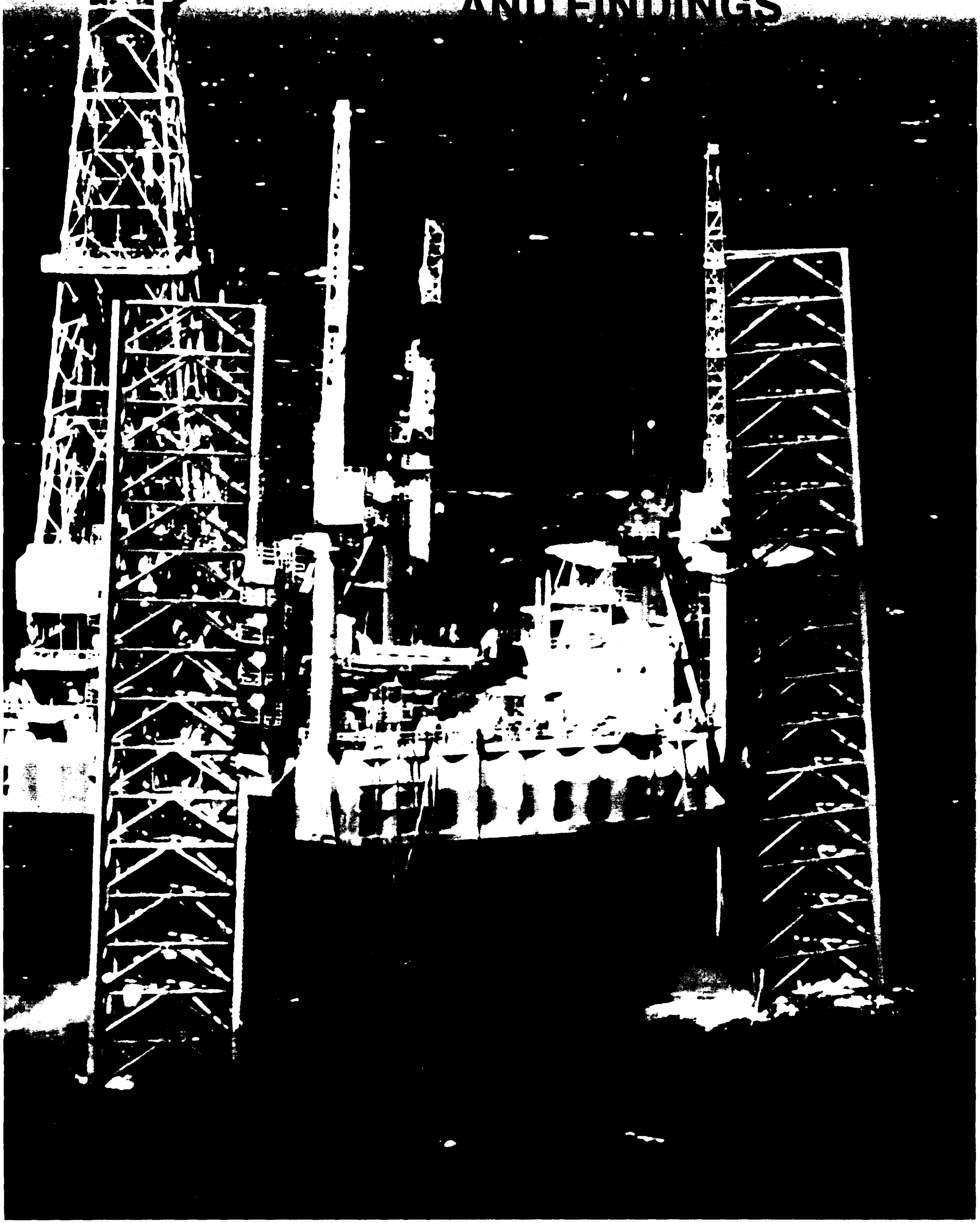
Chapter 5

ENERGY ISSUES, POLICIES, AND FINDINGS



Chapter 5.- ENERGY ISSUES, POLICIES, AND FINDINGS

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ENERGY ISSUES, POLICIES, AND FINDINGS

Chapter 5

SUMMARY

The automobile transportation system now uses over 5 million barrels per day (MMBD) of petroleum, or about **30** percent of total U.S. consumption. More efficient automobile designs and the shift to smaller cars are expected to lead to a decline in petroleum consumption by automobiles under Base Case conditions. By **2000,** it is estimated that automobiles will use between 4.2 and **4.8** MMBD, or about **20** percent of expected U.S. petroleum consumption at that time.

The United States now imports about 50 percent of its petroleum at a cost of over $42 billion per year. Petroleum imports account for a major part of the current $27 billion annual balance-of-payments deficit. In the Base Case, it is estimated that as much as **70** percent of U.S. petroleum supply in the year 2000 would be imported. If so, the cost of imports could rise to over $146 billion per year. (All dollar amounts specified are in 1975 dollars unless noted otherwise.) However, it is doubtful that this level of petroleum imports can be sustained. Several studies have predicted a shortfall by the late 1980's, and the threat of another oil embargo is always present. In addition, most experts predict severe depletion of worldwide petroleum supplies within 50 years.

For these reasons, this study considered changes in present Federal policies and programs, both to achieve greater conservation of petroleum by automobiles and to expedite the development of alternate automotive energy sources.

Among the petroleum conservation policies considered *were:*

- More stringent fuel-economy standards,
- Auto use disincentives and transit promotion,
- Improved transportation system management,
- Auto use controls,
- Increased gasoline taxes, and
- Gasoline rationing.

Although the first four of these policies would have beneficial effects, none is expected to produce petroleum conservation of significant magnitude or to avoid the serious consequences of a petroleum shortfall or embargo. More stringent measures, such as greatly increased gasoline taxes and gasoline rationing, were also considered. These measures could be used to conserve fuels and to control the consequences of an embargo or longrun shortage of petroleum, but they might entail serious economic penalties.

Conservation, however, is not a permanent solution. Sooner or later, the automobile transportation system will have to convert to alternate energy sources. Between 1980 and 2000, it may be possible to start using shale oil, coal liquids, alcohol, gasohol, or electrical energy storage on a large scale. As of now, there is no clear choice **as** to which would be the most technologically and economically feasible. All of the alternatives are more costly and require more total energy than petroleum. None is likely to be available before 1990 unless an active development and investment program is begun immediate] y.

BACKGROUND

Today, more than 80 percent of U.S. households own one or more automobiles, and over **90** percent of personal travel is by automobiles. Under Base Case assumptions, it is estimated that vehicle miles traveled will increase by 75 percent to 1.8 trillion miles per year by 2000. It is expected that new car sales will be about 16 million per year then, compared to 11 million now. The total of automobiles in operation will grow from the present **100** million vehicles to **148** million,

The growth of automobile use in our society has been made possible, in part, by the availability of low-cost petroleum, Government policies, which have kept fuel prices low, have stimulated and helped sustain this growth. Automobiles now use over 5 MMBD of petroleum, or about **30** percent of total U.S. consumption. (See figure **24.)** Under Base Case conditions, the use of petroleum by automobiles in **2000** is projected to be **0.4** MMBD or about 8 percent below the 1975 level. This reduction is more substantial than it may appear because it comes about despite a 75-percent increase in automobile travel by the end of the century.

The future availability of automotive fuel must be set in the context of total U.S. petroleum supply and demand. At present, total demand exceeds domestic supply to the point that about half of the U.S. needs are met with imported oil. Despite current conservation policies and emphasis on increasing domestic production, it is estimated that the need for foreign oil will grow and could reach as high as 70 percent of demand by 2000. The Base Case assumes that U.S. fuel demand would be 22.4 MMBD, of which as much as 15.4 MMBD would have to be obtained abroad or provided by alternative energy sources yet to be developed.

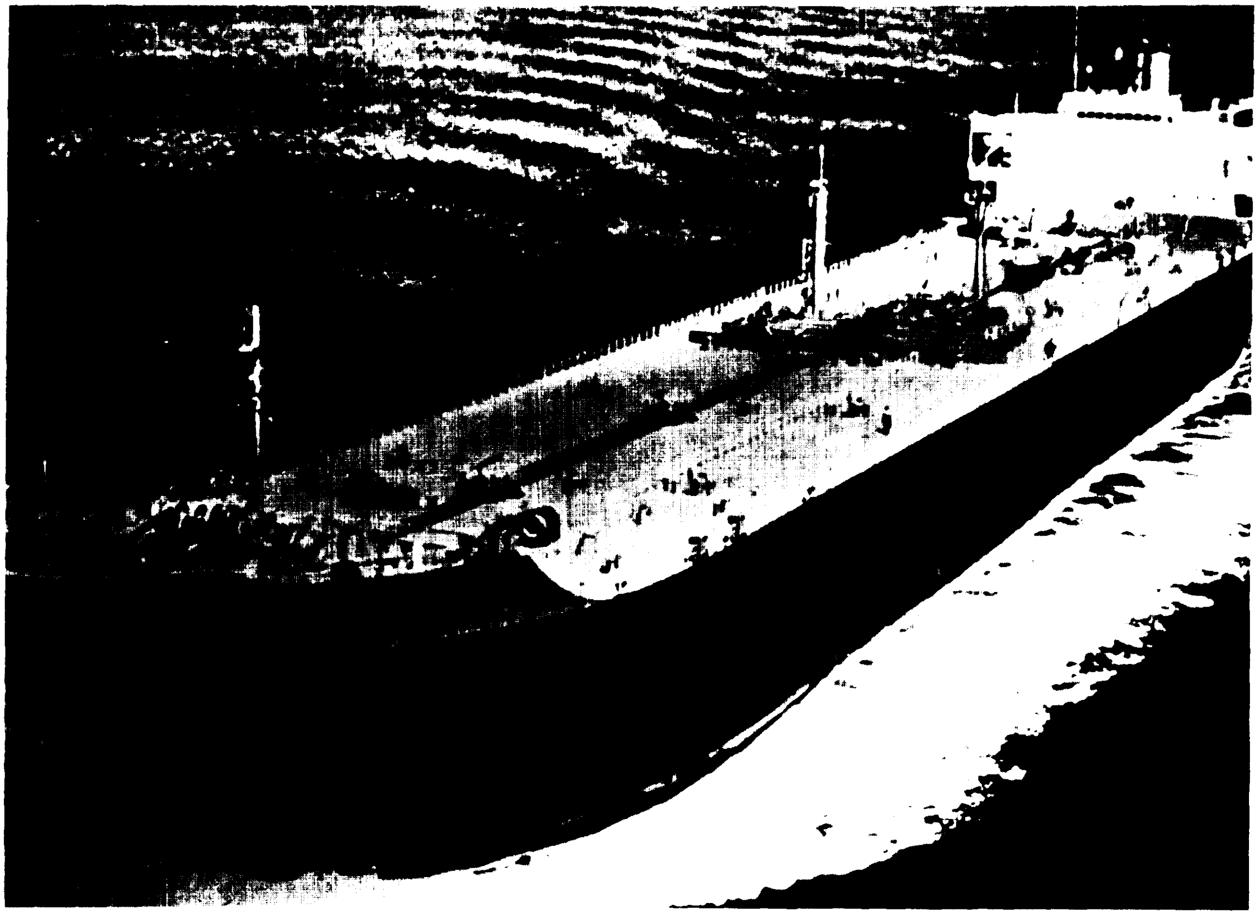
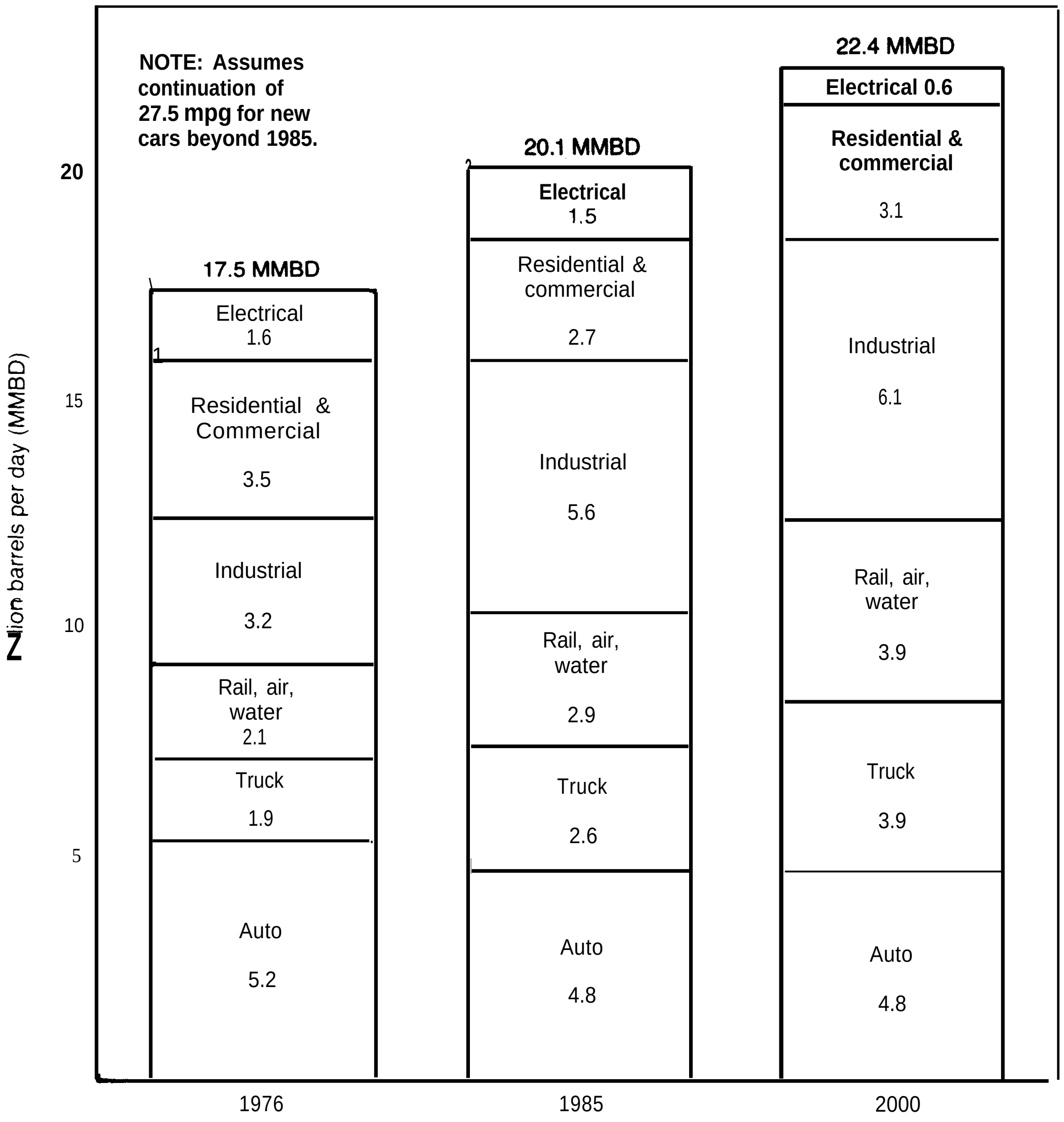


