United States General Accounting Office

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Report to the Chairman, Environment, Energy, and Natural Resources Subcommittee, Committee on Government Operations, House of Representatives

May 1993

ENERGY POLICY

Other Nations' Policies to Reduce Oil and Coal Use in Transport and Industry

GAO/RCED-93-139

GAO

United States
General Accounting Office
Washington, D.C. 20548

Resources, Community, and
Economic Development Division

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May 28, 1993

The Honorable Mike Synar
Chairman, Environment, Energy, and
Natural Resources Subcommittee
Committee on Government Operations
House of Representatives

Dear Mr. Chairman:

As requested, this report discusses the key policies adopted by Canada, France, Germany, Japan, and South Korea to promote energy efficiency and conservation of oil and coal in their industrial and transportation sectors.

As agreed with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from the date of this letter. At that time, we will send copies to the appropriate congressional committees and the Secretaries of State and Energy. We will also make copies available to others on request.

Please contact me at (202) 512-3841 if you or your staff have any questions. Major contributors to this report are listed in appendix II.

Sincerely yours,

Victor S. Rezendes
Director, Energy and Science Issues

Executive Summary

Purpose

U.S. oil and coal consumption are projected to increase by almost one-fifth over 1990 levels by 2010. The nation's continued heavy reliance on fossil fuels, particularly oil and coal, raises questions about its ability to meet energy security, environmental, and economic objectives. As a result, the Chairman, Environment, Energy, and Natural Resources Subcommittee, House Committee on Government Operations, expressed interest in how other industrialized nations have dealt with this dilemma. He asked GAO to report on (1) the factors that influence the type and amount of energy nations use and, specifically, the trends in energy supply and use in Canada, France, Germany, Japan, and South Korea and (2) the key policies and programs these nations have adopted to promote conservation and the efficient use of oil and coal in their transportation and industrial sectors, which consume large amounts of those fuels. GAO, where appropriate, compared the policies it observed in these nations with those adopted by the United States.

Background

The principal energy policy objective of the United States is to balance the need for secure supplies of reasonably priced energy with the goals of a cleaner environment and economic growth. The nation's reliance on coal and oil, which account for nearly two-thirds of the nation's total energy supply, make achieving this balance difficult. The United States depends on these fuels because historically they have been plentiful and their prices have been low relative to those of other sources of energy.

As in the United States, energy policy in Canada, France, Germany, Japan, and South Korea seeks to balance energy security, environmental protection, and economic growth. In these five countries, as in the United States, most coal and most oil are consumed in the industrial, electricity generation, and transportation sectors. The consumption of coal and oil contributes significantly to air pollution and to emissions of gases that may increase the potential for global warming. Also, heavy reliance on oil increases a nation's economic vulnerability to sudden increases in the world price of oil. On the other hand, the availability of oil at low prices has contributed to economic growth.

Results in Brief

The amount and types of energy a country consumes are influenced by many factors, ranging from the availability and price of energy resources to geography, climate, and population. Economic factors, such as the rate of economic growth, the overall standard of living, and the types of goods and services produced, also affect energy consumption. These economic

factors are in turn affected by the availability and price of energy. Policymakers fashion energy policy within this web of interacting factors.

Following the oil shocks of the 1970s, the countries GAO surveyed generally reduced their dependence on oil and, with the exception of France and Germany, increased their use of coal in an effort to diversify their energy sources. Similarly, the use of nuclear power increased in all countries, particularly in France. At the same time, energy intensity—the amount of energy used to produce a unit of gross domestic product (GDP)—declined in all countries except South Korea. However, while lower energy intensity in the countries' industrial sectors generally resulted in lower energy consumption, declining energy intensity in the countries' transportation sectors were accompanied by increasing oil consumption. Overall, Japan, France, and Germany consume less energy per unit of GDP than the United States, while their energy prices are higher. However, South Korea and Canada use energy more intensively than the United States, despite higher energy prices.

In the transportation sectors of the five nations GAO reviewed, taxes on fuels and vehicles are the principal means used to promote the efficient use and conservation of oil. Gasoline prices are significantly higher than in the United States, largely because of higher taxes on gasoline and oil. Furthermore, all five nations impose motor vehicle taxes based on vehicle attributes that affect fuel efficiency. The United States has taken a different approach to reducing oil consumption in its transportation sector by relying on mandatory fuel economy standards to improve vehicle fuel efficiency. In the five nations' industrial sectors, policies and programs for promoting the efficient use of coal and oil include mandated energy audits, energy efficiency standards, and tax breaks and other subsidies for investment in energy-saving equipment and for conservation. By comparison, the U.S. government does not provide tax breaks for investment in such equipment, although several state and federal programs provide energy audits for small- and medium-sized industrial firms, and a few states offer low-interest-rate loans to small firms to invest in energy-efficient equipment.

GAO's Analysis

Countries' Varied Consumption Patterns Reflect the Many Factors That Affect Energy Use

The intensity of a nation's energy use and the types of fuels a nation consumes depend on many factors. The overall price of energy and the relative prices of different fuels affect the quantity and type of fuels consumed. Climate, geography, and energy resource endowment, as well as economic growth and the types of goods and services produced, all influence energy consumption. So do the policies and programs adopted by government, particularly energy pricing policies. Following the energy price shocks of the 1970s, the countries GAO surveyed experienced substantial improvements in energy efficiency and a shift away from oil as their predominant fuel. These trends slowed with the decline in oil prices in the mid-1980s. The United States consumes more energy to produce a unit of GDP than Germany, France, or Japan, where average energy prices are higher. These higher energy prices are largely the result of various taxes. The new U.S. administration recently proposed a tax on the energy content of most fuels. However, it is not clear if the increase in energy prices resulting from such a tax would be sufficient to cause a significant decrease in energy intensity.

Despite higher energy prices, South Korea and Canada use energy more intensively than the United States. Canada's cold climate and dispersed population, South Korea's rapid industrialization, and the preponderance of energy-intensive industries in both countries account for their higher energy intensity. Furthermore, oil use for transportation is not decreasing, despite an improved average vehicle energy efficiency. Rising living standards and disposable incomes have allowed residents of South Korea, Japan, France, and Germany to buy more cars and use them more, despite relatively high fuel prices and vehicle taxes.

Nations Employ Different Means to Achieve Policy Goals in Their Transportation and Industrial Sectors

The nations GAO surveyed encourage energy efficiency in transportation by employing policies that raise the price of fuels and inefficient vehicles. All five have substantially higher taxes on motor fuels, particularly gasoline, than the United States. Gasoline taxes range from $0.78 a gallon in Canada to $2.33 a gallon in France. All 50 U.S. states and the federal government impose taxes on gasoline, which average about $0.37 per gallon. In the five countries, these taxes were generally imposed to raise revenues, but government representatives stated that the taxes also contribute to reducing demand for gasoline.

The nations surveyed levy both a vehicle purchase tax or fee and an annual ownership fee based on vehicle characteristics related to fuel economy, such as engine size. The Canadian province of Ontario, in addition to imposing a sales-tax surcharge based on the fuel economy of new vehicles, provides modest rebates to the purchasers of new vehicles with fuel economy levels over 39 miles per gallon. In contrast, the United States taxes only the most fuel-inefficient new vehicles—those that average 22.5 miles per gallon or less—and does not provide incentives to purchase more efficient vehicles.

In contrast to their reliance on taxation in the transportation sector, in the industrial sector four of the five nations GAO surveyed have emphasized policies that provide financial assistance to help defray the cost of investment in energy-efficient equipment. Japan, Canada, and South Korea have programs to provide grants and low-interest-rate loans to industry for investment in energy-efficient plant and equipment. The United States, primarily at the state level, has programs to provide low-interest loans for such investments by firms and nonprofit organizations, although on a much smaller scale. Tax breaks to industry can also be designed to encourage energy efficiency. For example, Japan and France offer investment tax credits on purchases of energy-efficient plant and equipment.

Japan and France also require industrial firms that consume large amounts of energy to undergo energy audits to identify ways to improve energy efficiency. In Japan, audits help ensure compliance with energy-efficiency standards. The U.S. Department of Energy and several states provide free energy audits to small- and medium-sized manufacturing firms and small businesses. However, these programs are smaller than Japan's and France's energy audit programs, are not targeted at firms that consume large amounts of energy, are voluntary, and are not tied to efficiency standards.

Recommendations

GAO is not making recommendations in this report.

Agency Comments

GAO discussed the contents of this report with the Division Chief of the Office of Global Energy at the Department of State and with the Director, Office of International Organizations and Policy Development; the Deputy Director, Office of Energy Demand Policy; and analysts from the Energy Information Administration at the Department of Energy. These officials

generally agreed with GAO's findings and provided several technical comments, which have been incorporated where appropriate. As requested, however, GAO did not obtain written agency comments on a draft of this report.

Contents

Abbreviations

ADEME	Agency for Environment and Energy Management (France)
Btu	British thermal unit
CNG	compressed natural gas
DOE	Department of Energy
EC	European Community
GAO	General Accounting Office
GDP	gross domestic product
IEA	International Energy Agency
LPG	liquified petroleum gas
MITI	Ministry of Industry and International Trade (Japan)
OECD	Organization for Economic Cooperation and Development
OPEC	Organization of Petroleum Exporting Countries
R&D	Research and Development
SO_2	sulfur dioxide
VAT	value-added tax

Introduction

The stated energy policy objective of the United States is to balance the nation's need for secure supplies of reasonably priced energy with the goals of a cleaner environment and economic growth. Policymakers have sought to achieve this balance, in part, by adopting legislation to address environmental concerns and improve energy efficiency. However, despite these efforts, the United States continues to rely heavily on low-cost fossil fuels, most notably oil and coal—an approach that raises concerns about energy security, the environment, and other issues. While the new administration plans to continue to pursue a balance between energy security, economic, and environmental concerns, it also intends to increase its promotion of energy efficiency, conservation, and alternative energy sources. As in the United States, energy policy in France, Germany, Japan, South Korea, and Canada is aimed at achieving a balance among energy security, environmental protection, and economic growth. The priority given to each of these goals, however, varies from country to country.

The United States Has a Threefold Energy Policy Objective

The 1991 National Energy Strategy outlined the nation's threefold energy policy objective: balancing the nation's need for secure supplies of reasonably priced energy with the goals of achieving a cleaner environment and maintaining economic growth. In recent years, policymakers have reiterated and taken steps to address these goals. For example, the Energy Policy Act of 1992,[1] signed into law on October 24, 1992, includes provisions that provide for improved energy efficiency. The act specifies federal energy priorities to be considered in future plans.[2] These priorities or goals include

- the implementation of standards for more efficient use of fossil fuels,
- the use of tax policy to influence the development and consumption of energy and electricity,
- increased investment in energy-efficient equipment and technologies,
- stabilization of and eventual reduction in emissions of greenhouse gases,
- an increase in the efficiency of the nation's total energy use by 30 percent over 1988 levels by the year 2010,
- an increase in the percentage of energy derived from renewable resources by 75 percent over 1988 levels by the year 2005, and

[1]P.L. 102-486.

[2]Under the law, the Department of Energy (DOE) was to submit the next National Energy Policy Plan (the National Energy Strategy was such a plan) to the Congress on April 1, 1993. However, because of expanded requirements for the contents of the plan and the change of administrations in January 1993, the Secretary of Energy may request that the Congress change the submission date to April 1, 1994. As of mid-April 1993, DOE had not submitted such a request.

- a reduction in the nation's oil dependence from the 1990 level of approximately 40 percent of total energy use to 35 percent by the year 2005.

The act also contains provisions promoting energy efficiency in the industrial sector, including

- the establishment of a grant program for industry associations that support programs to improve industrial energy efficiency (grants are available only to associations that set voluntary energy-efficiency improvement targets);
- a requirement for a report on the potential effectiveness of federally mandated energy-efficiency reporting requirements and voluntary targets for energy-intensive industries, including an evaluation of potential costs and benefits;
- the establishment of grant programs to help states train people to conduct energy assessments of industrial processes; and
- the establishment of criteria for energy assessments of industrial processes for each industry, to be made available to interested parties such as state and local governments, public utility commissions, utilities, and representatives of affected industries.

In addition, the act authorizes incentive payments to owners or operators of qualified renewable energy facilities that generate and sell electricity.

Among the act's provisions for the transportation sector is a requirement that the Department of Energy (DOE) (1) determine the feasibility of and means to reach the goals of replacing 10 percent of conventional motor fuels with alternative fuels by 2000 and 30 percent by 2010, (2) submit a 5-year plan for the development of technologies to reduce oil and gas demand in transportation, and (3) implement a research and development program for electric motor vehicles in cooperation with the private sector.

To address continuing air pollution problems, some of which are associated with energy use, the Congress passed the Clean Air Act Amendments of 1990.[3] The amendments placed additional restrictions on emissions from new light-duty vehicles (passenger cars and light trucks), effective in the mid-1990s. The amendments also require that cleaner vehicle fuels and fleet vehicles that use such fuels be sold in certain areas. For industry, the amendments added a program to combat acid rain by assigning, and allowing firms to buy and sell, emission reduction credits.

[3]P.L. 101-549, enacted Nov. 15, 1990.

When considering policies to address the goals of protecting the environment and/or securing energy supplies, U.S. policymakers have given substantial weight to the possible impact of these policies on economic growth. For instance, the United States resisted calls from its industrialized counterparts to set binding targets for carbon dioxide emission reduction at the United Nations Conference on Environment and Development in Brazil in the summer of 1992, in part because such targets could impede economic growth. In addition, the United States decided against including certain measures designed to reduce the nation's dependence on oil and/or clean up the environment in the 1991 National Energy Strategy because of the perceived negative impact of such measures on the economy.[4]

The new administration's energy policy goals appear to be similar to those of recent administrations. The Secretary of Energy stated, for example, that the new administration will attempt to craft an energy policy that integrates concerns about energy supply, the environment, and the economy. However, the Secretary also emphasized the administration's goals of maximizing energy conservation and efficiency and promoting alternative energy sources.[5]

The United States Has Remained Heavily Dependent on Oil and Coal

In striving to achieve a balance between the nation's need for secure supplies of reasonably priced energy and the goals of a cleaner environment and economic growth, the United States continues to rely heavily on oil and coal to meet its energy needs. Oil and coal account for nearly two-thirds of the economy's total primary energy supply. In 1990, oil accounted for 99.9 percent of the energy used in the transportation sector; coal fueled 56 percent of U.S. electricity generation; and oil and coal furnished about 32 and 11.5 percent, respectively, of industry's energy consumption. According to the Energy Information Administration, oil and coal consumption will increase by about one-fifth over 1990 levels by 2010, assuming that real energy prices do not increase substantially and projections of economic growth are reasonably accurate.

Heavy reliance on these fuels, however, creates some difficulties. For example, heavy dependence on oil increases the economy's vulnerability

[4]These measures included higher corporate average fuel economy standards for cars and light trucks, higher gasoline taxes, a tax on all fuels according to their heat content (a British thermal unit, or Btu, tax), and an ad valorem—or sales—tax applied to all energy.

[5]Confirmation hearing for Energy Secretary-Designate Hazel R. O'Leary, before the Energy and Natural Resources Committee, United States Senate, Washington, D.C., Jan. 19, 1993.

to sudden increases in the price of oil. In addition, combustion of oil and coal contributes to air pollution, which has negative environmental and health consequences. For example, sulfur dioxide (SO_2) emissions from the combustion of coal are major precursors to acidic deposition (acid rain), which damages lakes and streams. Furthermore, asthmatics and people with chronic lung or cardiovascular disease are particularly sensitive to SO_2 emissions. Coal and oil are also major sources of carbon dioxide emissions, the main greenhouse gas that may lead to global warming. The transportation, industrial, and electricity-generation sectors combined contribute about 88 percent of total U.S. carbon emissions from energy combustion.

Energy Policy Priorities Vary Among Countries

Like the United States, the five countries we reviewed emphasize maintaining economic growth, securing energy supplies, and achieving a cleaner environment as the principal components of their energy policies. However, the priority each country gives these goals within its overall energy policy varies. These differing priorities generally derive from differences in the countries' economies, resources, geography, and other factors.

Japan

Because it has few indigenous energy resources, Japan is more susceptible to energy supply disruptions than most industrialized nations. Japan imports more than 80 percent of its energy resources, including most of its oil. Seventy percent of this oil comes from the Middle East. As a result, Japan's main energy policy objectives center around lessening vulnerability to supply disruptions by promoting energy conservation, increasing fuel diversity, and building up emergency oil stocks.

France

Like Japan, France focuses its energy policy primarily on ensuring stable energy supplies. Ensuring stable energy supplies is of primary importance to France because it has few fossil fuel reserves. France seeks to accomplish stable supplies by developing domestic energy production capacity, thus reducing dependence on imported fossil fuels. France imports almost all of its oil, nine-tenths of its natural gas, and about two-thirds of its coal. Domestic energy production in France is centered mainly around nuclear power. Other objectives of French energy policy include environmental protection and maintaining reasonably priced energy supplies to enhance economic competitiveness. France views its reliance on nuclear power as a step toward meeting these objectives

because nuclear power has allowed France to reduce emissions associated with electricity generated by burning fossil fuels while maintaining relatively low electricity prices.

Germany

Germany's stated energy policy objective is to promote "a secure and cost-effective [energy] supply, environmental friendliness, and the conservation of resources."[6] To help ensure secure energy supplies, Germany has relied heavily on its domestic coal resources and plans to continue to do so, although to a lesser degree.

This heavy use of coal would appear to complicate meeting some of Germany's environmental objectives. For instance, Germany plans to reduce carbon dioxide emissions by 25-30 percent from 1987 levels by 2005. These emissions are particularly problematic in the former East Germany, where energy consumption is inefficient and pollution levels are high, in part because of extensive reliance on lignite coal. Lignite consumption in the former East Germany is expected to decline considerably in the coming years. This change, coupled with planned improvements in energy efficiency, should substantially reduce pollution, including carbon dioxide emissions. All new sources of emissions in eastern Germany are required to meet federal standards; existing emissions sources will be shut down or brought into compliance by 1996.

