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Energy audits, upgrades can boost profits at industrial facilities

White Paper

Summary

A compelling case is made that significant savings and profits can be realized by performing energy audits and executing retrofits and upgrades at industrial facilities.

The owners of an average small- to mid-sized industrial facility could save 10 % on their power bill and $42,000 annually by auditing energy use and implementing recommendations to upgrade equipment and change operations, according to data from a U.S. Department of Energy program.

University professors and students in 24 locations across the United States are involved in the Industrial Assessments Centers (IACs). Data from those centers, the results of more than 16,000 on-site industrial assessments, suggest such significant savings, or even greater, are possible depending on the type of manufacturing facility.

For years, industrial and commercial facilities viewed their electrical utility bill as the cost of doing business. Then, those energy costs began to spike as fossil fuel costs rose to unprecedented heights—more than $100 per barrel in the case of oil. Concurrently, energy efficiency technology innovations that deliver energy savings with no sacrifice in performance (and sometimes improves in product quality, production rate, safety, etc.) accelerated in development.

Even though oil prices have settled, the surge of interest in energy retrofits remains unabated as governments and environmentally conscious companies look to curb greenhouse gases blamed for climate change and utilities seek to extend the capacity of existing power-generation plants. And of course the specter of higher fuel costs looms in the future.

Average Possible Electrical Usage Savings

9.96 %

$42,224

Source: US DOE, IAC Database (Recommendations Per Assessment), 1981–2015

New source of profit

Indeed, American facilities have found a potential new source of profit margin by becoming more efficient by cutting their monthly energy bills.

The U.S. government's Department of Energy has set up programs to help industrial companies curb energy costs and thus greenhouse gases. One of those, completes in-depth assessments on plant operation in order to identify energy efficiency improvements, minimize waste and pollution and improve productivity. The IACs compile the data for their assessment for use by industry in a database accessible online. (see **http://iac.rutgers.edu/database/topten/**)

Users can glean valuable information from the database by approximating potential electrical and natural gas energy savings by taking a look at the average results obtained at similar industrial plants. The database also lets user identify frequently recommended efficiency measures for each industrial plant.

Another energy savings estimate tool is the Plant Energy Profiler, into which a user inputs annual energy use and cost data as well as a breakout of energy use by operating process or system in a given plant. A default breakout of energy use by production process is offered in the absence of the specific data. (see **https://ecenter.ee.doe.gov/em/tools/Pages/ePEP.aspx**)

A white paper commissioned by Fluke Corporation, "Estimating Annual Energy Use and Potential Savings at Industrial Facilities," explores these two programs in depth and can serve as a guide to industrial users. (See Appendix)

Beyond the federal government programs, local utilities have launched customer service campaigns aimed at assisting facility manager to make better use of the power they are consuming.

Why do this? Utilities have capacity concerns and it's easier to curb waste than it is to build power plants. Even getting a new power plant approved through the tangled regulatory framework can take years. And the random oil spill or nuclear plant disaster show just how limited the options are for generating new power.

Thus, electrical utilities have a keen interest in avoiding having to add to their existing generation capacity. And facility managers have incentives to reduce power waste and become more efficient. If a company's profit margin is 5 %, saving $30,000 in energy costs equates to sales of $600,000, and many energy-savings measures may have simple payback of several years or less.

"Energy studies are essential for identifying opportunities for energy saving measures with proven returns on investments," said Rob Penney, senior energy engineer at Washington State University's Energy Program. "If you can't measure it, you can't manage it. Take advantage of the excellent audit tools and on-line information resources available to ensure cost-effective success."

Energy audit basics

A basic energy audit can help determine which operational function consumes the most energy per month. Many facilities have identified the easy targets—energy consumption that can be decreased without substantial investment as well as to take advantage of government energy-efficiency subsidies. Common examples

- Shutting off equipment and systems overnight instead of leaving them on
- Upgrading lighting systems to more energy efficient LED banks and motion sensors switches.
- Upgrading chillers to high-efficiency models
- Fixing leaks in compressed air lines
- Adding controls to match mechanical equipment output to performance requirements

For more effective energy savings, it's best to take a systems approach. Rather than replacing a component with something similar, start with end uses, then look at distribution systems, and finally look at the central plant. For a compressed air system, this would mean reconsidering wasteful end uses (such as sweeping the floor—get a broom!), then fixing distribution leaks, and finally considering a more efficient compressor, which may now be sized smaller than the previous equipment.

Add to those examples yet another major concern that can hit facility manager's bottom line—dirty power.

Energy engineers have known for many years that imperfections in the purity of power—such as harmonic distortion and load unbalance -- caused three-phase equipment performance issues. And in the case of power factor diminished the usability of the distributed electricity. Utility companies sometimes even charge for excessive power factor.

But it was only a decade ago the IEEE along with academics sought to quantify the amount of power made unusable by such imperfections.

In two studies, one at an automobile plant and another at an industrial park, Professors Vincente Leon and Joaquín Montañana at the University of Valencia in Spain were able to quantify annual energy savings from power quality adjustments.

In the industrial park example, the utility was able to save $14,000 a year by installing time-control relays to disconnect a capacitor bank at night; and the automobile plant upgraded transformers and installed capacitors and regulator controls for a savings of $50,000.

Hailed as a breakthrough, their Unified Power measurement took recommendation of the IEEE-1459-2000 standard that defined the sources of specific wastes and calculated the energy wastes of reactive power, harmonics and unbalance in the electrical system.

Fluke learned of the breakthrough and approached the two professors about a partnership. The result: Fluke engineers were able to transition the science from academic research into Unified Power measurement feature and an Energy Loss Calculator that is now available in portable handheld power quality analyzers. Both parties hold patents on different aspects of the new capability.

Quantify energy waste

Handheld energy analyzers, such as the Fluke 1730 Three-Phase Electrical Energy Logger, deploy Unified Power measurement calculations to express power and energy data that directly quantify the waste energy in electrical system by measuring harmonics and unbalance waste in terms of kilowatts. The measurements also factor the cost of each kilowatt hour to calculate the cost of waste energy over a week, a month or a year.

Armed with handheld energy analyzers, engineers or electricians can log the energy to equipment known to consume large quantities of power, then quantify the savings to make a case to manager for improvements in their plants.

