

Quantifying Relative Energy, Economic and Environmental Impacts of Northeast Regional Industries

Lawrence Ambs, University of Massachusetts, Amherst
Sharon Tracey, University of Massachusetts, Amherst
Hwei-ling Greeney, University of Massachusetts, Amherst
James Booker, Alfred University

ABSTRACT

The Northeast Regional Industries of the Future Project identifies, at a regional level, the manufacturing industries with the greatest economic, energy, and environmental impacts in the seven northeastern states of New York, Massachusetts, Connecticut, Rhode Island, New Hampshire, Maine, and Vermont. The objective of the project was to identify and relate these regional industries to the National Industries of the Future (IOF) to help the Department of Energy and the states in the northeast target energy and waste reduction efforts in industries in these states; help build partnerships in energy and waste reduction; and provide industry information in developing State (IOF) programs in each state. A variety of economic, energy, and environmental indicators were used to assess the relative and overall impact of the regional industries examined. The report identifies five industry sectors as having the largest overall economic, energy, and environmental impact in the northeast region: Forest Products, Chemicals and Plastics, Instruments and Related Products, Communication and Information Products, and Printing and Publishing. Forest Products and Chemicals and Plastics have the greatest overall impact in the region and are also National IOFs. The other three industries all have strong linkages to several of the National IOFs.

Introduction

The Northeast Regional Industries of the Future Project identifies, at a regional level, the manufacturing industries with the greatest economic, energy, and environmental impacts in the seven northeastern states of New York, Massachusetts, Connecticut, Rhode Island, New Hampshire, Maine, and Vermont. The objective of identifying regional priority industries is to provide information to assist the Department of Energy and the states in understanding the relationship between industries important in these seven northeastern states and the National Industries of the Future (IOF); to target energy and waste reduction efforts in industries in the northeastern states; to build regional partnerships in energy and waste reduction; and to increase participation in the State Industries of the Future Program. Because of the close geographic proximity of the northeastern states and the important economic linkages between them, a regional approach was undertaken to provide an overview of the overall impact of industrial activity in the region on energy use and the environment.

The project team included researchers from the National Environmental Technology Institute and the Center for Energy Efficiency and Renewable Energy at the University of Massachusetts/Amherst and the Center for Environmental and Energy Research at Alfred University, working in collaboration with the Northeast Regional Industrial Technology Collaborative. Scott Smith of the New York State Energy Research and Development

Agency provided valuable oversight and coordination for the Northeast Regional Industrial Technology Collaborative. Work on this project was supported by contract # SR ENE 1000 OH12UM3 from the Office of Industrial Technologies in the U.S. Department of Energy.

DOE National Industries of the Future

The Northeast Regional Industries of the Future Project supports the Department of Energy (DOE), Office of Industrial Technologies' efforts to improve the resource efficiency of the nation's most energy and waste intensive industries. In the U.S., about 83% of industrial energy use is in the manufacturing sector. Within manufacturing, about 80% of energy use is consumed by seven basic industries at the front end of the manufacturing food chain: *Petroleum Refining, Chemicals, Forest Products, Steel, Aluminum, Metal Casting, and Glass*. When the focus shifts from the national level to the northeast region of the United States however, the picture changes as many of the National IOFs have a small presence in the northeast region, with the most notable exceptions of Forest Products and Chemicals/Plastics. In addition to these two industries, high value added, less energy intensive industries such as printing and publishing, instruments, and computer equipment characterize the region. In conducting the study, the researchers looked at not only the National IOFs but also further down the production line to manufacturing fabrication and assembly industries, which, on the national level, account for the remaining 20% of energy used in the industrial sector. The goal was to provide information on manufacturing industries in the northeast that would assist DOE and the states in identifying regional priority industries, targeting energy and waste reduction efforts in the region, and helping to forge the partnerships necessary for successful State Industries of the Future Programs.

The Starting Point: Industry Definitions

The Standard Industrial Classification (SIC) system is a method of categorizing the activities of business establishments. Manufacturing activities are defined within the SIC 20-39 range. The National IOFs identified by DOE's Office of Industrial Technologies are based on the two-digit SIC codes, with some modifications for particular industries. This report focused exclusively on the manufacturing sector with the industries included listed in Table 1. The project team used the National IOF definitions as a starting point, modified some of these, and added others based on manufacturing activity in the northeastern states (Food Processing, Textiles/Apparel, Printing/Publishing, Fabricated Metals, Industrial/Power Machinery, Information/Communication Products, and Instruments/Related Products). These distinctions are noted in column three of the Table.

