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An Analysis of Federal Incentives Used to Stimulate Energy Consumption

August 1981

Prepared for the U.S. Department of Energy
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AN ANALYSIS OF FEDERAL INCENTIVES USED TO STIMULATE ENERGY CONSUMPTION

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PREFACE

In March 1978, Pacific Northwest Laboratory published "An Analysis of Federal Incentives Used to Stimulate Energy Production." Since that time, considerable discussion has centered around the analysis contained there. A two-and-a-half day workshop brought together 28 contributors to energy policy, representing a wide variety of professional skills and training. Insights gained from this discussion, coupled with additional interaction and research by the Pacific Northwest Laboratory team, have been incorporated into the two revised versions of "An Analysis of Federal Incentives Used to Stimulate Energy Production."

Those reports, and subsequent reports dealing with the results of incentives and the use of incentives in Japan, France, and West Germany, concentrated on incentives directed to the production of energy. This report is an attempt to complete the analysis by concentrating on the incentives directed to energy consumption. As in the other reports, we examine the incentives used with regard to the traditional energy forms of hydroelectricity, nuclear energy, coal, oil, natural gas, and the transmission and distribution of electricity. We also concentrate on the positive, as opposed to the negative incentives. Therefore, as is discussed in more detail in Chapter II of this report, conservation efforts are outside the scope of this report. We examine incentives to increase demand, not reduce it.

When this report is combined with our previous work, the intent is a relatively comprehensive view of the incentives to expand the production and consumption of traditional energy forms. That comprehensive view could be useful in designing and implementing incentives to expand the consumption and production of energy from renewable forms.

ACKNOWLEDGMENTS

This research effort was multidisciplinary. As each investigator had an opportunity to review the total manuscript, all contributed to the total product. Major emphasis was given by specific investigators to particular chapters. The introductory chapter was written by the program leaders, Dr. Bruce W. Cone, economist, and Dr. Roland J. Cole, policy analyst and lawyer and Dr. Alfred A. Marcus, political scientist. The theoretical chapter was written by Dr. Paul E. Sommers, economist, and Dr. Alfred Marcus, political scientist, with the assistance of Dr. Michael Lindell. The analysis of generic incentives was written by Dr. Sommers, Dr. Marcus, Mr. Frederic A. Morris, policy analyst and lawyer, and Michael Huelshoff, political scientist. The chapter on electricity was written by Mr. John C. Emery, economist, Mr. Phil Petty, economist, and Mr. William Dowes, electricity expert. The chapters describing incentives to coal, gas, and oil were written by Dr. William J. Sheppard, fuels analyst; and Mr. David E. Lenerz, energy economist. Dr. Cone and Dr. Cole wrote the final chapter describing the applications to solar energy policy. Ms. Catherine Eschbach assisted investigators in researching and editing the volume. Ms. Sandra Smith, Human Affairs Research Centers; Ms. Shirley Flink, Pacific Northwest Laboratory; and Ms. Judy Demaree, Columbus Laboratory, prepared the working papers and draft reports. Preparation of this volume was supervised by Dr. Cole, with editing assistance from Dr. Gary Brock and Mr. Orvin Johnson.

The investigators drew on a broad spectrum of resources to assemble the information presented in this report. The authors wish to acknowledge the contribution of the original idea upon which this research was based to Dr. Roger H. Bezdek, formerly of the Department of Energy and now of the Department of Treasury. The continued guidance of Dr. James C. Easterling is gratefully acknowledged.

Dr. Sommers, Dr. Marcus, Mr. Morris, and Mr. Huelshoff acknowledge the help of the following people with the chapter defining generic incentives: Mr. Greene, Chief of Engineering, U.S. Army Corps of Engineers; Ms. Greenwell, Internal Revenue Services; Mr. Hixson, Tennessee

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AN ANALYSIS OF FEDERAL INCENTIVES USED TO STIMULATE ENERGY CONSUMPTION

I. INTRODUCTION

This report is one of a series of analyses of public incentives directed toward energy resources. The purpose of the series is to gain insights into the kinds and amounts of public incentives that could be required to induce 20% of the nation's energy budget from renewable resources by the year 2000. The initial analysis focused on federal incentives used to stimulate traditional energy production.(1) The latest update of that analysis estimates that incentives to energy production from traditional sources have cost $252 billion (1978$).(2) During the analysis leading to that estimate, the question of incentives that stimulated consumption of energy was frequently raised. The purpose of the analysis presented here is to identify federal incentives that have increased the consumption of coal, oil, gas, and electricity.

The rationale for conducting analyses of public incentives directed toward energy resources has to do with the cost competitive nature of solar or renewable energy resources. Some argue that the consumer can purchase warmth or work or mobility at less cost by means of coal or oil or nuclear energy than by means of sunshine or wind or biomass. The argument concludes that this fact, in and of itself, relegates renewable energy resources to a small place in the national energy budget. The argument would be valid if energy prices were set in perfectly competitive markets. They are not. The costs of energy production have been underwritten unevenly among energy resources by the Federal Government. A hypothesis tested in the analysis that follows is that the costs of energy consumption have also been underwritten unevenly, both across different energy resources, and among different user sectors.

Were the rationale for conducting analyses of public incentives toward energy resources limited to the cost competitive nature of renewable energy, the subject could easily be relegated to the insignificant in the larger debate about public intervention in the marketplace. However, given the current reality of a mixed economy responding to both public and private stimuli, an analysis of public incentives can form the basis of initial insights into the kind, quantity, and duration of incentives to stimulate renewable energy resource use.

PURPOSE OF THE RESEARCH

The purpose of the research presented in this report is to identify and quantify federal incentives to stimulate energy consumption. Such a focus raises the question of why study attempts to increase demand, when conservation, or attempts to decrease demand, seems to be the most relevant policy issue. Three major reasons keep the focus on attempts to increase demand. First, one of the ways in which the government hopes to decrease the use of traditional forms of energy is by increasing the use of renewable forms. By studying what the government has done in the past to increase the use of traditional forms, one can learn about opportunities and pitfalls for application to renewable energy. Second, many past actions taken to increase demand for traditional forms have continuing effects. A study of these historical incentives may have value for conservation in the sense that it highlights government actions whose impacts will need to be counteracted in order for conservation efforts to be effective. Finally, one can find a significant amount of analysis of conservation incentives, but very little analysis of demand-generating incentives.

Therefore, this analysis is essential to complete the picture of historical incentives and to provide background information needed to design future incentives. An understanding of incentives used to stimulate consumption is of particular interest because the production and consumption of renewable energy are more likely to be embodied in a single resource allocating decision than are the production and consumption of energy from traditional sources.

DEFINITION OF INCENTIVES

Recent discussions in policy analysis have focused on the use of taxes and requirements for policy purposes.[3] Economists, in particular, have argued that taxes are a better means for directing corporate behavior into socially beneficial areas than requirements. The taxes/requirements debate, however, provides a narrow perspective on the range of governmental activities. The typology used in this report captures more of the activities in which the government actually engages--not only regulating and collecting taxes, but also providing services, distributing money, and buying and selling goods and services. Each of these activities has unique attributes and consequences and may be appropriate for accomplishing different policy objectives.

Previous analysis has led to the division of incentives into six categories:[4]

(1) Levying a tax or the exemption or reduction of one that is levied in similar situations are defined as taxation;

(2) Actions in which the Federal Government gives out money without receiving anything directly or immediately in return are defined as disbursements;

(3) Requirements are demands made by government, backed by criminal and civil sanctions;

(4) Nontraditional governmental services are offered in activities where private ownership is possible but public ownership better serves the general public welfare such as research, development, and dissemination of energy-related technology;

(5) Traditional governmental services are offered in activities where private ownership is not practical within the current political system, such as ownership of highways and waterways.

(6) Market activities consist of governmental involvement in one or more of the steps of production, exchange, or consumption of energy.

In addition, one can identify a seventh type of action used in this context, exhortation. Exhortation refers to the government simply talking to the private sector, requesting its compliance with governmental goals, and appealing to its self-interest or to its moral, ethical, or patriotic ideals. However, such activities, while conceptually distinct, are hard to distinguish in practice from the information dissemination activities that are part of category 4, nontraditional services. Therefore, this report will include exhortation as part of category 4.

DEFINITION OF ENERGY FORMS AND ENERGY-CONSUMING SECTORS

The energy forms analyzed in this report are coal, oil, gas, and electricity. Nuclear energy and hydroelectricity are considered in the end-use form of electricity. Identification and quantification are achieved by analyzing incentives to energy forms as they apply to six specific sectors. These sectors consist of residential, commercial, industrial, transportation, agricultural, and public. The pattern of energy consumption by sector is the result (or "dependent variable") that this report helps partially explain by reference to various federal incentives ("independent variables"). Further details of the patterns of energy consumption in the U.S. are contained in Appendix A to this chapter.

Residential

The residential sector consists of single-family and multifamily residences and mobile homes. End-uses of energy include space heating, water heating, cooking, air-conditioning, refrigeration, operating appliances, and lighting. The residential sector is highly fragmented, comprising many consumers, each of whom uses only a small amount of energy. There are more than 75 million residences in the U.S.[5]. In 1973 these consumers used 20.5% of all the energy consumed in the U.S. Most of the use, 10.4% of the total energy use, was for space heating; 3.1% was for water heating. The consumption of residential and commercial users increased by nearly 3% annually between 1973 and 1978, the largest growth rate among energy-using sectors.[1]

Commercial

The commercial sector includes schools, offices, restaurants, artisan shops, and department stores.[6] In some cases decision making is by individual entrepreneurs, in some cases, by organizations of various types. As defined, the commercial sector includes economic activity in the following Standard Industrial Classification codes: SIC--Wholesale Trade; SIC--Retail Trade; SIC--Finance, Insurance, and Real Estate; and

SIC--Services such as auto repair, health, education, and welfare.[7] The commercial sector is nearly as fragmented as the residential sector. Commercial consumption was 14.4% of total energy consumption in 1973 and grew at about 3% annually between 1973 and 1978. End uses in the commercial sector were more evenly divided than in the residential sector: 5.1% of total energy consumed in 1973 was for commercial space heating; 3.9% was for commercial lighting; and 2.0% was for water heating.

Industrial

The industrial sector consists of construction and manufacturing activities in the Standard Industrial Classification system (SIC). Manufacturing includes food, apparel, lumber and paper, chemicals, metals, and machinery. We also include utilities (part of SIC) in this category. Industrial decision makers are primarily large corporate entities, complex bureaucracies with independent profit-making centers, specialization, and a great deal of professionalization. The industrial sector is the largest energy-using sector of the economy. In 1977, industry's net energy consumption was 22.2 quadrillion Btu, which accounted for 36.6% of the net energy consumed in the U.S.[8] Industrial consumption was larger than consumption in both residential and commercial sectors combined; but industrial consumption, unlike residential or commercial consumption, has been declining at a rate above 1% per year since 1973. Most industrial energy used (about one-half of total industrial use in 1973) was used for process steam; in the same year one-third of industrial energy was used for direct heat, slightly less than one-third for electric drive, and about seven-sixths for feedstocks.

Transportation

The transportation sector includes economic activities in Standard Industrial Classification railroads, trucking, and air and water transportation. Transportation firms in SIC provide transportation services for other sectors. This user category also includes transportation provided by each of the other energy user categories for its own consumption, including personal transportation furnished by the individual. Transportation decision making is highly fragmented. Both individuals (in the final demand sector) and organizations (in other sectors) are involved, implying a variety of decision-making patterns and influences. Most of the energy consumed in this sector is for highway travel. In 1977, the net energy used in all modes of transportation accounted for one-third of the total net energy consumed in the U.S.[9] Since 1973, the energy used in transportation has grown in proportion to total energy use, but by less of a percentage than energy used in the residential and commercial sectors.

Agricultural

The agricultural sector includes farming, ranching, and related activities undertaken by individual farmers and by large corporate "agri-business" organizations. SIC includes these activities, as well as fishing and forestry operations. In addition to SIC, we include SIC #1--Mining, in this sector. Thus, this sector encompasses all natural resource extraction and cultivation activities. Direct primary fuel use by the agricultural sector accounts for only about 2% of the nation's total energy use a number smaller than any for the other sectors. (Feedstock uses of energy are not included in the percentage figure.) Of the 2% of the total U.S. energy used by the agricultural sector, half goes for fueling farm vehicles and a quarter is used to drive machines for irrigation pumping, grain handling, and feed processing. Crop drying accounts for 8%, and the remainder is used for various other purposes. The energy efficiency of the internal combustion and electrically driven machines used in agriculture are one determinant of energy demand in this sector.[10] Decision making in the agricultural sector is dispersed among numerous small farmers in addition to many large operators.

Public

The public sector consists of federal, state, and local governmental units. These units are classified in the Standard Industrial Classification Code as SIC--Public Administration and include activities such as executive agencies, legislatures, and judicial bodies, and programs such as public order and safety, environmental quality, economic growth,and national security. Decisions in the public sector are made by numerous, diverse bureaucratic units in different settings and situations. The Federal Government is the largest single user of energy in the economy, and accounted for 2.2% of the total energy consumed in the United States in FY-1978.[11] Six million Federal Government employees used this energy in 490,000 buildings, in the operation of more than 500,000 aircraft and motor vehicles of all types, and in the operation of government-owned plants such as uranium enrichment plants. The 10 largest energy-using federal agencies accounted for over 98% of the energy consumed by the Federal Government.[12] Relative to other sectors, the public sector is probably more concentrated in a relatively smaller number of decision-making bodies.

Given these patterns of energy use by sector, the problem is to identify federal actions directed toward each of these sectors that have resulted in changes in the consumption of energy and then to classify and to quantify these actions by incentive type and energy source.

APPROACH TO THE ANALYSIS

The problem is to specify expenditures for the six types of public actions defined above. Such actions will be directed toward one or more of the six energy-consuming sectors defined above for the purpose of inducing changes in the consumption of one or more of the four energy forms listed above. The specification could result in the identification and quantification of federal incentives to stimulate energy consumption summing to 144 elements. In order to appropriately account for each incentive within the 144 elements, a rigorous analytical approach is taken that begins with a theoretical analysis of the problem in the abstract, broadens to a generic analysis of current governmental incentive-creating actions affecting each of the six sectors, and then narrowing to analysis by energy form. Chapter II presents the theoretical analysis that establishes the structure for the subsequent empirical analyses. Chapter III describes, from a public policy point of view, the array of currently used incentives as they apply to the consumption of energy among sectors. Chapters IV-VII focus on the coal, oil, gas, and electric power industries and their views of public actions that shifted the demand for their products. Conclusions with respect to solar policy are drawn in the final chapter.

An analysis of federal incentives used to stimulate energy consumption is complex because of the interrelationships between production and consumption over time. Oil depletion deductions that reduce an oil company's taxes, and therefore its costs, had resulted in increased production at lower cost. The ultimate result is an increase in the consumption of oil. However, the oil depletion allowance has been identified in other reports of this series as an incentive used to stimulate energy production. To minimize the confounding of incentives that initially impact consumption from those which initially impact production, a rigorous theoretical analysis is presented in the second chapter. The authors of that chapter draw on the theory of demand literature as found in the discipline of economics and elsewhere to identify the relationship between each of the six types of incentives identified above and the resultant forces or changes in energy consumption.

The structured framework of the theoretical chapter allows the authors of the third chapter to broaden the analysis to include the vast arena of public policy actions. Investigators, knowledgeable about the structure and activities of the Federal Government, note the actions taken in a single year in order to establish an initial data base of public activity. This data base establishes the parameters of federal actions that could lead to increased energy consumption. The point of the third chapter is to: (1) identify each federal action taken in 1978 that could have induced increased consumption of energy; (2) categorize the actions by incentive type; (3) relate each action to one or more market sectors; and (4) estimate the cost or revenue foregone. The results appear as a table that estimates the cost of the federal action by type of incentive impacting consumption in each of the six consuming sectors and its associated descriptive analysis.

In the subsequent empirical chapters the focus narrows and concentrates on those federal actions that expand the market for coal, oil, gas, and electricity. Much of the action taken in Washington, D.C., is the result of stimuli from the rest of the country. For example, an energy-producing industry has fallen on depressed times as a result of losses of markets, and legislators are asked to take action. An energy-consuming industry faces layoffs due to a shortage and the administration is asked to help. Investigators with knowledge about the structure and activities of the coal, oil, gas, and electric power industries focus on federal actions taken over time to strengthen the data base established in the third chapter.

The purpose of the concluding chapter is to combine (1) the results gained from the broad perspective of public policy actions; (2) the insights gleaned from the narrow perspective of expanded markets for specific forms of energy; and (3) the results of current research reports that focus on achieving the 20% goal for renewable energy resource use by the year 2000. In the first section of chapter eight, the conclusions to each of the preceeding chapters are combined and presented as incentives used to stimulate the consumption of coal, oil, gas, and electricity. Next, conclusions are drawn by tabulating incentives from each chapter as they apply to the consumption of energy within the residential, commercial, industrial, transportation, agricultural, and public sectors. Finally, these conclusions are considered in light of current knowledge with respect to achieving a national energy budget that includes a 20% use of solar energy.

NOTES - CHAPTER I

1. B. W. Cone et al., An Analysis of Federal Incentives Used to Stimulate Energy Production. Report for U.S. Department of Energy by Pacific Northwest Laboratory, PNL-2410 (Rev. II), p. 274, February 1980.

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II. A THEORETICAL APPROACH TO ANALYZING CONSUMPTION INCENTIVES

PURPOSE

In this chapter we develop a systematic framework for examining the governmental incentives used to stimulate energy consumption. There are three elements in our framework: (1) energy demand, (2) the determinants of energy demand, and (3) governmental incentives. Our aim is to trace the influence of public incentives on private consumption decisions. Economists define a perfectly competitive, free-market economy as one in which government does not affect private transactions; ours is not such an economy. The pattern of energy use is influenced by the impact of various governmental incentives on energy demand. In this chapter, we will develop the economic theory of demand, identify determinants of demand, and develop a typology for understanding the impact of governmental incentives.

This systematic framework serves three purposes in our research. First, it helps us achieve comprehensiveness, providing a checklist of categories that we examine in order to uncover all relevant governmental incentives. Second, it helps us achieve compatibility. The research involves staff at three locations, in many different disciplines. This systematic framework helps researchers make compatible judgments about what to include and exclude. Third, it helps us achieve unity by providing a scheme for organizing the results of the many different research efforts into a unified report. In the next five chapters we will apply this framework to determine the pattern of governmental expenditures used to stimulate consumption.

ENERGY DEMAND

Energy demands are derived from production relationships in all energy-consuming sectors. Fuels and energy consumed by residential, industrial and other users do not actually constitute part of the commodity consumed by customers. Rather, energy inputs are used in some form of production process in each sector to produce goods and services. In the residential sector, households produce heat, light, and other "commodities" for use within the household sector.[1] The commercial, industrial, agricultural, and public sectors use energy and other inputs to produce goods or services for other sectors. Energy is used for transportation services by all of the other economic sectors. Thus, economists speak of energy demand functions as derived demand functions because they are derived from the functions that describe the goals and preferences of a sector and from the production relationships available in the sector.[2]

In the abstract terms of the economist, assume that decision makers have a set of goals, including profits or program achievements, and preferences including those for particular energy forms. These goals and preferences are represented by a function $P(P_1, P_2, \ldots, P_n)$. Decision makers maximize goal achievement subject to the constraints imposed by the production process. The production process is represented by the function $F(F_1, F_2, \ldots, F_n)$. By analyzing the constrained maximization problem

$$\text{Max } P(\ ) \text{ subject to } F(\ )$$

one can arrive deductively at the derived energy demand function for the sector:

$$D(\ ).$$

The arguments in the demand function D( ) may include any of the arguments in P( ) or F( ), and the form of this function, represented by the functional D, will be determined by the functionals P and F. For purposes of this chapter, it is not necessary to discuss the exact form of the preference and production functions. Our focus will be on the types of variables included in the derived energy demand functions of each economic sector. It is important to remember, however, that the form of the demand function, represented by the functional D, is a reflection of the forms of the preference function and of the production function constraint. In addition, variables that are determinants of preferences or production relationships may show up in the derived demand function.

The energy demand curve, a two-dimensional theoretical construct, and the demand surface, the n-dimensional equivalent, model the functional relationship between the quantity of energy purchased and the variables thought to determine that choice.(3) The variables conventionally assumed to affect demands for a commodity X include the price of the commodity P_x, the price of substitutable goods P_s, the price of complementary goods P_c, preference variables Z, income or budget of the decision maker Y, and variables representing the production process constraints T. The relationship between these variables and consumer purchases of a commodity Q_x is often written as the following equation:

$$Q_x = D(P_x, P_s, P_c, Z, Y, T)$$

As discussed below, the specific variables included will vary depending on whether consumer or producer demands for energy are being considered.

Several statements can be made about the normal direction of effect of the various variables in this equation. The higher the price of a good, the lower is the quantity purchased, other things being equal; that is, P_x has a negative sign. The higher the price of substitutable goods, the greater the quantity of X purchased. For example, if the price of heating oil increases while the price of natural gas remains the same, purchases of natural gas are likely to increase. Thus, P_s has a positive sign. Complementary goods are those consumed together with a given commodity. Resort price increases, for example, may result in reduced vacation travel and less gasoline consumption. Thus, P_c normally has a negative sign. Preference variables may have either positive or negative signs. Some consumers may prefer gas furnaces to oil, other things being equal. Various energy users will have different preferences about future versus present costs, and will therefore choose technologies with different capital/fuel cost ratios. Income increases normally lead to increases in the quantity of a commodity purchased. However, there is a special class of commodities, called "inferior" goods, whose consumption decreases as income increases. Coal for home heating may be an inferior good, since more affluent consumers may prefer electric, oil, or gas heat.

The significance of this discussion for energy demand is, first, that energy forms are often substitutable. Thus, the prices of alternative fuels must be included in the demand function for a given fuel. Second, many complementary goods are needed for people to consume energy. These goods include devices that convert energy into useful work, heat, and light. The prices of these devices also must be included in energy demand functions. Third, the preference for particular forms and uses of energy may change. Although consumers did not always consider solar power as an alternative means of home heating, now changes in preference as well as price have given greater appeal to this source of energy, which is renewable and allegedly cleaner. Fourth, it appears that in a growing economy, where incomes are rising, energy consumption is greater per capita, although this relationship varies greatly over time, as will be noted. Finally, technological changes may have important impacts on patterns of energy consumption. Technology determines the quantity and quality of energy required to produce desired goods and services.

To facilitate analysis, demand curves are often portrayed in a two-dimensional diagram. Assume for the moment that all variables other than the price of the commodity itself are fixed in magnitude. The relationship between the quantity, Q_x, and the price, P_x, can then be shown as in Figure 1. The statement that P_x in the previous equation has a negative sign is interpretated graphically as a line with a negative slope, as in Figure 1. The consumer may change the quantity of X consumed for two reasons, the first of which is illustrated in Figure 1. P_x may change from P_0 to P_1. The consumer will then move to a different position on the demand curve, from Q_0 to Q_1. This movement is referred to as a movement along the curve. In this instance, lower price results in greater consumption.

Consumption levels may also change with changes in the parameters determining the relationship between P and Q. That is, at any given level of P, there is a greater or lesser demand for X. This phenomenon is referred to as a shift of the demand curve and is graphed in Figure 2.

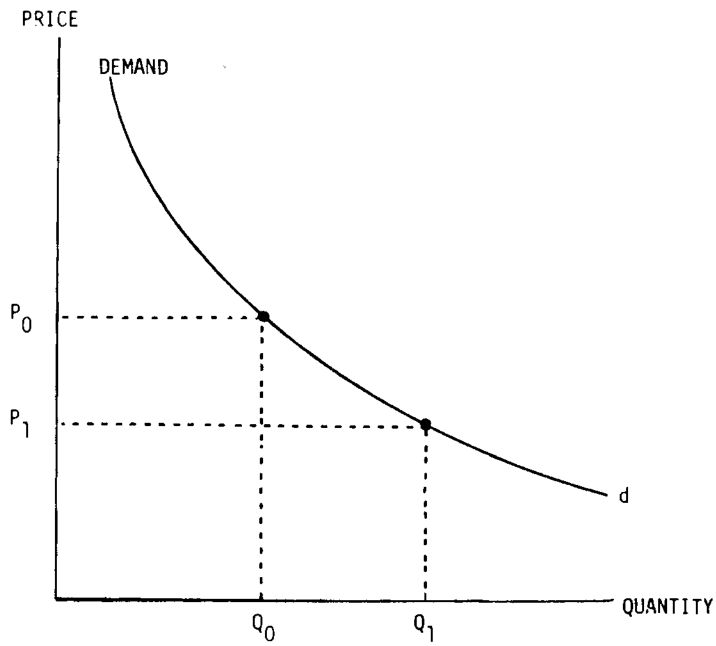

FIGURE 1. Movement along a Demand Curve

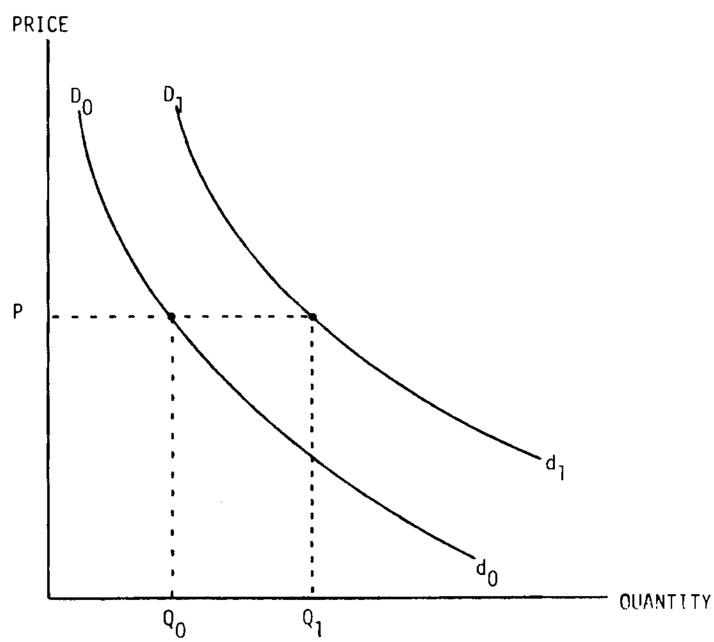

FIGURE 2. Shift of a Demand Curve

The original demand curve, D_0d_0, shifts to D_1d_1. At any given price, more of the commodity will be consumed.

In the multivariate case, demand surfaces may shift with respect to one, several, or all of the variables in the demand function. A change in the magnitude of a preference variable Z results in a movement along the multidimensional demand surface of the multivariate demand function. However, viewed on a two dimensional graph in P-Q space, this movement will appear as a shift of the two-dimension slice of the demand surface. The significance of this point is discussed below, following the introduction of several additional concepts.

Elasticity of demand is defined as the percent change in the quantity demanded divided by the percent change in the variable under consideration. If the variable is price, then elasticity refers to the percent change in quantity demanded divided by the percent change in the price. If the variable is income, then elasticity refers to the percent change in the quantity demanded divided by the percent change in income. Demand is said to be "inelastic," or relatively unresponsive to changes of a determining variable, if the elasticity is less than one in absolute value. Conversely, demand is said to be "elastic" if the absolute value of the elasticity is greater than one. If the elasticity is one, it is said to be "unitary". The concept of elasticity is associated with movements along a demand surface rather than shifts of the curve. Note also that elasticities vary at different points along a given demand surface. They have to be evaluated at one or more useful reference points such as the mean demand level of a surveyed population.

Supplier-Consumer Interaction

Consumer demand does not by itself determine the level of energy consumption. Consumption levels are determined by the simultaneous decisions of energy suppliers and energy consumers, constrained and influenced by government policies (see Figure 3). It is not our task here to explain the determinants of energy supply. We undertook that task in previous volumes.(4) However, we need to distinguish those consumption

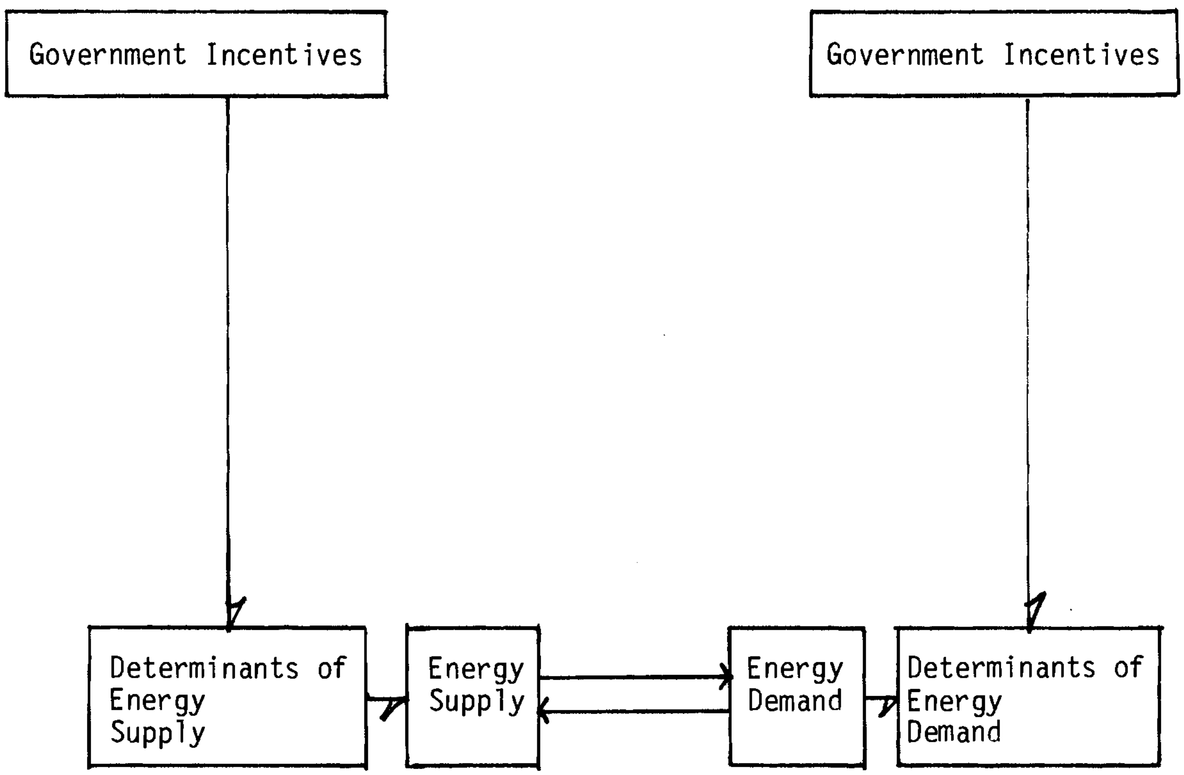

FIGURE 3. A Model of Consumption Decisions

increases induced by changes in the supply sector from those induced by changes in the demand sector.

Increased demand for energy may result from shifts of the supply curve, as shown in Figure 4. Consider consumers and suppliers initially in equilibrium at point a, the intersection of demand curve D_0d_0 and supply curve S_0s_0. If governmental programs induce energy suppliers to provide more units of energy at every price level, the supply curve shifts from S_0s_0 to S_1s_1, and the quantity demanded increases from Q_a to Q_b. This is a supply side, or production incentive, the kind we dealt with in our previous research.

Incentives for energy demand, on the other hand, are actions taken by the Federal Government to induce energy users to demand more energy. Demand may increase either because one of the variables affecting demand is increased or decreased, resulting in movement along a fixed demand curve towards greater energy consumption (as in Figure 1), or because the consumer's demand curve has been shifted away from the origin with respect to one or more determining variables, resulting in greater demand for energy at any given price level (as in Figure 2). Demand incentives exist if federal actions change variables in the demand function to increase the quantity purchased. They also exist if actions of the Federal Government shift energy demand surfaces, resulting in a change in the parametric relationships between determining variables and the quantity of energy purchased.

