97-1017 E
November 21, 1997

Industrial Energy Intensiveness and Energy Costs in the Context of Climate Change Policy

Bernard A. Gelb
Specialist in Industry Economics
Economics Division

Summary

International negotiations are under way regarding measures to stabilize concentrations of atmospheric "greenhouse gas" in order to forestall feared changes in the global climate. In late October, President Clinton announced the U.S. negotiating position. Inasmuch as the burning of fossil fuels produces greenhouse gases, the issue of how stabilization measures would affect major energy-using industries is raised. As shown in this report, the amount, cost, and mix of energy sources used vary widely even among U.S. energy-intensive industries, suggesting a wide range of potential effects.

The Policy Context[1]

There is concern that human activities affect the energy-exchange balance between Earth, the atmosphere, and space, inducing changes in the global climate. Possible results could be seen as both positive and negative. The burning of fossil fuels in particular has increased the amount of carbon dioxide (CO_2) and other gases in the atmosphere. If these gases continue to accumulate at current rates, global warming could occur through intensification of the natural "greenhouse effect" that makes the Earth's climate habitable. Such warming could affect agriculture, forestry, and water resources, and, under certain scenarios, lead to rising or falling sea levels depending upon climate system responses.

Policy options to curb emissions stress energy efficiency and conservation, tree planting to offset atmospheric CO_2, market-oriented strategies such as carbon taxes, and substituting nuclear and renewable energy and less CO_2-intensive fossil fuels. But there are scientific uncertainties regarding the magnitude, timing, rate, and regional effects of the potential climatic change. Given the uncertainties and the potential unevenness of impacts, there is disagreement about what are the appropriate policy responses.

[1] A substantial portion of this section is taken from CRS Issue Brief 89005, *Global Climate Change*, which should be consulted for more extensive coverage of global climate change issues.

President Clinton announced on October 22, 1997, the U.S. negotiating position for the December 1997 meeting of the Framework Convention on Climate Change in Kyoto, Japan. The U.S. would commit to reducing its greenhouse gas emissions to 1990 levels by the year 2012, and cut them further in the next 5 years. Decreases would be effected through (1) $5 billion in tax cuts and spending on research and development in new technologies over five years, (2) consulting with and rewards to industries for near-term actions, (3) restructuring the electric utility industry (raising energy efficiency in electricity generation), and (4) joint implementation projects in which emission reduction credits would be shared between countries with "emission budgets" and those without, and (5) domestic and international emissions trading, to begin after 10 years. Only with developing nation participation (in the future) would the commitment become effective.

Many in U.S. business and some in labor contend that the proposal will raise energy prices, slow economic growth, and cost jobs. Some environmental groups say the proposal is insufficient, putting the world at risk of serious environmental dislocations. Other countries have proposed greater and faster emission reductions. Congress would have to ratify any treaty and fund any federal spending, but there is concern about economic effects and possible U.S. action in the absence of action by developing nations.

The possibility of reducing greenhouse gas emissions by taxation or other measures raises the issue of how energy-using industries would be affected. Removing greenhouse gases after combustion imposes severe technical difficulties and cost penalties. Industry and commercial transportation account for about half of U.S. CO_2 emissions from fossil energy consumption. Such emissions by U.S. industry rose 19% between 1986 and 1996.

The Data and Comparisons

This report presents and briefly analyzes data on the amount, cost, and distribution by source of energy used by a number of U.S. energy-intensive sectors and "industries." While the report does not analyze how measures to reduce greenhouse gas emissions would affect particular industries, it indirectly provides guidance. The levels of detail for the sectors or industries included differs, with some industries constituting components of industry groups or sectors. Because energy materials used as raw materials do not undergo combustion, they are excluded from the energy measures shown. However, energy from "fuel" produced and consumed in the same establishment, such as byproducts and waste, is included inasmuch as its combustion produces greenhouse gas emissions.

Energy-intensiveness varies widely even among sectors and industries selected for energy-intensiveness. For example, energy use for heat and power ranged from 6,900 Btu[2] per dollar of value added for food and kindred product manufacturing in 1994 to 46,300 Btu for commercial air transportation (**Table 1**). For ease of comparison, the industry groups and sectors presented in this report are ranked by ratio of energy outlays to value of shipments or revenues in **Table 2**. The data also show that energy producing industries also *use* energy intensively; coal mining and oil and natural gas extraction are more energy intensive than the average manufacturing industry.

---

[2] A British thermal unit (Btu) is the heat needed to raise the temperature of a pound of water one degree Fahrenheit.

