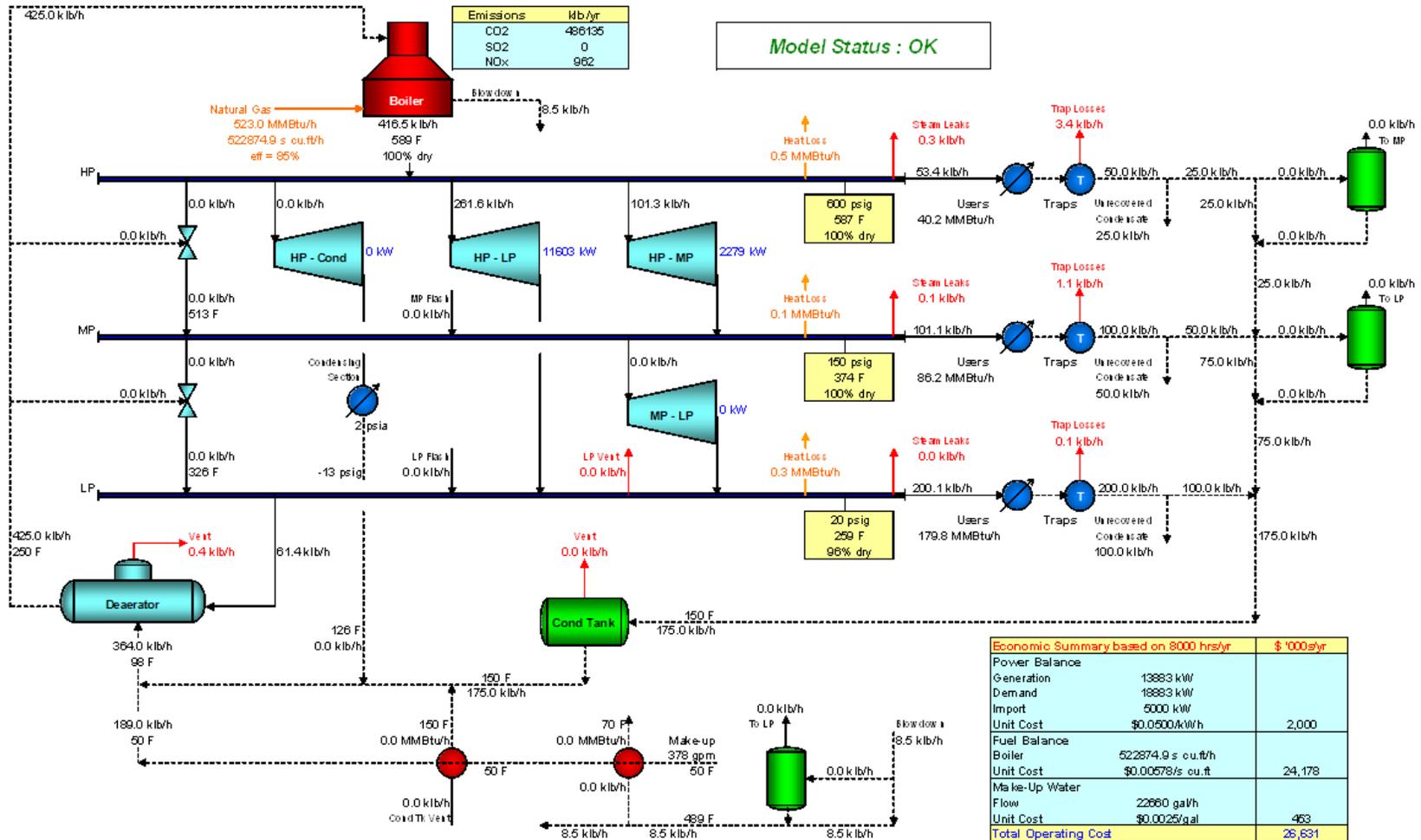
- Can develop approximate models of real steam systems
- Contains key features of typical steam systems
- Can quantify the magnitude—energy, cost, and emissions-savings—of potential steam improvement opportunities

SSAT (cont)