Where only a two-digit SIC code is listed in column one in Table 1, all three and four digit sectors of the SIC code were included in the study. All economic and environmental data was collected and analyzed using the definitions in Table 1 since comparable state data were available at the three and four-digit levels for SIC codes 20-39. The energy data, however, were only available at the two-digit SIC level by region and therefore the energy impact is approximated by using two-digit SIC categories in the report. The modified two-digit SIC definitions used for energy data are indicated and described in the Energy section of this report.

Table 1. Manufacturing Industry Sectors Included in the Report ^a

SIC CODE	SIC DESCRIPTION	INDUSTRY CHARACTERIZATION
29	Petroleum Refining and Related Industries	PETROLEUM REFINING ^b Narrowed National IOF
24	Lumber and Wood Products, except Furniture	FOREST PRODUCTS
26	Paper and Allied Products	National IOF
28	Chemicals	CHEMICALS ^c
308	Miscellaneous Plastic Products	National IOF
32	Glass/Stone/Clay	GLASS ^d Expanded National IOF
3331	Primary Smelting of Copper	MINING ^e Narrowed National IOF
3339	Primary Smelting and refining of Nonferrous Metals	
3341	Secondary Smelting and Refining of Nonferrous Metals	
3351	Rolling, Drawing, and Extruding of Copper	
3356	Rolling, Drawing, and Extruding of Nonferrous Metals	
3357	Drawing and Insulating of Nonferrous Wire	
3399	Primary Metal Production, not elsewhere classified	
331	Steel Works, Blast Furnaces, and Rolling and Finishing Mills	STEEL National IOF
3334	Primary Production of Aluminum	ALUMINUM National IOF
3353	Aluminum Sheet, Plate and Foil	
3354	Aluminum Extruded Products	
3355	Aluminum Rolling and Drawing	
3321	Grey and Ductile Iron Foundries	METAL CASTING National IOF
3322	Malleable Iron Foundries	
3324	Steel Investment Foundries	
3325	Steel Foundries, not elsewhere classified	
3363	Aluminum Die Casting	
3364	Nonferrous Die Casting, except Aluminum	
3365	Aluminum Foundries	
3366	Copper Foundries	
3369	Nonferrous Foundries, except Aluminum and Copper	
3398	Metal Heat Treating	
3462	Iron and Steel Forgings	
3463	Nonferrous Forgings	
20	Food Processing	FOOD PROCESSING Regional Industry
22	Textiles	TEXTILES/APPAREL Regional Industry
23	Apparel	
27	Printing and Publishing	PRINTING/PUBLISHING Regional Industry
34 except 3462, 3463	Fabricated Metals	FABRICATED METALS Regional Industry
35 except 357 361, 362, 364 369 except 3695	Industrial Machinery Electric Distribution Equipment, Elec. Apparatus, Lighting, Wiring Misc. Electric Equipment	INDUSTRIAL/POWER MACHINERY Regional Industry
357 365-367 3695	Computer Equipment Audio/Video, Communications, Electronic Components Magnetic/Optical Recording Media	INFORMATION/COMMUNICATIO N PRODUCTS Regional Industry
38	Instruments and Related Products	INSTRUMENTS/RELATED PRODUCTS -- Regional Industry

^a Where only a two-digit SIC code is listed with no further breakdown: indicates that all three and four digit industries within code are included.

^b Oil and Gas Extraction SIC (13) was not included in this study.

^c Chemicals/Plastics includes all of SIC 28 - products (SIC 283, 284, 285, 289) and inputs (SIC 281,282,286,287) and SIC 308 (miscellaneous plastics).

^d Glass National IOF was expanded to include all of SIC 32 (not just Glass SIC 321-23). Also includes Stone, Clay and Concrete Products.

^e This report does not include SIC 10 (Metal), SIC 12 (Coal) and SIC 14 (Nonmetallic Minerals) due to lack of data across all indicators used.

The indicators used in the analysis to measure regional impacts include gross regional product (value added), employment, employee compensation, and business taxes paid (*economic indicators*); total quantity of energy purchased and CO₂ emissions (*energy indicators*); and VOC emissions, total Criteria Air Pollutants (VOC, SO_x, NO_x, CO, total/fine particulates), and Toxic Release Inventory data (*environmental indicators*). The report ranks industries separately for economic, energy, and environmental impacts.