TABLE 1. Energy Intensiveness and Relative Energy Costs of Selected Major Energy-Using Sectors and Industries, 1994

Sector, Industry Group, and Industry [a]	Energy Use		Energy Purchases as a % of Value of Shipments [c]
	Energy for Heat and Power (trillion BTU) [b]	Thousand BTU per $ of value added	
ALL FARMING [d e]	945	11.5	4.4
ALL MINING [f]	1,843	19.1	3.9
Metal mining [f]	157	30.5	11.1
Coal mining [f]	167	10.9	3.9
Oil & natural gas extraction [f]	1,231	18.2	2.6
Nonfuel nonmetal mining [f]	288	33.9	9.9
ALL MANUFACTURING	16,515	10.3	1.8
Food & kindred products	1,183	6.9	1.3
Lumber & wood products	435	10.7	1.7
Paper & allied products	2,634	41.6	4.3
Paper mills	1,292	86.1	8.9
Paperboard mills	930	104.6	8.6
Chemicals & allied products	3,273	18.1	3.1
Industrial inorganic chemicals, n.e.c.	344	35.2	8.1
Plastics materials & resins	319	21.1	3.5
Industrial organic chemicals, n.e.c.	1,370	56.3	5.0
Nitrogenous fertilizers	286	145.5	11.7
Petroleum & coal products	3,263	114.1	2.8
Petroleum refining	3,153	135.1	2.8
Stone, clay, & glass products	945	23.9	5.1
Hydraulic cement	329	117.5	17.3
Primary metals	2,568	39.8	5.1
Blast furnaces & steel mills	1,824	88.1	7.1
Aluminum smelters & refineries	201	112.0	22.5
TRANSPORTATION	11, 500	n.e.	n.e.
Air transportation [e h]	2,218	46.3	10.5
Trucking [j]	n.e.	n.e.	8.9 [j]
ELECTRIC UTILITIES	30,881	n.e.	22.5 [k]

See next page for sources and notes.

Sources: Air Transport Association, faxed data; U.S. Department of Agriculture, Economic Research Service. *Agricultural Resources and Environmental Indicators, 1996-97*; U.S. Department of Commerce (DoC), Bureau of Economic Analysis. *Survey of Current Business*, August 1996; DoC, Bureau of the Census. *1994 Annual Survey of Manufactures*; (DoC), Bureau of the Census. *1992 Census of Mineral Industries, Fuels and Electric Energy Consumed*; U.S. Department of Energy (DOE), Energy Information Administration (EIA). *Annual Energy Outlook 1996*; DOE, EIA. *Household Vehicles Energy Consumption 19*94; DOE, EIA, *Manufacturing Consumption of Energy 1994*; DOE, EIA, *Monthly Energy Review*, October 1997; DOE, Oak Ridge National Laboratory. *Transportation Energy Data Book: Edition 15*; U.S. Department of Transportation (DOT), Federal Aviation Administration. *FAA Aviation Forecasts, Fiscal Years 1997-2008*; DOT, Office of Airline Information. *Air Carrier Financial Statistics Quarterly*; Executive Office of the President. *Economic Report of the President*, Transmitted to the Congress February 1997; author's estimates.

Note: 1994 is the latest year for which detailed energy use data are available for most industries.
n.e. Not estimated, due to data shortcomings. n.e.c. Not elsewhere classified.
[a] Not all components are shown for broader categories.
[b] British thermal unit (Btu): Heat needed to raise temperature of a pound of water one degree Fahrenheit.
[c] Expenditures for fuel and electricity for heat and power as a percent of value of shipments.
[d] Excludes forestry, fisheries, and agricultural services. Energy purchases are related to cash receipts from farm marketings.
[e] Energy intensity figures are per dollar of gross product, a concept similar to value added.
[f] Data for these industry groups are for 1992.
[g] Transportation sector as defined by the Energy Information Administration, excludes household vehicles.
[h] Excludes general aviation; energy use data are for aircraft fuel only. Energy purchases are related to transportation operating revenues.
[i] Includes non-air courier services; excludes auxiliaries to nontransportation companies and independent owner-operators with no paid employees.
[j] Energy use data are for vehicle use only. Energy purchases are related to operating revenues.
[k] Based on "price component" figures derived by the EIA rather than calculated from aggregate data.

The effect on an industry's costs relative to its prices is a major criterion for judging the effect of emission reduction measures. An indication of the importance of energy in an industry's cost structure, and in the prices it charges for its products, is the ratio of energy outlays to value of shipments or revenues (**Table 1**).[3] Affected by the relative cost of the energy source(s) it uses most and the value of its products, an industry's energy cost ratio relative to those of other industries may well differ markedly from its relative energy intensiveness in Btu per dollar of value added. Cement manufacturers are 12% more energy intensive than paperboard mills, but their energy cost ratio is about 100% greater. The latter is one of the industries that obtains large amounts of energy from materials produced on site, such as byproducts and waste materials, which they do not buy per se.

Because different energy sources yield different levels of CO_2 and other greenhouse gas emissions per unit of energy, differences in energy source mix also are relevant. Thus, although energy-intensiveness is nearly the same for paper and for steel mills, the latter

[3] An industry's value of shipments or revenues is the aggregate price of its products, which includes any profit. These measures are appropriate as proxies for total costs because that portion of price accounted for by profit can be considered an opportunity cost, more or less what the capital invested would yield in another endeavor or in a financial instrument.

