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US Department of Energy Better Plants Program Energy Treasure Hunt Exchange Toolkit

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OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE US DEPARTMENT OF ENERGY

ORNL/TM-2019/1081

Energy and Transportation Science Division

US Department of Energy Better Plants Program Energy Treasure Hunt Exchange Toolkit

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ABSTRACT

The US Department of Energy's (DOE's) Better Buildings, Better Plants Program works with manufacturing companies to improve their facilities' energy efficiency. By partnering with the program, companies commit to long-term energy efficiency goals, typically 25% energy savings in 10 years. The program provides technical support to help partners obtain their goals and recognizes partners' outstanding achievements. One of the technical support offerings from the program is the Energy Treasure Hunt Exchange In-Plant Training. The Treasure Hunt Exchange is an adaptation of the Kaizen methodology for energy efficiency originally developed by Toyota. DOE developed the Energy Treasure Hunt Exchange Toolkit to facilitate program partners' execution of the energy treasure hunt processes. The toolkit covers three phases of an energy treasure hunt for all major energy systems: pump systems, fan systems, process heating systems, process cooling systems, steam systems, compressed air systems, lighting systems, and motor systems. All the tools included in the toolkit can be downloaded from the DOE website. The purpose of this report is to provide Better Plants partners an overview of the toolkit and detailed descriptions of its capabilities.

1. INTRODUCTION

The US Department of Energy's (DOE's) Better Buildings, Better Plants (Better Plants) Program is a voluntary partnership initiative to drive significant energy efficiency improvement across energy-intensive industrial companies and organizations. As of January 2019, 205 manufacturing companies and public water and wastewater treatment plants are partnering with DOE through the Better Plants Program to improve the energy efficiency of their facilities.

By partnering with Better Plants, partners pledge long-term ambitious energy savings goals, typically 25% over 10 years. These partners receive national recognition for their achievements, technical support from technical account managers, access to in-plant training (InPLT) and other energy savings resources, and networking opportunities.

InPLTs are two- to four-day events led by experts in energy-intensive manufacturing processes and systems. The experts train facility staff on how to establish energy management systems, conduct plant energy assessments, use DOE tools and resources, and implement cost-effective projects. Better Plants partners can apply to host training or just participate in the training events. Better Plants currently offers InPLTs in several topics: pump systems, fan systems, process heating systems, steam systems, compressed air systems, industrial refrigeration systems, water and wastewater treatment processes, the 50001 Ready Program, and energy treasure hunts.

The energy treasure hunt InPLTs can take two different forms: (1) a full "exchange" in which two partners each send their energy team to the other's facility to conduct energy treasure hunts or (2) a more traditional energy treasure hunt in which only staff from the host facility attend. To promote best practices, knowledge sharing, and networking, the Better Plants program encourages the full exchange format.

DOE developed the Energy Treasure Hunt Exchange Toolkit to facilitate planning treasure hunt events, executing the energy treasure hunt, identifying energy conservation opportunities, performing savings estimations, and tracking the results. This report provides Better Plants partners an overview of the toolkit and detailed descriptions of its capabilities.

2. ENERGY TREASURE HUNT EXCHANGE TOOLKIT OVERVIEW

The three phases of the treasure hunt process and the associated tools and documents are shown in Figure ***1*** and the following subsections. The materials can be downloaded from https://betterbuildingsinitiative.energy.gov/energy-treasure-hunt-exchange-toolkit. PDF versions of the documents and screen captures of the tools are included as appendixes.

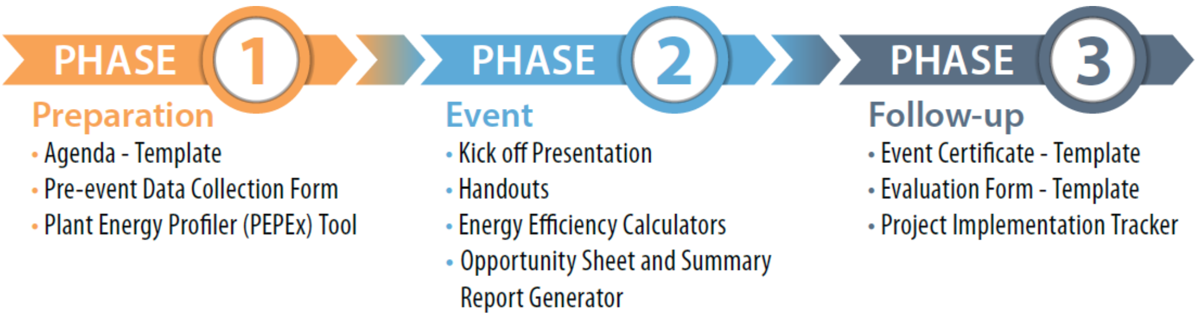


Figure 1. Three phases of energy treasure hunts.

2.1 PHASE 1—ENERGY TREASURE HUNT PREPARATION TOOL LIST

- Save the Date template (MS Office Word file)
- Agenda template (MS Office Word file)
- Pretraining Data Collection Form (MS Office Excel file)
- Plant Energy Profiler Excel (PEPEx) Tool (MS Office Excel file)
- Plant Water Profiler (PWP) Tool (MS Office Excel File)

2.2 PHASE 2—ENERGY TREASURE HUNT EVENT TOOL LIST

- Kickoff Presentation template (MS Office PowerPoint file)
- Handouts
  - Check Lists (PDF file)
  - Data Collection Sheets (MS Office Excel file)
  - Cheat Sheets (PDF file)
  - Info Cards (PDF file)
- Calculators
  - Electricity Savings Calculator (MS Office Excel file)
  - Natural Gas Savings Calculator (MS Office Excel file)
  - Steam Savings Calculator (MS Office Excel file)
  - Water Savings Calculator (MS Office Excel file)
- Opportunity Sheets (MS Office Excel file)
- Summary Report Generator (MS Office Excel file)

2.3 PHASE 3—ENERGY TREASURE HUNT FOLLOW-UP TOOL LIST

- Participation Certificate template (MS Office PowerPoint file)
- In-plant Training Evaluation Form template (MS Office Word file)
- Project Implementation Tracker (MS Office Word file)

3. TOOLS FOR PHASE 1—ENERGY TREASURE HUNT PREPARATION

Proper planning helps the facilitator set up more effective teams, identify and target high potential operations, and avoid surprises on the day of the event. The toolkit provides two templates to aid in planning the event and in informing participants about the event: the Save the Date Announcement (see Appendix A) and the Agenda (see Appendix B).

Gathering relevant information and analyzing the data before the event is a crucial part of planning that provides a better understanding of the facility and its operations before the event begins and reduces the time spent gathering data during the event. The toolkit provides the Pretraining Data Collection Form (see Appendix C) for this purpose, which provides a structured approach to collecting relevant information without missing out on required data.

Depending on the level of time and effort the facilitator is looking to put into the preparation, the toolkit provides two data collection and analyzing options. The "Essential data" section of the form contains items crucial to running the event, such as the energy sources used, operating shifts, annual energy consumption, and utility costs. The "Helpful data" section contains information that is useful to planning a more effective event. This focuses on information about the process equipment, including specifications, efficiency, and operating hours.

For a more detailed analysis, the user can use the PEPEx, which helps identify how energy is being consumed at a plant and shows the potential for improvement in each system. Similarly, the PWP Tool helps illustrate the water flows in a plant, calculates the "true cost of water" of the facility (such as the costs associated with water procurement, treatment, and consumption and wastewater disposal), and helps identify areas for improvement in each system.

4. TOOLS FOR PHASE 2—ENERGY TREASURE HUNT EVENT

During the treasure hunt event, the participating teams investigate specific systems to identify possible energy savings opportunities, quantify the savings, and summarize the results. The tools for phase 2 help the participants and the facilitator at each step of this process. The toolkit includes a template for the kickoff presentation for the first day of the event (see Appendix D). The facilitator can use this to introduce participants to the treasure hunt process and provide an overview of the facility and its systems.

4.1 HANDOUTS

The handouts provide guidance to help participants identify opportunities and collect the relevant data to quantify savings. Although the handouts provide the necessary information for anyone to start identifying opportunities and gathering data, they are designed to be used as guides only to help the participants get started and are not meant to be all-encompassing checklists. The toolkit contains four different types of handouts for each system type: **checklists, data collection sheets, cheat sheets, and info cards**.

The **checklists** breakdown the system and the various components to be assessed by the treasure hunt participants, along with the typical parameters required to identify opportunities. They also outline the most common low-cost/no-cost opportunities associated with the system and provide a sketch of the system. Figure 2 is an example checklist, and the rest can be found in Appendix E. Checklists have been created for seven systems:

- Chilled water systems
- Compressed air systems
- Lighting systems
- Process equipment
- Process heating systems
- Pump and fan systems
- Steam systems

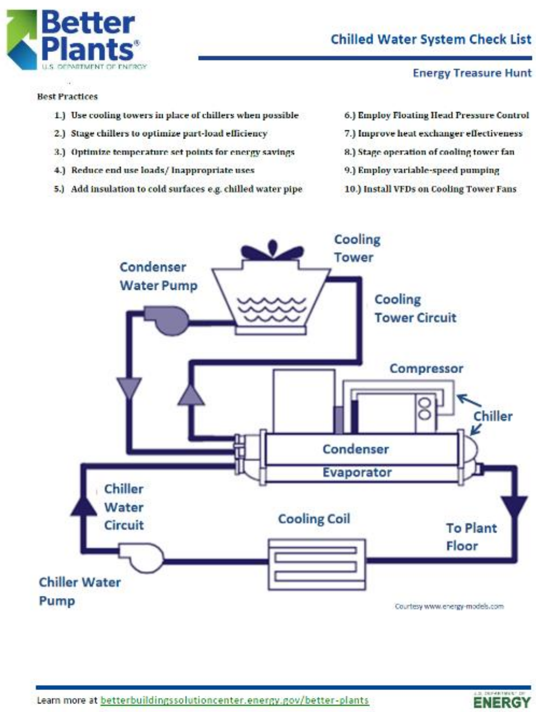


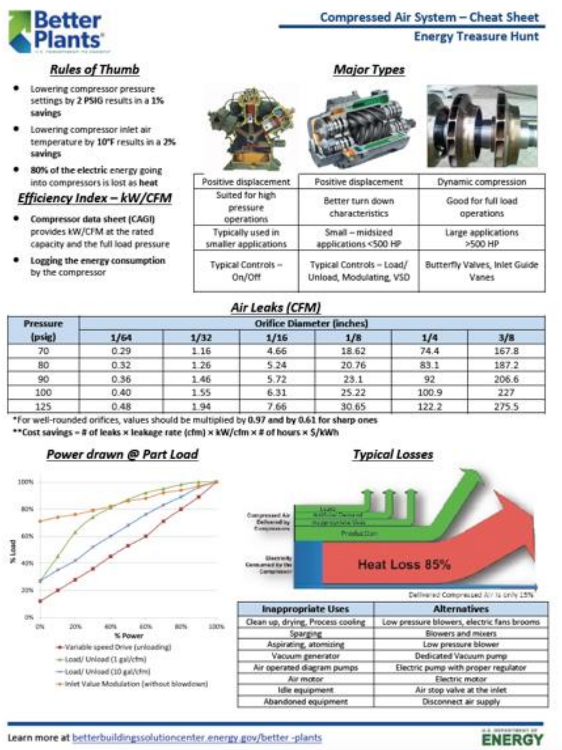
Figure 2. Checklist for chilled water systems.

The **data collection sheets** list the minimum amount of information that must be measured to quantify the savings associated with the most common opportunities identified in treasure hunt events. In addition, these sheets provide tips on where and how to collect the required data. The data collection sheets can be found in Appendix F and have been created for five systems:

- Lighting systems
- Pump and fan systems
- Compressed air systems
- Steam systems
- Chilled water systems

The system-specific **cheat sheets** are repositories of system charts, default tables, rules of thumb, and more. The sheets serve multiple purposes: help participants better understand the system's operation; help participants perform back-of-the-envelope estimates of energy savings; and provide quick references to check the feasibility of some opportunities. The cheat sheets can be found in Appendix G, and Figure 3 provides an example. There are six system-specific cheat sheets:

- Lighting systems
- Pump and fan systems
- Process heating systems
- Process cooling systems
- Compressed air systems
- Steam systems


Better Plants

Compressed Air System – Cheat Sheet

Energy Treasure Hunt

Rules of Thumb

- Lowering compressor pressure settings by **2 PSIG** results in a **1% savings**
- Lowering compressor inlet air temperature by **10°F** results in a **2% savings**
- **80% of the electric** energy going into compressors is lost as **heat**

Efficiency Index – kW/CFM

- **Compressor data sheet (CAGI)** provides kW/CFM at the rated capacity and the full load pressure
- **Logging the energy consumption** by the compressor

Major Types

Positive displacement	Positive displacement	Dynamic compression
Suited for high pressure operations	Better turn down characteristics	Good for full load operations
Typically used in smaller applications	Small – midsized applications <500 HP	Large applications >500 HP
Typical Controls – On/Off	Typical Controls – Load/ Unload, Modulating, VSD	Butterfly Valves, Inlet Guide Vanes

Air Leaks (CFM)

Pressure (psig)	Orifice Diameter (inches)					
	1/64	1/32	1/16	1/8	1/4	3/8
70	0.29	1.16	4.66	18.62	74.4	167.8
80	0.32	1.26	5.24	20.76	83.1	187.2
90	0.36	1.46	5.72	23.1	92	206.6
100	0.40	1.55	6.31	25.22	100.9	227
125	0.48	1.94	7.66	30.65	122.2	275.5

*For well-rounded orifices, values should be multiplied by **0.97 and by 0.61 for sharp ones**

Cost savings = # of leaks × leakage rate (cfm) × kW/cfm × # of hours × $/kWh

Power drawn @ Part Load

Typical Losses

Inappropriate Uses	Alternatives
Clean up, drying, Process cooling	Low pressure blowers, electric fans brooms
Sparging	Blowers and mixers
Aspirating, atomizing	Low pressure blower
Vacuum generator	Dedicated Vacuum pump
Air operated diagram pumps	Electric pump with proper regulator
Air motor	Electric motor
Idle equipment	Air stop valve at the inlet
Abandoned equipment	Disconnect air supply

Learn more at betterbuildingssolutioncenter.energy.gov/better -plants

ENERGY

Figure 3. Cheat sheet for compressed air systems.

The **info cards** include top energy conservation measures, frequently used formulas, common rules of thumb, unit conversions, and reference tables for major energy systems. The cards are very handy for quick references (see Figure 4) and can be found in Appendix H. Info cards are available for eight systems:

- Pump systems
- Fan systems
- Process heating systems
- Process cooling systems
- Compressed air systems
- Steam systems
- Motor systems
- Water systems

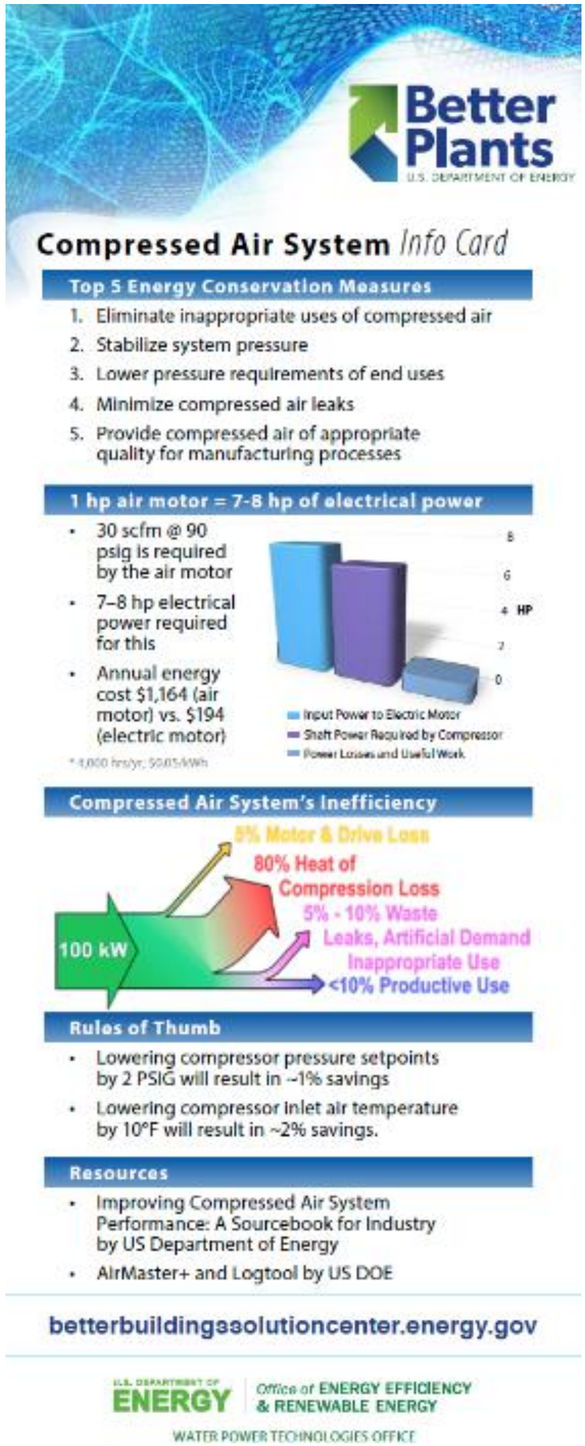


Figure 4. Info card for compressed air systems.

4.2 OPPORTUNITY SHEETS

The toolkit also provides an **opportunity sheet** template to help properly document the identified energy savings opportunity and prevent information loss between project identification and implementation. Opportunity sheets streamline the information transfer by providing a standard format to capture and summarize the specifics of a potential energy saving measure. Each opportunity identified during an energy treasure hunt exchange gets its own opportunity sheet. Appendix I shows a screenshot of the opportunity sheet template.

4.3 ENERGY TREASURE HUNT CALCULATORS

The toolkit contains nine calculators to help participants quantify the energy savings from opportunities or best practice implementation identified during the Energy Treasure Hunt Exchanges. Each energy or utility type (including water) has its respective "Treasure Hunt Calculator"; Appendix J provides several screenshots of each calculator. The treasure hunt calculators can help estimate the savings associated with typical treasure hunt opportunities such as scheduling or turning equipment on or off, reducing the load on the equipment. Calculators are also available to help quantify results for very specific opportunities (reducing compressed air leaks, reducing compressor pressure, and insulation and lighting improvements).

The results from the calculators provide the information needed to populate the opportunity sheets. Using the calculators is optional and can be bypassed when energy savings are estimated using other calculators or methods more familiar to the user.

Although not included in the toolkit download, DOE is currently developing the MEASUR tool suite as a "one stop shop" for energy savings calculations. This software is open source and cross-platform compatible, and the algorithms were developed by systems experts and are technology and vendor agnostic. When complete, MEASUR will include updated versions of the programs formerly known as the Pumping System Assessment Tool (PSAT), Process Heating Assessment and Survey Tool (PHAST), Fan System Assessment Tool (FSAT), Steam System Modeler Tool (SSMT), and AIRMaster+. MEASUR is available for download with several of the systems available for assessments. Figure 5 shows a screenshot of the home screen. The energy treasure hunt calculators discussed previously will also be incorporated into MEASUR, complementing the more than 40 calculators already included, some of which can be seen in Figure 6.

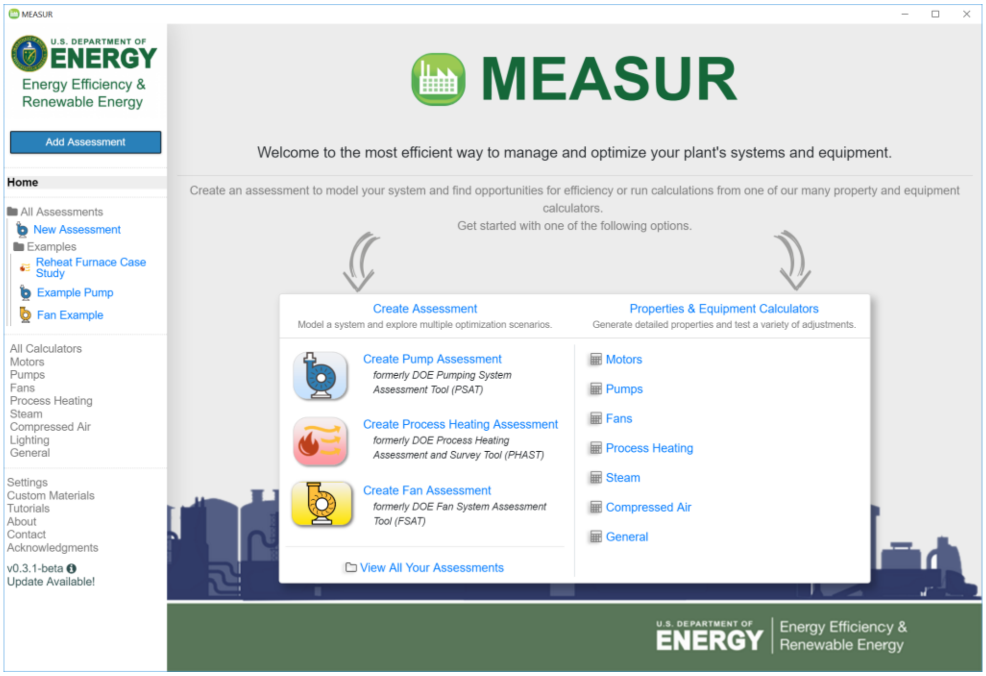


Figure 5. MEASUR tool suite home screen.

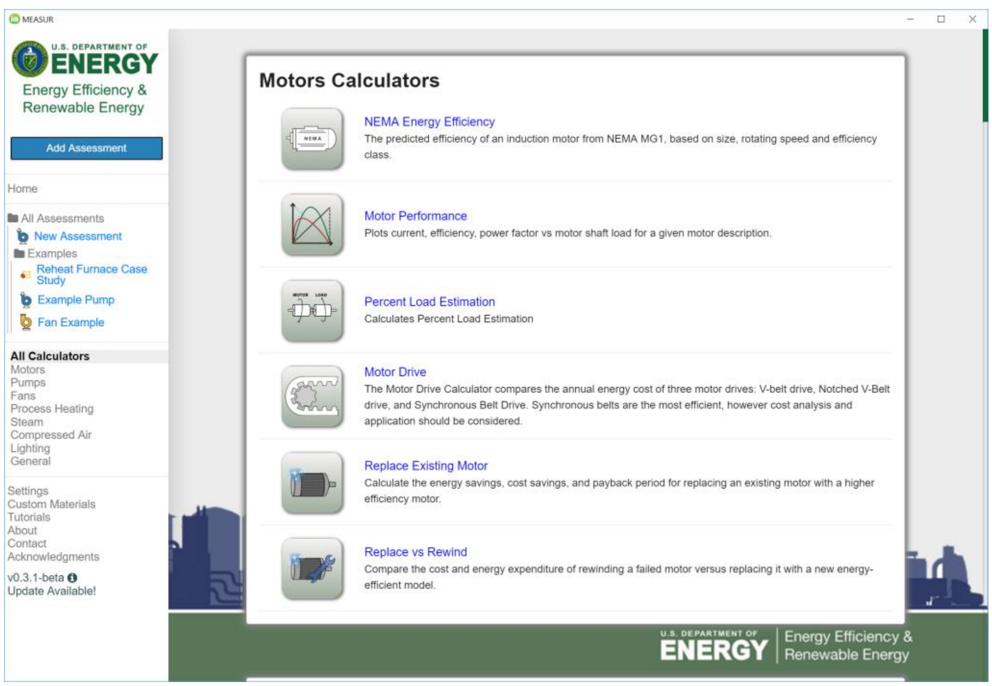


Figure 6. MEASUR tool suite calculator collection screen.

4.4 SUMMARY REPORT GENERATOR

After identification and quantitative analysis of individual opportunities, the results are rolled up and summarized to create a report for presentation to management. This is made easier with use of the

summary report generator (shown in Appendix K), which automatically rolls up the individual opportunity sheets and creates appropriate summary tables and charts.