The Northeast Region

The northeast region of the U.S., the geographical focus of this study, is composed of the six New England states plus New York. The region stretches from Lake Erie on the west to the maritime provinces of Canada on the east. In addition to including most of the nation's largest (greater New York City), and all of the seventh largest (greater Boston) metropolitan areas, the region includes 19 other Metropolitan Statistical Areas (MSAs) with populations between 50,000 and 100,000. Much of the land area in the region is only sparsely populated, however, with county population densities of less than 20 per square mile found from western New York to Maine.

Table 2 broadly summarizes physical and socioeconomic factors that help characterize the region's individual states. Total population in the region is nearly 32 million, spread over an area of 123,000 square miles. In population, the region includes 11.6% of the U.S. population, but only 3.3% of the land area. In economic terms, average regional incomes are 20% above the national average, while incomes at the state level range from among the highest in the nation in highly populated states (Connecticut, Massachusetts, and New York) to among the lowest (Maine).

	Population ^a	Land Area Sq. Miles ^b	Per Capita Income ^c	Unemploy- ment Rate ^d	Productivity ^e \$/Worker	Ozone Levels ^f	Per Capita Energy Consumption, 1996 ^b Mil Btu/Capita	Gross State Product Growth 1988-97 ^c
U.S.A.	272,690,813	3,717,796	\$26,482	4.5%	\$51,811	40%	349	24.1%
Northeast Region	31,692,534	122,644	\$31,816	4.7%	\$61,459	73%	245	12.3%
Connecticut	3,282,031	5,544	\$37,700	3.4%	\$66,321	100%	252	17.0%
Maine	1,253,040	33,741	\$23,002	4.4%	\$40,372	36%	433	9.0%
Massachusetts	6,175,169	9,241	\$32,902	3.3%	\$56,352	100%	251	13.1%
New Hampshire	1,201,134	9,283	\$29,219	2.9%	\$51,783	44%	258	27.5%
New York	18,196,601	53,989	\$31,679	5.6%	\$65,761	64%	228	10.5%
Rhode Island	990,819	1,231	\$26,924	4.9%	\$49,589	100%	239	10.3%
Vermont	593,740	9,615	\$24,217	3.4%	\$39,741	0%	276	14.2%

^a 1999 Level. Source: U.S. Census Bureau, 1999.

^b Source: Statistical Abstract of the United States, 1999.

^c 1998 level. Source: Bureau of Economic Analysis, 2000.

^d 1998 level. Source: Bureau of Labor Statistics, 2000.

^e 1997 level. Total gross state/regional/national product per full or part-time worker. Source: Author calculations and Bureau of Economic Analysis, 2000.

^f Population in non-attainment areas. Source: Environmental Protection Agency, 2000.

Regional air quality varies inversely with population density: states along the heavily populated Atlantic seaboard tend to have poor air quality as measured by ambient ozone concentrations, while less densely populated parts of the region fall outside ozone non-attainment areas. Total energy usage per capita in the region is only 70% of the national average; energy usage in Maine distinctly differs from other states in the region, with consumption 24% higher than the national average. Regional economic growth over the past ten years has generally lagged that of the U.S. as a whole, with only one state in the region exceeding the national average rate of the Gross State Product (GSP).

Measuring the Economic Impact of Regional Industries

While no single measure of economic activity can capture the diverse impacts of economic activity, a number of standard measures can be used to estimate different dimensions of these impacts. The project team selected four indicators to estimate the impacts of economic activity in the region: gross regional product (value added), employment, employee compensation, and business taxes paid. For each economic indicator, the value for each SIC code was divided by the maximum value among the industries to obtain a normalized ranking. The normalized ranks were then summed to measure overall economic impact.

The economic data used in the analysis was obtained from the Minnesota IMPLAN Group, using the database containing 1996 figures on industry output, employment, and value added, as well as a calculation of demand for industry outputs. The data set was separable to the county level, with data available for each county within the seven-state study area. The IMPLAN data is derived from many different government sources and compiled into a single data set useful for input output analysis. Some of the original sources of data include the U.S. Bureau of Economic Analysis, U.S. Bureau of Labor Statistics, U.S. Census Bureau, U.S. Department of Agriculture, and the U.S. Geological Survey.

Gross Regional Product

Gross Regional Product (GRP) or value added, is identical to the widely reported Gross Domestic Product for the nation as a whole, but restricted to the seven-state region and each specific industry sector. The indicator measures the total increase in market value produced in each sector, exclusive of purchases of inputs from other economic sectors. Gross Regional Product can be measured as, the sum of employee compensation plus business profit and rental income, plus taxes paid

Gross Regional Product is derived from the National Income and Products Accounts data published in the Survey of Current Business and maintained by the Bureau of Economic Analysis, an agency of the U.S. Department of Commerce. Table 3 summarizes the Gross Regional Product by industry sector for the seven-state region. The leading industries in terms of GRP are Information/Communications Products, Chemicals/Plastics, Printing/Publishing, and Industrial/Power Machinery.