Steam System Assessment Tool

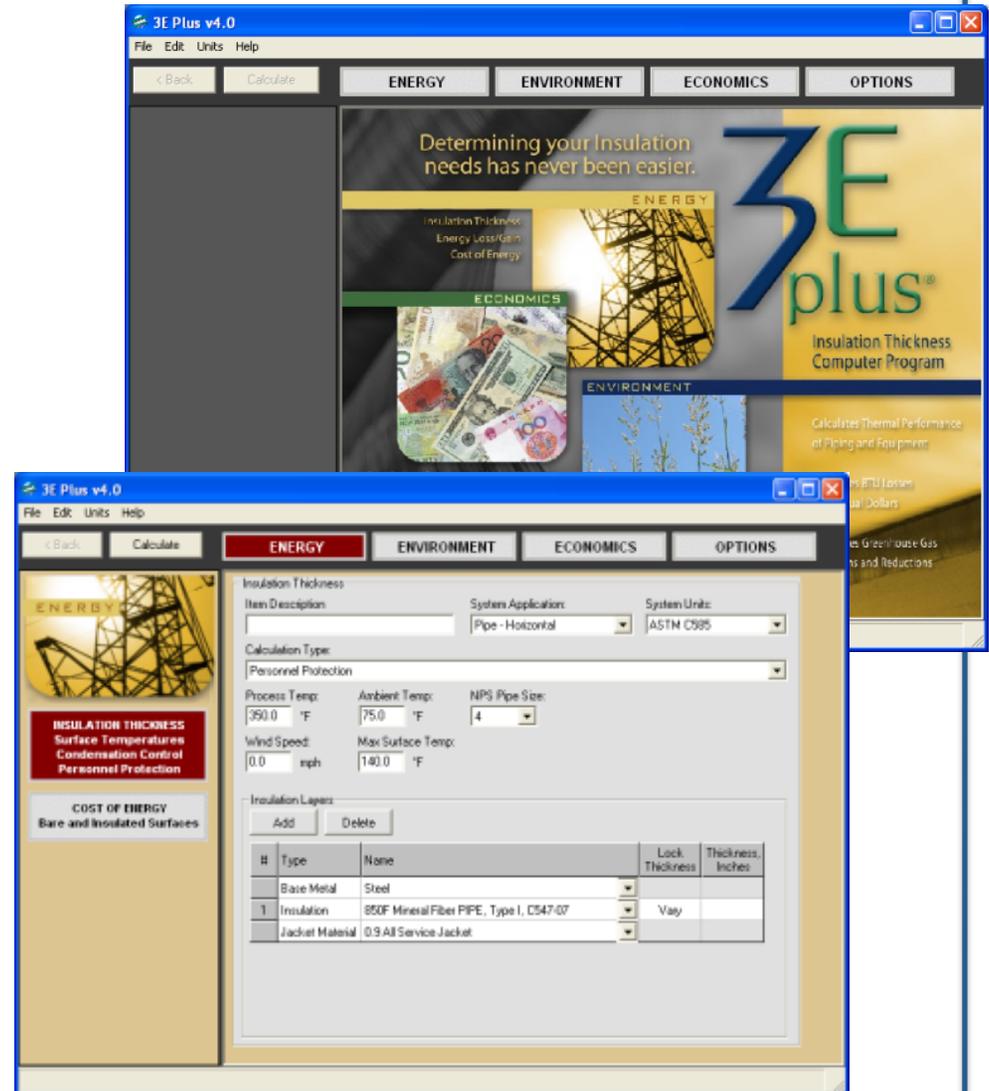
SSAT Default 3 Header Model

Current Operation



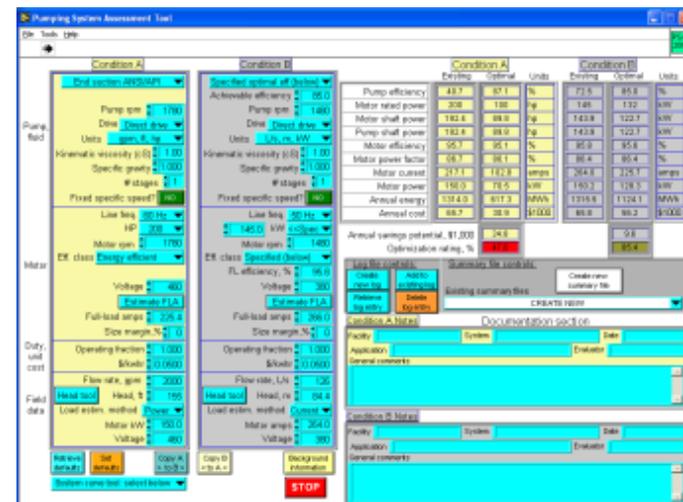
3E Plus

- Calculates the heat loss of various types and thickness of insulation for given operating conditions
- Uses built-in thermal performance relationships of generic insulation materials
- Estimates project cost and emissions savings



