ENERGY USE AND EMISSIONS OF CARBON DIOXIDE: FEDERAL SPENDING AND CREDIT PROGRAMS AND TAX POLICIES

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NOTES

Throughout this paper, the words "receipts" and "revenue" are used to refer to income, regardless of whether the income is classified as budget receipts or offsetting collections. Similarly, the term "budget authority" is used to refer to the authority to incur obligations, regardless of whether this authority is technically "budget authority" or takes some other form.

Details in the tables may not add to totals because of rounding.

Budget authority, obligations, receipts, loan levels, and tax revenues reported in this paper are estimates by the Congressional Budget Office based on available data at the time of the analysis and may differ from actual figures for fiscal year 1990.

PREFACE

Rising concentrations of carbon dioxide and certain other gases in the atmosphere may increase average world temperatures, an effect known as global warming. At the request of the Senate Committee on Energy and Natural Resources, this paper examines federal spending and credit programs and tax policies that relate directly or indirectly to the use of fossil fuels and to emissions of carbon dioxide that result from the combustion of fossil fuels. In keeping with the Congressional Budget Office's (CBO's) mandate to provide nonpartisan analysis, no recommendations are made.

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CHAPTER I
SUMMARY AND INTRODUCTION

Concern is growing that rising concentrations in the atmosphere of certain gases (including carbon dioxide, methane, chlorofluorocarbons, and nitrous oxide) may increase average world temperatures, an effect known as global warming. Some investigators estimate that, at current emission rates, about 50 percent of the warming that may eventually occur as a result of man-made emissions is attributable to carbon dioxide. The United States contributes about one-fifth of worldwide emissions of carbon dioxide from man-made sources. Nearly all the U.S. emissions of carbon dioxide come from the combustion of fossil fuels--coal, petroleum, and natural gas. Policy responses to the potential threat of global warming may include limiting emissions of carbon dioxide. Such limits would require changing both the amounts and the sources of energy that are supplied and consumed.

Many current federal programs and policies may affect emissions of carbon dioxide either by encouraging or discouraging the overall use of energy or by altering the mix of energy sources on which the nation relies. While no current program or policy has the reduction of carbon dioxide emissions as its primary or even secondary objective, some existing programs might be expanded, contracted, or modified as part of a national policy to reduce emissions.

This study examines federal nonregulatory measures, which include spending and credit programs and tax policies, that directly affect energy use and consequent emissions of carbon dioxide. These programs and policies may either raise or lower the current or future prices of particular energy sources and, thus, either decrease or increase energy consumption and associated emissions. To the extent possible, this study assesses whether each program or policy is likely to decrease or increase emissions of carbon dioxide, compared with a baseline in which the measure did not exist, and whether the effect is likely to be large or small.

Two categories of federal programs and policies that could affect energy use and emissions of carbon dioxide are not considered in this study. The first omitted category contains government programs that are regulatory in nature, such as fuel-efficiency standards for automobiles and activities governing the operations of electric utilities that are nuclear-fueled or fossil-fired. Licensing and permitting fees and fines for noncompliance, which are used to finance or enforce the regulatory process, are also omitted from this study.

The second omitted category contains large federal programs that could affect energy use through their long-term effects on the distributions of income and population, on the characteristics of the housing stock, or on the development of the nation's transportation system. Examples are the interest deduction for home mortgages and federal spending on highways, which are believed to have contributed jointly to the nation's low-density, automobile-dependent pattern of settlement.

Effects on energy use from federal spending on highways and other transportation programs are discussed in the appendix.

What impacts do federal spending and credit programs and tax policies have on energy use and resulting emissions of carbon dioxide? Some nonregulatory measures, such as taxes on gasoline, are likely to decrease emissions; others, such as research and development (R&D) on coal, are likely to increase emissions. Most individual programs and policies, however, do not have an appreciable impact because they do not involve sufficient resources or were not explicitly designed to affect emissions of carbon dioxide. An earlier study by the Congressional Budget Office found that taxes far larger than those currently levied on fossil fuels would be required to reduce substantially the rate of growth in U.S. emissions of carbon dioxide over the long term.[1] In the aggregate, it is unclear whether these existing spending and credit programs and tax policies decrease or increase emissions of carbon dioxide. Because of offsetting effects on emissions, however, the overall impact is probably small.

EFFECTS OF FEDERAL PROGRAMS AND POLICIES ON EMISSIONS OF CARBON DIOXIDE

The federal spending and credit programs included in this study primarily support industries that extract fuels or generate energy. Tax policies that directly affect energy prices or the prices of energy-using products, such as cars, are also discussed. Programs and policies that decrease consumption of energy generated from fossil fuels may decrease emissions of carbon dioxide. Conversely, programs and policies that increase use of fossil fuels may increase emissions. Included in the former category are measures that increase consumption of energy generated from nonfossil sources, which include nuclear and solar or other renewable energy. Since nonfossil sources have low or no emissions of carbon dioxide, substitution of nonfossil for fossil sources of energy would decrease emissions overall.

Within these categories, a number of federal nonregulatory measures may affect the pattern of energy consumption in the United States. Approximately $2.3 billion is currently appropriated to R&D on technologies that supply energy from both fossil and nonfossil sources. Producers of both fossil and renewable sources of energy receive special treatment under the income tax code or are subject to different excise tax rates. The federal government has spending and credit programs that support various public and private generators of electricity that use fossil, nuclear, and renewable sources of energy. Almost $15 billion is collected annually from taxes on fossil fuels in different forms; over $6 billion is collected from taxes on transportation-related products and services. Finally, grants and services provided

1. See Congressional Budget Office, *Carbon Charges as a Response to Global Warming: The Effects of Taxing Fossil Fuels* (August 1990).

by the federal government may also influence patterns of energy supply or consumption.

Taxes on Energy and Related Products and Services

Taxes may reduce emissions of carbon dioxide by reducing fuel consumption. Taxes included are those on transportation fuels, on other travel-related products (such as motor vehicles) and services, and on coal and crude oil (see Table 1). More than half of these taxes are paid on highway motor fuels. Taxes on these fuels, which contribute to the Highway Trust Fund, may be responsible for reducing emissions of carbon dioxide by as much as 3 percent. Transportation spending financed by the highway and other trust funds may also affect emissions. In comparison with fuel taxes, the effects of transportation-related taxes are smaller primarily because these taxes indirectly reduce energy use by increasing the cost of transportation and, thus, discouraging travel. The remaining taxes on transportation fuels and other taxes on fossil fuels generate much less revenue. The impacts on energy use and consequent emissions of carbon dioxide are also comparably smaller.

Federal Measures That May Expand the Energy Supply

The effects of many federal programs, apart from taxes, cannot easily be quantified. A qualitative assessment suggests that, on balance, federal R&D and other spending programs, credit programs, and preferential tax treatment may slightly encourage the use of fossil fuels. Thus, these programs could counteract the effects of taxes that discourage the consumption of fossil fuels.

Preferential tax treatment for energy industries and energy-related federal spending and credit programs may encourage the use of fossil fuels by stimulating additional energy production and by reducing the prices of both fossil and nonfossil sources of energy. The great bulk (almost 90 percent) of energy consumed in the United States comes from fossil fuels. Increasing the total amount of energy consumed, without changing the relative proportions of different types of energy, increases the consumption of fossil fuels and associated emissions of carbon dioxide. Further, these tax preferences and spending programs may alter not only the total amount but also the mix of energy consumed. Currently, more funding and tax credits are provided for energy from fossil fuels than for energy from other sources. This support may promote the consumption of fossil fuels by making them relatively cheaper and, thus, more attractive to consumers.

Energy Research and Development. Nearly all sources of energy receive federal funding for R&D on new or improved technologies for producing electricity and other forms of energy supply (see Table 2). Over time, funds for almost all of these

TABLE 1. SUMMARY OF EXCISE TAXES AND FEES THAT MAY REDUCE THE USE OF FOSSIL FUELS (Fiscal year 1990, in billions of dollars)

Fuel or Product	Revenue	Percentage of Total
Gasoline, Diesel, and Other Highway Motor Fuels	12.7	61
Aviation, Shipping, and Motorboat Fuels	0.4[a]	2
Transportation-Related Products and Services[b]	6.2	29
Coal and Crude Oil	1.7	8
Total	20.9	100

SOURCE: Congressional Budget Office.

a. Includes revenue deposited into the Leaking Underground Storage Tank Trust Fund.

b. Includes tires, trucks, trailers, cargo, tickets, and so forth.

TABLE 2. FEDERAL RESEARCH AND DEVELOPMENT FOR ENERGY SUPPLY AND CONSERVATION (Fiscal year 1990, in millions of dollars)

	Budget Authority	Percentage of Total
Fossil Fuels	971	39
General Energy Supply[a]	629	25
Nuclear	589[b]	23
Conservation	192[c]	8
Solar and Renewable[d]	138	5
Total	2,520	100

SOURCES: Congressional Budget Office; and Department of Energy, *Posture Statement and Fiscal Year 1991 Budget Overview* (January 1990).

a. Includes training, equipment, technical analysis, and multiprogram facilities.

b. Includes an estimated $6 million of nuclear, nondefense research in the Advances for Cooperative Work Trust Fund.

c. Gross budget authority excluding grants to state and local governments.

d. Includes solar, wind, biomass, and geothermal energy and electric energy transmission and storage systems.

energy R&D programs have declined dramatically in real terms.[2] Between 1980 and 1989, R&D on solar and other renewable energy declined by 85 percent, and energy conservation R&D fell by 54 percent. Nuclear fission R&D, including some activities unrelated to energy supply, declined by 73 percent; fossil energy R&D, excluding clean coal research, fell by 65 percent. Although funding for magnetic fusion R&D rose in 1981 and 1982, current funding is about the same as it was in 1980 (in real terms).

Funding of R&D on fossil fuels, which accounts for about 39 percent of total federally funded R&D on energy supply and conservation, is directed primarily to coal and, to a lesser extent, petroleum. Fossil fuel R&D seeks to create new uses and markets, to develop techniques for fuel extraction, to improve combustion technologies, and to reduce emissions of conventional pollutants associated with fossil fuel combustion. Successful R&D in these areas may expand use of fossil fuels and so increase emissions of carbon dioxide. Gains in the efficiency of combustion, however, may mitigate any increases.

R&D activities focusing on fossil fuels are not likely, at least in the short term, to increase greatly emissions of carbon dioxide. While R&D on coal concentrates on developing new uses and technologies, R&D on petroleum and natural gas focus on extraction techniques. Over the longer term, use of coal could expand as new markets are developed or as the environmental impacts of coal are reduced. Since oil prices are determined in world markets, enhanced production from domestic wells may lead to the substitution of domestic for imported oil but not to increased consumption.

R&D on nonfossil sources of energy--nuclear and solar or other renewable energy, which account for about 28 percent of total energy-related research--may lead to new, environmentally acceptable technologies. These improvements may reduce the cost and increase the consumption of energy from nonfossil sources. If nonfossil fuels displaced fossil fuels, emissions of carbon dioxide would decline.

While it is difficult to predict if and when technologies that result from R&D will enable nonfossil sources to capture a large portion of the energy market, the impact on emissions of carbon dioxide is likely to be small for several reasons. First, nonfossil energy currently accounts for only about 11 percent of total energy consumed in the United States (see Figure 1). Annual growth rates in energy consumption over the next two decades are projected to be 2.4 percent for renewable sources, 0.6 percent for nuclear, and between 0.7 percent and 2.0 percent for fossil fuels.[3] Even if R&D were to increase considerably the rate of growth for nonfossil

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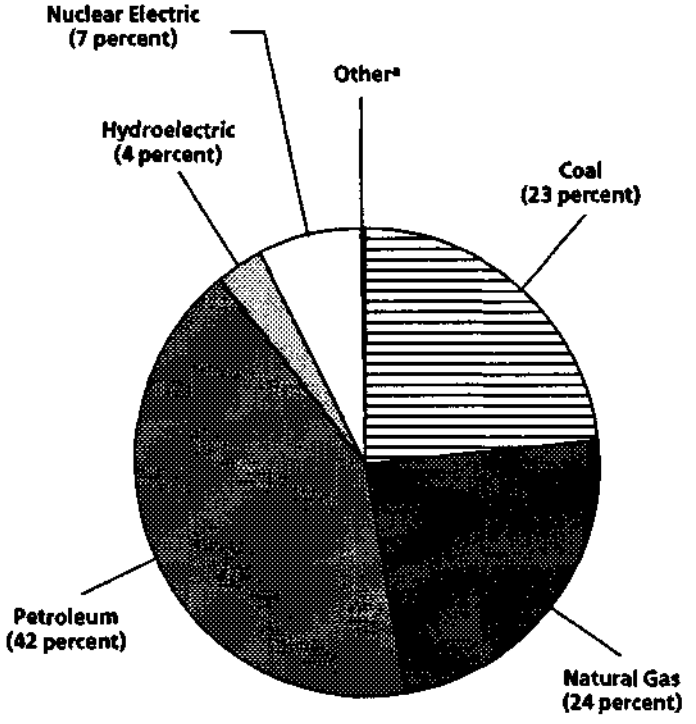
2. Ronald J. Sutherland, "An Analysis of the U.S. Department of Energy's Civilian R&D Budget," *The Energy Journal*, vol. 10 (January 1989), pp. 35-54; *Budget of the United States Government, Fiscal Year 1990*; and *Budget of the United States Government, Fiscal Year 1991.*

3. Department of Energy, Energy Information Administration, *Annual Energy Outlook 1990* (January 1990), Table A2.

Figure 1.
U.S. Consumption of Energy, 1989 (By source)



SOURCE: Congressional Budget Office using data from Department of Energy, Energy Information Administration, *Annual Energy Review 1989* (May 1990).

NOTE: Measured in British thermal units.

a. Approximately 0.3 percent of energy consumed includes electricity produced by geothermal, wood, wind, and solar sources and net imports of coal coke.

energy, displacement of fossil fuel energy and, hence, a reduction in U.S. emissions of carbon dioxide would not be large over the next decade.

Second, even if R&D results in lower costs of production, nonfossil sources of energy may still have difficulty competing with fossil fuel sources. Several factors account for this difficulty: large current price differences between fossil and nonfossil energy, R&D that may open new markets or expand existing markets for coal, and R&D or other activities that may expand supplies of natural gas. Finally, not all of the increase in the use of nonfossil energy would come at the expense of fossil fuels. Reductions in the relative price of nonfossil sources of energy increase their use. Only part of the effect of price reductions, however, is decreased consumption of other forms of energy; total energy consumption may also rise.

Preferential Tax Treatment. Tax preferences provide incentives that may increase the domestic supply of energy. Preferences include income tax credits or deferrals and special deductions, exclusions, or exemptions from taxable income. Preferential treatment also includes differing excise tax rates. As displayed in Table 3, extractive industries benefit from several forms of preferential income tax treatment. Solar and renewable industries benefit from investment and production incentives in the form of income tax credits and an exemption from the excise tax on motor fuels. Tax preferences are also available to certain electrical and other energy suppliers, which generate energy primarily from fossil fuels.

The net impact of tax credits and other tax preferences that benefit both extractive industries and producers of renewable sources of energy may be an increase in emissions of carbon dioxide over the long term. Overall, these tax preferences may reduce energy prices and increase the production and consumption of domestic energy, both fossil and renewable, and so increase emissions of carbon dioxide. Further, tax preferences may also shift the fuel mix toward fossil fuels.

Taken individually, however, these tax preferences are not likely to increase the quantity of energy consumed to any large extent. In particular, the impact of tax preferences for the extractive industries on fossil fuel use is likely to be small in the short term because of the structure of energy markets. This effect is particularly true for petroleum, whose prices are determined in world markets. For natural gas and, to a lesser degree, for coal, tax preferences may encourage consumption in the longer term since prices are determined domestically. Coal, however, is already considerably cheaper to use than alternative fuels. For these and other reasons, coal use is not very responsive to changes in price. In addition, tax preferences for the coal industry do not significantly contribute to reduced coal prices; together, on average, they equal about 1 percent of the price of mined coal.

Tax advantages may also slightly encourage the production of solar and renewable forms of energy. Over the long term, consumption of solar and renewable energy may rise in response to lower prices resulting from increased production. Since many available tax credits have expired, the prices of solar and renewable sources of energy are not likely to fall dramatically relative to those of fossil fuels.

TABLE 3. TAX PREFERENCES FOR FOSSIL AND NONFOSSIL SOURCES OF ENERGY (Fiscal year 1990, in millions of dollars)

Tax Preference	Revenue Loss
Fossil	
Percentage Depletion for Fuel Minerals	520[a]
Expensing of Exploration and Development Costs for Fuel Minerals	230[a]
Special Rules for Mining Reclamation Reserves	35
Expensing of Tertiary Injectants[b]	20
Alternative Fuel Production Tax Credit	10
Nonfossil	
Alcohol Fuel Exemption from Excise Tax on Motor Fuels	400
Conservation and New Technology Tax Credits[c]	45[d]
Alcohol Fuel Tax Credit	35
Electric[e]	
Tax-Exempt Bonds for Energy Facilities[f]	150[g]

SOURCE: Congressional Budget Office estimates using data from Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 1990-1994*, 101:1 (February 28, 1989).

