Oak Ridge National Laboratory  
Official TM Cover: PEPEx Algorithm



Thomas Wenning

Sachin Nimbalkar

Kiran Thirumaran

3/2/2016

|  |
| --- |
| **DOCUMENT AVAILABILITY** |
| Reports produced after January 1, 1996, are generally available free via US Department of Energy (DOE) SciTech Connect.  ***Website*** <http://www.osti.gov/scitech/>  Reports produced before January 1, 1996, may be purchased by members of the public from the following source:  National Technical Information Service  5285 Port Royal Road  Springfield, VA 22161  ***Telephone*** 703-605-6000 (1-800-553-6847)  ***TDD*** 703-487-4639  ***Fax*** 703-605-6900  ***E-mail*** info@ntis.gov  ***Website*** <http://www.ntis.gov/help/ordermethods.aspx>  Reports are available to DOE employees, DOE contractors, Energy Technology Data Exchange representatives, and International Nuclear Information System representatives from the following source:  Office of Scientific and Technical Information  PO Box 62  Oak Ridge, TN 37831  ***Telephone*** 865-576-8401  ***Fax*** 865-576-5728  ***E-mail*** reports@osti.gov  ***Website*** <http://www.osti.gov/contact.html> |

|  |
| --- |
| This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof. |
|  |

ORNL/TM-2017/73028

Energy and Transportation Science Division

PEPEx ALGORITHM

Thomas Wenning (Oak Ridge National Laboratory)

Sachin Nimbalkar (Oak Ridge National Laboratory)

Kiran Thirumaran (Oak Ridge National Laboratory)

Date Published: March 2, 2017

Prepared by

OAK RIDGE NATIONAL LABORATORY

Oak Ridge, TN 37831-6283

managed by

UT-BATTELLE, LLC

for the

US DEPARTMENT OF ENERGY

under contract DE-AC05-00OR22725

CONTENTS

[LIST OF FIGURES iv](#_Toc466635692)

[LIST OF TABLES iv](#_Toc466635693)

[ACRONYMS v](#_Toc466635694)

[1. OVERVIEW 1](#_Toc466635695)

[2. PEPEx Algorithm 1](#_Toc466635696)

[2.1 INTRODUCTION 1](#_Toc466635697)

[2.2 Step 1: Basic Information 1](#_Toc466635698)

[2.3 Step 2: Energy and production 2](#_Toc466635699)

[2.3.1 Units of Measurement 2](#_Toc466635700)

[2.3.2 Facility’s Energy and Production Data 2](#_Toc466635701)

[2.3.3 Site to Source conversion (optional) 2](#_Toc466635702)

[2.4 Step 3: Energy Use Systems 2](#_Toc466635703)

[2.5 Step 4: Energy Savings oppOrtunity 3](#_Toc466635704)

[3. Results 3](#_Toc466635705)

[3.1 Annual Energy Use 3](#_Toc466635706)

[3.2 Potential Annual Energy Savings 4](#_Toc466635707)

[3.3 Suggested Next Steps 5](#_Toc466635708)

[APPENDIX A. Energy Distribution by Industry A-1](#_Toc466635709)

[APPENDIX B. PEPEx Scorecard Questions and Scores B-14](#_Toc466635710)

[APPENDIX C. PEPEX Suggested Next Steps C-38](#_Toc466635711)

LIST OF FIGURES

[Figure 1.The Excel Worksheet Tabs categorized based on their function. 1](#_Toc466635712)

LIST OF TABLES

[Table 1. Ranges for PEPEx Scorecard Results 4](#_Toc466635713)

[Table 2. Potential Percent of Savings for each End Use 4](#_Toc466635714)

[Table A-1. Industry: All Manufacturing (NAICS 31-33) A-2](#_Toc466635715)

[Table A-2. Industry: Aluminum (NAICS 3313) A-3](#_Toc466635716)

[Table A-3. Industry: Cement (NAICS 327310) A-4](#_Toc466635717)

[Table A-4. Industry: Chemicals (NAICS 325) A-4](#_Toc466635718)

[Table A-5. Industry: Computers and Electronics (NAICS 334, 335) A-5](#_Toc466635719)

[Table A-6. Industry: Food and Beverage (NAICS 311-312) A-6](#_Toc466635720)

[Table A-7. Industry: Forest Products (NAICS 321, 322) A-6](#_Toc466635721)

[Table A-8. Industry: Foundries (NAICS 3315) A-7](#_Toc466635722)

[Table A-9. Industry: Glass (NAICS 3272, 327993) A-8](#_Toc466635723)

[Table A-10. Industry: Machinery (NAICS 333) A-9](#_Toc466635724)

[Table A-11. Industry: Fabricated Metals (NAICS 332) A-9](#_Toc466635725)

[Table A-12. Industry: Petroleum Refining (NAICS 324110) A-10](#_Toc466635726)

[Table A-13. Industry: Plastics (NAICS 326) A-11](#_Toc466635727)

[Table A-14. Industry: Iron and Steel (NAICS 3311, 3312) A-11](#_Toc466635728)

[Table A-15. Industry: Textiles (NAICS 313-316) A-12](#_Toc466635729)

[Table A-16. Industry: transportation Equipment (NAICS 336) A-13](#_Toc466635730)

[Table B-1. Combined Heat and Power Scorecard Question B-15](#_Toc466635731)

[Table B-2. Compressed Air Scorecard Questions B-18](#_Toc466635732)

[Table B-3. Process Cooling and Refrigeration Scorecard Questions B-22](#_Toc466635733)

[Table B-4. Process Heating Scorecard Questions B-27](#_Toc466635734)

[Table B-5. Pumps Scorecard Questions B-30](#_Toc466635735)

[Table B-6. Steam Generation Scorecard Questions B-32](#_Toc466635736)

[Table C-1. Suggested Next Steps C-39](#_Toc466635737)

ACRONYMS

PEP Plant Energy Profiler

PEPEx Plant Energy Profiler Excel

DOE Department of Energy

ORNL Oak Ridge National Laboratory

MECS Manufacturing Energy Consumption Survey

EIA Energy Information Administration

CHP Combined Heat and Power

HVAC Heating, Ventilation and Air-Conditioning

kWh Kilowatt hour

MMBTU Million Btu

HRSG Heat Recovery Steam Generator

FSAT Fan System Assessment Tool

PSAT Pump System Assessment Tool

CWSAT Chilled Water System Assessment Tool

PHSAT Process Heating System Assessment Tool

# OVERVIEW

This document outlines the underlying logic and computations performed by the Plant Energy Profiler Excel or PEPEx tool. The goal is to present the algorithm in plain text so that it can be reviewed and validated by subject matter experts, and for reference in any future design or upgrade efforts.

# PEPEx Algorithm

## INTRODUCTION

The PEPEx tool consists of four data collection sheets (input sheets) which are used to estimate the amount of energy used to support the operation of a plant and potential energy savings opportunities. In the results sheet, the tool plots the current energy consumption (electric, natural gas, steam and other fuels) of the plant. The potential energy savings are also calculated based on user inputs. The sections below outline the data and scorecard values collected by PEPEx and how they are used for computation. Further, each step defined in this section corresponds to a input sheet that needs to be completed by the user.

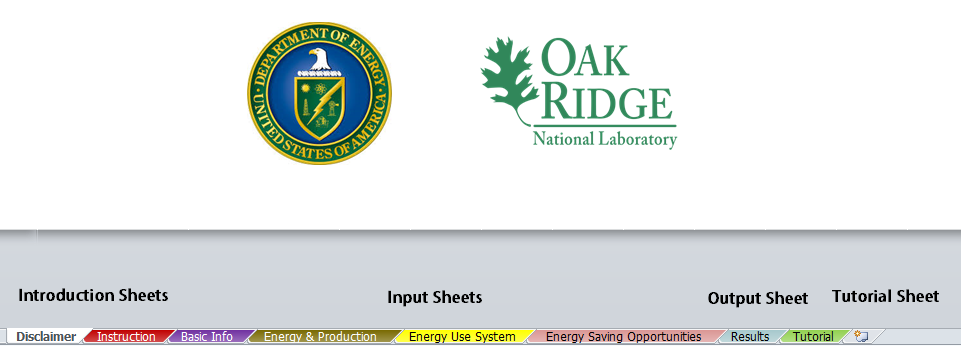


Figure 1.The Excel Worksheet Tabs categorized based on their function.

## Step 1: Basic Information

In the basic info sheet, PEPEx asks for plants contact information, plants' operating schedule and some general energy management questions. While a majority of these questions are for book-keeping purposes, the industry type and the energy management questions affect the results and play into the tools algorithm.

The type of industry selected by the user determines default energy use distribution values for step three, based on data from the latest EIA Manufacturing Energy Consumption Survey (MECS). See appendix A for the default breakdown of energy use by the system for each industry choice.

The general energy management scorecard evaluates the energy management steps that have been taken at the plant; including the energy management plan, appointment of an energy management team, and approach for determining the economic impact of energy efficient equipment. The answers to these questions affect the recommendations but do not affect the savings

## Step 2: Energy and production

The second input sheet in the PEPEx application is “Energy and Production”. The following section lays out the data defined in this section and how it is used by the tool.

### Units of Measurement

PEPEx allows the user to input the energy data for each fuel in their preferred unit, these units needs to be defined in the first section of this sheet. In order to display results for the various energy sources together and to calculate energy intensity, PEPEx converts all the input data to a common output unit. This output unit needs to be defined by the user in this section as well.

### Facility’s Energy and Production Data

In this section, the total electricity, natural gas, steam and any other fuel provided to the plant is collected. For each energy stream, the user is asked to enter either the monthly or annual units purchased and associated cost. The user may choose to not enter the cost information in this section and can alternatively use the “Unit cost of Energy” below to provide this information. The energy consumption values gathered in this section are used to calculate the annual energy and the potential savings.

Along with the energy data, the production information for the plant is collected. This step is optional. Similar to energy the user can enter the production data by month or for the entire year. This section is optional, but if complete, the information is used to calculate energy intensity and associated graphs.

### Site to Source conversion (optional)

The user also has the option to input a source energy factor for each fuel used. Source Energy factor is used to calculate the source energy for each energy stream. Source energy incorporates all transmission, delivery and production losses associated with each energy stream.

The default source factor for each stream is provided, based on those used in Energy Star Portfolio Manager. The user may wish to make appropriate changes to this factor to account for losses associated with transmission, delivery, and production of each energy stream. PEPEx calculates all its results in terms of "site energy" unless explicitly stated.

## Step 3: Energy Use Systems

In this section, the percent of total annual energy use that each major system in the plant consumes is defined. Default values are set based on the industry selected in Step one: Basic Info, but the distribution profile can be edited by the user to provide a more custom view of the plant.

This section asks the user to select all of the energy use systems that are used in the plant and the associated primary and secondary fuel. The systems selected in this section determine which questions and scorecards will be needed in step four. The system choices that are shown in this step include:

* Combined Heat and Power
* Compressed Air
* Electrochemical Processes
* Fans and Blowers
* Industrial Facilities (Lighting, HVAC, and Facility Support)
* Materials Handling
* Materials Processing
* Process Cooling and Refrigeration
* Process heating
* Pumps
* Steam Generation Equipment

## Step 4: Energy Savings oppOrtunity

This sheet is used to characterize the potential energy saving opportunities for the various major systems in the plant. For each system, the user is asked to rank the energy saving opportunity level based on whether or not an energy savings assessment has been done on the system and how much effort has been put into conserving energy for that system. Data collected in this section affects recommended next steps and the magnitude of potential savings identified in the results section. If the energy savings opportunity for a system is ranked as “high”, a recommendation to perform a detailed system assessment at the site is provided in the suggested next steps section.

