CHAPTER 9: INDUSTRIAL SECTOR

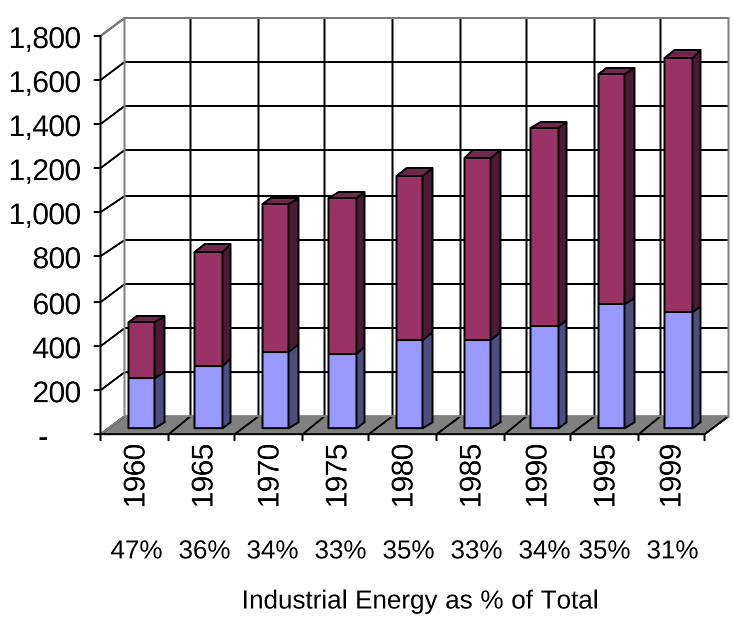
Introduction

Industry in North Carolina is now using about 691 trillion Btu's of energy per year, or about 31% of the total energy used in the state. Because the sector plays such a major role, developing policies that support industrial energy efficiency is a crucial component of retaining a strong manufacturing economy. More efficient industries will also support the goals of the State Energy Plan

Historical Energy Use

Figure 9-2 shows historical energy use in the industrial sector. Since 1960, the percentage of total net energy use that occurred in industry declined from 41% to 31%. One possible explanation for the slow growth and recent drop in industrial energy use that the employment and business income have shifted somewhat from industrial to service-oriented enterprises which occur in commercial buildings. However, Figure 9-3 reveals that a slump in energy consumption still occurs when the two sectors area combined. Thus,

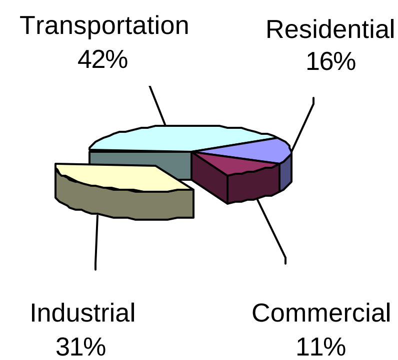
Figure 9-2:
Historic Industrial and Total Energy Use (TBtu)



the North Carolina economy witnessed unprecedented growth throughout the 1990's despite a reduction in energy consumption in the two sectors most closely aligned with business and economic growth.

Figure 9-4 and 10-5 show that industry uses a fairly symmetrical set of fuels. Over the past 40 years, electricity, wood and waste, petroleum, and natural gas have supplied fairly even percentages of industrial energy needs.

Figure 9-1:
North Carolina Energy Use Breakdown by Sector for 19[…]
(1,678 TBtu total)



The development of policies that support industrial efficiency is a crucial component of retaining a strong manufacturing economy and will directly support the goals of the State Energy Plan.

Figure 9-3: Industrial and Commercial Net Energy Use in North Carolina (TBtu)

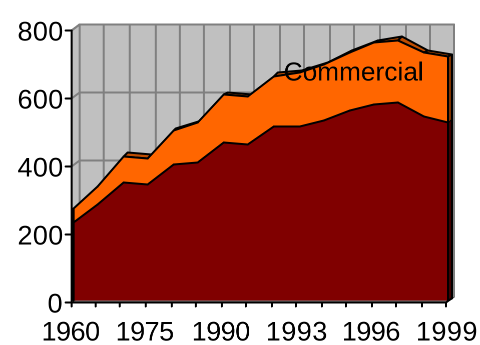


Figure 9-4: Industrial Energy Use by Fuel, 1999 (TBtu)

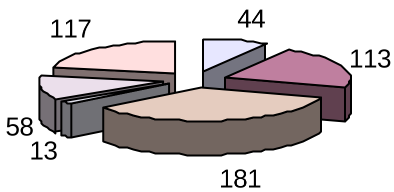


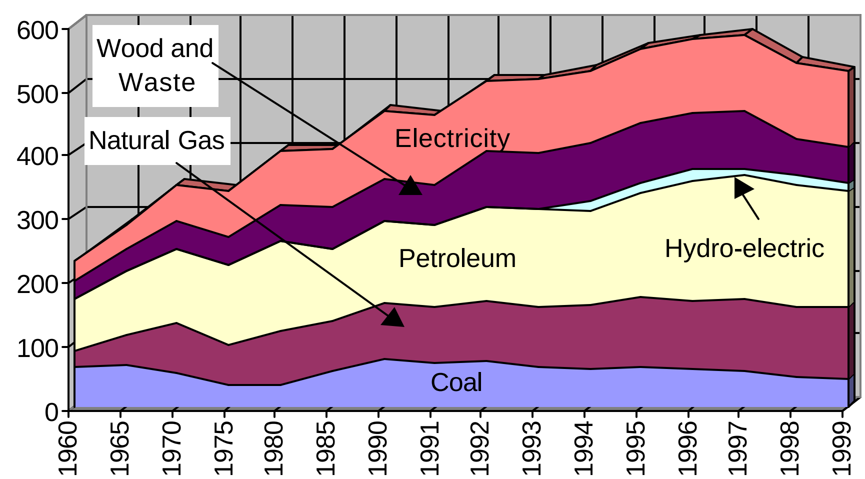
Table 9-1 depicts the fuel mix for the industrial sector over the past 40 years. The major change has been a substantial drop in the amount of coal used in the sector balanced by a rise in the use of natural gas and electricity. In addition, substantial industrial hydroelectric generation has been installed. With the upcoming arrival of new natural gas pipelines in North Carolina, the market share of natural gas should grow.