Photo Credit: U.S. Department of Energy

Figure 24.—U.S. Petroleum Demand

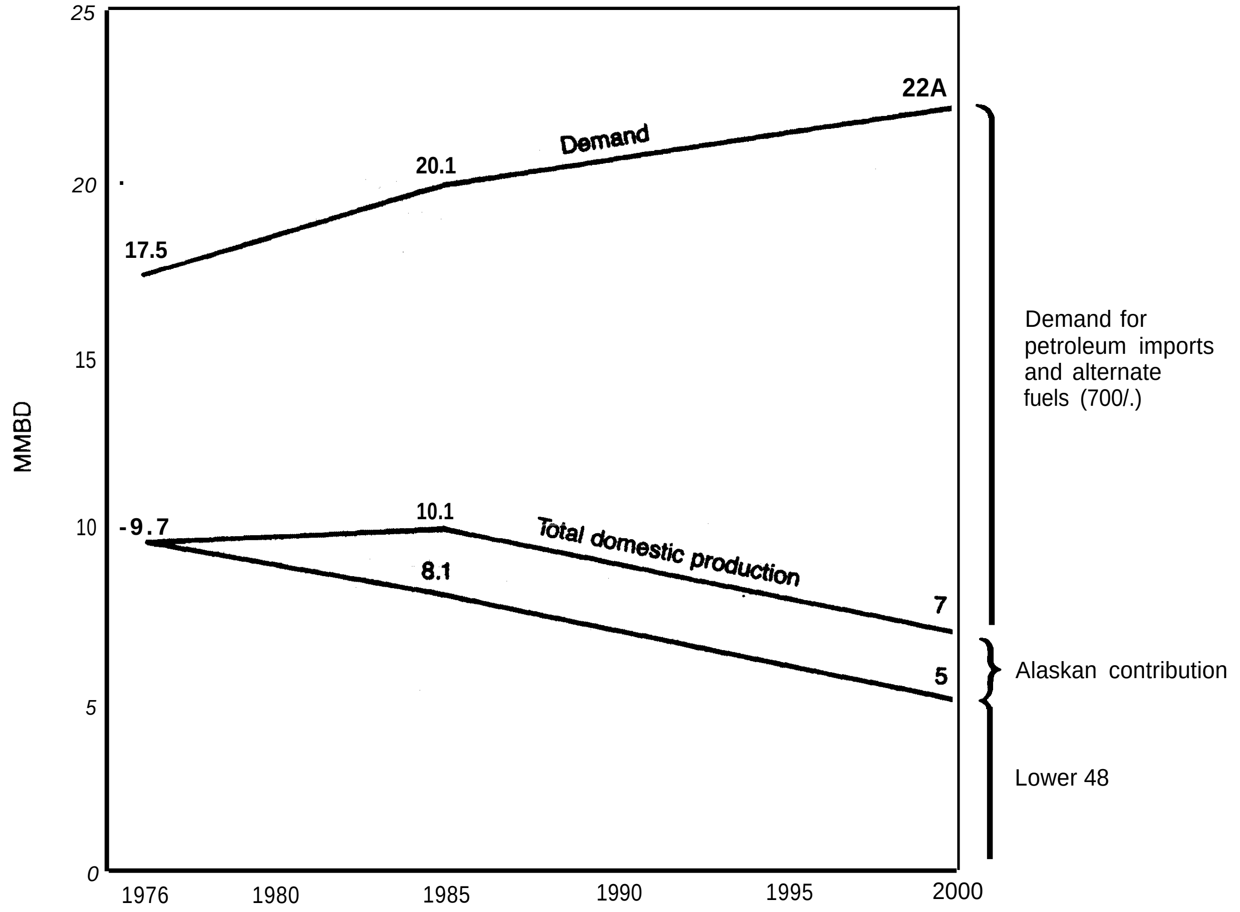


SOURCE: *Sydec/EEA*, p. III-88

The peaking of petroleum production—first in the United States and later throughout the world—has been predicted by several experts, among them M. King Hubbert. Hubbert projected that U.S. production could be expected to peak by the late 1970's, which it has. He has also forecasted that world production will peak sometime between 1985 and 2000.[1] Other ex-

[1] M. King Hubbert, testimony in Hearings before the Subcommittee on the Environment of the Committee on Interior and Insular Affairs, U.S. House of Representatives, 93rd Congress, June-July 1974, Serial No. 93-55, pp. 58-78. Also M. King Hubbert, Chapter XIX in *Project Interdependence: U.S. and World Energy Outlook Through 1990*, Committee Print 95-33, U.S. Government Printing Office, Washington, D.C., November 1977

Figure 25.—U.S. Petroleum Supply and Demand (MMBD)



SOURCE: Adapted from *Sydec EEA*, p III-92

perts disagree with Hubbert's view and estimate that the world production of petroleum from proven reserves will be adequate to meet demand through 2000 and beyond.

The likelihood of a petroleum shortage over the next two to three decades depends on a number of factors or events, including:

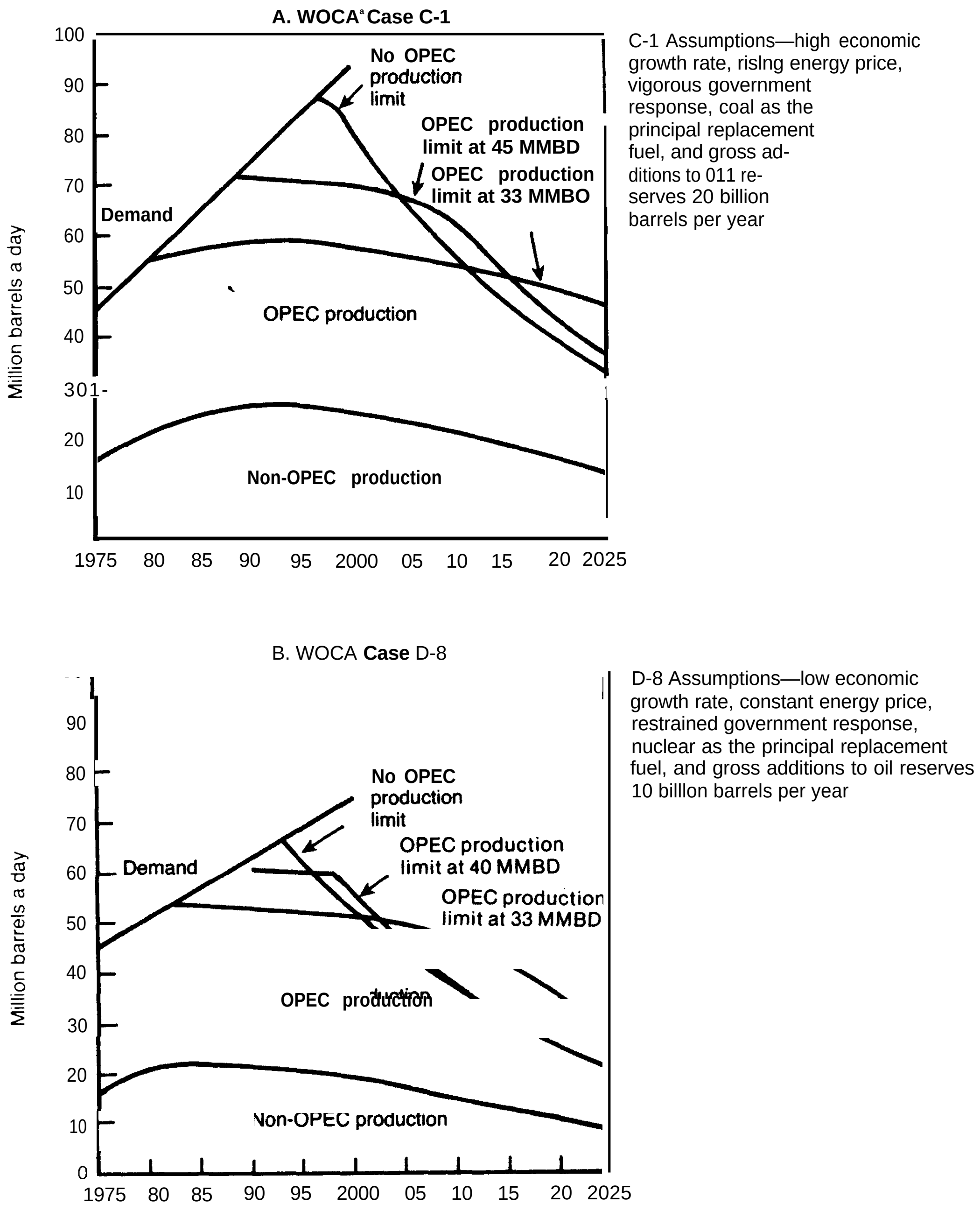
- Growth in world demand for oil,
- Drilling and finding rates for oil,
- Growth of production capacity in the oil-producing nations,
- Production and pricing policy decisions of oil-producing nations, and
- Rates of commercialization of alternative liquid fuels.

It is beyond the scope of the present study to investigate in detail the factors affecting the balance between petroleum supply and demand. Several independent analyses, of which the Workshop on Alternative Energy Strategies (WAES)[2] is probably the most exhaustive, point to the prospect that world demand for oil could outstrip the growth of new oil-producing capacity within the next decade.

The WAES study projects sufficient petroleum supply to meet demand up to 1985. However, after 1985 a gap between supply and unconstrained demand will appear and widen rapidly. (See figure 26.) By 2000, under even the

[2]MIT Workshop on Alternative Energy Strategies (WAES), *Energy: Global Prospects 1985-2000 (New* York: McGraw-Hill, 1977).

Figure 26.— Estimates of World Oil Production



'WOCA—World Outside Communist Area

SOURCE Workshop on Alternate Energy Strategies (WAES)' *Energy Global Prospects 1985-2000,* p 20

most *optimistic* scenarios, shortfalls of 25 to 35 percent are projected. The WAES study concluded that, to keep supply and demand in balance through **2000** while maintaining economic growth, there would have to be a massive shift to coal and nuclear power, with petroleum reserved almost exclusively for transportation and petrochemical feedstocks. WAES also concluded that, while there is a range of opportunities for closing the petroleum supply and demand gap, they require enormous planning efforts, intensive engineering, and major capital investments with leadtimes usually of 10 or more years. In order to close the gap, development efforts would have to be started immediately for an adequate supply of alternative fuels to be assured by 1985-90.

Actually, the complete exhaustion of oil resources will not occur. As production by conventional methods declines and oil becomes more scarce, the price will rise and more expensive recovery methods and novel technologies will be employed to produce additional oil or alternatives. As this process continues, the price of oil as an automotive fuel could become prohibitively high. If major improvements in oil recovery techniques were made, they would probably not raise the peak production level. They would be more likely to create a plateau in the production curve or to make decline from the peak less abrupt.

Accompanying the prospect of a long-term decline in petroleum reserves is the short-term threat of a major disruption in supply, such as a repetition of the 1973-74 oil embargo, To deal with temporary disruptions of petroleum supply, the Carter Administration has adopted several policies. The first is to expand the strategic petroleum reserve to 1 billion barrels which, combined with domestic production and emergency conservation measures, would supply essential domestic needs for about 10 months during an embargo.[3] The process of building up the level of petroleum storage was begun in 1977 and will take some years to complete. The second policy is a standby rationing system which, as currently planned, involves "white market" (transferable) coupons.[4]

The control of the price and supply of imports is largely in the hands of the OPEC nations and other foreign oil producers. The price of imported crude oil has risen since the 1973 oil embargo. In the Base Case, it is assumed that the world oil price will increase 3 percent per year, with the result that the price in constant dollars will double by 2000.

Probably the most serious impact of these market conditions, aside from the threat of another oil embargo, is the effect on the balance of payments, the value of the dollar, and employment. In 1977, the cost of imported oil **was $42.1 billion,** making it a major contributor to the $26.7 billion deficit in the balance of payments. In 1985, with the price of petroleum at

[3]Executive Office of the President, Energy Policy and Planning, *The National Energy Plan* Proposal, Apr. 29, 1977,

[4]*Federal Register 43,* (June *28,* 1978, Part II): 2813328168, "Contingency Gasoline Rationing Plan, " Proposed Rules.

Photo Credlf U S Department of Energy

$17 per barrel and imports at 10 MMBD, the annual cost would be $62 billion. If the price of petroleum were to double by 2000, reaching $26 per barrel, the cost of importing oil at the rate of 15.4 MMBD to meet domestic requirements would be $146 billion annually.

The problem of adequate petroleum supply will begin when production peaks and will grow worse with each succeeding year. For perspective, it should be noted that a shortfall of only 10 percent would limit consumption more severely than all of the conservation and curtailment policies normally considered. Thus, there is a clear need to explore a range of policy options to achieve greater conservation of petroleum as an automobile fuel and to hasten the development of alternate energy sources.

PRESENT POLICY

Before turning to an examination of alternatives, it is necessary to look briefly at the major policies now being pursued to see what effects they can be expected to have on petroleum consumption by automobiles.

Energy Policy and Conservation Act

The Energy Policy and Conservation Act (EPCA), enacted in December 1975, seeks to promote energy conservation in a variety of ways, many directly aimed at the automobile transportation system. Prominent among these are the new car fuel-economy standards mandated for model years 1978 through **1985.** Standards for light trucks will also go into effect beginning with the 1979 model year. (See table 44.)

Table 44.— Fuel-Economy Standards Assumed for the Base Case'

Model year	Sales-weighted new car fleet average
1978	18[b]
1979	19[b]
1980	20[b]
1981	22[c]
1982	24[c]
1983	26[c]
1984	27[c]
1985	27.5[b]
1990	27.5/30.0[d]
2000	27.5/35.0[d]

[a]Values shown are those to be achieved on the EPA prototype vehicle dynamometer tests Fuel consumption estimates prepared for this study assume that performance by vehicles in use is 10 to 20 percent less
[b]Mandated by, EPCA
[c]Administratively determined by the Secretary of Transportation
[d]Fuel economy assumptions for Case A and Case B, respectively

EPCA provides the Secretary of Transportation with authority to amend the average fuel economy standard for model year 1985, or any subsequent model year. However, any such amendment may not lower the standard beyond 26 mpg without approval of both Houses of Congress. EPCA does not make provision for standards beyond 1985. One policy issue is whether the 1985 standards should be maintained or increased further between 1985 and **2000.**

In addition to mandating automobile fuel-economy characteristics, EPCA also provides for programs to foster energy conservation in automobile use. Among these are:

- Promotion of carpools, vanpools, and public transportation,
- Encouragement to States and municipalities to adopt right-turn-on-red laws, and
- Transportation system management and transportation controls.