NOTE: Because of interactions between tax code provisions, adding separately reported tax expenditures can be misleading.

a. May not represent the current subsidy to the industry because of the decline in exploration and development activities over the past decade.

b. Chemical processes to enhance oil recovery.

c. Several of the supply credits have expired.

d. Reflects the current budget impacts of both current and expired credits.

e. May include generation of electricity from fossil or nonfossil sources.

f. Part of the exclusion has expired.

g. Reflects the current budget impacts of both current and expired exclusions.

In addition, alcohol fuels, which benefit from two of the tax credits, contribute little to current energy consumption and are unlikely to affect substantially the use of fossil fuels in the short term.

Spending and Credit Programs. Finally, a number of spending programs (other than R&D) and credit programs subsidize public and private suppliers of electricity and energy for heating and cooling from both fossil and nonfossil sources. These programs tend to expand the supply of energy; examples, which include the production and marketing of federal hydroelectric power, are presented in Table 4. Unless the mix of fuel sources used to generate energy shifts substantially away from fossil fuels, emissions of carbon dioxide may increase. Grants to state and local governments for energy conservation may decrease emissions of carbon dioxide and are the exception.

The Omnibus Budget Reconciliation Act of 1990

The discussion of impacts on emissions of carbon dioxide focuses on federal programs and policies in effect during fiscal year 1990. The Omnibus Budget Reconciliation Act of 1990 (OBRA 1990) increases several existing taxes on fossil fuels and transportation-related products and services and imposes some new taxes as well. OBRA 1990 also modifies or extends several existing tax preferences and adds some new credits. Relevant provisions of OBRA 1990 are noted in the text and appear in Box 1. Because of these new taxes and tax credits, the impacts in fiscal year 1991 and future years will differ from those presented here. In particular, several of the taxes on transportation fuels will rise by 25 percent to 60 percent, and effects on emissions of carbon dioxide will be comparably larger.

INTERPRETING THE IMPACTS ON FOSSIL FUEL USE

The net effect of current federal programs and policies on the consumption of fossil fuels is likely to be small and, except for taxes, no individual measure has a substantial influence on emissions of carbon dioxide. The findings of this study concerning the impacts of individual programs on energy use, and concerning the potentially offsetting effects of other nonregulatory and regulatory programs, are supported by other studies.

An earlier study of the long-term impact of federal energy policies on energy prices and consumption found that the energy policies existing in 1980 encouraged use of some forms of energy and reduced use of others.[4] Some federal revenue and spending programs contributed to the predicted change in the mix of energy consumed. For example, gasoline taxes reduced oil consumption in the

4. Paul F. Dickens III and others, "Net Effects of Government Intervention in Energy Markets," *The Energy Journal*, vol. 4 (April 1983), pp. 135-149.

TABLE 4. SELECTED FEDERAL PROGRAMS THAT MAY AFFECT CONSUMPTION OF ENERGY (Fiscal year 1990, in millions of dollars)

Program	Budget Authority
Tennessee Valley Authority	5,942[a]
Power Marketing Administrations	3,357[b]
Rural Electrification Administration	913[c]
Nuclear Waste Disposal Fund	295[d]
Energy Conservation Grants	217[e]

SOURCES: Congressional Budget Office; *Budget of the United States Government, Fiscal Year 1991;* Department of Energy, *Posture Statement and Fiscal Year 1991 Budget Overview* (January 1990); and *Energy and Water Development Appropriations for 1991,* Hearings before the Subcommittee on Energy and Water Development of the House Committee on Appropriations, 101:2 (1990), pt. 4.

a. Gross obligations, not net of power receipts.

b. Not net of power receipts; combines budget authority for most PMAs with gross obligations for the Bonneville Power Administration and the Western Area Power Administration.

c. Gross loan obligations.

d. Not net of receipts.

e. Gross budget authority.

BOX 1
SELECTED PROVISIONS OF THE OMNIBUS BUDGET RECONCILIATION ACT OF 1990 THAT AFFECT ENERGY USE

Changes in Excise Taxes

Imposes an additional 5-cents-per-gallon tax on motor fuels;

Modifies exemption for ethanol-blend fuels;

Doubles gas guzzler tax;

Imposes 10 percent luxury tax on certain cars, boats, yachts, and aircraft;

Extends the tax on fuel for deposit into the Leaking Underground Storage Tank Trust Fund;

Increases and extends taxes on aviation fuel and travel; and

Increases tax on commercial cargo for deposit into the Harbor Maintenance Trust Fund.

Changes in Income Taxes

Extends new technology tax credits for solar and geothermal energy;

Changes tax credits for ethanol production;

Adopts 15 percent tax credit for enhanced oil recovery costs; and

Modifies several tax preferences for certain industries that extract fuel minerals.

transportation sector. The tax-exempt status of government-owned public utilities, such as the Tennessee Valley Authority, tended to reduce electricity prices. Conservation programs, many of which have since been massively scaled back, contributed to a decline in electricity consumption, despite lower prices. Regulatory programs also played a large role in altering the mix of energy consumed. The study found that price controls on natural gas and requirements that new electricity generating plants use coal-fired boilers increased the use of coal and natural gas. Moreover, R&D grants, subsidies for new technologies, and preferential tax treatment for extractive industries did not play a significant role in prices of natural gas or oil over a 10-year period.

The effects of other events on energy prices and energy consumption may mitigate or mask the impacts of federal policies, both regulatory and nonregulatory. Rising energy prices are powerful inducements for consumers and businesses to become more energy efficient. Studies of U.S. energy use between 1973 and 1980 attributed about 70 percent of energy savings to higher prices. The remaining energy savings were attributed, in part, to government conservation programs.[5] More strikingly, another study found that higher gasoline prices--not the federal standards governing the fuel economy of automobiles, which took effect in 1978--were the dominant influence on gasoline purchases before 1984.[6]

Knowledge about the relationships among current federal spending and credit programs and tax policies and their effects on energy use may influence future decisions to expand or contract such measures. Congressional proposals related to global warming and emissions of carbon dioxide have contained both regulatory and nonregulatory measures to promote energy efficiency, conservation, or the production of energy from nonfossil sources. These proposals should be evaluated in terms of competing national goals, which may include energy independence and the reduction of pollutants, such as those contributing to acid rain. The effectiveness of these proposed programs and policies should also be compared with measures explicitly designed to reduce emissions of carbon dioxide or other greenhouse gases.

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5. John H. Gibbons and others, "Energy Conservation in the Federal Government," in John C. Sawhill and Richard Cotton, eds., *Energy Conservation: Successes and Failures* (Washington, D.C.: Brookings Institution, 1986).

6. See John W. Mayo and John E. Mathis, "The Effectiveness of Mandatory Fuel Efficiency Standards in Reducing the Demand for Gasoline," *Applied Economics*, vol. 20, no. 2 (February 1988), pp. 211-219; and Robert W. Crandall and others, *Regulating the Automobile* (Washington, D.C.: Brookings Institution, 1986), p. 117.

CHAPTER II
NONREGULATORY PROGRAMS AND POLICIES AFFECTING ENERGY USE

The federal government has a variety of spending and credit programs and tax policies that may affect energy use. Some of these nonregulatory measures provide price incentives, such as taxes or fees; others provide grants or products and services. Federal measures that reduce consumption of fossil fuels (coal, petroleum, and natural gas) or that specifically reduce consumption of fuels high in carbon can directly reduce emissions of carbon dioxide. Measures that encourage the use of nonfossil fuels (nuclear, solar and other renewable energy sources) indirectly reduce emissions.

The impact of federal nonregulatory programs and policies on energy use and the resulting emissions of carbon dioxide depends on how much these measures influence the decisions of consumers and producers. Decisions that determine the types of energy used in each sector depend, in large part, on the relative prices and availability of the different types of energy and of energy-using and energy-conserving products and technologies. Programs and policies that significantly alter these relative prices will be the most effective in changing patterns of energy use and consequent emissions of carbon dioxide. Moreover, nonregulatory measures that focus on consumption decisions may more quickly change decisions that determine energy use, whereas measures that focus on investment decisions or the development of new technology may more effectively change energy use over a longer term.

ENERGY USE AND THE GREENHOUSE EFFECT

Atmospheric levels of carbon dioxide and other gases--including methane, chlorofluorocarbons, and nitrous oxide--are increasing primarily as a result of human activity. These gases and particles trap a portion of the sun's heat (infrared radiation) near the earth, a process referred to as the "greenhouse effect." Some investigators argue that this effect, in conjunction with rising levels of greenhouse gases, may increase the earth's average surface temperature; higher average temperatures may significantly alter global climate patterns, including potentially adverse variations in temperature, precipitation, and soil moisture. Although substantial uncertainty surrounds both the amount and the consequences of global warming, the increase in average global temperature predicted for sometime in the second half of the next century ranges from around 2° to 9° Fahrenheit above current temperatures.[1]

1. For discussions of the processes, predictions, and uncertainties underlying the greenhouse effect and its consequences, see Environmental Protection Agency, Office of Policy, Planning, and Evaluation, *Policy Options for Stabilizing Global Climate*, vol. I, draft report to the Congress (February 1989); Climate Institute, *Coping with Climate Change, Proceedings of the Second North*

Carbon dioxide is the dominant greenhouse gas. Based on emission rates in the past decade, carbon dioxide accounts for an estimated 57 percent of the increase in greenhouse gases that creates the potential for global warming. Of the remaining worldwide emissions of greenhouse gases, chlorofluorocarbons contribute about 24 percent and, together, methane and nitrous oxide account for approximately 19 percent of the potential change in climate.[2]

Most of the carbon dioxide from man-made sources is emitted during the burning of fossil fuels. Coal and oil, together, contribute approximately 84 percent of worldwide emissions of carbon dioxide from fossil fuels; the remainder is attributable to natural gas (see Table 5). Worldwide deforestation from the cutting and burning of trees--most of which is occurring in the tropical forests of South America, Asia, and Africa--is responsible for an estimated one-tenth to one-third of man-made emissions of carbon dioxide.[3]

Not only the amount but also the type of fossil fuel burned affects the emissions of carbon dioxide. Since the carbon content of fossil fuels varies, the carbon dioxide emitted during combustion, per unit of useful energy obtained, also varies. Natural gas has the lowest emissions of carbon dioxide per British thermal unit (Btu); oil emits about 40 percent more carbon dioxide than natural gas; and coal emits 72 percent to 95 percent more. Synthetic oil or gas produced from coal emits two to three times as much carbon dioxide as natural gas because of the additional energy required for conversion.[4] As Table 5 illustrates, the relative contribution of each fuel to emissions of carbon dioxide in the United States differs from its prevalence in energy consumption. Coal accounts for about one-third of U.S. emissions and natural gas for about one-fifth, although each accounts for about one-fourth of energy consumption from fossil fuels.

American Conference on Preparing for Climate Change: A Cooperative Approach (Washington, D.C.: Climate Institute, 1989); and Intergovernmental Panel on Climate Change, "Policy Makers Summary of the Scientific Assessment of Climate Change," Report from Working Group I (Bracknell, United Kingdom: June 1990).

2. Ozone, water vapor, and other trace gases may also contribute to the greenhouse effect. See J. Hansen and others, "Regional Greenhouse Climate Effects," in Climate Institute, *Coping with Climate Change*, pp. 68-81.

3. Department of Energy, Office of Energy Research, *Atmospheric Carbon Dioxide and the Global Carbon Cycle* (December 1985), pp. xvii-xix and p.6; and Environmental Protection Agency, *Policy Options*, pp. II-14 to II-16.

4. James J. MacKenzie, *Breathing Easier: Taking Action on Climate Change, Air Pollution, and Energy Insecurity* (Washington, D.C.: World Resources Institute, 1988); George M. Woodwell, "Atmospheric CO_2 and Policy in Development of Resources of Energy," statement before the Senate Committee on Governmental Affairs, in *Carbon Dioxide Accumulation in the Atmosphere, Synthetic Fuels and Energy Policy: A Symposium*, Committee Print No. 79-14378, 96:1 (July 30, 1979), pp. 111-118; and Gregg Marland, "Carbon Dioxide Emission Rates for Conventional and Synthetic Fuels," *Energy*, vol. 8, no. 12 (1983), pp. 981-992.

TABLE 5. CONSUMPTION OF FOSSIL FUEL ENERGY AND RESULTING CARBON DIOXIDE EMISSIONS WORLDWIDE, 1988 (In percent)

Fossil Fuel	Energy Consumption[a]		CO_2 Emissions[b]	
	World	United States	World	United States
Coal	32	26	39	33
Oil	45	48	45	49
Natural Gas	23	26	16	19
Total	100	100	100	100

SOURCES: Congressional Budget Office calculations using data from Department of Energy, Energy Information Administration, *International Energy Annual 1988* (November 1989), Table HL2. Carbon dioxide coefficients adapted by CBO from Gregg Marland, "Carbon Dioxide Emission Rates for Conventional and Synthetic Fuels," *Energy*, vol. 8, no. 12 (1983), pp. 981-992.

a. Measured in British thermal units (Btus).

b. Calculated by applying coefficients to estimates of fossil fuel use. The coefficients, expressed as billions of tons of CO_2 per quadrillion Btus, are: coal (.101), oil (.082), and natural gas (.058).

The United States is responsible for about one-fifth of the potential change in climate resulting from worldwide emissions of greenhouse gases from man-made sources and about one-fourth of worldwide emissions of carbon dioxide from fossil fuel combustion.[5] Emissions of carbon dioxide from each sector in the economy reflect both the type and quantity of the fossil fuel used. As Figure 2 illustrates, electric utilities and transportation activities each contribute about one-third of U.S. emissions of carbon dioxide.[6] Residential and commercial buildings, together with industry, account for the remaining emissions. The contribution of electric utilities to U.S. emissions of carbon dioxide (33 percent) is slightly higher than their portion of U.S. energy consumption (28 percent) because almost 80 percent of their fossil energy consumption is in the form of coal. Residential and commercial buildings rely primarily on natural gas, which results in a slightly lower contribution to emissions of carbon dioxide (12 percent) than expected for the percentage of energy from fossil fuels consumed in the United States (14 percent).

Federal nonregulatory programs and policies, therefore, can indirectly affect global warming to the extent that these measures affect the consumption of fossil fuels, which in turn affects emissions of carbon dioxide. Programs and policies that affect sectors in the economy that use large amounts of energy are more likely to have an impact on emissions. In addition, those measures that affect consumption of fossil fuels containing relatively more carbon have a greater impact on emissions of carbon dioxide. The next section discusses the categories of federal programs and policies that are considered in this study.

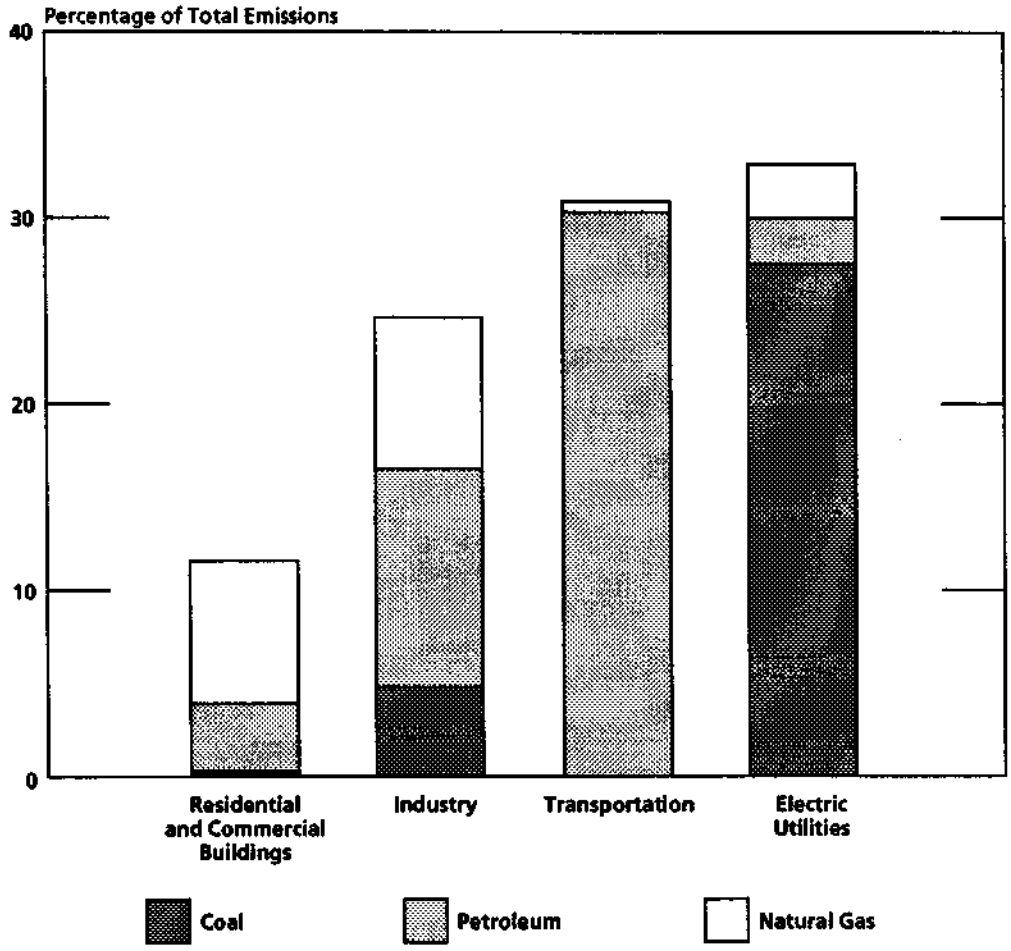
CATEGORIES OF FEDERAL NONREGULATORY PROGRAMS AND POLICIES

Federal nonregulatory programs and policies that affect energy use fall into three categories: spending programs, credit programs, and tax policies. Within each of these categories, federal measures either directly or indirectly influence the amounts of fossil fuel burned and carbon dioxide released into the atmosphere. This study discusses the nonregulatory measures that provide support to industries that extract or produce energy (from both fossil and nonfossil sources), those that influence the prices of different types of energy through taxes or tax exemptions, and those that encourage energy conservation. This study also includes some programs and policies

5. Environmental Protection Agency, *Policy Options*, vol. I, Figure 4-1.

6. These estimates may overstate the contribution of petroleum and, hence, the transportation sector to emissions of carbon dioxide since some petroleum is consumed in the form of chemical feedstocks--using energy-carrying materials not as fuels but as raw materials in production, such as plastics produced from petroleum. The contribution of petroleum is 46 percent, and transportation accounts for 29 percent of U.S. emissions of carbon dioxide from fossil fuel combustion, using conversion factors reported in Mark A. Deluchi and others, "Transportation Fuels and the Greenhouse Effect," Research Report UER-180, Division of Environmental Studies, University of California, Davis (December 1987).