At present, petroleum is the major supplier of energy to the industrial sector, contributing about 35% of total energy needs. Petroleum, electricity and natural gas, combine to provide about 78% of fuel needs, while coal, wood, and waste contribute a significant 20%.

Table 9-1:
Fuel Mix in the Industrial Sector

	Coal	Natural Gas	Petroleum	Hydro-electric	Wood and Waste	Electricity
1960	27.1%	11.9%	34.9%	0.2%	12.7%	13.1%
1970	15.5%	22.1%	33.6%	0.0%	12.9%	15.8%
1980	8.4%	21.5%	34.9%	0.0%	13.8%	21.4%
1990	16.1%	19.2%	27.6%	0.2%	14.0%	23.0%
1999	8.4%	21.5%	34.5%	2.4%	11.1%	22.2%

Figure 9-5:
Historical Fuel Use by North Carolina Industry (TBtu)



Industry Classification Systems

The industrial sector is difficult to analyze because it is so diverse and because state specific data for North Carolina is so sparse. The industrial sector includes such differing activities as agriculture, mining, construction, and manufacturing. Another complicating factor is that the categories for classifying industries by type of activity have recently changed.

Until 1998 the federal government used the SIC (Standard Industrial Classification) system to segment the activities of the industrial sector. In 1998 the government changed to a new classification system, the NAICS (North American Industry Classification System), which was developed jointly by the United States, Canada, and Mexico to provide improved comparability in statistics about business activity across North America.

NAICS industries are identified by a 6-digit code, in contrast to the 4-digit SIC code. The longer code accommodates a larger number of sectors and allows more flexibility in designating subsectors. The international NAICS agreement fixes only the first five digits of the code. The sixth digit, where used, identifies subdivisions of NAICS industries that accommodate user needs in individual countries. Thus, 6-digit U.S. codes may differ from counterparts in Canada or Mexico, but at the 5-digit level they are the same.

Table 9-2 compares the two systems. At the highest classification level (three digit NAICS and two digit SIC) there is little difference. There is only one additional category in the NAICS (314 - Textile Product Mills) that does not have a counterpoint in the SIC.

The industrial categories in Table 9-2, while similar, are not exactly identical -- industrial activities that fall into one category in the SIC sometimes now appear in another in the NAICS. Therefore, energy use in one (two digit) SIC code will not equal the use in the corresponding (three digit) NAICS code. The North Carolina State Energy Plan uses the SIC system wherever possible. When necessary (due to a lack of other data), NAICS data is used.

The categories for classifying industries by type of activity have recently changed, adding to the difficulty in analyzing energy use.

Benefits of the new NAICS industry classification system

- NAICS identifies hundreds of new, emerging, and advanced technology industries. And NAICS reorganizes industries into more meaningful sectors -- especially in the service-producing segments of the economy.
- NAICS was developed in cooperation with Statistics Canada and Mexico's INEGI. NAICS provides for comparable statistics among the three NAFTA trading partners.
- NAICS defined industries according to a consistent principle: businesses that use similar production processes are grouped together.
- NAICS will be reviewed every 5 years, so classifications and information keep up with our changing economy.

Table 9-2: Comparison of SIC and NAICS Codes			
SIC Code	SIC Major Group and Industry	NAICS Code	NAICS Subsector and Industry
20	Food and kindred products	311	Food
21	Tobacco products	312	Beverage and Tobacco Products
22	Textile mill products	313	Textile Mills
		314	Textile Product Mills
23	Apparel and other textile products	315	Apparel
31	Leather and Leather Products	316	Leather and Allied Products
24	Lumber and wood products	321	Wood Products
26	Paper and allied	322	Paper
27	Printing and publishing	323	Printing and Related Support
29	Petroleum and Coal Products	324	Petroleum and Coal Products
28	Chemicals and allied	325	Chemicals
30	Rubber and misc. plastics	326	Plastics and Rubber Products
32	Stone, clay, glass	327	Nonmetallic Mineral Products
33	Primary metal industry	331	Primary Metals
34	Fabricated metal	332	Fabricated Metal Products
35	Industrial machinery	333	Machinery
36	Electronic equipment	334	Computer and Electronic Products
38	Instruments and Related Products	335	Electrical Equip., Appliances, and Components
37	Motor vehicles/trans. equip.	336	Transportation Equipment
25	Furniture and fixtures	337	Furniture and Related Products
39	Miscellaneous Manufacturing Industries	339	Miscellaneous

Industrial Energy Use by Subsector

Energy use by industry is not available for North Carolina; however, EIA provides national data. Subsector energy use in the state can be estimated by using the national energy data along with state and national economic data for each subsector. The technique assumes that energy use per dollar of industrial output is fairly similar for state and national industrial facilities within a sector. The following approach was used to obtain estimates of energy use by industrial subsector,:

1. Find the ratio between North Carolina Gross State Product and National (United States) Gross Domestic Product for each industrial subsector (SIC or NAICS Code). Table 9-3 shows projected historical gross state product by SIC Code.
2. Find national energy use by fuel type for the industrial subsector.
3. Multiply the national energy use by the ratio in (1) above, which yields an estimate of state energy use for each subsector, shown in Table 9-3.
4. To get energy use by fuel type in each sector, as shown in Table 9-4, use national energy data by sector and fuel type, along with state and national economic data, as in Steps 1 through 3 above. Multiply energy use per dollar of national output for each fuel type and subsector by the ratio of state and national income.
5. Aggregate all of the data and compare total predicted energy use by fuel type to actual energy use for the industrial sector in North Carolina. Perform a final correction by multiplying estimated energy use by industrial subsector by the ratio of calculated and estimated fuel use.