Pumping System Assessment Tool (PSAT)

- Helps users assess efficiency improvements of pumping system operations
- Can calculate potential energy and associated cost savings
- Uses pump performance data from Hydraulic Institute standards



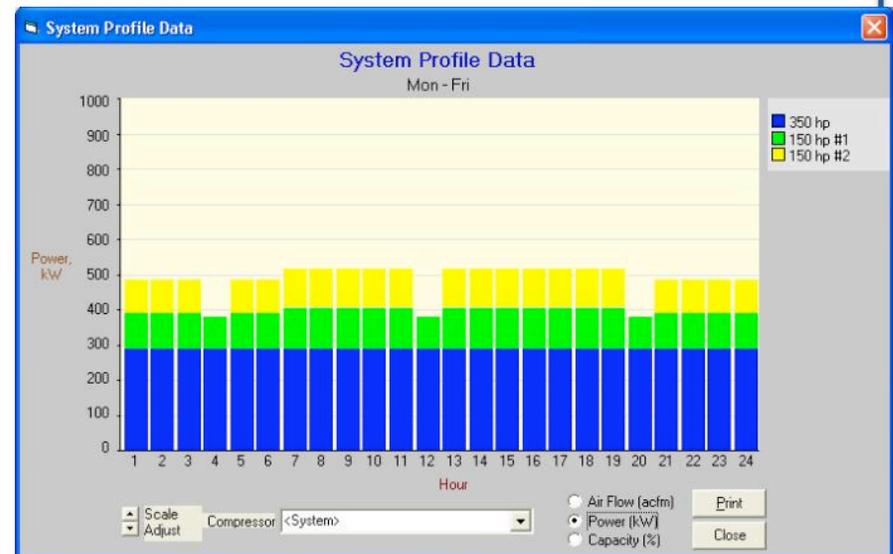
MotorMaster+

- A motor selection and management tool
- Contains a catalog of more than 20,000 low-voltage induction motors
- Features motor inventory management tools
 - Maintenance log tracking
 - Efficiency analysis
 - Savings evaluation



AIRMaster+

- Provides a systematic approach to assessing compressed air systems
- Models existing and future improved system operations
- Can model an unlimited number of interconnected compressors
- Contains database of most commercially available compressors



Software Tools

- QuickPep
- Steam System Tool Suite
 - Steam System Scoping Tool
 - Steam System Assessment Tool
 - 3E Plus ® Insulation Thickness Tool
- AIRMaster+ (Compressed Air)
- Pumping System Assessment Tool
- Fan System Assessment Tool
- Process Heating Assessment & Survey Tool
- Industrial Facilities Tool Suite
- Chilled Water System Analysis Tool
- MotorMaster+

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Industrial Technologies Program Tools Suite
Steam System Assessment Tool v.3.0

Electricity Units: kWh

Energy Use System	Annual Electricity Consumption	Energy Consumption (kWh)	Energy Consumption (MMBtu)	Percentage of Total
Combined heat and power (cogeneration)	0.00		0	0.00%
Compressed air	13,069,920.00	13,069,920	44,594	9.47%
Industrial Facilities (Lighting, HVAC, and Facility Support)	6,500,000.00		22,179	4.68%
Fans and Blowers	9,500,000.00	9,500,002	32,415	6.84%
Motor and generator	1,000,000.00		3,489	0.73%
			1,089	2.34%
			6,773	16.21%
			9,964	31.66%
			0	0.00%
			7,246	20.53%
			2,796	2.70%
			5,601	5.62%
			1,659	

Pumping System Assessment Tool

Condition 1: Vertical turbine
 Condition 2: Vertical turbine
 Condition 3: Vertical turbine
 Condition 4: Vertical turbine

Pump and Motor parameters:
 Pump: Pump size, Discharge, Units, Volumetric efficiency, Specific gravity, #stages, Fixed specific speed, Line freq, HP, Motor size, Motor class, Voltage, Full-load amp, Size margin, Operating fraction, Horsepower, Shaft torque, Full-load speed, Motor size, Voltage.