Employment

Total employment levels are defined as the sum of all full-time and part-time workers, measured as an annual average. The estimated levels include self-employed

workers. This indicator provides a measure of the contribution of each sector in providing the opportunity for workers to earn income or employment. The total and part-time employment numbers are summarized for the seven states in the northeast region by industry sector in Table 3. The industries employing the greatest numbers of workers in the region include Printing/Publishing, Industrial/Power Machinery, Information/Communication Products, and Instruments/Related Products.

Employee Compensation

Employee compensation is one important measure of economic health of an industry as it is important to consider not only the number of jobs produced in each industry sector, but the quality of the jobs in terms of monetary compensation. Employee compensation, including wage and salary income, together with employee benefits, is summarized by industry sector for the seven states in the northeast region in Table 3. The income derived by self-employed individuals (proprietor income) is also included. Industries with the highest employee compensation include Information/Communication Products, Printing/Publishing, and Instruments/Related Products.

Business Taxes

Business taxes are a component of the value added by an industry sector. They are defined in this report to be the sum of taxes paid to local, state, and national governments. Note that this indicator of business taxes is often called "Indirect Business Taxes." Table 3 summarizes the indirect business taxes paid by industry sector in the seven northeastern states. The Food Processing industry pays indirect business taxes nearly three times that of the next industry, Chemicals/Plastics. Business taxes are high in the Food Processing industry due to sin taxes on malt beverages and distilled liquor, which account for 74% of all taxes paid by the industry.

Overall Economic Impact

Table 3 shows the composite ranking of the four economic indicators, summing the normalized impact for each industry to assess the relative economic impact of industries in the seven-state region. The fifteen industry sectors can be clustered in three general groups based on their relative composite rankings. The industry sectors with the greatest economic impact include Printing/Publishing, Information/Communication Products, Industrial/Power Machinery, Chemicals/Plastics, Instruments/Related Products, Food Processing, Fabricated Metals, Forest Products, and Textiles/Apparel. Industry sectors with a more moderate economic impact include Glass/Stone/Clay, Mining, and Petroleum. The least significant industries to the regional economy include Metal Casting, Steel, and Aluminum.

Measuring the Energy Impact of Regional Industries

Two energy indicators were chosen to represent energy use in the region: total quantity of energy purchased and CO₂ emissions. These indicators were chosen because they

Table 3. Gross Regional Product, Employment, Employee Compensation and Indirect Business Taxes by Industry Sector (1996)

Industry Sectors	Gross Regional Product		Average Employment		Employee Compensation		Indirect Business Taxes		Overall Rank
	Million \$ / Year	Max Rank	Number	Max Rank	Million \$ / Year	Max Rank	Million \$ / Year	Max Rank	
Printing/Publishing	18,867	0.91	258,684	1	12,546	0.96	437	0.39	3.26
Information/Com. Products	20,768	1	207,035	0.8	13,088	1	425	0.38	3.18
Industrial/Power Machinery	17,439	0.84	237,584	0.92	11,795	0.9	331	0.3	2.96
Chemicals/Plastics	20,030	0.96	169,850	0.66	9,886	0.76	478	0.43	2.81
Instruments/Related Products	13,740	0.66	191,558	0.74	12,309	0.94	284	0.26	2.6
Food Processing	10,382	0.5	109,310	0.42	4,814	0.37	1,114	1	2.29
Fabricated Metals	11,627	0.56	143,445	0.55	6,355	0.49	267	0.24	1.84
Forest Products	9,182	0.44	137,701	0.53	5,477	0.42	239	0.22	1.61
Textiles/Apparel	6,886	0.33	169,994	0.66	5,348	0.41	109	0.1	1.5
Glass/Stone/Clay	3,244	0.16	46,255	0.18	2,145	0.16	112	0.1	0.6
Mining	2,366	0.11	31,487	0.12	1,585	0.12	131	0.12	0.47
Petroleum Refining	1,694	0.08	11,671	0.05	598	0.05	207	0.19	0.37
Metal Casting	979	0.05	15,592	0.06	707	0.05	26	0.02	0.18
Steel	750	0.04	9,207	0.04	514	0.04	37	0.03	0.15
Aluminum	384	0.02	5,219	0.02	296	0.02	20	0.02	0.08

reflect the total energy used by industry and the impact energy use has on climate change. Energy data was obtained from the Energy Information Agency (EIA) 1994 Manufacturing Energy Consumption Survey (MECS). The final tabulated data includes the aggregate sum for the seven-state region assessed at the two-digit SIC level only.