Table 9-3 - NC Gross State Product, 1987 and 1995– 2000 (in Millions of Year 2000 $)

SIC Code		1987	1995	1996	1997	1998	1999	2000
20	Food	2,059	3,152	3,089	3,204	3,170	3,459	3,566
21	Tobacco	4,120	5,982	5,863	6,100	6,853	7,487	8,834
22	Textile	5,083	6,272	6,399	6,500	6,525	6,449	6,247
23	Apparel	1,252	1,486	1,469	1,442	1,415	1,322	1,284
24	Lumber	1,655	2,181	2,057	2,124	2,160	2,387	2,289
25	Furniture	1,802	2,407	2,556	2,802	3,000	3,210	3,296
26	Paper	1,140	1,777	1,686	1,623	1,680	1,749	1,807
27	Printing	1,081	1,406	1,535	1,586	1,664	1,788	1,836
28	Chemicals	4,785	8,611	8,771	9,411	9,411	9,999	10,91
29	Petroleum	0	0	0	0	0	0	0
30	Rubber	1,201	1,871	2,017	2,114	2,305	2,406	2,443
31	Leather	0	0	0	0	0	0	0

32	Stone	1,078	1,499	1,536	1,721	1,790	1,966	2,031
33	Metal	639	981	940	974	983	929	979
34	Fab Metal	1,396	1,945	2,076	2,177	2,268	2,400	2,424
35	Ind Mach	2,738	3,819	3,920	4,118	4,561	4,524	4,820
36	Electronic	3,219	5,398	5,630	6,096	5,850	6,082	6,658
37	Vehicles	888	1,499	1,407	1,473	1,702	1,815	1,834

Table 9-4: Industrial Energy Use in 1998 by Fuel and Sector

SIC	Major Group and Industry	Electricity	Residual Fuel Oil	Distillate Fuel Oil	Natural Gas	LPG and Kerosene	Coal	Coke and Breeze	Wood, Waste, Other	Total
20	Food and kindred products	6	1	2	7	2	4	0	2	23
21	Tobacco products	2	0	0	1	0	9	0	0	12
22	Textile mill products	29	8	7	14	8	6	0	4	76
23	Apparel and textile prdcts	1	0	0	1	0	0	0	0	1
24	Lumber and wood prdcts	4	0	7	2	2	0	0	17	32
25	Furniture and fixtures	3	0	0	1	0	0	0	3	7
26	Paper and allied prdcts	7	12	2	8	1	8	0	38	75
27	Printing and publishing	2	0	0	0	0	0	0	0	2
28	Chemicals	30	7	3	52	29	16	0	36	173
29	Petroleum, coal prdcts	0	0	0	0	0	0	0	0	0
30	Rubber and msc plastics	7	1	0	2	1	0	0	0	11
31	Leather	0	0	0	0	0	0	0	0	0
32	Stone, clay, glass	6	1	4	9	2	14	0	3	38
33	Primary metals	10	1	1	7	1	1	13	6	41
34	Fabricated metal prdcts	3	0	1	2	1	1	0	0	7
35	Industrial machinery	4	0	1	2	1	0	0	0	7
36	Electronic equipment	5	0	0	2	0	0	0	0	7
37	Motor vehicles/ trans. equip.	2	0	1	1	1	0	0	0	6
	Totals	**119**	**31**	**29**	**111**	**47**	**59**	**13**	**110**	**518**

Table 9-4 shows estimated consumption of energy by SIC code for the manufacturing sector for years 1987 - 2000. Table 9-5 projects that 7 industry subsectors consume over 85% of energy resources for the industrial sector.

Table 9-5: Industrial Energy Fuel Mix in 1998 by Fuel and Sector

SIC	Major Group and Industry	Electricity	Residual Fuel Oil	Distillate Fuel Oil	Natural Gas	LPG and Kerosene	Coal	Coke and Breeze	Wood, Waste, Other	Total
21	Tobacco products	2%	0%	0%	1%	0%	16%	0%	0%	2%
22	Textile mill products	24%	26%	25%	13%	18%	10%	0%	3%	15%
24	Lumber and wood prdcts	4%	0%	25%	2%	4%	0%	0%	15%	6%
26	Paper and allied prdcts	6%	37%	6%	7%	2%	14%	0%	35%	15%
28	Chemicals	25%	24%	11%	47%	61%	27%	0%	33%	33%
32	Stone, clay, glass	5%	2%	14%	8%	3%	24%	0%	3%	7%
33	Primary metal industry	8%	5%	4%	6%	1%	2%	100%	6%	8%
	Total	73%	94%	84%	84%	89%	92%	100%	95%	86%

The three largest energy users in the manufacturing sector in 1998 were chemicals (173 TBtu or 33% of the total energy used in manufacturing), textiles (76 TBtu or 15% of the total energy), and paper (75 TBtu or 15% of the total energy). These three industries accounted for about 63% of the energy used in manufacturing in the state in 1998.

Table 9-5 reveals the following key subsectors by fuel type:

- Electricity – Textiles and Chemicals used 49% of the industrial total
- Fuel oil – Textiles, Paper, and Chemicals used 87% of residual fuel oil; Textiles, Lumber, and Chemicals, along with Stone, Clay and Glass, used 75% of all distillate fuel oil
- Natural gas – Textiles and Chemicals used 60% of industry's total
- LPG and Kerosene – Textiles and Chemicals used 79%
- Coal – Tobacco, Textiles, Paper, Chemicals, and Stone, Clay, Glass used 91%
- Coke and Breeze – All consumed by Primary Metals sector
- Other – Lumber, Paper, and Chemicals used 83%, much of which was fuel supplied by wood and waste materials

Energy-Intensity Ratios

The Energy-Intensity Ratio is simply the energy used by an industrial activity divided by the economic value of the product produced. A primary driver that often separates energy intensive industries from those that are less energy intensive is the need for process heat. Thus, strategies to reduce energy consumption for these industries focus more heavily on boilers and direct process uses such as thermal systems, motors, compressors, and steam systems. In industrial facilities with medium and light energy intensity ratios, motor efficiency, lighting, and heating and cooling measures are likely to be the key efficiency measures.