Nationwide 55 Mph Speed Limit

The 55 mph speed limit for highway traffic was established in 1974 as a means to save gasoline during the oil embargo. The law was especially effective during its first year or two, when compliance was much higher than it is today. Reduced speed not only saved petroleum but also provided an important extra benefit in lessening highway fatalities and injuries. More recently, the law has been less effective because of declining compliance and unwillingness by some States to enforce the law rigorously. A survey by the Department of Transportation showed that, during the first 6 months of 1977, from 30 to 77 percent of the vehicles on highways in various States exceeded the 55 mph limit.[5] Congress empowered the Secretary of Transportation to cut off highway construction funds to States failing to enforce the 55 mph speed limit, but this sanction has never been invoked. Lack of enforcement remains the major deficiency of this law.

Emergency Petroleum Allocation Act

The Emergency Petroleum Allocation Act, passed in November 1973, provides the Administration with authority to allocate petroleum and to set price controls during an emergency. The responses by the Federal Government to the 1973-74 embargo consisted primarily of the measures authorized under this Act.

The Electric and Hybrid Vehicle Act

The Electric and Hybrid Vehicle Research, Development, and Demonstration Act was passed in September 1976 and amended in 1978. Its aim is to foster the use of electric- and hybrid-vehicles as an alternative to petroleum-fueled automobiles. The intent of this law **was** to:

- Encourage and support research on, and development of, electric- and hybrid-vehicle technologies,
- Demonstrate the economic and technological practicability of electric and hybrid vehicles for personal and commercial use in urban areas and for personal and agricultural use in rural areas,
- Facilitate, and remove barriers to, the use of electric- and hybrid-vehicles instead of gasoline- and diesel-powered vehicles, and
- Promote the substitution of electric- and hybrid-vehicles for many gasoline- and diesel-powered vehicles now used in routine shorthaul, low-load applications, where such subs itution would be eneficial.

[5]U.S. Department of Transportation, Office of the Secretary, *Report to the President on Compliance with the 55 MPH Speed Limit*, Oct. 14, 1977, p. 1.

Responsibility for administering the Act was placed on the Energy Research and Development Administration (ERDA), now incorporated into the Department of Energy (DOE). Funding of $37.5 million has been requested by DOE for FY 1979 to handle these responsibilities. Work already completed includes initial studies and analysis of program requirements, review of the state of the art, publication of the first set of performance standards, and plans for a loan guarantee program. In addition, R&D has begun on batteries, components, and vehicles to assist industry in improving product performance, utility, and reliability. A demonstration program has been formulated to place at least 200 electric-vehicles on the road by 1979 and between 7,500 and 10,000 by 1984.[6]

Advanced Automotive Technology and Synthetic Fuels Development

The Department of Energy inherited from the Environmental Protection Agency (EPA) a program to promote development of new technologies for automobile engines, transmissions, and drivetrain components. DOE has entered into a cost-sharing contract with an industry consortium to develop the Stirling engine over an 8-year period. DOE also expects to place contracts for development of **gas turbine** engines—a continuation of the R&D work performed by the Chrysler Corporation with Federal support since the 1950's.

The Department of Energy also inherited from EPA a program for the development of synthetic fuels. The program originally concentrated on state-of-the-art and feasibility studies. At the present time, small pilot plants are being built to test alternative processes for converting oil shale and coal to synthetic fuel. Emphasis on this program has grown considerably within the past year.

[6]*Electric and Hybrid Vehicle Act, Statutes at Large 90, 1260 (1976), U S Code* vol. *15*, sec. *2501-2514*, vol. *42*, sec. *2451* and *2473*, as amended by the *ERDA Authorization Act of 1978*, P.L. 95-238, 95th Cong., 2d sess., Feb. 25, 1978, S, 1340, Title VI.

ISSUES

The automobile transportation system is confronted with a serious challenge. Abundant low-cost petroleum is no longer assured. Growing petroleum imports, of which automobile fuel demand is a large part, have contributed to a serious negative balance of payments. Efforts to conserve petroleum have so far been slow, difficult, and limited in results. All alternatives to petroleum are more costly and require major investments with high risks. All will take many years to bring to full development and commercialization. Thus, something clearly needs to be done about the way in which automobiles use energy and about assuring a continuing supply of energy for personal transportation. The policy questions facing the Government, the industry, and the public can be summed up in two basic issues:

- Should the Government adopt policies to effect a transition from petroleum to alternate energy sources for automobiles? When should the transition be made? What are the feasible paths?
- Should specific limits or allocations be established for petroleum consumption in the automotive transportation sector? Or, alternatively, should the Government let the market price balance supply and demand?

Concerning the first issue, the Federal Government may have to become involved because the capital requirements are so high and the risks so great that private industry would be unlikely to undertake the needed research and development without strong encouragement and perhaps Federal Government participation. Federal Government involvement might also be necessary to ensure a smooth and expeditious transition and to prevent disruption of supply with resulting hardships on citizens and the economy.

The second issue, limiting petroleum consumption, must be confronted while the longer term transition is taking place. If a petroleum shortfall occurs, there will be a need to consider further measures to reduce fuel consumption in all sectors, including automobile transportation. The issue addressed in this report is how to achieve petroleum conservation by the automobile transportation system through policies that do not have severe negative impacts on consumers, the auto industry, or the economy in general.

POLICY ALTERNATIVES

Policies to deal with the issues outlined above were analyzed in two ways. First, a policy case was constructed to deal with the combined impacts and effects of several policies working together to conserve petroleum. Second, an analysis was carried out of the impacts and effects of individual policies to conserve petroleum or to encourage the transition to alternative sources.

Petroleum Conservation Policy Case

The rationale of the Petroleum Conservation Policy Case was to foster substantial reduction in fuel consumption by automobiles without major adverse impacts in the areas of mobility, environment, safety, and cost. Specific policies within this set include:

- EPCA fuel-economy standards for new cars as now mandated for **1978-85,** with escalation of the standards to 33 mpg in 1990 and 40 mpg in 2000,
- New car fuel-economy standards that establish a minimum of 16 mpg for all cars in the **1980** model year and an increase of 1 mpg each year thereafter until reaching 21 mpg in 1985,
- An excise tax on fuel-inefficient automobiles (“gas guzzlers”) that increases from a maximum of $553 in 1979 to $3,856 in 1985, and

- An increased gasoline tax to keep average fleet fuel cost per mile constant after 1979– the increase amounting to 7 cents per gallon in 1980 and 18 cents per gallon by 2000.

The gasoline tax would be adequate until 1985 to serve also as an incentive to alternative fuel production. Depending on fuel prices and auto fuel efficiencies after 1985, additional taxes might be required to maintain the price advantage of alternate fuels. The assumptions for this set of policies are summarized and compared with the Base Case in table **45.**

As a supplement to the Petroleum Conservation Policy Case, the analysis was extended to consider the consequences of a staged rationing program designed to bring about forced reductions in petroleum consumption for the long term.

In addition to Federal policies that have a direct impact on the cost of driving and on fuel economy, there are other measures that could divert or reduce reliance on conventional automobiles and conventional auto fuels. For example, a gasoline tax or rationing program might be accompanied by Federal subsidies for electric car development and purchase. Stringent fuel-economy standards for new cars could be accompanied by increasing Federal R&D for auto technologies. The negative effects of a gasoline tax on mobility could be somewhat alleviated by subsidies for mass transit and vanpooling. These supporting policies to improve mobility, while clearly important to the success of energy conservation efforts, are not examined in detail in this chapter, but they are considered later in chapter 8.

Individual Policies Analyzed

The range of policy alternatives for effecting automobile petroleum conservation and a transition to alternate sources is extensive. Time and resources did not permit analysis of all the alternatives. The policies selected for study here are those that focus on actions related to the automobile. These policies address what the automobile sector could do to lower demand for petroleum while continuing to meet basic transport needs. For example, policies that would

Table 45.—Assumptions and Conditions for Petroleum Conservation Case

Assumptions	Base Case	Petroleum Conservation
Highway		
Total highway expenditures	Increases with inflation (stable in constant dollars).	Increases at 1/2 inflation rate (declines 40% by 2000 in constant dollars).
Mass transportation		
Capital improvements	Increase current dollar funding 10% per year to 1985. Hold constant in real dollars to 2000.	Increase current dollar funding 15% per year to 1985. Hold constant in real dollars to 2000.
Operations	Same as above.	Double funding initially. Increase 15% per year to 1985. Increase 10°/0 per year 1985-2000 (all current dollars)
Auto feul *economy*	EPCA 27.5 mpg beyond 1985.	33 mpg by 1990; 40 mpg by 2000. Gas-guzzler tax and ban.
Highway speed	Moderate enforcement (present average of 62 mph).	Rigid enforcement of 55 mph limit.
Safety		
Occupant restraints	Airbags or equivalent on new vehicles as scheduled.	Mandatory seat belt use only.
Technology		
Propulsion	**10%** of new cars diesel by **1985; 25°/0 by 2000. Negligible electric vehicles in use.**	25% of new cars diesel by 1985; 60% by 2000.11 million electric vehicles in use by 2000. Neglible use of advanced engine technologies.
Fuels	4.4°/0 diesel by 1985; 17.9°/0 diesel by 2000.	Increase % of diesel fuel; accelerate transition to synfuels. Potential for gas rationing.

SOURCE *Sydec/EEA,* p 1.7

give priority to the auto in the allocation of petroleum were not considered. In assessing the transition policies, no attempt was made to determine how other sectors might make use of the new energy forms.

Petroleum Conservation Policies

Basically, these policies are designed to influence behavior in two ways:

1. To promote the design and sale of fuel- efficient vehicles, and
2. To promote more energy-conscious use of automobiles *or* to provide alternative modes of transportation.

In table 46, several policies have been listed in each of these categories. Four policies from this list are analyzed in this chapter:

- Tighter fuel-economy standards,
- Higher gasoline prices,
- Free-market pricing, and
- Gasoline rationing.

Table 46.—Policy Options for Automobile Fuel Conservation

Vehicle fuel-efficiency policies

- **Tighter fuel** economy standards
- Gas-guzzler ban
- Gas-guzzler tax
- Efficiency incentive tax
- National inspection and maintenance program
- Scrappage of fuel-inefficient cars
- Subsidized industry research and development

Automobile use policies

- Improvements to traffic flow
- Stricter enforcement of 55 mph speed limit
- Deregulation of gasoline and diesel fuel prices
- High gasoline taxes
- Gasoline rationing
- Carpooling and vanpooling promotion and priorities
- Public transit expansion
- Subsidized telecommunications networks
- Public education and appeals
- Auto use controls
- Annual VMT-based tax

Transition to Alternate Sources

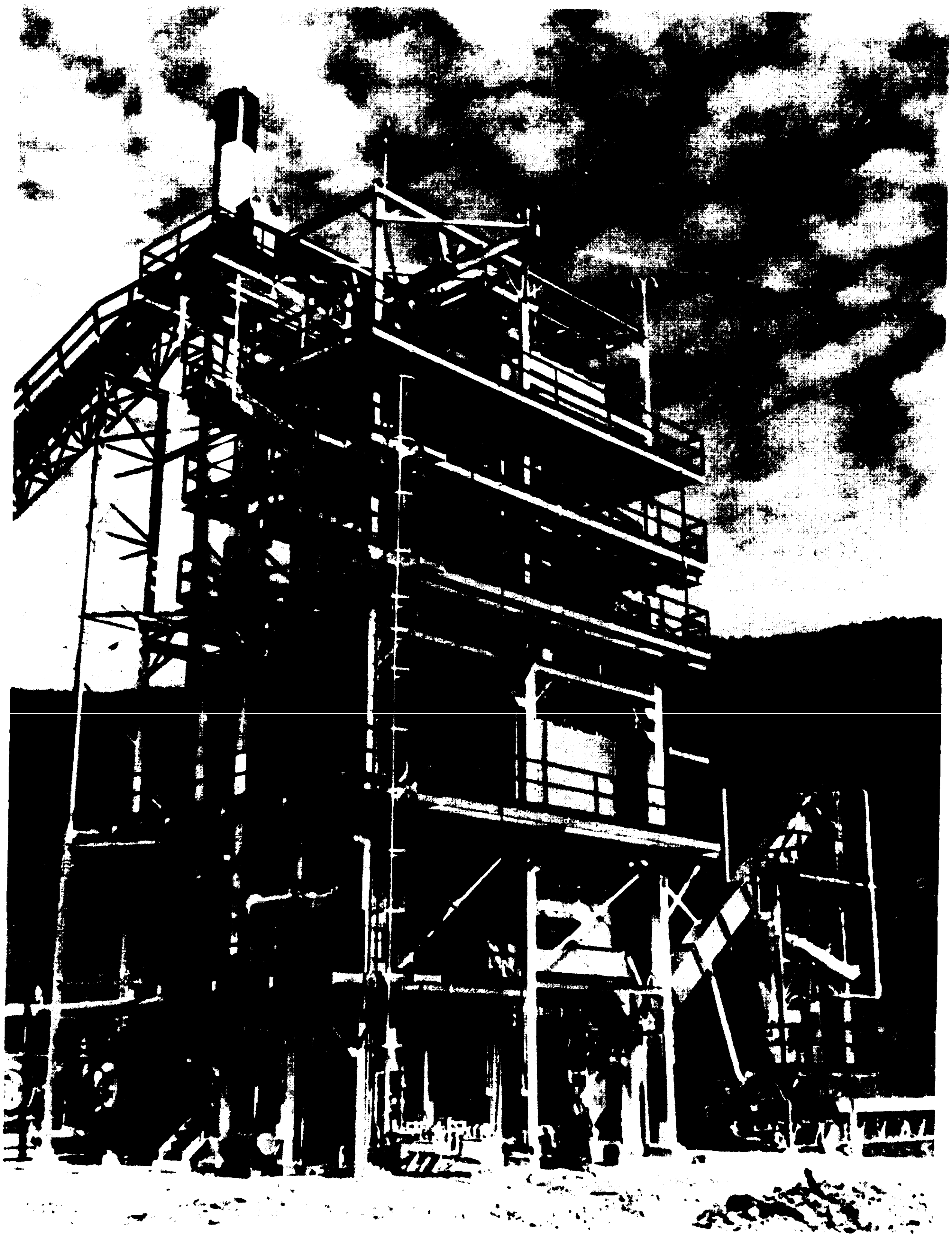
Policies to stimulate transition to alternate energy sources for automobiles were divided into three groups according to the type of energy source promoted: synthetic liquid fuel, alcohol fuels, and electric- or hybrid-vehicles.