Some of those recommendations might include adding capacitor banks to resolve power factor issues, or changing the type of electronic equipment. And in the case of unbalance, installing unbalance compensation equipment or increasing the over electrical distribution system capacity. Even the installation of a harmonic filter will improve overall power quality and increase both equipment reliability, efficiency and lifespan and decrease downtime.

But with the new Unified Power capability, coming up with the cost of labor and equipment necessary to mitigate harmonics and unbalance as compared to the amount of energy wasted, becomes a relatively straightforward ROI equation.

And once the changes are implemented, a routine of monitoring equipment with the handheld analyzers can be a way of ensuring smooth and efficient operations. With new tools—such as handheld energy analyzers—and resources available only justifying the costs of upgrades and improvements at the facility are easier than ever.

Top 10 Recommendations for Energy Savings (all industries)

1. Utilize higher efficiency lamps and/or ballasts
2. Eliminate leaks in inert gas and compressed air lines
3. Use most efficient type of electrical motors
4. Install compressor air intakes in coolest locations
5. Reduce the pressure of compressed air to the minimum required
6. Utilize energy efficient belts and other improved mechanisms
7. Install occupancy sensors
8. Use more efficient light source
9. Insulate bare equipment
10. Analyze Flue gas for proper air/fuel ratio

Source: US DOE, IAC Database, 1981–2015

Total Recommendations: 126,706 Recommendations Per Assessment: 7.6				
Average Recommended Savings Per Assessment	**Usage Reduction**	**% Reduction**	**Cost ($) Savings**	**Unit**
All energy	12,554	8.37 %	$77,296	MMBtu
Electrical	796,884	9.96 %	$42,224	kWh
Natural gas	3,838	7.57 %	$21,510	MMBtu
Waste			$9,198	
Productivity			$49,962	
Total			$136,456	

Top 10 Recommendations for Energy Savings in Chemical Manufacturing (NAICS 325)

1. Install equipment to utilize waste fuel
2. Repair and eliminate steam leaks
3. Use waste heat to produce steam to drive a steam turbine generator
4. Establish burner maintenance schedule for boilers
5. Increase the amount of condensate returned
6. Operate boilers on high fire setting
7. Install equipment (eg compactor) to reduce disposal costs
8. Use steam pressure to generate power
9. Recover waste heat from equipment
10. Use a fossil fuel engine to cogenerate electricity or motive power, and utilize heat

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Estimating annual energy use and potential savings at industrial facilities

A White Paper by:
Gilbert A. McCoy, PE, Energy Systems Engineer
Washington State University Energy Program

Overview

The U.S. Department of Energy (DOE) provides two tools to assist industrial plant end users, utility staff, consultants, and equipment distributors to estimate annual energy savings at a "typical" industrial facility. One tool is the Industrial Assessment Center (IAC) database, which contains results from over 16,000 energy assessments. This database allows users to identify both the annual average electrical energy use by plant type as well as the potential energy use reduction. The database allows users to approximate potential electrical and natural gas energy savings due to an examination of the average results obtained at similar industrial plants. The IAC database also allows users to identify the most frequently recommended efficiency measures for each industrial plant type.

The second energy savings estimation approach is the on-line **Plant Energy Profiler** software tool (also known as "Quick PEP" or "ePEP"). The user of this tool must provide only annual energy use and cost data. Quick PEP then attempts to provide more detailed or "targeted" information as it allows the user to provide a breakout of energy use by operating process or system in a given plant. (If the plant staff has not tracked energy flows in their facility, the software tool provides a default breakout of energy use by production process based upon Manufacturing Energy Consumption Survey (MECS) data). Based upon level of prior efficiency work, the software tool assigns a "High", "Medium" or "Low" potential for additional savings, and then provides a report showing potential savings for each plant production process. While the software tool doesn't indicate how to obtain these additional savings, a list of typical savings measures is provided for each plant process (such as a compressed air system or pumping systems).

Many documents exist that provide energy use data at the industrial sector level or that specify industry-specific efficiency measures and approaches. Information that is made available by the Environmental Protection Agency's **Energy Star** Buildings and Plants program and from Lawrence Berkeley National Laboratory's Industrial Energy Analysis program's Sector Assessments will be listed. The UK's Carbon Trust also provides many useful sector specific publications.

The IAC Assessment Database

The U.S. Department of Energy (DOE) has long supported the Industrial Assessment Center (IAC) program. Under this program, engineering school faculty and upper class and graduate students perform no-cost energy assessments at small and mid-sized industries. The industrial plants selected are from the manufacturing sector (SIC 20-39) with:

- Gross annual sales below $100 million
- Fewer than 500 employees at a plant site, and
- Annual energy bills more than $100,000 but less than $2.5 million.

The IAC teams conduct a one or two-day site visit to familiarize themselves with equipment and process operations and to take engineering measurements. Utility bills are examined to document annual purchased fuel, energy, demand, and power factor penalty costs. The team then performs a detailed examination of potential energy savings opportunities and prepares a report containing recommendations along with estimates of total installed costs, annual savings, and simple paybacks for required investments in improved performance equipment. The IAC program currently involves 34 engineering schools. Since the inception of the program, 16,263 assessments have been completed at small and mid-sized industrial plants with over 122,000 efficiency improvement, waste minimization, or productivity enhancement recommendations made.

An IAC database was originally created as a basic tracking and field management monitoring tool. In 2001, this database was put online with a series of search and analysis tools added to allow for public inspection of program activity, energy efficiency recommendations, and other metrics. The public now has access to almost all assessment results with only the plant name and contact person information being restricted. The IAC database is at: **http://iac.rutgers.edu/database/arc/** A User's Manual for the IAC Assessment database is available for downloading at: **http://iac.rutgers.edu/manual_database.php**

Using the NAICS Classification Index to obtain industry specific data

Industrial plant data is categorized by Standard Industrial Classification (SIC) code numbers, now replaced by the North American Industry Classification System (NAICS). NAICS is an industrial classification system that groups establishments into industries based on the similarity of their production processes (OMB, North American Industry Classification System, United States, 2007). The NAICS structure employs 2, 3, 4, 5 and 6-digit descriptors that allow for detailed industrial plant categorization. For instance:

Sector 11 is Agriculture, Forestry, Fishing, and Hunting
Subsector 111 is Crop Production
Industry Group 1113 is Fruit and Tree Nut Farming
Industry Sub-Group 11131 Orange Groves.