Table 9-6: Energy Intensity Ratios of North Carolina Industry

Energy Intensity Ratios -- North Carolina Industry -- Rank Ordered		Gross State Product ($ million)	Energy Use (TBtu/ year)	1,000 Btu/ dollar of income
Heavy				
26	Paper & allied products	1,680	75.5	44.93
33	Primary metals	983	40.7	41.37
32	Stone, clay, glass	1,790	37.9	21.17
28	Chemicals	9,999	172.9	17.30
24	Lumber & wood products	2,160	31.6	14.63
22	Textile mill products	6,525	76.0	11.65
Medium				
20	Food and kindred products	3,170	23.1	7.29
30	Rubber, plastics	2,305	11.1	4.82
34	Fabricated metal	2,268	7.5	3.29
Light				
25	Furniture & fixtures	3,000	7.0	2.32
37	Motor vehicles/ trans. Equip.	2,593	5.9	2.29
21	Tobacco products	6,853	11.8	1.73
35	Industrial machinery	4,561	7.0	1.54
27	Printing, publishing	1,664	2.1	1.26
36	Electronic equip.	5,850	6.8	1.16
23	Apparel, textile products	1,415	1.5	1.03

Table 9-7:
% of Industrial Energy Use by End Use Category

	National	South Region
Other	1.34%	1.29%
Refrigeration	1.19%	1.18%
Lighting	1.19%	0.89%
Electricity Generation	1.37%	1.85%
Electro-Chemical	1.69%	1.32%
HVAC	3.91%	2.53%
Machine Drive	9.57%	8.53%
Boiler Fuel	20.56%	21.92%
Process Heat	22.94%	23.65%
End Use Not Reported	36.23%	36.84%

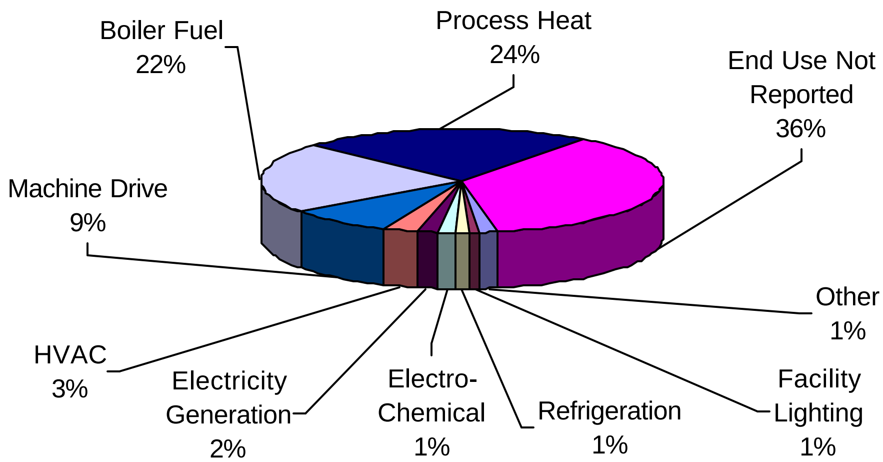
Historical Use of Energy by End Use

To better determine and evaluate energy efficiency measures in the industrial sector, it is important to know the specific end uses involved in industrial processes in the state. The Energy Information Administration reports national and regional data on the following end uses by fuel: (Ref 20)

1. Boiler fuel
2. Process heating
3. Process cooling and refrigeration
4. Machine drive
5. Electro-chemical processes
6. Other process use
7. Facility HVAC (heating, ventilation, and air conditioning)
8. Facility lighting
9. Other facility support
10. Onsite transportation
11. Conventional electricity generation
12. Other non-process use
13. End use not reported

Table 9-7 summarizes EIA data on end use for both the nation as a whole and for the south region, which includes the states from Texas eastward and Kentucky southward. Note that the end use percentages are quite similar for all categories. Figure 9-6 shows the regional data graphically.

Figure 9-6:
% of Industrial Energy Consumption by End Use – South Region



The end use category with the highest percentage is unfortunately "End Use not Reported." Industries chose not to report certain data for concern that it might violate privacy concerns. The two major uses reported were process heat and boiler fuel, with machine drive, mainly motors, and heating and cooling showing moderate use. Minor uses included electro-chemical processes, facility lighting, refrigeration and process cooling, and several other needs.

Based on the above breakdown, projected energy use by end use in North Carolina's industries is:

	End Use %	Energy Use (TBtu)
Lighting	1.3%	8.4
Refrigeration	1.3%	7.7
Other	0.9%	5.8
Electro-Chemical	1.8%	12.0
Electricity Generation	1.3%	8.6
HVAC	2.5%	16.5
Machine Drive	8.5%	55.4
Boiler Fuel	21.9%	142.4
Process Heat	23.7%	153.7
End Use Not Reported	36.8%	239.4

Saving Energy in Industrial Facilities

Introduction

The potential for energy saving improvements in industry fall into four primary categories:

1. General Energy-Saving Technologies. These are technologies that are applicable to all manufacturing sectors. Examples are high efficiency lighting and computer control of air conditioning.
2. Industry specific Energy-Saving Technologies.
3. Energy Management Activities. Examples are energy audits, load control, and a full-time energy manager.
4. Other Innovative Approaches: changing processes or

Some key considerations in developing policies and programs targeted at the industrial sector include:

- What are the Energy-Saving Technologies and management activities that should be considered for implementation by the manufacturing industries in North Carolina?

Four types of energy saving improvements for industry are considered in the State Energy Plan:

- *General Energy-Saving Technologies*
- *Industry Specific Energy-Saving Technologies*
- *Eenergy Management Activities*
- *Other Innovative Approaches*

- To what extent have these energy saving measures already been adopted?
- What government policies and actions can be effective in encouraging efficiency improvements in the industrial sector?

