Energy Conservation Market Analysis

A study to identify energy conservation opportunities for Minnesota's manufacturers

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Minnesota Technical Assistance Program
MnTAP

Project Goals & Objectives

The overall goal of the project is to help Minnesota utilities meet the 1.5% annual energy savings goal by assisting Minnesota business and industry to identify opportunities to become more energy efficient.

To achieve the overall goal, MnTAP conducted industrial market sector analyses to identify sector-specific energy efficiency opportunities for eight investor-owned utilities. This project included collecting information on the highest operational energy uses, greatest conservation opportunities, potential energy savings, and mechanisms to assist industry sectors achieve energy conservation.

Utility Companies Represented

Alliant Energy
CenterPoint Energy
Great Plains Gas
Greater Minnesota Gas
Minnesota Energy Resources Corp.
Minnesota Power
Ottertail Power
Xcel Energy

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About MnTAP

The Minnesota Technical Assistance Program (MnTAP) is an outreach and assistance program at the University of Minnesota that helps Minnesota businesses develop and implement industry-tailored solutions that prevent pollution at the source, maximize efficient use of resources, and reduce energy use and cost to improve public health and the environment.

Established in 1984, MnTAP is funded primarily by the Minnesota Pollution Control Agency's Prevention and Assistance Division and is located at the University of Minnesota in the School of Public Health, Division of Environmental Health Sciences. The University's mission, carried out on multiple campuses and throughout the state, is threefold: research and discovery, teaching and learning, and outreach and public service.

Executive Summary

Industrial energy efficiency can have a significant impact on Minnesota's utility companies' ability to reach their energy savings goal of 1.5% of gross annual retail energy sales, as mandated by the Next Generation Act of 2007. Prior to this study, little was known about what energy conservation opportunities exist within industrial facilities and the impact those opportunities can have on energy use. The information in this report is designed to help utility companies, manufacturers, technical assistance programs, and consultants understand industrial energy efficiency opportunities and work towards energy efficiency in manufacturing facilities.

The Minnesota Technical Assistance Program (MnTAP), in an effort to identify readily-available energy efficient technologies and practices, collected and analyzed energy data for manufacturing sectors within eight utility service areas in Minnesota. The analysis included identifying significant manufacturing sectors and sub-sectors within each utility service territory and then researching conservation opportunities that may exist for facilities within those sectors and sub-sectors. The research was conducted in this manner since the underlying assumption of the project was that facilities with similar manufacturing processes would have similar energy conservation opportunities.

Each utility was provided with information regarding the available industrial energy conservation opportunities as well as a conservative estimate of energy savings achievable through implementation of the opportunities. An example of the opportunities and savings identified for sub-sectors is shown in Table 1. The savings estimates provided are based upon readily-available technologies and behaviors that can reduce energy consumption. In Table 1, rebate information was not factored into the savings estimates; however, rebates were accounted for and reported for each utility in the report.

Table 1. MnTAP reported energy savings and technology opportunities for manufacturing sub-sectors.

Sector	Sub-Sector	Estimated Thermal Savings	Estimated Electrical Savings	Energy Efficient Technologies Identified for the Sub-Sector
Chemical Manufacturing	Ethanol Production	20%	11%	Boiler best practices, corn fractionation, motor and pump improvements, anaerobic digestion of thin stillage
	Pharmaceutical Manufacturing	18%	16%	Heat recovery opportunities, equipment and piping insulation, process controls, adding adjustable speed drives
Fabricated Metals	Machine Shops	15%	9%	Compressed air system improvements, boiler tuning and best practices, fan and paint ventilation optimization
	Sheetmetal Fabrication	24%	15%	Process heat system optimization, reduction in cure time and overheating, compressor control and intake modification
Food Processing	Poultry Processing	11%	15%	Steam, boiler, and equipment best practices; heat recovery; refrigeration improvements; motor opportunities
	Commercial Bakeries	10%	16%	Direct fired best practices, boiler blowdown heat recovery, thermal oxidizer improvements, cooling improvements
Primary Metals	Steel Products	20%	15%	Flue gas optimization, furnace optimization, process control improvements, waste heat recovery
	Aluminum Operations	14%	19%	Iso thermal melting technologies, reverberatory furnace improvements, insulation installation and improvements

From this study, MnTAP determined that there are conservation opportunities available for most manufacturing facilities and utility companies should be encouraging industrial energy efficiency as a way to meet their conservation goals. Estimated natural gas savings for the sectors identified for six gas utilities was just over 25 million therms, which is approximately 8% of recent annual consumption amounts. Electrical savings for four utilities, as estimated by MnTAP, tops 271 million kWh or approximately 7% of annual consumption. Both of these savings estimates were based upon readily available conservation technologies and practices.

While the assumption about sectors and sub-sectors held true, the study revealed that quite often a sub-sector or even sector may be dominated by a few large energy users that can benefit the most from energy conservation strategies. In those instances, utilities need to work with the facilities to provide incentives for conservation.

The information provided in this report can help utilities evaluate their current rebate programs and help shape future rebate offerings. The technologies identified as opportunities for energy savings should be included in rebate programs, if possible.

This report not only provides information about the findings of the study, including sector-specific energy conservation opportunities, but also directs readers to sub-sector summaries that provide details about processes, energy use, and savings opportunities. Additionally, MnTAP completed a benchmarking analysis as part of this project. The energy benchmarks derived from the energy use data are included in the sub-sector summary sheets and a separate benchmarking report is available online (http://www.mntap.umn.edu/resources/DOC/index.html).

This report also includes information about energy efficiency solutions such as the U.S. Department of Energy; and resources for supporting energy efficiency programs. Utility companies and industrial facilities should take advantage of programs within the State of Minnesota, including MnTAP, that can provide assistance for implementation of energy efficient technologies.

MnTAP, with a 25-year history of successfully providing manufacturers with pollution prevention and energy efficiency solutions, can work with facilities and utilities to further scope and study facility-specific opportunities for conservation. Additionally, MnTAP can conduct energy efficiency studies, place interns in facilities to address specific questions and implement solutions, or facilitate teams to develop company-wide support of energy efficiency options.

Table of Contents

Project Summary

In 2008, industrial facilities in Minnesota used 615 trillion Btus, including 30,000 gigawatt hours of electricity and 100 million MCF of natural gas. Generating electricity and burning natural gas results in pollutant emissions including sulfur dioxide (SO_2), nitrogen oxides (NOx), particulate matter, carbon dioxide (CO_2), lead, and mercury. Therefore, energy conservation can have significant environmental and economic impacts. Recently, the Minnesota Legislature passed the Next Generation Energy Act of 2007, which calls for all utilities in Minnesota to achieve an energy savings goal of 1.5% of gross annual retail energy sales. To move toward that goal, utilities need to focus energy efficiency efforts on industrial energy users.

To help utilities understand where conservation opportunities may exist within industrial facilities, The Minnesota Technical Assistance Program (MnTAP) has completed market sector energy analyses for manufacturing sectors within eight utility service areas in Minnesota. MnTAP evaluated industrial sectors for Alliant Energy, CenterPoint Energy, Greater Minnesota Gas, Great Plains Gas, Minnesota Energy Resources Corporation (MERC), Minnesota Power, Ottertail Power Company, and Xcel Energy. Final reports have been submitted to each utility and address energy consumption, sub-sector operations, number and size of facilities, existing and emerging technologies, and energy conservation potential.

Data Analysis and Reporting

Each utility provided MnTAP with energy use data for its industrial users. At a minimum, the data included facility identification, SIC or NAICS codes, and energy consumption. Some utilities included facility name and rebate information, while others did not. Table 1 highlights the consumption data provided by each utility. It is important to note that not all utilities provide both electric and gas services. Therefore, when data is not listed in a table, the utility does not provide that service to facilities in that sector or sub-sector.

Two utilities provided data that was outside the norm of the other utilities: Xcel Energy and Greater Minnesota Gas. Xcel Energy did not provide gas use data for food processing facilities; while the utility does provide gas to food processing facilities, MnTAP did not analyze this sector for the utility due to the missing data. Greater Minnesota Gas has a very small industrial base and the two facilities they identified were very different from the other facilities analyzed through this study. One of the two facilities, an asphalt plant, did not have significant energy use; additionally, this sector had not previously been identified for other utilities. The other facility was a poultry raising facility, which is essentially a large farming operation and not manufacturing. Due to the variance in the data and the lack of further information, MnTAP does not include these facilities further in this report.

Table 1. Industrial energy consumption as reported by each utility.

Utility	Gas Customers			Electric Customers		
	# of facilities	Annual Use (therms)	% of total	# of facilities	Annual Use (kWh)	% of total
Alliant Energy	19	3,686,926	1.16%	38	184,703,932	4.68%
CenterPoint Energy	249	227,365,550	71.41%	-	-	-
Great Plains Gas	53	34,260,860	10.76%	-	-	-
Greater Minnesota Gas	2	328,356	0.10%	-	-	-
MERC	323	4,575,704	1.44%	-	-	-
Minnesota Power	-	-	-	295	320,232,100	8.12%
Ottertail Power	-	-	-	139	244,310,601	6.20%
Xcel Energy	870	48,182,000	15%	3,568	3,193,390,000	81%
TOTAL	**1,516**	**318,399,396**	**100%**	**4,040**	**3,942,636,633**	**100%**

MnTAP analyzed the data and sorted facilities into manufacturing sectors. The primary sectors identified and analyzed during this project included chemical manufacturing (including ethanol), food processing, primary metals, metal fabrication, printing, wood products, industrial drying, and pulp and paper. Tables 2 and 3 provide information on the number of facilities analyzed within each sector for each utility analyzed.

Table 2. Number of gas customers identified in each sector for each utility.

Utility	Sectors								
	Fab. Metals	Primary Metals	Chemical Mfg	Food Proc.	Printing	Ind. Drying	Wood Prod.	Pulp & Paper	Other
Alliant Energy	12	0	2	5	0	0	0	0	0
CenterPoint	68	26	27	98	30	0	0	0	0
Greater Mn Gas	0	0	0	0	0	0	0	0	2
Great Plains Gas	5	2	6	14	0	0	0	0	26
MERC	192	0	21	61	0	49	0	0	0
Xcel Energy	416	45	70	0	300	0	0	39	0
TOTAL	**693**	**73**	**126**	**178**	**330**	**49**	**0**	**39**	**28**

Table 3. Number of electric customers identified in each sector for each utility.

Utility	Sectors								
	Fab. Metals	Primary Metals	Chemical Mfg	Food Proc.	Printing	Ind. Drying	Wood Prod.	Pulp & Paper	Other
Alliant Energy	15	1	7	15	0	0	0	0	0
Minnesota Power	143	4	25	64	0	0	59	0	0
Ottertail Power	61	1	14	51	0	0	12	0	0
Xcel Energy	1,462	162	181	603	1,071	0	0	89	0
TOTAL	**1,681**	**168**	**227**	**733**	**1,071**	**0**	**71**	**89**	**0**

As a whole, the chemical manufacturing sector consumed just over 38% of all industrial gas use, but only 13% of the annual electricity use. This is primarily due to the ethanol facilities and their gas consumption. Food processing was another sector that accounted for a significant amount of the electrical and gas use. The fabricated metals sector used a significant amount of electrical energy, but little gas. Table 4 includes the energy consumption of each of the sectors analyzed.

Table 4. Energy consumption data for each sector analyzed.

Sector	Gas Customers			Electric Customers		
	# of facilities	Annual Use (therms)	% of total	# of facilities	Annual Use (kWh)	% of total
Chemical Manufacturing	126	121,846,681	38.3%	227	508,184,994	12.9%
Food Processing	178	106,129,160	33.3%	733	1,093,818,350	27.7%
Fabricated Metals	693	28,913,817	9.1%	1,681	1,069,876,577	27.1%
Primary Metals	73	17,897,256	5.6%	168	330,988,784	8.4%
Printing	330	12,645,000	4.0%	1,071	450,170,000	11.4%
Industrial Drying	49	1,019,676	0.3%	-	-	0.0%
Wood Products	-	-	0.0%	71	125,431,928	3.2%
Pulp and Paper	39	28,758,000	9.0%	89	364,166,000	9.2%
Other	28	1,189,806	0.4%	-	-	-
TOTAL	**1,516**	**318,399,396**	**100.0%**	**4,040**	**3,942,636,633**	**100.0%**

Once facilities were assigned to a sector, MnTAP then grouped them into sub-sectors based on the similarity of their manufacturing processes. In some cases, the similarity of a sub-sector's process was well defined by SIC or NAICS codes; in other cases, MnTAP found that facilities with similar processes were listed in two or more NAICS or SIC codes. Additionally, there were some cases where MnTAP found facilities that had very different types of manufacturing processes and energy use within one classification. In those cases, the facilities were divided into different sub-sector groups. Once identified, sub-sectors were ranked by energy consumption. The goal of the project was to select the top five sub-sectors in each sector for each utility, in terms of energy consumption, and analyze those sub-sectors in detail to provide information about energy use and conservation opportunities. Following that analysis, the goal was to recommend three sub-sectors for further energy conservation assistance. However, based on the characteristics of each utility, their sectors, and the resulting sub-sectors, anywhere from one to ten sub-sectors were recommended instead. Table 5 lists the sub-sectors identified within each sector that have been further developed and analyzed for savings opportunities. Not all sub-sectors listed in Table 5 were appropriate for each utility; more information on specific and recommended sub-sectors is included later in this report.

One of the underlying assumptions of this project was facilities with similar processes could be grouped within a utility service area and would have similar conservation opportunities. Each utility would then be able to develop conservation programs that would address the facility groups and encourage conservation project implementation in multiple facilities at one time. While this is true on a state-wide basis and for a few sub-sectors, more typically the sub-sectors MnTAP identified consisted of a relatively few similar facilities and, frequently, one or two of the facilities dominated the energy consumption.

Table 5. Sub-sectors identified and analyzed within each sector.

Sector	Sub-Sectors	
Chemical Manufacturing	Ethanol production Pharmaceutical manufacturing Resin production Shingle manufacturing	Asphalt production Explosives manufacturing Compressed gas production Paint, ink, and adhesive production
Food Processing	Dried dairy products Poultry processing Meat processing Rendering Seafood processing Cheese, whey, and butter processing Sugar manufacturing from beets	Snack chip production Soybean processing Pet food manufacturing Commercial bakeries Fruit and vegetable canning Frozen fruit and vegetable processing
Fabricated Metals	Transportation equipment manufacturing Metal tube manufacturing Stamping and forging operations Industrial equipment manufacturing Coating, plating, polishing, and finishing	Metal can manufacturing Structural metal products Heat treating Machine shops Steel metal fabrication
Primary Metals	Non-ferrous metals operations Steel products Iron feedstock production	Iron operations Precious metal operations Aluminum operations
Printing	Web-fed heat set printers Newspaper printing	Heat set printers
Industrial Drying	Grain elevators with drying operations	
Wood Products	Reconstituted wood products Primary sawmills	Secondary millwork
Pulp and Paper	Pulp and paper mills Board converting (non-heat set)	Extruding and paper coating Multi-wall converting with heat set operations

Conservation Potential Estimates

A significant part of each report provided to the utilities involved conservation potential estimates. These figures provide each utility with an idea of the energy savings that might be feasible over the next five years if industrial facilities take advantage of energy conservation opportunities. However, the figures provided by MnTAP should not suggest guaranteed savings or annual savings potential.

When developing the potential savings estimates, MnTAP utilized three methods:

1. Identifying reports or case studies for specific sub-sectors that gave estimates for specific changes
2. Using reports or factsheets on technologies that gave estimates for implementation of that technology across industries
3. Building upon U.S. Department of Energy (DOE) Industrial Assessment Center (IAC) recommendations for energy conservation within specific sub-sectors by one of the following methods:
   a Averaging savings estimates for specific recommendations within a sub-sector and using that average directly
   b Averaging savings estimates for categories of IAC recommendations

We believe the first method is the most reliable; however, it was also the least available. The second method was the second choice, and using the IAC savings estimates was the third choice. The IAC recommendations were the most commonly used for estimating savings based upon their availability. There are concerns with using this data, because IAC assessments are relatively short and tend to be more general than specific to the process evaluated. As a result, savings estimates may be conservative in many cases.

The potential conservation estimates provided to the utilities indicate savings potential for opportunities that have been implemented in similar facilities with adequate to attractive payback; however, they do not account for changing energy prices. Gas prices in particular have recently retreated from record highs and may reduce the incentive for implementing changes to conserve thermal energy. The analysis that MnTAP completed makes no attempt to factor in recent changes in the wider economy including a tightened money supply and reduced sales for many sectors. It is possible that facilities will have a more difficult time with larger capital-intensive projects in the coming years, thereby potentially hindering utilities' ability to reach their energy conservation goals.

Accounting for Rebates Awarded

Some utilities provided information on rebates awarded to industrial facilities within the last five to ten years. When provided with that information, MnTAP adjusted the potential conservation estimates to account for projects already completed. To adjust the data, the potential conservation estimate for the sub-sector was applied to each facility and then any energy savings reported through rebates awarded to that facility were subtracted from the original savings estimate. By using this methodology, some facilities and some sub-sectors appear to have significantly less conservation opportunities available due to already completed projects. Additional information on rebate programs is included in the next section of this report.

Tables 6 and 7 highlight the savings potential for each utility and each sector identified. Savings estimates are based solely on the remaining savings potential for each of the recommended sub-sectors within each sector. Due to the substantial variability in the rebate data provided by each utility, there is no common basis for what constitutes a recently implemented conservation activity. Therefore, the remaining savings estimates only reflect the rebate data that each utility provided and should not be compared between utilities. Additionally, the totaled savings reported in the tables only reflect the data provided and should be used with caution.

Table 6. Thermal energy savings potential for sectors and utilities based upon savings estimates for recommended sub-sectors.

	Chemical Mfg.		Food Processing		Fabricated Metals		Primary Metals		Printing		Industrial Drying		Pulp and Paper		Overall Utility Savings	
Utility	**(therms)**	**(%)**	**(therms)**	**(%)**	**(therms)**	**(%)**	**(therms)**	**(%)**	**(therms)**	**(%)**	**(therms)**	**(%)**	**(therms)**	**(%)**	**(therms)**	**(%)**
Alliant Energy	-	-	116,200	4%	117,500	16%	-	-	-	-	-		-		233,700	6%
CenterPoint Energy	11,329,616	10%	2,235,474	3%	1,766,365	11%	359,516	3%	989,397	12%	-	-	-	-	16,680,368	7%
Greater MN Gas															0	
Great Plains Gas	2,630,000*	22%	1,703,000*	8%	-	-	170,000*	19%	-	-	-	-	-	-	4,503,000*	13%
MERC	48,500	10%	125,900	15%	283,950	13%	-	-	-	-	210,600	21%	-	-	668,950	15%
Xcel Energy	14,000*	1%	**-	-	730,300*	7%	498,000*	13%	480,000	11%	-	-	1,287,000	4%	3,009,300*	6%
TOTAL	**14,022,116**	**12%**	**4,180,574**	**4%**	**2,898,115**	**10%**	**1,027,516**	**6%**	**1,469,397**	**12%**	**210,600**	**21%**	**1,287,000**	**4%**	**25,095,318**	**8%**

** Rebate data was not provided for these sectors; therefore, this is a gross savings potential estimate and the overall savings either entirely excludes rebate project impacts or is made up of sector totals that are a mixture of gross and net savings estimates*

*** Gas consumption and gas conservation analysis was not a part of the project scope for the evaluation of the Xcel Energy food sector.*

Table 7. Electrical energy savings potential for sectors and utilities based upon savings estimates for recommended sub-sectors.

	Chemical Mfg.		Food Processing		Fabricated Metals		Primary Metals		Printing		Wood Products		Pulp and Paper		Overall Utility Savings	
Utility	**(kWh)**	**(%)**	**(kWh)**	**(%)**	**(kWh)**	**(%)**	**(kWh)**	**(%)**	**(kWh)**	**(%)**	**(kWh)**	**(%)**	**(kWh)**	**(%)**	**(kWh)**	**(%)**
Alliant	0	0%	3,979,500	6%	986,400	6%	180,800	5%	-	-	-	-	-	-	5,146,700	3%
Mn Power	691,500	3%	5,477,000	6%	7,484,900	10%	5,177,300	9%	-	-	7,146,300	11%	-	-	25,977,000	8%
Ottertail	2,233,900	12%	12,787,100	9%	1,031,700	5%	1,232,200	23%	-	-	9,724,400	16%	-	-	27,009,300	11%
Xcel Energy	38,302,000*	10%	31,624,000*	4%	19,452,000*	2%	32,500,000*	12%	60,017,000	13%	-	-	31,460,000	9%	213,355,000*	7%
TOTAL	**41,227,400**	**8%**	**53,867,600**	**5%**	**28,955,000**	**3%**	**39,090,300**	**12%**	**60,017,000**	**13%**	**16,870,700**	**13%**	**31,460,000**	**9%**	**271,488,000**	**7%**

** Rebate data was not provided for these sectors; therefore, this is a gross savings potential estimate and the overall savings either entirely excludes rebate project impacts or is made up of sector totals that are a mixture of gross and net savings estimates*

Rebate Analysis

MnTAP analyzed rebates awarded by each utility, if the data was provided, to determine the extent of recently implemented conservation activity. The data also provided insight into what technologies had been readily implemented by companies and rebated by the utilities.

Conducting an analysis of rebate data was not part of the original scope of work for this project, but was suggested by CenterPoint Energy and Minnesota Energy Resources in early discussions of the project. Representatives from both utilities believed that including a rebate analysis was a way to account for recent conservation activity within facilities. Doing so could result in a more realistic savings estimate.

Once requested, five of the eight utilities provided rebate data of their choosing. The most significant variation among the data included the timeframe reflected; data sets ranged from two years to ten years of information. The period of rebate data was determined by each utility and was at least in part related to the ease or difficulty in extracting relevant data from their systems. Additionally, rebate data for Xcel Energy, Great Plains Gas, and Greater Minnesota Gas was significantly different from the other five utilities.

- Xcel Energy: The analysis that MnTAP conducted of four of Xcel Energy's sectors (chemical manufacturing, food processing, primary metals, and fabricated metals) was done on a contract basis directly with the utility and pre-dated this study. The results of that work are included in this report with the utility's permission. The analysis of the other two sectors (pulp and paper and printing) was part of this study; therefore MnTAP only analyzed rebate data for those two sectors.

- Great Plains Gas: The utility does offer a rebate program to customers, but chose to not provide rebate data for this study.

- Greater Minnesota Gas: This utility only has one industrial customer, which has not been awarded any rebates recently.

MnTAP analyzed rebate data for sectors included in each utility study, as identified in Tables 2 and 3. In some instances, the utilities provided complete rebate data for their customers; however, only those customers included in the conservation analysis were also included in the rebate analysis. For example, a utility may have included rebate data for textile manufacturing, which was not one of the primary sectors identified for that utility's analysis. Therefore, MnTAP did not analyze the rebate data for those facilities. Additionally, some utilities expressed difficulties in extracting complete rebate data due to variability in assigned SIC and NAICS code descriptions of facility functions. Table 8 highlights the utility rebate data provided to and analyzed by MnTAP for this project.

Table 8. Rebate data as provided by each utility.

Utility	Years Provided	# of Rebates	Gas Customers			Electric Customers		
			Annual Use (therms)	Rebate Savings (therms)	% of Total Use	Annual Use (kWh)	Rebate Savings (kWh)	% of Total Use
Alliant Energy	1998-2008	110	3,686,926	751,434	20.4%	184,703,932	115,595,152	62.6%
CenterPoint Energy	2000-2007	268	227,365,550	23,859,790	10.5%	-	-	-
MERC	2007-2008	32	4,575,704	36,520	0.8%	-	-	-
Minnesota Power	2004-2009	207	-	-	-	320,232,100	44,146,773	13.8%
Ottertail Power	2000-2009	482	-	-	-	244,310,601	3,004,769	1.2%
Xcel Energy*	2005-2009	573	48,182,000	4,679,924	9.7%	3,193,390,000	43,590,510	1.4%
TOTAL		**1,672**	**318,399,396**	**29,327,669**	**9.2%**	**3,942,636,633**	**206,337,204**	**5.2%**

**Xcel Energy only provided rebate data for facilities within the pulp and paper and printing sectors.*

It is important to note that while Table 8 reflects that Xcel Energy's reported rebates account for 9.7% of current annual thermal use and 1.4% of current annual electrical use, those figures are skewed due to the lack of rebate data provided for facilities within the chemical manufacturing, fabricated metals, food processing, and primary metals sectors. It is likely that Xcel Energy has seen more savings, both thermal and electrical, through their rebate program than is included in this study.

Additional variability in rebate data may also exist due to differences in measurement and verification procedures among the utilities. For example, one utility may award a significant number of rebates, but they don't reflect a significant amount of energy savings. Another utility may award fewer rebates, but realize more savings.

In total, the utilities reported rebated savings of over 29 million therms and 206 million kWh. Overall, the most thermal and electrical energy savings were reported by facilities in the chemical manufacturing sector, primarily ethanol facilities.

In terms of gas conservation, Figure 1 and Table 9 show the rebated savings by utility and sector. The chemicals sector had the largest savings impact (35%) with ethanol facilities accounting for almost all the rebated savings. Remaining savings for rebated projects are more evenly distributed among sectors with food processing at 20%, paper at 14%, and fabricated metals at 13%.

Figure 2 and Table 10 show the electrical savings impact from rebated projects by sector. The chemical manufacturing sector accounted for almost half the electrical savings rebated over this period; these savings were realized largely by ethanol plants and specifically those in the Alliant Energy service area. The food processing, fabricated metals, and printing sectors each also account for more than 10% of the electrical savings achieved through rebated projects.

Figure 1. Breakdown of rebated thermal savings achieved by each sector.

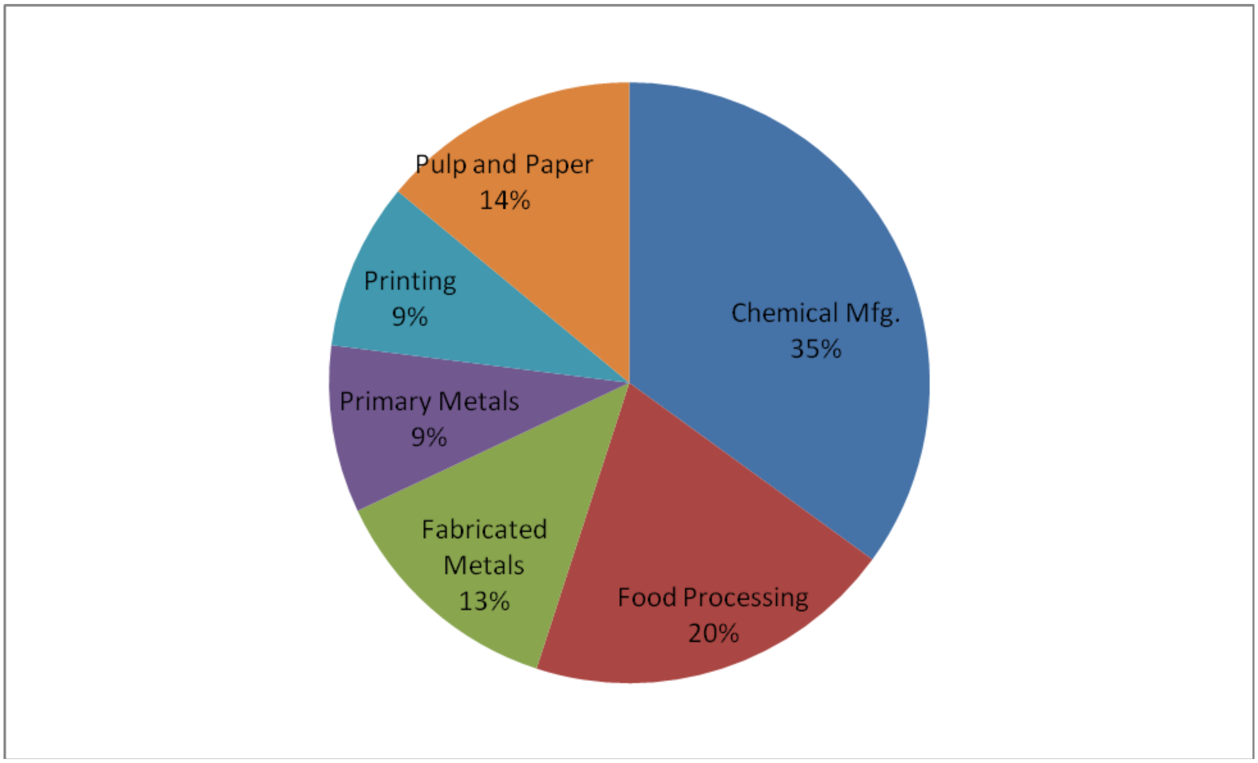


Figure 2. Breakdown of rebated electrical savings achieved by each sector.

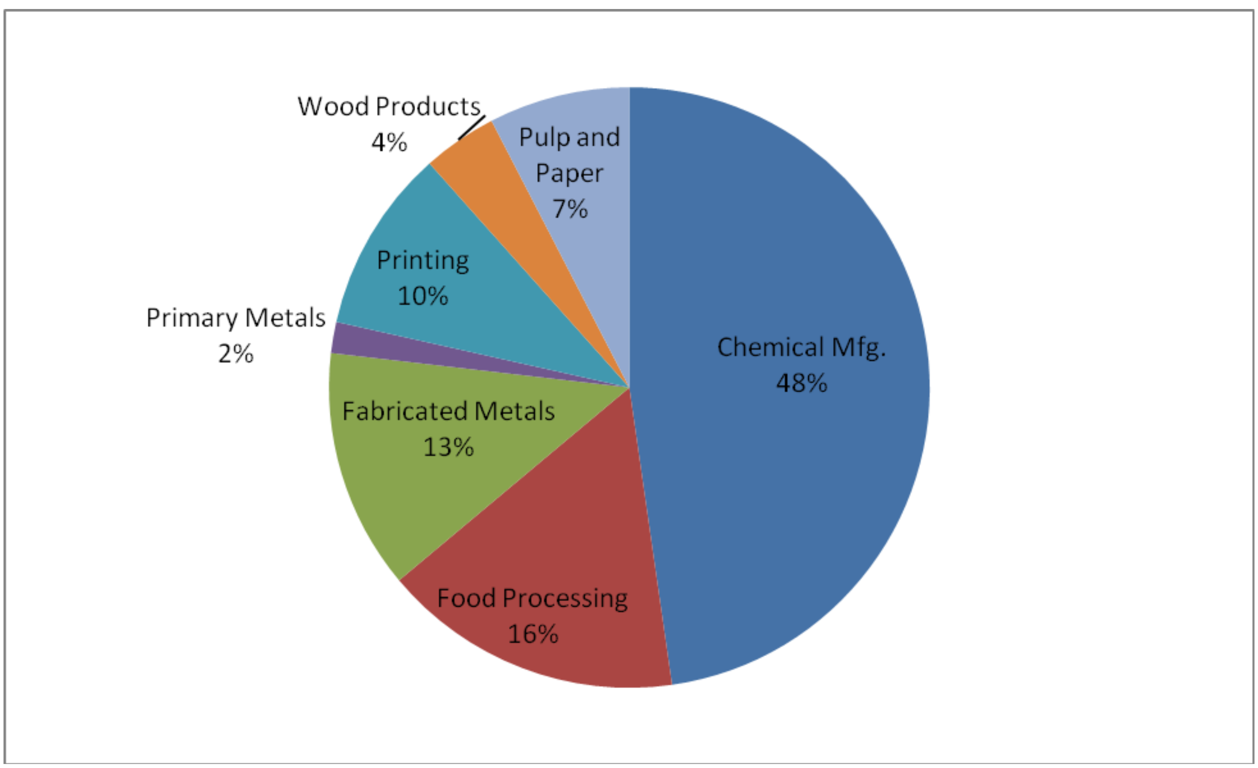


Table 9. Thermal energy rebates awarded to facilities within specific sectors.

Utility	Chemical Mfg.		Food Processing		Fabricated Metals		Primary Metals		Printing		Pulp and Paper		Overall Utility Savings	
	(therms)	(%)	(therms)	(%)	(therms)	(%)	(therms)	(%)	(therms)	(%)	(therms)	(%)	(therms)	(%)
Alliant Energy	0	0.0%	210,077	28%	541,357	72%	-	-	-	-	-	-	751,434	3%
CenterPoint Energy	10,329,290	43%	5,638,330	24%	3,121,280	13%	2,713,660	11%	2,057,230	9%	-	-	23,859,790	81%
MERC	0	0.0%	5,824	16%	30,696	84%	-	-	-	-	-	-	36,520	0.1%
Xcel Energy	-	-	-	-	-	-	-	-	444,390	10%	4,235,534	91%	4,679,924	16%
TOTAL	**10,329,290**	**35%**	**5,854,231**	**20%**	**3,693,333**	**13%**	**2,713,660**	**9%**	**2,501,620**	**9%**	**4,235,534**	**14%**	**29,327,669**	**100%**

Table 10. Electrical energy rebates awarded to facilities within specific sectors.

Utility	Chemical Mfg.		Food Processing		Fabricated Metals		Primary Metals		Printing		Wood Products		Pulp and Paper		Overall Utility Savings	
	(kWh)	(%)	(kWh)	(%)	(kWh)	(%)	(kWh)	(%)	(kWh)	(%)	(kWh)	(%)	(kWh)	(%)	(kWh)	(%)
Alliant	72,652,601	63%	27,076,568	23%	15,865,983	14%	-	-	-	-	-	-	-	-	115,595,152	56.0%
Mn Power	2,964,797	7%	12,461,076	28%	15,045,413	34%	4,179,371	9%	-	-	9,496,116	22%	-	-	44,146,773	21.4%
Ottertail Power	417,259	14%	790,224	26%	1,325,524	44%	0	0%	-	-	471,762	16%	-	-	3,004,769	1.5%
Xcel Energy	-	-	-	-	-	-	-	-	24,673,904	57%	-	-	18,916,605	43%	43,590,510	21.1%
TOTAL	**76,034,657**	**36.8%**	**40,327,868**	**19.5%**	**32,236,920**	**15.6%**	**4,179,371**	**2.0%**	**24,673,904**	**12.0%**	**9,967,878**	**4.8%**	**18,916,605**	**9.2%**	**206,337,204**	**100.0%**

The rebate analysis was also used to determine what types of conservation opportunities are readily being implemented and what types of changes and technologies might not be understood well and therefore may remain as opportunities. Table 11 highlights the different types of projects that were awarded rebates from the utilities that submitted data. The most commonly rebated projects were motor improvements, which appear to be a standard rebate across many utility companies. Lighting and building improvements are also rebated regularly and assumed to be part of the prescriptive rebate programs of many utilities. Few rebates were awarded for design improvements, energy management systems, and energy design assistance. It is likely that these three areas would fall into custom rebate programs, which are larger in scope and require more evaluation than prescriptive rebates.

Table 11. Number of rebates awarded to various projects and their impact on energy use.

	Gas Rebates			Electric Rebates		
Rebate Project	**# Awarded**	**Therms Saved**	**% of Therms Saved**	**# Awarded**	**kWh Saved**	**% of kWh Saved**
Process	128	13,057,211	45%	105	109,654,629	53%
Energy Recovery	43	4,347,645	15%	0	-	-
Boiler	71	4,002,963	14%	0	-	-
Process Direct Fire	70	3,559,590	12%	0	-	-
Thermal Oxidizers	12	2,968,980	10%	0	-	-
Building	56	1,268,140	4%	180	11,782,274	6%
Miscellaneous	2	96,000	0%	24	-	-
Energy Design Assistance	4	27,140	0%	5	2,111,736	1%
Motors	0	-	-	593	29,987,785	15%
Refrigeration	0	-	-	22	19,936,120	10%
Compressed Air	0	-	-	117	16,892,548	8%
Lighting	0	-	-	236	15,604,216	8%
Energy Management Systems	0	-	-	6	367,895	0%
Design	3	-	-	0	-	-
TOTAL	**389**	**29,327,669**	**100%**	**1288**	**206,337,204**	**100%**

As shown in Figures 3 and 4, process improvements had the largest impact on savings as reported in the rebate data. The process rebates accounted for the largest portion of electrical (53%) and thermal (45%) savings, but accounted for only 8% of the number of electrical rebates awarded and only 32% of gas rebates. This indicates that process improvements can have substantially more savings impact than other types of conservation projects, such as motor or lighting improvements. Process improvements are often unique to each facility so they can be more difficult for a utility to encourage; however, some utilities have been quite successful in promoting process changes and awarding rebates. Among sectors, there can be common process improvement themes like heat recovery, heat loss reduction, material flow concentration, or mass movement reduction (weight or distance). Refrigeration improvements are electrical projects where impacts tend to be disproportionately large (10%) compared to rebate numbers (2%). Refrigeration is largely confined to food processing facilities, which generally were the larger electrical users for each utility. In terms of gas rebates awarded, thermal oxidizer improvements also had disproportionate impact (10%) to rebate numbers (3%).

Figure 3. Breakdown of the impact of thermal rebates by project type.

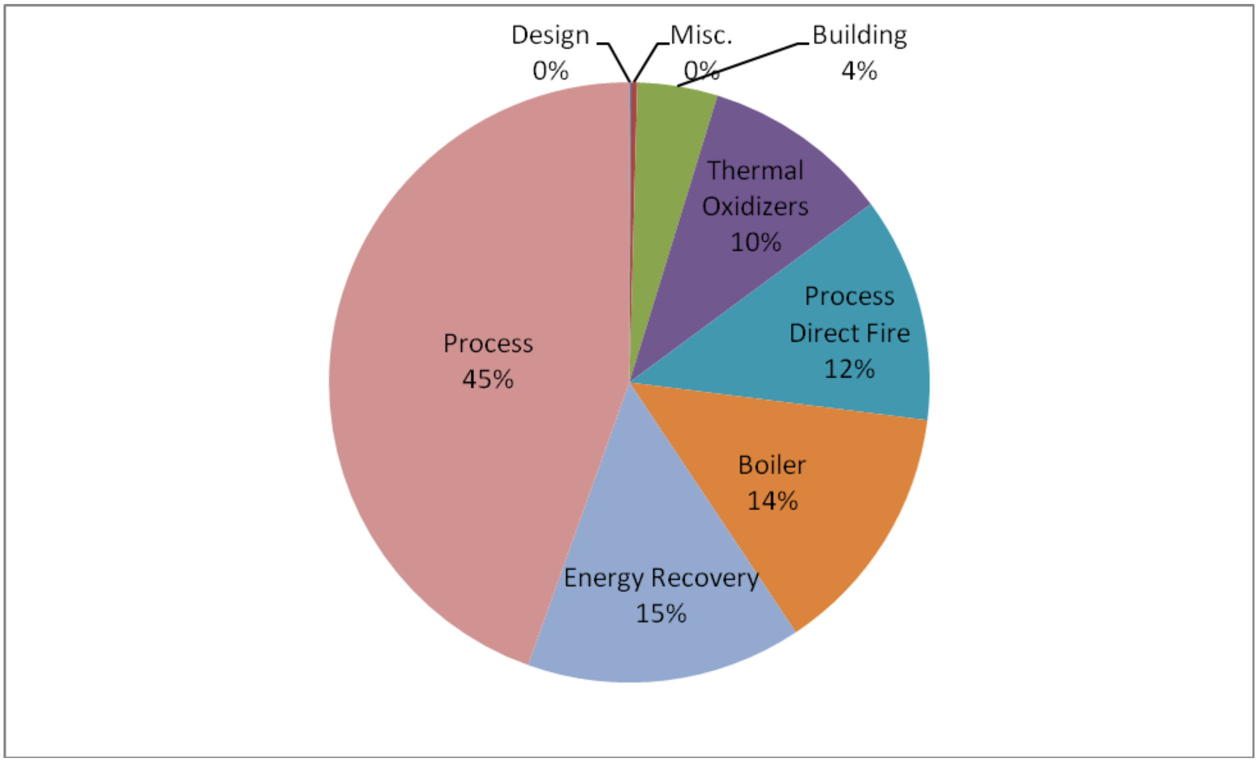
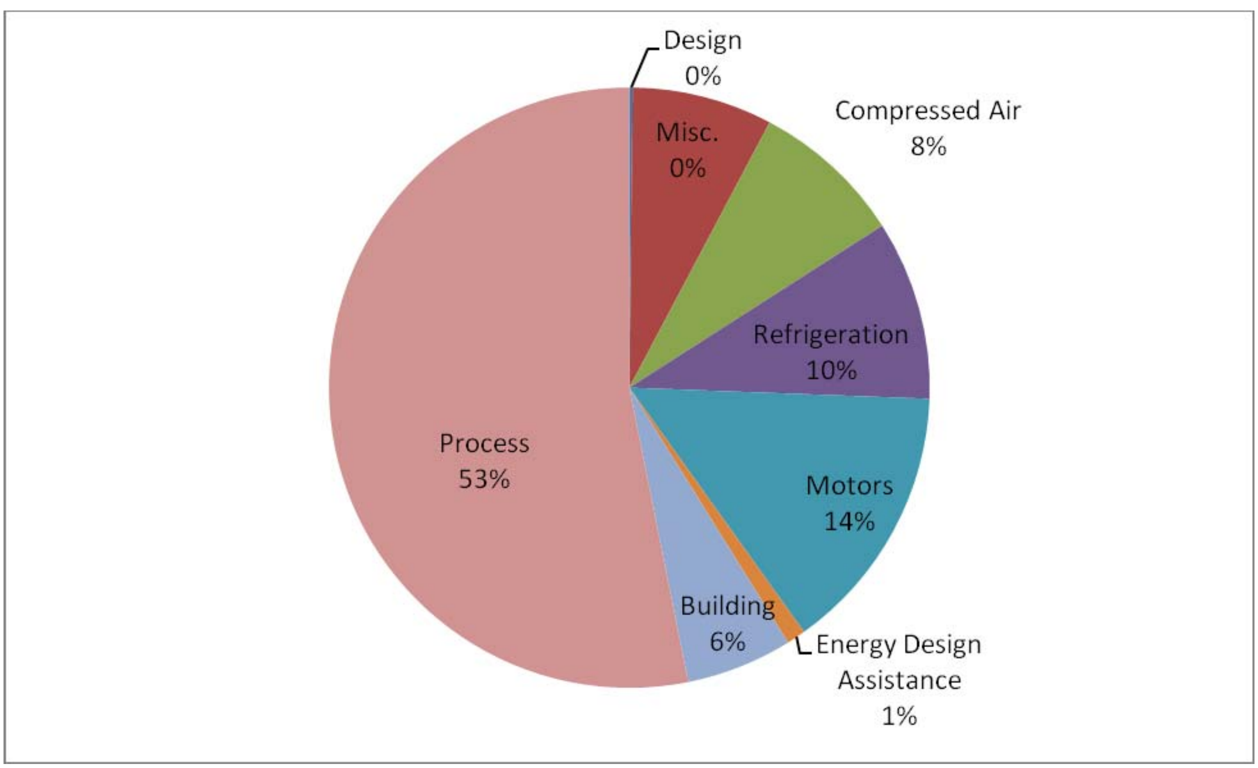


Figure 4. Breakdown of the impact of electric rebates by project type.



Chemical Manufacturing Sector

Sector Description

The chemical manufacturing sector includes facilities that are engaged in the production of ethanol, nitrogen fertilizer, and asphalt as well as the manufacturing of pharmaceuticals, compressed gases, resins, abrasives, perfumes/cosmetics, agricultural chemicals, adhesives, organics dyes, and surface cleaning products. Each utility reported energy use by chemical manufacturing facilities.

Table 12. Industrial energy consumption for the chemical manufacturing sector as reported by each utility.

Utility	Gas Customers			Electric Customers		
	# of facilities	Annual Use (therms)	% of total	# of facilities	Annual Use (kWh)	% of total
CenterPoint Energy	27	108,142,894	88.8%	0	0	0.0%
Great Plains Gas	6	12,022,610	9.9%	0	0	0.0%
Xcel Energy	70	1,186,000	1.0%	181	366,073,000	72.0%
MERC	21	486,285	0.4%	0	0	0.0%
Alliant Energy	2	8,892	0.0%	7	96,669,008	19.0%
Minnesota Power	0	0	0.0%	25	26,319,478	5.2%
Ottertail Power	0	0	0.0%	14	19,123,508	3.8%
TOTAL	**126**	**121,846,681**	**100.0%**	**227**	**508,184,994**	**100.0%**

Table 13 lists all the recommended sub-sectors in the chemical manufacturing sector, which account for 97.8% of the gas use and 78% of the electrical use of all chemical manufacturing facilities in these utility service areas. The table also highlights the savings potential for each recommended sub-sector. In total, the amount of estimated natural gas savings remaining for the recommended sub-sectors is just over 14 million therms or 12% of the total gas consumption of the recommended sub-sectors and 11.5% of the chemical manufacturing sector overall. The amount of estimated electrical savings is 66.5 million kWh or 17% of the recommended sub-sectors and 13.1% of the chemical manufacturing sector as a whole. The ethanol industry dominates the chemical manufacturing sector in terms of energy use. These facilities consume the most gas, 97% of the sector's gas consumption and 96% of the savings potential. Ethanol facilities consume the second highest amount of electricity within the overall sector. However, these facilities dominate the chemical manufacturing sector's electrical consumption outside the Xcel Energy service area.

Table 13. Savings estimates for each recommended sub-sector in the chemical manufacturing sector by utility.