5. TOOLS FOR PHASE 3—TREASURE HUNT FOLLOW UP

The energy treasure hunt exchange follow-up involves prioritizing the identified energy savings opportunities and determining the next steps for project implementation. The Project Implementation Tracker helps with this task and is used to check the status of energy projects against the implementation schedule and to monitor project results. Screenshots of the tracker can be found in Appendix L. The follow-up phase also includes templates for Participation Certificates (see Appendix M) and an Evaluation Form (shown in Appendix N) for use in postevent activities.

6. SUMMARY

The Better Plants Program is a voluntary partnership initiative to drive significant energy efficiency improvement across energy-intensive industrial companies and organizations. The program provides technical support, national recognition, and networking opportunities. One of the technical support offerings is Energy Treasure Hunt Exchange In-plant Training. DOE developed the Energy Treasure Hunt Exchange Toolkit to assist partners in energy treasure hunt processes.

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APPENDIXES

APPENDIX A. SAVE THE DATE TEMPLATE

Your Logo

SAVE THE DATE

US DOE's In-Plant Training Energy Treasure Hunt Exchange

Company Name

Facility Address

May 1 to 3, 201X

ABC limited, ORNL, and U.S. DOE's Advanced Manufacturing Office are organizing an Energy Treasure Hunt Exchange to identify day-to-day operational energy efficiency improvements in the manufacturing process and associated systems. The in-plant training will prepare plant personnel with hands-on experience on how am Energy treasure hunt is run in addition to identifying and, evaluating energy efficiency projects. Participants will be provided with practical information to identify energy saving projects and the necessary tools to quantify the associated savings. The focus will be on identifying low cost operational opportunities for energy optimization and documenting them.

Participants will learn:

- The value/benefits of a treasure hunt exchange
- What to look for in an energy treasure hunt and how to profile equipment energy use
- How to identify equipment and process opportunities
- Methods for collecting energy data and common data collection tools
- How to effectively present outcomes of the Treasure Hunt Exchange
- How to understand calculation tools and ROI methodologies
- What are relevant diagnostic tools and how to use them
- Use of Tools to calculate energy savings from identified opportunities
- How to select processes, plants, departments for treasure hunts
- The importance of Team makeup – processes and people
- Prioritizing energy-saving opportunities
- Replication across facilities, departments, business units
- Preparation of treasure hunt outcome for management presentation

Additionally:

- At least one employee will learn how to be a facilitator to conduct internal treasure hunts

The training will focus on four fundamental elements that every treasure hunt exchange needs to have in order to be effective. These four elements are:

1. A profile of the equipment/systems to be analyzed and an equipment checklist
2. Data collection protocols and tools
3. Calculators and calculation methodologies (baselines & ROI metrics)
4. Relevant energy diagnostic equipment and how to use them

Contacts

- Designation, Name , contact@company.com
- Designation, Name , facilitator@company.com

Get to Know the Presenters: Brief Bio Sketches

Presenter 1: Short bio

Presenter 2 : Short bio

APPENDIX B. AGENDA TEMPLATE

Energy Treasure Hunt Exchange

Dates: Sunday, May XX, 201X – Tuesday, May XX, 201X

Partner Site: Your Name, TN facility - 1 ABC Drive. Tonawanda, TN 37919

ABC limited, ORNL, and U.S. DOE's Advanced Manufacturing Office is organizing an Energy Treasure Hunt Exchange to identify day-to-day operational energy efficiency improvements in the manufacturing process and associated systems. The event will be led by Presenter 1 at the ABC Ltd. plant is located in Tonawanda, Tennessee. The plant manufactures original equipment and replacement parts for the consumer and commercial markets. In addition to identifying projects for the host facility, the event will equip the participants with the knowledge and tools required to take the treasure hunt concept and apply it in their other facilities.

Pre-Training Webinar **April XX, 2017 at 9:30 AM ET**	In preparation for the INPLT, join us for a pre-training webinar on treasure hunt exchanges. More Info and to Register - https://attendee.gotowebinar.com/register/878154244193730XXX

	10:00 AM - 12:00 PM	12PM to 1P	1:00 PM – 5:30 PM
Day 1 **Sunday X/XX/2017** **(Observing the idle facility)**	Safety / Plant Orientation Opening Remarks Kick off Objectives and Overview of the Treasure Hunt Exchange Assign teams and leaders	Lunch	Gather into Teams Tour the facility and look for opportunity Discuss initial findings/ideas Plan for Monday morning

	8:00 AM - 12:00 PM	12PM to 1P	1:00 PM – 5:30 PM
Day 2 **Monday X/XX/2017** **(Observing the operating facility)**	Welcome from Management Layout plan for the day Detail Sheet Training Observe facility and operations	Lunch	Begin detail sheets Additional data collection in the facility Identify top ideas

	8:00 AM - 12:00 PM	12PM to 1P	1:00 PM – 4:00 PM
Day 3 **Tuesday XX/XX/2017**	Recap top ideas Wrap up details sheets and field observations Roll up data sheets	Lunch	Dry run management presentation Present to management

Get to Know the Presenters: Brief Bio Sketches

Mr. Presenter 1: Short bio

Mr. Presenter 2 : Short bio

PPE Requirements

Use this section to instruct participants on sign-in procedure, photo ID requirements, policy on electronics, PPE requirements, parking etc.

APPENDIX C. PRETRAINING DATA COLLECTION SHEETS

Energy Treasure Hunt In-Plant Training

Advanced Information Request

This document is requested to be completed at least 2 weeks prior to the energy treasure hunt

The document is broken down into three section (three tabs of the excel workbook)

1.) **Essential Data** - All fields listed in this sheet are key to running a successful treasure hunt and is to be filled by the user.

2.) **Helpful Data** - The fields listed in this session are helpful to have in advance and make it easier to effectively plan for the treasure hunt event. It is recommended that the user goes through the various sections in this sheet and complete it based on information readily available.

The **Plant Energy Profiler Excel (PEPEx)** is recommend for users who would like to provide the treasure hunt facilitator with more information about the facility. In addition to providing the facilitator with the knowledge required to tailor the treasure hunt event, the PEPEx will also help the user better understand the energy usage and the existing opportunities in the facility.

It takes a user with an understanding of the various systems in the plant an average of 20 minutes to complete the tool. Interested users are encouraged to seek the help of the facilitator to complete PEPEx document. PEPEx is included in the Treasure Hunt Toolkit and can also be downloaded from the DOE website.

Essential Information

Plant Contact Information:

Corporation Name:		Location:	
Plant Name:		Primary Contact for Assessment:	
Primary Product:		Address	
Industry Type:		Phone:	
Specify if other:		E-mail:	
Specific Problems or Areas of Interest related to Plant's Energy use:			

Plant's Operating Schedule:

Shift No.	Hours of Operation/Day	Days/Week	Weeks/Year	Annual Hours
1				
2				
3				
Office Hours				
Others				

Unit Cost of Energy:

Instructions:

1) Please provide unit costs for different energy types used in your plant and the corresponding unit.

2) Please provide Steam/Compressed Air cost only if user is buying steam/compressed air from a utility or a third-party enterprise.

3) A proxy can be used if there is concern with sharing the cost data

Energy Type	Unit Price	Unit
Electricity		$/
Natural Gas		$/
Steam		$/
Other Fuel		$/
Compressed Air		$/

Helpful Data

Team Information - Optional

	Team - 1	Team - 2	Team - 3	Team - 4	Team - 5
Area of Focus					
Team Leader					
Member 1					
Member 2					
Member 3					
Member 4					
Member 5					
Member 6					

Plant Data:

Items	Value	Additional Comments
Annual Production Volume		
Plant Square Footage		
Office Square Footage		
Number of Employees		
Certification (ISO 50001, 140001)		
Energy Management System (Yes/No)		

Facility Equipment Data:

The table below provides a framework of the typical systems in a manufacturing plant, please feel free to add/remove systems from the list as per your facilities configuration.

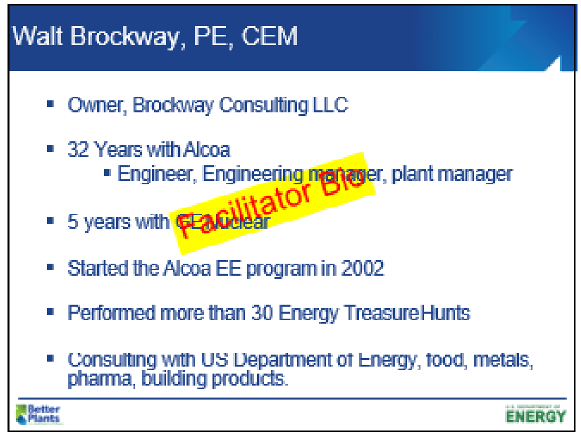
Building Equipment	Equipment Number	Size	Estimated (Hrs/year)	Load Factor (%)	Index Unit	Index Value	Control Strategy/ Additional Comments
Compressor					kW/100 SCFM		
					kW/100 SCFM		
					kW/100 SCFM		
Boilers					MMBTU/klb		
					MMBTU/klb		
Chillers					kW/kGal		
					kW/kGal		
Furnaces							
etc.							

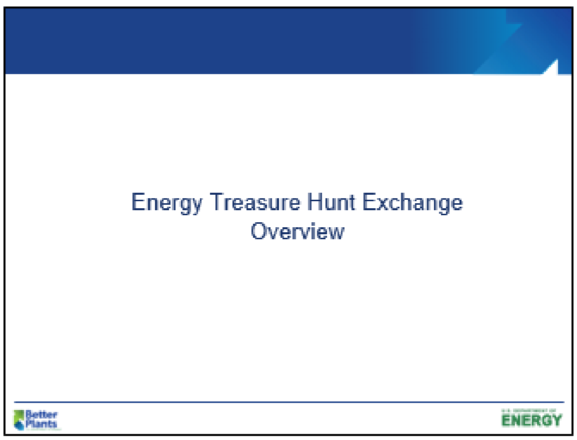
Process Equipment Data:

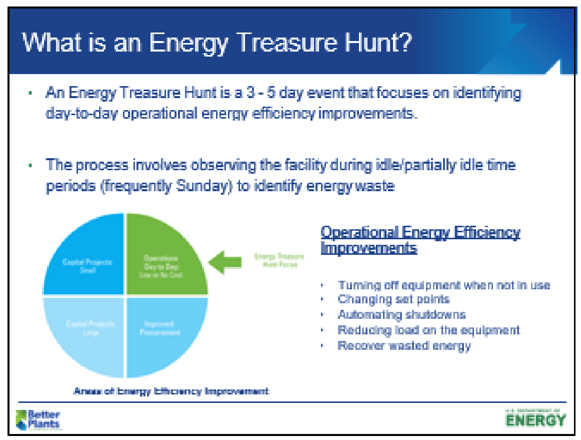
The table below provides a framework of the typical processes in a manufacturing plant, please feel free to add/remove processes from the list as per your facilities configuration.

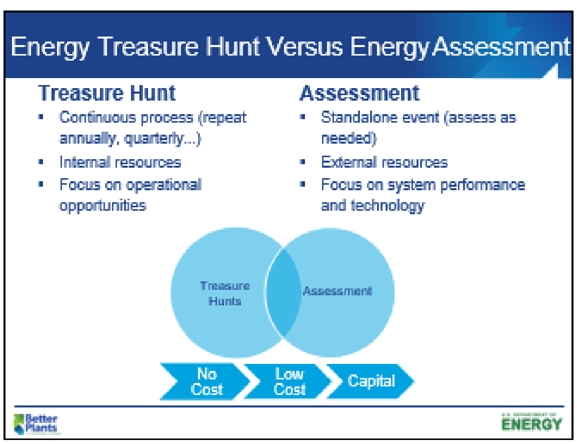
Process Equipment	Total Size	Estimated (Hrs/year)	Load Factor (%)	Additional Comments/information on the process
Incinerators				
Furnace 1				
Furnace 2				
Press 1				
Press 2				
Press 3				
Paint booth				
etc.				

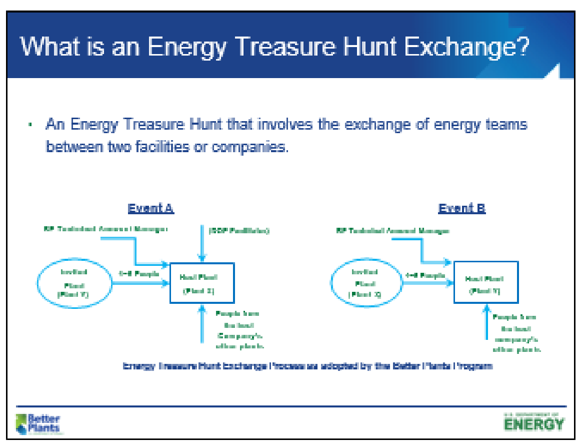
APPENDIX D. ENERGY TREASURE HUNT OPENING PRESENTATION TEMPLATE



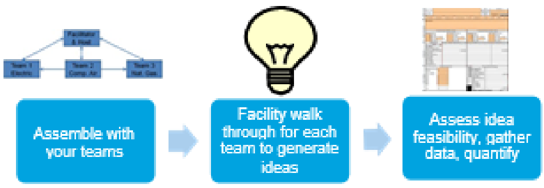








The Basic Mission



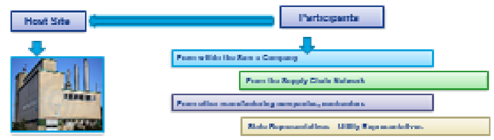
At the end of each day the teams brief each other on what they will pursue

Participant Overview – Energy Treasure Hunt

- All departments have a role to play in improving energy efficiency

  Successful energy programs are horizontal in an organization, not vertical

- Energy treasure hunt draw participants from across all operations and from outside the host facility.



Learning Objectives – All Participants

The event aims to educate all the participants on,

- What an energy treasure hunt exchange is, its value and benefits
- How to evaluate equipment energy use (both idle and non-idle times)
- How to identify equipment and process opportunities
- Methods for collecting energy data and common data collection tools
- How to effectively present outcomes of the treasure hunt

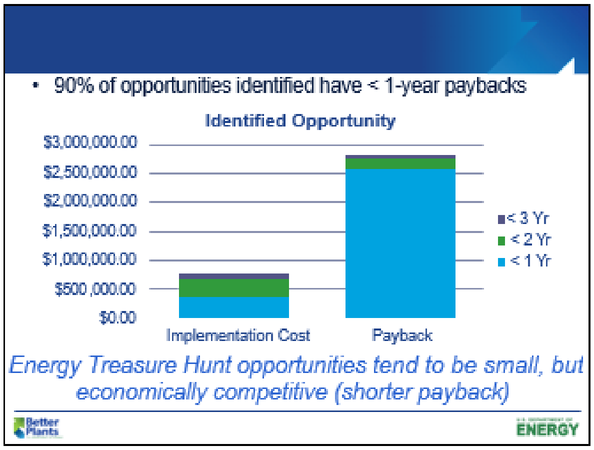
Learning objectives - Future Facilitators

- Treasure hunt facilitation
- How to select processes, plants, departments for treasure hunts
- Use of diagnostic tools and techniques
- The importance of Team makeup – processes and people
- Prioritizing energy-saving opportunities
- Replication across facilities, departments, business units
- Preparation of treasure hunt outcome for management

Advantages of a Treasure Hunt

- A Treasure Hunt Exchange encompasses both training and a "hunt"
  - Does not require sophisticated technical analysis
  - Calculations are (relatively) simple
  - Can be applied by employees of varying disciplines
  - Train selected participants to facilitate future treasure hunts
- A three-day activity – at completion, the facility has sufficient information to execute identified opportunities and an employee who can facilitate future treasure hunts within the organization
- Opportunities/ideas are solicited from many disciplines and can be replicated across similar processes and businesses
- The Treasure Hunt process can be replicated and repeated (through this training)

Some Stats on Energy Treasure Hunts



• 90% of opportunities identified have < 1-year paybacks
Identified Opportunity
$3,000,000.00
$2,500,000.00
$2,000,000.00
$1,500,000.00
$1,000,000.00
$500,000.00
$0.00
Implementation Cost
Payback
< 3 Yr
< 2 Yr
< 1 Yr
Energy Treasure Hunt opportunities tend to be small, but economically competitive (shorter payback)
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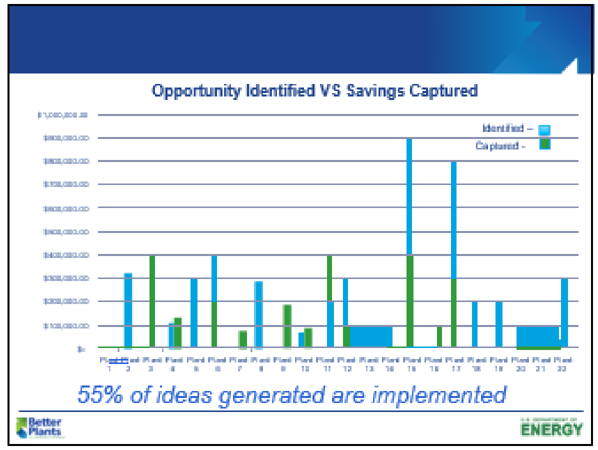

Opportunity Identified VS Savings Captured
Identified –
Captured -
55% of ideas generated are implemented
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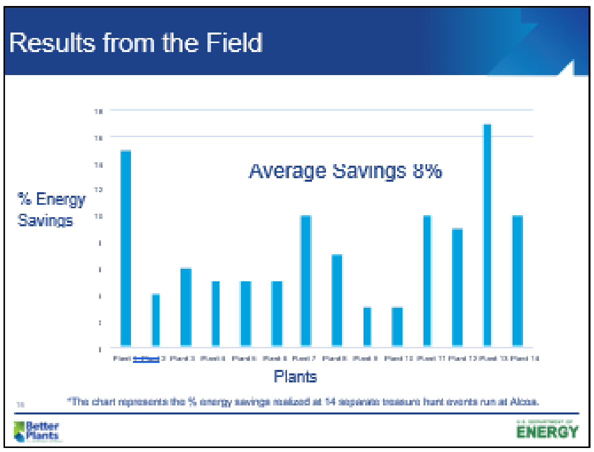

Results from the Field
Average Savings 8%
% Energy Savings
Plants
*The chart represents the % energy savings realized at 14 separate treasure hunt events run at Alcoa.
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Facility Information
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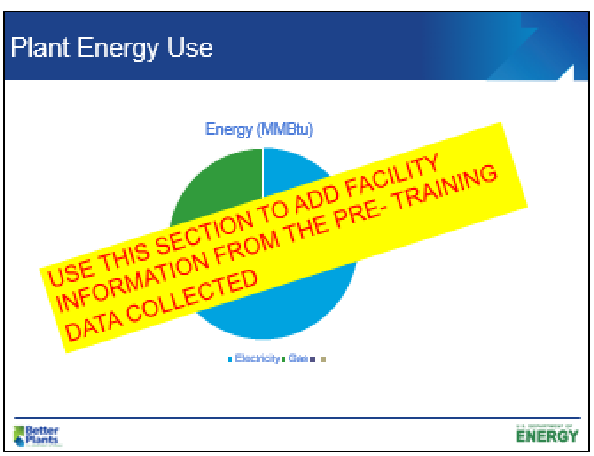

Plant Energy Use
Energy (MMBtu)
USE THIS SECTION TO ADD FACILITY INFORMATION FROM THE PRE- TRAINING DATA COLLECTED
Electricity
Gas
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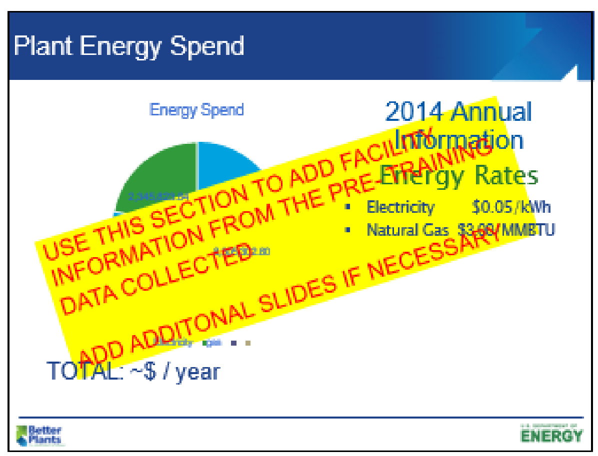

Plant Energy Spend
Energy Spend
2014 Annual Information
Energy Rates
Electricity $0.05/kWh
Natural Gas $3.00/MMBTU
USE THIS SECTION TO ADD FACILITY INFORMATION FROM THE PRE-TRAINING DATA COLLECTED
ADD ADDITONAL SLIDES IF NECESSARY
TOTAL: ~$ / year
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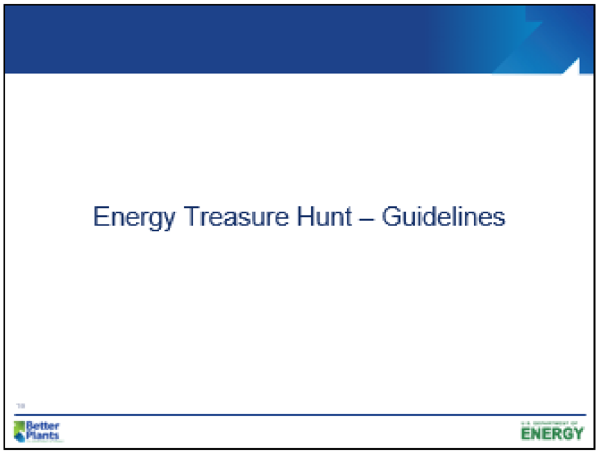

Energy Treasure Hunt – Guidelines
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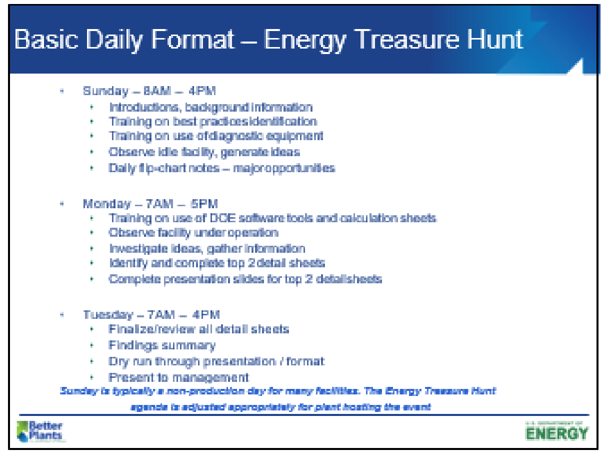

Basic Daily Format – Energy Treasure Hunt
Sunday – 8AM – 4PM
Introductions, background information
Training on best practices identification
Training on use of diagnostic equipment
Observe idle facility, generate ideas
Daily flip-chart notes – major opportunities
Monday – 7AM – 5PM
Training on use of DOE software tools and calculation sheets
Observe facility under operation
Investigate ideas, gather information
Identify and complete top 2 detail sheets
Complete presentation slides for top 2 detail sheets
Tuesday – 7AM – 4PM
Finalize/review all detail sheets
Findings summary
Dry run through presentation / format
Present to management
Sunday is typically a non-production day for many facilities. The Energy Treasure Hunt agenda is adjusted appropriately for plant hosting the event
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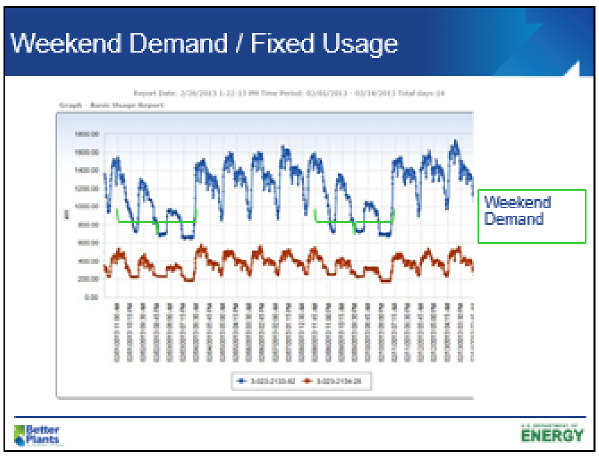