TABLE 2: Selected Major Energy-Using Industry Groups and Industries Ranked by Energy Intensiveness, 1994

Industry Group	Thousand Btu of Energy for Heat & Power Per Dollar of Value Added
Air transportation	46.3
Paper & allied products manufacturing	41.6
Primary metal manufacturing	39.8
Nonfuel nonmetal mining	33.9
Metal mining	30.5
Stone, clay, & glass products manufacturing	23.9
Oil & gas extraction	18.2
Chemicals & allied products manufacturing	18.1
All farming	11.5
Coal mining	10.9
Lumber & wood products manufacturing	10.7
Individual Manufacturing Industry	
Nitrogenous fertilizers	145.5
Petroleum refining	135.1
Hydraulic cement	117.5
Aluminum smelters & refineries	112.0
Paperboard mills	104.6
Blast furnaces & steel mills	88.1
Paper mills	86.1
Industrial organic chemicals, n.e.c.	56.3

Source: Table 1. Descriptions of industries and of energy use coverage apply as in Table 1.

are apt to be affected more by CO_2 emission reduction measures inasmuch as 38% of steel mills' energy is obtained from coal compared with 15% for paper. The Energy Information Administration (EIA), U.S. Department of Energy, estimates that full combustion of coal yields about 26 metric tons of carbon per billion Btu; most petroleum products yield 19 to 21½ tons; and natural gas yields about 14 metric tons. The EIA does not include biofuel emissions in its estimates of CO_2 emissions. Because the carbon in biofuels such as wood waste was absorbed from the atmosphere during their formation, carbon emitted during their combustion does not constitute a change in the overall carbon budget in the long run. This report has included the heat content of these materials inasmuch as it is not determined how an international treaty will treat their emissions.[4]

[4] See EIA. *Emissions of Greenhouse Gases in the United States 1996*. Washington, DC, October 1997.

TABLE 3. Distribution of Energy for Heat and Power by Energy Type, Selected Major Energy-Using Industry Groups and Industries, 1994 (percent of total)

Sector, Industry Group, & Industry	Coal [a]	Natural Gas	All Petroleum	Electricity	Other [b]	TOTAL
ALL FARMING	*	5.8	78.3	15.9	*	100
ALL MINING [c]	3.4	56.4	11.3	14.3	14.6	100
Metal mining [c]	9.5	21.7	22.3	40.1	6.4	100
Coal mining [c]	5.4	0.6	40.7	25.7	27.5	100
Oil & gas extraction [c]	*	73.7	5.4	9.2	11.8	100
Nonfuel nonmetal mining [c]	13.5	33.3	14.6	40.2	23.3	100
ALL MANUFACTURING	11.5	37.2	4.8	16.1	31.0	100
Food & kindred products	14.1	53.3	4.6	16.7	11.3	100
Lumber & wood products	1.5E	11.0	5.0	15.6	66.7	100
Paper & allied products	11.7	21.8	7.1	8.5	51.0	100
Paper mills	15.1	21.0	7.7	9.1	47.1	100
Paperboard mills	10.9	21.4	5.7	4.9	57.1	100
Chemicals & allied products	7.8	57.9	2.5	15.9	15.9	100
Industrial inorganic chemicals	10.0E	40.0E	3.0	41.9	5.2	100
Plastics materials & resins	10.0E	45.0E	1.6	17.6	15.7	100
Industrial organic chemicals	6.7	61.1	0.6	4.7	26.9	100
Nitrogenous fertilizers	*	93.4	*	4.5	1.7	100
Petroleum & coal products	0.2E	25.0	4.3	3.7	66.8	100
Petroleum refining	0.2E	24.0	3.7	3.6	68.5	100
Stone, clay, & glass products	29.8	45.6	3.6	13.0	7.9	100
Hydraulic cement	62.6	7.6	1.8	11.2	16.7	100
Primary metals	28.8	31.2	2.3	19.2	18.5	100
Blast furnaces & steel mills	37.8	26.1	2.6	8.1	25.4	100
Aluminum smelters & refineries	*	8.5	1.8	91.0	0.1	100
COMMERCIAL TRANSPORTATION	*	0.1	99.8	0.1	*	100
Air transportation	*	*	100.0	*	*	100
Trucking	*	*	100.0	*	*	100
ELECTRIC UTILITIES [d]	55.1	8.6	2.2	33.6 [e]	0.4 [f]	100

Sources: Same as in table 1. Descriptions of industries and of energy use apply as in Table 1.

E - Estimated by author.
* Less than 0.05 percent, or zero.
[a] Includes coke and breeze.
[b] In mining, includes fuels not specified by kind. In manufacturing, includes fuel produced and consumed in the same establishment, including waste, and byproducts.
[c] Data are for 1992.
[d] Data are for 1996.
[e] Nuclear and hydropower.
[e] Geothermal, wood, waste, wind, photovoltaic, and solar thermal energy.