Utility	SIC Description	# of Facilities	Gas			Electricity		
			Total Use (therms)	Remaining Potential Savings * (therms)	Est. Savings (%)	Total Use (kWh)	Remaining Potential Savings * (kWh)	Est. Savings (%)
Alliant Energy	Ethanol Production	2	-	-	-	94,324,136	0	0%
CenterPoint Energy	Ethanol Production	9	104,127,797	10,970,000	11%	-	-	-
	Pharmaceutical Manufacturing	9	1,934,912	308,200	15.9%	-	-	-
	Resin Production	1	834,758	51,500	6%	-	-	-
Great Plains Gas	Ethanol Production	1	11,436,350	2,630,000**	23%	-	-	-
Minnesota Energy	Pharmaceutical Manufacturing	6	256,897	36,200	14%	-	-	-
	Explosives Manufacturing	1	77,327	12,300	15.9%	-	-	-
Minnesota Power	Ethanol Production	1	-	-	-	20,031,200	691,500	3%
Ottertail Power	Ethanol Production	1	-	-	-	17,973,800	2,233,900	12%
Xcel Energy	Compressed Gas	6	21,212	2,758**	13%	20,288,592	5,072,148**	25%
	Shingle Manufacturing	1	-	-	-	33,829,875	11,826,900**	35%
	Ethanol Production	7	-	-	-	32,172,273	892,800**	3%
TOTAL		**45**	**118,689,254**	**14,010,874**	**12%**	**218,619,876**	**20,717,248**	**9%**

* *After facility-specific rebates were subtracted.*

** *No rebate data was provided or evaluated.*

Table 14 combines the recommended sub-sectors from each utility into common sub-sectors. Ethanol production accounts for the most gas use as well as estimated gas savings. The shingle manufacturing sub-sector consisted of a single facility with large electrical consumption; this facility and its savings opportunities do not have broad applicability in the State of Minnesota. The analyses of both the compressed gas and shingle manufacturing sub-sectors occurred early in this project and may have higher savings estimates than what is actually feasible due, in part, to the lack of information about rebates and savings already achieved.

It is important to note that in Table 14, the consumption and estimated savings data only reflects the aggregate for the facilities analyzed in this study across seven utilities. Therefore, the percentage of estimated savings may be skewed by variations in utility rebate programs, and perhaps also by variation in facility energy use and facility-specific opportunities.

Table 14. Savings estimates for each recommended sub-sector in the chemical manufacturing sector.

		Gas			Electricity		
Sub-sector	**# of Facilities**	**Total Use (therms)**	**Remaining Savings (therms)**	**Est. Savings (%)**	**Total Use (kWh)**	**Remaining Savings* (kWh)**	**Est. Savings (%)**
Ethanol Production	21	115,564,147	13,599,954	11.8%	164,501,409	3,818,200	2.3%
Pharmaceutical Mfg.	15	2,191,809	344,400	15.7%	-	-	-
Resin Production	1	834,758	51,472	6.2%	-	-	-
Compressed Gas	6	21,212	2,758	13.0%	20,288,592	5,072,148	25.0%
Explosives Mfg.	1	77,327	12,300	15.9%	-	-	-
Shingle Mfg.	1	-	-	-	33,829,875	11,826,900	35.0%
TOTAL	**45**	**118,689,254**	**14,010,874**	**11.8%**	**218,619,876**	**20,717,248**	**9.5%**

* *After facility-specific rebates were subtracted where provided.*

Savings estimates were determined by evaluating the technologies available for energy conservation. Tables 15 and 16 highlight technologies and energy conservation opportunities that facilities can take advantage of. Not all technologies or opportunities apply to every facility within a sub-sector; however, these tables are meant to provide an overview of the potential. Additionally, the savings opportunities and technologies were identified as having the greatest impact on facilities within a sub-sector. For example, all facilities may benefit from HVAC improvements; however, they were only recommended for sub-sectors where the potential for savings was the greatest.

Table 15. Recommended gas energy conservation opportunities. A ★ indicates the best opportunities for each sub-sector.

Opportunity	Savings Range	Sub-Sectors				
		Ethanol Production	Pharmaceutical Mfg.	Resin Production	Explosives Mfg.	Compressed Gas
Corn fractionation	5-15%	★				
Preheat drying combustion air	4-8%	✓				
Cold cooking	5-10%	★				
Steam system optimization	1-17%	★				
Process heat system optimization	1-14%		★		★	★
Heat recovery	4-10%	✓	★		★	
Facility HVAC improvements	0-5%		★		✓	★
Boiler system improvements	3-8%	✓	✓	★	✓	
Burner upgrades/improvements	0-10%			★	★	

Table 16. Recommended electrical energy conservation opportunities. A ★ indicates the best opportunities for each sub-sector.

Opportunity	Savings Range	Sub-Sectors			
		Ethanol Production	Pharmaceutical Mfg.	Compressed Gas	Shingle Mfg.
Corn fractionation	83%	★			
Increase screen size on hammer mill	27%	✓			
Not drying stillage	3%	★			
Optimize dust collection system	40%	★			
Replace hammer mills with roller mills	85%	✓			
Motor optimization	1-2%	✓		★	★
Pump optimization	0-1%	✓		★	✓
Insulate heaters	1%				
Air compressor system optimization	0-2%		✓	✓	✓
Process control improvements	0-2%		✓	★	✓
Process heat system improvements	1-2%				★
Facility HVAC improvements	0-3%		★	✓	★
Lighting improvements	0-3%		★	✓	✓

Food Processing Sector

Sector Description

Industries included in the food processing sector typically prepare food items for consumers or foodservice providers. These industries commonly engage in processes such as cooking, freezing, canning, and packaging. Seven of the eight utilities reported significant energy use by food processing manufacturing facilities, as shown in Table 17. The food processing sector was generally either the largest or second largest energy consuming sector for utilities, except for Greater Minnesota Gas, which has one manufacturing customer, which does not manufacture food products.

Xcel Energy customers account for over 70% the electrical consumption, while CenterPoint Energy customers account for nearly 80% of the gas consumption of this sector. However, the overall gas consumption data is incomplete, in terms of comparing utilities, as Xcel Energy's food processing gas customers are not included in the study. The food processing sector analysis for Xcel Energy was conducted prior to this study for the Minnesota Department of Commerce. The previous project, funded by Xcel Energy, did not include an analysis of gas customers and potential savings.

Table 17. Industrial energy consumption for the food processing sector as reported by each utility.

	Gas Customers			Electric Customers		
Utility	**# of facilities**	**Annual Use (therms)**	**% of total**	**# of facilities**	**Annual Use (kWh)**	**% of total**
CenterPoint Energy	98	82,181,222	77.4%	-	-	-
Great Plains Gas	14	20,157,010	19.0%	-	-	-
Alliant Energy	5	2,932,776	2.8%	15	68,156,160	6.23%
MERC	61	858,161	0.8%	-	-	-
Minnesota Power	-	-	-	64	98,231,239	9.0%
Ottertail Power	-	-	-	51	138,357,951	12.6%
Xcel Energy*	-	-	-	603	789,072,559	72.1%
TOTAL	**178**	**106,129,169**	**100.0%**	**733**	**1,093,817,909**	**100.0%**

**Gas consumption for food processors in the Xcel Energy service territory was not provided by the utility or analyzed by MnTAP.*

Table 18 lists all the sub-sectors included in the food processing sector that were recommended for energy savings efforts for each utility. The recommended sub-sectors account for 52.3% of the gas use and 42.3% of the electrical use of all food processing facilities in these utility service areas.

Table 18 also provides information about the savings potential remaining for each recommended sub-sector. The estimated natural gas savings remaining for the recommended sub-sectors is 4.2 million therms, which is 7.6% of the total gas consumption of the recommended sub-sectors and 4% of the food processing sector overall. The amount of estimated electrical savings is 53 million kWh or 11.5% of the recommended sub-sectors and 4.9% of the food processing sector as a whole.

The consumption and estimated savings data shown in Table 18 only reflects the facilities analyzed in this study across seven utilities. Therefore, the percentage of estimated savings may be skewed by variations in utility rebate programs, and perhaps also by variation in facility energy use and facility-specific opportunities.

Table 18. Energy use information and savings estimates for each recommended sub-sector in the food processing sector.

Utility	SIC Description	# of Facilities	Gas			Electricity		
			Total Use (therms)	Remaining Potential Savings* (therms)	Est. Savings (%)	Total Use (kWh)	Remaining Potential Savings* (kWh)	Est. Savings (%)
CenterPoint Energy	Poultry processing	12	8,827,593	625,000	7.1%	-	-	-
	Dried food products	8	8,764,409	59,500	0.7%	-	-	-
	Cheese and butter processing	3	8,491,882	640,200	7.5%	-	-	-
	Rendering	2	7,258,921	547,300	7.5%	-	-	-
	Fruit and vegetable canning	7	7,019,971	363,400	5.2%	-	-	-
Alliant Energy	Vegetable processing	5	-	-	-	26,910,996	2,703,900	10.0%
	Meat processing	5	1,437,624	26,200	1.8%	18,877,536	62,400	0.3%
	Dried dairy products	2	742,428	50,500	12.0%	6,357,072	833,700	13.1%
	Margarine manufacturing	1	422,316	65,700	8.9%	10,182,948	441,800	4.3%
Great Plains Gas	Soybean processing	1	3,304,160	450,000	13.6%	-	-	-
	Rendering	1	3,507,150	608,000	17.3%	-	-	-
	Cheese processing	1	2,856,400	377,000	13.2%	-	-	-
	Poultry processing	2	1,998,790	268,000	13.4%	-	-	-
Minnesota Energy	Bakeries	10	341,488	64,400	18.9%	-	-	-
	Food processors w/ water heating	44	330,416	42,200	12.5%	-	-	-
	Vegetable canning	2	107,006	9,100	8.5%	-	-	-
	Poultry processing	3	77,275	10,200	13.2%	-	-	-
Minnesota Power	Meat processing	7	-	-	-	30,529,116	3,160,200	10.4%
	Rendering	1	-	-	-	24,948,375	1,532,800	6.1%
	Seafood processing	3	-	-	-	14,323,582	459,700	3.2%
	Citric acid production	1	-	-	-	4,534,200	324,300	7.2%
Ottertail Power	Meat processing	5	-	-	-	34,215,492	5,719,400	16.7%
	Cheese & whey processing	1	-	-	-	23,246,307	3,510,200	15.1%
	Soybean processing	1	-	-	-	21,509,620	1,112,100	5.2%
	Sunflower seed & rice processing	2	-	-	-	13,521,747	943,600	7.0%
	Snack chip manufacturing	1	-	-	-	10,951,560	876,100	8.0%
	Pet food manufacturing	1	-	-	-	10,654,189	625,700	5.9%
Xcel Energy	Poultry processing	7	-	-	-	108,000,000	16,200,000	15%
	Dairy processing	17	-	-	-	53,000,000	7,000,000	12%
	Commercial bakeries	21	-	-	-	51,000,000	7,650,000	15%
TOTAL		**177**	**55,487,829**	**4,206,700**	**7.6%**	**462,762,740**	**53,155,900**	**11.5%**

* *After facility specific rebates were subtracted.*

** *No rebate data provided or evaluated.*

Table 19 shows data for common sub-sectors recommended for energy conservation assistance. Rendering offers the most potential natural gas savings remaining while poultry processing offers the most electrical savings potential.

Table 19. Savings estimates for each recommended sub-sector in the food processing sector.

		Gas			Electricity		
Sub-sector	**# of Facilities**	**Total Use (therms)**	**Remaining Potential Savings * (therms)**	**Est. Savings (%)**	**Total Use (kWh)**	**Remaining Potential Savings * (kWh)**	**Est. Savings (%)**
Cheese and Butter Processing	22	11,348,282	1,017,200	9.0%	76,246,307	10,510,200	13.8%
Poultry Processing	24	10,903,658	903,200	8.3%	108,000,000	16,200,000	15.0%
Rendering	4	10,766,071	1,155,300	10.7%	24,948,375	1,532,800	6.1%
Dried Foods	10	9,506,837	110,000	1.2%	6,357,072	833,700	13.1%
Fruit and Vegetable Canning	14	7,126,977	372,500	5.2%	26,910,996	2,703,900	10.0%
Soybean Processing	2	3,304,160	450,000	13.6%	21,509,620	1,112,100	5.2%
Meat Processing (not poultry)	19	1,437,624	26,200	1.8%	83,622,144	8,942,000	10.7%
Margarine Manufacturing	1	422,316	65,700	15.6%	10,182,948	441,800	4.3%
Bakeries	31	341,488	64,400	18.9%	51,000,000	7,650,000	15.0%
Food Processors w/ Water Heating	44	330,416	42,200	12.8%	-	-	-
Seafood Processing	3	-	-	-	14,323,582	459,700	3.2%
Citric Acid Production	1	-	-	-	4,534,200	324,300	7.2%
Sunflower Seed & Rice Proc.	2	-	-	-	13,521,747	943,600	7.0%
Snack Chip Manufacturing	1	-	-	-	10,951,560	876,100	8.0%
Pet Food Manufacturing	1	-	-	-	10,654,189	625,700	5.9%
TOTAL	**179**	**55,487,829**	**4,206,700**	**7.6%**	**462,762,740**	**53,155,900**	**11.5%**

* *After facility specific rebates were subtracted where provided.*

Technologies for energy conservation were researched and evaluated for each of the recommended sub-sectors. From that research, MnTAP developed savings estimates for each sub-sector in each utility service area. Tables 20 and 21 highlight technologies and energy conservation opportunities that facilities can take advantage of. Not all technologies or opportunities apply to every facility within a sub-sector; however, these tables are meant to provide an overview of the potential.

Table 20. Recommended gas conservation opportunities. A ★ indicates the best opportunities for each sub-sector.

Opportunity	Savings Range	Sub-Sectors								
		Bakeries	Fruit & Veg Canning	Rendering	Dried Food Products	Meat Processing	Soybean Processing	Poultry Processing	Margarine Mfg.	Cheese & Butter Proc.
Boiler improvements / best practices	1-8%	✓	★	★	✓	★	✓	✓		★
Direct fired improvements /best practices	0.1-1%	✓			✓	✓	✓	✓		✓
Process equipment heat recovery	0.5-13%	★		★	★	✓	✓	★		★
Facility HVAC improvements	1-8%	✓	✓							
Improved process equipment	0.5-4%	★	★	✓	✓	✓	✓	✓	✓	✓
Product wash improvements	1%		✓							
Steam best practices and improvements	0.5-11%		✓	✓	✓	✓	✓	✓	✓	✓
Water heating improvements	2-10%			★		★		★		★

Table 21. Recommended electrical energy conservation opportunities. A ★ indicates the best opportunities for each sub-sector.

Opportunity	Savings Range	Sub-Sectors													
		Bakeries	Fruit & Veg Canning	Rendering	Dried Food Products	Meat Processing	Soybean Processing	Poultry Processing	Margarine Mfg.	Cheese & Butter Proc.	Seafood Processing	Citric Acid Production	Seed & Rice Proc.	Snack Chip Mfg.	Pet Food Mfg.
Compressed air improvements	0.5-3%	✓	★	★	★	✓	★	★	✓	★	✓	✓	✓	✓	✓
Facility HVAC Improvements	0.5-2%	✓	✓		✓	✓		✓	✓	✓	✓			✓	✓
Improved process equipment	9.7%	★	✓	✓	✓	✓	★	✓	✓	✓	✓	✓	✓	★	★
Lighting improvements	0.5-2%	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Motor improvements including pumps and fans	1-1.5%	✓	✓	★	★	✓	✓	✓	✓	✓	★	✓	★	★	★
Process design improvements	2-4%		✓	✓	✓	✓			✓			✓	✓		
Refrigeration improvements	2-10%	✓	✓		✓	★		★	✓	★	★				

Fabricated Metals Sector

Sector Description

The fabricated metals sector includes a broad grouping of facilities including machine shops, stamping operations, or construction equipment manufacturer. Six of the eight utilities reported energy use by fabricated metals facilities, as shown in Table 22. The fabricated metals sector generally had the most facilities included for each utility and overall accounted for the most facilities analyzed in the study.

CenterPoint Energy and Xcel Energy customers together account for nearly 90% of the thermal consumption, while Xcel Energy customers alone account for nearly 90% of the electrical consumption of this sector.

Table 22. Industrial energy consumption for the fabricated metals sector as reported by each utility.

	Gas Customers			Electric Customers		
Utility	**# of facilities**	**Annual Use (therms)**	**% of total**	**# of facilities**	**Annual Use (kWh)**	**% of total**
Alliant Energy	12	745,257	2.6%	15	16,334,659	1.5%
CenterPoint Energy	68	15,712,688	54.9%	0	0	0.0%
MERC	193	2,211,582	7.7%	0	0	0.0%
Minnesota Power	0	0	0.0%	143	74,272,494	6.9%
Ottertail Power	0	0	0.0%	61	21,124,424	2.0%
Xcel Energy	416	9,938,430	34.7%	1,462	958,145,366	89.6%
TOTAL	**689**	**28,607,957**	**100.0%**	**1,681**	**1,069,876,943**	**100.0%**

Table 23 lists all the sub-sectors included in the fabricated metals sector that were recommended for energy savings efforts for each utility. The recommended sub-sectors account for 45% of the gas use and 41% of the electrical use of all fabricated metals facilities in these utility service areas. Information is also provided regarding the savings potential remaining for each recommended sub-sector. The estimated natural gas savings remaining for the recommended sub-sectors is nearly 2.9 million therms, which is 22.4% of the total gas consumption of the recommended sub-sectors and 10% of the fabricated metals sector overall. The amount of estimated electrical savings is 60 million kWh or nearly 14% of the recommended sub-sectors and 6% of the sector's total current energy use.

Table 23. Energy use data and savings estimates for recommended sub-sectors in the fabricated metals sector.

Utility	SIC Description	# of Facilities	Gas			Electricity		
			Total Use (therms)	Remaining Potential Savings* (therms)	Est. Savings (%)	Total Use (kWh)	Remaining Potential Savings* (kWh)	Est. Savings (%)
Alliant Energy	Sheetmetal Products	2	331,413	94,800	28.6%	4,622,495	832,000	18%
	Plating, Polishing and Finishing	2	89,684	22,600	25.2%	882,455	154,400	17.5%
CenterPoint Energy	Plating, Polishing and Finishing	18	3,570,933	637,600	17.8%	-	-	-
	Ordnance and Ammo Manufacturing	6	3,363,437	553,600	16.5%	-	-	-
	Metal Tube Manufacturing	4	1,026,337	381,600	37%	-	-	-
	Metal Can Manufacturing	2	763,989	193,600	25%	-	-	-
Minnesota Energy	Machining & Custom Tool/Die Shops	88	635,277	102,800	16%	-	-	-
	Coating, Plating, Polishing, & Finishing	9	587,884	146,300	25%	-	-	-
	Sheetmetal Products	19	215,022	34,900	16%	-	-	-
Minnesota Power	Stamping and Forging Operations	7	-	-	-	32,788,741	4,329,500	13.2%
	Boat Manufacturing	21	-	-	-	8,256,004	1,733,300	21.0%
	Machine Shops***	3	-	-	-	11,128,464	788,500	7.1%
	Medium Duty Equipment	28	-	-	-	7,869,431	633,600	8.1%
Ottertail Power	Medium Duty Industrial Equipment	20	-	-	-	7,695,572	1,031,700	13.4%
Xcel Energy	Machine Tool and Die Shops	520	1,811,737	634,100	35%	176,944,411	31,850,000	18%
	Computer Components/ Hardware	55	131,498	26,300	20%	141,860,215	14,186,000	10%
	Metal Can Manufacturing	5	418,048	71,000	17%	47,876,568	5,266,400	11%
TOTAL		**809**	**12,945,259**	**2,899,200**	**22.4%**	**439,924,356**	**60,805,400**	**13.8%**

** After facility specific rebates were subtracted.*

*** No rebate data provided or evaluated.*

**** Only three facilities within this sub-sector are recommended for conservation efforts.*

Energy use data for recommended sub-sectors is shown in Table 24. The plating, polishing, and finishing sub-sector offers the most potential natural gas savings while machine and custom tool/die shops offer the most electrical savings potential. It is important to note that in Table 24, the consumption and estimated savings data only reflects the aggregate for the facilities analyzed in this study across six utilities. The percentage of estimated savings may be skewed by variations in utility rebate programs, and perhaps also by variation in facility energy use and facility-specific opportunities.

Table 24. Savings estimates for each recommended sub-sector in the fabricated metals sector.

		Gas			Electricity		
Sub-sector	**# of Facilities**	**Total Use (therms)**	**Remaining Potential Savings* (therms)**	**Est. Savings (%)**	**Total Use (kWh)**	**Remaining Potential Savings* (kWh)**	**Est. Savings (%)**
Plating, Polishing, and Finishing	29	4,248,501	806,500	19.0%	882,455	154,400	17.5%
Ordnance and Ammo Manufacturing	6	3,363,437	553,600	16.5%	-	-	-
Machine and Custom Tool/Die Shops	611	2,447,014	736,900	30.1%	188,072,875	32,638,500	17.4%
Metal Tube Manufacturing	4	1,026,337	381,600	37.0%	-	-	-
Metal Can Manufacturing	7	1,182,037	264,600	22.4%	47,876,568	5,266,400	11.0%
Sheetmetal Products	21	546,435	129,700	23.7%	4,622,495	832,000	18.0%
Computer Components/Hardware	55	131,498	26,300	20.0%	141,860,215	14,186,000	10.0%
Stamping and Forging Operations	7	-	-	-	32,788,741	4,329,500	13.2%
Boat Manufacturing	21	-	-	-	8,256,004	1,733,300	21.0%
Medium Duty Equipment	48	-	-	-	15,565,003	1,665,300	10.7%
TOTAL	**809**	**12,945,259**	**2,899,200**	**22.4%**	**439,924,356**	**60,805,400**	**13.82%**

** After facility specific rebates were subtracted where provided.*

Technologies for energy conservation were researched and evaluated for each of the recommended sub-sectors. From that research, MnTAP developed savings estimates for each sub-sector in each utility service area. Tables 25 and 26 highlight technologies and energy conservation opportunities that facilities can take advantage of. Not all technologies or opportunities apply to every facility within a sub-sector; however, these tables are meant to provide an overview of the potential.

Table 25. Recommended gas conservation opportunities.

Opportunity	Savings Range	Sub-Sectors									
		Sheetmetal Products	Plating, Polishing, Finishing	Ordnance and Ammo Manufacturing	Metal Tube Manufacturing	Metal Can Manufacturing	Machine and Custom Tool/Die Shops	Computer Components and Hardware	Stamping and Forging Operations	Boat Manufacturing	Medium Duty Equipment Mfg.
Process heat system optimization	1-20%	✓	✓		✓	✓	✓	✓	✓		
Heat recovery	2-59%			✓	✓	✓	✓		✓		
Facility HVAC improvements	5-35%	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 26. Recommended electrical energy conservation opportunities. A ★ indicates the best opportunities for each sub-sector.

Opportunity	Savings Range	Sub-Sectors							
		Sheetmetal Products	Plating, Polishing, Finishing	Metal Can Manufacturing	Machine and Custom Tool/Die Shops	Computer Components and Hardware	Stamping and Forging Operations	Boat Manufacturing	Medium Duty Equipment Mfg.
Process improvements and optimization	2-9%	✓	✓		★		★		
Facility HVAC and lighting improvements	1-6%	✓	★	✓	✓	★	★	★	
Pump and fan optimization	2-6%	✓	✓	✓	✓	★	✓	✓	
Compressed air improvements	1-9%	★	★	★	★	★	★	★	★
Process motor optimization	1-4%	★	✓	★	★			✓	★
Fan and paint ventilation modifications	1%	✓						★	✓
Electrochemical process efficiency	10%		★						
Welding system controls	1%	★		★				✓	★

Primary Metals Sector

Sector Description

The primary metals sector includes a broad grouping of primary metals industries. These industries commonly engage in smelting and refining ferrous and non-ferrous metals from ore or scrap feedstocks and also process metals by casting or otherwise forming various manufactured metal products. The entire primary metals sector uses energy in processes such as melting, alloying, heating, and producing metal products. Six of the eight utilities reported energy use by primary metals facilities, as shown in Table 27. Energy use totals for Xcel Energy do not include one facility in the service area, which is exempt from the conservation improvement program (CIP).

Table 27. Industrial energy consumption for the primary metals sector as reported by each utility.

	Gas Customers			Electric Customers		
Utility	**# of facilities**	**Annual Use (therms)**	**% of total**	**# of facilities**	**Annual Use (kWh)**	**% of total**
Alliant Energy	-	-	0.0%	1	3,544,105	1.1%
CenterPoint Energy	26	13,084,766	73.1%	-	-	-
Great Plains Gas	2	913,480	5.1%	-	-	-
Minnesota Power	-	-	-	4	56,381,679	17.0%
Ottertail Power	-	-	-	1	5,300,000	1.6%
Xcel Energy*	45	3,898,995	21.8%	162	265,763,484	80.3%
TOTAL	**73**	**17,897,241**	**100.0%**	**168**	**330,989,268**	**100.0%**

Table 28 lists the sub-sectors included in the primary metals sector that were recommended for energy savings efforts. The recommended sub-sectors account for 94% of the gas use and 85% of the electrical use of all primary metals facilities in these utility service areas. The table also provides information about the savings potential remaining for each recommended sub-sector. The estimated natural gas savings remaining for the recommended sub-sectors is just over 1 million therms, which is 6.1% of the total gas consumption of the recommended sub-sectors and 5.7% of the primary metals sector overall. The amount of estimated electrical savings is 39 million kWh or nearly 14% of the recommended sub-sectors and 12% of the sector's total current energy use.

Table 28. Savings estimates for each recommended sub-sector in the primary metals sector.

Utility	SIC Description	# of Facilities	Gas			Electricity		
			Total Use (therms)	Remaining Potential Savings* (therms)	Est. Savings (%)	Total Use (kWh)	Remaining Potential Savings* (kWh)	Est. Savings (%)
Alliant Energy	Aluminum Operations	1	-	-	-	3,544,105	180,800	5.1%
CenterPoint Energy	Aluminum Operations	13	8,881,509	170,700	2%	-	-	-
	Heat Treating Operations	5	2,678,664	66,000	2.4%	-	-	-
	Iron Operations	3	1,227,715	122,800	10%	-	-	-
Great Plains Gas	Aluminum Operations	1	744,820	170,000	22.8%	-	-	-
Minnesota Power	Iron Casting Operations	2	-	-	-	46,694,799	4,321,000	9.3%
	Iron Feedstock Production	1	-	-	-	9,604,800	856,300	8.9%
Ottertail Power	Aluminum Operations	1	-	-	-	5,300,000	1,232,200	23.2%
Xcel Energy	Aluminum Operations	21	1,780,957	231,500	13%	91,808,808	12,853,200	14%
	Iron Operations	17	1,077,655	258,600	24%	88,904,942	16,002,900	18%
	Heat Treating Operations	10	348,628	7,000	2%	36,436,318	3,643,600	10%
TOTAL		**75**	**16,739,948**	**1,026,600**	**6.1%**	**282,293,772**	**39,090,000**	**13.9%**

** After facility specific rebates were subtracted.*

*** No rebate data provided or evaluated.*

Energy use data and potential savings estimates for recommended sub-sectors are shown in Table 29. The aluminum operations sub-sector offers the most potential natural gas savings while the iron operations sub-sector offers the most electrical savings potential.

The consumption and estimated savings data in Table 26 only reflects the facilities analyzed in this study across six utilities. Therefore, the percentage of estimated savings may be skewed by variations in utility rebate programs, and perhaps also by variation in facility energy use and facility-specific opportunities.

Table 29. Savings estimates for each recommended sub-sector in the primary metals sector.

		Gas			Electricity		
Sub-sector	**# of Facilities**	**Total Use (therms)**	**Remaining Potential Savings* (therms)**	**Est. Savings (%)**	**Total Use (kWh)**	**Remaining Potential Savings* (kWh)**	**Est. Savings (%)**
Aluminum Operations	37	11,407,286	572,200	5.0%	100,652,913	14,266,200	14.2%
Heat Treating Operations	15	3,027,292	73,000	2.4%	36,436,318	3,643,600	10.0%
Iron Operations	22	2,305,370	381,400	16.5%	135,599,741	20,323,900	18.0%
Iron Feedstock Prod.	1	-	-	-	9,604,800	856,300	8.9%
TOTAL	**75**	**16,739,948**	**1,026,600**	**6.1%**	**282,293,772**	**39,090,000**	**13.8%**

** After facility specific rebates were subtracted where provided.*

Technologies for energy conservation were researched and evaluated for each of the recommended sub-sectors. From that research, MnTAP developed savings estimates for each sub-sector in each utility service area. Tables 30 and 31 highlight technologies and energy conservation opportunities that facilities can take advantage of. Not all technologies or opportunities apply to every facility within a sub-sector; however, these tables are meant to provide an overview of the potential. Additionally, the savings opportunities and technologies were identified as having the greatest impact on facilities within a sub-sector.

Table 30. Recommended gas conservation opportunities. A ★ indicates the best opportunities for each sub-sector.

		Sub-Sectors			
Opportunity	**Savings Range**	**Aluminum Operations**	**Heat Treating Operations**	**Iron Operations**	**Iron Feedstock Production**
Fired heaters upgrades/optimization	6-10%	✓		✓	
Furnace optimization	2-24%	★	★	★	★
Process heat optimization	2-16%	✓			
Waste heat recovery	0.5-5%	★	★		

Table 31. Recommended electrical energy conservation opportunities. A ★ indicates the best opportunities for each sub-sector.

Opportunity	Savings Range	Sub-Sectors			
		Aluminum Operations	Heat Treating Operations	Iron Operations	Iron Feedstock Production
Process heat system optimization	1-5%	★			
Materials processing improvements	1-2.3%	✓		✓	★
Pump and fan optimization	1-7%	✓			
Existing furnace optimization	9-18%	✓	★	★	
Compressed air optimization	1.6%	★			★
Facility improvements	1.5%	✓		✓	✓

Printing Sector

Sector Description

This sector includes a wide array of printers whose products include direct-mail advertisements and inserts, magazines, catalogs, books, newspapers and periodicals, posters, business forms, flyers, stationery, greeting cards, and personalized items. The main use of gas by printers is for drying and pollution control equipment; although, printers who do not exceed volatile organic compound (VOC) emission thresholds do not require pollution control equipment. Electricity is used in the facilities for HVAC, lighting, press operation, and other processes. Two of the eight utilities reported energy use by printers, as shown in Table 32.

Table 32. Industrial energy consumption for the printing sector as reported by each utility.

	Gas Customers			Electric Customers		
Utility	# of facilities	Annual Use (therms)	% of total	# of facilities	Annual Use (kWh)	% of total
CenterPoint Energy	30	8,244,000	65.2%	-	-	-
Xcel Energy	300	4,401,000	34.8%	1,071	450,170,000	100.0%
TOTAL	**330**	**12,645,000**	**100.0%**	**1,071**	**450,170,000**	**100.0%**

When analyzing the utility data for this sector, the SIC codes seemed to be assigned to facilities based on which press type is predominantly used by the facility; however, the press type has little influence on the use of energy. Three sub-sectors were identified based upon their process equipment and printing processes. Table 33 lists the sub-sectors included in the printing sector that were recommended for energy savings efforts. The recommended sub-sectors account for 95% of the gas use and 97% of the electrical use of all printing facilities in the two utility service areas represented.

The table also provides information about the savings potential remaining for each recommended sub-sector. The estimated natural gas savings remaining for the recommended sub-sectors is just under 1.5 million therms, which is 12.3% of the total gas consumption of the recommended sub-sectors and 12% of the printing sector overall. The amount of estimated electrical savings is 60 million kWh or nearly 14% of the recommended sub-sectors and 13% of the sector's total current energy use.

It is important to note that in Table 33, the consumption and estimated savings data only reflects the aggregate for the facilities analyzed in this study for the two utility companies. Therefore, the percentage of estimated savings may be skewed by variations in utility rebate programs, and perhaps also by variation in facility energy use and facility-specific opportunities.

Table 33. Savings estimates for each recommended sub-sector in the printing sector.

Utility	SIC Description	# of Facilities	Gas			Electricity		
			Total Use (therms)	Remaining Potential Savings* (therms)	Est. Savings (%)	Total Use (kWh)	Remaining Potential Savings* (kWh)	Est. Savings (%)
CenterPoint Energy	Heat Set Printers	18	7,757,932	989,397	12.8%	-	-	-
Xcel Energy	Non-Heat Set Printing	181	927,338	138,000	14.9%	312,128,662	43,814,000	14.0%
	Heat Set Printers	38	2,719,745	262,000	9.6%	65,234,908	8,508,000	13.0%
	Newspapers, Periodicals, & Books	261	550,911	80,000	14.5%	57,616,843	7,695,000	13.4%
TOTAL		**498**	**11,955,926**	**1,469,397**	**12.3%**	**434,980,413**	**60,017,000**	**13.8%**

* *After facility specific rebates were subtracted.*

Energy use data and potential savings estimates for the three recommended sub-sectors in the printing sector are shown in Table 34. The heat set printers offers the most potential gas savings while the non-heat set printers offer the most electrical savings potential. The difference in these two types of printers is the use of thermal energy to set the inks on the paper in heat set printing.

Table 34. Savings estimates for each recommended sub-sector in the printing sector.

Sub-sector	# of Facilities	Gas			Electricity		
		Total Use (therms)	Remaining Potential Savings * (therms)	Est. Savings (%)	Total Use (kWh)	Remaining Potential Savings * (kWh)	Est. Savings (%)
Heat Set Printers	56	10,477,677	1,251,397	11.9%	65,234,908	8,508,000	13.0%
Non-Heat Set Printers	181	927,338	138,000	14.9%	312,128,662	43,814,000	14.0%
Newspapers, Periodicals, & Books	261	550,911	80,000	14.5%	57,616,843	7,695,000	13.4%
TOTAL	**498**	**11,955,926**	**1,469,397**	**12.3%**	**434,980,413**	**60,017,000**	**13.8%**

** After facility specific rebates were subtracted.*

As part of this project, MnTAP identified technologies for energy conservation and researched and evaluated them for each of the recommended sub-sectors. From that research, MnTAP developed savings estimates for each sub-sector in each utility service area. Tables 35 and 36 highlight technologies and energy conservation opportunities that facilities can take advantage of. Not all technologies or opportunities apply to every facility within a sub-sector; however, these tables are meant to provide an overview of the potential. Additionally, the savings opportunities and technologies were identified as having the greatest impact on facilities within a sub-sector. Thermal oxidizers are specifically only found in heat set printing facilities; therefore, the other two sub-sectors have few thermal efficiency improvements available.

Table 35. Recommended gas conservation opportunities. A ★ indicates the best opportunities for each sub-sector.

Opportunity	Savings Range	Sub-Sectors		
		Heat Set Printers	Non-Heat Set Printers	Newspapers, Periodicals, & Books
Replace thermal oxidizer with more efficient equipment	3-13%	★		
Replace obsolete dryers with more efficient ones	4-22%	★		
Recover heat from dryer exhaust	6-30%	★		
Integrate dryers and recuperative thermal oxidizer		✓		
Make facility HVAC improvements	0-5%	✓	★	★

Table 36. Recommended electrical energy conservation opportunities. A ★ indicates the best opportunities for each sub-sector.

Opportunity	Savings Range	Sub-Sectors: Heat Set Printers	Sub-Sectors: Non-Heat Set Printers	Sub-Sectors: Newspapers, Periodicals, & Books
Improve compressed air system	1-5%	★	★	✓
Make motor improvements including VFDs, proper sizing, etc.	3-11%	★	✓	★
Optimize pump systems	0-2%	★		
Install high efficiency LED lighting	2-7%	✓	★	★

Industrial Drying Sector

Sector Description

The industrial drying sector originally included three types of facilities: dried food, grain elevators with drying, and miscellaneous drying facilities. However, once combined with information from other utilities, only one type of facility remained that was unique to this sector: grain elevators with drying operations. This type of facility was only analyzed for Minnesota Energy Resources Corporation (MERC), which only supplies natural gas to these customers. Therefore, no electrical use or savings were developed. Data about this sector is shown in Table 37.

Table 37. Industrial energy consumption for the industrial drying sector as reported by MERC.

	Gas Customers			Electric Customers		
Utility	# of facilities	Annual Use (therms)	% of total	# of facilities	Annual Use (kWh)	% of total
Minnesota Energy Resources	12	502,010	100%	-	-	-

Table 38 lists information about the grain elevators with drying operations sub-sector, as it was recommended for energy savings efforts. This sector accounts for 50% of the gas use of all the facilities identified with drying operations in the MERC service territory. The table also provides information about the savings potential remaining for the sub-sector. The estimated natural gas savings is just over 165,000 therms, which is one-third of the total gas consumption of these facilities. This amount of savings can be significant for a grain drying facility; however, it should be noted that these facilities operate seasonally, so the savings must be achieved during the drying season (approximately October through March).

Table 38. Savings estimates for the recommended sub-sector in the industrial drying sector.

			Gas		
Utility	SIC Description	# of Facilities	Total Use (therms)	Remaining Potential Savings* (therms)	Est. Savings (%)
MERC	Grain elevators with drying operations	12	502,010	165,600	33%

** After facility specific rebates were subtracted.*

Grain elevators with drying operations are not typically classified as manufacturing operations. However, MnTAP still identified these facilities as significant gas users with potential for energy conservation measures. Table 39 highlights technologies and energy conservation opportunities that drying facilities can take advantage of.

Table 39. Recommended gas energy conservation opportunities for grain elevators with drying operations.

Opportunity	Savings Range
Routine maintenance on drying equipment	0-2%
Use flue gases to heat process or service water	4-8%
Use waste heat from hot flue gases to preheat combustion air	2-4%
Microwave livestock feed drying (beet pulp)	0-3%
Switch to combination drying	4-8%

Wood Products Sector

Sector Description

The wood products sector is made up of facilities that represent multiple industries including reconstituted or engineered wood products such as fiberboard and laminated strand lumber; kiln-dried or green lumber; wood shavings, veneers, shims, trusses, and pallets; building components such as windows, doors, moldings, cabinets; and even toothpicks and popsicle sticks. Two of the eight utilities reported energy use by wood product manufacturers, as shown in Table 40. Both utilities only supply electrical power; therefore, no gas use or savings were reported.

Table 40. Industrial energy consumption for the wood products sector as reported by each utility.

	Gas Customers			Electric Customers		
Utility	# of facilities	Annual Use (therms)	% of total	# of facilities	Annual Use (kWh)	% of total
Minnesota Power	-	-	-	59	65,027,210	51.8%
Ottertail Power	-	-	-	12	60,404,718	48.2%
TOTAL	**-**	**-**	**-**	**71**	**125,431,928**	**100.0%**

Three sub-sectors were identified based upon their process equipment and manufacturing processes. Table 41 lists the sub-sectors included in the wood products sector that were recommended for energy savings efforts. The recommended sub-sectors account for 95% of the gas use and 97% of the electrical use of all wood products facilities in the two utility service areas represented.

The table also provides information about the savings potential remaining for each recommended sub-sector. The estimated electrical savings remaining for the recommended sub-sectors is 16.8 million kWh, which is 13.9% of the total electrical energy consumption of the recommended sub-sectors and 13.4% of the sector overall.

Table 41. Savings estimates for each recommended sub-sector in the wood products sector.

			Electricity		
Utility	SIC Description	# of Facilities	Total Use (kWh)	Remaining Potential Savings* (kWh)	Est. Savings (%)
Minnesota Power	Reconstituted Wood Products	3	47,721,452	4,535,500	9.5%
	Secondary Millwork	37	11,346,577	1,448,700	12.8%
	Primary Sawmills	19	5,959,181	1,162,100	19.5%
Ottertail Power	Oriented Strand Board	1	43,211,000	7,348,900	17.0%
	Saw Mills	4	13,296,340	2,375,500	17.9%
TOTAL		**64**	**121,534,550**	**16,870,700**	**13.9%**

** After facility specific rebates were subtracted.*

When compared, the reconstituted wood products and oriented strand board sub-sectors contain facilities with similar operations. Therefore, those two sub-sectors were combined to create one overall sub-sector (Reconstituted Wood Products) within the wood products sector. Energy use data and potential savings estimates for the three recommended sub-sectors in the wood products sector are shown in Table 42. The reconstituted wood products sub-sector offers the most potential electrical savings in terms of kWh; however, a larger percentage of savings compared to use is available in the primary sawmills sub-sector.

It is important to note that in Table 42, the consumption and estimated savings data only reflects the aggregate for the facilities analyzed in this study for the two utility companies. Therefore, the percentage of estimated savings may be skewed by variations in utility rebate programs, and perhaps also by variation in facility energy use and facility-specific opportunities.

Table 42. Savings estimates for each recommended sub-sector in the wood products sector.

Sub-sector	# of Facilities	Electricity		
		Total Use (kWh)	Remaining Potential Savings* (kWh)	Est. Savings (%)
Reconstituted Wood Products	4	90,932,452	11,884,400	13.1%
Secondary Millwork	37	11,346,577	1,448,700	12.8%
Primary Sawmills	23	19,255,521	3,537,600	18.4%
TOTAL	**64**	**121,534,550**	**16,870,700**	**13.9%**

** After facility specific rebates were subtracted.*

Technologies for energy conservation were researched and evaluated for each of the recommended sub-sectors within both utility service areas. Savings estimates were derived based upon what opportunities are available. Table 43 highlights technologies and energy conservation opportunities that wood products facilities can take advantage of. Not all technologies or opportunities apply to every facility within a sub-sector; however, these tables are meant to provide an overview of the potential. Additionally, the savings opportunities were identified as having the greatest impact on facilities within a sub-sector.

Table 43. Recommended electrical energy conservation opportunities. A ★ indicates the best opportunities for each sub-sector.

Opportunity	Savings Range	Sub-Sectors		
		Reconstituted Wood Products	Secondary Millwork	Primary Sawmills
Utilize energy-efficient belts and other improved mechanisms	0-3%	✓	✓	✓
Install compressor air intakes in coolest locations	0-1%	✓		
Use AFDs to replace mechanical drives	1-4%	★	★	★
Replace hydraulic / pneumatic equipment with electric equipment	2-5%	★		
Install new high efficient fan motors at lower power and reduce fan speed	3-8%	★		
Install a compressor control sequencer	1-2%	✓	★	★
Fix compressed air leaks to allow reduction in pressure	1-2%	✓	✓	★
Use most efficient type of electric motors	0-2%		✓	
Switch radial fan from dirty air side to clean air side	1-2%		★	

Pulp and Paper Sector

Sector Description

Facilities included in the pulp and paper products manufacturing sector include pulp and paper mills, board converting with both board converting non-heat set printing, extruding and paper coating, and multi-wall converting with heat set printing. One of the eight utilities reported energy use by pulp and paper facilities, as shown in Table 44.

This sector was relatively small, only accounting for about 9% of each the gas and electric use analyzed. However, pulp and paper facilities accounted for nearly 50% of the gas use analyzed for Xcel Energy.

Table 44. Industrial energy consumption for the printing sector as reported by each utility.

Utility	Gas Customers			Electric Customers		
	# of facilities	Annual Use (therms)	% of total	# of facilities	Annual Use (kWh)	% of total
Xcel Energy	39	28,758,000	100%	89	364,166,000	100%

When identifying sub-sectors with significant gas and electric savings potential, two sub-sectors appeared to have both thermal and electrical conservation opportunities: pulp and paper mills and multi-wall converting with heat set operations. One other sub-sector, board converting with non-heat set operations, has savings opportunities available on the electric side only. Table 45 lists the sub-sectors included in the pulp and paper sector that were recommended for energy savings efforts. The recommended sub-sectors account for 47% of the gas use and 95% of the electrical use of all facilities in the one utility service area.

The table also provides information about the savings potential remaining for each recommended sub-sector. The estimated gas savings remaining for the recommended sub-sectors is nearly 1.3 million therms, which is 9.4% of the total natural gas consumption of the recommended sub-sectors and 4.4% of the sector overall. The amount of estimated electrical savings is just over 31.4 million kWh or 9.1% of the recommended sub-sectors and 6.6% of the sector's total current energy use. In this sector, the pulp and paper sub-sector offers the greatest potential for energy savings.

Table 45. Savings estimates for each recommended sub-sector in the pulp and paper sector.

Utility	SIC Description	# of Facilities	Gas			Electricity		
			Total Use (therms)	Remaining Potential Savings* (therms)	Est. Savings (%)	Total Use (kWh)	Remaining Potential Savings* (kWh)	Est. Savings (%)
Xcel Energy	Pulp and paper	9	12,600,827	1,167,000	9.3%	227,733,691	24,505,000	10.8%
	Multi-wall converting w/ heat set	8	1,073,189	120,000	11.2%	19,415,808	2,026,000	10.4%
	Board Converting, non-heat set printing	68	-	-	-	98,991,745	4,929,000	5.0%
TOTAL		**85**	**13,674,016**	**1,287,000**	**9.4%**	**346,141,244**	**31,460,000**	**9.1%**

** After facility specific rebates were subtracted.*

As part of this project, MnTAP identified technologies for energy conservation and researched and evaluated them for each of the recommended sub-sectors. From that research, MnTAP developed savings estimates for each sub-sector. Tables 46 and 47 highlight technologies and energy conservation opportunities that facilities can take advantage of. Not all technologies or opportunities apply to every facility within a sub-sector; however, these tables are meant to provide an overview of the potential. Additionally, the savings opportunities and technologies were identified as having the greatest impact on facilities within a sub-sector.

Table 46. Recommended gas energy conservation opportunities. A ★ indicates the best opportunities for each sub-sector.