Weekend Demand / Fixed Usage
Graph - Basic Usage Report
Weekend Demand
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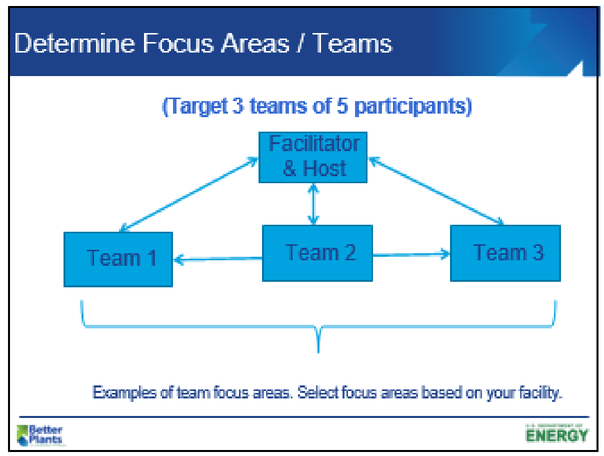

Determine Focus Areas / Teams
(Target 3 teams of 5 participants)
Facilitator & Host
Team 1
Team 2
Team 3
Examples of team focus areas. Select focus areas based on your facility.
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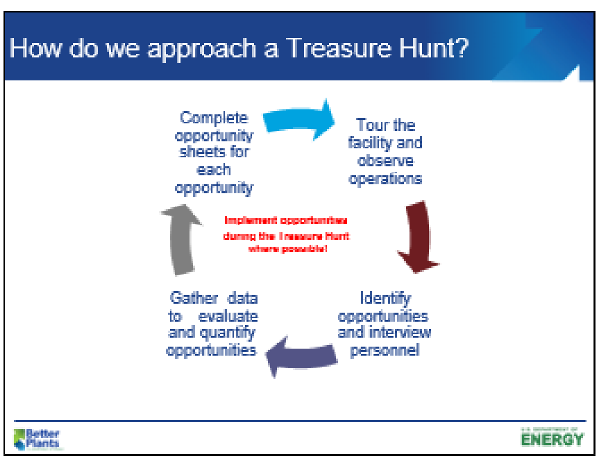

How do we approach a Treasure Hunt?
Complete opportunity sheets for each opportunity
Tour the facility and observe operations
Implement opportunities during the Treasure Hunt where possible!
Identify opportunities and interview personnel
Gather data to evaluate and quantify opportunities
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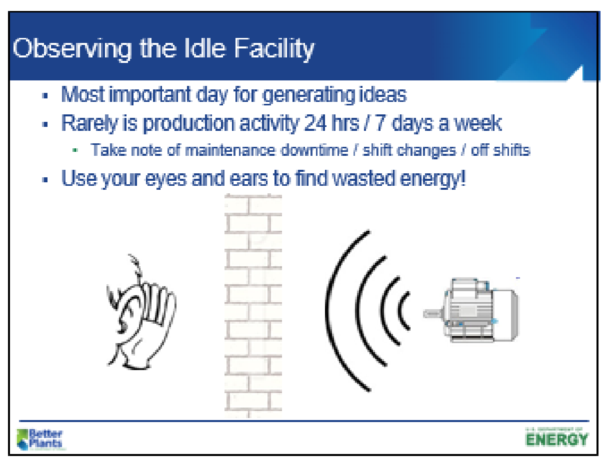

Observing the Idle Facility
Most important day for generating ideas
Rarely is production activity 24 hrs / 7 days a week
Take note of maintenance downtime / shift changes / off shifts
Use your eyes and ears to find wasted energy!
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Fixed vs. Variable Energy Usage

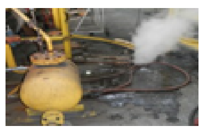
1) Control operating times
2) Automate shutdowns
3) Control temperature set points
4) Just in time operations

Typical Treasure Hunt opportunities – Lighting

- Turn off excess lighting where possible. During a treasure hunt, experiment by turning off lights and then measuring the available lumens.
- At infrequently occupied areas, Implement shut down procedures or install occupancy sensors.
- Identify unnecessary lighting. Robots do not need light to work.
- Retrofit lighting with more efficient technology.
- LED can save more on maintenance than energy in some applications.

Typical Treasure Hunt opportunities – Steam

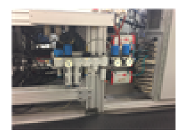
- General steam leaks
- Broken Steam Traps
- Condensate leaks
- Boiler Tune up
- Poor or missing insulation
- Building heat with poor control



Typical Treasure Hunt Opportunities – Compressed Air

- Operate at the lowest practical pressure set point
- Replace pneumatic energy with electrical energy where practical
- Evaluate high efficiency nozzles
- Eliminate inappropriate end use applications
- Optimize control strategy
- Perform a leak survey
- Install solenoid valves on open blowing
- No loss condensate drains

bag test on compressed air leaks!



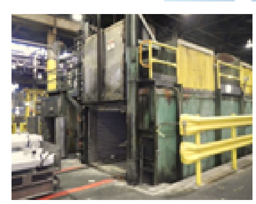
Typical Treasure Hunt opportunities - Exhaust

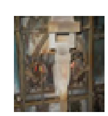
Exhaust systems frequently operate regardless of production requirements. Implement shut down procedures or automate shut down based on production processes.

- Fume hoods
- Scrubbers
- Dust collectors
- Extraction systems
- Chip collectors

Typical Treasure Hunt opportunities – Process Heating

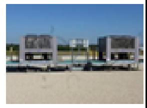
- Combustion tuning
- Combustion efficiency – burner upgrades, recuperators
- Poor furnace insulation
- Furnace shut downs / non-production management
  - Temperature set points
  - Recirculation fans / blowers
  - Minimize ramp up time
  - Excessive soak time



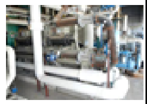


Typical Treasure Hunt opportunities – Cooling / HVAC

- Cooling Towers
  - Match tower capacity with process requirements
    - Less active cooling may be needed during night, colder seasons, and non-production
  - Check for throttled pumps / opportunities for VFD

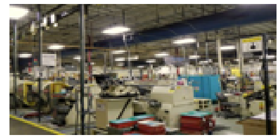


- HVAC / Makeup Air / Comfort Cooling
  - Use programmable thermostats to optimize cooling schedule
    - Particularly in non-24/7 areas such as offices, warehouses, partial production areas
  - Challenge temperature set points
  - Less makeup air may be needed during non-production, if possible, shut down a few units



Typical Treasure Hunt opportunities – Process Equipment

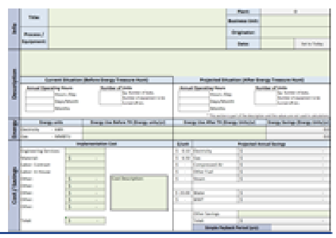
- Ensure auxiliary energy is minimized during non-production
  - Shut down lubrication pumps, valve off compressed air, consoles, lighting panels
- Production cells should have a shut-down procedure during idle time
- If the process is not a bottleneck in plant production, consider batch processing and avoid constant idle time waiting for product
- Optimize throughput
  - parts washers
  - cooling tables / fans
  - die heaters
  - Extrusion machines



Documentation using Opportunity Sheet

- An opportunity detail sheet is a tool that helps organize and document information about identified opportunities
- Each opportunity should have an individual "opportunity sheet"

Information captured
- Description
- Implementation costs
- **Energy Saved**
- Cost Savings
- Payback Metrics



Important instructions for opportunity sheets

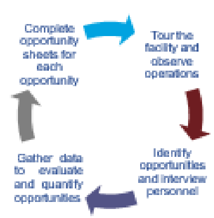
- Each team leader will be given a flash drive with a copy of a blank master opportunity sheet that is "read only"
- For each opportunity open up the master opportunity sheet and "save as" the title of the opportunity.
  - There will be a separate opportunity sheet for each opportunity your team identifies.
- User inputs on the opportunity sheet are marked by green cells– do not modify non-user input cells, this can break the macros embedded in the spreadsheet or modify important formulas
- You may append new blank worksheets or "tabs" in a detail sheet if you wish to do off sheet calculations or document further information

Useful Resources

Useful Resources

The following resources are made available to help participants with each step of the treasure hunt process

- Energy Calculators
  - To find "Energy Saved" for opportunity sheet
- Handouts
  - To help identify opportunity
- Diagnostic Equipment
  - To help collect accurate data



Energy Calculators

- To quantify the energy savings associated with an identified opportunity
- The results from the calculator are used to populate the opportunity sheets.

Two types of Energy Efficiency Calculators are available

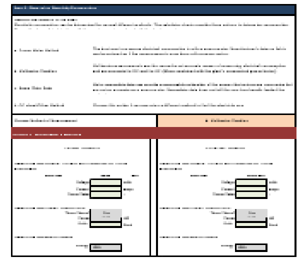
I. **Treasure Hunt Calculators**
   - To estimate the savings associated with typical operational opportunities, e.g. Scheduling the equipment, reducing the load on the equipment etc.

II. **Opportunity Specific Calculators**
   - Available for some common opportunities that can't be easily quantified using the treasure hunt calculator e.g. Insulation, lighting replacement etc.

Participants can use their own method or tool to quantify savings, however, the result of the calculation and description still needs to be captured in the standard opportunity sheet provided.

Treasure Hunt Calculators

- Each energy source (and water) has its individual Treasure Hunt Calculator
- All the treasure hunt calculators have three common steps
  - Step 1: Determining operational time each year
  - Step 2: Determine the rate of energy use
  - Step 3: Determining consumption.
- The calculators provide different ways to calculate "rate of energy use" depending on the energy source
- The calculators are designed for ease of use



Energy Treasure Hunt Calculator– Electricity

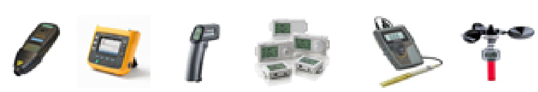
Energy Calculators - Suite

The following calculators are available as part of the toolkit and DOE is continuously working to improve the portfolio of calculators available.

- Compressed Air System
  - Compressed Air - Treasure Hunt Calculator
  - Compressed Air Leak - Calculator
  - Reduce Compressor Pressure - Calculator
- Electricity
  - Electricity - Treasure Hunt Calculator
  - Lighting Calculator
- Natural Gas
  - Natural Gas - Treasure Hunt Calculator
- Steam System
  - Steam - Treasure Hunt Calculator
- Water
  - Water - Treasure Hunt Calculator

Data Gathering Tools

- DOE provides energy diagnostic equipment and teaches the participants how to use them
- Helps participants evaluate equipment performance and quantify energy performance improvement more accurately



Handouts

- System specific handout sheets are provided by DOE to help participants identify and quantify energy savings opportunities.
- Three sets of handouts for each system type is available;
  - System Checklist
  - Data Collection Sheet
  - System Cheat Sheet
- **The handouts are not meant to be all encompassing**
- Participants should only use the handouts as a tool to get started and not solely rely on it

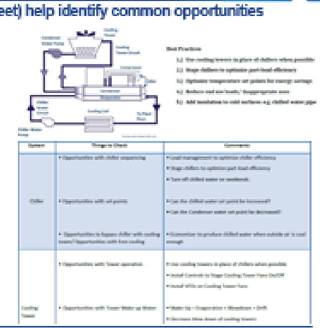
Handout 1 – System Checklist

Checklist (things to look for sheet) help identify common opportunities

- The handout provides a list of best practices
- Typical system schematic is provided wherever applicable
- A list of "things to check" is provided by system area

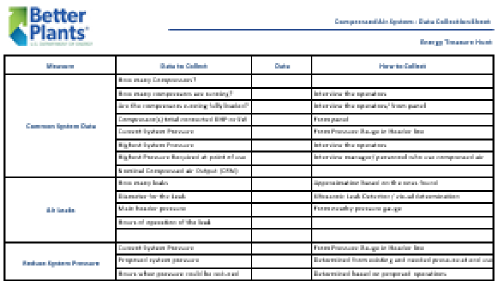
Checklist are available for

- Compressed air system
- Steam system
- Process heating system
- Chilled water system
- Pump and Fan system
- Lighting and
- Process Equipment



Handout 2 – Data Collection Sheets

Data Collection Sheet help collect the right data to quantify common opportunities



Compressed Air System : Data Collection Sheet

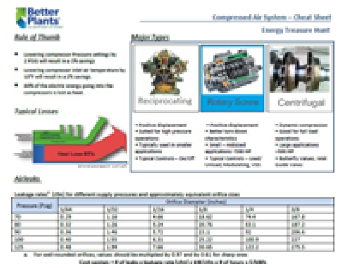
Energy Treasure Hunt

Measure	Data to Collect	Data	How to Collect
Common System Data	How many Compressors?		
	How many compressors are running?		Interview the operators
	Are the compressors running fully loaded?		Interview the operators/ from panel
	Compressor(s) total connected BHP or kW		From panel
	Current System Pressure		From Pressure Gauge in Header line
	Highest System Pressure		Interview the operators
	Highest Pressure Required at point of use		Interview managers/ personnel who use compressed air
	Nominal Compressed air Output (CFM)		
Air leaks	How many leaks		Approximation based on the ones found
	Diameter for the Leak		Ultrasonic Leak Detection / visual determination
	Main header pressure		From nearby pressure gauge
	Hours of operation of the leak		
Reduce System Pressure	Current System Pressure		From Pressure Gauge in Header line
	Proposed system pressure		Determined from existing and needed pressures at end use
	Hours when pressure could be reduced		Determined based on proposed operations

Handout 3 – System Cheat Sheets

Cheat Sheet help to quickly estimate savings associated with common opportunities

- Cheat Sheets provide common "Rule of Thumb" for a system
- Provide typical system performance information
- Help participants estimate savings associated with commonly identified opportunities



Summary

I. Walkthrough the facility and observe operations

II. Identify opportunities

III. Collect relevant data

IV. Quantify Savings

Leverage available Resources

V. Create Opportunity Sheet

Questions / Comments

Gather your teammates and head out!

APPENDIX E. CHECKLISTS

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Lighting System Check List

Energy Treasure Hunt

Best Practices

1.) Use motion sensors in seldom used area.
2.) Turn off fixtures that are blocked by obstructions
3.) Turn off/dim lights near windows/ skylights.
4.) Use photo sensors for outdoor lighting
5.) Determine required light leveland de-lamp
6.) Clean dirty and yellowed lenses
7.) Lower lights beneath scaffolding
8.) Add reflectors to fluorescentlights
9.) Look at LED replacement options
10) Add task lighting over critical areas and decrease general area lighting.

System	Things to Check	Comments
Indoor Areas – Lighting	• Opportunities with lighting levels/quality.	• Possibility for de-lamping/dimming. • IES has recommendations by area. • Add task lighting over critical areas and decrease general area lighting.
	• Opportunities with lighting replacement.	• Incandescent → LED/CFL, e.g. Exit signs • Metal Halide → LED; T12 → T8s fluorescents
	• Opportunities with burnt out lamps	• Remove /Replace
Indoor Areas - Controls	• Opportunity with areas that are infrequently occupied	• Candidate for motion/occupancy sensors
	• Opportunity with areas that have scheduled occupancy	• Candidate for timed switches.
	• Opportunity with areas that have ambient lights	• Are lights ON near the windows/skylight? → Photocells
Outdoors	• Opportunities with lighting replacement. • Opportunities with lighting controls.	• LED in place of HID lamps. • Photocell can be used to make the outdoor lights turn ON only when there is no sunlight.

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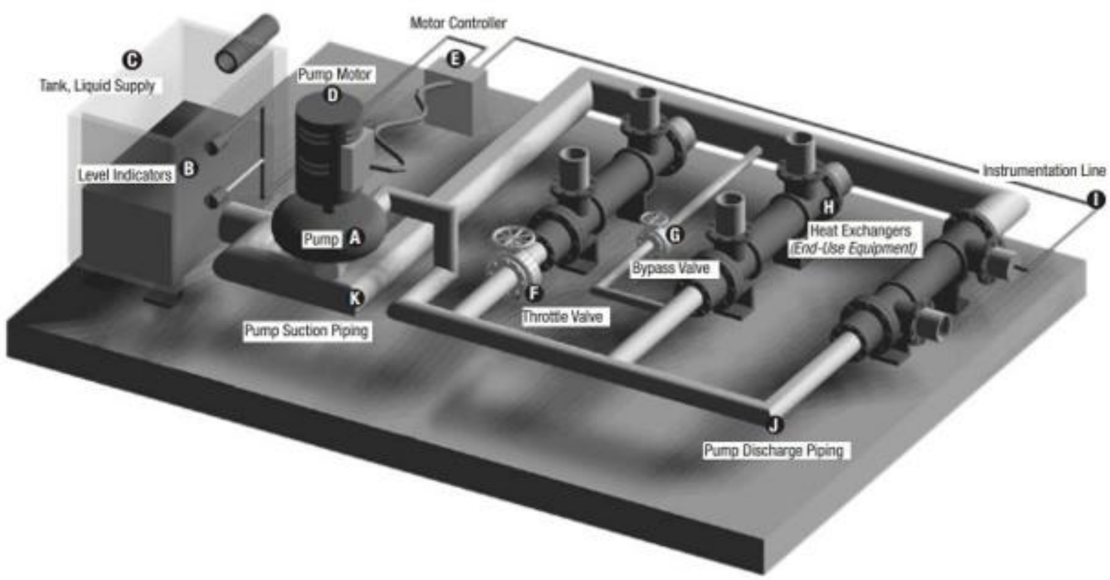
Pumps and Fan System Check List

Energy Treasure Hunt

Best Practices

1.) Turn off motors when not in use
2.) Size the motors correctly
3.) Use energy efficient motors
4.) Use cogged V belts or synchronous belt drives
5.) Trim impellers or use a VSD instead of using bypass or valves throttling (in cases of excess flow/oversized pumps)
6.) Use low head-loss fitting
7.) Reduce pipe/duct length and turns
8.) Reduce entrance/exit head loss
9.) Install variable speed drive (VSD)
10.) In intermittent operations, run motor slower and longer



System	Things to Check	Comments
Pumps and Fans	• Opportunity with motor sizing	• Oversized motors consume more energy • Look into resizing the motor or apply variable speed control
	• Opportunity with motor efficiency	• Are NEMA premium efficiency motors used? • Are the motors the right type for the application, e.g. totally enclosed vs. partially enclosed?
	• Opportunity with motor control	• Is the equipment controlled for flow or pressure? Any throttling? • Is there more flow than required to meet system requirements? → Higher flow requires more energy
	• Opportunity with scheduling	• Can the fan/blower be turned off or down during low production times? • Can fan/pump be cycled with production throughput?
	• Opportunity with degraded motors	• Are the motors worn out/eroded? → degraded equipment performance
	• Opportunity with optimizing pump flow	• Are pumps being run dead headed? • Suction problems – inadequate suction head, poor geometry, obstructions • Are there opportunities to reduce head? • Is re-circulation used instead of pump control?
System	• Opportunity with leaks	• Identify and fix air and water leaks
	• Are redundant units being run?	• Shut them down
	• Opportunity with optimizing duct/pipe sizing/flow paths	• Are there any unneeded flow paths? → More work needed to overcome friction losses • Is there sufficient distance between fan and the first elbow tee? Fans need piping to be 3 x diameter of the fan blade before the first elbow tee to avoid system effect.

Best Practices

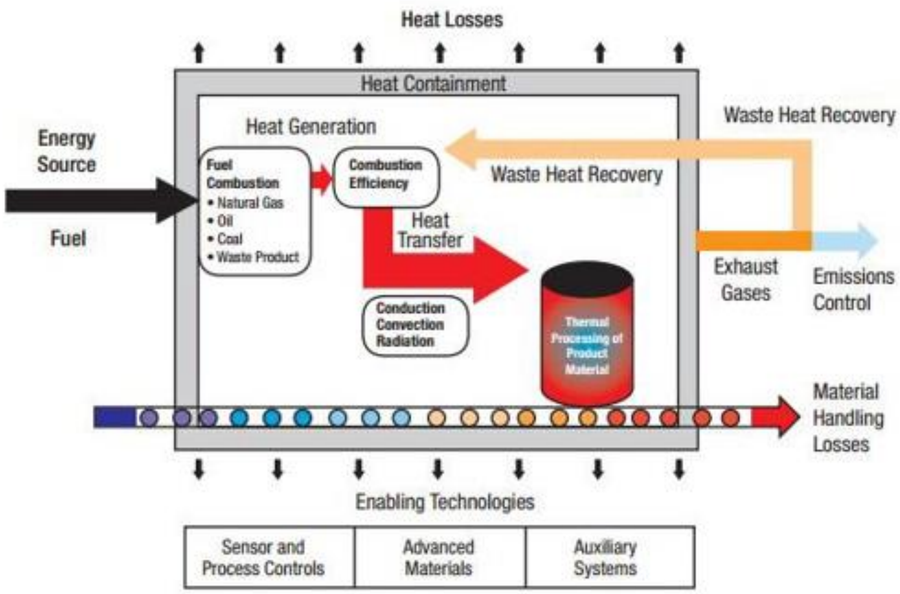
1.) Optimize oxygen level in flue (exhaust) gases or optimize combustion burner air-fuel ratio

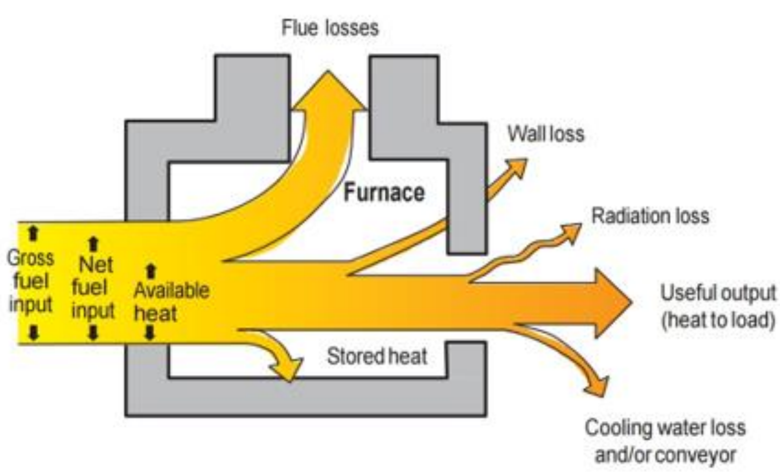
2.) Reduce/eliminate openings and air leakage in the furnace

3.) Furnace scheduling, loading, shut down - avoiding delays, waits, cooling between operations, etc.

4.) Clean heat transfer surfaces - radiant tubes, heat exchangers, heater tubes, electrical heating elements

5.) Use of flue or exhaust gas heat for combustion air preheating or waste heat recycling





Component	Things to Check	Comments
Heat Generation	• Combustion air leakage • Opportunities with Fuel/Air ratio	• Does the combustion air leak downstream of control valve? • Linkage condition can lead to poor control of the fuel/air mixture over the range of operating conditions. • Excess oxygen in the furnace exhaust gases indicates unwanted excessive air • Flame un-stability indicates improper fuel/air control
Heat Containment	• Reduce Heat Losses • Opportunities with insulation • Opportunities with Waste Heat recovery	• Higher than necessary operating temperature leads to increased losses • Reduce/eliminate openings and air leakage in the furnace • Clean heat transfer surfaces • Insulate associated piping to avoid sagging and distortion. • Is the furnace properly insulated? Any cracks/holes? • What is the temperature of the exhaust? • Can the heat from the exhaust be recovered and used?
Enabling Technology	• Opportunities with furnace operation/scheduling • Opportunities with material handling	• Is there frequent and avoidable furnace starts and stops? • Are there long periods of idle time between batches? • Are there extended periods of low-capacity furnace operation? • Is batch production possible? • Can the conveyors be stopped during non-production? • Can the weight of the fixtures be reduced/alternate fixtures removed? • What is the temperature of the components going out? • Can heat be recovered from the components?