Demand incentives, as defined here, may have a paradoxical result of failing to reach the goal of increased energy consumption. Consider a case with consumers and suppliers initially in equilibrium, at point a in Figure 5. Policies that shift the demand curve up from D_0d_0 to D_1d_1 are unambiguously classified as demand incentives. The quantity demanded increases from Q_a to Q_b. But policies which lower the price from P_a to P_c are also demand incentives, even though suppliers reduce the quantity supplied to Q_c' while consumers demand Q_c. The result is a shortage of $(Q_c - Q_c')$ units, a paradoxical result.

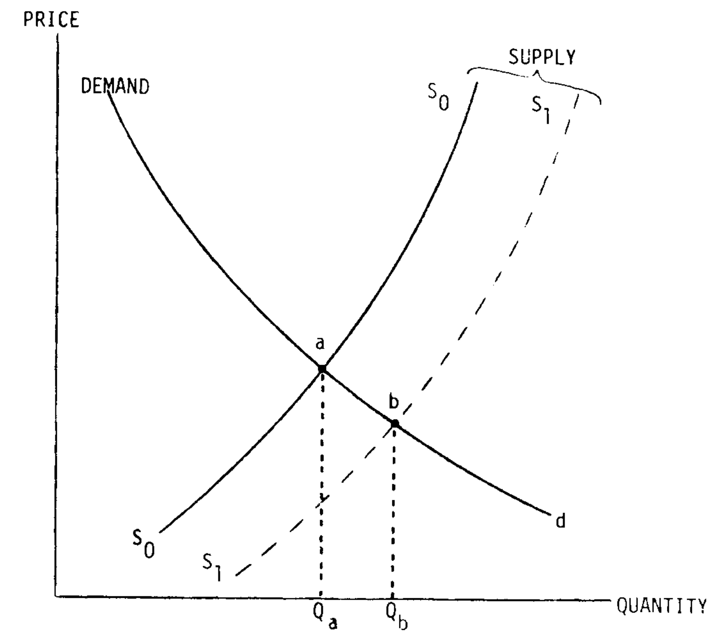

FIGURE 4. Supply-Induced Demand Changes

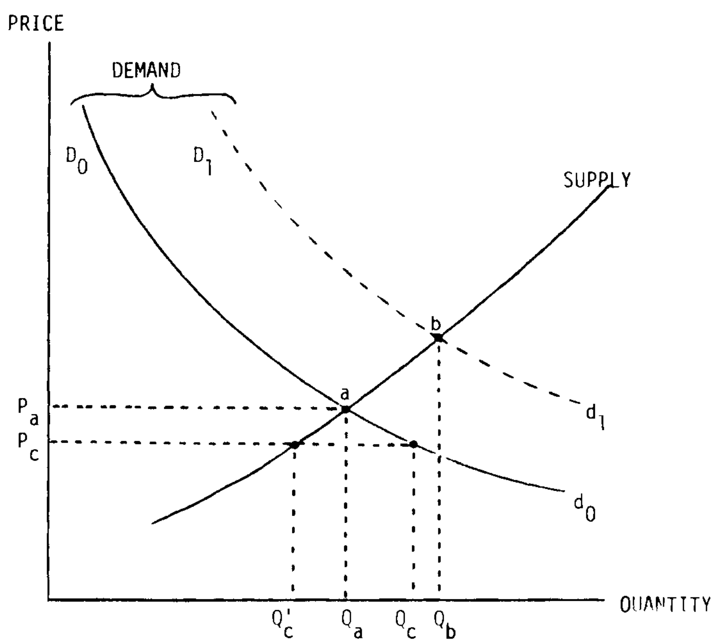

FIGURE 5. Unbalanced Demand Incentives

This study of demand incentives is concerned with upward shifts in demand curves and with movements to the right along demand curves. It does not deal with demand increases resulting from policies aimed strictly at the supply side. The results of incentives to demand likewise are not considered in this volume.[5] For our purposes, then, it does not matter whether movements along the demand curve are accompanied by supply curve shifts. We cannot assume perfect or evenly balanced policy design and implementation. Paradoxical results are possible.

If excess production or shortages are to be avoided, movements along the supply curve away from an initial equilibrium must be accompanied by a shift of the demand curve, and movements along the demand curve must be accompanied by a shift of the supply curve. Any policy affecting a variable that is both a supply and demand determinant, such as the price of an energy form, will result in movements along both curves. It will then be necessary to balance policies that shift one or the other curve to re-establish an equilibrium. Such balanced policies require more foresight and comprehensive policy design than is often possible. Hence, it is likely that unbalanced policies will be implemented, encouraging movements along supply curves without corresponding movements along demand curves or inducing movements along demand curves without corresponding movements on the supply side. On the other hand, policies that affect only demand determinants can be thought of as shifting the demand curve, as viewed in two dimensional P-Q space.

Additional Disciplinary Perspectives on Demand Theory

The theoretical framework presented above is based on standard economic theory. Other disciplines contribute valuable additional perspectives to this framework as discussed below.

A psychological perspective points out that the variables mentioned above have to be perceived and assembled by the individual or organization making a demand decision. The perception and assembly may vary from individual to individual, although not randomly so. Studies of information gathering and processing have suggested that individuals and organizations use simple rules of thumb to facilitate decision making.

Tversky and Kahneman refer to these rules of thumb as heuristics and biases in assembling and processing information.(6) Attempts to change these heuristics or to counteract these biases might lead to changes in demand and therefore should be counted as demand incentives. Information programs, a type of nontraditional services, are an example. In terms of the abstract energy demand function above, such incentives could operate by changing the perceived value of one of the variables (prices or preference), or by modifying the function that relates perceptions of individual variables to the quantity of energy demanded.

Because human beings are limited in their ability to receive and process information, individuals may not appear to act rationally. This phenomenon, called "bounded rationality" by Simon,(7) can be incorporated in our framework as a preference variable.

Attitudes and beliefs about the consequences of particular courses of action may also affect individual demand functions. Pallock and Cummings have demonstrated the relationship between attitudes and energy consumption patterns.(8) The effect of attitudes can be thought of as explaining individual values of price elasticities or of taste variables explicitly included in demand functions.

A sociological perspective on energy demand would note that the total demand function is really the function of a set of individual demand functions. It would also note that these individual demand functions vary with the characteristics of the individual decision makers. Important individual characteristics include education, family size, region of the country, and political philosophy. In terms of the equation above, the taste variables and the functional forms may vary systematically across social groups. Collier has suggested that social class is an important variable that either predicts tastes or modifies the form of demand functions.(9) Although attempts to change social groups are probably too indirect and too unlikely to show up as energy incentives, actions targeted at groups particularly sensitive to a specific variable in an energy demand equation will probably be important energy incentives.

A political science perspective, as well as some sociological perspectives, contributes two insights. First, the perspective focuses on the truism that individual decision makers do not always get what they want. The process for translating demand into actual consumption may be crucial. Certain individuals and organizations will inevitably be able to come closer to their ideal outcome than others. In addition, bargaining among the many participants in energy consumption decisions is apt to lead to outcomes in which no decision maker gets exactly what he or she wants. In terms of the equation above, this insight affects the function that relates the variables to demand. In particular, it gives clues as to which consumers will have the power to respond freely to changes in the individual variables--that is, to have more elastic demands than other consumers.

The second insight contributed by the political science perspective is that many energy consumption decision makers are organizations rather than individuals. Chapter I has already discussed how some sectors, particularly the industrial sector, are composed largely of organizational decision makers. According to most observers, organizations are even more subject to heuristics and biases than are individuals.(10) Governmental actions that change organizational heuristics and biases may be particularly important energy incentives.

The net result of adding these disciplinary perspectives to a basic demand formulation is to highlight three types of action that might otherwise have been overlooked. First, the psychological perspective tells us to look at attempts to change the attitudes, heuristics, and biases of individuals, in the knowledge that information availability and information overload are important variables affecting the value of preference variables and the shape of the demand function. Second, the sociological perspective tells us to look for actions targeted at specific social groups. Third, the political science perspective tells us to look for unequal elasticities across social groups and to pay particular attention to attempts to change the heuristics and biases of organizational decision makers. The values of preference variables included in demand functions can be expected to vary across social groupings, and the functional form itself may vary. At a minimum, we should expect variations in variables and functions across classes of users as discussed in the third section of this chapter.

THE DETERMINANTS OF ENERGY DEMAND

To summarize the discussion thus far, the following types of variables may affect energy demand:

- o price
- o price of substitutes
- o price of complements: stock of energy-using appliances or capital goods; energy efficiency of appliances or capital goods; rate at which appliances or capital goods are used; labor and parts for operation and maintenance
- o preference
- o income
- o technology.

The price of complements may be divided into three specific variable types: the stock of energy using appliances or capital goods on hand, their energy efficiency, and the rate at which the appliances or capital goods are used. Specific variables included in demand functions vary importantly with the type of user. In this section we discuss the particular determinants that are appropriate for six categories: residential, commerical, industrial, agricultural, transportation, and public.

We have surveyed empirical literature on energy demand for each of the sectors to determine the types of variables authors include in energy demand functions. Variables that empirical researchers include in sector demand functions meet the test of having major effects on demand. Thus, the discussion that follows identifies types of variables that have major effects on user sectors.

Short-Run Demand Determinants

In the short run, since the rate of use is often the only determinant of energy demand that can be changed, short-run incentives often focus on this variable. The exact meaning of "short run," however, is somewhat difficult to specify. Basically, short run refers to a period of time during which the capital stock can be regarded as fixed, where long run refers to a time frame long enough for all variables, including capital stock, to be substantially modified. In the short run, the residential rate of use may be affected by the price of the various forms of energy, by consumer income, and by social norms.[11] Although price may remain somewhat inelastic in the short run, it has been found to be the major variable affecting the rate of use in the industrial sector.[12] Exhortation also may be a way to affect short-run energy use in some situations.[13] In addition, availability may be another important determinant of the rate of use, since energy supplies are occasionally interrupted and unavailable for substantial periods of time.[14] We hypothesize that price and physical availability will be major short-run determinants for the other sectors as well.

GOVERNMENTAL INCENTIVES

A definition of energy consumption incentives can now be offered using the theoretical constructs already introduced. An incentive to stimulate energy consumption is a Federal Government action whose major purpose or effect is either to change the value of one or more of the variables in an energy demand function in a direction that results in greater quantity demanded, or to shift the entire demand surface in the direction of greater quantity demanded. Under this definition, analysts can search for consumption incentives by considering whether given federal action is directed at a variable included in an energy demand function, or whether the action has the intent or effect of shifting the entire demand surface, as by adding a whole new class of demands.

The "major purpose or effect" criterion is intended to screen out federal actions with minimal impacts on energy demand. Operationally, analysts can use elasticity estimates as a guide in deciding whether an action directed at a particular energy demand determinant is likely to have a "major" energy result. Judgments as to major energy-related intent are more difficult. Analysts may need to rely on statements of legislative or executive intent for actions that need justification on this basis. Particularly in the case of unbalanced incentives, statements of intent will be needed to justify the classification of an action as a demand incentive.

In order to be classified as demand incentives, federal actions must be directed at energy users without any intermediate steps involving supply decisions. Intermediate steps involving regulatory agencies or other sectors of the economy are permissible under our definition. Thus, federal actions that lead state regulatory commissions to set lower than otherwise retail electric power rates can be considered demand incentives, but actions affecting wholesale rates only would not be. Actions that stimulate investments in energy-using capital equipment would be classified as energy demand incentives only if energy use were a major effect of the action.

A final qualification of the demand incentive definition is that we are concerned with positive or demand-increasing incentives only. We are not attempting to measure the costs of disincentives to energy demand. We have noted that energy forms are substitutable; thus any incentive to one energy form may be a disincentive to another form. For the purpose of measuring costs of incentives, we wish to measure the total cost of all demand-increasing actions, leaving the task of measuring the net effects of these actions to later research.

Governmental action aimed at the variables in energy demand functions or directly aimed at energy consumption takes a variety of forms. In Chapter 1 we defined six types of actions that the government might take to provide consumption incentives. These action types are:

- taxation
- requirements
- traditional services
- nontraditional services
- disbursements
- market activity.

The concept of incentive type adds a fourth dimension to our examination of consumption incentives. We have four energy forms, six basic determinants of energy demand, six consumption sectors, and six incentive types. These categories provide a total of 4 x 6 x 6 x6, or 864 separate possible categories of consumption incentives. A 864-item checklist is quite long; we hope that our understanding of these categories and the processes that surround them can guide us and others in searching for all of the incentive types actually used by the government. We suspect that many of the categories will seldom or never be used, for reasons discussed below, while other categories will be used quite frequently.

The rest of this report is devoted to exploring this 864-item checklist. In Chapter III, we investigate consumption incentives incentive type by incentive type. In Chapters IV, V, VI, and VII, we then assign an energy form to each chapter. To investigate each chapter's checklist, which now has 216 items, we start with each consumption sector and then each demand determinant. In each case, the investigators looked at what increased the demand for an energy form in a sector, and then asked whether government was involved in some way. This is directly the opposite of the investigators in Chapter III, who looked at each incentive type and asked whether some action of that type related to energy consumption. This division of the problem reduces the 864 items to a more manageable total. In Chapter III, for instance, the investigators look at 6 incentive types and 6 determinants of demand for a total of 36 items. In Chapters IV through VII, the investigators look at 6 consuming sectors and 6 determinants of demand for a total of 36 items. The cross-cutting nature of the research is designed to ensure that as few items as possible are missed, given that it is impossible to exhaustively check all the items in a 864-item checklist. Tables 1 and 2 diagram the checklists of Chapter III on the one hand, and each of the energy form chapters on the other.

An aid through this long checklist would be a set of theories or empirical research that established the presence or absence of connections between dimensions of this checklist. Appendix A presents a survey of literature on empirical connections between demand determinants and consuming sectors. We are not aware of any previous attempts to explicitly make any of the rest of the connections we are seeking. We

TABLE 1. Chapter III Checklist

Incentive Type	Demand Determinant
Taxation	price
price of complement	
price of substitutes	
preferences	
income	
technology	
Disbursements	price
price of complement	
price of substitutes	
preferences	
income	
technology	
Requirements	price
price of complement	
price of substitutes	
preferences	
income	
technology	
Traditional or Nontraditional	price
price of complement	
price of substitutes	
preferences	
income	
technology	
Market Activities	price
price of complement	
price of substitutes	
preferences	
income	
technology	
Exhortation	price
price of complement	
price of substitutes	
preferences	
income	
technology	

TABLE 2. Chapters IV-VII Checklist

Sector	Demand Determinant
Residential	price price of complement price of substitutes preferences income technology
Commercial	price price of complement price of substitutes preferences income technology
Industrial	price price of complement price of substitutes preferences income technology
Transportation	price price of complement price of substitutes preferences income technology
Agricultural	price price of complement price of substitutes preferences income technology
Public	price price of complement price of substitutes preferences income technology

hope that the results of our efforts in subsequent chapters and in comparable attempts in other policy areas will add to a body of theory in this area.

QUANTIFICATION OF INCENTIVES

In this volume, we estimate the dollar costs of incentives, not their impacts on the users at whom they are aimed. The major conceptual problem in measuring costs is that incentives are not always aimed directly at the energy consumer. They may be aimed at another industry that produces an energy-consuming capital good, or complementary good, while still having a major impact in stimulating energy consumption. For example, the construction of roads in the United States is often funded by disbursements from the Federal Treasury to state governments, which in turn contract with road construction companies to carry out the work. The increased availability of high-speed highways that results is a stimulus to automobile driving, which in turn spurs gasoline demand. In theoretical terms, the price of an energy complement is reduced, thereby encouraging greater consumption of energy. The problem in this volume is to determine how much, if any, of the highway disbursement should be counted as an energy consumption incentive cost.

If a general microeconomic model of the U.S. economy were available, one disaggregated by industries such as highway construction and highway transportation and by energy demand sectors such as gasoline demanders, then one could, in theory, measure the impact of a highway disbursement on energy demand through a sequence of shifted supply and demand curves and movements along those supply and demand curves. The proportion of the highway subsidy that eventually affects gasoline demand could then be allocated to energy-incentive cost categories. A second possibility is to use an input/output table of the U.S. economy. The highway transportation output vector would have energy industry input rows. The sum of these inputs, a number between 0 and 1, could be used to allocate a proportion of the highway disbursement to energy industries.

Both of these proposed allocation methods are somewhat arbitrary. A highway disbursement is, in fact, a disbursement aimed at the highway construction industry, not at the energy industry. The intent is not to increase energy consumption, rather to provide cheaper transportation in a region. We recommend that analysts avoid arbitrary allocations. Incentives with a clear energy-related intent should be listed separately from those with no energy-related intent but with major energy-consumption results.

Another, somewhat easier quantification problem exists for market activity. Market activity increases aggregate energy demands above what would exist in the absence of governmental actions. In this category of incentives, transportation and energy utility expenditures by the Federal Government may be considered energy incentives to the extent that these expenditures ultimately increase the demand for energy. For this type of incentive to energy, we recommend the use of input/output coefficients to measure the "pass-through" of funds from the public sector to the appropriate energy sectors. By adding up the energy coefficients under the appropriate output vector, one can determine the proportion of an expenditure which should be allocated to energy industries.

The income variable found in residential energy-demand functions presents additional quantification issues. Many federal actions affect the income of consumers, yet very few have any energy-related intent. Due to the variety of ways consumers spend their income, a general income-enhancing policy is not likely to have a major energy result. Thus, we can rule out fiscal and monetary policies, most income tax deductions, and general income assistance programs on both major intent and major result criteria.

However, income assistance programs which affect energy complements may deserve consideration as energy-consumption incentives. For example, the deductability of mortgage interest on federal personal income tax returns is an income-related program that is directly linked to the price of an energy complement. The link to energy consumption is through the complementary price variable in the demand function rather than through the income variable. Similarly, interest subsidies through the Federal Housing Administration, Farmers Home Administration, Veterans

Administration and secondary market operations have an effect through the complementary price variable.

It may be argued that these actions fail to qualify as energy incentives on the major results criteria; that is, the major effect of these policies may be encouraging home ownership by particular classes of people and in particular locations but without any demonstrable major effects on energy consumption.

SUMMARY

Our discussion in this chapter has been based on the following framework: the government provides incentives in the form of taxes, requirements, services, disbursements, and market activity. The incentives, in turn, influence demand functions, affecting such key variables as price, income, and preference. These variables determine the demand for energy consumed by particular sectors.

If a governmental action affects a determinant of demand, then it is an incentive to demand. Tables with incentive types and determinants of demand unique to particular sectors can thus be constructed, tasks that will be undertaken in subsequent chapters.

Our purpose in the following chapters will be to explore the impact of incentives on demand. The next chapter deals with this issue generically, across energy forms; later chapters will deal with it in regard to particular forms of energy. We intend these chapters to relate particular governmental actions to particular demand determinants using tables such as Tables B-1 to B-5 as a guide to the classification of those actions.

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III. GENERIC ANALYSIS OF CONSUMPTION INCENTIVES IN FISCAL 1978

INTRODUCTION

In this chapter, we will present our findings on the amount of money that was allocated to stimulate consumption by type of incentive in FY-1978.[1] Many governmental actions are aimed at several energy forms, as our analysis will show. The remaining chapters in this volume will consider actions used to stimulate consumption of particular energy forms over the period 1950 to 1978. In this chapter, we will look at incentives of various types aimed at different energy forms in 1978. This cross-sectional approach, focused on a single year, is intended to uncover incentives not covered in the chapters that focus on a single energy form.

METHODOLOGY

Actual spending by agencies of the Federal Government during FY-1978 is reported in the Appendix of the FY-1980 budget.[2] We searched the entire Appendix, looking for examples of each type of incentive. As a check to ensure that we did not miss any relevant programs, we used the subject index of the United States Government Manual[3] to ensure that we considered every federal agency involved in activities which might stimulate energy consumption. This cross-checking procedure involved using the subject categories in the manual to locate agencies concerned generically with energy, with particular energy forms, and with types of energy uses. For tax incentives, we also examined the Internal Revenue Code[4] and the Budget of the United States: Government Special Analyses, Fiscal Year 1980.[5] We also consulted Brannon's work on energy taxes[6] to ensure that we did not miss any relevant taxes.

For each agency with energy-related activities, each budget line item which appeared to be an example of one of the types of incentives was then further investigated. We determined whether the budget activity was directed at one of the energy demand determinants identified in the theory chapter; what incentive type, user class, and energy form were involved;

and what the level of expenditure was in FY-1978. Descriptions of the activities covered by each budget line item are summarized in Appendix A to this chapter. In most cases, the Appendix description was sufficient to determine whether or not the line item was in fact an example of a particular type of incentive. In cases where the Appendix description was not sufficient, additional sources were consulted as necessary. Telephone calls to the agencies involved were used in some cases, and in other cases we consulted previous editions of the Budget in order to get better descriptions of the programs as they existed during FY-1978. The persons we interviewed in various agencies are acknowledged in Appendix B.

TAXATION

Taxation incentives were found only in the case of oil. One program, deductions for nonbusiness state and local gasoline, diesel and motor fuel taxes, accounts for the entire cost we estimated. Taxation incentives constituted 45.6% of the incentives with energy-related intent. The result of this program is to increase consumer income, thereby stimulating energy consumption to some degree. Because the income stimulus is linked to gasoline expenditures, the stimulus to energy consumption may be greater than for general income policies. There is also a small price effect. Note, however, this program was eliminated in FY-1979.

One might argue that this deduction was not on energy consumption incentive but was rather a matter of tax equity. In general, a tax paid by a citizen to a state or local juridiction is allowed as a deduction on federal personal income taxes reflecting the principle that income used to pay one tax should not be taxed again by the Federal Government. Such taxes are general revenue raising measures and include state income tax, state and local property taxes, inheritance taxes (up to a limit) and state and local general sales taxes. Others are excluded, such as state liquor taxes, cigarette taxes, and other excise taxes passed for specific purposes. Although equity may have been involved in including highway fuel taxes, which are frequently dedicated to highway use, among the general revenue taxes, the fact that it was considered separately and was not included with the special excise taxes shown intent to give this energy item privileged status, with the knowledge that it would increase consumption in a small way. The elimination of this deduction could be thus considered removal of the privileged status so as to discourage highway fuel consumption.

There are five other taxation incentives provided to the oil sector, but, for these, estimates of the revenue foregone in FY-1978 are not available.[7] These programs, which have not been included in our list of expenditures, are:

- credit for gasoline excise taxes paid by farmers
- credit for gasoline excise taxes used for nonhighway purposes or by local transit systems
- credit for diesel and special motor fuel excise taxes used for farm or public transportation purposes or re-sold
- an exemption from the manufacturer's excise tax on trucks, buses, and tractors for school, bus, camper coach or ambulance use, and
- exemption from the excise tax on use for transit-type buses.

One tax item that is not included in the Treasury analysis has been estimated separately. This is the exemption of state and local governments from the payment of federal highway fuel taxes. For 1978 this amounted to $99.5 million. (Details of the calculation are in Chapter 5.) All of these programs increase revenues or income in the agricultural, public, or residential sectors, thereby stimulating energy demands.

DISBURSEMENTS

Three programs use disbursements to stimulate energy demand. A program in the Community Service Administration pays heating bills for the elderly and poor during severe weather emergencies, and two Department of Energy programs provide funds for the demonstration and ultimate commercialization of solar technologies. These disbursements constitute 14.7% of the total number of incentives with energy-related intent. All three of these programs increase the income of the recipient sector in a manner linked to energy consumption. Thus, energy demand is stimulated through either price or income variables.

Disbursements account for 43.8% of the incentives with nonenergy-related intent. They include a large number of different programs administered by the Department of Transportation, the Department of the Interior, the Department of Agriculture, and various independent agencies. These programs, which distributed over 12 billion dollars in FY-1978, provided funds for mass transit, railroads, road construction, and water-related transportation projects. The latter includes appropriations for the St. Lawrence Seaway and the Panama Canal. These disbursements reduce the cost of energy complements, thereby stimulating energy consumption.

REQUIREMENTS

While taxation incentives are aimed only at oil consumption, requirements are aimed at four forms of energy: coal, oil, natural gas, and electricity. The two agencies responsible for regulating consumption are located within the Department of Energy (DOE). Both started earlier as independent regulatory commissions and were incorporated into DOE. The Economic Regulatory Administration (ERA) is the successor to the Federal Energy Administration, which was created by the Nixon administration to allocate oil supplies after the 1973-74 oil embargo. ERA now regulates crude oil prices and availability. These activities hold down the price of oil to consumers, thereby stimulating consumption. The ERA also plays a role in encouraging coal consumption by ordering the conversion of existing oil-fired or dual purpose utility boilers to coal-burning boilers only. These orders are intended to shift the coal demand curve up at all price levels. The Federal Energy Regulatory Commission (FERC) is heir to the Federal Power Commission (FPC), a regulatory agency created in the 1930s by the Roosevelt Administration. FERC controls prices of interstate natural gas and electricity. ERA and FERC programs account for 6.1% of total consumption incentives with energy-related intent. Other forms of energy, including solar, have not yet been subjected to governmental pricing requirements.

SERVICES

Only one energy-related service incentive was found. (The outreach activities for conservation or renewable resources are outside our scope.) This is the expenditure by the Department of Energy's Energy Information Administration for energy supply and demand modeling. This activity mixes supply and demand research. Even at the level of individual studies, it is often impossible to separate demand-related aspects of the work from supply-related issues. As economic theory indicates, actual market outcomes are the result of the simultaneous interaction of suppliers and demanders. In addition, such studies have a public goods character; their results are equally valuable to energy users and energy providers. Therefore, we have included the entire 1978 budget outlay for EIA's energy-economic modeling. This outlay was 2.6% of the total consumption incentives with energy-related intent. The rationale for inclusion of this program is that the information provided to energy consumers about probable energy prices allows consumers to make rational energy choices. By providing information, EIA may change the perceived value of demand determinants for energy consumers in any use sector.

Spending for services amounts to 9.5% of the total incentives with nonenergy-related intent. Such organizations as the Interstate Commerce Commission, the National Oceanic and Atmospheric Administration, the Corps of Engineers, the Federal Aviation Administration, and the Civil Aeronautics Board provide these services. They set rates, grant operating authority, regulate mergers, conduct research, provide for protection of navigation, establish safety rules, and administer safety programs. By providing these services to a major energy-using sector, these organizations ultimately impact energy demand by making energy complements less costly.

MARKET ACTIVITIES

One energy-related market activity was found. The acquisitions of crude oil for storage in the Strategic Petroleum Reserve are an incentive to oil consumption in two respects. First, DOE revenue or "income" is increased, thereby stimulating the agency to procure more oil. Secondly, all oil consumers benefit from the "insurance" aspects of the reserve, by having a higher probability of avoiding supply disruptions as a result of the reserve. With the availability of oil ensured to a degree, consumers in all sectors may increase oil demands. This effect can be viewed as an increase in the value of a preference variable, security of supply. This program accounts for 31% of the incentives with energy-related intent.

A major proportion of incentives with nonenergy-related intent are market activities. Government expenditures for transportation, lighting, heating, and cooling amount to over $13.4 billion per year according to our estimate, or 46.7% of the incentives with nonenergy-related intent. The transportation use of energy was estimated using input/output coefficients to determine the proportion of the governmental transportation expenditure which was ultimately spent on energy. Nontransportation energy expenditures by the government were mainly lighting, heating, and cooling of governmental buildings. Nontransportation energy expenditures were estimated from consumption quantity data and national average energy prices (see Table A-2 in Appendix A for details of these estimates). The rationale for considering these activities as energy incentives is that agencies receive income, or budgets, which result in demands for energy. We note that other energy consumers must view governmental energy purchases as a disincentive to their own energy consumption, since prices are likely to be higher than otherwise.

The bulk of the government's market activities were for the acquisition of electricity. Eleven billion of the $13.4 billion in market activity, or 82%, was used for this purpose. Oil was the second largest procurement category, with over $1.5 billion in expenditures in 1978. Natural gas and coal purchases were even smaller. The least significant governmental procurement expenditure was for solar. Solar purchases came to only 0.3% of the total market incentives.

The net effect of some of the service and disbursement incentives with nonenergy-related intent is not clear. The Panama Canal, for example, is a substitute transportation route for ships which would otherwise have to go around the tip of South America. By building and maintaining the Panama Canal, the U.S. Government actually conserves oil which might have been used to power ships all the way around South America. However, the existence of the Canal may encourage overseas commerce which otherwise would not have happened, thereby increasing oil consumption. Similarly, the St. Lawrence Seaway is an alternative to overland transportation modes, and the net effect on energy consumption is not apparent. This is the case with governmental subsidies for railroads and mass transit as well. There are alternative methods of transportation and it is not clear what effect subsidizing alternatives in various proportions for various purposes has had on net energy consumption. While Chapter II defines incentives as governmental actions whose major intent or effect was to stimulate energy demand, it is not clear whether these actions have been, on balance, a stimulant or depressant of aggregate demand. This issue can not be resolved without attempting to measure the results of the incentive program, a task which is outside the scope of this volume.

Much of the subsidizing of consumption has not been by design. It has largely been a response to people's needs, available technologies, and existing patterns of energy use. The government's intention was not to favor one form of energy over another, but to facilitate the provision of a service (the transportation of goods and people) that entails energy consumption. The stimulation of commerce and the economic development of particular regions was in many cases also an intent. The impact on energy consumption has been inadvertent, although not difficult to foresee, and therefore these programs, even with these reservations, are included as energy consumption incentives.

The magnitude of spending on programs with nonenergy-related intent, but possibly major energy results, compared to spending on programs with a clearly energy-related intent, is overwhelming. While nearly $29 billion was spent on the programs with nonenergy-related intent, only about $2 billion was spent on programs with a clearly energy-related intent. If the energy consumption results of the programs with nonenergy-related intent are at all substantial, much of the government's impact on energy consumption patterns may be inadvertent. The impacts may stem from the fact that the government itself is a major actor in the U. S. economy, and, therefore, a major consumer of energy. Second order effects on energy consumption also stem from governmental programs affecting the transportation sector.

CONSUMPTION INCENTIVES BY ENERGY USERS

The energy-use sectors identified in Chapter I are residential, commercial, industrial, transportation, agricultural, and public. Chapter II sketches a number of hypotheses concerning probable relationships between incentive types and classes of energy users. The energy consumption incentive data can be reorganized by user class to check these hypotheses. Tax incentives and one disbursement program are the only incentives provided directly to the residential sector. The commercial sector receives no incentives directly. The industrial sector is the target of both requirements and market activity, but receives no disbursement incentives, just as we hypothesized. The transportation sector receives many incentives with nonenergy-related intent. The disbursement incentives provide funds to entities in the public sector which in turn construct transportation systems or offer transportation services. The service incentives provide information, sets of standards and safety-related services to transportation entities in the private sector. Agriculture receives some tax incentives. The public sector receives disbursements which encourage the use of solar energy, and budgets which result in energy procurements. One service program benefits all energy users.

CONCLUSION

Tables 3, 4, and 5 summarize our estimates of the costs of consumption incentives. Table 3 covers incentives with energy-related intent, while Table 4 summarizes the full costs of government activities which were undertaken for nonenergy-related reasons, but which may have major energy consumption results. Table 5 reorganizes these data by user type.