Synthetic fuels from coal or shale oil would require the least change in the automobile and energy systems. Although the technologies for producing liquids from coal and shale oil are quite different, the end product from either would be a synthetic crude oil. Such a product could then be refined into gasoline, diesel fuel, or any other suitable liquid through conventional petroleum-refining processes.

Neither coal-based nor shale-based synfuels technology now exists on a commercial scale in the United States. Commercial technologies now employed in other nations (notably South Africa) produce fuel that is substantially more expensive than gasoline derived from petroleum. Uncertainties about the eventual cost of production, about the technology to mitigate environmental damage, and especially about the future price of petroleum-based gasoline are presently the main barriers to development of these alternatives. Policies to encourage the development of synfuels must assure developers that the fuels they eventually produce will be marketable and that they will receive a reasonable rate-of-return on investment. The policies that could be adopted to stimulate development of production facilities and marketing of synfuels are listed in table 47.

A second major alternative to gasoline is a fuel composed of alcohol or a blend of gasoline and alcohol. Several alcohols are under consideration, but the most likely candidate is methanol (methyl alcohol). Several experiments with methanol as an automobile fuel are now underway in the United States and in other countries. Methanol can be derived from coal, from natural gas, from organic wastes, and from biomass.

Methanol may be used as a substitute automobile fuel in two different *ways: as* a mixture or blend, i.e., the “gasohol” alternative, and as a “true” replacement for gasoline. Some proponents suggest that the former strategy could be employed as a precursor to the latter.



Oil Shale Retorting

Photo Credit U S Department of Energy

Table 47.—Policy Options to Promote Synfuels

Strategy	Policy measures
Regulation	• Relax environmental standards for coal mining, shale oil mining, and synfuels processing. • Regulate synfuels industry as a public utility, guaranteeing a reasonable rate of return. • Deregulate prices of oil and remove gasoline price ceilings.
Taxes and subsidies	• Increase investment tax credits for synfuels producers. • Guarantee Government price support for syncrude. • Federal Government purchase and resell sync rude. • Loan guarantees. • Direct loans.
Government RD&D	• Accelerate oil shale and coal liquefaction RD&D with main emphasis on commercialization. • Support research to reduce potential environmental impacts of synfuel processing.
Government commercialization	• Establish Government owned and operated synfuels industry (i.e., similar to TVA).

SOURCE Adapted from SRI p I 20

Because methanol cannot be easily mixed with gasoline in the present fuel distribution system, policies aimed at promoting a methanol distribution and storage system need to be considered as well. Methanol would have to be transported and stored in separate facilities. If gasohol blends were the chosen alternative, the two fuels would be mixed at the pump.

Table 48 shows a range of policy options to encourage the production and use of alcohol-based automobile fuels.

A third alternative, which may be pursued in conjunction with either or both of the previous

Table 48.—Policy Options to Promote Alcohol Fuels

Strategy	Policy measures
Regulation	• Set different emissions and performance standards for automobiles using alcohol or alcohol-gasoline blends. • Require that an increasing proportion of new automobiles be designed to use a alcohol-gasoline blends. • Require automobile fuel distributors and retailers to handle alcohol.
Taxes and subsidies	• Subsidize automobile industry development of alcohol-gasoline or pure alcohol engines. • Subsidize purchase of autos using gasoline-alcohol fuels. • Provide tax credit for retrofitting used cars to make use of blended fuels. • Subsidize development of alcohol fuel conversion, distribution, and storage systems. • Purchase and operate a Government-owned fleet of alcohol or alcohol-gasoline fueled automobiles.
Government RD&D	• Accelerate RD&D on integrating alcohol into existing fuel distribution systems. • Accelerate RD&D on long-term alternative automobile engines.

SOURCE Adapted from SRI p I 22

courses of action, is to encourage a shift to electrically powered automobiles. Assuming that electric cars are a viable and economic alternative to conventionally powered automobiles, electricity itself is readily available from any number of energy-conversion processes.

Electric automobiles (and hybrid-vehicles) have the general advantages of making very efficient use of electricity and, in comparison with conventional autos, they may be more environmentally benign. At present, however, neither battery- nor electric-car technology is sufficiently advanced to produce an electric car that is, on the whole, competitive with conventional automobiles in terms of range, performance, and cost.

The major stakeholders involved in a shift to electric automobiles include automobile users, the automobile manufacturers and after-markets, and, to some extent, the fuel distribution system. Policies to promote electrics must focus on the activities and interactions among these three major groups.

Table 49 summarizes policy options for encouraging the development and use of electric or hybrid automobiles. (In general, hybrids are considered a less well-developed technology than pure electrics. However, most of the same policy options are applicable.) As a second way to promote electric-vehicles, table 49 also lists complementary policies to discourage the use of conventional automobiles.

Table 49.— Policy Options to Promote Electric Automobiles

	Policy measures	
Strategy	**Policies encouraging electric automobiles**	**Policies discouraging use of conventionally powered automobiles**
Regulation	• Require that a proportion of new auto sales be electric automobiles by a certain year. • Change utility pricing to encourage use of off peak times to recharge electric autos. • Relax certain standards for electric automobiles (e. g., safety). • Give electric vehicles credit for being low or non petroleum users in computing corporate average fuel economics.	• Increase restrictions on air emissions of conventionally powered automobiles, especially in urban areas. • Establish restricted zones for conventional automobiles. • Reduce performance on conventional cars • Allocate petroleum.
Taxes and subsidies	• Subsidize automobile industry development of electric automobiles and batteries. • Subsidize parts or all oft he cost of electric automobiles (e. g., insurance, fuel, maintenance, etc.). • Purchase and operate a Government electric-automobile fleet. • Subsidize purchases of electrics for commercial automobile fleets.	• Increase taxes on conventional autos. • Increase cost of access to highways and parking for conventional automobiles. • Increase taxes on conventional automobile fuels.
Government RD&D	• Accelerate Government RD&D on batteries, electric automobiles, and hybrid automobiles.	

SOURCE Adapted from SRI, p 1.23

EFFECTS

The analysis of policy alternatives concentrated on two types of outcomes—effects and impacts. Effects were defined as the primary and intended results of pursuing a policy action, i.e., outcomes directly related to the objectives of the policy. Impacts were defined as secondary or unintended results, falling in areas not directly related to policy objectives.

As an illustration of the distinction between effects and impacts, consider the energy policies discussed in this chapter. The objective of these policies is either to conserve petroleum or to promote the use of alternate energy sources. The effects of these policies, therefore, are the amount of petroleum saved or the degree to which other forms of energy are substituted. The impacts of these policies are the other results that follow in areas such as environmental pollution, safety, mobility, cost, and so on. Effects are, by definition, positive outcomes since every policy can be presumed to attain its objective to a greater or lesser degree. Impacts may be positive or negative. For example, the 55 mph speed limit was implemented to conserve petroleum, but also is credited with significant reductions in highway fatalities (a positive impact). A negative impact of this policy was the increase in trip times.

The overall worth of a policy must, be judged by weighing advantages against disadvantages and striking some suitable balance. During the assessment, this process was carried only part way to completion. An attempt was made to identify effects and impacts and, where possible, to express them in quantitative terms. Where quantitative measurement was not possible, estimates were made of the direction and general magnitude of possible outcomes. However, no attempt was made to balance effects against impacts in an overall evaluation of policies or to analyze the more subtle interactions between effects and impacts.

The effects of the energy policies examined are presented under three headings:

1. Effects of Petroleum Conservation Policy Case,
2. Effects of Conservation Policies, and
3. Effects of Transition to Alternate Sources.

In certain instances, results of the analysis of the Petroleum Conservation Policy Case have been used as supporting material in the discussions of the effects and impacts of individual policies. The findings presented in this section are synopses and highlights of more detailed information in the contractors' reports. Impacts are considered separately in the next section.

Effects of Petroleum Conservation Policy Case

The reduced automobile fuel consumption estimates for this policy case derive from four basic policies:

1. Higher fuel-economy standards (4o mpg by 2000),
2. Fuel-economy minimum (ban on autos with fuel efficiency under 21 mpg after 1985),
3. Excise tax on fuel-inefficient autos (gas-guzzler tax of up to $3,856 after 1985), and
4. Increased gasoline tax (an additional 18 cents per gallon over the Base Case in 2000).

The effects of these policies would be substantial. As shown in table 50, auto fuel consumption in 1985 would be reduced to 4.6 MMBD, about 5 percent less than in the Base Case. By 2000, automobile fuel consumption would be down to 3.4 MMBD or 29 percent below the Base Case. These savings would be achieved without a major reduction in auto VMT—only 3 percent. ' The fuel-economy of the average car in 2000 would be nearly 21/2 times that of its 1975 counterpart.

[7] About 5 percent of the total VMT would be in electric vehicles. This mileage has not been used in computing mpg statistics. See *Sydec/EEA*, pp. IV-54 to IV-58.

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Table 50.—Automobile Energy Demand, Petroleum Conservation Case

	Actual	Base Case[a]		Petroleum Conservation Case		Rationing Case
	1975	1985	2000	1985	2000	2000
Automobile VMT (trillion). .	1.03	1.43	**1.80**	1.42	1.74	**1.53**
Diesel penetration (percent of new car sales)	(b)	10	**25**	25	60	(d)
New car fuel economy (mpg)						
EPA standard@)	None	27.5	27.5	27.5	40.0	(d)
Attained— EPA certification value.	15.6	28.5	29.4	31.5	40.0	(d)
Attained—actual driving	14.0	23.2	25.0	25.6	34.0	(d)
Fleet fuel economy (mpg)						
Attained— EPA certification value.	15.1	24.0	**28.5**	**24.8**	**37.6**	(d)
Attained—actual driving	13.6	19.4	**24.6**	**20.3**	**32.1[e])**	(d)
Annual auto fuel consumption						
Billions of gallons. ... , .	76.0	**73.9**	**73.3**	70.1	51.7	45.8
MMBD equivalent	5.0	**4.8**	**4.8**	4.6	3.4	3.0
Percent of domestic consumption	30.6	**23.9**	**21.4**	23.1	16.2	14.6

[a]Base Case "A" as defined in chapter 3.
[b]Insignificant.
[c]The EPA certification value for a particular car is the weighted average of performance in the EPA urban cycle (55 percent) and rural cycle (45 percent).
[d]Quantitative estimates not available. Presumably new cars would average more than in the Petroleum Conservation Case and more than 60 percent would be diesels
[e]Excludes electric vehicle VMT.
SOURCE: Adapted from *Sydec/EEA*, p. IV-56

Also shown in table **50** are the results of the analysis of long-term, mandatory rationing. This policy, which would be implemented gradually between 1985 and 2000 to control the allocation of auto fuels between diesel and gasoline autos, is discussed later. Compared to the Petroleum Conservation Policy Case, rationing could reduce auto fuel consumption to 3.0 MMBD in **2000,** or **6** gallons per week per car. The table indicates that auto fuel consumption in **2000** might be only 14.6 percent of total domestic consumption; however, if the situation were severe enough to warrant rationing, other sectors would likely be forced to reduce their consumption more than anticipated here.

Additional effects of this policy case relate to the transition to alternate energy sources. It is believed that in 2000, alternate fuel utilization might reach 3.75 MMBD (as opposed to the 2.75 MMBD envisioned for the Base Case). Up to 11.5 million electric vehicles might be on the road; they would account for approximately 5 percent of the VMT. These and other effects are explored further under the separate policy discussions which follow.

Effects of Conservation Policies

This analysis focuses on four individual policies, each designed to promote greater fuel conservation by the automobile system. The four considered are:

1. Higher fuel-economy standards, which represent a strengthening and extension of the present EPCA policy,
2. Increased gasoline taxes to raise the price of gasoline and thereby discourage unnecessary driving,
3. Free-market pricing and deregulation to let petroleum prices rise as supply decreases, thereby providing additional disincentives to automobile use, and
4. Rationing, either as a short-term response to an embargo or as a long-term measure to impose a ceiling on consumption of motor fuel.

Higher Fuel-Economy Standards

Imposition of higher fuel-economy standards for automobiles is an important policy option to counterbalance the projected growth in automobile travel between now and 2000. The automobile fleet traveled about 1.07 trillion vehicle miles in 1976. Base Case projections indicate that by 1985 auto travel will increase to 1.43 trillion vehicle miles and by 2000 to 1.80 trillion vehicle miles. This growth will have important implications on the magnitude of future auto fuel consumption and on the merits of further increases beyond the **1985** EPCA fuel-economy standards.

In **1976,** automobiles consumed **5.2** MMBD of fuel. In 1985, it is expected that consumption will have fallen slightly to 4.8 MMBD, Assuming that the current EPCA new car standard of 27.5 mpg for 1985 remains in effect until 2000, auto fuel consumption would also be 4.8 MMBD. However, if the standard were raised gradually to 35 mpg (as in Base Case B) or to 40 mpg (as in the Petroleum Conservation Case), auto fuel consumption could drop to 4.2 and 3.4 MMBD, respectively, assuming the appropriate supporting policies are also instituted, Each of the higher mpg levels assumes a higher penetration of diesels into the market. The Petroleum Conservation Case assumes higher fuel and excise taxes and an mpg floor; it also assumes that 5 percent of the VMT will be electric cars.