General Energy-Saving Technologies

There are four categories of general energy savings technologies -- technologies that are applicable to most industrial facilities.

1. Control systems for the facility-wide environment (controls for space heating equipment, cooling equipment, and lighting)
2. Computer control of processes or major energy-using equipment (examples are boilers, furnaces, and conveyors used in the manufacturing process)
3. Waste heat recovery systems (capture heat exhausted from one process for use in another)
4. More efficient motors

Table 9-8 uses results of an EIA survey on energy efficient practices in industry along with projected number of industrial establishments in the state to estimate number of facilities that have not implemented the above four technologies. The table shows a very low market penetration rate for the efficiency measures. Thus, there appears to be widespread potential for reducing energy needs through general energy-saving technologies.

Table 9-8:
Market Penetration of General Energy-Saving Technologies

Technology	Energy management systems	Computer controlled processes	Waste heat recovery	High efficiency motors
EIA Survey Results				
Installed	8%	15%	7%	25%
Not Installed	82%	75%	83%	63%
Not sure	10%	10%	10%	12%
Estimated Number of Facilities in North Carolina				
Number of Firms	8,607	8,665	8,667	8,608
Installed	688	1,299	606	2,152
Not Installed	7,057	6,498	7,193	5,423
Not sure	860	866	866	1,032

Source: Energy Information Admininstration, U.S. Department of Energy

Heating, Ventilation, and Air Conditioning (HVAC) — consume about

2.5% of total industrial energy and offer high potential for providing savings on energy bills. HVAC measures are discussed under General-Energy Saving Technologies and Energy Management through efficiency measures such as:

- Improving insulation and air tightness of ductwork.
- Installing energy management system to optimize system performance.
- Using more efficient motors or variable speed drives for air handlers.
- Replacing older units with higher efficiency models.

Lighting Systems draw about 1.3% of a typical manufacturing facility's energy use. Efficiency measures are primarily:

- Replace incandescent fixtures with fluorescents or incandescent bulbs (lamps) with compact fluorescents.
- Install high efficiency ballasts and lamps in fluorescent fixtures
- Use lighting controls that automatically shut off lighting in unused areas and turn it on whenever occupied.
- Implement daylighting techniques including state-of-the-art dimming technologies that maintain indoor lighting at prescribed illumination levels.

Industry-Specific Measures

Sample Measures

Throughout the country, energy experts have identified, analyzed, and installed a plethora of energy-saving technologies that are specific to each industry. EIA developed lists of approximately 300 Energy-Saving Technologies specific to individual industries (22), including the following examples:

For Primary Metals:

- Dry quenching during the coking process
- External desulfurization of the charge for iron-making
- Hydrocarbon injection to maintain blast furnace temperatures
- Direct reduction iron-making -- sponge iron produced directly from iron ore
- Waste heat boilers/heat exchangers in combination with reheat furnaces
- Evaporative cooling of skid rails
- Electric induction reheat furnaces

For the Food Industry:

- Infrared heating
- Microwave drying
- Closed-cycle heat pump system used to recover heat
- Open-cycle heat pump system used to produce steam

Of the hundreds of technologies specific to each type of industrial activity, the overall average percentage reporting use of these technologies was a disappointing 5%.

- Gas-driven rotary engines and/or turbines
- Membrane separation
- Irradiation
- Freeze concentration
- Membrane hyperfiltration to separate water from food product

Of the hundreds of technologies specific to each type of industrial activity, the overall average percentage reporting use of these technologies was a disappointing 5%. Fully 82% reported they were not using these energy-saving technologies while another 13% reported not knowing whether they had been adopted.

Measures for Specific Equipment

Boilers comprise nearly one third of all manufacturing energy use. Boilers are used to convert the energy stored in fossil fuels and wood into useful thermal energy carried in pressurized steam. In North Carolina, those industries that use the largest number of boilers are furniture, paper products, and chemicals. Average annual savings from the most efficient combination of boiler measures can equal roughly 3% of total facility energy use. Efficiency measures include:

- Size boilers to meet the steam loads of the facilities
- Periodically adjust the air/fuel ratio—"tune-ups"
- Recover waste heat (reduce the amount of unused heat leaving the boiler stacks)

Steam systems are found where boilers are found, as they are used to deliver the steam produced in the boiler. In those facilities where steam system improvements were recommended, average anticipated savings totaled 2% of total facility energy use with payback periods less than 6 months. Efficiency measures include:

- Properly select, size, and maintain your distribution system steam traps.
- Insulate all distribution system pipes, flanges, and valves.
- Ensure that steam mains are properly laid out, sized, adequately drained, and adequately air vented.
- Ensure that distribution system piping is correctly sized to produce the appropriate system pressure drops.
- Ensure that distribution system piping is adequately supported, guided, and anchored, and that appropriate allowances are made for pipe expansion at operating temperatures
- Utilize vapor recompression
- Collect and use high-pressure condensate

Process Heat. Aside from steam and boilers in industrial facilities, there are numerous other process heat applications, such as furnaces. Process heat reduction measures are estimated to produce average facility energy savings of just over 2%. Efficiency measures:

- Insulate and contain heat in the combustion process

Steam Trap Case Study

A Huls America Inc. specialty chemical plant in Somerset, AL replaced several disc traps which were failing them regularly) with forged steel inverted bucket traps. Within days of this improvement on a specific application, operations reported that steam use on that particular unit was cut in half. After many of their less reliable traps were replaced, a 10% reduction in the entire facility's energy consumption was realized. Two-thirds of this reduction was in natural gas; of the gas savings, 70% was attributed to the steam trap program. Also, trap defective rates across the facility dropped from 12.4% in January, 199 to 4.6% in December, 1996.

Source: Power Specialties Co.