Motor parameters:
 Motor size, Voltage, Full-load amp, Size margin, Operating fraction, Horsepower, Shaft torque, Full-load speed, Motor size, Voltage.

Summary table:
 Condition 1: Pump efficiency 89.9%, Motor rated power 148.4 hp, Motor shaft power 148.4 hp, Motor efficiency 89.9%, Motor power factor 88.1%, Motor current 142.9 amps, Motor power 112.0 kW, Annual energy 89.1 MWh, Annual cost \$9.1, Optimization rating 3.3.

<http://www1.eere.energy.gov/industry/bestpractices/software.html>
http://www1.eere.energy.gov/femp/information/access_tools.html

Technical Resources

- BestPractices Publications
 - Handbooks, Sourcebooks
 - Tip Sheets, Fact Sheets
- Training
 - BP Software Tool Introduction Webinars
 - BP End User Training (1-day)
 - BP Qualified Specialist Training (3-day)

<http://www1.eere.energy.gov/industry/bestpractices/resources.html>

Industrial Technologies Program

Improving Steam System Performance

A Sourcebook for Industry

Energy Tips – Steam

Steam Tip Sheet #3 • January 2008

U.S. Department of Energy Efficiency and Renewable Energy
Bringing you a program that is clean, abundant, reliable

Suggested Actions

- Determine the stack temperature after the boiler has been tuned to manufacturer's specifications. The boiler should be operating at three-to-five percent excess air levels with all heat transfer surfaces clean.
- Determine the minimum temperature to which stack gases can be cooled subject to areas such as dew point, cold-lead corrosion, and economic heat transfer surfaces. (See Exhaust Gas Temperature Limits below)
- Study the cost-effectiveness of installing a feedwater economizer or air preheater in your boiler.

Use Feedwater Economizers for Waste Heat Recovery

A feedwater economizer reduces steam boiler fuel requirements by transferring heat from the flue gas to incoming feedwater. Boiler flue gases are often rejected to the stack at temperatures more than 100°F to 150°F higher than the temperature of the generated steam. Generally, boiler efficiency can be increased by 1% for every 40°F reduction in the gas temperature. By recovering waste heat, an economizer can often reduce fuel requirements by 3% to 10% and pay for itself in less than 3 years. The table provides examples of the potential for heat recovery.

Initial Stack Gas Temperature, °F	Recoverable Heat, MBtu/hr			
	25	40	100	200
400	1.3	2.6	5.3	9.6
500	2.3	4.6	9.2	16.4
600	3.3	6.5	13.0	23.1

Based on natural gas fuel, 10% excess air, and a final stack temperature of 200°F.

Example

A 90%-efficient boiler generates 45,000 pounds per hour (3-hr) of 150-pound-per-square-inch-gauge (psig) steam by burning natural gas. Condensate is returned to the boiler and mixed with makeup water to yield 117°F feedwater. The stack temperature is measured at 500°F. Determine the annual energy savings that will be achieved by installing an economizer given 8,400 hours per year (hr-yr) of boiler operation at a fuel cost of \$3.00 per million Btu (\$3,000/MBtu).

From the steam tables, the following enthalpy values are available:

For 150-psig saturated steam: 1,195.5 Btu/lb
For 117°F saturated water: 84.97 Btu/lb

Boiler heat output = 45,000 lb/hr × (1,195.5 – 84.97) Btu/lb
= 50 million Btu/hr

The recoverable heat corresponding to a stack temperature of 500°F and a natural gas-fired boiler load of 50 MBtu/hr is read from the table (above) as: 4.6 MBtu/hr.