This database structure allows users to "drill down" to obtain ever more detailed information. An activity summary is available at each level of the database. To view an activity summary for a particular industry type, access the on-line NAICS Code list at: **http://iac.rutgers.edu/database/naics/** A sample list is shown in Figure 1. Note that this list indicates that 244 assessments have been conducted at "Wood Products Manufacturing" plants (NAICS 321). Clicking on the 321xxx indicates that 70 of these assessments have been conducted at sawmills (NAICS 3211) with 517 energy efficiency recommendations made (see Figure 2).

Using the "Statistics" box to view average annual energy use and potential savings

Clicking on "Statistics" on the drop down list on the left of the screen brings up the "Search Parameters" data entry box (shown below).

Enter the NAICS code (3, 4, 5, or more digits) to bring up a display that summarizes the findings and energy savings potential of the 70 plants for which assessments were conducted (See Figure 3). Note that this screen shows an average sawmill electrical energy use of 12,162,373 kWh annually. The potential reduction in electrical energy usage given adoption of all recommended measures is 2,425,274 kWh/year, equivalent to a 19.94% decrease in the baseline energy consumption. Natural gas use and potential savings are also given.

NAICS Code	Description	Time Assessed	Recommendations
311xxx	Food Manufacturing	612	5,251
312xxx	Beverage and Tobacco Product Manufacturing	106	882
313xxx	Textile Mills	70	507
314xxx	Textile Product Mills	43	348
315xxx	Apparel Manufacturing	28	209
316xxx	Leather and Allied Product Manufacturing	4	27
321xxx	Wood Product Manufacturing	244	1,775
322xxx	Paper Manufacturing	260	2,197
323xxx	Printing and Related Support Activities	134	1,105
324xxx	Petroleum and Coal Products Manufacturing	71	555
325xxx	Chemical Manufacturing	367	3,048
326xxx	Plastics and Rubber Products Manufacturing	512	4,428
327xxx	Nonmetallic Mineral Product Manufacturing	186	1,438
331xxx	Primary Metal Manufacturing	334	2,974
332xxx	Fabricated Metal Product Manufacturing	667	5,512
333xxx	Machinery Manufacturing	414	3,380

Figure 1. Industrial Classification Index Showing Number of Assessments (3-Digit Level).

NAICS Code	Description	Time Assessed	Recommendations		
3211xx	Sawmills and Wood Preservation	70	5,251	Summary	Map
3212xx	Veneer, Plywood, and Engineered Wood Product Manufacturing	56	882	Summary	Map
3219xx	Other Wood Product Manufacturing	118	507	Summary	Map

Figure 2. Industrial Classification Index Showing Assessments Completed (4-Digit Level).

70 Matching Assessments				
Initial Plant Averages	**Usage**	**Cost ($)**	**Unit Cost**	**Unit**
All energy	217,713	$884,750	$6.25	MMBtu
Electrical	12,162,373	$578,259	$0.051	kWh
Natural gas	15,937	$75,640	$3.41	MMBtu

Total Recommendations: 126,706 Recommendations Per Assessment: 7.6				
Average Recommended Savings Per Assessment	**Usage Reduction**	**% Reduction**	**Cost ($) Savings**	**Unit**
All energy	30,261	13.90%	$153,026	MMBtu
Electrical	2,425,274	19.94%	$107,049	kWh
Natural gas	1,933	12.56%	$13,691	MMBtu

Figure 3. Average Electrical Energy Use and Potential Savings by 4-Digit NAICS Code.

Appendix #1 shows the Number of Assessments, Average Plant Electrical Energy Use (kWh/year); Use Reduction Due to Recommended Measures (kWh/year); and the Potential Use Reduction (%) for the 90 4-digit industrial manufacturing sector NAICS codes. Summary values for natural gas consumption and potential savings are also stated. Note that the potential energy savings can be converted into dollar savings through using local utility rates or national average rates. The U.S. Energy Information Administration gives an average retail price of electricity for industrial sector customers of $0.061/kWh as of December, 2013. The corresponding rate for commercial sector customers is $0.0977/kWh. Natural gas prices for industrial customers are $4.39/1000 cubic feet (approximately 1 million Btu (MMBtu)) as of September, 2013.

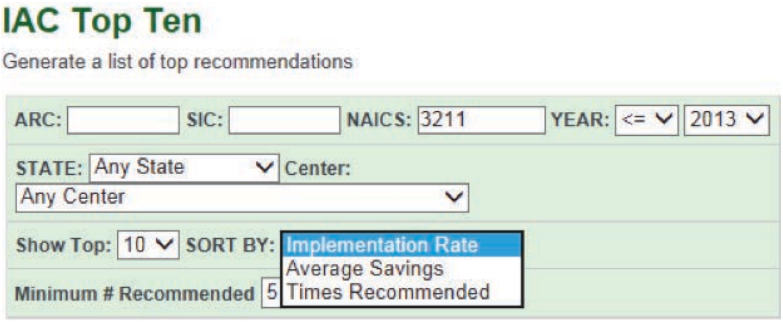
Appendix #1 also provides summary statistics for all 16,265 industries for which energy assessments were completed. The average annual plant electrical energy use was 7,944,301 kWh with an average electrical energy savings potential of 9.91%. The potential natural gas use reduction was found to be 7.62 %

The "Top Ten" efficiency measure recommendations list

Clicking on the Top Ten Energy Recommendations icon (shown below) allows the database user to identify the top 10 (or top 20, 30, 40, or 50) energy savings recommendations identified for the plants that were assessed within the selected NAICS code. The IAC Top Ten search box allows for measures to be listed in descending order of times recommended, implementation rate, or by average savings (see Figure 4). The measure list created identifies the average measure savings and installation cost. Be sure to enter the NAICS code number as the select box is not originally filled in. After making all selections, click on the "Generate" button to create the desired measure list.

The quick plant energy profiler on-line software tool

The Quick Plant Energy Profiler (Quick PEP) is described as an excellent first step towards improving the energy efficiency of an industrial plant. Quick PEP is designed to help plant staff to understand how their plant is using energy and what they can do to begin saving (Industrial Technologies Program, Save Energy Now program, **The Quick Plant Energy Profiler**). Quick PEP is designed to be completed within an hour and, after annual electrical energy, production, and fuel consumption data have been entered, establishes an energy use baseline (energy use and cost per unit of product), profiles how energy is being used in a plant, identifies typical energy efficiency upgrades and cost-saving areas of opportunity, and



#	ARC	Description	Times Rec'd	Average Savings	Average Cost	Average Payback	Imp Rate
1	2,7142	Utilize higher efficiency lamps and/or ballasts	52	$9,514	$24,830	2.8	41.18 %
2	2,4236	Eliminate leaks in inert gas and compressed air lines/valves	51	$6,356	$2,021	0.4	85.11 %
3	2,4111	Utilize energy-efficient belts and other improved mechanisms	29	$4,279	$4,318	1.0	59.26 %
4	2,4231	Reduce the pressure of compressed air to the minimum required	22	$2,599	$2,427	0.7	75.00 %
5	2,4133	Use most efficient type of electric motors	19	$14,327	$47,613	4.1	55.56 %

Figure 4. Top Ten Energy Savings Recommendations by Industry Type.