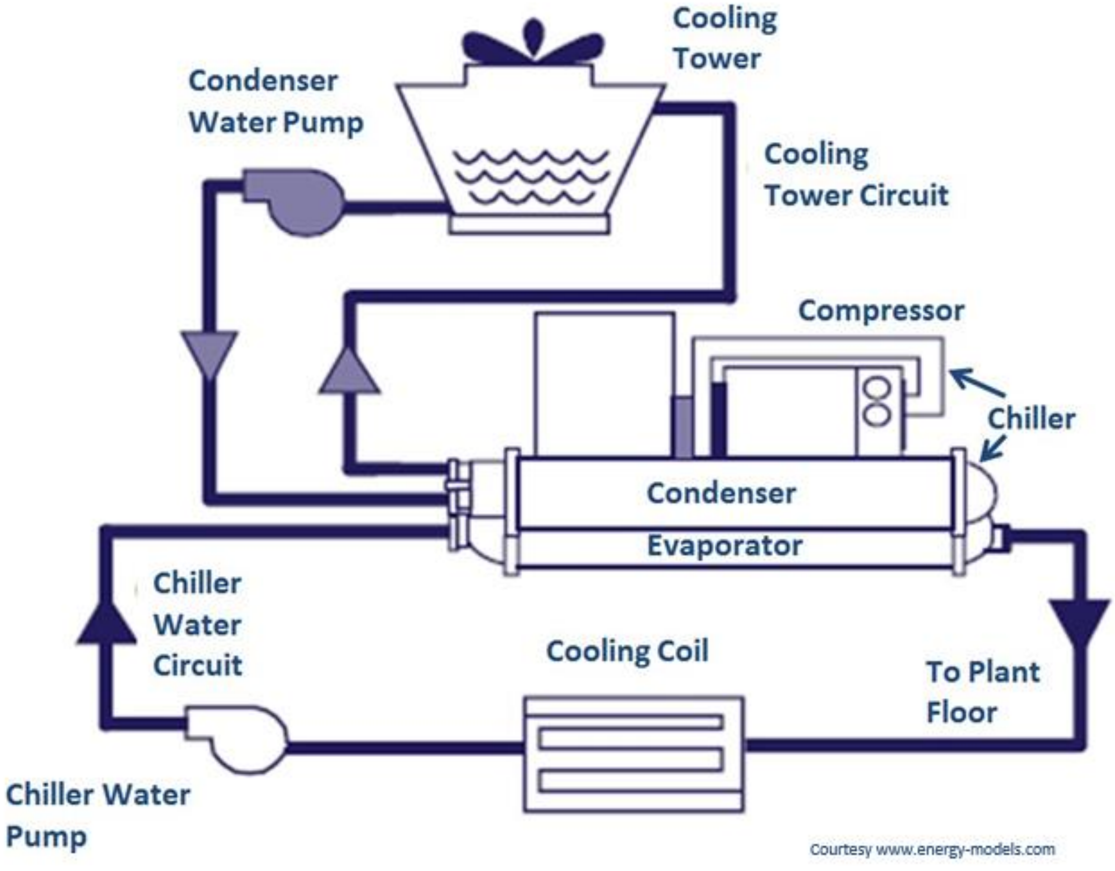
For more info – Improving Process Heating System Performance – A Sourcebook for Industry, 3rd Edition.

Chilled Water System Check List

Energy Treasure Hunt

Best Practices

1.) Use cooling towers in place of chillers when possible
2.) Stage chillers to optimize part-load efficiency
3.) Optimize temperature set points for energy savings
4.) Reduce end use loads/Inappropriate uses
5.) Add insulation to cold surfaces e.g. chilled water pipe
6.) Employ Floating Head Pressure Control
7.) Improve heat exchanger effectiveness
8.) Stage operation of cooling tower fan
9.) Employ variable-speed pumping
10.) Install VFDs on Cooling Tower Fans

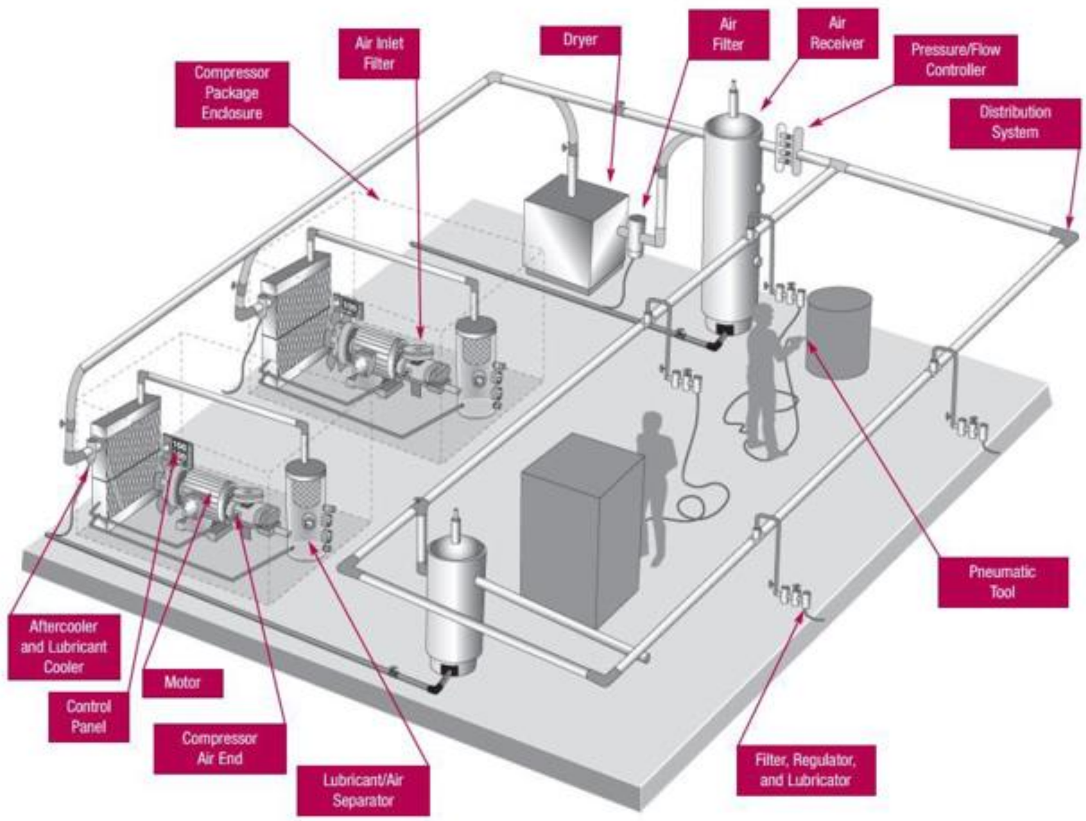


Courtesy www.energy-models.com

System	Things to Check	Comments
Chiller	• Opportunities with chiller sequencing	• Load management to optimize chiller efficiency. • Stage chillers to optimize part-load efficiency • Turn off chilled water on weekends.
	• Opportunities with set points	• Can the chilled water set point be increased? • Can the Condenser water set point be decreased?
	• Opportunities to bypass chiller with cooling tower/Opportunities with free cooling	• Economizer to produce chilled water when outside air is cool enough
Cooling Tower	• Opportunities with Tower operation	• Use cooling towers in place of chillers when possible • Install Controls to Stage Cooling Tower Fans On/Off • Install VFDs on Cooling Tower Fans
	• Opportunities with Tower Make-up Water	• Make-Up = Evaporation + Blowdown + Drift • Decrease blow down of cooling towers • Conductivity controller to automatically control blowdown • Water treatment opportunities • Opportunities with evaporation
Distribution and End use	• Opportunities with pumping	• Sequence pumps using appropriate controls
	• Interfacing chilled water use to production	• Turn off when no parts are present
	• Reduce end use loads	• Reduce set points during non-production hours • Add heat exchangers between heated and cooled processes
	• Opportunities with insulation	• Add or repair mechanical insulation
	• Inappropriate uses of chilled water	• Is chilled water recirculated when it could be shut off?

Best Practices

1.) Fix Air Leaks
2.) Reduce Compressor Discharge Pressure
3.) Restrict compressed air flow on weekends
4.) Automate compressor shut off when not needed
5.) Switch pneumatic tools to electronic mechanical tools
6.) Remove Inappropriate Uses
7.) Install sufficient Storage & stabilize system
8.) Use VFD machine for trimming
9.) Use no loss condensate drain
10) Reduce Blow-off in centrifugal compressor

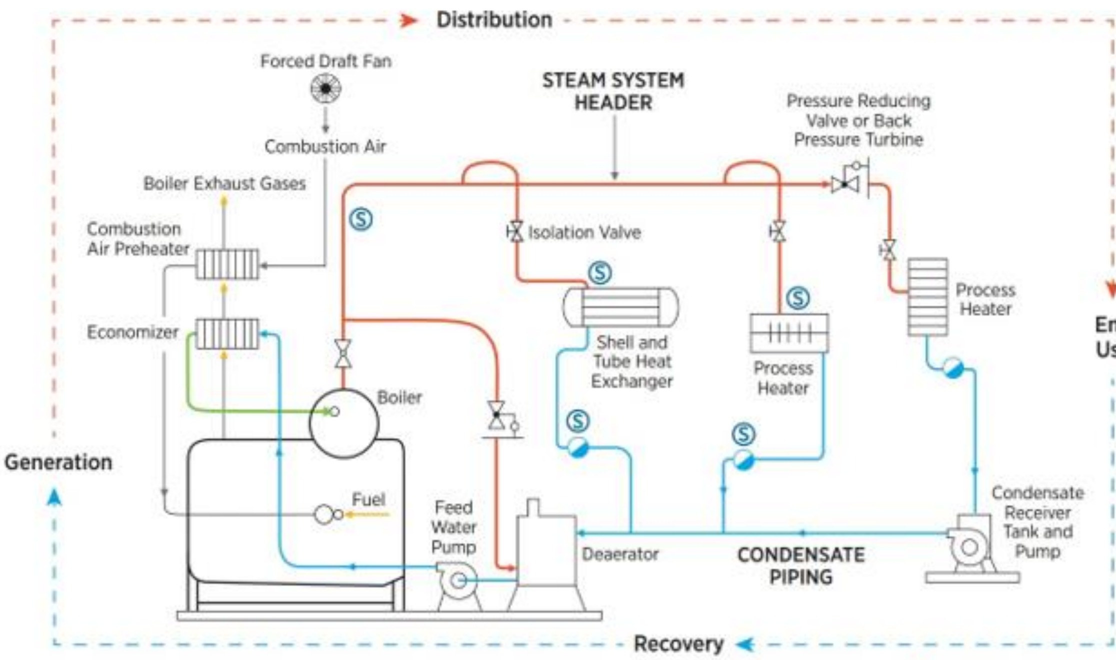


Components of a Typical Industrial Compressed Air System.

System	Things to Check	Comments
Compressor Room	• Opportunities with compressor controls	• Turned off/down compressor during weekend/between shifts? • Automatic turnoff based on timer • Use control scheme optimized for given load
	• Opportunities with optimizing compressor discharge pressure	• Pressure drop across the filters/dryer acceptable? Typical 3-5 PSI • Minimize pressure drop & reduce compressor discharge pressure leads to energy savings • What is the system pressure and what is the required pressure at end use? • Energy decreases by 1% for every 2-3 PSI discharge pressure decrease
	• Heat recovery Opportunities	• 80% of compressor energy is dissipated as heat. • Can we use this for space heating or process heating needs?
	• Opportunities with compressor sequencing (multi compressor system)	• Is the VFD used on the trim compressor? • Programmable Logic Control (PLC)-based multi-compressor controls can be used to sequence based on given load.
Compressed Air System	• Compressed air storage	• Does the system have the necessary air storage?
	• Opportunity for no loss condensate drain	• Zero loss drain separate condensate(water) without air loss
	• Air leaks	• Is there a program to fix leaks?
End Use	• Interfacing air use to process line	• Turn off when no parts are present
	• Opportunities with how compressed air used in the process	• Solenoid valves can shut off unnecessary air • Are there any unregulated end uses that could benefit from vortex nozzles or FRLs? • Are there any inappropriate uses of compressed air? Example: Personnel cooling, using air to move parts, open blowing, cabinet cooling, padding, mixing, agitation.

Best Practices

1.) **Reduce Steam demand and pressure**
2.) **Optimize Fuel/Air Ratio**
3.) **Fix Steam Traps**
4.) **Insulate Pipes and Tanks**
5.) **Recover condensate/flash steam and capture water & heat**
6.) **Preheat boiler feed water**
7.) **Install automated blowdown controls**
8.) **Optimize deaerator vent rate**
9.) **Adjust steam system based on production**
10) **Identify and close off dead legs (unused to sections of steam header)**



Steam System Schematic

System	Things to Check	Comments
Individual Boilers	• Opportunity with Boiler efficiency • Opportunity with Blowdown • Opportunity with scheduling	• Are the boilers operating efficiently? When was the last time boiler tune-up was done? (boiler tune up should include minimizing excess air, cleaning boiler heat transfer surfaces, and improving fuel/air ratio control) • Automated blowdown results in lesser water wastage • Improving feed water treatment can also avoid excessive blowdown • Is heat recovery from boiler blowdown possible? • Can boiler be turned off on weekends? • Can we reset pressure back during weekends/non-production?
Boiler System	• Opportunities with system optimization • Automated stack dampers • Combustion air temperature • Feed water temperature	• Can we sequence the boilers so that the boiler operates in higher load? Boilers on high fire operate more efficiently • Stack dampers reduce losses • Hotter the combustion air, lesser work on boiler Possible to direct warmest air to combustion intake? • Hotter the feed water, lesser the work on boiler • Can the feed water be pre-heated from blowdown or exhaust?
Distribution System	• Opportunity with header pressure • Opportunity with dead legs • Recover steam for low-pressure applications • Steam leaks • Un-insulated lines/ Tanks • Steam Trap Failure	• Can boiler header pressure be reduced? • Closing off dead legs can reduce the amount of steam needed • Install back-pressure turbines instead of Pressure reducing valves (PRVs) • Steam Leaks, un-insulated steam lines/condensate lines/flash tanks; all result in energy being lost. • Failed open traps have significant energy losses.

Best Practices

1.) Slow the process equipment during low production

2.) Switch off auxiliary process equipment during idle time

3.) Eliminate inappropriate uses of compressed air in machine lines

4.) Optimize control set points

5.) Waste Heat recovery

Any recommended changes to production must involve discussion and agreement with production leaders

System	Things to Check	Comments
Production Line - General	• Opportunities with scheduling the production line during non-production	• Can the equipment be turned off during breaks? • Is the equipment turned off right after the end of the shift? Can the warm up time be reduced?
	• Opportunities during periods of low load/ idle time	• Can the equipment be slowed down when production is low? • Is batch production possible?
	• Opportunity with set points. (Temperature/ pressure etc.)	• Is it possible to change the min/max set point requirements to save energy?
	• Waste Heat Recovery opportunities	• Is there wasted energy that can be recovered or reused?
	• Opportunities with system optimization	• What is the overall system requirement? Operate 2 pieces of equipment at 80% instead of 1 at 40%? • Are there any gaps in the production line that can be shortened/eliminated (where a product can lose heat)
Production Line – Auxiliary Equipment	• Opportunities with auxiliary equipment control	• Are exhaust systems/steam supply/water supply inter-locked with production as opposed to running continuously
	• Opportunities with auxiliary equipment scheduling	• Can pumps, agitators, etc. be pulsed rather than run full time? Throttling of fluid flow? • Heaters left on during idle time
	• Compressed air inappropriate use in production	• E.g. Compressed air used to move parts/personnel cooling

APPENDIX F. DATA COLLECTION SHEETS

Better Plants U.S. DEPARTMENT OF ENERGY

Lighting System - Data Collection Sheet

Energy Treasure Hunt

Measure	Data to Collect	Data	How to Collect
Common System Data	Average hours of office Lighting		From Schedule if automated/Interview
	Average hours of floor Lighting		From Schedule if automated/Interview
	Average Lumens level in Office Spaces		From light meter
	Average Lumens level in manufacturing floor		From light meter
	Existing Control Strategy in Offices		Interview with plant personnel
	Existing Control Strategy on the Floor		Interview with plant personnel
	Daylighting potential, e.g. windows, skylights		Interview with plant personnel
Lighting Replacements 1 (Location -)	Existing type of lights		Fixture label/See Cheat Sheet
	Number of Fixture		Physical counting/From lighting plans
	Wattage of Fixture (including ballast)		Fixture label/Reference table online
	Hours of Operation		From Schedule if automated/Interview
	Wattage of Proposed fixture		Specification Sheets - Available Online
Turn Off Lights (Location -)	Existing Type of lights		Fixture label/See Cheat Sheet
	Number of Fixture to be turned off		Physical Counting/From lighting plans
	Wattage of Fixture (including ballast)		Fixture label/Reference table online
	Existing Hours of Operation		From schedule if automated/Interview
	Proposed Hours of Operation		Specification Sheets - Available Online
De-lamp Lights (Location -)	Existing Type of lights		Fixture label/See Cheat Sheet
	Number of Fixtures		Physical Counting/From lighting plans
	Number of lamps per fixture		Physical Counting
	Number of lamps to be de-lamped per fixture		Based on the amount of excess lighting levels
	Existing Wattage of Fixture (including ballast)		Fixture label/ Reference table online
	Wattage of Fixture (including ballast) upon de-lamping		Calculate from percent de-lamped
	Existing Hours of Operation		Interview with plant personnel
Occupancy Sensors (Location -)	Existing Type of lights		Fixture label/See Cheat Sheet
	Number of Fixture to be on Sensor		Physical Counting/From lighting plans
	Wattage of Fixture (including ballast)		Fixture label/Reference table online
	Existing Hours of Operation		From Schedule if automated/Interview
	Proposed Hours of Operation		Interview with plant personnel
	Number of Occupancy sensor		Good judgement

Better Plants U.S. DEPARTMENT OF ENERGY

Pumps/Fans System - Data Collection Sheet

Energy Treasure Hunt

Measure	Data to Collect	Data	How to Collect
Pumps - Common System Data	Condition of seals & impeller		Visual inspection
	Condition of piping (leaks, friction & cavitation)		Visual inspection
	Amount of static and dynamic head		Name Plate/Interview operators
	Suction pressure & discharge pressure		Pump gauges
	Size of pumps relative to load		
	Pumping system controls		Interview operators
Turn off fan/pump motor when possible 1	Motor Location/System it's used in		
	Motor Rating		Name Plate
	Percent Load (%)		Interview the operators
	Nameplate Efficiency		Name Plate
	Current operating hours per year		Interview the operators
	Proposed operating hours per year		Determined based on proposed operations
Turn off fan/pump motor when possible 2	Motor Location/System it's used in		
	Motor Rating		Name Plate
	Percent Load (%)		Interview the operators
	Nameplate Efficiency		Name Plate
	Current operating hours per year		Interview the operators
	Proposed operating hours per year		Determined based on proposed operations
Belt Replacement (notched belt)	Motor Location/System it's used in		
	Motor Rating		Name Plate
	Nameplate Efficiency		Name Plate
	Current operating hours per year		Interview the operators

Better Plants U.S. DEPARTMENT OF ENERGY

Chilled Water System - Data Collection Sheet

Energy Treasure Hunt

Measure	Data to Collect	Data	How to Collect
Common System Data	How many Chillers?		
	How many Chillers are running?		Interview the operators
	Chillers Capacity(s) HP or kW		From panel/Nameplate
	Cooling Tower Size		From panel/Nameplate
	Current Chilled Water Temperature Pressure		From temperature Gauge on chilled water side
	Current Condenser Water Temperature Pressure		From temperature Gauge on condenser water side
	Lowest Temperature Required at floor		Interview operators who run equipment that use chilled water
	Is the system closed or open loop?		Interview operators who run equipment that use chilled water
Reduce/Setback Chilled water Temperature	Current setpoint Temperature		From temperature Gauge on chilled water side
	Proposed setpoint Temperature		Determined from existing and needed temperature at end use
	Hours when pressure could be reduced		Determined based on proposed operations
Increase Condenser Temperature	Current setpoint Temperature		From temperature Gauge on condenser water side
	Proposed setpoint Temperature		Determined from existing and needed temperature at end use
	Hours when pressure could be reduced		Determined based on proposed operations

Compressed Air System - Data Collection Sheet

Energy Treasure Hunt

Measure	Data to Collect	Data	How to Collect
Common System Data	How many compressors?		
	How many compressors are running?		Interview the operators
	Are the compressors running fully loaded?		Interview the operators/from panel
	Compressor(s) total connected BHP or kW		From panel
	Current System Pressure		From Pressure Gauge in Header line
	Highest System Pressure		Interview the operators
	Highest Pressure Required at point of use		Interview manager/personnel who use compressed air
	Nominal Compressed air Output (CFM)		From panel
Air Leaks	How many leaks		Approximation based on the ones found
	Diameter for the Leak		Ultrasonic Leak Detector/visual determination
	Main header pressure		From nearby pressure gauge
	Hours of operation of the leak		
Reduce System Pressure	Current System Pressure		From Pressure Gauge in header line
	Proposed system pressure		Determined from existing and needed pressure at end use
	Hours when pressure could be reduced		Determined based on proposed operations
Use Blower instead of compressed air	Location		
	Inappropriate operation		Open blow-off, air, motor, etc.
	Main header pressure		From nearby pressure gauge
	Hours of operation of the blower		Interview manager/personnel who use compressed air
	Diameter of the blower orifice		Using suitable tool/method
Waste heat recovery	Compressor Size		Name Plate
	Area of waste heat use		Space heating? At process?
	Average power drawn by compressor		Digital Panels on compressor, data logging, spot measurement
	Average hours of operation of the compressor		Digital Panels on compressor, data logging, spot measurement
Lossless Drain	Purge Time		Timer
	Cycle Time		Timer
	Number of Drains		
	Type of existing drain & performance		Interview operators
	Pressure		From nearby pressure gauge
	Diameter of drain orifice		Scale/approximation
	Operating Hours		Operating hours of compressor system

Steam System - Data Collection Sheet

Energy Treasure Hunt

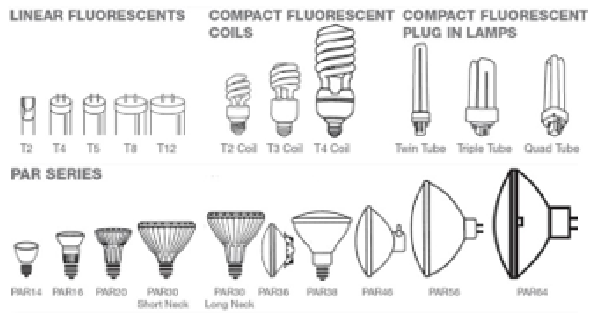
Measure	Data to Collect	Data	How to Collect
Common System Data	How many boilers?		
	How many boilers are running?		Interview the operators
	Boiler capacity(s) (BTU or lbs./hour)		From panel
	Total generation capacity (lbs./hour)		From panel
	Average steam generation rate (lbs./hour)		From panel
	Average boiler blowdown rate		Interview the operators
	Current System Pressure		From pressure gauge in header line
	Highest Pressure on header		Interview the operators
	Highest Pressure Required at floor		Interview manager/personnel on the floor
	Stack Temperature		
Steam Leaks	How many leaks/defective traps		Approximation based on the ones found
	Diameter of the leak		Ultrasonic Leak Detector/visual determination
	Pressure on line		From nearby pressure gauge
	Hours of operation of the leak (or boiler)		
Reduce System Pressure/ Pressure Setback	Current System Pressure		From pressure gauge in header line
	Proposed system pressure		Determined from existing and needed pressure at end use
	Hours when pressure could be reduced		Determined based on proposed operations
Waste heat recovery	Boiler size		Name Plate
	Area of waste heat use		Combustion Air? At process?
	Average stack temperature		Digital panels, data logging, spot measurement
	Average hours of operation of the boiler		Digital panels, data logging, spot measurement

APPENDIX G. CHEAT SHEETS

Better Plants®
U.S. DEPARTMENT OF ENERGY

Lighting System – Cheat Sheet
Energy Treasure Hunt

Identifying Lighting Types



LED Options

LED Fixtures – Lamp + Fixture

LED Retrofits – Lamp to fit into existing fixture

Lighting Level Recommendations by IES

Offices	Foot-candles	Assembly	Foot-candles	Electronic Manufacturing	Foot-candles
Drafting	50-200	Rough Easy seeing	25-50	Impregnating	20-50
General/private offices	50-100	Rough difficult seeing	50-100	Insulating coil windings	50-100
Conference Areas	20-70	Medium	100-200	**Sheet Metal Works**	**Foot-candles**
Corridors, Stairways	20	Fine	200-500	General	100
Lobbies, lounges	0-20	Extra Fine	500-1000	Galvanized, inspection	100-200
Automobile Manufacturing	**Foot-candles**	**Machine Shop**	**Foot-candles**	**Warehousing/ Storage**	**Foot-candles**
Final assembly, finishing	200	Medium bench, rough grinding, buffing	50-100	Inactive	5-10
Body assembly	100	Rough bench	20-50	Active – Rough bulky	10-20
Body manufacturing	100	Fine bench and work	200-500	Active – Medium	20
Frame assembly	50	Welding	20-50	Active – Fine	20-50

Lighting Controls

Dimmers:
To provide variable indoor lighting.
Occupancy sensors:
To turn on/off lights based on activity in light levels.
Photo sensors:
To turn on/off lights based on ambient light levels.
Timers:
To turn on and off lights at specific times.