The user also has the option to use a scorecard to determine energy savings potential associated with a system by choosing the scorecard option from the drop-down list.

The scorecards are available for the following systems,

* Combined Heat and Power Scorecard
* Compressed Air Scorecard
* Process Cooling and Refrigeration Scorecard
* Process Heating Scorecard
* Pumps Scorecard
* Steam Generation Equipment Scorecard

For each system scorecard, the user may be asked questions about the components, hours of use, measurement and monitoring procedures, maintenance, etc. A full list of questions is shown in tables B.1 through B.6 of Appendix B.

The energy use systems questions are used to determine the level of opportunity to save energy. In each scorecard, the answer to each question is assigned a number value. The total for each scorecard is calculated and used to determine the energy savings opportunities for the system area. Refer to tables B.1 through B.6 in appendix B for the amount of points assigned to each answer. Section 3.2 provides a table that summarizes how the energy saving opportunity level for each system area is computed.

# Results

PEPEx computes potential annual energy savings and suggested next steps, based on the answers provided in the scorecards, supplied energy, and energy use distribution data.

## Annual Energy Use

The total annual electricity, fuel, steam and other fuel is calculated in the results section. The total cost of the electricity, fuel, steam and other fuel is also calculated. The total energy consumption is calculated by converting the energy uses entered in Step 1: Energy and Production into the same unit and summing the inputs.

## Potential Annual Energy Savings

Potential energy savings is calculated based on the ranking given to energy use system and the industry selected in Step 1. Answers in Step 2: Energy Use Systems Scorecards and Step 3: Energy Savings Opportunities are assigned a number value. The total for each system is then calculated. Based on the total for the system, a ranking of high, medium, or low is assigned to the energy savings opportunity for that system. See tables B.1 through B.6 in Appendix B for the values assigned for each answer. The key for each system is shown below.

Table 1. Ranges for PEPEx Scorecard Results

|  |  |  |  |
| --- | --- | --- | --- |
| Scorecard | Minimum Point Value | Maximum Point Value | Ranking |
| Compressed Air | 0 | 40 | High |
| Compressed Air | 40 | 80 | Medium |
| Compressed Air | 80 | 100 | Low |
| Process Cooling and Refrigeration | 0 | 40 | High |
| Process Cooling and Refrigeration | 40 | 85 | Medium |
| Process Cooling and Refrigeration | 85 | 100 | Low |
| Process Heating | 0 | 25 | High |
| Process Heating | 25 | 50 | Medium |
| Process Heating | 50 | 100 | Low |
| Pumps | 0 | 40 | High |
| Pumps | 40 | 80 | Medium |
| Pumps | 80 | 100 | Low |
| Combined heat and power (cogeneration) | 0 | 40 | High |
| Combined heat and power (cogeneration) | 40 | 80 | Medium |
| Combined heat and power (cogeneration) | 80 | 100 | Low |
| Steam Generation Equipment | 0 | 50 | High |
| Steam Generation Equipment | 50 | 80 | Medium |
| Steam Generation Equipment | 80 | 100 | Low |

Each end use is assigned a ranking of high, medium, or low depending on the score. The ranking for each end use corresponds to a potential percentage of savings. Table 2 lists the percentage savings corresponding to each combination of end use and savings opportunity ranking. The potential percentage of savings is multiplied by the current energy use to determine the potential energy savings.

For example, consider a compressed air system that used 1,000 kWh of energy a year. If the opportunity to save energy in the system was ranked as high, the tool would estimate that the system could save 15% of their annual energy use corresponding to an annual savings of 150 kWh.

Table 2. Potential Percent of Savings for each End Use

|  |  |  |  |
| --- | --- | --- | --- |
| End Use | High Savings Opportunity (%) | Medium Savings Opportunity (%) | Low Savings Opportunity (%) |
| Combined heat and power (cogeneration) | 5 | 3 | 1 |
| Compressed air | 20 | 15 | 5 |
| Electrochemical Processes | 0 | 0 | 0 |
| Fans and Blowers | 10 | 10 | 10 |
| Industrial Facilities (Lighting, HVAC and Facility Support) | 15 | 15 | 15 |
| Materials Handling | 0 | 0 | 0 |
| Materials Processing | 0 | 0 | 0 |
| Process cooling and refrigeration | 15 | 10 | 5 |
| Process heating:  Aluminum and Alumina  Cement  EAF Steel  Foundries  Glass and Glass Products  Integrated Steel | 40 | 25 | 10 |
| Process heating:  Chemicals and Allied Products  Fabricated Metal Products  Petroleum Refining | 25 | 15 | 7.5 |
| Process heating (all others) | 15 | 10 | 5 |
| Pumps | 15 | 10 | 10 |
| Steam Generation Equipment | 20 | 15 | 5 |

## Suggested Next Steps

Suggested next steps are determined by the savings opportunity for the system. Each answer in the scorecards is assigned a number value. See tables B.1 through B.6 in Appendix B for the values assigned for each answer. The total from all the answers is calculated for each energy use system. Based on the total from the section, an energy savings opportunity ranking of high, medium, or low is assigned to the system. This ranking determines which recommendations will be shown in the suggested next steps section of the results. See Appendix C for the key that determines which recommendations will be shown given the ranking for the system.

Questions about the user’s current energy management practices are asked in the scorecards in steps 1 If the user states they are currently doing energy management practices that may show up as a recommendation, such as, measuring and monitoring their current energy use, then this suggestion would not show up in the recommendations section.

1. Energy Distribution by Industry

Table A-1. Industry: All Manufacturing (NAICS 31-33)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | End Use | % Electricity Usage | % Steam Usage | % Fuel Usage |
| Process Uses | Conventional Boilers | 3% | 0% | 17% |
| CHP/Cogeneration | 0% | 0% | 32% |
| Other Electricity Generation | 0% | 0% | 0% |
| Process Heating | 11% | 80% | 42% |
| Process Cooling and Refrigeration | 7% | 0% | 0% |
| Electro-Chemical Process | 8% | 0% | 0% |
| Pumps | 14% | 7% | 1% |
| Fans | 8% | 3% | 1% |
| Compressed Air | 9% | 0% | 0% |
| Materials Handling | 7% | 0% | 0% |
| Materials Processing | 13% | 0% | 0% |
| Other Machine Driven Systems | 2% | 1% | 0% |
| Other Process Uses | 1% | 1% | 2% |
| Nonprocess Uses | Facility HVAC | 9% | 8% | 4% |
| Facility Lighting | 7% | 0% | 0% |
| Other Facility Support | 2% | 0% | 0% |
| Onsite Transportation | 0% | 0% | 1% |
| Other Nonprocess Uses | 0% | 0% | 0% |
|  |  | 100% | 100% | 100% |

Table A-2. Industry: Aluminum (NAICS 3313)

|  |  |  |  |
| --- | --- | --- | --- |
| End Use | % Electricity Usage | % Steam Usage | % Fuel Usage |
| Conventional Boilers | 0% | 0% | 3% |
| CHP/Cogeneration | 0% | 0% | 12% |
| Other Electricity Generation | 0% | 0% | 0% |
| Process Heating | 5% | 4% | 76% |
| Process Cooling and Refrigeration | 1% | 0% | 2% |
| Electro-Chemical Process | 78% | 0% | 0% |
| Pumps | 1% | 59% | 1% |
| Fans | 2% | 23% | 0% |
| Compressed Air | 2% | 0% | 0% |
| Materials Handling | 6% | 0% | 0% |
| Materials Processing | 2% | 0% | 0% |
| Other Machine Driven Systems | 0% | 9% | 0% |
| Other Process Uses | 0% | 0% | 1% |
| Facility HVAC | 1% | 6% | 3% |
| Facility Lighting | 2% | 0% | 0% |
| Other Facility Support | 1% | 0% | 1% |
| Onsite Transportation | 0% | 0% | 1% |
| Other Nonprocess Uses | 0% | 0% | 0% |
|  | 100% | 100% | 100% |

Table A-3. Industry: Cement (NAICS 327310)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | End Use | % Electricity Usage | % Steam Usage | % Fuel Usage |
| Process Uses | Conventional Boilers | 0% | 0% | 0% |
| CHP/Cogeneration | 0% | 0% | 11% |
| Other Electricity Generation | 0% | 0% | 0% |
| Process Heating | 9% | 4% | 88% |
| Process Cooling and Refrigeration | 0% | 0% | 0% |
| Electro-Chemical Process | 0% | 0% | 0% |
| Pumps | 6% | 59% | 1% |
| Fans | 11% |  | 0% |
| Compressed Air | 11% | 0% | 0% |
| Materials Handling | 36% | 0% | 0% |
| Materials Processing | 10% | 0% | 0% |
| Other Machine Driven Systems | 1% | 9% | 0% |
| Other Process Uses | 2% | 0% | 0% |
| Nonprocess Uses | Facility HVAC | 7% | 6% | 0% |
| Facility Lighting | 4% | 0% | 0% |
| Other Facility Support | 2% | 0% | 0% |
| Onsite Transportation | 0% | 0% | 1% |
| Other Nonprocess Uses | 0% | 0% | 0% |
|  |  | 100% | 100% | 100% |

Table A-4. Industry: Chemicals (NAICS 325)

|  |  |  |  |
| --- | --- | --- | --- |
| End Use | % Electricity Usage | % Steam Usage | % Fuel Usage |
| Conventional Boilers | 4% | 0% | 25% |
| CHP/Cogeneration | 0% | 0% | 44% |
| Other Electricity Generation | 0% | 0% | 0% |
| Process Heating | 5% | 86% | 22% |
| Process Cooling and Refrigeration | 8% | 0% | 1% |
| Electro-Chemical Process | 14% | 0% | 0% |
| Pumps | 16% | 7% | 2% |
| Fans | 7% | 3% | 1% |
| Compressed Air | 17% | 0% | 0% |
| Materials Handling | 1% | 0% | 0% |
| Materials Processing | 14% | 0% | 0% |
| Other Machine Driven Systems | 1% | 1% | 0% |
| Other Process Uses | 1% | 0% | 2% |
| Facility HVAC | 6% | 4% | 1% |
| Facility Lighting | 4% | 0% | 0% |
| Other Facility Support | 1% | 0% | 0% |
| Onsite Transportation | 0% | 0% | 0% |
| Other Nonprocess Uses | 0% | 0% | 0% |
|  | 100% | 100% | 100% |

Table A-5. Industry: Computers and Electronics (NAICS 334, 335)

|  |  |  |  |
| --- | --- | --- | --- |
| End Use | % Electricity Usage | % Steam Usage | % Fuel Usage |
| Conventional Boilers | 1% | 0% | 31% |
| CHP/Cogeneration | 0% | 0% | 0% |
| Other Electricity Generation | 0% | 0% | 0% |
| Process Heating | 15% | 15% | 31% |
| Process Cooling and Refrigeration | 9% | 0% | 1% |
| Electro-Chemical Process | 1% | 0% | 0% |
| Pumps | 5% | 1% | 0% |
| Fans | 3% | 0% | 0% |
| Compressed Air | 4% | 0% | 0% |
| Materials Handling | 2% | 0% | 0% |
| Materials Processing | 7% | 0% | 0% |
| Other Machine Driven Systems | 5% | 0% | 0% |
| Other Process Uses | 6% | 0% | 2% |
| Facility HVAC | 24% | 84% | 30% |
| Facility Lighting | 12% | 0% | 0% |
| Other Facility Support | 6% | 0% | 0% |
| Onsite Transportation | 0% | 0% | 3% |
| Other Nonprocess Uses | 1% | 0% | 1% |
|  | 100% | 100% | 100% |