Canada

Canada's federal energy policy is embodied in its larger economic policy, which in recent years has generally favored market principles over government intervention. By relying on market principles, Canada seeks to promote economic growth by allowing markets to function more efficiently. This approach represents a divergence from the government's previous extensive involvement in the energy sector. For example, the federal government previously set oil prices in an attempt to balance opportunities for economic growth among energy-producing and -consuming provinces.

Because Canada has extensive indigenous energy resources, achieving energy security and reducing vulnerability to oil supply disruptions are not the overriding energy policy objectives for Canada that they are for France and Japan. However, improving energy efficiency remains a major energy policy objective for Canada, which views such improvements as an important element in its efforts to address environmental problems.

[6]Energy Policy for the United Germany, Federal Ministry of Economics (Bonn, Germany: 1991), p. 4.

Problems such as potential climate change and excessive SO_2 emissions have become key factors in energy policy decisions in Canada.

South Korea

South Korea's energy policy has largely been shaped by the potentially conflicting goals of providing low-cost energy supplies to maintain industrial competitiveness and achieving greater energy security. South Korea is one of the fastest-growing economies in the Asia-Pacific region. To sustain this growth, the government seeks to maintain low energy prices.

Because South Korea, too, has few indigenous energy resources, growth in energy demand raises concerns about energy security. In fact, South Korea has fueled the industrialization of its economy primarily with imported energy; its dependence on imports rose from about 10 percent in 1964 to just above 91 percent in 1991. South Korea has addressed some of its concerns about energy security by diversifying the countries from which it imports oil;[7] encouraging the use of coal, an indigenous resource; developing a nuclear power capacity for some of its electricity generation; and endorsing the need for energy conservation.

Objectives, Scope, and Methodology

The Chairman, Environment, Energy, and Natural Resources Subcommittee, House Committee on Government Operations, asked us to report on (1) the factors that influence the type and amount of, as well as trends in, energy supply and use in Canada, France, Germany, Japan, and South Korea and (2) the key energy policies and programs adopted by these countries to promote the efficient use and conservation of coal and oil in their industrial and transportation sectors.

We agreed with the requester to focus on these five countries because our initial review of the literature revealed that one or several aspects of each country's energy policy and/or situation were noteworthy. Both Japan and Germany are major economic competitors of the United States. Japan is the least energy-intensive of the industrialized nations. France has very high gasoline taxes and has succeeded in reducing its energy-related carbon dioxide emissions by developing a large nuclear power capacity. Canada is similar to the United States in that it possesses significant energy resources and is a large country with a dispersed population. South

[7]While such an approach may provide some added security against immediate supply disruptions, it provides little protection against the price shocks that accompany oil supply disruptions in a global market. These price shocks harm nations' economies; the severity of their impact depends on how dependent a nation's economy is on oil.

Korea's economy is one of the most rapidly growing among the industrializing nations, and it has a variable oil import fee.

To identify factors that influence the type and amount of energy used by the nations we reviewed, particularly in transportation and industry, we surveyed available literature and spoke with several international energy analysts. In addition, we analyzed relevant data provided by the International Energy Agency (IEA) to identify trends and patterns of energy supply and use. The IEA is an autonomous body established in 1974 within the framework of the Organization for Economic Cooperation and Development (OECD) to implement an international energy program. We also reviewed the standard questionnaire IEA uses to solicit these data from the subject countries. Where noted, we also analyzed data from other sources, including the International Road Federation, the International Monetary Fund, and the governments of the countries we reviewed. However, we did not attempt to verify the data in our analysis by tracing it either to the countries' submissions to the IEA or to source documents in the countries.

To identify the energy policies adopted by the five countries, we surveyed available literature and discussed this information with representatives of the embassies of Canada, France, and Germany in Washington, D.C. Representatives of the South Korean embassy provided written responses to our questions; the Japanese embassy referred us to Japanese government officials in Tokyo, Japan.

We obtained additional information on the specific policies and programs adopted by each country from government officials in each of the countries we reviewed. We also interviewed knowledgeable analysts, academicians, and members of industry associations in each of these countries. (App. I includes a detailed list of the agencies and entities whose officials we contacted in each country.)

To determine the energy policies adopted in the United States at both the state and federal levels, we interviewed officials from the Department of Energy. We also spoke with representatives of various nongovernmental organizations, such as the National Association of State Energy Officials. Finally, we reviewed various statements of U.S. energy policy; DOE program documents; pertinent laws, such as the Energy Policy Act of 1992; and the available literature on relevant aspects of U.S. energy policy.

As requested, we did not obtain written agency comments on a draft of this report. However, we discussed the factual information and results of this analysis with the Director, Office of International Organizations and Policy Development, and Deputy Director, Office of Energy Demand Policy, in the Department of Energy, as well as with officials from the Energy Information Administration. We also discussed this information with the State Department's Division Chief for Energy Consuming Countries within the Office of Global Energy, and with officials of U.S. embassies in several of the nations we reviewed. Finally, we sought verification of key aspects of the factual information contained in this report from government officials in the countries we surveyed. These officials generally agreed with the information presented. They did provide some technical comments, which have been incorporated where appropriate. We conducted our work from February 1992 through March 1993 in accordance with generally accepted government auditing standards.

Patterns of Energy Consumption in Five Industrialized Countries Reflect a Variety of Influences

In the aftermath of the price shocks of 1973-74 and 1979-80, the United States and all five countries we examined generally showed declines in energy intensity—the amount of energy consumed per unit of gross domestic product. While there are many factors that influence energy intensity, declining energy intensity is generally associated with increased energy efficiency. Between 1973 and 1990, both oil and coal intensity—the amount of oil or coal consumed per unit of GDP—decreased in these nations. The trends towards lower energy and oil intensity generally slowed in 1986, when world oil prices dropped significantly. In addition, between 1973 and 1990 the amount of oil consumed decreased in the United States and in all the countries we reviewed, except South Korea. However, over the same period, the amount of coal consumed increased in the United States and in all the countries we reviewed, except France and Germany. Notwithstanding declining trends in energy, oil, and coal intensity, all the countries we surveyed, like the United States, continue to depend on oil and coal for over half of their total primary energy supply.[1]

Many factors influence the type and quantity of energy nations consume and the intensity at which they consume it. Among these factors are the price and availability of energy resources, climate, and population density. In addition, economic factors, such as the types of goods and services countries produce and their state of industrialization, level of economic activity and growth, and standard of living also affect levels of energy consumption. The interaction of these factors, in conjunction with the fiscal, monetary, and energy policies nations adopt, affect the price of using various fuels. Price, in turn, is an important determinant of the type, level, and intensity of energy use. In the nations we reviewed, one or more of these factors seems to have a predominant effect on energy consumption patterns.

[1]Total primary energy supply is the amount of energy consumed directly by end-users plus the energy losses incurred in the production and distribution of energy products (primarily the generation and transmission of electricity). A country's primary energy can come from both domestic production and from imports.

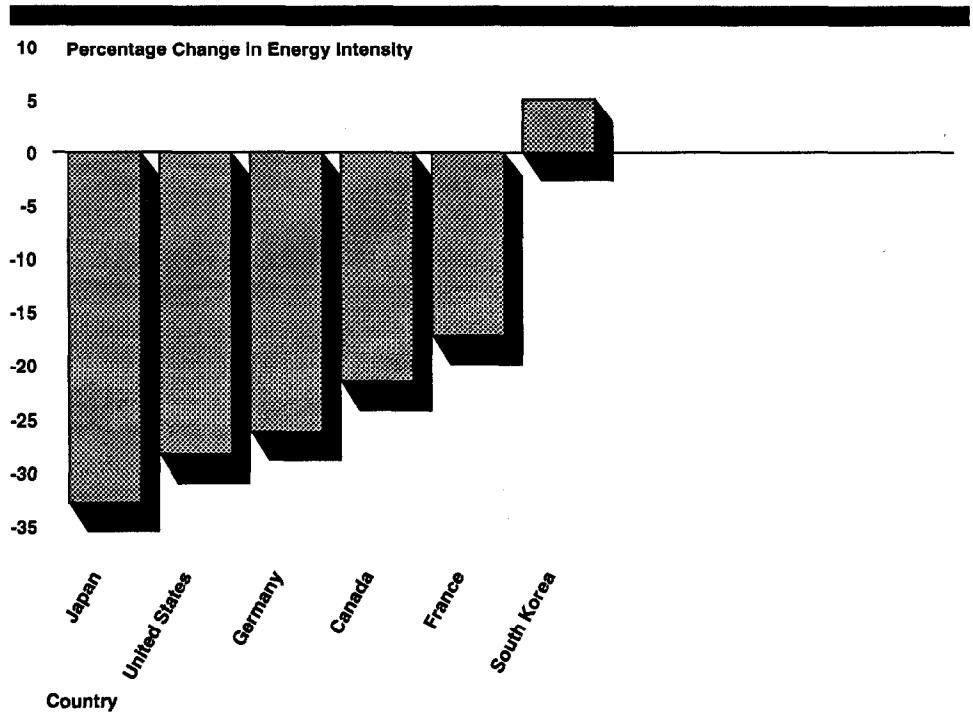
Energy Intensity Has Generally Decreased, but the Industrial and Transportation Sectors Show Different Patterns

Since the first oil price shock, the overall intensity of energy use has decreased in all of the countries we reviewed except South Korea, where it has increased slightly. This indicates that, among other things, these countries are more energy-efficient now than they were 20 years ago. Higher energy prices following the oil price shocks of the 1970s are part of the explanation for this decline, as the price of energy is one of the factors that influences energy intensity. However, the effect of the decline in energy intensity on energy consumption differs between the industrial and transportation sectors. In the industrial sectors of the nations we examined, lower energy intensity has been accompanied by lower energy consumption, particularly oil consumption. However, in the transportation sectors, oil consumption has increased despite a decrease in the intensity of energy use in that sector. There are several explanations for this disparity, including the greater availability of substitute fuels for the industrial sector, changes in the structure of the nations' industrial sectors towards production of less energy-intensive goods, and growing numbers of vehicles traveling greater distances.

Energy Intensity Has Generally Decreased

Between 1973 and 1990, four of the five countries we surveyed, as well as the United States, reduced the intensity of their overall energy use, as shown in figure 2.1. That is, the United States and these four countries used less energy to produce each unit of domestic economic output in 1990 than in 1973. Two major oil price shocks occurred during this period, the first in 1973-74 and the second in 1979-80.

Figure 2.1: Change in Overall Energy Intensity, 1973-90



Source: Based on data from the International Energy Agency.

While there are many factors that influence energy intensity, declining energy intensity is generally associated with increased energy efficiency. However, overall energy intensity masks variations in energy efficiency between economic sectors and does not highlight changes in the absolute amounts of energy consumed in different sectors. For instance, while the industrial and transportation sectors in all five countries and the United States experienced substantial decreases in energy intensity after 1973—that is, they used less energy to produce a unit of industrial output or to travel a given distance—the absolute amount of energy consumed in the transportation sector increased. This increase is significant to policymakers because the transportation sectors of the nations we surveyed and the United States are heavily dependent on oil, and any increase in oil consumption increases their economies' vulnerability to oil price shocks. The absolute amount of energy consumed by industry decreased between 1973 and 1990 in the United States and in three of the

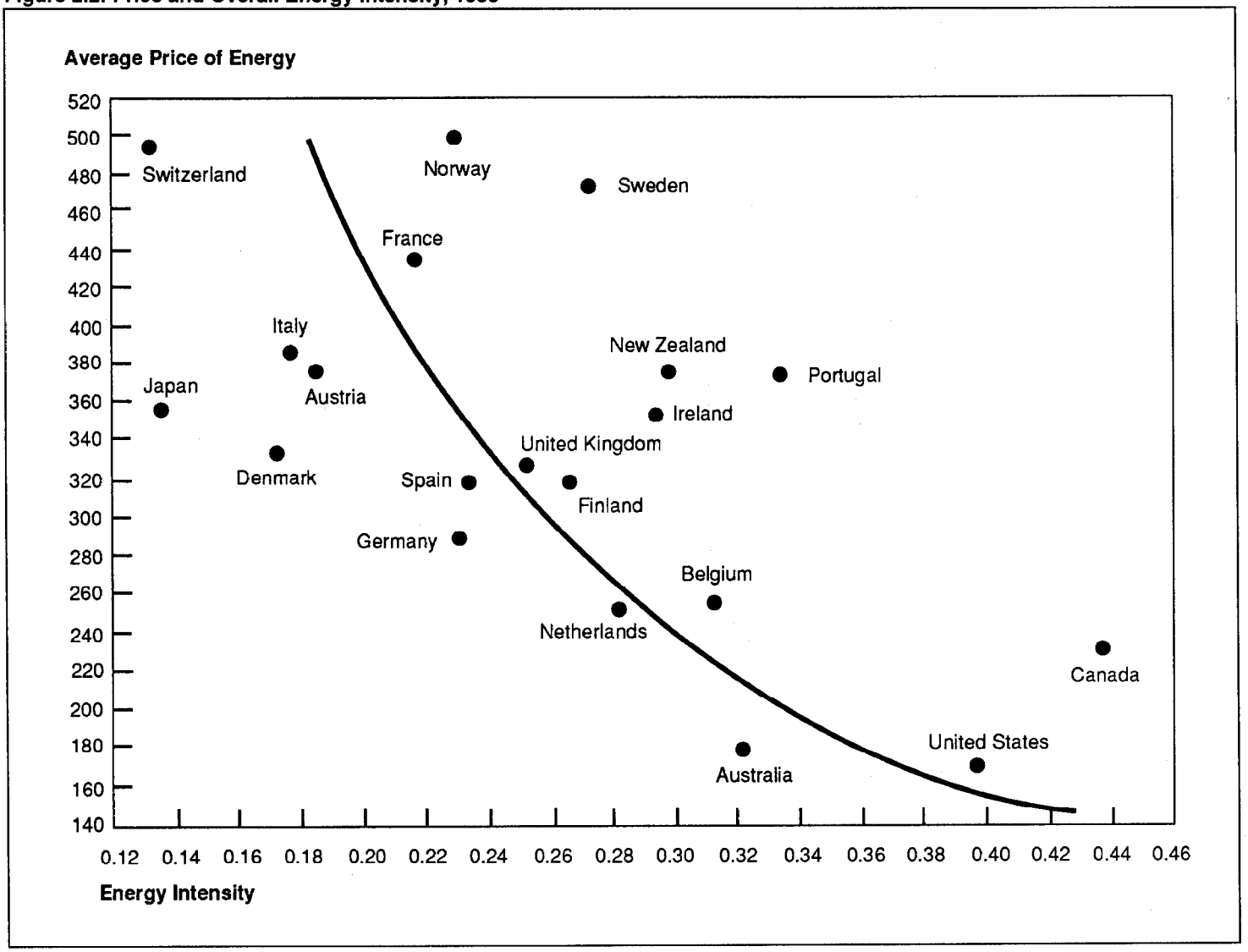
countries we examined. Industrial energy consumption increased in South Korea and Canada in the same period.

While the magnitude of change in energy intensity varied across the five countries, Japan and the United States experienced the largest decrease, followed by Germany, Canada, and France. However, while energy intensity in South Korea increased slightly between 1973 and 1990, its absolute energy consumption more than tripled in that period. This substantial increase in energy consumption was precipitated by rapid industrialization and high economic growth.

Declining trends in energy intensity began roughly after the first oil crisis, when energy consumption began growing at a slower rate than GDP, thus decoupling the growth in GDP from energy consumption for the first time in the postwar period. Between 1973 and 1990, Japan's GDP increased by 93 percent in real terms, yet energy consumption increased by just 33 percent; France's GDP grew by 49 percent, while energy use increased by only 25 percent. However, the rate of decline in energy intensity, particularly oil intensity, generally slowed between 1986 and 1990, when world oil prices dropped significantly and most industrialized countries were experiencing strong economic growth.

Figure 2.2 illustrates the relationship between energy prices and energy intensity for the IEA member nations. The least energy-intensive nations of the five we examined—Japan, France, and Germany—pay relatively high average prices for energy. Other factors also play important roles in determining the intensity of energy use within each country and, more specifically, within the transportation and industrial sectors of their economies.

Figure 2.2: Price and Overall Energy Intensity, 1988



Note 1: The average price of energy is expressed per ton of oil equivalent. Figures are in 1988 U.S. dollars.

Note 2: Energy intensity is expressed as the total primary energy supplied in tons of oil equivalent per $1,000 of GDP at 1988 prices and exchange rates.

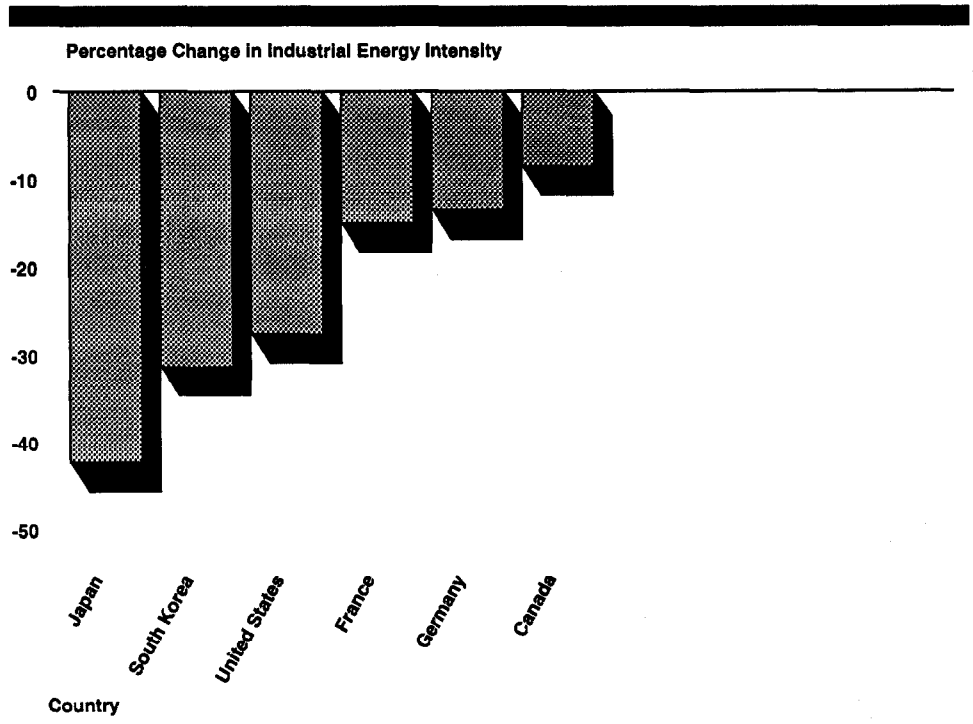
Note 3: The regression line is ln(e) = 2.36 - (0.65) ln(p), where e = energy intensity and p = the average price of energy.