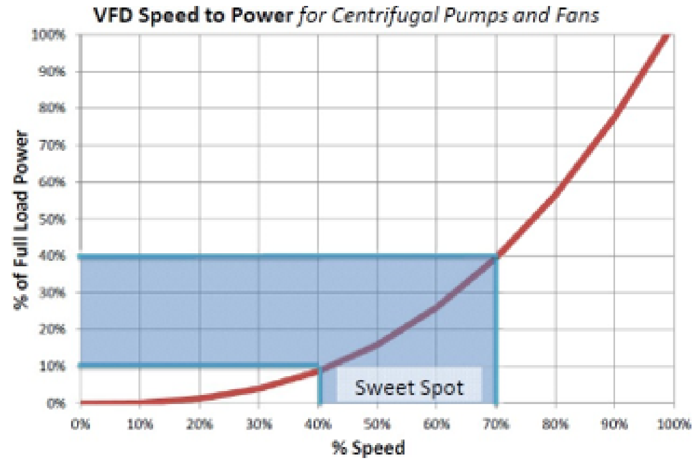
Tips

- Make use of lighting plans to get the count of lights
- De-lamping is an easy way to reduce lighting levels and energy use
- LED retrofits (available are all applications) are cheaper than LED fixtures
- Leverage sky lighting

Centrifugal Fan and Pump VFD Power Relationship

% Loading	Cycling % Power	VFD % Power
110%	100%	133%
100%	100%	103%
90%	90%	78%
80%	80%	56%
70%	70%	39%
60%	60%	26%
50%	50%	16%
40%	40%	9%
30%	30%	4%
20%	20%	1%
10%	10%	0%
0%	0%	0%

VFD inverter efficiency ~ 97%



* *Avoid running VFDs fully loaded by setting maximum speed to ≤90%.*

Affinity Laws	Flow ∝ Speed Flow ∝ Speed^2 Flow ∝ Speed^3
Real World	%Power = (%Speed)$^{2.7}$

Conversion Factors

$$1\ l/s = 15.85\ GPM,\ 1\ l/s = 2.12\ CFM$$
$$1\ psi = 2.31\ ft\ w.g.,\ 1\ psi = 27.7\ in\ w.g.$$
$$1\ hp = 0.746\ kW$$

Calculating kWh

$$Pump\ BHP = \frac{GPM \times Head\ (ft\ w.g.)}{3960 \times Efficiency}$$

$$Fan\ BHP = \frac{CFM \times SP\ (in.w.g)}{6356 \times Efficiency}$$

$$kW = \frac{Brake\ Horsepower \times 0.746}{Motor\ Efficiency}$$

$$kW = \frac{Amp \times Volt \times \sqrt{3} \times Power\ Factor}{1{,}000}$$

Motor Efficiency and Power Factor

Motor Name Plate (HP)	Standard Efficiency	Premium Efficiency	Approx. Power Factor
1	74	82	0.62
5	84	90	0.70
10	87	91	0.73
25	90	93	0.77
50	91	94	0.80
100	92.2	94.7	0.82
250	93.3	95.2	0.85
500	94.0	95.5	0.91
1000	94.5	95.7	0.92

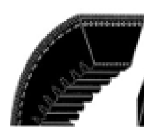
Consideration Criteria for VFD

- **High Horse power** (>15 hp)
- **Long operating hours** (>2000 hrs)
- Loads that could benefit from **soft start/shut-off capability**
- Loads with **variable torque requirements**

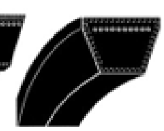
Power Transmission

Coupling Type	Efficiency
Gear Drives	55%-98%
Standard V-Belt	~92%
Notched V-Belt	~95%
Synchronous Belt	~98%
Direct Shaft Coupling	100%

Notched V-Belt



Standard V-Belt



Rules of Thumb

- **Air-Fuel Ratio**: For most systems 2- 3% of oxygen with a 10-50 ppm combustible indicates ideal operating conditions
- **Preheated Combustion Air**: Processes operating above 1600°F are generally good candidates for air preheating

Percent Fuel Savings gained from Preheated Combustion Air

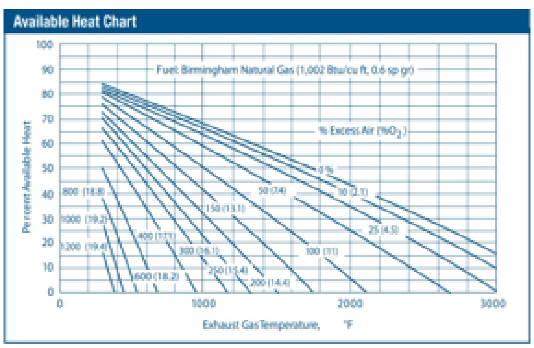
Furnace Exhaust Temperature, °F	Preheated Air Temperature, °F					
	600	800	1,000	1,200	1,400	1,600
1,000	13	18	–	–	–	–
1,200	14	19	23	–	–	–
1,400	15	20	24	28	–	–
1,600	17	22	26	30	34	–
1,800	18	24	28	33	37	40
2,000	20	26	31	35	39	43
2,200	23	29	34	39	43	47
2,400	26	32	38	43	47	51

Efficiency Reduction caused by soot deposits

Soot Layer Thickness		
1/32 inch	1/16 inch	1/8 inch
2.5%	4.5%	8.5%

Savings obtainable by tuning burner air-gas ratio

Available Heat Chart



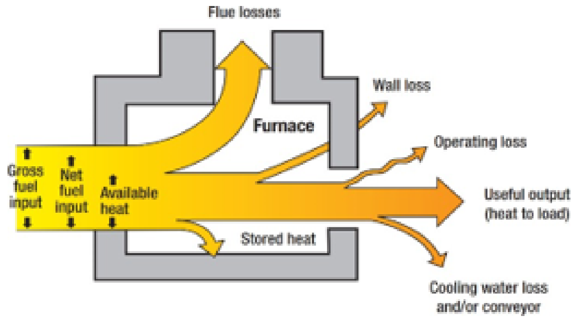
Determine the available heat under present and desired conditions by reading up from the flue gas temperature to the curve representing the excess air or O_2 level; then, read left to the percentage available heat (AH)

$$\% \textbf{ Fuel Savings} = 100 \times \frac{\% \textbf{ AH}_{\textbf{Desired}} - \% \textbf{ AH}_{\textbf{Actual}}}{\% \textbf{ AH}_{\textbf{Desired}}}$$

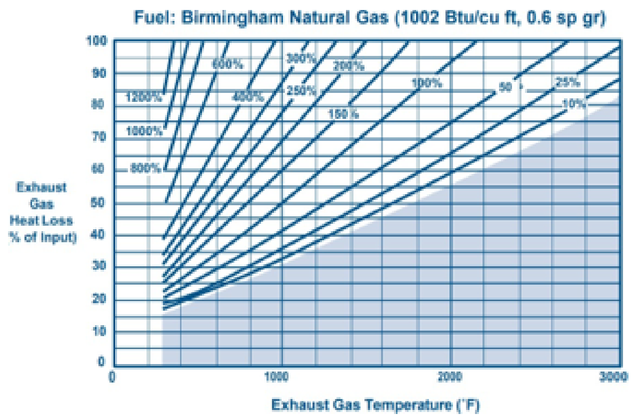
Potential applications of oxygen-enhanced combustion

Industry	Applications
Steel	Reheat, soaking pits, ladles
Aluminum	Melting
Copper	Smelting and melting
Glass	Melting
Pulp and Paper	Lime kilns, black liquor boilers
Petroleum	Process heaters, crackers
Power Production	Coal-fired steam boilers
Chemical	Sulfur

Energy loss diagram in a fuel-based process heating system



Heat lost in exhaust gases @ various exhaust gas temperatures and percentages of excess air



Commonly used waste heat management systems by temperature range

Ultra-High Temperature (>1600°F)	High Temperature (1200°F to 1600°F)	Medium Temperature (600°F to 1200°F)	Low Temperature (250°F to 600°F)	Ultra-Low Temperature (< 250°F)
• Refractory (ceramic) regenerators • Heat recovery boilers • Regenerative burners • Radiation recuperator • Waste heat boilers including steam turbine-generator based power generation • Load or charge preheating	• Convection recuperator (metallic) – mostly tubular • Radiation recuperator • Regenerative burners • Heat recovery boilers • Waste heat boilers including steam turbine-generator based power generation • Load or charge preheating • Metallic heat wheels (regenerative system)	• Convection recuperator (metallic) of many different designs • Finned tube heat exchanger (economizers) • Shell and tube heat exchangers for water and liquid heating • Self-recuperative burners • Waste heat boilers for steam or hot water condensate • Load-charge (convection section) preheating • Metallic heat wheel • Heat pipe exchanger	• Convection recuperator (metallic) of many different designs • Finned tube heat exchanger (economizers) • Shell and tube heat exchangers for water and liquid heating • Heat pumps • Direct contact water heaters • Condensing water heaters or heat exchangers • Metallic heat wheel • Heat pipe exchanger	• Shell and tube type heat exchangers • Plate type heat exchangers • Air heaters for waste heat from liquids • Heat pumps • HVAC applications (i.e., recirculation water heating or glycol-water recirculation) • Direct contact water heaters • Non-metallic heat exchangers

Rules of Thumb for Chilled Water Systems

- ΔT of 10°F = 2.4 gpm/ton; ΔT of 12°F = 2 gpm/ton; ΔT of 16°F = 1.5gpm/ton.
- On a centrifugal chiller, if the chilled water temperature is raised by 2˚F to 3˚F, the system efficiency can increase by 3 - 5%.
- On a centrifugal chiller, if condenser water temperature is decreased by 2˚F to 3˚F, the system efficiency can increase by 2 - 3%.
- For every 10°F of water temperature drop across the cooling tower, there is an evaporative loss of approximately 1%, equating to 2.5 to 4.0 gpm per 100 tons of capacity.

Rules of Thumb for HVAC Systems

<table>
<tr><td>Ventilation Rate</td><td>5 CFM/person</td><td rowspan="7">Set points for distribution system</td><td rowspan="2">Rebuilt Systems Design</td><td colspan="2">55°F supply air</td></tr>
<tr><td>Fan Energy</td><td>1000-1500 CFM/hp</td><td colspan="2">30°- 40° rise reheat coils</td></tr>
<tr><td>Chiller Size</td><td>300-400 ft^2/ton</td><td rowspan="2">Dual Duct and Multizone design</td><td colspan="2">55° cold deck</td></tr>
<tr><td>Ton</td><td>12,000 BTU/ton</td><td colspan="2">70-105° hot deck – with ODA Reset Schedule</td></tr>
<tr><td>Chilled Water</td><td>2.4 GPM/ton (10°F rise)</td><td rowspan="3">VAV</td><td colspan="2">55°F cooling</td></tr>
<tr><td>Condenser Water</td><td>3 GPM/ton (10°F rise)</td><td colspan="2">10% box leakage flow</td></tr>
<tr><td>People Load</td><td>450 BTU/person/hr</td><td colspan="2">40-50% minimum fan volume</td></tr>
<tr><td>Infiltration</td><td>0.5-1.5 ACH without building pressurization</td><td colspan="4">Typical Chiller Efficiencies in kW/ton</td></tr>
<tr><td rowspan="3">Heat Transmission Through Envelope</td><td>Overall Building – 0.15 to 0.5 BTU/ft^2/F</td><td>Chiller Type</td><td>ASHRAE Standard 90.1 Minimum</td><td>Good</td><td>Best</td></tr>
<tr><td rowspan="2">See ASHRAE Handbook of Fundamentals for accurate heat loads by envelope types</td><td>Air- Cooled</td><td>1.26</td><td>1.21</td><td>1.13</td></tr>
<tr><td>Water - Cooled</td><td>0.72</td><td>0.65</td><td>0.45</td></tr>
</table>

Quick Calculations and Conversions

$$EER = COP \times 3.412$$

$$kW/Ton = 12/EER$$

$$kW/Ton = 12/(COP \times 3.412)$$

$$1\ psi = 2.31\ ft\ w.g.$$

$$1\ l/s = 15.85\ GPM$$

$$1\ l/s = 2.12\ CFM$$

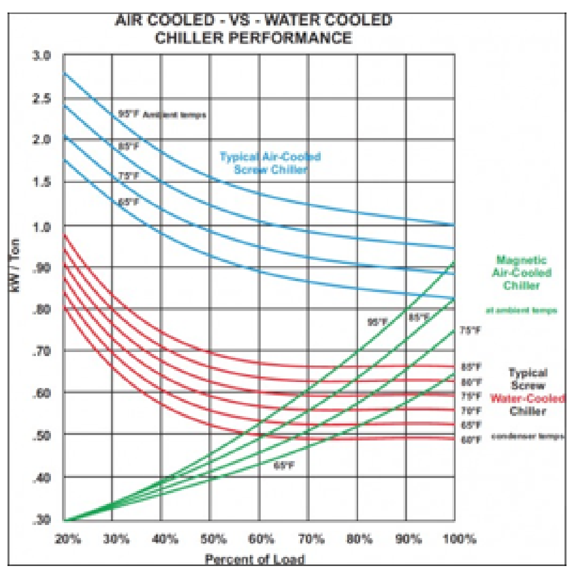
$$Q(Btu/hr) = 500 \times GPM \times \Delta T\ (Chilled\ Water)$$

$$Q(Btu/hr) = 1.08 \times CFM \times \Delta T\ (Air\ Sensible\ Heat)$$

$$Q(Btu/hr) = 0.69 \times CFM \times \Delta \left(\frac{gr}{lb}\right) (Air\ Latent\ Heat)$$

$$Q(Btu/hr) = 4.5 \times CFM \times \Delta h\ (Air\ Total\ Heat)$$

$$Ton\ (Cooling\ Tower) = 15\ MBH = 15{,}000\ BTU/h$$



Compressed Air System – Cheat Sheet
Energy Treasure Hunt

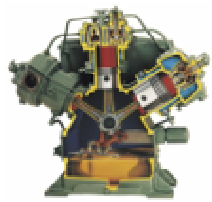
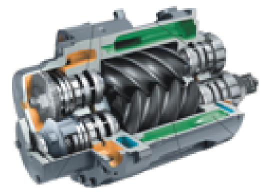
Rules of Thumb

- Lowering compressor pressure settings by **2 PSIG** results in a **1% savings**
- Lowering compressor inlet air temperature by **10°F** results in a **2% savings**
- **80% of the electric** energy going into compressors is lost as **heat**

Efficiency Index – kW/CFM

- **Compressor data sheet (CAGI)** provides kW/CFM at the rated capacity and the full load pressure
- **Logging the energy consumption** by the compressor

Major Types


Positive displacement	Positive displacement	Dynamic compression
Suited for high pressure operations	Better turn down characteristics	Good for full load operations
Typically used in smaller applications	Small – midsized applications <500 HP	Large applications >500 HP
Typical Controls – On/Off	Typical Controls – Load/ Unload, Modulating, VSD	Butterfly Valves, Inlet Guide Vanes

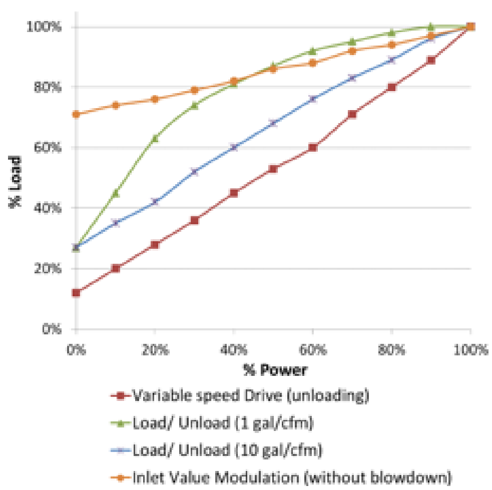
Air Leaks (CFM)

Pressure (psig)	Orifice Diameter (inches)					
	1/64	1/32	1/16	1/8	1/4	3/8
70	0.29	1.16	4.66	18.62	74.4	167.8
80	0.32	1.26	5.24	20.76	83.1	187.2
90	0.36	1.46	5.72	23.1	92	206.6
100	0.40	1.55	6.31	25.22	100.9	227
125	0.48	1.94	7.66	30.65	122.2	275.5

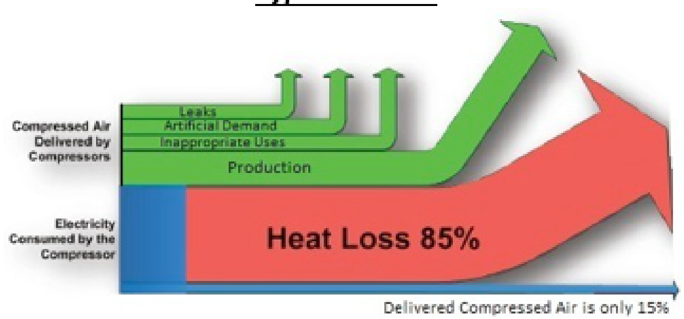
*For well-rounded orifices, values should be multiplied by **0.97 and by 0.61 for sharp ones**

****Cost savings = # of leaks × leakage rate (cfm) × kW/cfm × # of hours × $/kWh**

Power drawn @ Part Load



Typical Losses



Inappropriate Uses	Alternatives
Clean up, drying, Process cooling	Low pressure blowers, electric fans brooms
Sparging	Blowers and mixers
Aspirating, atomizing	Low pressure blower
Vacuum generator	Dedicated Vacuum pump
Air operated diagram pumps	Electric pump with proper regulator
Air motor	Electric motor
Idle equipment	Air stop valve at the inlet
Abandoned equipment	Disconnect air supply

Rules of Thumb

- Average efficiency of a steam boiler is 80%.
- 10 PSI drop in header pressure is 1% energy reduction
- Every 10.7°F rise in boiler feedwater temperature yields ~1% steam energy savings
- Unmaintained steam system - 15% to 30% of traps failed
- Ideal, maintained steam system - 5% of traps failed

Improve Boiler Combustion Efficiency

Excess (%)		*Combustion Efficiency*				
		Flue gas temp. minus combustion air temp (F)				
Air	*Oxygen*	*200*	*300*	*400*	*500*	*600*
9.5	*2.0*	*85.4*	*83.1*	*80.8*	*78.4*	*76.0*
15.0	*3.0*	*85.2*	*82.8*	*80.4*	*77.9*	*75.4*
28.1	*5.0*	*84.7*	*82.1*	*79.5*	*76.7*	*74.0*
44.9	*7.0*	*84.1*	*81.2*	*782.2*	*75.2*	*72.1*
81.6	*10.0*	*82.8*	*79.3*	*75.6*	*71.9*	*68.2*

Calculating Steam Cost

Energy required to produce one pound of saturated steam, BTU					
Operating Pressure (psig)	*Feed water Temperature, F*				
	50	***100***	***150***	***200***	***250***
150	*1178*	*1128*	*1078*	*1028*	*977*
450	*1187*	*1137*	*1087*	*1037*	*986*
600	*1184*	*1134*	*1084*	*1034*	*984*

$$\$/1000\ lbs\ of\ steam = \frac{\$/MMBTU \times 1000\ lbs \times Btu/lb}{Combustion\ Efficiency \times 10\text{^}6}$$

Insulate Steam and Condensate Lines

Heat Loss per 100 feet of Uninsulated steam, line, MMBTU/yr				
Line Diameter (in.)	*Steam Pressure (psig)*			
	15	***150***	***300***	***600***
1	*140*	*285*	*375*	*495*
2	*235*	*480*	*630*	*840*
4	*415*	*850*	*1120*	*1500*
8	*740*	*1540*	*2030*	*2725*
12	*1055*	*2200*	*2910*	*3920*

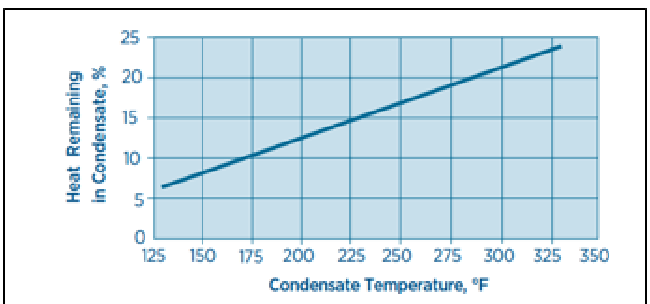
Heating Value of Fuels

Fuel Type	*Units*	*LHV*	*HHV*
Natural Gas	Btu/CF	983	1,089
Residual Oil	Btu/Gal	140,353	150,110
LPG	Btu/Gal	84,950	91,410
LNG	Btu/CF	74,720	84,820
Coal - Bituminous	Btu/lbs	11,230	11,723

Higher Heating Value (HHV): Total energy from combustion process

Lower Heating Value (LHV): Assumes eat of condensation cannot be recovered

Return Condensate to Boiler



Losses with steam Trap Failure

Trap Orifice Diameter (in.)	Steam Loss, lb/hr			
	15 psig	100 psig	150 psig	300 psig
1/32	0.85	3.3	4.8	-
1/16	3.4	13.2	18.9	36.2
1/8	13.7	52.8	75.8	145
3/16	30.7	119	170	326
1/4	54.7	211	303	579
3/8	123	475	682	1,303

Conversion Factors

$1\ boiler\ hp = 33{,}475\ Btu/hr$

$1\ boiler\ hp = 9.8\ kW$

$1\ lb/hr\ steam\ (300\ psi, staturated) = 1{,}202\ Btu/hr$

$1\ gal\ water = 8.35\ lb$

$1\ psi = 6.89\ kPa$

Steam Trap Failure

Obvious Signs	Less Obvious Signs
• Steam flashing	• Higher than necessary pressure
• Water Hammer	• Excessive condensate & chemical losses
• Pump cavitation	• Condensate water too hot
	• Boilers running continuously

APPENDIX H. INFO CARDS

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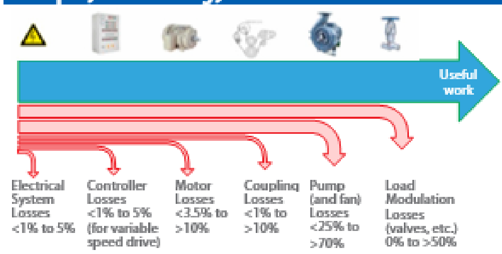
Pump System *Info Card*

Top 10 Energy Conservation Measures

1. Shut down pumps when not needed by manufacturing processes
2. Operate the minimum number of pumps that systems require
3. Use VFD instead of throttle valve for flow control
4. Trim or change pump impellers on oversized pumps
5. Reduce pipe and valve pressure losses
6. Re-tune pumping system when manufacturing process requirements change
7. Restore internal housing clearance
8. Replace worn throat bushings, wear rings, impellers, and pump bowls
9. Install new properly sized/selected pumps
10. Replace standard efficiency motors with NEMA premium motors

