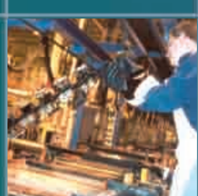
Energy Trends in Selected Manufacturing Sectors:

Opportunities and Challenges for Environmentally Preferable Energy Outcomes







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3.4 Food Manufacturing

3.4.1 Base Case Scenario

Recent Sector Trends Informing the Base Case

Value of shipments: ↑

Major fuel sources: Natural gas, electricity, coal

Current economic and energy consumption data are summarized in Table 30 on page 3-32.

Situation Assessment

Food manufacturing (NAICS 311) is a multi-billion dollar industry that transforms livestock and agricultural products into a diverse set of products for intermediate or final consumption by humans (or by animals as animal feed). Within the NAICS, industry subsectors are distinguished by the raw materials (generally of animal or vegetable origin) they process into food products. The industry is highly diversified and dominated by large-scale, capital-intensive firms, with more than 26,000 facilities across the United States.[107] Agribusiness participates in EPA's Sector Strategies Program.

From 1997 to 2004 the food manufacturing sector showed economic growth in terms of value added and total value of shipments (see Table 30). Much of the industry's energy consumption takes place in the East North Central and West North Central regions.[108]

While the food-processing sector is typically amongst the largest manufacturing energy consumers in states where the industry is located, and has the fifth-highest energy consumption of the sectors considered in this analysis, its energy intensity is relatively low (see Table 16). Still, energy is an important input cost for the industry, typically ranking third along with capital in terms of business costs; raw materials and labor are the dominant cost factors.

For food manufacturing, the most important fuels are natural gas, purchased electricity, and coal.[109] According to DOE, approximately 9 percent of the industry's electricity demand is met with onsite power systems, with the majority of that electricity (95 percent) produced in cogenerating units that also produce steam.[110]

The following eight subsectors consume approximately half of the total energy used by the food manufacturing industry: wet corn milling; beet sugar; soybean oil mills; malt beverages; meat packing; canned fruits and vegetables; frozen fruits and vegetables; and bread, cake, and related goods. It is estimated that 40 percent of the value of processed food is added through energy-intensive manufacturing. Process heating and cooling systems (steam systems, ovens, furnaces, and refrigeration units) have the greatest energy requirements in food manufacturing (over 75 percent of the sector's energy use) and are necessary to maintain food safety. Motor-driven systems (pumps, fans, conveyors, mixers, grinders, and other process equipment) represent 12 percent of the sector's energy use, and facility functions (heat, ventilation, lighting, etc.) comprise approximately 8 percent.[111] The sector also has the largest transportation demand of the sectors considered in this analysis, comprising more than 20 percent of the manufactured commodity shipping ton-miles recorded by DOT in 2002 (see Table 11).[112]

Recent fuel consumption trends (1998 to 2002) show increased coal usage, which may indicate that some companies are increasing coal consumption in response to increases in the price of natural gas.[113] (For a detailed discussion of fuel-switching and the limitations thereof, please see Section 2.2.3.) Rising energy costs are a motivator for increased energy efficiency in the food manufacturing industry. Energy ranks third among input costs, behind raw materials and labor, but is often viewed as a fixed cost. The industry may have substantial potential for energy efficiency improvement, as historically it has not taken a strategic approach to energy management, and firms often lack awareness of energy efficiency opportunities. Moreover, the margins in the food manufacturing industry are relatively thin compared to other manufacturing and processing industries; thus, the sector may be typically slower to adopt technologies and processes that require significant capital outlays.

To provide more information to the sector, a Food Industry Resource Efficiency team (FIRE) developed an energy portal for food processors through the State Technologies Advancement Collaborative (STAC) program, administered by the National Association of State Energy Officials for DOE. Other organizations, such as Efficiency Vermont and the Northwest Alliance, work toward assisting specific commodity processors in their regions with improving energy efficiency. This regional approach recognizes that food production and processing tends to be geographically distinctive: wine processing in northern California, dairy in Wisconsin, and so forth.

Table 30 summarizes current economic trend and energy consumption data originally presented in Chapter 2.