Opportunity	Savings Range	Sub-Sectors		
		Pulp & Paper Mills	Multi-Wall Converting	Board Converting
Boiler O_2 tuning	2-25%	✓	✓	✓
Insulate pipes and tanks	1-15%	✓	✓	✓
Improve process measurements, control, calibration	5-10%	★	★	✓
Heat recovery of flue gas to preheat combustion air	3-25%	✓	★	✓
Heat recovery of flue gas to heat secondary operations	3-25%	✓		
Heat recovery from compressors and plant equipment	1-54%		✓	★
Insulate extrusion equipment	1-5%		★	
Repair and eliminate steam leaks	0.2-0.6%	✓		
Preventative maintenance and remove boiler scaling	1%	✓		
Pinch analysis, balance cold and hot streams energy loads	8-22%	★		
Improve drying operations and equipment	varies	★		
Facility HVAC improvements	0.5-14%	✓	✓	★
Improve thermal oxidizers	1-3%		✓	★

Table 47. Recommended electrical energy conservation opportunities. A ★ indicates the best opportunities for each sub-sector.

Opportunity	Savings Range	Sub-Sectors		
		Pulp & Paper Mills	Multi-Wall Converting	Board Converting
Steam pressure reduction for electric generation	0.2%	✓		
Plant power factor improvement to reduce line resistance and improve motor operation	2%	✓		
Replace motors with soft-start or VFD supplies	1.4%	✓		★
Process motor optimization & load reduction, belt improvements	0.1-13%	★	★	★
Properly size pumps/impellers and install pump controls	1.0-3.0%	★		
Compressed air improvements, cold air intake, fix leaks and controls	0.1-1%	✓	★	★
Combined Heat and Power (CHP) Integration	varies	★		
HVAC and lighting upgrades	0-1%	✓	★	✓
Turn off equipment when not in use	0.1-3.4%	✓	✓	✓

Thermal Cross-Sector Opportunities

While researching opportunities for energy conservation, a number of technologies or practices were identified that are applicable to multiple sub-sectors or sectors. Table 48 provides information about which opportunities apply to each sector. Since these opportunities apply to more than one type of facility or sector, they may provide utilities with significant energy savings for less effort than custom facility-specific conservation measures.

Table 48. Thermal cross-sector opportunities and their applicability. A ★ indicates the best opportunities for each sector.

Opportunity	Chemical Mfg.	Food Proc.	Fab. Metals	Primary Metals	Printing	Ind. Drying	Pulp & Paper
Burners and burner controls	★	★	✓	★	✓	★	★
Thermal oxidizer upgrades	★	*			★		
Turbulators	✓	✓	✓	✓	✓		✓
Direct-fired water heating	✓	★					
Heating system best practices	★	✓	★	★	✓	✓	★
Boiler heat recovery	**	★		✓	✓	✓	
Process heat recovery	**	★	★	★	★	✓	★
Combined heat and power	**	✓					
Facility HVAC improvements	✓	✓	★	✓	★	✓	✓

** Applicable for rendering facilities only*

*** Applicable to ethanol production only*

Upgrading burners and installing burner controls, as well as instituting best practices for heating systems and improving HVAC systems can result in energy savings for facilities within all industrial sectors.

Efficient burners

Efficient burners should be capable of maintaining a stable flame, at low excess air, throughout the firing range. Significant operating time above 7% O_2 suggests a large conservation opportunity, but even below this level, a 1% reduction in O_2 yields a 1% improvement in operating efficiencyi. Larger efficiency improvements occur at higher excess air levels. A reasonable target concentration is 3-4% excess air for the most commonly used portions of the firing range, and lower levels are possible with improved controls. Burner turndown can be another important feature of efficient burners. The low range for high turndown burners can range from 20% of high fire, down to as low as 5% of high fire in a few cases. Turndown allows a burner to idle at low to very low levels rather than shutting off with the attendant purge and start-up losses. There are a few burners that combine high turndown with the capability to operate at low excess air throughout the firing range, but many high turndown burners cannot operate at low excess air. If a choice needs to be made between high turndown and low excess air operation, low excess air will generally produce greater energy savings. If significant time is spent at low fire, it may be appropriate to consider other conservation options such as a smaller boiler or small, dedicated, remote heaters for some heat demands. The use of an economizer can somewhat decrease the impact of excess air reduction.

Burner controls

In terms of improving burner controls, O_2 trim typically has the biggest impact. O_2 control is required by code to operate boilers at less than 3% excess O_2 and can achieve levels below 1%. Trim control does require a burner that can operate stably within the desired control range.

Thermal oxidizer upgrades

Thermal oxidizers are pollution control devices that burn hydrocarbon fumes released by manufacturing processes. They are common in ethanol production, organic chemical manufacturing, petroleum refining, and high speed printing operations. Thermal oxidizers can consume 5-20% of a facility's thermal energy. Upgrading from recuperative oxidizers to regenerative oxidizers generally cuts this fuel use in half, and upgrading to include catalytic media can cut fuel by an additional 50%.

Turbulators

Turbulators are inserts that fit into an existing boiler's fire tubes and can also be employed in some ovens, furnaces, and other direct fire applications where flue gases travel through tubes. Turbulators increase turbulence in the tubes, which improves heat transfer from the flue gas to the process media to be heated (water, steam, or air). They are a low cost, simple method for improving the efficiency of boilers, equipment using radiant tubes, and other equipment using tubes for flue gas as a heat transfer surface.

Direct-fired water heating

Direct-fired water heating systems can be appropriate when there is a large demand for hot water for process or cleaning needs. These systems put the water to be heated directly in contact with the flue gases and increase the efficiency of water heating from around 80% in a boiler used for water heating to close to 99%. They work best for heating temperatures less than 140°F and efficiency decreases with high temperature set-points. They also work best if they can modulate their output over variations in demand; efficiency will also decrease if hot water is recirculated to meet lower demand.

Heating system best practices

Facilities can implement heating system best practices to reduce thermal energy use. Generally best practices with the greatest probable impact on thermal losses are testing for and repairing leaks in steam traps and lines and adding insulation to bare steam lines. Other practices include improving the thickness of insulation, repairing insulation as needed, improving condensate return, improving boiler feed water quality to reduce blow-down, and cleaning heat exchange surfaces to improve heat transfer.

Boiler heat recovery

Boiler heat recovery can save a significant amount of energy as 15-20% of a boiler's heat input can be lost up the stack. Stack economizers are the most common method of boiler heat recovery. Economizers are a heat exchanger that is placed in the flue gases to capture a portion of that heat. This heat can be used to preheat combustion air to possibly generate low grade steam, to preheat returning condensate and boiler feed water, or to heat or pre-heat process or domestic water. In general, care must be taken with a standard economizer to ensure that the flue gases reach a temperature lower than 140°F in order to prevent corrosion and premature failure of the economizer. Condensing economizers are specifically designed to be corrosion resistant and are a relatively new development. They are more complex to evaluate and implement, but they can capture more heat, are generally more robust, and can be used for a wider range of heating applications. In all cases, there must be a sufficient amount of recoverable heat to justify the installation, and the timing of heat demand must match the firing of the boiler, or thermal storage must be included as part of the design.

Process heat recovery

Process heat recovery is possible wherever waste heat is released, although the best recovery opportunities will be in cases where the waste heat temperature and total amount of heat is high. The difficulty is how to utilize the recovered heat; this will likely vary in each plant. Possible uses of waste heat include: process or domestic water heating, product or raw material pre-heating; process or ventilation air heating; or possibly in boiler systems. The simplest heat recovery systems will use waste heat to preheat other operations directly, but it may also be feasible or necessary to upgrade waste heat with heat pumps or to store heat to allow for differences in supply and demand timing.

Combined Heat and Power

Combined heat and power systems come in a number of forms. The most recognizable form is where fuel is burned to generate electricity and to provide process heat at an industrial site. Generally fuel consumption increases, but total energy consumption decreases because of the utilization of waste heat from electrical generation and the elimination of distribution losses. The best applications would be in facilities that run 24 hours a day, either five or seven days a week, and where electrical costs are high. Another form would be a pressure reducing turbine on a high pressure steam system that either generates electricity or produces shaft work directly. A third form of combined heat and power is a heat engine that converts waste heat into mechanical or electrical power. The applications for the latter two forms are very narrow at this point.

Facility HVAC improvements

Lowering the temperatures of unoccupied spaces during winter months can reduce thermal energy use. Radiant heating can also limit thermal energy use and it can be used to keep people and materials in spaces warm while minimizing air heating. Additional improvements may include lowering ventilations rates as ventilation needs decrease and using push-pull ventilation and unheated air for local process exhaust to reduce the demand for heated building air.

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i Steam System Survey Guide, Greg Harrel, Oak Ridge National Laboratory, 2001, ORNL/TM-2001/263

Electrical Cross-Sector Opportunities

A range of opportunities are available for energy conservation and are applicable across many of the sectors. Table 49 provides a look at which opportunities would help facilities in each sector conserve energy.

Table 49. Cross-sector opportunities and their applicability to each sector. A ★ indicates the best opportunities for each sector.

Opportunity	Fab. Metals	Food Proc.	Chem. Mfg	Primary Metals	Printing	Wood Products	Pulp & Paper
Compressed air improvements	★	★	✓	★	★	★	★
Motor improvements	★	✓	★	★	✓	★	★
Process control improvements	★	✓	★	✓	✓	✓	✓
Pump & fan improvements	✓	★	★	★	✓	★	★
Facility HVAC improvements	✓	✓	✓	✓	★	✓	✓
Lighting improvements	✓	✓	✓	✓	★	✓	✓
Refrigeration improvements		★	✓				

Compressed Air

Compressed air is a very expensive and energy-intensive utility commonly used for air tools and control valves, as well as occasionally for drives, media blasting, cooling, and blow-offs. Common improvements include repairing leaks in piping and equipment, reducing the compressor output pressure, using a cold-air intake, setting up remote air receivers, correcting large system pressure drops, controlling the loading pattern of the compressed air system, and reducing inappropriate uses such as process cooling and cleaning. More costly solutions include properly sizing and distribution of the compressed air system, improving sequencing controls, and installing variable speed compressors to handle variable loads.

Process Motors

Motors are an item where lifetime operating costs (primarily electricity) typically dwarf the purchase cost, but upgrades can be hard to justify for motors that still function. Motor replacement plans can be useful in preparing for eventual motor failure by predetermining what should replace a failed motor (NEMA premium, rewound, spare). In a failed motor situation, understanding what other motors in the facility can be moved from less critical applications to cover for the failed equipment can provide more time to install the best replacement rather than the fastest replacement. Motors typically drawing less than 30-40% of full load amps are likely to be over-sized and should be evaluated for replacement with smaller motors. These motors will have low efficiencies and low power factors. An additional motor improvement could include installing adjustable speed drives (ASDs) to more allow motors to operate at speeds appropriate to the intended use.

Pumps, and Fans

Pumps and fans, like motors, have lifetime operating costs that can frequently dwarf the purchase cost of a pump or fan system. Through the design process, there is a tendency to over-size pump and fan systems to ensure they will provide sufficient flow. Proper sizing of pumps and fans is important. Looking for situations where more liquid or gas is being moved is a place to start. In heating and cooling situations, if the temperature out is similar to the temperature in, flow is probably higher than necessary. Then look for medium to large pump and fan systems that are drawing less than 30-40% of full load amps. Throttling flow with valves or dampers should be avoided as a means of controlling flow. Consider variable speed drives for variable flow applications. Using multiple pumps or fans operating in parallel is another way to handle variable flow.

Process Controls

Automating or refining controls can avoid over-processing and can shut unnecessary equipment off or move it in low energy stand-by. It is estimated that improving process controls could save up to 9% of total energy use.

Lighting

T-5 and T-8 fluorescence, reflectors, CFLs, occupancy sensors, and some LED configurations can be a low-cost, rapid-payback opportunity. One significant advantage of newer lighting systems is more consistent light output over the life of the system, resulting in less degradation.

Facility HVAC Improvements

There are a number of HVAC improvements that can lead to electrical energy savings. Some of these may include:

- Lowering temperatures of unoccupied spaces during winter months.
- Using radiant heating to keep people and materials warm while minimizing air heating.
- Lowering ventilation rates as needs diminish to decrease both heat and fan energy.
- Using adjustable speed pumps to match cooling supply to demand.
- Using push-pull ventilation and unheated air for local process exhaust to reduce the demand for heated building air.

Refrigeration

Refrigeration improvements include best practices of keeping condensers clean and avoiding frost build-up. More substantial changes include[ii]:

- Reducing head pressure at least seasonally, as sometimes equipment upgrades and modifications are needed
- Increasing suction pressure
- Utilizing thermosiphon oil cooling
- Improving compressor sequencing
- Using multiple levels of compression for different temperature requirements
- Utilizing cool outside temperatures to maximize refrigeration efficiency when available
- Investigating heat recovery or de-superheating ammonia refrigeration which may have relatively small electrical saving impacts, but can be a significant reduction in over-all energy consumption

Refrigeration systems are a likely application for adjustable speed drives on pumps for chilled water distribution and cooling towers, fans for evaporators, and condensers and for the compressors themselves. Where there is a large demand for low grade heat, such as hot water for cleaning operations in food manufacturing, heat recovery can be applied to refrigeration systems, where as much heat as possible is removed with a condensing heat exchanger to pre-heat water. The increased condenser capacity can allow a reduction in head pressure during warm periods and may allow the shutdown of some portions of the original condenser / cooling tower during colder periods.

[ii] *[Focus on Energy, Dairy Processing Best Practices Guidebook, 2006 pp16; Energy Savings for a Cheese Plant, www.baseco.com/casestudies/Dairy Product.pdf IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/assessments.php; Energy Savings Potential for Commercial Refrigeration Equipment, 1996,DOE]*

Thermal vs. Electrical Conservation Opportunities

MnTAP evaluated energy use for both electric and gas utilities, as well as a few that provide both services. Some of the utilities, primarily those that supply both gas and electricity, have encouraged both gas and electric conservation measures for customers. There were some indications where utilities have encouraged conservation measures that would decrease the use of the opposite energy source (ie; a gas utility encouraging electrical conservation measures or vice versa). MnTAP applauds this practice and encourages its continuation as much as possible whether utilities act alone or in cooperation with other utilities, because:

- A number of conservation opportunities cross thermal and electrical boundaries. For example, using heat recovery to drive an absorption chiller can reduce electrical use but not gas use.
- Customers are likely to be interested in saving money by conserving the most energy, whether it is electrical or gas.
- Opportunities will be missed whenever conservation efforts concentrate on one form of energy or one type of energy use; this can result in sub-optimization of a customer's manufacturing process.

Technologies that Cross Thermal and Electrical Boundaries

Within the primary metals sector, improving the process of melting metal is a key conservation opportunity discussed in this analysis, where furnace technologies cross electrical and thermal boundaries. Both gas and electric technologies are available for melting; however, some electric melting technologies appear to perform more efficiently and with less metal loss. A facility converting from gas-fired melting furnaces to the best electric melting furnaces, should see a net reduction in energy use.

Another example of a technology that crosses thermal and electrical boundaries is anaerobic digestion in ethanol production and a few other applications. This process uses waste solids to produce biogas, which can be burned to serve thermal and potentially electrical demands. Done well, anaerobic digestion with electrical generation can reduce total energy use. However, anaerobic digestion without electrical generation simply allows a facility to switch their energy source from fossil fuel to renewable bio-fuel.

While MnTAP understands that promoting competing energy technologies or alternative fuels may not be in the best interest of a utility, there are a few reasons that might make these technologies more palatable.

- Improving technologies to reduce overall energy use can potentially make a customer more competitive and better able to remain viable. Such a customer is more likely to remain a customer of the utility, even if it is a smaller customer than before the technology installation.
- Viable facilities have the potential to drive growth of neighboring customers; those customers nearby could become larger customers for the utility.
- There might be a profit potential for such technologies should a utility company choose to serve as an owner of operations like anaerobic digesters and combined heat and power installations.

Methodology

MnTAP analyzed manufacturing sectors for energy use and potential energy savings by grouping facilities into sub-sectors based on the similarity of their manufacturing processes. In some cases, the similarity of a sub-sector's process was well defined by 4-digit SIC codes; in other cases, MnTAP found two or more 4-digit SIC codes containing facilities with very similar processes. In those cases, we grouped the facilities into sub-sector groups across SICs.

Once identified, sub-sectors were ranked by gas consumption. The goal of the project was to select the top five sub-sectors, in terms of electricity and gas consumption, and analyze them in detail for energy use and conservation opportunities, and then recommend three sub-sectors for further energy conservation assistance. However, based on the characteristics of the sectors and the makeup of the various utility customer bases, we departed from this goal in some sectors.

Sub-sector Details

MnTAP prepared summary sheets for each sub-sector analyzed. Those are included in the Appendix and provide the following information for each sub-sector, when available:

- Sub-sector description including SIC codes and energy use
- Energy savings estimates
- Process description, including steps
- Industry benchmarks as determined by MnTAP
- Energy use profiles
- Case studies references for energy savings

Energy Savings Methodology

When developing the potential savings estimates, MnTAP utilized three methods:

1. Identifying reports or case studies for specific sub-sectors that gave estimates for specific changes
2. Using reports or factsheets on technologies that gave estimates for implementation of that technology across industries
3. Building upon DOE Industrial Assessment Center (IAC) recommendations for gas conservation within specific sub-sectors by one of the following methods:
   a Averaging savings estimates for specific recommendations within a sub-sector and using that average directly
   b Averaging savings estimates for categories of IAC recommendations

We believe the first method is the most reliable; however, it was also the least available. The second method was the second choice, and using the IAC savings estimates was the third choice. The IAC recommendations were the most commonly used for estimating savings based upon their availability. There are concerns using this data though, because IAC assessments are relatively short and tend to be more general than specific to the process evaluated. As a result, savings estimates may be low.

Data Quality

There are a number of factors that introduced uncertainty into the analysis and thus into our savings estimates and conclusions.

Facility Characterization

Each utility was asked to provide at least 12 months of energy use data. Some provided more than that if it was readily available. Additionally, the data included some facility identifiers; these ranged from city and SIC/NAICS to facility name and address. MnTAP attempted to match the customer information with facilities in the Dun & Bradstreet Million Dollar Directory (MDD) and Harris Directory of Minnesota Manufacturers within both relevant SICs or NAICSs and each utility service area to better characterize the processes at the facility. In some cases, facilities were readily matched, thereby identifying the process and savings opportunities were easier. However, a significant number of facilities, particularly in the Xcel Energy service territory, could not be matched with directory entries. While additional attempts were made to characterize facility operations from internal knowledge, the Internet, and other sources, there is some uncertainty in the categorization of some facilities.

Energy Footprints and Literature Sources

The DOE provides a model of energy use in footprints it has established for specific NAICS codes, covering typical fuel and electric consumption. MnTAP used the DOE developed energy footprints for a number of industrial sub-sectors when a more specific footprint was not found in other literature sources. The limitations of the DOE footprints include a broad scope and lack of process specificity in many cases.

The DOE food and beverage footprint and the chemicals footprint were overly broad for the specific sub-sectors we attempted to characterize in those sectors. Therefore, MnTAP adjusted the footprints for specific sub-sectors by removing clearly irrelevant energy uses and processes.

The literature found on food processing was mixed; there was a sufficient amount of information on vegetable processing, and margarine processing, but little on meat processing, or food drying. Additionally, there was very little literature that specifically described the fabricated metals sector energy use and conservation opportunities. Some of the literature MnTAP used is from Canada and Europe, which raises questions of whether there are geographic differences in industrial processes.

IAC Data

While determining savings opportunities, MnTAP used case studies and assessments from the Department of Energy Industrial Assessment Centers. This data provided useful information; however it did have some drawbacks. The IAC-assessed facilities are found nation-wide and, in many cases, may not be representative of Minnesota operations. Additionally, some of the IAC assessments may be dated.

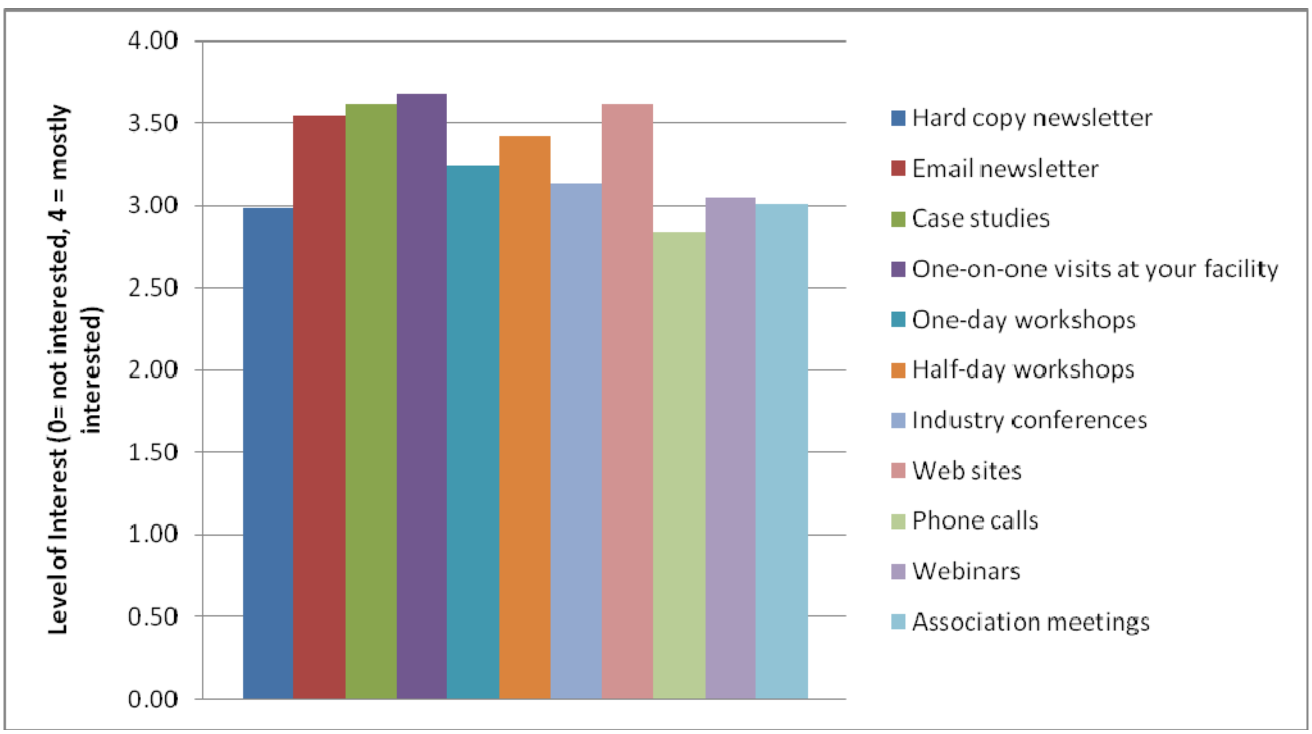
Next Steps

Utilities in Minnesota are working to meet the State goal of achieving an energy savings of 1.5% of gross annual retail energy sales. Therefore, the goal of this project was to determine where, within manufacturing, energy conservation opportunities exist. The project objectives were to research feasible solutions and technologies for energy conservation and to develop information that can be used by utilities as well as consultants and technical assistance programs to help manufacturers reduce their energy use. While many savings opportunities can be applied to a sub-sector or sector as a whole, other opportunities are best addressed on a facility-by-facility basis.

The information developed through this study highlights savings opportunities and is included in its basic form in the sub-sector summary sheets developed for each individual utility. This information was developed in increments over the course of the project and, in a number of cases, the later work is more complete than earlier work. The generic overall summary sheets included in this report are the most reliable form of this information. There is a more detailed discussion of a number of the conservation opportunities applicable to specific sub-sectors in each individual utility report and in the discussion of cross-sector opportunities.

MnTAP surveyed businesses in 2009 and found that most are interested in on-site assistance to address energy and pollution prevention questions. Figure 5 shows what types of information sources companies are likely to look to for energy efficiency and pollution prevention information. The recommendations outlined in this chapter provide information about how to use this study to help manufacturers in ways that they deemed most beneficial through the survey.

Figure 5. Level of interest in learning more about energy efficiency opportunities as reported in the 2009 MnTAP business survey.



Site Visits to Identify Opportunities

Over 60% of respondents to the MnTAP survey identified that on-site assistance to identify opportunities would be valuable to their company or organization. Site visits, as currently conducted by MnTAP, are typically a one-day tour of a facility to identify what concerns the company has in regards to energy use and what opportunities may be available. A follow-up letter from MnTAP is sent after the site visit to further identify the opportunities and provide economic information about the significant opportunities. In addition to providing on-site assistance to identify opportunities, 70% of businesses that responded to the MnTAP survey felt that assistance with documenting payback and other economic factors of opportunities would be valuable.

Using the information that MnTAP researched and reported through this study can help MnTAP and other organizations quickly identify which opportunities are most significant within a certain type of facility.

A MnTAP site visit can be used as a screening opportunity for a facility. MnTAP staff members can visit the facility to verify the opportunities that present the greatest energy reduction opportunity and then arrange for a more in-depth assessment by other organizations or consultants such as DOE-qualified specialists.

The on-site work, in MnTAP's experience, tends to engage facilities in making improvements and taking advantage of opportunities such as rebate or loan programs.

Interns or Teams to Implement Opportunities

Once a site visit or assessment has been completed, companies receive a list of potential opportunities. If a facility does not have staff available to begin implementing projects shortly after the list is developed, those opportunities may not be implemented. Therefore, developing a team or supporting an intern may help move projects forward.

In a team situation, a variety of staff members, including at least one representative from management, are asked to join a team to address energy efficiency opportunities. Engaging multiple staff members from many areas of the facility can help ensure that projects get done and many ideas are considered. MnTAP has worked with pollution prevention and energy efficiency teams for 1-2 years each and seen positive results and significant implementation.

Employing a highly qualified student as an intern is another option for assisting with implementation. An intern can investigate opportunities, develop implementation plans, and assist with implementation. Since the intern is not an essential part of the manufacturing process, he or she is less likely to be pulled away from the project to address manufacturing issues. MnTAP sponsors an intern program and has seen significant implementation by companies who have hosted MnTAP interns. Over 25 years, companies that have participated in MnTAP's intern program have implemented approximately 50% of the recommendations identified by the interns. When asked about employing interns or co-op students, 50% of businesses that responded to the survey felt that either option would be valuable to their company.

Trainings on Conservation Opportunities

Trainings, such as DOE qualified trainings, on conservation opportunities can help facilities understand their energy-using systems and what opportunities may exist for increasing the efficiency of those systems. More than half of the survey respondents felt that off-site trainings would be beneficial for learning about opportunities. Additionally, webinars or webcasts of trainings are becoming more popular and often sponsored by trade associations or the DOE.

The trainings may be a first step for a facility to become engaged in energy efficiency opportunities. These trainings can range from steam systems to compressed air or refrigeration. They should be offered throughout the state, sponsored perhaps by utility companies, and offered at a low cost for attendees.

Demonstration or Pilot Projects

Some of the opportunities identified through this study require the purchase of new equipment. 71% of businesses responding to the MnTAP survey believe that a demonstration of new equipment would be valuable prior to the purchase of that equipment and 50% believe a pilot trial of the equipment would be valuable.

Demonstrations of equipment in use at a facility can allow other facilities to understand how the equipment works and its advantages and disadvantages. Further, a pilot of such equipment can allow a facility to trial the equipment on-site and determine if it meets their needs and fits within the current manufacturing process. Conducting both demonstration and pilot projects would require coordination between vendors, companies, utilities, and potentially a technical assistance provider like MnTAP.

Information Sources

The results of the MnTAP survey indicate that businesses are looking for energy efficiency information and are primarily going to assistance providers and utilities for the information. Therefore, both of these entities, as well as others, need to develop and offer energy efficiency information. This can include case studies, newsletters, web sites, links to other organizations, etc. Manufacturers need information in order to make educated decisions about changes that can affect energy use as well as their processes.

Conclusion

Overall, this study identified opportunities within manufacturing facilities that can reduce energy use. This information was developed with the intent that utilities will use it to help direct their assistance and rebate programs, and that other organizations within Minnesota will use it to help manufacturers reduce energy use, become more efficient, and save money.

Appendix A: Chemical Manufacturing Sub-Sector Sheets

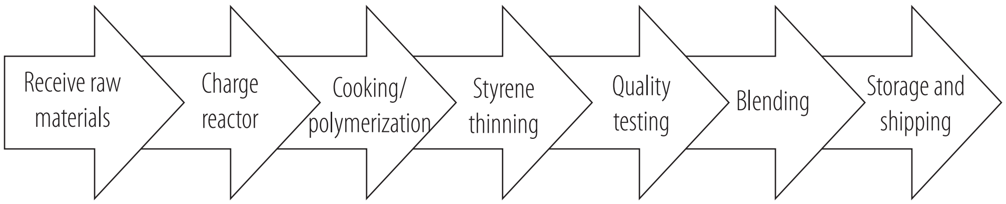
Resin Production

Sub-sector Description

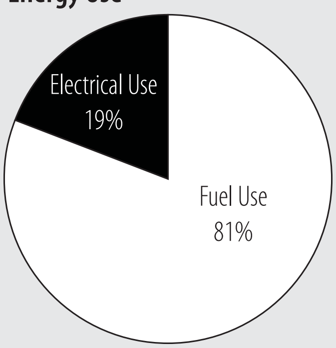
Resin manufacturing is a fuel-intensive industry. One process, which uses a significant amount of fuel energy is cooking the resin, or initiating polymerization. This process creates the polymer chains that only solidify into a hard plastic once catalyzed. Fuel energy is used in this process by the thermal oxidizer for VOC destruction and in burners to heat the resin.

Facility Type	SIC	NAICS	
Resin production	2821	325211	

Process Information



Energy Use[1]



Benchmarks

The following thermal and/or electrical benchmarks were derived from facility-specific energy use, employee numbers, and area data for the facilities that MnTAP analyzed. These benchmarks can be used to predict how efficient your facility is in comparison to peer facilities. If your facility's energy use is less efficient than your peers, there may be energy conservation opportunities available. The benchmarks included have been tested for reliability; however, they should be used with some caution. For more information on the benchmarking study including how to use the benchmarks, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

	Most efficient 25%	More efficient 25%	Less efficient 25%	Least efficient 25%
kWh/employee	< 6,097	6,097 - 10,256	10,256 - 17,253	> 17,253

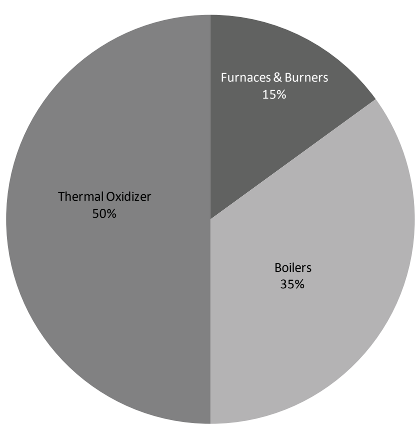
Savings Potential

Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

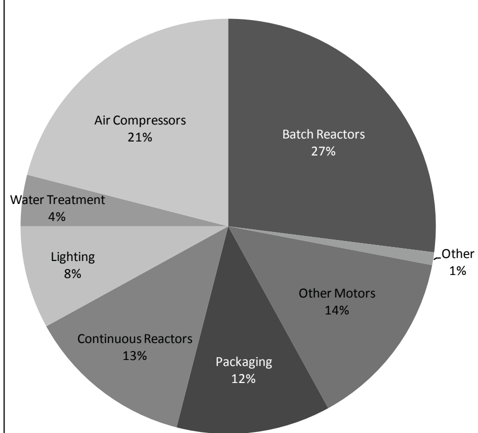
Estimated Fuel Savings: 24%

Energy Use Footprints

Fuel Use[1]



Electricity Use[1]



Fuel Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Thermal Oxidizer Opportunities[2]			
Co-generation w/heat recovery system and HE chiller[3]	2-5 yr design and install, over $250,000 capital expense	10-15%	
Boiler Opportunities[4]			
Steam system optimization[5]	Can vary greatly depending on project scope	1-17%	
Burner Improvements[6]		0-5%	
TOTAL FUEL SAVINGS ESTIMATE			**24%**

Electric Savings Estimate and Opportunities

MnTAP researched and analyzed this sub-sector for a natural gas utility. Therefore, electric savings opportunities and an estimate of potential savings were not identified as part of MnTAP's industrial energy efficiency study.

References

1. http://www.baseco.com/Publications/ACEEE%202003%20Hydrocarbon%20Resin%20Manufacturing.pdf
2. Estimate from previous known data
3. http://apps1.eere.energy.gov/industry/bestpractices/energymatters/pdfs/ft_bragg_success_story.pdf
4. Best Practices in Steam System Management, Fred L. Hart, US Dept of Energy, David Jaber, Alliance to Save Energy, Steam Digest 2001.
5. Solutions for Energy Security and Facility Management Challenges, Joyce Wells and the Association for Energy Engineers. Fairmont Press 2004.
6. http://www1.eere.energy.gov/industry/bestpractices/printable_versions/pdfs/phast_tool.pdf

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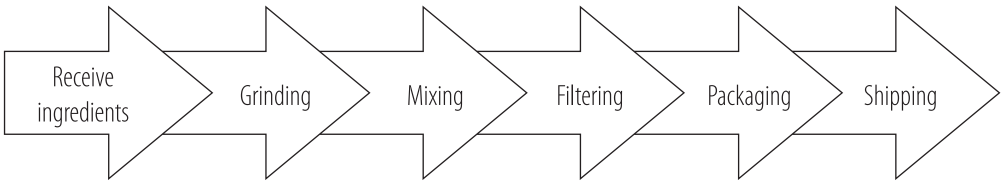
Paint, Ink, and Adhesive Production

Sub-sector Description

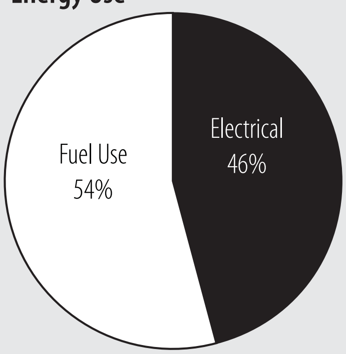
Facilities in this sub-sector mix pigments, solvents, and binders into paints and other coatings, such as stains, varnishes, lacquers, enamels, shellacs, and water repellent coatings for concrete and masonry. They also may manufacture allied paint products as well as adhesives.

Facility Type	SIC	NAICS		Facility Type	SIC	NAICS
Adhesives and Sealants	2891	325520		Paints	2851	325510
Inks	2893	325910				

Process Information



Energy Use[1]



Benchmarks

Thermal and electrical benchmarks were unable to be reliably derived from facility-specific energy use, sales, employee numbers, and area data. For more information about the benchmarking study that MnTAP conducted and how to determine if your facility may have energy efficiency opportunities remaining, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

Savings Potential

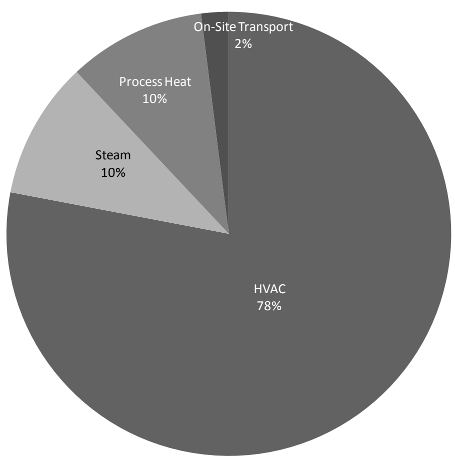
Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

Estimated Fuel Savings: **26%**

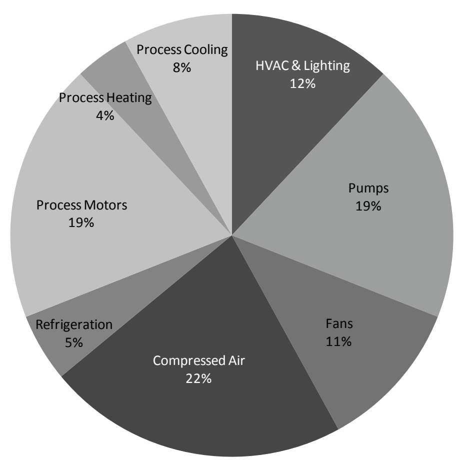
Estimated Electric Savings: **23%**

Energy Use Footprints

Fuel Use[2]



Electricity Use[3]



Fuel Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements			
Process heat system optimization[4]		0-2%	
Insulate bare equipment[5,6]		0-1%	
Use heat in flue gases to preheat products or materials[5]		0-1%	
Improve boiler system		0-3%	
Facility HVAC & Lighting Improvements			
HVAC improvements[7] (adaptive climate)		10-20%	
Install air seals around truck loading dock doors[8]		1-2%	
Use heat exchanger to exchange building exhaust air with make-up air[9]		3-8%	
TOTAL FUEL SAVINGS ESTIMATE			**26%**

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements			
Pump system optimization[10]		1-4%	
Replace air driven motors with hydraulic pumps[11]		2-3%	
Process heat system optimization[4]		0-1%	
Use heat in flue gases to preheat products or materials[5]		0-1%	
Process control - turn systems off when not in use[12]		1-3%	
Better process controls[13]		0-2%	
Use ASD for variable pump, blower, and compressor loads[6,14]		4-8%	
Use most efficient type of electric motors[14,15,16]		0-2%	
Compressed air optimization[17]		2-7%	
Eliminate leaks in inert gas and compressed air lines and valves[18,19]		1-2%	
Facility HVAC & Lighting Improvements			
Lighting illumination reduction[19]		0-1%	
Utilize higher efficiency lamps and/or ballasts[20]		1-2%	
TOTAL ELECTRIC SAVINGS ESTIMATE			**23%**

References

1 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/assessments.php
2 Developed from DOE Chemical Sector diagram by redistributing 18% HVAC to process heat and steam. http://www1.eere.energy.gov/industry/chemicals/footprints_detailed.html
3 Developed from DOE Chemical Sector diagram by redistributing electrochemical process electricity use to pumps, fans, compressed air, and process motors. http://www1.eere.energy.gov/industry/chemicals/footprints_detailed.html
4 http://www1.eere.energy.gov/industry/bestpractices/pdfs/em_proheat_seven.pdf
5 http://iac.rutgers.edu/database/findassessment.php?ID=WV0327
6 http://iac.rutgers.edu/database/findassessment.php?ID=OK0709
7 The Adaptive Climate Controller from Opto Generic Devices V-HVAC Inc. http://apps1.eere.energy.gov/industry/bestpractices/energymatters/articles.cfm/article_id=284
8 http://iac.rutgers.edu/database/findassessment.php?ID=MA0596
9 http://iac.rutgers.edu/database/findassessment.php?ID=AM0496
10 http://www.pumpsystemsmatter.org/
11 Interview with Midway Industrial Supply Rep, Equipment. Graco Viscount Hydraulic 2-Ball Piston Pumps (3 times more efficient than air-powered pumps)
12 http://iac.rutgers.edu/database/findassessment.php?ID=IC0075
13 Carbon Trust, Chemical Sector: Introducing energy saving opportunities for business (August 2006)
14 http://iac.rutgers.edu/database/findassessment.php?ID=BD0255
15 http://iac.rutgers.edu/database/findassessment.php?ID=UU0012
16 http://iac.rutgers.edu/database/findassessment.php?ID=MO0229
17 http://www1.eere.energy.gov/industry/bestpractices/compressed_air.html
18 http://iac.rutgers.edu/database/findassessment.php?ID=SF0252
19 http://iac.rutgers.edu/database/findassessment.php?ID=DL0019
20 http://iac.rutgers.edu/database/findassessment.php?ID=UD0615, http://iac.rutgers.edu/database/findassessment.php?ID=GT0679, http://iac.rutgers.edu/database/findassessment.php?ID=MO0146, http://iac.rutgers.edu/database/findassessment.php?ID=TA0062

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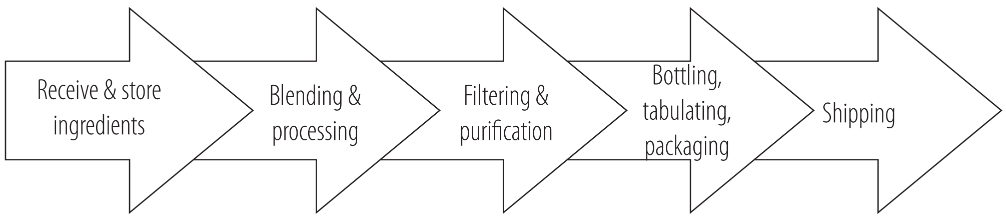
Pharmaceutical Manufacturing

Sub-sector Description

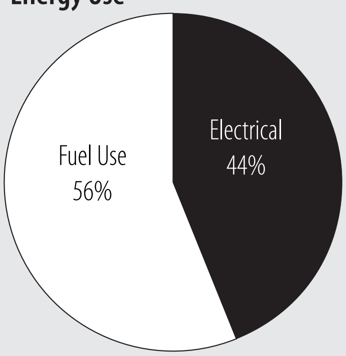
There are four process types used in pharmaceutical manufacturing. Through fermentation, microorganisms produce the end product, which then must be separated and purified. Extraction is used when no other means are available and uses larger organisms to produce the desired product, which then has to be separated and purified. Chemical synthesis can be used to create the desired drug product without the use of biological organisms. Lastly, mixing or compounding the purified ingredients is necessary for all pharmaceutical manufacturing processes.

Facility Type	SIC	NAICS		Facility Type	SIC	NAICS
Pharmaceutical Preparations	2834	325412		Medicinal and Botanical Prod.	2833	325411
In Vivo Diagnostic Substances	2893	325412		Biological Products & Vaccines	2836	325414
Skin and Haircare Products	2844	325620				

Process Information



Energy Use[1]



Benchmarks

Thermal and electrical benchmarks were unable to be reliably derived from facility-specific energy use, sales, employee numbers, and area data. For more information about the benchmarking study that MnTAP conducted and how to determine if your facility may have energy efficiency opportunities remaining, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

Savings Potential

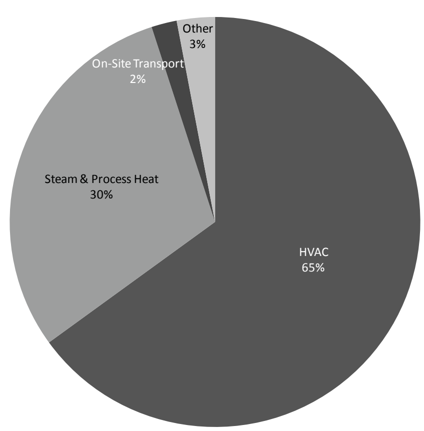
Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

Estimated Fuel Savings: 18%

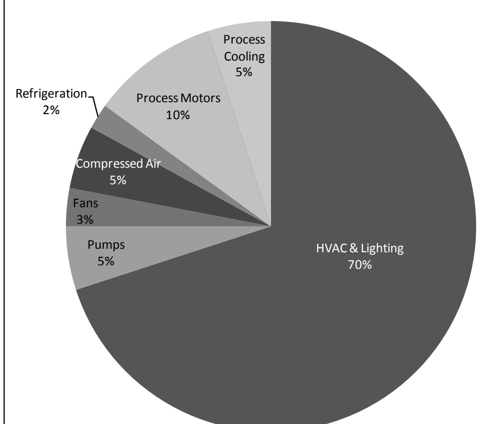
Estimated Electric Savings: 16%

Energy Use Footprints

Fuel Use[1]



Electricity Use[1]



Fuel Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Heat System Improvements[2]			
Boiler O_2 tuning[3]	< 2 years	1-8%	
Insulate bare equipment and piping[4]	2 years	1-5%	
Repair steam leaks[5]	< 1 year	0-3%	
Heat recovery of flue gas to preheat combustion air or heat secondary operations[6]	5 years	3-8%	
Improve process measurements, control, and calibration[7]	3 years	2-3%	
Heat Recovery Opportunities			
Recover heat from compressed air systems[8]	4 years	0-2%	
Recover heat from material processing[9]	4 years	1-4%	
Recover heat from flue gas to heat boiler water[10]	4 years	0-1%	
Facility HVAC & Lighting Improvements			
Use efficient building insulation[11]	2 years	0-1%	
Properly tune make-up air units in clean rooms[12]	2 years	1-9%	
TOTAL FUEL SAVINGS ESTIMATE			**18%**

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements			
Pump system optimization[13]		0-2%	
Use adjustable speed drive to replace mechanical drive[14]		0-6%	
Change procedures/equipment/operating conditions[15]		0-1%	
Better process controls[7]		0-1%	
Facility HVAC & Lighting Improvements			
Utilize higher efficiency lamps and/or ballasts[6,16]		0-2%	
HVAC improvements[17]		0-10%	
Repair and eliminate steam leaks[6]		0-1%	
Replace existing HVAC unit with high efficiency model[15,18]		0-1%	
TOTAL ELECTRIC SAVINGS ESTIMATE			**16%**

References

1. IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/assessments.php
2. http://www1.eere.energy.gov/industry/bestpractices/pdfs/em_proheat_seven.pdf
3. IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=SF0224
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6. IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=MS0335
7. Carbon Trust, Chemical Sector: Introducing energy saving opportunities for business. August 2006
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10. IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=DL0028
11. IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=TN0106
12. IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=UF0397
13. http://www.pumpsystemsmatter.org/
14. IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=IC0141
15. IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=MI0047
16. IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=MI0162
17. The Adaptive Climate Controller from Opto Generic Devices V-HVAC Inc. http://apps1.eere.energy.gov/industry/bestpractices/energymatters/articles.cfm/article_id=284
18. http://iac.rutgers.edu/database/findassessment.php?ID=LE0259

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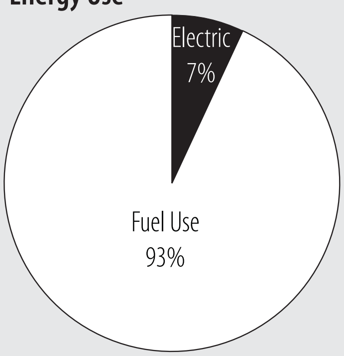
Ethanol Production

Sub-sector Description

The primary product at ethanol facilities is fuel-grade ethanol. A by-product can also produced at such facilities: dried distillers grains (DDGs). There are eight essential steps in the ethanol production process: grain receiving/handling, starch conversion, fermentation, distillation, dehydration, separation, drying, and shipping. Starch conversion, distillation, and drying are the most fuel intensive operations in the process, consuming 99% of the natural gas used by each facility.