Source: Organization for Economic Cooperation and Development.

Energy Intensity Has Generally Decreased in the Industrial Sector

The energy intensity of the industrial sectors in the United States and all of the nations we reviewed decreased between 1977 and 1987, as illustrated in figure 2.3. The trend towards lower energy intensity was pronounced in South Korea, which in 1973 had by far the most energy-intensive industrial sector of the nations we reviewed. South Korea's industrial sector is now slightly less energy-intensive than Canada's industrial sector. Of the nations we examined, Japan achieved the greatest reduction in industrial energy intensity, about 43 percent, compared with a 28-percent decrease in the United States.

Figure 2.3: Change in Industrial Energy Intensity, 1977-87



Sources: Based on industrial GDP data provided by the World Bank and industrial energy-use data provided by the International Energy Agency.

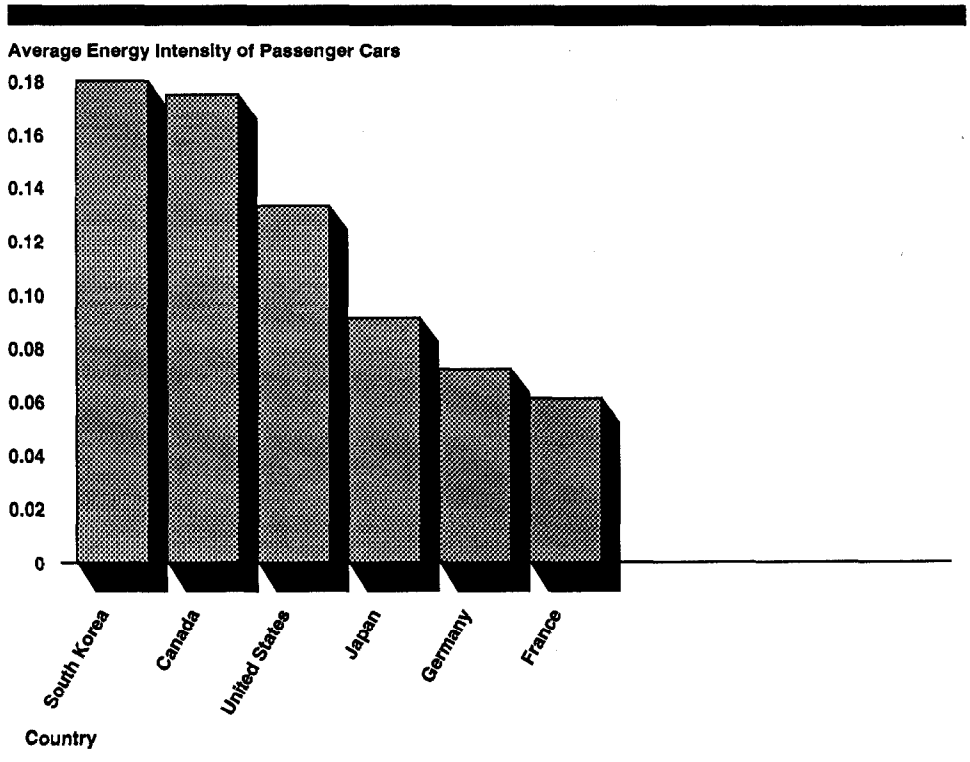
Many factors combine to influence the intensity of energy use in a nation's industrial sector. For example, the price of energy, differences in the rate of growth or contraction between energy-intensive industries and less-energy-intensive industries, and technological factors, such as the rate

of capital stock turnover, all influence overall energy intensity in the industrial sector.

Energy Intensity in the Transportation Sector Generally Decreased, While Consumption Increased

Transportation energy intensity—the amount of energy consumed to travel a given distance—decreased in all of the nations we reviewed, but most notably in the United States and Canada. Figure 2.4 illustrates the levels of passenger-car energy intensity in 1989. Oil, in the form of gasoline and diesel fuel used by highway vehicles, accounts for most energy consumption in the transportation sectors of the nations we reviewed and in the United States. Canada and the United States have experienced comparatively large decreases in transportation energy intensity. These decreases were largely due to the fact that motor vehicle fleets in these two countries were highly inefficient in 1979 compared with other nations' fleets. Since 1979, the efficiency of the vehicle fleets has improved in all of the nations we examined except South Korea. However, oil consumption in the transportation sector is increasing in all nations, although most rapidly in South Korea. Canada and the United States have the slowest rates of increase in oil consumption for transportation.

Figure 2.4: Passenger Car Energy Intensity, 1989



Note 1: Data are for 1989 except for South Korea where the most recent data available are for 1988.

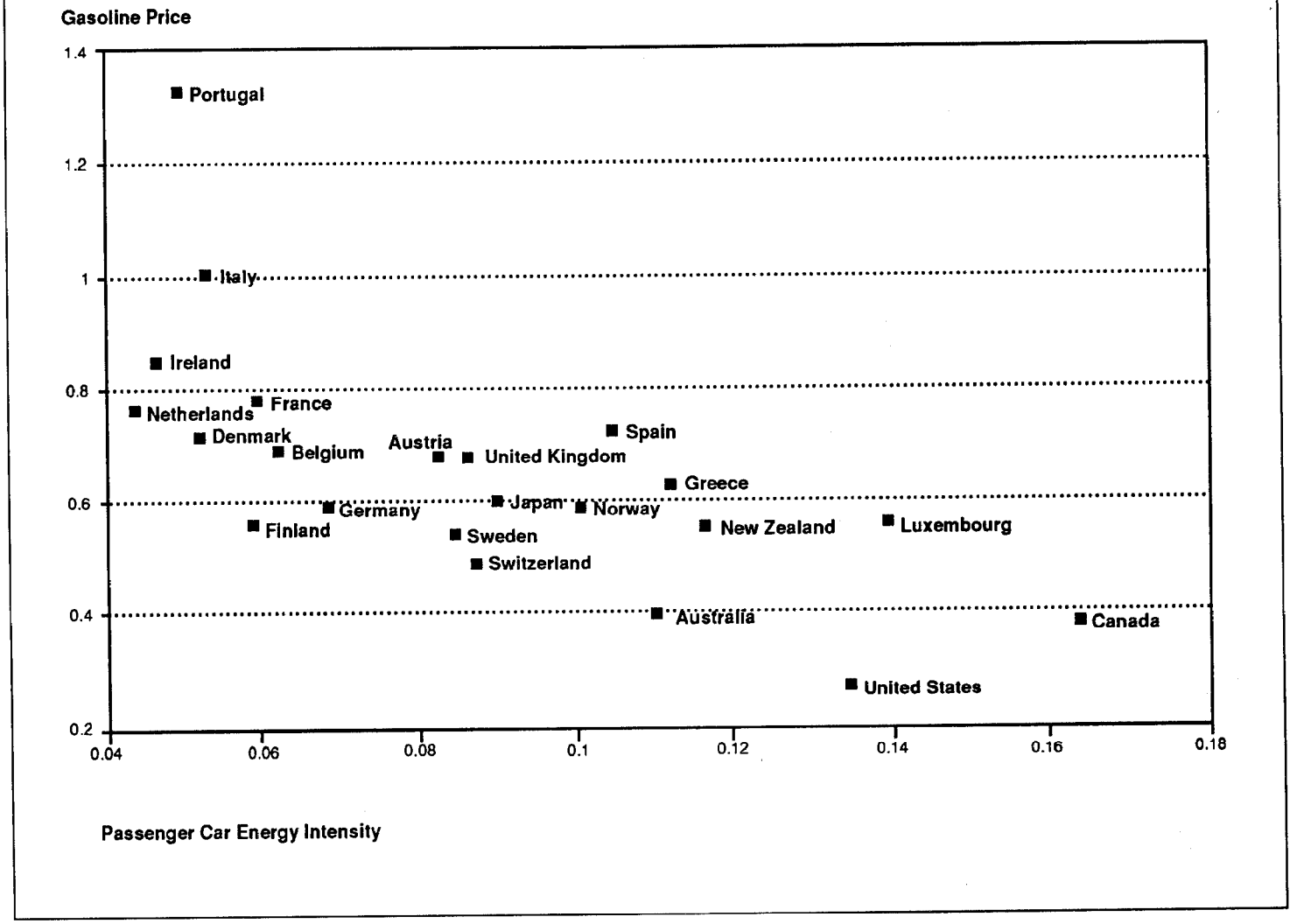
Note 2: Energy intensity is expressed as the ratio of gasoline supplied in thousand metric tons to kilometers traveled in millions.

Source: Based on data from the International Energy Agency and the International Road Federation.

Unlike in the industrial sector, the decline in energy intensity in the transportation sectors in the United States and in the nations we surveyed has not resulted in a decrease in the overall amount of energy consumed by the sector. Other factors besides energy intensity largely determine energy consumption in the transportation sector. Average distances traveled vary between countries, as does the number of vehicles. These factors, along with the fuel efficiency of a nation's vehicle fleet, are the major determinants of fuel consumption in a nation's transportation sector. The price paid for fuel also influences the average distances traveled and the fuel efficiency of the vehicle fleet. Figure 2.5 illustrates

the relationship between gasoline prices and the average amount of gasoline consumed to drive a given distance—passenger-car energy intensity—for the IEA member countries.

Figure 2.5: Gasoline Prices and Passenger Car Energy Intensity



Note 1: Gasoline prices are for 1989 in U.S. dollars per liter. Price data were converted from national currencies by the IEA using purchasing power parities. Purchasing power parities are a means of facilitating comparison of price data by controlling for exchange rate fluctuations and differences in domestic price levels among countries.

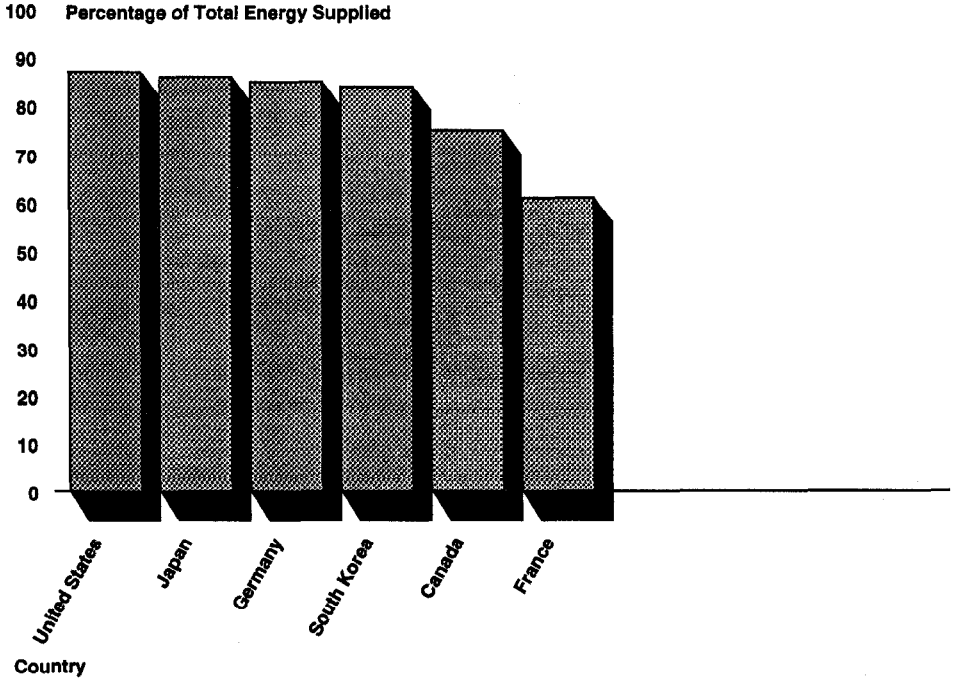
Note 2: Data on distances traveled used in calculating energy intensity are preliminary.

Source: Based on data from the Organization for Economic Cooperation and Development.

Fossil Fuels Are the Predominant Energy Source

Oil and coal remain significant sources of energy in all of the countries we examined. As illustrated in figure 2.6, fossil fuels (including natural gas) account for the majority of energy consumed in the United States and the five nations we examined. In fact, such fuels account for about 85 percent of the total consumption in Japan, Germany, South Korea, and the United States. However, the mix of fossil fuels used in most countries has changed over time, with oil's share of total energy consumption generally decreasing and coal's share increasing. Furthermore, the intensity with which nations use both fuels has generally decreased.

Figure 2.6: Reliance on Fossil Fuels, 1990



Note: Fossil fuels include crude oil, imported oil products, coal, and natural gas.

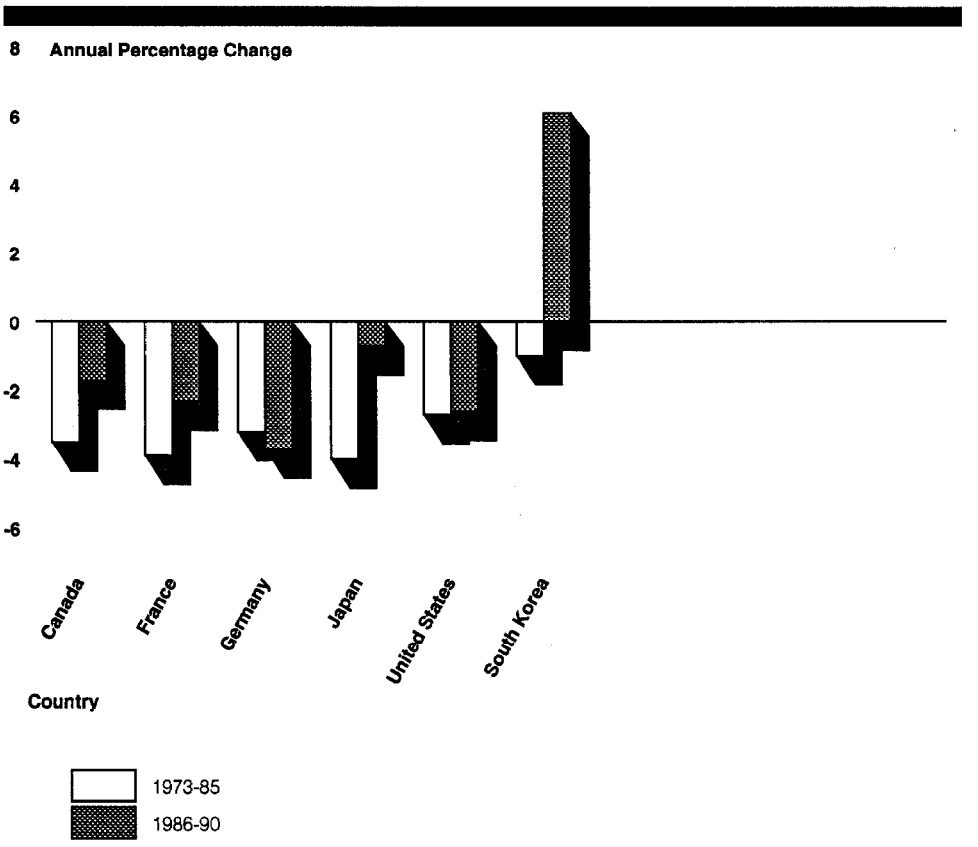
Source: Based on data from the International Energy Agency.

Oil Consumption and Intensity Have Generally Decreased

While all the countries surveyed, except South Korea, consumed less oil in 1990 than in 1973, oil still accounts for at least 40 percent of total consumption in all of these countries. Furthermore, in 1991, reliance on oil approached 60 percent in South Korea and Japan. The amount of oil consumed per unit of GDP—oil intensity—decreased in all the countries

between 1973 and 1990. However, as illustrated by figure 2.7, since 1986 the rate of decline in oil intensity has slowed in Japan, France, Canada, and the United States, and oil intensity has actually increased in South Korea. By contrast, since 1986 the rate of decline in oil intensity in Germany was actually higher than in the earlier period. As mentioned above, much of the decrease in oil consumption occurred in the industrial sector, while oil consumption in the transportation sector increased in all the countries between 1973 and 1990. Decreased oil use in the industrial sector can be attributed partly to industry's switch to fuels other than oil, structural shifts away from energy-intensive industries, and improvements in energy efficiency and conservation. In the nations we examined, the transportation sector, unlike the industrial sector, had few viable alternatives to oil use. As a result, switching from oil to other forms of energy did not occur in that sector as it did in the industrial sectors.

Figure 2.7: Rate of Change in Oil Intensity During Periods of High and Low Oil Prices



Note: Oil intensity is expressed as the ratio of the total supply of oil and oil products to GDP in thousands of 1985 dollars.

Source: Based on data from the International Energy Agency.