Table A-6. Industry: Food and Beverage (NAICS 311-312)

|  |  |  |  |
| --- | --- | --- | --- |
| End Use | % Electricity Usage | % Steam Usage | % Fuel Usage |
| Conventional Boilers | 2% | 0% | 48% |
| CHP/Cogeneration | 0% | 0% | 18% |
| Other Electricity Generation | 0% | 0% | 0% |
| Process Heating | 6% | 78% | 25% |
| Process Cooling and Refrigeration | 26% | 0% | 0% |
| Electro-Chemical Process | 0% | 0% | 0% |
| Pumps | 11% | 3% | 1% |
| Fans | 5% | 1% | 0% |
| Compressed Air | 5% | 0% | 0% |
| Materials Handling | 4% | 0% | 0% |
| Materials Processing | 17% | 0% | 0% |
| Other Machine Driven Systems | 4% | 1% | 0% |
| Other Process Uses | 1% | 0% | 2% |
| Facility HVAC | 9% | 16% | 4% |
| Facility Lighting | 7% | 0% | 0% |
| Other Facility Support | 2% | 0% | 1% |
| Onsite Transportation | 0% | 0% | 0% |
| Other Nonprocess Uses | 0% | 0% | 0% |
|  | 100% | 100% | 100% |

Table A-7. Industry: Forest Products (NAICS 321, 322)

|  |  |  |  |
| --- | --- | --- | --- |
| End Use | % Electricity Usage | % Steam Usage | % Fuel Usage |
| Conventional Boilers | 6% | 0% | 8% |
| CHP/Cogeneration | 0% | 0% | 79% |
| Other Electricity Generation | 0% | 0% | 0% |
| Process Heating | 5% | 85% | 10% |
| Process Cooling and Refrigeration | 2% | 0% | 0% |
| Electro-Chemical Process | 1% | 0% | 0% |
| Pumps | 24% | 5% | 1% |
| Fans | 15% | 2% | 0% |
| Compressed Air | 4% | 0% | 0% |
| Materials Handling | 6% | 0% | 0% |
| Materials Processing | 16% | 0% | 0% |
| Other Machine Driven Systems | 11% | 1% | 0% |
| Other Process Uses | 1% | 0% | 0% |
| Facility HVAC | 5% | 8% | 1% |
| Facility Lighting | 5% | 0% | 0% |
| Other Facility Support | 1% | 0% | 0% |
| Onsite Transportation | 0% | 0% | 1% |
| Other Nonprocess Uses | 0% | 0% | 0% |
|  | 100% | 100% | 100% |

Table A-8. Industry: Foundries (NAICS 3315)

|  |  |  |  |
| --- | --- | --- | --- |
| End Use | % Electricity Usage | % Steam Usage | % Fuel Usage |
| Conventional Boilers | 0% | 0% | 3% |
| CHP/Cogeneration | 0% | 0% | 0% |
| Other Electricity Generation | 0% | 0% | 0% |
| Process Heating | 46% | 4% | 79% |
| Process Cooling and Refrigeration | 2% | 0% | 0% |
| Electro-Chemical Process | 4% | 0% | 0% |
| Pumps | 3% | 59% | 1% |
| Fans | 5% | 23% | 0% |
| Compressed Air | 5% | 0% | 0% |
| Materials Handling | 14% | 0% | 0% |
| Materials Processing | 3% | 0% | 0% |
| Other Machine Driven Systems | 0% | 9% | 0% |
| Other Process Uses | 2% | 0% | 1% |
| Facility HVAC | 9% | 6% | 13% |
| Facility Lighting | 5% | 0% | 0% |
| Other Facility Support | 2% | 0% | 1% |
| Onsite Transportation | 0% | 0% | 1% |
| Other Nonprocess Uses | 0% | 0% | 0% |
|  | 100% | 100% | 100% |

Table A-9. Industry: Glass (NAICS 3272, 327993)

|  |  |  |  |
| --- | --- | --- | --- |
| End Use | % Electricity Usage | % Steam Usage | % Fuel Usage |
| Conventional Boilers | 0% | 0% | 9% |
| CHP/Cogeneration | 0% | 0% | 0% |
| Other Electricity Generation | 0% | 0% | 0% |
| Process Heating | 37% | 4% | 86% |
| Process Cooling and Refrigeration | 3% | 0% | 0% |
| Electro-Chemical Process | 0% | 0% | 0% |
| Pumps | 9% | 59% | 0% |
| Fans | 7% | 23% | 0% |
| Compressed Air | 7% | 0% | 0% |
| Materials Handling | 4% | 0% | 0% |
| Materials Processing | 15% | 0% | 0% |
| Other Machine Driven Systems | 2% | 9% | 0% |
| Other Process Uses | 5% | 0% | 0% |
| Facility HVAC | 5% | 6% | 5% |
| Facility Lighting | 6% | 0% | 0% |
| Other Facility Support | 0% | 0% | 0% |
| Onsite Transportation | 0% | 0% | 0% |
| Other Nonprocess Uses | 0% | 0% | 0% |
|  | 100% | 100% | 100% |

Table A-10. Industry: Machinery (NAICS 333)

|  |  |  |  |
| --- | --- | --- | --- |
| End Use | % Electricity Usage | % Steam Usage | % Fuel Usage |
| Conventional Boilers | 1% | 0% | 19% |
| CHP/Cogeneration | 0% | 0% | 8% |
| Other Electricity Generation | 0% | 0% | 0% |
| Process Heating | 7% | 35% | 27% |
| Process Cooling and Refrigeration | 3% | 0% | 0% |
| Electro-Chemical Process | 0% | 0% | 0% |
| Pumps | 9% | 1% | 0% |
| Fans | 7% | 0% | 0% |
| Compressed Air | 7% | 0% | 0% |
| Materials Handling | 5% | 0% | 0% |
| Materials Processing | 15% | 0% | 0% |
| Other Machine Driven Systems | 2% | 0% | 0% |
| Other Process Uses | 2% | 0% | 4% |
| Facility HVAC | 23% | 64% | 36% |
| Facility Lighting | 15% | 0% | 0% |
| Other Facility Support | 3% | 0% | 2% |
| Onsite Transportation | 1% | 0% | 1% |
| Other Nonprocess Uses | 1% | 0% | 2% |
|  | 100% | 100% | 100% |

Table A-11. Industry: Fabricated Metals (NAICS 332)

|  |  |  |  |
| --- | --- | --- | --- |
| End Use | % Electricity Usage | % Steam Usage | % Fuel Usage |
| Conventional Boilers | 1% | 0% | 15% |
| CHP/Cogeneration | 0% | 0% | 2% |
| Other Electricity Generation | 0% | 0% | 0% |
| Process Heating | 20% | 35% | 65% |
| Process Cooling and Refrigeration | 3% | 0% | 0% |
| Electro-Chemical Process | 2% | 0% | 0% |
| Pumps | 10% | 1% | 0% |
| Fans | 7% | 0% | 0% |
| Compressed Air | 8% | 0% | 0% |
| Materials Handling | 6% | 0% | 0% |
| Materials Processing | 17% | 0% | 0% |
| Other Machine Driven Systems | 2% | 0% | 0% |
| Other Process Uses | 3% | 0% | 0% |
| Facility HVAC | 10% | 64% | 15% |
| Facility Lighting | 10% | 0% | 0% |
| Other Facility Support | 2% | 0% | 1% |
| Onsite Transportation | 0% | 0% | 1% |
| Other Nonprocess Uses | 0% | 0% | 0% |
|  | 100% | 100% | 100% |

Table A-12. Industry: Petroleum Refining (NAICS 324110)

|  |  |  |  |
| --- | --- | --- | --- |
| End Use | % Electricity Usage | % Steam Usage | % Fuel Usage |
| Conventional Boilers | 1% | 0% | 15% |
| CHP/Cogeneration | 0% | 0% | 16% |
| Other Electricity Generation | 0% | 0% | 0% |
| Process Heating | 3% | 97% | 65% |
| Process Cooling and Refrigeration | 6% | 0% | 0% |
| Electro-Chemical Process | 0% | 0% | 0% |
| Pumps | 50% | 1% | 1% |
| Fans | 8% | 1% | 0% |
| Compressed Air | 13% | 0% | 0% |
| Materials Handling | 2% | 0% | 0% |
| Materials Processing | 9% | 0% | 0% |
| Other Machine Driven Systems | 2% | 0% | 0% |
| Other Process Uses | 0% | 0% | 2% |
| Facility HVAC | 3% | 1% | 0% |
| Facility Lighting | 2% | 0% | 0% |
| Other Facility Support | 1% | 0% | 0% |
| Onsite Transportation | 0% | 0% | 0% |
| Other Nonprocess Uses | 0% | 0% | 0% |
|  | 100% | 100% | 100% |

Table A-13. Industry: Plastics (NAICS 326)

|  |  |  |  |
| --- | --- | --- | --- |
| End Use | % Electricity Usage | % Steam Usage | % Fuel Usage |
| Conventional Boilers | 1% | 0% | 52% |
| CHP/Cogeneration | 0% | 0% | 0% |
| Other Electricity Generation | 0% | 0% | 0% |
| Process Heating | 15% | 59% | 24% |
| Process Cooling and Refrigeration | 9% | 0% | 0% |
| Electro-Chemical Process | 0% | 0% | 0% |
| Pumps | 13% | 3% | 1% |
| Fans | 7% | 1% | 1% |
| Compressed Air | 9% | 0% | 0% |
| Materials Handling | 7% | 0% | 0% |
| Materials Processing | 12% | 0% | 0% |
| Other Machine Driven Systems | 3% | 0% | 0% |
| Other Process Uses | 2% | 0% | 2% |
| Facility HVAC | 11% | 37% | 18% |
| Facility Lighting | 9% | 0% | 0% |
| Other Facility Support | 3% | 0% | 1% |
| Onsite Transportation | 1% | 0% | 1% |
| Other Nonprocess Uses | 0% | 0% | 0% |
|  | 100% | 100% | 100% |

Table A-14. Industry: Iron and Steel (NAICS 3311, 3312)

|  |  |  |  |
| --- | --- | --- | --- |
| End Use | % Electricity Usage | % Steam Usage | % Fuel Usage |
| Conventional Boilers | 0% | 0% | 10% |
| CHP/Cogeneration | 0% | 0% | 14% |
| Other Electricity Generation | 0% | 0% | 1% |
| Process Heating | 41% | 4% | 70% |
| Process Cooling and Refrigeration | 0% | 0% | 0% |
| Electro-Chemical Process | 4% | 0% | 0% |
| Pumps | 4% | 59% | 0% |
| Fans | 7% | 23% | 0% |
| Compressed Air | 7% | 0% | 0% |
| Materials Handling | 22% | 0% | 0% |
| Materials Processing | 6% | 0% | 0% |
| Other Machine Driven Systems | 1% | 9% | 0% |
| Other Process Uses | 0% | 0% | 2% |
| Facility HVAC | 3% | 6% | 2% |
| Facility Lighting | 4% | 0% | 0% |
| Other Facility Support | 0% | 0% | 0% |
| Onsite Transportation | 0% | 0% | 0% |
| Other Nonprocess Uses | 0% | 0% | 0% |
|  | 100% | 100% | 100% |