Total Quantity of Energy Purchased

Industry consumes energy in a variety of forms and for a variety of purposes. In some cases what is normally an energy resource is used as a feedstock or raw material in the manufacture of a product. In other cases, particularly in the Forest Products industry, leftover or scrap feedstock are used as an energy supply without its being tabulated as a purchased energy quantity. These distinctions cannot be obtained from the MECS data. The primary energy indicator chosen from the MECS data set was Total Quantity of Purchased Energy, which includes electricity, residual fuel oil, distillate fuel oil, natural gas, liquefied petroleum gas, coal, coke, and other minor constituents. Total Quantity of Purchased Energy includes all energy purchased by a facility and includes the energy purchased for consumption and for inventory purposes, but not the energy produced on-site.

The data were converted to a common unit of trillion BTU/year (10¹² Btu/year) and ranked according to two-digit SIC categories. This results in somewhat different groupings for four industries when compared to the more detailed analysis possible in evaluating the economic and environmental data. These differences are noted by a different industry title for these four industries as indicated in Table 4: Chemicals/Plastics/Rubber, Electronics, Primary

Metals, and Industrial Machinery. The annual consumption of each SIC was then divided by the maximum consumption in order to obtain a normalized ranking. As might be expected, the quantity of purchased energy by the Forest Products industry with 184 trillion Btu/year greatly exceeded all other SIC categories. Within this sector, Paper and Allied Products (SIC 26) is the source of most of the energy consumed with 172 trillion Btu/year or 97% of the total. Chemicals/Plastics ranks second with 110 trillion Btu/year, twice the energy consumed of the third ranked industry, Glass/Stone/Clay, and the next several industry groups with comparatively similar energy consumption levels.

CO₂ Emissions

Carbon dioxide (CO₂) emissions from natural sources as well as energy utilization are a major source of greenhouse gases, contributing to global warming trends. Different fossil fuel types yield different quantities of CO₂ when consumed. Energy purchase data from the MECS report was converted to an equivalent CO₂ production basis in thousand tons/year. A normalized ranking was then obtained by dividing each production rate by that of the largest sector, the Forest Products industry, with the results shown in Table 4. Once again, Forest Products ranks number one, producing twice the CO₂ emissions (4,119 thousand tons/year) of the next largest emitter (Chemicals/Plastics/Rubber with 2,134 thousand tons/year). Within the Forest Products industry sector, Paper and Allied Products (SIC 26) is responsible for about 95% of the emissions.

Overall Energy Impact

The overall energy impact of industries in the northeast region at the two-digit SIC level is summarized in Table 4. The top three ranked industries are National IOF industries (Forest Products, Chemicals, and Glass). The fourth and fifth ranked industries, Instruments/Related Products and Electronics, have strong linkages to the National IOFs and are important to the regional economy.

Industry Sectors	SIC	CO ₂ Emissions		Energy Consumption		Overall Rank
		Thousand Tons/Year	Maximum Rank	Trillion Btu/Year	Maximum Rank	
Forest Products	24 and 26	4,119	1	184	1	2
Chemicals/Plastics/Rubber	28 and 30	2,134	0.52	110	0.6	1.12
Glass/Stone/Clay	32	771	0.19	55	0.3	0.49
Electronics	36	980	0.24	45	0.24	0.48
Instruments/Related Products	38	891	0.22	47	0.26	0.48
Food Processing	20	611	0.15	36	0.2	0.35
Fabricated Metals	34	485	0.12	38	0.21	0.33
Primary Metals	33	482	0.12	35	0.19	0.31
Textiles/Apparel	22 and 23	415	0.1	36	0.2	0.3
Industrial Machinery	35	420	0.1	27	0.15	0.25
Printing/Publishing	27	287	0.07	30	0.16	0.23
Petroleum Refining	29	863	0.21	3	0.02	0.23

Measuring the Environmental Impact of Regional Industries

The selection of environmental indicators was largely guided by the availability of accessible national data reported consistently across the seven states and across the different industry sectors under study, and available at the three and four digit SIC level. Many industrial activities result in toxic and hazardous waste production. Three indicators were selected to assess environmental impacts: criteria air pollutants (CAPs) emissions, volatile organic compound (VOC) emissions, and toxic release inventory (TRI) emissions. Data were gathered for each indicator at the four-digit SIC level for each industry sector for the seven states of New York, Massachusetts, Connecticut, Rhode Island, Vermont, New Hampshire, and Maine. Each of the indicators and emission totals for the northeast region is described below.