Table 30: Current economic and energy data for the food manufacturing industry

Economic Production Trends				
	Annual Change in Value Added 1997-2004	Annual Change in Value Added 2000-2004	Annual Change in Value of Shipments 1997-2004	Annual Change in Value of Shipments 2000-2004
	2.5%	2.5%	0.8%	1.8%
Energy Intensity in 2002				
	Energy Consumption per Dollar of Value Added (thousand Btu)	Energy Consumption per Dollar Value of Shipments (thousand Btu)	Energy Cost per Dollar of Value Added (share)	Energy Cost per Dollar Value of Shipments (share)
	6.0	2.6	3.3%	1.5%
Primary Fuel Inputs as Fraction of Total Energy Supply in 2002 (fuel use only)				
Natural Gas	Net Electricity	Coal	Other[qqq]	Fuel Oil
52%	21%	17%	8%	3%
Fuel-Switching Potential in 2002: Natural Gas to Alternate Fuels				
			Switchable fraction of natural gas inputs	28%
		Fuel Oil	LPG	Electricity
Fraction of natural gas inputs that could be met by alternate fuels		71%	41%	13%
Fuel-Switching Potential in 2002: Coal to Alternate Fuels				
			Switchable fraction of coal inputs	20%
		Natural Gas	LPG	Fuel Oil
Fraction of coal inputs that could be met by alternate fuels		83%	19%	13%

[qqq] "Other" fuels include waste materials used as fuel.

Expected Future Trends

In the United States, increasing demand for fresh processed foods by individual consumers and by HRI (hotel, restaurant, institutional) customers has increased energy consumption by the food manufacturing industry. Demographically, the increase in two-earner couples, increased disposable income, and an aging population are all pushing the system to deliver more ready-to-eat or fast-prepared foods. Additionally, if the next wave of food consumption entails more fresh foods, particularly more fruits and vegetables, energy utilization may increase, since reducing spoilage will require even more sophisticated and possible lengthy supply chains, cold-chain accuracy, hot house expansions, etc. AGF projects continued economic growth for the food manufacturing industry through 2020 due to increases in population and disposable income, and the fact that foreign competition is less of a limiting factor than it is for other industries.[114]

Under its reference scenario, CEF projects that energy consumption by the food manufacturing sector will increase by 19 percent from 1997 to 2020, primarily driven by continued economic growth in the sector (the value of industry output is assumed to increase at the rate of 1.2 percent per year). Energy intensity (energy consumption per dollar value of output) is expected to decrease at the slow rate of 0.5 percent per year. Consumption of all fuel types is projected to increase. No large-scale changes in the sector's fuel mix are projected, though the projected minor shift from natural gas to petroleum may be unlikely given the increases in the price of oil that have occurred since the CEF study was published. The sector will continue to remain dependent on natural gas. Supporting CEF projections, AGF predicts that overall natural gas consumption by the food manufacturing industry will increase at 0.4 percent annually through 2020.[115]

Table 31 summarizes the CEF base case projection for the food manufacturing sector. The small renewables fraction is primarily attributable to the use of bio-waste as fuel.

Table 31: CEF reference case projections for the food manufacturing industry

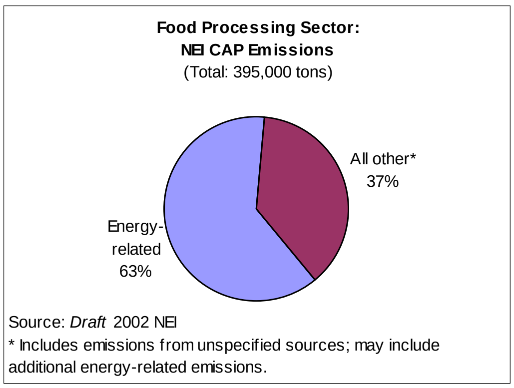
	1997 Reference Case		2020 Reference Case	
	Consumption (quadrillion Btu)	Percentage	Consumption (quadrillion Btu)	Percentage
Petroleum	0.209	17%	0.272	18%
Natural gas	0.625	50%	0.701	48%
Coal	0.183	15%	0.228	15%
Renewables	0.014	1%	0.020	1%
Delivered electricity	0.208	17%	0.251	17%
Total	1.239	100%	1.472	100%
Annual % change in energy intensity (energy consumption per dollar value of output)				-0.5%
Overall % change in energy use (1997-2020)				19%

In an effort to assess the impact of recent trends that may have affected industry energy consumption since the CEF report was produced, we also examined reference case energy consumption projections for the food manufacturing sector produced in connection with EIA's *Annual Energy Outlook 2006* (AEO 2006), which also uses the NEMS model but incorporates more recent energy and economic data.