Figure 2.
U.S. Emissions of Carbon Dioxide, 1989
(By sector and energy source)



SOURCE: Congressional Budget Office using data from Department of Energy, Energy Information Administration, *Monthly Energy Review, April 1990* (July 1990).

that may indirectly affect emissions of carbon dioxide by changing the decisions that determine purchases of transportation-related products and services.

Spending Programs

Federal spending programs that affect energy consumption include research and development (R&D), grants to state and local governments and to the private sector, and products and services provided or subsidized by the federal government.

Research and Development. The federal government funds a number of R&D programs, which support private research, government research conducted in-house, and the national research laboratories. Each of these components of government R&D may contribute to innovation that results in new or improved technologies for generating or using energy.

R&D grants covered in this study focus on fossil fuel energy, nonfossil forms of energy, and energy conservation. The effects of these grants on emissions of carbon dioxide depend on whether or not government funding successfully stimulates additional R&D, on whether that R&D eventually results in commercial adoption of new technologies, and on how these technologies affect fossil fuel use.[7] In the past, energy technologies have required 15 to 30 years of development before commercially producing energy and another 15 years of operation before significantly contributing to energy supplies.[8] In addition, while government funding of R&D in new technologies may be crucial during the initial stages, tax credits or other incentives that allow industry flexibility may be more effective in commercializing new technologies.[9]

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7. The extent to which research and development (R&D) is successful depends on a number of factors, including the type of research that is funded, the involvement of the private-sector in designing projects, the extent to which the results of government-sponsored research are disseminated in the private sector, and the extent to which additional private sector research is encouraged. See Congressional Budget Office, *Using Federal R&D to Promote Commercial Innovation* (April 1988). Successful energy R&D also depends on the relative prices of competing energy technologies and on the uncertainty associated with the level of federal funding, which affects long-term planning by industry. See Christopher Flavin, "Creating a Sustainable Energy Future," in Lester R. Brown and others, *State of the World 1988* (New York: W.W. Norton and Company, 1988). For discussion of the factors affecting the success of R&D on energy conservation, see John H. Gibbons and others, "Energy Conservation in the Federal Government," in John C. Sawhill and Richard Cotton, eds., *Energy Conservation: Successes and Failures* (Washington, D.C.: Brookings Institution, 1986).

8. See Thomas A. Starrs, "Legislative Incentives and Energy Technologies: Government's Role in the Development of the California Wind Energy Industry," *Ecology Law Quarterly*, vol. 15 (1988), p. 108.

9. Starrs, "Legislative Incentives," p. 123.

Grants. In addition to federal grants for R&D, which are considered separately in this study, federal programs provide grants for other purposes to state and local governments and to industry. Most of these grants are for the transportation sector, although some grants may affect energy consumption more directly. The effects of these grant programs on fossil fuel consumption and consequent emissions of carbon dioxide depend on how the grants influence decisions in the public and private sectors.

Federal grants designed to encourage specific public services for state and local governments also increase their funds available to finance other public investment. In addition, state and local governments may use federal grants to lower the fees charged or the taxes levied on the private sector while still providing the same level of public services. Grants that are ultimately passed on to consumers also increase their effective income and encourage the purchase of goods and services. Similarly, grants to industry may encourage investment in equipment or may offset other investment or operating costs.

Energy-Related Products and Services. The federal government operates a number of programs that promote the availability of various types of energy or subsidize their use or generation. Most programs considered here target fossil, nuclear, or hydroelectric energy. The remainder affect energy conservation or the supply of electricity. The impact of these programs on energy use depends on what type of energy is affected and on the prices and available quantities of the product or service provided.

Credit Programs

Federal programs that guarantee loans and make loans directly to private industry, such as electric power cooperatives, provide these borrowers with access to credit or with lower interest rates than they could otherwise obtain on the private market. These programs may encourage investment in capital and equipment or defray operating expenses. Credit programs covered in this study target the supply of electricity. How much these programs are likely to change patterns of energy use depends on the level of borrowing under the program, the way the program operates, and the uses for the loan funds.

Tax Policies

Tax policy can influence energy use in two ways. First, federal taxes on fossil fuels and transportation-related taxes may discourage fossil fuel consumption and, thus, decrease consequent emissions of carbon dioxide. Second, preferential treatment under the income tax code and exemptions from excise taxes may encourage the development of new fuel supplies or energy-producing technologies, both fossil and nonfossil.

Taxes. Federal taxes considered in this study are levied on fossil fuels, including coal, motor fuels, and other petroleum products, and on travel-related products and services. These taxes may increase the relative prices of energy or transportation and thereby reduce energy consumption. The extent of this effect depends on the size of the tax and on how the tax affects prices to consumers. How much of the tax consumers bear depends, in part, on how suppliers respond to any resulting decline in purchases by consumers. If suppliers respond to declining demand by absorbing part of the tax, then the tax has a smaller effect in reducing consumption than if consumers were to bear the full amount of the tax.

Effects of taxes on purchases also depend on how responsive consumers are to price changes. Whether or not consumers reduce purchases of taxed products depends, for example, on how essential the product is. Lack of good substitutes for the taxed product may limit how much consumers reduce purchases, at least in the short term.

Tax Expenditures and Excise Tax Exemptions. Tax preferences that affect energy use either provide special treatment to certain activities under the income tax laws or exempt certain products from excise taxes. In both cases, the federal government collects less revenue than it would otherwise. Revenue losses arising from provisions in the federal income tax code that give selective relief to groups of taxpayers or special incentives for particular types of economic activity are known as "tax expenditures." Tax expenditures may arise from exclusions, exceptions, or deductions from taxable income. The term also applies to credits, which are subtracted from tax liabilities as ordinarily computed, and to deferrals of tax liabilities.

These tax preferences may affect production and consumption decisions by changing relative prices. Most of the tax preferences related to the use of energy benefit firms engaged in extracting fossil fuels, producing energy from renewable sources, or generating electricity. These preferences effectively lower the cost of capital to firms by altering the rate at which capital and equipment may be depreciated or by providing income tax credits for investment or production. In doing so, these tax preferences may stimulate investment or defray operating expenses in the affected industry, which may ultimately result in lower prices. Exemptions from excise taxes, while not defined as tax expenditures, may influence taxpayers' decisions in similar ways.

The design of tax credits is crucial to their success. Although investment tax credits may stimulate investment, they often indiscriminately reward capital investment in energy-producing equipment. Credits designed to stimulate production of energy or investment in energy-efficient equipment may be more effective in increasing energy supply than broad-based tax credits.[10] Similarly, scant evidence exists to show that the now-expired residential energy tax credit for installation of weatherstripping, insulation, and related home improvements significantly motivated

10. Starrs, "Legislative Incentives," pp.140-141.

consumers to make energy-conserving investments. Only 10 percent to 20 percent of homeowners who claimed the credit in 1983 reported that they undertook conservation measures because of the tax credit.[11]

MEASURING THE IMPACTS ON ENERGY USE

How do spending and credit programs and tax policies affect decisions about energy consumption when measured against a baseline in which these policies do not exist? Budgetary resources, which include budget authority, loans, tax collections, and tax expenditures, are a limited measure of the impact of a program or policy on decisions that affect energy use in the public and private sectors. The budget for a program or the revenue gain or loss from a tax or tax expenditure does not always measure the economic incentives created. Problems in inferring impacts also occur because the effects of federal spending or taxes depend not only on current budget or revenue levels of a program or policy but also on other factors such as the history of the program or policy, interactions among federal programs and policies, and other economic or political events.

Budgetary Resources

Budgetary resources can provide some clues to the probable impact of a program on energy use. For example, a large appropriation for R&D is more likely to affect future innovation than a small appropriation; awarding additional or larger direct loans is more likely to stimulate investment than awarding fewer or smaller loans. Similarly, a tax levied at a high rate or on a broad base generates more revenue and is more likely to have an impact on private decisions.

Since the impacts of programs on energy use and emissions of carbon dioxide depend primarily on how relative energy prices changes, budgetary resources poorly indicate the impacts of different types of programs. For example, the budget authority for federal R&D grants cannot easily be compared with the budget authority for enterprise-type programs that involve the government directly in energy production. Similarly, budget authority does not indicate the extent to which an enterprise provides a subsidy to purchases. Although the net cost of running the program better indicates the potential impacts on energy prices, the usefulness of this measure depends, in part, on how efficiently government programs are run in comparison with those in the private sector. Low unit costs of goods and services provided by the government cannot be presumed; if a program serves multiple purposes, being comparable with the private sector is not always desirable.

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11. Department of Energy, Energy Information Administration, *An Economic Evaluation of Energy Conservation and Renewable Energy Tax Credits* (October 1985). See also Karen Griffin, "State Government Conservation Programs," in Sawhill and Cotton, eds., *Energy Conservation*.

Budgetary resources are also a limited measure of the impacts on energy use among similar types of programs. The impact on energy use of loan programs affecting energy production, for example, depends not only on the size of the loans but also on the availability of alternative credit and on the interest rate subsidy provided by the federal government. It further depends on the profitability of alternative capital investments that the loan may allow.

Similarly, the impact of taxes on energy use depends both on the number of consumers or producers that are affected and on how individual decisions determining energy use are altered. The revenue collected from a specific tax depends on the sizes of the tax rate and the tax base (what is being taxed). A tax with large revenue may have an overall impact on energy use, even if individual decisions are not substantially affected. The impact may not be as large, however, as for a tax with smaller revenue but with more direct effects on energy use.

Cumulative, Competing, and Complementary Effects

For some nonregulatory programs and policies with a long history of government intervention, such as federal grants to state and local governments for highway projects, the impacts on energy use depend on the cumulative effects of past programs and policies. Expectations in the private sector and in state and local governments are affected by federal programs. If current federal spending on highways were eliminated, the pattern of spending by state and local governments would change in response to the reduced federal aid. Similarly, if federal gasoline taxes were eliminated, states could rely more heavily on state gasoline taxes as sources of revenue.

In addition, for programs with a long history of federal funding, such as energy R&D or construction and maintenance of hydroelectric power projects, the impacts of current spending on energy use depend on the capital base or the information base that has built up. For example, small changes in R&D spending may eventually result in incremental improvements in technology. At the same time, the future benefits of the current program depend not only on current spending but also on advances in knowledge that occur as a result of past programs.

Further, interactions between both regulatory and nonregulatory programs and policies have impacts on energy use. When the benefits of R&D for energy supply will be realized depends not only on the rate at which knowledge and technology advance but also on the trends in relative energy prices for both existing and developing sources of energy. In turn, these price differences may depend, in part, on other energy policies.

Competing and complementary effects between government programs and other events also make the impacts of current nonregulatory measures difficult to isolate. Federal financial support to industry in the form of tax preferences or R&D funding has arguably been instrumental in the development of the nuclear power

industry as well as in expanding some forms of solar and renewable energy production.[12] Federal nonregulatory programs and policies, however, may not have played a strong role in other areas of energy production. For example, the increased U.S. dependence on coal over other fossil fuels may be attributed, in large part, to price differences that persist between fossil and alternative fuels for reasons unrelated to federal nonregulatory measures. Similarly, increased energy efficiency and conservation during the early part of the past decade is frequently explained by the rising oil prices of the late 1970s and early 1980s rather than by federal regulatory and nonregulatory actions.

12. Starrs, "Legislative Incentives," p. 112.

CHAPTER III
FEDERAL PROGRAMS AND POLICIES THAT MAY DECREASE EMISSIONS OF CARBON DIOXIDE

The federal nonregulatory programs and policies that may decrease emissions of carbon dioxide from fossil fuel combustion fall into four categories: taxes on fossil fuels, transportation-related taxes, spending programs and tax preferences for nonfossil sources of energy, and energy conservation programs. Taxes that raise the prices of fossil fuels discourage their use and decrease the emissions of carbon dioxide resulting from combustion. Taxes that raise the prices of certain products, notably transportation vehicles, may also decrease fuel use by discouraging travel. Spending programs and tax preferences that assist the development of nonfossil sources of energy (including hydroelectric and nuclear) may also shift energy use away from fossil fuels. Finally, since most energy is produced using fossil fuels, programs that encourage energy conservation are included as well.

The overall effects of these federal programs and policies on emissions of carbon dioxide are likely to be measurable but small. The taxes on motor fuels (gasoline and diesel), in particular, may decrease emissions of carbon dioxide in the United States by up to 3 percent over the short and long terms. Other fuel taxes and transportation-related taxes are likely to have a smaller impact than taxes on motor fuels because of both the relative size of the tax revenue and its indirect effect on energy use. Because many conservation and renewable energy programs and tax preferences were substantially scaled down during the past decade and remain relatively small, their impacts in reducing the consumption of fossil fuels are also not likely to be large. Finally, the effects of spending programs to encourage nuclear power are only likely to occur in the long term.

ENERGY FROM FOSSIL FUELS

A number of taxes currently levied on fossil fuels and travel-related products or services may decrease fossil fuel use and carbon dioxide emissions by a small amount. The Omnibus Budget Reconciliation Act of 1990 (OBRA 1990) increases several of these taxes. It also imposes some new taxes that could affect energy use, notably, a 2.5-cents-per-gallon tax on fuels used in rail transportation (effective December 1, 1990) and a luxury tax equal to 10 percent of the retail price (above specified limits) of certain automobiles, boats, yachts, and aircraft (effective January 1, 1991).

Taxes on Fuels and Transportation-Related Taxes

The revenue collected from most fuels and transportation-related taxes is deposited in trust funds (see Table 6). These taxes, as well as miscellaneous excise taxes and fees, are described in the following sections.

TABLE 6. EXCISE TAXES AND FEES THAT MAY REDUCE THE USE OF FOSSIL FUELS (Fiscal year 1990, in billions of dollars)

Tax or Fee	Revenue
Highway Trust Fund	
Fuel taxes	12.7
Other taxes	2.1
Airport and Airway Trust Fund	
Fuel taxes	0.1
Other taxes	3.7
Hazardous Substance Superfund (Petroleum taxes)	0.6
Leaking Underground Storage Tank Trust Fund (Fuel taxes)	0.2
Inland Waterway Trust Fund (Fuel tax)	0.1
Oil Spill Liability Trust Fund (Petroleum tax)	0.2
Aquatic Resources Trust Fund (Fuel tax)	0.1
Harbor Maintenance Trust Fund (Cargo tax)	0.2
Black Lung Disability Trust Fund (Coal tax)	0.7
Abandoned Mine Reclamation Fund (Coal fee)	0.3
Gas Guzzler Tax[a]	0.1
Ship Passenger International Departure Tax[a]	b

SOURCE: Congressional Budget Office.

a. Miscellaneous excise taxes deposited into the general fund.

b. Less than $50 million.

Highway Trust Fund. Excise taxes on transportation fuels and other taxes related to highway travel are the primary sources of financing for this fund. Taxes on motor fuels are 9 cents per gallon of gasoline and 15 cents per gallon of diesel fuel in fiscal year 1990. OBRA 1990 raises these taxes by 5 cents per gallon (effective December 1, 1990). Half of that additional revenue is designated for the Highway Trust Fund; the other half is retained in the general fund.