Criteria Air Pollutants

Airborne pollutants, produced by fossil fuel combustion and industrial activities, are responsible for a range of environmental problems including smog, acid rain, eutrophication of rivers and lakes, and a variety of health problems. Under the Clean Air Act, EPA has established National Ambient Air Quality Standards for six "criteria" air pollutants (CAPs): nitrogen dioxide (NO_x), sulfur dioxide (SO_x), ozone (O_3), carbon monoxide (CO), small particulates (less than 2.5 micrometers), and lead (Pb). When considering pollution caused by industrial sources, VOCs, SO_x , and NO_x are of particular concern as EPA has estimated that 40% of VOC emissions, 25% of SO_x emissions and 15% of NO_x emissions are due to industrial sources.

As one environmental indicator, the study uses the total sum of CAP emissions by industry sector for the seven-state aggregate as shown in Table 5. For total CAP emissions in the seven states, the largest industrial emitter by far is the Forest Products industry with 100.5 thousand tons/year, or 44% of the total emissions, and almost three times the emissions of the next largest emitter, Glass/Stone/Clay. The Paper and Allied Products industry (SIC 26) accounts for 94% of the CAP emissions within the Forest Products sector. The CAP emissions of each industry sector are divided by the maximum CAP emissions of the largest emitter, Forest Products, to obtain the normalized ranking in Table 5. The zero reported for Petroleum Refining indicates a lack of reportable data, not zero emissions in the region.

VOC Emissions

EPA has estimated that industrial sources are responsible for 40% of all volatile organic compounds (VOC) emissions. VOCs contribute not only to ozone formation and smog, but include a variety of chemicals known to be hazardous to human health and others that are suspected carcinogens. As Table 5 shows, the largest industrial emitters of VOCs are Forest Products and Chemicals/Plastics, releasing 13.7 and 13.1 thousand tons/year respectively, followed by Instruments/Related Products with 8.1 thousand tons/year, Printing/Publishing with 5.8 thousand tons/year, and Fabricated Metals with 5.5 thousand tons/year. Forest Products and Chemicals/Plastics alone account for almost 50% of the reported VOC emissions. A large amount of VOC releases in Forest Products are due to the use of glues and resins in the industry. In the Chemicals/Plastics industry solvent production is a major source of VOCs. The VOC emissions of each industry sector is divided by the

maximum VOC emissions of the largest emitter, Forest Products, to obtain the normalized rankings in Table 5.

Toxic Waste Releases

Toxic wastes have potentially severe effects on human health and the environment and are monitored by EPA through the Toxic Releases Inventory (TRI) System. The TRI database includes self-reported facility release data for manufacturing industries SIC 20-39 for more than 600 chemicals if a firm meets the following criteria: has ten or more full-time employees, manufactures or processes more than 25,000 pounds of designated chemicals, or uses more than 10,000 pounds of designated chemicals. TRI data is available by four-digit SIC codes for all manufacturing facilities and allows comparison across states and industry sectors. Reported releases include toxic chemical discharges to air, water, land, contained releases in underground wells, and transfers. Importantly, because TRI data generally captures large facilities but not small facilities, the emissions data underestimates emissions for industries characterized by many small facilities such as the printing industry.

Table 5 summarizes the TRI emissions by industry sector. The Forest Products industry and Chemicals/Plastics industry are the leading industries in TRI emissions in the northeast, producing 6.3 thousand tons/year and 4.9 thousand tons/year respectively. Within the Forest Products sector, 97% of the TRI emissions are produced by the Paper and Allied Products industry. Other large TRI emitting industries in the northeast are Instruments/Related Products, Steel, and Glass/Stone/Clay. The TRI emissions of each industry sector is divided by the maximum TRI emissions of the largest emitter, Forest Products, to obtain the normalized rankings in Table 5.