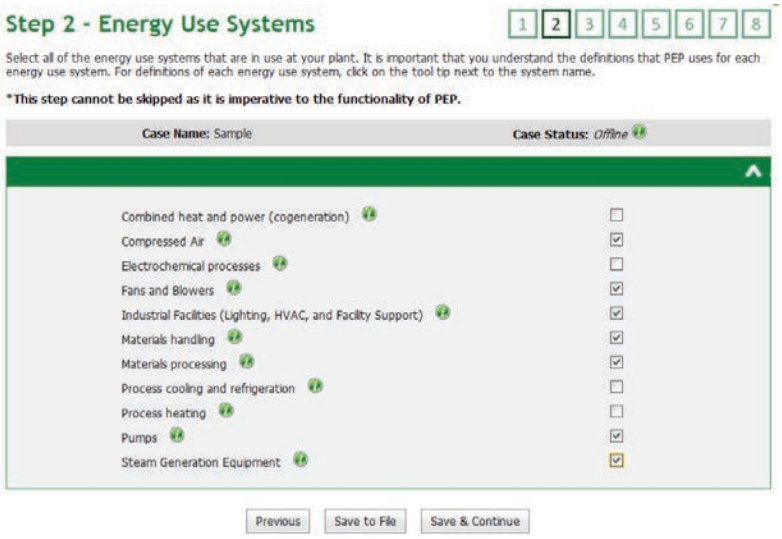
calculates annual carbon dioxide emissions. Quick PEP helps plant staff to launch an energy management program by focusing on the plant systems that likely offer the greatest energy savings.

To get started, one must input the amount of energy purchased (electricity, fuel and steam) and the average cost for each energy type; production types and amounts; and identify the major energy consuming systems in the plant (steam, process heating, compressed air, pumps, fans). Optional score cards use responses to determine the degree to which efficiency measures have already been incorporated into the plant systems. Quick PEP may be accessed at the Tools and Resources listing at: **https://ecenter.ee.doe.gov/em/tools/Pages/ePEP.aspx** Alternatively, the software tool can be downloaded to your desktop. A Quick PEP tutorial is available at: **https://ecenter.ee.doe.gov/EM/tools/Documents/epep/ePEP%20Tutorial%2011.9.11.pdf**

Initiate a new analysis by clicking on "Start New Case". A new "Case Information" menu appears where the Case Name, Plant Name, State, County, and Industry type are input. Responses are link states and counties to greenhouse gas emission factors and provide a default breakout of electrical energy use by plant process or system (The breakout differs by NAICS code). Note that users can elect to register with the DOE and save cases to file. Not registering and being assigned a login password means that inputs will be lost at the end of the session. When you have entered all data, click "Save and Continue".

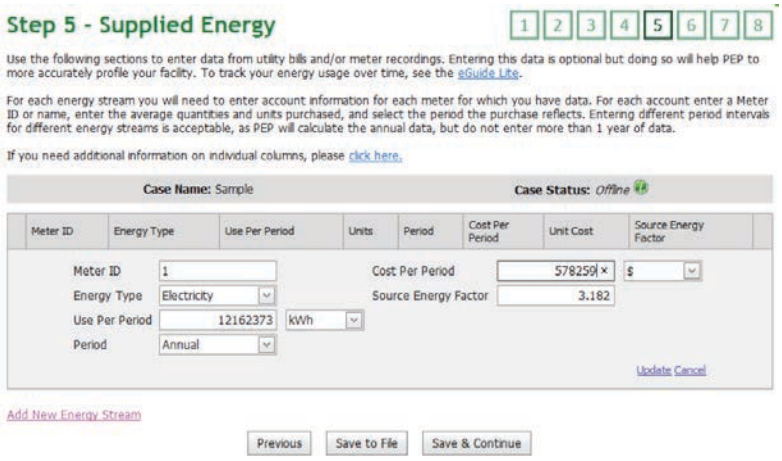
Let's mock up a typical lumber mill with plant average fuel use and costs as summarized from the IAC database (see Figure 3). On **Step 2 – Energy Use Systems**, click on the boxes to identify the energy consuming systems within your plant of interest.

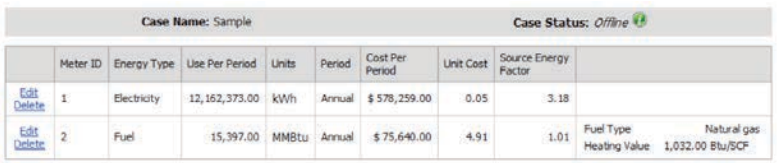
Note that the number boxes at the top right portion of the screen can be used to navigate between Steps. **Step 3 – Energy Use System Scorecards** is optional and allows the software tool user to enter information on a plants general energy management practices. **Step 4 – Production Data** is also optional.



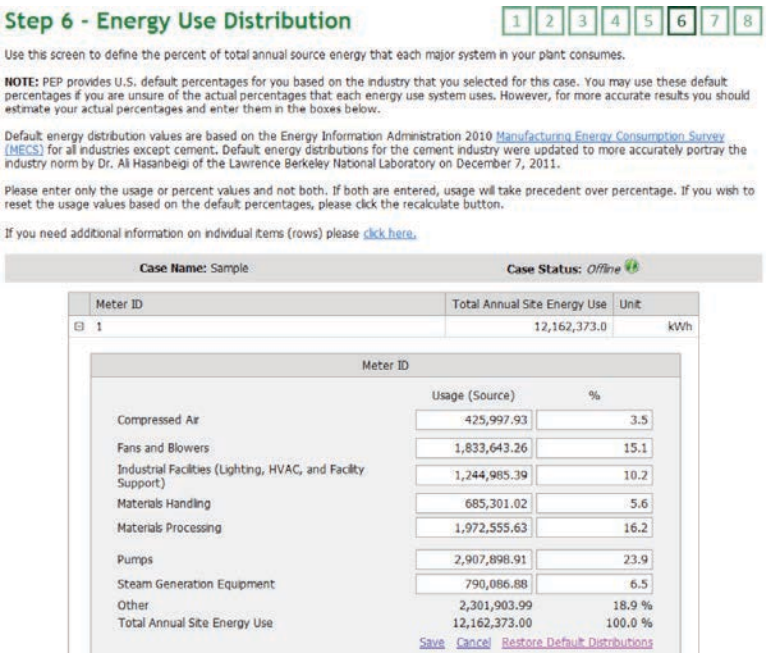
Click on the 5 box to access **Step 5 – Supplied Energy** data entry boxes. Then click on "Add New Energy Stream". The box below shows how the screen appears when electrical energy data from Table 3 is entered.