Table A-15. Industry: Textiles (NAICS 313-316)

|  |  |  |  |
| --- | --- | --- | --- |
| End Use | % Electricity Usage | % Steam Usage | % Fuel Usage |
| Conventional Boilers | 1% | 0% | 48% |
| CHP/Cogeneration | 0% | 0% | 11% |
| Other Electricity Generation | 0% | 0% | 0% |
| Process Heating | 10% | 77% | 30% |
| Process Cooling and Refrigeration | 12% | 0% | 0% |
| Electro-Chemical Process | 0% | 0% | 0% |
| Pumps | 10% | 3% | 1% |
| Fans | 7% | 1% | 1% |
| Compressed Air | 8% | 0% | 0% |
| Materials Handling | 6% | 0% | 0% |
| Materials Processing | 17% | 0% | 0% |
| Other Machine Driven Systems | 2% | 1% | 0% |
| Other Process Uses | 1% | 0% | 1% |
| Facility HVAC | 14% | 18% | 7% |
| Facility Lighting | 10% | 0% | 0% |
| Other Facility Support | 2% | 0% | 0% |
| Onsite Transportation | 0% | 0% | 1% |
| Other Nonprocess Uses | 0% | 0% | 0% |
|  | 100% | 100% | 100% |

Table A-16. Industry: transportation Equipment (NAICS 336)

|  |  |  |  |
| --- | --- | --- | --- |
| End Use | % Electricity Usage | % Steam Usage | % Fuel Usage |
| Conventional Boilers | 1% | 0% | 17% |
| CHP/Cogeneration | 0% | 0% | 6% |
| Other Electricity Generation | 0% | 0% | 0% |
| Process Heating | 14% | 0% | 28% |
| Process Cooling and Refrigeration | 6% | 0% | 1% |
| Electro-Chemical Process | 1% | 0% | 0% |
| Pumps | 8% | 5% | 1% |
| Fans | 5% | 2% | 0% |
| Compressed Air | 6% | 0% | 0% |
| Materials Handling | 4% | 0% | 0% |
| Materials Processing | 12% | 0% | 0% |
| Other Machine Driven Systems | 2% | 1% | 0% |
| Other Process Uses | 3% | 70% | 12% |
| Facility HVAC | 19% | 23% | 32% |
| Facility Lighting | 15% | 0% | 0% |
| Other Facility Support | 4% | 0% | 1% |
| Onsite Transportation | 1% | 0% | 1% |
| Other Nonprocess Uses | 1% | 0% | 0% |
|  | 100% | 100% | 100% |

1. PEPEx Scorecard Questions and Scores

Table B-1. Combined Heat and Power Scorecard Question

| **Combined Heat and Power Scorecard Questions** | | | |
| --- | --- | --- | --- |
| **Question Number** | **Question** | **Answer** | **Score** |
| 1 | Check which items are part of your CHP system: | "Supplementary Fired HRSG" AND "Condensing Steam Turbogenerator(s)" | 12 |
| 2 | If you have a Gas Turbine or Diesel generator, is the exhaust gas used for: | "Direct heating (dryer, kiln or preheated furnace air)"  OR "Steam Generation" | 60 |
| 3 | Do you use the turbo-generator for peak load shaving? | No | 0 |
| 3 | Do you use the turbo-generator for peak load shaving? | Yes | 0 |
| 4 | If an HRSG is a part of the system, how many steam generation levels? | 1 | 36 |
| 4 | If an HRSG is a part of the system, how many steam generation levels? | 2 or more | 60 |
| 5 | What type of deaerator to you have? | External | 12 |
| 5 | What type of deaerator to you have? | Integral | 18 |
| 6 | If the HRSG has supplementary firing, does the HRSG run at maximum firing or maximum steam generation capacity all the time? | No | 0 |
| 6 | If the HRSG has supplementary firing, does the HRSG run at maximum firing or maximum steam generation capacity all the time? | Yes | 60 |
| 7 | Are the Boilers used as the swing steam load production or the HRSG? | Boilers (HRSG base loaded) | 60 |
| 7 | Are the Boilers used as the swing steam load production or the HRSG? | HRSG (Boilers base loaded) | 0 |
| 8 | Is your HRSG stack temperature: | <=300 degrees F | 60 |
| 8 | Is your HRSG stack temperature: | Between 300 - 400 degrees F | 48 |
| 8 | Is your HRSG stack temperature: | >400 degrees F | 24 |
| 9 | If the HRSG is supplementary fired, what is the typical HRSG fired operating temperature? | 1500 degrees F or greater | 30 |
| 9 | If the HRSG is supplementary fired, what is the typical HRSG fired operating temperature? | 1400 degrees F | 12 |
| 9 | If the HRSG is supplementary fired, what is the typical HRSG fired operating temperature? | 1200 degrees F or less | 0 |
| 10.1 | On hot standby? | No | 24 |
| 10.1 | On hot standby? | Yes | 0 |
| 10.2 | At minimum load? | No | 12 |
| 10.2 | At minimum load? | Yes | 0 |
| 11 | If this is a condensing turbine, do you have to run the turbine for extended periods at low to minimum load to keep it on-line? | No | 6 |
| 11 | If this is a condensing turbine, do you have to run the turbine for extended periods at low to minimum load to keep it on-line? | Yes | 0 |
| 12 | If you have a condensing steam turbine as a part of your cogeneration unit, what is the average condensing pressure? | <2 in Hg | 18 |
| 12 | If you have a condensing steam turbine as a part of your cogeneration unit, what is the average condensing pressure? | Between 2 - 4 in Hg | 12 |
| 12 | If you have a condensing steam turbine as a part of your cogeneration unit, what is the average condensing pressure? | >4 in Hg | 6 |
| 13 | Do you use evaporative cooling on the GT inlet air temp? | No | 0 |
| 13 | Do you use evaporative cooling on the GT inlet air temp? | Yes | 24 |
| 13.1 | Is the energy for this cooling supplied by the HRSG? | No | 36 |
| 13.1 | Is the energy for this cooling supplied by the HRSG? | Yes | 0 |
| 14 | Do you have large seasonal variations in gas turbine inlet air temp? | No | 12 |
| 14 | Do you have large seasonal variations in gas turbine inlet air temp? | Yes | 0 |
| 15 | Do you sell excess steam or is there a potential customer for excess steam? | No | 0 |
| 15 | Do you sell excess steam or is there a potential customer for excess steam? | Yes | 12 |
| 16 | Do you export power to the grid or external customers? | No | 0 |
| 16 | Do you export power to the grid or external customers? | Yes | 0 |
| 16.1 | If so, what fraction of the full imported power cost do you receive? |  | ((12\*[Answer])/  100) |
| 17 | What is the average load factor (average/rated power production ratio) for the cogeneration unit? |  | ((25\*[Answer])/  100) |
| 18 | What is the average net heat rate of the cogeneration unit (Net Btu's of the fuel/kWh of power produced)? | 5,000 or less | 120 |
| 18 | What is the average net heat rate of the cogeneration unit (Net Btu's of the fuel/kWh of power produced)? | 5,000 - 7,000 | 96 |
| 18 | What is the average net heat rate of the cogeneration unit (Net Btu's of the fuel/kWh of power produced)? | > 7,000 | 48 |
| 18 | What is the average net heat rate of the cogeneration unit (Net Btu's of the fuel/kWh of power produced)? | Don't know | 24 |
| 19 | What is the average cogeneration unit operating stream factor (on-line time as a fraction)? |  | case when (100/(100 -[Answer]) > 100 then 100 else (100/(100 -[Answer]) end |
| 20 | How many unplanned trips per year? |  | case when (6 \* (7 - [Answer])) < 0 then 0 else (6 \* (7 - [Answer])) end |
| 21 | How often is the overall cogeneration efficiency monitored? | Continuously | 60 |
| 21 | How often is the overall cogeneration efficiency monitored? | Monthly | 30 |
| 21 | How often is the overall cogeneration efficiency monitored? | Annually | 12 |
| 22 | Do you have on-line dynamic load optimization? | No | 0 |
| 22 | Do you have on-line dynamic load optimization? | Yes | 60 |
| 23 | How do you control exhaust NOx levels? | NULL | 60 |
| 23 | How do you control exhaust NOx levels? | Water injection | 36 |
| 23 | How do you control exhaust NOx levels? | Steam injection | 36 |
| 23 | How do you control exhaust NOx levels? | Low NOx burners | 40 |
| 24 | Do you have a program for preventive maintenance of the CHP system? | Routine lubrication | 2 |
| 24 | Do you have a program for preventive maintenance of the CHP system? | Borescope inspections | 2 |
| 24 | Do you have a program for preventive maintenance of the CHP system? | Instrument calibrations | 2 |
| 24 | Do you have a program for preventive maintenance of the CHP system? | Blade cleaning - peanut/almond shells | 4 |
| 25 | Do you have a program for predictive maintenance? | Lube oil sampling | 6 |
| 25 | Do you have a program for predictive maintenance? | Advanced diagnostics | 6 |
| 25 | Do you have a program for predictive maintenance? | Instrument histograms | 6 |
| 26 | Do you periodically re-certify cogen operators? | No | 0 |
| 26 | Do you periodically re-certify cogen operators? | Yes | 6 |

Table B-2. Compressed Air Scorecard Questions

| **Compressed Air Scorecard Questions** | | | |
| --- | --- | --- | --- |
| **Question Number** | **Question** | **Answer** | **Score** |
| 1.1 | Have you developed a basic block diagram of the system? | No | 0 |
| 1.1 | Have you developed a basic block diagram of the system? | Yes | 200 |
| 1.2 | Have you developed a pressure profile of your system to determine peak demand and dynamics of demand? | No | 0 |
| 1.2 | Have you developed a pressure profile of your system to determine peak demand and dynamics of demand? | Yes | 100 |
| 1.3 | Have you estimated total compressed air flow during different shifts? | No | 0 |
| 1.3 | Have you estimated total compressed air flow during different shifts? | Yes | 100 |
| 1.4 | Have you measured pressure at various points in the system to determine pressure drop? | No | 0 |
| 1.4 | Have you measured pressure at various points in the system to determine pressure drop? | Yes | 100 |
| 1.5 | Have you measured compressed air temperature at various points in the supply system? | No | 0 |
| 1.5 | Have you measured compressed air temperature at various points in the supply system? | Yes | 200 |
| 1.6 | Have you estimated leak load? | No | 0 |
| 1.6 | Have you estimated leak load? | Yes | 100 |
| 2.1 | Do you meet or exceed compressor and dryer manufacturer's requirements for maintenance? | No | 0 |
| 2.1 | Do you meet or exceed compressor and dryer manufacturer's requirements for maintenance? | Yes | 100 |
| 2.2 | Do you periodically check ventilation openings to the compressor room to make sure they are free of obstructions? | No | 0 |
| 2.2 | Do you periodically check ventilation openings to the compressor room to make sure they are free of obstructions? | Yes | 200 |
| 2.3 | Do you inspect condensate drains daily? | No | 0 |
| 2.3 | Do you inspect condensate drains daily? | Yes | 100 |
| 2.4 | Do you periodically inspect and replace hoses that have become cracked or worn? | No | 0 |
| 2.4 | Do you periodically inspect and replace hoses that have become cracked or worn? | Yes | 100 |
| 2.5 | Do you periodically inspect and replace end-use filters, check regulators, and lubricators to maintain functionality? | No | 0 |
| 2.5 | Do you periodically inspect and replace end-use filters, check regulators, and lubricators to maintain functionality? | Yes | 200 |
| 3.1 | Have you adjusted your compressor controls in the last year? | No | 0 |
| 3.1 | Have you adjusted your compressor controls in the last year? | Yes | 100 |
| 3.2 | Have you developed a control strategy that allows you to efficiently match supply with demand? | No | 0 |
| 3.2 | Have you developed a control strategy that allows you to efficiently match supply with demand? | Yes | 300 |
| 3.3 | Do you monitor compressor operation to avoid rapid cycling of equipment? | No | 0 |
| 3.3 | Do you monitor compressor operation to avoid rapid cycling of equipment? | Yes | 100 |
| 4.1 | Do you have a few high pressure applications that determine the operating pressure for your entire plant? | No | -100 |
| 4.1 | Do you have a few high pressure applications that determine the operating pressure for your entire plant? | Yes | 0 |
| 4.2 | Have you investigated ways to serve high pressure applications at a lower pressure? | No | 0 |
| 4.2 | Have you investigated ways to serve high pressure applications at a lower pressure? | Yes | 100 |
| 5.1 | Do you have a few end use applications requiring high quality air that determine the air quality for the entire plant? | No | 0 |
| 5.1 | Do you have a few end use applications requiring high quality air that determine the air quality for the entire plant? | Yes | -100 |
| 5.2 | Have you investigated ways to serve these high air quality applications with point-of-use solutions? | No | 0 |
| 5.2 | Have you investigated ways to serve these high air quality applications with point-of-use solutions? | Yes | 100 |
| 6.1 | Are you using any of the following to supply the intermittent, high volume applications? (Check all that apply) | Secondary Storage Receivers | 100 |
| 6.1 | Are you using any of the following to supply the intermittent, high volume applications? (Check all that apply) | Separate compressor, booster or amplifier | 100 |
| 6.1 | Are you using any of the following to supply the intermittent, high volume applications? (Check all that apply) | "Secondary Storage Receivers" OR "Separate compressor, booster or amplifier" | 100 |
| 7.1 | Have you analyzed your end-users to make sure they could not be more efficiently use alternative energy sources? | No | 0 |
| 7.1 | Have you analyzed your end-users to make sure they could not be more efficiently use alternative energy sources? | Yes | 100 |
| 7.2 | Is compressed air being sent to abandoned equipment? | No | -300 |
| 7.2 | Is compressed air being sent to abandoned equipment? | Yes | -30 |
| 8.1 | Have you estimated the amount of leakage in your system? | No | 0 |
| 8.1 | Have you estimated the amount of leakage in your system? | Yes | 100 |
| 8.2 | Do you have the equipment to detect leaks (e.g., ultrasonic leak detector) or do you outsource leak detection? | No | 0 |
| 8.2 | Do you have the equipment to detect leaks (e.g., ultrasonic leak detector) or do you outsource leak detection? | Yes | 100 |
| 8.3 | Do you have an ongoing leak management program? | No | 0 |
| 8.3 | Do you have an ongoing leak management program? | Yes | 200 |
| 9.1 | Does your plant have a demand for space heating or hot water? | No | 0 |
| 9.1 | Does your plant have a demand for space heating or hot water? | Yes | 100 |
| 9.2 | Are you using heat recovery on your compressed air system? | No | 00 |
| 9.2 | Are you using heat recovery on your compressed air system? | Yes | 100 |