Energy Use[1]



Savings Potential

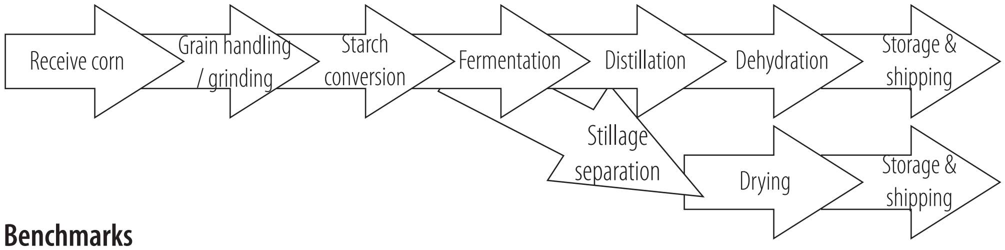
Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

Estimated Fuel Savings: 20%

Estimated Electric Savings: 11%

Facility Type	SIC	NAICS	
Ethanol Production	2869	325193	

Process Information



Benchmarks

The following thermal and/or electrical benchmarks were derived from facility-specific energy use, employee numbers, and area data for the facilities that MnTAP analyzed. These benchmarks can be used to predict how efficient your facility is in comparison to peer facilities. If your facility's energy use is less efficient than your peers, there may be energy conservation opportunities available. The benchmarks included have been tested for reliability; however, they should be used with some caution. For more information on the benchmarking study including how to use the benchmarks, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

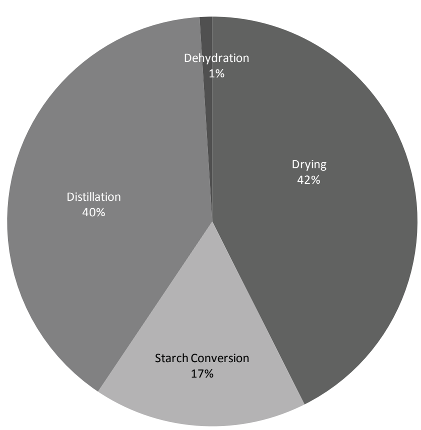
	Most efficient 25%	More efficient 25%	Less efficient 25%	Least efficient 25%
kWh/square feet	< 1,070	1,070 - 1,422	1,422 - 1,889	> 1,889
kWh/employee	< 612,896	612,896 - 803,404	803,404 - 1,053,129	> 1,053,129
therms/employee	< 241,686	241,686 - 302,801	302,801 - 379,369	> 379,369

Additionally, energy use benchmarks for ethanol facilities have been developed for energy use per gallon of ethanol produced. This is another way to ensure your facility is operating efficiently as compared to your peers'.

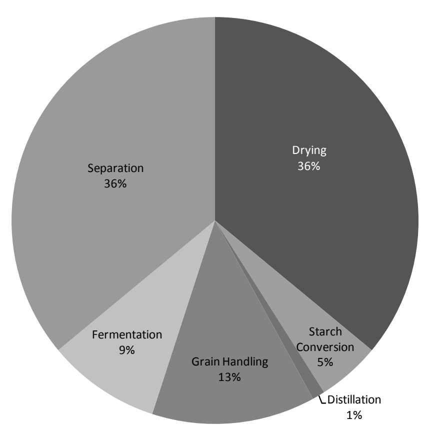
	Average thermal energy use		Average electrical energy use	
	Start up before 1999	Start up after 2005	Start up before 1999	Start up after 2005
Energy per gal[1]	37,000 Btu/gal	29,000 Btu/gal	1.02 kWh/gal	0.61 kWh/gal

Energy Use Footprints

Fuel Use[2]



Electricity Use[2]



Fuel Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements			
Boiler best practice: tune and maintain	< 1 year	0-0.5%	
Steam best practice: maintain traps, repair leaks, minimum operating pressure, capture condensate, insulate distribution components	< 2 years	0.2-1%	
Boiler opportunity: new burner, O_2 control, turbulator, small boiler, clean tubes, feed water improvements, boiler refractory insulation	2-10 years	0.1-1%	
Boiler heat recovery: economizer, feed water, combustion air, process water	2 years	0.4-1%	
Preheat dryer combustion air[3]	< 1 year	4-8%	
Cold cooking OR corn fractionation[4,5]		5-15%	
TOTAL FUEL SAVINGS ESTIMATE			**20%**

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements			
Use multiple speed motors or ASD for variable pump, blower and compressor loads[6]	< 1 year	2-6%	
Corn fractionation[5]		5-15%	
Not drying stillage[7]		0-1%	
Hammermill improvements			
Combined Heat and Power (CHP) from natural gas combustion[8]		Varies	
Combustion of biomass (DDGS or corn stover) to provide combined heat and power		Varies	
Anaerobic digestion of thin stillage		Varies	
TOTAL ELECTRIC SAVINGS ESTIMATE			**11%**

References

1. N. Kelly and K. DeWahl. Ethanol Benchmarking and Best Practices, MnTAP. (March 2008).
2. J.R. Kwiatkowski, A.J. McAloon, F. Taylor, and D.B. Johnston. Modeling the process and costs of fuel ethanol production by the corn dry-grind process. (August 2005).
3. J. Wells and the Association for Energy Engineers. Solution for Energy Security and Facility Management Challenges. (2004).
4. http://www.genecor.com/cms/resources/file/ebf95c076d3afc7/STARGEN%20Backgrounder.pdf
5. A. Austin. A Renewed Future, Ethanol Producer Magazine. (January 2009).
6. IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=UD0745
7. http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V3B-4RKMB5B-4&_user=616288&_coverDate=08%2F31%2F2008&_rdoc=1&_fmt=full&_orig=search&_cdi=5726&_sort=d&_docanchor=&view=c&_acct=C000032378&_version=1&_urlVersion=0&_userid=616288&md5=cca31f5b4398c7ed28626de6d6fa2a90#secx11
8. http://www.ethanoltoday.com/index.php?option=com_content&task=view&id=5&fid=53&Itemid=6

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Appendix B: Food Processing Sub-Sector Sheets

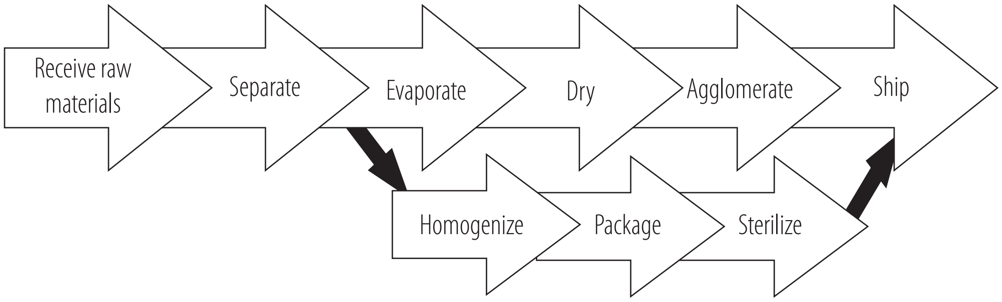
Dried Dairy Products

Sub-sector Description

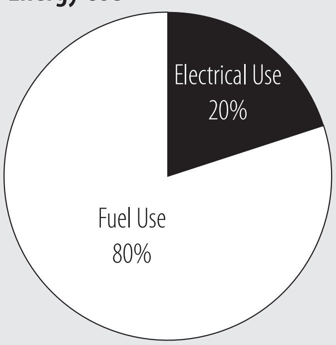
Facilities in this sub-sector manufacture dry, condensed, and evaporated milk and dairy substitute products.

Facility Type	SIC	NAICS	
Dried dairy products	2023	311514	

Process Information



Energy Use[1]



Benchmarks

Thermal and electrical benchmarks were unable to be reliably derived from facility-specific energy use, sales, employee numbers, and area data. For more information about the benchmarking study that MnTAP conducted and how to determine if your facility may have energy efficiency opportunities remaining, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

Savings Potential

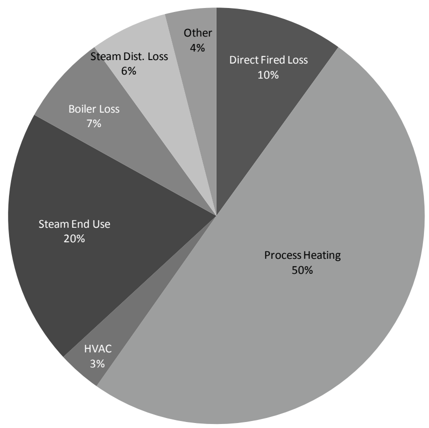
Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

Estimated Fuel Savings: 6%

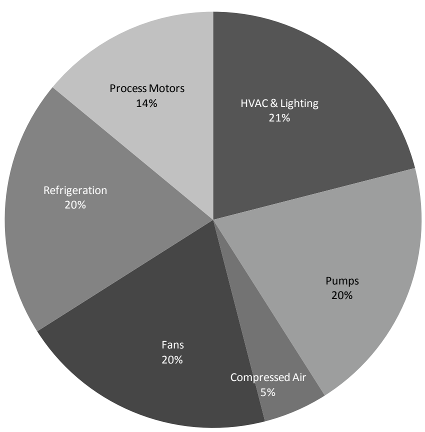
Estimated Electric Savings: 6%

Energy Use Footprints

Fuel Use[2]



Electricity Use[2]



Fuel Savings Estimate and Opportunities[1,3,4,5]

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Direct Fired Loss Opportunities			
Direct fire best practice: tune and maintain	< 1 year	0.1-0.7%	
Steam Distribution Improvements			
Boiler improvements: burner, O_2 control, turbulator, small boiler, new boiler, clean tubes, feed water improvements, insulation, heat combustion air	1-10 years	1-4%	
Boiler heat recovery: economizer, feed water	2-3 years	0.4-1.5%	
Boiler best practice: tune and maintain	< 2 years	1-3%	
Steam best practice: maintain traps, repair leaks, minimum operating pressure, capture condensate, insulate distribution	< 2 years	1-5%	
Process Equipment Improvements		22%	
Equipment heat recovery: process, dryer, refrigeration	1-6 years	1-15%	
Improve drying and heating operations	5-10 years		
Multiple effect evaporators or vapor recompression			
Direct fire water heater		20%	
Thermal storage (hot), provide opportunity for reducing peak loads			
TOTAL FUEL SAVINGS ESTIMATE			**6%**

Electric Savings Estimate and Opportunities[1,3,4]

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process and Equipment Improvements			
Replace hydraulic / pneumatic equipment with electric equipment	2-3 years	0.4-1.8%	
Use most efficient equipment at maximum capacity and less efficient equipment only when necessary	< 1 year	0.3%	
Modify refrigeration system to operate at a lower pressure	3-4 years	2-5%	
Install new refrigeration equipment	3-5 years	11-30%	
Improve freezer insulation	< 2 years	0.05-0.5%	
Optimize pump and fan operations	1-4 years		
Upgrade motors, install ASDs	2-5 years	0.5-5%	
Compressed air best practices: lower pressure, eliminate wasteful uses, repair leaks, improve dryers and filters, improve control and staging	< 2 years	0.2-2.5%	
Improve process control	< 2 years	0.3-1.4%	
Improve utilization of cooling towers and cooling tower water treatment	2-5 years	0-5%	
Operate an absorption chiller on waste heat	2-5 years		
Facility and HVAC Improvements		22%	
Lighting and HVAC improvements		0.5-1%	
TOTAL ELECTRIC SAVINGS ESTIMATE			**6%**

References

1 DOE Industrial Assessments. http://iac.rutgers.edu/database/assessments.php

2 Generalized Food and Beverage Energy Footprint, DOE, http://www1.eere.energy.gov/industry/energy_systems/pdfs/food_footprint.pdf. Percentages adjusted by researcher to reflect higher drying levels.

3 Savings calculated by analyzing processed meat and drying assessments conducted by DOE. http://iac.rutgers.edu/database/assessments.php

4 http://alpha.cres.gr/besss/elearning/bess/pdfs/Outer_Ring/Case_Study_no.pdf

5 Energy Efficiency Improvement and Cost Saving Opportunities for the Fruit and Vegetable Processing Industry, August 2007, Lawrence Berkeley National Lab, http://ies.lbl.gov/iespubs/LBNL-59289.pdf

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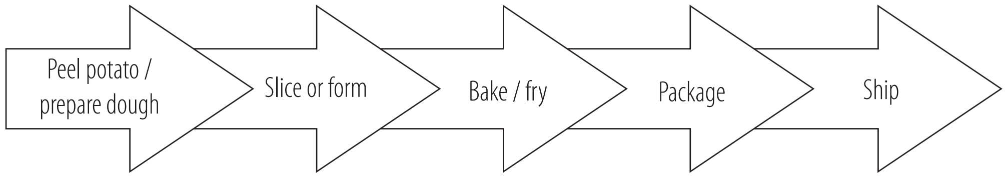
Snack Chip Production

Sub-sector Description

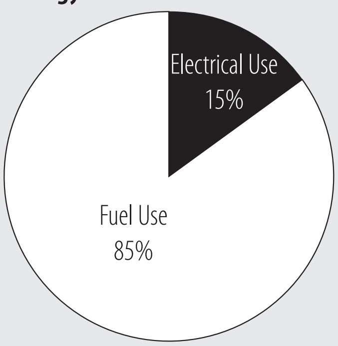
Facilities that manufacture potato chips, corn chips, and similar snacks are included in this sub-sector.

Facility Type	SIC	NAICS	
Potato and Corn Snack Foods	2096	311919	

Process Information



Energy Use[1]



Benchmarks

The following thermal and/or electrical benchmarks were derived from facility-specific energy use, employee numbers, and area data for the facilities that MnTAP analyzed. These benchmarks can be used to predict how efficient your facility is in comparison to peer facilities. If your facility's energy use is less efficient than your peers, there may be energy conservation opportunities available. The benchmarks included have been tested for reliability; however, they should be used with some caution. For more information on the benchmarking study including how to use the benchmarks, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

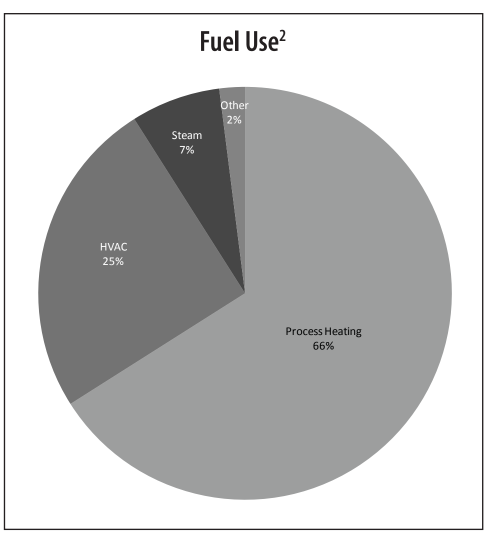
	Most efficient 25%	More efficient 25%	Less efficient 25%	Least efficient 25%
kWh/square feet	< 27	27 - 44	44 - 72	> 72
kWh/employee	< 6,010	6,010 - 11,768	11,768 - 23,043	> 23,043

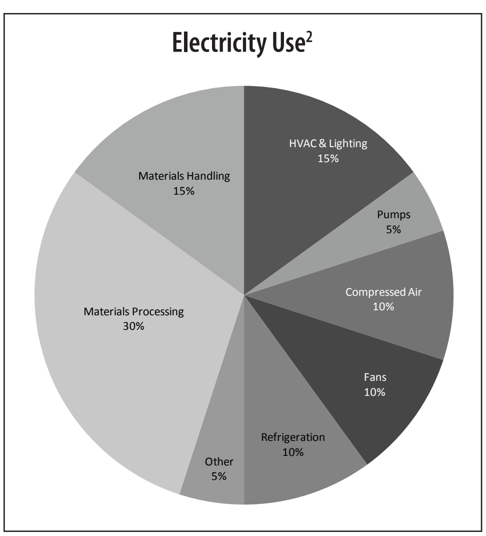
Savings Potential

Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

Estimated Electric Savings: 8%

Energy Use Footprints





Fuel Savings Estimate and Opportunities

MnTAP researched and analyzed this sub-sector for an electric utility. Therefore, fuel savings opportunities and an estimate of potential savings were not identified as part of MnTAP's industrial energy efficiency study.

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Best Practices: compressed air (fix leaks, lower pressure, use cool air, eliminate inappropriate uses, use blowers[3])	< 1 year	0-6%	
Best Practices: motors (replacement plan, preventive maintenance)		-	
Best Practices: process equipment (shut off, optimize settings)		-	
Compressed air (upgrade, better sequence/control, heat recovery, replace inefficient uses)		-	
Motor opportunities (upgrade motors & belts, ASD)[4]	1 year	0-14%	
Process equipment opportunities (improve controls, change product design, change process, upgrade equipment)[5]		-	
Lean Manufacturing (reduce material transport, reduce the length of transport, just enough processing, just enough heating or cooling)			
Facility Improvements			
HVAC (close building openings/leaks, reduce heated space, reduce temperature, upgrade equip, upgrade controls)	< 1 year	0-1%	
Lighting (upgrade, use controls occupancy, light)	< 1 year	0-8%	
TOTAL ELECTRIC SAVINGS ESTIMATE			**8%**

References

1 DOE Industrial Assessments. http://iac.rutgers.edu/database/assessments.php

2 Generalized Food and Beverage Energy Footprint, DOE, http://www1.eere.energy.gov/industry/energy_systems/pdfs/food_footprint.pdf. Electrical adjusted to increase fans, reduce pumps, eliminate refrigeration, reduce cooling. Gas adjusted for space heating using other data.

3 Energy Savings for a Bread Plant, www.baseco.com/casestudies/Bread Plant.pdf

4 Energy Savings for a Cheese Plant, www.baseco.com/casestudies/Dairy Product.pdf

5 www.foodprocessing.com/articles/2007/012.html

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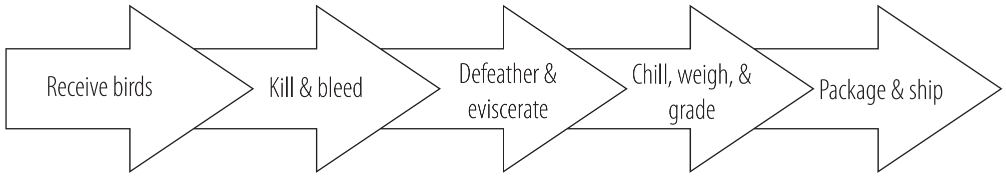
Poultry Processing

Sub-sector Description

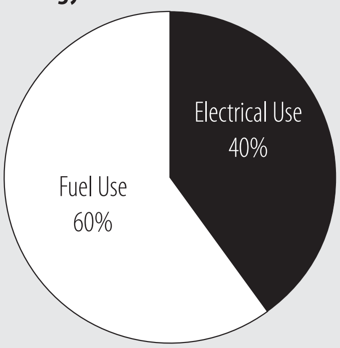
In the poultry processing sub-sector, facilities slaughter poultry and/or prepare processed poultry by-products.

Facility Type	SIC	NAICS	
Poultry Processing	2015	311615	

Process Information



Energy Use[1]



Benchmarks

The following thermal and/or electrical benchmarks were derived from facility-specific energy use, employee numbers, and area data for the facilities that MnTAP analyzed. These benchmarks can be used to predict how efficient your facility is in comparison to peer facilities. If your facility's energy use is less efficient than your peers, there may be energy conservation opportunities available. The benchmarks included have been tested for reliability; however, they should be used with some caution. For more information on the benchmarking study including how to use the benchmarks, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

	Most efficient 25%	More efficient 25%	Less efficient 25%	Least efficient 25%
kWh/employee	< 22,934	22,934 - 42,222	42,222 - 77,732	> 77,732

Savings Potential

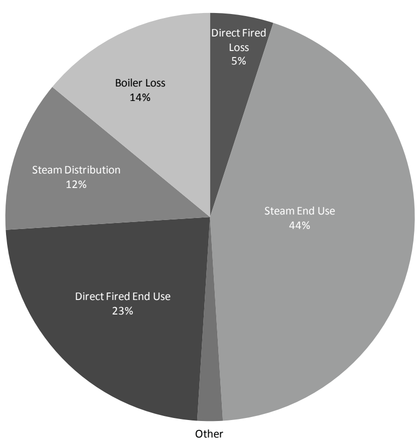
Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

Estimated Fuel Savings: 11%

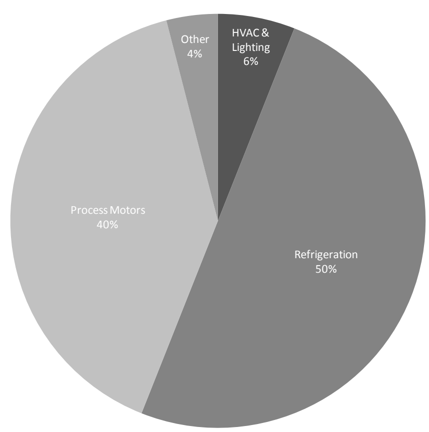
Estimated Electric Savings: 15%

Energy Use Footprints

Fuel Use[2]



Electricity Use[3]



Fuel Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Steam best practice: maintain traps, repair leaks, minimum operating pressure, capture condensate, insulate distribution components	< 2 years	1-6%	
Boiler opportunity: burner, O_2 control, turbulator, small boiler, clean tubes, feed water improvements	1-10 years	1-17%	
Boiler heat recovery: feed water, combustion air, process water, economizer	2 years	1-5%	
Boiler best practice: tune and maintain	< 2 years	0.1-1%	
Heat recovery from process equipment: hot water tanks/overflow and refrigeration	1-6 years	1-16%	
Dry/blow-off surface water before browning		0.1-0.2%	
Equipment best practice: insulate and maintain	< 2 years	0.5-2%	
Improved process equipment: direct-fired water heater		3-10%	
TOTAL FUEL SAVINGS ESTIMATE			**11%**

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Best Practices: cooling refrigeration (clean condenser, optimize temps, avoid frost)	< 1 year	0.5-9%	
Best Practices: compressed air (fix leaks, lower pressure, use cool air,eliminate inappropriate uses)	< 1 year	0.2-3%	
Best Practices: motors (replacement plan, preventive maintenance)	1-2 years	0.3%	
Best Practices: process equipment (shut off, optimize settings)	1 year	0-6%	
Cooling & refrigeration opportunities (upgrade, recover heat, reduce floating head pressure, increase suction pressure setpoint, improve compressor sequencing, use ASDs, use ammonia sub-cooling, insulate, recover heat)[4,5,6,7]	2 years	0.5-21%	
Compressed air and vacuums (upgrade, better sequence/control, heat recovery, replace inefficient uses)	3 years	0-0.2%	
Motor opportunities (upgrade motors & belts, ASD)[8]	3-4 years	0.2-14%	
Process equipment opportunities (improve controls, change product design, change process, optimize pumps and fans)[9]	< 1 year	0.3-8%	
Lean Manufacturing (reduce material transport, just enough processing, just enough heating or cooling)			
Facility Improvements			
HVAC (close building openings/leaks, reduce heated space, reduce T, upgrade equip, upgrade controls)	1 year	0-2.5%	
Lighting (upgrade, use controls (occupancy, light)	1-2 years	0.2-5%	
TOTAL ELECTRIC SAVINGS ESTIMATE			**15%**

References

1 DOE Industrial Assessments. http://iac.rutgers.edu/database/assessments.php
2 Generalized Food and Beverage Energy Footprint (modified). DOE. http://www1.eere.energy.gov/industry/energy_systems/pdfs/food_footprint.pdf
3 Poultry Industry Energy Uses. Tri-State Generation and Transmission Association. http://tristate.apogee.net/et/ezifpeu.asp
4 Focus on Energy, Dairy Processing Best Practices Guidebook, 2006 pp16
5 Focus on Energy, Dairy Processing Best Practices Guidebook, 2006 pp 30
6 Focus on Energy, Dairy Processing Best Practices Guidebook, 2006 pp 31-35
7 Energy Savings for a Frozen Food Processing Plant, www.baseco.com/casestudies/Frozen Food Processing.pdf
8 Energy Savings for a Cheese Plant, www.baseco.com/casestudies/Dairy Product.pdf
9 www.foodprocessing.com/articles/2007/012.html

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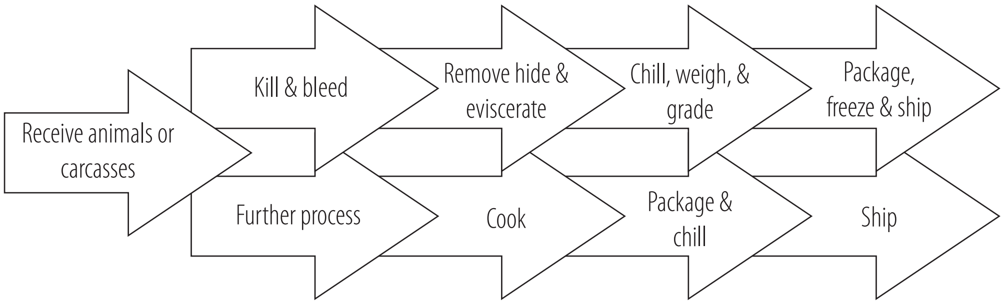
Meat Processing

Sub-sector Description

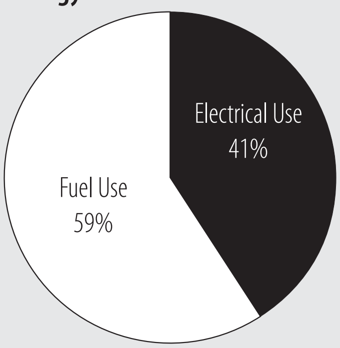
This sub-sector includes two types of facilities: those that slaughter large animals and process raw cuts of meat to be sold or to be used on the same premises and those that purchase meat and further process it into products.

Facility Type	SIC	NAICS		Facility Type	SIC	NAICS
Meat (non-Poultry) Processing	2011	311611		Meat Processing (non-slaughter)	2013	311612

Process Information



Energy Use[1]



Benchmarks

The following thermal and/or electrical benchmarks were derived from facility-specific energy use, employee numbers, and area data for the facilities that MnTAP analyzed. These benchmarks can be used to predict how efficient your facility is in comparison to peer facilities. If your facility's energy use is less efficient than your peers, there may be energy conservation opportunities available. The benchmarks included have been tested for reliability; however, they should be used with some caution. For more information on the benchmarking study including how to use the benchmarks, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

	Most efficient 25%	More efficient 25%	Less efficient 25%	Least efficient 25%
kWh/employee	< 23,037	23,037 - 33,052	33,052 - 47,422	> 47,422

Savings Potential

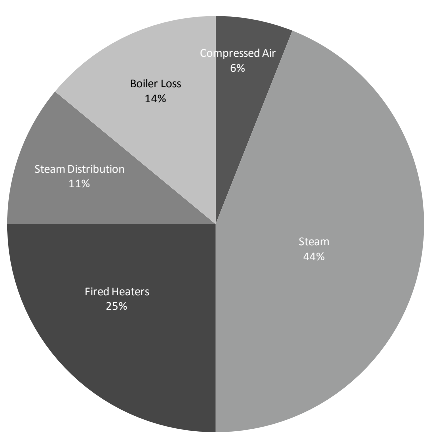
Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

Estimated Fuel Savings: 7%

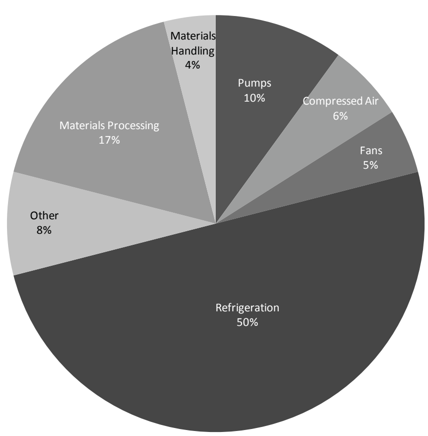
Estimated Electric Savings: 15%

Energy Use Footprints

Fuel Use[2]



Electricity Use[2]



Fuel Savings Estimate and Opportunities[1,3]

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Steam best practice: maintain traps, repair leaks, minimum operating pressure, capture condensate, insulate distribution components	1-2 years	0.5-5%	
Boiler opportunity: burner, O_2 control, turbulator, small boiler, clean tubes, feed water improvements, insulation, new boiler, heat combustion air	1-10 years	0.5-10%	
Boiler heat recovery: feed water, economizer, blowdown	2 years	0.1-1%	
Boiler best practice: tune and maintain	< 2 years	0.1-0.5%	
Direct fire best practice: tune and maintain	< 1 year	0.1-0.5%	
Improve retort insulation	< 2 years	0.1-0.7%	
Equipment best practices: insulate and maintain	< 2 years	0.5-2%	
Direct-fired water heaters	< 2 years	3-10%	
Heat recovery from process equipment or refrigeration	1-6 years	0.5-2%	
TOTAL FUEL SAVINGS ESTIMATE			**7%**

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Best Practices: cooling refrigeration (clean condenser, optimize temps, avoid frost)	< 1 year	0.5-9%	
Best Practices: compressed air (fix leaks, lower pressure, use cool air,eliminate inappropriate uses)	< 1 year	0.2-3%	
Best Practices: motors (replacement plan, preventive maintenance)	1-2 years	0.3%	
Best Practices: process equipment (shut off, optimize settings)	1 year	0-6%	
Cooling & refrigeration opportunities (upgrade, recover heat, reduce floating head pressure, increase suction pressure setpoint, improve compressor sequencing, use ASDs, use ammonia sub-cooling, insulate, recover heat)[4,5,6,7]	2 years	0.5-21%	
Compressed air and vacuums (upgrade, better sequence/control, heat recovery, replace inefficient uses)	3 years	0-0.2%	
Motor opportunities (upgrade motors & belts, ASD)[8]	3-4 years	0.2-14%	
Process equipment opportunities (improve controls, change product design, change process, upgrade equipment)[9]	< 1 year	0.3-8%	
Lean Manufacturing (reduce material transport, reduce the length of transport, just enough processing, just enough heating or cooling)			
Facility Improvements			
HVAC (close building openings/leaks, reduce heated space, reduce T, upgrade equip, upgrade controls)	1 year	0-2.5%	
Lighting (upgrade, use controls (occupancy, light)	1-2 years	0.2-5%	
TOTAL ELECTRIC SAVINGS ESTIMATE			**15%**

References

1 DOE Industrial Assessments. http://iac.rutgers.edu/database/assessments.php
2 Generalized Food and Beverage Energy Footprint (modified). DOE. http://www1.eere.energy.gov/industry/energy_systems/pdfs/food_footprint.pdf
3 http://alpha.cres.gr/besss/elearning/bess/pdfs/Outer_Ring/Case_Study_no.pdf
4 Focus on Energy, Dairy Processing Best Practices Guidebook, 2006 pp16
5 Focus on Energy, Dairy Processing Best Practices Guidebook, 2006 pp 30
6 Focus on Energy, Dairy Processing Best Practices Guidebook, 2006 pp 31-35
7 Energy Savings for a Frozen Food Processing Plant, www.baseco.com/casestudies/Frozen Food Processing.pdf
8 Energy Savings for a Cheese Plant, www.baseco.com/casestudies/Dairy Product.pdf
9 www.foodprocessing.com/articles/2007/012.html

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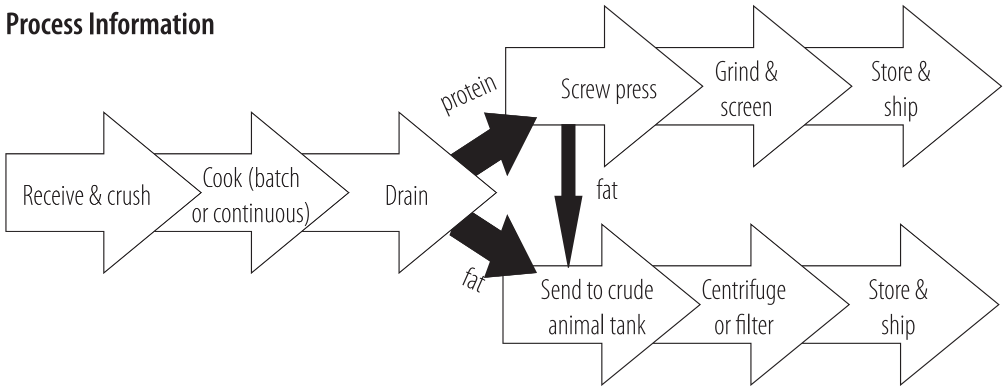
Rendering

Sub-sector Description

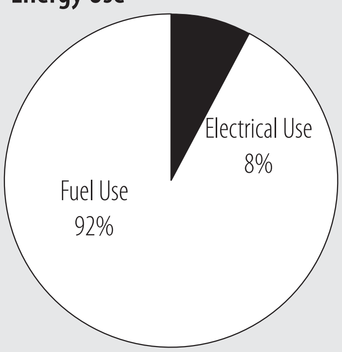
Rendering operations process meat and animal by-products from meat processing and some food service operations to create protein meal, blood meal, bone meal, and oil products that are used for animal feed, fertilizer, and cooking.

Facility Type	SIC	NAICS	
Rendering	2077	311613	

Process Information



Energy Use[1]



Benchmarks

Thermal and electrical benchmarks were unable to be reliably derived from facility-specific energy use, sales, employee numbers, and area data. For more information about the benchmarking study that MnTAP conducted and how to determine if your facility may have energy efficiency opportunities remaining, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

Savings Potential

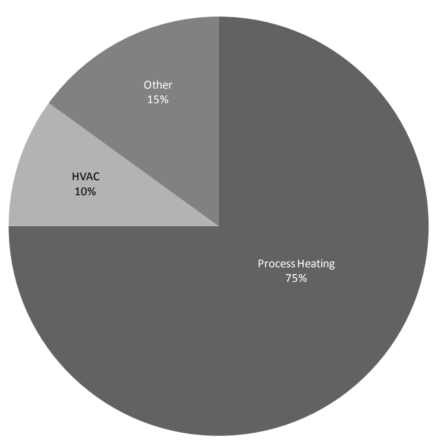
Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

Estimated Fuel Savings: 15%

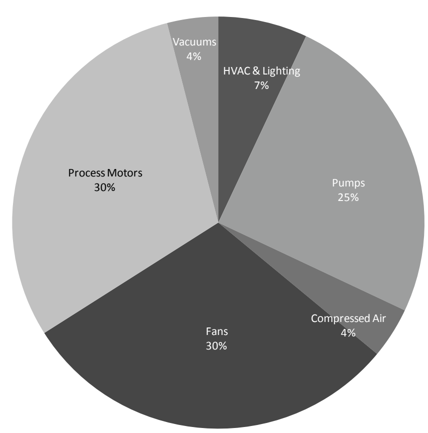
Estimated Electric Savings: 7%

Energy Use Footprints

Fuel Use[2]



Electricity Use[2]



Fuel Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Steam best practices: insulate steam/hot water lines and bare equipment and repair steam traps/eliminate leaks[3,4]	< 2 years	1-2%	
Process heat recovery: recover waste heat from cookers or evaporators[2,5]	1-6 years	1-5%	
Heat recovery via adsorption cooling[6]			
Implement boiler best practices		1-2%	
Implement process equipment best practices[2]		0.5-1%	
Improved de-watering before drying			
Replace recuperative with regenerative thermal oxidizer	2-5 years	9-13%	
Replace regenerative thermal oxidizer with catalytic regenerative thermal oxidizer	< 1 year	2-6%	
Boiler heat recovery: economizer, feed water, combustion air, process water[6]	2 years	0.5-5.6%	
Implement boiler opportunities: improved burners, O_2 control, turbulator, small boiler, new boiler, minimize boiler blowdown with better wash treatment, insulate[6]	1-10 years	1-26%	
TOTAL FUEL SAVINGS ESTIMATE			**15%**

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Compressed air best practices: fix leaks, lower pressure, use cool air, eliminate inappropriate uses	< 1 year	0.3-0.5%	
Upgrade, better sequence/control, heat recovery, replace inefficient uses	3 years	0.5-1.5%	
Motors best practices: replacement plan, preventive maintenance	< 2 years	0-0.3%	
Upgrade motors & belts, ASD	3 years	0.2-14%	
Use cog belts or efficient transmissions		0.1-5%	
Install ASDs on fans or pumps, boiler combustion blowers, and HVAC chilled water pumps		0.1-6.7%	
Process equipment best practices: shut off, optimize settings	1 year	0-6%	
Improve controls, change product design, change process, upgrade equipment	< 1 year	0.3-8%	
Pump and fan optimization			
Lean Manufacturing: reduce material transport, just enough processing, just enough heating or cooling			
Facility Improvements			
HVAC: close building openings/leaks, reduce heated space, reduce T, upgrade equip, upgrade controls	1 year	0-2.5%	
Lighting: upgrade, use controls (occupancy, light)	1-2 years	0.1-1%	
TOTAL ELECTRIC SAVINGS ESTIMATE			**7%**

References

1. DOE Industrial Assessments. http://iac.rutgers.edu/database/assessments.php
2. Best Available Techniques in the Slaughterhouses and Animal By-products Industries, May 2005. European Commission.
3. Average of energy savings from 2 IAC studies. http://iac.rutgers.edu/database/assessments.php. (Ruiz-Avila study, IAC LT0046)
4. 2 IAC studies. http://iac.rutgers.edu/database/assessments.php. (MIRINZ and Ruiz-Avila study; IAC SD0147 and WV0277)
5. Meat Research Corp, Australian Meat Technology; Nat Resources Canada
6. Energy Efficiency Improvement and Cost Saving Opportunities for the Fruit and Vegetable Processing Industry, August 2007, Lawrence Berkeley National Lab, http://ies.lbl.gov/iespubs/LBNL-59289.pdf

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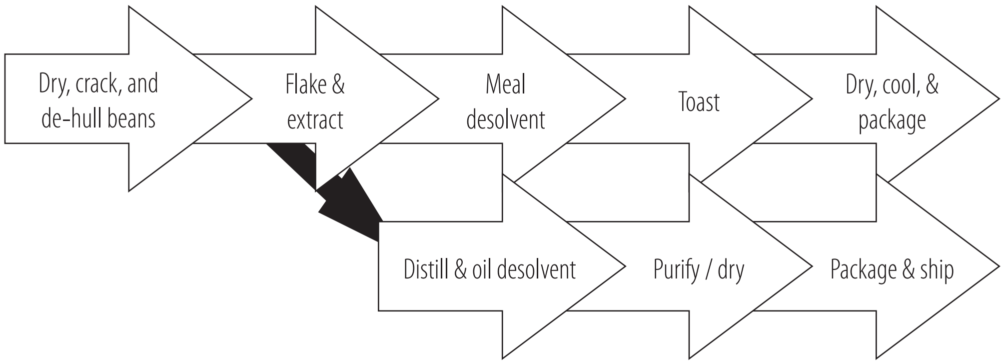
Soybean Processing

Sub-sector Description

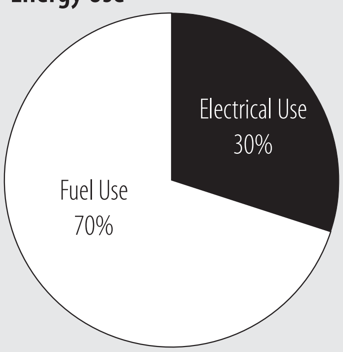
Facilities in this sub-sector crush soybeans to produce soybean oil, soybean cake and meal, and soybean protein isolates and concentrates.

Facility Type	SIC	NAICS	
Soybean Processing	2075	311222	

Process Information



Energy Use[1]



Benchmarks

Thermal and electrical benchmarks were unable to be reliably derived from facility-specific energy use, sales, employee numbers, and area data. For more information about the benchmarking study that MnTAP conducted and how to determine if your facility may have energy efficiency opportunities remaining, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

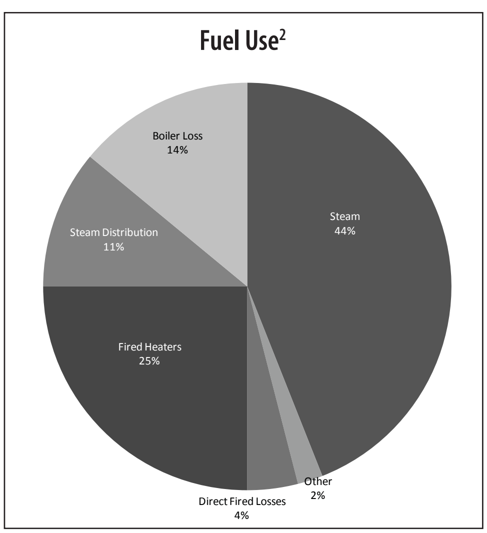
Savings Potential

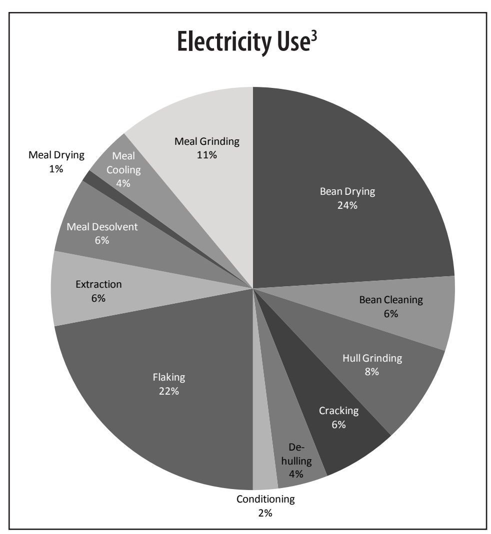
Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

Estimated Fuel Savings: 6%

Estimated Electric Savings: 5%

Energy Use Footprints





Fuel Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Steam best practice: maintain traps, repair leaks, minimum operating pressure, capture condensate, insulate distribution components[4]	< 2 years	0.3-2%	
Boiler heat recovery: feed water, combustion air, process water, economizer[5]	2 years	0.5-2%	
Boiler best practice: tune and maintain[4]	< 2 years	0.1-1.3%	
Recirculate dryer cooling and drying air[6]		1-5%	
Improved process equipment		0.5-4%	
Upgrade dryer and add automated controls[7]		0.5-2%	
Microwave feed drying[8]		2-5%	
Routine maintenance on drying equipment[7]		0.5-1%	
Insulate and maintain equipment	< 3 years	0.2-1%	
Direct fired opportunities: burner upgrade, insulate, direct fired water heating, preheat drying air with dryer exhaust[1]	1-4 years	0.5-10%	
TOTAL FUEL SAVINGS ESTIMATE			**6%**

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Best Practices: compressed air (fix leaks, lower pressure, use cool air,eliminate inappropriate uses)	< 1 year	0.1-1.2%	
Best Practices: motors (replacement plan, preventive maintenance)		-	
Best Practices: process equipment (shut off, optimize settings)		-	
Motor opportunities (upgrade motors & belts, ASD)	1 year	0.1-5%	
Install ASDs on boiler combustion blowers and HVAC chilled water pumps[9]		1.4-1.7%	
Process equipment opportunities (improve controls, change product design, change process, upgrade equipment)		-	
Pump and fan optimization[10]			
Lean Manufacturing (reduce material transport, just enough processing, just enough heating or cooling)			
Facility Improvements			
HVAC (close building openings/leaks, reduce heated space, reduce T, upgrade equip, upgrade controls)	< 1 year	0.1%	
Lighting (upgrade, use controls (occupancy, light)	< 1 year	0.0-0.8%	
TOTAL ELECTRIC SAVINGS ESTIMATE			**5%**

References

1 DOE Industrial Assessments. http://iac.rutgers.edu/database/assessments.php
2 Generalized Food and Beverage Energy Footprint, DOE, http://www1.eere.energy.gov/industry/energy_systems/pdfs/food_footprint.pdf
3 LifeCycle Inventory of Biodiesel and Petroleum Diesel, NREL/SR-580-24089
4 Soy Assessments (calculated by KD); http://iac.rutgers.edu/database/assessments.php; DOE
5 Energy Efficiency Improvement and Cost Saving Opportunities for the Fruit and Vegetable Processing Industry, August 2007, Lawrence Berkeley National Lab, http://ies.lbl.gov/iespubs/LBNL-59289.pdf
6 AE-701, Nov 1994, Dr. Kenneth J. Hellevang, PE. Extension Agricultural Engineer, NDSU
7 Strategies For Managing Energy-Related Grain Drying Costs. Wisconsin Focus on Energy. 2007.
8 Pulp frequency: Scientists test energy-saving microwaves to dry beet pulp for livestock feed. AURI AG Innovation News Apr-Jun 2009.
9 Energy Savings for a Cheese Plant, www.baseco.com/casestudies/Dairy Product.pdf
10 www.foodprocessing.com/articles/2007/012.html

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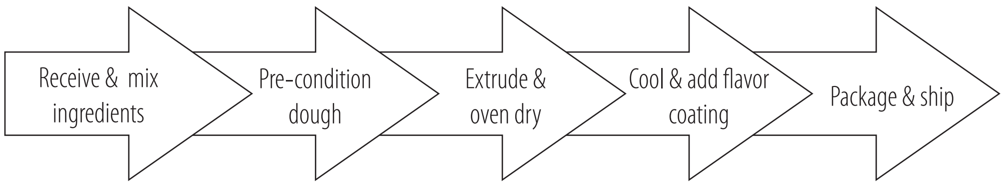
Pet Food & Animal Feed Manufacturing

Sub-sector Description

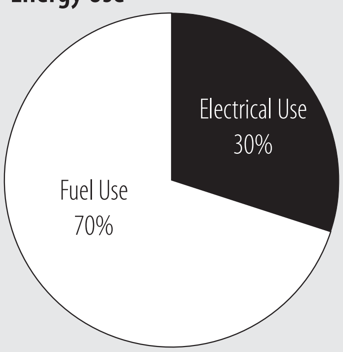
Pet food manufacturing facilities produce dog and cat food from cereal, meat, and other ingredients. These preparations may be canned or dry. Additionally, this sub-sector includes facilities that produce feed for livestock from grains.