Click on the "Update" button to save these inputs. Repeat the process to add fuel and/or purchased steam information. The completed screen now should appear as follows. "Save and Continue" to advance to Step 6.

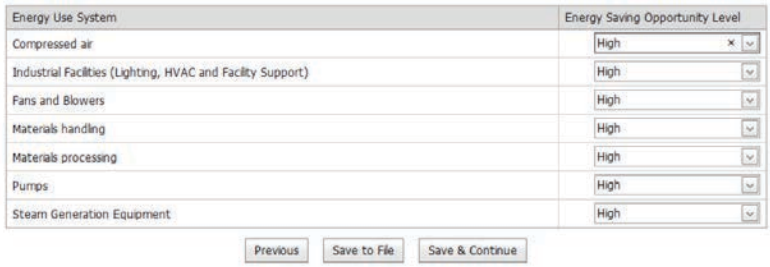




Step 6 – Energy Use Distribution gives the default electrical energy use breakout distribution by plant process. Compressed Air is assumed to account for 3.5 % of purchased electrical energy while pumping accounts for 23.9 %. This is a very crude approximation of energy flows as the general "Forest Products" grouping includes lumber mills, plywood plants, fiberboard plants, pulp mills (Kraft, Thermomechanical), and integrated pulp and paper mills. It is likely that pumps is overesti-mated for a lumber mill (pumping can account for up to 60 % of electrical energy use at a Kraft mill) while dry kiln fans may be understated. Note that power loggers can be used to monitor energy flows in an actual plant and allow an industrial energy manager to input a realistic breakout that repre-sents energy flows in their plant. After entering appropriate breakout values, again click on "Save and Continue".

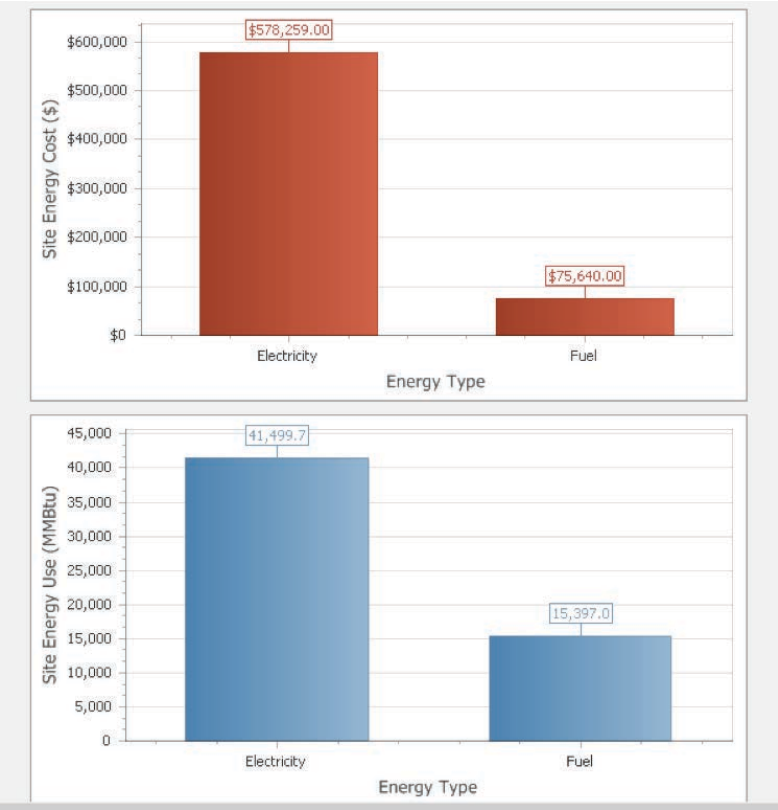


Step 7 – Energy Savings Opportunities allows software tool users to indicate the Energy Savings Opportunity (High, Medium or Low) consistent with each plant process or system. "High" is selected when little attention has been given to efficient operation in the past.



We are now ready to proceed to **Step 8 – Case Results** where the Quick PEP results can be observed. The first graphic, the Annual Energy Use Summary (see below), shows the on-site energy use and costs by fuel type.

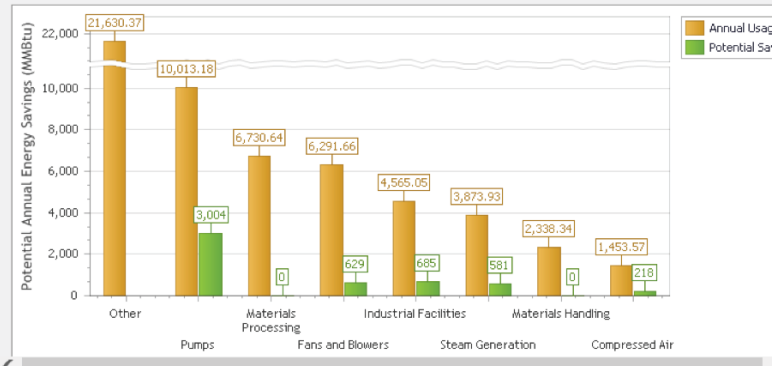
The second set of graphs shows the potential annual electrical energy savings (in MMBtu/year) for each energy consuming system in the plant. Note that the overall expected savings of 5,117 MMBtu/year is equivalent to 1,499,267 kWh/year (or an electrical energy use reduction of 12.3 %). It is not surprising that this value varies from the 2,425,274 kWh/year derived from the IAC database as due to the use of a default electrical energy use breakout.