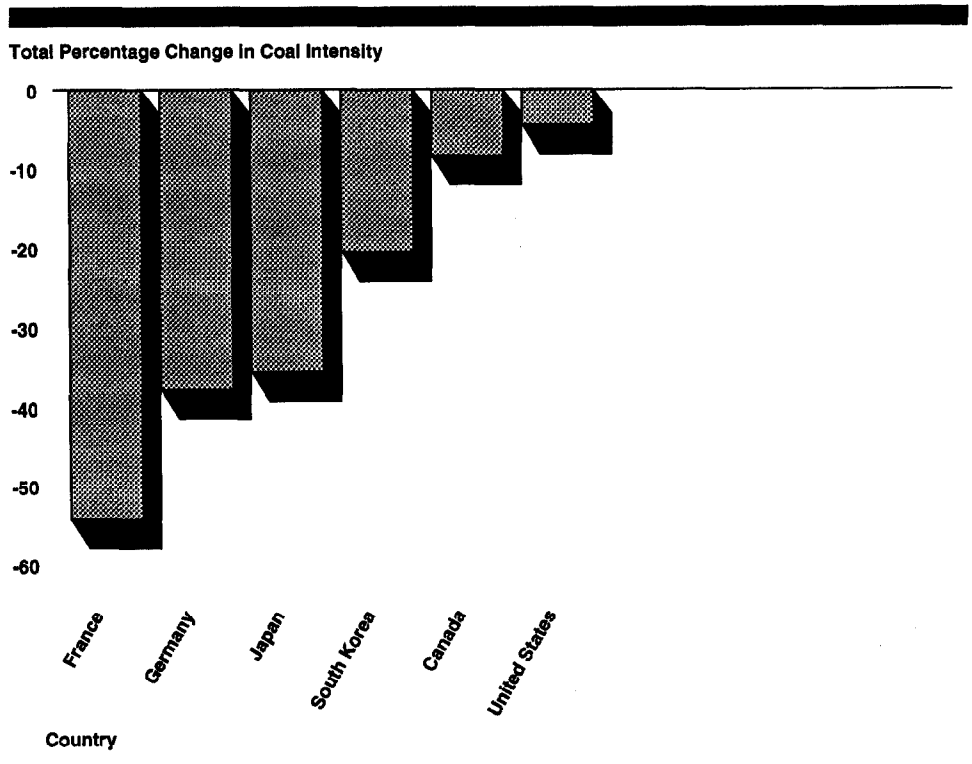
Continued low oil prices could work to reverse the trend towards lower oil dependence in these nations and in the United States. Expectations about increased oil production capacity among some Organization of Petroleum Exporting Countries (OPEC) nations, renewed production in Iraq and Kuwait, and increased production in non-OPEC producing countries are all factors in the projections of relatively low future oil prices.

Coal Consumption Has Increased Despite Less Intensive Use

Coal also remains a significant energy source. Between 1973 and 1990, coal consumption increased in all the countries except France and Germany. In fact, Japan sought to increase coal consumption after the oil

price shocks as part of an effort to diversify its fuel sources away from oil. Similarly, South Korea has promoted its domestic anthracite industry for energy security reasons. At the same time, however, the intensity with which these nations used coal—the amount of coal consumed to produce a unit of GDP—decreased between 1973 and 1990, as illustrated by figure 2.8.

Figure 2.8: Change in Coal Intensity, 1973-90



Source: Based on data from the International Energy Agency.

Several Factors Affect Patterns of Energy Consumption

Patterns of energy consumption result from the interaction of many factors and the policies and programs governments adopt. For example, the scant availability of domestic energy resources in Japan and France have played a significant role in these countries' efforts to promote energy conservation programs and to develop energy resources such as nuclear power within their borders. The relative abundance of coal in Germany partially explains the German government's policy of encouraging consumption of domestic coal through various subsidies. In Canada, the

abundance of energy resources, cold climate, and dispersed population help explain that country's high energy intensity. South Korea's rapid economic growth has led to increased industrial energy consumption as well as higher living standards. Higher living standards, in turn, have resulted in a rapid rise in both vehicle ownership and the rate of growth in oil consumption for transportation. Lastly, the U.S. economy is significantly larger than the economies of the five nations we reviewed and, despite the decline in the intensity of its energy use over the last two decades, consumes many times more energy than the other nations.

Japan's Lack of Energy Resources Helps Shape Energy Policy

As a relatively small island nation with few domestic reserves of energy resources, Japan imported over 80 percent of its primary energy supply and 99 percent of its oil in 1990. As shown in table 2.1, Japan produces just 16 percent of its total primary energy supply domestically. Japan has reduced its oil dependence from 78 percent of its total energy supplied in 1973 to 58 percent in 1990, partly by increasing its use of other fuels—particularly nuclear energy, natural gas, and coal—in industry and in electricity generation. In fact, coal consumption in Japanese industry increased by 6 percent between 1973 and 1990, while oil consumption decreased by almost 29 percent. Figure 2.9 illustrates these trends in the evolution of energy supply in Japan.

Table 2.1: Percentage of Fuel Supply Provided Through Domestic Production, 1990

Country	Total energy	Solid fuels	Oil	Natural gas
Canada	131%	141%	122%	161%
France	47	50	4	10
Germany	47	97	4	24
Japan	16	[a]	[a]	4
South Korea	24	33	0	0
United States	86	115	56	95

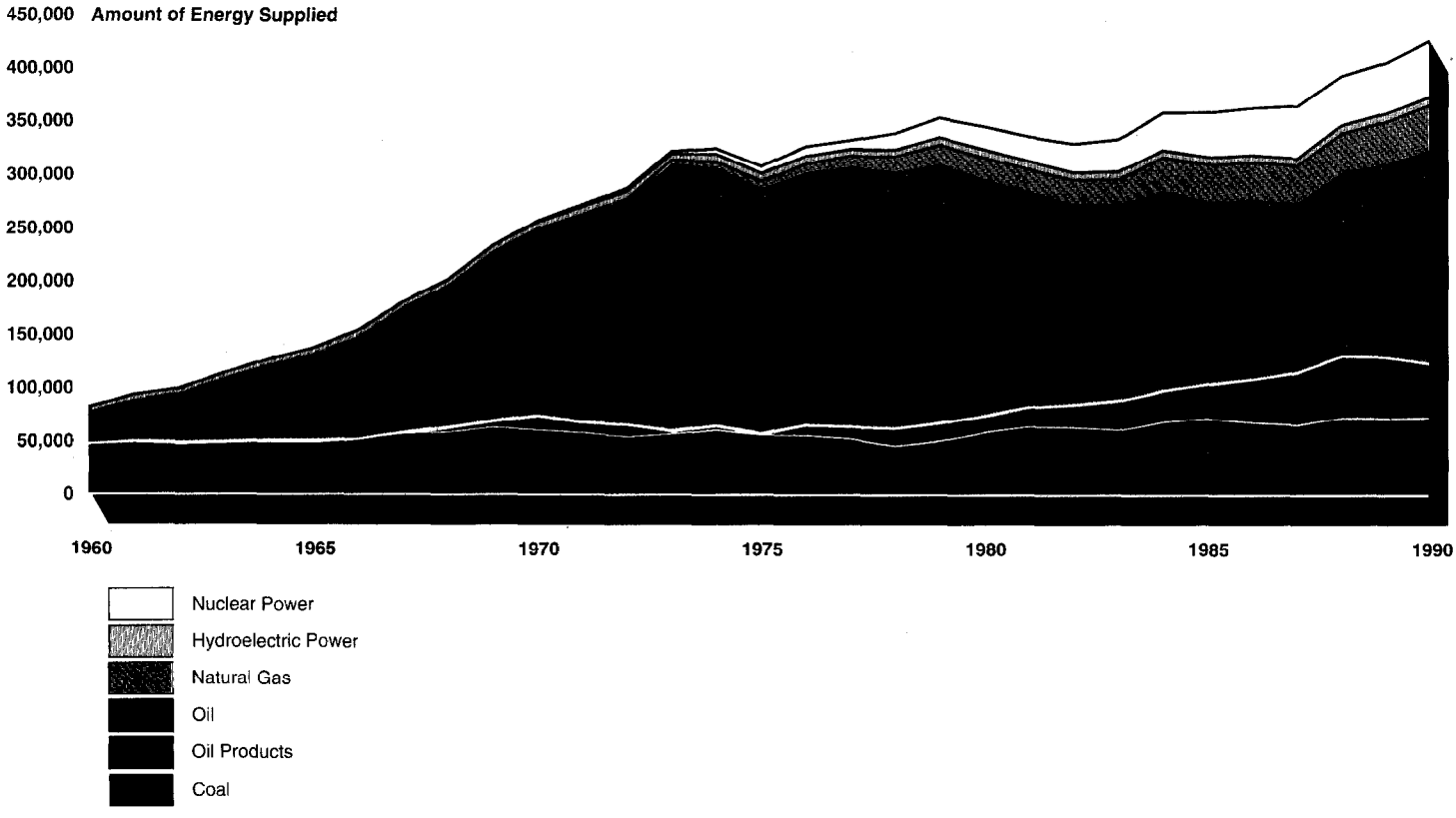
Note 1: Figures are calculated as domestic production divided by the total amount of energy or fuel supplied.

Note 2: Domestic production in excess of 100 percent of total energy or the specific fuel indicates that the country exports energy or that fuel.

[a]Less than 1 percent.

Source: Based on data from the International Energy Agency.

Figure 2.9: Evolution of Japan's Energy Supply



Note: The amount of energy is expressed as the total energy supplied in thousands of tons of oil equivalent.

Source: Based on data from the International Energy Agency.

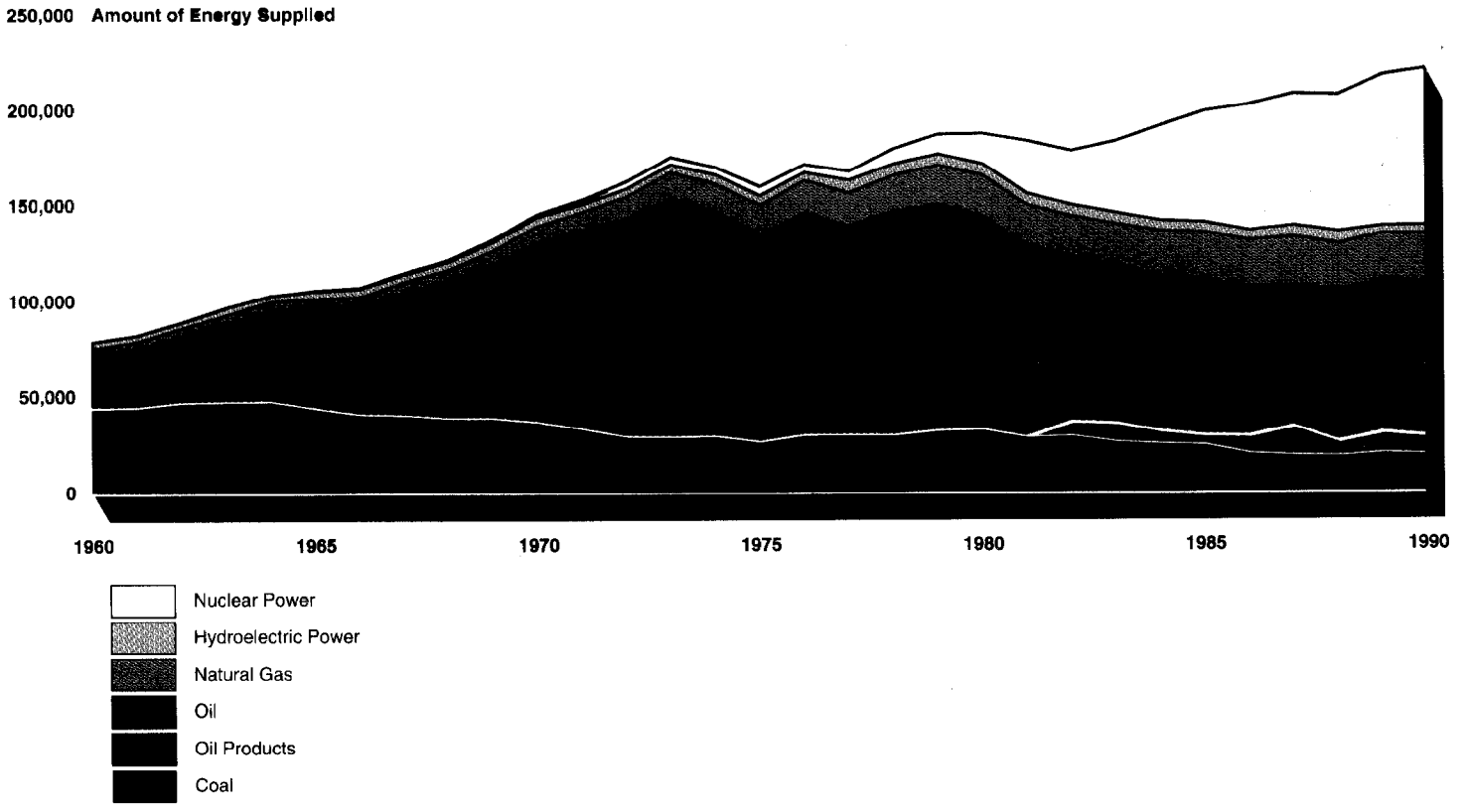
Unlike Japan's industrial sector, the transportation sector has substantially increased its energy consumption, particularly oil. Between 1973 and 1990, oil consumption in the transportation sector rose by 70 percent. This growth in oil consumption was triggered by increased car ownership, which almost doubled between 1973 and 1988, rising from 132 to 251 vehicles per 1,000 inhabitants. The improved standard of living achieved in Japan during the 1980s is a significant factor in this growth. Per capita GDP—a measure of living standards—increased by 70 percent between

1973 and 1990. Living standards also influence the types of cars desired. The Japanese have increasingly been buying larger, more powerful cars. As a result, new vehicle fuel economy has decreased in recent years. Between 1974 and 1988, the share of vehicles with an engine capacity above 1.5 liters increased from 33 percent to 41 percent.

France Has Achieved Greater Energy Independence Through Nuclear Energy

France, like Japan, is a country with few energy resources. As table 2.1 showed, France imports 96 percent of its oil, 90 percent of its natural gas, and about 50 percent of its coal supplies. France, like Germany, used less coal in both amount and proportion of its total energy supply in 1990 than in 1973. Furthermore, France experienced a 30-percent reduction in the share oil represented in its total energy supply; this reduction was the greatest of the nations we surveyed. In 1973, coal and oil accounted for 16.5 and 70.4 percent, respectively, of total primary energy supply. In 1990, however, coal accounted for 9.2 percent and oil accounted for 40.3 percent of France's energy supply. As illustrated in figure 2.10, coal and oil were largely replaced by nuclear energy. In the industrial sector, the share of total consumption supplied by electricity increased from 12 percent in 1973 to over 20 percent in 1990. During the same period, the share of industrial energy consumption supplied by coal dropped from 20 percent to just over 17 percent, and the share supplied by oil dropped from over 58 percent to just over 37 percent. France's 56 operating nuclear power plants now generate 75 percent of the electricity in the country and account for 78 percent of total domestic energy production and 37 percent of the total energy used by the French economy. Use of nuclear energy has contributed significantly to the 25-percent reduction in carbon dioxide emissions that France has achieved since 1980.

Figure 2.10: Evolution of France's Energy Supply



Note: The amount of energy is expressed as the total energy supplied in thousands of tons of oil equivalent.

Source: Based on data from the International Energy Agency.

As was the case in Japan, energy consumption in France's transportation sector has grown substantially since 1973. Energy consumption in the transportation sector, consisting almost entirely of oil, increased 53 percent between 1973 and 1990. Between 1975 and 1992, France's private vehicle fleet grew by 57 percent. Increased growth in energy consumption for transportation took place after world oil prices fell in 1986 and after the French government slowed the rate of growth in

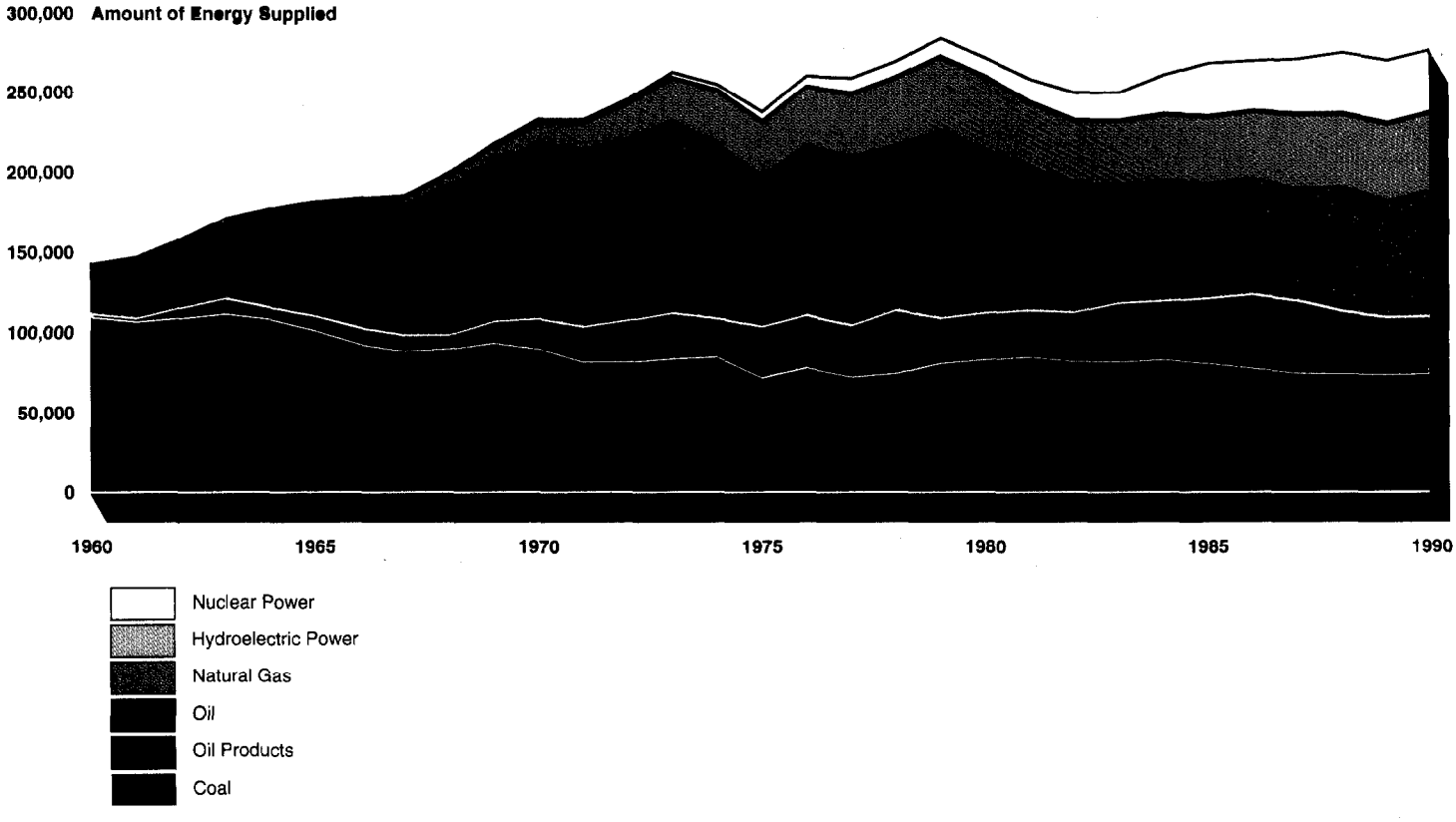
gasoline taxes beginning in 1988. In addition, the number of vehicle-miles traveled has been increasing since 1984.