Table B-3. Process Cooling and Refrigeration Scorecard Questions

| **Process Cooling and Refrigeration Scorecard Questions** | | | |
| --- | --- | --- | --- |
| **Question Number** | **Question** | **Answer** | **Score** |
| 1.1 | When was the last time your refrigeration system was audited? | 1 year or less | 12 |
| 1.1 | When was the last time your refrigeration system was audited? | >2 years ago | 6 |
| 1.1 | When was the last time your refrigeration system was audited? | >5 years ago | 0 |
| 1.2 | How often do you monitor refrigeration costs? | Continuously | 8 |
| 1.2 | How often do you monitor refrigeration costs? | Quarterly | 4 |
| 1.2 | How often do you monitor refrigeration costs? | Yearly | 2 |
| 1.2 | How often do you monitor refrigeration costs? | Never/Don't know | 0 |
| 1.3 | Do you monitor compressor efficiencies? | No | 0 |
| 1.3 | Do you monitor compressor efficiencies? | Yes | 4 |
| 2.1 | Do you have a regular maintenance program? | No | 0 |
| 2.1 | Do you have a regular maintenance program? | Yes | 8 |
| 2.2 | Do you regularly inspect the following (quarterly or less): Refrigerant charge level? | No | 0 |
| 2.2 | Do you regularly inspect the following (quarterly or less): Refrigerant charge level? | Yes | 2 |
| 2.3 | Do you regularly inspect the following (quarterly or less): Compressors? | No | 0 |
| 2.3 | Do you regularly inspect the following (quarterly or less): Compressors? | Yes | 1 |
| 2.4 | Do you regularly inspect the following (quarterly or less): Condensers and Evaporators (fouling)? | No | 0 |
| 2.4 | Do you regularly inspect the following (quarterly or less): Condensers and Evaporators (fouling)? | Yes | 1 |
| 3.1 | What is the average refrigeration compressor load factor versus design (typical/estimated)? | >= 100% | 8 |
| 3.1 | What is the average refrigeration compressor load factor versus design (typical/estimated)? | >50% | 4 |
| 3.1 | What is the average refrigeration compressor load factor versus design (typical/estimated)? | Don't know | 0 |
| 3.2 | What % of operating time do you spend at less than 50% load? | 30% or less | 4 |
| 3.2 | What % of operating time do you spend at less than 50% load? | 60% or more | 2 |
| 3.2 | What % of operating time do you spend at less than 50% load? | Don't know | 0 |
| 3.3 | What mechanism do you use to unload your compressors? | Variable speed drives | 8 |
| 3.3 | What mechanism do you use to unload your compressors? | Cylinder unloading (reciprocating) /Slide valves (screw) /Variable inlet guide vanes (centrifugal) | 6 |
| 3.3 | What mechanism do you use to unload your compressors? | Automated Compressor on/off control | 4 |
| 3.3 | What mechanism do you use to unload your compressors? | Manual Compressor on/off control | 3 |
| 3.3 | What mechanism do you use to unload your compressors? | Suction throttling | 2 |
| 3.3 | What mechanism do you use to unload your compressors? | Hot gas bypass | 0 |
| 4.1 | Is your refrigeration compressor suction pressure typically: | At or near design pressure | 5 |
| 4.1 | Is your refrigeration compressor suction pressure typically: | < design presure by more than 15% | 2 |
| 4.1 | Is your refrigeration compressor suction pressure typically: | Don't know | 0 |
| 4.2 | What is the typical temperature difference between evaporator refrigerant and process stream outlet? | Within 5 °F of design | 4 |
| 4.2 | What is the typical temperature difference between evaporator refrigerant and process stream outlet? | >5 °F of design | 2 |
| 4.2 | What is the typical DT between evaporator refrigerant and process stream outlet? | Don't know | 0 |
| 4.3 | Is your refrigeration compressor discharge pressure typically: | At or near design pressure | 4 |
| 4.3 | Is your refrigeration compressor discharge pressure typically: | > design presure by more than 10% | 2 |
| 4.3 | Is your refrigeration compressor discharge pressure typically: | Don't know | 0 |
| 4.4 | Do you have condenser performance problems? | Not at all | 2 |
| 4.4 | Do you have condenser performance problems? | Only periodically during summer months | 1 |
| 4.4 | Do you have condenser performance problems? | Throughout summer months | 1 |
| 4.4 | Do you have condenser performance problems? | Continuously | 0 |
| 5.1 | How old is your refrigeration equipment (average)? | <10 years | 2 |
| 5.1 | How old is your refrigeration equipment (average)? | 10-20 years | 1 |
| 5.1 | How old is your refrigeration equipment (average)? | >20 years | 0 |
| 5.2 | Have you ever performed a Pinch Analysis study to check if refrigeration loads have been minimized? | No | 0 |
| 5.2 | Have you ever performed a Pinch Analysis study to check if refrigeration loads have been minimized? | Yes | 8 |
| 5.3 | Backpressure (extraction) steam turbines |  | ((11\*[Answer])/100) |
| 5.4 | Variable speed electric motors |  | ((5\*[Answer])/100) |
| 5.5 | Electric motors w/o variable speed drives |  | ((3\*[Answer])/100) |
| 5.6 | Condensing steam turbines |  | ((0\*[Answer])/100) |
| 6.1 | How are cooling tower fans controlled? | Always on | 0 |
| 6.1 | How are cooling tower fans controlled? | Manual on/off control | 3 |
| 6.1 | How are cooling tower fans controlled? | Fan pitch control | 5 |
| 6.1 | How are cooling tower fans controlled? | Automated on/off control | 7 |
| 6.1 | How are cooling tower fans controlled? | Combination of above | 4 |
| 6.2 | How is blowdown controlled? | Automatically | 7 |
| 6.2 | How is blowdown controlled? | Manually | 0 |
| 6.2 | How is blowdown controlled? | Combination of above | 4 |
| 7.1 | Which parameters do you monitor regularly? | Ambient air temperature profiles for year | 1 |
| 7.1 | Which parameters do you monitor regularly? | Ambient air wet bulb temperature profile for year | 1 |
| 7.1 | Which parameters do you monitor regularly? | Cooling tower blowdown cycles | 1 |
| 7.1 | Which parameters do you monitor regularly? | Cooling water flow demand | 1 |
| 7.1 | Which parameters do you monitor regularly? | Delta T across towers | 1 |
| 7.1 | Which parameters do you monitor regularly? | Cycles of concentration | 1 |
| 8.1 | Are overall cooling water flowrates above or below design? | Above | 0 |
| 8.1 | Are overall cooling water flowrates above or below design? | Below | 4 |
| 8.1 | Have you optimized water vs air cooling loads? | No | 0 |
| 8.1 | Have you optimized water vs air cooling loads? | Yes | 3 |
| 8.2 | Do you have uneven water distribution problems in cooling towers? | No | 7 |
| 8.2 | Do you have uneven water distribution problems in cooling towers? | Yes | 0 |
| 8.3 | How close are basin temperature approaches to wet bulb temp? | Around 5°F | 3 |
| 8.3 | How close are basin temperature approaches to wet bulb temp? | > 5°F | 0 |
| 8.4 | Distribution piping fouling? | No | 1 |
| 8.4 | Distribution piping fouling? | Yes | 0 |
| 8.5 | Cooling water exchanger fouling problems? | No | 2 |
| 8.5 | Cooling water exchanger fouling problems? | Yes | 0 |
| 8.6 | Higher than design cooling loads? | No | 1 |
| 8.6 | Higher than design cooling loads? | Yes | 0 |
| 8.7 | Do you monitor cooling water exchanger fouling rates and/or pressure drops? | No | 0 |
| 8.7 | Do you monitor cooling water exchanger fouling rates and/or pressure drops? | Yes | 7 |
| 8.8 | Do you have the following cooling water distribution problems in the process units? | Capacity problems | 2 |
| 8.8 | Do you have the following cooling water distribution problems in the process units? | Starving some users | 2 |
| 8.9 | Do you have sludge or sediment problems in cooling tower basins? | No | 4 |
| 8.9 | Do you have sludge or sediment problems in cooling tower basins? | Yes | 0 |
| 9.1 | Mechanical draft towers |  | ((4\*[Answer])/100) |
| 9.1 | If not, what is the primary reason: | Emergency on-line backup supply criteria | 0 |
| 9.1 | If not, what is the primary reason: | System capacity (high discharge pressures) | 0 |
| 9.1 | If not, what is the primary reason: | Ease of operation | 0 |
| 9.1 | If not, what is the primary reason: | N/A | 0 |
| 9.11 | What type of cooling tower fill is used? | Splash Film | 0 |
| 9.11 | What type of cooling tower fill is used? | Film Fill | 1 |
| 9.12 | Do cooling tower fans have adjustable pitch blades? | All | 4 |
| 9.12 | Do cooling tower fans have adjustable pitch blades? | Some | 2 |
| 9.12 | Do cooling tower fans have adjustable pitch blades? | None | 0 |
| 9.13 | Do the cooling tower fans have adjustable speed drives? | All | 6 |
| 9.13 | Do the cooling tower fans have adjustable speed drives? | Some | 4 |
| 9.13 | Do the cooling tower fans have adjustable speed drives? | None | 0 |
| 9.2 | Natural draft towers |  | ((2\*[Answer])/100) |
| 9.3 | Cooling ponds |  | ((1\*[Answer])/100) |
| 9.4 | Spray Ponds |  | ((0\*[Answer])/100) |
| 9.5 | Backpressure turbine drives |  | ((5\*[Answer])/100) |
| 9.6 | Variable speed drives |  | ((3\*[Answer])/100) |
| 9.7 | Motor drives |  | ((2\*[Answer])/100) |
| 9.8 | Condensing turbine drives |  | ((0\*[Answer])/100) |
| 9.9 | Are you running the minimum number of pumps? | No | 0 |
| 9.9 | Are you running the minimum number of pumps? | Yes | 3 |
| 10.1 | What is the general condition of cooling tower fill? | Excellent | 10 |
| 10.1 | What is the general condition of cooling tower fill? | Adequate | 5 |
| 10.1 | What is the general condition of cooling tower fill? | In need of replacement | 0 |