Potential Annual Energy Savings (MMBtu)

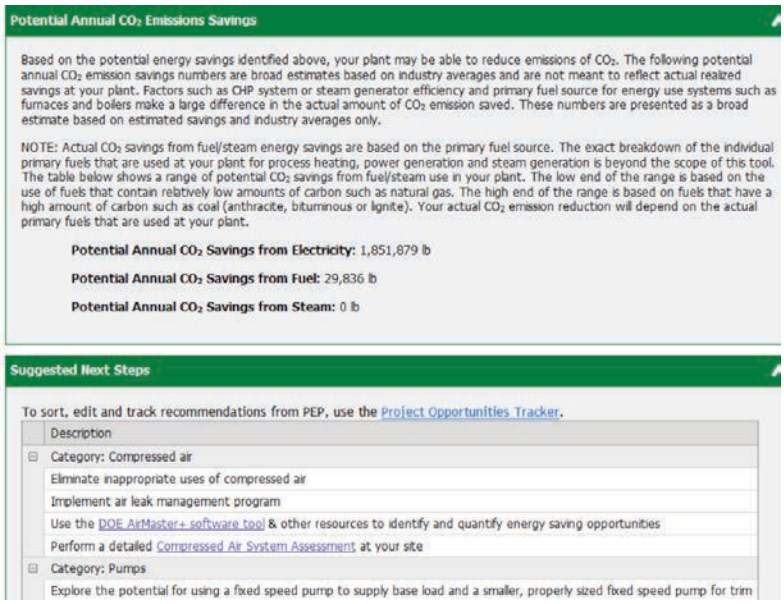
The savings shown below correspond with the system and component recommendations shown in the suggested next step table. The United Nations Industrial Development Organization Motor Systems Efficiency Supply Curves report shows that higher savings may be achievable for each system area.

System Name	Site Energy Use (MMBtu)	Potential Energy Savings (MMBtu)	Potential Energy Savings (%)	Savings Opportunity Score
Compressed Air	1,453.6	218.0	15.0 %	Medium
Fans and Blowers	6,291.7	629.2	10.0 %	Medium
Industrial Facilities	4,565.1	684.8	15.0 %	Medium
Materials Handling	2,338.3	0.0	0.0 %	Medium
Materials Processing	6,730.6	0.0	0.0 %	Medium
Pumps	10,013.2	3,004.0	30.0 %	Medium
Steam Generation	3,873.9	581.1	15.0 %	Medium
Other	21,630.4			
Total	56,896.7	5,117.0		



The Quick PEP Case Results display ends with an estimate of greenhouse gas emission reductions and with a listing of "Suggested Next Steps" for reducing the energy use of each in-plant energy system (see graphic on next page). The Next Steps are comprised of general actions that should always be taken and which are addressed in U.S. DOE Energy Tips sheets plus referrals to the DOE suite of advanced energy management software tools.

Quick PEP is designed to be an **"Attention Grabber"**. Its primary purpose is to provide a rough estimate to plant management of the potential benefits associated with establishing an energy management team and designing an energy management plan. While the quality of the output is based upon the accuracy of the input values, Quick PEPs visual appeal can be effective in convincing plant management that energy efficiency activities can provide considerable energy and economic benefits.



Potential Annual CO_2 Emissions Savings

Based on the potential energy savings identified above, your plant may be able to reduce emissions of CO_2. The following potential annual CO_2 emission savings numbers are broad estimates based on industry averages and are not meant to reflect actual realized savings at your plant. Factors such as CHP system or steam generator efficiency and primary fuel source for energy use systems such as furnaces and boilers make a large difference in the actual amount of CO_2 emission saved. These numbers are presented as a broad estimate based on estimated savings and industry averages only.

NOTE: Actual CO_2 savings from fuel/steam energy savings are based on the primary fuel source. The exact breakdown of the individual primary fuels that are used at your plant for process heating, power generation and steam generation is beyond the scope of this tool. The table below shows a range of potential CO_2 savings from fuel/steam use in your plant. The low end of the range is based on the use of fuels that contain relatively low amounts of carbon such as natural gas. The high end of the range is based on fuels that have a high amount of carbon such as coal (anthracite, bituminous or lignite). Your actual CO_2 emission reduction will depend on the actual primary fuels that are used at your plant.

Potential Annual CO_2 Savings from Electricity: 1,851,879 lb

Potential Annual CO_2 Savings from Fuel: 29,836 lb

Potential Annual CO_2 Savings from Steam: 0 lb

Suggested Next Steps

To sort, edit and track recommendations from PEP, use the Project Opportunities Tracker.

	Description
⊟	Category: Compressed air
	Eliminate inappropriate uses of compressed air
	Implement air leak management program
	Use the DOE AirMaster+ software tool & other resources to identify and quantify energy saving opportunities
	Perform a detailed Compressed Air System Assessment at your site
⊟	Category: Pumps
	Explore the potential for using a fixed speed pump to supply base load and a smaller, properly sized fixed speed pump for trim

Further information on industrial sector energy use

The U.S. Environmental Protection Agency (EPA) has long examined energy usage, emissions, and expected future energy consumption trends within selected industrial manufacturing sectors. A good overview of their methodology is provided in **Energy Trends in Selected Manufacturing Sectors: Opportunities and Challenges for Environmentally Preferable Energy Outcomes http://www.epa.gov/sectors/energy/** Energy Star provides tools for benchmarking and tracking facility energy performance as well as energy performance indicators for plants. Industry-specific resources for various industry types are listed on the Energy Star Buildings and Plants website: **http://www.energystar.gov/buildings/facility-owners-and-managers/industrial-plants/measure-track-and-benchmark/energy-star-energy-0**

Efficiency information is available for the following industries:

Another useful source of industrial energy use information is the Industrial Energy Analysis page for the Lawrence Berkeley National Laboratory. Sector assessments are available at: **http://industrial-energy.lbl.gov/node/96** Finally, the Carbon Trust website (UK) contains a wealth of industrial and other sector specific publications: **http://www.carbontrust.com/resources/guides/sector-based-advice** Energy savings advice is available for those in the Agriculture and Horticulture, Ceramics and Glass, Construction, Food and Drink, HealthCare, Higher Education, Hospitality, Mining and Quarrying, Plastics and Rubber, and Schools sectors.