However, the magnitude of the additional savings to be achieved by further raising the EPCA standard tend to have a decreasing value as automobile fuel efficiency improves. For example, for a motorist traveling 10,000 miles annually, shifting from a 12-mpg car to a 27.5-mpg car will save 470 gallons per year. A shift from a 27.5-mpg car to a 40-mpg car saves only 114 gallons. Moreover, the incremental cost of achieving these fuel-economy improvements may increase. However, when consideration is given to the projected growth in fleet auto travel, higher fuel-economy standards can still produce meaningful savings. It is well recognized that there are practical limitations on continuing fuel-economy improvements. It is not known what the maximum auto fuel efficiency could be, but improvements up to 35 mpg and eventually up to 40 mpg by the year **2000,** are thought possible. [8] Several cars listed in EPA's **1978** *Gas Mileage Guide* attain over 35 mpg, and at least three makes could meet a 40-mpg standard. [9]

Under current EPCA standards, the total fuel consumed by automobiles is expected to start declining slowly in a few years, as the fuel economy of the fleet as a whole begins to offset the growth in VMT. Just how soon the peak will be reached and how much motor vehicle fuel consumption will then decline depends, in part, on the fuel-economy standards imposed on light trucks. Light-truck sales, which were 15 percent of auto sales in **1965,** rose to 31 percent of auto sales in 1976. The concern is that many households may be substituting lightweight trucks for automobiles. To the extent that this is the case, fuel-economy gains achieved by shifting to more energy-efficient autos may be offset by the sales of lightweight trucks. Standards for light trucks go into effect for the 1979 model year and have been established for the 1980 and 1981 model years. [10]

Thus, under current EPCA standards, automobile fuel consumption could remain within the range of 4 to 5 MMBD through the year 2000. To bring consumption down further, more stringent fuel-economy standards would be necessary. These higher standards would have the effect of accelerating the present trend toward production and purchase of the smaller compact and subcompact automobiles, some of which can already achieve **40** mpg. However, there are factors that could limit this trend. One is the willingness of automobile owners to switch to smaller cars, which may have less comfort, performance, and utility than vehicles now in use. Another potential limiting factor is the ability of the automobile industry to respond. The capital requirements to accomplish the conversion to smaller, more fuel-efficient cars are large and may pose a threat to the continued viability of one or two domestic manufacturers.

An additional fuel-economy policy would be to ban the sale of any car that did not meet a specified minimum mpg. This would save more

[8] *Sydec/EEA*, pp. IV-5, 48, and 54

[9] U.S. Environmental Protection Agency and U.S. Department of Energy, *1978 Gas Mileage Guide*, Second Edition (Washington, D.C.: U.S. Government Printing Office, February 1978).

[10] *Federal Register* 42 (Mar. 14, 1977): 13807; *Federal Register* 43 (Mar. 23, 1978): 11995-12014, "Light Truck Fuel Economy Standarcis, ' Final Rules

fuel than the current EPCA standards alone and would force an earlier shift away from large fuel-inefficient cars. Proponents of the ban argue that the expected increase in gasoline price would not by itself induce new car purchasers to buy more efficient vehicles and that stronger measures are needed. They also contend that the inconvenience of reduced size would be relatively slight. Most vehicles on the road today are oversized, given the low average occupancy. In addition, most trunk and cargo space is normally empty.

Opponents of the mpg floor fear that this measure would abolish the "family-sized" car needed by large families. They argue that the number of cars eliminated is relatively small (depending on where the floor is set), that the fuel savings would not be appreciable, and that persons who today own large, inefficient cars would be encouraged to keep them even longer.

Gasoline Taxes

Since the fuel economy of new cars is already mandated by EPCA, an increase in motor fuel taxes would serve mainly to reduce consumer demand for fuel. Consumers would react by buying more efficient new cars, by scrapping older cars sooner, by driving less, or by carpooling or using transit where available. The effectiveness of additional gasoline taxes depends on how large they are and when they are implemented. The current taxes on gasoline range from 9 to 14 cents, depending upon the State. They are intended as revenue-raisers, rather than gas-savers.

Several factors could limit the effectiveness of a gasoline tax increase. First, even a tax increase as large as the 50 cents originally proposed in the National Energy Plan, if implemented gradually over a 10-year period, would produce only moderate annual increases in real gasoline prices. Small incremental price increases are not seen as serious deterrents to gasoline consumption, particularly in a period in which incomes may be rising as fast as the price of gasoline. Second, doubling the price of fuel would raise the total cost per mile of driving by only about 20 percent. (See figure 27.) Third, over time the increasing fuel efficiency of the average car will compensate for the higher fuel costs, To be effective, a tax increase would have to be large and immediate.[11]

There are disadvantages associated with high gasoline taxes. They constrain mobility. They are inflationary and regressive. They remove large sums of money from the economy. They produce no incentive for producers to expand supplies. To alleviate some of these undesirable impacts, tax rebates have been proposed.

The first major consumer benefit expected of rebates is compensation for the regressiveness of the tax. The success of this would depend upon how the rebates are made and how quickly they are offered. In addition, rebates could put back into the economy the billions of dollars removed by the tax (close to $40 billion could be removed by a 50-cent-per-gallon tax on automobile driving alone). It is also thought that rebates could make the tax more politically acceptable. Finally, it is believed that any increase in driving caused by the refund would be negligible, since the change in total income caused by the rebates would be relatively small.

The extent to which aggregate gasoline consumption and automobile travel can be reduced by gasoline price increases is difficult to measure since consumer reaction to higher gas prices has been tested only in a limited range. The data that are available indicate that small increases in the price of gasoline are ineffective in achieving significant reductions in VMT and, therefore, in fuel consumption. The analysis carried out in the Petroleum Conservation Case indicates that the 10-cent gas tax would produce a decline in total VMT of about 3.2 percent from the Base Case. This assumes a price elasticity of – .22, which is an indication that, once discretionary travel is eliminated through increases in gasoline price, further reductions will be more and more difficult to achieve.[12] Table 51 shows three recent assessments of the projected gasoline savings that could be realized from the gasoline tax program proposed in the original National Energy Plan.

The penetration of electric vehicles into the auto fleet by the year 2000 would also serve to reduce liquid fuel consumption. Since it is

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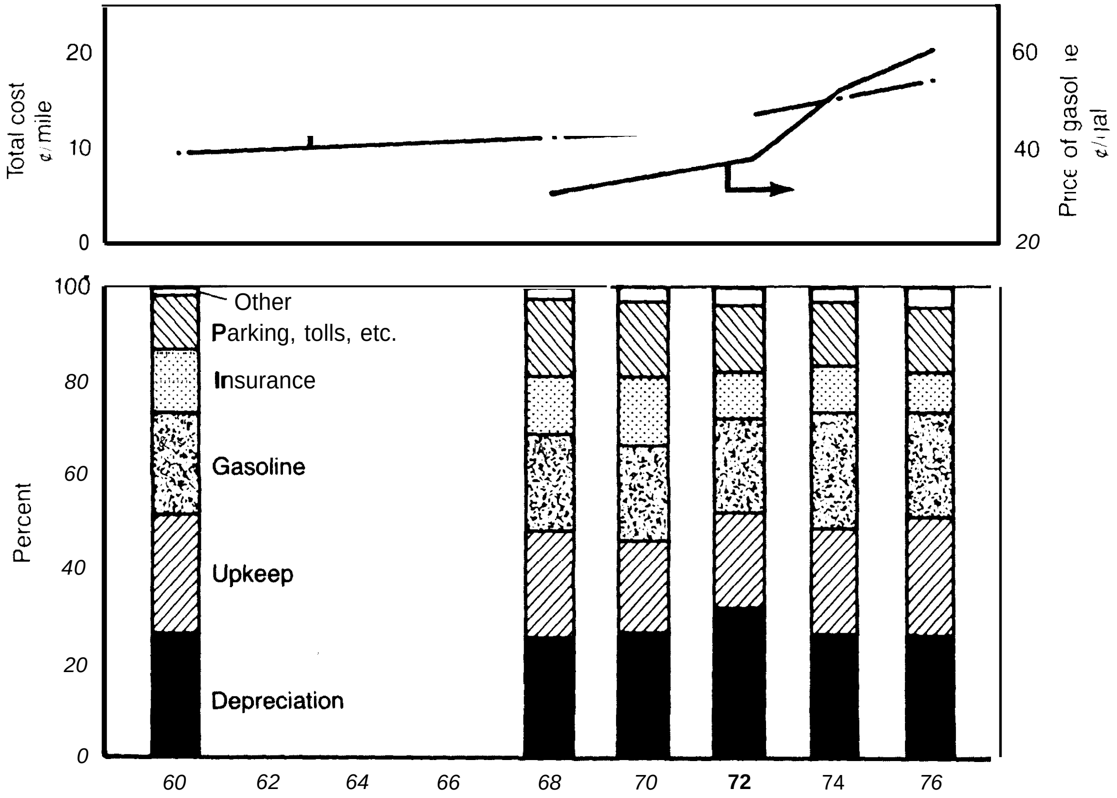
[11] U.S. Congress, Office of Technology Assessment, *Analysis of the Proposed National Energy Plan* (Washington, D. C.: U.S. Government Printing Office, August 1977), p. 90.

[12] SRI, p. 1-13.

Figure 27.—Cost of Operating a Suburban-Based Automobile (in current dollars)



SOURCE: U.S. Department of Transportation, Federal Highway Administration, *Cost of Owning and Operating an Automobile, 1976*

Table 51.—Projected Gasoline Savings Under the National Energy Plan Standby Gasoline Tax (thousand barrels per day)

	1980	1985	1990
Administration[a]	200	350	400
Congressional Budget Office			
Partial tax[b]	—	65	200
Full tax[c]	65	150	260
Sweeney			
Without gas-guzzler tax	140	370	450
With gas-guzzler tax	150	490	740

[a]The Administration has estimated that these savings would occur as a result of the imposition of the tax. It has also estimated that a saving of 830,000 barrels per day by 1985 is necessary to avoid triggering the tax.
[b]Assumes a tax schedule of 20 cents in 1985 and 45 cents in 1990.
[c]Assumes the gasoline tax is imposed at the maximum rate—that is, 10 cents in 1980, 35 cents in 1985, and 50 cents in 1990.
SOURCES: Administration, Executive Office of the President, *The National Energy Plan*, April 1977; Congressional Budget Office, *President Carter's Energy Proposals: A Perspective*, Stanford University, James Sweeney, *The Impact of the President's Proposed Gasoline Tax and Gas Guzzler Tax on Gasoline Consumption*, 1977.

assumed that electricity is not taxed under the Petroleum Conservation Case, VMT by gasoline-powered vehicles would be reduced both because of electric-vehicle use and because of the effects of the gasoline tax.

Imposition of a gasoline tax would also spur the production and sale of alternative fuels. In the Base Case, shale oil products (which are assumed to be exempt from taxes) are expected to become competitive with natural crude oil products by 1985. Coal-derived liquids would become competitive in about 1995. The effect of additional gasoline taxes would be to move forward the dates at which shale oil and coal liquids become competitive to 1982 and 1985, respectively. Alcohol and gasohol would become competitive somewhat earlier.

As the after-tax price of gasoline approaches the price of alternative fuels, the reluctance to invest in alternative fuel plants would probably diminish. On the other hand, environmental regulations and water availability will become increasingly important constraints. The net effect of improved price competitiveness created by a gasoline tax could raise total alternate fuel production levels up to 3.75 MMBD by the year 2000, about 35 percent above the Base Case projection of 2,75 MMBD.

Free-Market Pricing

The existing Federal ceilings on the price of gasoline are a few cents above current market prices. Free-market pricing would remove these ceilings. As petroleum demand grows and supplies become scarcer, the price would rise to progressively higher equilibrium points. It is believed that higher prices would reduce consumer demand and provide an incentive for producers to expand supplies by searching for new sources or by continuing to pump oil out of wells as they become less profitable.

Photo Credit U S Department Of Energy

Allowing the gasoline market to seek its own unimpeded price level would mean abandoning the present Federal Government policy of regulating petroleum prices. Under the Emergency Petroleum Allocation Act of 1973, a four-tier price system was established. The lowest prices (first tier) apply to "old oil, " defined as oil from existing wells up to the levels that were produced in the base year of 1975. The next lowest prices (second tier) apply to "new oil, " defined as oil produced from wells drilled since 1975 or oil obtained from existing wells in excess of 1975 production levels. The next higher prices (third tier) apply to oil from stripper wells, which are wells that produce no more than 10 barrels per day. During the fall of 1977, Congress established a fourth price tier to be applied to Alaskan oil. This sets the price of Alaskan oil at the price of imported oil (including the price of entitlements) and makes Alaskan oil the highest priced domestic source.

This pricing scheme for oil was designed with two major objectives in mind: to keep the price of oil down, thereby protecting the consumer from higher prices and limiting profit levels of oil producers, and to encourage exploration for and production of oil from domestic oil sources. The need to protect consumers is based on the recognition that oil prices on the world market are set by the OPEC nations and that these prices are considerably greater than the cost of producing oil from wells that existed before the fourfold price increase of oil in 1974. This is the rationale for the distinction between "old oil" and "new oil" in the existing oil price regulations. It is recognized, however, that keeping prices low encourages consumption.

Deregulation of oil prices would preserve the second objective of present oil-pricing policy, encouragement of domestic exploration. However, it would conflict with the objective of consumer protection and reduction of high profit levels to domestic oil producers who are able to obtain oil at low cost from existing wells.

Opposition to extending the market approach has developed on several grounds. First, the price set by OPEC does not reflect the normal market equilibrium price nor does it have any relation to the cost of production. Second, expert opinion varies widely on whether freeing oil prices from all controls would yield significant additional supply from new and existing sources. Third, there are questions about the extent of economic disruption that might be caused by decontrol. The resulting higher prices would be a heavy economic burden on auto-dependent people with low and moderate incomes.

Rationing

The two approaches to fuel conservation discussed above are based on the premise that drivers will use less fuel because it costs more. Rationing is a mandatory approach that places a limitation on the amount of fuel allocated to a vehicle or a driver. Some rationing approaches would allow high fuel users to be able to purchase additional gasoline, but at significantly greater cost.

The plan proposed by the Ford Administration would have allowed users to purchase up to a specified amount of gasoline at the normal price, A large tax of 50 cents or more would be assessed on additional amounts purchased. Drivers not requiring their full quota of untaxed gas could sell the rights to this gas to other drivers. The plan of the Carter Administration would allow the transfer of ration rights, but would place an absolute ceiling on the total amount of gasoline available to all automobile drivers. Special classes of users and trucks would receive larger quotas. [14]

If a rationing plan limited individual vehicles or drivers to specified quotas, motorists could compensate in several ways. It is believed that the primary response would be a shift to more fuel-efficient automobiles in order to maintain normal travel patterns. Some drivers might also respond in other ways to conserve fuel—by shifting to carpools or by eliminating certain trips, either altogether or by shifting to transit. The exact nature of these responses and any inconvenience to the motoring public would depend upon how the rationing was carried out, the extent to which special exceptions or user classes were permitted, and the rate at which the ceiling was lowered. Ideally, the ceiling would be lowered at a measured rate, designed to give consumers adequate notice to purchase more fuel-efficient cars and avoid the consequences of a fuel limitation.

[13] *Sydec FEA*, p. IV-58.

[14] *Federal Register* 43...28133-28168.