AEO 2006 projects faster growth in the industry's value of shipments than CEF (2 percent per year) and a similar rate of decrease in energy intensity (0.6 percent per year). Overall, AEO 2006 projects that sector energy consumption will increase 24 percent from 2004 levels by 2020. The industry's energy needs will continue to be met by natural gas (54 percent of total energy inputs in 2020), purchased electricity (22 percent), and coal (17 percent). Consumption of all fuels is projected to increase, with the exception of petroleum, which is expected to decline by 6 percent over the period. The largest percentage increases in fuel consumption are for renewables (43 percent increase from 2004 to 2020), natural gas (30 percent increase), and purchased electricity (24 percent increase).

Environmental Implications

Figure 12: Food manufacturing sector: energy-related CAP emissions



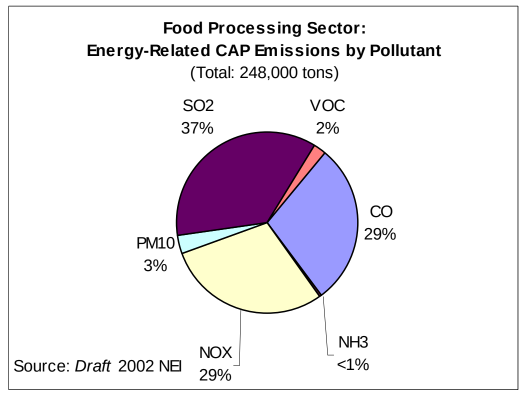
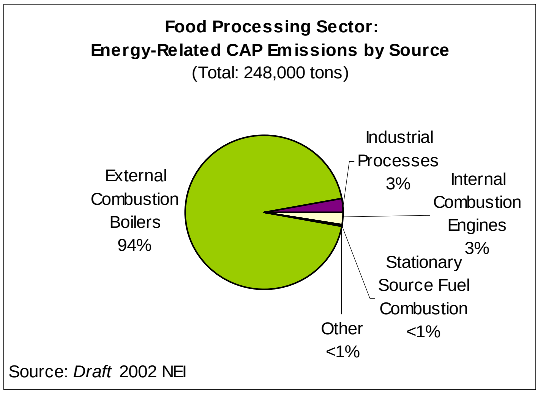


Figure 12 compares NEI data on energy-related CAP emissions with non-energy-related CAP emissions for the food manufacturing sector. According to the figure, energy-related CAP emissions comprise a relatively large fraction of total CAP emissions, in part due to the sector's substantial process heating and cooling requirements. According to MECS data (see Table 30), purchased electricity (net) meets roughly 20 percent of the sector's energy needs. As NEI data attribute emissions associated with electric power generation to the generating source rather than the purchasing entity, there are substantial energy-related CAP emissions that are not represented in NEI data for this sector.

Effects of Energy-Related CAP Emissions

SO_2 and NO_x emissions contribute to respiratory illness and may cause lung damage. Emissions also contribute to acid rain, ground-level ozone, and reduced visibility.

Figure 13: Food manufacturing sector: CAP emissions by source category and fuel usage