Aluminum	Brewing	Cement	Chemicals
Corn Refining & Milling	Dairy Processing	Food Processing & Baking	Glass
Metal Casting	Motor Vehicle Assembly	Petrochemicals	Petroleum Refining
Pharmaceuticals	Pulp & Paper	Ready Mix Concrete	Shipbuilding
Steel & Iron	Textiles	Vehicle Parts Manufacturing	Wineries

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Appendix 1

Annual energy use and potential savings at various types of industrial facilities

NAICS Code # and Description	Number of Assessments	Average Plant Electrical Energy Use, kWh/year	Use Reduction Due to Recommended Measures, kWh/year	Potential Use Reduction %	Average Plant Natural Gas Use, MMBtu/year	Use Reduction Due to Recommended Measures, MMBtu/year	Potential Gas Use Reduction %
212 Mining and Quarrying							
2121 Coal Mining	1	31,461,500	839,207	2.67	22,014	0	0
2122 Metal Ore Mining	3	402,056,594	46,419,400	11.55	0	0	0
2123 Non-metallic Mineral and Quarrying	15	24,998,619	2,303,381	9.21	222,461	110,055	22.42
2131 Mining Support Activities	2	820,920	60,038	7.31	0	0	0
311 Food Manufacturing							
3111 Animal Food	36	6,296,398	341,293	5.42	85,669	5,771	6.74
3112 Grain and Oilseed Milling	45	11,089,707	1,020,764	9.2	90,308	8,978	9.94
3113 Sugar and Confectionery	27	8,651,691	1,324,504	15.52	164,682	7,136	4.33
3114 Fruit and Vegetable	111	11,793,562	810,557	6.87	136,883	5,772	4.22
3115 Dairy Products	85	12,019,683	1,195,555	9.95	64,480	1,054	1.63
3116 Meat and Poultry	94	16,183,384	1,034,011	6.39	92,889	8,116	8.74
3117 Seafood Products	13	6,105,349	686,799	11.25	5,795	1,115	19.24
3118 Bakeries and Tortillas	78	8,373,049	1,137,940	13.59	51,134	5,129	10.03
3119 Other Foods (Snack, Coffee, Tea, Spice, Dressings)	123	7,638,885	1,061,066	13.89	67,215	4,393	6.54
312 Beverage and Tobacco Products							
3121 Beverage Manufacturing	99	9,807,060	1,327,539	13.54	52,277	6,539	12.51
3122 Tobacco Products	7	16,751,785	1,058,263	6.48	73,499	6,259	8.52
313 Textile Mills							
3131 Fiber, Yarn, and Thread Mills	13	26,382,360	1,407,127	5.33	36,047	8,220	22.8
3132 Fabric Mills	27	16,848,047	723,261	4.29	57,315	21,307	37.17
3133 Textile and Fabric Finishing	30	7,325,910	502,726	6.86	68,289	8,307	12.16
3141 Textile Furnishings (Carpets and Rugs)	21	21,289,963	1,291,869	6.07	102,852	12,682	12.33
3149 Other Textile Product Mills	22	6,957,809	616,206	8.86	14,805	1,792	12.11
315 Apparel Manufacturing							
3151 Knitting Mills (Hosiery, Socks, Outerwear)	11	9,135,143	927,032	10.15	40,854	529	1.3
3152 Cut and Sew Manufacturing	14	1,567,932	317,004	20.22	6,759	1,240	18.35
3159 Other Apparel (Hats, Gloves, Ties)	3	5,419,966	523,492	9.66	14,428	1,007	6.98
316 Leather and Allied Products							
3161 Leather and Hide Tanning	2	2,460,100	221,707	9.01	26,584	5,799	21.81
3162 Footwear Manufacturing	0						
3169 Other Leather Products (Luggage, Handbags)	2	835,192	221	0.03	1,125	59	5.2
321 Wood Products							
3211 Sawmills and Wood Preservation	70	12,162,373	2,425,274	19.94	15,397	1,933	12.56
3212 Veneer, Plywood, Engineered Wood Products	56	19,438,717	2,671,218	13.74	147,405	13,209	8.96
3219 Other Wood Products (Windows, Pallet, Containers)	118	7,753,014	1,141,276	14.75	28,296	2,093	7.4

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322 Paper Manufacturing							
3221 Pulp, Paper, and Paperboard	62	62,447,808	5,143,953	8.24	552,278	33,116	6
3222 Converted Paper Products (Box, Bag, Paperboard, Sanitary Products, Stationery, Tablets)	197	10,710,414	691,885	6.46	42,947	5,205	12.12
323 Printing							
3231 Printing and Related Support	133	7,818,375	731,109	9.35	24,112	2,970	12.32
324 Petroleum and Coal Products							
3241 Petroleum and Coal Products (Refineries, Asphalt, Oil and Grease)	71	28,563,102	615,847	2.16	529,814	40,753	7.69
325 Chemical Manufacturing							
3251 Basic Chemical Manufacturing	80	57,568,960	3,379,006	5.87	479,407	95,665	19.95
3252 Resin, Synthetic Rubber, Artificial Fibers, Filaments	68	18,854,569	1,582,887	8.4	108,298	4,615	4.26
3253 Pesticides and Fertilizers	14	11,344,201	2,454,206	21.63	86,284	8,170	9.47
3254 Pharmaceutical and Medicines	68	13,757,288	1,901,111	13.82	52,676	(–)2,429	(–)4.61
3255 Paints, Coatings, and Adhesives	49	5,540,328	482,118	8.7	46,610	5,541	11.89
3256 Soaps and Cleaning Compounds	29	7,656,772	898,729	11.74	2,175,128	10,738	0.49
3259 Other Chemical Products (Inks, Explosives, Films, Resins)	60	14,500,855	2,257,824	15.57	137,056	5,331	3.89
326 Plastic and Rubber Products							
3261 Plastic Products Manufacturing (Pipes, Foams, Bottles)	428	11,458,788	1,311,754	11.45	14,844	1,027	6.92
3262 Rubber Products (Tires, Hoses)	84	19,458,087	3,868,578	19.88	84,092	8,937	10.63
327 Nonmetallic Mineral Products							
3271 Clay and Refractory Products (Pottery, China, Porcelain, Bricks, Electrical, Plumbing Products)	44	10,604,762	1,205,598	11.37	155,963	18,655	11.96
3272 Glass and Glass Products	52	14,733,158	1,651,645	11.21	141,171	1,145	0.81
3273 Cement and Concrete Products	45	19,362,641	1,192,849	6.16	81,615	1,909	2.34
3274 Lime and Gypsum	12	16,211,237	6,419,974	39.6	576,825	24,880	4.31
3279 Other Nonmetallic Minerals (Cut Stone, Mineral Wool)	33	8,732,730	758,364	8.68	62,027	10,888	16.26
331 Primary Metal Manufacturing							
3311 Iron and Steel Mills, Ferroalloys	18	100,034,075	1,854,653	1.85	136,834	(–)14,579	(–)10.65
3312 Steel Product Manufacturing (Rolled, Pipe, Wire)	67	11,938,836	1,210,320	10.14	90,730	21,715	23.93
3313 Alumina and Aluminum Production & Processing	60	18,742,776	1,341,696	7.16	251,753	22,718	9.02
3314 Nonferrous Metals (except Al)	39	13,956,545	1,292,120	9.26	70,056	11,227	16.03
3315 Foundries	150	13,069,697	1,015,839	7.77	127,549	18,313	14.36