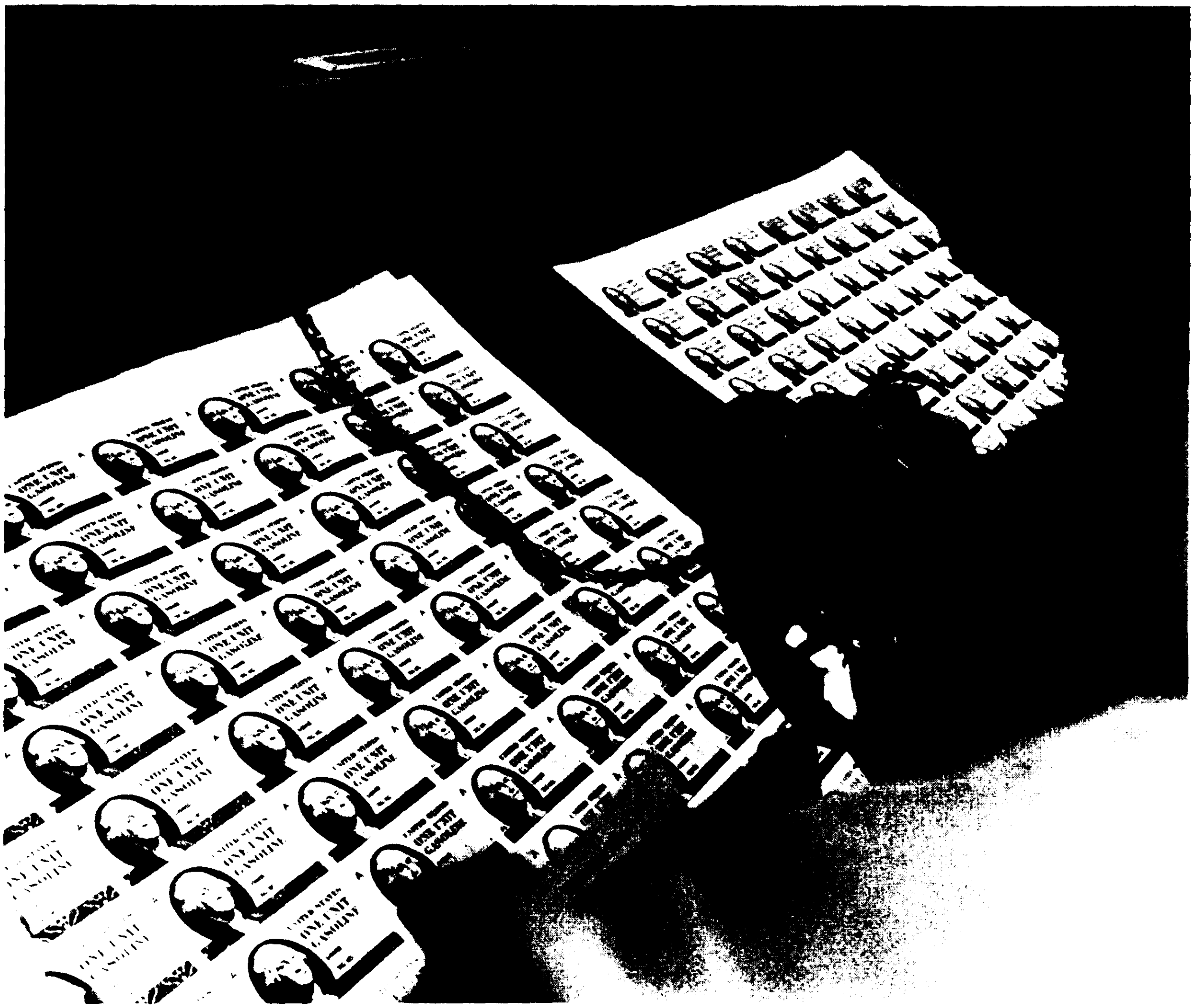


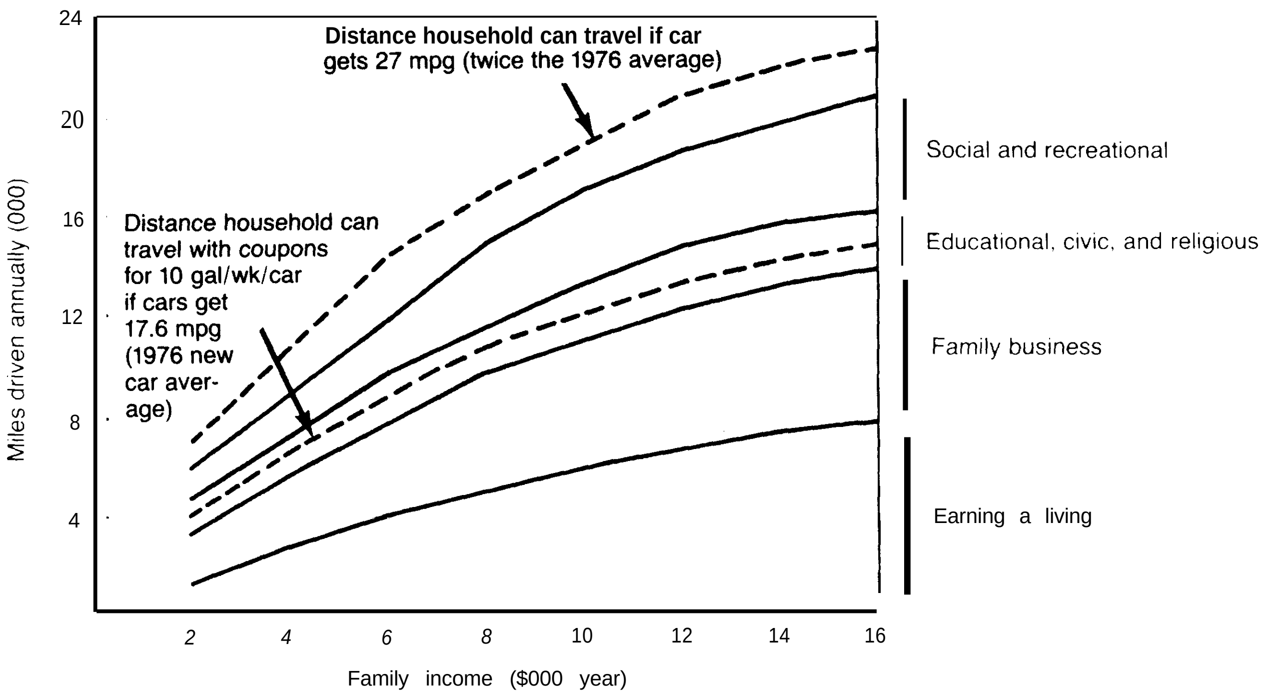
Photo Credit U S Department o/ Energy

A rationing program would have different effects on each segment of the population. For example, rural dwellers typically drive longer distances than urban dwellers. Thus, farmers would probably suffer more than office workers, unless exceptions were built into the administration of the rationing program, Moreover, owners of large, fuel-inefficient cars would be more severely affected than owners of fuel-efficient cars. Figure 28 shows the effect on mobility by trip purpose of a rationing plan that limits households to 10 gallons of gasoline per car per week. If the household were using a 27-mpg car, mobility would not be significantly affected. However, a household using a 17.6-mpg car would have to cut back sharply on trips (probably nonwork trips) or use public transit to get to work.

Under the Base Case assumptions, the unconstrained fuel demand of the Nation as a whole would rise substantially, as would the need for imported petroleum. In 1985, imports would account for 50 percent of domestic consumption. In 2000, imports would amount to 68 percent, assuming that that amount of oil was available on the world market. If, after 1985, imports were restricted by policy to 50 percent[15] of consumption, allowable imports would fall to 7.o MMBD. Maximum consumption would be limited to 14 MMBD, instead of 22.4 MMBD if demand were unconstrained. (See figure 29.) If the burden of this reduction fell equally on all sectors of the economy, total automobile petroleum consumption would be restricted to 3.0

[15] The 50-percent level is arbitrary and was chosen for illustrative purposes only.

Figure 28.—Miles Driven Annually, by Family Income and Trip Purpose



SOURCE Sydec *EEA* p IV-62

MMBD in 2000. This would amount to an allocation of about 6 gallons per week per car, assuming a fleet of 148 million vehicles. The Base Case assumes the average car would require 9.6 gallons per week in 2000; current usage is estimated at 15 gallons per week.

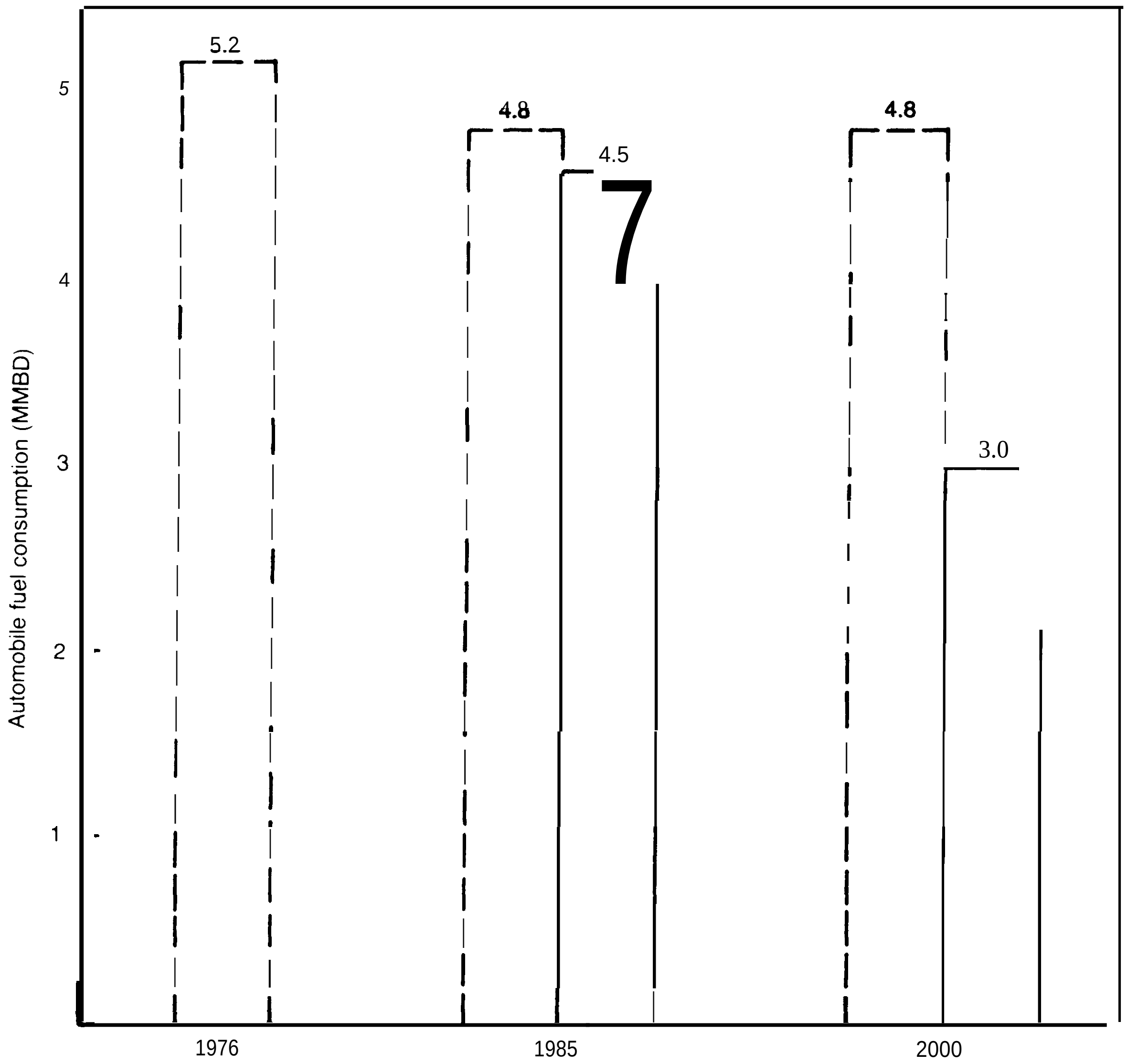
A rationing program implemented gradually over a long period would allow petroleum users to change their automobile ownership and usage patterns to minimize adverse impacts. Most of the responses previously outlined would be adopted in varying degrees by different population segments. This is not to say that mobility would remain unrestricted, since there would not be the freedom of choice that exists today. Overall VMT would drop by about 15 percent from the Base Case to 1.53 trillion miles per year. It is probable that the long-term impacts would be severe for- travel-dependent industries. Businesses such as resorts and drive-in restaurants might survive short-term disruptions but not a long-term erosion of their revenue source.

If the rationing system involved white market (transferable) coupons, the wealthier segments of society would find their mobility less restricted than other groups. Also, with a white market, there would be a transfer of income from high fuel users to low fuel users. Compared to the impacts of deregulation, consumers and not producers would benefit from the higher price. However, without the added income, producers would not have the incentive to expand supplies.

Effects of Transition to Alternate Energy Sources

The need to make a transition from petroleum-based fuels to alternate energy sources for all sectors has become increasingly evident in recent years. The demand for petroleum has grown so great worldwide that what were once thought of as very large *reserves* are now viewed as inadequate to meet demand —possibly as early as the 1980's or 1990's. Other projections (based on the economic viewpoint that the cost of petroleum becomes prohibitively high because of scarcity) conclude that the point

Figure 29.—Effects of Gasoline Rationing on Automobile Fuel Consumption



Assumptions
- Oil imports restricted to 50% of total oil consumption.
- 1985 limit equivalent to 12 gallons per week per car.
- 2000 limit equivalent to 6 gallons per week per car.
- Fuel consumption of light-duty trucks would also be limited in same proportion as cars.

— — — Without rationing

— Limit if rationing is imposed

SOURCE: *Sydec/EEA*, p. IV-60

may be reached in 25 to 50 years.[16] During that period, the demand for petroleum by automobiles is expected to be between 4 and 5 MMBD.

Through stringent conservation, it is estimated that automobile petroleum consumption could be reduced by 10 to 15 percent. However, these savings will be difficult to achieve and will require several years to realize. Even if ag-

[16]MIT Workshop on Alternative Energy Strategies (WAES), *Energy: Global Prospects 1985-2000*; Executive Office of the President, *The National Energy Plan*; U.S. Central Intelligence Agency, *The International Energy Situation: Outlook to 1985*, ER 77-102400, April 1977; U.S. Department of Interior, Office of Energy Programs, *Forecast of Likely U.S. Energy Supply/Demand Balances for 1985 and 2000 and Implications for U.S. Energy Policy* (Springfield, Va.: National Technical Information Service, Jan. 20, 1977).

gressive conservation policies were initiated, they would not solve the long-term problem, but simply postpone it a few years. Since transition to alternate energy sources will take even longer to accomplish, efforts to start the transition must be undertaken soon if these resources are to be available when the supply of petroleum eventually begins to decline.