Compressed Air System Case Study

Company: Southeastern Container, Enka, NC

Summary: Improvements to compressed air system with two 800 horsepower compressors

- Project Implementation Costs: $80,000
- Annual Energy Cost Savings $180,000
- Simple Payback 0.44 yrs
- Demand Savings 189 kW
- Annual Energy Savings 7,400,000 kWh

Source: U.S. D.O.E. Best Practices Web Page

- Control combustion air carefully to obtain complete combustion as efficiently as possible
- Recover process waste heat where possible for other applications that require low-grade sources of heat, such as preheating process fluids or providing space heat to facilities
- Upgrade or repair burners, other process heat maintenance and repair procedures

Compressed air systems are found in heavy machinery and central air distribution systems that rely on hydraulic control systems. Air compressors typically have high electricity requirements. According to the U.S. D.O.E., optimizing compressed air systems can reduce energy use 20% to 50%. (28) Typical measures to reduce energy waste in compressed air systems include:

- Match compressor size with load requirements
- Reduce the system air pressure
- Eliminate air leaks
- Reduce or eliminate compressed air use where possible and go to digital or electronic controls

Process cooling is integral to many manufacturing processes to reduce temperatures or provide refrigeration. Energy savings from process cooling improvements, such as the examples listed below, are estimated to be about 1% of facility energy use:

- Upgrade to energy efficient chillers and refrigeration units
- Adjust temperature settings to acceptable, but higher levels
- Check for proper refrigerant charging to ensure efficient operation
- Conduct regular maintenance procedures

Cogeneration, also know as Combined Heat and Power (CHP), refers to either the use of excess process heat to provide steam to generate electricity or the use of excess steam from the generation of electricity for process heating needs. CHP plants offer the highest efficiency of electricity power generation as the combined production of electricity and steam for process heat provides efficiencies of 60% and above. They also add flexibility to a industrial facility's energy management system. The electricity generated can be used on-site or could be sold to electric utilities depending on existing regulatory rules. The sections on Electricity and Renewable Energy address some of the key issues and policy recommendations regarding distributed electrical generation, as found in CHP facilities.

Motors—represent a key target area for efficiency measures as motors are present in virtually all industrial facilities. According to DOE (), there are approximately 12.4 million electric motors of more than 1 horsepower in service in U.S. manufacturing plants. Approximately 2.9 million of these motors fail every year, with 600,000 resulting in replacements. The rest are repaired. Since these motors consume 679 billion kWh annually (23 percent of all electricity sold in the United States), even small efficiency improvements can have dramatic economic and environmental consequences.

Motor management, which includes motor planning, evaluation, analysis,

Process Heating Case Study

Wabash Alloys, an aluminum recycler and provider of aluminum alloy in East Syracuse, NY, invested in an energy-efficient kiln that heats scrap aluminum for reuse. They have reduced metal loss and emissions of VOCs. Wabash Alloys experienced an energy savings of 55% over conventional equipment.

Source: U.S. D.O.E. Best Practices Web Page

"Too many decisions regarding compressed air systems are made on a first-cost basis, or with an "if it ain't broke, don't fix it" attitude. To achieve optimum compressed air system economics, compressed air system users should select equipment based on life-cycle economics, properly size components, turn off unneeded compressors, use appropriate control and storage strategies and operate and maintain the equipment for peak performance. "
U.S. Department of Energy (28)

Motor Efficiency Case Study

Company: Nissihinbo California, Inc.
Summary: Retrofitted 15 fan motors with variable frequency drives

- Project Implementation Costs: $130,000
- Annual Energy Cost Savings $100,950
- Simple Payback 1.3 yrs
- Demand Savings 189 kW
- Annual Energy Savings 1,579,400 kWh

Total Annual Emissions Reductions*

- CO_2 716,500 lbs
- Carbon Equivalent 195,400 lbs
- SO_2 110 lbs
- NO_x 730 lbs
- CO 380 lbs
- Particulates 10-24 lbs

* Note: Emissions reductions would be greater for most facilities. More than half of the electricity saved at NCI was generated by hydroelectric and geothermal plants.

Motor Repair Case Study

Company: Stroh Brewery Co.
Summary: Trimmed pump impeller for glycol cooling system

- Project Implementation Costs: $1,500
- Annual Energy Cost Savings $19,000
- Simple Payback 0.1 yrs
- Demand Savings 58 kW
- Annual Energy Savings 508,000 kWh

Total Annual Emissions Reductions*

- CO_2 634,000 lbs
- Carbon Equivalent 173,000 lbs
- SO_2 1,800 lbs
- NO_x 2,100 lbs
- CO 90 lbs
- Particulates 80 lbs

Source: U.S. D.O.E. – Best Practices

procurement, and repair, has the potential to provide energy savings of 5-6 percent. In 1998, the U.S Department of Energy found that:

- Only 19 percent of personnel in the U.S. industrial sector knew about "premium-efficiency" motors
- Just 11 percent of customers actually wrote specifications for motor purchases and only 67% of these included efficiency requirements in their specifications)
- Only 12 percent of customers reported that they consider energy costs of new motors when considering whether to rewind or purchase new motors
- Very few customers provide specifications to rewind contractors even though improper rewinding can reduce motor efficiency by 1-2 percent. (CEE)
- Too often decisions to repair or replace a motor are based on availability or short-term economics, not evaluation and planning. When motor equipment failure occurs, the highest priority is to return the equipment to service - not optimize motor performance. The costs associated with this type of decision-making can be high, resulting in higher operational costs, poor equipment performance, and unreliable service. These consequences could be avoided if more senior managers took advantage of the opportunity to reduce costs and improve performance through better motor management.

As the case studies in the sidebar show, the economic payback from improved motor systems, whether replacements or repairs, can be exceedingly favorable. However, the facility owner or operator must first have an interest and commitment to improving the efficiency of their production process.