Pump System Energy Losses



**Courtesy of Bhaskaran Gopalakrishnan*

Pump Brake Horse Power Formula

$$\text{Pump Brake Horse Power (hp)} = \frac{\text{Flow Rate (GPM)} \times \text{Head (ftw.c.)} \times SG}{3960 \times \text{Pump efficiency}}$$

Pump Affinity Laws

$$\frac{Q_2}{Q_1} = \frac{N_2}{N_1} \qquad \frac{H_2}{H_1} = \left(\frac{N_2}{N_1}\right)^2 \qquad \frac{P_2}{P_1} = \left(\frac{N_2}{N_1}\right)^3$$

Q = Pump flow rate

N = Pump speed
H = Pump head

P = Pump power

Rules of Thumb

1. Annual motor operation cost: $300/hp*
2. Decreasing pump flow rate by 50% can reduce pump power by 88%

** Based on 5 cents/kWh, 93% efficiency, 3 shifts, 7 days a week operation, two weeks off/ downtime.*

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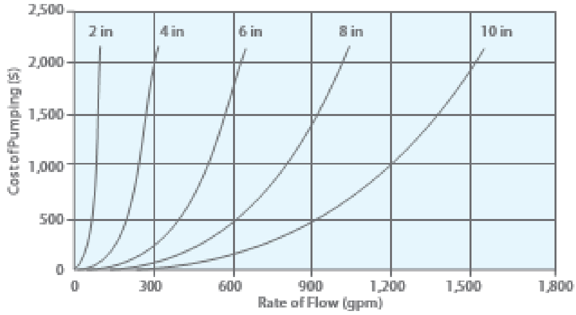
Pump System *Info Card*

Unit Conversion

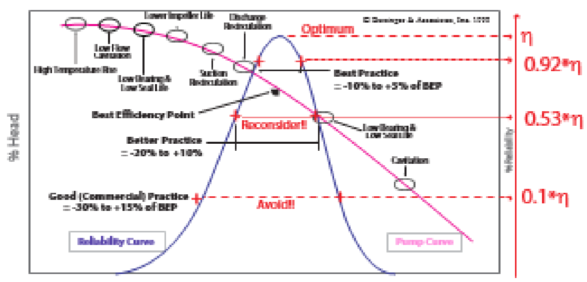
1 ft w.c. = 0.43 psi; 1 GPM = 0.00144 MGD; 1 hp = 0.746 kW

Annual Water Pumping Cost for 1,000 Feet of Pipe



**Based on 1,000 ft. for clean iron and steel pipes (schedule 40) for pumping 70°F water. Electricity rate of 0.05 $/kWh and 8,760 operating hours annually. Combined pump and motor efficiency of 70%.*

Pump Curve Sensitivity for Pump Reliability



**Courtesy of P. Barringer*

Energy Cost for Pump Driven by 100-hp Motor

Operating Time	Energy Costs for Various Electricity Costs				
	2¢ per kWh	4¢ per kWh	6¢ per kWh	8¢ per kWh	10¢ per kWh
1 hour	$1.60	$3.30	$4.90	$6.60	$8.20
24 hours	$39	$79	$119	$159	$198
1 month	$1,208	$2,416	$3,625	$4,833	$6,042
1 year	$14,500	$29,000	$43,600	$58,000	$72,600

Resources

1. Integrated EnergyTool Suite by US Department of Energy
2. Improving Pumping System Performance: A Sourcebook for Industry by US Department of Energy
3. Pump Tip Sheets by US Department of Energy

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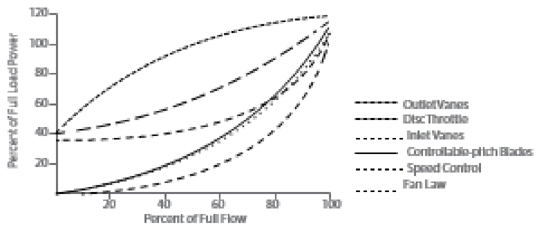
Fan System *Info Card*

Top 5 Energy Conservation Measures

1. Shut down fans when not needed by manufacturing processes
2. Use VFD instead of modulating dampers for air flow control
3. Use VFD instead of inlet guide vanes for air flow control
4. Replace standard V-belts with cogged V-belts
5. Operate close to Best Efficiency Point

Fan Capacity Control Options



Fan Brake Horse Power Formula

$$\text{Fan Brake Horse Power (hp)} = \frac{\text{Flow Rate (CFM)} \times \text{Head (in w.c.)}}{6356 \times \text{Fan Efficiency}}$$

Fan Affinity Laws

$$\frac{Q_2}{Q_1} = \frac{N_2}{N_1} \qquad \frac{H_2}{H_1} = \left(\frac{N_2}{N_1}\right)^2 \qquad \frac{P_2}{P_1} = \left(\frac{N_2}{N_1}\right)^3$$

Q = Fan flow rate

N = Fan speed
H = Fan head

P = Fan power

Rules of Thumb

1. Fan power: 1000-1500 CFM/hp
2. Fan annual energy cost: $350/1000 CFM (24/7 operation)
3. Air handling unit fan air flow sizing: 400 CFM/ton

Unit Conversion

1 in w.c. = 0.036 psi; 1 CFM = 28.3 l/min; 1 HP = 745.7 W

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Fan System *Info Card*

Air Density Correction Factors

Temp (°F)	Altitude (ft)							
	0 (Sea Level)	1000	2000	3000	4000	5000	6000	7000
50	1.04	1	0.97	0.94	0.9	0.87	0.84	0.81
55	1.03	0.99	0.96	0.93	0.89	0.86	0.83	0.8
60	1.02	0.98	0.95	0.91	0.88	0.85	0.82	0.79
70	1	0.96	0.93	0.89	0.86	0.83	0.8	0.77
80	0.99	0.95	0.92	0.88	0.85	0.81	0.79	0.76
90	0.97	0.94	0.90	0.86	0.83	0.8	0.77	0.75
100	0.95	0.93	0.88	0.85	0.81	0.78	0.75	0.73
110	0.94	0.92	0.86	0.83	0.8	0.77	0.74	0.72
120	0.93	0.9	0.85	0.82	0.79	0.76	0.73	0.71
130	0.91	0.88	0.83	0.81	0.78	0.75	0.72	0.70
140	0.89	0.86	0.81	0.8	0.77	0.73	0.71	0.68
150	0.87	0.84	0.80	0.79	0.75	0.72	0.70	0.67

**Air Density at sea level and 70° F: 0.075 lbm/ft³*

Air Speed and Volume Flow Rate Calculation Formulas

Air speed using actual air density	$V\left(\frac{ft}{min}\right) = 1096.7 \times \sqrt{\frac{P_V(in.\ w.c.)}{D\left(\frac{lbs}{ft^3}\right)}}$
Air speed using air density at sea level and 70° F	$V\left(\frac{ft}{min}\right) = 4005 \times \sqrt{P_V(in.\ w.c.)}$
Air volume flow rate	$Q\left(\frac{ft^3}{min}\right) = A(ft^2) \times V\left(\frac{ft}{min}\right)$
Air velocity pressure	$P_V = P_T - P_S$

Where: V=Air speed; P_V=Air velocity pressure; D=Air density; Q=Air volume flow rate; A=Cross section area; P_T=Air total pressure; P_S=Air static pressure

Energy Cost for Fan Driven by 100-hp Motor

Operating Time	Energy Costs for Various Electricity Costs				
	2¢ per kWh	4¢ per kWh	6¢ per kWh	8¢ per kWh	10¢ per kWh
1 hour	$1.30	$3.30	$4.90	$6.60	$8.20
24 hours	$39	$79	$119	$159	$198
1 month	$1,208	$2,416	$3,625	$4,833	$6,042
1 year	$14,500	$29,000	$43,600	$58,000	$72,600

**Assuming 90% motor efficiency*

Resources

1. Improving Fan System Performance: A Sourcebook for Industry by US Department of Energy
2. Fan System Assessment Tool (FSAT) by US Department of Energy
3. Advanced Variable Air Volume System Design Guide by Energy Design Resources

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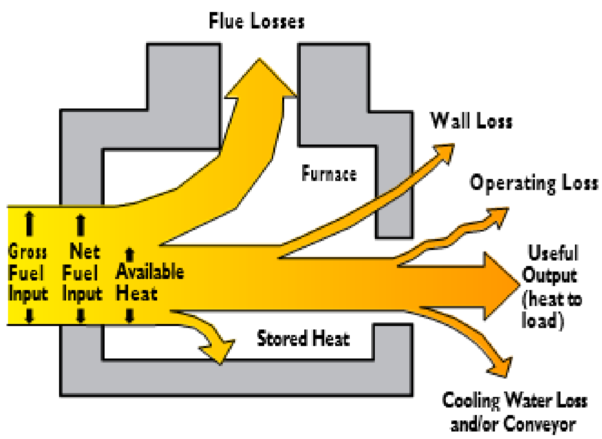
Process Heating System *Info Card*

Top 10 Energy Conservation Measures

1. Check and optimize burner air-to-fuel ratios
2. Consider oxygen-enriched combustion
3. Check and clean heat transfer surfaces
4. Reduce air infiltration in furnaces
5. Install furnace pressure controllers
6. Reduce radiation losses from heating equipment
7. Install waste heat recovery systems on fuel-fired furnaces
8. Preheat combustion air
9. Use flue gases to preheat loads
10. Use waste heat for external processes

Energy Loss Diagram In a Fuel-Based Process Heating System



Resources

- Improving Process Heating Systems Performance: A Sourcebook for Industry by US Department of Energy
- Process Heating Assessment and Survey Tool (PHAST) by US DOE

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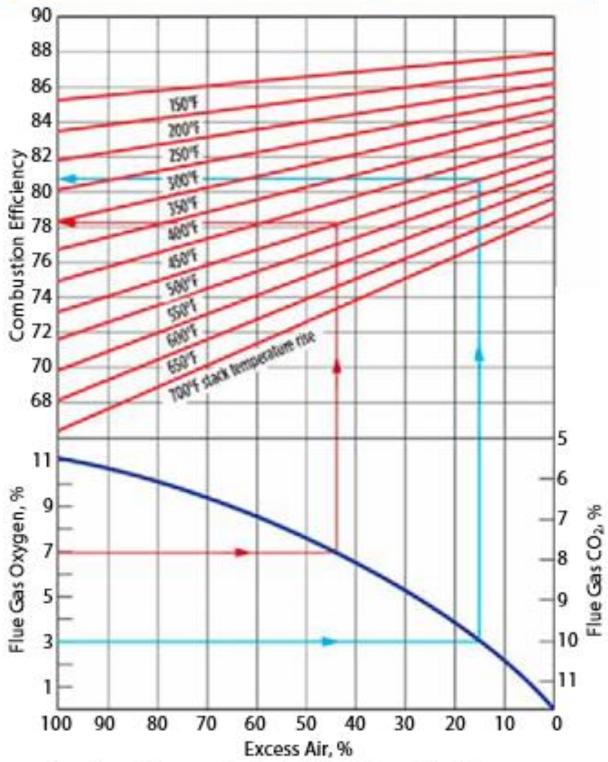
Process Heating System *Info Card*

Percent Fuel Savings Gained from Using Preheated Combustion Air

Furnace Exhaust Temp (F)	Preheated Air Temperature (F)					
	600	800	1,000	1,200	1,400	1,600
1,000	13%	18%	NA	NA	NA	NA
1,200	14%	19%	23%	NA	NA	NA
1,400	15%	20%	24%	28%	NA	NA
1,600	17%	22%	26%	30%	34%	NA
1,800	18%	24%	28%	33%	37%	40%
2,000	20%	26%	31%	35%	39%	43%
2,200	23%	29%	34%	39%	43%	47%
2,400	26%	32%	38%	43%	47%	51%

Natural Gas Combustion Efficiency Curve



Source: Energy Management Handbook, 4th Edition, Fairmont Press 2001

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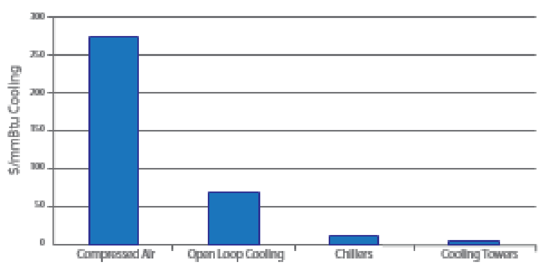
Process Cooling System *Info Card*

Top 5 Energy Conservation Measures

1. Convert chilled water systems from constant to variable flow by replacing 3-way with 2-way control valves and installing VFDs on distribution pumps
2. Convert condensing water systems from constant to variable flow by installing VFDs on condensing water pumps
3. Convert cooling tower fans from 1-speed or 2-speed to variable speed by installing VFDs
4. Reset chilled water supply temperature setpoints based on the process load
5. Reset condensing water entering temperature setpoints based on the ambient wet bulb temperature

Process Cooling Systems' Cost Comparison



Water Cooled Chiller Comparison

Chiller Type	Capacity [1] Range (tons)	First Cost [2] Range ($/ton)	COP Range	IPLV Range (COP)
Reciprocating/ Scroll	50–230 (400)	$200–$250	4.2–5.5	4.6–5.8
Screw	70–400 (1250)	$225–275	4.9–5.8	5.4–6.1
Centrifugal	200–2000 (10,000)	$180–$300	5.8–7.1	6.5–7.9
Single-effect Absorption	100–1700	$300–$450	0.60–0.70	0.63–0.77
Double-effect Absorption	100–1700	$300–$550	0.92–1.20	1.04–1.30
Engine Driven	100–3000 (10,000)	$450–$600	1.5–1.9	1.8–2.3

[1] Capabilities in parentheses are maximum sizes available
[2] First cost includes allowance for contractor mark-ups

Courtesy of Energy Design Resources

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Process Cooling System *InfoCard*

Rules of Thumb

1. 1°F increase of chilled water temperature improves the chiller efficiency by approximately 1.5%; 1°F decrease of condensing water temperature improves the chiller efficiency by approximately 1.5%
2. Pump sizing: 2.0 – 2.4 GPM/ton for chilled water and 2.5 – 3.0 GPM/ton for condensing water
3. Distribution pipe sizing: 10 ft/s water velocity or 4 ft w.c. pressure loss per 100 ft

Unit Conversion

1. kW/ton = 12/EER; EER = COP × 3.413; kW/ton = 12/(COP × 3.413)
2. 1 refrigeration ton = 12,000 Btu/hr
   1 cooling tower ton = 15,000 Btu/hr
3. 1 HP =745.7 W; 1 ft w.c.= 0.433 psi
4. C = (F – 32) × (5/9)

Integrated Partial Load Value (IPLV) Equation

$$IPLV = \frac{1}{\frac{1\%}{A} + \frac{42\%}{B} + \frac{45\%}{C} + \frac{12\%}{D}}$$

Where: A – kW/ton @ 100% load
B – kW/ton @ 75% load
C – kW/ton @ 50% load
D – kW/ton @ 25% load

Cooling Tower Water Consumption

Cooling Tower Usage (Million Gallons/Year)				
Chiller Tonnage	Cycles of Concentration			
	3	5	7	8
100	2.0	1.7	1.6	1.5
200	4.0	3.4	3.1	3.1
400	8.0	6.7	6.3	6.1
600	12.1	10.0	9.4	9.2
800	16.1	13.4	12.5	12.3
1000	20.1	16.8	15.6	15.3
2000	40.2	33.5	31.2	30.6
3000	60.3	50.3	46.9	46.0
4000	80.4	67.0	62.6	61.3
5000	100.5	83.8	78.2	76.6

Resources

1. ASHRAE Handbook: HVAC Systems and Equipment by ASHRAE
2. Chilled Water Plant Design Guide by Energy Design Resources

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Compressed Air System *Info Card*

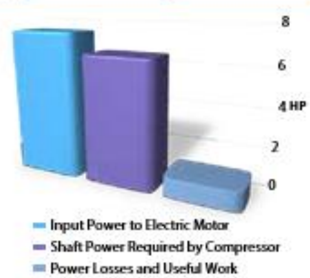
Top 5 Energy Conservation Measures

1. Eliminate inappropriate uses of compressed air
2. Stabilize system pressure
3. Lower pressure requirements of end uses
4. Minimize compressed air leaks
5. Provide compressed air of appropriate quality for manufacturing processes

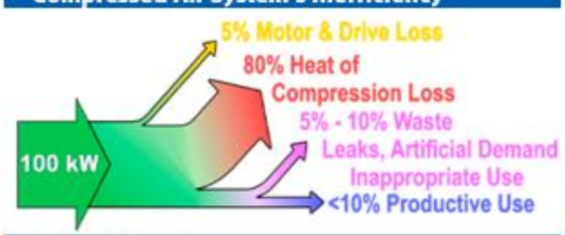
1 hp air motor = 7-8 hp of electrical power

- 30 scfm @ 90 psig is required by the air motor
- 7–8 hp electrical power required for this
- Annual energy cost $1,164 (air motor) vs. $194 (electric motor)

* 4,000 hrs/yr; $0.05/kWh



Compressed Air System's Inefficiency



Rules of Thumb

- Lowering compressor pressure setpoints by 2 PSIG will result in ~1% savings
- Lowering compressor inlet air temperature by 10°F will result in ~2% savings.

Resources

- Improving Compressed Air System Performance: A Sourcebook for Industry by US Department of Energy
- AirMaster+ and Logtool by US DOE

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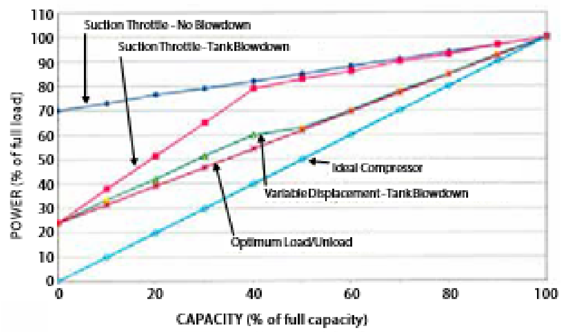
Compressed Air System *Info Card*

Annual Air Leaks Costs

**Based on $0.075/kWh*

Pressure (Psig)	Equivalent Orifice Diameter (in.)					
	1/64	1/32	1/16	1/8	1/4	3/8
70	$34	$137	$551	$2,202	$8,799	$19,844
80	$38	$149	$620	$2,455	$9,827	$22,138
90	$43	$173	$676	$2,732	$10,880	$24,433
100	$47	$183	$746	$2,983	$11,932	$26,845
125	$57	$229	$906	$3,625	$14,451	$32,581

Control Strategies



Potential Inappropriate Uses

Potential Inappropriate Uses	Alternatives
Clean up, Drying, Process Cooling	Low pressure blowers, Electric fans, Brooms
Sparging	Blowers and mixers
Aspirating, Atomizing	Low pressure blowers
Vacuum generators	Dedicated vacuum pumps
Air operated diaphragm pumps/motors	Electric pumps with proper regulators
Air motors	Electric motors
Idle equipment	Install air stop valves at the inlet
Abandoned equipment	Disconnect air supply

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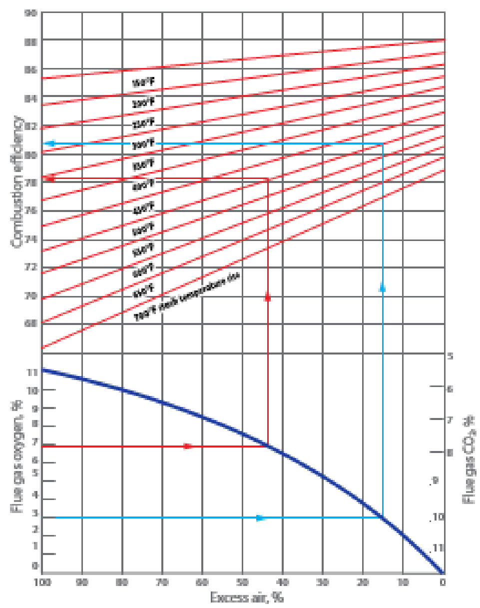
Steam System *Info Card*

Top 10 Energy Conservation Measures

1. Inspect and repair steam traps
2. Insulate steam distribution and condensate return lines and cover heated open vessels
3. Install condensing economizers
4. Use feedwater economizers for waste heat recovery
5. Minimize boiler blowdown
6. Recover heat from boiler blowdown
7. Replace pressure-reducing valves with backpressure turbo-generators
8. Use low-grade waste steam to power absorption chillers
9. Upgrade boilers with energy-efficient burners
10. Optimize the air-to-fuel ratio to improve combustion efficiency

Natural Gas Combustion Efficiency Curve



Source: Energy Management Handbook, 4th Edition, Fairmont Press 2001

Rules of Thumb

1. Every 40°F increase in the combustion air temperature improves efficiency by roughly 1%
2. Every 40°F increase in stack temperature results roughly 1% efficiency loss

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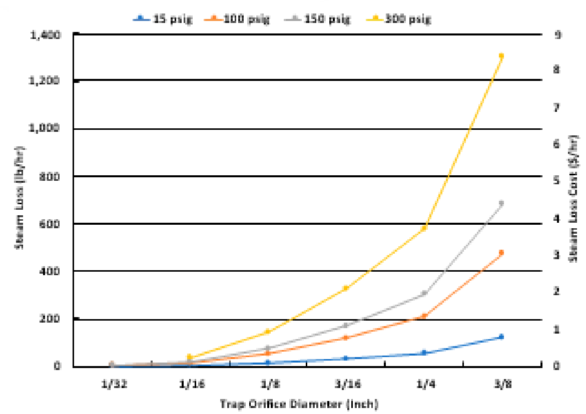
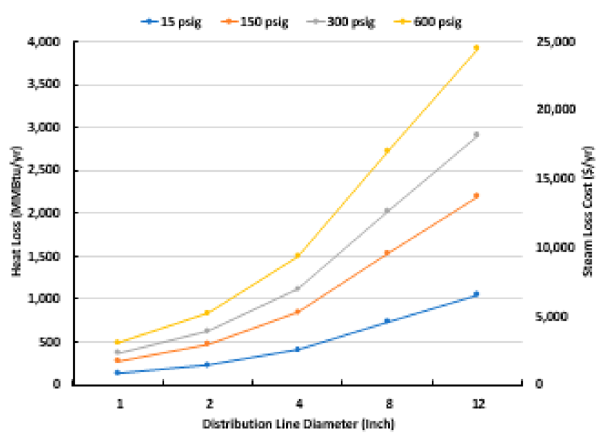
Steam System *Info Card*

Leaking Steam Trap Discharge Rate and Cost



**Based on Natural Gas unit rate of $0.5/therm and boiler efficiency of 80%.*

Heat Loss Per 100 Feet of Uninsulated Steam Line



***Based on Natural Gas unit rate of $0.5/therm and boiler efficiency of 80% and 8,760 operating hours per year.*

Resources

1. Steam System Modeler Tool (SSMT) by US DOE
2. Steam System Scoping Tool (SSST) by US DOE
3. Insulation tool - 3EPlus by Insulation Institute
4. Improving Steam System Performance: A Sourcebook for Industry by US DOE
5. Steam System Survey Guide by US DOE
6. Steam Tip Sheets by US DOE

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Motor System *Info Card*

Top 5 Energy Conservation Measures

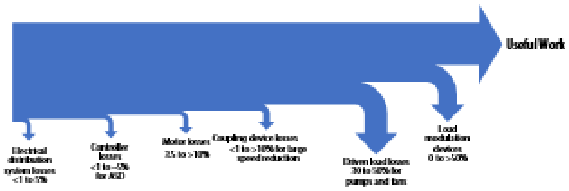
1. Turn off motors when not in use
2. Replace standard V-belts with notched or synchronous belt drives
3. Replace standard efficient motors with energy efficient/premium efficient motors
4. Mitigate voltage unbalance
5. Improve power factor

Annual Energy Savings for Premium vs. Standard Efficiency Motors

Motor Horse-power	Standard Efficiency		Premium Efficiency		Annual Cost Savings
	Motor Efficiency	Annual Energy Cost	Motor Efficiency	Annual Energy Cost	
10	86.7	$6,884	91.7	$6,508	$375
25	89.9	$16,596	93.6	$15,940	$656
50	91.6	$32,576	94.5	$31,577	$1,000
100	92.2	$64,729	95.4	$62,558	$2,171
200	93.3	$127,931	96.2	$124,075	$3,857

Note: Based on an 1,800 RPM TEFC motor in operation 8,000 hours per year (hrs/year) at 75% load at an electrical rate of $0.1/kWh.