Several other excise taxes finance this trust fund, including a tax of 12 percent on the selling price of heavy trucks, a tax on tires for heavy trucks, and a tax on the use of heavy vehicles. Through the Federal Highway Administration, the National Highway Traffic Safety Administration, and the Urban Mass Transportation Administration, this trust fund provides grants to states and localities for construction and improvement of interstate highways, for urban and rural transportation programs, and for related research programs.

Airport and Airway Trust Fund (AATF). The taxes that finance this fund are a ticket tax, a tax on freight, excise taxes on fuels, and an international departure tax. OBRA 1990 raises most of these taxes (effective December 1, 1990). Federal fuel taxes for general aviation use--excluding commercial, scheduled flights--are 12 cents per gallon (15 cents per gallon in OBRA 1990) on gasoline and 14 cents per gallon (17.5 cents per gallon in OBRA 1990) on jet fuel. Air passengers pay an 8 percent (10 percent in OBRA 1990) tax on domestic airline tickets, and international travelers pay a departure tax of $6 per person. Shipping costs for air freight are subject to a tax of 5 percent (6.25 percent in OBRA 1990). Additional revenue generated from the excise taxes on aviation fuels increased by OBRA 1990 is deposited in the general fund through 1992 and thereafter in the AATF. Expenditures from this trust fund support airport and airway expansion and improvements, as well as a portion of operating expenses for the Federal Aviation Administration.

Hazardous Substance Superfund. Financing for the Superfund comes, in large part, from taxes on crude oil, a tax on chemical feedstocks, a tax on imported chemical derivatives, and a corporate environmental tax. The taxes that may affect energy use are the crude oil taxes, which equal 9.7 cents per barrel for domestic crude oil and imported petroleum products. Before December 12, 1989, the rate was 8.2 cents per barrel on domestic crude oil and 11.7 cents per barrel on imported petroleum products. The Superfund provides funds for the implementation of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The act authorizes the federal government to respond to spills and other releases (or threatened releases) of hazardous substances, as well as leaking hazardous waste dumps.

Leaking Underground Storage Tank (LUST) Trust Fund. Revenue from a 0.1-cent-per-gallon tax on petroleum fuels for transportation, including gasoline and other motor fuels and fuels used for transport on inland waterways, is deposited in this trust fund. These taxes were scheduled to expire after December 31, 1991, or earlier if net revenue reached $500 million. The taxes expired on August 30, 1990, when the

latter condition was met. OBRA 1990 reimposes the tax at the same rate (effective December 1, 1990). The LUST trust fund was established to finance the cleanup of leaking underground petroleum tanks and other cleanup activities not covered by CERCLA.

Inland Waterway Trust Fund. Taxes on diesel and other fuels used by vessels engaged in commercial transportation on the inland waterway system finance this fund. The tax rate is 11 cents per gallon through 1990 and rises gradually to 20 cents per gallon in 1995 and thereafter. Expenditures from this fund finance construction and rehabilitation projects undertaken by the Army Corps of Engineers for navigation on inland and coastal waterways.

Oil Spill Liability Trust Fund. A crude oil tax of 5 cents per barrel (effective January 1, 1990) finances this fund. The purpose of the fund is to offset costs of cleanup, restoration of natural resources, and compensation of losses from oil spills that threaten U.S. resources or occur on or near U.S. navigable waters.

Aquatic Resources Trust Fund. This fund is financed by several sources, including a tax on motorboat fuels, which equals 9 cents per gallon in fiscal year 1990. OBRA 1990 raises the rate by 5 cents (effective December 1, 1990). Half of the additional revenue is designated for the Aquatic Resources Trust Fund; the remaining half is retained in the general fund. Expenditures from this trust fund finance programs that promote boat safety and projects that restore and manage sport and recreational fish in U.S. waters.

Harbor Maintenance Trust Fund. Revenue deposited in this fund primarily comes from two sources: an excise tax, currently equal to 0.04 percent of commercial value, imposed on commercial cargo loaded and unloaded at specified U.S. ports open to public navigation; and charges and tolls imposed by the Saint Lawrence Seaway Development Corporation. OBRA 1990 raises the excise tax to 0.125 percent (effective January 1, 1991). Over 90 percent of the receipts comes from the harbor maintenance excise tax. The bulk of the fund finances portions of the cost of activities conducted by the Army Corps of Engineers to maintain channel depths in harbors for more than 180 ports nationwide. The remainder of the fund finances the Saint Lawrence Seaway Development Corporation and the toll rebate program.

Black Lung Disability Trust Fund. This fund is financed by an excise tax on the tonnage of mined coal. The tax rate is $1.10 per ton for coal mined underground and 55 cents per ton for coal mined on the surface (but no more than 4.4 percent of the selling price of coal). The fund pays compensation and other benefits to miners and their survivors and finances the black lung program.

Abandoned Mine Reclamation Fund. A reclamation fee assessed on every ton of mined coal finances this fund. The fee is assessed at the rate of 35 cents per ton of surface-mined coal and 15 cents per ton of underground-mined coal or, alternatively, at 10 percent of the value of the coal at the mine, whichever is less. Also levied is a fee of 10 cents per ton of lignite coal or, alternatively, 2 percent of the value of the

coal at the mine, whichever is less. The fund was established to remedy public health, safety, and environmental problems resulting from past surface and underground coal-mining practices.

Gas Guzzler Tax. Revenue from an excise tax on domestic and imported cars that do not achieve specified fuel-economy ratings is deposited in the general fund. Vehicles with ratings less than 22.5 miles per gallon are currently subject to a tax ranging from $500 to $3,850, depending on the rating. OBRA 1990 doubles the gas guzzler tax (effective January 1, 1991).

Ship Passenger International Departure Tax. Passengers on a covered voyage, which is defined by duration of voyage and other qualifications, pay an excise tax of $3 each. Revenue from this tax is deposited in the general fund.

Impacts of Taxes on Energy Use

Taxes on transportation fuels and travel-related products and services may reduce emissions of carbon dioxide directly by reducing fuel use or indirectly by reducing travel. Most of the taxes deposited in the trust funds are justified, at least in part, as user fees. Since these trust funds finance federal transportation programs, tax collections deposited in these funds may also affect carbon dioxide emissions by altering federal spending patterns. This portion of the paper focuses on how taxes may alter energy use by changing prices. Transportation spending programs that could affect emissions of carbon dioxide are discussed in the appendix.

The taxes on crude oil, the gas guzzler tax, and the two taxes on coal may also reduce the use of fossil fuels and, consequently, emissions of carbon dioxide. At the levels of taxation now in effect, however, such reductions are likely to be minor.

Taxes on Transportation Fuels. Taxes on fuels used for highway, air, and water transportation may increase fuel prices in the short term, resulting in reductions in discretionary travel and fuel use. Businesses and individuals may also switch to transportation modes that become cheaper because of changes in relative fuel prices. Switching between modes may increase or decrease emissions of carbon dioxide, depending on the relative fuel efficiency and the emissions associated with alternative modes. Over the longer term, higher fuel prices may reduce fuel use, not only because transportation habits change but also because the demand increases for more fuel-efficient motor vehicles, planes, and boats. Any decline in fuel use because of increased fuel efficiency may be partially offset by increases in total travel as a result of lower travel costs.

Most of the revenue from taxes on transportation fuels is from taxes on highway fuels. By raising the price to consumers, taxes on gasoline and diesel fuel may reduce fuel consumption and the resulting emissions of carbon dioxide in both

the short and long terms.[1] Excluding air travel, single-occupancy vehicles are the least fuel-efficient mode of personal transportation; trucking is the least fuel-efficient freight mode (see Table A-2). Thus, switching between modes--that is, away from single-occupancy vehicles and trucking--may also reduce emissions.

The excise taxes on gasoline and diesel fuel that finance the Highway Trust Fund generate almost $13 billion annually in revenue (at the rates effective during fiscal year 1990), or about 97 percent of the revenue from the transportation fuel taxes (listed in Table 6) and about 86 percent of the revenue from taxes on transportation fuel, petroleum, and coal, combined. The transportation sector accounts for about 31 percent of U.S. emissions of carbon dioxide, most of which come from petroleum use. Motor gasoline and diesel fuels, not all of which are taxable, account for about four-fifths of all petroleum products used for transportation (see Figure 3). Thus, all taxable gasoline and diesel motor fuels currently account for, at most, one-fourth of U.S. emissions of carbon dioxide.

In 1989, the federal excise taxes on motor fuels as a percentage of price (excluding the federal tax) averaged around 9 percent or 10 percent for motor gasoline and 18 percent or 19 percent for diesel fuel. Since fuel purchases are somewhat unresponsive to changes in fuel prices, the percentage decline in gasoline and diesel purchases over the short term, and possibly over the long term, will be smaller than the percentage changes in price.[2] Thus, the decline in U.S. emissions of carbon dioxide because of these fuel taxes may, over time, be as high as 3 percent or as low as less than 1 percent. The remaining taxes on transportation fuels generate much less revenue; thus, impacts on energy use and emissions of carbon dioxide would also be comparably smaller. In addition, highway gasoline tends to be more responsive to price changes than other fuels, including other highway fuels and aviation gasoline.[3]

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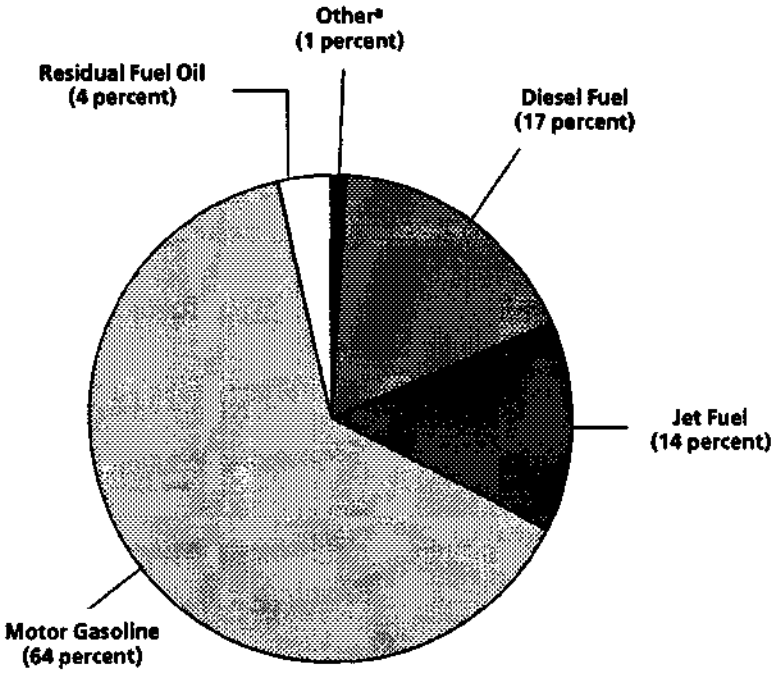
1. In addition to the partial exemptions for gasohol and diesohol, several groups of users are wholly exempt from the excise taxes on gasoline and diesel fuel that finance the Highway Trust Fund. These exemptions are for state and local governments, certain buses, and off-highway uses. Exemptions may slightly increase fuel consumption and emissions of carbon dioxide (relative to taxing all fuels).

2. The elasticity of demand estimates the percentage change in consumption that results from a 1 percent increase in price. In the long term, consumption is more responsive (elastic) to price changes than in the short term. Elasticity of demand estimates for gasoline cluster at roughly -0.7 to -1.0 in the long term (approximately 10 years) and -0.2 to -0.3 in the short term. See Carol A. Dahl, "Gasoline Demand Survey," *Energy Journal*, vol. 7 (January 1986), pp. 67-82; and Douglas R. Bohi and Mary Beth Zimmerman, "An Update on Econometric Studies of Energy Demand Behavior," *Annual Review of Energy*, vol. 9 (1984), pp. 105-154. The Energy Information Administration has estimated elasticity of gasoline demand at -0.32 for the long term and -0.18 for the short term. See Department of Energy, "Estimates of PC-AEO Model Energy Demand Elasticities," draft (January 6, 1989).

3. Dahl, "Gasoline Demand Survey."

Figure 3.
U.S. Consumption of Petroleum Products by the Transportation Sector, 1989



SOURCE: Congressional Budget Office using data from Department of Energy, Energy Information Administration, *Annual Energy Review 1989* (May 1990).

NOTE: Measured in British thermal units.

a. Includes asphalt and road oil, kerosene, aviation gasoline, and lubricants.

Taxes on Travel-Related Products and Services. These taxes may also slightly decrease emissions of carbon dioxide. The aggregate effect of these travel-related taxes is likely to be much smaller than that of the fuel taxes, in part because the revenue generated is smaller but also because these taxes indirectly discourage energy use by discouraging travel. As with fuel consumption, travel decisions are not very responsive in the long term to the costs of transportation services.[4]

The revenue collected from three nonfuel taxes is deposited in the Highway Trust Fund: a sales tax on trucks and trailers; an excise tax on tires, inner tubes, and tread rubber; and a tax on use of heavy highway vehicles. These taxes are levied on heavy vehicles and may raise shipping costs and discourage the transport of products by truck. The impact of these taxes on energy use, however, depends also on the switching that occurs between alternative modes of freight.

The gas guzzler tax raises the price to consumers of purchasing less fuel-efficient vehicles, which may discourage consumption and production of less fuel-efficient automobiles. The short-term impact may be to discourage consumers from purchasing new automobiles that have low fuel efficiency; over the longer term, some producers may modify or phase out models that are subject to the tax. The impact of this tax, however, is not likely to be large. About 100,000 new vehicles are subject to the tax annually (out of approximately 10 million sold) and pay, on average, under $1,000 per vehicle in 1990. Since the cars subject to the tax tend to be luxury and sport models, the tax is, in general, small relative to the selling price.

The revenue collected from several taxes, other than fuel taxes, is deposited into the AATF. If the effect of these aviation taxes is an increase in the price of commercial and private air travel, relative to alternative forms of transportation and recreation, then their immediate impact may be a reduction in discretionary travel and a switch to alternative forms of transportation for both business and recreational purposes. Since air travel is the least fuel-efficient form of transportation for both people and freight, all these effects tend to reduce fuel consumption and, thus, may reduce emissions of carbon dioxide.

The reduction in emissions of carbon dioxide as a result of transportation-related taxes is slight. Of these taxes, the ticket tax on air travel generates the most revenue, and is therefore more likely to affect the amount of travel and fuel use. In addition, air travel is more responsive to price changes than other forms of travel. However, since consumption of commercial jet fuel is responsible for approximately 4 percent of U.S. emissions of carbon dioxide, the 8 percent ticket tax (in effect for

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4. The elasticity of vehicle-miles driven relative to changes in the cost of travel (based on the price of gasoline and the fuel efficiency of the vehicle) is around -0.3 in the long term. See Ali M. Reza and Michael H. Spiro, "The Demand for Passenger Car Transport Services and for Gasoline," *Journal of Transport Economics and Policy*, vol. 13 (September 1979), pp. 304-319. A study of the impact of fuel efficiency on gasoline consumption supports these results. See Roger D. Blair and others, "The Impact of Improved Mileage on Gasoline Consumption," *Economic Inquiry*, vol. 23 (April 1984), pp. 209-217.

fiscal year 1990) is likely to result in less than a 0.6 percent reduction in U.S. emissions of carbon dioxide.[5]

Taxes on Coal and Crude Oil. The taxes on coal or petroleum products probably have only a slight effect on U.S. emissions of carbon dioxide. As discussed in the next chapter, purchases of coal are unresponsive to changes in price; petroleum purchases are more responsive, but the taxes on crude oil probably have little effect on domestic prices or on consumption.[6] Despite the substantial amount of revenue raised between 1981 and 1984 by the petroleum taxes that contributed to the Superfund, these taxes were small relative to the costs of production and appeared to have had little or no effect on industry behavior.[7]

ENERGY FROM RENEWABLE SOURCES

A number of federal programs encourage the supply of solar and other renewable energy (see Table 7). Renewable sources of energy include geothermal, ocean, hydroelectric, and solar. Solar sources of energy include wind, biomass, solar thermal, and photovoltaic technologies.

Program and Policy Descriptions

This study examines federal research grants and other federal spending programs and tax preferences that may expand the use of solar and renewable sources of energy. These programs may displace fossil fuels and, thus, reduce emissions of carbon dioxide from combustion.

Solar and Renewable Energy Research and Development (R&D). This program supports solar and renewable R&D. About one-third of the funding is devoted to extraction technologies for geothermal energy, electric energy systems, and energy storage systems.[8] About two-thirds of the funding goes to solar thermal and

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5. One set of estimates of the elasticity of domestic air travel relative to changes in fares ranges between -0.65 and -1.9, depending on the travel class and time. See Mahlon R. Straszheim, "Airline Demand Functions in the North Atlantic and Their Pricing Implications," *Journal of Transport Economics and Policy*, vol. 12 (May 1978), pp. 179-195.