This analysis of $31.1 billion in federal incentives used to stimulate energy consumption reveals a concentration of incentives in

TABLE 3. Energy Consumption Incentives with Energy-Related Intent by Incentive Type and Energy Form (Thousands of 1978 dollars)

	Coal	Oil	Natural Gas	Electricity	Other	Total	Percentage
Taxation		979,500				979,500	42.1%
Disbursements		158,076			125,530	283,606	12.2%
Requirements	4,055	77,873	19,193	15,854		116,975	5.0%
Services					50,654	50,654	2.2%
Market Activity		897,148				897,148	38.5%
Total	4,055	2,112,597	19,193	15,854	176,184	2,327,883	100%
Percentage	0.2%	90.8%	0.8%	0.7%	7.6%	100%	

TABLE 4. Energy Consumption Incentives With Nonenergy-Related Intent by Incentive Type and Energy Form (Thousands of 1978 dollars)

	Coal	Oil	Natural Gas	Electricity	Other	Total	Percentage
Taxation							
Disbursements		12,625,744				12,625,744	43.8%
Requirements							
Services		2,740,471				2,740,471	9.5%
Market Activity	187,973	1,519,742	652,750	11,054,284	40,000	13,454,749	46.7%
Total	187,973	16,885,957	652,750	11,054,284	40,000	28,820,964	100%
Percentage	0.6%	58.6%	2.3%	38.3%	0.1%	100%	

TABLE 5. Energy Consumption Incentives by User Type for 1978 (Thousand 1978 dollars)[a]

	Residential	Commercial	Industrial	Transportation	Agricultural	Public	All	Total	Percentage
Taxation	880,000				(b)	99,500		979,500	3.1
Disbursements	158,076			(12,625,744)		125,530		12,909,350	41.4
Requirements			116,975					116,975	0.4
Services				(2,740,471)			50,654	2,971,125	9.0
Market Activity						897,148 (13,454,749)		14,351,897	45.6
Total	1,038,076		116,975	15,366,215		14,576,927	50,654	31,148,847	
Percentage	3.3%		0.4%	49.3%		46.8%	0.2%	100%	

(a) Incentives with nonenergy-related intent are shown in parentheses.
(b) Tax incentives to agricultural sector exist but the dollar values of these incentives are not available.

particular energy forms, user classes, and incentive types in FY-1978. Most of the consumption incentives came about as a consequence of the funding on nonenergy-related activities, $28.8 billion in all. Because these activities imply energy consumption, impacts on consumption patterns are likely. Government agencies used an estimated $14.4 billion of energy products in carrying out their programs, and $15.3 billion was spent on transportation-related disbursements and services. About $2.3 billion was spent on programs with clearly energy-related intent. Nearly half (42%) of this amount was a tax incentive for gasoline consumption, and about 39% was allocated to Strategic Petroleum Reserve purchases. The remaining 19% was distributed across a variety of disbursement, service, and requirement activities.

These patterns of consumption incentives for traditional energy forms suggest a number of directions for solar policy. The indirect incentives to traditional energy forms, using disbursements and market activity, may have had major influences in shaping energy consumption patterns in the United States. Analogous opportunities exist which solar policymakers may want to take advantage of.

For example, programs are emerging for reindustrialization to combat productivity problems in American industry. There may be opportunities for solar applications in this context, provided that a solar energy source contributes to the central program goals of productivity and competitiveness in world markets. Programs for communications systems could have requirements for use of solar power at remote sites or other circumstances where solar systems are just competitive and may need an extra boost from the government. In both cases government disbursements may be an appropriate mechanism for influencing private sector decisions.

Market activity by the Federal Government is a powerful influence on consumption patterns in the country. As the data in Appendix B show, the Federal Government is the single largest energy consumer in the country. As a major energy consumer, it can influence overall consumption patterns. Furthermore, by being the leader in setting new consumption patterns, the government can influence the decisions of other energy consumers in the country. In circumstances where careful analysis shows that solar technologies are economically competitive, the government can require use of solar technologies rather than other competitive traditional energy forms. In some circumstances, government purchases at somewhat noncompetitive prices can be used to build manufacturer experience and volume, thereby driving future prices down into a competitive range and providing real benefits to the rest of society. This is part of the rationale for the Federal Photovoltaic Utilization Program. This idea may be applicable to other solar technologies. Other arguments of a public goods character, such as protecting energy consumers from dependence on foreign energy supplies, may be used to justify government procurements of solar energy sources at prices above competitive levels. Thus, for both reasons of cost competitiveness and promotion of the general public interest, it is likely that market activity should be a major component of government solar policies.

Disbursements and market activity programs may be the major areas deserving additional emphasis beyond the solar programs already in place. Tax credits are available to energy consumers who install solar energy technologies in buildings. There is discussion of accelerated depreciation and other tax mechanisms to give incentives to commercial and industrial energy consumers. Research and development and information dissemination programs exist, providing service incentives to solar energy users. In the requirements area there has been consideration of technical standards for solar products which would assure consumers of receiving quality products. Additional requirements programs could be constructed. For example, a building permit applicant with a solar installation in his designs might receive faster processing of his application than other applicants. Requirement trade-offs may be possible in some cases, such as giving a solar-powered consumer in industry a credit for the pollution he does not create and an ability to use that credit in another installation or to sell it.

As in the case of the traditional energy forms, both direct solar incentives and indirect solar incentives which are tied to other government programs may be possible. A variety of incentive types need to be utilized. In particular, disbursement and market activity programs deserve additional emphasis, and creative use of requirements programs may be possible to supplement the existing tax, service, and requirement incentives which are already in place.

NOTES - CHAPTER III

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2. U.S. Office of Management and Budget, The Budget of the U.S. Government, Fiscal Year 1980, Appendix. Government Printing Office, Washington, DC, 1979.

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4. United States Internal Revenue Code.

5. U.S. Office of Management and Budget, Budget of the U.S.: Government Special Analyses, Fiscal Year 1980. Government Printing Office, Washington, DC, 1979.

6. G. M. Brannon, Energy Taxes and Subsidies: A Report to the Energy Policy Project of the Ford Foundation. Ballinger, Cambridge, MA, 1974.

7. Ms. Greenwell of the Internal Revenue Service in a telephone interview, July 21, 1980, stated that data on the value of these tax deductions are not available.

IV. COAL CONSUMPTION INCENTIVES

INTRODUCTION

Over the past few years there has been a great deal of federal interest in increasing the use of coal as a substitute for oil and natural gas. While still below expectations, coal consumption has risen to the highest levels in history. In 1950, U.S. consumption of coal was 494.1 million tons. The annual figure dropped gradually through the 1950s before starting to climb in the early 1960s. A record level of 679 million tons was consumed in 1979. By far the largest portion, 77.6%, was used by electric utilities. The remainder was divided among coke plants, 11.3%, other industry, 9.7%, and retail sales, 1.3%. The recent growth in consumption can be attributed in part to incentives provided by the federal government. These incentives will be discussed sector by sector, starting with the residential.

HISTORY OF COAL IN THE U.S. IN BRIEF

Coal was first used in Western Europe as far back as the 12th or 13th Century and by 1600 it was well established in England, Germany, Belgium, and France.(1) In England by the mid-1700s, wood for charcoal was so scarce and costly that the iron industry was being constrained. About the year 1760, coke manufacturing and ironmaking using coke were developed. From that time on, the rise of industrialization and the use of coal went hand in hand. Coal was used in steam engines which were used for pumping water, powering industrial processes, and running locomotives. Coal also readily replaced wood for residential and commercial heating.

In the United States, coal use followed a somewhat different course. The first coal used by the American colonists was imported from Europe. (Coal had been used in North America as early as 1000 AD by the Hopi Indians in Arizona for heating and firing pottery.) The first recorded commercial coal transaction in the United States was a 32-ton shipment from the James River district in Virginia to New York in 1758. For the next several decades, coal production and use remained at a very low level because wood and water power were very abundant, transportation was inadequate for long-distance coal movement, and industrialization had not proceeded very far. Thus, until 1830, production was sporadic and markets were very local in nature. The years between 1830 and 1850 saw substantial growth in the amount and extent of coal production and use as the nation grew geographically and industrially. By 1850, coal mining had become established as a viable commercial activity.

Following the Civil War, the railroads expanded tremendously. For several reasons, this was the single most important factor causing the great rise in coal consumption experienced in the latter half of the 19th century. First, the trains themselves used great amounts of coal. Steam locomotives switched to coal from wood, which was starting to become less available and more costly in some areas. Second, construction of the railroads required great amounts of iron and steel, which in turn required coking coal. The Bessemer process for steelmaking was introduced about 1860. This made possible the large-scale, low-cost production of steel and greatly increased the demand for coal. Finally, the railroads made expansion of coal mining possible by providing the transportation network necessary for serving the expanding markets.

Prior to the development of the railroads, the only method of transporting coal for long distances was by water. Steamboats were used to carry coal on the inland waterways. By the 1840s, these vessels also became one of the first markets for coal west of the Appalachians.

In the residential and commercial sectors, coal use was concentrated in areas near the eastern Pennsylvania anthracite fields. As early as the first decade of the 19th Century, anthracite coal was sold by the bushel for home heating in the large eastern cities. Anthracite coal consumption actually outstripped the more plentiful bituminous coal until after the Civil War.

By 1885, coal surpassed wood as the most important source of energy. At that time, 42% of the total coal consumption was accounted for by use in locomotives and 13% was used to make coke. Only in domestic use did wood remain dominant, and that was rapidly changing.

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In the late 1880s, several developments affected the coal industry. Manufactured gas and electric power opened new markets for coal. At the same time, however, oil, and to a lesser extent natural gas, were starting to displace coal in some markets. In addition, efficiency improvements reduced the need for as much coal to perform a unit of work. For example, five pounds of coal were required to obtain one horsepower of mechanical work using an early steam engine, whereas, an internal combustion engine could do the same with coal gas derived from only one pound of coal. The net result of these factors was that by 1907, coal provided 78% of total domestic requirements.

Coal declined in relative importance after 1907 due to new oil discoveries although absolute consumption continued to increase through 1918 as a result of World War I. Thereafter, coal consumption declined until 1935, when it again started to increase. Domestic consumption peaked in 1943 during World War II, although post-war exports boosted production to a 1947 peak. Consumption gradually declined throughout the late 1940s and 1950s due to loss of the home heating and railroad markets. A low point was reached in 1961 and only in the past few years has coal consumption grown to the point where the 1943 peak has been surpassed.

The stagnation of the coal industry in the 1920-1935 period was due to competition from oil, a prolonged strike, and the economic downturn starting in 1930. After World War II the stagnation was due primarily to a loss of markets to natural gas and petroleum products. The railroads switched to more efficient diesel engines. (Maritime vessels made the switch to oil after World War I.) Coal was not used in any of the fastest growing segments of the transportation sector, road, air, and pipeline. Manufactured gas reached a peak in the 1940s. Steel industry coke consumption peaked in the 1950s. In addition, the home heating market for coal disappeared after World War II because of the availability of cheap, abundant, and clean oil and gas. Only the electric utility industry provided a growth market, and this was less than might be expected because of tremendous improvements in generation efficiency and competition from oil and natural gas and, by the 1960s, nuclear power. Only in the industrial market did coal remain dominant, and even this edge has been lost over the past two decades. The recent increase in coal consumption is due almost entirely to greater use by electric utilities.[2][3] Historical consumption figures are provided in Table 6.

RESIDENTIAL/COMMERCIAL

Only about one percent of total coal consumption is accounted for by residential and commercial users. It is limited almost exclusively to the Eastern coal producing states. Residential and commercial coal consumption has fallen steadily for decades as homeowners and businesses turned to cleaner, more convenient fuels for their energy needs. Table 7 depicts the trend for residential use of coal.

The commercial sector has followed a similar pattern. Today, few commercial buildings even have the space necessary for coal storage and handling. Those businesses continuing to use coal are generally large institutions, frequently with their own electric generating facilities. Very few new commercial or residential buildings are being constructed with coal burning capability.

INDUSTRIAL

For the purposes of this report, the industrial sector includes manufacturing establishments, coke plants, and electric utilities. These industries account for about 99% of total coal consumption in the United States.

Coke plants consume high-grade metallurgical coal. Over the past few years, coke production has been down due to a slump in domestic steel production, a decreased coke-to-steel ratio, and an increase in the use of the electric furnace.

The other major non-utility use of coal is for industrial process heat, and in-plant electricity generation. Steam coal sales to industrial customers increased slightly in 1978 and again in 1979 after falling steadily for many years. The pollution control laws persuaded many

TABLE 6. Sectoral Coal Consumption (Million Short Tons)[(a)]

Year	Electric Utilities	Coke Plants	Other Industry and Misc.	Transportation	Residential and Commercial	Total
1979	528.8	77.1	65.9		9.1	680.9
1978	481.2	71.4	63.1		9.5	625.2
1977	477.1	77.7	61.5		9.0	625.3
1976	448.4	84.7	61.8		8.9	603.8
1975	406.0	83.6	63.6		9.4	562.6
1974	391.8	90.2	74.9	0.1	11.4	558.4
1973	389.2	94.1	68.0	0.1	11.1	562.6
1972	351.8	87.7	72.9	0.2	11.7	524.3
1971	327.3	83.2	75.6	0.2	15.2	501.6
1970	320.2	96.5	90.2	0.3	16.1	523.2
1969	310.6	93.4	93.1	0.3	18.9	516.4
1968	297.8	91.3	100.4	0.4	20.0	509.8
1976	274.2	92.8	101.8	0.5	22.1	491.4
1966	266.5	96.4	108.7	0.6	25.6	497.7
1965	244.8	95.3	105.6	0.7	25.7	472.0
1964	225.4	89.2	103.1	0.7	27.2	445.7
1963	211.3	78.1	101.9	0.7	31.5	423.5
1962	193.2	74.7	97.1	0.7	36.5	402.2
1961	182.1	74.2	95.9	0.8	37.3	390.3
1960	176.6	81.4	96.0	3.0	40.9	398.0
1959	168.4	79.6	92.7	3.6	40.8	385.1
1958	155.7	76.8	100.5	4.7	47.9	385.7
1957	160.8	108.4	106.5	9.8	49.0	434.5
1956	158.3	106.3	114.3	13.8	64.2	456.9
1955	143.8	107.7	110.1	17.0	68.4	447.0
1954	118.4	85.6	98.2	18.6	69.1	389.9
1953	115.9	113.1	117.0	29.6	79.2	454.8
1952	107.1	97.8	117.1	39.8	92.3	454.1
1951	105.8	113.7	128.7	56.2	101.5	505.9
1950	91.9	104.0	120.6	63.0	114.6	494.1
1949	84.0	91.4	121.2	70.2	116.5	483.2
1948						570.1
1947						594.1
1946						554.3
1945	71.6	95.3		126.9	158.3	611.2
1944						649.0
1943						650.9
1942						596.6
1941						544.8
1940	49.1	81.4		86.6	124.0	479.9
1939						425.8
1938						381.5
1937						481.2
1936						461.5
1935	30.9	50.5		78.7	122.6	407.4

TABLE 6. (continued)

Year	Electric Utilities	Coke Plants	Other Industry and Misc.	Transportation	Residential and Commercial	Total
1934						399.3
1933						367.3
1932						357.4
1931						430.3
1930	42.9	69.8		101.9		522.6
1929						591.0
1928						572.5
1927						574.5
1926						609.8
1925	40.2	74.5		122.6		563.3
1924						564.7
1923						605.9
1922						483.7
1921						473.8
1920	37.1	76.2		145.9		594.4
1919						529.3
1918						650.7
1917						621.7
1916						565.0
1915						510.0
1914						495.0
1913						546.2
1912						515.4
1911						477.5
1910						487.7
1909						447.6
1908						403.8
1907						467.3
1906						404.4
1905						384.0
1904						343.8
1903						351.8
1902						297.5
1901						286.9
1900						262.8
1895						190.7
1890						156.4
1885						109.6
1880						79.2
1875						55.7
1870						40.6
1865						24.5
1860						20.1
1855						16.3
1850						8.5

Sources: 1949-1979 Annual Report to Congress 1979, Vol. 2, Energy Information Administration, DOE, 1980.
1850-1948 Energy in the American Economy 1859-1975, Sam H. Schurr and Bruce C. Hetschest, Johns Hopkins Press, Baltimore, 1960.

(a) Sectoral consumption prior to 1949 is not calculated on precisely the same basis as post 1949 data.

TABLE 7. Housing Units Heated by Coal

Year	Number(million)	Percentage
1950	14.8	34.6
1960	6.5	12.2
1970	1.8	2.9
1977	0.5	0.6

Source: Energy Information Administration 1979 Annual Report to Congress, vol. 2, p. 181.

companies to switch to natural gas or distillate fuel oil. Current prices and shortages have produced some switching back.

By far the largest coal users are the electric utilities. Utility consumption of coal has increased steadily for decades, with particularly rapid growth during the 1970s. This has occurred despite large increases in coal utilization costs, notably for pollution control equipment. Historically, coal using utilities have been concentrated near the Eastern coal producing areas. Recently, large coal-fired plants have been constructed near the Western coal fields as well. Utilities serving the coastal areas are planning for large amounts of coal-based generation to serve future demand. It is expected that electricity production will account for most of the anticipated increases in future coal use.

Requirements

Energy Supply and Environmental Coordination Act

As a response to the conditions which followed the 1973 oil embargo, Congress passed the Energy Supply and Environmental Coordination Act (ESECA) of 1974.(4) Among other things, ESECA authorized the Federal Energy Agency, under certain conditions, to prohibit the use of oil and gas by facilities able to use coal. Conversion orders could be issued for planned or existing powerplants or planned industrial major fuel burning installations (MFBI). By requiring powerplants and MFBIs to burn coal instead of oil or natural gas, it was felt that a major contribution could be made toward the goals of alleviating shortages of relatively scarce fuels and reducing imports.

For a number of reasons, ESECA did not have a large impact. For one thing, a decline in the demand for electricity caused a delay in the construction of many new powerplants. Secondly, most new powerplants were already being designed for coal or nuclear energy, since oil and gas were very expensive and of questionable availability. Thirdly, there was substantial opposition by environmental agencies and others to the use of coal in some locations. (Many plants had only recently switched from coal to oil to meet air emission standards.) Fourthly, the process of issuing orders for fuel switching was rather lengthy and cumbersome: the FEA was required to issue a "Notice of Intent," and an environmental impact statement, economic analysis, and other information were required. In addition, public hearings were required. Finally, a "Notice of Effectiveness" was to be issued. This included the analyses which were utilized in the decision-making process and also contained a compliance schedule by means of which the conversion was to be completed. As a result, few powerplants were actually constructed for or converted to coal in response to ESECA provisions.

Although ESECA was originally scheduled to be effective only until June 30, 1975, it was twice extended. The Energy Policy and Conservation Act of 1975 extended the authority to issue orders to June 30, 1976, and its period of enforcement until December 31, 1984.(5) It also extended FEA authority to fuel conversion of existing industrial facilities. In July 1977, the authority to issue orders was extended to December 31, 1978.(6) This authority was eventually allowed to expire because Congress, in 1978, passed a tougher law, the Powerplant and Industrial Fuel Use Act (see below).

On the basis of discussions with DOE personnel, it has been determined that it is impossible to measure whether or not the ESECA program had any real impact. As of early 1980, 32 of the 49 powerplants which were issued orders are now burning coal. However many, if not most, of these plants voluntarily converted for economic reasons. Nonetheless this program is considered an incentive because its intent was clearly to increase coal use.

Powerplant and Industrial Fuel Use Act of 1978

The Powerplant and Industrial Fuel Use Act (PIFUA) constitutes one of the five major portions of the National Energy Act of 1978. Among the major purposes of the act are "to conserve natural gas and petroleum for uses, other than electric utility or other industrial or commercial generation of steam or electricity," and "to encourage and foster the greater use of coal and other alternate fuels."(7) To acomplish these ends, the Department of Energy has undertaken a program to require certain facilities to switch from oil or gas to an alternative fuel, generally coal. In addition, there is a general prohibition against the use of oil or gas as a primary energy source in new electric powerplants and major fuel-burning installations. Existing powerplants must switch by 1990.

The result of the Act will be to increase the consumption of coal. The impact will be felt initially through DOE fuel switching orders and, over the long-run, by the construction of new coal-burning plants. As of the end of 1979, no plants had completed the switch to coal as a result of PIFUA. Therefore, the impact on the consumption of coal to that time is zero.

Another incentive to encourage the use of coal is provided in Section 602 of PIFUA. This allows the Secretary of Energy to make a loan for the purpose of financing air pollution control equipment to any person who owns or operates an electric powerplant converting to coal or another alternative fuel. The interest rate and fee on the loan are set so that the Treasury incurs no revenue loss. Therefore, the value of the loan is the difference between the market interest and fee rates and the rates charged by the government. The amount of this subsidy will vary among firms, but is expected to be relatively insubstantial for the majority.

Finally, Section 803 of PIFUA adds a $100 million authorization to the Railroad Rehabilitation and Improvement Fund in order "to provide financial assistance to railroads for maintenance, rehabilitation, improvement and acquisition of equipment and facilities which will be used for the rail transportation of coal."(8) This fund was established by the Railroad Revitalization and Regulatory Reform Act of 1976 to subsidize service on certain routes which otherwise would be abandoned.

The Cost of ESECA and PIFUA Incentives. The cost of administering the ESECA and PIFUA programs in FY1978 was $4.1 million, according to the Appendix to the 1980 U. S. Budget. The annual costs of running these programs for fiscal years 1975 through 1977 were not itemized in the Budget, but presumably would be less. This is a relatively minor incentive as measured by its administrative costs. Ten million dollars total for the period is used here as an estimate.

Services

Research and Development

Among the factors limiting the use of coal are environmental regulations, particularly air pollution standards which prescribe limits on sulfur oxide emissions from coal burning installations. This is a serious problem for the electric utility industry. It has been estimated that because it is difficult to obtain low-sulfur coal, over 150 million tons have been used for power generation that did not conform to these regulations. This problem is increased by the high cost, and in some cases questionable effectiveness, of stack gas scrubbers and other desulfurization processes for reducing coal combustion pollutants.

Extensive research is under way to provide workable antipollutant processes, including different types of scrubbers, fluidized-bed combustion, solvent refining, and others. To encourage the installation of flue gas desulfurization equipment, it has been suggested that until these processes become high performance, proven techniques, consideration be given to classify them under the Internal Revenue Code to permit the rapid write-off of their capital costs.(9)

Just as the sulfur content of coal has become an increasingly important factor in the use of coal, so are relative heating values of coals, both in their direct relation to SO_2 regulations and their costs. Generally coals of high value command the highest prices.

Considerable research has been done by the Federal Government and industry on the preparation of coal to reduce impurities, including sulfur, as an alternative to post-combustion abatement.

Research on new uses of coal, including low-rank coal such as lignite, has been carried on for many years by the Bureau of Mines. During the Kennedy Administration, the Office of Coal Research was established to develop new processes for the use of coal, including research, development, and demonstration. With the establishment of ERDA, the Office of Coal Research and coal use activities of the Bureau of Mines were transferred out of the Department of the Interior.

Through the efforts of the U.S. Bureau of Mines, the synthetic fuel developments achieved by the Germans during World War II were evaluated in a program at Louisiana, Missouri. German Lurgi hydrogenation units were evaluated using U.S. coals. Only minor economic use was made of the information developed at that time, but it has provided useful background information for the present synfuels program.

Because of the total lack of information relative to the feasibility of underground coal gasification, the U.S. Bureau of Mines developed a field-scale test and methodological evaluation at Gorgas, Alabama, in 1948. This work is being continued now in Wyoming. To date no commercial installations have resulted from this research.

One of the major forces underlying many coal research programs (as well as those involving other energy sources) is the large utility market, which is continually expanding to meet increasing requirements for electric power. This research is motivated by our inadequate domestic supplies of oil and natural gas and our increasing dependence on high-cost foreign oil, plus all the attendant adverse implications. In addition to research and development on coal combustion techniques, DOE is engaged in extensive and vitally needed research on coal gasification, coal liquefaction, and solvent refining. These programs are positive secondary incentives for coal use.

Cost of Coal Use R&D Incentives. Major federal expenditures on coal use R&D are listed in Table 8. The figures for the earlier years

TABLE 8. Federal Coal Use Research and Development Expenditures (Million Dollars)

Fiscal Year	Coal Use (DOE)[a]	Energy-related Environmental Control (EPA)[c]	Total Current $	Total 1978 dollars
1978	526.3	111.8[b]	638.1	638.1
1977	490.7	94.0	584.7	629.7
1976	330.3	49.4	325.6	373.1
1975	276.2	75.3	351.5	476.0
1974	78.0	16.4	520.4	688.5
1973	43.8			64.3
1972	32.9			51.3
1971	30.7			49.5
1970	16.7			28.1
1969	18.1			32.2
Total				3030.1

(a) An Analysis of Federal R&D Funding by Budget Function 1969-1979, National Science Foundation.
(b) Estimated.
(c) Equal to 93.3% of EPA energy R&D expenditures, based on examination of 1976 program.

represent Bureau of Mines and Office of Coal Research activities. The huge increase in 1975 reflects the heightened national interest in coal use which was one result of the 1973 oil embargo and subsequent price increases. The 1975 figures also reflect and consolidate an expansion of existing programs into the Energy Research and Development Administration.

Upon creation of the Department of Energy, ERDA coal use programs were transferred to the new cabinet level department. The R&D effort was expanded to include accelerated development of environmentally acceptable technologies for conversion of coal into liquid and gaseous forms; advanced energy conversion systems such as MHD and fuel cells; improved methods for direct coal combustion; clean coal preparation technologies; and environmental control equipment.

Table 8 also includes estimates of EPA expenditures on coal related environmental R&D. Included are air, water and solid waste abatement systems and new technology for preventing and controlling pollution. These programs aid the use of coal by contributing to the development of more economical and efficient control devices which are necessary for coal burning installations. The total in 1978 dollars amounts to $3 billion.

TRANSPORTATION

A negligible amount of coal is used in the transportation sector. At one time, the railroads consumed a substantial amount of coal to power locomotives. This has been phased out almost completely in favor of diesel fuel. No other modes of transportation currently make use of any measurable amount of coal.

AGRICULTURAL

A negligible amount of coal is used in agriculture. Some older farms utilize coal for heating buildings. There are no other uses that account for measurable amounts of coal use in the agricultural sector.

PUBLIC

Public sector use of coal is limited primarily to two categories. The first group consists of large institutions such as prisons, military bases, hospitals and schools. Included are local, state and federal facilities. These institutions use coal for heating buildings and in some cases for generating electricity for their own use. Because of high coal transportation costs, institutional use of coal is limited almost exclusively to the major coal producing states east of the Mississippi.

The other category of public sector use consists of federal research and demonstration facilities. These include pilot, demonstration and full-scale plants used to demonstrate developing technologies. The total amount of coal consumed at such facilities is quite small.

CONCLUSIONS

Demand impacts of federal actions relative to coal have had only small effects and the amount spent for these actions has been small.

About $10 million has been spent administering the coal switching activities of the Department of Energy, a requirement activity that influenced preference in the demand function. (This assumes it is a preference to avoid fines and jail terms, not the lack of price impacts of avoiding the fines that produced the demand change.) Of greater potential long-term impact is research and development aimed at making use of coal cleaner and more economic, especially in the form of synthetic fuels. Expenses for these nontraditional services amount to about $3 billion. This affects the demand function by changing the technology factor. These costs are tabulated in Table 9.

TABLE 9. An Estimate of the Cost of Incentives Used to Stimulate the Demand for Coal (Millions 1978 Dollars)

MAJOR SECTOR

Incentive Type	Residential	Commercial	Industrial	Agricultural	Transportation	Public	Total
Taxation							
Disbursements							
Requirements			10.0Z				10.0
Traditional Services							
Nontraditional Services			3030.1T				3030.1
Market Activity							
Total			3040.1				3040.1
Total T							3030.1
Total Z							10

Z = Preference Determinant of Demand
T = Process Technology Determinant of Demand

NOTES - CHAPTER IV

1. S.H. Schurr and B.C. Netschert, Energy in the American Economy, 1950-1975. Johns Hopkins Press, Baltimore, MD, 1960.

2. Energy Information Administration, Annual Report to Congress 1979, vol. 2. Government Printing Office, Washington, DC, 1980.

3. Bituminous Coal Institute, Bituminous Coal, Facts and Figures. Washington, DC, 1948.

4. Pub. No. 93-319, June 22, 1974, 88 Stat. 246.

5. Pub. No. 94-163, December 22, 1975, 89 Stat. 871.

6. Pub. No. 95-70, July 21, 1977.

7. Powerplant and Industrial Fuel Use Act of 1978. Title I, Section 102, codified in 45 U.S.C.A. 8301(a) (Supp. 1979).

8. Powerplant and Industrial Fuel Use Act of 1978. Title VIII, Section 803, codified in 45 U.S.C.A. 822 (Supp. 1979).

9. Coal Task Force Report, Project Independence Blueprint. Federal Energy Administration, U.S. Department of Interior, Government Printing Office, Washington, DC, November 1974.

V. OIL CONSUMPTION INCENTIVES

INTRODUCTION

The consumption of refined oil products in the United States increased from 2,358 million barrels in 1950 to 6,880 million barrels in 1978 before falling somewhat to 6,728 million barrels in 1979. The transportation sector accounts for the largest share, 51.8% in 1979. The remainder is consumed by: industry, 20.0%; the residential and commercial sectors, 18.6%; and electric power plants, 9.6%. In some cases, the consumption of oil has been encouraged by federal action. This chapter presents a view of the federal programs which have been undertaken to increase the demand for oil, or which have had such an effect for demand even though not directly intentional. Each major consuming sector will be analyzed, beginning with the residential sector.

HISTORY OF OIL IN THE U.S. IN BRIEF

In August, 1859, oil was struck at Titusville, Pennsylvania at a depth of 69 feet.[1][2] Following this first well, the petroleum industry expanded rapidly. In ten years, annual production expanded from 0.5 million barrels to 42.5 million. In these early days, output could not be controlled, and much ran onto the ground and into nearby creeks. As production fluctuated with frequent cycles of depletion and new discoveries, prices gyrated wildly. The price per barrel of oil was $19.25 in January 1860; it fell to $0.10 in January 1862, and then increased to $11.00 in December, 1864. These fluctuations were moderated somewhat as equipment was developed for collecting, transporting, processing, and marketing the oil.

The search for oil had begun in response to a need for economical and efficient illuminants. By the mid-1800s, animal and vegetable oils, in particular sperm oil, were becoming scarce and costly. Petroleum was known for decades to exist in oil springs, seeps and saltwells. It was used in limited quantities for illumination and lubrication and as a medicine. A useful distillation process had been developed in the coal oil industry, while well drilling methods came from the salt industry.

With the markets and technology in hand, all that was needed was a steady supply of oil. In 1854, a company was formed to search for oil in the area around the springs on Oil Creek in Pensylvania. After five years, the venture paid off with the strike at Titusville.

In the early years, about 70 percent of the crude oil was converted into illuminating oil. Demand for illuminants was growing rapidly from a variety of causes. Expanded literacy increased the need for lights bright enough for reading. Industrialization and urbanization created a need for lights in factories and apartments. Coal gas was available in large cities, but not in the small towns and rural areas where most of the population resided. It was the demand for illuminants that spurred the growth of the oil industry in the early years. Kerosene was the dominant product, while lubricants also became important in the latter decades of the 19th century.

From the first successful well in 1859, the oil industry experienced rapid and almost uninterrupted growth. Just one year after Col Drake's well, 15 refineries had been built. By 1863, there were 60 plants in the Pittsburgh area alone. Most were crude stills which wasted much of the oil. One problem was a lack of markets for products other than kerosene.