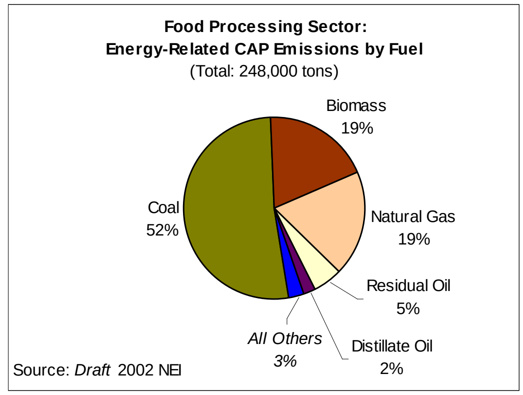


Figure 13 presents NEI data on the sources of energy-related CAP emissions shown in Figure 12. NEI data classify the majority of energy-related CAP emissions as produced by external combustion boilers. As noted previously, NEI data classifications are problematic due to reporting inconsistencies, but equipment classified under “external combustion boilers” likely includes steam systems used for process heating. Segments of the food manufacturing industry with high boiler usage include sugar, malt beverages, corn milling, and meat packing. As noted previously, more than 75 percent of the sector’s energy requirements are for process heating and cooling systems, which, according to DOE classifications include steam systems, fired systems, and cooling units. Motor-driven systems are another substantial end use of energy[116] but are primarily electric so associated emissions would not be captured in NEI.

According to NEI data shown in Figure 14, 52 percent of the sector’s energy-related CAP emissions are from coal consumption, and 19 percent are from natural gas consumption. The emissions intensity of coal is evident from this figure, as MECS data (see Table 30) report that coal comprises approximately 16 percent of the sector’s energy inputs compared with more than 50 percent for natural gas. Sulfur dioxide and nitrogen oxides (both linked to coal combustion), are fairly equal contributors to energy-related CAP emissions for the food manufacturing industry. (As noted in Section 2.3.3, NEI data on carbon monoxide emissions appear higher than would be expected for stationary sources, so we do not address carbon monoxide data in our assessment of CAP emissions for each sector.) Given AEO 2006 and CEF reference case projections of increasing energy consumption through 2020, energy-related CAP emissions are expected to increase as well, with the majority of energy-related CAP emissions continuing to occur at the facility level.

As NEI data do not include carbon dioxide emissions, we use carbon dioxide emissions estimates from AEO 2006, which totaled 92 million metric tons for the food manufacturing sector in 2004. AEO 2006 projects that the industry’s carbon dioxide emissions will increase 19 percent from 2004 to 2020—a somewhat smaller increase than the projected growth in energy consumption (24 percent). Though we do not address transportation energy use in detail in this analysis, the sector also has extensive freight shipping needs.

3.4.2 Best Case Scenario

Opportunities

Table 32 ranks the viability of five primary opportunities for improving environmental performance with respect to energy use (Low, Medium, or High). A brief assessment of the ranking is also provided, including potential barriers.

Table 32: Opportunity assessment for the food manufacturing industry

Opportunity	Ranking	Assessment (including potential barriers)
Cleaner fuels	Medium	There is potential for increased switching to waste fuels (such as used vegetable oil that can be reused as boiler fuel) and reduced use of coal as boiler fuel. Limitations on this opportunity are imposed by technical constraints (type of boiler and burners in place) and economic constraints (relative price of coal versus less emissions-intensive fuels). Permitting considerations (NSR/PSD) may also affect fuel-switching.
Increased CHP	High	CEF cites increased cogeneration as the greatest energy efficiency opportunity for the sector. One area of opportunity is increased use of waste heat (e.g., using boiler flue gases in CHP processes,[117] or from refrigeration processes, where heat from engines used to drive compressors can be used to preheat water or for space heating at the plant). New CHP installations also face barriers in terms of utility rates and interconnection requirements if electricity production is expected to exceed onsite demand, and also from NSR/PSD permitting.[118]
Equipment retrofit/ replacement	Medium	Energy efficiency gains are achievable through retrofits or replacement of existing equipment with more efficient new models, particularly in steam systems since these systems have the largest energy requirements and associated energy losses. Equipment-related opportunities noted by DOE include replacing steam systems with direct-fired drying equipment (impulse drying, infrared drying, and press drying).[119] Other areas for steam system retrofits or equipment replacement include boilers, pipes, valves, traps, heat exchangers, and preheaters.
Process improvement	High	Process improvement opportunities include changes in operating techniques to implement best energy management practices, optimizing energy consumption in scheduling processing activities, wastewater reuse, and conversion and/or sale of byproducts. For example, while dehydration systems were originally designed for maximum product throughput, newer systems include recirculating dampers. ACEEE has made several recommendations for the food products industry including industry practices such as pasteurization and sterilization by cold pasteurization and electron beam sterilization; evaporation and concentration by supercritical extraction and protein separation, drying by vapor recompression supercritical extraction; and chilling, cooling, and refrigeration by controlled atmosphere packaging. In some cases, process changes must be reviewed, certified, and approved by USDA, Food and Drug Administration, or other regulatory agencies; the added cost of this regulatory review may serve as a barrier to efficiency improvement.
R&D	Medium	A recent LBNL study notes that membrane technologies can reduce energy requirements associated with traditional filtration, separation, and evaporation processes, and also increase byproduct recovery.[120] Advanced cooling and refrigeration processes also offer potential energy savings, though it is important to note that many larger plants already use ammonia refrigeration systems, which are quite efficient and provide the multiple refrigeration temperatures often required in food manufacturing plants. In addition to membrane technologies and refrigerants, there is also continued research and progress on uses of byproducts, byproduct reduction, analytical methods, sanitizing and cleaning agents and procedures, wastewater treatment technologies, and packaging technologies.