Germany Seeks to Utilize Its Domestic Coal Resource

With the exception of coal, Germany has limited energy resources. Forty-seven percent of its total primary energy supply in 1990 was produced domestically.[2] Coal accounted for 55 percent of German domestic energy production in 1990. According to the IEA, when the former East Germany is included, coal accounted for an estimated 60 percent of domestic energy production in 1991. As illustrated in figure 2.11, however, coal's share of total energy consumption has slowly decreased, dropping from 32 percent of the total energy supplied to the former West Germany in 1973 to 27 percent in 1990. While Germany imports about 95 percent of the oil it consumes, its oil dependence decreased from 56 percent to 41 percent of its total energy needs between 1973 and 1990. Decreases in the share coal and oil provided in the total energy supply were offset by increases in the share provided by nuclear power and natural gas. In the industrial sector, coal consumption decreased by 11 percent and oil consumption decreased by 43 percent between 1973 and 1990.

[2]Unless otherwise noted, data are for the former West Germany only.

Figure 2.11: Evolution of Germany's Energy Supply



Note: The amount of energy is expressed as the total energy supplied in thousands of tons of oil equivalent.

Source: Based on data from the International Energy Agency.

One of Germany's major energy-policy challenges will be to fully integrate and restructure the energy sector in eastern Germany. According to the IEA, before unification, the energy sector in eastern Germany depended largely on lignite coal, was highly inefficient in its energy use, and had few pollution controls. Furthermore, all nuclear power plants with Soviet-designed reactors in eastern Germany have been shut down for safety reasons. Although some energy experts have indicated that the German government has set an unrealistic target of reducing carbon dioxide emissions by between 25 and 30 percent from 1987 levels by the

year 2005, unification may facilitate meeting such targets. For example, lignite coal consumption in eastern Germany, a major source of greenhouse gas emissions, is expected to decrease significantly as energy efficiency improves and the use of natural gas, a cleaner-burning fuel, increases.

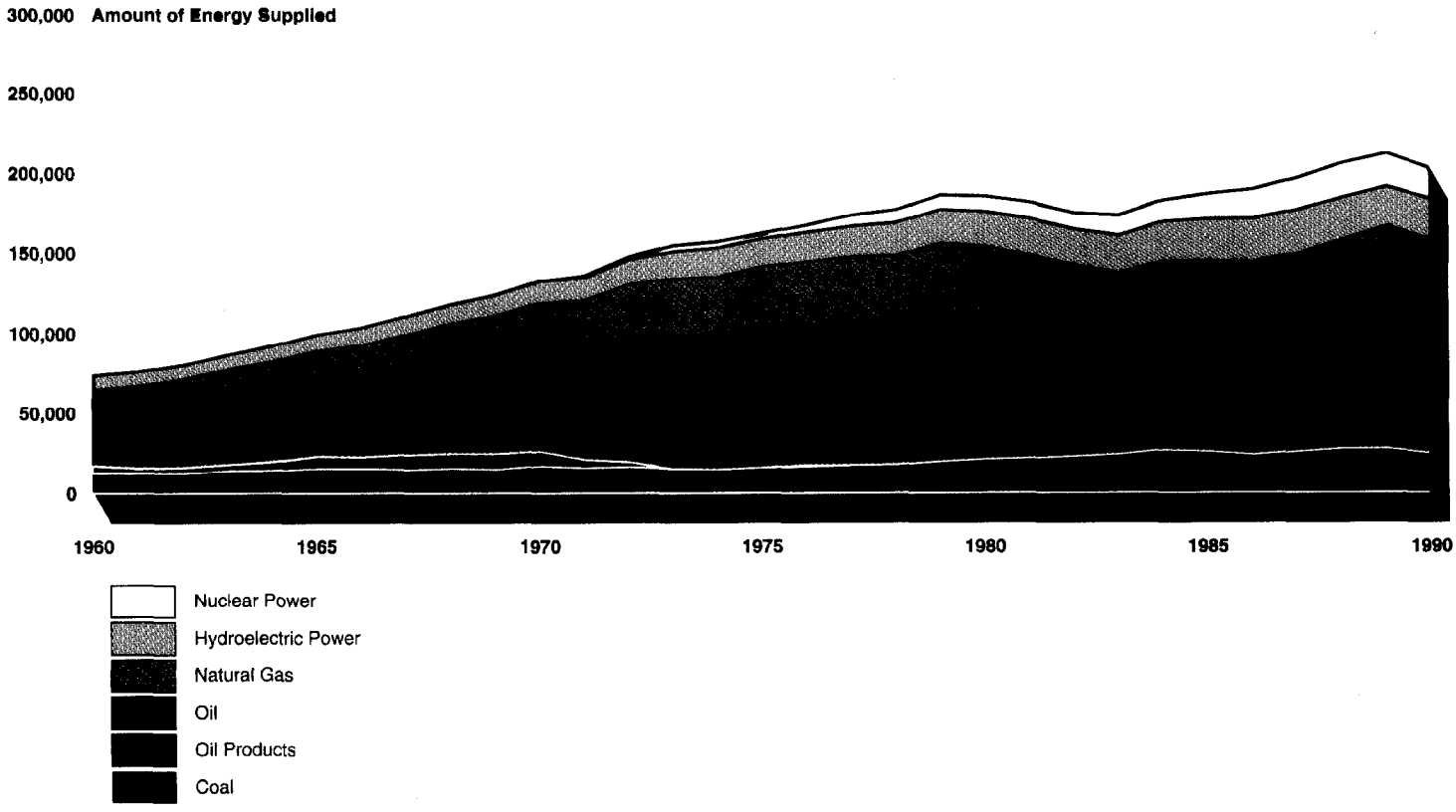
While German industry's use of coal and oil has declined, energy use in the transportation sector—virtually all oil—increased by 57 percent between 1973 and 1990. The growth in the number of vehicles is clearly a factor in the growth in energy consumption in the transportation sector. In 1990, the private passenger vehicle fleet in western Germany totaled 31 million cars, an increase of 9 million vehicles since 1980. (The population of western Germany increased by less than 2 million inhabitants between 1979 and 1990.) This growth in vehicle ownership can be attributed, in part, to improved living standards in Germany. Living standards increased by 20 percent between 1979 and 1990 (measured as GDP per capita). Vehicle ownership and gasoline consumption are expected to increase significantly in the former East Germany as living standards improve there. Since 1986, lower oil prices and higher living standards have also increased the demand for more powerful, and less fuel-efficient, automobiles. The average fuel efficiency of new cars in 1988 was 29.8 miles per gallon, down from 31.3 miles per gallon in 1986. Furthermore, the share of the vehicle fleet with engines larger than 1.5 liters increased from 57 percent to 61 percent in just 3 years between 1985 and 1988.

Diverse and Abundant Resource Base Contributes to Canada's High Energy Intensity

Unlike the other nations we surveyed, Canada has a large and diverse energy resource base. As table 2.1 showed, Canada produces 30 percent more energy than it consumes, making the country a net energy exporter. The abundance of energy resources, combined with factors such as a widely dispersed population and cold climate, contributes to making Canada one of the most energy-intensive economies among major industrialized nations. Per capita energy demand in Canada ranked second among the 24 OECD countries in 1989, behind Luxembourg. Canada also ranked second among OECD nations in energy production, behind the United States. Partly because energy is abundant and prices are low, Canada's industrial base is skewed towards energy-intensive industries, such as pulp and paper manufacturing and iron and steel making. As illustrated in figure 2.12, hydroelectric power provided 12 percent of Canada's energy supply in 1990. In fact, hydroelectric power accounts for over half of the electricity generated in the country. Canada has the lowest average electricity prices for industry of the five nations we reviewed. In

addition, Canada possesses large natural gas reserves, and natural gas prices paid by industry are similarly the lowest of the nations we reviewed.

Figure 2.12: Evolution of Canada's Energy Supply



Note: The amount of energy is expressed as the total energy supplied in thousands of tons of oil equivalent.

Source: Based on data from the International Energy Agency.

Despite a gradual decline since 1980, industrial energy intensity in Canada remained higher in 1990 than in 1973. High industrial energy intensity can be attributed to the preponderance of energy-intensive industries in the country's industrial sector. The pulp and paper industry is by far the most

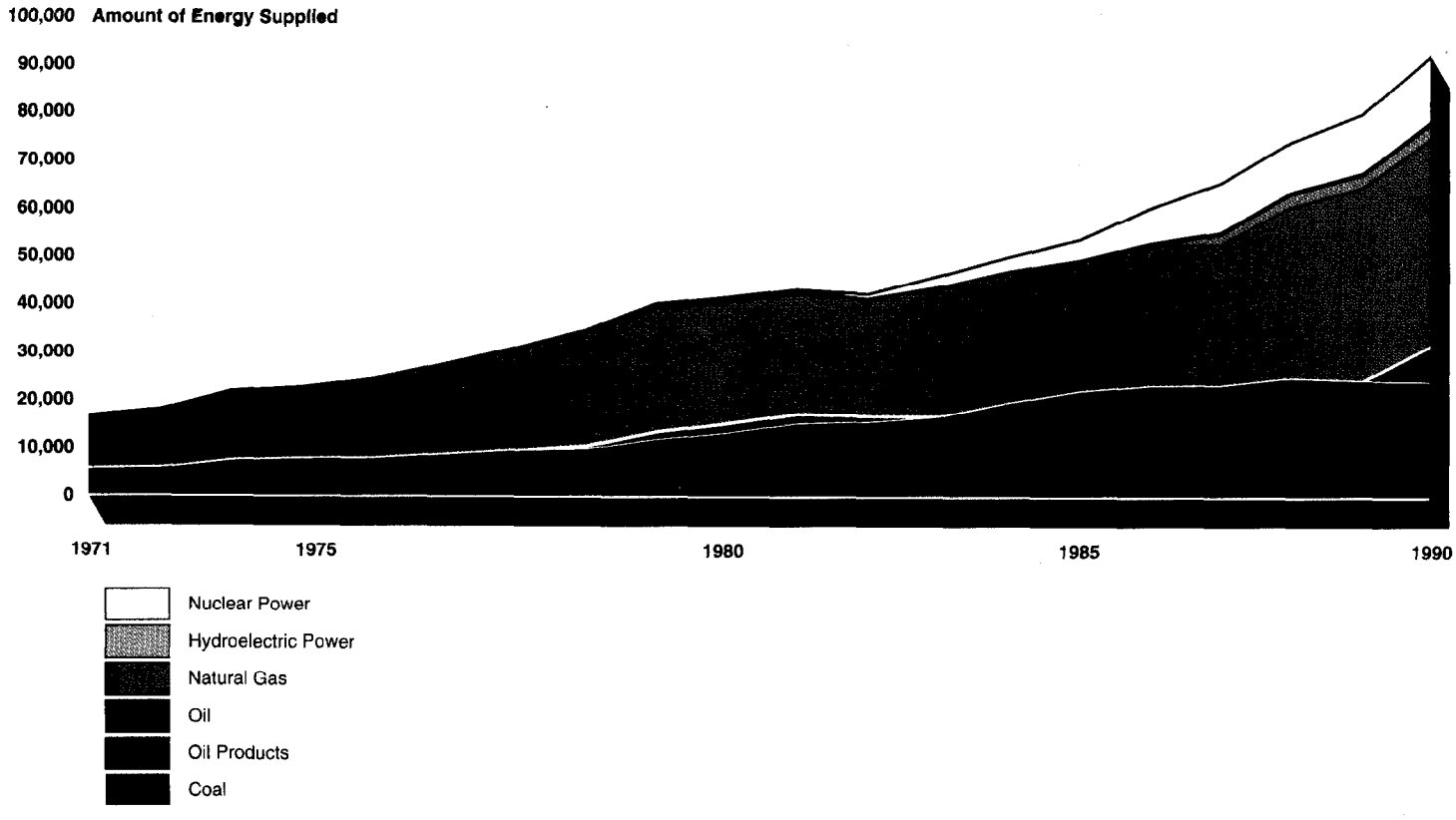
intensive and largest energy user, accounting for 29 percent of total industry energy demand in 1989. The iron and steel industry accounted for an additional 11 percent of industrial energy use in Canada in 1989. At the same time, however, the absolute amounts of coal and oil consumed by industry decreased by 30 percent and 16 percent, respectively, between 1973 and 1990.

Canada's transportation sector accounted for 26 percent of total energy consumption in 1990, down slightly from its 28 percent share in 1973. At the same time, however, the amount of energy consumed by transportation, consisting almost entirely of oil, increased 17 percent. Growth in transportation energy consumption and vehicle ownership rates have been significantly lower in Canada than in the other four countries we reviewed. Canada had a relatively higher living standard in the 1970s, which contributed to its high rate of vehicle ownership at that time. However, between 1980 and 1988, the number of cars per 1,000 inhabitants increased by a modest 7 percent. Canadians drive more miles, on average, than do drivers in any of the other four nations we examined and in the United States. This high mileage is largely due to Canada's widely dispersed population and relatively low fuel prices.

Rapid Industrialization Drives South Korea's Energy Consumption

Over the last 30 years, the South Korean economy grew at an average annual rate of 8.8 percent after inflation. Such rapid economic growth transformed what in 1960 was a largely agrarian economy into a modern, rapidly industrializing one in 1990. Rapid economic growth between 1973 and 1990 was accompanied by substantial increases in energy consumption. The total primary energy supplied to the South Korean economy more than tripled between 1973 and 1990. As a resource-poor country, however, South Korea imports over three-quarters of its primary energy requirements and nearly all of its oil and natural gas. Anthracite coal, South Korea's major indigenous energy resource, accounted for about 7 percent of the country's total energy supply in 1991. However, imported bituminous coal accounted for almost all industrial coal use and for 60 percent of all coal consumed in South Korea in 1991.

Figure 2.13: Evolution of South Korea's Energy Supply



Note 1: The amount of energy is expressed as the total energy supplied in thousands of tons of oil equivalent.

Note 2: Data on South Korea's energy supply were not available for 1960-70.

Source: Based on data from the International Energy Agency.

Trends in South Korea's oil and coal consumption and energy intensity varied somewhat from those observed in the four other countries we surveyed. While overall energy intensity declined between 1973 and 1990 in the other countries, it increased in South Korea. Similarly, South Korea's oil intensity increased by 6 percent annually between 1986 and 1990, while oil intensity decreased in the other nations. As illustrated in figure 2.13, the share of South Korea's total energy needs supplied by oil

decreased from 65 percent in 1973 to 55 percent in 1990. The absolute amount of oil supplied to South Korea increased about 260 percent over the same period. Trends toward increasing oil consumption are likely to continue as consumption increases in the transportation sector.

Between 1982 and 1991, energy consumption in South Korea's industrial sector increased at an average annual rate of 8.3 percent—slightly slower than the real rate of economic growth—and now accounts for over one-half of total consumption. Oil consumption in the industrial sector increased by over 13 percent annually between 1986 and 1990. In the last 2 years, demand for naphtha (a petroleum derivative) for use as a feedstock in the petrochemical industry has increased rapidly. In addition, consumption of bituminous coal, all imported, increased significantly between 1986 and 1990, largely because of an increased demand for coking coal for steel production.[3] South Korea's petrochemical and iron and steel industries are both highly energy-intensive, and their growth highlights the government's industrial policy of fostering such industries, particularly at a time when world oil prices are low.

The transportation sector in South Korea accounts for roughly 19 percent of total end-use energy consumption, and gasoline and diesel fuel account for 75 percent of the energy consumed by this sector. However, the transportation sector's share of overall consumption of oil products, 28.4 percent in 1990, is still relatively low in comparison with that of other industrialized nations. Growth in this sector has been rising rapidly, in tandem with growth in the number of vehicles. In the last two decades, vehicle ownership has grown rapidly, although the rate of vehicle ownership remains below that in the other countries we examined. In 1980, there were about 6.6 cars for every 1,000 South Koreans; in 1990, this figure rose to 50 vehicles for every 1,000 inhabitants. This rapid growth has continued despite the recent slowdown in economic growth. Furthermore, growth in the number of vehicles has outpaced road construction, exacerbating traffic congestion. As a result, fuel consumption can increase as vehicles spend more time idling in traffic.