The success of the oil industry was dependent upon an adequate transportation network. Wooden barrels were first utilized. A wooden pipeline, 1,000 feet long, was built in 1862 to transport crude oil from the field to the nearest railroad. By 1866, hundreds of wooden tank cars had been built to carry crude oil. The first iron train car was manufactured in 1869, followed by a steel tank in 1893. By 1865, hundreds of cast iron gathering pipelines were used to transport oil to the railroads. In 1879, the first large pipeline was constructed, the 110 mile Tide-Water line. By 1910, over 20,000 miles of trunkline and 24,000 miles of gathering lines had been built.

In the 1800s, oil production greatly outstripped consumption. Great amounts of illuminating oil were exported to Europe. Petroleum exports made up as much as three-fourths of total U.S. exports in some years. The first full cargo of oil in barrels crossed the Atlantic in 1861. In 1863, oil was first transported in a subdivided cargo hold. The first steam tanker was a Russian ship built in Sweden in 1878. This ship was also important because in burned oil as a fuel. The prototype of the modern oil tanker was a German vessel launched in England in 1886.

Throughout the 19th century, oil was demanded mainly for its use as an illuminant. By the 1880s, its potential as a source of heat energy was also starting to be recognized. The use of oil for a fuel received a great impetus from the discovery of the Ohio-Indiana fields in the 1880s. This oil was not suitable for refining into illuminants. In order to market the great quantities being produced from these fields, a campaign was begun to increase the use of oil as a fuel. This had been difficult previously because the major oil fields were located in coal mining regions. Oil as a fuel was first utilized by industry, and then made its way into residential use. In these years, a substantial amount of crude oil was burned directly, without the benefit of refining. By the first decade of the 20th century, fuel oils passed kerosene in importance.

With the coming of the automobile, the mix of oil products changed dramatically. In 1876, the first gasoline-fueled, 4-stroke cycle engine was invented in Germany. Following this, development was so rapid that by the early 1890s, motor cars were so efficient and successful that there have been no fundamental changes in the typical automobile engine to the present day. In 1900, there were 8000 cars registered in the United States. This number expanded to over one million in 1913, ten million in 1921, and 20 million in 1925. Consumption of gasoline grew commensurately. By the early 1930s, gasoline passed fuel oil as the major petroleum product. By this time kerosene had become a minor product, used more as a fuel than as an illuminant.

To this day, gasoline remains the most important petroleum product, about 38 percent of consumption. This is shown by the historical statistics of oil product consumption given in Table 10.[3][4][5]

During World War II, large amounts of high octane gasoline was needed for military airplanes. The Federal Government mounted a crash program to produce "avgas" in existing refineries. The technology developed and

TABLE 10. Domestic Petroleum Consumption (Million Barrels)

	Motor Fuel(a)	Kerosene(b)	Distillate Fuel Oil	Residual Fuel Oil	Total(c)
1979	2565.9	65.7	1251.9	1102.3	6880.2
1978	2704.6	65.7	1251.9	1102.3	6880.2
1977	2620.7	65.7	1222.7	1120.5	6726.9
1976	2554.7	62.0	1145.6	1024.8	6390.4
1975	2434.5	58.4	1040.2	897.9	5956.8
1974	2387.1	65.7	1076.7	963.6	6077.2
1973	2434.5	80.3	1127.8	1029.3	6318.1
1972	2335.1	84.2	1065.1	926.0	5991.4
1971	2193.6	91.2	970.9	839.5	5551.6
1970	2109.7	94.9	927.1	803.0	5365.5
1969	2018.4	98.5	901.5	722.7	5161.1
1968	1919.9	102.5	874.7	669.8	4900.7
1967	1810.4	98.5	817.6	653.3	4584.4
1966	1755.6	102.2	795.7	627.8	4409.2
1965	1675.3	98.5	777.4	587.6	4201.1
1964	1610.4	179.3	750.3	556.3	4033.2
1963	1631.5	171.5	748.2	540.2	3920.1
1962	1584.1	164.2	733.6	547.5	3796.0
1961	1533.0	146.0	693.5	547.5	3642.7
1960	1511.6	131.8	682.5	560.0	3586.8
1959	1485.5	109.5	660.6	562.1	3478.4
1958	1434.4	113.1	653.3	529.2	3328.8
1957	1394.3	109.5	616.8	547.5	3215.6
1956	1362.5	117.1	614.9	563.6	3213.5
1955	1335.9	116.8	580.3	558.4	3087.9
1954	1230.0	116.8	525.6	521.9	2832.4
1953	1204.5	113.1	489.1	562.1	2774.0
1952	1141.9	120.8	475.8	556.3	2660.8
1951	1091.3	124.1	448.9	565.7	2562.3
1950	992.8	116.8	294.2	554.8	2357.9
1949	912.5	102.2	328.5	496.4	2102.4
1948	871.3	112.2	340.6	500.5	2113.7
1947	795.0	102.5	298.3	518.5	1984.8
1946	735.4	89.1	242.9	480.0	1792.8
1945	696.3	75.6	226.1	523.4	1772.7
1944	632.5	71.8	209.3	512.0	1671.3
1943	568.2	68.6	208.1	467.0	1521.4
1942	589.1	69.8	185.7	405.7	1449.9
1941	667.5	69.5	172.8	383.4	1485.8
1940	5898.5	68.8	180.9	340.2	1326.6
1939	555.5	60.5	135.0	323.5	1231.1
1938	523.0	56.4	117.4	291.8	1137.1
1937	519.4	55.0	116.8	325.5	1169.7
1936	481.5	51.4	102.8	307.9	1092.8
1935	434.8	47.6	86.0	280.7	983.7

TABLE 10. (contd)

	Motor Fuel[a]	Kerosene[b]	Distillate Fuel Oil	Residual Fuel Oil	Total[c]
1934	410.3	44.2	74.8	265.5	920.2
1933	377.0	38.5	64.7	269.0	868.5
1932	373.9	33.2	65.1	243.1	835.5
1931	403.4	31.3	334.7[d]		903.2
1930	394.8	34.7	368.5		926.4
1929	376.0	36.0	415.2		940.1
1928	332.0	36.2	384.0		860.4
1927	299.8	37.5	339.3		802.3
1926	264.4	38.1	339.6		781.1
1925	223.9	40.0	307.0		727.0
1924	185.0	36.7	290.8		687.9
1923	156.7	35.0	261.4		652.4
1922	127.9	34.9	237.1		530.9
1921	107.5	29.5	195.7		456.8
1920	101.2	33.1	186.0		455.8
1919	81.8	33.2	163.8		374.5
1918	74.5	34.4	142.8		359.4
1917	56.3		131.6		
1915					243.2
1910					173.6
1905					105.1
1900					39.6
1895					29.7
1890					27.7
1885					7.2
1880					17.2
1875					2.0
1870					2.0
1865					1.8
1860					0.5

Sources:
- 1949-1979 Annual Report to Congress 1979, EIA/DOE
- 1917-1948 Petroleum Facts and Figures, 1950, API
- 1860-1915 Energy in the American Economy 1850-1975, Schurr, Netschert.

(a) Prior to 1964, motor gasoline data included aviation gasoline and special naphtha.
(b) Prior to 1952, naphtha-type jet fuel was also included.
(c) Data for 1860-1915 represent apparent consumption (i.e., not adjustment for stock changes) Consumption for 1880, and to a lessor extent 1890, are overestimated
(d) Fuel oil information was combined before 1931.

installations erected helped to encourage the development of the high compression automobile engine in the postwar period. The greater efficiency of these engines was to a large extent counterbalanced by the larger size and weights of the cars that evolved into the "gas guzzler" of the late 1960s and early 1970s. No attempt has been made to quantify this as an incentive for consumption.

ALL SECTORS

This section discusses incentives that apply to all sectors consuming oil.

Requirements

Ever since general price controls were first imposed (August 15, 1971), the Federal Government has maintained some form of control over oil prices. Maximum prices or margins have been placed on oil products consumed domestically and crude oil produced in the U.S. Crude oil price controls have led to an increase in consumption compared to the free market case where higher prices prevail. Controls on product prices (to the extent they have achieved their objective) have caused an increase in product consumption and therefore increased demand for crude oil. Each of these is discussed in more detail below.

Crude Oil Price Controls

Specific price controls on oil, as opposed to general price controls, were instituted with the Emergency Petroleum Allocation Act (EPAA) of 1973. Starting in 1974, pricing regulations separated crude oil production into two categories: Old Oil and New Oil. Both categories were controlled, but at different levels. Stripper oil (oil from a property averaging no more than 10 barrels of oil per day) was exempted from price controls.

Since the initial price control scheme for crude oil, additional laws and regulations have altered the method and level of control. Old Oil and New Oil have been renamed Lower Tier and Upper Tier, while separate categories have been added for oil from the Alaskan North Slope and from the Naval Petroleum Reserves. Each change in the program has been primarily aimed at encouraging domestic production while keeping prices down. The effect on production has been discussed elsewhere. The impact upon consumption depends on the magnitude of the difference between the price of domestic crude oil and the world market price.

If the price of U.S. production were not controlled, it would rise to approximately the price on the world market. Some difference would remain because of the differences in transportation costs and quality. For a constant-quality product, the price paid at the refinery for each source of crude would tend toward equality. Therefore, by assuming that the average quality of imported crude is equal to domestic crude, the difference between composite refiner acquisition cost and the cost of imported oil is a measure of the consumption incentive resulting from price controls. The calculation is given in Table 11; the incentive amounts to $80 billion (1978$). In the summary table, this amount is allocated to sectors according to the ratios of petroleum consumption in the period 1974-1978, using data referenced below and from DOE. (5)

Oil Product Price Controls

Price controls on oil products have the same origin as those on crude oil, The Economic Stabilization Act of 1970. On August 15, 1971, the President made use of his powers under this act to impose a freeze on wages, prices, and rents. The authority to control prices was extended three times until it finally expired on April 30, 1974. Over this period the comprehensiveness and approach to price controls evolved through four distinct phases. By Phase 4, authority over petroleum prices was transferred from the Cost of Living Council to the Federal Energy Office.

While general price controls ended in 1974, the Emergency Petroleum Allocation Act of 1973 continued controls on oil through February 1975. Controls were extended two additional times, through November 15, 1975. The Energy Policy and Conservation Act, enacted December 22, 1975, not only extended price control authority an additional 40 months (with standby authority through September 30, 1981) but also gave the President the authority to remove controls from products, subject to disapproval by Congress. Middle distillates, residual fuel oil, naphthas, and other

TABLE 11. Crude Oil Price Control Incentives

Year	Refiner Acquisition Cost ($/bbl) Imported	Composite	Crude Input to Refineries (million bbls)	Incentive (million dollars)	Incentive in 1978 dollars
1978	14.57	12.46	5,377	11,345	11,345
1977	14.53	11.96	5,330	13,698	14,753
1976	13.49	10.89	4,910	12,717	14,573
1975	13.93	10.38	4,541	16,121	19,538
1974	12.52	9.07	4,429	15,280	20,215
Total					80,424

Source: Monthly Energy Review, Energy Information Administration, various issues.

minor products were decontrolled in 1976. These were followed by jet fuel in 1979 and butane and natural gasoline on January 1, 1980.

The price of oil products is determined largely by the price of crude oil. Because the price of imported crude continued to rise while the price of domestic crude was controlled, it was impossible to set a fixed price ceiling on oil products. Therefore, increased costs of crude have been allowed to be passed on to the product price. The margin between crude costs and the selling price of products has been the portion of the final price that has been controlled. However, sellers were allowed to bank any unrecouped costs and recover them at a later time. (This banking system was eliminated for retail sales of gasoline in 1979 in exchange for an increase in the sales margin.)

The impact of product price controls is difficult to assess. Until 1979, the maximum allowed price was generally above the actual price of various products. This is evidenced by a continual positive net bank of unrecouped costs. Thus, the market price has generally been below the allowed price. However, for certain refiners and retailers, the margin controls may have been a real constraint. This would be true for those firms whose non-oil costs rose substantially, either through inefficiency or higher unit costs. Thus, controls on oil product prices probably reinforced the trend toward increased efficiency. This has been accomplished by phasing out smaller retailing operations in favor of larger ones and by refiners selling off or dropping operations in areas of marginal profitability. To the extent that product price controls may have forced some efficiencies on the industry, prices of products have been somewhat lower and consumption higher than would have been the case in the absence of controls. No quantitative measures of this impact has been made.

Market Activity

Strategic Petroleum Reserve

To diminish the vulnerability of the U.S. to oil supply interruption, the Strategic Petroleum Reserve was established under the Energy Policy and Conservation Act of 1975. Work got underway in FY1976 with expenditures in that year of $3.0 million, ($3.4 million 1978$) in the transition quarter. In FY197, expenditures were $123 million, ($132 million 1978$) and in FY1978, $897 million, a total of $1,032 million (1978$).

As discussed in Chapter 3, this program is considered a direct incentive to oil users since it gives the consumer protection. (It also has impacts in improving national security and economic stability). A more stable outlook changes the preference for oil at any given price.

RESIDENTIAL

The number of homes using oil products as the principal heating source has been declining since 1960. As of 1977, approximately 5.6% of all residential units were heated by LPG and 21.3% by fuel oil or kerosene. The current proportion is undoubtedly lower as the trend from oil to natural gas has accelerated. Oil products are also used for some other appliances, especially stoves, but these are relatively minor uses.

The Federal Government operates programs that assist low income and handicapped persons to pay their heating bills. (These programs are described in the chapter on natural gas.) These programs provide a direct subsidy for the consumption of energy. Based on the fact that 29.2% of all residences are heated by oil, the share of this subsidy allocated to oil is $58.4 million per year for FY-1977 through FY-1979. Thus for the years 1977 and 1978, the total was $121.3 million (1978$)

As a further example, the federal government has aided a Massachusetts program to subsidize consumption of home heating oil. A $6.5 million federal grant was used to obtain fuel oil which in turn was sold to "needy" homeowners at a substantial discount. With the help of the grant, one million barrels of crude oil was purchased from Venezuela, processed into fuel oil and other products, and sold to homeowners in early 1980.

COMMERCIAL

The commercial sector utilizes a wide range of oil products, including distillates, residual oil, and LPG. Heating of buildings is the largest single use. Oil has declined as a percentage of commercial sector energy use for over a decade, and in absolute terms for several years. This is attributed both to conservation and to fuel switching.

INDUSTRIAL

The industrial sector, including power plants, accounts for nearly 30% of the oil consumed in the United States. The major industrial oil consuming sectors are primary metals, chemicals, and refineries. Electric utilities use oil to power conventional steam plants, both base load and intermediate units, and for internal combustion and gas turbine peaking units.

Nontraditional Services

Industrial consumption of oil has increased in recent years, in part as a replacement for natural gas which has been curtailed to industrial customers. Many industries have also converted to oil from coal in order to meet environmental standards. For the same reasons, electric utilities have also greatly increased their consumption of oil. This trend was reversed in 1979, however, as huge increases in the price of oil have made oil-fired generation generally uneconomical.

Industrial consumption of oil is encouraged by federal programs that reduce the cost of using oil products. Such federal programs are relatively insignificant. The largest programs are those which aim to improve the efficiency of pollution control equipment. Federal funds spent for oil pollution control R&D amount to $75 million (1978$) and are presented in detail in Table 12.

TRANSPORTATION

Automobiles and trucks account for approximately 75% of the fuel consumed by the transportation sector. Gasoline is currently the major product; however, gasoline consumption is declining as autos become more fuel efficient. Diesel fuel consumption is much lower, but growing rapidly.

Air transportation accounts for the next largest share of this sector's fuel consumption, approximately 10 to 11% and growing. The other significant oil consumers in this sector are railroads, water-borne carriers, and pipelines.

Government actions affecting the transportation sector can increase the demand for oil by encouraging modes of transportation which are relatively more energy intensive than others. Federal incentives and subsidies which have reduced the cost of energy intensive modes of transportation are described in this section.

Changes in the transportation system over the years have had a substantial impact on the consumption of oil. The trend has generally been toward greater use of energy-intensive modes of transportation. The Federal Government has contributed toward this trend through programs aimed at improving utilizaton of airways and highways, often at the expense of more fuel-efficient modes such as the railways. The subsidization of air and surface transportation is included as an was prepared as follows. Total state sales tax collections were estimated from the total highway fuel gallonage and the average state gasoline taxes. The amount deducted from income taxes was estimated by multiplying this figure by an index number, which was developed by multiplying the fraction of taxpayers itemizing deductions by the average fraction of gross adjusted income collected as personal income tax times an empirical factor. This empirical factor was required because the marginal tax rate for itemizers was desired, but fractional overage tax rate for the whole population was all that was available. The factor was derived from the average of the factors derived from the treasury estimates for the 4 years for which we had complete data. For the earlier years, only data for 1950, 1955, 1960, 1965, and 1970 were available for some of the tax factors, and these were applied to entires 5-year periods. Therefore, the estimates appear to have discontinuities, but the overall result is probably an adequate approximation. Some of the discontinuities are the result of changes in the tax laws; others are artifacts of the approach.)

As shown in Table 13, we estimate that a total of over $24 billion in 1978 dollars was given in income incentives to individuals in the form of income tax deductions over the years 1950 to 1978. The value of this incentive increased from only a little over $200 million per year in the early 1950s to a peak of over $1.4 billion in 1969. Since then the yearly incentive has declined to less than $1 billion per year. As noted in Chapter III, this incentive was eliminated in 1979 as a way of discouraging gasoline consumption, a response to recurrent gasoline shortages and pressure to reduce oil imports.

Traditional Services

Air Transportation

Air transportation is relatively energy inefficient compared with other modes of transportation. Thus, as federal support for air travel has increased the consumption of fuel has also increased. Some government subsidies have been direct, such as those to airlines and airports. Others have been more indirect, such as providing traffic control services free of charge. The two federal agencies responsible for the support of

TABLE 12. Federal Oil Utilization R&D Expenditures (Million Dollars)

Fiscal Year	Energy Related Environmental Control (EPA)[a]	Marine Environmental Protection (Coast Guard)	Total Incentive	Incentives in 1978 $
1978	8.0[b]	5.9	13.9	13.9
1977	6.8	6.0	12.8	13.8
1976	3.6	5.5	9.1	10.4
1975	5.4	5.4	10.8	13.1
1974	1.2	8.1	9.3	12.3
1973		7.8	7.8	11.5
Total				75.0

Source: An Analysis of Federal R&D Funding by Budget Function 1969-1979, Natural Science Foundation.

(a) This is 6.7% of total EPA energy R&D Budget, based on examination of 1976 program.
(b) Estimated.

incentive toward the increased consumption of oil, although the subsidization is not intended as such.

Taxation

Deduction of Non-Business State Gasoline Taxes

During the period under study, non-business state and local gasoline taxes could be deducted in calculating personal income tax. For the reasons detailed in Chapter 3, this was considered a direct incentive with an income effect on demand, although it also had a price effect.

The calculated amount for the period 1950-1978 is $24.1 billion (1978$).

For 1974-78, estimates are available from the special study on tax expenditures in the U.S. Budget, vol. 4. For earlier years, an estimate

TABLE 13. Value of Itemizing Non-Business State Highway Fuel Taxes

	Total Highway Fuel Use 10^9 gal	Average State Gasoline Tax ¢/gal	Fraction of Itemized Return	Income Tax as % of Gross Adjusted Income	Value of Itemized Deductions million current $	Value of Itemized Deductions million 1978 $
1978	123.1	7.83			920	920
1977	119.6	7.79	0.280	14.6	685	738
1976	113.8	7.71	0.307	14.1	710	814
1975	107.1	7.65	0.318	13.1	820	994
1974	104.5	7.57	0.357	14.0	865	1144
1973	108.6	7.53	0.347	13.5	780	1145
1972	103.3	7.32	0.348	13.0	697	1086
1971	95.9	7.09			910	1467
1970	90.7	7.01	0.480	13.7	852	1431
1969	86.5	6.84			792	1410
1968	81.4	6.62			722	1353
1967	76.3	6.45			503	983
1966	73.3	6.42			481	967
1965	69.8	6.41	0.415	12.1	458	946
1964	66.7	6.31			430	905
1963	63.7	6.22			405	852
1962	60.5	6.18			400	863
1961	58.2	6.09			379	827
1960	56.8	5.94	0.395	13.3	361	795
1959	55.3	5.86			347	776
1958	52.4	5.65			317	715
1957	51.0	5.58			226	523
1956	49.4	5.54			217	512
1955	46.9	5.35	0.302	12.9	199	485
1954	43.6	5.19			180	436
1953	42.0	5.10			170	415
1952	39.9	4.83			89	219
1951	37.5	4.75			82	207
1950	35.0	4.65	0.196	11.6	75	204
Total						24,132

Sources: Highway Statistics Summary to 1975, and Annual DOT Statistical Abstract of the United States Volume 4 (Special Studies) Budget of the United State 1975-1979 OMB.

air transportation are the Civil Aeronautics Board (CAB) and the Federal Aviation Administration (FAA).

Federal Aviation Administration. Most governmental programs in support of air transportation are carried out by the Federal Aviation Administration, Department of Transportation. (From 1958 to 1967, the FAA was an independent agency. Prior to that, its functions were performed primarily by the Civil Aeronautic Authority, affiliated with the Commerce Department.) From its beginning, the FAA has had as its primary function the development and operation of a nationwide air navigation and traffic control system. Along the way, it has also become heavily involved in air safety, airport development, aircraft research and development, and other related programs.

Currently, the FAA operates 25 centers to monitor and control enroute flights of civil and military aircraft, control towers at 427 major airports, and 323 flight service centers. These facilities are continually being modified and improved to handle an increased traffic load in a safe, efficient manner. An essential part of this function is the sponsorship of R&D programs to improve control systems and to improve productivity. In the area of air safety, the FAA is responsible for ensuring the air worthiness of aircraft, the competency of airmen, and the adequacy of flight procedures.

Direct financial assistance has been provided under two programs, aircraft loan guarantees and airport development grants. The former program was begun in 1957 in an attempt to reduce airline subsidies and improve the operation of feeder and small airlines. The Federal Government guaranteed 90% of loans made to short-haul and feeder lines for the purchase of new aircraft. The initial limit of $5 million per company was raised to $10 million in 1962. The program expired in 1977.

Airport Development Grants. Starting with the Federal Airport Act of 1946, matching grants have been provided to state and municipal airports for planning, acquisition, and construction activities. Originally funds were made available on a 50% matching basis according to a rigid allocation formula. Several amendments and extensions were made over the years to increase the program's funding and flexibility. Total funding remained fairly modest, however, until passage of the Airport and Airway Development Act of 1970.

The 1970 Act was a response to the increasing inadequacy of the nation's airports to handle the larger planes and heavy traffic imposed upon them. These problems were brought to the forefront by slowdowns and demonstrations by the air traffic controllers. To obtain the large sums of money required to thoroughly upgrade the airway system, Congress set up a trust fund similar to the Highway Trust Fund which had been established earlier to develop the Interstate Highway System. The trust fund is financed through a series of user charges and excise taxes. The largest source of revenue is a 7.5% tax on gross domestic air fares. Others are excise taxes on aviation fuel, tires and tubes (all formerly dedicated to the Highway Trust Fund), a per pound tax on aircraft, a tax on freight waybills, and a headtax on international passengers. With these sources of revenue, the federal support for airports grew substantially. The source of funding also changed from general funds to user charges and thus altered the degree of federal subsidization.

FAA Support for Air Transportation. The increased consumption of oil by the air transportation sector is directly related to the mileage flown by airplanes, which is directly related to the number of passengers who fly in airplanes, which in turn is related to the cost of air fares. Thus, the federal subsidies to air transportation, often in the form of services, ultimately lead to the increased consumption of oil. These subsidies have been discussed above. Their dollar value is listed in Table 14. Included are all FAA programs which have supported the civilian air transportation sector. From this amount are subtracted excise taxes which are comparable to user charges. The net incentive calculated in this manner is 15.8 billion for the period from 1950 to 1978 (1978$).

Federal Highway Program. The Federal Government became involved in the construction of roads as early as 1806. Federal activity in highway construction and operation was relatively insubstantial until the foundations for the modern program were set in 1916 with the Federal Road Act. Until the 1950s, the major source of support was the ABC program which provided 50% matching funds to states for the construction of (A)

TABLE 14. Incentives for Petroleum Consumption in Air Transportation (Million Dollars)

Year	(A) Civil Air Traffic Percent	(B) Expenditures	(C) Excise Taxes and User Fees	(D) Incentive	Incentive in 1978 $
1978	83.0[a]	2748	1545	736	736
1977	82.7	2537	1384	714	769
1976	82.6	2855	1362	996	1141
1975	81.4	1716	1058	339	411
1974	81.1	1616	868	443	586
1973	79.4	1665	758	564	828
1972	79.0	1546	649	572	892
1971	78.0	1347	563	488	786
1970	79.1	1190[a]	257	684	1149
1969	78.0	922	251	468	833
1968	76.2	764	207	375	703
1967	73.7	703	183	335	655
1966	69.4	717	154	344	691
1965	64.6	717	140	323	668
1964	60.5	743	123	327	688
1963	61.2	723	122	320	682
1962	62.2	689	107	322	695
1961	62.8	680	100	327	713
1960	63.0	549	100	246	542
1959	60.9	511	98	213	477
1958	58.5	391	87	142	320
1957	62.6	276	84	89	206
1956	60.0[a]	192	77	38	91
1955	60.0[a]	129	68	9	22
1954	60.0[a]	114	58	10	24
1953	60.0[a]	135	50	31	76
1952	60.0[a]	137	42	40	98
1951	60.0[a]	149	39	50	126
1950	60.0[a]	181	29	80	217
Total					15,825

Source: Civil Traffic from FAA Statistical Handbook, Expenditures and Taxes from Appendix to U.S. Budget, Taxes 1950-70, estimated.

(a) Estimated $D = (A \cdot B) - C$

primary, (B) secondary, (C) and urban roads. Funding was generally kept at a level comparable to revenues received from existing fuel and vehicle taxes.

The federal highway program was enlarged substantially with the inauguration of the Interstate System. Although designated in 1944, this system was not funded until 1952. Relatively modest two-year appropriations were made in 1952 and 1954, the former on the traditional 50-50 matching basis, the latter increasing the federal share to 60%. It was not until the Highway Act of 1956 that the Highway Trust Fund was established. Most existing fuel, vehicle, and accessory taxes were increased and dedicated to the Trust Fund. At the same time, the federal match was increased to 90%. Tax rates have been changed over the years to reflect current funding needs, but the Trust Fund has remained the basic source of federal financing for ABC and interstate projects.

Incentives for Use of Highway Fuels. Federal funding of highway development, especially the interstate system, has resulted in a greatly improved network of roads in this country. This has lead to the greater use of motor vehicles for both personal and freight transportation. To a large extent, this has come at the expense of the railroads, a more energy-efficient mode of transportation. The tremendous improvement in the highway system has also contributed to energy-inefficient spatial development patterns such as urban sprawl. As these examples point out, a byproduct of federal expenditures on highways has been an increase in the consumption of oil.

At the same time that the Federal Government has been spending funds on highways, it has also been collecting excise taxes on motor fuel, motor vehicles, and related parts and products. These taxes can be considered a user fee. By taking the difference between tax revenues and highway expenditures, the net government subsidy can be determined. The result, as presented in Table 15, shows that highways have received a subsidy only during the past few years. Prior to that, automotive excise taxes raised more revenue than was spent on highways. Over the period 1950-1978, the government raised net revenues of $60.6 billion, measured in 1978 dollars.

TABLE 15. Subsidies for Highway Use of Petroleum

Year	Highway Expenditures (million $)	Highway Taxes (million $)	Subsidy (million $)	Subsidy in 10^6 1978 $
1978	8,244	6,970	1,274	1,274
1977	7,701	6,525	1,176	1,267
1976	7,959	6,031	1,928	2,210
1975	7,371	5,603	1,768	2142
1974	6,112	5,846	266	352
1973	5,443	5,948	-505	-741
1972	5,465	5,315	150	234
1971	5,632	7,249	-1,617	-2,605
1970	5,214	6,800	-1,586	-2,665
1969	4,567	6,748	-2,161	-3,847
1968	4,828	6,055	-1,227	-2,301
1967	4408	5,524	-1,116	-2,181
1966	4,517	5,424	-907	-1,823
1965	4,160	5,716	-1,556	-3,218
1964	4,249	5,635	-1,386	-2,915
1963	3,759	5,246	-1,487	-3,169
1962	3,174	4,769	-1,595	-3,440
1961	2942	4,242	-1,300	-2,835
1960	2726	4,397	-1,671	-3,681
1959	3217	3,761	-544	-1,218
1958	2,477	3,132	-655	-1,478
1957	1,474	3,513	-2,039	-4,726
1956	902	2,858	-1,956	-4,694
1955	791	2,736	-1,945	-4,738
1954	700	2,204	-1,504	-3,650
1953	660	2,183	-1,523	-3,715
1952	574	1,867	-1,293	-3,178
1951	494	1,548	-1,049	-2,635
1950	500	1,479	-979	-2,653
Total				-60,626

Source: 1950-1975, Summary of Highway Statistics to 1975; 1976-1978, Highway Statistics (annual), various issues, Federal Highway Administration.

Although the Federal Government has not generally subsidized the highways as such, federal highway programs can be considered an incentive for use of motor fuel. Without the system of federal roads, it is very unlikely that the individual states would have independently developed a comparable system. Therefore, it is most likely that greater reliance would have been placed on mass transit and railroads. Although it is not possible to know with certainty what would have happened in the absence of federal aid to highways, the likely consequence is a reduction in oil consumption. The magnitude of this incentive, however, is impossible to determine.

Incentives for Mass Transit. Under the aegis of the Urban Mass Transportation Administration is a program to provide grants (disbursements) to cities and other jurisdictions to upgrade and expand mass transit. One of the goals of this program is to decrease the use of petroleum. Thus these grants encourage the use of bus diesel fuel, but will discourage the use of gasoline. Since the net effect is intended to be an overall decrease, this subsidy program is not considered an incentive to petroleum use. (The increased use of electricity, due to the program, is considered an effect to be analyzed; see the electricity chapter.)

Motor Vehicle Emission Standards. The 1970 Clean Air Act Amendments required strict motor vehicle emission standards, a requirement which encourages greater fuel use. The administrator of the Environmental Protection Agency was authorized to establish standards which lowered carbon monoxide, hydrocarbons, and nitrogen oxides by 90%. In addition, fuel additives could be controlled if they endangered public health or interfered with pollution control devices.

As a result of the standards promulgated by EPA, oil consumption has increased. This has occurred in two ways. First, fuel efficiency has been lowered in order to meet the emission standards. (This is hidden by measures taken to meet mandatory mileage requirements and the trend toward smaller cars.) Second, more crude oil is required at the refinery to produce a gallon of constant-octane gasoline because of the ban on lead in gasoline for new cars with catalytic converters.

Even though emission standards have increased oil consumption, that was not the intent and can hardly be called an incentive. Furthermore, gasoline consumption has been reduced overall by federal mileage requirements. Therefore, vehicle emission standards and fuel additive regulation have not been considered further.

Disbursements

Subsidies to Airlines. Federal Government subsidies to the airline industry began with the Air Mail Act of 1925. This act authorized the U.S. Postal Service to contract with private carriers to transport airmail. Payments to the airlines, made on a pound-mile basis, generally exceeded airmail postage receipts. By the early 1930s, the average payment was about three times as large as postal revenue. After 1934, these subsidies were progressively reduced to the point where airmail produced a net revenue during World War II. After 1945, however, payments to carriers again generally exceeded postage receipts.

A substantial change in the federal subsidy program was made by the Presidential Reorganization Plan of October 1, 1953. This reorganization separated subsidies to be made by the Civil Aeronautics Board (CAB) and payments for postal services to be made by the Postal Service subject to rate approval by CAB. The subsidy was revised further by the Air Subsidy Revision Act of 1958. This act provided that, for purposes of subsidy calculation, airlines could exclude capital gains realized on the sale of old equipment if the proceeds were used to purchase new flight equipment. No other major changes were made until the 1978 Airline Deregulation Act. In addition to setting a timetable for abolishing the CAB, this act phased out the existing subsidy system over a seven year period. At the same time a new subsidy program was instituted to preserve "essential air transportation," primarily in the form of service to small cities expected to be discontinued because of deregulation.