Table B-4.Process Heating Scorecard Questions

| **Process Heating Scorecard Questions** | | | |
| --- | --- | --- | --- |
| **Question Number** | **Question** | **Answer** | **Score** |
| 1 | Have you conducted a detail energy assessment for your heating equipment using tools such as Process Heating Survey and Assessment Tool (PHAST) to identify energy saving opportunities? | No | 0 |
| 1 | Have you conducted a detail energy assessment for your heating equipment using tools such as Process Heating Survey and Assessment Tool (PHAST) to identify energy saving opportunities? | Yes | 150 |
| 2 | Do you measure oxygen (O2) and Carbon Monoxide CO or combustible in flue gases and "tune" the burners periodically to maintain low values for O2 and combustibles in the furnace flue gases? | No | 0 |
| 2 | Do you measure oxygen (O2) and Carbon Monoxide CO or combustible in flue gases and "tune" the burners periodically to maintain low values for O2 and combustibles in the furnace flue gases? | Yes | 100 |
| 3 | Have you sealed openings in furnaces and repaired cracks, and damaged insulation in furnace walls, doors etc.? | No | 0 |
| 3 | Have you sealed openings in furnaces and repaired cracks, and damaged insulation in furnace walls, doors etc.? | Yes | 50 |
| 4 | Do you regularly clean heat transfer surfaces to avoid build up of soot, scale or other material? | No | 0 |
| 4 | Do you regularly clean heat transfer surfaces to avoid build up of soot, scale or other material? | Yes | 25 |
| 5 | Do you have a program for calibration/adjustment of sensors (i.e. thermocouples), controllers, valve operators etc.? | No | 0 |
| 5 | Do you have a program for calibration/adjustment of sensors (i.e. thermocouples), controllers, valve operators etc.? | Yes | 25 |
| 6 | Do you operate the furnace at or close to design load by proper furnace scheduling and loading, and avoid delays, waits between production? | No | 0 |
| 6 | Do you operate the furnace at or close to design load by proper furnace scheduling and loading, and avoid delays, waits between production? | Yes | 25 |
| 7 | Do you maintain proper (balanced or slightly positive) pressure in furnaces to avoid air leakage in the furnace? | No | 0 |
| 7 | Do you maintain proper (balanced or slightly positive) pressure in furnaces to avoid air leakage in the furnace? | Yes | 50 |
| 8 | Flue gas heat recovery (check all that apply): | A heat recovery system (i.e. recuperator, regenerator, water or heating etc.) is used to recover heat from the furnace flue gases. | 100 |
| 8 | Flue gas heat recovery (check all that apply): | "Heat of flue gases from the furnace or air preheater is used to heat charge material, fixtures etc." OR "Heat of flue gases from the furnace or air preheater is used for lower temperature processes such as steam generation, water heating or air heating for the plant or other application." | 25 |
| 8 | Flue gas heat recovery (check all that apply): | "A heat recovery system (i.e. recuperator, regenerator, water or heating etc.) is used to recover heat from the furnace flue gases." AND  ( "Heat of flue gases from the furnace or air preheater is used to heat charge material, fixtures etc." OR "Heat of flue gases from the furnace or air preheater is used for lower temperature processes such as steam generation, water heating or air heating for the plant or other application." ) | 67 |
| 9 | Do you use design of fixtures, trays and other material handling system components with minimum weight and proper material? | No | 0 |
| 9 | Do you use design of fixtures, trays and other material handling system components with minimum weight and proper material? | Yes | 50 |
| 10 | Do you use proper insulation for (or minimize use of) water or air cooled parts such as rolls, load supports etc. used in furnaces? | No | 0 |
| 10 | Do you use proper insulation for (or minimize use of) water or air cooled parts such as rolls, load supports etc. used in furnaces? | Yes | 50 |
| 11 | Are you using oxygen enriched air or oxy-fuel fired burners for high temperature processes? | No | 0 |
| 11 | Are you using oxygen enriched air or oxy-fuel fired burners for high temperature processes? | Yes | 100 |
| 12 | Are you using the most cost effective source of heat for processes where it is possible use alternate energy sources (i.e. steam vs. electricity vs. fuel firing) where applicable? | No | 0 |
| 12 | Are you using the most cost effective source of heat for processes where it is possible use alternate energy sources (i.e. steam vs. electricity vs. fuel firing) where applicable? | Yes | 50 |
| 13 | Do your heating equipment and other heated parts use cost effective type and thickness of insulation? | No | 0 |
| 13 | Do your heating equipment and other heated parts use cost effective type and thickness of insulation? | Yes | 25 |

Table B-5. Pumps Scorecard Questions

| **Pumps Scorecard Questions** | | | |
| --- | --- | --- | --- |
| **Question Number** | **Question** | **Answer** | **Score** |
| 1.1 | Valve throttling or bypass flow regulation |  | ([Answer] \* 0)/100 |
| 1.2 | Turning pumps on and off to match needs |  | ([Answer] \* 35)/100 |
| 1.3 | Constant load - pump matched to meet need at pump best efficiency point |  | ([Answer] \* 50)/100 |
| 1.4 | Adjustable speed drives |  | ([Answer] \* 45)/100 |
| 1.5 | Combination of above, other, or unknown |  | ([Answer] \* 20)/100 |
| 2.1 | Are pump performance curves readily available? |  | ([Answer] \* 3.75)/100 |
| 2.2 | Are the system head-capacity curves well understood (static and dynamic head components)? |  | ([Answer] \* 3.75)/100 |
| 2.3 | Are pumps tested at installation to compare performance with the manufacturer's curve? |  | ([Answer] \* 3.75)/100 |
| 2.4 | Is motor power or current measured and pump efficiency estimated as a part of the installation test? |  | ([Answer] \* 2.5)/100 |
| 2.5 | Are pumps periodically tested or performance measures trended to check for performance degradation? |  | ([Answer] \* 5)/100 |
| 2.6 | Do you evaluate the potential energy cost savings (compared to optimal commercially available equipment operating at the existing head and flow rates)? |  | ([Answer] \* 2.5)/100 |
| 2.7 | What percentage of your systems have permanently installed flow meters? |  | ([Answer] \* 3.75)/100 |
| 3.1 | Do you purchase energy efficient or premium efficiency motors as a standard practice? (Applies to all motors, regardless of size) | No | 0 |
| 3.1 | Do you purchase energy efficient or premium efficiency motors as a standard practice? (Applies to all motors, regardless of size) | Yes | 3.25 |
| 3.2 | Do you have a motor repair/replacement decision policy in place? (This question applies to all motors) | No | 0 |
| 3.2 | Do you have a motor repair/replacement decision policy in place? (This question applies to all motors) | Yes | 2.6 |
| 3.3 | Do you include energy-efficiency guidelines in pump purchase specifications (e.g., minimum operating efficiency, specify precision castings, coated bowls, etc.)? | No | 0 |
| 3.3 | Do you include energy-efficiency guidelines in pump purchase specifications (e.g., minimum operating efficiency, specify precision castings, coated bowls, etc.)? | Yes | 3.25 |
| 3.4 | Are energy factors a primary consideration when repairing or replacing an existing pump that has failed? | No | 0 |
| 3.4 | Are energy factors a primary consideration when repairing or replacing an existing pump that has failed? | Yes | 3.9 |
| 4.1 | Percentage of operators that could explain how to read and use a pump head-capacity curve: |  | ([Answer] \* 4.8)/100 |
| 4.2 | Percentage of system engineers that could explain all standard pump performance curves: head, power, efficiency, and NPSHR: |  | ([Answer] \* 7.2)/100 |