There are a number of different energy resources that can be used to produce fuels similar to gasoline or diesel fuel, and there are a number of other fuels that can potentiality replace gasoline or diesel fuel for- powering automobiles. Roughly, these alternate energy sources fall into four categories:

- Synthetic liquid fueIs (synfuels): These are liquid fuels that are chemically similar to crude petroleum and that can be refined into automobile fuels. They can be derived from either coal or oil shale. Using these would require little or no change in the automobile fuel distribution system or in engine technology.

- Alcohol fuels: Alcohol (primarily ethanol or methanol) can be used in pure form or i n blends of up to 20 percent or more with gasoline. Ethanol is currently widely used as **a** blend **(2o** percent) in Brazil, and is available in scattered Midwestern U.S. locations. Methanol requires large-scale production facilities. Ethanol, which can be produced in smaller scale plants, is most easily obtained from biomass (i. e., plants, grain, or municipal and agricultural wastes). Alcohol fuels currently cost more than gasoline, but have a higher octane rating. Blended fuels require no changes in auto engines, but neat (pure) alcohol would. Alcohol tends to improve engine efficiency (miles per gallon equivalent) and burns cleaner than gasoline. Principal considerations include price and availability, and the need for special storage and distribution facilities to ensure against water contamination which affects the combustion process. (Chapter 10, Technology, contains more background information.)

- Electricity: A number of U.S. and foreign automobile manufacturers are doing research and development on electrics. Major problems with the current state of electric automobiles include poor performance compared to conventionally powered cars, high initial cost, and limited capacity to store energy.

- Longer term alternatives: A number of different automobile fuel systems have been proposed for the longer term (post-2000), including hydrogen-powered cars, [uel-cell-powered automobiles, and the use of blended fuels based on hydrogen, such as hydrazine. Generally, these technologies are still in their infancy.

Estimates of alternative fuel production and sales for 1985 and 2000 are inherently speculative because there are few facilities now in operation on a commercial scale. Table 52 summarizes several recent production estimates for 2000. The Base Case assumed that alternative fuel production would be about **2.75** MMBD under current policies. While there are high rewards from producing synthetic gasolines from coal or shale oil, the price today is far from competitive with conventional gasoline, and the environmental risks are of great concern. Shale-derived liquids would become price competitive by about 1985 and coal-derived fuels around 1995. The Base Case also assumes that alcohol and gasohol would be part of the **2.75** MMBD (or equivalents) of liquid fuels.

The cost, performance, and market acceptance of electric vehicles are highly dependent on the state of battery technology. At present, battery technology is not adequate for large-scale application in electric vehicles. Although the lead-acid system is readily available and is already in actual use, its high weight, low specific power, and low specific energy sharply limit vehicle range between recharges. Improved batteries will be needed to make the electric vehicle competitive with conventional automobiles in performance and cost.

Table 53 presents several projections of the market penetration of electric and hybrid vehicles in 1985 and 2000. The variation in the range of estimates is indicative of the high degree of uncertainty associated with the development and successful commercialization of advanced battery systems. For this study, it is estimated that the size of the electric vehicle fleet will be

Table 52.—Estimates of Synthetic Fuel Production in 2000 (MMBD)

	Coal liquids	Oil shale	Methanol	Total
Stanford Research Institute	2.0	4.0	4.0	10.0
MIT Workshop on Alternate Energy Strategies.	0-1.3	2.0	—	2.0-3.3
Department of Transportation. . .	0.9	3.4	·	4.3
Department of Interior	0.7	2.0	—	2.7
EXXON	—	—	—	0.5
Sydec/EEA.	0.75	2.0	—	2.75

SOURCES: Stanford Research Institute, *Impacts of Synthetic Liquid Fuel Development, Vol. I: Analysis*, prepared for U.S. Energy Research and Development Administration, ERDA 76-129/1; MIT Workshop on Alternative Energy Strategies (WAES), *Energy: Global Prospects 1985-2000;* U.S. Department of Transportation, *Fuels and Materials Resources for Automobiles in the 1980-1990 Decade*, 1976; U.S. Department of the Interior, *Forecast of Likely U.S. Energy Supply/Demand Balances for 1985 and 2000 and Implications for U.S. Energy Policy;* EXXON Corporation, *Energy Outlook 1977-1990*, 1977.

negligible in 1985. By the year 2000, it is projected that, with the incentive of policies such as those in table 49, the size of the electric vehicle fleet could fall midway between the high and low estimates of table 53—or about 11.5 million. Estimates of hybrid-vehicle penetration are speculative. The currently limited Federal support for all-electric vehicles is an indication that projections of hybrid-vehicle penetration may be overly optimistic.

Comparisons of the relative efficiency of conventional automobiles with battery-electric- and hybrid-vehicles are difficult because size and performance differ significantly in current designs. For example, if present conventionally powered autos were designed for reduced performance comparable with currently available electric and hybrid vehicles, their energy consumption in terms of Btu's per mile would be quite similar. However, most of the potential electric- and hybrid-vehicles are somewhat smaller than today's diesel and gasoline cars and hence show better energy utilization. (See table 54,)

Table 53.– Projections of Electric Vehicle Penetration

	1980	1985	1990
Projection of new electric car sales			
ERDA —transportation energy conservation	22,500	500,000	2 million
ERDA—market oriented program planning study.	—	10/0	21 0/0
Math-Tech, Inc.	40	4,000	8,800
Projection of electric vehicle fleet			
ERDA—transportat ion energy conservation	22,400	1 million	18 million
ERDA—market oriented program planning study.	—	45,000	5.2 million
Math-Tech, Inc.	40	9,000	66,400
Projection of electric-hybrid vehicle fleet			
Stanford Research Institute.	—	75,000	500,000

SOURCES: U.S. Energy Research and Development Administration, *TEC Electric Vehicle Scenario*, February 1977; Market Oriented Program Planning Study, memo dated June 20, 1977, from Paul J. Brown, Chairman, Transportation Working Group; Math-Tech, Inc., *Draft Final Report: An Analysis of Federal Incentives to Stimulate Consumer Acceptance of Electric Vehicles*, August 1977; Stanford Research Institute, *Technology Assessment of Alternative Transportation Fuels*, Management Report #15, April 1977

Table 54.—Comparison of Fuel Economies

	Vehicle type	Fuel economy[a]		
		kWh/mi	Mpg	Btu/mi
All electric	Lead-acid 2-passenger	0.44	—	1,502
	Lead-acid 4-passenger	0.79	.	2,696
	Nickel-zinc 4-passenger	0.51	—	1,741
	Lithium-sulfur 4-passenger	0.45	—	1,536
Hybrid ICE/electric[b]	Lead-acid 4-passenger	0.625	29	2,786
	Nickel-zinc 4-passenger	0.45	32	2,247
	Sodium-sulfur 4-passenger	0.476	27	2,470
Conventional ICE	Subcompact	—	34.3	3,644
	Compact	—	28.1	4,448
Diesel	Subcompact	—	42.9	3,235
	Compact	—	35.1	3,954

[a]1 kWh = 3,413 Btu
1 gal diesel = 138.8 10^3 Btu
1 gal gas = 125 10^3 Btu
[b]Hybrid fuel economy assumes that 30 percent of the driving is with a gasoline engine and 70 percent with a battery
SOURCE: *Sydec/EEA*, p. IV-39.

IMPACTS

The primary effects of the policies discussed in this chapter will be conservation of petroleum or development of alternate energy sources. The impacts, defined here as secondary consequences not directly related to policy objectives, will fall in the areas of environment, safety, mobility, cost to the consumer, and capital requirements for the automobile and fuel industries. Not all of these impacts are adverse. There are some important secondary benefits from conserving petroleum and making a transition to new energy sources. This section describes the major impacts that could result from pursuing the energy policies discussed above.

Environment

Impacts of Petroleum Conservation

In the aggregate, automobile emissions are influenced by three principal factors: emission standards, engine types, and vehicle miles traveled. Since none of the fuel conservation policies considered here assumes any change in automobile emission standards, the air quality impacts of conservation will result solely from engine characteristics and vehicle miles traveled. Of these, VMT is expected to have the more powerful influence.

Analysis of the Petroleum Conservation Case, which does not include gasoline rationing, shows very little difference from the Base Case in terms of aggregate automobile emissions. With two exceptions, automobile emissions will be reduced in 1985 and 2000, but only slightly. Table 55 shows the expected national aggregates of four automobile emissions in 1985 and 2000, with and without the adoption of Petroleum Conservation Case policies.

Table 56 is an analysis of the factors that will influence automobile emissions in the Petroleum Conservation Case. For the three criteria pollutants (CO, HC, and NO_x), there would be reductions of 8 to 10 percent in automobile emissions, compared to the Base Case. Nearly all of these reductions are attributable to the decrease in automobile travel brought about by energy conservation measures.

Policies in the Petroleum Conservation Case are expected to lead to a much higher proportion of diesel automobiles in the fleet, as much as 60 percent of new car sales by 2000 (compared to 25 percent in the Base Case). Because diesel engines emit more particulate matter than gasoline engines, the impact of greater diesel use by 2000 would be higher levels of particulates—about 384,000 tons in 2000 because of the high

Table 55.—Air Quality Impacts of Petroleum Conservation Case (million tons per year)

	1985		2000	
Automobile emissions	Base Case	Petroleum Conservation	Base Case	Petroleum Conservation
Carbon monoxide	32.6	32.3	27.3	25.1
Hydrocarbons	3.5	3.4	2.9	2.7
Nitrogen oxides	2.7	2.7	2.9	2.7
Total suspended particulates[b]	0.077	0.140	0.363	0.384

[a]Assumes no change in currently mandated new car emission standards
[b]Includes lead.
SOURCE: *Sydec/EEA*, pp. III-13, IV-64, and supplementary report.

Table 56.—Factors Influencing Change in Automobile Emissions for the Petroleum Conservation Case

	Automobile emissions in 2000 (million tons)			
	Carbon monoxide	Hydro- carbons	Nitrogen oxides	Particulates[a]
Base Case	27.30	2.94	2.90	0.363
Decreased VMT	– 2.18	– 0.23	– 0.24	—
Increased diesels		– 0.06	—	+ 0.021
Petroleum Conservation Case	25.12	2.65	2.66	0.384
Net difference	– 2.18	– 0.29	– 0.24	+ 0.021
Percent difference	– 8%	– 10%	– 8%	+ 6%

[a]Includes lead.
SOURCE: *Sydec/EEA*, pp. III-113, IV-64, and supplementary report

use of diesels in contrast to 363,000 tons with only moderate diesel use.

In contrast with other petroleum conservation measures, gasoline rationing would have a major beneficial impact on air quality. If gasoline and diesel fuel consumption were restricted to about 6 gallons per car per week by rationing in 2000, VMT would drop nearly 15 percent from Base Case projections. The impact, in terms of automobile emissions, would be corresponding decreases in pollutants from automobile exhaust. This would be at least double, and perhaps triple, the reductions expected from any other combination of petroleum conservation policies.

Impacts of Transition to Alternate Energy Sources

The use of electric vehicles to replace gasoline or diesel vehicles would reduce mobile source emissions but would cause some rise in powerplant emissions within the region. Table 57 shows the per-mile emissions of gasoline and diesel vehicles in the year 2000 and the emissions from a coal- or oil-fired generating plant used to supply power for an electric vehicle for 1 mile of travel. As this table shows, the use of electric vehicles necessitates a trade-off of environmental impacts. Vehicle emissions in downtown areas will be reduced, but emissions of NO_x and SO_2 from powerplants within the region will increase. The benefit of trading off CO and HC for NO_x and SO_2, would have to be assessed on a regional basis, taking into consideration the other emission sources in the region. On the whole, however, it may prove technologically easier and economically sounder to control emissions from one or more stationary sources than thousands of mobile sources,

The two most promising synthetic liquid fuels for automobiles come from oil shale and liquefaction of coal. Extensive development of either of these synfuels poses serious environmental problems in the regions where processing and refining facilities are located. Some of these impacts can be reduced or mitigated by careful control of the processing plants and by judicious site selection.

[17]*Sydec/EEA*, p. IV-62.

Table 57.— Electric Vehicle Emissions Compared to Gasoline Vehicle Emissions in 2000

	Gasoline vehicle emissions (composite vehicle) (gm/mi)	Electric vehicle powerplant emissions[a]	
		Coal-fired (gm/mi)	Oil-fired (gm/mi)
CO	3.78	0.012-0.021	.0001
HC	0.461	0.004-0.007	.0001
NO_x[b]	1.139	1.51-2.66	0.649-1.14
SO_2	0.13	2.597-4.57	1.731-3.02

[a]Assumes that powerplant emissions are controlled to EPA New Source Performance Standards
[b]Assumes standard of 1.0 gm per mile from 1981 to 2000.
SOURCE: *Sydec/EEA*, p. IV-66.

The air pollutants produced by a coal liquefaction plant include hydrogen sulfide, ammonia, particulate matter, hydrocarbons, sulfur dioxide, carbon monoxide, and nitrogen dioxide. Other trace materials, such as polycyclic organic matter and heavy metals, may also be present in waste streams. The major sources of these emissions are coal impurities (either offgases or their treatment wastes), fugitive emissions from leaking equipment, airborne particulate from coal handling, and exhaust from combustion of coal.

Large amounts of water are used in the coal liquefaction process for product purification, cooling, steam generation, and sanitary systems. Water demand for a full-scale liquefaction plant is on the order of **50,000** gallons per day. This water, ultimately discharged as waste, requires treatment to remove suspended particulate, ammonia, hydrogen sulfide, trace metals, tars, oils, and phenols.

Two other environmental characteristics of liquefaction are of particular concern: the inherently hazardous nature of organic compounds generated in this process, and the environmental impacts specific to the use of liquefied coal products. Process and waste streams may contain certain organic compounds of a toxic or carcinogenic nature that are hazardous to workers. Plant layout can reduce or eliminate some of these compounds from waste streams. The remaining carcinogenic and toxic organic compounds can be eliminated from gaseous emissions, water effluents, and solid wastes by oxidation and decomposition.