6. In 1980, the Congress enacted a windfall profit tax on crude oil. Although the tax was formally repealed in 1988, it essentially yielded no revenue after 1986 because market prices of oil were below base prices.

7. Robert W. Hahn, *A Primer on Environmental Policy Design* (New York: Harwood Academic Publishers, 1989); and Robert W. Hahn, "An Evaluation of Options for Reducing Hazardous Waste," *Harvard Environmental Law Review*, vol. 12 (1988), pp. 201-230.

8. Hydropower was not funded in 1990.

TABLE 7. FEDERAL PROGRAMS THAT MAY EXPAND THE SUPPLY OF RENEWABLE ENERGY (Fiscal year 1990, in millions of dollars)

Program	Budget Authority	Receipts	Revenue Loss
Solar and Renewable Energy Research and Development[a]	138	n.a.	n.a.
Conservation and New Technology Tax Credits[b]	n.a.	n.a.	45[c]
Alcohol Fuel Exemption from Excise Tax	n.a.	n.a.	400
Alcohol Fuel Tax Credit	n.a.	n.a.	35
Power Marketing Administrations	3,357[d]	3,728	n.a.
Power Projects of the Bureau of Reclamation	107[e]	n.a.	n.a.
Power Projects of the U.S. Army Corps of Engineers	338[f]	n.a.	n.a.

SOURCES: Congressional Budget Office; Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 1990-1994*, 101:1 (February 28, 1989); *Budget of the United States Government, Fiscal Year 1991*; Department of Energy, *Posture Statement and Fiscal Year 1991 Budget Overview* (January 1990); *Energy and Water Development Appropriations for 1991*, Hearings before the Subcommittee on Energy and Water Development of the House Committee on Appropriations, 101:2 (1990), pt. 4; Telephone communication with Mollie Buckee, Bureau of Reclamation, July 25, 1990; and Telephone communication with Annette Muscarella, Army Corps of Engineers, November 7, 1990.

NOTE: n.a. = not applicable.

a. Includes solar, wind, biomass, and geothermal energy and electric energy transmission and storage systems.

b. Several of the supply credits have expired.

c. Reflects supply incentives only. This estimate reflects the current budget impacts of both current and expired credits.

d. Combines budget authority for most PMAs with gross obligations for the Bonneville Power Administration (BPA) and the Western Area Power Administration. Amount shown is not net of receipts and includes some nonpower-related activities, such as the BPA's fish and wildlife enhancement program.

e. Net of collections from federal and nonfederal sources and reported for construction and operation and maintenance of only power projects.

f. Reported for construction and operation and maintenance of only multiple-purpose power projects.

photovoltaic energy systems, wind and ocean energy systems, biofuel energy from biomass, and other forms of renewable energy.

Conservation and New Technology Tax Credits. Homeowners and businesses have had a variety of tax credits available to encourage energy conservation and conversion to solar and renewable energy sources. Many of these credits have expired, including business tax credits for investments in wind systems and biofuel facilities as well as residential tax credits for conservation (see Box 2). The three surviving credits, which were scheduled to expire after September 30, 1990, are 10 percent credits for investment in solar and in geothermal energy facilities and a 15 percent credit for investment in ocean thermal facilities. OBRA 1990 extends the credits for solar and geothermal energy through December 31, 1991. The estimate of revenue loss, as presented in Table 7, is based on law prior to OBRA 1990. This loss reflects both surviving investment credits and the continuing budget effects of expired credits.

Alcohol Fuel Exemption from Excise Tax on Motor Fuels. Motor fuels containing at least 10 percent alcohol (not including alcohol made from coal, petroleum, or natural gas) are partially exempt from federal excise taxes on gasoline and diesel fuels.[9] Exemptions of 5 2/3 cents per gallon and 6 cents per gallon apply to alcohol-gasoline and alcohol-diesel fuel blends, respectively. OBRA 1990 reduces these rates to 5.4 cents per gallon (effective December 1, 1990). Other exemptions apply to "neat" alcohol fuels (at least 85 percent methanol, ethanol, or other alcohol) derived from nonfossil sources or from petroleum or natural gas.

Alcohol Fuel Income Tax Credit. As an alternative to the excise tax exemption for gasohol and diesohol, an income tax credit is available to producers of fuel-blending alcohol. The producers, however, cannot claim both the credit and the exemption on the same fuel. The credit was originally established at 40 cents per gallon and raised to 60 cents per gallon. OBRA 1990 reduces this credit to 45 cents or 54 cents per gallon, depending on the proof of the alcohol (effective January 1, 1991) and establishes a new credit of 10 cents per gallon for eligible small ethanol producers. The credit is intended to encourage substitution of alcohol (not including alcohol made from fossil fuels) for petroleum-based gasoline and diesel fuels. No credit is currently in effect for neat alcohol fuels.[10]

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9. The exemption for alcohol fuel is included here because it is a relevant instance of excise tax differentiation. Gasoline and alcohol-blend fuels are taxed differently and, relative to a baseline of equivalent taxation, the alcohol exemption may encourage production and consumption of alcohol fuel.

10. As an attempt to curb imports of alcohol fuels and protect domestic production, the Omnibus Budget Reconciliation Act of 1980 established a tariff on ethanol imported from some countries. The tariff was raised to 60 cents per gallon by 1984 legislation and reduced to 45 cents or 54 cents per gallon by the Omnibus Budget Reconciliation Act of 1990. Little or no duty is currently collected. Telephone communication with Maureen Lorenzetti, Information Resources, Inc., 1989.

BOX 2
EXPIRED RENEWABLE ENERGY PROGRAMS

The development of renewable energy sources was encouraged by several programs that have essentially expired. As a result of these programs, past investment in energy-producing and energy-conserving equipment may continue to affect emissions of carbon dioxide. These programs may also have continuing budget effects.

The Geothermal Resources Development Fund. This fund was intended to subsidize loans for geothermal energy projects by supporting the Geothermal Loan Guarantee Program. From 1979 to 1986, eight loan guarantees were issued. Of those, three have been repaid, and five have defaulted.[1] Applications for loan guarantees are no longer being accepted.

Solar and Conservation Small Business Loans. The Small Business Administration is authorized to guarantee loans for small manufacturers of solar equipment and other renewable energy and energy conservation businesses. The program is still in operation, although at an extremely low level of activity.

Biomass Energy Development. During the first half of the 1980s, both the Department of Energy (DOE) and the Department of Agriculture (USDA) provided assistance to companies engaged in commercial production of alcohol and other fuels from crops, timber, biomass, and waste from agricultural, animal, rural, and urban sources. Three loan guarantees that have since defaulted were issued by DOE, which also entered into three small cooperative ventures to produce ethanol. The USDA issued loan guarantees to production plants for alcohol fuels as part of its business and industry program. Ten plants received guarantees under this program, of which six have defaulted. Authority to assist additional alcohol fuel plants under these programs has expired.

Assistance for Solar and Conservation Improvements. In 1980, the Congress created the Solar Energy and Energy Conservation Bank within the Department of Housing and Urban Development to encourage energy conservation and the use of solar energy. Through the states, this bank provided loan subsidies and grants for the installation of equipment to residences and to agricultural and commercial buildings. The solar bank was abolished by law in 1988.

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1. Migdon R. Segal, Congressional Research Service, *Alcohol Fuels* (June 6, 1990).

Power Marketing Administrations (PMAs). Federal PMAs, which are under the jurisdiction of the Department of Energy (DOE), market electricity generated primarily by federal hydropower projects. Approximately 4.4 percent of U.S. electricity is marketed through the PMAs.[11] Electricity rates are uniform throughout a marketing area and are supposed to cover operating expenses (including interest and depreciation) without returning a profit to the government. Capital investments for federal dams and electric power and irrigation facilities are financed by federally appropriated funds, which must be repaid at interest rates ranging from 0 percent to 16 percent. The outstanding debt of PMAs to the federal government is estimated at $13.9 billion for the end of fiscal year 1990. By law, the PMAs must use income from power sales to cover all operating costs and repay all federal investments for these facilities within a "reasonable period." In some cases, the principal payments on the federal debt obligations are being deferred until the end of the asset lives of the investments.

Power Projects of the Bureau of Reclamation. The Bureau of Reclamation within the Department of the Interior administers both a construction program and an operation and maintenance (O&M) program for hydroelectric power provided by federal facilities. The construction program develops and manages water for irrigation, municipal and industrial use, salinity control, dam safety, applied engineering, and flood control in 17 western states. The O&M program manages about 35 projects affecting power supply, municipal and industrial water supplies, irrigation, flood control, and other public benefits.

Power Projects of the U.S. Army Corps of Engineers. The Army Corps of Engineers, through its construction program, finances projects for development of water resources with navigation, flood control, water supply, hydroelectric power, and other public benefits. The O&M program finances navigation, flood control, and multiple-purpose projects for which the Corps is responsible.

Program and Policy Impacts on Energy Use

Programs supporting renewable energy could stimulate investment and R&D, thereby reducing the long-term costs of producing energy from renewable sources. Lower costs of adopting these technologies may result in lower prices and increased use of renewable energy. If electric utilities and the residential and industrial sectors shift away from energy based on fossil fuels, emissions of carbon dioxide will fall.

Several nonconventional sources of heat and electricity, such as wind power and various solar technologies, are already cost competitive with other energy technologies in certain circumstances. Additional support in these areas could

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11. Department of Energy, Energy Information Administration, *Electric Power Annual 1988* (December 1989), Table 8; and *Financial Statistics of Selected Electric Utilities 1988* (February 1990), Table 67.

potentially decrease reliance on fossil fuels in the short term.[12] Other renewable energy sources, such as geothermal, may not yet be technologically or economically viable, although they may be more successful in the longer term.

The combined effects of programs that encourage the use of renewable energy technologies is likely to be slight, in part because of the relatively small amounts of total spending and the few exemptions that are currently active. Appropriations for R&D on solar and renewable energy declined in real terms by more than 85 percent between 1979 and 1989 and are currently equal to only about 5 percent of the spending on energy R&D considered in this study. The relatively small size of both the R&D program and the tax credits for renewable energy, compared with support for fossil and nuclear energy, contribute to the difficulties that renewable energy technologies have in competing with other fuels. Hence, the impact of renewable energy programs on decisions about energy consumption and consequent emissions of carbon dioxide is likely to be slight.

Two programs aim at stimulating domestic production of alcohol fuels from nonfossil sources. The impact of these programs on emissions of carbon dioxide is also likely to be slight. Fuels blended with ethanol (produced from corn or biomass), such as those fuel blends sold in the United States, contribute less to emissions of carbon dioxide than do fossil motor fuels, because organic matter removes some carbon from the atmosphere as it grows. The 10 percent alcohol-blend fuel sold in the United States uses primarily ethanol derived from corn; about 8 percent of the gasoline sold in the United States is an alcohol blend. Production and use of gasohol is estimated to reduce emissions of carbon dioxide by 4.2 percent, compared with gasoline (per unit of energy), taking into account the carbon dioxide absorbed from the atmosphere by the next annual crop.[13] The Department of Agriculture has concluded that the current alcohol subsidy is essential to the continuation of commercial ethanol production at current crude oil prices.[14] The small amount of alcohol-blend fuel (including imported ethanol) consumed in the United States suggests that, even if all alcohol fuels were replaced with gasoline, the effect on emissions of carbon dioxide would be slight--less than 0.2 percent.

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12. Robert L. Pirog and Stephen C. Stamos, Jr., *Energy Economics: Theory and Policy* (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1987), pp. 276-312; James M. Griffin and Henry B. Steele, *Energy Economics and Policy* (Orlando: Academic Press, Inc., 1986), pp. 348-366; and Thomas A. Starrs, "Legislative Incentives and Energy Technologies: Government's Role in the Development of the California Wind Energy Industry," *Ecology Law Quarterly*, vol. 15 (1988), p. 110.

13. Migdon R. Segal, Congressional Research Service, *Ethanol Fuel and Global Warming* (March 6, 1989).

14. Department of Agriculture, *Ethanol: Economic and Policy Tradeoffs* (January 1988). Without the federal subsidy, crude oil prices must be at least $40 per barrel for ethanol (from corn) to be cost competitive.

The supply of hydroelectric power is promoted through the PMAs, which market power and build facilities for the transmission of electricity, and through the Army Corps of Engineers and the Bureau of Reclamation, both of which develop water projects and build dams for hydroelectric power, flood control, and other purposes. These programs may enhance the quantity or the efficiency of hydroelectric power. The effects of deferred principal repayments permitted to the PMAs may reduce wholesale prices, which may encourage the use of federally supplied hydroelectric power over the alternative of privately supplied power.

The net impact of the hydroelectric programs on emissions of carbon dioxide depends on whether federal hydroelectric power reduces reliance on electricity generated from fossil fuels. If, as a result of federal spending, hydropower were supplied to areas that would otherwise be dependent on fossil fuels, then emissions of carbon dioxide from combustion would be reduced. If the federal programs merely substitute for privately supplied hydroelectric power, such programs may not affect emissions.

Either way, the effects of hydroelectric power projects on emissions of carbon dioxide are not likely to be large. Hydropower is not generally regarded as able to provide major additional electrical capacity in the near future because of the limited availability of economically and environmentally acceptable sites. In addition, hydroelectric power, which is the only renewable energy source that makes a significant contribution to energy supply, currently accounts for only 4 percent of total U.S. energy consumption.

ENERGY FROM NUCLEAR SOURCES

Federal support for nuclear energy comes through research grants and other spending programs. Increased availability of energy from nuclear sources may displace the use of energy from fossil sources and thus reduce emissions of carbon dioxide.

Nuclear Energy Programs

Five federal programs currently support the development of nuclear energy supply (see Table 8).

Magnetic Fusion Research and Development. The long-term goal of this program is the development of fusion as a viable technology for the production of electric power.

Nuclear Fission Research and Development. The intent of federal support for R&D on nuclear fission is to ensure that nuclear energy continues to grow as a source of electricity in the United States. About one-third of the budget authority reported in Table 8 for nuclear fission R&D finances this program's civilian reactor component, which supports industry efforts to design and develop advanced nuclear reactors. The

TABLE 8. FEDERAL PROGRAMS THAT MAY EXPAND THE SUPPLY OF NUCLEAR ENERGY (Fiscal year 1990, in millions of dollars)

Program	Budget Authority	Receipts
Magnetic Fusion Research and Development	320	n.a.
Nuclear Fission Research and Development[a]	262	n.a.
Advances for Cooperative Work Trust Fund[b]	27[c]	27
Nuclear Waste Disposal Fund	295[c]	538
Uranium Supply and Enrichment	1,412[c]	1,368

SOURCES: Congressional Budget Office; Department of Energy, *Posture Statement and Fiscal Year 1991 Budget Overview* (January 1990); and *Energy and Water Development Appropriations for 1991*, Hearings before the Subcommittee on Energy and Water Development of the House Committee on Appropriations, 101:2 (1990), pt. 4.

NOTE: n.a. = not applicable.

a. Includes the civilian reactor research and development (R&D) program, civilian waste R&D, facilities, and program direction. Excludes R&D for space and defense and for remedial action to treat or stabilize radioactive waste or decontaminate various facilities.

b. In the past, defense projects have accounted for 70 percent to 80 percent of total program spending.

c. Not net of receipts.

program also supports R&D for civilian waste storage and disposal activities, although spending is at a very low level. The remainder of the funds is for directing the entire nuclear R&D program and may include space and defense activities that are largely unrelated to energy supply.

Advances for Cooperative Work Trust Fund. This fund finances R&D on civilian reactor safety and testing, defense applications, magnetic fusion, and other projects. Foreign governments and federal agencies reimburse DOE for the cost of the work. In the past, defense research has accounted for between 70 percent and 80 percent of activities supported by this fund. The bulk of nondefense work has been in the area of civilian reactor safety and testing and magnetic fusion, although a small amount of nondefense research is on fossil energy and basic energy sciences.

Nuclear Waste Disposal Fund. Appropriations from this fund finance the nuclear waste disposal program. The goal of the program is to construct a permanent geologic repository for disposing of spent nuclear fuel and high-level radioactive waste from commercial and defense activities. The fund is paid for by electric utilities that operate nuclear power plants.

Uranium Supply and Enrichment. Uranium ore must be processed and enriched before being used as a fuel for nuclear reactors. This program intends to meet commercial and U.S. government requirements for uranium enrichment by providing these services economically and reliably. Revenue collected in return for these services offsets the cost of the program.

Program Impacts on Energy Use

The R&D and other support programs may expand the development of nuclear energy from fission and magnetic fusion. Current research on nuclear fission may, over time, reduce the costs and improve the safety of generating nuclear power and disposing of and cleaning up nuclear waste. These effects, in turn, may lead to increased investment in nuclear power plants and less use of fossil fuels, hydroelectric power, and other forms of electricity generation. Similarly, research on magnetic fusion may lead to the development of an acceptable and economically viable technology for producing nuclear energy from fusion as an alternative to conventional forms of energy. Since nuclear fission and magnetic fusion contribute less to emissions of carbon dioxide than does electricity generated from fossil fuels, expanded development of these energy alternatives and reduced use of fossil fuels may decrease emissions of carbon dioxide.