Table B-6. Steam Generation Scorecard Questions

| **Steam Generation Scorecard Questions** | | | |
| --- | --- | --- | --- |
| **Question Number** | **Question** | **Answer** | **Score** |
| 1.1 | Do you monitor your Fuel Cost To Generate Steam - in terms of ($) / (1000 lbs. of steam produced)? | No | 0 |
| 1.1 | Do you monitor your Fuel Cost To Generate Steam - in terms of ($) / (1000 lbs. of steam produced)? | Yes | 10 |
| 1.2 | How often do you calculate and trend your Fuel Cost To Generate Steam? | at least quarterly | 10 |
| 1.2 | How often do you calculate and trend your Fuel Cost To Generate Steam? | at least annually | 5 |
| 1.2 | How often do you calculate and trend your Fuel Cost To Generate Steam? | less than annually | 0 |
| 2.1 | Do you Measure your Steam/Product Benchmark - in terms of (lbs. of steam needed) / (unit of product produced)? | No | 0 |
| 2.1 | Do you Measure your Steam/Product Benchmark - in terms of (lbs. of steam needed) / (unit of product produced)? | Yes | 10 |
| 2.2 | How often do you Measure and Trend your Steam/Product Benchmark - in terms of (lbs. of steam needed) / (unit of product produced)? | at least quarterly | 10 |
| 2.2 | How often do you Measure and Trend your Steam/Product Benchmark - in terms of (lbs. of steam needed) / (unit of product produced)? | at least annually | 5 |
| 2.2 | How often do you Measure and Trend your Steam/Product Benchmark - in terms of (lbs. of steam needed) / (unit of product produced)? | less than annually | 0 |
| 3.1 | Do you measure and record Critical Energy Parameters for your Steam System? | Steam Production Rate (to obtain total steam production) | 10 |
| 3.1 | Do you measure and record Critical Energy Parameters for your Steam System? | Fuel Flow Rate (to obtain total fuel consumption) | 6 |
| 3.1 | Do you measure and record Critical Energy Parameters for your Steam System? | Feedwater Flow Rate | 6 |
| 3.1 | Do you measure and record Critical Energy Parameters for your Steam System? | Makeup Water Flow Rate | 4 |
| 3.1 | Do you measure and record Critical Energy Parameters for your Steam System? | Blowdown Flow Rate | 2 |
| 3.1 | Do you measure and record Critical Energy Parameters for your Steam System? | Chemical Input Flow Rate | 2 |
| 3.2 | How intensely do you meter your steam flows? | by major user/equip | 20 |
| 3.2 | How intensely do you meter your steam flows? | by process unit | 10 |
| 3.2 | How intensely do you meter your steam flows? | by area or building | 5 |
| 3.2 | How intensely do you meter your steam flows? | by plant as a whole (i.e., total boiler output) | 2 |
| 3.2 | How intensely do you meter your steam flows? | not at all | 0 |
| 4.1 | Does Your System Steam Trap Maintenance Program Include The Following Activities? | Proper Trap Selection For Application | 10 |
| 4.1 | Does Your System Steam Trap Maintenance Program Include The Following Activities? | At Least Annual Testing Of All Traps | 10 |
| 4.1 | Does Your System Steam Trap Maintenance Program Include The Following Activities? | Maintaining A Steam Trap Database | 10 |
| 4.1 | Does Your System Steam Trap Maintenance Program Include The Following Activities? | Repairing/Replacing Defective Traps | 10 |
| 5.1 | How often do you ensure that your Water Chemical Treatment System is functioning properly? | at least daily | 10 |
| 5.1 | How often do you ensure that your Water Chemical Treatment System is functioning properly? | at least weekly | 5 |
| 5.1 | How often do you ensure that your Water Chemical Treatment System is functioning properly? | less than weekly | 0 |
| 5.2 | How often do you NEED to clean Fireside or Waterside deposits in your Boiler? | every 5-10 years | 10 |
| 5.2 | How often do you NEED to clean Fireside or Waterside deposits in your Boiler? | every 1-5 years | 5 |
| 5.2 | How often do you NEED to clean Fireside or Waterside deposits in your Boiler? | once/year or more | 0 |
| 5.3 | How often do you measure Conductivity (or Total Dissolved Solids [TDS]) in your Boiler and determine what your Steam and Mud Drum Blowdown Rate (or Top and Bottom Boiler Blowdown Rate) should be? | continuous, or at least once/shift | 10 |
| 5.3 | How often do you measure Conductivity (or Total Dissolved Solids [TDS]) in your Boiler and determine what your Steam and Mud Drum Blowdown Rate (or Top and Bottom Boiler Blowdown Rate) should be? | once/day | 5 |
| 5.3 | How often do you measure Conductivity (or Total Dissolved Solids [TDS]) in your Boiler and determine what your Steam and Mud Drum Blowdown Rate (or Top and Bottom Boiler Blowdown Rate) should be? | once/week or less | 0 |
| 6.1 | Is your Boiler Plant equipment and piping system insulation (refractory, piping, valves, flanges, vessels, etc.) maintained and in good condition? | insulation excellent | 10 |
| 6.1 | Is your Boiler Plant equipment and piping system insulation (refractory, piping, valves, flanges, vessels, etc.) maintained and in good condition? | insulation good, but can be improved | 7 |
| 6.1 | Is your Boiler Plant equipment and piping system insulation (refractory, piping, valves, flanges, vessels, etc.) maintained and in good condition? | insulation inadequate | 0 |
| 6.2 | Is your Steam Distribution, End Use, and Condensate Recovery equipment insulation (piping, valves, flanges, heat exchangers, etc.) maintained and in good condition? | insulation excellent | 20 |
| 6.2 | Is your Steam Distribution, End Use, and Condensate Recovery equipment insulation (piping, valves, flanges, heat exchangers, etc.) maintained and in good condition? | insulation good, but can be improved | 14 |
| 6.2 | Is your Steam Distribution, End Use, and Condensate Recovery equipment insulation (piping, valves, flanges, heat exchangers, etc.) maintained and in good condition? | insulation inadequate | 0 |
| 7.1 | How would you characterize Steam Leaks in your Steam System? | none | 10 |
| 7.1 | How would you characterize Steam Leaks in your Steam System? | minor | 8 |
| 7.1 | How would you characterize Steam Leaks in your Steam System? | moderate | 3 |
| 7.1 | How would you characterize Steam Leaks in your Steam System? | numerous | 0 |
| 8.1 | How often do you detect noticeable Water Hammer in your Steam and Condensate Recovery System? | less than once a month | 10 |
| 8.1 | How often do you detect noticeable Water Hammer in your Steam and Condensate Recovery System? | monthly or weekly | 5 |
| 8.1 | How often do you detect noticeable Water Hammer in your Steam and Condensate Recovery System? | daily or hourly | 0 |
| 9.1 | Boiler Plant Equipment - boiler, deaerator, feedwater tank, chemical treatment equipment, blowdown equipment, economizer, combustion air preheater, insulation, etc.? | No | 0 |
| 9.1 | Boiler Plant Equipment - boiler, deaerator, feedwater tank, chemical treatment equipment, blowdown equipment, economizer, combustion air preheater, insulation, etc.? | Yes | 5 |
| 9.2 | Distribution System Equipment - piping (including design), steam traps (types, sizes, locations), air vents, valves, pressure reducing stations, insulation, etc.? | No | 0 |
| 9.2 | Distribution System Equipment - piping (including design), steam traps (types, sizes, locations), air vents, valves, pressure reducing stations, insulation, etc.? | Yes | 5 |
| 9.3 | End Use System Equipment - turbines, piping (including design), heat exchangers, coils, jacketed kettles, steam traps (types, sizes, locations), air vents, vacuum breakers, pressure reducing valves, insulation, etc.? | No | 0 |
| 9.3 | End Use System Equipment - turbines, piping (including design), heat exchangers, coils, jacketed kettles, steam traps (types, sizes, locations), air vents, vacuum breakers, pressure reducing valves, insulation, etc.? | Yes | 5 |
| 9.4 | Recovery System Equipment - piping (including design), valves, fittings, flash tanks, condensate pumps, condensate meters, insulation, etc.? | No | 0 |
| 9.4 | Recovery System Equipment - piping (including design), valves, fittings, flash tanks, condensate pumps, condensate meters, insulation, etc.? | Yes | 5 |
| 10.1 | How often do you measure your overall Boiler Efficiency - [(heat absorbed to create steam) / (energy input from fuel)]? | at least quarterly | 10 |
| 10.1 | How often do you measure your overall Boiler Efficiency - [(heat absorbed to create steam) / (energy input from fuel)]? | at least annually | 5 |
| 10.1 | How often do you measure your overall Boiler Efficiency - [(heat absorbed to create steam) / (energy input from fuel)]? | less than annually | 0 |
| 10.2 | Flue gas temperature? | No | 0 |
| 10.2 | Flue gas temperature? | Yes | 5 |
| 10.3 | Flue gas Oxygen content? | No | 0 |
| 10.3 | Flue gas Oxygen content? | Yes | 5 |
| 10.4 | Flue gas CO content? | No | 0 |
| 10.4 | Flue gas CO content? | Yes | 5 |
| 10.5 | How do you control Excess Air in your Boiler to maximize Boiler Efficiency? | automatically | 10 |
| 10.5 | How do you control Excess Air in your Boiler to maximize Boiler Efficiency? | manually | 5 |
| 10.5 | How do you control Excess Air in your Boiler to maximize Boiler Efficiency? | not at all | 0 |
| 11.1 | Feedwater Economizer and/or Combustion Air Preheater | No | 0 |
| 11.1 | Feedwater Economizer and/or Combustion Air Preheater | Yes | 10 |
| 11.2 | Blowdown Heat Recovery | No | 0 |
| 11.2 | Blowdown Heat Recovery | Yes | 5 |
| 12.1 | How often do you check the Quality of Steam that is output from your Boiler to the Distribution System, and ensure that you are generating Dry Steam? | at least quarterly | 10 |
| 12.1 | How often do you check the Quality of Steam that is output from your Boiler to the Distribution System, and ensure that you are generating Dry Steam? | at least annually | 5 |
| 12.1 | How often do you check the Quality of Steam that is output from your Boiler to the Distribution System, and ensure that you are generating Dry Steam? | less than annually | 0 |
| 13.1 | Do you have an operational automatic blowdown controller on your Boiler? | No | 0 |
| 13.1 | Do you have an operational automatic blowdown controller on your Boiler? | Yes | 10 |
| 13.2 | What is the frequency of High Level Alarms (possibly indicating boiler undersized) or Low Level Alarms (possibly indicating boiler oversized) for your Boiler? | less than 1/month | 10 |
| 13.2 | What is the frequency of High Level Alarms (possibly indicating boiler undersized) or Low Level Alarms (possibly indicating boiler oversized) for your Boiler? | 1-5 per month | 5 |
| 13.2 | What is the frequency of High Level Alarms (possibly indicating boiler undersized) or Low Level Alarms (possibly indicating boiler oversized) for your Boiler? | more than 5/month | 0 |
| 13.3 | How often do you experience steam pressure fluctuations of greater than 10% of your Boiler Operating Pressure? | less than 1/month | 5 |
| 13.3 | How often do you experience steam pressure fluctuations of greater than 10% of your Boiler Operating Pressure? | 1-5 per month | 3 |
| 13.3 | How often do you experience steam pressure fluctuations of greater than 10% of your Boiler Operating Pressure? | more than 5/month | 0 |
| 14.1 | How do you reduce steam pressure in your steam system? | Steam generated at required pressure or PRVs appropriately applied | 10 |
| 14.1 | How do you reduce steam pressure in your steam system? | Backpressure turbines used in parallel with PRVs | 10 |
| 14.1 | How do you reduce steam pressure in your steam system? | Boiler control used to reduce pressure | 5 |
| 14.1 | How do you reduce steam pressure in your steam system? | Excess steam vented and/or used inefficiently | 0 |
| 15.1 | How much of your available Condensate do you recover and utilize? | greater than 80% | 10 |
| 15.1 | How much of your available Condensate do you recover and utilize? | 40% to 80% | 6 |
| 15.1 | How much of your available Condensate do you recover and utilize? | 20% to 40% | 3 |
| 15.1 | How much of your available Condensate do you recover and utilize? | less than 20% | 0 |
| 16.1 | How much of your available Flash Steam do you recover and utilize? | greater than 80%, or flash steam unavailable | 10 |
| 16.1 | How much of your available Flash Steam do you recover and utilize? | 40% to 80% | 6 |
| 16.1 | How much of your available Flash Steam do you recover and utilize? | 20% to 40% | 3 |
| 16.1 | How much of your available Flash Steam do you recover and utilize? | less than 20% | 0 |