Optimal Future Trends

CEF's advanced energy scenario projects a smaller increase in sector energy consumption (8 percent from 1997 to 2020) than under the business-as-usual scenario (19 percent increase). According to CEF, cogeneration is expected to play an important role in increasing energy efficiency in the food manufacturing sector, contributing to a faster decrease in energy intensity (decline of 0.9 percent per year) than was projected in the reference case (decline of 0.5 percent per year). The effects of increased CHP may also be evident through a slight decline in purchased electricity (1 percent) in the advanced case, despite the overall trend of increasing energy consumption. Over the same period, consumption of natural gas and petroleum is expected to increase by 14 percent and 15 percent, respectively, and coal use is expected to decline by 16 percent. CEF's advanced case employs the AEO 1999 HiTech case assumptions concerning rates of deployment of energy-efficient equipment, and also assumes increased energy efficiency for boilers and commercial buildings.

CEF's advanced case projections are summarized in Table 33.

Table 33: CEF advanced case projections for the food manufacturing industry

	1997 Advanced Case		2020 Advanced Case	
	Consumption (quadrillion Btu) [rrr]	Percentage	Consumption (quadrillion Btu)	Percentage
Petroleum	0.210	17%	0.242	18%
Natural gas	0.630	51%	0.718	53%
Coal	0.184	15%	0.155	12%
Renewables	0.014	1%	0.022	2%
Delivered electricity	0.208	17%	0.206	15%
Total	1.246	100%	1.343	100%
Annual % change in energy intensity (energy consumption per dollar value of output)				-0.9%
Overall % change in energy use (1997-2020)				8%

Environmental Implications

Under the advanced energy scenario, CEF projects a smaller increase in sector energy consumption than under its reference case, which is a net gain in terms of energy-related CAP emissions. The advanced case also predicts a shift from coal to natural gas that does not occur under the reference case, which would lead to lower CAP emissions at the facility level than are expected under the business-as-usual conditions—particularly sulfur dioxide and nitrogen oxides.

Despite the overall increase in sector energy consumption, under the advanced energy scenario, CEF projects the food manufacturing industry to achieve an 11 percent reduction in carbon emissions levels by 2020. Projected carbon emissions reductions are attributable to efficiency gains from increased CHP and reductions in purchased electricity (which is

[rrr] As is the case with several sectors addressed in the CEF analysis, there are slight differences between 1997 fuel consumption data in the reference and advanced cases. We could find no explanation for such differences in the CEF analysis, but it could be that CEF made modifications to the base year (1997) parameters under the advanced case as compared with the reference case.

associated with substantial energy losses, as discussed previously), and reductions in the use of carbon-intensive energy sources such as coal. However, replacing purchased electricity with petroleum and natural gas will also have the effect of shifting energy-related CAP and carbon emissions from the utility level to the facility level. The location of carbon emissions is not important from a climate perspective. However, energy trends that are environmentally preferable from a climate perspective may also lead to less-than-optimal trends for facility emissions of criteria air pollutants.

3.4.3 Other Reference Materials Consulted

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