At the end of 1989, 110 nuclear generating plants were operating in the United States, which was an all-time high. The total number of units planned, under construction, or operating in that year was 121, well below the analogous total of 236

in 1975. Further, no new plants have been ordered in the United States since 1978.[15] Several economic factors contributed to the decline in the number of nuclear units planned, including slow growth in electricity demand, high construction costs for nuclear plants, and a short operating life relative to other utilities. Recent progress in nuclear R&D is revealing the potential for nuclear reactor systems that are smaller and easier to operate than the present generation. In addition, improvements in the design of containment systems and other modifications have substantially reduced the chance of a severe accident.[16]

While the future of nuclear energy has become less bleak in recent years, the magnitude of the impacts of the nuclear fission and the magnetic fusion programs on U.S. energy use is not likely to be great. Several factors inhibit the expansion of nuclear power in the short term: the long lifetime of existing electric utility plants, the length of time currently required to build a nuclear power plant, and the social and political complications associated with constructing nuclear power plants. Thus, nuclear fission R&D will likely reduce emissions of carbon dioxide only in the long term. The impacts of the magnetic fusion program are even more long term, since the link to emissions of carbon dioxide depends on the success of the program, which is in its initial stage.

The remaining spending programs on nuclear energy provide services to enrich uranium for domestic and foreign nuclear utilities and provide financing to construct facilities for the disposal of nuclear waste. They would probably have only a small impact on emissions of carbon dioxide, particularly because enriched uranium is only a small portion of the cost of a reactor.[17] Moreover, foreign enrichment services are available at similar or lower costs than domestic enrichment services, so the domestic services do not significantly contribute to the economic viability of nuclear technology.[18] The contribution of the program to the stability of the domestic supply of enriched uranium, however, may be a factor in decisions to construct new nuclear utilities. By financing the design and construction of facilities for the disposal of high-level nuclear waste, the Nuclear Waste Disposal Fund may make nuclear energy more acceptable and, thus, decrease slightly emissions of carbon dioxide in the long term by reducing the use of fossil fuels.

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15. Department of Energy, Energy Information Administration, *Annual Energy Review 1989* (May 1990), p. 219.

16. John J. Taylor, "Improved and Safer Nuclear Power," *Science*, vol. 244 (April 21, 1989), pp. 318-325.

17. Pirog and Stamos, *Energy Economics*, p. 180; and Ph. Darmayan, "The Economics of Uranium Supply and Demand," *International Atomic Energy Agency Bulletin*, vol. 23 (June 1981), pp. 3-7.

18. Congressional Budget Office, *U.S. Uranium Enrichment: Options for a Competitive Program* (October 1985).

The sole program that supports the development and use of new energy-efficient measures for transportation, industry, buildings, and other energy uses is in the Department of Energy (see Table 9). The R&D portion of the program focuses on several specific goals: developing more fuel-efficient technologies and fuels for use in transportation, increasing the energy efficiency and thermal integrity of buildings, and reducing energy waste and promoting cogeneration within industry. The grants portion of this conservation program provides funds to state and local governments for assistance in weatherizing homes and offices and for state conservation programs.

Since almost 90 percent of the energy consumed in the United States is produced from fossil fuels, investing in and modifying equipment for energy conservation may reduce emissions of carbon dioxide.[19] The effect of current spending levels, however, is not likely to be large. Past federal support for research on energy conservation has been cited as contributing to the development and commercialization of energy-saving technologies, although this view is not universally held.[20] Spending on conservation R&D is just under half (in real terms) of its level in 1979, and the impacts of current spending may not be as great as in the past. To the extent that improvements in energy efficiency in buildings, industry, and transportation have not been exhausted, current research that results in the development of lower cost and more effective technologies could decrease emissions of carbon dioxide.

Grants to state and local governments for weatherization of homes, schools, and other buildings and for other purposes could also potentially decrease emissions of carbon dioxide. The DOE estimates that weatherization efforts reduce energy use for home heating by 14 percent.[21] Thus, the potential exists for significant saving through energy conservation in residences and other buildings. The effects of current spending on reducing energy consumption, however, is not likely to be great. Since its inception, the weatherization grants program has weatherized 1.9 million homes, approximately 10 percent of eligible homes. About 60,000 institutional buildings have also received assistance for energy-efficient modifications. Given the relatively small number of homes and institutions targeted for weatherization each year, compared with total energy consumption, the impact on emissions of carbon dioxide of annual appropriations to this particular conservation program is likely to be very slight.

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19. Department of Energy, *Annual Energy Review 1989*, Table 3.

20. *Proposed Fiscal Year 1989 Budget Request (DOE's Renewable Energy and Energy Conservation Programs)*, Hearing before the Subcommittee on Energy Research and Development of the Senate Committee on Energy and Natural Resources, 100:2 (May 18, 1988).

21. *Department of the Interior and Related Agencies Appropriations for 1991*, Hearings before the Subcommittee on the Department of the Interior and Related Agencies of the House Committee on Appropriations, 101:2 (1990), pt. 3.

TABLE 9. FEDERAL PROGRAM TO PROMOTE ENERGY CONSERVATION (Fiscal year 1990, in millions of dollars)

Program Component	Budget Authority	Receipts
Grants to State and Local Governments	217	41
Research and Development	192	n.a.
Total	409[a]	41

SOURCES: Congressional Budget Office; and Department of Energy, *Posture Statement and Fiscal Year 1991 Budget Overview* (January 1990).

NOTE: n.a. = not applicable.

a. Not net of offsetting receipts.

CHAPTER IV
FEDERAL PROGRAMS AND POLICIES THAT MAY INCREASE EMISSIONS OF CARBON DIOXIDE

The federal nonregulatory programs and policies that may increase emissions of carbon dioxide split into two categories. First, programs and policies that encourage the development or consumption of fossil fuels may increase emissions, whether these measures are research and development programs that further fossil fuel technologies or tax policies that benefit extractive industries. Second, programs and policies that promote the generation of electricity or production of energy for heating and cooling may increase emissions of carbon dioxide.

These programs and policies have only a small effect on emissions in the short and long terms. Most of the programs and policies that encourage the use of fossil fuels are designed to stimulate conventional uses of fossil fuels. Such measures may encourage more investment in extractive industries or industries using fossil fuels, such as electric utilities. If lower energy prices result, more consumption of energy may lead to increased emissions of carbon dioxide. The resulting increase in emissions is not likely to be significant, in part, because the effects of these measures on energy prices are not likely to be large and because energy consumption is not very responsive to small changes in price.

ENERGY FROM FOSSIL FUELS

Two types of federal programs encourage the use of fossil fuels: certain R&D programs, and preferential tax treatment (see Tables 10 and 11).

Research and Development Programs

R&D programs may expand use of fossil fuels by improving the technologies for extraction and the efficiency of combustion or by developing new uses and opening up new markets for fossil fuels.

Clean Coal Technology. This R&D program was created in 1984 to assist private industry, especially the electric utility sector, in developing commercial technologies that burn coal more cleanly, efficiently, and economically. The emphasis continues to be primarily on reducing emissions of sulfur dioxide and nitrogen oxides from coal combustion. The program requires at least 50 percent cost-sharing with industry and provides for recouping public investments from major commercial successes. The technologies being developed are of two basic types: retrofitting plants to reduce emissions, and repowering plants both to reduce emissions and to improve fuel efficiency. Until recently, funding from the Department of Energy focused primarily on repowering technologies. The program is structured so that a total of $2.7 billion will be spent on demonstration projects between fiscal years 1986 and 1992.

TABLE 10. FEDERAL RESEARCH AND DEVELOPMENT THAT MAY EXPAND THE USE OF FOSSIL FUELS (Fiscal year 1990, in millions of dollars)

Research and Development	Budget Authority
Clean Coal Technology	554
Fossil Energy	417
Coal	275
Petroleum	40
Gas	14
Other[a]	87

SOURCE: Congressional Budget Office using data from Department of Energy, *Posture Statement and Fiscal Year 1991 Budget Overview* (January 1990).

a. Includes program direction, management support, plant, and equipment.

TABLE 11. TAX PREFERENCES THAT MAY EXPAND THE USE OF FOSSIL FUELS (Fiscal year 1990, in millions of dollars)

Tax Preference	Revenue Loss
Percentage Depletion for Fuel Minerals	
Oil and gas	300
Other fuels (Primarily coal)	220
Expensing of Exploration and Development Costs for Fuel Minerals	
Oil and gas	140[a]
Other fuels (Primarily coal)	80[a]
Special Rules for Mining Reclamation Reserves	35
Expensing of Tertiary Injectants[b]	20
Alternative Fuel Production Credit	10

SOURCE: Congressional Budget Office estimates using data from Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 1990-1994*, 101:1 (February 28, 1989).

NOTE: These estimates may differ from those in Table 3 because of rounding and interactions between tax expenditures.

a. Estimates may not represent the current subsidy to the industry because of the decline in exploration and development activities over the past decade.

b. Chemical processes to enhance oil recovery.

Fossil Energy R&D. R&D on fossil energy promotes more efficient methods for the extraction, recovery, and use of coal, oil, and natural gas reserves. Coal R&D emphasizes technologies that may open up new markets for coal, such as methanol or other transportation fuels derived from coal. Funding also supports the development of technologies that use coal more efficiently or that reduce emissions of pollutants. The R&D for oil and natural gas focuses primarily on identifying new resources and on extracting and improving technologies for recovery.

Tax Preferences

Tax preferences may promote investment in industries that extract fossil fuels or convert them to other usable forms of fuel. Under normal income tax rules for cost recovery of investments in plant and equipment, the costs of such capital assets cannot be fully deducted when purchased. Instead, the purchase price must be capitalized over the useful life of the asset either through depreciation or depletion. Oil and gas wells and mineral mines enjoy special rules for cost recovery. A tax credit also exists for the production of alternative fuels, such as synthetic gas. The Omnibus Budget Reconciliation Act of 1990 introduced a 15 percent tax credit for costs attributable to projects for enhanced oil recovery and qualified exploration (effective January 1, 1991). OBRA 1990 also modifies or broadens the application of several tax preferences for extraction technologies, and estimates of revenue losses in future years may change accordingly.

Percentage Depletion for Fuel Minerals. Percentage depletion permits some producers of fuel minerals to deduct a certain percentage of a property's gross income.[1] This deduction contrasts with cost depletion, which is limited to the actual cost of the investment. Under cost depletion, outlays not recovered immediately through expensing are deducted over the useful life of the property.

Expensing of Exploration and Development Costs for Fuel Minerals. Intangible drilling costs, which include certain expenses for discovering oil, gas, and other fuel minerals, may be deducted as current expenses rather than capitalized over the useful life of the property and thereby written off more slowly.

Special Rules for Mining Reclamation Reserves. Costs for reclamation may be accrued and deducted as the coal or ore is mined, rather than after all the coal or ore is removed from the leased property and the actual reclamation costs are incurred.

Expensing of Tertiary Injectants. Certain chemical injectants that are used to enhance the process of recovering oil may be deducted as current year expenses rather than capitalized and recovered through depreciation.

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1. Production from geothermal deposits is also eligible for percentage depletion.

Alternative Fuel Production Tax Credit. A nonrefundable $3 credit (in 1979 dollars) per barrel of oil-equivalent production is provided for several forms of alternative fuel. The full credit is available as long as the price of oil stays below $23.50 per barrel (in 1979 dollars); the credit is phased out as the average price of oil rises to $29.50 per barrel (in 1979 dollars). The credit encourages the production of oil, gas, and synthetic fuels from nonconventional sources, such as shale and tar sands.[2]

Program Impacts

The effects of these programs in expanding consumption of fossil fuels is not likely to be large. More than half of the funding for R&D on energy from fossil fuels relates to coal, which has the highest carbon dioxide emissions per Btu among the fossil fuels. By providing lower cost and environmentally acceptable coal technologies, these programs could increase domestic reliance on coal in the long term, in preference to other fossil fuels or nonfossil energy sources. The potential increase in emissions of carbon dioxide will be less if future projects focus on improving the efficiency of combustion. Repowering technologies tend to increase energy efficiency, while some retrofitting technologies tend to decrease efficiency. The tax preferences for coal extraction may also expand exploration and development of fuel minerals and could lead to increased domestic supply. The current effect of these preferences in reducing coal prices is probably small; together, the revenue losses equal about 1 percent, on average, of the price of mined coal.

In the coal market, imports are relatively low, and prices are largely determined in domestic markets. Thus, incentives that reduce the cost of production could result in both lower prices and increased consumption, relative to nonfossil or other fossil fuels. The impact may be slight, however, since demand for coal is relatively stable and not responsive to changes in price.[3] For existing users (such as electric utilities), coal is already a considerably more cost-effective fuel than any alternatives. In addition, utilities, which account for almost 85 percent of U.S. coal

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2. Alternative fuels were also supported by the Energy Security Act, which established the Synthetic Fuels Corporation (SFC) in 1980. The SFC was authorized to aid private synthetic fuels (synfuel) projects with loans, loan guarantees, and other ways to produce liquid fuels and synthetic gas from oil shale, tar sands, and coal. The SFC has since been abolished, and there is no new budget authority. The largest of the five synfuel projects funded, the Great Plains Gasification project, has been sold to the private sector and continues to produce the equivalent of 24,000 barrels per day of synthetic natural gas. The remaining four projects still receive subsidies under agreements signed before the SFC was abolished. Total outlays of about $100 million to $150 million per year will continue for the next few years.

3. Both short- and long-term elasticities of demand for energy are generally low, around -0.14 and -0.20 for oil, -0.23 and -0.28 for natural gas, -0.28 and -0.34 for purchased electricity, and close to zero for coal. Elasticities may vary across sectors, depending on the prices and quantities available of alternative fuels and technologies using these fuels. Department of Energy, Energy Information Administration, "Estimates of PC-AEO Model Energy Demand Elasticities," draft (January 6, 1989), Table 1.

consumption, offer coal producers long-term contracts (ranging from 10 to 30 years); these contracts account for 80 percent of total coal sales.[4] Research that may open new markets for coal, such as the liquid fuels program, could expand coal use. These programs are a relatively small part of total coal research. Given the many current environmental problems associated with coal, these programs are unlikely to expand coal use significantly in the short term.

The remaining spending on R&D and tax preferences benefit the petroleum and natural gas industries and the production of alternative fuels. As with coal, these programs may encourage extraction and development of new energy supplies. The relatively small loss of revenue associated with the tax credit for alternative fuels suggests that its impact on energy supply is likely to be slight. Little R&D is devoted to fossil fuels other than coal; thus, the impacts on oil and gas consumption are likely to be small. Finally, the tax preferences for extraction may have an impact on oil and gas consumption; however, these policies may not alter energy prices greatly.

Tax preferences for extraction of natural gas, unlike those for coal, may eventually stimulate consumption and increase emissions of carbon dioxide. Consumption of natural gas in the United States currently is rising, in part because of lower prices resulting from weaker regulations on price and distribution but also because of a growing market for electricity generated outside the electric utility industry. Since nearly 7 percent of gas consumed in the United States comes from imports, primarily from Canada, the U.S. prices for natural gas are determined in the North American market. A federal program or policy that lowers production costs should reduce gas prices in both the United States and Canada and result in an increase in North American consumption of natural gas and in the associated emissions of carbon dioxide.

In the petroleum industry, prices for crude oil are determined in the world market, which is dominated by the large producers of the Organization of Petroleum Exporting Countries (OPEC). As a result, R&D or tax preferences that may affect the costs of producing oil in the United States will have no measurable effects on oil prices or the consumption of petroleum products. The main result will be the substitution of domestic oil for imported oil and, consequently, no change in emissions of carbon dioxide.

ENERGY SUPPLIES

Several programs may encourage the use of fossil fuels to supply electricity or energy for heating and cooling. These programs work through federally extended credit, tax preferences, federal funding of R&D for general purposes, or other spending (see Table 12).

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4. Robert L. Pirog and Stephen C. Stamos, Jr., *Energy Economics: Theory and Policy* (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1987), pp. 192-195.

TABLE 12. FEDERAL PROGRAMS THAT MAY EXPAND THE SUPPLY OF ENERGY (Fiscal year 1990, in millions of dollars)

Program	Budget Authority	Receipts	Revenue Loss
Rural Electrification Administration[a]	913[b]	n.a.	n.a.
Tennessee Valley Authority	5,942[c]	5,500	n.a.
Tax-Exempt Bonds for Energy Facilities[d]	n.a.	n.a.	150[e]
Supporting Research and Technical Analysis	607	n.a.	n.a.
Multiprogram Laboratories Facilities Support	22	n.a.	n.a.

SOURCES: Congressional Budget Office; Joint Committee on Taxation, *Federal Tax Expenditures for Fiscal Years 1990-1994*, 101:1 (February 28, 1989); and *Budget of the United States Government, Fiscal Year 1991*.