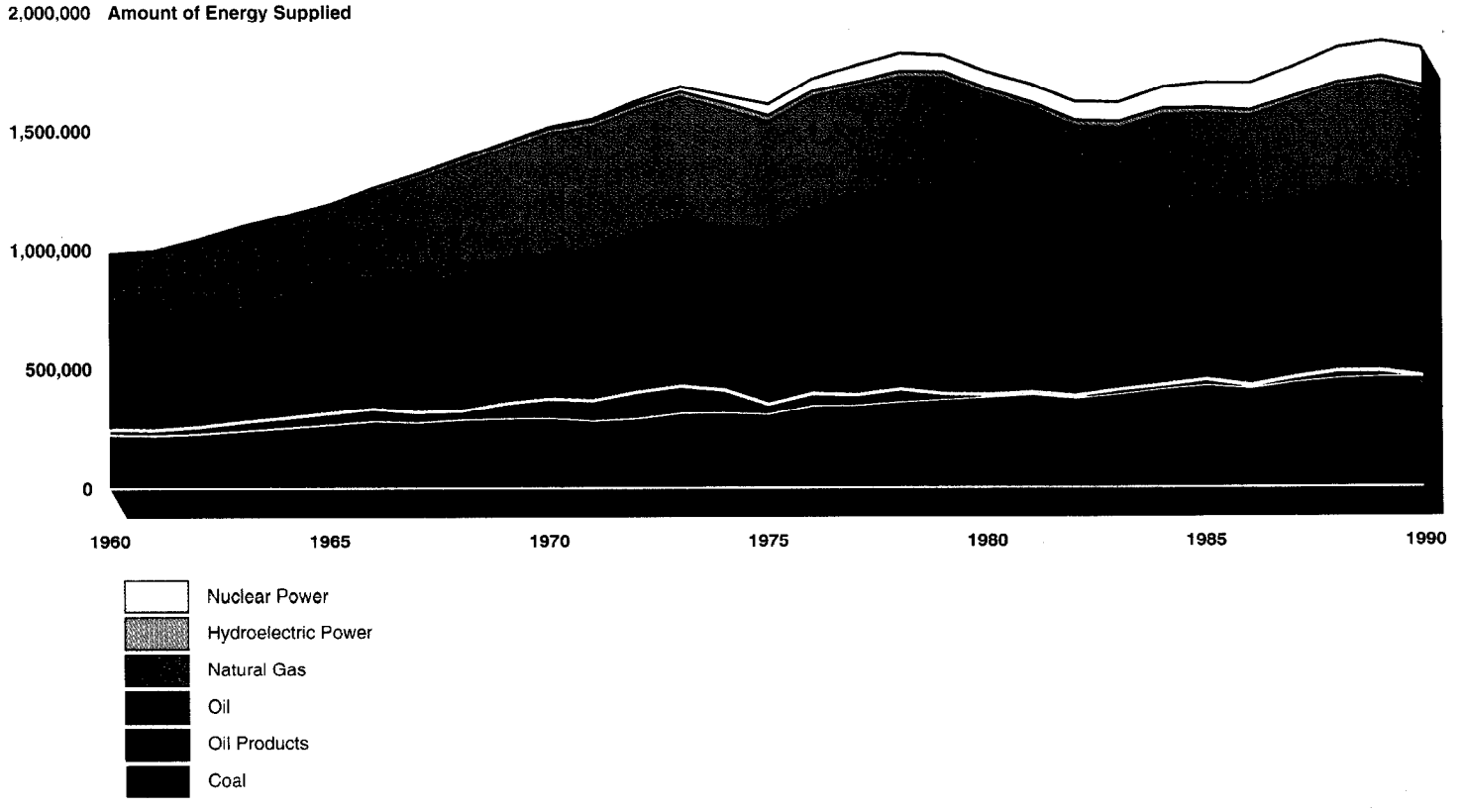
The Large Economy of the United States Requires Large Amounts of Energy

With less than 5 percent of the world's population, the United States accounts for 25 percent of the world's energy consumption, 20 percent of the world's coal consumption, and 26 percent of the world's oil consumption. This high level of consumption is due in part to the sheer

[3]Coke is generally made by baking bituminous coal, or blends of bituminous coal, at high temperatures to remove the volatile components and fuse the remaining fixed carbon and ash. It is used both as a fuel and a reducing agent in smelting iron ore in blast furnaces.

size of the U.S. economy. The U.S. gross domestic product in 1990 was over 2.5 times larger than Japan's, over 6 times larger than Germany's, and nearly 28 times larger than South Korea's. Despite improvements over the last 20 years, the United States remains relatively energy-intensive, requiring 68 percent more energy to produce a unit of GDP than Japan, 14 percent more than France, and 8 percent more than Germany. This high energy intensity is partly a result of the historical availability of low-cost domestic energy. As table 2.1 showed, the United States produces 86 percent of its energy supply domestically and is a net exporter of coal. In fact, the United States has significant reserves of coal and natural gas and has historically been a major oil producer. The availability of these domestic energy sources has been a factor in the evolution of the U.S. energy supply, which is depicted in figure 2.14. The United States imported about 42 percent of its oil in 1990. The trend will likely be toward increased imports as demand rises and domestic oil production declines in the future.

Figure 2.14: Evolution of the U.S. Energy Supply



Note: The amount of energy is expressed as the total energy supplied in thousands of tons of oil equivalent.

Source: Based on data from the International Energy Agency.

The United States has made significant progress in improving energy efficiency in the industrial sector. As mentioned earlier, industrial energy intensity declined by 28 percent between 1977 and 1987. At the same time, the amount of coal consumed by industry decreased by 29 percent, and oil consumption decreased 5 percent between 1973 and 1990. However, electricity use in industry increased 32 percent over the same period, and much of this electricity was provided by coal-fired plants. In fact, the share of electricity produced with coal increased from 46 percent in 1973 to

56 percent in 1990, while the share produced with oil declined significantly, to 4 percent in 1990.

As a result of a large number of vehicles driving a large number of miles, the U.S. transportation sector consumes large amounts of oil. In fact, the U.S. transportation sector consumes more than twice as much oil as the combined transportation sectors of all five of the nations we surveyed. The Unites States has the highest rate of vehicle ownership of the nations we reviewed, with 573 vehicles per 1,000 inhabitants in 1988. This ownership rate is 26 percent higher than the rate in Canada, the nation with the next highest rate. At the same time, however, the rate of growth in vehicle ownership in the Unites States is slower than in any of the other nations we examined. This slow growth rate is largely due to the fact that the United States is saturated with automobiles. The United States also has a low population density. Thus, the population typically travels longer distances than it does in the other nations we surveyed except Canada. Nevertheless, while the United States has a huge vehicle fleet that travels over long distances, it experienced the greatest improvement in new-car average fuel efficiency between 1979 and 1988 of the nations we reviewed—an improvement of almost 30 percent. In comparison, there was no change in Japan in the same period. In fact, new-car average fuel efficiency in the United States is about the same as the level in most other industrialized nations. However, the average fuel efficiency of all cars in the United States is 24 percent lower than the new car average because older, less-efficient vehicles still make up a significant portion of the vehicle fleet.

Observations

Energy consumption patterns have generally been similar in the nations we reviewed and in the United States. Over the last two decades, the amount of coal and oil used to generate a unit of GDP have generally declined in all the nations. The United States, with a 28-percent decline in overall energy intensity, was second only to Japan of the nations we examined in the percentage decrease in energy intensity achieved between 1973 and 1990. Yet the United States remains more energy-intensive than Japan, France, and Germany.

The United States and the nations we surveyed, with the exception of South Korea, have been successful at reducing the intensity of oil and coal use and the amount of oil used by industry. Since the oil price shocks of the 1970s, nations have improved industrial energy efficiency and generally reduced the proportion of energy-intensive industries in the

economy. In addition, they have employed substitutes for oil when possible. France is particularly noteworthy in this regard. Largely by promoting and switching to nuclear power, France has reduced the share of total energy consumption supplied by oil by 30 percent since 1973. France is one of the two nations among those we surveyed that reduced its overall consumption of coal. This reduction in coal consumption has had the additional environmental benefit of helping reduce France's carbon dioxide emissions by 25 percent over 1980 levels.

Efforts to reduce oil consumption in the transportation sectors have met with mixed results. Since 1973, the oil intensity of road transportation has decreased in the United States and the countries we reviewed. However, unlike in the industrial sector, in the transportation sector the amount of oil consumed has not decreased along with energy intensity. It appears that in France, Germany, Japan, and especially in South Korea, consumption in the transportation sector has not declined because rising living standards have resulted in higher rates of vehicle ownership. Furthermore, it appears that higher living standards, which are associated with higher levels of disposable income, have overwhelmed relatively high fuel prices in these countries as a deterrent to gasoline consumption. By contrast, low motor fuel prices and high living standards in the United States and Canada encourage vehicle use and fuel consumption. While the average fuel efficiency of the vehicle fleets of these two countries has improved more than it has in the other nations we examined, the average number of miles traveled per vehicle has also risen. Furthermore, unlike the industrial sector, the transportation sector lacks alternatives to oil as a transport fuel. The transportation sector's ability to reduce oil consumption is thus limited, particularly given the rising numbers of vehicles in some countries. Continued heavy reliance on oil in the transportation sectors of the United States and these other nations should be of concern to policymakers because it impairs the nations' ability to reduce their overall dependence on oil and the resulting economic vulnerability to sudden increases in its price.

Price is a major determinant of the type, amount, and intensity of energy used in transportation and industry. One way that nations influence price is through energy taxes. Taxes and other means that nations adopt to promote energy efficiency and conservation are the subject of the next chapter.

Nations' Approaches to Reducing Energy Use in Transport and Industry Differ

The policies adopted by the five countries we reviewed to promote energy efficiency and the conservation of oil and coal differ between the transportation and industrial sectors. Policies for the transportation sector generally involve taxation of fuels and vehicles, while policies aimed at industry often involve financial incentives. Motor fuel taxes are significantly higher in these five countries than they are in the United States and have been adopted primarily to raise general budget revenues. Vehicle taxes, employed in all of the nations we examined, are generally based on vehicle attributes related to fuel efficiency. The United States also levies taxes on motor fuels and on the purchase and ownership of automobiles. However, vehicle taxes in the United States are generally not closely linked to fuel efficiency or are set at such a low fuel-efficiency level that they apply to very few vehicles.

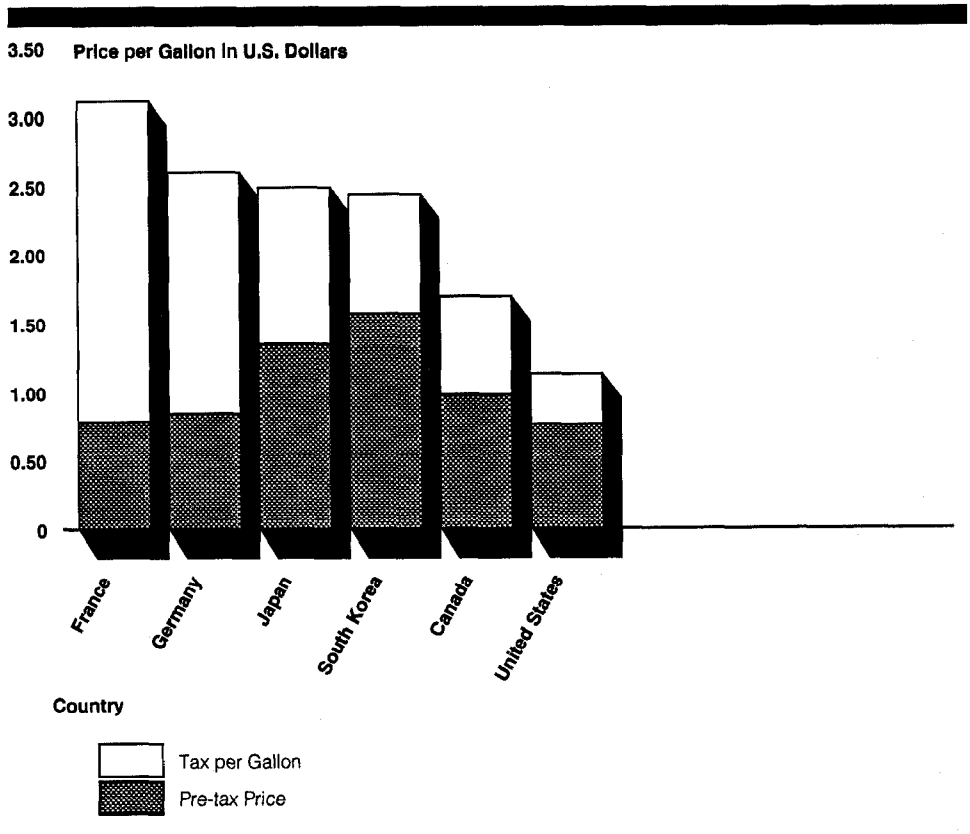
In the industrial sector, financial incentives generally take the form of tax incentives or subsidized loans for investments in energy-efficient plants and equipment. Japan and France require that the energy consumption of large industrial consumers be managed primarily through energy audits. However, other policies, such as government subsidies for the production of coal and mandated long-term contracts to ensure its consumption, do little to foster energy efficiency and conservation of that fuel. The United States has programs in place at the state and federal levels to provide free energy audits to some businesses. However, these efforts are not targeted at large industrial consumers and are not backed by industrial energy-efficiency standards. Several states provide low-interest loans to industry for investment in energy-saving equipment, but these programs are relatively modest in size and, again, are not targeted at large industrial energy users.

Policies Affecting the Transportation Sector Generally Involve Taxing Fuels and Vehicles

The nations we reviewed all impose taxes on motor fuels and on the purchase and ownership of automobiles, primarily to raise budget revenues—a fiscal policy objective. All of the countries we examined have substantially higher retail gasoline prices than the United States. As shown in figure 3.1, most of this difference can be attributed to higher taxes levied on gasoline and oil. In Japan, energy taxes are earmarked for diverse and sometimes conflicting purposes. As in the United States, gasoline tax revenues in Japan are generally earmarked for road construction—a transportation policy objective. However, using these revenues to build additional roads may detract from the goal of conserving fuel by encouraging more road travel. Japan and Germany also raised funds for their contributions to the Persian Gulf War through higher taxes

on petroleum products, primarily motor fuels. In France, Germany, Canada, and South Korea, gasoline taxes are the source of most of the revenues the governments derive from taxes on oil and oil products. These revenues are channeled into the general budget. Along with taxes on gasoline, all countries levy variable vehicle registration fees or taxes based on engine size and other factors affecting vehicle fuel efficiency. In the United States, the federal government and the states also levy various taxes on the purchase and/or ownership of motor vehicles, but these are not as closely linked to vehicle attributes related to fuel economy as taxes in the other nations we reviewed. The Canadian province of Ontario has adopted a fee-rebate program to promote the purchase of fuel-efficient vehicles and a joint government-utility company program that provides incentives to consumers to convert their newly purchased new or used vehicles to run on compressed natural gas.

Figure 3.1: Gasoline Prices and Excise Taxes, 1991



Source: Based on data from the International Energy Agency.

Gasoline Taxes Make Up the Bulk of Energy and Oil Taxes

In addition to levying taxes on various fuels (such as petroleum, liquified petroleum gas, and aviation fuel), Japan levies a tax on gasoline. The gasoline tax constitutes 45.7 percent of the price paid at the pump, and accounts for nearly two-thirds of all of Japan's energy tax revenues. Revenues from the gasoline tax are earmarked for road construction and improvement—a transportation policy objective. Japan also taxes liquified petroleum gas (LPG) and, at the local level, places an additional small tax on gasoline and a tax on gas oil (light oil), with the revenues again earmarked for road construction and improvement. Japan also levies a 3-percent consumption tax—a national sales tax—on gasoline and LPG on top of other taxes on these fuels.

In addition, Japan levies a petroleum tax, which is assessed on crude oil, oil products, natural gas, and gaseous hydrocarbons that are either produced domestically or imported. Under the petroleum tax, imported crude and oil products are taxed at $2.40 per barrel.[1] Natural gas is taxed at $5.34 per ton and gaseous hydrocarbons at $4.97 per ton. In 1991, the Japanese government raised the petroleum tax by 50 percent for one year to finance Japan's contribution to the Persian Gulf War. Most of petroleum tax revenues (93 percent) are used to finance oil and gas exploration projects overseas, government and private-sector oil stockpiling, and revitalization of the domestic oil refining industry. The remaining revenues finance research and development (R&D) activities that fall under Japan's so-called Sunshine Project, which focuses on solar, geothermal, and hydrogen energy, and the so-called Moonlight Project, which focuses on developing energy conservation technologies. Revenues from the petroleum tax are also used to develop coal liquefaction and gasification technologies.

France levies an internal tax on petroleum products that applies to several categories of oil products. However, 91 percent of the revenues from France's tax on petroleum products comes from taxes on gasoline and diesel fuel. Excise taxes on gasoline make up about three-quarters of the price paid at the pump. The internal tax on petroleum products was adopted to raise general budget revenues—a fiscal policy objective. This tax was originally fully indexed to the rate of inflation, but the rate of growth of the tax was reduced to 75 percent of the annual inflation rate between 1989 and 1990, 50 percent between 1991 and 1992, and 75 percent in 1993. Thus, the level of the tax, adjusted for inflation, and its effectiveness at deterring gasoline consumption, is shrinking over time. The French government also levies an 18.6-percent value-added tax (VAT)

[1]All currencies are in 1991 U.S. dollars unless otherwise noted.

on top of the taxes on gasoline. In addition to taxing diesel fuel at a lower rate than both leaded and unleaded gasoline, the French government also grants rebates to all passenger car drivers for the VAT portion of diesel and LPG fuel taxes but does not do so for gasoline taxes.

In 1991, diesel vehicles accounted for 25 percent of France's automotive production and 18 percent of the total private vehicle fleet. An official from the Ministry of Industry and International Trade indicated that lower excise taxes on diesel fuel and VAT rebates for diesel fuel purchases fulfill both environmental and energy-security objectives. Diesel engines are generally more fuel-efficient than gasoline engines of comparable horsepower and emit less carbon dioxide. Diesel vehicles also emit less carbon monoxide than comparable gasoline-fueled vehicles.

Germany's mineral oil tax, imposed in 1930, is the largest single excise tax the German federal government collects. In 1989, revenues from taxes on motor fuels accounted for 93 percent of the total revenues raised by the mineral oil tax. According to officials from the Ministry of Finance, the mineral oil tax is designed to raise general revenues for the German government—a fiscal policy objective. The tax is levied on the use of oil as both motor fuel and heating fuel. Taxes on gasoline make up more than two-thirds of the price paid at the pump. The German government also levies a 15-percent VAT on top of taxes on gasoline and diesel. Unlike Canada and the United States, Germany taxes motor fuels only at the federal level, although the Länder (regional) governments levy taxes on motor vehicles. In 1991, the German government increased the mineral oil tax by roughly 37 percent for gasoline and 22 percent for diesel fuel to finance the costs of reconstructing eastern Germany and to fund its contribution to the Persian Gulf War.