Facility Type	SIC	NAICS		
Dog and Cat Food	2047	311111		

Process Information



Energy Use[1]



Benchmarks

The following thermal and/or electrical benchmarks were derived from facility-specific energy use, employee numbers, and area data for the facilities that MnTAP analyzed. These benchmarks can be used to predict how efficient your facility is in comparison to peer facilities. If your facility's energy use is less efficient than your peers, there may be energy conservation opportunities available. The benchmarks included have been tested for reliability; however, they should be used with some caution. For more information on the benchmarking study including how to use the benchmarks, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

	Most efficient 25%	More efficient 25%	Less efficient 25%	Least efficient 25%
kWh/employee	< 10,357	10,357 - 21,310	21,310 - 43,846	> 43,846

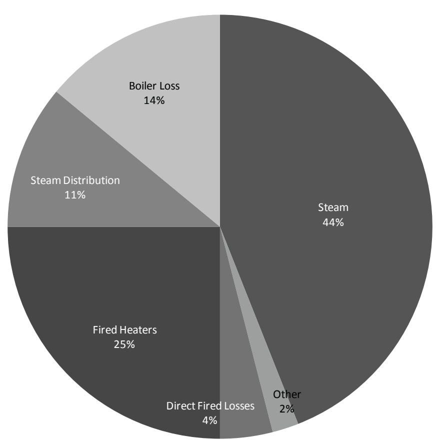
Savings Potential

Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

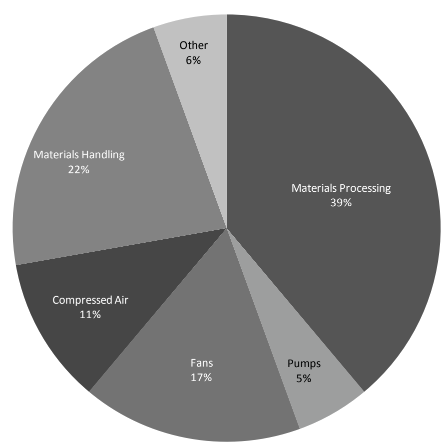
Estimated Electric Savings: 6%

Energy Use Footprints

Fuel Use[2]



Electricity Use[2]



Fuel Savings Estimate and Opportunities

MnTAP researched and analyzed this sub-sector for an electric utility. Therefore, fuel savings opportunities and an estimate of potential savings were not identified as part of MnTAP's industrial energy efficiency study.

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Best Practices: compressed air (fix leaks, lower pressure, use cool air,eliminate inappropriate uses)	< 1 year	0.1-2%	
Best Practices: motors (replacement plan, preventive maintenance)		-	
Best Practices: process equipment (shut off, optimize settings)		-	
Compressed air (upgrade, better sequence/control, heat recovery, replace inefficient uses)		-	
Motor opportunities (upgrade motors & belts, ASD)[3]	1 year	0.1-5%	
Process equipment opportunities (improve controls, change product design, change process, upgrade equipment)[4]		-	
Lean Manufacturing (reduce material transport, reduce the length of transport, just enough processing, just enough heating or cooling)		-	
Facility Improvements			
HVAC (close building openings/leaks, reduce heated space, reduce T, upgrade equip, upgrade controls)	< 1 year	0.1%	
Lighting (upgrade, use controls (occupancy, light)	< 1 year	0.0-0.8%	
TOTAL ELECTRIC SAVINGS ESTIMATE			**6%**

References

1 DOE Industrial Assessments. http://iac.rutgers.edu/database/assessments.php

2 Generalized Food and Beverage Energy Footprint, DOE, http://www1.eere.energy.gov/industry/energy_systems/pdfs/food_footprint.pdf. Adjusted to increase fans, reduce pumps, eliminate refrigeration, reduce cooling (electrical).

3 Energy Savings for a Cheese Plant, www.baseco.com/casestudies/Dairy Product.pdf

8 www.foodprocessing.com/articles/2007/012.html

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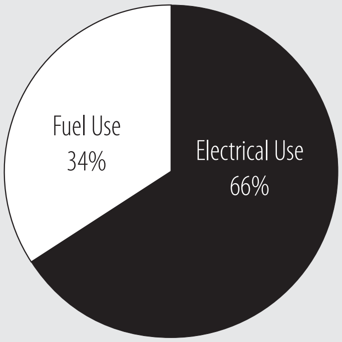
Seafood Processing

Sub-sector Description

This sub-sector includes facilities that preparing fresh and raw or cooked frozen fish and other seafoods and seafood preparations.

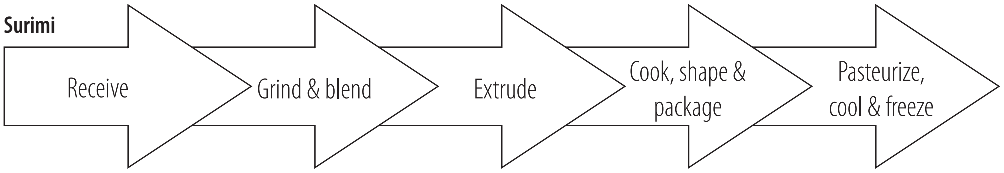
Facility Type	SIC	NAICS		Facility Type	SIC	NAICS
Seafood Canning	2091	311711		Fresh/Frozen Seafood Proc.	2092	311712

Energy Use[1]

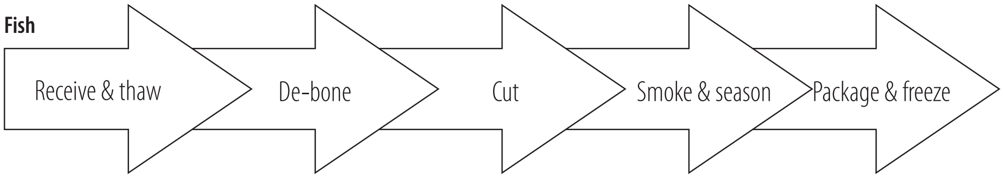


Process Information

Surimi



Fish



Benchmarks

Thermal and electrical benchmarks were unable to be reliably derived from facility-specific energy use, sales, employee numbers, and area data. For more information about the benchmarking study that MnTAP conducted and how to determine if your facility may have energy efficiency opportunities remaining, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

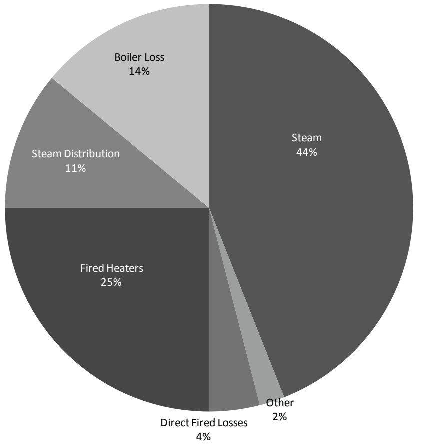
Savings Potential

Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

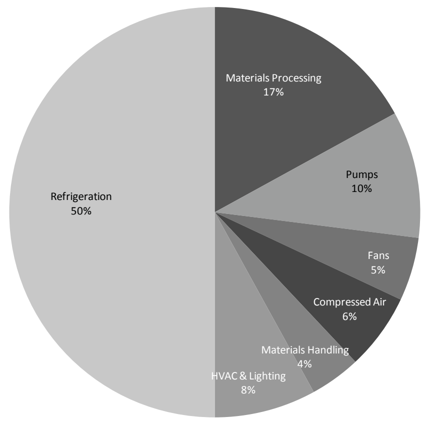
Estimated Electric Savings: 15%

Energy Use Footprints

Fuel Use[2]



Electricity Use[3]



Fuel Savings Estimate and Opportunities

MnTAP researched and analyzed this sub-sector for an electric utility. Therefore, fuel savings opportunities and an estimate of potential savings were not identified as part of MnTAP's industrial energy efficiency study.

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Best Practices: cooling refrigeration (clean condenser, optimize temps, avoid frost)[1]	< 1 year	0-8%	
Best Practices: compressed air (fix leaks, lower pressure, use cool air,eliminate inappropriate uses)[1]	< 1 year	0.1-3.5%	
Best Practices: motors (replacement plan, preventive maint.)[1]	1 year	0.1-0.5%	
Best Practices: process equipment (shut off, optimize settings)[1]	< 1 year	1-11%	
Cooling & refrigeration opportunities (upgrade, recover heat, reduce floating head pressure, increase suction pressure setpoint, improve compressor sequencing, use ASDs, use ammonia sub-cooling, insulate, recover heat)[1,2,3,4,5,6]			
Compressed air (upgrade, better sequence/control, heat recovery, replace inefficient uses)[2]	1 year	0-4%	
Motor opportunities (upgrade motors & belts, ASD)[1,8,9]	2 years	0.2-8%	
Process equipment opportunities (improve controls, change product design, change process, upgrade equipment)[1]	1-2 years	0.4-1%	
Lean Manufacturing (reduce material transport, reduce the length of transport, just enough processing, just enough heating or cooling)			
Facility Improvements			
HVAC (close building openings/leaks, reduce heated space, reduce T, upgrade equip, upgrade controls)	1-2 years	0.1-11%	
Lighting (upgrade, use controls (occupancy, light)	2 years	0.1-2%	
TOTAL ELECTRIC SAVINGS ESTIMATE			**15%**

References

1 DOE Industrial Assessments. http://iac.rutgers.edu/database/assessments.php
2 Generalized Food and Beverage Energy Footprint, DOE, http://www1.eere.energy.gov/industry/energy_systems/pdfs/food_footprint.pdf
3 Focus on Energy, Dairy Processing Best Practices Guidebook, 2006 pp16
4 Focus on Energy, Dairy Processing Best Practices Guidebook, 2006 pp 30
5 Focus on Energy, Dairy Processing Best Practices Guidebook, 2006 pp 31-35
6 Conserving Energy in Blast Freezers using Variable Frequency Drives, http://seagrant.oregonstate.edu/sgpubs/onlinepubs/fisheng/IETC_Report.pdf
7 Energy Savings for a Frozen Food Processing Plant, www.baseco.com/casestudies/Frozen Food Processing.pdf
8 Energy Savings for a Cheese Plant, www.baseco.com/casestudies/Dairy Product.pdf
9 www.foodprocessing.com/articles/2007/012.html

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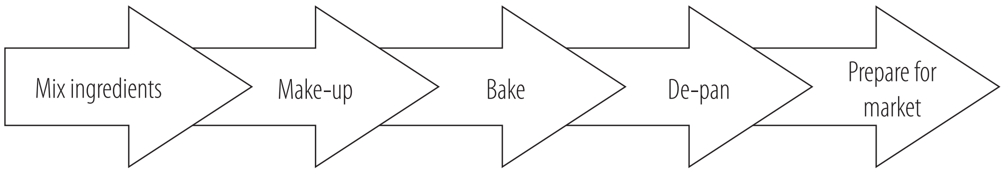
Commercial Bakeries

Sub-sector Description

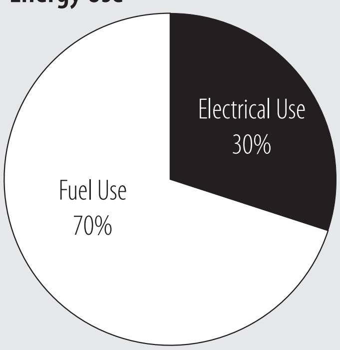
Commercial bakeries specialize in manufacturing fresh or frozen bread and bread-type rolls and fresh cakes, pies, pastries and other similar "perishable" bakery products.

Facility Type	SIC	NAICS	
Bakeries	2051	311812	

Process Information



Energy Use[1]



Benchmarks

The following thermal and/or electrical benchmarks were derived from facility-specific energy use, employee numbers, and area data for the facilities that MnTAP analyzed. These benchmarks can be used to predict how efficient your facility is in comparison to peer facilities. If your facility's energy use is less efficient than your peers, there may be energy conservation opportunities available. The benchmarks included have been tested for reliability; however, they should be used with some caution. For more information on the benchmarking study including how to use the benchmarks, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

	Most efficient 25%	More efficient 25%	Less efficient 25%	Least efficient 25%
kWh/square feet	< 18	18 - 33	33 - 59	> 59
kWh/employee	< 6,502	6,502 - 10,926	10,926 - 18,362	> 18,362
therms/employee	< 494	494 - 666	666 - 899	> 899

Savings Potential

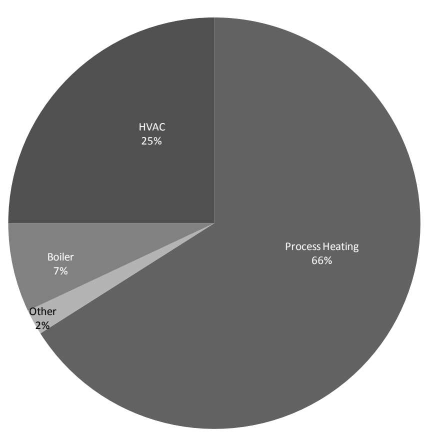
Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

Estimated Fuel Savings: **10%**

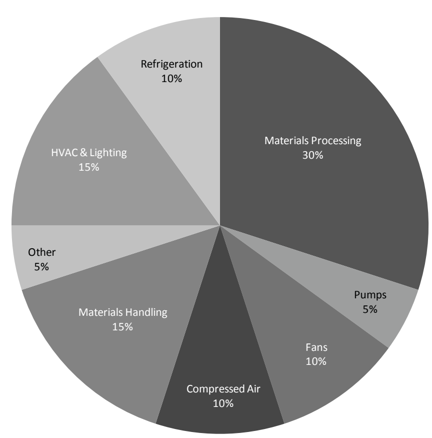
Estimated Electric Savings: **16%**

Energy Use Footprints

Fuel Use[2]



Electricity Use[2]



Fuel Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Direct fired best practices: reduce combustion air flow, insulate, maintain, optimize T, minimize oven ventilation[1]	< 1 year	0.5-3%	
Best practices boiler: minimize blowdown & steam bleed, O_2 tuning, minimize pressure, tune & maintain burner[1]	< 1 year	0.5-1.5%	
Best practices steam: repair traps & leaks, return condensate, insulate, isolate unused lines, shut down unused equip.	< 1 year	0.1-1.4%	
Best practices equipment: insulate, isolate hot equip., reduce leaks [infiltration, exfiltration], improve seals and insulation[3]	1-3 years	0.2-2%	
Boiler opportunities: improve burners & control, O_2 trim, new boiler, right-sized boiler, turbulators, improve feed water[1]	1-3 years	0.5-1.7%	
Recover heat from boiler blowdown or oven exhaust[1,4]	< 3 years	0.4-5%	
Heat pipe to recover oven heat for proofing oven[5]	3.5 years		
Heat recovery from thermal oxidizers[6]			
Improve large ovens[7]	4 years	0.2-2.8%	
Facility Improvements			
Reduce make-up air, insulate[8], use radiant heaters and set back thermostats		0.5-1.0%	
TOTAL FUEL SAVINGS ESTIMATE			**10%**

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Best Practices: cooling refrigeration (clean condenser, optimize temps, avoid frost)		-	
Best Practices: compressed air (fix leaks, lower pressure, use cool air,eliminate inappropriate uses)[9]	< 1 year	0-6%	
Best Practices: motors (replacement plan, preventive maintenance)		-	
Best Practices: process equipment (shut off, optimize settings)		-	
Cooling & refrigeration opportunities (upgrade, recover heat, reduce floating head pressure, increase suction pressure setpoint, improve compressor sequencing, use ASDs, use ammonia sub-cooling, insulate, recover heat)[10]		-	
Compressed air (upgrade, better sequence/control, heat recovery, replace inefficient uses)		-	
Motor opportunities (upgrade motors & belts, ASD)[9,10]	1 year	0-14%	
Process equipment opportunities (improve controls, change product design, change process, upgrade equipment)[12]		-	
Lean Manufacturing (reduce material transport, just enough processing, just enough heating or cooling)		-	
Facility Improvements			
HVAC (close building openings/leaks, reduce heated space, reduce T, upgrade equip, upgrade controls)	< 1 year	0-1%	
Lighting (upgrade, use controls (occupancy, light)	< 1 year	0-8%	
TOTAL ELECTRIC SAVINGS ESTIMATE			**16%**

References

1 DOE Industrial Assessments. http://iac.rutgers.edu/database/assessments.php
2 Generalized Food and Beverage Energy Footprint, DOE, http://www1.eere.energy.gov/industry/energy_systems/pdfs/food_footprint.pdf. Adjusted.
3 http://www.buseco.monash.edu.au/mgt/agribis/energyaward2003.html
4 http://earth2tech.com/2008/10/17/german-baking-supplier-cuts-bakeries-energy-waste-25-percent/
5 http://www.p2pays.org/ref/04/03323.htm
6 http://www.airmanagement.com/Onsite/Weston/weston.html
7 http://www.totalbakingsolutions.com/Energy_efficiency.htm
8 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=UD0280
9 Energy Savings for a Bread Plant, www.baseco.com/casestudies/Bread Plant.pdf
10 Focus on Energy, Dairy Processing Best Practices Guidebook, 2006 pp16, 30, 31-35
11 Energy Savings for a Cheese Plant, www.baseco.com/casestudies/Dairy Product.pdf
12 www.foodprocessing.com/articles/2007/012.html

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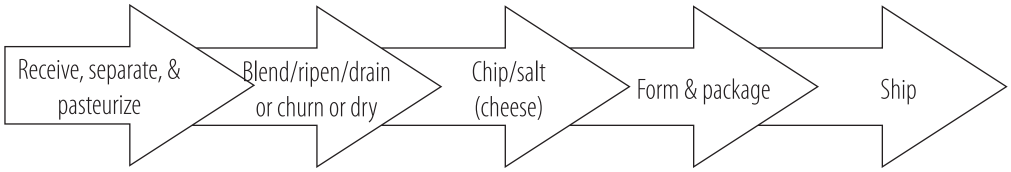
Cheese, Whey, and Butter Processing

Sub-sector Description

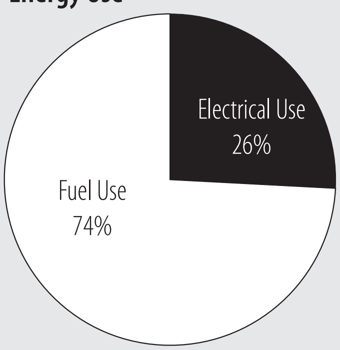
Facilities in this sub-sector manufacture cheese products from raw milk and/or processed milk products.

Facility Type	SIC	NAICS	
Cheese Processing	2022	311513	

Process Information



Energy Use[1]



Benchmarks

The following thermal and/or electrical benchmarks were derived from facility-specific energy use, employee numbers, and area data for the facilities that MnTAP analyzed. These benchmarks can be used to predict how efficient your facility is in comparison to peer facilities. If your facility's energy use is less efficient than your peers, there may be energy conservation opportunities available. The benchmarks included have been tested for reliability; however, they should be used with some caution. For more information on the benchmarking study including how to use the benchmarks, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

	Most efficient 25%	More efficient 25%	Less efficient 25%	Least efficient 25%
therms/square feet	< 98.71	98.71 - 119.31	119.31 - 144.22	> 144.22
therms/employee	< 24,825	24,825 - 27,798	27,798 - 31,127	> 31,127

Savings Potential

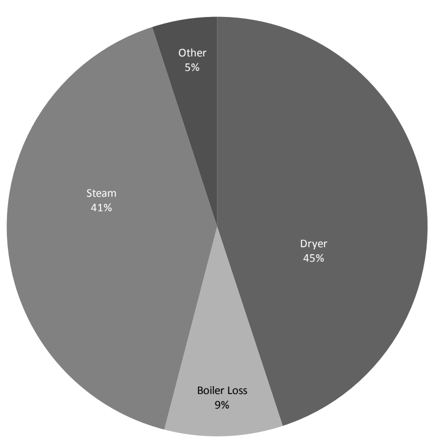
Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

Estimated Fuel Savings: **11%**

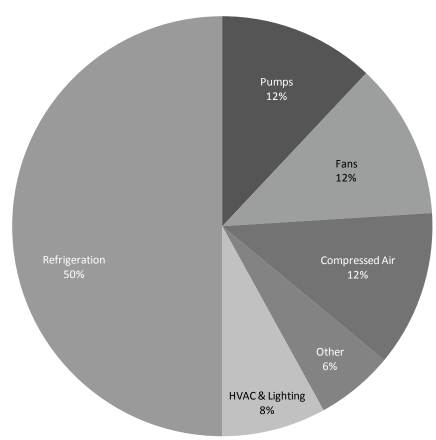
Estimated Electric Savings: **14%**

Energy Use Footprints

Fuel Use[2]



Electricity Use[2]



Fuel Savings Estimate and Opportunities[1]

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Direct fire opportunity: install more efficient burners, control, insulation, direct fired water heaters	3-4 years	0.1-0.3%	
Boiler best practice: tune and maintain	< 1 year	0.4-2%	
Steam best practice: maintain traps, repair leaks, minimum operating pressure, capture condensate, insulate distribution components	< 2 years	0.5-3%	
Boiler opportunity: efficient burners, O_2 control, turbulator, small boiler, clean tubes, feed water improvements	3-5 years	0.1-2%	
Boiler heat recovery: feed water, combustion air, process water	2 years	0.2-2.5%	
Equipment heat recovery: compressor, refrigeration, process	1-6 years	0.5-10%	
Equipment best practice: insulate and maintain	< 3 years	0.2-1%	
Improved process equipment		0.5-2%	
TOTAL FUEL SAVINGS ESTIMATE			**11%**

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Best Practices: cooling refrigeration (clean condenser, optimize temps, avoid frost)	4 years	-	
Best Practices: compressed air (fix leaks, lower pressure, use cool air, eliminate inappropriate uses)[1]	< 1 year	0.1-1.2%	
Best Practices: motors (replacement plan, preventive maintenance)		-	
Best Practices: process equipment (shut off, optimize settings)		-	
Cooling & refrigeration opportunities (upgrade, recover heat, reduce floating head pressure, increase suction pressure setpoint, improve compressor sequencing, use ASDs, use ammonia sub-cooling, insulate, recover heat)[3,4,5,6]		1-20%	
Compressed air (upgrade, better sequence/control, heat recovery, replace inefficient uses)	< 1 year	0.6%	
Motor opportunities (upgrade motors & belts, ASD)[1,4]	2 years	0.2-2%	
Process equipment opportunities (improve controls, change product design, change process, upgrade equipment)[1,7]	< 1 year	0-14%	
Lean Manufacturing (reduce material transport, reduce the length of transport, just enough processing, just enough heating or cooling)			
Facility Improvements			
HVAC (close building openings/leaks, reduce heated space, reduce T, upgrade equip, upgrade controls)[1]	< 1 year	0.05-0.1%	
Lighting (upgrade, use controls (occupancy, light)	1 year	0-6%	
Reduce lighting in over lit and unused space[4]		4.8%	
TOTAL ELECTRIC SAVINGS ESTIMATE			**14%**

References

1 DOE Industrial Assessments. http://iac.rutgers.edu/database/assessments.php
2 Mn Dairy industry contact
3 Focus on Energy, Dairy Processing Best Practices Guidebook, 2006. pp 16
4 Energy Savings for a Cheese Plant, www.baseco.com/casestudies/Dairy Product.pdf
5 Focus on Energy, Dairy Processing Best Practices Guidebook, 2006. pp 30
6 Focus on Energy, Dairy Processing Best Practices Guidebook, 2006. pp 31-35
7 www.foodprocessing.com/articles/2007/012.html

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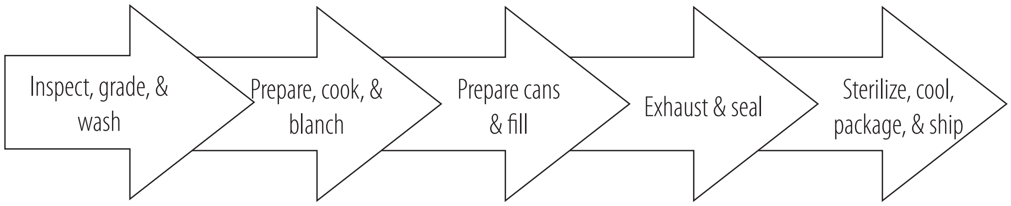
Fruit and Vegetable Canning

Sub-sector Description

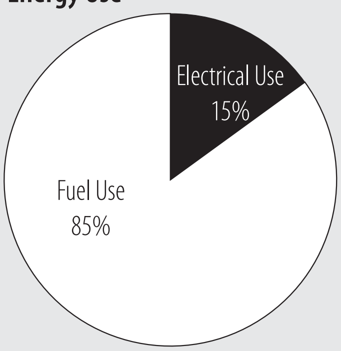
Canning facilities manufacture canned, pickled, and brined fruits and vegetables. In Minnesota, corn and beans are the primary products canned in these facilities; however, additional products may include canned juices; canned jams and jellies; canned tomato-based sauces; and pickles, relishes, and sauerkraut.

Facility Type	SIC	NAICS	
Fruit and Vegetable Canning	2033	311421	

Process Information



Energy Use[1]



Benchmarks

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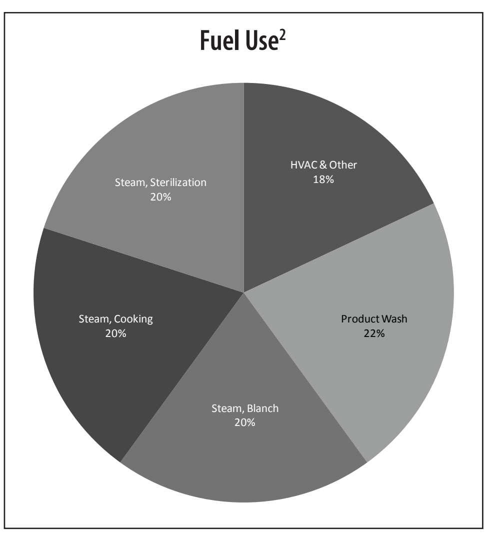
Savings Potential

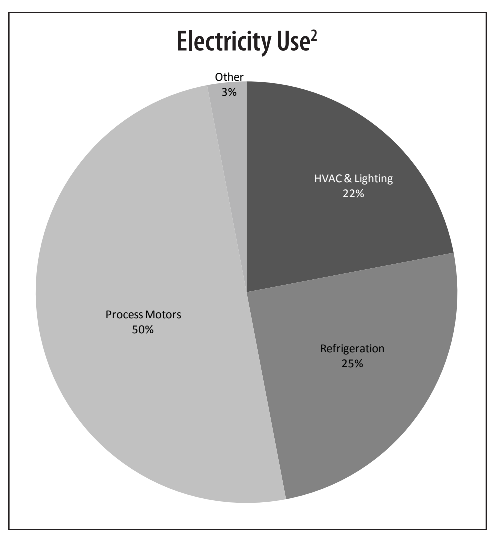
Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

Estimated Fuel Savings: 9%

Estimated Electric Savings: 5%

Energy Use Footprints





Fuel Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Direct fire opportunity: burner, control, insulation	3-4 years	0.5-3.8%	
Direct fire best practices: tune and maintain	< 1 year	0.1-0.3%	
Boiler opportunity: burner, O_2 control, turbulator, small boiler, clean tubes, feed water improvements	3-5 years	1-3.4%	
Boiler heat recovery: feed water, combustion air, process water	2 years	0.5-2%	
Boiler best practices: tune and maintain	< 1 year	0.1-0.3%	
Steam best practices: maintain traps, repair leaks, minimum operating pressure, capture condensate, insulate distribution components	< 2 years	0.1-0.6%	
Install more efficient burners (burners with stable flame at low fire and low excess air)	2-5 years		
Improved process equipment	3 years	1-2%	
TOTAL FUEL SAVINGS ESTIMATE			**9%**

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Replace hydraulic / pneumatic equipment with electric equipment	2-3 years	0.4-1.8%	
Use most efficient equipment at maximum capacity and less efficient equipment when necessary	< 1 year	0.3%	
Optimize pump and fan operation	1-4 years		
Improved control	< 2 years	.3-1.4%	
Improve utilization of cooling towers and cooling tower water treatment[4]	2-3 years	0-1.7%	
Operate an absorption chiller on waste heat	2-5 years		
Compressed air improvements: lower pressure, repair leaks, improve dryers and filters, and improve controls and staging	< 1 year		
Motor improvements		1%	
Lighting and HVAC improvements		0.5-1%	
TOTAL ELECTRIC SAVINGS ESTIMATE			**5%**

References

1 DOE Industrial Assessments. http://iac.rutgers.edu/database/assessments.php
2 Energy Use in Minnesota Agriculture, Barry Ryan and Douglas G.Tiffany, Minnesota Agricultural Economist Newsletter, No. 693, Fall 1998, pp288
3 Utility rebate data
4 Intern engineering report for General Mills, 2001. MnTAP site visit information from freezing facility in Minnesota.

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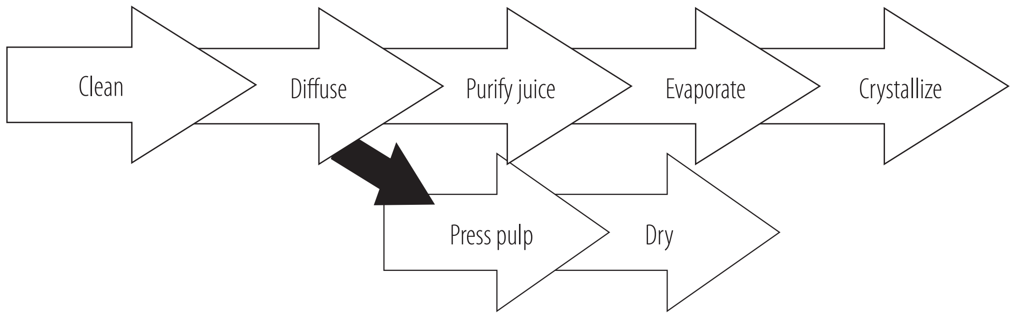
Sugar Manufacturing from Beets

Sub-sector Description

Facilities in this sub-sector manufacture refined sugar from sugar beets.

Facility Type	SIC	NAICS		
Beet Sugar Manufacturing	2063	311313		

Process Information



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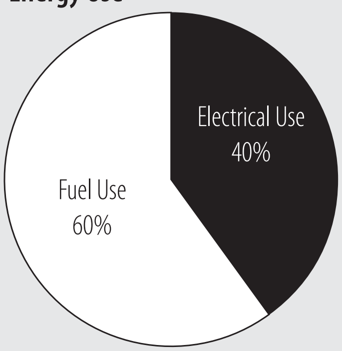


Benchmarks

Thermal and electrical benchmarks were unable to be reliably derived from facility-specific energy use, sales, employee numbers, and area data. For more information about the benchmarking study that MnTAP conducted and how to determine if your facility may have energy efficiency opportunities remaining, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

Savings Potential

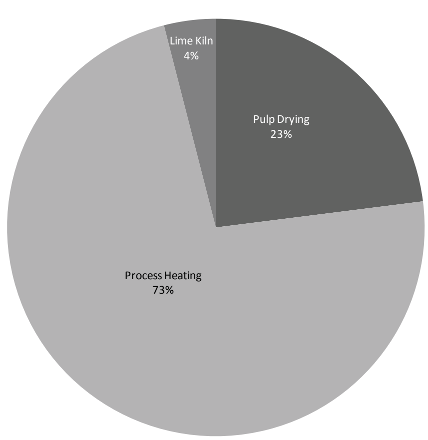
Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

Estimated Fuel Savings: 4%

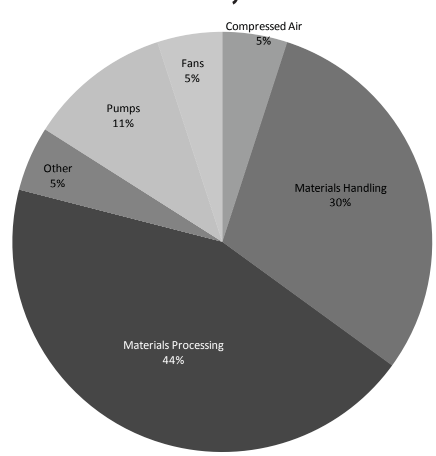
Estimated Electric Savings: 3%

Energy Use Footprints

Fuel Use[2]



Electricity Use[2]



Fuel Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Direct fire opportunity: burner, control, insulation, concentrate whey before drying, recover heat to preheat inlet and combustion air, direct fired water heating	2-4 years	0.1-0.5%	
Boiler best practice: tune and maintain	< 1 year	0-0.5%	
Direct fire best practice: tune and maintain		0-0.5%	
Steam best practice: maintain traps, repair leaks, minimum operating pressure, capture condensate, insulate distribution components	< 2 years	0.2-1%	
Boiler opportunity: new burner, O_2 control, turbulator, small boiler, clean tubes, feed water improvements, boiler refractory insulation	2-10 years	0.1-1%	
Boiler heat recovery: economizer, feed water, combustion air, process water	2 years	0.4-1%	
Equipment best practices: insulate and maintain	< 3 years	0-0.5%	
Heat recovery via absorption cooling			
TOTAL FUEL SAVINGS ESTIMATE			**4%**

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Best Practices: compressed air (fix leaks, lower pressure, use cool air,eliminate inappropriate uses)[1]	< 1 year	0.1-0.3%	
Best Practices: motors (replacement plan, preventive maintenance)		-	
Best Practices: process equipment (shut off, optimize settings)		-	
Compressed air (upgrade, better sequence/control, heat recovery, replace inefficient uses)		-	
Motor opportunities (upgrade motors & belts, ASD)[1,3]	2 years	0.2-4%	
Process equipment opportunities (improve controls, change product design, change process, upgrade equipment)[4]		-	
Lean Manufacturing (reduce material transport, reduce the length of transport, just enough processing, just enough heating or cooling)			
Facility Improvements			
HVAC (close building openings/leaks, reduce heated space, reduce T, upgrade equip, upgrade controls)[1]	< 1 year	-	
Lighting (upgrade, use controls occupancy, light)[1]	2.5 years	-	
TOTAL ELECTRIC SAVINGS ESTIMATE			**3%**

References

1 DOE Industrial Assessments. http://iac.rutgers.edu/database/assessments.php
2 MPCA Emission Inventory Summary for 2007
3 Energy Savings for a Cheese Plant, www.baseco.com/casestudies/Dairy Product.pdf
4 www.foodprocessing.com/articles/2007/012.html

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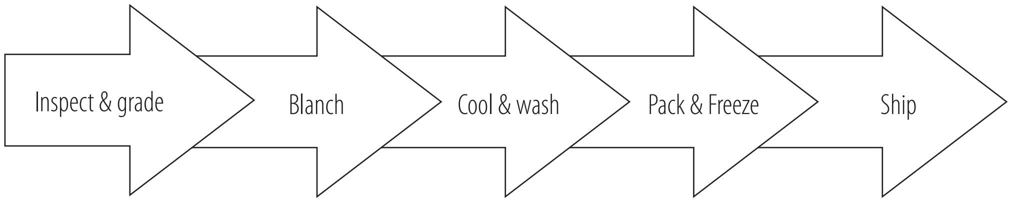
Frozen Fruit and Vegetable Processing

Sub-sector Description

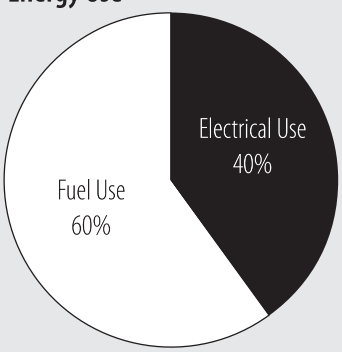
This sub-sector includes facilities that manufacture frozen fruit, frozen juices, frozen vegetables, and frozen specialty foods (except seafood). Final products can include frozen dinners, entrees, and side dishes; frozen pizza; frozen whipped toppings; and frozen waffles, pancakes, and french toast.

Facility Type	SIC	NAICS	
Frozen Fruit and Vegetable Mfg.	2037	311411	

Process Information



Energy Use[1]



Benchmarks

Thermal and electrical benchmarks were unable to be reliably derived from facility-specific energy use, sales, employee numbers, and area data. For more information about the benchmarking study that MnTAP conducted and how to determine if your facility may have energy efficiency opportunities remaining, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

Savings Potential

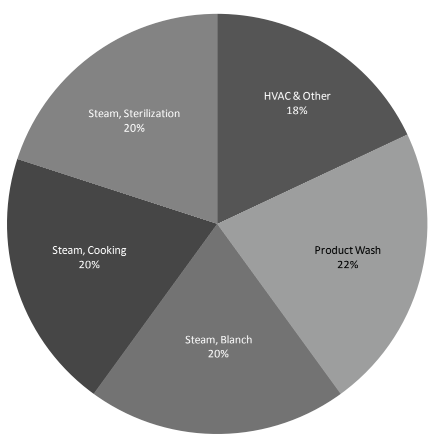
Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

Estimated Fuel Savings: 9%

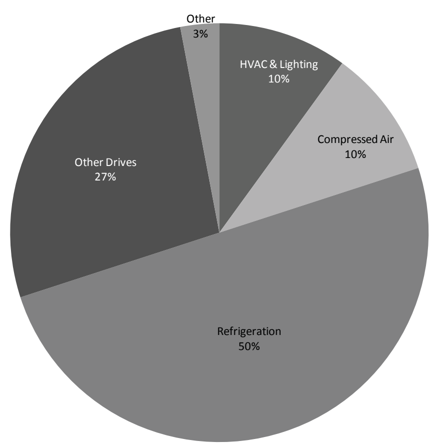
Estimated Electric Savings: 10%

Energy Use Footprints

Fuel Use[2]



Electricity Use[2]



Fuel Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Direct fire opportunity: burner, control, insulation	3-4 years	0.5-3.8%	
Direct fire best practices: tune and maintain	< 1 year	0.1-0.3%	
Boiler opportunity: burner, control, turbulator, small boiler, clean tubes, feed water improvements	3-5 years	1-3.4%	
Boiler heat recovery: feed water, combustion air, process water	2 years	0.5-2%	
Boiler best practices: tune and maintain	< 1 year	0.1-0.3%	
Steam best practices: maintain traps, repair leaks, minimum operating pressure, capture condensate, insulate distribution components	< 2 years	0.1-0.6%	
Install more efficient burners (burners with stable flame at low fire and low excess air)	2-5 years		
Improved process equipment	3 years	1-2%	
TOTAL FUEL SAVINGS ESTIMATE			**9%**

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Replace hydraulic / pneumatic equipment with electric equipment	2-3 years	0.4-1.8%	
Use most efficient equipment at maximum capacity and less efficient equipment when necessary	< 1 year	0.3%	
Modify refrigeration to operate at a lower pressure or higher suction	3-4 years	2.4-5%	
Install new refrigeration equipment[3]	3-5 years	11-30%	
Improve freezer insulation			
Optimize pump and fan operation	1-4 years		
Improved control	< 2 years	.3-1.4%	
Improve utilization of cooling towers and cooling tower water treatment[4]	2-3 years	0-1.7%	
Operate an absorption chiller on waste heat	2-5 years		
Compressed air improvements: lower pressure, repair leaks, improve dryers and filters, and improve controls and staging	< 1 year		
Motor improvements		1%	
Lighting and HVAC improvements		0.5-1%	
TOTAL ELECTRIC SAVINGS ESTIMATE			**10%**

References

1 DOE Industrial Assessments. http://iac.rutgers.edu/database/assessments.php
2 Energy Use in Minnesota Agriculture, Barry Ryan and Douglas G.Tiffany, Minnesota Agricultural Economist Newsletter, No. 693, Fall 1998, pp288
3 Utility rebate data
4 Intern engineering report for General Mills, 2001. MnTAP site visit information from freezing facility in Minnesota.

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Appendix C: Fabricated Metals Sub-Sector Sheets

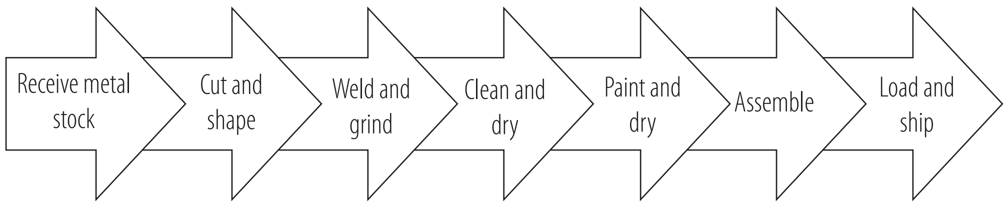
Transportation Equipment Manufacturing

Sub-sector Description

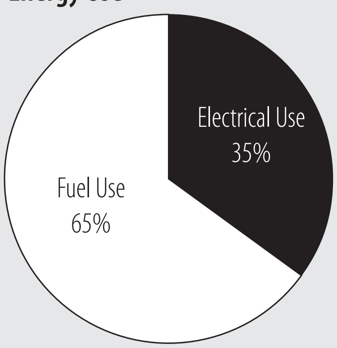
Facilities in this sub-sector utilize production processes similar to those of other machinery manufacturing establishments: bending, forming, welding, machining, and assembling metal or plastic parts into components and finished products. These particular facilities produce equipment for transporting people and goods.

Facility Type	SIC	NAICS		Facility Type	SIC	NAICS
Ship and boat building	3732	336611		Other transportation equip.	3799	336910
Machine shops, other mfg	3599	332710		Motor vehicle body & trailer mfg	3711	336211
Bus and other vehicle mfg	3713	336211		Boat manufacturing	3732	336612

Process Information



Energy Use[1]



Benchmarks

Thermal and electrical benchmarks were unable to be reliably derived from facility-specific energy use, sales, employee numbers, and area data. For more information about the benchmarking study that MnTAP conducted and how to determine if your facility may have energy efficiency opportunities remaining, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

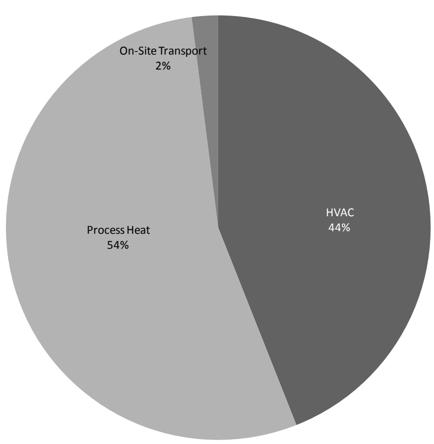
Savings Potential

Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

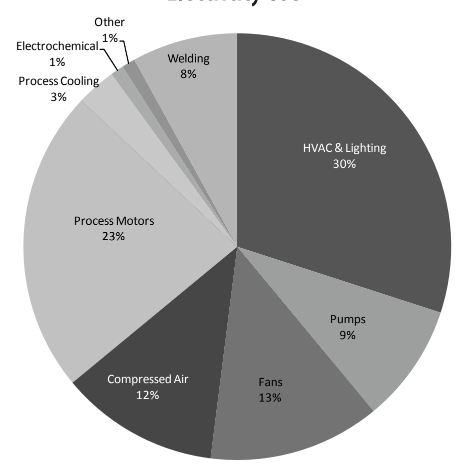
Estimated Electric Savings: 19%

Energy Use Footprints

Fuel Use[2]



Electricity Use[2]



Fuel Savings Estimate and Opportunities

MnTAP researched and analyzed this sub-sector for an electric utility. Therefore, fuel savings opportunities and an estimate of potential savings were not identified as part of MnTAP's industrial energy efficiency study.

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Reduce compressed air pressure to minimum required and repair leaks[3]	< 1 year	4.3%	
Update compressor controls and intake location[4]	< 1 year	3.4%	
Replace motors with soft-start or ASD supplies[5]	2 years	1.5%	
Properly size motors and pumps, select efficient replacements[6]	3 years	1.9%	
Turn off equipment when not in use or reduce power consumption in stand-by[7]	< 1 year	1.7%	
Optimize plant power factor, install power factor correction devices[8]	1-2 years	0.02%	
Fan and paint ventilation optimization and modification[2]	2-3 years	5.0%	
Welding control and inverter technologies[9]	5 years	5.0%	
Facility Improvements			
Facility HVAC improvements[2]	< 1 year	2.0%	
Lighting improvements[10]	2 years	3.0%	
TOTAL ELECTRICAL SAVINGS ESTIMATE			**19%**

References

1 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/assessments.php
2 C. Galitsky and E. Worrell. Energy Efficiency Improvement and Cost Savings Opportunities for the Vehicle Assembly Industry. Lawrence Berkley National Laboratory. January 2003.
3 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=TA0067
4 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=SU0228
5 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=SD0394
6 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=OK0662
7 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=SF0304
8 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=UU0050
9 http://www.americanmachinist.com/304/Issue/Article/False/9124/Issue
10 A. Price and M.H. Ross. Reducing Industrial Electricity Costs - An Automotive Case Study. The Electricity Journal, July 1989: 40-51.