Typical Motor System Losses



Rules of Thumb: Replace Instead of Rewind If…

- Motors are standard and easy to purchase
- The process down time will be significantly reduced
- Motor power is less than 50 hp
- The cost of rewinding exceeds 60% of the price of a new motor

Motor Formulas

$$P(kW, estimated) = \frac{Rated\ Horsepower \times 0.746 \times \%\ Motor\ Load}{Motor\ Efficiency}$$

$$P(kW, measured, 3\text{-}phase) = \frac{Amp \times Vol \times \sqrt{3} \times Power\ Factor}{1000}$$

$$Horsepower = \frac{Torque(ft\text{-}lb) \times RPM}{5252}$$

$$Synchronous\ Speed = \frac{120 \times Frequency\ (Hz)}{Number\ of\ Poles}$$

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Motor System *Info Card*

Unit Conversions

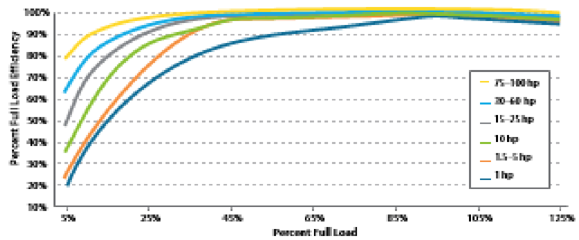
1 hp = 745.5 W = 550 lb • ft/s

1 kW = 1.341 hp = 738 lb • ft/s

Adjustable Speed Drive Part-Load Efficiency

Variable Drive hp Rating	Efficiency (%)					
	Load, Percent of Drive Rated Power Output					
	12.5	25	45	50	75	100
5	80	88	91	92	94	95
10	83	90	93	94	95	96
50	86	92	95	95	96	97
100	89	94	95	96	97	97
200	81	95	96	96	97	97

Motor Part Load Efficiency



Shaft Alignment Tolerances for Direct-Coupled Shafts

Motor Speed (RPM)	Parallel Offset (mils) Short Flex Couplings		Angular Misalignment (mils per inch) Spacer Couplings	
	Excellent	Acceptable	Excellent	Acceptable
900	3.0	6.0	1.2	2.0
1,200	2.5	4.0	0.9	1.5
1,800	2.0	3.0	0.6	1.0
3,600	1.0	1.5	0.3	0.5

Source: Alan Luedeking, Ludeca Inc. "Shaft versus Foot Alignment Tolerances: A Critique of the Various Approaches," 2008.

Resources

1. Improving Motor and Drive System Performance: A Sourcebook for Industry by US Department of Energy
2. Motor Tip Sheets by US Department ofEnergy
3. Premium Efficiency Motor Selection and Application Guide - A Handbook for Industry. Washington D.C, US Department of Energy
4. EASA Standard AR100-2015: Recommended practice for the repair of rotating electrical apparatus by Electrical Apparatus Service Association, Inc.

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Water System *Info Card*

Water Saving Opportunities

Manufacturing Processes

1. Install timers/sensors to automatically shut off water flow when water is not required
2. Set equipment to the minimum flow rates required by processes and recommended by manufacturers
3. Reuse water from other parts/processes of the facilities

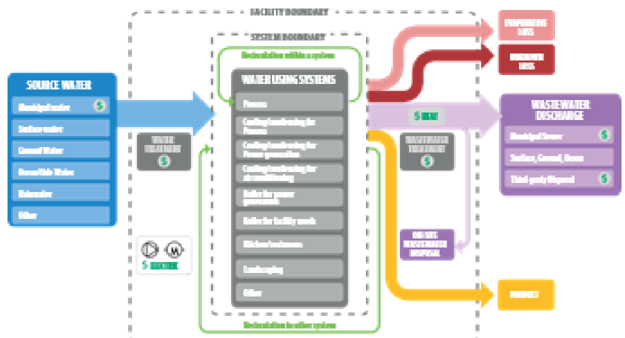
Cooling Water Systems

1. Eliminate water overflowing from cooling tower basins
2. Set the ball float valves to the correct size
3. Install flowmeters and conductivity sensors on blowdown lines
4. Operate blowdown operated in continuous mode
5. Eliminate once-through water cooling by using closed loop chilled water

Steam Systems

1. Check and replace steam traps regularly
2. Install boiler blowdown flash tank to recover flash steam
3. Install conductivity sensors on boilers to automatically control surface blowdown

Water Flow Diagram with True Cost Components and System Water Balance



Rules of Thumb

- In cooling towers, **1%** of the water recirculation rate must be evaporated for every **ΔT of 10 °F**.
- A boiler making **10,000 lb/hr** of steam requires **20 GPM** of feedwater.
- Steam blowdown rates typically range from **4% to 8%** of boiler feedwater.
- **~15% to 30%** of steam traps may be failed in steam systems that are only maintained every **3 to 5 years**.

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Water System *Info Card*

Formula and Unit Conversions

$$\text{Cooling tower blowdown water} = \frac{\text{Evaporation Loss}}{\text{Cycle of Concentration} - 1}$$

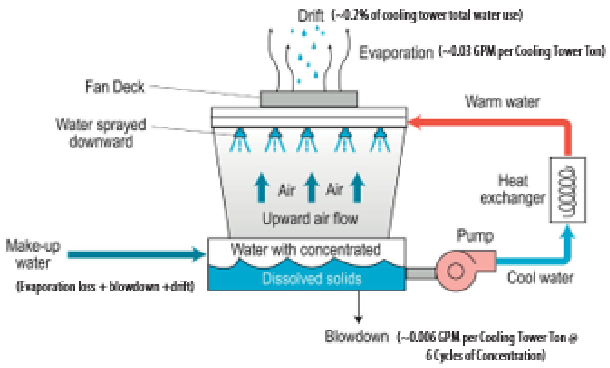
$$\text{Cycle of Concentration} = \frac{\text{Makeup Water}}{\text{Blowdown}}$$

$$1\ gal = 3.785\ liter = 0.134\ ft^3 = 0.00379\ m^3$$

$$1\ gpm = 0.063\ l/s = 0.23\ m^3/hr$$

$$1\ gal\ water = 8.35\ lbs$$

Cooling Tower Water Loss



Cooling Tower Annual Water Usage for Different Sized Chillers at Varying Cycles of Concentration

Cooling Tower Usage (Million Gallons/Year)						
Chiller Tonnage (Nameplate)	Cycles of Concentration					
	3	4	5	6	7	8
100	2	1.8	1.7	1.6	1.6	1.5
200	4	3.6	3.4	3.2	3.1	3.1
400	8	7.2	6.7	6.4	6.3	6.1
500	10	8.9	8.4	8	7.8	7.7
600	12.1	10.7	10	9.7	9.4	9.2
800	16.1	14.3	13.4	12.9	12.5	12.3
1000	20.1	17.9	16.8	16.1	15.6	15.3

**Assuming that the annual operation is 8760 hours.*

Resources

1. DOE Plant Water Profiler (PWP) tool. https://www.energy.gov/eere/amo/software-tools
2. Guideline for Estimating Unmetered Industrial Water Use by US Department of Energy
3. Byers, William, Industrial Water Management: A Systems Approach, Wiley-AIChE, 2003

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APPENDIX I. OPPORTUNITY SHEETS

Energy Treasure Hunt - Plant's Cost Information

Instructions:	
Please respond to the following questions on Plant's cost information	
Input values in cells colored in green	
Choose appropriately from the cells colored in pink	
Please DO NOT insert any value in cells colored in grey	

Plant Name:				
Scope of Energy Treasure Hunt:				
Instructions:	1) Check boxes for items that are to be considered within the scope of the treasure hunt event. Leave check box blank if it does not apply.			
	2) Please check boxes associated with steam/compressed air cost only if user is buying them from a utility or a third-party enterprise. DO NOT check the boxes if these are generated onsite using boilers/air compressors, etc.			
Electricity	☐ Yes		Other Fuels	☐ Yes
Natural Gas	☐ Yes		Water Savings	☐ Yes
Steam (only if purchased)	☐ Yes		Waste Water	☐ Yes
Compressed Air (only if purchased)	☐ Yes		Emissions	☐ Yes

Unit Cost of Primary Energy Consumed:		
Instructions:	1) Please provide unit costs for different energy types used in your plant.	
	2) Please provide steam/compressed air cost only if user is buying steam from a utility or a third-party enterprise. Do not provide costs if these are generated onsite using boilers/air compressors.	
Energy Type	Unit Price	Unit

Other Metrics:		
Instructions:	1) Please provide unit costs for the items listed.	
	2) The default value for CO2 emissions is 1.552 lb/kWh for electricity; 114.2 lb/MMBTU for Natural Gas	
Energy Type	Unit Price	Unit

Info				
Title:		Plant:	0	
		Business Unit:		
Process / Equipment:		Originator:		
		Date:		

Description

Description:

Current Situation (Before Energy Treasure Hunt)		Projected Situation (After Energy Treasure Hunt)	
Annual Operating Hours	Number of Units	Annual Operating Hours	Number of Units
Hours/Day	Eg. Number of leaks, Number of equipment to be turned off etc.	Hours /Day	Eg. Number of leaks, Number of equipment to be turned off etc.
Days/Month		Days/Month	
Months		Months	

* This section is part of the description and the values are not used in calculations.

En			
Energy units	Energy Use Before TH (Energy units/yr)	Energy Use After TH (Energy Units/yr)	Energy Savings (Energy Units/yr)

Cost / Savings

Implementation Cost	
Engineering Services:	
Material:	$ -
Labor: Contract	
Labor: In House	
Other:	$ -
Other:	$ -
Other:	$ -
Other:	$ -
Other:	$ -
Total:	$ -

Cost Description:

$/unit	Projected Annual Savings	
$ -	Electricity	$ -
$ -	Gas	$ -
$ -	Compressed Air	$ -
$ -	Other Fuel	$ -
$ -	Steam	$ -
$ -	Water	$ -
$ -	WWT	$ -
	Other Savings	
	Total:	$ -
	Simple Payback Period (yrs.):	

APPENDIX J. CALCULATORS

Compressed Air Reduction - Energy Treasure Hunt Calculator

The calculator is designed to be used as part of the Energy Treasure Hunt event to quantify the energy savings associated with reducing compressed air usage.

This calculator can be used to calculate the energy savings of typical energy savings opportunities like:

- Turn off compressed air to a production line/machine during non-production.
- Reduce compressed air going into a production line/machine.
- Eliminating inappropriate use of compressed air
- Use Engineered Nozzles in place of open blow off etc.

Calculation Steps - Determining annual energy use of a piece of equipment is a three-step process:

Step 1: Determine operational time each year

Step 2: Determine the rate of energy use

Step 3: Multiply operational time by energy rate to determine consumption.

Enter items into the cells in Green, choose from cells in Pink and the Grey Cell will be calculated from your entries.

Step 1 - Determine the Operation time

Before Energy Treasure Hunt			After Energy Treasure Hunt		
Seconds/minute		*Seconds*	Seconds/minute		*Seconds*
Minutes or cycles/hour		*Min/cycle*	Minutes or cycles/hour		*Min/Cycle*
Hours/day		*hr.*	Hours/day		*hr.*
Days/month		*Day*	Days/month		*Day*
Months/year		*Month*	Months/year		*Month*
Operation Time	0	Min/yr.	Operation Time	0	Min/yr.

Step 2 - Determine Compressed Air Flow

Identify the method to be used:

Compressed air consumption can be determined by several different means. The calculator sheets provide three options to determine consumption. The determination means will always start with the most accurate and end with the least accurate that is acceptable.

a. Compressed Air Flow Meter	Getting the flow measurement straight from a calibrated air flow meter reading. This is the best way to measure compressed air consumption.
b. Bag Method	The bag method estimates the air flow using a trash bag by counting the time it takes to fill it. This is the second most accurate means of measuring compressed air consumption.
c. Orifice/ Pressure Method	Estimation of air flow using the pressure at the point of use and the diameter of the orifice. This is the least accurate method permissible for determining compressed air use. The user must know the air pressure at the point of use for this to be accurate.
d. Off-sheet/Other Method	Choose this option if you are using a different method to find the compressed air use
Choose Method of Measurement	

Step 3 - Total Energy Savings

Choose Output Metric	

Note: To get the results in units consistent with the "Opportunity Sheet", Choose "Electricity (kWh)" if the compressed air is generated onsite using air compressors, choose "Compressed air (kSCF)" only if compressed air is bought from outside the facility.

Compressed Air - System Pressure Reduction Savings

The calculator is designed to be used as part of the Energy Treasure Hunt event to quantify the <u>energy savings associated with reducing compressed air system pressure.</u>

The benefit of lowering system pressure is two-fold:
1.) Reducing the pressure lowers the work done by the compressor and hence lesser electricity is drawn.
2.) Reducing the pressure also lowers the amount of air delivered to plant and thus cuts down on the air lost in the form of artificial demand and air leaks.

This calculator only calculates the electricity saved at the compressor by reducing system pressure.

Calculation Steps - Determining annual energy use of a piece of equipment is a three-step process:

Step 1: Determine operational time each year

Step 2: Define Compressor Energy and Pressure

Step 3: Calculate savings at the compressors

Enter items into the cells in Green, choose from cells in Pink and the Grey Cell will be calculated from your entries.

Step 1 - Determine the Operation time

Before Energy Treasure Hunt			After Energy Treasure Hunt		
Hours/day		*hr.*	Hours/day		*hr.*
Days/month		*Day*	Days/month		*Day*
Months/year		*Month*	Months/year		*Month*
Operation Time	0	Hrs./yr.	Operation Time	0	Hrs./yr.

Step 2 - Define Compressor Energy and Pressure

Current Situation			Projected Situation		
Data Item	Value	Unit	*Data Item*	Value	Unit
Enter baseline KW demand.		kW			
Enter baseline pressure		psig	Enter proposed pressure		psig
Total Annual Consumption	-	kWh	Total Annual Consumption	-	kWh

Step 3 - Total Energy Savings

Choose Output Metric	

Note: To get the results in units consistent with the "Opportunity Sheet", Choose "Electricity (kWh)" if the compressed air is generated onsite using air compressors, choose "Compressed air (kSCF)" <u>only</u> if compressed air is bought from outside the facility.

Compressed Air - Leak Survey

The calculator is designed to be used as part of the Energy Treasure Hunt event to quantify the energy savings associated with reducing compressed air leaks

Calculation Steps - Determining annual energy use of a piece of equipment is a three-step process:

Step 1: Define the annual hours and the operating condition

Step 2: Determine the rate of leak using one of the three methods available

Step 3: Multiply operational time by leak rate to determine annual loss in terms of flow or energy.

Enter items into the cells in pink; choose from cells in blue and the Grey Cell will be calculated from your entries.

Step 1 - Define the operation time and condition

Seconds/minute		*Seconds*	Compressed Air Temperature		*F*
Minutes or cycles/hour		*Min/cycle*	Atmospheric Pressure	14.7	*psia*
Hours/day		*hr.*	Discharge coefficient	1	
Days/month		*Day*			
Months/year		*Month*			
Operation Time	0	Hrs./yr.			

Step 2 - Determine Compressed Air loss through leak

Compressed air loss can be determined by several different means. The calculator sheets provide four options to determine loss, to be chosen in column 4 of the survey table

a. Estimate	The most high-level way to determine the leak rate is to estimate it based on the visual and audible clues. The criteria and the default leak rate for this method are given below. The user can change this as required.			
	Minimal	Feel but cannot hear in quiet environment	0.1	sft³/min
	Small	Feel and hear in quiet environment	0.8	sft³/min
	Medium	Feel and hear in moderate noise	3.0	sft³/min
	Large	Feel and hear in high noise	5.0	sft³/min
	Severe	Feel and hear at great distance	10.0	sft³/min
b. Decibels Method	The decibels method is used when an Ultrasonic probe is used to scan for leaks. Use the dB vs CFM chart that comes along with the specific leak detector to estimate loss.			
b. Bag Method	The bag method estimates the air loss using a trash bag by counting the time it takes to fill it.			
c. Orifice/ Pressure Method	Estimation of air loss using the pressure at the point of use and the diameter of the orifice. The user must know the air pressure at the point of use for this to be accurate.			

Leak Survey - Table

Number	Location	Description (What is Leaking?)	Identification Type	Calculate	Leak	Leak Rate Estimate [sft³/min]	Sound Intensity at 3 ft. [dB]	Leak Rate Estimate [kscf/yr.]
1	None	None				0.00		0
2	None	None				0.00		0
3	None	None				0.00		0
4	None	None				0.00		0
5	None	None				0.00		0
6	None	None				0.00		0
7	None	None				0.00		0
8	None	None				0.00		0
9	None	None				0.00		0
10	None	None				0.00		0
11	None	None				0.00		0
12	None	None				0.00		0
13	None	None				0.00		0
14	None	None				0.00		0
15	None	None				0.00		0

16	None	None				0.00		0
17	None	None				0.00		0
18	None	None				0.00		0
19	None	None				0.00		0
20	None	None				0.00		0
	Total Leak Rate				cfm -	0.00	kcf / yr. -	0

Step 3 - Total Energy Savings

Choose Output Metric	

Note: To get the results in units consistent with the "Opportunity Sheet", Choose "Electricity (kWh)" if the compressed air is generated onsite using air compressors, choose "Compressed air (kSCF)" <u>only</u> if compressed air is bought from outside the facility.

Electricity Reduction - Energy Treasure Hunt Calculator

The calculator is designed to be used as part of the Energy Treasure Hunt event to quantify the energy savings associated with reducing electricity usage.

This calculator can be used to calculate the energy savings of typical energy savings opportunities like:

- Reduce the operation time of equipment which uses electricity.
- Reduce the size/load of the equipment which uses electricity.
- Turn off equipment that uses electricity
- Lower the frequency of a variable speed drive motor

Calculation Steps - Determining annual energy use of a piece of equipment is a three-step process:

Step 1: Determine operational time each year

Step 2: Determine the rate of energy use

Step 3: Multiply operational time by energy rate to determine consumption.

Enter items into the cells in Green, choose from cells in Pink and the Grey Cell will be calculated from your entries.

Step 1 - Determine the Operation time

Before Energy Treasure Hunt			After Energy Treasure Hunt		
Seconds/minute		Seconds	Seconds/minute		Seconds
Minutes or cycles/hour		Min/cycle	Minutes or cycles/hour		Min/Cycle
Hours/day		hr.	Hours/day		hr.
Days/month		Day	Days/month		Day
Months/year		Month	Months/year		Month
Operation Time	0	hrs./yr.	Operation Time	0	hrs./yr.

Step 2 - Determine Electricity Consumption

Identify the method to be used:

Electricity consumption can be determined by several different methods. The calculator sheets provide three options to determine consumption. The methods are listed starting with the most accurate and end with the least accurate.

a. Power Meter Method	The best way to measure electrical consumption is with a power meter. Manufacturer's data on lights can be entered as if the measurements were done with a power meter.
b. Multimeter Reading	Multimeter measurements are the second most accurate means of measuring electrical consumption and are accurate for DC and for AC (When combined with the plant's uncorrected power factor).
c. Name Plate Data	Motor nameplate data can provide a reasonable estimation of the energy that motors are consuming but are not as accurate as a power meter. Nameplate data does not tell the user how heavily loaded the motor is.
d. Off-sheet/Other Method	Choose this option if you are using a different method to find the compressed air use

Choose Method of Measurement	

Step 3 - Total Energy Savings

Values for Opportunity Sheet

Electricity - Current Situation	0	kWh	**Savings**	0	kWh
Electricity Used - Projected Situation	0	kWh			

Lighting Calculator

The calculator is designed to be used as part of the Energy Treasure Hunt event to quantify the energy savings associated with lighting opportunity

This calculator can be used to calculate the energy savings of typical energy savings opportunities like:

- Reduce the operation time of lighting equipment.
- Reduce the number of the lighting fixtures.
- Turn off lights

Calculation Steps - Determining annual energy use of a piece of lighting equipment is a three-step process:

Step 1: Determine operational time each year

Step 2: Determine the electricity used per lighting fixture

Step 3: Multiply operational time by electricity used to determine consumption.

Enter items into the cells in Green, choose from cells in Pink and the Grey Cell will be calculated from your entries.

Step 1 - Determine the Operation time

Before Energy Treasure Hunt

Hours/day		hr.
Days/month		Day
Months/year		Month
Operation Time	0	hrs./yr.

After Energy Treasure Hunt

Hours/day		hr.
Days/month		Day
Months/year		Month
Operation Time	0	hrs./yr.

Step 2 - Determine Electricity Consumption per Lighting Fixture

Current Situation

How would you like to input wattage?	

Proposed Situation

How would you like to input wattage?	

Natural Gas Reduction - Energy Treasure Hunt Calculator

The calculator is designed to be used as a part of the Energy Treasure Hunt event to quantify the energy savings associated with reducing natural gas.

This calculator can be used to calculate the energy savings of typical energy savings opportunities like:

- Reduce the operation time of equipment which uses natural gas.
- Decrease the flow rate of the "fluid" being heated. (The most common "fluids" heated are water and air.)
- Turn off equipment that uses natural gas
- Change set point to a lower temperature.

Calculation Steps - Determining annual energy use of a natural gas using piece of equipment is a four-step process:

Step 1: Determine operational time each year

Step 2: Determine the energy efficiency of the system

Step 3: Determine the rate of energy use

Step 4: Multiply operational time by energy rate to determine consumption.

Enter items into the cells in Green, choose from cells in Pink and the Grey Cell will be calculated from your entries.

Step 1 - Determine the Operation time

Before Energy Treasure Hunt			After Energy Treasure Hunt		
Seconds/minute		*Seconds*	Seconds/minute		*Seconds*
Minutes or cycles/hour		*Min/cycle*	Minutes or cycles/hour		*Min/Cycle*
Hours/day		*hr.*	Hours/day		*hr.*
Days/month		*Day*	Days/month		*Day*
Months/year		*Month*	Months/year		*Month*
Operation Time	0	hrs./yr.	Operation Time	0	hrs./yr.

Step 2 - Determine the Natural Gas System Efficiency

	Value	*Unit*		*Value*	*Unit*
Efficiency		%	Efficiency		%

Step 2 - Determine Natural Gas Consumption

Identify the method to be used:

Natural Gas consumption can be determined by several different means. The calculator sheet provides three options to determine consumption. The determination means will always start with the most accurate and end with the least accurate that is acceptable.

a. Flow Meter Method	The best way to measure natural gas consumption is with a flow meter. The user must understand the units the meter is measuring the time over which the measurement is made to correctly determine consumption.
b. Mass Flow Method for Air	This method uses the mass flow of air heated by the natural gas to backtrack the natural gas consumption. The mass flow of air can be determined either from a mass flow meter or using nameplate data. Using mass flow meter readings is much more accurate than the name plate readings. Mass flow calculations use ASHRAE accepted formulae to calculate consumption.
c. Mass flow Method for Water	This method uses the mass flow of water heated by the natural gas to backtrack the natural gas consumption. The mass flow of water can be determined either from a mass flow meter or using nameplate data. Using mass flow meter readings is much more accurate than the name plate readings. Mass flow calculations use ASHRAE accepted formulae to calculate consumption.
d. Off-sheet/Other Method	Choose this option if you are using a different method to find the natural gas use

Choose Method of Measurement

Step 3 - Total Energy Savings

Values for Opportunity Sheet

Electricity - Current Situation	0.00	MMBTU	**Savings**	0.00	MMBTU
Electricity Used - Projected Situation	0.00	MMBTU			

Insulation - Energy Treasure Hunt Calculator

The calculator is designed to be used as a part of the Energy Treasure Hunt event to quantify the energy savings associated with insulating hot pipes and

Calculation Steps.