Many of the organic liquids derived from coal are both carcinogenic and toxic (as is natural crude oil), and it is not expected that the products of liquefaction can be rendered wholly inert. Rather, elaborate and rigorous procedures must be developed to ensure that workers and handlers of the liquefaction products are protected from inhalation, skin exposure, or ingestion of these substances. Use of coal-derived fuels and feedstocks may produce new secondary pollution problems during subsequent processing or utilization.

Liquefaction produces a low-ash, low-sulfur fuel that has a high nitrogen content. In fact, liquefaction of coal can actually increase the nitrogen content on a per-Btu basis. To avoid damaging the catalysts in the refinery, some of this nitrogen must be removed before the fuel is refined to gasoline. Unless denitrified, coal-derived liquid gasoline used as a motor fuel can result in higher emissions of nitrogen oxide than gasoline refined from petroleum.

Coal liquids also contain a high proportion of benzene, which has recently been recognized as a carcinogen, Coal-derived gasoline typically contains **5** to **10** percent benzene, in comparison to about 2 percent in gasoline from petroleum. Both EPA and the Occupational Safety and Health Administration (OSHA) are expected to issue regulations pertaining to exposure to benzene in petroleum refining and gasoline handling.

Shale oil can be produced by either of two processes: surface retorting or underground (in situ) processing. Surface processing is characterized by significant land disturbance in mining operations, large volumes of spent shale, relatively high water use, and air and water emissions from retort operations. In situ processing minimizes these impacts but increases the potential for ground water contamination, aquifer disruption, and subsidence or uplifting at the surface.

Gaseous emissions are expected to be greater for surface retorting of oil shale than for underground processing. The primary air pollutants include hydrogen sulfide (which could either be converted to elemental sulfur or the less harmful sulfur oxide), particulate (which can be physically collected or contained), and hydrocarbons (which can be contained or incinerated). Other pollutants include ammonia, nitrogen oxides, carbon monoxide, and toxic trace elements. Control systems are available for these pollutants, but their efficiency and dependability in these specific applications have not been demonstrated.

Many of these emissions do not occur with in situ processing. However, upgrading, refinement, and storage of the product are steps common to both processes and similar impacts will occur. One potential impact specific to in situ processing is the production and release of gaseous pollutants from underground retorting. The effectiveness of techniques to minimize formation of gaseous pollutants and to contain and treat them will not be known until the technology of in situ processing has undergone additional field testing.

The amount of water required in shale processing may constrain the exploitation of major oil shale deposits in arid regions. The principal deposits of oil shale are found in Colorado, Utah, and Wyoming, where water supply is limited. Extensive development of these deposits, using present mining and surface-retorting methods, could cause unacceptable burdens on the water supply and could cause economic hardship for farming and industry in these areas. Comparatively, in situ processing requires less water for shale processing than surface retorting and refining.

Water effluents from shale processing plants are also an environmentaI hazard. With surface retorting, spent shale leachate, runoff, and contaminated retort water can contaminate local water supplies if not properly collected and treated. Retort water, primarily composed of water formed by combustion and pyrolysis but including a small quantity of ground water, generally contains unacceptable concentrations of dissolved solids, ammonia, hydrogen sulfide, and organic compounds.

During in situ processing, backflood water (natural ground water that reenters an in situ retort after its development) becomes contaminated as it contacts the spent, or partially spent, oil shale and newly exposed mineral materials. In a similar way, Ieachate and runoff from surface-processed shale disposal areas occurs if the shale is exposed to rain and snowfall. Laboratory studies of leaching retorted shale indicate that inorganic solids, hydrocarbons, and toxic trace elements may be present.

Site management and land reclamation are important environmental concerns in the commercialization of oil shale. Oil shale mining causes significant disruption of the land, both in excavation and in disposing of the solid wastes produced by shale processing. In surface retorting, these wastes—consisting mainly of spent shale, mining debris, and shale fines—are deposited above ground, where prevention of leaching and contamination of water by organic materials are major problems. With in situ retorting, most of this waste is left underground, but special precautions must be taken to avoid geological disturbance. Hydraulic and explosive fracturing by in situ retorting can cause physical disruption and cracking of strata. There may also be severe disruption of adjacent aquifers and subsidence or uplifting at the surface. Depending upon the proximity and structure of aquifers, drinking supplies from ground water may be contaminated, or there may be changes in the flow and storage characteristics of aquifers. Subsidence at the surface, which may not occur immediately, can damage buildings and roadways or affect options for subsequent land use.

Safety

The energy conservation policies in the Petroleum Conservation Case are expected, on the whole, to have a beneficial impact on safety. The reduction in automobile VMT brought about by Petroleum Conservation Case policies is expected to result in a proportionate reduction in automobile-related death and injury. Thus, while the death and injury toll will continue to rise through the period 1975-2000, the increase is not projected to be as great as it would be under Base Case conditions.

Enforcement of a national 55 mph speed limit, intended primarily as an energy conservation measure, will also result in decreases in automobile accidents—approximately 5 percent in urban areas and **6** percent in rural areas. This projected reduction is consistent with the observed reductions in fatal accident involvements which have been attributed to the 55 mph speed limit since 1974. In the Petroleum Conservation Case, the proportion of small cars in the fleet is expected to grow to **90** percent by 1985, compared to **69** percent in the Base Case. The higher proportion of small, and perhaps less crashworthy, vehicles in the fleet could have an adverse impact on safety.

Mobility

The conservation policies selected for the Petroleum Conservation Case were those that promised to reduce petroleum consumption by automobiles without major adverse impacts on mobility. The analysis supports this expectation. Under the Petroleum Conservation Case, total automobile VMT is projected to drop less than 1 percent from the Base Case level in 1985, due primarily to adjustments in the gasoline tax designed to keep the cost per mile of driving constant. By **2000,** the reduction in automobile VMT is projected to be 3 percent below the Base Case level, again due to increased gasoline taxes. However, this reduction is not expected to be proportionate for all types of driving. There would be significant elimination or shortening of automobile trips for shopping, social, and recreational purposes. There would also be slight VMT reductions as a result of shifting to higher occupancy automobiles or to transit for work trips.

The conditions of travel (e.g., congestion and average travel speed) are expected to be virtually the same under the Base Case and the Petroleum Conservation Case, Travel speeds will be slightly higher than under the Base Case, but they will still be considerably lower than the prevailing 1975 speeds. [19]

Because of the policy of increased transit funding, transit ridership is projected to increase—3 percent higher in 1985 and 8 percent higher in **2000** compared to the Base Case. Some of this increased ridership will be the result of automobile drivers shifting to transit (primarily for work trips), and the remainder will represent new trips by the elderly, poor, and handicapped because of improved transportation service.

Policies to promote the development and use of alternate energy sources will have a generally beneficial impact on mobility, particularly by automobile, since they will contribute to alleviating the severity of the projected petroleum shortfall. In fact, the preservation of automobility is the underlying reason for promoting a transition program. However, the higher projected prices of all fuels will have a slight dampening effect on automobile use.

Cost and Capital

Impacts of Petroleum Conservation

Under the Petroleum Conservation Case, the assumed higher cost of fuel and increased gasoline taxes will combine to raise automobile operating costs slightly over Base Case levels in both **1985** and **2000** for all size classes. The magnitude of these cost increases would differ greatly according to automobile size.

The total price (in 1975 dollars) for gasoline (including taxes) is projected to be **$0.777** per gallon in **1985** for the Base Case and **$0.907** per gallon under Petroleum Conservation policies. This would amount to an average increase of **12** percent in the fuel cost per mile of auto travel This price increase ranges from under $0.03 per mile for subcompacts to over $0.05 for standard and large cars. For the year 2000, the price of gasoline including taxes is projected to be $1.39 per gallon, compared to $1.21 per gallon in the Base Case. This increase of $0.18 per gallon represents a 1.5-percent rise in price and adds $0.04 per mile to the cost of driving a subcompact and up to $0.07 for large cars.

[18] Haus C. Joksch, *Analysis of the Future Effects of the Fuel Shortage and Increased Small Car Usage Upon Traffic Deaths and Injuries*, prepared for Transportation Systems Center, DOT-TSC-OST-75-21A (Hartford, Conn.: Center for the Environment and Man, Inc., January 1976).

[19] *Sydec/EEA*, p. IV-42

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The annual auto sales in 1985 are projected to be only slightly lower (1.5 percent) than under the Base Case. However, the mix of new car sales changes dramatically from the present and from 1985 Base Case projections. (See table 58.) Under the Base Case, it is expected that 69 percent of the cars sold would be compacts or subcompacts (including small luxury cars). Under the Petroleum Conservation Case, nearly 90 percent of the cars sold would be in these classes. Cars now classified as standard and intermediate would virtually disappear.

Under the Base Case, it was assumed that 18 percent of new car sales in 1985 would be imports. The Petroleum Conservation policies, however, would create a strong demand for fuel-efficient cars. To maintain 82 percent of the market, U.S. manufacturers would have to shift their product mix much more rapidly than in the Base Case. Domestic small car production would increase from 3.2 million in 1976 to 9.2 million by 1985 if the Petroleum Conservation policies were in force.

While the volume of new car sales would not be appreciably affected in the Petroleum Conservation Case, manufacturer's revenues would be somewhat lower than in the Base Case. Gross revenue from sales in 1985 would be up about $8 billion from 1975–approximately $4.5 billion less than the $12.5 billion increase expected under Base Case conditions for 1985. As a percentage of 1975 sales, manufacturer's gross revenue would be 20 percent higher under Petroleum Conservation policies, compared to 32 percent higher in the Base Case.

The Base Case projects a 10-percent penetration of the new car market by diesel automobiles in 1985. Under Petroleum Conservation policies, manufacturers would be likely to emphasize diesels as a way to meet tighter fuel-economy standards. The fuel economy of diesels would also make them attractive to consumers. These factors could combine to boost diesel sales to 25 percent of the new car market by 1985. Since diesels are assumed to sell at $100 to $200 above gasoline-powered cars, the increase in diesel sales could lead to an additional $100 million to $200 million in manufacturer's revenues, compared with the Base Case.

Along with the projected decline in automobile sales and manufacturers' revenues, the capital requirements of the industry would increase. The Petroleum Conservation Case would require additional capital expenditures for retooling and changes in vehicle production lines and would require writing off investments in some current lines of intermediate and large cars. The combination of increased capital requirements and the change to a less profitable mix would severely strain the industry's ability to generate capital from internal sources. Further difficulty would be added by the introduction of electric vehicles, which would be viewed as an entirely new economic venture that would cut into the sales of gasoline-powered cars. Production of electric vehicles on a large scale would be an essentially new product line for an

Table 58.—1985 New Car Sales Mix for the Petroleum Conservation Case (thousands)

	1976		1985 Base Case		1985 Petroleum Conservation	
Model	Number	Percent	Number	Percent	Number	Percent
Subcompact	2,225	22	3,940	30	5,300	41
Compact	1,921	19	3,940	30	4,657	36
Intermediate	2,831	28	2,111	16	798	6
Standard	2,022	20	936	7	0	0
Small luxury	506	5	1,196	9	1,569	12
Large luxury	606	6	935	7	540	4
Total	10,111		13,058		12,891	

NOTE Numbers may not add due to rounding
SOURCE *Sydec/EEA,* p IV.80

industry still engaged in manufacturing gasoline-powered cars, and would add considerably to the industry's capital requirements.

The combination of increased capital requirements, lower revenues and profits, intensified competition in the *lower* size classes, and increased penetration of new engine technology would place stress on the less profitable firms in the industry and increase the likelihood that they might suffer severe financial losses. Further, increasing small-car demand would encourage foreign producers to locate in the United States, perhaps reducing the market share of domestic manufacturers.

Impacts of Transition to Alternate Energy Sources

An estimate was made of the approximate amount of capital required to develop alternative fuel industries capable of supplying 2.75 MMBD by 2000. This analysis was based on the assumption that 2.0 MMBD would be produced from shale oil and 0.75 MMBD from coal. This estimate, however, is highly speculative because of uncertainty about the costs of construction, pollution abatement, and synfuel processing. Furthermore, the ability of the petroleum industry to finance this level of investment will depend on the success of the industry in generating cash flow from its previous investment.

A recent study by Stanford Research Institute[20] estimated the capital costs of synfuel production facilities. Shale oil production of 2 MMBD would require **20** plants, each capable of producing 100,000 barrels per day. These plants are estimated to cost **$823** million each, or a total of **$16.5** billion. Coal synthetic liquid fuel production of **0.75** MMBD would require approximately eight plants capable of producing 100,000 barrels per day. Costs for these plants are estimated to be $1.3 billion each, or a total of **$10.4** billion. Thus, about **$27** billion would have to be invested between **1980** and 1995 to create an industry capable of producing **2.75** MMBD of synthetic fuels by 2000.

To place the **$27** billion in context, it is estimated that $116.5 billion will be invested by the entire energy industry by **1985** and **$207.8** billion will be invested by 1995.[21] Of this, **$36.2** billion by 1985 and $47.4 billion by 2000 will be invested by the petroleum industry for conventional fuel production. In **2000,** energy investments will constitute approximately **32** percent of fixed investment by all U.S. business. The capital requirements for alternative fuels would raise this to 35 percent.

The impact of changes in the mix of gasoline and diesel fuel are important from the standpoint of the refining industry. It is projected that petroleum conservation policies will result in greater use of diesels, which would account for about 10 percent of the motor fuel consumed in 1985 and almost 50 percent by 2000. The most likely impact of this shift in fuel mix would be to create pressures on the relative prices of refinery products and on refinery product demands. The premium price that has been paid for crudes with high gasoline content would no longer apply in a situation where rising diesel fuel consumption drives up the refinery demand for previously low-cost crudes with high kerosene and distillate fuel content. As the proportion of gasoline to diesel fuel decreases, the price of diesel fuel relative to gasoline would rise due to the increased allocation of total refinery costs to diesel production. Also, shifts in relative prices would probably result in shifts in markets for the fuels. For example, lower cost gasoline could become an attractive feedstock for petrochemicals, displacing distillate fuels.

Pressures on prices and on investment and operating costs because of changes in auto fuel mix might be offset by the extent to which the fuel mix shift reduced the total demand by refineries for crude oil. The costs of crude oil inputs may be a much more significant factor in total refinery costs than the annualized capital investment costs. Thus, to the extent that the relatively higher fuel economy of diesels would not result in increased travel demand, the increased proportion of diesels in the fleet would result in reduced crude oil requirements for refiners.

[20] E M Dic kson, et d] *Synthetic Liquid Fuels Development Assessment*, of Crit; 111 *Factors* prepared tor l-' S Energy Research and [Development Administration, ERDA 7b-12Q 2 (Menlo Park, Calif SRI In ternational July 1 976

[21] Ibid.