Annual Savings = (4.6 MBtu/hr × 8,400 hr-yr) ÷ \$3.00
= \$126,000

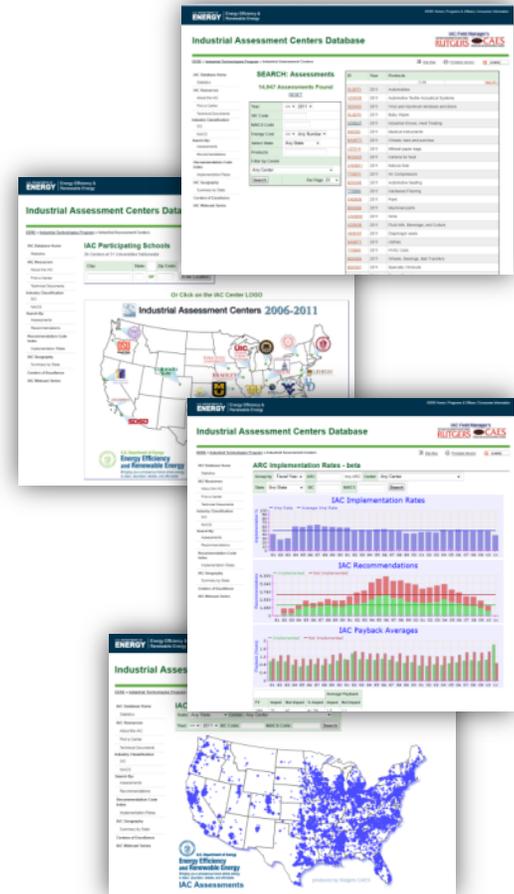
Exhaust Gas Temperature Limits

The lowest temperature to which the gas can be cooled depends on the type of fuel used: 250°F for natural gas, 300°F for coal and low sulfur content fuel oils, and 350°F for high sulfur fuel oils. These limits are set to prevent condensation and possible corrosion of the stack.

U.S. Department of Energy Efficiency and Renewable Energy
Energy Efficiency and Renewable Energy
Energy Efficiency and Renewable Energy

IAC Online Database System

- Collection of publicly available assessment and recommendation data
- Contains ~15,000 Assessments
- Access to:
 - Assessments results
 - Energy and cost savings by recommendation
 - Recommendation statistics
 - Case studies
 - Technical documents



Observations from Industry: Building Internal Capacity

- Seeing industries and organizations use DOE training to build internal capacity
- Assemble traveling teams to perform assessments
- Rely on DOE available tools and training

The screenshot shows the 'Training Calendar' page on the ITP BestPractices website. The page includes a navigation menu, a 'BestPractices' header, and a 'Training Calendar' section. The calendar lists several training events, including webinars and workshops, with details on dates, locations, descriptions, and contact information.

Sorted By Date	Sort By Location	Sort By Event	Description	Contact
May 4, 2011	Webcast	WERCOST: eeffMaster+ Version 2.0	AIRMaster+ is a free online software tool that helps users analyze energy use and savings opportunities in industrial compressed air systems.	eMaster+
May 10-13, 2011	Portland, Oregon	Specialist Qualification: AIRMaster	This 3.5-day intensive training explains how AIRMaster+ works, how to collect field data, enter data, and interpret the results.	Tanya Stevens 340-598-2137 tstevens@energy.gov
May 11, 2011	Downey, California	Process Heating Systems Management	This 1-day workshop includes an introduction to process heating and process heating equipment such as furnaces, ovens, dryers, heaters, kilns, etc., used by the industry.	Larry Bennett 942-403-7570 lbennett@energy.gov
May 12, 2011	Norfolk, Virginia	Steam Systems Management	This 1-day course covers the operation of typical steam systems and discusses methods of system efficiency improvement.	Shirley Simpson 276-656-8880 ssimpson@energy.gov
May 12, 2011	Webinar	WEBINAR: Fundamentals of Pumping System Assessments: An Overview of the ASME Energy Assessment for Pumping Systems Standard	WEBINAR: Fundamentals of Pumping System Assessments: An overview of the ASME Energy Assessment for Pumping Systems Standard	Register: www.PumpSystemAssessmentsWebinars For more information contact: Kathy Durak , kathy.durak@energy.gov 973-267-9700 ext. 216
May 10, 2011-June 8, 2011	Webinar	WEBINAR: Fundamentals of Compressed Air (Last 11 Four-Part Series)	This Web-based version of the popular Fundamentals of Compressed Air Systems training uses an interactive format that enables the instructor to diagram examples, give pop quizzes and answer students' questions in real time.	Compressed Air Challenge Training Coordinator cachallenge@energy.gov cachallenge
May 18-19, 2011	Sacramento, California	Advanced Management of Compressed Air (Last 2)	This intensive 2-day workshop provides in-depth technical information on troubleshooting and making improvements to industrial compressed	Paul Gillies 916-732-0375 pgillies@energy.gov

Questions?

Thank-you

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