The Canadian government levies a federal excise tax on motor fuels (gasoline and diesel) and, like states in the United States, provincial governments levy their own taxes on motor fuels. Provincial and federal excise taxes on gasoline account for, on average, about 42 percent of the price paid at the pump. Similar to Japan, the Canadian federal government also levies a 7-percent national sales tax on top of the federal and provincial excise taxes on motor fuels. The Canadian federal government used to offer very small rebates, about 5 U.S. cents per gallon on the federal excise tax on gasoline of about 78 U.S. cents per gallon. These rebates were available to farmers, fishermen, trappers and miners, and commercial and/or business users—groups thought to have little ability to change their driving behavior to lessen their gasoline tax burden—as well

as to charities and to the physically disabled. However, when the federal sales tax was introduced in January 1991, the government phased out the rebate on gasoline taxes—except for charities and the physically disabled. Both charities and the physically disabled are eligible for a rebate on the full 7-percent national sales tax on purchases of gasoline and diesel. In addition, on April 1, 1992, the government announced that the ethanol and methanol portions of blended fuels would be exempt from excise taxes.

The South Korean government levies excise taxes on gasoline and diesel fuel. Tax rates on diesel fuel are significantly lower than they are for gasoline. According to an official with the Ministry of Energy and Resources, excise taxes on gasoline are intended to help reduce gasoline demand. South Korea levies a 10-percent VAT on top of excise taxes on gasoline and diesel. Revenues from gasoline and diesel taxes are used for road construction, although a small part of the revenues from gasoline taxes are used for railway construction—both transportation policy objectives.

Countries Levy Vehicle Taxes on the Basis of Engine Capacity

Four of the five nations we reviewed levy vehicle taxes that vary with the capacity of the engine. Japan levies a graduated automobile tax that is based on the cylinder capacity—engine size—of passenger cars. All owners of a registered vehicle are required to pay an annual tax according to engine size. Because engine size is directly related to vehicle fuel efficiency, the tax rate increases with engine capacity. Prefectural (regional) governments collect the revenues from this tax, which are used for road construction and improvement—a transportation policy objective. The Japanese government also imposes a motor-vehicle tonnage tax at the time vehicle owners obtain inspection certificates for their vehicles. The tax rate is based on the weight of the vehicle and the period covered by the inspection permit. Three-quarters of the revenues from this tax are credited to the general budget, and the remainder are earmarked for construction and improvement of local roads to meet fiscal and transportation policy objectives.

Motor vehicle taxation in France is based on a vehicle's "fiscal horsepower," calculated on the basis of the engine capacity, type of motor fuel, and type of transmission. The French government imposes two types of vehicle ownership taxes: an annual "vignette" tax and a one-time registration tax, both of which are based on the fiscal horsepower calculation. The vignette tax is based on ten categories of fiscal horsepower, each of which has a tax rate that varies by region. The

registration tax is a fixed tax for each unit of fiscal horsepower, but that tax also varies by region and vehicle age. The vignette tax for a 1992 Renault 25 (11 units of fiscal horsepower) in Paris is $198, while the registration fee is $287. The vignette tax also varies with the age of the vehicle; vehicles older than 5 years are subject to half the standard tax. For vehicles 20-25 years old, a modified version of the fiscal horsepower formula is used to calculate the vignette tax. These vehicles are exempt from the registration tax.

The German government imposes an annual vehicle ownership tax that is measured on the basis of the cylinder capacity of passenger car engines. The tax rates are lower for gasoline-powered vehicles than they are for vehicles with diesel engines. Diesel vehicles are taxed at a higher rate as a way of offsetting the lower taxes on diesel fuel. For example, the owner of a compact, four-cylinder vehicle with an engine capacity of 1,850 cubic centimeters and an engine with reduced emissions pays about $141. The owner of a diesel vehicle with the same engine capacity would pay $231.

South Korea's vehicle registration tax is based on engine cylinder capacity. The annual tax on a car with a 1,600 cubic centimeter engine is roughly $439. The government places an additional 30-percent surcharge (or $132) on this fee for passenger cars; the surcharge is used for education. Eighty percent of the revenues from the vehicle registration tax goes to local governments; the remainder is used for road construction—a transportation policy objective.

Canada's Province of Ontario Has Implemented a Fee-Rebate Program

In 1989, the Province of Ontario implemented a fee-rebate program to promote the use and production of fuel-efficient vehicles and to raise revenues. Under the fee-rebate program, purchasers of fuel-efficient vehicles receive rebates and purchasers of fuel-inefficient vehicles are charged additional fees. The fee (or rebate) is collected (or paid) only once, when the vehicle is purchased, as a surcharge or credit on the sales tax. This program also helps meet fiscal policy objectives. The net revenues (fees minus rebates) average about $40 million (U.S. dollars) per year, according to estimates from the provincial government. Ontario is the only province in Canada that has introduced a fee-rebate program.[2]

Ontario's fee-rebate program covers new passenger cars and sports utility vehicles but not mini-vans. As shown in table 3.1, the fee ranges from $65 (U.S.) on passenger cars with a fuel-economy rating of less than 39 miles

[2]Motor vehicle taxation in Canada varies among provinces.

per gallon to about $6,110 on cars with a fuel-economy rating of less than 13 miles per gallon. Passenger cars with a fuel-economy rating over 39 miles per gallon receive a rebate of about $87; these vehicles accounted for 4 percent of the vehicles sold in 1991.

Table 3.1: Ontario's Fee-Rebate Program, 1991

	Tax levels in U.S. dollars		Percent of sales	
Highway fuel economy in miles per gallon	Cars	Sports utility vehicles[a]	Cars[b]	Sports utility vehicles[b]
Over 39	($87.28)	0	4.0%	[c]
39.0 - 30.0	65.46	0	62.0	2.0%
29.9 - 28.0	65.46	$65.46	22.0	[c]
27.9 - 26.5	65.46	65.46	4.0	0.2
26.4 - 25.0	218.20	174.57	5.0	0.1
24.9 - 19.6	1,047.39	349.13	3.0	93.0
19.5 - 15.7	2,094.79	698.26	0.1	4.0
15.6 - 13.0	3,840.45	1,396.53	[c]	0.1
Under 13	6,109.80	2,793.05	[c]	[c]

[a]Sports utility vehicles refers to light trucks.

[b]Figures do not add to 100 because of rounding.

[c]There were no examples in this category.

Source: Ontario Ministry of Energy.

Government and Utility Provide Incentives for Converting Vehicles to Compressed Natural Gas

To increase sales of natural gas—an alternative to gasoline as a transportation fuel—Consumers Gas, a natural gas utility in Ontario, began a program in 1982 to encourage the use of natural gas vehicles.[3] This program assists customers with the costs of installing a compressed natural gas (CNG) conversion kit when they purchase new or used vehicles. Consumers Gas and the Canadian federal government support the program by refunding part of the vehicle conversion costs. Customers pay Consumers Gas for the costs of the fuel cylinders through their monthly gas bills, but they receive refunds from the utility for the cost of installing those cylinders. The Ontario Energy Board permits Consumers Gas to recoup the costs of the cylinder-installation refunds in the utility's rate base. Table 3.2 shows the costs of installation and the refund/grant amounts.

[3]As of June 30, 1992, there were 13,332 natural gas vehicles, 50 public compressed natural gas fueling stations, and 40 conversion shops in Ontario.

Table 3.2: Ontario's Natural Gas Conversion Grants and Refunds, 1992

Installation costs and refunds in U.S. dollars	Used vehicle	New vehicle
Cost of installation	$2,015 - $2,741	$2,015 - $2,741
Consumers Gas refund[a]	($121 - $282)	($121 - $282)
Federal grant	($403)	($403)
Provincial sales tax refund	($133 - $169)	($806 maximum)
Cost to the customer[b]	$1,358 - $1,886	$685 - $1,249

[a]The amount refunded depends on the number of cylinders installed on the vehicle. The more cylinders installed, the larger the refund amount.

[b]The cost to the customer does not include the cost of the fuel cylinder. Cylinders can be purchased, or rented from Consumers Gas for $6 to $9 per month, depending on the number of cylinders. The rental or purchase fee is added to the customer's monthly gas bills.

Source: Based on information from Consumers Gas, Toronto, Ontario.

The United States Employs Similar but Smaller Taxes

Like the five nations we reviewed, the United States imposes excise taxes on motor fuels, and the federal government and many states also impose taxes and fees on vehicle purchases and ownership. However, U.S. taxes on motor fuels are much lower than those of the other nations, and taxes and fees on vehicle purchases and ownership are not as closely linked to vehicle attributes related to fuel efficiency. The United States has chosen a different approach to improving the fuel efficiency of vehicles by setting mandatory fuel economy standards.

Taxes imposed on gasoline by the U.S. federal government and the states averaged about $0.37 per gallon in 1991. Energy taxes in the countries we surveyed were generally imposed as fiscal measures—to raise revenues—but government representatives in those nations stated that such taxes have the additional benefit of reducing demand for gasoline and other fuels subject to such taxes. Officials from all of the nations believed that if the United States does nothing else to reduce its oil consumption, it should impose higher taxes on gasoline. Like Germany and Japan, the United States has increased its gasoline tax to raise revenues to address specific national priorities, including fiscal and transportation policy objectives. The United States raised its excise tax on gasoline by $0.05 per gallon in 1990; one-half of this amount was earmarked for deficit reduction and the remainder for transportation purposes.

The United States also has several programs in place, at both the state and federal level, to tax or collect fees on the purchase and/or ownership of vehicles. In addition, some localities tax vehicles as property on the basis of their estimated value. However, these taxes and fees are generally of lesser magnitude and/or are not as well targeted at increasing vehicle fuel efficiency as most of the programs we observed in other countries. The United States, unlike the nations we reviewed, requires that new vehicles from each domestic or foreign manufacturer's stock sold in the United States meet an average fuel-economy level. This level is currently set at 27.5 miles per gallon. In addition, the Energy Tax Act of 1978 established the so-called "gas guzzler" tax. The gas guzzler tax is collected on new vehicles that achieve fuel economies lower than 22.5 miles per gallon. As such, this tax applies primarily to luxury or high-performance vehicles, which make up a very small percentage of U.S. automobile production and sales. In fact, according to DOE, only 2 of the 20 car models subject to the tax are manufactured in the United States. All states impose an annual vehicle registration fee. In some cases, this fee is based on vehicle weight—heavier vehicles are assessed a higher fee. Heavier vehicles typically consume more gasoline to travel a given distance. At the local level, most vehicle taxes are based on a vehicle's estimated value. Taxes are therefore lower on older, less valuable vehicles. Older vehicles are, on average, less fuel-efficient and pollute more than newer vehicles.

California has several times considered a program similar to the fee-rebate program we observed in the Canadian province of Ontario but has not yet enacted such a program. However, the state of Maryland recently enacted a law creating a program similar in approach. At the federal level, two bills containing fee-rebate proposals were introduced in the 102nd Congress. Neither bill was included in the Energy Policy Act of 1992 (P.L. 102-486), which was signed into law on October 24, 1992.

The United States has recently placed greater emphasis on converting its future vehicle fleet to nonpetroleum fuels—providing alternatives to oil use in the transportation sector—than have the other countries we reviewed. However, these efforts are in their early stages. The Energy Policy Act of 1992 contained several provisions designed to encourage the introduction of alternative-fueled vehicles to the U.S. automobile fleet. These include requirements for the use of alternative-fueled vehicles in government and private vehicle fleets, low-interest-rate loans for businesses to help defray the costs of converting or purchasing such vehicles, tax incentives for buying or converting such vehicles, and tax incentives for the purchase of refueling equipment.

Financial Incentives and Energy Audits Affect the Industrial Sector's Energy Consumption

The policies we observed for promoting energy efficiency and conservation in the industrial sectors of the countries we reviewed took the form of special tax treatment and subsidies for investment in energy-saving equipment and mandated energy audits for large industrial energy consumers. Japan and South Korea provide subsidized loans for business purchases of energy-efficient plant and equipment. Japan and France provide investment tax credits for investments in energy efficiency and conservation. The Province of Ontario in Canada has a program designed to accelerate the market entry of new energy-efficient technologies and offers companies financial incentives or loans to implement approved energy savings in their plants. Both Japan and France require large industrial consumers to conduct energy audits—critical evaluations of their energy consumption with the aim of improving energy efficiency. Japan also has mandatory energy-efficiency standards for a variety of industrial processes. The United States has several programs at the state and federal level similar to the energy audit and loan programs we observed in Japan, France, and South Korea, although the U.S. programs are of a lesser magnitude and are voluntary.

Japan and Korea Offer Subsidized Loans for Investments in Energy Efficiency

Through several government-owned financial institutions, the Japanese government offers low-interest loans for business investment in energy-efficient equipment and equipment to facilitate using energy sources other than oil. These loans are targeted at equipment that improves the recovery of wasted heat, cogeneration systems, coal distribution facilities, systems for standardizing electric power loads, gas-fired heating and air-conditioning, and energy-efficient equipment for small- and medium-sized companies. To help meet the government's objective of diversifying Japan's fuel mix away from oil, these financial institutions also lend money for the construction of LPG storage facilities and nuclear power plants and for the conversion of oil-fired plants to alternative energy sources (e.g., liquified natural gas and coal).[4] All major gas companies can apply for low-interest loans for building liquified natural gas facilities and gas pipelines.

The Japan Development Bank is by far the largest lender, having lent nearly $4 billion in 1991 (28 percent of the bank's total lending) in new loans for "resources and energy"—defined as projects to develop alternative energy sources to oil and to encourage energy and resource

[4]These loans are also made for the construction of oil storage facilities related to the government's requirement that private firms stockpile oil supplies in case of a supply disruption. Providing loans for oil storage facilities appears inconsistent with the stated objective of diversifying energy sources away from oil but nevertheless contributes to improved energy security.

conservation. To qualify for subsidized loans, businesses must show that their investments will reduce energy and/or oil consumption by 20 percent for existing facilities and 40 percent for new projects.

In South Korea, the Petroleum Development Corporation, a government corporation, also provides subsidized loans to industry to promote the use of energy-saving equipment.[5] The government allows a 1-year deferment before the first payments on the loan must be made. In addition, the Korea Energy Management Corporation, a government-owned organization responsible for funding and encouraging energy conservation and efficiency, provides low-interest loans for various energy management projects. The loans have a 3-to-5-year grace period and a 5-year repayment period. If an energy management project is expected to result in a 20-percent energy savings, the interest rate on the loan is 5 percent; projects resulting in 10-percent energy savings have a 10-percent interest rate.

Japan Provides Tax Incentives for Investments in Energy Efficiency

The Japanese government provides businesses with tax incentives to invest in energy-efficient plant and equipment. During the year in which such equipment is first used, businesses can claim (1) a 7-percent investment tax credit on the purchase price of the equipment,[6] or (2) a 30-percent depreciation allowance on the purchase price of the equipment. In addition, businesses can claim a deduction of up to 83 percent of the value on energy-efficient equipment subject to the municipal property tax.

Ontario Provides Grants to Accelerate the Market Entry of Energy-Efficient Technologies

The Province of Ontario has a program designed to accelerate the market acceptance of new energy-efficient technologies manufactured by Ontario companies. Under this program, begun in 1991, competitions are held biannually to choose technologies for which incentive grants will be awarded to first-time industrial buyers. The purpose of the grants is to reduce the risk to companies of adopting new energy-efficient technologies. Grants of up to $400,000 are provided directly to buyers of the winning products. The grants cover 50 percent of the buyers' eligible costs, which include the (1) purchase, shipping, and installation of the new product and (2) costs of monitoring and reporting the energy performance of the new product.

[5]The Petroleum Development Corporation also provides loans for domestic and overseas oil and gas exploration, city gas projects, oil pipelines, and renewable energy projects.

[6]The value of the tax credit cannot exceed 20 percent of the business's tax liability during the fiscal year in which the deduction is claimed.

Ontario's Accelerated Payback Program

Ontario Hydro, the utility that supplies electric power to the Province of Ontario, offers companies financial incentives in the form of cash rebates to implement approved energy-saving measures in their plants. One of the barriers companies face in making energy-efficiency improvements is the long payback period on these kinds of investments. All industrial customers that consume over 10,000 kilowatt-hours of electricity annually are eligible for the program. Any project that saves electricity by using a proven technology with an expected operating life of at least 10 years is eligible for the program. Both new plant designs and retrofiting projects are eligible. The amount Ontario Hydro provides in the form of a cash payment for each energy-saving project is the lesser amount of (1) the cost of reducing the payback to 18 months or (2) 10 cents per kilowatt-hour for the first year of energy savings achieved by the project. A maximum of $261,800 (U.S.) is provided per project.

Energy Managers in Japan Help Ensure Industrial Energy Efficiency

Under Japan's energy conservation law, large industrial firms are required to meet energy-efficiency standards for certain industrial processes. To help ensure industry's compliance with these standards, the Japanese government has created a system of energy auditing for large industrial consumers. This system is administered by the Ministry of International Trade and Industry (MITI) in conjunction with the Energy Conservation Center, an organization jointly financed by MITI and various energy-consuming industrial firms.

The energy conservation law requires MITI to designate as an "energy management factory" any manufacturing, mining, electricity, and gas and heat supply firm that (1) consumes more than 18,900 barrels of oil equivalent per year or (2) consumes more than 12 gigawatt-hours[7] of electricity per year. The government has designated roughly 4,600 energy management factories; in 1991, these firms accounted for 70 percent of total final energy consumption in the industrial sector.

Under MITI's rules, designated factories are required to appoint up to four "heat managers" or "electricity managers," depending on the factories' level and type of energy consumption. For example, factories with an annual consumption of 126,000 to 314,994 barrels of oil equivalent of fuel per year (or 200 to 499 gigawatt-hours per year for electricity-intensive industries) require two energy managers. Factories consuming 315,000 to 629,994 barrels of oil equivalent (or 500 or more gigawatt-hours of

[7]One gigawatt-hour is equivalent to one billion watts of power supplied to, or taken from, an electrical circuit steadily for one hour.

electricity per year) are required to have three energy managers. These managers are trained and certified by the Energy Conservation Center. Failure to appoint energy managers can result in a fine.