The primary purpose of airline subsidies has been to support economically marginal airlines and air routes. It has had the effect of increasing the number of flights above the number that fares alone would support. These extra flights have increased the amount of aviation fuel consumed by the airlines.

The amount of the airline subsidy is $3.3 billion (1978$), as given in Table 16. Estimates had to be made for the years 1950-1953, because during these years the subsidy was paid through "excessive" air mail hauling rates and no separate accounting was maintained. Subsidies to airlines for operating otherwise unprofitable routes are an indirect incentive for oil consumption. They have had the effect of increasing aviation fuel consumption, although that has not been the intent.

AGRICULTURE

The primary agricultural use of petroleum is for operating farm vehicles. Smaller amounts are used to power other farm equipment such as irrigation pumps and conveyors. Many farm residences also depend upon petroleum products, mainly fuel oil and LPG, for heating and cooking. While the agricultural sector is quite dependent upon oil, the total amount consumed for all uses is quite small in comparison to other sectors.

PUBLIC

At the federal level, petroleum accounts for nearly 60% of the total energy consumed. Over 80% of all energy is used by the Defense Department. Other major users are the Energy Department, the Postal Service, General Services Administration and the Veterans Administration. DOD utilizes petroleum primarily for vehicles and equipment while in the other departments space heating is the major use.

State and local governmental units are also large consumers of petroleum products. Gasoline and diesel fuel for highway and off-highway use account for the major share of governmental use. Space heating of public buildings is the other significant use of petroleum.

The public sector includes federal, state, local, and regional governmental units of all kinds. The multitude of governmental agencies and departments provide a wide range of services and functions. Many of these governmental units have energy-use characteristics similar to firms in the private sector. Therefore, some of the incentives discussed with regard to other sectors, such as industrial or commercial, would apply to the public sector as well. This section will not include the incentives

TABLE 16. Federal Subsidies to Airlines

Year	Subsidy (10^6 dollars)	Subsidy (10^6 1978 dollars)
1978	74.0	74.0
1977	82.2	88.5
1976[a]	90.2	103.4
1975	62.7	76.0
1974	73.5	97.6
1973	65.6	96.3
1972	67.3	104.9
1971	63.1	101.7
1970	39.7	66.7
1969	46.1	82.1
1968	56.8	106.4
1967	65.3	127.6
1966	76.9	154.6
1965	82.5	170.6
1964	87.0	182.9
1963	82.7	176.3
1962	83.5	180.0
1961	80.2	174.8
1960	62.3	137.4
1959	52.4	117.3
1958	43.7	98.5
1957	43.4	100.5
1956	36.1	86.8
1955	57.5	140.0
1954	48.5	117.8
1953	37.8[b]	92.2
1952	37.8[b]	92.9
1951	37.8[b]	95.0
1950	37.8[b]	102.5
Total		3,345.1

Source: Appendix to the U.S. Budget, various years.

(a) Includes Transition Quarter
(b) Estimated

discussed elsewhere, but will cover only those which are unique to government.

Taxation

Exemption From Highway Taxes. Nonfederal governments do not pay federal highway taxes. These public entities are exempt from fuel taxes, vehicle taxes, and all the other related excise taxes which are dedicated to the construction and maintenance of the federal highway system, and many state and local roads as well. This is considered an incentive for the consumption of motor fuels.

The amount of this incentive is equal to the amount of federal automotive excise taxes foregone. Since this figure is unavailable, it had to be estimated. This was done by the following formula:

$$T_G = T_P \left(\frac{F_G}{F_P} \right)$$

where T_G = Automotive excise taxes not collected from state, county, and municipal government

T_P = Automotive excise taxes collected from private and commercial highway users

F_G = Motor fuel consumed on the highways by state, county, and municipal government

F_P = Motor fuel consumed on the highways by private and commercial users.

Calculated in this manner, the total incentive for the period 1950-1978 is $4.0 billion dollars, as shown in Table 17.

CONCLUSIONS

The incentives for oil consumption are given in Table 18. The largest by far is the "under pricing" of crude oil, due to price controls which amounts to more than $80 billion, an example of a price determinant of demand. Another price determinant of demand is the exemption from federal highway taxes granted to state and local governments, which amounted to $3.9 billion. An improved technology determinant of demand, principally in the form of improved airports and aviation facilities, amounted to $15.8 billion. Income determinants in the form of deduction of non-business state fuel taxes from federal income taxes, disbursements to the airlines and disbursements to poor households amounted to $27.6 billion. The construction of roads was supported by the highway user tax; except for recent years, the tax collected has exceeded Federal expenditures. The net overcollection of $60.6 billion 1978$ has not been included in the table. (There is no doubt that the Federal efforts had a great deal to do with the building of roads, thus making it easier to use motor fuel, but the effect cannot be quantified in terms of dollars of expenditure. Certainly improved technology and changed preferences outweighed the income and price effects of overcollection.)

TABLE 17. Incentives for Government Consumption of Petroleum Used by Highway Vehicles

Year	(a) Govt. Highway Fuel Use (10^6 gal)	(b) Total Highway Fuel Use (10^6 gal)	(c) Automotive Taxes (10^6 dollars)	(d) Incentive (10^6 dollars)	Incentive 1978 10^6 $
1978	1758	123090	6970	99.5	99.5
1977	1760	119625	6525	96.0	103.4
1976	1720	113781	6031	91.2	104.5
1975	1688	107101	5603	88.3	107.0
1974	1595	104516	5846	89.2	118.0
1973	1590	108648	5948	87.0	127.7
1972	1526	103310	5315	78.5	122.4
1971	1473	95881	7249	111.4	179.5
1970	1405	90730	6800	105.3	176.9
1969	1420	86537	6748	110.7	197.1
1968	1347	81425	6055	100.2	187.9
1967	1289	76269	5524	93.4	182.5
1966	1228	73279	5424	90.9	182.7
1965	1180	69776	5716	96.7	200.0
1964	1142	66718	5635	96.5	202.9
1963	1105	63374	5246	91.5	195.0
1962	1047	60520	4769	82.5	178.0
1961	1028	58155	4242	75.0	163.6
1960	983	56781	4397	76.1	167.7
1959	922	55308	3761	62.7	140.3
1958	876	52445	3132	52.3	118.0
1957	819	50954	3513	56.5	131.0
1956	763	49367	2858	44.2	106.1
1955	735	46915	2736	42.9	104.5
1954	703	43579	2204	35.6	86.4
1953	642	42021	2183	33.4	81.5
1952	607	39910	1867	28.3	69.6
1951	575	37489	1548	23.7	59.5
1950	551	35043	1479	23.3	63.1
Total					3956.3

Sources: *Summary of Highway Statistics to 1965*; *Summary of Highway Statistics to 1975*; *Highway Statistics (annual)*, various issues, Federal Highway Administration.

(d) = (a ÷ b) x c

TABLE 18. An Estimate of the Cost of Incentives Used to Stimulate the Demand for Oil (Millions 1978 Dollars)

MAJOR SECTOR

Incentive Type	Residential	Commercial	Industrial	Agricultural	Transportation	Public	Total
Taxation					24,132 I	3,956 P	28,088
Disbursements	121 I				3,345 I		3,466
Requirements	12,749 P	(a)	30,624 P (b)	(b)	34,665 P	2,386 P	80,424
Traditional Services					15,825 T (c)		15,825
Nontraditional Services			75 T				75
Market Activity						1,032 Z	1,032
Total	12,870		30,699		79,967	7,347	127,878
Total P							84,380
Total I							25,598
Total T							15,900
Total Z							1,032

P = Price determinant of demand
I = Income determinant of demand
T = Processor technology determinant of demand
Z = Preference determinant of demand

(a) included in residential
(b) includes electric utilities and non-transportation agriculture
(c) the negative value ($60.6 billion) of the highway trust fund is omitted

NOTES - CHAPTER V

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VI. NATURAL GAS CONSUMPTION INCENTIVES

INTRODUCTION

The consumption of natural gas in the U.S. has closely paralleled production because imports and exports have been relatively minor. Consumption grew from 5.77 trillion ft^3 in 1950 to 22.10 trillion ft^3 in 1972. Annual consumption then gradually declined through 1977, followed by a slight upward movement in 1978 and 1979. The industrial sector is the largest user of natural gas (40.2% in 1979) although its share has been falling, largely because of curtailments. Consumption of natural gas by other sectors is as follows: residential, 25.7%; commercial, 13.6%; electric utilities, 17.9%; and transportation, 2.7%. (The discussion of incentives for consumption begins with the residential sector.)

HISTORY OF NATURAL GAS IN U.S. IN BRIEF

Knowledge of the existence of natural gas was first recorded about 900 BC, although it undoubtedly was known long before that time. Such historical figures as Julius Ceasar and George Washington have mentioned it in their writings.(1) The earliest manifestations were in the form of burning springs caused by the accidental lighting of gas seeps from the earth. In later years, it was often encountered in drilling water and salt wells. Today, natural gas has become a major source of our energy. It is utilized in over 25,000 separate processes as well as being a feedstock for chemical production.

It is generally accepted that natural gas was formed from decayed plant and animal matter in sediments on the bottom of prehistoric oceans. The gas, often dissolved in oil, was trapped in geological structures where it is found today. These structures can range in size up to hundreds of square miles and several thousand feet thick, although most are much smaller. The greatest amount of natural gas is found in a few large fields. In the United States, 50 percent of the gas has been produced from just 100 large fields.

Natural gas is a combination of gaseous hydrocarbons, mainly methane, but normally also including sizeable amounts of ethane, propane, and butane, and lesser amounts of other gases. Normally, most of the ethane, propane, butane, and higher hydrocarbons is removed in gas processing plants and sold as natural gas liquids (NGL). The gas which is sold to the ultimate customer is almost entirely methane. Sometimes natural gas is found with considerable amounts of carbon dioxide, nitrogen, or hydrogen sulfide. The carbon dioxide and hydrogen sulfide can be easily removed by chemical treatment. Nitrogen removal requires partial liquefication and is seldom done.

For many years, natural gas was considered to be an unwanted byproduct of oil production. Most gas was vented or flared because there was no adequate method of gathering and delivering it to customers. As recently as 1930, more gas was wasted than was utilized. It wasn't until the development of high strength, thin walled welded steel pipe in the 1920s that long distance gas transmission became practical.

The first recorded use of natural gas in the United States was at Fredonia, New York, in 1821. A gas seep was accidently lighted. This discovery led to the drilling of a shallow well from which gas was piped to a nearby inn for use in lighting.

Five years earlier, in Baltimore, the manufactured gas industry got its start. A man named Rembrant Peale used gas manufactured from coal to light his museum. It was so successful that he decided to establish a gas company, the predecessor to the Baltimore Gas and Electric Company.

Manufactured gas for lighting soon spread to other large cities. By 1850, gas lighting service was offered in 23 cities, and by 1870 it was available in 26 communities. The technology was fairly simple. Coal, wood, tar, or tallow was roasted in a closed container. This produced a gas that was piped into the distribution system. Because this gas had a low heating value, it was used almost exclusively for illumination.

While the manufactured has industry was thriving, natural gas got off to a very slow start. The first natural gas company was the Fredonia Gas Light and Waterworks Company, founded in 1865, and the first large scale use was in 1883 in Pittsburgh. Gas was piped from a nearby field in

Westmoreland, Pennsylvania, for use in the steel and glass industries. It was later made available for home use.

There were no meters. Unlimited amounts of gas were sold for $1/month for a cooking range, $0.75/month for heaters, and $0.15/month for each light. When meters were introduced, the charge was 6 to 76¢ per thousand cubic feet (mcf). At the same time, manufactured gas cost from $1 to $1.75 per mcf. The great difference in heating value and luminosity between natural and manufactured gas led to a change in the unit of measurement from one based on candlepower to one based on heating value.

Although natural gas was more desirable than manufactured gas, its use was limited by transportation problems. Up to 1920, natural gas was used only in cities nearby the gas fields of Appalachia and the Midwest. The industry was subject to numerous boom and bust cycles as new fields were discovered and then rapidly depleted.

Meanwhile, the manufactured gas industry was also having problems. The introduction of electric lighting during the 1880s posed a severe challenge to gas illumination. The competition was met initially by the introduction of the Welsbach gas mantle, which improved gas lighting efficiency by seven times. The longer-run strategy for manufactured gas was to develop other uses, especially for uses in cooking and water heating. During the early part of the century, the typical home made the switch from gas lighting and coal cooking to electric lighting and "cooking with gas."

In the mid 1920s, the depletion of the Appalachian and Midwest gas fields, coupled with the discovery of huge new deposits in the Southwest, led to the need to develop a method of long distance gas transmission. By nature gas is difficult to transport and store. At atmospheric pressure, natural gas has only 1% to 3% of the heating value of an equal volume of solid or liquid fuel. One thousand cubic feet of gas can be compressed to 27 cubic feet, but this volume has only 6% to 7% of the heating value of an equal volume of oil or coal. Gradual progress in transmission technology was made in the late 1800s and early 1900s, so that by 1920 long distance transmission lines were practical.

The first attempt to transport natural gas on a large scale was in Rochester, New York in 1870. A 25-mile line was constructed of hollowed pine logs. It was a failure. The first successful line was a 2-inch, 5-mile long wrought iron line which served Titusville, Pennsylvania. The first high-pressure pipeline was built in 1891 to serve Chicago from a field 120 miles away in Indiana. The field was soon depleted and the line abandoned.

Modern pipeline systems began with a breakthrough by the Magnolia Gas Company in 1925. Their pipe was a large diameter (14"-18") long distance (217 mi.) all welded pipe. Welded pipe greatly reduced leakage which had been as much as 20-40% with the old bolted pipes. The transmission system developed rapidly after this. The first 1000 mile line, from the Texas Panhandle to Chicago, was completed in 1931. Numerous improvements in materials, auxillary equipment and size were made in the following years. Today pipelines are up to 48" in diameter and carry a pressure of about 1000 psi.

During this period, the manufactured gas industry continued to gain customers and increase sales. The superiority of natural gas in both price and heating value was, however, startina to dominate the market. Many manufactured gas companies purchased natural gas to supplement, then replace manufactured gas. Manufactured gas customers, sales, and revenue peaked in the late 1940s. By the late 1960s, manufacured gas was no longer significant. One of the key factors in bringing natural gas to the East Cost was the conversion to natural gas of the Big Inch and Little Inch oil pipelines, which had been built during World War II as means of bringing crude oil to the East Coast without fear of German submarine attack.

During the 1920s and 1930s, many abuses existed in the gas industry.(2) Manufactured gas companies attempted to keep out natural gas to prolong the life of their investments and keep the price of gas high. A few holding companies controlled much of the gas (and electric) industry and competition was stifled. These practices lead to Congressional investigation which culminated in the Natural Gas Act of 1938. The Natural Gas Act gave the Federal Power Commission jurisdiction over interstate gas pipeline companies, and the states retained authority over intrastate distribution companies.

Today, natural gas is used substantially in all sectors except transportation. The largest use is for heating of residential and commercial buildings. Because heating needs are very seasonal, gas companies have very large summer/winter use differentials. Typically, residential use is 5 time greater in the winter than in the summer, commercial use is 3 1/2 time as great, while industrial use is somewhat larger in the summer due to greater availability.[3][4] The seasonal nature of gas sales has led to the development of underground storage facilities near load centers.

In recent years, gas consumption has leveled off after years of continuous growth. This has been due to supply shortages which caused customers to be curtailed and hookup bans enacted. Historical gas consumption data are presented in Table 19.

ALL SECTORS

Requirements

The definition and concept of a public utility were derived from the common law of England. Early English courts regulated certain occupations affected with a "public interest," requiring that they

- o serve all who apply within the franchise
- o serve the maximum requirements of a customer
- o provide a safe and adequate service
- o prevent unjust discrimination
- o charge a reasonable price for services rendered.

Because the natural gas industry required the investment of large sums of capital over an extended period, it was natural for the gas transmission companies to evolve as large monopolies, each able to serve wide geographic areas without competition from other gas transmission companies. Two or more such utilities serving the same area would result in costly and unnecessary duplication of facilities.

TABLE 19. Gas Industry Statistics

Year	Number of Customers (10^3)	Sales (10^{12} Btu)	Revenue (10^6 Dollars)	Price ($/$10^6$ Btu)
1979	46,478.3	15,440.3	38,947.1	2.52
1978	45,788.8	14,748.4	32,149.9	2.18
1977	45,273.9	14,340.9	28,303.2	1.97
1976	44,941.5	14,813.5	23,701.2	1.60
1975	44,554.5	14,862.9	19,074.3	1.29
1974	44,267.3	16,000.3	15,242.5	0.95
1973	43,711.0	16,479.9	12,987.3	0.79
1972	42,954.8	17,082.1	12,465.2	0.73
1971	42,241.8	16,685.7	11,357.4	0.68
1970	41,482.1	16,043.5	10,282.6	0.64
1969	40,854.0	15,391.6	9,479.6	0.62
1968	39,930.0	14,472.2	8,781.2	0.61
1967	39,076.5	13,488.3	8,260.7	0.61
1966	38,228.4	12,859.1	7,869.9	0.61
1965	37,337.5	11,980.3	7,407.0	0.62
1964	36,463.3	11,591.2	7,132.7	0.62
1963	35,551.0	10,766.3	6,726.8	0.62
1962	34,683.4	10,234.8	6,444.9	0.63
1961	33,830.5	9,589.0	5,992.9	0.62
1960	33,053.8	9,287.7	5,617.4	0.60
1959	32,065.9	8,791.8	5,065.2	0.58
1958	31,242.1	8,028.6	4,568.3	0.57
1957	30,476.0	7,703.5	4,133.6	0.54
1956	29,536.6	7,254.2	3,850.1	0.53
1955	28,478.8	6,658.6	3,449.7	0.52

TABLE 19. (continued)

Year	Number of Customers (10^3)	Sales (10^{12} Btu)	Revenue (10^6 Dollars)	Price (\$/10^6 Btu)
1954	27,528	6,143.8	3,052.1	0.50
1953	26,705	4,644.4	2,718.6	0.48
1952	25,850	5,270.4	2,467.3	0.47
1951	24,953	4,822.2	2,228.1	0.46
1950	24,001	4,209.0	1,948.0	0.46
1949	23,035	3,579.0	1,688.6	0.47
1948	22,245	3,388.5	1,579.5	0.47
1947	21,416	2,988.2	1,395.6	0.47
1946	20,636	2,637.9	1,212.6	0.46
1945	19,977	2,586.8	1,152.8	0.45
1944	19,585	2,512.0	1,108.2	0.44
1943	19,064	2,341.5	1,064.0	0.45
1942	18,734	2,084.9	994.3	0.48
1941	18,126	1,900.9	914.0	0.48
1940	17,600	1,723.5	871.7	0.51
1939	17,128	1,592.7	814.2	0.51
1938	16,876	1,468.2	777.2	0.53
1937	16,605	1,577.3	801.9	0.51
1936	16,170	1,469.3	770.1	0.52
1935	15,819	1,292.4	726.9	0.56
1934	15,512	1,206.3	702.9	0.58
1933	15,195	1,053.1	679.9	0.65
1932	15,532	1,044.1	723.2	0.69

By defining an industry as a "public utility," benefits are realized by both the utility and the population served. The principal obligations of a company as a public utility are: to serve all who request service if it can be reasonably supplied, to serve its customers without unreasonable discrimination, to set rates which have been judged reasonable by regulatory authorities and have customer acceptance, and to maintain adequate and safe facilities. In return, the companies designated as public utilities are compensated with the following benefits: the opportunity to earn a fair return upon the value of their property used and useful in public service, franchise rights in their area of operation, exercise of eminent domain, and the use of public ways.[5]

The natural gas companies were initially regulated by state and local agencies. However, with technological advances in pipeline materials and joining, pipeline companies experienced tremendous growth between 1926 and 1932, expanding rapidly into the interstate market. By the early 1930s, concerns were raised that no regulatory body had influence over gas produced in one state and transported for resale in another state. These concerns arose over waste of gas, the desire of consumers for inexpensive gas, monopolistic control of pipelines by producers and gas utility holding companies, and discriminatory rates charged distribution companies. In 1938, the Natural Gas Act was passed, giving the Federal Power Commission regulatory powers over transmission companies operating in interstate markets.

Essentially, the Federal Government allows the interstate natural gas transmission companies to operate in a monopolistic manner. Since tremendous amounts of money must be spent on the construction of a gas transmission line, it is beneficial to the company to be assured of a market. The Federal Energy Regulatory Commission (FERC) requires the company to obtain a "certificate of convenience and necessity" before granting authority to a company to build and operate a natural gas pipeline facility, to extend an existing natural gas facility, or to sell gas in interstate commerce.[6] The natural gas transmission company is responsible for investigating the demand for its product over a specified period, usually 20 years, and to demonstrate that it can provide this level of service for that period. The regulation of pipeline rates and level of service has encouraged customers to utilize natural gas even though it is monopolistically supplied. To some extent, FERC regulation has lowered both real and expected natural gas rates and thus has increased consumption.

In return for their services to the public, the utilities are generally granted the right of eminent domain or the use of public right of way. The Natural Gas Act of 1938 extended this right to natural gas transmission companies by providing that a holder of a certificate of public convenience and necessity may acquire right-of-way or other property by the right of eminent domain. This right, which may be exercised in federal district courts or in state courts, has increased the consumption and utilization of natural gas by greatly reducing the time and expense that would have to be spent in negotiation for land rights with individual land owners.

Price Controls

In the 1954 case of Phillips Petroleum v. the State of Wisconsin et al., the U.S. Supreme Court ruled that producers of natural gas were subject to the same price regulations as companies transmitting and distributing natural gas. The Court ruled that the

> regulation of the sales in interstate commerce for resale made by a so-called independent natural gas producer is not essentially different from regulation of such sales when made by an affiliate of an interstate pipeline company. In both cases, the rates charged may have direct and substantial effect on the price paid by the ultimate consumers. Protection of consumers against exploitation at the hands of natural gas companies was the primary aim of the Natural Gas Act.

The intent of the Court is clear: consumers are to be protected from the possibility of rapidly rising fuel bills once they are committed to a natural gas system. This was deemed necessary because natural gas is monopolistically supplied at the point of sale to the final customer, even though competition exists in the primary market, i.e., sales from producer to transmission company. While the intent to protect the consumer has remained the primary aim of wellhead price controls, the actual impact has varied among customer classes. The variable impact results from the methods which have been used to distribute the shortages which were caused by the price controls.

For industrial customers, price controls have meant lower rates, but, in recent years, also widespread unavailability. Industrial consumption of natural gas, especially for uses such as boiler fuel where close substitutes exist, has been curtailed in many areas throughout the country. On the other hand, where natural gas has been available at the controlled price, consumption has been encouraged by lower rates (compared to a free market situation). Furthermore, gas has been readily available to industrial customers in intrastate markets, partially as a result of price controls on gas sold interstate. The net impact has been lower total industrial consumption, falling by approximately 20% from 1973 to 1978. Use of gas by electric utilities also fell over the same period. As a conclusion, it can be said that price controls increased the desirability for natural gas by industrial customers as a whole, but did not increase consumption due to supply constraints.

The picture for residential and commercial customers is not as clear. These customers generally have not been subject to curtailments. On the other hand, bans on the hookup of new customers have been implemented in many areas, due to shortages caused by price controls. Thus, controls have had opposing effects on residential and commercial customers. For existing customers, the price has been kept down and consumption has been encouraged; for many potential customers the unavailability of gas has meant the need to use other fuels. Overall it would appear that there has been a decrease in consumption by the residential and commercial sectors in comparison to the amount that would have been used in the absence of price controls. Total consumption of natural gas by these sectors has remained level over the 1970s and one would expect it to have increased. (For example, most of the homes built with electric heating in recent years would be expected to have used gas if it had been available, even at a higher price.)

Unlike the situation for oil, where imports have made up the difference between domestic production and consumption, the shortages caused by natural gas price controls have caused real curtailments. While controlled prices have encouraged consumption, they have actually resulted in consumption being below the amount expected in the absence of controls. Nonetheless, wellhead price controls on natural gas are included as a federal incentive for consumption, for that was clearly the intent. These controls are a clear example of an "unbalanced incentive" as defined in Chapter II. The results of these incentives, particularly their interaction with each other, are outside the scope of this study. The net costs of the well head price incentives were analyzed and quantified as incentives to producers in the previous study in this series on the cost of incentives to energy producers. These incentives cost $243.3 million (1978$) over the period 1938 to 1978. (7)

RESIDENTIAL

Approximately three-fourths of the residential housing units in the United States are heated by natural gas. Gas is also used extensively for water heating and cooking and to a lesser extent for other purposes such as clothes drying.

While the number of residences using gas as the primary energy source has continued to increase, the total amount of gas consumed has not changed significantly over the past decade. This is due to conservation measures spurred by rapidly increasing rates. Nevertheless, at the present time natural gas is the most economical heating source and it continues to be overwhelmingly preferred by residential customers. Residential sales of natural gas are shown in Table 20.

Disbursements

Energy Assistance Programs

Since FY-1977, the Community Services Administration (CSA) has operated a program that provides assistance to families which have problems paying their fuel bills. Services include the payment of utility and heating oil bills, purchase of blankets and space heaters, and payment of reconnecting fees where service has been suspended. To be eligible, one must have an income of less than 125% of the federal poverty level or be a Supplemental Security Income (SSI) recipient. A maximum of $400 may be provided for each family.

TABLE 20. Residential Sector Gas Statistics

Year	Number of Customers (10^6)	Sales (10^{12} Btu)	Consumption per Customer (10^6 Btu)	Revenue (10^6 Dollars)	Price ($/$10^6$ Btu)
1979	42,821.3	5,083.1	118.6	14,832.9	2.92
1978	42,183.2	5,106.7	121.0	12,938.9	2.53
1977	41,682.4	4,946.3	118.7	11,540.8	2.33
1976	41,337.6	5,014.2	121.3	9,941.0	1.98
1975	40,950.3	4,991.0	121.9	8,445.5	1.69
1974	40,626.7	4,864.8	119.6	6,899.4	1.42
1973	40,115.5	4,993.6	124.5	6,247.0	1.25
1972	39,428.0	5,141.8	130.4	6,094.2	1.19
1971	38,788.7	5,040.1	129.9	5,635.4	1.12
1970	38,097.0	4,923.7	129.2	5,207.3	1.06
1969	37,538.3	4,820.4	128.4	4,883.0	1.01
1968	36,691.1	4,552.7	124.1	4,567.3	1.00
1967	35,915.1	4,365.3	121.1	4,382.8	1.00
1966	35,141.8	4,175.4	118.8	4,195.3	1.00
1965	34,340.8	3,999.0	116.5	4,029.6	1.01
1964	33,551.2	3,869.7	115.3	3,894.9	1.01
1963	32,710.8	3,668.0	112.1	3,727.9	1.02
1962	31,893.0	3,536.0	110.9	3,603.3	1.02
1961	31,118.2	3,321.0	106.7	3,376.8	1.02
1960	30,417.5	3,188.1	104.8	3,177.4	1.00
1959	29,529.6	2,973.9	100.7	2,870.5	0.97
1958	28,786.5	2,812.5	97.7	2,378.9	0.92
1957	28,101.2	2,598.5	92.5	2,657.6	0.94
1956	27,241.0	2,464.3	90.5	2,236.5	0.91
1955	26,282.6	2,238.7	85.2	2,007.4	0.90

TABLE 20. (continued)

Year	Number of Customers (10^6)	Sales (10^{12} Btu)	Consumption per Customer (10^6 Btu)	Revenue (10^6 Dollars)	Price ($/$10^6$ Btu)
1954	25,398	2,003.1	78.9	1,782.7	89.0
1953	24,647	1,803.3	73.2	1,574.4	87.3
1952	23,852	1,734.8	72.7	1,456.7	84.0
1951	23,042	1,620.4	67.9	1,335.0	82.4
1950	22,146	1,383.9	62.5	1,177.1	85.1
1949	21,264	1,182.7	55.6	1,031.3	87.2
1948	20,562	1,115.3	54.2	957.9	85.9
1947	19,835	1,008.6	50.8	861.6	85.4
1946	19,157	848.2	44.3	754.1	88.9
1945	18,607	774.9	41.6	705.2	91.0
1944	18,320	731.2	42.2	666.7	91.2
1943	17,838	700.1	39.2	647.6	92.5
1942	17,511	667.9	38.1	622.7	93.2
1941	16,904	586.2	34.7	574.8	98.1
1940	16,381	582.3	35.5	573.3	98.5
1939	15,926	528.9	33.2	537.6	101.6
1938	15,697	495.6	31.6	522.6	105.4
1937	14,466	498.7	32.2	528.3	104.9
1936	15,026	478.4	31.8	516.1	107.9
1935	14,725	444.4	30.2	503.1	113.2
1934	14,440	420.1	29.1	494.3	117.7
1933	14,441	423.7	29.3	495.4	116.9
1932	14,452	467.2	32.3	537.1	115.0

Sources: Gas Facts, American Gas Association, 1979
Gas Facts, American Gas Association, 1954

The annual appropriation for this program from FY-1977 through FY-1979 was $200 million.[8] By assuming that the funds were allocated by fuel in the same percentage as nationwide residential heating fuel types, we estimate that the amount allocated to natural gas was $96.8 million per year. (In 1977, 48.4% of residential units were heated by natural gas, 29.2% by oil, and 22.4% by electricity or other.[9] Thus, the total incentive for 1977 and 1978 was $201.1 million (1978$).

Since FY-1980, federal assistance programs have been greatly expanded. CSA has been provided $400 million to continue its energy assistance program. In addition, HEW has been allocated $800 million, and the Social Security Administration, $400 million for similar programs.

Requirements

Natural Gas Policy Act of 1978

In addition to establishing a mechanism for the eventual decontrol of the wellhead price of natural gas, the Natural Gas Policy Act (NGPA) of 1978 mandated a change in the traditional method of pricing sales by interstate pipeline companies. Traditionally, the costs of expensive gas have been combined with the costs of less expensive gas to form an average upon which the price to customers, mainly distribution companies, was based. The NGPA altered this by requiring incremental pricing under specified circumstances.

For several categories of natural gas production established by NGPA, production companies are allowed to charge prices well above the average, controlled price. If these prices rise above a certain threshold calculated by the Department of Energy, the excess costs must be passed on to industrial boiler customers up to a maximum limit which is tied to the price of an alternative petroleum fuel. Initially, FERC has chosen the price of high sulfur No. 6 fuel oil as the maximum that industrial customers can be charged for an equivalent amount of natural gas. If a pipeline cannot recover all of its costs through this method, then it can charge the remainder to other categories of customers.

A primary intent and effect of the incremental pricing requirement is to keep down the price of gas to residential customers. By passing on the costs of some expensive gas only to industrial customers, other customer classes are partially insulated from rate increases. Lower rates result in greater consumption by these classes, although total natural gas consumption may not be significantly altered, depending upon relative price elasticity among customer classes. Since the incremental pricing provisions of NGPA did not go into effect until 1980, there has been no impact or costs over the time period of this study.

COMMERCIAL

The commercial sector uses natural gas for much the same purposes as the residential sector - space heating, water heating and cooking. Natural gas consumption in the commercial sector is affected by weather patterns and the level of business activity in the short-run. In the longer-run, the rate of implementation of efficiency measures is also important. Over the past several years, conservation efforts have largely balanced an increase in the number of commercial customers so that total natural gas consumption has changed very little. Commercial sales of natural gas are shown in Table 21.