NOTE: n.a. = not applicable.

a. Excludes the Rural Telephone Bank and related activities.

b. Gross direct loan obligations.

c. Gross obligations for only the power program, not net of power receipts.

d. Part of the exclusion has expired.

e. This estimate reflects the current budget impacts of both current and expired exclusions.

Rural Electrification Administration (REA). The REA, an agency within the Department of Agriculture, administers the Rural Electrification and Telephone Revolving Fund, which, among other functions, provides direct loans to rural electric cooperatives. The fund is financed by appropriations and also by loans from the Federal Financing Bank, which charges an interest rate equal to that on comparable Treasury borrowing, plus one-eighth of 1 percent. Most direct loans made by the REA to cooperatives carry an interest rate of 5 percent. In addition, the REA guarantees some loans that are made to cooperatives by nonfederal lenders. The REA committed $150 million in guaranteed loans during fiscal year 1990. Outstanding loans at the end of fiscal year 1990 are estimated at $35.1 billion (direct) and $2.6 billion (guaranteed).

Tennessee Valley Authority (TVA). The TVA is a government-owned corporation created for the development of a river basin that comprises parts of seven states. The TVA operates hydroelectric facilities, coal-fired and nuclear-fueled electric generating plants, and an extensive transmission network. The TVA transmits about 3.6 percent of the electricity generated in the United States.[5] Approximately 70 percent of its power output is generated by coal-fired facilities, 16 percent is hydroelectric, 14 percent comes from nuclear, and less than 1 percent uses oil or natural gas.[6] The TVA, which is required to maintain relatively low electricity rates, sells the bulk of its power to publicly owned utilities and to electric cooperatives in the region. The TVA's power program is intended to be self-supporting; however, it can borrow at subsidized rates against future revenue from power sales. In addition, the TVA has a number of other functions, such as flood control. Outstanding loans at the end of fiscal year 1990 are estimated at $168 million.

Tax-Exempt Bonds for Energy Facilities. Under current law, state and local governments may issue industrial development bonds to finance local facilities that furnish electricity or gas or to finance local heating and cooling facilities. Interest on these bonds is tax-exempt. The loss in revenue estimated for this tax preference also results from various provisions that have expired or been repealed and that authorize tax-exempt financing of small-scale hydroelectric and steam-generating facilities and alcohol-production facilities. The budget effects of this preference will continue until the bonds are retired.

Supporting Research and Technical Analysis. This program evaluates energy research activities and provides support for university-related research and manpower training. The program is divided into several components, including basic energy

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5. Department of Energy, Energy Information Administration, *Electric Power Annual 1988* (December 1989), Table 8; and *Financial Statistics of Selected Electric Utilities 1988* (February 1990), Table 67.

6. Department of Energy, Energy Information Administration, *Electric Power Monthly, February 1989* through *Electric Power Monthly, December 1989* (May 1989 through March 1990), Table 36; and *Electric Power Monthly, January 1990* (April 1990), Table 39.

sciences, energy research analysis, and purchasing instruments for university research. This program covers many forms of energy, ranging from nuclear to combustion technologies.

Multiprogram Laboratories Facilities Support. This program provides funds for maintaining roads, buildings, and other facilities at the multiprogram national laboratories.

Program Impacts

If these programs result in lower prices for electricity and energy for heating and cooling, then additional consumption in response to lower prices may increase emissions of carbon dioxide. The REA provides financial assistance primarily in the form of direct loans to rural utility cooperatives. Most of the electricity generated by these cooperatives comes from fossil fuels. Thus, the subsidized loans provided by the REA may slightly increase emissions of carbon dioxide by enabling many cooperatives that depend on the low-interest loans to expand and maintain viable electric services to rural communities. Further, if the rates charged by cooperatives were higher without low-interest loans, then lower rates would slightly encourage consumption of electricity. The total effects on emissions of carbon dioxide, however, are not likely to be large, since cooperatives generate only about 5 percent of the electricity generated by electric utilities in the United States.[7]

The impacts of the federally owned TVA on carbon dioxide emissions depend primarily on the rates charged for electricity. While the TVA does not have access to the favorable repayment terms available to the power marketing administrations, it can borrow at a lower interest rate than is available to private utilities. Thus, the TVA may charge lower rates than a private supplier would, encouraging the sale of more electricity and increasing associated emissions of carbon dioxide. The impact on emissions must take into account, however, not only the rates that would be charged but also the type of power that would be supplied in the absence of TVA power. The proportions in which the TVA uses fossil and nonfossil fuels to generate electricity are similar to the national average and, thus, the effects on emissions are likely to be slight.

Tax-exempt financing, which is permitted by the tax exemption for industrial development bonds, reduces the cost of capital and may encourage public investment in local energy supply. If additional investment occurs, then lower prices for electricity and gas may result. If local facilities that benefit from tax exemptions are primarily fired by fossil fuels, then additional consumption in response to lower prices may increase emissions of carbon dioxide.

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7. Department of Energy, *Electric Power Annual 1988*, Figure 4.

Finally, the two R&D programs support research on both fossil and nonfossil sources of energy; thus, the impact on emissions of carbon dioxide is unclear. To the extent that these programs foster technologies for fossil fuels, emissions of carbon dioxide may rise. Increased use of technologies for nuclear and renewable energy, however, may displace some use of fossil fuels and reduce emissions of carbon dioxide. Either impact is likely to be small for two reasons. First, the link between supporting research and the development of commercially viable energy technology is indirect; significant portions of both programs are devoted to expanding basic energy sciences and evaluating research. Second, these programs provide support not only for research on energy supply but also for all energy-related research in DOE, which includes extensive research with space and defense applications; biological and environmental research; environmental, safety, and health research; and other programs largely unrelated to carbon dioxide levels in the atmosphere.

CHAPTER V
OTHER FEDERAL IMPACTS ON ENERGY USE AND EMISSIONS

The focus of this study has been on nonregulatory programs and policies that may affect energy use and emissions of carbon dioxide. Other programs and policies that may affect energy use were omitted from this study, however, because limitations of the available data make it difficult to determine their effects. Such programs that are more directly related to energy use are discussed below. Transportation programs, which are only indirectly related to energy use, are mentioned briefly here and are discussed more fully in the appendix. A final section highlights several programs and tax policies that relate to energy use and global warming but are outside the scope of this study.

DIRECT EFFECTS ON ENERGY USE

Several nonregulatory federal programs have direct but undetermined effects on energy use (see Table 13). These programs include a grants program and several management programs for fuel minerals.

Low-Income Home Energy Assistance

As part of the Family Support Administration in the Department of Health and Human Services, this program makes grants to states and Native American tribes. These grants aid low-income households with high-energy costs through payments to eligible households, energy suppliers, and building operators. This energy assistance program provides funds to states, which then use their allotments to help eligible households pay their home heating or cooling bills, meet energy-related emergencies, or fund low-cost weatherization projects. Since the program subsidizes both energy use and weatherization, the net impact on emissions of carbon dioxide is undetermined.

Minerals Management Programs

Four programs fall under the general category of energy and minerals management. Two of these programs control mineral leasing onshore and offshore; the other two programs manage federal oil reserves.

Strategic Petroleum Reserve. The intent of this program is to decrease the vulnerability of the United States to disruptions in world petroleum markets by creating a stockpile of crude oil for use in the event such disruptions occur. The goal of the program is to achieve 1 billion barrels of storage capacity; the reserve currently holds just under 600 million barrels of crude oil.

TABLE 13. FEDERAL PROGRAMS WITH AN UNDETERMINED IMPACT ON ENERGY USE (Fiscal year 1990, in millions of dollars)

Program	Budget Authority	Receipts
Low-Income Home Energy Assistance	1,393	n.a.
Strategic Petroleum Reserve	625[a]	n.a.
Naval Petroleum and Oil Shale Reserves	189[b]	700
Energy and Minerals Management	66[c]	907
Minerals Management Service	176[d]	3,004

SOURCES: Congressional Budget Office; *Budget of the United States Government, Fiscal Year 1991*; Department of Energy, *Posture Statement and Fiscal Year 1991 Budget Overview* (January 1990); and *Department of the Interior and Related Agencies Appropriations for 1991*, Hearings before the Subcommittee on the Department of the Interior and Related Agencies of the House Committee on Appropriations, 101:2 (1990), pt. 3.

NOTE: n.a. = not applicable.

a. Includes estimated spending authority from a transfer of funds from the naval petroleum reserve receipts.

b. Budget authority is for operating expenses and is not net of receipts.

c. Not net of receipts from leasing fuel minerals onshore.

d. Not net of receipts from leasing fuel minerals offshore.

Naval Petroleum and Oil Shale Reserves. This program has several goals: to explore, conserve, and develop the naval petroleum reserves; to produce the reserves at maximum efficient rates; and to use, store, or sell portions of the reserves. The reserves currently produce oil and gas to meet ongoing requirements of the commercial sector, and also provide a standby source of petroleum for the military.

Energy and Minerals Management. This program within the Bureau of Land Management (BLM) in the Department of the Interior may affect the supply of fossil fuels. The BLM has full responsibility for mineral leasing and supervision of mineral operations on public land and on approximately 300 million acres of federal property under other agency jurisdictions and ownerships. The BLM program leases federal land for mineral extraction onshore, performs resource and economic evaluation, and supervises the development of minerals on federal and Native American lands, including oil, gas, coal, oil shale, tar sands, phosphates, sodium, potash, and geothermal energy.

Minerals Management Service. The Minerals Management Service in the Department of the Interior supervises exploration, development, and production of oil, gas, and other minerals on the Outer Continental Shelf (OCS). The service also collects royalties, rents, and bonuses due to the federal government and Native American lessors from minerals produced from federal, Native American, and OCS lands.

Impacts of Minerals Management

The impacts on emissions of carbon dioxide attributable to these energy and minerals management programs depend, in part, on the prices that are charged and the rate at which the lands are leased under federal leasing programs. Leasing and development prices for federal lands that are lower than prices for comparable privately owned or managed lands may increase the rate at which fossil fuels are extracted and may expand domestic supplies of fossil fuels in the near future. Conversely, government leasing of these lands at higher prices than would be charged by the private sector restricts domestic supplies. The impacts on emissions also depend on the legislation governing leases on these lands. For the past nine years, the Congress has halted leasing for some OCS lands. The specific land precluded from leasing varies but generally includes territories off New England and California and sometimes Florida, the mid-Atlantic, and Alaska.

Overall, the impacts of these minerals management programs on emissions are uncertain. Federal pricing policies could influence domestic consumption of fossil fuels, especially for fuel minerals such as coal, whose prices are largely determined in domestic markets. The data, however, are not available to determine the effect of federal leasing policies on consumption. For oil, which is the focus of the reserves programs, prices are determined in world markets. Consequently, domestic policies may have little or no effect on U.S. consumption of energy, except in the event of a crisis.

INDIRECT EFFECTS ON ENERGY USE

A number of federal nonregulatory programs and policies are only indirectly related to, but may have an effect on, energy consumption. Because of the complexities of these programs and their interactions with the economy, the direction of the net effect on energy use and carbon dioxide emissions cannot be determined.

Transportation spending programs, which include grants to state and local governments for highways and mass transit as well as expenditures on air traffic control and waterway and harbor maintenance, are in this category along with tax credits or grants for investment in transportation equipment. These programs expand travel opportunities but also provide more direct travel routes and otherwise improve the efficiency of fuel used in travel. Net impacts on energy consumption and emissions of carbon dioxide depend, therefore, on the extent to which total travel and the fuel efficiency of travel are altered, despite switching between modes with different fuel efficiencies. Because these programs focus more on transportation services than on energy consumption, the effects of these programs on energy use are difficult to determine. These transportation programs are discussed more fully in the appendix.

OTHER RELATED PROGRAMS

Three programs could affect emissions of carbon dioxide by improving national understanding of the global warming issue, or through their effects on energy use by the federal government and industry.

Global Change Research. Through its Committee on Earth Sciences, the Federal Coordinating Council for Science, Engineering, and Technology has developed a strategy for interagency research on global change. This strategy is designed to reduce scientific uncertainty and develop more reliable predictions on which to base policies in response to global climate change. Federal support in fiscal year 1990 for research on global climate change is channeled through the following federal agencies.[1]

1. Committee on Earth Sciences, *Our Changing Planet: The Fiscal Year 1991 United States Global Change Research Program*, a report to accompany *Budget of the United States Government, Fiscal Year 1991.*

Agency	Budget Authority (Millions of dollars)
National Aeronautics and Space Administration	489
National Science Foundation	55
Department of Energy	50
Department of Agriculture	21
Department of Commerce (National Oceanic and Atmospheric Administration)	18
Environmental Protection Agency	13
Department of the Interior (U.S. Geologic Survey)	13
Total	659

General Tax Preferences for Business. General tax preferences for business investment, such as accelerated depreciation rules, may encourage investment in energy-using or energy-efficient equipment over alternative expenditures, such as for insulation. These tax preferences do not, however, clearly increase energy use in general or favor one energy source over another.

Federal Consumption of Energy. Federal agencies consume approximately 2.3 percent of all energy (over 80 percent by the Department of Defense), and several agencies have internal programs to reduce energy consumption.[2] The Department of Energy's In-house Energy Management program funds retrofit projects for energy conservation within DOE. Budget authority for DOE's program is about $19 million annually. Other federal agencies also have energy retrofit projects. Combined spending on conservation among all federal agencies has recently been between $50 million and $60 million annually.[3]

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2. Department of Energy, Energy Information Administration, *Annual Energy Review 1989* (May 1990), Tables 3 and 9.

3. Telephone communication with Richard Brancato, Department of Energy, October 12, 1989.

CHAPTER VI
STRATEGIES FOR ADDRESSING GLOBAL WARMING

The results of this study suggest that some federal policies, such as taxes on fossil fuels and related products, may slightly reduce use of fossil fuels and associated emissions of carbon dioxide. At the same time, federal programs that stimulate conventional energy supplies may increase fossil fuel use and consequent emissions. Overall, current federal nonregulatory programs and policies do not greatly alter energy use in ways that systematically affect emissions of carbon dioxide.

The absence of significant effects on energy use or emissions should not suggest that the programs and policies considered were ineffective in meeting their objectives. Current energy policies reflect almost two decades of changing and occasionally conflicting viewpoints about how best to meet the goals of protecting national security and preventing the reoccurrence of the energy shortages of the 1970s. Thus, tax credits that benefit the extractive industries coexist with taxes on fossil fuels, and small amounts of conservation and renewable energy tax credits compete with subsidies for electricity generated from fossil fuels. While these policies may not conflict in their design to reduce U.S. reliance on imported petroleum, they can conflict in their impacts on the environment.

Since the distribution of energy use by sector has not been constant over time, the effects of government programs and policies on emissions of carbon dioxide may change as patterns of energy use change. Over the last two decades, energy consumption by electric utilities to generate electricity has been rising as a percentage of total energy consumption, as buildings and industry replace direct fuel combustion with electricity use. Energy consumption by electric utilities rose by about 21 percent between 1979 and 1989, while use of fossil fuels by industry and in residential and commercial buildings fell by about 13 percent. At the same time, energy consumption in the transportation sector rose by about 8 percent and also rose slightly as a percentage of energy consumption by all sectors.[1] Coal and nuclear power have played an increasing role in electricity generation, up from around 45 percent and 12 percent in the late 1970s, respectively, to 55 percent and 20 percent in 1989.[2]

1. Department of Energy, Energy Information Administration, *Annual Energy Review 1989* (May 1990), Table 4.

2. Ibid., Table 90.

PROPOSALS IN THE CONGRESS

The design of an appropriate strategy to affect energy use and associated emissions of carbon dioxide relies on an understanding of how federal programs and policies affect the amount and types of energy consumed and of what type of pollution results from different sources of energy. This paper studies how federal spending and credit programs and tax policies may alter energy consumption and the resulting emissions of carbon dioxide that may contribute to global warming. This study also provides a snapshot of current policy and, in a limited way, a framework for evaluating potential impacts on energy use from adopting new federal nonregulatory programs and policies or modifying existing ones.

In recent years, the Congress has introduced a number of legislative proposals in response to public concern over the potential impacts of climate change on water resources, agriculture, forests, biodiversity, health, productivity, and energy demand. Many of these proposals call for a national energy plan and for programs to improve understanding of climate issues and policy options. In addition to regulatory approaches to energy conservation, several proposals address energy efficiency and support accelerated development of nonfossil sources of energy. Proposed changes in tax policy, including taxes on fossil fuels as well as tax credits to encourage energy supply, have appeared in a number of energy-related proposals.[3] Other proposals include programs that foster international cooperation or stimulate conservation and forestry-related efforts in developing countries.