Step 1: Determine operational time each year

Step 2: Determine the energy efficiency of the system

Step 3: Determine the rate of energy use

Enter items into the cells in Green, choose from cells in Pink and the Grey Cell will be calculated from your entries.

Step 1 - Determine the Operation time

Before Energy Treasure Hunt

Seconds/minute		*Seconds*
Minutes or cycles/hour		*Min/cycle*
Hours/day		*hr.*
Days/month		*Day*
Months/year		*Month*
Operation Time	0	hrs./yr.

After Energy Treasure Hunt

Seconds/minute		*Seconds*
Minutes or cycles/hour		*Min/Cycle*
Hours/day		*hr.*
Days/month		*Day*
Months/year		*Month*
Operation Time	0	hrs./yr.

Step 2 - Determine the Natural Gas System Efficiency

	Value	*Unit*
Efficiency		%

	Value	*Unit*
Efficiency		%

Step 2 - Determine Natural Gas Consumption

This calculator uses the temperature of the pipe/tank heated by the natural gas to backtrack the natural gas consumption.

Users can use either the surface temperature or the internal fluid temperature of the bare pipe/tank as the input variable to estimate the energy savings within the acceptable levels of error.

Choose if the insulation is for a pipe or a tank	

Step 3 - Total Energy Savings

Values for Opportunity Sheet

Natural Gas - Current Situation		MMBtu
Natural Gas - Projected Situation		MMBtu

Savings		MMBtu

Steam Reduction - Energy Treasure Hunt Calculator

The calculator is designed to be used as a part of the Energy Treasure Hunt event to quantify the energy savings associated with reducing steam

This calculator can be used to calculate the energy savings of typical energy savings opportunities like:

- Reduce the operation time of equipment which uses steam.
- Decrease the flow rate of the "fluid" being heated. (The most common "fluids" heated are water and air.)
- Reduce the operational hours of the boiler house
- Change set point to a lower temperature.

Calculation Steps - Determining annual energy use of a piece of equipment is a four-step process:

Step 1: Determine operational time each year

Step 2: Determine the energy efficiency of the system

Step 3: Determine the rate of energy use

Step 4: Multiply operational time by energy rate to determine consumption.

Enter items into the cells in Green, choose from cells in Pink and the Grey Cell will be calculated from your entries.

Step 1 - Determine the Operation time

Before Energy Treasure Hunt			After Energy Treasure Hunt		
Seconds/minute		*Seconds*	Seconds/minute		*Seconds*
Minutes or cycles/hour		*Min/cycle*	Minutes or cycles/hour		*Min/Cycle*
Hours/day		*hr*	Hours/day		*hr*
Days/month		*Day*	Days/month		*Day*
Months/year		*Month*	Months/year		*Month*
Operation Time	0	hrs/yr	Operation Time	0	hrs/yr

Step 2 - Determine the Steam System Efficiency

	Value	*Unit*		*Value*	*Unit*
Efficiency		%	Efficiency		%

Step 3 - Determine Steam Consumption

Identify the method to be used:

Steam consumption can be determined by several different means. The calculator sheet provides three options to determine consumption. The determination means will always start with the most accurate and end with the least accurate that is acceptable.

a. Flow Meter Method	The best way to measure steam consumption is with a flow meter. The user must understand the units the meter is measuring the time over which the measurement is made to correctly determine consumption.
b. Mass Flow Method for Air	This method uses the mass flow of air heated by the steam to back track the steam consumption. The mass flow of air can be determined either from a mass flow meter or using nameplate data. Using mass flow meter readings is much more accurate than the name plate readings. Mass flow calculations use ASHRAE accepted formulae to calculate consumption.
c. Mass flow Method for Water	This method uses the mass flow of water heated by the steam to backtrack the steam consumption. The mass flow of water can be determined either from a mass flow meter or using nameplate data. Using mass flow meter readings is much more accurate than the name plate readings. Mass flow calculations use ASHRAE accepted formulae to calculate consumption.
d. Off-sheet/Other Method	Choose this option if you are using a different method to find the natural gas use
Choose Method of Measurement	

Step 4 - Total Energy Savings

Choose Output Metric	

Note: To get the results in units consistent with the "Opportunity Sheet", Choose "Natural Gas/Fuel Oil ... (MMBTU)" if the steam is generated onsite using boilers, choose "Steam (klb) only if steam is bought from outside the facility.

Water/ Waste-Water Reduction - Energy Treasure Hunt Calculator

The calculator is designed to be used as part of the Energy Treasure Hunt event to quantify the water or waste-water savings.

This calculator can be used to calculate the energy savings of typical energy savings opportunities like:

- Reduce the operation time of equipment which uses water
- Recycle the water being used
- Engineer rinses and washers

Calculation Steps - Determining annual energy use of a piece of equipment is a three-step process:

Step 1: Determine operational time each year

Step 2: Determine the rate of water use

Step 3: Multiply operational time by water use rate to determine consumption.

Enter items into the cells in Green, choose from cells in Pink and the Grey Cell will be calculated from your entries.

Step 1 - Determine the Operation time

Before Energy Treasure Hunt			After Energy Treasure Hunt		
Seconds/minute		Seconds	Seconds/minute		Seconds
Minutes or cycles/hour		Min/cycle	Minutes or cycles/hour		Min/Cycle
Hours/day		hr	Hours/day		hr
Days/month		Day	Days/month		Day
Months/year		Month	Months/year		Month
Operation Time	0	mins/yr	Operation Time	0	mins/yr

Step 2 - Determine Water/ Waste-Water Consumption

Identify the method to be used:

Water consumption can be determined by several different means. The calculator sheets provide three options to determine consumption. The determination means will always start with the most accurate and end with the least accurate that is acceptable.

a. Metered Flow	The best way to measure water consumption is with a totalizing flow meter.
b. Bucket Method	The second most accurate means of measuring water consumption is the bucket method.
c. Off-sheet/Other Method	Choose this option if you are using a different method to find the compressed air use

Choose Method of Measurement	

Step 3 - Total Energy Savings

Values for Opportunity Sheet

Water/ Waste-Water - Current Usage	0.00	kgal
Water/ Waste-Water - Projected Usage	0.00	kgal

Savings	0.00	kgal

APPENDIX K. SUMMARY REPORT

Automatic Summary Report Generator - Instructions

NOTE

- This generator requires that you use TH Opportunity Sheet's general format, it will not work if you deleted any rows or columns in the Opportunity sheet.

- This workbook uses macros.
  To Enable Macros: Tools->Macros->Security... -> Choose Low or Medium (May also be done by Allowing ' Macros when opening Excel))
  If your Network Administrator has Disabled Macros, you cannot take advantage of this tool. You can still use the format if you wish to manually generate the report.

- All worksheets are protected to preserve formulas & general page layout. If you need to make a change
  Tools->Protection...->Unprotect Sheet (password "energy") will unprotect any individual sheet.
  Tools->Protection...->Protect Sheet (password "energy" two times) will re-protect any individual sheet.

- PLEASE DO NOT ADD OR DELETE ROWS OR COLUMNS on any of the sheets.

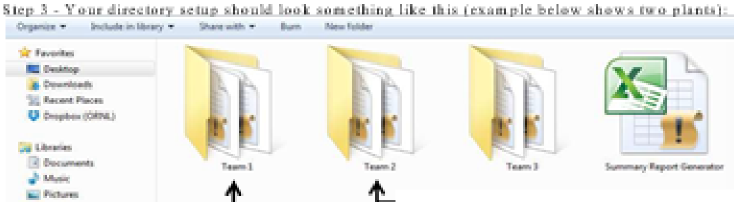
Generating the Summary Report - Steps

Step 1 - Begin by Organizing your detail sheets into a sub folder or sub folders broken down by team / facilities/ process etc.
Note:

- Please provide a brief & descriptive folder name (E.g. 'Production Line 1', 'West Facility, etc.), folder name must not be longer than 31 Characters!!
- Each folder must not contain more than 30 opportunity sheets! Create separate folders if you exceed 30. ***
- Similarly, there cannot be more than 8 Folders. The worksheet can be modified but may require changes imbedded VBA macro.

Step 2 - Copy this file Blank Summary Report Generator.xlsm to the directory containing the sub folders created in step #1
Note - The directory must ONLY contain sub folders with opportunity sheets of the Master format

Step 3 - Your directory setup should look something like this (example below shows two plants):



This file

Folder containing Team 2's Opportunity sheets

Folder containing Team 1's Opportunity sheets

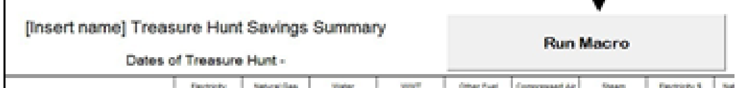
Step 4 - Click on sheet labeled 'Total' next to this instructions sheet:

Note - Ignore the sheet named 'Master' it will be copied by the macro, it CAN NOT be hidden

Step 5 - Type in Plant Name or Company Name (Cell A1) & Treasure Hunt Date (Cell A2)

Step 6 - Save and Close all Opportunity Sheets currently open.

Step 7 - Click 'Run Macro Button'



Step 8 - Be patient, the macro will open every Opportunity Sheet in every folder to copy the information, the following will appear when the macro has finished:

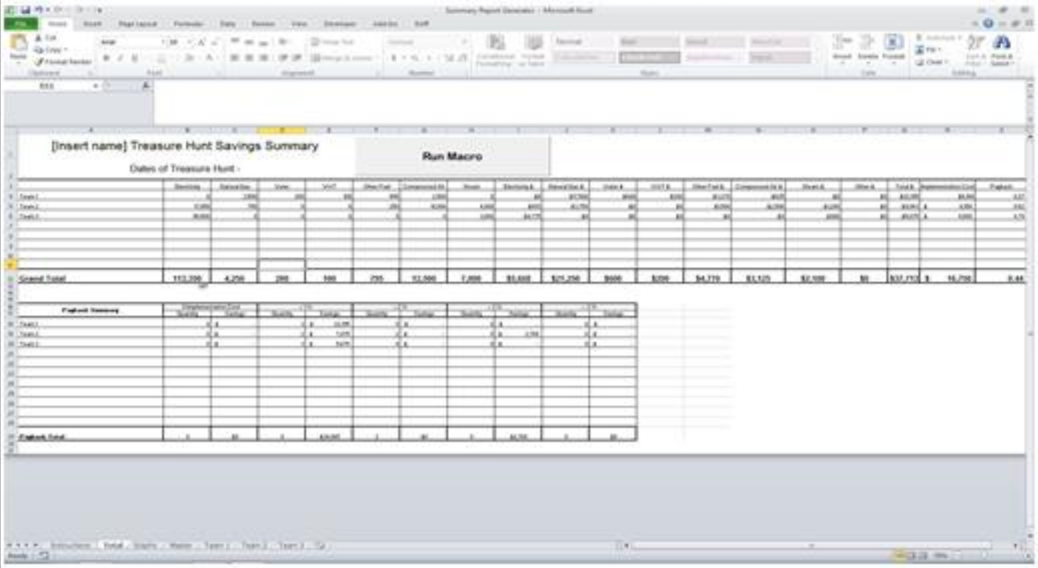
Step 9 - You will notice that the macro created a new Excel Sheet with a summary for each directory & titled them accordingly.

Note - The last summary sheet in the workbook will be selected.

Step 10 - Save your work using Save As... To preserve the original "BLANK" versions contents

Step 11 - Print sheets created in step 8 if necessary

Step 12 - Click back to the sheet labeled 'Total', it should now look something like this (print if necessary):



Step 13 - Additional Graphs are presented in the sheet named " Graphs" - Fill in the necessary inputs and the graphs will be populated.

Inputs

Total Utility Expenditures - Current	
Total CO2 Emmisions - Current	

[Insert name] Treasure Hunt Savings Summary					Dates of Treasure Hunt -														
Teams	Electricity Savings	Natural Gas Savings	Water Savings	Waste Water Savings	Other Fuel Savings	Compressed Air Savings	Steam Savings	Electricity Cost Savings	Natural Gas Cost Savings	Water Cost Savings	Waste Water Cost Savings	Other Fuel Cost Savings	Compressed Air Cost Savings	Steam Cost Savings	Other Cost Savings	Total Cost Savings	Implementation Cost	Payback	CO2 Reduction
Grand Total	0	0	0	0	0	0	0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$ -		0

Payback Summary	0 Implementation Cost		< 1 Yr		< 2 Yr		< 3 Yr		> 3 Yr	
	Quantity	Savings	Quantity	Savings	Quantity	Savings	Quantity	Savings	Quantity	Savings
Payback Total	0	$0	0	$0	0	$0	0	$0	0	$0

Inputs

Total Utility Expenditures - Current	
Total CO2 Emissions - Current	

Outputs

Utility Expenditures

Current Utility Cost	$0
Treasure Hunt savings	$0
Projected Utility Cost	$0

Identified Opportunities

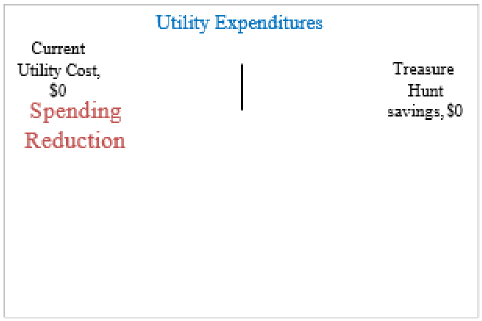
	Number of Opportunities	Payback
< 1 Year	0	$0
< 2 Years	0	$0
< 3 Years	0	$0
> 3 Years	0	$0
Total	0	$0

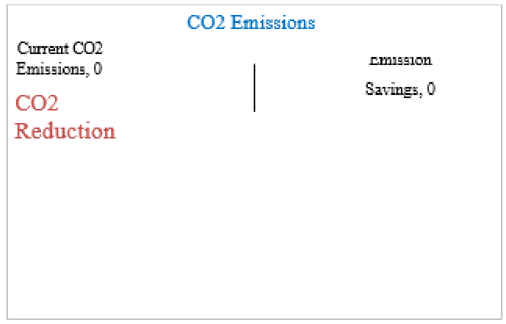
Percent Cost Savings

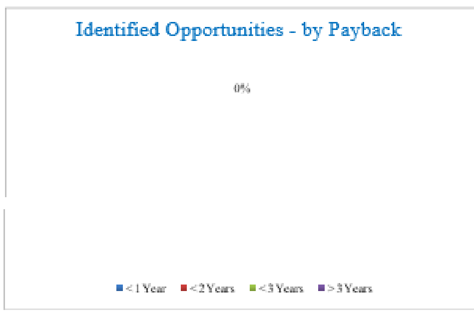
CO2 Emissions

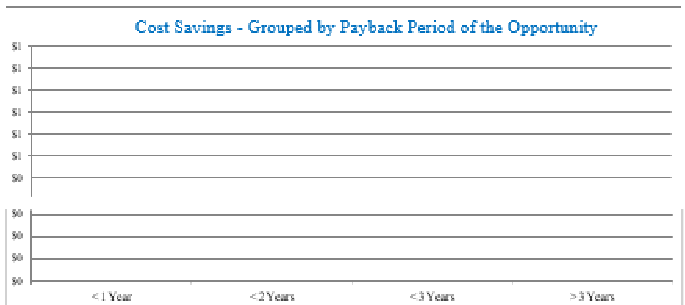
Current CO2 Emissions	0
Emission Savings	0
Projected CO2 Emissions	0

Percent Emission Savings









Opportunity	Electricity Savings	Natural Gas Savings	Water Savings	Waste Water Savings	Other Fuel Savings	Compressed Air Savings	Steam Savings	Electricity Cost Savings	Natural Gas Cost Savings	Water Cost Savings	Waste Water Cost Savings	Other Fuel Cost Savings	Compressed Air Cost Savings	Steam Cost Savings	Other Cost Savings	Total Cost Savings	Implementation Cost	Payback	CO2 Reduction
								$ -	$ -	$ -	$ -	$ -			$ -	$ -	$ -		0
								$ -	$ -	$ -	$ -	$ -			$ -	$ -	$ -		0
								$ -	$ -	$ -	$ -	$ -			$ -	$ -	$ -		0
								$ -	$ -	$ -	$ -	$ -			$ -	$ -	$ -		0
								$ -	$ -	$ -	$ -	$ -			$ -	$ -	$ -		0
								$ -	$ -	$ -	$ -	$ -			$ -	$ -	$ -		0
								$ -	$ -	$ -	$ -	$ -			$ -	$ -	$ -		0
								$ -	$ -	$ -	$ -	$ -			$ -	$ -	$ -		0
								$ -	$ -	$ -	$ -	$ -			$ -	$ -	$ -		0
								$ -	$ -	$ -	$ -	$ -			$ -	$ -	$ -		0
								$ -	$ -	$ -	$ -	$ -			$ -	$ -	$ -		0
								$ -	$ -	$ -	$ -	$ -			$ -	$ -	$ -		0
								$ -	$ -	$ -	$ -	$ -			$ -	$ -	$ -		0
								$ -	$ -	$ -	$ -	$ -			$ -	$ -	$ -		0
								$ -	$ -	$ -	$ -	$ -			$ -	$ -	$ -		0
								$ -	$ -	$ -	$ -	$ -			$ -	$ -	$ -		0
								$ -	$ -	$ -	$ -	$ -			$ -	$ -	$ -		0
								$ -	$ -	$ -	$ -	$ -			$ -	$ -	$ -		0
								$ -	$ -	$ -	$ -	$ -			$ -	$ -	$ -		0
								$ -	$ -	$ -	$ -	$ -			$ -	$ -	$ -		0
								$ -	$ -	$ -	$ -	$ -			$ -	$ -	$ -		0
								$ -	$ -	$ -	$ -	$ -			$ -	$ -	$ -		0
								$ -	$ -	$ -	$ -	$ -			$ -	$ -	$ -		0
								$ -	$ -	$ -	$ -	$ -			$ -	$ -	$ -		0
								$ -	$ -	$ -	$ -	$ -			$ -	$ -	$ -		0
								$ -	$ -	$ -	$ -	$ -			$ -	$ -	$ -		0
								$ -	$ -	$ -	$ -	$ -			$ -	$ -	$ -		0
TOTAL	0	0	0	0	0	0	0	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -		0

Payback Summary

0 Implementation Cost		< 1 Yr		< 2 Yr		< 3 Yr		> 3 Yr	
Quantity	Savings	Quantity	Savings	Quantity	Savings	Quantity	Savings	Quantity	Savings
0	$ -	0	$ -	0	$ -	0	$ -	0	$ -

APPENDIX L. PROJECT IMPLEMENTATION TRACKER

Project Implementation Tracker - Instructions
·Copy the individual opportunities and associated metrics from the " Summary Report Generator" into the Master Sheet of the tracker. ·You can use the "Project Tracking Sheet" to prioritize and track the progress of these projects (Input fields are color coded with Green) ·Once an "Effort to Implement" is defined for each opportunity (Column D of the Project tracking sheet), the Project Prioritization Chart can be used as a visual aid to prioritize projects. ·Worksheet password - "energy"

Project Implementation Team	
Member 1	
Member 2	
Member 3	
Member 4	
Member 5	
Member 6	
Member 7	
Member 8	
*For drop down in Project Tracking Sheet	

Opportunity	Electricity Savings	Natural Gas Savings	Water Savings	Waste Water Savings	Other Fuel Savings	Compressed Air Savings	Steam Savings
TOTAL	0	0	0	0	0	0	0

APPENDIX M. ENERGY TREASURE HUNT PARTICIPATION CERTIFICATE TEMPLATE

Better Plants®
U.S. DEPARTMENT OF ENERGY

Certificate of Completion - Better Plants Energy Treasure Hunt Exchange

Awarded to

(First Name, Last Name)

For completing a multi-day Energy Treasure Hunt Exchange Led by instructor (Instructor Name) at (Company name)'s (plant location – city, state), facility, (Month, Days, Year)

Presented by the U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy

(Instructor Signature)

U.S. DEPARTMENT OF ENERGY

APPENDIX N. TREASURE HUNT EVALUATION FORM TEMPLATE

Better Plants® CHALLENGE U.S. DEPARTMENT OF ENERGY

Evaluation Form

Energy Treasure Hunt

Evaluation Form (2 Pages Total)
Training Site: Plant Name, City, State
Date: (M/D/Y) - (M/D/Y)

Please Complete and return to your facilitator at the conclusion of this Energy Treasure Hunt Exchange

Participant Name: **Job Title:**

Organization/Address: **Phone:** **Email:**

Are you responsible for managing energy consumption at your organization? YES / NO. If YES, please indicate Plant Level or Corporate Level: ______________

1.0 What is your principal business type? Mark only one.

1. Manufacturer
2. State Agency - Energy Efficiency Program
3. Utility (Natural Gas)
4. Utility (Electricity)
5. Utility (Water or Other)
6. Industrial Assessment Center (IAC)
7. Other (Specify) __

2.0 What industry or industries do you work in (if applicable)? Check all that apply.

1. Primary Metals	5. Food Processing	9. Plastics and Rubber	13. Furniture and related products
2. Fabricated Metal Products	6. Paper Manufacturing	10. Computer and Electronic Products	14. Machinery Manufacturing
3. Chemicals	7. Textiles and Textile Products	11. Electrical Equipment, Appliances and Components	15. Water/Wastewater Treatment
4. Petroleum and Coal Products	8. Wood Products	12. Transportation Equipment Manufacturing	16. Other and Miscellaneous Manufacturing

3.0 What is your main reason for attendance?

1. Acquire New Skills 2. Interest in Topic Area 3. Required by Employer 4. Update Skills 5. Job-Related Incentive
6. Other_____

4.0 Participants feedback on Treasure Hunt event:	Strongly Disagree		Neither Agree Nor Disagree		Strongly Agree
4.1 The event provided information that I will apply to my job	1	2	3	4	5
4.2 The event provided adequate time for asking questions & discussion.	1	2	3	4	5
4.3 The facilitator made clear the goals-objectives of the treasure hunt exchange	1	2	3	4	5
4.4 The facilitator provided helpful guidance throughout the process	1	2	3	4	5
4.5 The facilitator provided effective training on calculating and documenting energy savings	1	2	3	4	5
4.6 The facilitator responded to the questions and issues effectively	1	2	3	4	5
4.7 The handouts, calculators and opportunity sheets provided were easy to use	1	2	3	4	5
4.8 The handouts, calculators provided were helpful	1	2	3	4	5
4.9 The facilitator trained an employee of the host to facilitate future treasure hunts	1	2	3	4	5

5.0 How effective was the workshop at providing information on:	Not Effective		Moderately Effective		Very Effective	Not Applicable
5.1 Identifying opportunities to save energy.	1	2	3	4	5	N/A
5.2 Quantifying energy savings associated with the identified opportunities	1	2	3	4	5	N/A
5.3 Documenting energy savings opportunities	1	2	3	4	5	N/A
5.4 Background on the various systems in the plant	1	2	3	4	5	N/A

6.0 Other Comments:

6.1 Would you recommend the treasure hunt exchange to other Plant(s) in your organization?	Yes / No
6.2 What actions do you expect to take as a result of this training?	
6.3 As a result of this training, do you feel comfortable facilitating a similar event at other plants in your organization?	Yes / No
6.4 What are your comments or suggestions for improving this treasure hunt exchange? • • • •	

7. **Based on what I learned today, I will implement some energy savings Best Practices when I go back to my plant**

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

← *Strongly Disagree* ↑ *Agree* → *Strongly Agree*

Comments: **Best Practices**, I intend to pursue in my plant are:

7.1 --

7.2 --

7.3 --

7.4 --

7.5 --

8. **Would you like to be contacted about the following DOE Technical Assistance programs:**

Combined Heat and Power (CHP)? Yes / No
Industrial Assessment Centers (IAC)? Yes / No
Superior Energy Performance (SEP)? Yes / No
50001 Ready? Yes / No

9. **Can DOE follow up with you in about a year to see what practices you have put in place as a result of this INPLT?**
Yes / No