INDUSTRIAL

Although industry is the largest natural gas consuming sector, total consumption has declined substantially since the early 1970s. The primary reason is that industry has had to bear the brunt of the nationwide gas shortages which occurred in the mid and late 1970s. (Industrial gas consumption continued to increase in the abundant intrastate markets.) Gas used as an industrial and electric utility boiler fuel was curtailed most extensively. Industrial sales of natural gas are shown in Table 22.

Repeated curtailments and higher prices led industry to switch to other fuels and also to find ways of conserving. Now that gas is more available, many industrial are switching back to gas from oil. Total consumption is not rising to pre-curtailment levels, however, due to the efficiency measures that have been put into place.

TABLE 21. (continued)

Year	Number of Customers (10^6)	Sales (10^{12} Btu)	Consumption per Customer (10^6 Btu)	Revenue (10^6 Dollars)	Price ($/$10^6$ Btu)
1954	1,990	540.5	271.6	377.7	0.70
1953	1,926	498.0	258.6	338.9	0.68
1952	1,869	492.9	263.7	321.3	0.65
1951	1,787	455.9	255.1	294.4	0.65
1950	1,739	410.4	236.0	265.6	0.64
1949	1,657	372.4	224.7	238.1	0.64
1948	1,571	353.6	225.1	220.9	0.62
1947	1,474	310.7	210.8	190.8	0.61
1946	1,377	263.0	191.0	161.0	0.61
1945	1,278	249.7	195.4	148.6	0.60
1944	1,177	220.8	187.6	133.1	0.60
1943	1,141	208.3	182.6	127.5	0.61
1942	1,137	199.0	175.0	127.0	0.64
1941	1,137	164.9	145.0	114.3	0.69
1940	1,138	159.8	140.4	112.0	0.70
1939	1,121	146.8	131.0	105.2	0.72
1938	1,094	138.0	126.1	101.1	0.73
1937	1,056	138.1	130.8	99.8	0.72
1936	1,058	136.9	129.4	97.3	0.71
1935	1,014	121.1	119.4	90.8	0.75
1934	990	110.2	111.3	86.8	0.79
1933	978	115.0	117.6	87.6	0.76
1932	999	119.3	119.4	92.8	0.78

Sources: Gas Facts, A.G.A., 1979
Gas Facts, A.G.A., 1954

TABLE 21. Commercial Sector Gas Statistics

Year	Number of Customers (10^6)	Sales (10^{12} Btu)	Consumption per Customer (10^6 Btu)	Revenue (10^6 Dollars)	Price ($/$10^6$ Btu)
1979	3,422.8	2,485.8	726.5	6,623.8	2.66
1978	3,369.8	2,499.5	743.6	5,695.7	2.28
1977	3,371.0	2,409.4	714.8	4,979.9	2.07
1976	3,371.5	2,422.6	718.6	4,075.0	1.68
1975	3,366.9	2,386.8	708.9	3,302.6	1.38
1974	3,392.0	2,293.4	676.1	2,539.3	1.11
1973	3,331.4	2,280.8	684.6	2,172.5	0.95
1972	3,263.6	2,275.7	697.3	2,063.8	0.91
1971	3,199.0	2,155.5	673.8	1,829.3	0.85
1970	3,130.9	2,006.6	640.9	1,620.3	0.81
1969	3,073.8	1,878.1	611.0	1,459.1	0.78
1968	3,003.6	1,704.9	567.6	1,315.4	0.77
1967	2,933.6	1,577.6	537.8	1,223.9	0.78
1966	2,868.2	1,462.8	510.0	1,135.4	0.78
1965	2,789.7	1,344.8	482.1	1,053.6	0.78
1964	2,712.2	1,273.5	469.5	998.4	0.78
1963	2,639.6	1,136.6	430.6	910.5	0.80
1962	2,597.9	1,092.9	420.7	874.4	0.80
1961	2,528.9	988.1	390.7	789.2	0.80
1960	2,458.3	919.8	374.2	723.4	0.79
1959	2,363.9	827.5	350.1	632.7	0.76
1958	2,286.6	764.9	334.5	571.2	0.75
1957	2,211.1	698.9	316.1	505.7	0.72
1956	2,140.3	655.8	306.4	471.3	0.72
1955	2,047.5	602.9	294.5	424.1	0.72

TABLE 22. Industrial Sector Gas Statistics

Year	Number of Customers (10^3)	Sales (10^{12} Btu)	Consumption per Customer (10^6 Btu)	Revenue (10^6 Dollars)	Price ($/$10^6$ Btu)
1979	189.4	7,555.0	39,434.4	16,960.9	2.24
1978	189.2	6,841.2	36,167.9	13,064.7	1.91
1977	173.3	6,710.7	38,717.2	11,385.2	1.70
1976	179.7	7,107.0	39,563.9	9,373.9	1.32
1975	183.5	6,837.1	37,253.5	6,718.1	0.99
1974	193.8	8,153.2	42,066.8	5,391.1	0.66
1973	209.1	8,370.8	40,051.7	4,196.7	0.50
1972	209.2	8,775.9	41,948.8	3,943.0	0.45
1971	304.7	8,645.5	42,235.0	3,568.6	0.41
1970	199.1	8,439.2	42,386.7	3,181.2	0.38
1969	192.7	8,135.8	42,220.0	2,919.0	0.36
1968	188.1	7,595.1	40,378.0	2,675.3	0.35
1967	181.2	7,014.3	38,710.3	2,460.9	0.35
1966	173.9	6,653.3	38,259.3	2,334.7	0.35
1965	166.2	6,146.5	36,982.6	2,148.0	0.35
1964	159.4	5,912.0	37,089.1	2,048.5	0.35
1963	161.7	5,438.1	33,630.8	1,905.7	0.35
1962	155.9	5,100.1	32,713.0	1,795.9	0.35
1961	146.7	4,785.6	32,621.7	1,658.3	0.35
1960	140.6	4,709.4	33,495.0	1,563.3	0.33
1959	136.3	4,563.1	33,478.4	1,431.2	0.31
1958	134.2	4,076.4	30,375.6	1,229.0	0.30
1957	132.0	4,047.6	20,663.6	1,149.9	0.38
1956	125.8	3,868.7	30,752.8	1,065.6	0.28
1955	121.2	3,535.1	29,167.5	937.6	0.27

TABLE 22. (continued)

Year	Number of Customers (10^3)	Sales (10^{12} Btu)	Consumption per Customer (10^6 Btu)	Revenue (10^6 Dollars)	Price (\$/10^6 Btu)
1954	112	3,309.5	29,549.1	820.5	0.25
1953	107	3,037.3	28,386.0	739.2	0.24
1952	104	2,799.0	26,913.5	639.2	0.23
1951	101	2,552.2	25,269.3	557.1	0.22
1950	100	2,288.7	22,887.0	479.6	0.21
1949	97	1,897.8	19,564.9	395.6	0.21
1948	94	1,798.1	19,128.7	377.4	0.21
1947	91	1,579.2	17,353.8	325.6	0.21
1946	87	1,460.2	16,783.9	284.3	0.19
1945	80	1,452.3	18,153.7	280.9	0.19
1944	82	1,463.5	17,847.6	293.3	0.20
1943	77	1,352.2	17,561.0	277.5	0.21
1942	78	1,172.3	15,029.5	237.5	0.20
1941	78	1,120.6	14,366.7	219.8	0.20
1940	73	954.4	13,074.0	181.9	0.19
1939	73	876.8	12,011.0	164.9	0.19
1938	75	794.1	10,588.0	144.9	0.18
1937	74	904.1	12,217.6	167.1	0.18
1936	77	828.0	10,753.2	151.5	0.18
1935	72	722.1	10,029.2	130.5	0.18
1934	74	669.9	9,052.7	119.2	0.18
1933	68	511.4	7,520.6	94.8	0.19
1932	73	453.4	6,211.0	90.7	0.20

TRANSPORTATION

The sole use of natural gas in the transportation sector is for pipeline pumps and compressors. The amount of gas used for this purpose has declined over the past decade, in part due to the use of more efficient equipment. Natural gas is not expected to play a major role in any other mode of transportation in the forseeable future.

AGRICULTURAL

Very little natural gas is used in agriculture. The primary use is for grain drying. Most farms are quite distant from gas distribution lines and so no significant increase in the use of natural gas is feasible.

PUBLIC

Federal, state and local government utilizes natural gas primarily for heating buildings. The largest categories are institutions and offices. At the federal level, gas contributes approximately 8 to 9% of the government's total energy requirements. No figures are available for state and local governments.

CONCLUSIONS

Wellhead price controls have had mixed effects on consumers. During one period, prices were high relative to intrastate prices and availability good. Later prices were low, relatively, and availability poor for industrial customers and non-existent for some potential residential customers. Net costs of $228.3 million have been tabulated elsewhere as incentives to producers.

One direct incentive for consumption has been payments to the poor for energy costs under the Community Service Administration program. The disbursements have amounted to $201.1 million and are an example of an income determinant of demand.

NOTES - CHAPTER VI

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VII. ELECTRICITY CONSUMPTION INCENTIVES

INTRODUCTION

Electricity consumption in the U.S. was approximately 56 billion kWh in 1926 and over two trillion kWh by 1978, a 38 fold increase. The number of customers in 1926 was 20.3 million and 87.7 million by 1978, a 4.3 fold increase. The average price of electricity in 1926 was 10¢/kWh (1978 $), declining to a minimum cost of 2.7¢/kWh (1978 $) in 1970 and rising to 3.5¢/kWh in 1978. The purpose of this chapter is to assess the federal involvement in stimulating the above-described increase in electricity consumption. It is somewhat longer than the other chapters because the Federal Government has shown a preoccupation with electricity and technologies to produce it.

In a discussion of the influence of the federal government on the consumption of electricity, a distinction must be made between policies that directly promote the usage of electricity and policies or actions for purposes other than increased electricity consumption, but which result inadvertently or incidentally in such increases. An example of the former is the TVA Act which promoted more usage by providing a plentiful low cost supply of electricity. An example of the latter is the Manhattan District Project, which was aimed at the production of nuclear weapons but which, incidentally, required large amounts of electric power for uranium separation thereby increasing overall national usage. Both of these classes of activity are discussed in this report, with intent to include all significant actions in the first class, but only those actions in the second class that involved use of substantial amounts of electricity.

The material in this chapter is arranged:

- To provide a brief history of electricity consumption in the U.S., with some discussion of the roles of private enterprise and the government
- To discuss how federal legislation and executive actions intended primarily to increase the supply or availability of electricity, to provide for the defense of the nation, to provide for the general welfare of the people, to protect health and safety, to provide an

emergency policy, and to promote scientific research, have, in fact, indirectly or incidentally caused increases in consumption of electricity

- To summarize how these actions may have affected consumption in the six sectors: residential, commercial, industrial, agriculture, transportation, and the public sector, and
- To draw conclusions.

HISTORY OF ELECTRICITY IN THE U.S.

The history of electricity consumption is interwoven with the history of its production by the electric industry. A history of the industry's growth and the technological developments that contributed to that growth is presented in the following section.

Statistics describing the growth of the industry since 1926 are provided in Table 23. The use of electricity from central stations actually began in 1882 with lighting customers served from Edison's Pearl Street Station in New York City. However, consumption by 1926 was only 2.78% of the consumption during 1978, so that Table 23 includes most of the historic growth in the U.S.

In the 53 years from 1926 through 1978 sales increased nearly 36 fold. Each year's sales were greater than the preceding year, except during the period of the Great Depression, the period following World War II, and the year 1974. The number of customers had increased 4.3 fold, the numbers rising in all years except 1931 and 1932. Revenues have increased nearly 46 fold, the amounts rising each year except 1931-33 and 1937. Prices in 1978 dollars declined from a high of 13.62¢/kWh in 1931 to 2.67¢/kWh in 1970, then rose to 3.6¢/kWh in 1978.

Growth in sales between 1930 and 1970 was at an average rate of about 7.6% per year. This rate began to drop in the mid-70s reaching an annual rate of 3.4% in the 1977-78 period. Since this report is concerned chiefly with activities to increase consumption, and since the federal government's influence in the 1970s has been toward reduction in consumption, events and consequences during the period 1930-70 are emphasized here.

TABLE 23. U.S. Electric Utility[a] Sales, Revenues, Customers, and Price 1926-1978

Year	Sales[b] (billion kWh)	Total Customers (thousands)	Revenues[b] (Current $) (millions $)	Price[c] (Current $) (¢/kWh)	Price[d] (1978 $) (¢/kWh)
1978	2,017.8	87,668.0	69,852.9	3.46	3.46
1977	1,950.8	85,590.2	62,610.0	3.21	3.46
1976	1,849.6	83,613.2	53,462.9	2.89	3.31
1975	1,733.0	81,844.9	46,853.5	2.70	3.27
1974	1,700.8	80,102.4	39,126.8	2.30	3.04
1973	1,703.2	78,461.3	31,662.9	1.86	2.73
1972	1,577.7	76,150.2	27,921.1	1.77	2.76
1971	1,466.4	74,265.1	24,725.2	1.69	2.72
1970	1,391.4	72,485.0	22,065.9	1.59	2.67
1969	1,307.2	70,292.1	20,139.3	1.54	2.74
1968	1,202.3	69,716.0	18,579.9	1.55	2.91
1967	1,107.0	68,167.5	17,222.7	1.56	3.05
1966	1,039.0	66,909.8	16,196.1	1.56	3.14
1965	953.4	65,557.5	15,158.4	1.59	3.29
1964	890.4	64,148.7	14,408.5	1.62	3.41
1963	830.8	62,857.5	13,697.2	1.65	3.52
1962	776.1	61,323.9	13,024.9	1.68	3.62
1961	720.7	60,130.2	12,169.3	1.69	3.69
1960[e]	683.2	58,869.8	11,515.7	1.69	3.72
1959	626.7	57,504.8	10,572.7	1.69	3.78
1958	569.2	56,208.5	9,733.8	1.71	3.86
1957	557.8	55,171.1	9,289.6	1.67	3.87
1956	530.1	53,994.9	8,698.3	1.64	3.94
1955	480.9	52,558.6	8,020.4	1.67	4.07
1954	410.9	51,214.6	7,277.3	1.77	4.30
1953	384.2	49,899.1	6,793.7	1.77	4.32
1952	342.5	48,450.6	6,137.3	1.79	4.40
1951	318.2	46,821.9	5,647.7	1.77	4.45
1950	280.5	44,986.3	5,086.5	1.81	4.91
1949	248.5	42,850.8	4,614.1	1.86	5.09
1948	240.7	40,722.0	4,313.3	1.79	4.85

TABLE 23. (continued)

Year	Sales(b) (billion kWh)	Total Customers (thousands)	Revenues(b) (Current $) (millions $)	Price(c) (Current $) (¢/kWh)	Price(d) (1978 $) (¢/kWh)
1947	217.6	38,431.9	3,852.8	1.77	5.17
1946	190.8	36,140.3	3,459.6	1.81	6.05
1945	193.6	34,031.1	3,341.5	1.73	6.27
1944	198.2	33,048.4	3,276.7	1.65	6.12
1943	185.9	32,396.3	3,077.6	1.66	6.26
1942	159.4	32,210.4	2,855.8	1.79	7.17
1941	140.1	31,607.4	2,665.1	1.90	8.42
1940	118.6	30,191.0	2,440.2	2.06	9.58
1939	105.8	29,105.3	2,289.6	2.16	10.15
1938	93.7	28,063.7	2,156.6	2.30	10.65
1937(f)	99.4	27,262.3	2,160.8	2.17	9.86
1936	90.0	26,205.9	2,044.6	2.27	10.69
1935	77.6	25,312.8	1,912.0	2.46	11.69
1934	71.1	24,662.8	1,831.9	2.58	12.57
1933	65.9	24,027.2	1,754.6	2.66	13.40
1932	63.7	23,877.7	1,813.7	2.85	13.62
1931	71.9	24,489.8	1,975.9	2.75	11.78
1930	74.9	24,555.7	1,991.0	2.66	10.40
1929	75.3	24,150.2	1,938.5	2.57	9.79
1928	67.0	23,155.3	1,784.3	2.66	10.13
1927	61.3	21,786.2	1,661.0	2.71	10.18
1926	56.1	20,295.5	1,520.2	2.71	9.99

Source: Edison Electric Institute, Historical Statistics of the Electric Utility Industry. Washington, DC, 1971. And Edison Electric Institute, Statistical Year Book of the Electric Utility Industry for 1978. Washington, DC, 1979.

(a) Consists of government-owned electric utilities including municipal systems, federal agencies, state projects, public power districts, REA-financed cooperatively-owned electric utilities, and investor-owned electric utilities.
(b) Excludes exports to Canada and Mexico.
(c) Determined by dividing revenues by sales.
(d) Inflated using the consumer price index.
(e) Alaska and Hawaii included since 1960.
(f) A new "Uniform System of Accounts" was established for 1937 and data from 1937 on are not directly comparable to data prior to 1937.

Origin of the Electric Industry

The scientific groundwork for the electric industry had been laid by 1840, and development of motors and arc lighting was accelerating. In 1849, Thomas Ewbank, a former commissioner of patents, wrote in a report on the subject of electric motors: "The belief is a growing one that electricity, in one or more of its manifestations, is ordained to effect the mightiest of revolutions in human affairs. In subtlety and power, in excitability, rapidity and intensity of action there is nothing like it. Its complete subjugation may be held as a climax of conquests in art, the apex to ambition in science--so blessed and boundless, so surpassing all anticipation, are the seeming results that must follow."(1)

These words may have seemed rather extravagant to Mr. Ewbank's contemporaries, but the results of work by Edison, Sprague, Thompson, Houston, Brush and others then must have been convincing. They had begun to apply the scientific principles discovered by Faraday, Oersted, and Ampere to the practical problems of lighting and motive power.

Start-up of the Pearl Street Station--1882

"The electric utility industry traces its origins to Thomas Edison's 1879 patent for the incandescent light and his subsequent development of a central generating station and associated transmission to supply the electricity to operate his lamps. Initially, following Edison's first station in New York in 1882, electric generating stations made low voltage direct current available for use by the people in the vicinity of the stations."(2)

Also in 1882, a hydroelectric station to serve 250 arc lights was built in Appleton, Wisconsin. This is referred to as the first U.S. hydroelectric central station, a companion to Edison's first thermal electric station.

Hydroelectric Power at Niagara Falls--1895

The modern central station era and the recognition of the supremacy of polyphase alternating current for generation and transmission began with initial operation of the first large hydroelectric units at Niagara Falls in 1895. In the preceding years water wheels developing mechanical transit companies in the U.S.. The technology was applied also in subways and elevators. Although use of electric railways declined in the first half of the 20th century, there is now a renewed interest in electric mass transit systems, such as the Bay Area Rapid Transit (BART) system in San Francisco.

Parallel installations of arc lights and motors had been taking place on the West Coast in the 1882-1895 period. Thus, the stage was set for development of the industry at various population centers throughout the nation. The period of growth following 1895 was stimulated by individual inventors and private lenders willing to take risks in a new venture in producton and sale of electricity.

The industry developed rapidly, with a number of private companies and small municipal agencies being formed to generate and distribute electricity. State governments established laws to permit privately-owned electric utilities to operate as monopolies in designated service areas, to levy taxes, and to regulate the utilities with respect to prices charged, financing practices, and quality of service.

Organization of Research and Development Laboratories, 1901-04

Around the turn of the century--"a new tone was being set in the electrical industry by men like Charles P. Steinmetz, who had become head engineer at General Electric in 1894 (at age 29), and by Benjamin G. Lamme, who had become chief engineer at Westinghouse in 1901 (at age 42). With their engineering achievements, based on an understanding of theory and the employment of complex mathematics, they were building a greater respect for the use of science in industry."(5)

Of considerable significance to the future of the industry was the institution of research laboratories by electrical equipment manufacturers. The General Electric Company founded such a laboratory in 1901, and Westinghouse in 1904. Research carried out in those laboratories could be conducted free from the pressures of manufacture and sales. Work there, and at certain universities, prepared the way for future advancements in the electric power industry. The founders of these laboratories saw the wisdom of Lord Kelvin's words "No great law in power had been built at Niagara Falls to serve adjacent factories by means of belts and pulleys. As an observer of such mechanical power transfer systems described it, "Belts! I had never seen so many--horizontal, vertical, and slanting . . . wide and heavy, flapping as they ran, and shooting little spurts (of static electricity) here and there, to an occasional guard rail . . . ."(3)

The greatest difficulty, however, was the "environmental" effect of the nearby factories on the beauty of Niagara Falls. Later, when it was found that the needed power could be transmitted electrically to factories at more remote locations, the river front was rapidly cleared of such eyesores.

In planning the first large hydroelectric project at Niagara Falls, a difficult question arose as to selection between direct and alternating current systems. An AC system was finally chosen. With the AC system, power could be delivered in larger amounts over greater distances. After this system proved successful, alternating current was used in most other new installations around the country. The standard AC frequency was then 25 Hz. Some 50 Hz installations were constructed but usage later became standardized at 60 Hz.

Niagara Falls had an early arc lighting installation of less capacity than that of Appleton. A number of such systems, in which a series of arc lights was fed by a generator for that purpose only, were built around the country. This phase of the industry flourished until the mid-1890s, followed by years of fewer new installations and gradual replacement of arc lights by other types. However, the arc lighting companies opened up the field for rapid expansion of electric utilities.

Electric railways and street cars were also developed early in the history of the industry, but later were displaced to a large extent by internal combustion means of locomotion. "In 1886, according to an estimate published at that time, the 500 horse railways operating in the U.S. utilized 120,000 horses for 25,000 cars, or more than four horses to a car."(4) This was the "market" that the electric car preempted in the cities. Elevated trains in New York City, surface street cars and interurban lines were electrified by the year 1890 in 40% of the rapid

Natural Philosophy has ever been discovered for its practical application, but the instances are innumerable of investigations apparently useless in this narrow sense of the word which have led to the most valuable results."(6)

These laboratories have carried the burden of research for the industry since that time, shared by the Electric Power Research Institute (EPRI) since 1972. EPRI is funded by the associated public and investor-owned utilities. It directs the lines of research to be followed, and supports work performed in a number of research centers, in cooperation with the research efforts of the electrical manufacturers. Finally, the Edison Electric Institute and the Tennessee Valley Authority have also conducted research for the electric utility industry.

The Interconnecting of Utilities in the South--1905-1914

During the early years of the century the industry expanded both in numbers of people served and in per capita consumption. In some areas the use of electricity for lighting occurred in advance of use for motor loads, but in the South the presence of numerous textile mills has caused motor loads to lead lighting.(7) The pooling of utility companies' resources by interconnecting their systems with transmission lines advanced rapidly in the southeastern states from 1905 to 1914, with the result that reliability of service was improved and economic benefits were realized.

Innovations in the Chicago Area--1905-1914

In 1882, Edison's former lieutenant, Samuel Insull, became president of the Chicago Edison Company, and in the ensuing years promoted rapid growth of the industry, not only in the city, but in all of Illinois and parts of adjacent states, both urban and rural. His innovations contributing to growth were the use of holding companies to broadly apply the best legal and engineering and financing talents, the active pursuit of economy of scale in generating and other equipment, and the introducton of the demand component in electricity pricing. His holding company practices later became abusive, leading to an extensive investigation by the Federal Trade Commission and passage of the Public Utility Act of

1935, but used properly at the earlier stage the holding companies served a good purpose.

Growth in the 1915-1930 Period

The young industry expanded during and after the World War I years, serving war production needs in nitrate, aluminum, steel and other materials. By 1930, its installed generating capacity was 32.4 megawatts, about 5.6% of its capacity in 1978.

Until the 1930s, the only actions of the Federal Government that may directly or indirectly have influenced electricity consumption were 1) the enactment of a form of preference clause in 1902, to provide for the sale of electricity from federal projects "for municipal purposes," 2) the requirement of licenses for privately owned hydroelectric projects in 1920, and 3) the construction of Wilson Dam at Muscle Shoals on the Tennessee River. The role of Wilson Dam in the formation of TVA is discussed later. None of these acts, up to that time, had a significant effect on electricity consumption, even though smaller dams constructed by the U.S. Army Corps of Engineers (USCE) had produced electricity in small quantities since 1902.

The era of Federal Government stimulation of consumption may be considered as commencing in 1933 with the creation of TVA.

The Tennessee Valley Authority, 1933

Construction of Wilson Dam on the Tennessee River was started early in 1918, with the electric output intended for production of nitrates for World War I. Other work for flood control, power development and navigation on the Tennessee River was continued in the 1920s; but these improvements developed only a small portion of the river's potential electric power. This activity was a forerunner to TVA--"When Roosevelt signed the Tennessee Valley Authority Act on May 18, 1933, the new agency began life as a more or less accidental product of World War I, the Great Depression, and the strong personalities of Roosevelt and Norris."(8) TVA, later set up as a government corporation financing its operations through sale of taxable revenue bonds, and empowered to build thermal generating plants as well as multipurpose hydro projects, and with its mission of regional development, is unique among U.S. institutions. One of its objectives was to serve as a "yardstick" for the price of electricity. By reducing price to a minimum, consumption with its accompanying benefits was to be increased. In this way the government directly influenced the consumption of electricity in Tennessee and parts of the surrounding states.

The Federal Power Act, passed in 1935, has the Section heading "An Abundant Supply of Electric Energy Throughout the U.S. with the Greatest Possible Economy and with Regard to the Proper Utilization and Conservation of Natural Resources." It expresses the national policy with regard to electricity consumption. The words "greatest possible economy" have been interpreted to mean "lowest reasonable price."(9) This policy was implemented in TVA and in the creation of REA and of marketing agencies for federal power, such as BPA.

The Rural Electrification Administration--1935

Only 10.9% of the farms in the U.S. had obtained electricity by 1935, the year the Rural Electrification Administration (REA) was created by Executive Order of the President.(10) Later that year the President issued Regulation No. 4 establishing REA as a lending agency. Early in 1936 Congress directed the REA Administrator to give preference in making loans to "States, Territories, and subdivisions and agencies thereof, municipalities, peoples' utility districts, and cooperative, nonprofit or limited dividend associations."(11)

In 1944, in the Pace Act, the interest rate on outstanding and future REA Loans was changed to a flat 2%. With REA able to make loans for purposes of rural electrification at low interest rates, and with imaginative engineering advances to lower the cost of distribution line construction, the electrification of farms proceeded rapidly. By June 1949, "more than 78% of the farms in this country were receiving central station electric service."(12)

Farmers, not all of whom were in favor of electrifying their home and farm operations even though the investment they had to make under REA was relatively small, were delighted with the service when they got it. "It could milk cows, pump water, warm pigs, hatch eggs, brood chicks, sharpen tools and drill holes," as well as light the house and yard, power the radio, electric iron, and washing machine.[13]

The Bonneville Power Administration, 1937

The Bonneville Power Administration (BPA) was established in 1937 to market power from Bonneville Dam and Grand Coulee Dam on the Columbia River to loads in the Pacific Northwest defined to include Oregon, Washington, Idaho and Montana. Since then, four other generally similar marketing agencies have been created: The Southwestern Power Administration, in Arkansas, Louisiana, Missouri, Oklahoma, Texas and Kansas; the Southeastern Power Administration, covering all or parts of West Virginia, Virginia, Kentucky, Tennessee, Mississippi, Alabama, Georgia, Florida, North Carolina and South Carolina; the Alaska Power Administration, covering Alaska; and the Western Area Power Administration, covering all or portions of North and South Dakota, Iowa, Nebraska, Wyoming, Kansas, Utah, Nevada, California, Colorado, Montana, Arizona, Minnesota, New Mexico, and Texas. By 1978 some 12% of the U.S. generating capacity was in federal projects. Most of the dams were multipurpose, i.e., for irrigation, flood control, navigation, electric power, recreation, and fishery.

These agencies own and/or operate transmission facilities, and enter into wheeling agreements or other arrangements necessary to transmit the federal power to markets. They are financed at rates of interest set by the government and are required to repay all costs allocated to electric power production to the treasury at a scheduled rate. The price charged for energy must be adequate to provide the revenues for such repayment.

Preference is given to publicly owned utilities in the delivery of power generated at dams constructed by the Corp of Engineers and the Bureau of Reclamation. The preference policy had been established prior to 1937, but BPA would prove to be the most significant application of the policy by reason of the large amount of generation, the coverage over a large area in the northwestern U.S., and the sharp price differential between hydro power from existing plants and thermal power from new plants. The advantage to preference customers of BPA was not so marked in the first few decades of BPA's existence, as it has been in later years, because substantial sales could be made to non-preferential customers. Power in excess of the needs of the Pacific Northwest was sold to California users over long distance transmission lines in the 1950s and following years.

Growth in the 1940s

The industry and the loads it served continued to grow during this period at a rate of doubling in every ten years. During the World War II period, the Federal Government built war plants for steel and aluminum production, which were large consumers of electricity. These plants were built for defense purposes, not for increasing energy consumption. After the war needs were over, the plants were sold to private companies, continuing the use of electricity.

Nuclear Power--1957

The Atomic Energy Act was revised in 1954 to provide for private ownership and operation of nuclear reactors for purposes of electric power generation. It authorized research and use of essential government facilities for commercial nuclear fuels production, set conditions for the release of classified information needed for nuclear power generation, and with the Price Anderson Act of 1957 made provisions for third party liability insurance coverage. Thus, the Federal Government opened the way for practical use of a new form of energy for production of electricity, to be used in addition to the traditional fossil-fuel-thermal and hydroelectric forms of central station generation.

The first commercial nuclear plant went into service in 1957, and 68 were operating by 1978.

Plans made in the early 1970s for future additions of nuclear capacity have been revised downward because of slowing of the load growth and uncertainty regarding public acceptance of additional plants after the Three-Mile-Island accident in 1979.

The New York Blackout--1965

By 1960--"The expanding use of electric energy in every aspect of American life has contributed to and, in turn, has been made possible by the rising standards of living and the increased productivity this country has enjoyed in this period."(14)

An incident of significance to the electric power industry occurred in 1965, when New York City and a large part of the surrounding northeastern seaboard area suffered a prolonged blackout. The outage affected parts of several states, and the circumstances were such that the government felt the necessity of investigating the reliability of service of the interconnected utilities serving major load centers. This inquiry led to proposed legislation aimed at maintaining an adequate level of reliability to ensure the health and safety of the people insofar as affected by the continuity of electric service. The industry itself realized the need for a more systematic surveillance of overall systems reliability, and as a result of concerted action formed the National Electric Reliability Council. The government bill was not passed. The NERC has acted since then as a body to coordinate utility measures taken to ensure reasonable and adequate levels of service, in the Middle Atlantic region and elsewhere.

A second New York City blackout occurred in 1977, with more looting and arson than had been experienced with the 1965 event. After an analysis of the causes, certain correctional measures were taken, but the consensus was that the long range plans of the concerned utilities in cooperation with NERC were adequate.

National Environmental Policy

The Water Pollution Control Act of 1965 and the Clean Air Act Amendments of 1967 and the National Environmental Policy Act of 1969 have had a profound effect on the electric power industry. Plants burning fossil fuels were required to clean up discharges to the air. The construction of nuclear plants was delayed and costs increased while water and air quality requirements were being defined and complied with. Potential sites for new thermal plants were sharply limited by provisions regarding effluents to surface waters. The consumption of electricity was increased to some extent through use of power in chemical and mechanical engineering processing operations necessary to meet air quality requirements.

National Energy Policy--1979

The most recent development to seriously affect the electric power industry has been the sharp increase in price, and the threat of shortage of petroleum fuels. OPEC actions, the realization that world resources are limited, and the need to decrease U.S. dependence on foreign supplies, has caused the government to re-examine and redefine national energy policy. To the electric utilities the policy means 1) more use of coal and nuclear energy and less of oil, 2) the expectation of more use of renewable energy, with its concommitant effects from connection of numerous small generators to the utility system, and changed patterns of demand on central station equipment; and 3) energy conservation, with changes in utility load patterns and growth.