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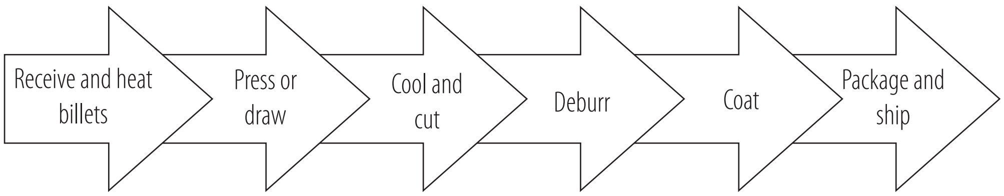
Metal Tube Manufacturing

Sub-sector Description

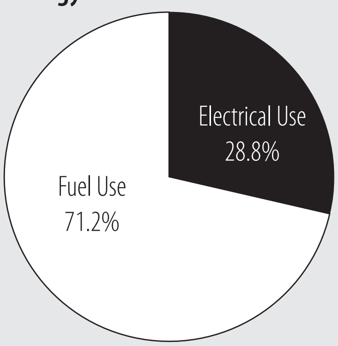
This industry group includes facilities establishments primarily engaged in manufacturing iron and steel tube and pipe, drawing steel wire, and rolling or drawing shapes from purchased iron, steel, or aluminum.

Facility Type	SIC	NAICS		Facility Type	SIC	NAICS
Steel pipe & tube manufacturing	3317	331210		Alum. tubing & extruded prod.	3354	331315

Process Information



Energy Use[1]



Benchmarks

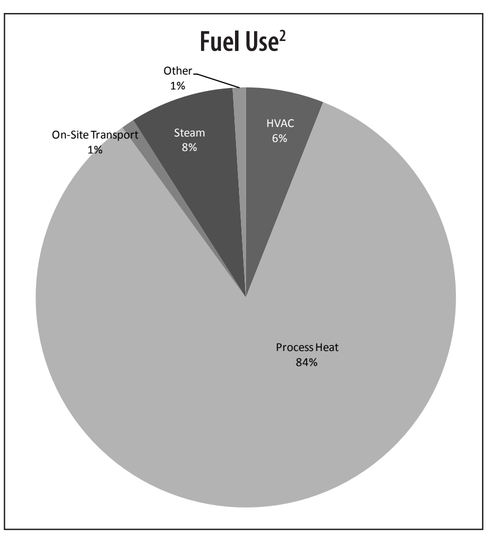
Thermal and electrical benchmarks were unable to be reliably derived from facility-specific energy use, sales, employee numbers, and area data. For more information about the benchmarking study that MnTAP conducted and how to determine if your facility may have energy efficiency opportunities remaining, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

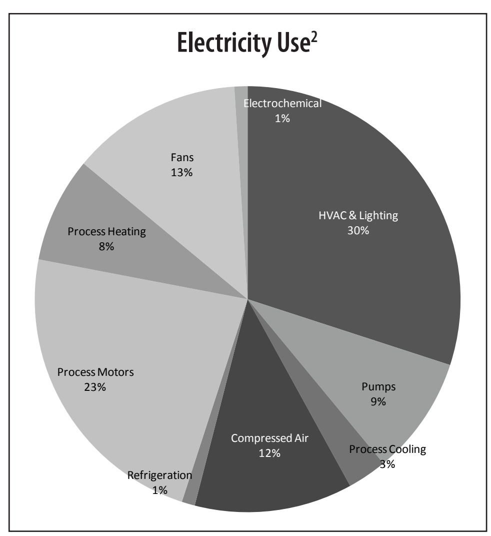
Savings Potential

Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

Estimated Fuel Savings: **42%**

Energy Use Footprints





Fuel Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Heat System Optimization[3]			
Boiler O_2 tuning[4]	< 2 years	5-25%	
Insulate bare equipment and piping[5]	2 years	2-15%	
Heat recovery of flue gas to preheat combustion air or heat secondary operations[6]	5 years	10-25%, 33%	
Improve process measurements, control, and calibration[6]	3 years	5-10%	
Upgrade heating and heat-treating equipment for better efficiency[7]	8 years	5-10%	
Heat Recovery			
Recover heat from compressed air systems[8]	4 years	4%	
Recover heat from material processing[9]	4 years	59%	
Recover heat from flue gas to heat boiler water[9]	4 years	1%	
Facility HVAC Improvements			
Use efficient building insulation[10]	2 years	1%	
Destratify air with circulation fans[11]	2 years	7%	
Use radiant heat for spot heating parts[4]	7 years	19%	
TOTAL FUEL SAVINGS ESTIMATE			**42%**

Electric Savings Estimate and Opportunities

MnTAP researched and analyzed this sub-sector for a natural gas utility. Therefore, electric savings opportunities and an estimate of potential savings were not identified as part of MnTAP's industrial energy efficiency study.

References

1 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/assessments.php
2 DOE Aluminum Industry Energy Footprint, http://www1.eere.energy.gov/industry/energy_systems/pdfs/aluminum_footprint.pdf
3 http://www1.eere.energy.gov/industry/bestpractices/pdfs/em_proheat_seven.pdf
4 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/findassessment.php?ID=BD0333
5 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/findassessment.php?ID=LL0192
6 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/findassessment.php?ID=UD0766
7 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/findassessment.php?ID=GT0815
8 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/findassessment.php?ID=WV0318
9 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/findassessment.php?ID=UM0338
10 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/findassessment.php?ID=TA0126
11 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/findassessment.php?ID=IA0434

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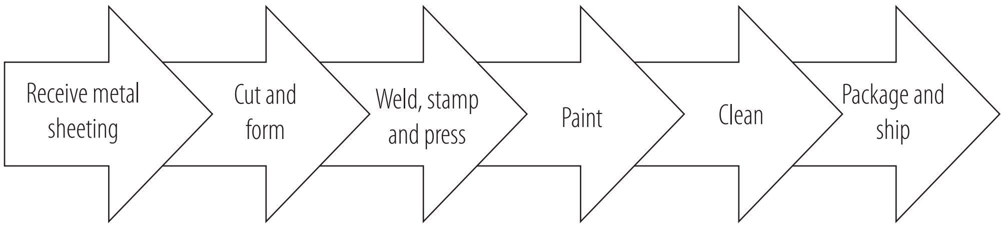
Metal Can Manufacturing

Sub-sector Description

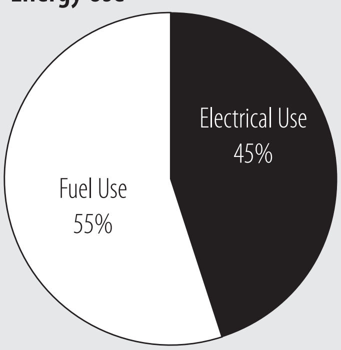
This sub-sector includes establishments primarily engaged in manufacturing metal cans, lids, and ends.

Facility Type	SIC	NAICS	
Metal can manufacturing	3411	332431	

Process Information



Energy Use[1]



Benchmarks

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Savings Potential

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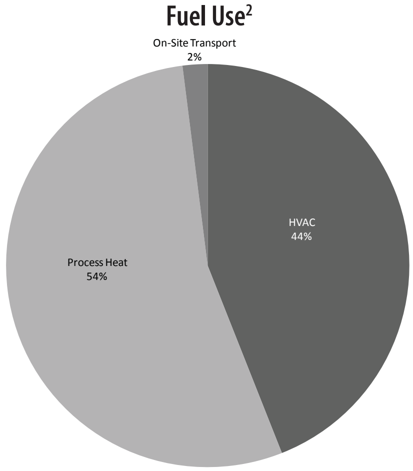
Estimated Fuel Savings: **25%**

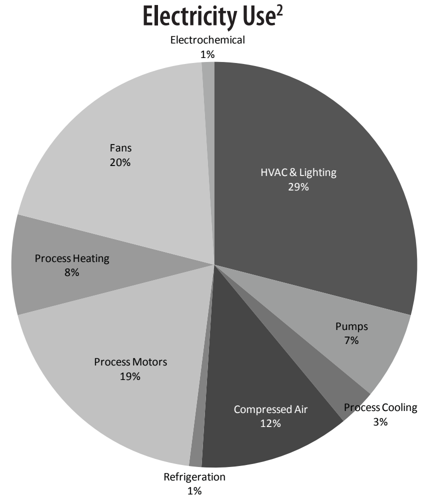
Estimated Electric Savings: **11%**

Energy Use Footprints

Fuel Use[2]



Electricity Use[2]



Fuel Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Heat Recovery			
Recover heat from compressed air system[3]	4 years	7-20%	
Process Heat System Optimization[4]			
Boiler O_2 tuning[5]	< 2 years	3-5%	
Heat recovery of flue gas to preheat combustion air or heat secondary operations[6]	5 years	10-25%	
Improve process measurements, control, and calibration[6]	3-4 years	5-10%	
Facility HVAC Improvements			
Reduce make-up air[7]	2 years	10%	
Use efficient building insulation[7]	2 years	14%	
Use radiant heat for spot heating work areas[8]	< 1 year	5%	
Replace inefficient gas-fired HVAC units[9]	> 3 years	3%	
TOTAL FUEL SAVINGS ESTIMATE			**25%**

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements			
HVAC improvements[9,10]		3-8%	
Pump and fan sizing optimization		25-30%	
Compressed air evaluation[4,11]		5-9%	
Motor load reduction[12]		4%	
Efficient motors and lighting[11,12]		2-3%	
Welding control[13-18]		20%	
Process heat system optimization[6]		2-25%	
TOTAL ELECTRIC SAVINGS ESTIMATE			**11%**

References

1 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/assessments.php
2 C. Galitsky and E. Worrell. Energy Efficiency Improvement and Cost Savings Opportunities for the Vehicle Assembly Industry. Lawrence Berkley National Laboratory, January 2003.
3 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=OR0182
4 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=WV0359
5 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=OR0598
6 http://www1.eere.energy.gov/industry/bestpractices/pdfs/em_proheat_seven.pdf
7 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=OR0007
8 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=DS0010
9 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=CO0595
10 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=CO0598
11 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=UW0009
12 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=UF0112
13 http://www.nema.org/energy/miller-inverter.html
14 http://findarticles.com/p/articles/mi_m0BFE/is_4_47/ai_n27645182
15 http://www.americanmachinist.com/304/Issue/Article/False/9124/Issue
16 http://adsabs.harvard.edu/abs/1980STIN...8119404T
17 http://www.osti.gov/bridge/servlets/purl/882565-ao9Lab/882565.PDF
18 http://www.p2pays.org/ref/08/07503.pdf

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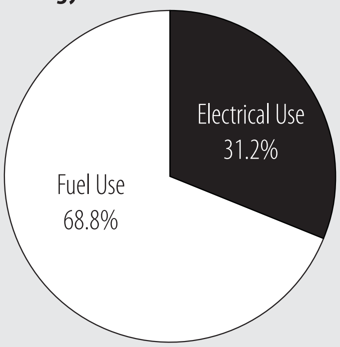
Structural Metal Products

Sub-sector Description

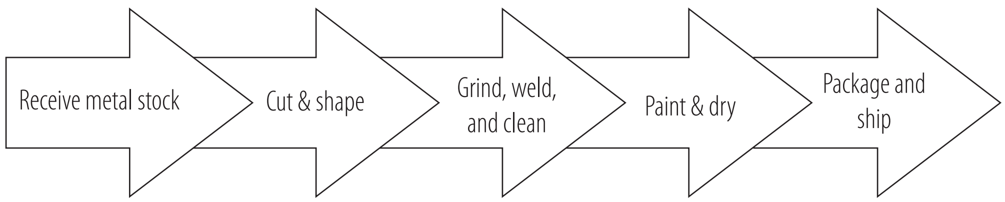
Facilities in this sub-sector are primarily engaged in manufacturing prefabricated metal buildings, panels and sections; structural metal products; and/or metal plate work products.

Facility Type	SIC	NAICS		Facility Type	SIC	NAICS
Office and store fixtures	2542	337215		Concrete reinforcing stock	3449	332312
Rolled steel shape mfg	3312	331221		Small arms ammunition mfg	3482	332992
Fabricated structural metal	3441	332312		Ordnance systems manufacturing	3489	332995
Door systems and screens	3442	336322		Industrial scale equipment	3596	333997
Heat exchangers and tanks	3443	332410		Amusement park equipment	3599	333319
Ornamental ironwork	3446	332323		Boat and lighthouse construction	3731	332312

Energy Use[1]



Process Information



Benchmarks

Thermal and electrical benchmarks were unable to be reliably derived from facility-specific energy use, sales, employee numbers, and area data. For more information about the benchmarking study that MnTAP conducted and how to determine if your facility may have energy efficiency opportunities remaining, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

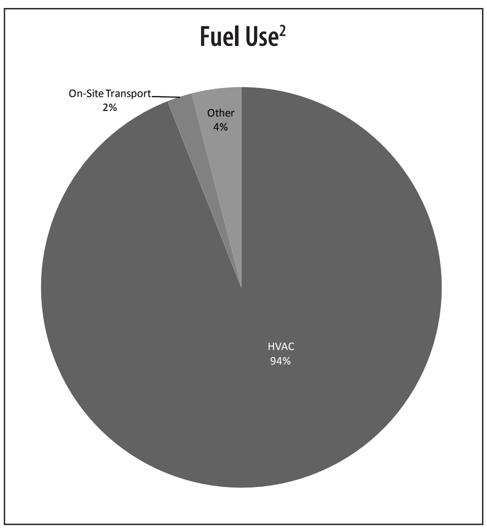
Savings Potential

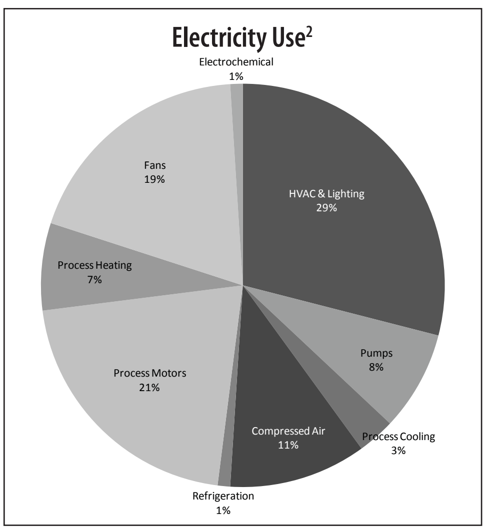
Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

Estimated Fuel Savings: 15%

Estimated Electric Savings: 14%

Energy Use Footprints





Fuel Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Heat Recovery[3]			
Recover heat from hot wastewater and water heaters[4]	4 years	5%	
Recover heat from compressed air system[5]	4 years	3-21%	
Recover heat from refrigeration condensers[6]	4 years	3%	
Recuperate heat from melt furnaces[7]	2 years	12-15%	
Process Heat System Optimization			
Pre-form process heat optimization[3]		2-25%	
Facility HVAC Improvements			
Reduce make-up air[8]	2 years	5-18%	
Use efficient building insulation[9]	2 years	6-8%	
Destratify air with circulation fans[9]	2 years	4%	
Use radiant heat for spot heating parts[5]	< 1 year	1%	
TOTAL FUEL SAVINGS ESTIMATE			**15%**

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements			
HVAC improvements[10,11]		13-22%	
Pump and fan sizing optimization		25-30%	
Compressed air evaluation[12,13]		8-12%	
Motor load reduction[14,15]		4-5%	
Efficient motors and lighting[10,16]		12-20%	
Welding control[17-22]		20%	
TOTAL ELECTRIC SAVINGS ESTIMATE			**14%**

References

1 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/assessments.php
2 C. Galitsky and E. Worrell. Energy Efficiency Improvement and Cost Savings Opportunities for the Vehicle Assembly Industry. Lawrence Berkley National Laboratory, January 2003.
3 http://www1.eere.energy.gov/industry/bestpractices/pdfs/em_proheat_seven.pdf
4 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/findassessment.php?ID=WV0225
5 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/findassessment.php?ID=BD0287
6 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/findassessment.php?ID=IA0394
7 Trade publications featuring recuperator manufacturers (i.e. Encon, First Thermal, North American Manufacturing Company)
8 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/findassessment.php?ID=WI0293
9 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/findassessment.php?ID=SU0255
10 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=AM0546
11 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=OK0744
12 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=UM0251
13 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=RU0110
14 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=OK043
15 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=UF0089
16 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=IC0005
17 http://www.nema.org/energy/miller-inverter.html
18 http://findarticles.com/p/articles/mi_m0BFE/is_4_47/ai_n27645182
19 http://www.americanmachinist.com/304/Issue/Article/False/9124/Issue
20 http://adsabs.harvard.edu/abs/1980STIN...8119404T
21 http://www.osti.gov/bridge/servlets/purl/882565-ao9Lab/882565.PDF
22 http://www.p2pays.org/ref/08/07503.pdf

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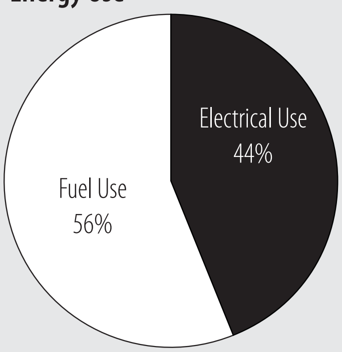
Stamping & Forging Operations

Sub-sector Description

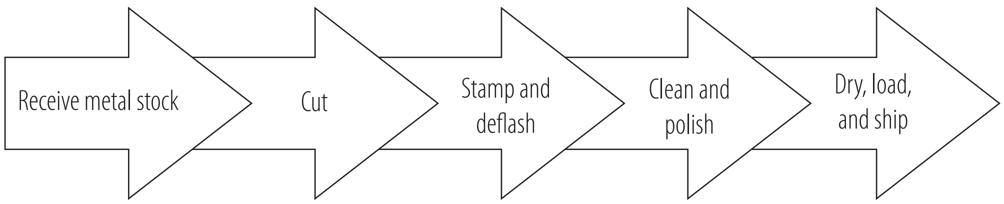
Facilities in this sub-sector manufacture forgings from purchased metals, metal custom roll forming products, metal stamped and spun products, and/or powder metallurgy products. Metal forging, metal stamping, and metal spun products facilities may perform surface finishing operations, such as cleaning and deburring, on the products they manufacture.

Facility Type	SIC	NAICS	Facility Type	SIC	NAICS
Forging and stamping	3321	332116	Arch. & structural metals mfg	3323	332323
Cutlery and hand tool mfg	3322	332211	Railroad rolling stock mfg	3365	336510
Gardening and hand tools	3423	332212	Hardware furnishings	3429	332510
Automotive stampings	3465	336370	All-trade metal stampings	3469	332116
Novelty and giftware	3499	332999			

Energy Use[1]



Process Information



Benchmarks

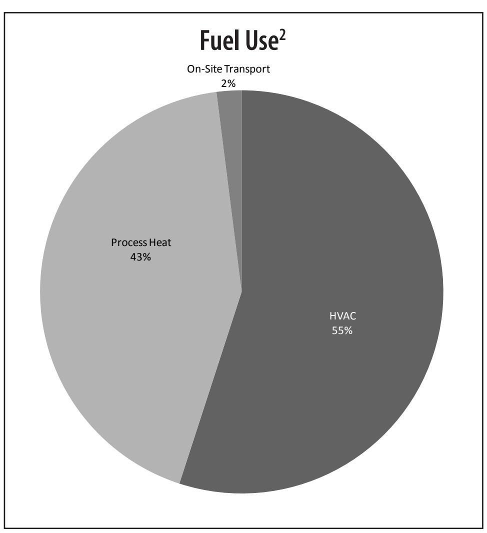
Thermal and electrical benchmarks were unable to be reliably derived from facility-specific energy use, sales, employee numbers, and area data. For more information about the benchmarking study that MnTAP conducted and how to determine if your facility may have energy efficiency opportunities remaining, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

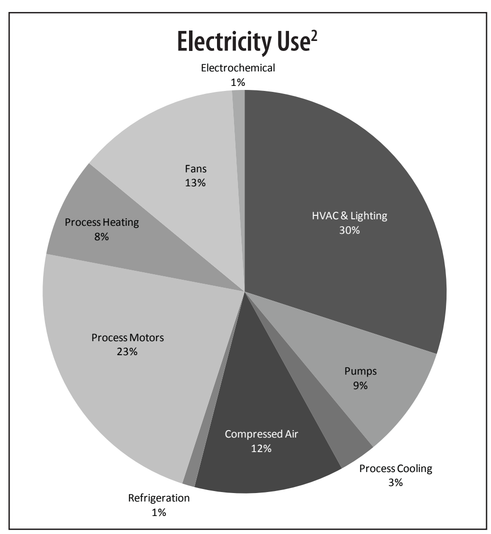
Savings Potential

Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

Estimated Electric Savings: 15%

Energy Use Footprints





Fuel Savings Estimate and Opportunities

MnTAP researched and analyzed this sub-sector for an electric utility. Therefore, fuel savings opportunities and an estimate of potential savings were not identified as part of MnTAP's industrial energy efficiency study.

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Reduce compressed air pressure to minimum required and repair leaks[3]	< 1 year	2-6%	
Update compressor controls and intake location[4]	< 1 year	3.4%	
Replace motors with soft-start or ASD supplies[5]	2 years	1.5-30%	
Properly size motors and pumps, select efficient replacements[6]	3 years	2-30%	
Turn off equipment when not in use or reduce power consumption in stand-by[7]	< 1 year	1.7%	
Optimize plant power factor, install power factor correction devices[8]	1-2 years	0.02%	
Utilize energy-efficient belts[9]	< 1 year	0-7.7%	
Facility HVAC Improvements			
Facility HVAC improvements[2]	< 1 year	2-14%	
Lighting improvements[10]	2 years	3-20%	
TOTAL ELECTRICAL SAVINGS ESTIMATE			**15%**

References

1. IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/assessments.php
2. C. Galitsky and E. Worrell. Energy Efficiency Improvement and Cost Savings Opportunities for the Vehicle Assembly Industry. Lawrence Berkley National Laboratory, January 2003.
3. IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=TA0067
4. IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=SU0228
5. IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=SD0394
6. IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=OK0662
7. IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=SF0304
8. IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=UU0050
9. IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=SU0264
10. Reducing Industrial Electricity Costs - An Automotive Case Study, A. Price and MH Ross, The Electricity Journal, July 1989: 40-51.

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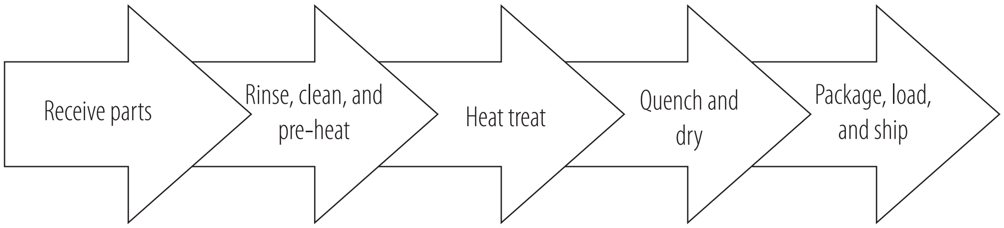
Heat Treating

Sub-sector Description

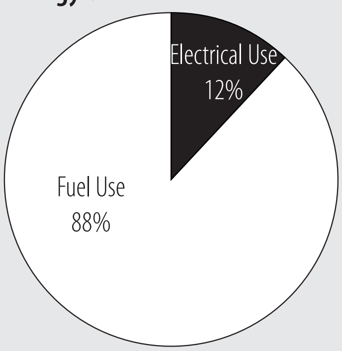
Facilities that are primarily engaged in heat treating, such as annealing, hardening, and tempering metals and metal products for the trade are included in this sub-sector. Some facilities specialize in heat treating as their sole function, while others heat treat metal as part of larger operations: metal casting or metal fabrication.

Facility Type	SIC	NAICS	
Metal/steel heat treating	3398	332811	

Process Information



Energy Use[1]



Benchmarks

Thermal and electrical benchmarks were unable to be reliably derived from facility-specific energy use, sales, employee numbers, and area data. For more information about the benchmarking study that MnTAP conducted and how to determine if your facility may have energy efficiency opportunities remaining, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

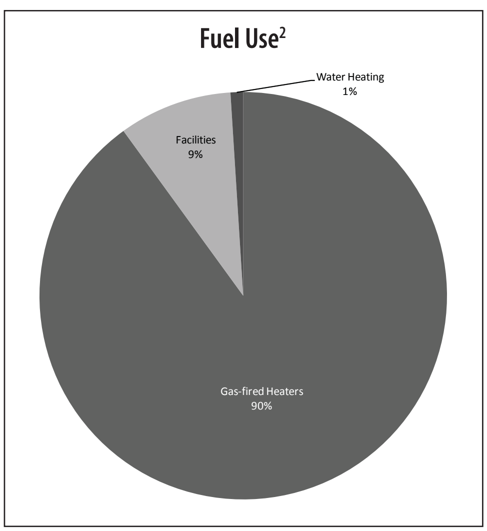
Savings Potential

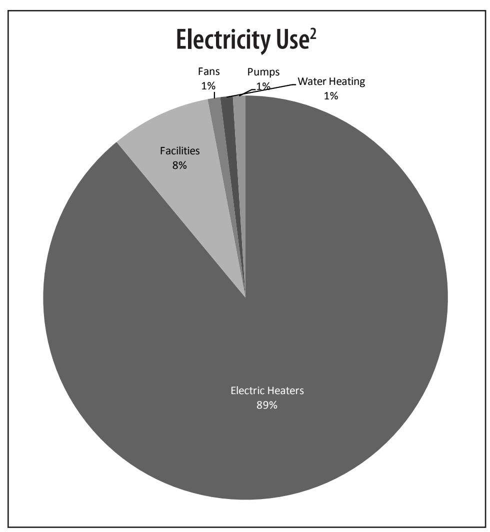
Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

Estimated Fuel Savings: 12%

Estimated Electric Savings: 22%

Energy Use Footprints





Fuel Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements			
Use waste heat from hot flue gases to preheat combustion air	1-2 years	14%	
Reduce combustion air flow to optimum	< 1 year	1-2%	
Insulate bare equipment	< 1 year	1-2%	
Increase insulation thickness	< 1 year	0-1%	
Improve air circulation with destratification fans / other methods	1-2 years	5-10%	
TOTAL FUEL SAVINGS ESTIMATE			**12%**

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Reduce compressed air pressure to minimum required and repair leaks[3]	< 1 year	4.3%	
Update compressor controls and intake location[4]	< 1 year	3.4%	
Replace motors with soft-start or ASD supplies[5]	2 years	1.5%	
Properly size motors and pumps, select efficient replacements[6]	3 years	1.9%	
Utilize energy-efficient belts[7]	< 1 year	0.9%	
Turn off equipment when not in use or reduce power consumption in stand-by[8]	< 1 year	1.7%	
Optimize plant power factor, install power factor correction devices[9]	1-2 years	0.02%	
Process heat optimization and process equipment insulation[10]	3 years	10.0%	
Facility HVAC Improvements			
Facility HVAC improvements[11]	< 1 year	11.0%	
Lighting improvements[12]	2 years	2.6%	
TOTAL ELECTRICAL SAVINGS ESTIMATE			**22%**

References

1 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/assessments.php
2 Journal of Heat Treating, 1989, SOderstrom and Lewald, http://www.springerlink.com/content/h9266765hn831827/fulltext.pdf.
3 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=TA0067
4 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=SU0228
5 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=SD0394
6 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=OK0662
7 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=SU0264
8 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=SF0304
9 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=UU0050
10 DOE Best Practices; http://www1.eere.energy.gov/industry/bestpractices/pdfs/em_proheat_seven.pdf
11 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=WI0504
12 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=IC0026

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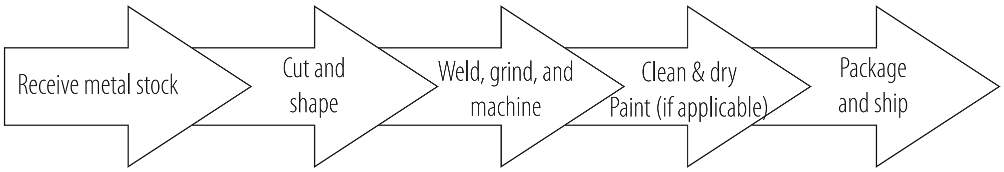
Machine Shops

Sub-sector Description

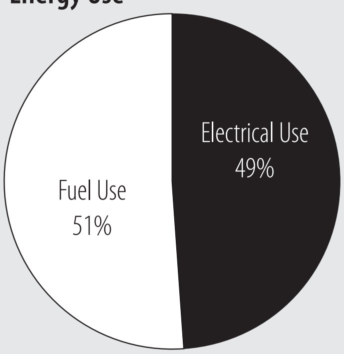
This sub-sector includes facilities that are engaged in machining metal and plastic parts and parts of other composite materials on a job or order basis. Generally machine shop jobs are low volume using machine tools such as lathes (including computer numerically controlled); automatic screw machines; and machines for boring, grinding, and milling.

Facility Type	SIC	NAICS		Facility Type	SIC	NAICS
Machine jobs, general	3544	332710		Spring and wire product mfg	3495	332611
Screw machining	3452	332722		Fabricated wire product mfg	3496	332618
Turned product and screw mfg	3451	332721				

Process Information



Energy Use[1]



Benchmarks

The following thermal and/or electrical benchmarks were derived from facility-specific energy use, employee numbers, and area data for the facilities that MnTAP analyzed. These benchmarks can be used to predict how efficient your facility is in comparison to peer facilities. If your facility's energy use is less efficient than your peers, there may be energy conservation opportunities available. The benchmarks included have been tested for reliability; however, they should be used with some caution. For more information on the benchmarking study including how to use the benchmarks, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

	Most efficient 25%	More efficient 25%	Less efficient 25%	Least efficient 25%
kWh/square feet	< 14	14 - 22	22 - 34	> 34
kWh/employee	< 6,090	6,090 - 11,242	11,242 - 20,752	> 20,752
therms/square feet	< 0.15	0.15 - 0.27	0.27 - 0.47	> 0.47

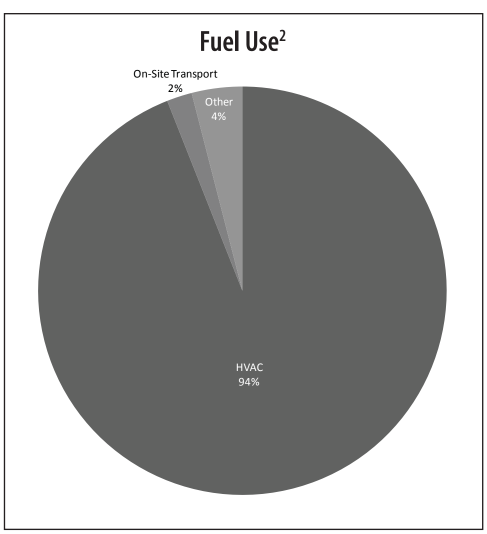
Savings Potential

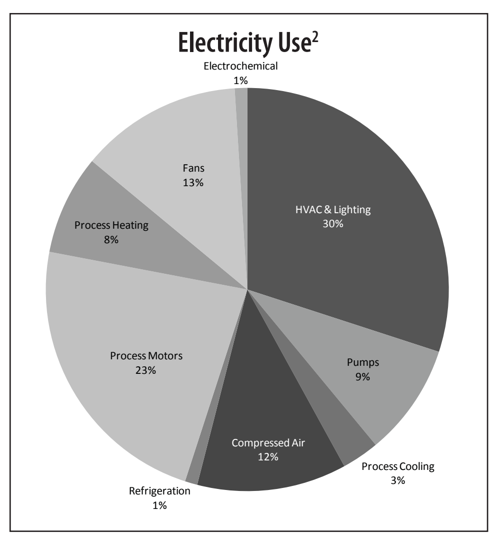
Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

Estimated Fuel Savings: 15%

Estimated Electric Savings: 9%

Energy Use Footprints





Fuel Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvement and Optimization			
Process heat system optimization[3]			
Boiler O_2 tuning[4]	< 2 years	1%	
Place insulating materials around ovens and hot water heaters/boilers[5]	2 years	6%	
Heat recovery of flue gas to preheat combustion air or heat secondary operations[6]	5 years	2%	
Recover heat from process equipment[7]	2 years	2%	
Recover heat from compressed air system[8]	4 years	2%	
Facility HVAC Improvements			
Reduce make-up air[9]	2 years	4%	
Use efficient building insulation[10]	2 years	4%	
Use radiant heating for spot area heating[11]	< 1 year	6%	
TOTAL FUEL SAVINGS ESTIMATE			**15%**

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Reduce compressed air pressure to minimum required and repair leaks[12]	< 1 year	4-9%	
Update compressor controls and intake location[13]	< 1 year	3.4%	
Replace motors with soft-start or ASD supplies[14]	2 years	1.5%	
Properly size motors and pumps, select efficient replacements[15]	3 years	1-4%	
Turn off equipment when not in use or reduce power consumption in stand-by[16]	< 1 year	1.7%	
Optimize plant power factor, install power factor correction devices[17]	1-2 years	0.02%	
Fan and paint ventilation optimization and modification[2]	2-3 years	5.0%	
Welding control and inverter technologies[18]	5 years	5.0%	
Facility HVAC Improvements			
Facility HVAC improvements[2]	< 1 year	1-2%	
Lighting improvements[19]	2 years	3-6%	
TOTAL ELECTRICAL SAVINGS ESTIMATE			**9%**

References

1 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/assessments.php
2 C. Galitsky and E. Worrell. Energy Efficiency Improvement and Cost Savings Opportunities for the Vehicle Assembly Industry. Lawrence Berkley National Laboratory, January 2003.
3 http://www1.eere.energy.gov/industry/bestpractices/pdfs/em_proheat_seven.pdf
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5 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/findassessment.php?ID=OK0239
6 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/findassessment.php?ID=WV0234
7 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/findassessment.php?ID=IA0032
8 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/findassessment.php?ID=IA130
9 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/findassessment.php?ID=WI0350
10 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/findassessment.php?ID=ME0277
11 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/findassessment.php?ID=BD0205
12 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=TA0067
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15 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=OK0662
16 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=SF0304
17 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=UU0050
18 http://www.americanmachinist.com/304/Issue/Article/False/9124/Issue
19 A. Price and M.H. Ross. Reducing Industrial Electricity Costs - An Automotive Case Study. The Electricity Journal, July 1989: 40-51.

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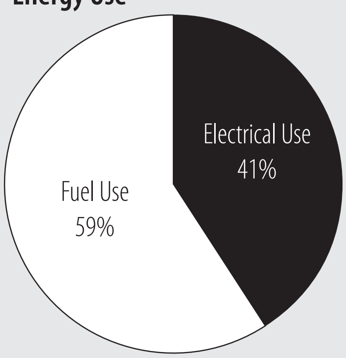
Industrial Equipment Manufacturing

Sub-sector Description

Facilities in this sub-sector create end products that apply mechanical force, for example, the application of gears and levers, to perform work. Some important processes for the manufacture of machinery are forging, stamping, bending, forming, and machining that are used to shape individual pieces of metal. Processes, such as welding and assembling are used to join separate parts together.

Energy Use[1]



Savings Potential

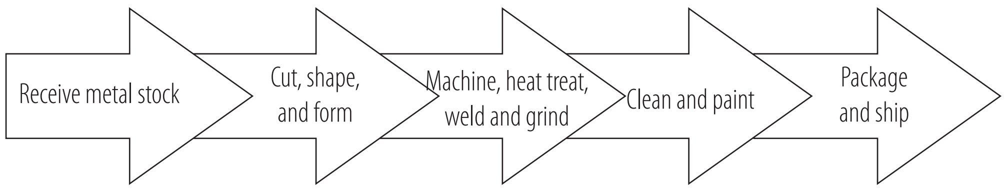
Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

Estimated Fuel Savings: 21%

Estimated Electric Savings: 13%

Facility Type	SIC	NAICS		Facility Type	SIC	NAICS
Heat exchanger/boiler mfg	3559	332410		Motors, pump, and fan mfg	3621	333612
Metal working machinery	3549	333518		General machinery mfg	3599	333120
Industrial machinery mfg	3523	333120				

Process Information

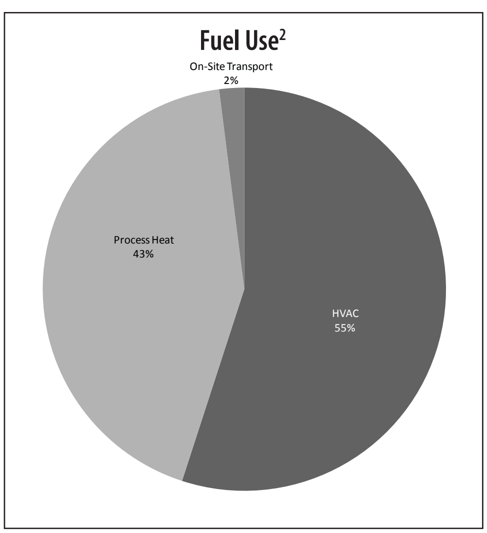


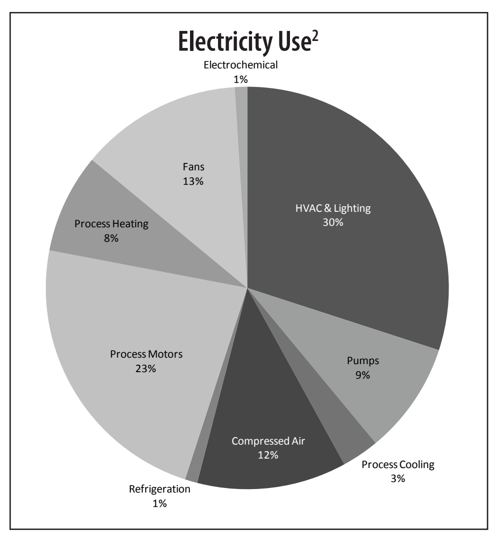
Benchmarks

The following thermal and/or electrical benchmarks were derived from facility-specific energy use, employee numbers, and area data for the facilities that MnTAP analyzed. These benchmarks can be used to predict how efficient your facility is in comparison to peer facilities. If your facility's energy use is less efficient than your peers, there may be energy conservation opportunities available. The benchmarks included have been tested for reliability; however, they should be used with some caution. For more information on the benchmarking study including how to use the benchmarks, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

	Most efficient 25%	More efficient 25%	Less efficient 25%	Least efficient 25%
kWh/employee	< 2,940	2,940 - 5,577	5,577 - 10,577	> 10,577
therms/employee	< 174	174 - 337	337 - 653	> 653

Energy Use Footprints





Fuel Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvement and Optimization			
Process heat system optimization[3]			
Boiler O_2 tuning	< 2 years	5%	
Place insulating materials around ovens, seal ovens, cover openings	2 years	2%	
Improve process measurements, control, and calibration	2 years	5%	
Heat recovery of flue gas to preheat combustion air or heat secondary operations	5 years	10%	
Use radiant heat for spot heating parts[4]	> 5 years	1%	
Modify processes to reduce cure times and overheating	2-3 years	5%	
Facility HVAC Improvements			
Reduce make-up air, push/pull ventilation[5]	2 years	5%	
Use efficient building insulation[6]	> 3 years	8%	
Use radiant heating for spot area heating[7]	< 1 year	5%	
TOTAL FUEL SAVINGS ESTIMATE			**21%**

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Reduce compressed air pressure and repair leaks[8]	< 1 year	4-9%	
Update compressor controls and intake location[9]	< 1 year	3.4%	
Replace motors with soft-start or ASD supplies[10]	2 years	1.5-4%	
Properly size motors and pumps, efficient replacements[11]	3 years	1.9%	
Utilize energy-efficient belts[12]	< 1 year	0.9%	
Turn off equipment when not in use or reduce power consumption in stand-by[13]	< 1 year	1.7%	
Optimize plant power factor, install correction devices[14]	2 years	0.02%	
Welding control and inverter technologies[15]	5 years	2-5%	
Facility HVAC Improvements			
Facility HVAC improvements[16]	< 1 year	1-11%	
Lighting improvements[17]	2 years	1-6%	
TOTAL ELECTRICAL SAVINGS ESTIMATE			**13%**

References

1 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/assessments.php
2 DOE Heavy Machinery Manufacturing Footprint. http:///www1.eere.energy.gov/industry/energy_systems/pdfs/machinery_footprint.pdf
3 http://www1.eere.energy.gov/industry/bestpractices/pdfs/em_proheat_seven.pdf
4 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/findassessment.php?ID=BD0287
5 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/findassessment.php?ID=MA0551
6 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/findassessment.php?ID=UD0280
7 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/findassessment.php?ID=UU0058
8 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=TA0067
9 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=SU0228
10 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=SD0394
11 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=OK0662
12 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=SU0264
13 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=SF0304
14 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=UU0050
15 http://www.americanmachinist.com/304/Issue/Article/False/9124/Issue
16 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=WI0504
17 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=UM0238

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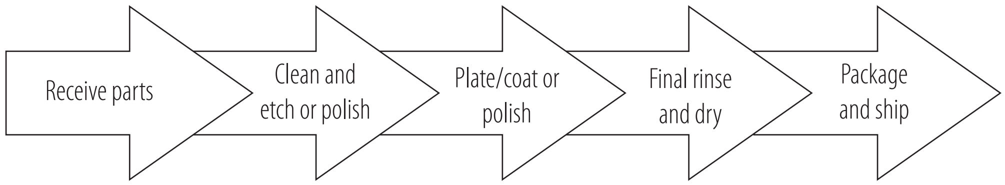
Plating, Polishing, Coating, and Finishing

Sub-sector Description

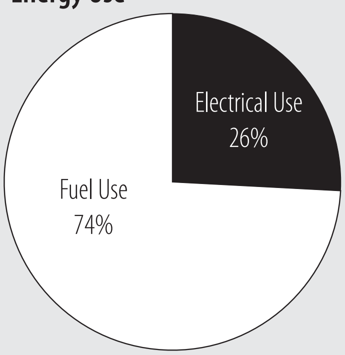
This sub-sector includes facilities engaged in engraving, chasing, or etching metals and metal products; electroplating, plating, anodizing, coloring, and finishing metals and metal products; and providing other metal surfacing services for the trade. Facilities in this industry generally coat, engrave, and metal formed products fabricated elsewhere.