CHOOSING EFFECTIVE STRATEGIES

This study has identified a number of nonregulatory programs and policies that may affect the amount and types of energy consumed in the United States. If the control of carbon dioxide emissions becomes a national goal, then policies that discourage emissions of carbon dioxide through reductions in fossil fuel combustion may figure prominently. Such policies include taxes on fossil fuels, energy conservation tax credits, grants, and funding for research and development. Similarly, programs that reduce reliance on fossil fuels by promoting the use of nonfossil sources of energy may reduce emissions of carbon dioxide. At the same time, however, carbon dioxide emissions can be reduced by cutting back on programs that encourage the use of conventional forms of energy.

An evaluation of alternative goals and trade-offs should precede the choice of federal programs and Congressional appropriations that could mitigate the perceived threat of global warming. Many of the nation's energy programs and policies have traditionally fostered energy independence for national security reasons. Encouraging

3. See Congressional Budget Office, *Carbon Charges as a Response to Global Warming: The Effects of Taxing Fossil Fuels* (August 1990), for a discussion of a tax on fossil fuels in proportion to their carbon content and its effects on the U.S. economy and on emissions of carbon dioxide.

renewable sources of energy may be consistent with these goals; however, reduced funding for programs that encourage the use of coal, such as R&D for alternative fuels, may be viewed less favorably.

Energy policy has also come under increasing scrutiny because of environmental pollutants, other than carbon dioxide, which are associated with fossil fuel combustion. Sulfur dioxide emissions from coal and other fossil fuels contribute to acid rain, and hydrocarbon releases from automobile exhaust contribute to low-level ozone pollution or smog. Programs designed to improve environmental quality may require different emphases than those designed to affect emissions from fossil fuels that may contribute to global warming.

The choice of responses to the potential threat of global warming must also include alternative approaches to mitigating or preventing the ecological and economic impacts of climate change. Carbon dioxide emitted from the combustion of fossil fuels is not the only culprit. A significant portion of global emissions of carbon dioxide resulting from human activity comes from deforestation. Policies that affect emissions of carbon dioxide may conflict with policies that reduce other greenhouse gases (methane, chlorofluorocarbons, and nitrous oxide), which contribute significantly to the perceived threat of global warming.

Moreover, prevention is not the only policy response. The possible occurrence of global warming and the distribution of its effects internationally are uncertain. These uncertainties may warrant combining policies for prevention with policies for research into the causes and consequences of global warming. The design of strategies for increasing the nation's ability to respond flexibly to climate change may also warrant attention.

Finally, much uncertainty remains concerning the effective design of many of the federal programs and policies considered here. Nonregulatory measures can operate along with regulatory or cooperative strategies. Funding appropriate R&D or designing effective tax incentives may be crucial in developing successful strategies for coping with the potential threat of climate change.

APPENDIX
TRANSPORTATION PROGRAMS

The Department of Transportation (DOT) and other federal agencies have a number of spending programs that finance construction and maintenance of the nation's transportation infrastructure (see Table A-1). These spending programs, as well as federal tax policies, may alter the amount or the mix of transportation services and equipment used. Federal spending occurs primarily in the form of grants, both to state and local governments and to the private sector. Grants for construction, equipment purchases, and operating expenses cover several modes of transportation, including highways, air, and mass transit. Transportation services, such as air traffic control, account for a large portion of the remaining spending. Research and development (R&D) programs, excluding those on safety, account for a small portion of total spending.

By changing either the extent to which each transportation mode is used or its fuel efficiency, these spending programs may indirectly affect the demand for fossil fuels and, thus, emissions of carbon dioxide. This impact depends primarily on two factors: the relative emissions of carbon dioxide per passenger-mile or per ton-mile of alternative transportation modes, and the changes in use for each transportation mode. Transportation spending that increases the total amount of travel or that leads to the substitution of less fuel-efficient modes for more efficient modes may increase fuel use and resulting carbon dioxide emissions. Conversely, reduced travel, increased fuel efficiency, or switching to more fuel-efficient modes may decrease emissions.

Since transportation modes differ in fuel efficiency, as measured in energy consumed per passenger-mile or per ton-mile (see Table A-2), spending programs that cause switching between transportation modes would change fuel consumption even if total travel were unchanged. For intracity passenger transportation, passenger vans are the most energy-efficient mode; single-occupancy automobiles are the least efficient. Buses, commuter rail, and rapid transit are all somewhere in between. Buses are more energy efficient than fixed-rail systems, when all energy for manufacturing vehicles, operating stations, traveling door-to-door (including access to transit) and other purposes is taken into account. For intercity passenger transportation, buses are most efficient, followed by rail systems, the automobile, and finally air. For freight transportation, barges have the lowest British thermal units (Btus) per ton-mile, followed by rail, truck, and air. Shipping, which is not included in Table A-2, is probably toward the low end of the fuel-consumption range and similar to barges.

Because the carbon content of fuels varies, the relative emissions of carbon dioxide per passenger-mile or per ton-mile across transportation modes varies slightly from the relative fuel efficiency. The ranking of transportation modes, however, is unchanged from that given above. Emissions of carbon dioxide per Btu are roughly

TABLE A-1. SELECTED TRANSPORTATION PROGRAMS
(Fiscal year 1990, in millions of dollars)

Program	Budget Authority	Revenue Loss
Highways		
Federal-Aid Highways	14,924	n.a.
Air		
Air Traffic Control	3,016	n.a.
Facilities and Equipment	1,721	n.a.
Grants-in-Aid for Airports	1,651	n.a.
Research, Engineering, and Development	170	n.a.
Payments to Air Carriers	31	n.a.
Rail		
Grants to the National Railroad Passenger Corporation	605	n.a.
Miscellaneous Rail Grants	8[a]	n.a.
Mass Transit		
Formula Grants	1,625	n.a.
Discretionary Grants	1,282	n.a.
Interstate Transfer Grants	159	n.a.
Washington Metro	85	n.a.
Research, Training, and Human Resources	10	n.a.
Water		
Corps of Engineers, Navigation Projects	1,222	n.a.
Coast Guard, Aids to Navigation	465	n.a.
Deferral of Tax on Shipping Companies	n.a.	100
Ocean Freight Differential	48	n.a.
General		
Tax-Exempt Bonds for Certain Transportation Facilities[b]	n.a.	650[c]

SOURCES: Congressional Budget Office; *Budget of the United States Government, Fiscal Year 1991;* and Telephone communication with Annette Muscarella, Army Corps of Engineers, November 7, 1990.

NOTE: n.a. = not applicable.

a. Includes budget authority to cover $3.5 million in loans to Amtrak.

b. This exclusion affects airports, high-speed rail facilities, docks, and certain other facilities. The exclusion has partially expired.

c. This estimate reflects the budget effects of both current and expired exclusions.

TABLE A-2. ENERGY REQUIREMENTS FOR MODES OF TRANSPORTATION
(In Btus per passenger-mile or ton-mile)

Mode	Propulsion Energy	Modal Energy[b]
Intracity Passenger		
Single-Occupancy Vehicle	11,000	14,220
Average Automobile	7,860	10,160
Car Pool	3,670	5,450
Van Pool	1,560	2,420
Rapid Rail		
Old	2,540	3,990
New	3,570	6,580
Commuter Rail	2,625	5,020
Bus	2,610	3,070
Intercity Passenger		
Air		
Northeast corridor	7,839	n.a.
Other	6,237	n.a.
Automobile	3,157	n.a.
Rail		
Northeast corridor	2,762	n.a.
Other	3,680	n.a.
Bus	981	n.a.
Intercity Freight		
Rail	660	1,720[b]
Truck	2,100	3,420[b]
Barge	420	990[b]
Air		
All cargo plane	26,250	28,610[b]
Belly freight	3,570	3,900[b]

SOURCES: Intracity passenger modes: Congressional Budget Office, *Urban Transportation and Energy: The Potential Savings of Different Modes* (December 1977), Table 9. Intercity passenger modes: Congressional Budget Office, "The Current and Future Savings of Energy Attributable to Amtrak" (May 1979), Table 1. Intercity freight transportation: Congressional Budget Office, "Energy Use in Freight Transportation," Working Paper (February 1982), Table 3.

NOTES: n.a. = not applicable; Btu = British thermal unit.

a. Accounts for all forms of energy, except where noted, including energy for propulsion, maintenance, construction, and vehicle manufacturing. Computed on door-to-door basis and adjusted for roundabout journeys.

b. Not computed on door-to-door basis.

equal for motor gasoline and diesel fuel.[1] The situation for rapid rail and commuter rail is slightly more complicated, since the former is powered by electricity and the latter by a combination of electricity and diesel fuel. In terms of emissions of carbon dioxide per Btu of input, electricity has about 20 percent lower emissions than petroleum because of the combination of nuclear energy, hydroelectric power, and coal.[2]

As discussed in the text, some transportation programs may decrease emissions of carbon dioxide by a small amount. By discouraging travel, the transportation taxes that contribute to the highway, the airport and airway, and other trust funds may slightly decrease fuel use and, thus, associated emissions of carbon dioxide. The impact on emissions of transportation programs, taken together, is undetermined. These programs include spending programs to expand and improve roads, facilitate water travel, finance mass transit, and improve air traffic control. They also include grants or tax preferences that promote investment or equipment purchases. By reducing costs, these programs may encourage travel, which increases emissions of carbon dioxide. Maintenance and other improvements, however, may improve fuel efficiency, which decreases emissions of carbon dioxide. In addition, the impact of transportation spending and related tax expenditures on emissions depends on the extent to which increases in travel reflect substitution between less and more fuel-efficient modes. The difficulties in determining the net effects of these programs on energy use can be illustrated using the impacts of the highway and mass transit spending programs on passenger travel.[3]

HIGHWAYS

Spending on construction and maintenance of highways affects emissions of carbon dioxide in two ways. Expanding and improving the road and highway system reduces the cost of road travel by providing faster, more direct, less crowded, and smoother routes. Reducing the cost of highway travel induces individuals to undertake more discretionary travel and also to switch from alternative modes of transportation. Single-occupancy automobiles (and to a lesser extent, multipassenger automobiles) are the least fuel-efficient intracity passenger mode and are less fuel-efficient than some intercity modes. Thus, increased passenger-miles may increase total fuel

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1. Mark A. Deluchi and others, "Transportation Fuels and the Greenhouse Effect," Research Report UER-180, Division of Environmental Studies, University of California, Davis (December 1987).

2. Department of Energy, Energy Information Administration, *Annual Energy Review 1989* (May 1990), Diagrams 1 and 5. About 29 percent of the electricity consumed is from nuclear energy and hydropower.

3. See Congressional Budget Office, *New Directions for the Nation's Public Works* (September 1988), for estimates of the energy required for selected intracity transportation modes, a description of the development of the highway system, and a discussion of federal financing and ridership on mass transit.

consumption and emissions of carbon dioxide, depending on the extent to which travel by alternative modes is reduced. At the same time, by reducing wear on vehicles, congestion, and delays, and by permitting drivers to use more direct routes, highway spending may reduce fuel consumption per passenger-mile and, thus, reduce emissions.

The net effect of spending on total energy consumption and on consequent emissions of carbon dioxide is difficult to determine. Approximately 18 percent of the budget for federal aid to highways in fiscal year 1990 is allocated to constructing the interstate highway system; another 20 percent is for interstate 4R (resurfacing, restoring, rehabilitation, and reconstruction); about 40 percent is devoted to construction, improvements, and maintenance of other state and local roads and bridges; the remainder is allocated to safety and other programs.

Spending on highway construction may slightly increase emissions of carbon dioxide for several reasons. By reducing congestion and improving travel conditions, construction improves access and also lowers time and travel costs associated with road use. While reduced congestion may result in increased fuel efficiency per vehicle-mile, improved access may lead to more discretionary travel. Total fuel use and consequent emissions of carbon dioxide are likely to rise. Decreasing the cost and increasing the convenience of automobile travel may also cause travelers to switch to automobiles from alternative forms of transportation, such as commuter and rapid-rail systems, buses, and passengers vans. These modes tend to use less energy per passenger-mile.

At the same time, while the data on this issue are not conclusive, some evidence suggests that highway spending on maintenance in recent years may actually have reduced emissions of carbon dioxide. The DOT has estimated that changes in highway conditions between 1983 and 1987 have slightly reduced the costs of travel (per vehicle-mile).[4] The unit cost of travel declined by 1.6 percent between 1983 and 1985, and by 1.0 percent from 1985 to 1987. Operating costs, including vehicle and tire wear, and fuel costs declined slightly more--by 2.1 percent and 1.1 percent, respectively, during the same two periods, or by about 0.7 percent annually.[5] Thus, although more travel may occur in response to highway improvements that reduce

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4. *The Status of the Nation's Highways and Bridges: Conditions and Performance*, Report of the Secretary of Transportation to the United States Congress, Committee Print No. 101-2 (June 1989); and *The Status of the Nation's Highways: Conditions and Performance*, Report of the Secretary of Transportation to the United States Congress, Committee Print No. 100-11 (June 1987).

5. The decline in costs estimated by the Department of Transportation reflects changes in highway conditions and does not reflect changes in prices during the time period.

travel costs, emissions of carbon dioxide may decline to the extent that fuel use declines more rapidly.[6]

The impact of past spending in the highway program, which focused largely on construction, may have increased carbon emissions. Over time, as the emphasis shifts away from the national highway system and away from construction projects, the impact on emissions may change. The goal set in 1956--to develop a national highway network based on interstate, primary, and secondary systems--has largely been attained. Currently, about half of federal highway funds are spent on the two national systems (the interstate and primary systems), compared with about 80 percent in 1970. Moreover, in the late 1970s when the 4R program began, emphasis in the federal budget started shifting away from construction for both the interstate and other systems. Currently, construction accounts for less than half of interstate spending.

MASS TRANSIT

Current programs for mass transit also have conflicting effects. Spending that increases use of mass transit may increase energy use and associated emissions of carbon dioxide; switching from single-occupancy automobiles to mass transit, however, may reduce emissions. In addition, programs that improve fuel efficiency for mass transit may also reduce emissions. The net impact, while undetermined, is likely to be slight, since all forms of mass transit together consume less than 0.2 percent of all electricity and less than 0.3 percent of all petroleum consumed in the United States.[7]

In terms of energy use and emissions of carbon dioxide per passenger-mile, bus and rapid-rail systems tend to be more efficient than single-occupancy automobiles, less efficient than van pools, and about the same as car pools or commuter rail. Thus, the impact of mass transit spending on emissions depends on both the total amount of transit travel that occurs and the extent to which travel in alternative modes is reduced. Spending that switches passengers from single-occupancy automobiles to mass transit may decrease emissions, whereas spending that increases total mass transit without diminishing alternative travel, or that leads to more rapid-rail travel at the expense of buses, may increase emissions by increasing energy use.

Nearly one-fourth of the national transit budget is financed federally. Intuitively, one would expect that spending on transit would encourage automobile

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6. Vehicle-miles traveled are not very responsive to changes in travel costs, as measured by changes in the price of gasoline and fuel efficiency. See Chapter III.

7. Department of Energy, Energy Information Administration, *Annual Energy Review 1988* (May 1989), Table 60; Department of Energy, *Annual Energy Review 1989*, Diagram 5; and American Public Transit Association, *Transit Fact Book*, 1989 edition (New York: American Public Transit Association, 1989), Table 30.

riders to use bus and rail service instead; however, on balance, the impact of transit spending on the use of mass transit appears to be small or nonexistent. Only 9 percent of work trips were made on transit systems in 1980, compared with 13 percent in 1970. In addition, between 1970 and 1986, the average annual increase in transit rides was only about 1 percent because of declining ridership in half of those years. In recent years, passenger-miles have risen even more slowly than ridership.[8] Thus, to the extent that spending has had any effect in increasing ridership, the effects are probably small and dwarfed by other factors. These factors include the growth in jobs and population in the suburbs and smaller cities, rising transit fares and costs despite federal subsidies, declining gasoline prices (until recently), and federal, state, and local spending on highways. These results are supported by past findings which suggest that the total number of trips taken on bus and rapid-rail systems is relatively unresponsive to fare changes and travel time.[9] Work trips are slightly more responsive to total travel time than are other types of trips, and work trips are also more responsive to travel time than to fare changes.

Transit spending, however, may decrease energy use in certain densely populated areas with higher use of transit services; in the older and larger cities, transit carries more than 25 percent of commuters. Spending that increases the overall energy efficiency of the transit system may also reduce the energy used in transportation. In addition, transit spending may decrease emissions of carbon dioxide in areas where electric-powered rail systems are supplied by hydroelectric or nuclear energy rather than by fossil fuels.

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8. American Public Transit Association, *Transit Fact Book*, Tables 15 and 23.

9. See Armando M. Lago and others, "Transit Service Elasticities: Evidence from Demonstrations and Demand Models," *Journal of Transport Economics and Policy*, vol. 15 (May 1981), pp. 99-119; Armando M. Lago and others, "Transit Ridership Responsiveness to Fare Changes," *Traffic Quarterly*, vol. 35 (January 1981), pp. 117-142; and Gerald Kraft and Thomas A. Domencich, "Free Transit," in M. Edel and J. Rothenberg, eds., *Readings in Urban Economics* (New York: Macmillan, 1972).