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332 Fabricated Metal Product Manufacturing							
3321 Forging and Stamping	65	7,670,391	952,127	12.41	57,249	5,357	9.36
3322 Cutlery, Utensil, Pot, Pan, and Tool Manufacturing	28	7,227,616	824,561	11.41	32,588	2,005	6.15
3323 Architectural and Structural Metals	143	6,270,054	475,764	7.59	15,377	1,781	11.58
3324 Boiler, Tank, and Shipping Container	65	8,018,463	781,695	9.75	41,294	2,177	5.27
3325 Hardware Manufacturing	7	3,099,184	204,250	6.59	14,766	3,321	22.49
3326 Spring and Wire Products	29	7,005,932	823,463	11.75	38,164	3,910	10.25
3327 Machined and Turned Products, Nuts, Screws, and Bolts	61	5,279,147	625,604	11.85	13,299	2,437	18.33
3328 Coating, Plating, Engraving, Heat Treating	121	4,066,816	492,387	12.11	47,743	6,607	13.84
3329 Other Fabricated Metal Products (Valves, Plumbing, Bearings, Ammunition, Pipe Fittings)	148	6,971,561	926,518	13.29	23,319	1,961	8.41
333 Machinery Manufacturing							
3331 Agriculture, Construction, and Mining	70	13,583,309	766,205	5.64	21,643	2,374	10.97
3332 Industrial Machinery (Woodworking, Sawmill, Food Product, Plastics, Textile, Electronics)	41	8,825,873	717,589	8.13	15,852	5,206	32.84
3333 Commercial& Service Industry	30	4,384,526	567,922	12.95	14,157	2,340	16.53
3334 Ventilation, Heating, Air–Conditioning, Refrigeration Equipment	63	6,605,714	724,526	10.97	20,211	2,205	10.91
3335 Metalworking Machinery (Forming, Cutting, Die Sets, Rolling Mill)	61	4,236,781	346,491	8.18	7,725	1,081	13.99
3336 Engine, Turbine, and Power Transmission Eqpt	34	10,187,266	1,031,344	10.12	29,050	5,162	17.77
3339 Other Machinery (Pumps, Compressors, Conveyor, Crane, Hoist, Handtools, Welding, Fluid Power)	115	7,295,874	780,085	10.69	50,038	3,045	6.09
334 Computer and Electronic Products							
3341 Computer and Peripheral Equipment	9	12,807,822	864,925	6.75	22,653	561	2.48
3342 Communications Equipment	10	7,979,084	627,618	7.87	4,748	1,997	42.07
3343 Audio and Video Equipment	1	1,425,680	179,900	12.62	1,406	38	2.7
3344 Semiconductor and Electronic Components	109	11,797,329	1,227,465	10.4	15,806	1,364	8.63
3345 Navigation, Measuring, Electromedical, and Control Instruments	60	6,504,719	715,339	11	9,531	898	9.42
3346 Manufacturing and Reproducing Magnetic and Optical Media	1	18,754,461	2,226,696	11.87	20,391	4,770	23.39
335 Electrical Equipment, Appliance, and Component Manufacturing							
3351 Lighting Equipment	13	8,145,480	541,300	6.65	40,666	7,598	18.68
3352 Household Appliances	7	7,699,429	540,063	7.01	12,394	1,759	14.2
3353 Electrical Equipment (Transformers, Motors, Generators, Relays and Controls)	54	6,264,122	276,118	4.41	24,396	1,667	6.83
3359 Other Electrical Eqpt (Batteries, Fiber Optic Cable, Wiring Devices)	69	11,474,509	853,946	7.44	48,846	9,127	18.68

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336 Transportation Equipment Manufacturing							
3361 Motor Vehicle Manufacturing	14	40,524,915	3,264,943	8.06	111,449	8,990	8.07
3362 Vehicle Body and Trailer Manufacturing	41	6,619,167	834,702	12.61	30,148	4,110	13.63
3363 Motor Vehicle Parts Manufacturing	194	12,246,247	1,180,508	9.64	26,576	3,696	13.91
3364 Aerospace Products and Parts	105	8,614,112	801,246	9.3	22,692	3,399	14.98
3365 Railroad Rolling Stock	5	6,155,435	647,589	10.52	59,608	13,344	22.39
3366 Ship and Boat Building	36	3,686,132	884,736	24	1,207	47	3.9
3369 Other Transportation Eqpt. (Motorcycles, Bicycle, Military Vehicles)	13	14,767,011	1,610,789	10.91	37,579	(–)12,207	(–)32.49
337 Furniture and Related Products							
3371 Household, Institutional Furniture, Kitchen Cabinets	83	4,230,608	682,143	16.12	9,400	1,123	11.95
3372 Office Furniture	40	8,672,666	515,246	5.94	26,972	6,263	23.22
3379 Other Furniture (Blinds, Mattresses, Shades)	14	4,442,558	478,349	10.77	10,415	1,953	18.75
339 Miscellaneous Manufacturing							
3391 Medical Equipment and Supplies	63	6,391,884	820,749	12.84	11,810	9,455	80.06
3399 Other Miscellaneous (Jewelry, Athletic Goods, Toys and Games, Pen and Pencils, Gaskets and Sealing Devices, Musical Instruments, Caskets, Broom, Brush and Mop Manufacturing)	95	6,117,778	1,532,479	24.92	19,648	(–)856	(–)4.36
Total for all industry	**16,265**	**7,944,301**	**787,582**	**9.91**	**51,015**	**3,889**	**7.62**