With conservation of fuels, questions arise--will conservation of petroleum fuels tend, in some areas, to shift heating loads to electric systems? If conservation lowers loads, changes load patterns, or reduces the rate of load growth, what effect will it have on revenues and unit prices?

Pricing principles are also being re-examined with the object of reducing incentive to consume electricity. The government has assumed certain regulatory powers over rate structure through the Public Utility Regulatory Policies Act (PURPA).

Summary

From the foregoing brief review of the history of the industry, in which acts of the Federal Government that may have affected consumption were highlighted, it is apparent that prior to 1933 the Federal Government limited its powers to certain licensing functions and to seeing that federal power went to municipal users. After that, it stimulated consumption to some degree. Electric service was regarded as contributing significantly to the welfare of the people, and it followed that all citizens were entitled to receive it at a fair price.

STRUCTURE OF THE INDUSTRY

Statistics on the growth in capacity in four categories of utilities--investor owned, federal, cooperatives, power districts and state projects, and municipal--are presented in Table 24.

In 1926, the total capacity was only 4.0% of 1978 capacity. Therefore, the period during which the government has had some influence on consumption is coincidental with approximately 96% of the growth. The table shows that the growth of investor-owned utilities was slow in the 1930s, accelerating to the double-each-decade rate after 1950. Federal power capacity picked up rapidly in the 1930s was still accelerating at a greater rate than investor-owned utilities in the 1940s and 1950s, then slowed to a rate less than the investor-owned utilities in the 1960s and 1970s. Cooperatives and others in that category have grown at a consistent rate, approximately tripling each decade from 1930 to 1970. Municipals have grown at a consistent rate of nearly doubling each decade over the entire period.

Number and Type of Utility Systems

The number and types of utility systems are shown in Table 25. (The classification of cooperatives and public (non-federal) utilities in Table 25 is somewhat different than in Table 24, so that generating capacity as a percent of total capacity differs.)

Technological Impact

Advancements in technology have led to increases in consumption of electricity. This applies to advances in both the electrical production systems and the utilization devices of industrial, commercial and residential consumers. In production systems such advances increase consumption by making electricity available to more people at lower cost. In the utilization devices, they increase the number and variety of the

TABLE 24. U.S. Electric Utility[(a)] Installed Generating Capacity by Ownership 1926-1978 (Thousand Kilowatts Nameplate)

Year	Investor Owned Utilities	Federal	Cooperatives, Power Districts, State Projects	Municipal Utilities	Total U.S.	U.S. Annual Capacity Change
1978[(b)]	453,647	54,282	36,957	34,426	579,312	18,951
1977	438,385	53,183	35,502	33,291	560,361	29,199
1976	415,504	51,707	33,349	30,602	531,162	22,748
1975	399,036	50,133	30,458	28,787	508,414	32,246
1974	376,122	45,518	27,204	27,324	476,168	36,293
1973	346,476	44,520	23,923	24,956	439,875	41,122
1972	314,353	40,408	20,943	23,049	398,753	29,673
1971	288,301	39,656	19,131	21,992	369,080	27,990
1970	262,675	38,718	18,756	20,941	341,090	27,741
1969	240,078	36,130	17,106	20,035	313,349	22,291
1968	220,766	34,956	15,907	19,429	291,058	21,806
1967	203,580	33,640	13,983	18,049	269,252	21,409
1966	185,671	32,608	13,016	16,548	247,843	11,716
1965	177,570	31,690	11,460	15,407	236,127	13,842
1964	167,704	28,343	11,039	15,199	222,285	11,736
1963	158,448	27,315	10,564	14,222	210,549	19,482
1962	144,577	24,315	9,246	12,929	191,067	10,399
1961	136,749	23,257	8,457	12,205	180,668	12,666
1960	128,450	22,350	5,703	11,499	168,002	11,161
1959	118,999	21,874	5,054	10,914	156,841	14,244
1958	108,202	20,436	4,142	9,817	142,597	13,474
1957	97,376	19,649	3,458	8,640	129,123	8,426
1956	91,145	18,336	2,891	8,325	120,697	6,225
1955	86,887	16,962	2,828	7,795	114,472	11,880
1954	79,127	13,567	2,673	7,225	102,592	11,090
1953	71,201	11,358	2,374	6,569	91,502	9,276
1952	64,349	9,678	2,180	6,019	82,226	6,451
1951	60,192	8,099	1,875	5,609	75,775	6,856
1950	55,175	6,921	1,539	5,284	68,919	5,819
1949	50,484	6,210	1,416	4,990	63,100	6,540
1948	45,381	5,526	1,292	4,361	56,560	4,238
1947	41,987	5,027	1,226	4,082	52,322	2,005
1946	40,335	4,920	1,101	3,961	50,317	206
1945	40,307	5,081	891	3,832	50,111	922
1944	39,733	4,886	886	3,684	49,189	1,238
1943	39,128	4,322	883	3,618	47,951	2,898
1942	37,442	3,216	868	3,527	45,053	2,648
1941	36,041	2,371	666	3,327	42,405	2,478
1940	34,398	1,944	435	3,150	39,927	1,064
1939	33,908	1,650	334	2,971	38,863	1,371
1938	33,246	1,156	310	2,780	37,492	1,872
1937	31,959	832	207	2,622	35,620	538
1936	31,787	803	184	2,308	35,082	646
1935	31,820	299	176	2,141	34,436	317
1934	31,547	288	182	2,102	34,119	-468
1933	32,163	232	171	2,021	34,587	200
1932	32,034	232	155	1,966	34,387	689
1931	31,498	231	154	1,815	33,698	1,314
1930	30,285	226	154	1,719	32,384	2,545
1929	27,953	214	138	1,534	29,839	2,034
1928	25,991	213	139	1,462	27,805	2,726
1927	23,418	209	131	1,321	25,079	1,693
1926	21,819	205	99	1,263	23,386	1,914

Source: Edison Electric Institute, Historical Statistics of the Electric Utility Industry. Washington, DC, 1971. And Edison Electric Institute, Statistical Year Book of the Electric Utility Industry for 1978. Washington, DC, 1979.

(a) Alaska and Hawaii included since 1963.
(b) Preliminary.

TABLE 25. Number and Ownership of Utility Systems in the United States in 1971

Ownership	Total Number of Systems	Generating Capacity Percent of Total
Investor-owned	300	78.5
Public (non-federal)	2,075	9.0
Cooperatives	1,048	1.5
Federal	125	11.0
Total	3,548	100

Source: U.S. Congress, Senate Committee on Interior and Insular Affairs, Electric Utility Policy Issues. U.S. Government Printing Office, Washington, DC, 1974.

work functions that can be performed and the comfort and pleasure that can be afforded through the use of electricity.

Some of the more important elements of the utilization of electrical devices are:

- the invention of the induction motor
- practical improvements in transformer design
- improvements of motors, and invention of complex motor controls
- the development of fluorescent, mercury vapor and sodium vapor lighting
- development of electrochemical and electrometallurgical processes for production of chemicals and light metals
- development of modern urban rail transportation systems such as BART of San Francisco
- the development of a number of major appliances over the years, such as food refrigeration, washers, dryers, water heaters, dishwashers, and microwave ovens
- the invention of television
- the use of electricity for space heating, by resistance or heat pumps
- the advent of economic space cooling.

No mention is made here of communications, electronic apparatus (other than television), semi-conductor devices, computers, or other devices that have small electrical requirements, important as they are, because of their relatively minor impact on overall electricity consumption.

The effects of the technological advances discussed above on consumption of electricity cannot be separated from other effects, but it will be evident to the reader that they have played an important part in the rising trend. The question may rightly be asked, "Has the Federal Government had an influence on the achievement of the many technical improvements that have come about over the last century, thereby indirectly influencing consumption?"

The government was certainly instrumental in the development of nuclear power, and perhaps also indirectly in the development of television through previous government-financed defense research in high voltage electronics. To the extent that the use of nuclear power helps keep electricity costs down, the government has stimulated consumption indirectly. Other effects on consumption, brought about by technological advancements may, on the whole, be credited to private enterprise with little or no assistance from government.

THE RESIDENTIAL SECTOR

As is evident from the history of the industry, the Federal Government has emphasized the desirability of plentiful, reasonably priced electricity being available to the people. The most direct manifestation of the success of this policy is the amount of electricity consumed in the residential sector. It is understood, of course, that consumption in the other sectors is conducive in its ultimate effects to the welfare of the people, but the way in which it is used is controlled by business and governmental institutions. The way in which electricity is used in the residential sector is influenced by the decisions of millions of people in their own self interest.

Residential Consumption Patterns and Growth

Table 26 contains statistics on residential consumption for the period 1950-78, embracing much of the span over which the Federal

Government exercised a significant, if not major, influence over consumption.

In a period of 29 years the national residential consumption has increased 9.7 fold, while the population has only doubled, indicating more intensive use. In that same period the price in dollars of constant value decreased to 52% of its 1950 price.

In 1950, the residential sales of electricity comprised about 25% of total national sales, and in 1978 about 33.6%. Sales had increased at an average rate of 8.45%/year over that 28 year period.

A breakdown of residential sales by region is presented in Table F-2 of Appendix F. The greatest growth occurred in the South and Southwest. The East South Central Region containing TVA, and the Pacific Region containing BPA and many public and private hydro electric plants, was lowest in unit price, but did not decline in average price level to the extent that had occurred in other regions, notably the West North Central Region from Missouri to the Dakotas. New England, Middle Atlantic, and Alaska and Hawaii, are the highest cost regions. Of these, New England, which started from the highest base, has had the greatest relative price reduction in the 28 year period.

A narrowing of the price difference is observable among the regions. Major hydropower resources have been developed and new central station plants in all regions are of the large thermal type. There is now a rather stable balance between investor-owned and publicly-owned power generation, transmission and distribution entities. Some differences will remain because of availability of different types of fuels, and the existence of federal and public non-federal entitites which bear little or no taxation and which can borrow at low interest rates.

Requirements

Effects of Rate Structure

Recently, the residential rates of most utilities were redesigned to promote residential consumption, as well as consumption in other sectors. In earlier stages of the industry added growth meant economy of scale, increasing efficiency and lowering unit cost. These goals were seen as

TABLE 26. U.S. Electric Utility Residential Sales, Revenues, Customers, and Price 1950-1978[(a)]

Year	Sales (billion kWh)	Total Customers (thousands)	Sales per Customer (kWh)	Revenues (millions $)	Price[(b)] (Current $) (¢/kWh)	Price[(c)] (1978 $) (¢/kWh)
1978	679.16	77,775.7	8,732	27,381.4	4.03	4.03
1977	652.35	75,923.1	8,592	24,687.5	3.78	4.07
1976	613.07	74,161.8	8,267	21,149.6	3.45	3.95
1975	586.15	72,570.2	8,077	18,803.2	3.21	3.89
1974	554.96	70,949.6	7,822	15,702.9	2.83	3.74
1973	554.17	69,438.4	7,981	13,194.8	2.38	3.49
1972	511.42	67,314.0	7,598	11,729.8	2.29	3.57
1971	479.08	65,650.0	7,298	10,483.5	2.19	3.53
1970	447.80	64,017.7	6,995	9,415.7	2.10	3.53
1969	407.92	62,598.9	6,516	8,532.7	2.09	3.72
1968	367.69	61,439.0	5,985	7,802.0	2.12	3.98
1967	331.53	60,033.4	5,522	7,183.9	2.17	4.24
1966	306.57	58,826.3	5,211	6,733.7	2.20	4.42
1965	280.97	57,596.0	4,878	6,328.8	2.25	4.65
1964	262.01	56,307.2	4,653	6,040.7	2.31	4.86
1963	241.69	55,073.1	4,389	5,722.5	2.37	5.05
1962	226.41	53,649.4	4,220	5,457.6	2.41	5.20
1961	209.02	52,569.1	3,976	5,115.8	2.45	5.34
1960	196.40	51,446.5	3,818	4,855.8	2.47	5.44
1959	180.19	50,403.4	3,575	4,514.7	2.51	5.62
1958	164.84	49,196.0	3,351	4,184.0	2.54	5.73
1957	152.59	48,265.7	3,162	3,909.5	2.56	5.93
1956	139.03	47,165.2	2,948	3,621.7	2.60	6.24
1955	125.37	45,827.6	2,736	3,322.8	2.65	6.46
1954	113.07	44,552.4	2,538	3,048.9	2.70	6.55
1953	101.24	43,380.4	2,334	2,777.1	2.74	6.68
1952	90.51	42,177.0	2,146	2,508.4	2.77	6.81
1951	80.51	40,656.6	1,980	2,264.8	2.81	7.06
1950	70.06	38,906.9	1,801	2,020.8	2.88	7.80

Source: Edison Electric Institute, Historical Statistics of the Electric Utility Industry. Washington, DC, 1971. And Edison Electric Institute, Statistical Year Book of the Electric Utility Industry for 1978. Washington, DC, 1979.

(a) Alaska and Hawaii included since 1960.
(b) Calculated by dividing revenues by sales.
(c) Inflated using the consumer price index.

being desirable by both industry and government. State government condoned rate structures aimed at achieving these goals, and the Federal Government was in passive agreement. The rate structures were based on sound economic reasoning at the time, i.e., they represented both a reasonable way of charging to recover fixed costs and a way of charging the incremental consumption to recover incremental fuel costs and other operating costs.

Only recently has it been recognized that the economic ground rules covering use of fuels did not account for all social costs, that fossil fuel resources are finite, and that political factors do not allow access to part of the world sources of petroleum fuels. Rate structures are now being revised accordingly; residential efficiency and conservation rather than increased consumption are being promoted. In 1979, for the first time, the Federal Government became involved in intra-state utility regulation for purposes of conservation, efficient use of facilities, and price equity through the Public Utility Regulatory Policies Act (PURPA). The passage of this legislation marks a decided change of emphasis in Federal Government policy regarding electricity consumption, as well as consumption of other types of energy.

Managing Consumption to Improve Load Factor

One aspect of efficient use of facilities (one purpose of PURPA) is improvement in load factor, the ratio of average load to peak load. Higher load factor means more electricity delivered with a given amount of capital investment, a goal always sought by utilities but not always achieved because of vagaries of residential usage. For example, electric water heaters are relatively heavy power consumers, and since they have storage capacity the utilities have from time to time tried to find a way to switch them off at peak load periods. Various schemes have been proposed in which signals would be transmitted over the power wiring to switch heaters off at peak load time. In the past, the incentives have not been sufficient to adopt such measures, but attention is again being given to the matter in order to decelerate the need for added generation and distribution facilities. Consumption of energy could remain the same, but with improved load factors the unit price could be reduced because of the spreading of fixed charges over more units of production. To the extent that the Federal Government may be able to contribute to price reductions from this cause, it may promote efficient consumption in the future.

Disbursements

Energy Assistance Program

Since FY-1977, the Community Services Administration (CSA) has operated a program that provides assistance to families which have problems paying their fuel bills. Services include the payment of utility and heating oil bills, the purchase of blankets and space heaters, and the payment of reconnecting fees where service has been suspended. To be eligible, one must have an income of less than 125% of the federal poverty level or be a Supplemental Security Income (SSI) recipient. A maximum of $400 may be provided for each family.

The annual appropriation for this program from FY-1977 through FY-1979 was $200 million.[15] By assuming that the funds were allocated by fuel in the same percentage as nationwide residential heating fuel types, we estimated that the amount allocated to electricity was $44.8 million per year. (In 1977, 48.4% of residential units were heated by natural gas, 29.2% by oil, and 22.4% by electricity or other.[16] Thus the total incentive for 1977 and 1978 was $93.0 million.

Market Activities

Federal Project Residential Sales

A direct federal incentive to increase the consumption of electricity in the residential sector has been provided through sales of electricity produced by various federal projects. Almost all of the power generated by federally owned facilities is marketed by the various power administrations. These facilities were constructed either by the Army Corps of Engineers or the Bureau of Reclamation. Some facilities are owned and operated by other agencies, such as the Bureau of Indian Affairs and the Department of the Interior, who primarily use the output for their own purposes. The power generated by these facilities is marketed by the various federal agencies listed previously.

The majority of the power marketed by these agencies is sold wholesale to utility customers who sell it retail to ultimate customers. However, there are a certain number of customers who are end users of the electricity who buy directly from federal agencies. Since the price of electricity purchased directly from a federal agency is lower than the price available from a utility, these direct purchasers have been given an incentive to consume electricity.

Table G-1, Appendix G, shows the number of residential customers served directly by federal projects, the level of sales, sales per customer, and price. In 1978, the average residential customer served by a federal project consumed 13,008 kWh in contrast to a national average residential use of 8,732 kWh (see Table 26). The average federal price to these customers was 1.75 ¢/kWh in 1978 while the national average residential price was 4.03¢/kWh (see Table 26).

It should be to noted that the federal power administrations do not normally sell power directly to residential customers. Of the 8,266 residential customers served by federal projects during 1978, 8,216 were served directly by the Bureau of Indian Affairs (BIA) from its Flathead Irrigation Project in Montana. This project generates some power and BIA purchases some power from Bonneville Power Administration. In the 29 years of data shown in Table G-1, Appendix G, the BIA sales account for the majority of the customers. During the early 1950s, TVA was selling power directly to residential customers but that stopped in 1953.

The value of the incentive to residential customers served directly by federal projects is calculated in Table 27. The assumption is made that if the lower priced federal power was not available, the residential customers would have to pay the national average price for their power. The incentive value to these customers is based on the difference between the federal price and the national price times the amount of power sold. This calculation may be an overestimate. If the current federal project customers had to pay a higher price for their power, they may not have consumed as much as they did. However, to incorporate this refinement into the calculation would require information of the responsiveness of the quantity of electricity consumed to changes in price. Since this

TABLE 27. Estimated Savings to the Residential Sector from Federal Project Electricity Sales 1950-1978

Year	Federal[a] Residential Sales (million kWh)	Average[a] Federal Price (¢/kWh)	Average[b] Utility Price (¢/kWh)	Price Differential (¢/kWh)	Savings[c] (thousands of current $)	Savings[d] (thousands of 1978 $)
1978	107.53	1.75	4.03	2.28	2,451.7	2,451.7
1977	100.57	1.73	3.78	2.05	2,061.7	2,220.5
1976	93.63	1.66	3.45	1.79	1,676.0	1,920.7
1975	90.75	1.34	3.21	1.87	1,697.0	2,056.8
1974	81.42	1.33	2.83	1.50	1,221.3	1,615.8
1973	77.61	1.32	2.38	1.06	822.7	1,207.7
1972	74.19	1.32	2.29	0.97	719.6	1,121.9
1971	67.07	1.31	2.19	0.88	590.2	950.8
1970	61.79	1.31	2.10	0.79	488.1	820.0
1969	60.89	1.31	2.09	0.78	474.9	845.3
1968	56.07	1.31	2.12	0.81	454.2	851.6
1967	53.54	1.29	2.17	0.88	471.2	920.7
1966	51.81	1.29	2.20	0.91	471.5	947.7
1965	50.06	1.28	2.25	0.97	485.6	1,004.2
1964	48.00	1.28	2.31	1.03	494.4	1,039.7
1963	45.77	1.28	2.37	1.09	498.9	1,063.2
1962	43.76	1.28	2.41	1.13	494.5	1,066.6
1961	41.55	1.29	2.45	1.16	482.0	1,051.2
1960	41.81	1.28	2.47	1.19	497.5	1,096.0
1959	39.17	1.27	2.51	1.24	485.7	1,087.0
1958	34.80	1.30	2.54	1.24	431.5	973.5
1957	33.72	1.31	2.56	1.25	421.5	977.0
1956	31.88	1.34	2.60	1.26	401.7	964.1
1955	30.51	1.34	2.65	1.31	399.7	973.7
1954	28.52	1.35	2.70	1.35	385.0	934.4
1953	27.50	1.40	2.74	1.34	368.5	898.8
1952	43.67	1.02	2.77	1.75	764.2	1,878.4
1951	50.84	0.96	2.81	1.85	940.5	2,362.5
1950	43.32	1.17	2.88	1.71	740.8	2,007.6
Total						37,309.1

(a) From Table C-1, Appendix C, columns 2 and 6.
(b) Current dollar price from Table 27, column 6.
(c) Price differential multiplied by sales.
(d) Inflated using the consumer price index.

information is not readily available, the unrefined estimate is determined to be a useful approximation. Therefore, it is estimated that the Federal Government provided a market activity incentive through the direct sale of electricity to residential customers valued at $37.3 million (1978 $).

Powers of Federal Government to Stimulate Residential Consumption

In the past it has been possible under the law for the Federal Government to stimulate residential consumption directly through the:

- generation of power in federal hydroelectric plants, and marketing through federal agencies
- regulation of interstate transfer prices
- regulation of financing practices of holding companies to hold prices down

or indirectly through the:

- deregulation of oil and gas price, with attendant price increases that would tend to make electric central or supplemental heating more attractive to residential consumers
- management of fiscal and monetary affairs so as to increase general affluence
- financing of research in scientific fields, usually for defense purposes, but often having results that are applicable in residential utilization devices
- extension of welfare aid to people who could not otherwise afford a life style that included a given level of electricity consumption.

In the future, the Federal Government may extend its regulatory powers with intent to promote efficiency and conservation. To the extent that better efficiency reduces unit prices, some added consumption may result.

THE COMMERCIAL SECTOR

The commercial use of electricity has advanced from the minimum lighting and oscillating fans of the general store to the brightly lit, air conditioned and elevator serviced multi-storied office building, the refrigerated open displays of the modern supermarket, the flood lighting of outdoor sports arenas, and the cooling, lighting and heating controls of airports, hotels, closed sports arenas, and theatres, convention halls and television broadcast studios.

As shown by the following statistics, the growth of commercial consumption closely parallels that of residential consumption, occurring at a much greater rate than population growth.

<u>Commercial Loads</u>

Growth in electricity demand came with the growth of the following items:

- o food refrigeration
- o ventilation
- o space cooling
- o elevators and conveyors
- o business machines, which individually do not require much power, but collectively have substantial loads
- o distribution losses in skyscrapers, where the losses approach those of small cities.

The motive for increased consumption in the commercial sector has been purely economic. The progressive business manager found that the more attractive stores and displays made possible by use of electricity increased his sales, and that a more comfortable environment increased the output and reduced the complaints of his employees in offices, stores, or warehouses.

The commercial user has had fewer options for use of electricity versus other energy forms than has the residential user, since competitive pressures required him to use ample amounts of electricity regardless of price. This is demonstrated in statistics which show that commercial consumption per customer in regions in which prices are low is no greater than that in regions of high price. For example, the East South Central Region with an average price of 3.14¢/kWh has slightly less commercial energy sales per customer than the Middle Atlantic Region with an average price of 5.49¢/kWh (see Table F-3, Appendix F). Thus, it can be concluded that the Federal Government's stimulation in the form of low price was not an important factor in the growth of commercial consumption.

Commercial Consumption Patterns and Growth

Table 28 contains statistics on commercial consumption for the period 1950-78. In 1950, commercial sales of electricity comprised about 21.5% of total national sales, and in 1978 about 23.8%. Commercial sales increased at an average rate of 8.28%/yr over the 28 year period as compared with 8.45%/yr for residential growth. The sales were from all categories of utilities, investor-owned, federal, and public non-federal at average 1978 prices ranging from 3.14 to 5.49¢/kWh in various regions of the country.

A breakdown of commercial sales by region is contained in Table F-3 of Appendix F. The tables shows the greatest growth occurring in the southern states and the Mountain region which includes Arizona and New Mexico and all states directly to the north of them.

The pattern of prices is similar to that of residential prices, being somewhat higher than residential prices in some regions and somewhat lower in other regions. The greatest difference is in the Pacific Region where the 1978 residential price is 3.14¢/kWh and the commercial price is 3.76¢/kWh.

The greatest reduction in commercial rates between 1950 and 1978 was in a zone from the Dakotas and Minnesota in the north to Texas and Louisiana in the south.

Market Activities

Federal Project Commercial Sales

Similar to the residential sector, federal project power is sold directly to the commercial sector. The level of sales, number of customers, sales per customer, and price for the years 1950 through 1978 are provided in Table G-2, Appendix G. In 1978, there were 3,413 commercial customers served directly by federal projects. These customers were relatively small, consuming an average of 16,680 kWh per customer compared to a national average of 52,550 kWh per customer (see Table 28).

TABLE 28. U.S. Electric Utility Commercial Sales, Revenues, Customers, and Price 1950-1978[a]

Year	Sales (billion kWh)	Total Customers (thousands)	Sales per Customer (kWh)	Revenues (millions $)	Price[b] (Current $) (¢/kWh)	Price[c] (1978 $) (¢/kWh)
1978	480.75	9,148.4	52,550	19,714.4	4.10	4.10
1977	469.23	8,943.7	52,465	18,021.5	3.84	4.14
1976	440.63	8,750.9	50,353	15,236.1	3.46	3.97
1975	418.07	8,591.1	48,663	13,486.6	3.23	3.91
1974	392.72	8,472.8	46,351	11,197.0	2.85	3.77
1973	396.90	8,361.8	47,466	9,147.2	2.30	3.38
1972	361.86	8,200.0	44,129	8,041.1	2.22	3.46
1971	333.75	8,002.6	41,705	7,072.0	2.12	3.42
1970	312.75	7,865.1	39,764	6,290.2	2.01	3.38
1969	286.69	7,744.9	37,017	5,704.8	1.99	3.54
1968	265.15	7,706.8	34,405	5,315.1	2.00	3.75
1967	242.49	7,579.6	31,992	4,935.9	2.04	3.99
1966	225.88	7,536.1	29,973	4,649.1	2.06	4.14
1965	202.11	7,420.0	27,239	4,312.9	2.13	4.40
1964	183.54	7,294.0	25,163	4,028.2	2.19	4.61
1963	166.52	7,232.1	23,025	3,788.3	2.27	4.84
1962	144.10	6,981.0	20,642	3,420.0	2.37	5.11
1961	134.86	6,843.6	19,706	3,168.1	2.35	5.13
1960	114.81	6,759.9	16,984	2,828.2	2.46	5.42
1959	109.08	6,462.5	16,879	2,598.5	2.38	5.33
1958	97.68	6,382.2	15,305	2,378.0	2.43	5.48
1957	91.70	6,291.5	14,575	2,240.6	2.44	5.66
1956	84.52	6,239.4	13,546	2,091.8	2.47	5.93
1955	77.88	6,156.3	12,650	1,943.8	2.50	6.09
1954	75.11	6,132.4	12,248	1,882.6	2.51	6.09
1953	70.86	6,004.3	11,802	1,781.7	2.51	6.12
1952	63.56	5,780.8	10,995	1,615.9	2.54	6.24
1951	58.77	5,678.6	10,349	1,493.3	2.54	6.38
1950	51.75	5,615.6	9,215	1,362.2	2.63	7.13

Source: Edison Electric Institute, Historical Statistics of the Electric Utility Industry. Washington, DC, 1971. And Edison Electric Institute, Statistical Year Book of the Electric Utility Industry for 1978. Washington, DC, 1979.

(a) Alaska and Hawaii included since 1960
(b) Revenues divided by sales
(c) Inflated using the consumer price index

The federal project price to commercial customers during 1978 was 2.36¢/kWh (see Table 29).

As with the residential sector, the power administrations do not sell directly to many commercial enterprises. Of the 3,413 customers served during 1978, 3,394 were served by the Bureau of Indian Affairs from the Flathead Irrigation Project in Montana.

The value of the incentive provided through the availability of low priced power to the commercial sector is calculated in Table 29. Again, this may be an overestimate because of potential reductions in the use of electricity if a firm was faced with the higher national average price. However, the incentive value is estimated to be $15.8 million (1978 $).

THE INDUSTRIAL SECTOR

The use of electricity for industrial purposes began with the textile mills of Niagara Falls. Since 1882 its use had permeated all U.S. mining, manufacturing and processing operations.

Industrial electrical equipment includes:

- motor drives of many kinds: for steel, textile, and paper mills; for pumping of water, refrigerants and chemicals; for air compression, machine tools, presses, cranes and many other purposes
- electric furnaces, welding, vulcanizing, and process heating and drying ovens
- manufacturing and processing systems operating controls
- electrochemical and electrometallurgical processes supplies
- factory lighting systems.

As the population, wealth and prosperity of the nation grew, and as more types of electric industrial equipment were developed and made available at attractive prices, the industrial consumption of electricity grew accordingly. The impetus for the production of goods (automobiles, for example) and consequent electricity consumption came chiefly from the private sector. However, in times of war, or in peace time defense programs, the Federal Government took measures to ensure adequate production in certain categories, thereby incidentally increasing electric

TABLE 29. Estimated Savings to the Commercial Sector from Federal Project Electricity Sales 1950-1978

Year	Federal[a] Commercial Sales (million kWh)	Average[a] Federal Price (¢/kWh)	Average[b] Utility Price (¢/kWh)	Price Differential (¢/kWh)	Savings[c] (thousands of current $)	Savings[d] (thousands of 1978 $)
1978	56.93	2.36	4.10	1.74	990.6	990.6
1977	88.22	1.93	3.84	1.91	1,685.0	1,814.8
1976	67.44	1.82	3.46	1.64	1,106.0	1,267.5
1975	66.68	1.91	3.23	1.32	880.2	1,066.8
1974	60.10	1.25	2.85	1.60	961.6	1,272.2
1973	61.51	1.18	2.30	1.12	688.9	1,011.3
1972	64.38	1.07	2.22	1.15	740.4	1,154.3
1971	49.86	1.19	2.12	0.93	463.7	747.0
1970	31.04	1.65	2.01	0.36	111.7	187.7
1969	28.88	1.84	1.99	0.15	43.3	77.1
1968	25.23	1.83	2.00	0.17	42.9	80.4
1967	35.04	1.46	2.04	0.58	203.2	397.1
1966	33.43	1.44	2.06	0.62	207.3	416.7
1965	31.23	1.43	2.13	0.70	218.6	452.1
1964	28.77	1.44	2.19	0.75	215.8	453.8
1963	26.39	1.45	2.27	0.82	216.4	461.1
1962	23.90	1.47	2.37	0.90	215.1	464.0
1961	20.32	1.52	2.35	0.83	168.7	367.9
1960	18.06	1.61	2.46	0.85	153.5	338.2
1959	15.16	1.66	2.38	0.72	109.2	244.4
1958	11.95	1.81	2.43	0.62	74.1	167.2
1957	11.73	1.82	2.44	0.62	72.7	168.5
1956	10.87	1.87	2.47	0.60	65.2	156.5
1955	10.09	1.88	2.50	0.62	62.6	152.5
1954	9.94	1.86	2.51	0.65	64.6	156.8
1953	9.28	1.89	2.51	0.62	57.5	140.2
1952	15.74	1.44	2.54	1.10	173.1	425.5
1951	23.88	1.33	2.54	1.21	289.0	726.0
1950	16.11	1.55	2.63	1.08	174.0	471.5
Total						15,829.7

(a) From Table C-2, Appendix C, columns 2 and 6.
(b) Current dollar price from Table 29, column 6.
(c) Price differential multiplied by sales.
(d) Inflated using the consumer price index.

demand, and acquiring facilities that were to be disposed of later to private industry.

Industrial loads are in a wide range of sizes, and are spread throughout all regions. Industries in which electricity costs are a large part of the overall costs of production seek sites having low-priced power. Aluminum production, for example, is concentrated in the Tennessee Valley, Massena, NY, the Ohio Valley, the West South Central region, and the Pacific Northwest, regions in which low cost power is, or was, available. (About 60% of the power used by the aluminum industry is from thermal sources and 40% from hydropower.) The Niagara Falls area was developed by private interests, and of course, TVA and most of the Columbia River hydroelectric projects were developed by the Federal Government.