Energy Management Options

Energy management options are the third category of industrial efficiency measure. Examples of these options are:

- Energy audits
- Electricity load control
- Special rate schedule
- Standby generation program
- Equipment rebates
- Power factor correction or improvement
- U.S. Environmental Protection Agency's Energy Star Program
- U.S. Environmental Protection Agency's Green Lights Program
- U.S. Department of Energy's Motor Challenge Program
- Equipment installation or retrofit for the primary purpose of improving energy efficiency affecting:
    - Steam production/system
    - Compressed air systems

- Direct/indirect process heating
- Direct process cooling, refrigeration
- Direct machine drive
- Facility HVAC
- Facility lighting
- Equipment installation or retrofit for the primary purpose of using a different energy source
- Full-time energy manager

As with other industrial efficiency measures, Energy Management Options suffer poor interest and implementation in our nation's industrial facilities. The EIA Industrial Survey showed:

- ♦ 89% of facilities do not conduct energy audits
- ♦ Only about 1% participate in EPA's Energy Star Program , Green Lights Program , or Motor Challenge Program.

Thus, the industrial sector has shown a widespread reluctance to adopt cost effective energy efficiency strategies. Many efficiency measures provide paybacks on the initial investment of 3 years or less. Because the sector is so critical, using at present 31% of statewide energy consumption, the state must determine how to compel industry to implement efficiency measures.

Other Innovative Approaches

Other approaches involve a rethinking of industrial processes to improve not only energy use, but also productivity, worker satisfaction, operating costs, and profitability. Examples include:

- ♦ "New Processes" are new methods of producing a product or some portion of that product that will reduce the number of processes and, therefore, the amount of energy required to manufacture that product.
- ♦ "New Machine Technology" refers to the development of new machines through advances in other technologies that allow a product or some portion of that product to be produced in more complex shapes. This approach reduces the number of components in the final product, manufactures the product faster with fewer rejects, or allows a new material or combination of materials to be used.
- ♦ "Automation" refers to mechanizing the movement of a product or portion of that product between each step during the manufacturing process.
- ♦ Fuel switching from high carbon to low carbon fuels (such as replacing the use of coal for energy production in the manufacturing process with natural gas) can lead to dramatic reductions in industrial energy use and air pollution emissions.
- ♦ Renewable energy technologies are being used on-site in industry around the state and country for thermal energy production, electricity, and in some situations, biogas.

Examples of Industrial Policies and Programs in Other States

Minnesota

- A fund was created to encourage production of alternative fuels through incentives to manufacturers.

Missouri

- The state is seeking legislation to establish a low-interest loan fund, tax credits or other incentives to attract manufacturers of cleaner technologies, such as fuel cells, photovoltaic modules or wind turbines, and stimulate the use of alternative-energy sources.

New Mexico

- Conferences are held, followed by technical assistance on energy efficiency technologies sponsored by state and private sector.
- There is a comprehensive database on existing energy efficiency technologies and utility rate structures, guidance prioritizing established technologies that need no database, training for educators and users, continuing education promotes environmental education (energy efficiency issues, energy management, demand side management, life cycle costs).
- New Mexico is working on the establishment of a database on industrial energy consumption to provide efficiency improvements, quantitative policy analysis and assessment.
- Federal labs are needed, as well as data pooled from existing sources; state assistance in implementing technologies in the private sector.
- There is a program similar to EPA Green Lights program, which recognizes voluntary adherence to new standards.
- There are tax penalties on inefficient technologies as opposed to credits for energy efficient technologies; or tax penalties fund rebates for energy efficiency systems.
- There is a database that is to be used for DSM/SSM and development of standards to disallow inefficient systems for usage.

Virginia

- Cape Charles Sustainable Technology Industrial Park (STIP) is an eco-industrial park that is taking advantage of a number of energy technologies, including solar energy systems. Occupants of STIP are awarded rebates if they exceed the "Minimum Sustainability Requirements." Sustainability audits are conducted annually. This Performance Incentive Award is given to owners in the form of a reduction of up to 5% of their annual assessment for exceeding minimum environmental criteria, and up to an additional 5% reduction for exceeding minimum social criteria. For occupants to lease their lots, the incentive award is in the form of a base rent reduction of up to 6% for exceeding minimum environmental criteria, and up to an additional 6% reduction for exceeding minimum social criteria.

Washington

- State Energy Program (SEP) Grants accelerate deployment of energy efficiency and renewable resources by providing long-term planning for code support in a rapidly changing electric industry.

Wisconsin

- Under the management of the Wisconsin Energy Bureau, Wisconsin's 23 northeastern counties receive the benefit of a host of energy efficiency and renewable energy Demand Side Management (DSM) programs.

Current Industrial Energy Efficiency Incentives in North Carolina

The North Carolina State Energy Office has a number of projects to market and promote energy efficiency to corporations located in North Carolina. Topics include technical training in energy management and sustainability, including reuse and recycling. Six programs aimed primarily at Industries in North Carolina are described on their Web Site (Ref 12):

- Alternative Cooling Technologies -- Educates industries about the benefits of evaporative cooling, desiccant dehumidification and absorption, and gas-fired chillers.
- Boiler Efficiency Technical Assistance *(statewide)* - Conducts boiler surveys in plants to identify needed improvements. Trains plant personnel on how to solve boiler efficiency problems and promotes state-of-the-art equipment to maintain optimum boiler efficiency.
- Energy Management Program *(statewide)* - will survey HVAC, lighting, chiller and cooling towers, and compressed air systems for the industrial sector. Follow-up workshops will provide basic and advanced training for facilities including the Certified Energy Manager's Program, and preventive maintenance.
- Energy Reduction through Industrial Partnerships *(statewide)* - Identifies opportunities for industrial facilities to save energy by identifying and establishing partnerships for the reuse of materials, water and energy.
- North Carolina Climate Wise/Energy Star for Industry *(statewide)* - Markets environmentally sound energy efficient programs to corporations and industry. Assists in developing inventory and pollution mitigation strategies to reduce greenhouse gases in the manufacturing process.
- North Carolina Industries of the Future *(statewide)* - Introduces, promotes, and provides methodology for industries, such as wood products, mining and chemicals, to enhance their competitiveness

through improved energy and environmental performance.