Facility Type	SIC	NAICS		Facility Type	SIC	NAICS
Metal painting/power coating	3479	332812		Plating, anodizing, etc.	3471	332813
Metal stamping w/plating	3469	332813		Machine shops w/painting	3599	332811
Plating and polishing services	3399	332813				

Process Information



Energy Use[1]



Benchmarks

The following thermal and/or electrical benchmarks were derived from facility-specific energy use, employee numbers, and area data for the facilities that MnTAP analyzed. These benchmarks can be used to predict how efficient your facility is in comparison to peer facilities. If your facility's energy use is less efficient than your peers, there may be energy conservation opportunities available. The benchmarks included have been tested for reliability; however, they should be used with some caution. For more information on the benchmarking study including how to use the benchmarks, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

	Most efficient 25%	More efficient 25%	Less efficient 25%	Least efficient 25%
kWh/square feet	< 21	21 - 31	31 - 47	> 47
kWh/employee	< 16,390	16,390 - 25,656	25,656 - 40,160	> 40,160
therms/square feet	< 1.17	1.17 - 2.53	2.53 - 5.47	> 5.47

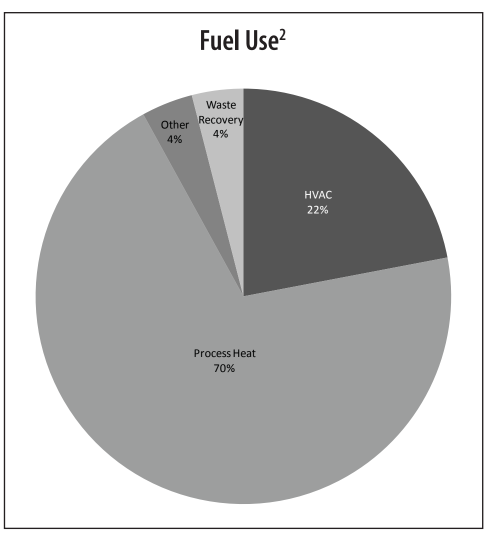
Savings Potential

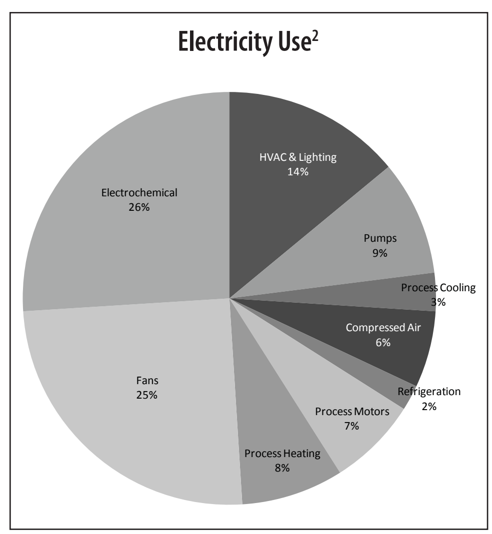
Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

Estimated Fuel Savings: 25%

Estimated Electric Savings: 17%

Energy Use Footprints





Fuel Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvement and Optimization			
Process heat system optimization[3]			
Boiler O_2 tuning[4]	< 2 years	5-25%	
Place insulating materials around ovens and hot water heaters/boilers[5]	2 years	6%	
Heat recovery of flue gas to preheat combustion air or heat secondary operations[6]	5 years	10-25%	
Recovery heat from process equipment[7]	2 years	2%	
Recover heat from compressed air system[8]	4 years	2%	
Use adequate insulation and maintain	2 years	2-15%	
Calibrate and maintain process sensors and control	2 years	5-10%	
Heat transfer improvement allowing better convection/radiation	> 3 years	5-15%	
Modify processes to reduce soak times and overheating	2-3 years	5-10%	
Facility HVAC Improvements			
Reduce make-up air, push/pull ventilation[3]	2 years	5%	
Use efficient building insulation[4]	> 3 years	8%	
Use radiant heating for spot area heating[5]	< 1 year	5%	
TOTAL FUEL SAVINGS ESTIMATE			**25%**

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Electrochemical process efficiency[2]	> 3 years	5%	
Pump optimization[12]	2 years	5%	
Process motor optimization and load reduction[13]	< 2 years	4%	
Reduce ventilation[14]	2.5 years	2%	
Compressed air improvements, cold air intake, fix leaks and controls[15]	< 1 year	9%	
Facility HVAC Improvements			
Facility HVAC improvements[16]	< 1 year	1%	
Lighting improvements[17]	2 years	5%	
TOTAL ELECTRICAL SAVINGS ESTIMATE			**17%**

References

1 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/assessments.php
2 Energy Center of Wisconsin Publication 319-2. Metal Finishers Technical Supplement. 2006.
3 http://www1.eere.energy.gov/industry/bestpractices/pdfs/em_proheat_seven.pdf
4 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/findassessment.php?ID=MO0112
5 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/findassessment.php?ID=OK0239
6 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/findassessment.php?ID=WV0234
7 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/findassessment.php?ID=IA0032
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9 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/findassessment.php?ID=WI0350
10 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/findassessment.php?ID=ME0277
11 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/findassessment.php?ID=BD0205
12 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=SD0243
13 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=IC0118
14 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=IC0009
15 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=MA0548
16 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=LM0123
17 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=IC0026

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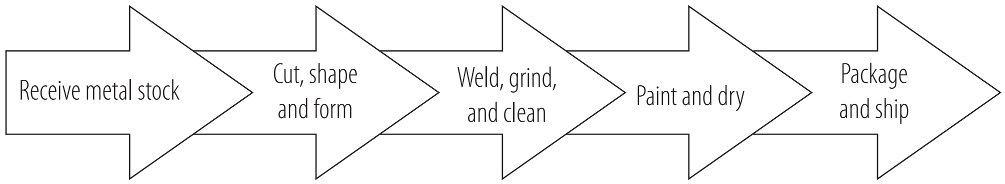
Sheet Metal Fabrication

Sub-sector Description

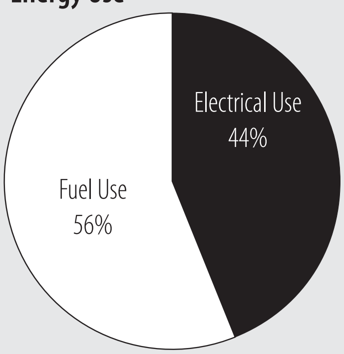
This sub-sector includes facilities that manufacture a variety of products from sheet metal. These products may include metal window frames, metal doors, sheet metal work, and ornamental and architectural metal products.

Facility Type	SIC	NAICS		Facility Type	SIC	NAICS
Sheet metal work manufacturing	3444	332322		Ornamental metal work mfg	3599	322323
Custom sheet metal fab.	3469	332322				

Process Information



Energy Use[1]



Benchmarks

The following thermal and/or electrical benchmarks were derived from facility-specific energy use, employee numbers, and area data for the facilities that MnTAP analyzed. These benchmarks can be used to predict how efficient your facility is in comparison to peer facilities. If your facility's energy use is less efficient than your peers, there may be energy conservation opportunities available. The benchmarks included have been tested for reliability; however, they should be used with some caution. For more information on the benchmarking study including how to use the benchmarks, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

	Most efficient 25%	More efficient 25%	Less efficient 25%	Least efficient 25%
kWh/square feet	< 8	8 - 16	16 - 32	> 32
kWh/employee	< 5,765	5,765 - 11,345	11,345 - 22,326	> 22,326

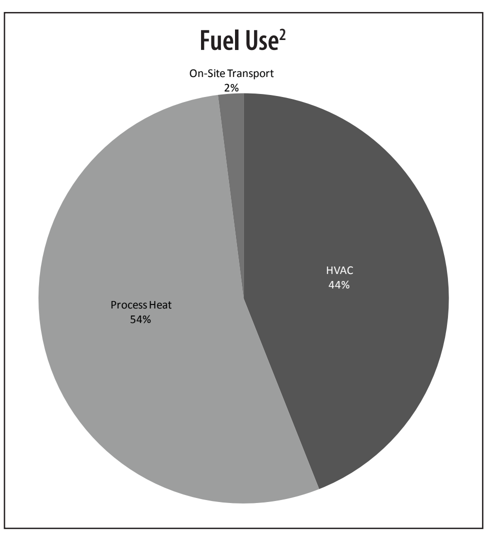
Savings Potential

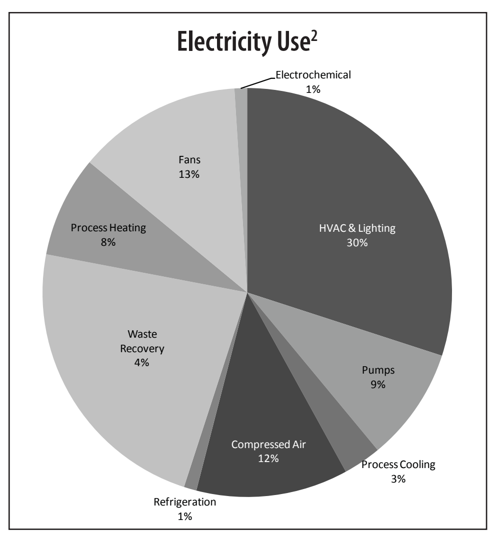
Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

Estimated Fuel Savings: 24%

Estimated Electric Savings: 15%

Energy Use Footprints





Fuel Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvement and Optimization			
Process heat system optimization[3]			
Boiler O_2 tuning	< 2 years	5-25%	
Place insulating materials around ovens, seal ovens, cover openings.	2 years	2-15%	
Heat recovery of flue gas to preheat combustion air or heat secondary operations	5 years	10-25%	
Improve process measurements, control, and calibration	3 years	5-10%	
Modify processes to reduce cure times and overheating	5 years	5-10%	
Facility HVAC Improvements			
Reduce make-up air[4]	2 years	2%	
Use efficient building insulation[5]	2 years	8%	
Install air curtains to direct oven heat in facility[6]	< 1 year	5%	
TOTAL FUEL SAVINGS ESTIMATE			**24%**

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Fan and paint ventilation modifications[7]	> 3 years	5%	
Reduce compressed air pressure to minimum required and repair leaks[8]	< 1 year	4.3%	
Update compressor controls and intake location[9]	< 1 year	3.4%	
Properly size motors and pumps, select efficient replacements[10]	3 years	1.9%	
Turn off equipment when not in use or reduce power consumption in stand-by[11]	< 1 year	1.7%	
Optimize plant power factor, install power factor correction devices[12]	1-2 years	0.02%	
Welding control and inverter technologies[13]	5 years	5.0%	
Facility HVAC Improvements			
Facility HVAC improvements[7]	< 1 year	2.0%	
Lighting improvements[14]	2 years	3.0%	
TOTAL ELECTRICAL SAVINGS ESTIMATE			**15%**

References

1 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/assessments.php
2 Energy Center of Wisconsin Publication 319-2. Metal Finishers Technical Supplement. 2006.
3 http://www1.eere.energy.gov/industry/bestpractices/pdfs/em_proheat_seven.pdf
4 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/findassessment.php?ID=WI0293
5 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/findassessment.php?ID=CO0006
6 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/findassessment.php?ID=UU0058
7 C. Galitsky and E. Worrell. "Energy Efficiency Improvements and Cost Savings Opportunities for the Vehicle Assembly Industry", Lawrence Berkley National Laboratory." January 2003.
8 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=TA0067
9 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=SU0228
10 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=OK0662
11 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=SF0304
12 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=UU0050
13 http://www.americanmachinist.com/304/Issue/Article/False/9124/Issue
14 A. Price and M.H. Ross. Reducing Industrial Electricity Costs - An Automotive Case Study. The Electricity Journal, July 1989: 40-51.

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Appendix D: Primary Metals Sub-Sector Sheets

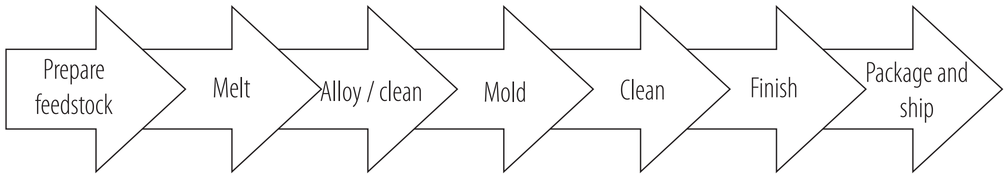
Non-Ferrous Metals Operations

Sub-sector Description

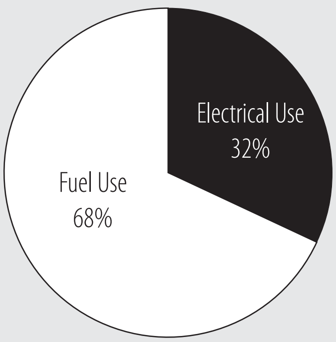
This industry includes facilities primarily engaged in the casting of non-ferrous metals (except aluminum) or smelting non-ferrous metals using electrolytic or other processes.

Facility Type	SIC	NAICS		Facility Type	SIC	NAICS
Lead smelting and refining	3339	331419		Non-ferrous die castings	3364	331522
Bronze die castings	3366	331522		Secondary non-ferrous metals	3341	331492
Copper foundries	3366	331525				

Process Information



Energy Use[1]



Benchmarks

Thermal and electrical benchmarks were unable to be reliably derived from facility-specific energy use, sales, employee numbers, and area data. For more information about the benchmarking study that MnTAP conducted and how to determine if your facility may have energy efficiency opportunities remaining, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

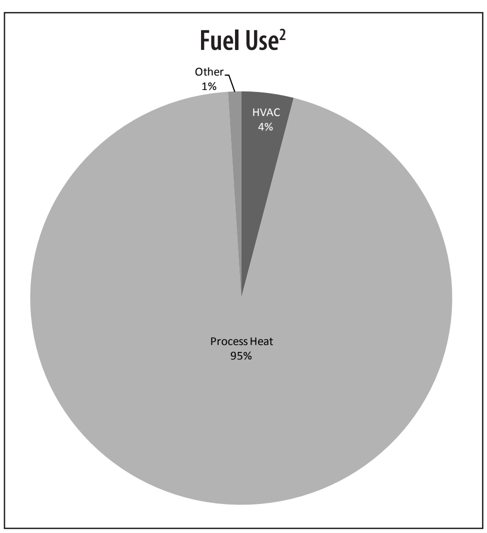
Savings Potential

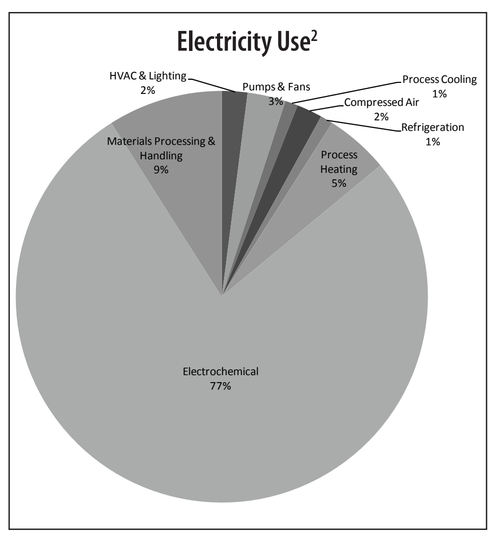
Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

Estimated Fuel Savings: **13%**

Estimated Electric Savings: **10%**

Energy Use Footprints





Fuel Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Furnace Optimization			
Isothermal melting technology using immersion heaters in a series of melting bays[3]		60-65%	
Reverberatory furnace improvements[4] (oxy-fuel staged combustion, and new refractories)		25%	
Stack or tower melting furnaces[5]		47%[7]	
Use waste heat from hot combustion gases to preheat combustion air		2.5%	
Use waste heat to produce steam to drive a steam turbine generator		7.4%	
Adjust burners for efficient operations		3.7%	
Replace fossil fuel equipment with electrical equipment[6]		5.9%	
TOTAL FUEL SAVINGS ESTIMATE			**13%**

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Reduce compressed air pressure to minimum required	< 1 year	0.3%	
Compressor - upgrade controls, install common header, reduce pressure, eliminate uses, close lines, eliminate leaks	< 1 year	3.9%	
Eliminate leaks in inert gas and compressed air lines/valves	< 1 year	1.5%	
Utilize energy-efficient belts and other improved mechanisms	< 1 year	0.3%	
Facility Improvements			
Utilize daylight whenever possible in lieu of artificial light	< 1 year	0.6%	
Install occupancy sensors	1 year	1.0%	
Utilize higher efficiency lamps and/or ballasts	< 1 year	4.4%	
Facility HVAC improvements, install vinyl strip, air curtains, etc, insulate glazing, walls, ceilings, and roof	1 year	7.7%	
Lighting improvements- turn off, occupancy sensors, lower fixtures, skylights, better efficiencies, etc.	1 year	0.78%	
Use more efficient light source	< 1 year	1.0%	
TOTAL ELECTRICAL SAVINGS ESTIMATE			**10%**

References

1 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/assessments.php

2 DOE Industrial Technologies Program Manufacturing energy and carbon footprints. http://www1.eere.energy.gov/industry/pdfs/aluminum_footprint.pdf, Manufacturing Energy and Carbon Footprint Sector: Alumina and Aluminum (NAICS 3313), page 2. NOTE: This footprint identifies NAICS 3313 manufacturing processes which include alumina and primary processing and some extrusion processes otherwise seen in the non-ferrous sub-sector. However, it is reasonable approximation of the non-ferrous brass and bronze casting industry energy use for this sub-sector.

3 Various citations, http://www1.eere.energy.gov/industry/aluminum/pdfs/itm.pdf http://www.apogeetechinc.com/apogeeadvancedheating.htm, http://apps1.eere.energy.gov/industry/bestpractices/energymatters/articles.cfm/article_id=271

4 DOE ITP, "Improving Energy Efficiency in Aluminum Melting" project fact sheet, July 2001.

5 "Energy-Efficient Stack Melter for Aluminum Die Cast", NYSERDA, February 24, 2006, http://www.nyserda.org/programs/industry/lexington_die.asp. Also "High-Productivity Aluminum Melting . . . that offers High Quality, too" Foundry Management and Technology, December 13, 2007, www.foundrymag.com/classes/article/article-draw.aspx?HBC=frontpage&CID=77106.

6 IAC, http://iac.rutgers.edu/database/findassessment.php?ID=UD0742

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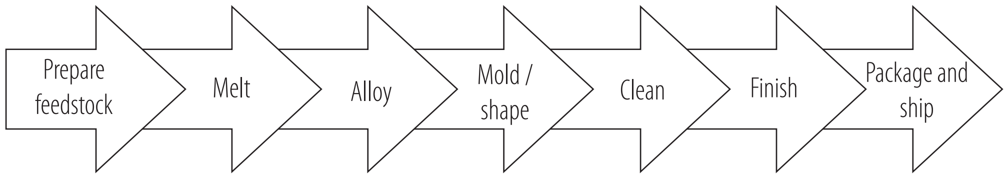
Steel Products

Sub-sector Description

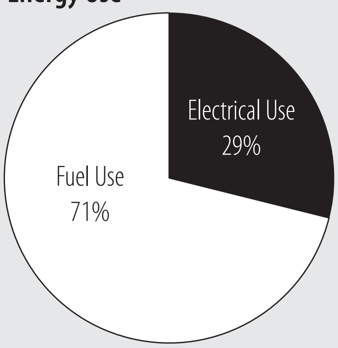
Facilities in this sub-sector are engaged in manufacturing steel investment castings or steel castings (non-investment). Investment molds are formed by covering a wax shape with a refractory slurry. After the refractory slurry hardens, the wax is melted, leaving a seamless mold. Investment molds provide highly detailed, consistent castings. Facilities in this industry purchase steel made in other facilities to manufacture products.

Facility Type	SIC	NAICS		Facility Type	SIC	NAICS
Steel investment foundries	3324	331512		Steel foundries	3325	331513

Process Information



Energy Use[1]



Benchmarks

Thermal and electrical benchmarks were unable to be reliably derived from facility-specific energy use, sales, employee numbers, and area data. For more information about the benchmarking study that MnTAP conducted and how to determine if your facility may have energy efficiency opportunities remaining, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

Savings Potential

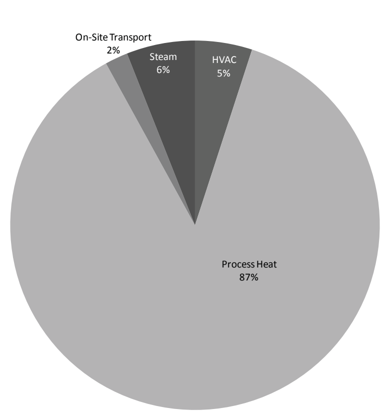
Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

Estimated Fuel Savings: 20%

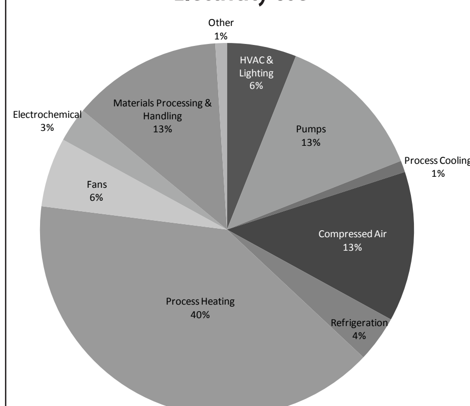
Estimated Electric Savings: 15%

Energy Use Footprints

Fuel Use[2]



Electricity Use[2]



Fuel Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Fired Heater Optimization			
Near net shape/strip casting[3]	< 1 year	90%	
Analyze flue gas for proper air/fuel ratio[4]	< 1 year	27%	
Use waste heat from hot flue gases to preheat combustion air[5,6]	1-2 years	18-21%	
Preheat combustion air with waste heat[7]	< 1 year	11%	
Use heat in flue gases to preheat products or materials, including scrap[8]	1-2 years	11%	
Improve combustion control capability[9]	2-3 years	17%	
Recover waste heat from equipment[10]	< 1 year	17%	
TOTAL FUEL SAVINGS ESTIMATE			**20%**

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Existing furnace optimization - maintenance and repair of refractory and closures, heat recovery where appropriate		15.4%	
Compressor - upgrade controls, install common header, reduce pressure, eliminate uses, close lines, eliminate leaks		1.5%	
Turn off furnace cooling tower fans and pumps after furnace has cooled		6.4%	
Turn off shakeout dust collector when not in use		5.8%	
TOTAL ELECTRICAL SAVINGS ESTIMATE			**15%**

References

1 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/assessments.php

2 DOE Industrial Technologies Program Manufacturing Energy and Carbon Footprints, http://www1.eere.energy.gov/industry/pdfs/steel_footprint.pdf, Sector: iron and steel (NAICS 3311, 3312), page 2.

3 LBNL Energy Analysis Department, "Emerging Energy-Efficient Technologies in Industry: Case Studies of Selected Technologies", May 2004, http://ies.lbl.gov/iespubs/54828.pdf, pages 4-9.

4 http://iac.rutgers.edu/database/findassessment.php?ID=UM0326

5 http://iac.rutgers.edu/database/findassessment.php?ID=UM0189

6 http://iac.rutgers.edu/database/findassessment.php?ID=UA0027

7 http://iac.rutgers.edu/database/findassessment.php?ID=MS0191

8 http://iac.rutgers.edu/database/findassessment.php?ID=SD0280

9 http://iac.rutgers.edu/database/findassessment.php?ID=MA0538

10 http://iac.rutgers.edu/database/findassessment.php?ID=UM0330

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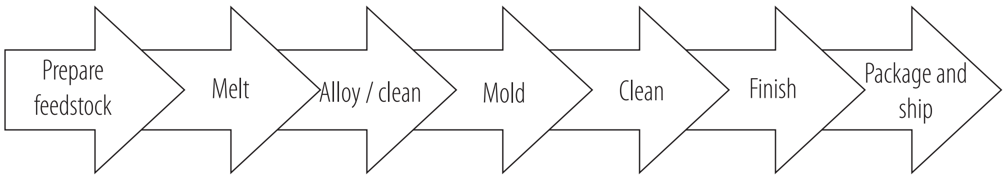
Iron Operations

Sub-sector Description

Facilities in this sub-sector pour molten pig iron and iron scrap into molds to manufacture castings such as cast iron man-hole covers, cast iron pipe, or cast iron skillets. Facilities in this industry purchase iron made in other establishments.

Facility Type	SIC	NAICS		Facility Type	SIC	NAICS
Grey iron castings	3321	331511		Malleable iron foundries	3322	331511

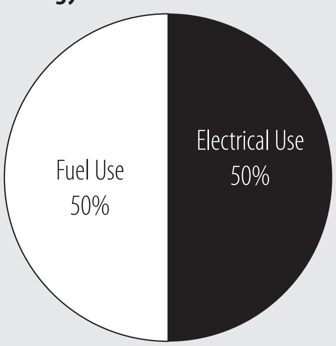
Process Information



Benchmarks

Thermal and electrical benchmarks were unable to be reliably derived from facility-specific energy use, sales, employee numbers, and area data. For more information about the benchmarking study that MnTAP conducted and how to determine if your facility may have energy efficiency opportunities remaining, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

Energy Use[1]



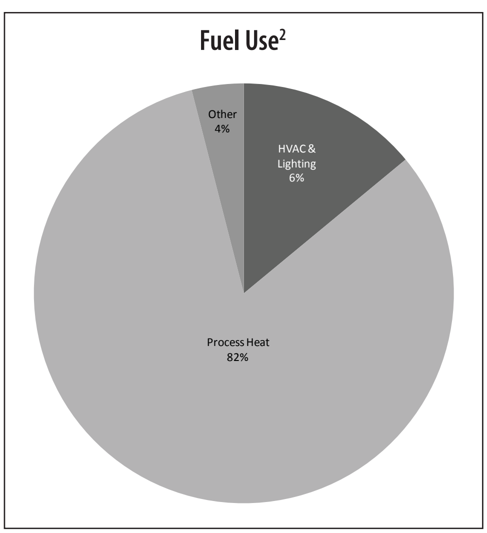
Savings Potential

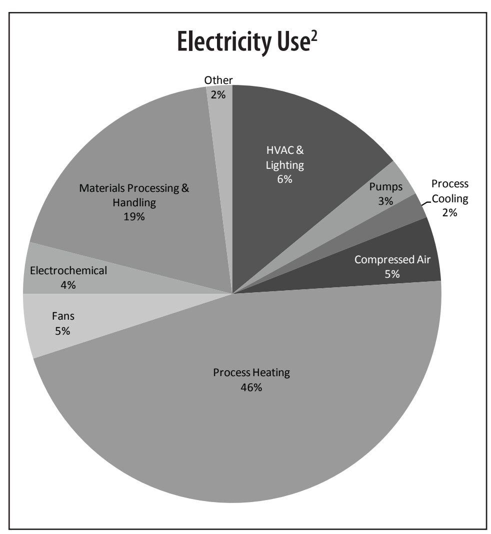
Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

Estimated Fuel Savings: 17%

Estimated Electric Savings: 20%

Energy Use Footprints





Fuel Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Fired Heater Optimization			
Air-to-air heat exchanger for preheating combustion gas for metal charge heating[3]	3-5 years	Unknown	
Relocate equipment to more efficient location[4]	< 1 year	14%	
Improve combustion control capability[4]	< 1 year	14%	
Adjust burners for efficient operation[5]	< 1 year	21%	
Use waste heat from hot flue gases to preheat combustion air[6]	< 1 year	36%	
Recover waste heat from equipment[7]	< 1 year	20%	
Use waste heat from flue gases to heat space conditioning air and cover open vessels[8]	2 years	30%	
Use heat in flue gases to preheat products or materials (like scrap)[8]			
TOTAL FUEL SAVINGS ESTIMATE			**17%**

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Insulate bare equipment	< 1 year	1.2%	
Increase insulation thickness	< 1 year	0.9%	
Utilize energy-efficient belts and other improved mechanisms	< 1 year	0.3%	
Use most efficient type of electric motors	3 years	1.1%	
Use multiple speed motors or ASD for variable pump, blower and compressor loads	3 years	2.2%	
Use ASD to replace motor-generator set, throttling system, or mechanical drives	1 year	0.3-0.9%	
Install compressor air intakes in coolest locations	< 1 year	1.0%	
Upgrade controls on compressors	< 1 year	3.2%	
Use / purchase optimum sized compressor	< 1 year	2.3%	
Reduce the pressure of compressed air to the minimum required	< 1 year	1.0%	
Eliminate or reduce compressed air used for cooling, agitating liquids, moving product, or drying	< 1 year	3.7%	
Eliminate leaks in inert gas and compressed air lines/ valves	< 1 year	2.2%	
Use synthetic lubricant	< 1 year	2.0%	
Turn off equipment when not in use	< 1 year	2.0%	
Facility Improvements			
Install occupancy sensors	1 year	0.8%	
Utilize higher efficiency lamps and/or ballasts	3 years	0.8%	
Use more efficient light source	1-2 years	1.7%	
TOTAL ELECTRICAL SAVINGS ESTIMATE			**20%**

References

1 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/assessments.php
2 DOE Industrial Technologies Program Manufacturing Energy and Carbon Footprints http://www1.eere.energy.gov/industry/pdfs/foundries_footprint.pdf, Manufacturing Energy and Carbon Footprint Sector: Foundries (NAICS 3315), page 2.
3 Focus on Energy case study, "Heat Recovery System Boosts Product Output, Reduces Energy Costs for Primary Metals Business, http://www.focusonenergy.com/files/Document_Management_System/Business_Programs/B_GI_MKCS_MotorCastings.pdf.
4 http://iac.rutgers.edu/database/findassessment.php?ID=IA0428
5 http://iac.rutgers.edu/database/findassessment.php?ID=MI0016
6 http://iac.rutgers.edu/database/findassessment.php?ID=UA0025
7 http://iac.rutgers.edu/database/findassessment.php?ID=IA0432
8 http://iac.rutgers.edu/database/findassessment.php?ID=ND0346

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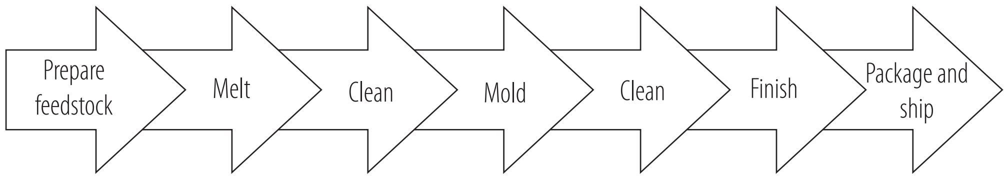
Aluminum Operations

Sub-sector Description

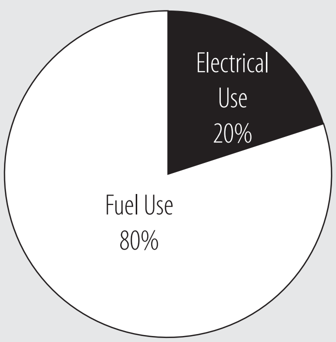
This sub-sector includes facilities that handle aluminum in a variety of ways: refining, recovering aluminum from scrap or dross, alloying purchased aluminum, manufacturing aluminum primary forms, or producing products from aluminum through casting processes.

Facility Type	SIC	NAICS		Facility Type	SIC	NAICS
Aluminum foundries	3365	331524		Aluminum die casting	3363	331521
Aluminum smelting (secondary)	3341	331314		Primary aluminum	3334	331312

Process Information



Energy Use[1]



Benchmarks

The following thermal and/or electrical benchmarks were derived from facility-specific energy use, employee numbers, and area data for the facilities that MnTAP analyzed. These benchmarks can be used to predict how efficient your facility is in comparison to peer facilities. If your facility's energy use is less efficient than your peers, there may be energy conservation opportunities available. The benchmarks included have been tested for reliability; however, they should be used with some caution. For more information on the benchmarking study including how to use the benchmarks, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

	Most efficient 25%	More efficient 25%	Less efficient 25%	Least efficient 25%
kWh/employee	< 20,734	20,734 - 32,105	32,105 - 49,713	> 49,713
therms/square feet	< 4.80	4.80 - 7.17	7.17 - 10.71	> 10.71
therms/employee	< 2,615	2,615 - 3,445	3,445 - 4,537	> 4,537

Savings Potential

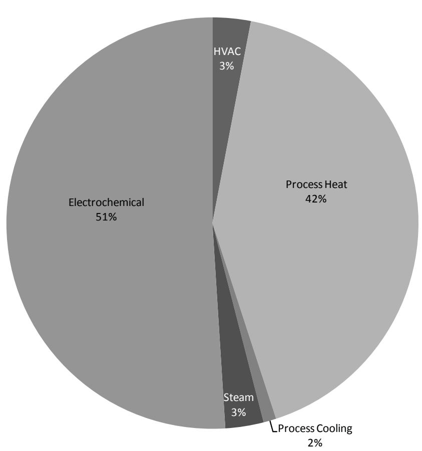
Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

Estimated Fuel Savings: **14%**

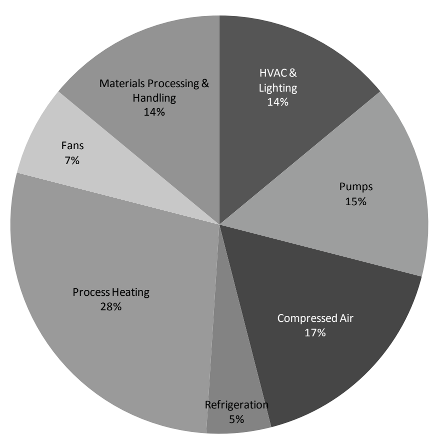
Estimated Electric Savings: **19%**

Energy Use Footprints

Fuel Use[2]



Electricity Use[2]



Fuel Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Heat Optimization			
Reverberatory furnace improvements (oxy-fuel staged combustion, and new refractories)[3]		25%	
Iso thermal melting using immersion heaters in a series of melting bays[4]		60-65%	
Stack or tower melting furnaces	3 years	47%[5,6,7]	
Improve combustion control capability[8]	< 1 year	2-39%	
Re-size charging openings or add a movable door on equipment	< 1 year	3.9%	
Use waste heat from hot flue gases to preheat combustion air[9]	< 2 years	2-29%	
Insulate bare equipment and increase insulation thickness	< 1 year	0.6-3%	
Use heat wheel or other heat exchanger to cross exchange building exhaust air with makeup air[10]	< 1 year	2.7%	
Cover open crucibles and ladles	< 1 year	2.0%	
Analyze fuel gas for proper air/fuel ratio[11]			
Facility Improvements			
Use waste heat from flue gases to heat space conditioning air	< 1 year	2.0%	
Recover heat from air compressor	< 1 year	4.6%	
TOTAL FUEL SAVINGS ESTIMATE			**14%**

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Insulate bare equipment	< 1 year	2.0%	
Use optimum thickness insulation	< 1 year	4.3%	
Utilize energy-efficient belts and other improved mechanisms	< 1 year	5.6%	
Use most efficient type of electric motors	2-3 years	6.4%	
Use multiple speed motors or ASD for variable pump, blower and compressor loads	< 2 years	3.8%	
Compressor - upgrade controls, install common header, reduce pressure, eliminate uses, close lines, eliminate leaks	< 1 year	3.9%	
Facility Improvements			
Facility HVAC improvements, install vinyl strip, air curtains, etc, insulate glazing, walls, ceilings, and roof	1 year	7.7%	
Lighting improvements- turn off, occupancy sensors, lower fixtures, skylights, better efficiencies, etc.	1 year	0.78%	
TOTAL ELECTRICAL SAVINGS ESTIMATE			**19%**

References

1 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/assessments.php

2 DOE Industrial Technologies Program Manufacturing Energy and Carbon Footprints, http://www1.eere.energy.gov/industry/pdfs/aluminum_footprint.pdf, Sector: alumina and aluminum (NAICS 3313), page 2. NOTE: This footprint identifies NAICS 3313 manufacturing processes which include alumina and primary processing and some extrusion processes otherwise seen in the non-ferrous sub-sector. However, it is reasonable approximation of the aluminum industry energy use for this sub-sector in its emphasis on fuel energy use.

3 DOE ITP. "Improving Energy Efficiency in Aluminum Melting." July 2001.

4 http://www1.eere.energy.gov/industry/aluminum/pdfs/itm.pdf; http://www.apogeetechinc.com/apogee-advancedheating.htm; http://apps1.eere.energy.gov/industry/bestpractices/energymatters/articles.cfm/article_id=271

5 "Energy-Efficient Stack Melter for Aluminum Die Cast." NYSERDA. February 24, 2006. http://www.nyserda.org/programs/industry/lexington_die.asp.

6 "High-Productivity Aluminum Melting . . . that offers High Quality, too" Foundry Management and Technology, December 13, 2007,

7 www.foundrymag.com/classes/article/articledraw.aspx?HBC=frontpage&CID=77106.

8 IAC http://iac.rutgers.edu/database/findassessment.php?ID=WV0190

9 IAC http://iac.rutgers.edu/database/findassessment.php?ID=WI0519

10 IAC http://iac.rutgers.edu/database/findassessment.php?ID=UM0174

11 IAC http://iac.rutgers.edu/database/findassessment.php?ID=UD0726

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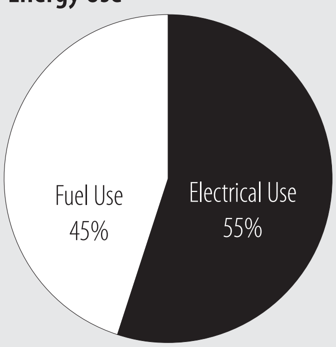
Appendix E: Printing Sub-Sector Sheets

Web-fed Heatset Printers

Sub-sector Description

The web-fed heatset printing sub-sector includes all printing methods which require natural gas fired air drying such as web-fed heat set lithography, gravure, flexography, and screen printing. The facilities in the sub-sector are characterized as large, and having long-run print jobs with higher volumes of output and faster production speeds requiring the use of dryers.

Energy Use[2]



Savings Potential

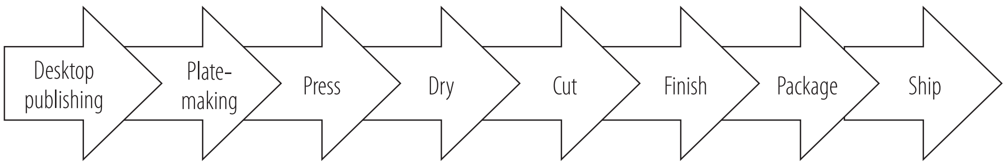
Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

Estimated Fuel Savings: 14%

Estimated Electric Savings: 15%

Facility Type	SIC	NAICS		Facility Type	SIC	NAICS
Lithographic commercial printing	2752	323110		Book publishing	2732	323117
Gravure commercial printing	2754	323111		Miscellaneous publishing	2759	323119
Envelopes	2677	322233		Manifold business forms	2761	323116
Blankbooks and looseleaf binders	2782	323118				

Process Information

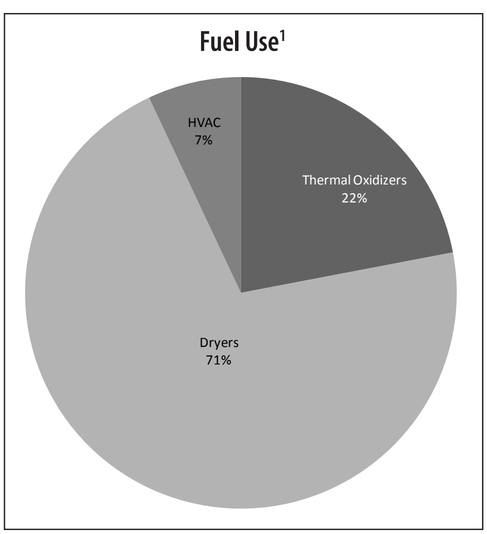


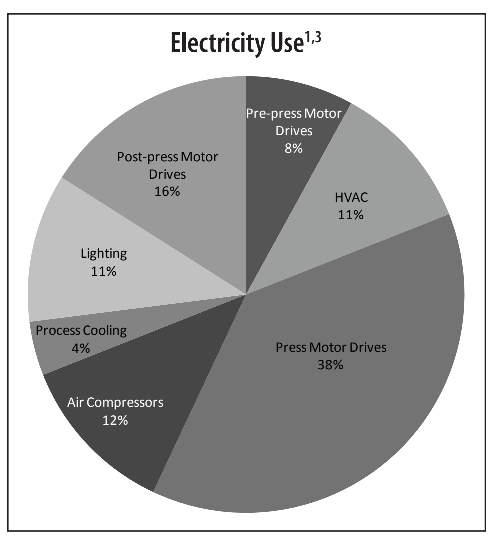
Benchmarks

The following thermal and/or electrical benchmarks were derived from facility-specific energy use, employee numbers, and area data for the facilities that MnTAP analyzed. These benchmarks can be used to predict how efficient your facility is in comparison to peer facilities. If your facility's energy use is less efficient than your peers, there may be energy conservation opportunities available. The benchmarks included have been tested for reliability; however, they should be used with some caution. For more information on the benchmarking study including how to use the benchmarks, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

	Most efficient 25%	More efficient 25%	Less efficient 25%	Least efficient 25%
kWh/employee	< 6,635	6,635 - 10,085	10,085 - 15,329	> 15,329
therms/employee	< 454	454 - 982	982 - 2,121	> 2,121

Energy Use Footprints





Fuel Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Heat Optimization			
Replace recuperative type thermal oxidizer with either option A or B			
A: Replace recuperative type thermal oxidizer with regenerative type[4,5,6]	2-5 years	3-8%	
B: Replace older regenerative thermal oxidizer with high efficiency RTO[4,5,6] *and retrofit RTO with catalyst to make it an RCO*[7]	2-5 years	1-6%	
Replace obsolete dryers with more efficient ones[8]	> 4 years	4-22%	
Recover heat from dryer exhaust[9,10]	< 2 years	6-30%	
Integrate dryer and RTO	> 4 years		
Recover heat from dryer or RTO	< 1 year		
Set dryer controls to match ink load	< 1 year		
Facility HVAC Improvements			
Lower space heating temperature during the winter season[11]	< 1 year	0-1%	
Use radiant heater for spot heating[12]	< 2 years	0-2%	
Install thermostats or timers[13]	< 1 year	0-5%	
TOTAL FUEL SAVINGS ESTIMATE			**14%**

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Air compressor improvements[14]	1-2 years	1-5%	
Repair leaks, reduce system pressure, decrease supply restrictions, increase storage, eliminate artificial demand and inappropriate uses (cooling, agitating liquids, moving product, drying, etc.), use electrically powered tools or blowers, maintain or replace filters, place air intake in coolest location			
Motors improvements[15]	2-5 years	3-11%	
Install ASDs, install premium efficiency motors, size motors for peak operating efficiency, eliminate voltage unbalance, utilize energy efficient belts, maintain proper shaft alignment, avoid rewinding motors more than twice			
Pump system optimization [16]	2-5 years	0-2%	
Eliminate dampers, throttles, or flow restrictions to reduce flow, turn off when not in use, optimize piping configuration for efficiency, maintain and use most efficient impeller type for application			
Facility Improvements			
Lighting (upgrade, use controls, use occupancy sensors)[17]	< 1 year	2-7%	
TOTAL ELECTRIC SAVINGS ESTIMATE			**15%**

References

1. "Best Practice Guide No. 6: Environmental Considerations". The Web Offset Champion Group. 2007.
2. IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/assessments.php (191 facilities)
3. "Electricity Use in the Printing Industry". Electronic Power Research Institute Ctr. for Materials Fab. 1994.
4. "Oxidizing Emissions." Industrial Paint & Powder 82 (2006): 35-39.
5. "RTO Innovation." Pollution Engineering 39 (2007): 50-54.
6. "Energy Management at Hess Print Solutions." GATFWorld. April 2008.
7. "Improve Catalytic Oxidizer Operation." Chemical Engineering Progress 103 (2007): 47.
8. IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=SD0043
9. IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=MA0605
10. IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=UD0778
11. IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=ST0010
12. IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=NV0123
13. IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=UL0177
14. http://www1.eere.energy.gov/industry/bestpractices/pdfs/compressed_air_sourcebook.pdf
15. http://www1.eere.energy.gov/industry/bestpractices/motors.html
16. http://www.pumpsystemsmatter.org/content_detail.aspx?id=372
17. http://www.aceee.org/press/op-eds/op-ed5.htm

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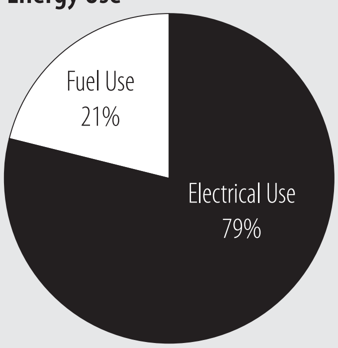
Non-Heatset Printers

Sub-sector Description

Printing operations across the non-heatset printing sub-sector vary widely among facilities, but in general have some of the same energy-consuming components including press motor drives, air compressors, and lighting. The electrical use footprint for this sub-sector is very similar to the other printing operations, while the gas use footprint is markedly different from heatset printing.