1. PEPEX Suggested Next Steps

Table C-1. Suggested Next Steps

|  |  |  |
| --- | --- | --- |
| Category | Recommendation | Savings Opportunity |
| Combined heat and power (cogeneration) | Consider use of heat from diesel generator engine (cooling water and exhaust gases) for steam generation or in heating processes. | High |
| Combined heat and power (cogeneration) | Consider use of heat from gas turbine exhaust gases for steam generation or in heating processes | High |
| Combined heat and power (cogeneration) | Develop and implement a preventive and predictive maintenance program for the system | High |
| Combined heat and power (cogeneration) | Maximize use of HRSG to meet the plant steam requirements, minimize load on boilers outside the co-gen system | High |
| Combined heat and power (cogeneration) | Consider use of HRSG with a duct burner (if not used currently) for gas turbine based on-site power generation system | Medium |
| Combined heat and power (cogeneration) | Investigate possibility of selling excess steam or/and power if there is a potential customer close by | Medium |
| Combined heat and power (cogeneration) | Minimize flue gases temperature from HRSG by recovering heat from HRSG flue gases | Medium |
| Combined heat and power (cogeneration) | Use system optimization tools to minimize combined cost of steam and electric power for the plant | Medium |
| Combined heat and power (cogeneration) | Analyze economics of use of additional CHP capacity to reduce peak power demand for the plant | Low |
| Combined heat and power (cogeneration) | Consider evaporative cooling for turbine combustion air using HRSG exhaust gases or other source of waste heat | Low |
| Combined heat and power (cogeneration) | Consider use of turbine exhaust gases for process heating equipment (process heaters, furnaces etc.) | Low |
| Compressed air | Eliminate inappropriate uses of compressed air | High |
| Compressed air | Implement air leak management program | High |
| Compressed air | Perform a detailed Compressed Air System Assessment at your site | High |
| Compressed air | Reduce compressor operating pressure with or without controls | High |
| Compressed air | Use the DOE AirMaster+ software tool & other resources to identify and quantify energy saving opportunities | High |
| Compressed air | Implement the recommendations of the Compressed Air System Assessment at your site | Medium |
| Compressed air | Install and operate equipment (including storage) that matches shifting demands | Medium |
| Compressed air | Install or upgrade system controls | Medium |
| Compressed air | Use the DOE AirMaster+ software tool & other resources to verify energy saving opportunities | Medium |
| Compressed air | Evaluate heat recovery with compressed air systems | Low |
| Compressed air | Monitor performance and document energy and cost savings on recently completed projects | Low |
| Compressed air | Replace inefficient cooling and drying equipment | Low |
| Compressed air | Install instrumentation to measure and trend compressed air cost indicators (kW/100 cfm) | Medium, Low |
| Fans and Blowers | Evaluate and reduce "system effect" through better inlet and outlet designs and duct sizing | High |
| Fans and Blowers | Improve O&M practices such as belt tightening, cleaning fans and changing filters regularly | High |
| Fans and Blowers | Minimize leakage and perform tightness tests, if needed | High |
| Fans and Blowers | Perform a detailed Fan and Blower System Assessment at your site | High |
| Fans and Blowers | Replace dampers, variable inlet vanes with electronic variable speed drives for meeting variable loads | High |
| Fans and Blowers | Use the DOE FSAT software tool & other resources to identify and quantify energy saving opportunities | High |
| Fans and Blowers | Implement the recommendations of the Fans / Blowers System Assessment at your site | Medium |
| Fans and Blowers | Reduce and control fan speed by using variable speed drives | Medium |
| Fans and Blowers | Reduce fan oversizing by matching demand with proper fan type and size (for example: Use of axial fan with controllable pitch blades) | Medium |
| Fans and Blowers | Replace standard V-belts with cogged V-belts | Medium |
| Fans and Blowers | Use the DOE FSAT software tool & other resources to verify energy saving opportunities | Medium |
| Fans and Blowers | Evaluate use of a back-pressure turbine drive instead of an electric motor, if applicable | Low |
| Fans and Blowers | Evaluate use of multiple smaller fans (operating close to their Best Efficiency Point) than one large fan | Low |
| Fans and Blowers | Install instrumentation to measure and trend fan performance (efficiency) periodically | Low |
| Fans and Blowers | Monitor performance and document energy and cost savings on recently completed projects | Low |
| Fans and Blowers | Replace electric motor with premium efficiency model | Low |
| Fans and Blowers | Replace fan / blower with more efficient model | Low |
| Industrial Facilities: (Lighting, HVAC, and Facility Support) | Evaluate lighting upgrades that includes implementing group relamp & maintenance programs | High |
| Industrial Facilities: (Lighting, HVAC, and Facility Support) | Implement night setback and weekend/vacation temperature / ventilation controls | High |
| Industrial Facilities: (Lighting, HVAC, and Facility Support) | Install occupancy sensors | High |
| Industrial Facilities: (Lighting, HVAC, and Facility Support) | Perform a detailed Lighting & HVAC System Assessment at your site to identify and quantify energy saving opportunities | High |
| Industrial Facilities: (Lighting, HVAC, and Facility Support) | Shut-off steam / chilled water flows to air handlers that are not needed or are out of service | High |
| Industrial Facilities: (Lighting, HVAC, and Facility Support) | Implement lighting control systems and zone areas based on task lighting | Medium |
| Industrial Facilities: (Lighting, HVAC, and Facility Support) | Implement the recommendations of the Lighting and HVAC System Assessment at your site | Medium |
| Industrial Facilities: (Lighting, HVAC, and Facility Support) | Install dry-bulb and/or enthalpy economizers | Medium |
| Industrial Facilities: (Lighting, HVAC, and Facility Support) | Optimize the operation of air handling units - start/stop | Medium |
| Industrial Facilities: (Lighting, HVAC, and Facility Support) | Rebalance the air-side system to reduce overall supply or meet changed zone demands | Medium |
| Industrial Facilities: (Lighting, HVAC, and Facility Support) | Evaluate incorporating daylighting, skylights, dimming, etc. | Low |
| Industrial Facilities: (Lighting, HVAC, and Facility Support) | Implement a central computerized Energy Management System | Low |
| Industrial Facilities: (Lighting, HVAC, and Facility Support) | Implement demand controlled ventilation (CO2 sensor-based) | Low |
| Industrial Facilities: (Lighting, HVAC, and Facility Support) | Install instrumentation to measure and trend efficiency (Watts per sq. ft) periodically | Low |
| Industrial Facilities: (Lighting, HVAC, and Facility Support) | Monitor performance and document energy and cost savings on recently completed projects | Low |
| Industrial Facilities: (Lighting, HVAC, and Facility Support) | Replace air conditioning unit or air handling unit with a properly sized higher efficiency unit | Low |
| Process cooling and refrigeration | Ensure proper refrigerant charge and eliminate non-condensable from the system | High |
| Process cooling and refrigeration | Evaluate use of variable speed drives on chilled water pumps, cooling tower fans, etc. | High |
| Process cooling and refrigeration | Float head pressure to minimum possible | High |
| Process cooling and refrigeration | Implement chilled water temperature and condenser water temperature reset | High |
| Process cooling and refrigeration | Perform a detailed Refrigeration / Process Cooling System Assessment at your site | High |
| Process cooling and refrigeration | Use the DOE CWSAT software tool & other resources to identify and quantify energy saving opportunities | High |
| Process cooling and refrigeration | Eliminate fouling on heat exchanger tubes | Medium |
| Process cooling and refrigeration | Evaluate use of an economizer in the system (cooling tower water vs. chilled water) | Medium |
| Process cooling and refrigeration | Implement a predictive maintenance program that correlates performance with fluid contaminants in the system | Medium |
| Process cooling and refrigeration | Implement the recommendations of the Refrigeration / Process Cooling System Assessment at your site | Medium |
| Process cooling and refrigeration | Incorporate optimized chiller sequencing and controls | Medium |
| Process cooling and refrigeration | Use the DOE CWSAT software tool & other resources to verify energy saving opportunities | Medium |
| Process cooling and refrigeration | Convert air-cooled chillers to water-cooled units | Low |
| Process cooling and refrigeration | Evaluate chiller replacement (type, size) for a more efficient overall system or plant efficiency | Low |
| Process cooling and refrigeration | Evaluate heat recovery from chiller systems | Low |
| Process cooling and refrigeration | Evaluate use of thermally driven (absorption, engine, steam-turbine driven) chiller systems to balance steam and electric demand | Low |
| Process cooling and refrigeration | Install instrumentation to measure and trend individual compressor and overall system performance (efficiency - kW/ton) periodically | Low |
| Process cooling and refrigeration | Monitor performance and document energy and cost savings on recently completed projects | Low |
| Process heating | Conduct a detail energy assessment for your heating equipment using tools such as Process Heating Survey and Assessment Tool (PHAST) to identify energy saving opportunities. | High |
| Process heating | Keep heat transfer surfaces clean by eliminating build up of soot, scale or other material. | High |
| Process heating | Measure oxygen (O2) and Carbon Monoxide CO or combustible in flue gases and take actions to reduce O2 in flue gases while maintaining near zero value for CO or combustibles. In certain cases safety requirements may require to have high values of O2 in flue gases. Consult your equipment supplier before making any changes. | High |
| Process heating | Operate the furnace at or close to design load by proper furnace scheduling and loading- avoid delays, waits, cooling between operations etc. as much a possible. | High |
| Process heating | Reduce or eliminate openings in the furnace to reduce radiation heat losses. Repair cracks and damaged insulation in furnace walls, doors etc. Keep the door opening to minimum during operations. | High |
| Process heating | Consider use of combustion air preheating by recovering heat from furnace flue gases. Evaluate use of recuperator, regenerators or regenerative burners. | Medium |
| Process heating | Consider use of heat from furnace flue gases to heat charge material, fixtures etc. | Medium |
| Process heating | Insulate water or air cooled parts used in the furnaces. Examples are: rolls, supports etc. used in furnaces. | Medium |
| Process heating | Maintain proper (balanced or slightly positive) pressure in furnaces using proper control to avoid air leakage in the furnace. | Medium |
| Process heating | Reduce weight of fixtures, trays and other material handling weight and use 'hot-return' as much as possible. | Medium |
| Process heating | Consider use of alternate source of heat such as switching from steam heating to direct fired heating for processes where possible. Consider safety and process requirements before making changes. | Low |
| Process heating | Consider use of heat from furnace flue gases in lower temperature processes, for steam generation, for water heating or air heating for the plant or other applications. | Low |
| Process heating | Consider use of oxygen enriched air or oxy-fuel fired burners for high temperature processes. | Low |
| Process heating | Design and build or rebuild furnaces and other heated components with adequate insulation to reduce wall heat losses | Low |
| Pumps | Evaluate the use of adjustable speed drives on pumps that have variable flow and are being throttled | High |
| Pumps | Explore the potential for using a fixed speed pump to supply base load and a smaller, properly sized fixed speed pump for trim | High |
| Pumps | Perform a detailed Pumping System Assessment at your site | High |
| Pumps | Turn pumps ON and OFF to match needs | High |
| Pumps | Use the DOE PSAT software tool & other resources to identify and quantify energy saving opportunities | High |
| Pumps | Identify the true pumping need (flow rate and head required) and ensure pumps are operating at their best efficiency point | Medium |
| Pumps | Implement the recommendations of the Pumping System Assessment at your site | Medium |
| Pumps | Use the DOE PSAT software tool & other resources to verify energy saving opportunities | Medium |
| Pumps | Monitor performance and document energy and cost savings on recently completed projects | Low |
| Pumps | Purchase premium efficiency motors and specify energy efficiency guidelines for new pump purchases and/or retrofits | Low |
| Pumps | Install instrumentation to measure and trend pump performance (efficiency) periodically | Medium, Low |
| Steam Generation Equipment | Implement a BestPractices based leak management program | High |
| Steam Generation Equipment | Improve boiler efficiency by proper air/fuel control | High |
| Steam Generation Equipment | Improve boiler efficiency by proper blowdown management | High |
| Steam Generation Equipment | Improve condensate recovery | High |
| Steam Generation Equipment | Improve thermal insulation of the overall steam system | High |
| Steam Generation Equipment | Perform a detailed Steam Energy System Assessment at your site | High |
| Steam Generation Equipment | Use the DOE Steam BestPractices Tools to identify and quantify energy saving opportunities | High |
| Steam Generation Equipment | Implement the recommendations of the Steam Energy System Assessment at your site | Medium |
| Steam Generation Equipment | Improve boiler efficiency by proper air/fuel control, blowdown management, etc. | Medium |
| Steam Generation Equipment | Use the DOE Steam BestPractices Tools to re-verify energy saving opportunities & prioritize | Medium |
| Steam Generation Equipment | Evaluate the use of back pressure steam turbines in lieu of pressure reducing stations | Low |
| Steam Generation Equipment | Implement heat recovery opportunities viz. economizers, combustion air preheaters, etc. | Low |
| Steam Generation Equipment | Install instrumentation to measure and trend steam cost indicators ($/Mlb) | Low |
| Steam Generation Equipment | Monitor performance and document energy and cost savings on recently completed projects | Low |
| Steam Generation Equipment | Implement a BestPractices based steam trap maintenance program | High, Medium |
| Steam Generation Equipment | Install instrumentation to measure and trend steam cost indicators ($/Mlb) | Medium, Low |