To simplify and modernize the North Carolina tax credits for solar and other renewable energy sources, new legislation was enacted in the 1999 legislative session. Fourteen different credits were eliminated and replaced by one general credit that covered residential and non-residential solar and other renewable energy property. A credit of 35% to $250,000 per installation was established for non-residential property for Biomass, Wind, Hydroelectric, and Solar Energy Equipment for: Domestic Water Heating, Active Space Heating, Combined Active Space and domestic Hot Water Systems, Daylighting, and Solar electric or other Solar Thermal Applications. (Ref 10).

In addition to the 35% corporate tax credit for renewable energy installations, North Carolina offers a corporate income tax credit to manufacturers of renewable energy products and equipment. The credit is equal to 25% of the installation and equipment costs of construction with no maximum limit to the credit except that it cannot exceed a taxpayer's tax liability in one year.

Policy Options for Industrial Energy Efficiency

Our recommendations emphasize overcoming the four basic barriers to the timely implementation of energy saving measures by industries in North Carolina. As stated at the beginning of this chapter, the four primary hurdles to industrial energy efficiency measures are: lack of information, reluctance to invest, low priority, and lack of skilled personnel.

This section sets forth measures that could be taken to achieve energy savings without significant government intervention and without placing the government and industries in adversarial positions. These measures emphasize voluntary programs involving cooperative efforts between government and industry. The State Energy Office should work with industry representatives to accomplish the following efforts:

Information/Education

North Carolina has provided information and comprehensive energy audit services to industry for many years. Unfortunately, many industrial facilities have not yet taken advantage of these services. In addition, many companies that have had energy audits or other energy evaluations have not taken advantage of efficiency measures that offer payback periods in the one to three year range. In order to achieve the goals of the state energy plan, the state needs to be more aggressive in promoting efficiency improvements in industry.

Financial Incentives

The State Energy Office should help formulate and refine new and existing incentive programs for industries that implement Energy-Saving Technologies and practices. The state should provide a tax credit to industries that invest in energy efficient equipment. While at the state faces huge economic hurdles with its own budget at present, the state must find ways to reduce its dependence on external energy resources. The industrial efficiency tax credit shall have the following guidelines:

- The industry must have received an energy audit or survey through the North Carolina Industrial Extension Service.
- The specific measure for which the tax credit is proposed must have been identified during the energy audit or survey.
- The basis for the tax credit is the additional cost for the energy feature of the investment. For example, if an industrial facility purchases a replacement motor, the tax credit will be based on the incremental cost for the high efficiency motor over a motor that operates on the minimum efficiency allowed by current manufacturing standards. If an industry refits a process to improve efficiency, the features that actually increase efficiency form the basis for the tax credit.
- The tax credit allowed is 40% of the additional investment.

The state shall also provide low interest loans to industries seeking to implement energy improvements in their facilities.

Funding for pilot projects to prove/test alternative energy source techniques should be made available. Technical assistance for non-traditional methods should be provided.

Develop New Energy Policies

To help assure that high efficiency motors are available and will be used, the facilities that repair or rewind motors should be required to be certified by the State. Certification criteria should include efficiency requirements set by the State..

A clearinghouse for coordination of the various state and federal energy programs should be created. A statewide voluntary challenge program for industrial energy efficiency improvements should also be created. These functions could be carried out by a new section in the State Energy Office. Provide incentives for and remove barriers to combined heat and power; create preferential treatments.

Develop policies and regulations for distributed generation in North Carolina. Also, provide incentives to Utilities for deployment of distributed generation.

In order to encourage the development and use of Co-generation, easy access to transmission should be provided. Also, preferential treatment and incentives for co-location and policies to wheel power should be developed. Policies on interconnection to encourage these activities should be implemented. Economic incentives to encourage "industrial ecosystems" should be provided. Expedited reviews by DENR should be encouraged. Through an industrial recruitment strategy, target appropriate industries to fit in industrial ecosystems.

Energy Audits/Assessments

Audit teams should be established and voluntary audits proposed for each industrial facility in the state that uses significant quantities of energy (owned by the large and/or energy-intensive industries in the state);

An annual energy audit and assessment should be conducted of each identified facility (upon request). A report of the audit should be provided to the facility owner detailing the audit's findings and recommending cost-effective measures to reduce energy use.

Energy Managers

Each major industrial facility in the State should be encouraged to hire a full-time qualified energy manager. Periodic reports evaluating the facility and identifying proposed improvements should be requested.

The Effect of Proposed Policies on Future Energy Use

A study conducted for the Energy Information Administration (Ref 13) concluded that (nationwide) energy savings of 7.4% in the industrial sector could be achieved by the year 2020 by implementing moderate energy saving programs. With a more aggressive program, savings of 16.5% by year 2020 were estimated. These savings excluded the effects of increased CHP (combined heat and power, or co-generation).

With moderate CHP implementation, the ORNL report estimated that national energy savings of 450 trillion Btu's could be achieved by 2020. With an aggressive program they estimated 2,367 trillion Btu's would be saved. Their "business as usual" scenario estimated 41,000 trillion Btu's of energy used by the industrial sector in 2020. Thus an additional 1.1% of energy could be saved in the moderate scenario and an additional 5.8% in the aggressive scenario.

Total savings are then estimated at 8.5% and 22.3% for the moderate and aggressive scenarios respectively.

These national energy savings by year 2020 were based on savings of fuel by fuel source as follows:

- Petroleum -- 8.4 quadrillion Btu's -- 18.8%
- Natural Gas -- 11.4 quadrillion Btu's -- 11.2%
- Coal -- 1.7 quadrillion Btu's -- 30.0%
- Electricity -- 10.0 quadrillion Btu's -- 22.1%

Applying similar percentages to industrial energy data in North Carolina provides estimated energy savings as follows:

Year 2020, North Carolina Industrial Energy Use, TBtu				
	Electricity	Petroleum	Natural Gas	Coal
	184	227	188	64
% Saved	22.1%	18.8%	11.2%	30%
Savings	41	43	21	19

The total energy savings projected for North Carolina in the year 2020 with aggressive energy saving programs implemented is 124 TBtu out of a total of 773 TBtu, or 16% of the total industrial energy use.

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