Table 5. CAP, TRI and VOC Emissions Seven-State Aggregate by Industry Sector							
Industry Sectors	CAP Emissions		TRI Emissions		VOC Emissions		Overall Rank
	Thousand Tons/Year	Normalized Rank	Thousand Tons/Year	Normalized Rank	Thousand Tons/Year	Normalized Rank	
Forest Products	100.5	1	6.3	1	13.7	1	3
Chemicals/Plastics	22.5	0.22	4.9	0.78	13.1	0.96	1.96
Instruments/Related Products	15	0.15	3.3	0.52	8.1	0.59	1.26
Glass/Stone/Clay	36	0.36	1.4	0.22	1.7	0.12	0.7
Printing/Publishing	6.3	0.06	0.5	0.08	5.8	0.42	0.56
Fabricated Metals	7.1	0.07	0.3	0.05	5.5	0.4	0.52
Industrial/Power Machinery	19.5	0.19	0.9	0.14	2.4	0.18	0.51
Steel	4.1	0.04	2.2	0.35	0.8	0.06	0.45
Textiles/Apparel	8.2	0.08	0.7	0.11	3.1	0.23	0.42
Information/Comm. Products	13.4	0.13	0.8	0.13	2	0.15	0.41
Mining	1.5	0.01	1.3	0.21	0.9	0.07	0.29
Food Processing	5.4	0.05	0.2	0.03	0.9	0.07	0.15
Metal Casting	2.6	0.03	0.5	0.08	0.3	0.02	0.13
Aluminum	0.5	0	0.5	0.08	0.07	0.01	0.09
Petroleum Refining	0.0 ^c	0	0.004	0	0.003	0	0

Overall Environmental Impact

The overall environmental impact of industries in the northeast region is summarized in Table 5. The numerical maximum rankings were summed across the three environmental indicators to obtain a sense of the relative environmental impact of each sector. The industry with the greatest environmental impact in the northeast region is by far the Forest Products industry and more specifically, Paper and Allied Products (SIC 26) included within the National IOF Forest Products industry sector. The two industries with the greatest environmental impact in the northeast region, Forest Products and Chemicals/Plastics, are also National IOFs and have twice the environmental impact of the other industries, excluding Instruments/Related Products, which ranks third and also has a major environmental impact. While not a National IOF, the manufacture of instruments has linkages to many of the National IOFs. Glass, ranked fourth is also a National IOF. Printing/Publishing, ranked fifth and the largest employer in the northeast of the industries analyzed, has close linkages to both the Forest Products and Chemicals/Plastics industries.

Northeast Regional Priority Industries

Overall Economic, Energy, and Environmental Impacts

To assess the relative and overall impact of the regional industries examined, the numerical ranks for each of the three measures (economic, energy, and environmental) were summed and normalized as depicted in *Figures 1, 2, and 3*.

Figure 1. Normalized Economic Impact of Industries

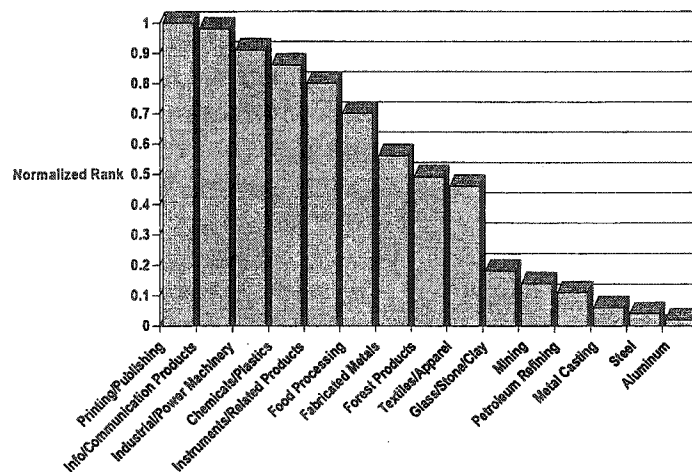


Figure 1 shows that the industries with the greatest economic impact include Printing/Publishing, Information/Communications Products, Industrial/Power Machinery, Chemicals/Plastics, and Instruments/Related Products. Food Processing, Fabricated Metals, Forest Products, and Textiles/Apparel have a moderate relative impact.