Energy Use[1]



Savings Potential

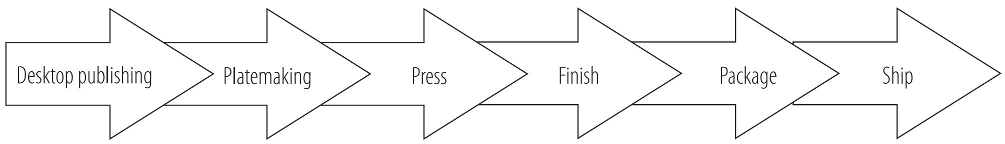
Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

Estimated Fuel Savings: 11%

Estimated Electric Savings: 12%

Facility Type	SIC	NAICS		Facility Type	SIC	NAICS
Lithographic commercial printing	2752	323110		Book publishing/printing	2732	323117
Gravure commercial printing	2754	323111		Coated and laminated paper	2672	322222
Envelopes	2677	322232		Manifold business forms	2761	323116
Packaging paper	2671	322221		Stationery	2678	322233
Greeting cards	2752	323110		Commercial printing, other	2759	323119
Newspaper & periodical printing	2752	323110		Book printing	2732	323117

Process Information



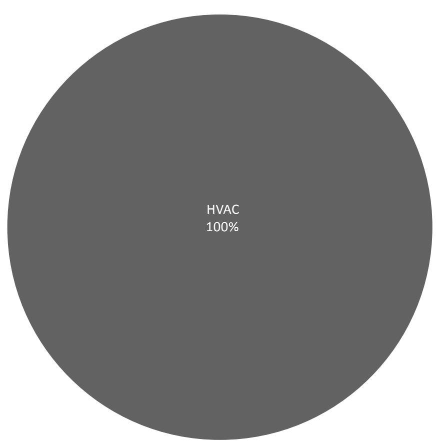
Benchmarks

The following thermal and/or electrical benchmarks were derived from facility-specific energy use, employee numbers, and area data for the facilities that MnTAP analyzed. These benchmarks can be used to predict how efficient your facility is in comparison to peer facilities. If your facility's energy use is less efficient than your peers, there may be energy conservation opportunities available. The benchmarks included have been tested for reliability; however, they should be used with some caution. For more information on the benchmarking study including how to use the benchmarks, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

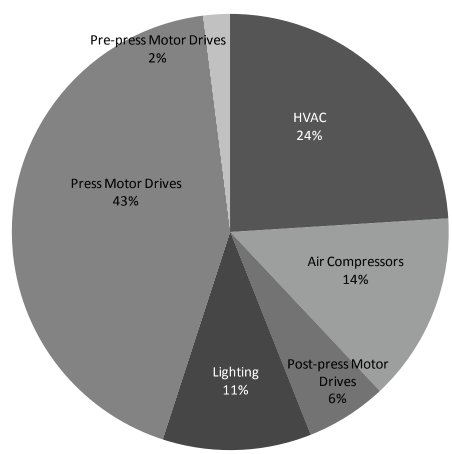
	Most efficient 25%	More efficient 25%	Less efficient 25%	Least efficient 25%
kWh/square feet	< 8	8 - 15	15 - 27	> 27
kWh/employee	< 4,566	4,566 - 8,103	8,103 - 14,378	> 14,378
therms/square feet	< 0.27	0.27 - 0.37	0.37 - 0.51	> 0.51

Energy Use Footprints

Fuel Use[1,2]



Electricity Use[1,2]



Fuel Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Facility HVAC Improvements			
Lower temperature during heating season[4]	< 1 year	0-5%	
Use radiant heat for spot heating[5]	< 1 year	0-20%	
Install programmable thermostats or timers[6]	< 1 year	0-10%	
Humidification System Improvements			
Replace steam humidification system with high-pressure fog humidification system	< 2 years		
TOTAL FUEL SAVINGS ESTIMATE			**15%**

Electricity Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Air Compressor Improvements (repair leaks, reduce pressure, artificial demand, and inappropriate use, heat recovery, filters, cool intake air, etc.)[7]	1-2 years	2-6%	
Repair leaks, reduce system pressure, decrease supply restrictions, increase storage, eliminate artificial demand and inappropriate uses (cooling, agitating liquids, moving product, drying, etc.), use electrically powered tools or blowers instead of air tools or nozzles, maintain or replace filters, place air intake in coolest location			
Motors improvements (install ASDs, install premium efficiency motors, eliminate voltage unbalance, general maintenance of belts, shaft alignment)[8]	2-5 years	2-10%	
Install ASDs, install premium efficiency motors, size motors for peak operating efficiency, eliminate voltage unbalance, utilize energy efficient belts, maintain proper shaft alignment, avoid rewinding motors more than twice			
Facility Improvements			
Lighting (upgrade, use controls, use occupancy sensors)[9]	< 1 year	2-5%	
TOTAL ELECTRIC SAVINGS ESTIMATE			**15%**

References

1 IAC Industrial Assessments. DOE. http://iac.rutgers.edu/database/assessments.php (194 facilities)
2 "Electricity Use in the Printing Industry" June 2004. Prepared by Energetics Inc, Columbia Maryland.
4 IAC Industrial Assessments; DOE, iac.rutgers.edu/database/findassessment.php?ID=ST0010
5 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=NV0123
6 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=UL0177
7 http://www1.eere.energy.gov/industry/bestpractices/pdfs/compressed_air_sourcebook.pdf
8 http://www1.eere.energy.gov/industry/bestpractices/motors.html
9 http://www.aceee.org/press/op-eds/op-ed5.htm

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Appendix F: Industrial Drying Sub-Sector Sheets

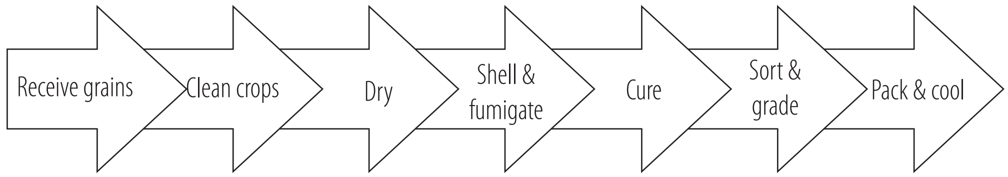
Grain Elevators with Drying Operations

Sub-sector Description

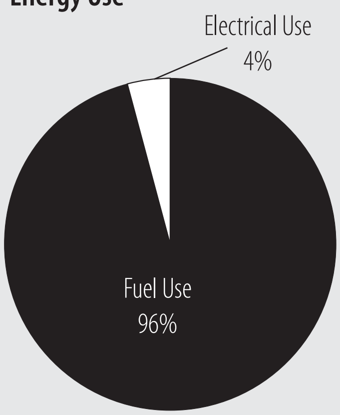
Several grain elevators perform services on crops, subsequent to their harvest, with the intent of preparing them for market or further processing. These services, for facilities in this sub-sector, include drying. Elevators engaged in drying grain use significantly more fuel energy than those that are primarily offices. Grain drying most often occurs between October and April/May each year.

Facility Type	SIC	NAICS	
Grain drying	2048	115114	

Process Information



Energy Use[1]



Benchmarks

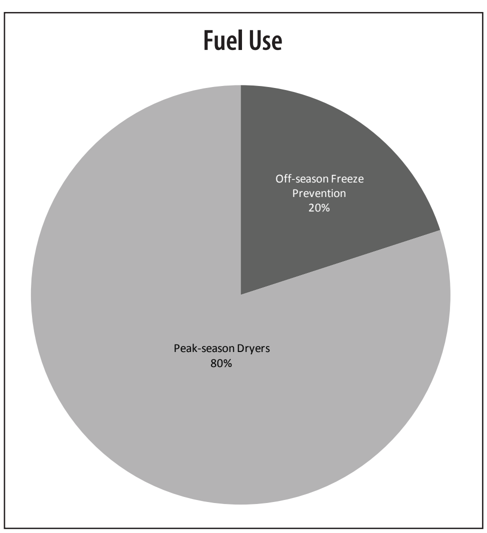
Thermal and electrical benchmarks were unable to be reliably derived from facility-specific energy use, sales, employee numbers, and area data. For more information about the benchmarking study that MnTAP conducted and how to determine if your facility may have energy efficiency opportunities remaining, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

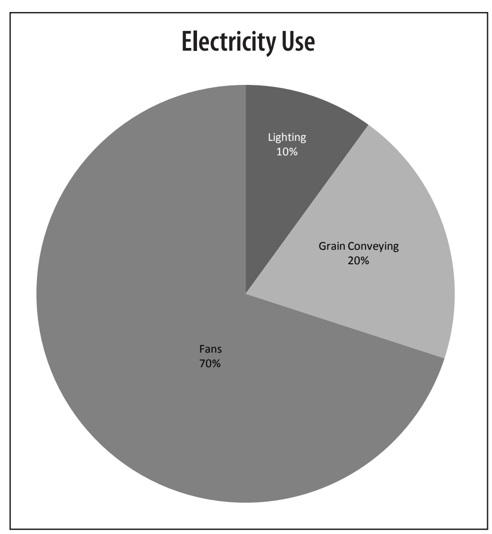
Savings Potential

Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

Estimated Fuel Savings: 30%

Energy Use Footprints





Fuel Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Routine maintenance on drying equipment[2]		0-2%	
Use flue gases to heat process or service water[3]		4-8%	
Use waste heat from hot flue gases to preheat combustion air[4]		2-4%	
Microwave livestock feed drying (beet pulp)[5]		0-3%	
Switch to combination drying[6]		4-8%	
Switch to dryeration or in-bin cooling[6]		1-3%	
Use of a stirring device in bin dryers[6]		2-4%	
Install waste heat recovery on column dryers[6]		0-2%	
TOTAL FUEL SAVINGS ESTIMATE			**30%**

Electric Savings Estimate and Opportunities

MnTAP researched and analyzed this sub-sector for a natural gas utility. Therefore, electric savings opportunities and an estimate of potential savings were not identified as part of MnTAP's industrial energy efficiency study.

References

1 "Preserving the Iowa Corn Crop: Energy Use and CO2 Release", Applied Engineering in Agriculture. VOL. 14(3):293-299. 1998.

2 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=AM0056

3 AURI AG Innovation News Apr-Jun 2009, "Pulp frequency: Scientists test energy-saving microwaves to dry beet pulp for livestock feed"

4 May be limited to smaller drying operations, such as individual farms

5 AE-701, Nov 1994, Dr. Kenneth J. Hellevang, PE. Extension Agricultural Engineer, NDSU

6 "Strategies For Managing Energy-Related Grain Drying Costs", Wisconsin Focus on Energy. 2007.

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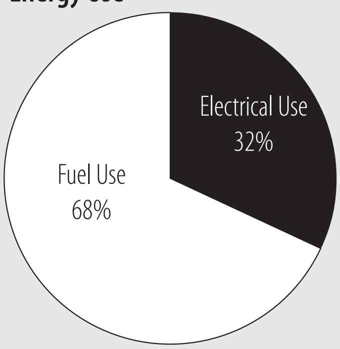
Appendix G: Wood Products Sub-Sector Sheets

Reconstituted Wood Products

Sub-sector Description

Facilities in this sub-sector manufacture reconstituted wood products. Products can include hardboard, particleboard, insulation board, medium-density fiberboard, wafer-board, and oriented strandboard.

Energy Use[1]



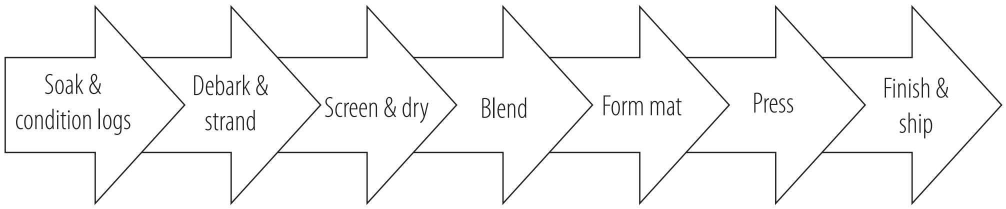
Savings Potential

Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

Estimated Electric Savings: 17%

Facility Type	SIC	NAICS	
Reconstituted wood products	2493	321219	

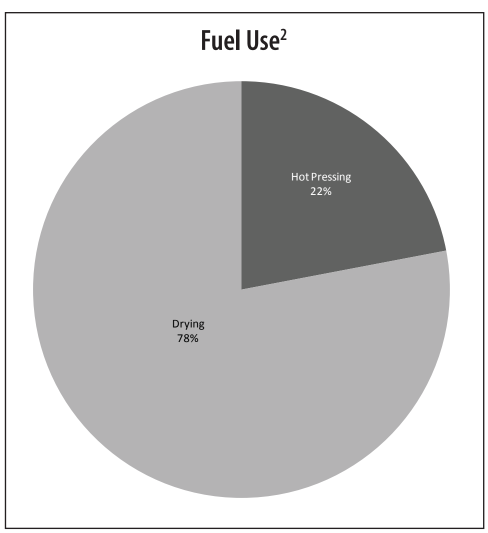
Process Information

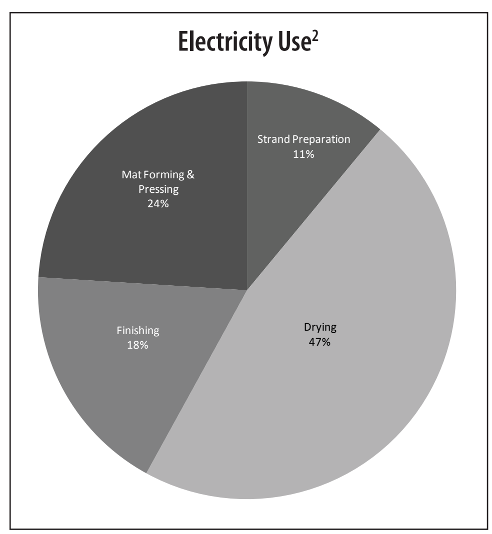


Benchmarks

Thermal and electrical benchmarks were unable to be reliably derived from facility-specific energy use, sales, employee numbers, and area data. For more information about the benchmarking study that MnTAP conducted and how to determine if your facility may have energy efficiency opportunities remaining, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

Energy Use Footprints





Fuel Savings Estimate and Opportunities

MnTAP researched and analyzed this sub-sector for an electric utility. Therefore, fuel savings opportunities and an estimate of potential savings were not identified as part of MnTAP's industrial energy efficiency study.

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Utilize energy-efficient belts and other improved mechanisms[3]	1-2 years	0-3%	
Install compressor air intakes in coolest locations[4]	< 1 year	0-1%	
Use ASDs to replace mechanical drives[5]	2 years	1-4%	
Replace hydraulic / pneumatic equipment with electric equipment[6]	< 1 year	2-5%	
Eliminate damper induced airflow restrictions, install new high efficient fan motors at lower power and reduce fan speed[7]	< 1 year	3-8%	
Install a compressor control sequencer to maximize efficiency of multiple compressor system[8]	2-5 years	1-2%	
Fix compressed air leaks to allow reduction in pressure[9]	< 1 year	1-2%	
Use more aspen and less maple and birch species (uses less electricity at waferizer)			
TOTAL ELECTRIC SAVINGS ESTIMATE			**17%**

References

1 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/
2 Adapted from "Energy Demand in Wood Processing Plants." J. Li, M. McCurdy, S. Pang. (2006)
3 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=OR0332
4 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=ME0172
5 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=DS0168
6 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=WI0183
7 "Forest Products: Improving Several Fan-Driven Systems in an Oriented Strand Board Manufacturing Facility"
8 "Energy Efficiency Opportunities in the Solid Wood Industries." Carroll-Hatch (International) LTD, January 1996.
9 "Status of Energy Use in The Wood Products Sector." J. Meil, L. Bushi, P. Garrahan, et. al., March 2009.

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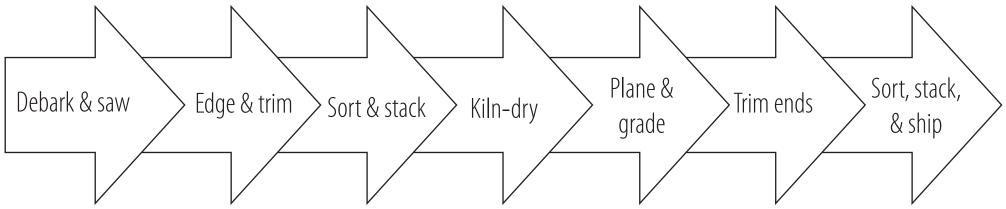
Primary Sawmills

Sub-sector Description

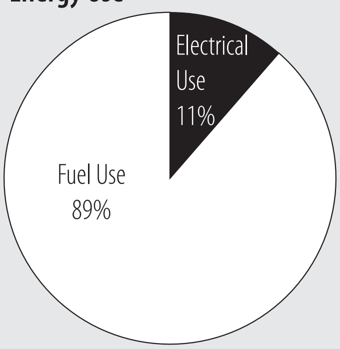
Sawmills primarily saw dimension lumber, boards, beams, timbers, poles, ties, shingles, shakes, siding, and wood chips from logs or bolts. The facilities may also plane rough lumber that is made on-site with a planing machine to achieve smoothness and uniformity of size.

Facility Type	SIC	NAICS	
Sawmills	2421	321113	

Process Information



Energy Use[1]



Benchmarks

Thermal and electrical benchmarks were unable to be reliably derived from facility-specific energy use, sales, employee numbers, and area data. For more information about the benchmarking study that MnTAP conducted and how to determine if your facility may have energy efficiency opportunities remaining, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

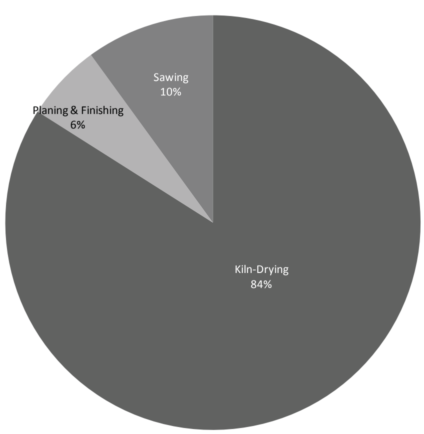
Savings Potential

Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

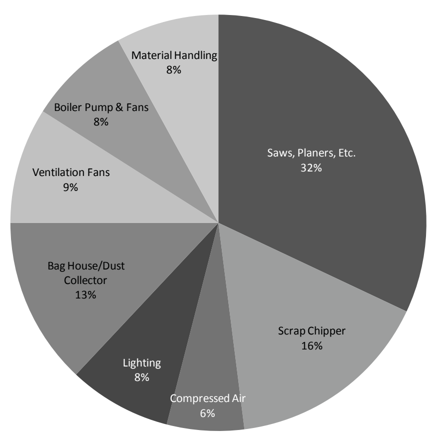
Estimated Electric Savings: 19%

Energy Use Footprints

Fuel Use[2]



Electricity Use[2]



Fuel Savings Estimate and Opportunities

MnTAP researched and analyzed this sub-sector for an electric utility. Therefore, fuel savings opportunities and an estimate of potential savings were not identified as part of MnTAP's industrial energy efficiency study.

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Utilize energy-efficient belts and other improved mechanisms[3]	1-2 years	1-3%	
Size electric motors for peak operating efficiency[4]	1-2 years	4-6%	
Use most efficient type of electric motors[5]	3.5 years	0-2%	
Use multiple speed motors or ASDs for variable pump, blower and compressor loads[6]	1-2 years	3-8%	
Install a compressor control sequencer to maximize efficiency of multiple compressor system[7]		1-3%	
Fix compressed air leaks to allow reduction in pressure[7]	< 1 year	2-3%	
TOTAL ELECTRIC SAVINGS ESTIMATE			**19%**

References

1 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/
2 "Status of Energy Use in The Wood Products Sector." J. Meil, L. Bushi, P. Garrahan, et. al., March 2009.
3 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=SU0246
4 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=OR0166
5 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=OR0463
6 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=MA0496
7 "Energy Efficiency Opportunities in the Solid Wood Industries." Carroll-Hatch (International) LTD, January 1996.

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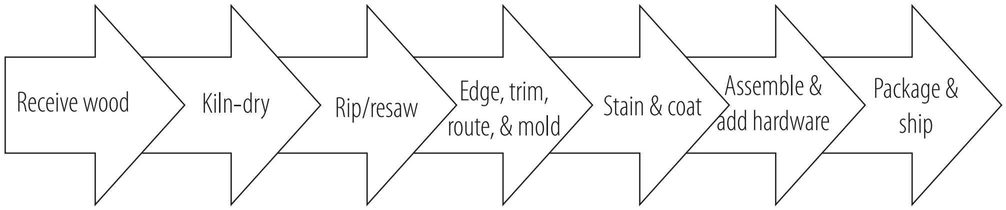
Secondary Millwork

Sub-sector Description

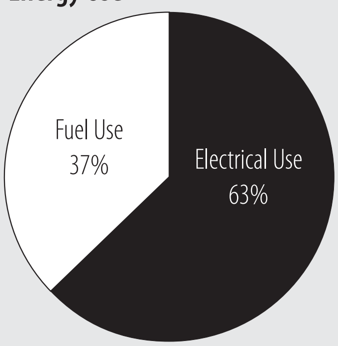
In this sub-sector, facilities manufacture a variety of wood products: hardwood and softwood cut stock and dimension stock (i.e., shapes); wood windows and doors; and other millwork including wood flooring. Equipment used in these facilities includes woodworking machinery such as jointers, planers, lathes, and routers to shape wood.

Facility Type	SIC	NAICS	
Secondary Millwork	2431	321214	

Process Information



Energy Use[1]



Benchmarks

Thermal and electrical benchmarks were unable to be reliably derived from facility-specific energy use, sales, employee numbers, and area data. For more information about the benchmarking study that MnTAP conducted and how to determine if your facility may have energy efficiency opportunities remaining, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

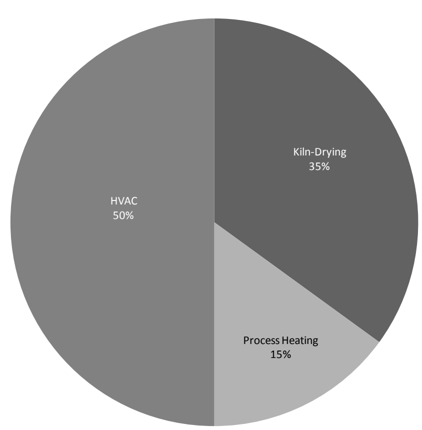
Savings Potential

Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

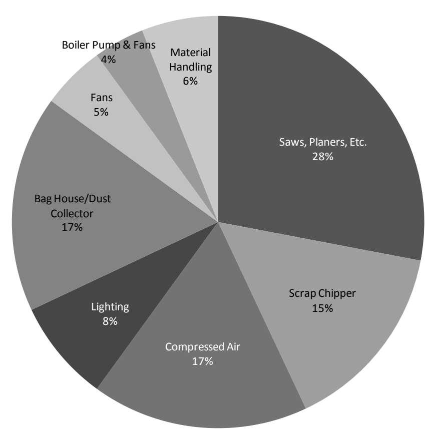
Estimated Electric Savings: 16%

Energy Use Footprints

Fuel Use[2]



Electricity Use[2]



Fuel Savings Estimate and Opportunities

MnTAP researched and analyzed this sub-sector for an electric utility. Therefore, fuel savings opportunities and an estimate of potential savings were not identified as part of MnTAP's industrial energy efficiency study.

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Utilize energy-efficient belts and other improved mechanisms[3]	1-2 years	1-2%	
Reduce the pressure of compressed air to the minimum required by repairing leaks[4]	< 1 year	4-6%	
Switch radial fan from "dirty" air side to "clean" air side backwardly inclined fan in low pressure sawdust conveying system, reduce motor size and flow[5]	1-2 years	2-4%	
Use multiple speed motors or ASDs for variable pump, blower and compressor loads[3]	1-2 years	1-3%	
Install a compressor control sequencer to maximize efficiency of multiple compressor system		1-2%	
TOTAL ELECTRIC SAVINGS ESTIMATE			**16%**

References

1 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/

2 "Reduce Energy Use at Lumber & Wood Processing Facilities". Efficiency Vermont. 2010. http://www.efficiencyvermont.com/stella/filelib/EVT_lumbertechFinal.pdf

3 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=NC0279

4 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=AS0407

5 "Energy Efficiency Opportunities in the Solid Wood Industries." Carroll-Hatch (International) LTD, January 1996.

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Appendix H: Pulp and Paper Sub-Sector Sheets

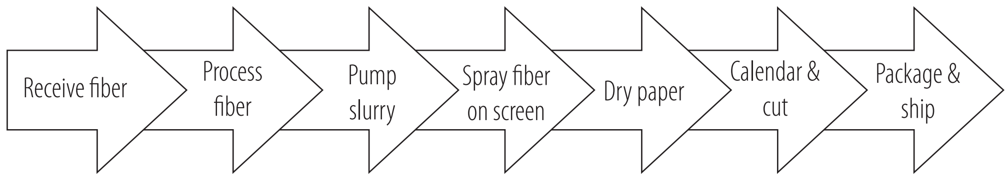
Pulp and Paper Mills

Sub-sector Description

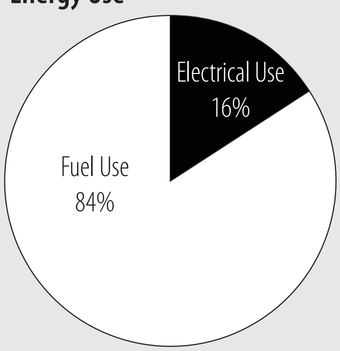
Pulp and paper mills make pulp, paper, or converted paper products. The manufacturing of pulp involves separating the cellulose fibers from other impurities in wood or used paper. The manufacturing of paper involves matting these fibers into a sheet.

Facility Type	SIC	NAICS		Facility Type	SIC	NAICS
Pulp mills	2611	322110		Paper mills	2621	322121
Paperboard mills	2679	322130				

Process Information



Energy Use[1]



Benchmarks

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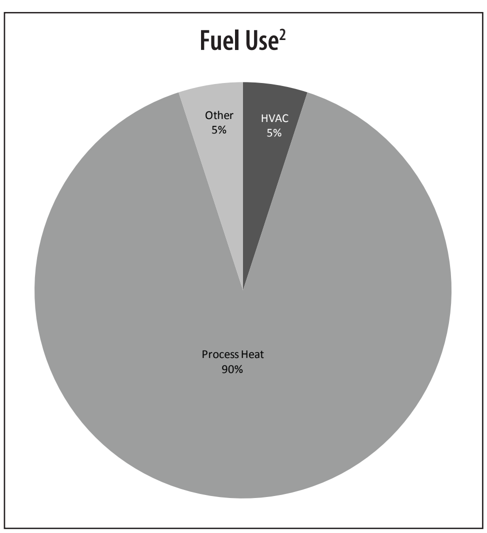
Savings Potential

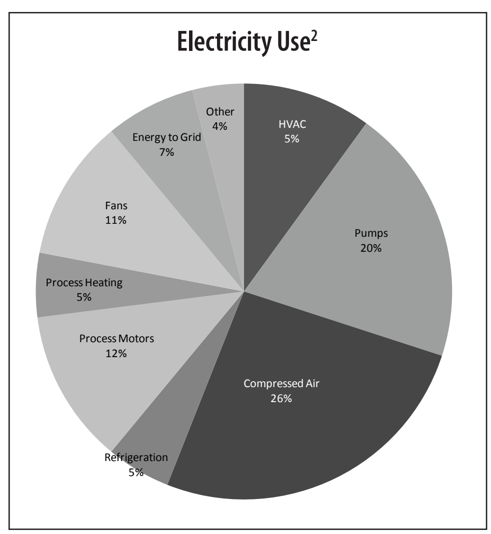
Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

Estimated Fuel Savings: 24%

Estimated Electric Savings: 12%

Energy Use Footprints





Fuel Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Heat System Optimization[3]			
Boiler O_2 tuning[4]	< 1 year	2-25%	
Insulate pipes and tanks[4]	1 year	1-15%	
Improve process measurements, control, calibration	2 years	5-10%	
Heat recovery of flue gas to preheat combustion air[5]	1-2 years	3-25%	
Heat recovery of flue gas to heat secondary operations[4,6]	1-2 years	3-25%	
Repair and eliminate steam leaks[4]	< 1 year	0.24-0.59%	
Preventative maintenance and remove boiler scaling[7]	< 1 year	1%	
Pinch analysis, balance cold and hot streams energy loads[6]	4 years	8-22%	
Press drying, impulse air, microwave, infrared, air impingement drying, steam impingement drying, and air less drying[7]	unknown	varies	
TOTAL FUEL SAVINGS ESTIMATE			**24%**

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process improvements and optimization			
Steam pressure reduction for electric generation[5]	3-4 years	0.2%	
Plant power factor improvement to reduce line resistance and improve motor operation[7]	2 years	2%	
Replace motors with soft-start or ASD supplies[5]	2 years	1.4%	
Process motor optimization & load reduction, belt improvements[7]	1-2 years	0.1-10.8%	
Properly size pumps/impellers and install pump controls to prevent dry or closed-conditions running[8]	< 1 year	1.0-3.0%	
Compressed air improvements, cold air intake, fix leaks and controls[9]	< 1 year	0.1-1%	
Combined Heat and Power (CHP) Integration[10]	unknown	varies	
Facility improvements			
Facility HVAC improvements[5]	< 1 year	0-0.1%	
Lighting improvements[11]	2 years	0.5-1%	
TOTAL ELECTRIC SAVINGS ESTIMATE			**12%**

References

1 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/
2 Adapted Source: DOE Forest Products Manufacturing Footprint, http://www1.eere.energy.gov/industry/energy_systems/pdfs/forest_footprint.pdf
3 http://www1.eere.energy.gov/industry/bestpractices/pdfs/em_proheat_seven.pdf
4 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=MS0291
5 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=WV0365
6 N. Martin, et. al., "Opportunities to Improve Energy Efficiency and Reduce Greenhouse Gas Emissions in the US Pulp and Ppaer Industry," Ernest Orlando Lawrence Berkeley National Laboratory, July 2000.
7 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=UW0030
8 "Augusta Newsprint: Paper Mill Pursues Five Projects Following Plant-Wide Energy Efficiency
9 MnTAP Intern Project Report, Boise Cascade Corporation 2007 (about 3.6%) IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=LL0249 (0.8%)
10 "Renewing Rock-Tenn: A Biomass Fuels Assessment for Rock-Tenn's Recycled Paper Mill," Green
11 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=LL0249

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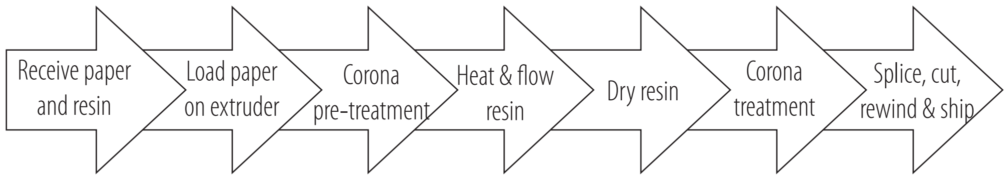
Extruding and Paper Coating

Sub-sector Description

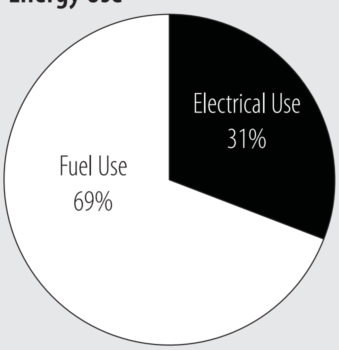
Facilities in this sub-sector cut and coat paper; cut and laminate paper and other flexible materials (except plastics film to plastics film); and laminate aluminum and other metal foils for non-packaging uses from purchased foils. These facilities purchase sheet materials and may print the products on-site.

Facility Type	SIC	NAICS		Facility Type	SIC	NAICS
Other coaters	2673	322222		Coating and laminating	2672	322221

Process Information



Energy Use[1]



Benchmarks

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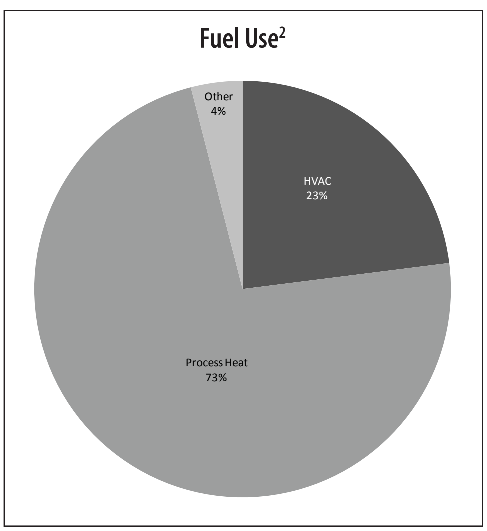
Savings Potential

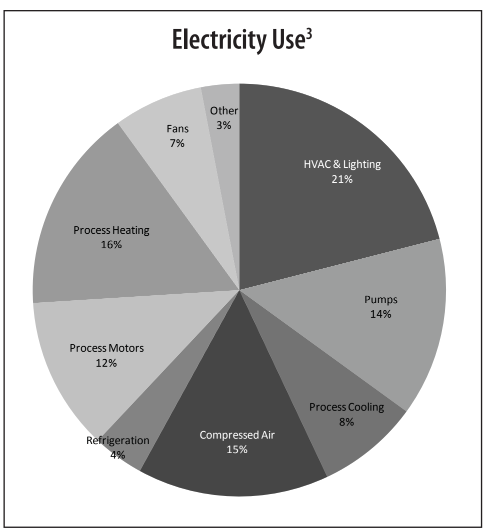
Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

Estimated Fuel Savings: 11%

Estimated Electric Savings: 12%

Energy Use Footprints





Fuel Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Heat System Optimization[2]			
Boiler O_2 tuning[4]	<1 year	1-14%	
Insulate pipes and tanks[5]	1-2 years	1-3%	
Improve process measurements, control, calibration	2 years	5-10%	
Heat recovery of flue gas to preheat combustion air[6]	2 years	1-41%	
Heat recovery from compressors and plant equipment[7]	1 year	1-54%	
Insulate extrusion equipment[8]	1-2 years	1-5%	
Facility HVAC Improvements			
Configure and operate spot heating during working hours[9]	< 1 year	1-62%	
Optimize make-up air ventilation, air recycling, reduce rate[10]	< 1 year	0.5-14.4%	
TOTAL FUEL SAVINGS ESTIMATE			**11%**

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Utilize energy-efficient belts[7]	< 1 year	0.1-13.4%	
Idle or turn of equipment when not in use, controls to shutdown[11]	< 1 year	0.1-3.4%	
Update to more efficient electric motors, NEMA[12]	3 years	0.1-4.7%	
Replace motors with soft-start or ASD supplies[13]	2-3 years	0.1-11.4%	
Insulate extrusion equipment[14]	1-2 years	1-12%	
Compressed air improvements, cold air intake, fix leaks, controls[9]	< 1 year	0.1-15.8%	
Facility Improvements			
Facility HVAC improvements[15]	< 1 year	0.1-0.4%	
Lighting improvements[16]	2 years	0.1-14%	
TOTAL ELECTRIC SAVINGS ESTIMATE			**12%**

References

1 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/assessments.php
2 "Best Practices Guide #6: Environmental Considerations", The Web Offset Champion Group, 2007.
3 "Electricity Use in the Printing Industry", Electronic Power Research Institute Center for Materials Fabrication, June 1994.
4 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=OD0121
5 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=DL0032
6 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=IA0241
7 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=WI0396
8 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=MA0602
9 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=MA0493
10 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=IA0266
11 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=SF0202
12 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=MO0113
13 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=WI0498
14 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=AM0205
15 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=IA0118
16 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=MI0127

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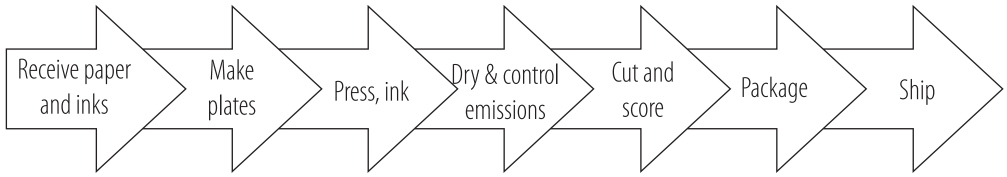
Multi-Wall Converting with Heat Set Operations

Sub-sector Description

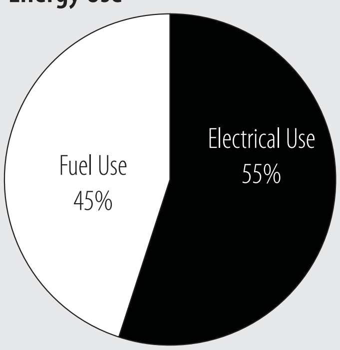
Facilities in this sub-sector manufacture corrugated and solid fiber boxes and related products from purchased paperboard. Final products include corrugated and solid fiberboard boxes, pads, partitions, display items, pallets, single face products, and corrugated sheets. Facilities in this sub-sector are set apart from other paperboard converting companies by their use of heat set operations in manufacturing their products.

Facility Type	SIC	NAICS		Facility Type	SIC	NAICS
Converted paper & paperboard	2679	32221		Folding paperboard containers	2657	322212
Corrugated box manufacturing	2653	322211				

Process Information



Energy Use[1]



Benchmarks

The following thermal and/or electrical benchmarks were derived from facility-specific energy use, employee numbers, and area data for the facilities that MnTAP analyzed. These benchmarks can be used to predict how efficient your facility is in comparison to peer facilities. If your facility's energy use is less efficient than your peers, there may be energy conservation opportunities available. The benchmarks included have been tested for reliability; however, they should be used with some caution. For more information on the benchmarking study including how to use the benchmarks, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

	Most efficient 25%	More efficient 25%	Less efficient 25%	Least efficient 25%
therms/employee	< 1,160	1,160 - 1,769	1,769 - 2,700	> 2,700

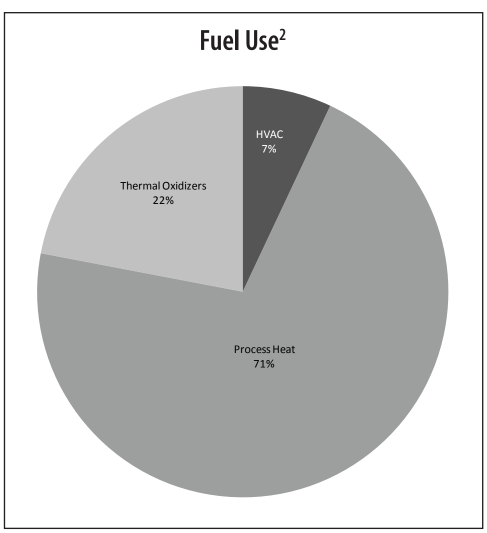
Savings Potential

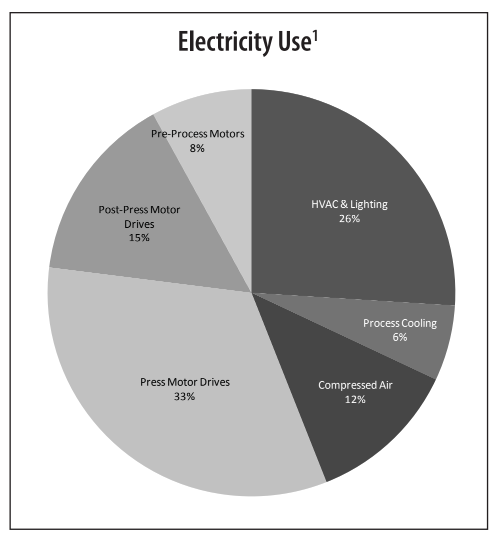
Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

Estimated Fuel Savings: 12%

Estimated Electric Savings: 12%

Energy Use Footprints





Fuel Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Heat System Optimization			
Boiler O_2 tuning[3]	< 1 year	0.5-71.9%	
Direct warm air to combustion source[4]	1-2 years	0.3-7.2%	
Insulate pipes and tanks[5]	1-2 years	0.1-62.2%	
Improve process measurements, control, and calibration[6]	2 years	0.3-13.9%	
Heat recovery of flue gas to preheat combustion air[7]	2 years	1.1-27.6%	
Heat recovery from compressors and plant equipment[8]	1 year	0.1-74.6%	
Replace recuperative or older regenerative thermal oxidizer with regenerative TO[9]	3 years	2-3%	
Install catalyst in recuperative TO to convert it to a regenerative[10]	2 years	1-3%	
Update drying technology, replace old dryers[11]	2 years	4-5%	
Insulate heat-set equipment[12]	1-2 years	0.3-44.1%	
Facility HVAC Improvements			
Configure and operate spot heating during working hours[13]	< 1 year	0.9-8.4%	
Optimize make-up air ventilation, air recycling, reduce rate[14]	1 year	3-15.3%	
Improve air circulation with forced destratification[15]	2 years	0.8-32.4%	
TOTAL FUEL SAVINGS ESTIMATE			**12%**

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Utilize energy efficient belts[16]	< 1 year	0.1-15.3%	
Idle or turn off equipment when not in use, controls to shutdown[17]	< 1 year	0.1-11.0%	
Update to more efficient electric motors, NEMA and regenerative[18]	3 years	0.1-55.1%	
Replace motors with soft-start or ASD supplies[19]	2 years	0.7-27.2%	
Utilize automated controls to operate press systems[20]	1-2 years	0.2-32.6%	
Maintain bearing lubrication, use synthetics where applicable[21]	< 1 year	0.2-2.6%	
Compressed air improvements, cold air intake, fix leaks, controls[22]	< 1 year	0.1-47.8%	
Facility Improvements			
Facility HVAC and lighting improvements[23,24]	1-2 years	0.1-56.4%	
TOTAL ELECTRIC SAVINGS ESTIMATE			**12%**

References

1 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/assessments.php
2 Adapted source: DOE Plastics and Rubber Products Footprint
3 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=DL0003
4 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=IA0090
5 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=MA0465
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14 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=NC0248
15 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=WI0277
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24 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?ID=AR0161

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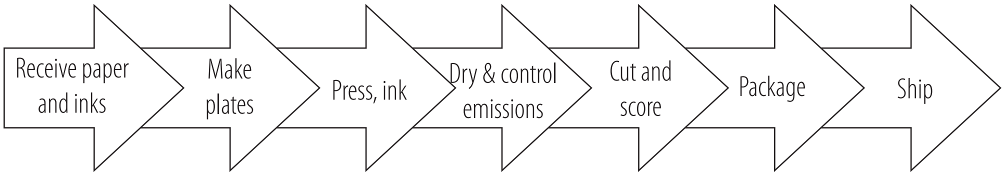
Board Converting (Non-Heat Set)

Sub-sector Description

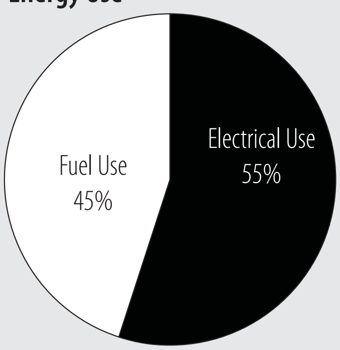
Facilities in this sub-sector manufacture corrugated and solid fiber boxes and related products from purchased paperboard. Final products include corrugated and solid fiberboard boxes, pads, partitions, display items, pallets, single face products, and corrugated sheets. Facilities in this sub-sector do not use of heat set operations for manufacturing their products.

Facility Type	SIC	NAICS		Facility Type	SIC	NAICS
Pulp/paper board converting	2621	322299		Paperboard converting	2631	322299
Converted paper/paperboard	2652	322299		Corrugated box manufacturing	2653	322211
Paper drums and tubes	2655	322214		Folding paperboard boxes	2657	322212
Paper bag manufacturing	2674	322223		Paper die-cutting	2675	322231

Process Information



Energy Use[1]



Benchmarks

The following thermal and/or electrical benchmarks were derived from facility-specific energy use, employee numbers, and area data for the facilities that MnTAP analyzed. These benchmarks can be used to predict how efficient your facility is in comparison to peer facilities. If your facility's energy use is less efficient than your peers, there may be energy conservation opportunities available. The benchmarks included have been tested for reliability; however, they should be used with some caution. For more information on the benchmarking study including how to use the benchmarks, view the report Web pages at http://www.mntap.umn.edu/resources/DOC/index.html.

	Most efficient 25%	More efficient 25%	Less efficient 25%	Least efficient 25%
kWh/square feet	< 24	24 - 37	37 - 58	> 58
kWh/employee	< 8,168	8,168 - 16,197	16,197 - 32,117	> 32,117
therms/employee	< 337	337 - 554	554 - 912	> 912

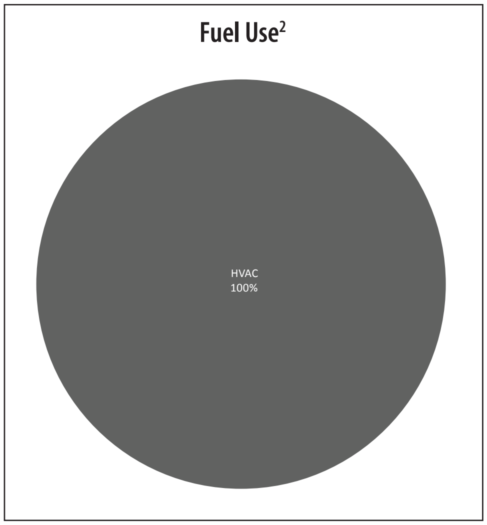
Savings Potential

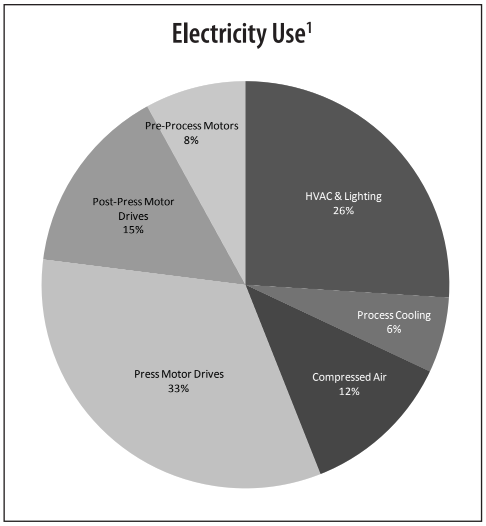
Opportunities and technologies for energy conservation were identified for facilities within this sub-sector. Industry case studies and reports of implementation were used to determine what opportunities may be available and achievable savings from those opportunities. However, additional energy conservation measures may apply to your facility. The tables on Page 2 of this summary reflect a number of energy conservation measures available for this sub-sector.

Estimated Fuel Savings: 9%

Estimated Electric Savings: 14%

Energy Use Footprints





Fuel Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Heat System Optimization[3]			
Heat recovery from compressors and plant equipment[4]	1 year	0.1-74.6%	
Facility HVAC Improvements			
Configure and operate spot heating during working hours[4]	< 1 year	0.9-8.4%	
Optimize make-up air ventilation, air recycling, reduce rate[5]	< 1 year	3.0-15.3%	
Improve air circulation with forced destratification[6]	2 years	0.8-32.4%	
TOTAL FUEL SAVINGS ESTIMATE			**9%**

Electric Savings Estimate and Opportunities

Improvement / Opportunity	Estimated Payback	Reported Savings	Overall Savings
Process Improvements and Optimization			
Utilize energy-efficient belts[7]	< 1 year	0.1-15.3%	
Idle or turn off equipment when not in use, controls to shutdown[8]	< 1 year	0.1-11.0%	
Update to more efficient electric motors, NEMA and regenerative[9]	3 years	0.1-55.1%	
Replace motors with soft-start or ASD supplies[10]	2 years	0.7-27.2%	
Utilize automated controls to operate press systems[11]	1-2 years	0.2-32.6%	
Maintain bearing lubrication, use synthetics where applicable[12]	< 1 year	0.2-2.6%	
Compressed air improvements, cold air intake, fix leaks, controls[12]	< 1 year	0.1-56.4%	
Facility Improvements			
Facility HVAC improvements[13]	< 1 year	0.1-2.5%	
Lighting improvements[14]	2 years	0.1-56.4%	
TOTAL ELECTRIC SAVINGS ESTIMATE			**14%**

References

1 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/assessments.php
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3 http://www1.eere.energy.gov/industry/bestpractices/pdfs/em_proheat_seven.pdf
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14 IAC Industrial Assessments; DOE, http://iac.rutgers.edu/database/findassessment.php?CO448

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