Energy managers are paid employees of the enterprise whose energy consumption they manage. They help to ensure compliance with energy-efficiency standards set by the energy conservation law. They submit detailed statements to MITI that include all aspects of fuel use for industrial processes (including electricity generation and cogeneration), the energy consumption ratings of equipment, and the changes and repairs required to meet efficiency standards. Failure to provide the required statements can result in a fine. In cases in which the energy-saving measures of a particular firm are insufficient to meet the standards, the minister may (1) recommend that the firm take specific actions to meet the standards or (2) require the firm to submit a detailed energy savings plan.

Under the energy conservation law, MITI designated the Energy Conservation Center as the body responsible for training the energy managers. The center also conducts energy audits of small- and medium-sized factories. These audits are financed either by government grants or by the Small Business Financial Corporation, a government-owned financial institution.

France Requires Large Industrial Energy Consumers to Conduct Energy Audits

France also requires large industrial energy consumers to conduct energy audits. Government engineers review the resulting audit reports and suggest actions to improve energy efficiency. Adopting these suggestions is voluntary. The government also provides assistance to small- and medium-sized businesses in measuring their energy use. In addition, the government has established regional information and audit centers to make research data on energy conservation and efficiency available to industrial energy consumers. Furthermore, businesses are granted a one-time tax deduction for investments in energy-saving equipment. However, unlike Japan, France has no mandatory industrial energy-efficiency standards or targets.

The United States Has Similar but Limited Programs in Place and Planned

Unlike Japan, South Korea, and Canada, the United States currently has no programs to provide direct financial incentives in the form of grants, tax breaks, and low-interest loans for investment in energy-efficient plant and equipment. The several programs in place at the state level are fairly

modest. Most of the state programs provide for low-interest-rate loans for investment in energy-efficient plant and equipment. Several states also provide small grants to help defray the cost of investment in energy-efficient equipment. We are aware of 10 states that had loan programs with 1991 funding totaling $51.1 million. In most cases, these programs also apply to the commercial and service sectors as well as to the industrial sector, and they are generally not targeted at large industrial energy users.

The United States, at both the state and federal levels, makes some use of energy audits in the industrial sector. However, unlike in Japan and France, in the United States industry participation is voluntary. Furthermore, energy audit programs run by states and the federal government are generally targeted at small- and medium-sized businesses and not necessarily at the largest energy consumers, as they are in Japan and France. The Energy Policy Act of 1992 requires that DOE evaluate and report to the Congress on the potential costs and benefits of adopting voluntary energy-efficiency targets for industry in this country. The act further tasks DOE with establishing criteria for energy assessments (audits). Finally, the act establishes a program to give grants to states to help them train energy assessors to provide energy audits of industrial processes. However, these efforts will not go as far as the other energy audit programs we observed. For example, unlike the Japanese and French programs, the audits are still voluntary for energy-intensive industries and, unlike the Japanese program, they are not backed by energy-efficiency standards or targets.

Other Policies Affect Industrial Energy Consumption

We identified additional policies that affect coal and oil consumption in the industrial sectors of the five countries we reviewed. With the exception of promoting nuclear power, these policies are not aimed at encouraging the efficient consumption or conservation of coal and oil but rather seek to influence the choice among different types of fuels and to help ensure stable oil supplies and prices. These policies include: in Germany, subsidies from the government and electricity consumers for the production of high-cost coal; in South Korea, a surcharge on petroleum imports used to stabilize supply and demand of oil and to finance the country's Petroleum Business Fund; in Japan, oil import tariffs, with revenues used to restructure the Japanese coal mining industry; and in France, nuclear energy as a way of reducing fossil fuel consumption. Lastly, all five countries foster their nuclear energy industries through significant expenditures on research and development.

Germany Subsidizes Uneconomic Coal Mines

For reasons of both energy security and social policy, the German government and electricity consumers subsidize the production of expensive hard coal. Coal producers also have long-term supply contracts with electric utilities (until 1995) and the iron and steel industries (until 2000) that require these industries to use domestically produced hard coal. The agreement between coal producers and electric utilities is supported by a German law providing for a special fund to subsidize electricity generated with hard coal.

The government provides direct aid to hard coal producers in the form of investment grants, bonuses to miners, and grants to promote sales of coking coal. Indirect aid is provided in the form of special capital depreciation measures for coal production facilities. Electricity consumers also subsidize hard coal production through a 7.5 percent levy on their electricity bills. According to the International Energy Agency, in 1990 the German government provided $2.9 billion in direct and indirect aid to hard coal producers. Electricity consumers provided an additional $4.3 billion in price supports. Together, the government subsidies and price supports amount to roughly $104 per metric ton of hard coal produced.

South Korea Levies a Surcharge on Oil Imports for Its Petroleum Business Fund

The South Korean government levies a surcharge on imports of crude oil and oil products to stabilize supply and demand of petroleum and petroleum products. The revenues from this surcharge, which was first collected in 1979, finance South Korea's Petroleum Business Fund. The surcharge is equal to the difference between the actual oil import cost and an assumed cost of oil determined by a price-setting process based on a government-authorized profit level. When oil prices are unexpectedly high, as they were during the Persian Gulf War, the Petroleum Business Fund is used to compensate South Korean refineries for higher oil acquisition costs, thus helping to stabilize the prices paid by consumers.

During the mid-1980s, when oil prices plunged in the world market, the surcharge for the Petroleum Business Fund was over $10 per barrel because the oil price set by the government reflected a higher historical crude oil price. Conversely, when the world price of oil increased during the Persian Gulf War, South Korea's Petroleum Development Corporation, which is responsible for administering the fund, incurred obligations of $1.4 billion to oil refiners to help defray their higher acquisition costs. This

mechanism, in combination with government price controls for oil products, is aimed at ensuring stable prices for consumers of oil products.[8]

Revenues from the fund are used for various purposes: 6 percent goes for support, such as operation of the Petroleum Development Corporation; 37 percent for compensating oil refiners and stabilizing oil prices; 39 percent for financing overseas exploration activities and other energy projects; and 18 percent for investment in stockpiling facilities and pipeline construction. The loans for overseas exploration provided by the Petroleum Development Corporation are written off if the projects are unsuccessful.

Oil Import Tariffs in Japan Finance Downsizing of the Coal Industry

Japan levies modest tariffs on imports of crude oil and somewhat higher tariffs on imported oil products. The revenues from these tariffs finance the downsizing of Japan's high-cost coal mining industry. For instance, funds are provided for retraining displaced coal miners, modernizing coal mines, and improving mine safety conditions. Economic development funds and price supports for production are also provided from these revenues. Japan has only 16 remaining coal mines out of about 222 mines that existed in 1965. The IEA has praised Japan for the orderly downsizing of its uneconomic domestic coal mining industry.[9]

As shown in table 3.3, tariffs are generally higher for oil products than they are for crude oil. For example, tariffs are about four times higher for gasoline and light crude oil than for crude oil. In 1991, the amount raised from import tariffs on both crude oil and oil products was about ¥110 billion ($817 million).

[8]The South Korean government recently discussed the possibility of assessing a fixed surcharge on oil imports to fund the Petroleum Business Fund as an alternative to the current system. A fixed surcharge would be assessed on the volume of oil imported and would be independent of fluctuations in world oil prices and currency exchange rates.

[9]The Energy Policies of IEA Countries: 1990 Review, International Energy Agency (Paris, France: 1991), pp. 306-307.

Table 3.3: Oil Import Tariffs in Japan, 1992

Product type	Tariff in yen per kiloliter[a]	Equivalent in U.S. dollars per barrel of oil equivalent
Heavy crude oil	¥315	$0.40
Light crude oil	1,290	1.67
Heavy fuel oil A	2,770	3.56
Heavy fuel oil B	2,580	3.32
Heavy fuel oil C	2,520	3.24
Gasoline	1,430	1.84
Kerosene	580	0.75

[a]One kiloliter is equivalent to 6.3 barrels of oil.

Source: Based on information from Ministry of Finance, Japan.

France's Nuclear Program Has Reduced Fossil Fuel Consumption

The French government made large-scale investments in the mid-1970s to develop a nuclear power program that now generates three-quarters of France's electricity supply. France has developed the domestic industrial capacity to support all phases of the nuclear fuel cycle, including the processing of fuel and the reprocessing of spent fuel, and considers nuclear energy a domestic energy resource.[10] To increase public acceptance, the government launched a campaign aimed at educating the public about the benefits of nuclear energy.

Several Nations and the United States Have Considered Broad Energy Taxes or Carbon Taxes

The European Community (EC), an organization that includes France and Germany, is considering a proposal to institute a variation on a carbon tax. The proposed tax would be based on both the carbon content and the energy content of a fuel in British thermal units (Btu). By including energy content as well as carbon content, the tax would also apply to energy generated from noncarbon-based fuels, such as nuclear energy. Because of concerns about international competitiveness, this proposal is contingent on the adoption of similar measures by both the United States and Japan. Until recently, the proposal had been dormant, largely because of opposition from industry and EC member nations, and the unlikely prospect of adoption by the United States of a comparable tax. However, the recent U.S. proposal to institute a broad energy tax has rekindled the debate within the EC over its proposed tax.

[10]Like the United States, France is seeking to develop a geologic repository for the long-term storage of high-level nuclear waste. The existence of this waste and the issue of how best to store it is an environmental concern both in France and in the U.S.

Japan is also considering carbon taxes as a means of reducing energy-related carbon dioxide emissions, but the government is divided on the advisability of such taxes. Some believe that carbon taxes are the best means of stabilizing carbon dioxide emissions. MITI, however, opposes such a tax on the grounds that it would harm an already sluggish economy and hurt industrial competitiveness. Furthermore, MITI fears that some firms may migrate to other countries that do not impose such taxes.

The new U.S. administration has proposed a broad-based energy tax to raise revenues to reduce the federal budget deficit. The tax would be based on the heat content of various fuels. The tax rate would be higher for oil and oil products—59.9 cents per million Btu for oil and oil products as compared with 25.7 cents for natural gas and other energy sources. Certain renewable energy sources, such as wind and solar energy, would be exempt from the tax. However, other carbon-free energy sources, such as nuclear energy and hydroelectric power, would be subject to the proposed tax. Although raising revenues is the primary objective of such a tax, the administration has cited energy security and environmental objectives in support of its proposal. The administration reasons that because this tax would raise energy prices (e.g., gasoline prices are projected to increase by about 7.5 cents per gallon and coal prices to industry by about 15 percent if the tax is implemented as proposed),[11] consumption of polluting fossil fuels and oil imports would decline, improving energy security and environmental quality. However, according to the Congressional Budget Office, the energy security benefits resulting from reduced oil imports would be small. Furthermore, as we have previously reported, if improving environmental quality were the primary objective, taxing pollutants directly could be more effective.[12]

Spending on Nuclear Energy Research Outpaces Spending on Other Energy Technologies

Japan and France, and to a lesser extent Canada, Germany, and South Korea, all use nuclear power as a substitute for plants fired by fossil fuels. Research and development spending is one important means by which these governments are promoting nuclear power. R&D spending on nuclear technologies far outpaces such spending on other energy technologies. For instance, in 1991 nuclear R&D spending represented 80 percent of the energy R&D budget in Japan, 80.8 percent in France, 58.6 percent in

[11]Statement of Robert D. Reischauer, Director, Congressional Budget Office, before the Senate Committee on Energy and Natural Resources, Feb. 24, 1993.

[12]Energy Policy: Options to Reduce Environmental and Other Costs of Gasoline Consumption (GAO/RCED-92-260, Sept. 17, 1992) and Environmental Protection: Implications of Using Pollution Taxes to Supplement Regulation (GAO/RCED-93-13, Feb. 17, 1993).

Germany, 42.8 percent in Canada, 31.7 percent in South Korea, and 32.4 in the United States.[13] Almost 17 percent of Japan's energy R&D budget is directed towards R&D on breeder reactors. Japan is planning to increase its use of breeder reactors in the future as a way of further improving its energy security. Breeder reactors generate more plutonium fuel than they consume and thus would not require imports of uranium, as conventional nuclear reactors now do. France supports a smaller breeder reactor program, and Germany terminated its breeder reactor program in March of 1991. However, the five countries we reviewed are all facing increased public opposition to the construction of additional nuclear capacity because of environmental and security concerns. In fact, the Canadian Province of Ontario, where nuclear power accounts for almost half of electricity production, imposed a moratorium on new nuclear plants in December 1990.

Observations

The countries we reviewed have adopted various policy measures that, in many cases, cannot easily be categorized as energy policy. Rather, these policies often appear aimed at meeting diverse policy objectives. Despite these diverse policy objectives, we observed that, in the transportation and industrial sectors, these countries often employ policies that affect the price of energy and energy-consuming goods, in turn influencing the behavior of energy consumers. In the transportation sector, motor fuels and vehicle taxes have often been adopted to raise revenues (a fiscal policy objective), some of which are earmarked for highway construction and maintenance (a transportation policy objective); the taxes also have the effect of dampening demand for inefficient vehicles and motor fuels (an energy policy objective). While higher fuel prices can function as a deterrent to fuel consumption, channeling the revenues to road building and upkeep may not enhance, and could detract from, oil conservation. Sustainable reductions in gasoline consumption will require further development of viable alternatives to oil use in motor vehicles, including other fuels. On the other hand, high motor fuel taxes, in combination with vehicle registration taxes that increase proportionately with vehicle size, increase the costs of owning and operating vehicles and encourage consumers to purchase smaller, more fuel-efficient vehicles. Encouraging the use of fuel-efficient vehicles, in turn, helps reduce air pollution and oil consumption, objectives common to all of the nations we reviewed. However, as discussed in chapter 2, increases in living standards and disposable income can, over time, offset the reduction in gasoline

[13]These figures include spending on R&D for nuclear fission (including breeder reactors) and nuclear fusion.

consumption brought about by gasoline taxes. Indexing such taxes to inflation could help sustain their effectiveness in deterring consumption.

In the industrial sector, policies whose objective is to encourage energy efficiency and conservation of oil and coal tend to be influenced by concerns about international competitiveness and economic growth. As a result, rather than relying on taxes (as in the transportation sector), such policies tend instead to provide industrial energy consumers with financial and tax incentives to invest in equipment that improves the efficiency of industrial processes. These incentives take the form of subsidized loans and investment tax credits or other kinds of tax breaks. Low-interest loans and preferential tax treatment make it less expensive for industries to invest in energy-efficient equipment. In the case of France and Japan, these policies are coupled with required energy audits for large industrial energy consumers. In addition, the most dramatic improvements in coal and oil conservation have occurred in France, largely as a result of the country's increased use of nuclear power. However, nuclear power brings with it significant environmental and security concerns, that can not be readily dismissed.

In general, energy prices for consumers in both the industrial and transportation sectors tend to be higher in the five countries we reviewed than in the United States. The higher prices paid for energy in these countries enhance the effectiveness of the policies that are adopted to promote energy efficiency and conservation. The Btu tax proposed in the United States would raise energy prices. However, it is not clear whether the price increase would be large enough to measurably enhance the effectiveness of new and existing programs aimed at encouraging energy efficiency and conservation of coal and oil in the industrial and transportation sectors. These programs include voluntary energy audits, industrial energy-efficiency targets, investment in mass transit, and requirements for the use of alternative fuels. On the other hand, energy intensity is likely to remain higher without such a tax. In addition, implementation of the U.S. proposal to institute a broad energy tax appears to place pressure on Japan to adopt some sort of tax, assuming that the U.S. tax is seen by the EC as comparable to its own tax proposal. The EC tax proposal is contingent on the U.S. and Japan adopting similar measures.

Organizations Contacted by GAO for This Review

Canada

Government Organizations	Department of Finance Ministry of Energy, Mines, and Resources Standing Committee on Energy, Mines, and Resources of the Canadian Parliament Ministry of Energy, Province of Ontario Ministry of Environment, Province of Ontario Ministry of Transportation, Province of Ontario Ontario Energy Board
Other Organizations	Association of Major Power Consumers Canadian Automobile Association Canadian Petroleum Association Canadian Trucking Association Consumers Gas Motor Vehicle Manufacturing Association National Association of Fleet Administrators Ontario Hydro

France

Government Organizations	Agency for Environment and Energy Management (ADEME) Ministry of Industry and International Trade, Department of Raw Materials and Energy
Other Organizations	French Union of Petroleum Industries French Association of Vehicle Manufacturers

Germany

Government Organizations	Ministry of Economics Ministry of Environment Ministry of Finance
Other Organizations	Association of German Automobile Industries Energy Studies Institute, Cologne University Federation of German Chambers of Commerce Wuppertal Institute for Climate, Environment, and Energy Policies

Japan

Government Organizations	Environment Agency Ministry of Finance Ministry of Foreign Affairs Ministry of International Trade and Industry
Other Organizations	Committee for Energy Policy Promotion Energy Conservation Center Japan Development Bank Japan Institute of Energy Economics Japan National Oil Corporation Mobil Sekiyu K.K. of Japan Tokyo Electric Power Company Tokyo Gas Company

South Korea

Government Organizations	Ministry of Energy and Resources Ministry of the Environment Petroleum Development Corporation

Other Organizations

Daehan Coal Corporation
Korea Gas Corporation
Korea Electric Power Corporation
Korea Energy Economics Institute

United States

Government Organizations

Department of Energy
Department of State

Other Organizations

Argonne National Laboratories
Brookings Institution
Environment and Energy Studies Institute
International Institute for Energy Conservation
Lawrence Berkeley Laboratory, International Energy Studies Program
National Association of State Energy Officials

International Organizations

International Energy Agency
International Monetary Fund
International Road Federation
Organization for Economic Cooperation and Development

Major Contributors to This Report

Resources, Community, and Economic Development Division, Washington, D.C.	James E. Wells, Jr., Associate Director Charles W. Bausell, Jr., Assistant Director Jonathan N. Kusmik, Assignment Manager Jaime E. Lizarraga, Evaluator-in-Charge Patton L. Stephens, Staff Evaluator Thomas Black, Staff Economist Phyllis Turner, Reports Analyst
Detroit Regional Office	Anthony Krukowski, Regional Management Representative Odell W. Bailey, Site Senior Evaluator Laurie Arora, Staff Evaluator Rick Belanger, Staff Evaluator
Far East Office, Honolulu, Hawaii	Ray Ridgeway, Site Senior Evaluator Joyce Akins, Staff Evaluator

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