Figure 2. Normalized Energy Impact of Industries

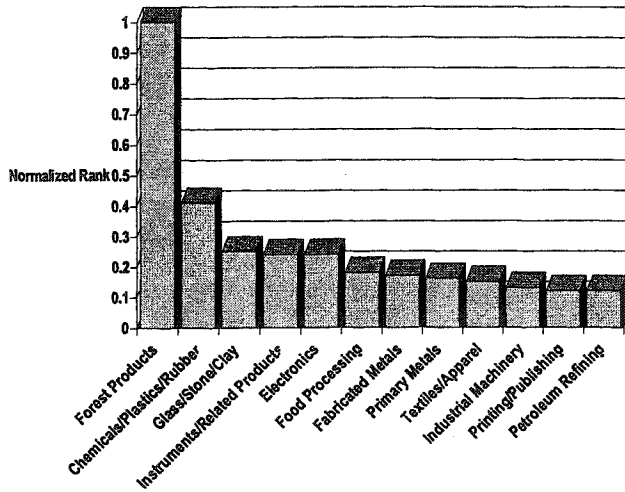
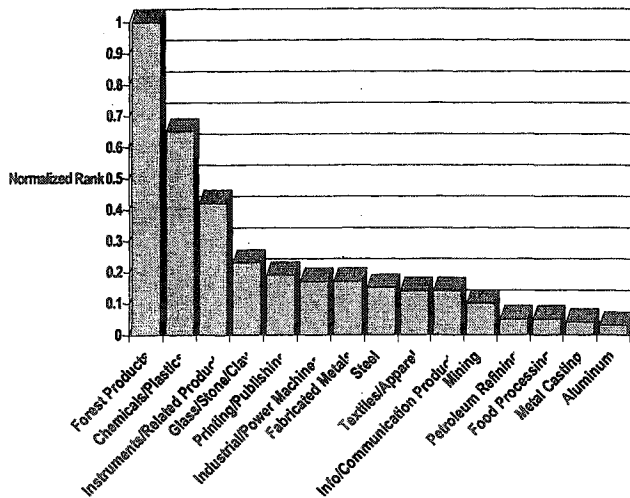


Figure 2 illustrates the relative energy impact of industries in the northeast region. Forest Products shows a significantly greater energy impact than any other industry. This is in spite of the fact that the energy impact is based on total energy purchases. Both Forest Products and the industry with the second largest impact, Chemicals/Plastics, consume renewable and recycled material and, as a result, total energy purchases may underestimate energy consumption by 30% or more. Industries with moderate energy impact include Glass/Stone/Clay, Instruments/Related Products, and Electronics.

Figure 3. Normalized Environmental Impact of Industries



As Figure 3 shows, the Forest Products industry has the largest environmental impact of the industries in the northeast region followed by Chemicals/Plastics, and Instruments/Related Products. Glass/Stone/Clay, Printing/Publishing, Industrial/Power Machinery, and Fabricated Metals have a moderate relative environmental impact. The environmental impacts of Printing/Publishing and Fabricated Metals are probably underestimated since the environmental data only includes emissions data over certain threshold levels, excluding smaller companies. Of the manufacturing industries analyzed in this report, the five

industry sectors with the largest overall economic, energy, and environmental impact in the northeast region are Forest Products, Chemicals/Plastics, Instruments/Related Products, Communication/Information Products, and Printing/Publishing. Of these regional priority industries, two – Forest Products and Chemicals/Plastics – are also National IOFs. The other three – Instruments/Related Products, Communication/Information Products, and Printing/Publishing – have strong linkages to several of the National IOFs.

Conclusion – Next Steps

Five priority industries, on a regional level, have been identified in this report as having the greatest impact on the economy, energy, and environment of the region: Forest Products, Chemical/Plastics, Information/Communications Products, Instruments/Related Products, and Printing/Publishing. In addition, although not discussed in this paper, the impact of regional industries on DOE's Industries of the Future was also examined through cross linkages, based on total purchases from one industry caused by activity in another sector. Regional priority industries were found to have important supply chain linkages to DOE's IOFs. For example, the Printing/Publishing industry in the northeast caused total purchases of \$9 billion from the IOFs nationally. Most of these purchases were from the Forest Products and Chemicals/Plastics industries. Understanding these industry relationships is an essential step toward building industry partnerships.

With funding from DOE's Office of Industrial Technologies, the northeast states have initiated a series of four regional workshops with the industry shown in this report to have the greatest overall impact, Forest Products. The goals of these workshops were to increase awareness of and participation in the DOE Industries of the Future program by Forest Products companies in the northeast region, develop a summary of regionally specific technology needs, and lay the groundwork for an on-going partnership between the northeastern states, DOE, and the Forest Products industry in the northeast.

The seven northeastern states will use the information presented in this report to evaluate industry priorities. The report should serve as a useful tool to engage stakeholders and partners in the industry/government partnership building process. As a first step, key economic development and environmental personnel in each state have been asked to review and comment on the draft report. The project partners will continue to work with industry to improve productivity, increase energy efficiency, improve environmental quality, and, in general, strengthen the manufacturing base in the northeastern states.