Industrial Consumption Patterns and Growth

Industrial consumption of electricity is presented in the statistics of Table 30. Sales have increased each year for which these statistics were available. In 1978, industrial sales were 38.8% of all sales, a greater portion than either the residential or commercial sectors. However, growth since 1950 averaged less than those sectors, 6.27%/yr.

Growth in the period 1950-70 was 7.22%/yr, about the same growth rate as total consumption in all sectors, but in the period 1970-78 growth in the industrial sector was only at an average of 3.98%/yr. Part of this decline may have been due to achievements in efficiency and conservation, and part may have been due to a decline in the rate of individual growth.

Sales per customer have increased greatly since 1950, but the number of industrial customers has not increased at as great a rate as the number of total utility customers (by 51% in 29 years for industrial versus 115% for all customers), showing that the average industrial entity of 1978 serves more people than that of the 1950 counterpart on the average.

Prices have followed the same general trends as the overall average, bottoming out in 1970, but today they are much higher relative to the 1950 price than the commercial and residential prices. This demonstrates that rate structures are changing. The changed position may be partially due

TABLE 30. U.S. Electric Utility Industrial Sales, Revenues, Customers, and Price 1950-1978[a]

Year	Sales (billion kWh)	Total Customers (thousands)	Sales per Customer (thousands kWh)	Revenues (millions $)	Price[b] (Current $) (¢/kWh)	Price[c] (1978 $) (¢/kWh)
1978	782.14	464.64	1,683.3	20,280.4	2.59	2.59
1977	757.17	448.01	1,690.1	17,629.3	2.33	2.51
1976	725.17	427.40	1,696.7	14,999.5	2.07	2.37
1975	661.56	414.67	1,595.4	12,707.5	1.92	2.33
1974	689.44	422.74	1,630.9	10,673.5	1.55	2.05
1973	687.24	413.38	1,662.5	8,073.6	1.17	1.72
1972	639.47	369.95	1,728.5	6,983.9	1.09	1.70
1971	592.70	355.97	1,665.0	6,134.0	1.03	1.66
1970	572.52	352.99	1,621.9	5,429.9	0.95	1.60
1969	557.22	348.65	1,598.2	5,044.9	0.91	1.62
1968	518.83	333.65	1,555.0	4,672.2	0.90	1.69
1967	486.04	324.22	1,499.1	4,364.8	0.90	1.76
1966	465.08	316.10	1,471.3	4,134.5	0.89	1.79
1965	433.37	309.62	1,399.7	3,884.7	0.90	1.86
1964	409.36	318.17	1,286.6	3,733.4	0.91	1.91
1963	388.40	320.73	1,211.0	3,596.1	0.93	1.98
1962	373.92	441.39	847.1	3,591.1	0.96	2.07
1961	347.43	515.39	674.1	3,369.7	0.97	2.12
1960	344.80	453.58	760.2	3,333.9	0.97	2.14
1959	312.62	443.38	705.1	3,009.7	0.96	2.15
1958	283.85	440.68	644.1	2,757.2	0.97	2.19
1957	291.91	429.95	678.9	2,753.7	0.94	2.18
1956	285.76	412.78	692.3	2,625.1	0.92	2.21
1955	257.94	402.44	640.9	2,416.4	0.94	2.29
1954	203.92	364.19	559.9	2,027.5	0.99	2.40
1953	193.71	352.88	548.9	1,931.9	1.00	2.44
1952	170.61	333.21	512.0	1,728.0	1.01	2.48
1951	161.23	322.19	500.4	1,614.9	1.00	2.51
1950	142.05	305.56	464.9	1,443.5	1.02	2.76

Source: Edison Electric Institute, Historical Statistics of the Electric Utility Industry. Washington, DC, 1971. And Edison Electric Institute, Statistical Year Book of the Electric Utility Industry for 1978. Washington, DC, 1979.

(a) Alaska and Hawaii included since 1960.
(b) Revenues divided by sales.
(c) Inflated using the consumer price index.

to preferential laws of the government, which allow less and less of the low-cost federal power to be contracted to industrial users.

Statistics on regional consumption are given for the years 1950 and 1978 in Table F-4 of Appendix F. They show the southern states as having the most rapid rate of growth. There is considerable variance in growth of sales per customer among the regions; one interpretation is that the greater increases of the western and southwestern states in this respect reflect the movement of more large industries to those states during that 28 year period, to accompany the smaller industries that were already there, thus increasing the average sales per customer.

A remarkable aspect is that the Mountain Region (Arizona and New Mexico and all states to the north of them) now has the lowest average industrial rate. No explanation of this fact is readily available.

Market Activities

Federal Project Industrial Sales

The most significant customer group in terms of federal project sales is the industrial sector. In 1978, 61 customers were sold federal project power directly. Sixteen of these direct service industrial customers were served by the BPA, two were served by the Bureau of Indian Affairs, and the remainder received their power from the TVA. These industrial customers contain some of the most energy intensive industries in the nation (see Tables 31 and 32 for a complete list of the industry types). This fact is brought out by contrasting the federal project average sales per customer in 1978 of 802 million kWh (Table G-3, Appendix G) with the national average sales per customer of 1.7 million kWh (Table 30). A significant industry in this group is aluminum reduction which alone represented approximately one-third of BPA's total sales during 1978.

These industries have been able to purchase power at a low price. Besides the fact that federal project power is relatively inexpensive to produce, these industries can be served at a lower cost because they operate continuously, demand large amounts of power, and tend to locate close to the source of the power, thus, lowering transmission costs.

TABLE 31. TVA Direct Sales to Industries - 1972 by Type of Product

	Millions of kWh
Aluminum	5,621
Chemicals, misc.	3,495
Phosphorus	2,150
Oil & Petroleum products	1,911
Alloys	1,619
Copper	1,351
Carbon	1,248
Paper	1,193
Textiles	446
Steel	199
Air products	58
Rubber	22
Other	347
Total	19,660

Source: Tennessee Valley Authority, Annual Report of the Tennessee Valley Authority--1972, vol. 2. TVA, Knoxville, TN, p. 52, 1973.

TABLE 32. BPA Direct Sales to Industries - 1978 by Type of Product

	Millions of kWh
Aluminum	23,942
Copper	111
Chemicals	789
Nickel	706
Carbon	260
Wood Products	193
Other	32
Total	26,033

Source: Bonneville Power Administration, Fiscal Year 1978 Financial and Statistical Summary. BPA, Portland, OR, p. 9, 1979.

These industries have also enabled the regional power systems to achieve economies of scale which benefits all customers. The incentive value calculated in Table 33 based on a price differential neglects these benefits. The value of the price incentive is estimated to be $11.9 billion (1978 $).

THE AGRICULTURAL SECTOR

This section is directed to the activities of the Rural Electrification Administration, United States Department of Agriculture. The scope of the programs implemented by the REA and their objectives will be discussed as far as they relate to, or had impact on, the consumption of electric energy. Some programs may have had an overlapping impact on both production and consumption, and these will be noted.

Residential consumption has already received attention in another section. Since it is estimated that residential consumption accounted for 80% of total electric energy consumption in rural America, and since the REA had a great deal to do with the stimulation of electric energy consumption in residential usages, the programs and objectives which impacted residential use will be noted and discussed in this section. It is also true that some of the energy accounted for in the residential section may more accurately be characterized as an agricultural sector usage, since on small farms especially, equipment or appliances were often purchased both for personal use and to aid in agricultural production.

Market Activities

The Rural Electrification Administration

The Rural Electrification Administration is the major organization which we will examine in the agricultural sector. The REA was established by executive order of the President on May 11, 1935. Statutory authority was provided by the Rural Electrification Act of 1936. The intent of the legislation was to create an organization to coordinate a program stimulating the use and dissemination of technologies related to electric energy to the sparsely populated regions of the United States.

The programs implemented by the REA over the years have single-mindedly centered on the objectives for which the agency was

TABLE 33. Estimated Savings to the Industrial Sector from Federal Project Electricity Sales 1950-1978

Year	Federal[a] Industrial Sales (million kWh)	Average[a] Federal Price (¢/kWh)	Average[b] Utility Price (¢/kWh)	Price Differential (¢/kWh)	Savings[c] (millions of current $)	Savings[d] (millions of 1978 $)
1978	48,922.3	1.10	2.59	1.49	728.9	728.9
1977	47,018.7	0.84	2.33	1.49	700.6	754.6
1976	45,012.0	0.85	2.07	1.22	549.2	629.4
1975	47,363.7	0.61	1.92	1.31	620.5	752.1
1974	46,180.5	0.49	1.55	1.06	489.5	647.6
1973	43,880.8	0.43	1.17	0.74	324.7	476.7
1972	42,222.5	0.40	1.09	0.69	291.3	454.2
1971	43,556.7	0.39	1.03	0.64	278.8	449.1
1970	46,577.2	0.34	0.95	0.61	284.1	477.3
1969	43,166.9	0.32	0.91	0.59	254.7	453.4
1968	40,717.8	0.32	0.90	0.58	236.2	442.9
1967	38,114.8	0.32	0.90	0.58	221.1	432.0
1966	34,844.9	0.31	0.89	0.58	202.1	406.2
1965	33,339.8	0.31	0.90	0.59	196.7	406.8
1964	29,399.6	0.31	0.91	0.60	176.4	371.0
1963	25,865.8	0.31	0.93	0.62	160.4	341.8
1962	21,856.1	0.32	0.96	0.64	139.9	301.8
1961	23,307.5	0.31	0.97	0.66	153.8	335.4
1960	23,995.7	0.30	0.97	0.67	160.8	354.2
1959	22,359.3	0.30	0.96	0.66	147.6	330.3
1958	21,220.3	0.30	0.97	0.67	142.2	320.8
1957	21,767.2	0.28	0.94	0.66	143.7	333.1
1956	19,638.5	0.28	0.92	0.64	125.7	301.7
1955	17,085.5	0.28	0.94	0.66	112.8	274.8
1954	15,734.4	0.29	0.99	0.70	110.1	267.2
1953	13,682.3	0.31	1.00	0.69	94.4	230.2
1952	13,307.7	0.33	1.01	0.68	90.5	222.4
1951	12,593.2	0.27	1.00	0.73	91.9	230.9
1950	10,623.8	0.25	1.02	0.77	81.8	221.7
Total						11,948.5

(a) From Table C-3, Appendix C, columns 2 and 6.
(b) Current dollar price from Table 33, column 6.
(c) Price differential multiplied by sales.
(d) Inflated using the consumer price index.

created: the electrification of rural areas. This objective was in keeping with the economic interests of rural America. With slogans encouraging rural Americans to "live better . . . electrically," the REA, through its information dissemination and educational activities, demonstration projects, marketing and promotional activities, and financial services, profoundly affected the rate at which the use of electric energy increased in rural areas.[17]

The activities that the REA encouraged and initiated, which stimulated the consumption of electric energy, were varied and wide ranging. Four examples taken from Electric Appliances and Equipment for the Farm Home by Louisan Mamer, Power Advisor with the REA, may illustrate this point.[18] In 1938, the agency worked with manufacturers to develop two new promotions: a large size farm refrigerator and a stripped down model range. Both were designed to sell at very low prices.

In 1940, REA released its first movie for promotional use, "Power and the Land." This film illustrates graphically some of the potential benefits to be derived from utilizing electric energy in agricultural usages.

Hot school lunches were provided as a part of an ongoing program. Six thousand electrically equipped lunch centers were installed before 1950. The provision of nutritious meals was only a by-product of the program, which sought to demonstrate on a continuing basis the usefulness and efficiency of electric appliances at these specially equipped lunch centers.

Home economists working for REA in the field were equipped with demonstration equipment, e.g., a lighting kit and projector lightmeter, cases of small appliances and utensils, literature, visual aids, projectors for slide presentations and movies. All of this equipment was provided to aid in the instruction of rural Americans concerning the advantages of electric energy. These educational efforts were tailored to the audience, some of whom were not able to adequately understand written brochures and manuals. Personal contact, individualized instruction, as well as group and cooperative instruction were all a part of the overall program of the REA.

A major area in which the REA had impact was in the provision of financing for the capital investments necessary to install electric powered appliances and farm equipment. The farm families' lack of funds made purchasing electric equipment and appliances very difficult. The REA has played a major role in removing financial barriers to the acquisition and use of equipment and appliances. Low interest loans and loan guarantees have provided the means whereby much of the capital investment in electric powered technolgies have been made. These loans were made for the acquisition of end use equipment as well as for electric energy generation equipment. The application of REA funds effected an altered pattern of consumption and an increased generating capacity for rural areas all over the United States.

Over the years, the emphasis and scope of the REA programs have been shifted from actively encouraging electric energy use for lighting, to promoting all kinds of residential and agricultural usages. For example, large refrigeration units, which could serve for preservation of produce as well as for personal food items not produced on the farm, were offered through REA cooperatives at very low prices. Home electrification was expected to provide the main source of revenue for rural systems, indeed, ninety percent of electricity sold during those early years was used in the home, according to REA estimates. By the sixties, 80% of the electric energy consumed in rural areas in which the REA had been active, was estimated to be consumed in the home.

Average monthly kWh consumption of the first 100 farms with electric service in 8 cooperatives was 45 kWh in 1937 and 275 in 1948. On a national basis, the REA's residential mean kWh per month was 50/kWh in 1939 and 134/kWh in 1949. In 1959, this residential average was 334 kWh/month.(19)(20)

The activities initiated by the Federal Government through the Rural Electrification Administration did effect a substantial change in the speed at which electric energy was made available to, and used by, persons in rural areas of the United States. This was the case by design. The objectives established by legislative mandate were clearly adhered to by the REA.

Electric Energy Consumption for Irrigation

Data on electric energy consumption for the agricultural sector are not readily available in series over the period of interest. However, there have been estimates made of agricultural energy use by energy types for a particular year.(21) Electric energy consumption for irrigation is presumed to represent a major portion of total electricity consumption in the agriculture sector. Gordon Sloggett estimated the total energy consumption of irrigation and then disaggregated this estimate by energy source. This study will be the basis for the following estimates. In 1974, Sloggett estimates that there were 41.243 million acres of land irrigated in the United States with water from lakes, wells, and rivers.(22) Two-hundred and sixty trillion Btu were required to distribute this water to the crops for on farm irrigation. This would cost an estimated $594 million in 1974 dollars.

Total energy use in 1974 for the United States was 72.35 quadrillion Btus. Based on this estimate, consumption of energy for irrigation was much less than 1% of the total energy budget of the United States for the year 1974.

Electricity was used to irrigate an estimated 15.6 million acres. This represents 39% of total acreage committed to irrigated farm production in 1974, according to the 1974 Census of Agriculture (1975, p. II-58). It is estimated that 19 billion kWh were consumed irrigating the 15.6 million acres by electricity. This is equivalent to 64,828 billion Btu or 25% of the total on farm pumping for irrigation in the United States. Taken as a percentage of total U.S. consumption of electric energy (1706 billion kWh in 1974), this amount equals 1.1%.

It is also estimated by Sloggett that the cost of this electric energy was $331 million. This is 55.9% of the total cost of on farm irrigation in 1974. That is 55.9% of the dollar value for all irrigation for 37% of the land irrigated. So, according to Sloggett, electric energy for irrigation is disproportionately costly.

All the estimates above refer only to on farm energy consumption for irrigation. However, there is the cost of the energy consumed delivering the irrigation water to the farm. It is estimated that the Bureau of Reclamation used 3.6 billion kWh to pump irrigation water in the year 1974. When this amount of energy is added to the on farm electricity consumption, the total amount of electric energy used in 1974 for irrigation purposes (on farm and delivery to farms) would be 21.6 billion kWh. An equivalent amount would be 73,699.2 billion Btu.

Summary

No attempt has been made to estimate the value of the promotional incentives that REA has carried out. Though these activities had appreciable impact in stimulating the consumption of electricity, they will be characterized as a non-quantifiable incentive.

The other area in which federal activities have influenced electricity consumption in the agricultural sector is in irrigation. In several instances, there has been federal involvement in the provision of power and water for agricultural usage. Although the electric energy used in irrigation represents a small fraction of total U.S. consumption of electricity, the value of this power is not insignificant. Capital investments in routing the water, providing electricity and administrative costs associated with these activities are considerable.

The fact that agricultural demand for electricity requires distribution over thousands of square miles to a relatively dispersed consumer group increases dramatically the fixed costs associated with providing the electric energy. With this fact in mind, comparing the average price of 1.7¢/kWh in 1974 with prices for other sectors as presented in this chapter for that year, one conclusion seems inevitable. The Federal Government has significantly lowered the price of electricity to the agricultural sector. This may be attributable to water projects, dams, inter-connection and transmission equipment the Federal Government has installed. Some water projects have as a by-product generation capacity for electricity.

Federal investment and other activities which lower costs of producing, distributing and marketing electric energy impact consumption, over time. This interaction makes difficult the task of specifying quantitatively only consumption incentives. This task remains for future investigation.

THE TRANSPORTATION SECTOR

The Federal Government has been actively encouraging electric energy consumption in the transportation sector as an alternative power source to petroleum based transportation modes. These programs will be highlighted in this section.

At the turn of the century, the electric vehicle emerged as a bright, new alternative to the horsedrawn buggy. In 1904, an estimated one-third of all vehicles in Boston, New York and Chicago were powered by electricity.[23]

By 1940, consumption of electricity for transit passenger vehicles reached 6,334 million kWh. In 1978 this amount was 2,223 million kWh, which represents a decline of approximately 65% over the 38 year period.[24] The decline in usage and production of the electric vehicle can be directly attributed to the coincident increase in production and utilization of the internal combustion engine automobile. The advantages the internal combustion engine enjoyed over electric powered automobiles were related to performance characteristics, such as range, acceleration, and weight of equivalent amount of stored energy. The decline in consumption of electricity by transit passenger vehicles is related to increased consumption of diesel fuel by competing transit passenger vehicles.

Transportation Consumption Patterns and Growth

About 51% of all economic activity in the transportation sector is related to passenger movements. Eighty-eight percent of all passenger-miles traveled in the U.S. annually is accomplished in the automobile; air travel accounts for 7.7%; and public transit (including buses, subways, street railways, and commuter rail systems) accounts for 2.9% of the total. Miscellaneous transportation modes (taxicabs, inland water transport, intercity rail) account for the remaining 1% of all passenger miles traveled annually.[25]

Over 70% of public transit trips are provided by diesel powered bus; 30% are provided by electric powered traction devices such as electric trolley bus, street rail, rapid rail transit, and electric commuter rail. These electric rail transit and trolley bus systems provide greater than 1% of the total passenger miles traveled annually.

Over the period being analyzed in this study, consumption of electric energy for the transportation sector has declined 26% from a high of 5.88 billion kWh in the year 1950 to a low of 4.34 billion kWh in year 1978 (refer to Table 34, for annual figures).

Over this same period, the total number of reported railroad and railway customers declined 79% from 145 in 1950 to 30 total customers in 1978. When the average annual sales/customer are figured they show a trend toward more electricity consumption/customer (27.76 million kWh in 1950, 58.47 million kWh in 1978). Taken together, these three facts lead to the conclusion that there has been an increasing amount of consolidation or concentration in the electric rail industry over time. This trend has occurred as demand for this mode of transportation has subsided as measured by amount of electricity consumed.

The decline in number of rail customers and the decline in the amounts of electric energy consumed for transportation purposes for the period can be related to the coincident growth in petroleum consumption. For example, "The Trend of Energy Consumption by Transit Passenger Vehicles" table in the Transit Fact Book, published by the American Public Transit Association (1980), shows a greater than four times increase in the amount of diesel fuel consumed over the period (from 98,600 gal/yr in 1950 to 422,017 gal/yr in 1978).[26]

The mean annual price paid for electricity in the U.S. by the transportation sector in 1950 was 1¢/kWh (refer to Table 34). In 1978, the transportation sector's mean annual price for electricity was nearly four times the 1950 level. However, when an appropriate index adjustment is made for the impact of inflation, the actual change in the effective price paid by customers in this sector for electric energy amounts to a 44% real increase over the period. The price of electric energy for the

TABLE 34. U.S. Electric Utility Railroad and Railway Sales, Revenues, Customers, and Price 1950-1978[a]

Year	Sales (billion kWh)	Total Customers	Sales per Customer (million kWh)	Revenues (millions $)	Price[b] (Current $) (¢/kWh)	Price[c] (1978 $) (¢/kWh)
1978	4.34	30	144.67	170.12	3.92	3.92
1977	4.21	28	150.36	145.68	3.46	3.73
1976	4.34	28	155.00	163.84	3.78	4.33
1975	4.27	29	147.24	159.16	3.73	4.52
1974	4.26	29	146.90	146.11	3.43	4.54
1973	4.19	46	91.09	91.90	2.19	3.21
1972	4.44	50	88.80	85.30	1.92	2.99
1971	4.54	48	94.58	77.86	1.71	2.75
1970	4.63	47	98.51	69.17	1.49	2.50
1969	4.53	49	92.45	62.98	1.39	2.47
1968	4.54	64	70.94	61.44	1.35	2.53
1967	4.57	65	70.31	60.61	1.33	2.60
1966	4.51	65	69.39	59.13	1.31	2.63
1965	4.65	66	70.46	60.90	1.31	2.71
1964	4.72	83	56.87	61.70	1.31	2.75
1963	4.67	117	39.92	61.75	1.32	2.81
1962	4.72	118	40.00	63.26	1.34	2.89
1961	4.69	94	49.89	62.87	1.34	2.92
1960	4.77	73	65.34	62.64	1.31	2.89
1959	4.13	70	59.00	52.91	1.28	2.86
1958	3.84	81	47.41	47.99	1.25	2.82
1957	4.14	95	43.58	50.69	1.22	2.83
1956	4.41	91	48.46	51.65	1.17	2.81
1955	4.56	95	48.00	52.50	1.15	2.80
1954	4.70	115	40.87	53.65	1.14	2.77
1953	4.98	122	40.82	53.69	1.08	2.63
1952	5.35	129	41.47	54.14	1.01	2.48
1951	5.76	142	40.56	56.90	0.99	2.49
1950	5.88	145	40.55	59.05	1.00	2.71

Source: Edison Electric Institute, Historical Statistics of the Electric Utility Industry. Washington, DC, 1971. And Edison Electric Institute, Statistical Year Book of the Electric Utility Industry for 1978. Washington, DC, 1979.

(a) Alaska and Hawaii included since 1960.
(b) Revenues divided by sales.
(c) Inflated using the consumer price index.

year 1950 in 1978 equivalent value dollars was 2.71¢/kWh. This can be compared to 3.92¢/kWh on average in the year 1978.

Disbursements

The Urban Mass Transportation Administration

In the postwar period there has been a marked decline in transit patronage.(27) In an effort to reverse this trend, the Urban Mass Transportation Administration was created to provide federal financial and technical assistance in the replacement and renewal of physical plant and equipment, and subsequently to provide financing of operating costs as well for mass transit systems throughout the country. A significant portion of the program receiving federal funds is based on electric powered traction devices, e.g., commuter rail, heavy rail, and other transit systems.

Federal objectives with regard to mass transit are apparent in the Urban Mass Transportation Administration's authorizing legislation where the Congress determined that "the welfare and vitality of urban areas, the satisfactory movement of people and goods within such areas, and the effectiveness of housing, urban renewal, highway and other federal programs are being jeopardized by the deteriorization or inadequate provision of urban transportation facilities and services" (DOT 1976, p. 1).

This statement reflects a general concern for urban areas, the perceived role of transit in these areas, and the condition of the transit sector. Objectives that the Urban Mass Transportation Administration has pursued over its history include:(28)

- o promoting the mobility of the public, including transit dependent groups such as the elderly and handicapped, the economically disadvantaged, and commuters
- o reducing urban transportation energy consumption
- o promoting economical development of urban areas
- o reducing ambient air and noise pollution levels.

None of these stated objectives include the stimulation of the demand for electric energy. But demand for energy in all of its forms is essentially a derived demand. Energy resources in and of themselves are rarely assimilated as final goods. The stimulus for the demand for electric energy is the demand for a final good or service for which electric energy is simply an input in the process of consumption.

With the federally funded capital investments in new rolling stock, plant and equipment, advance land acquisitions, and federal assistance to meet necessary operating expenses, there results an increased derived demand for the primary energy sources that power these mass transit systems. This increase in the demand for energy is latent until such time as the market for transportation services responds. The intent of this federal program is to induce utilization of public transit, and thereby stimulate demand for the primary energy resources utilized by the transit systems receiving federal funds.

To the extent possible, capital grants associated with electric powered transit systems have been isolated, converted to 1978 equivalent dollar values and summed in Table 35. These expenditures have been characterized as disbursement incentives stimulating final demand for electric energy.

Nontraditional Services

Research, Development and Demonstration Projects Related to Electric Energy: The EHV Program and Energy Storage Systems

The Federal Government's electric and hybrid vehicle (EHV) program is another example of research, development and demonstration that may exert tremendous influence on energy consumption patterns for the U.S. The distinguishing factor between this program and the UMTA Program, for the purposes of this study, is that the expenditures made for the development the electric and hybrid vehicle technology, if successful, will have the greatest future impact.

For several years, R&D Programs in the area of energy storage systems or batteries have been carried out by the Department of Defense. Work on thermal ammonia, silver-zinc, mercury, cadmium, nickel, magnesium, and lithium battery technologies have added a great deal to the efficiency of these technologies. Advancements in the area of electric energy storage systems have contributed significantly to the eventual commercialization

TABLE 35. Department of Transportation Cumulative UMTA Capital Grants Associated with Electric Powered Transit Systems, Urban Mass Transportation Administration (Thousands of Dollars)

Year	Current Dollar Amounts	Conversion Factors to 1978 $	1978 Equivalent Value $
1965	$28,141	2.068	58,195
1966	64,438	2.010	129,520
1967	110,589	1.954	216,090
1968	104,816	1.875	196,530
1969	121,931	1.780	217,037
1970	83,182	1.680	139,745
1971	160,226	1.611	258,124
1972	280,414	1.559	437,165
1973	602,520	1.468	884,499
1974	464,192	1.323	614,126
1975	754,209	1.212	914,101
1976	766,109	1.146	877,960
1977	875,000	1.077	1346250
1978	980,000	1.000	980,000
Total			$6,865,467

Source: U.S. Department of Transportation, Urban Mass Transportation Administration, The UMTA Rail Modernization Program: The Distribution of Capital Grant Funds for Rail Rehabilitation and Modernization, 1965-1977. U.S. Government Printing Office, Washington, DC, 1978. Also correspondence with Robert Abrams, Department of Transportation, Urban Mass Transportation Administration.

and use of electric and hybrid vehicles. The funds allocated to these areas are noted in Appendix H and added to the EHV program funds. The justification for doing this is that research in this area is complementary to the electric and hybrid vehicle program. Both areas of research contribute to the success or failure of this technology commercially.

The electric and hybrid vehicle program is managed by the Office of Transportation Programs, under the direction of the Assistant Secretary for Conservation and Solar Energy in the Department of Energy. Collateral research and development efforts in advanced energy storage systems (advanced battery research) are conducted by the Department of Energy's Electrical Chemical Division, Office of Electric Energy Systems (previously ERDA's Energy Systems Division, and the EC's Technical Development Division).

The major objective of the EHV program, the acceleration of development and commercialization of electric and hybrid vehicles, is being pursued through four major activities:

1. Demonstration projects in separate geographic and functional areas are designed to identify feasible market segments, life-cycle costs, barriers to acceptance and infrastructure requirements of EHVs.

2. Incentives facilitating EHV use, remove barriers through a program of loan guarantees, small business planning grants and technical assessments of alternative designs.

3. Research and Development is being conducted in the areas of vehicle systems, subsystems technology, and advanced electrical energy storage systems. Advancements in these areas will increase acceptance of EHVs and lower fixed and variable costs associated with this technology.

4. Product Engineering essentially coordinates the process of technology transfer between public and private sector entities. Through a coordinated effort of technical demonstrations and engineering field tests, newly developed technical advances in the R&D program as well as improvements in the energy storage systems are subjected to actual field use. Findings are then evaluated and made available to the private sector.

In Table 36, funds for the EHV program and battery research are listed and adjusted to 1978 dollar equivalents and summed. These amounts have been characterized as a non-traditional government service that is in effect an incentive stimulating consumption of electric energy.

THE PUBLIC SECTOR

In this section, consumption of electricity by the public sector will be analyzed and characterized. Where possible price/quantity relationships will be discussed. There are two separable areas which will be addressed: consumption for general operations and uranium enrichment facility consumption. Taken together, these activities represent a considerable portion of the total U.S. annual electric energy consumption.

Since the late sixties, federal outlays have remained close to 20% of GNP. Nevertheless, in absolute value, the rising federal expenditures have been promoting an increase in energy consumption. In 1974, a program was initiated to control and decrease federal energy consumption for general operations. Results from this program will be reported in brief.

Public Sector Consumption Patterns and Growth

The Federal Government is the single largest user of energy in the nation, accounting for 2.2% of the total energy used in the U.S. in 1978. This energy is used within the Federal Government by almost six million people, in more than 400,000 buildings, and in operating more than 650,000 vehicles of all types. In the aftermath of the 1973-74 oil embargo, the Federal Energy Management Program was initiated to encourage energy conservation in the Federal Government. The data and analysis contained in the annual reports for this program are the basis for the figures presented herein on electric energy consumption by the Federal Government.

In FY1978, the Federal Government's energy consumption of all forms equalled 1.70 quadrillion Btu (see Table 37).

The energy consumption for FY1978 was 5.9% less than in FY1975. Between FY1975 and FY1978, federal reliance on petroleum based fuels decreased, due to reduced use of diesel and aviation fuels. This reduction was almost entirely due to actions taken by the Department of Defense which consumes 4/5 of the energy used by the Federal Government.

Electric energy consumption for the Federal Government in FY1978 represented 28.1% of total federal energy consumption. This was an increase over the previous four years (refer to Table 36). Federal

TABLE 36. Federal Research and Development Expenditures Electric and Hybrid Vehicles and Batteries (Thousands Dollars)

Year	Battery[a]	EHV[b]	Total	Total 1978 $[c]
1962	2,713		2,713	5,851
1963	2,740		2,740	5,838
1964	4,160		4,160	8,748
1965	3,060		3,060	6,328
1966	3,828	385	4,213	8,468
1967	4,266	17	4,283	8,368
1968	5,362		5,362	10,053
1969	4,942	170	5,112	9,099
1970	5,045	595	5,640	9,475
1971	3,638	1,149	4,787	7,711
1972	3,439		3,439	5,361
1973	3,276	235	3,511	5,154
1974	4,020	558	4,578	6,056
1975	6,072	600	6,672	8,086
1976	17,010	1,893	25,575	37,339
TQ[d]	405		405	464
1977	19,661	21,210	40,871	44,018
1978	26,486	29,460	55,946	55,946
Total				242,363

(a) Table H-1, Appendix H, for specific Reference sources.
(b) Table H-2, Appendix H, for specific figures.
(c) Based on Consumer Price Index for Inflation Adjustment.
(d) Transition Quarter due to change of Federal Government fiscal year.

TABLE 37. Electrical Energy Purchased by Gaseous Diffusion Plants 1950-1978 (Million kWh)

Year	Oak Ridge	Paducah	Portsmouth	Total Supplied By TVA[(a)]
1978	7,586.7	12,438.1	14,015.4	16,293.4
1977	10,656.9	16,139.5	16,439.5	21,954.6
1976	10,969.5	16,172.7	13,339.8	22,290.4
1975	8,822.4	13,687.9	9,639.6	18,403.9
1974	8,149.4	12,504.5	8,108.1	16,902.6
1973	7,835.7	12,249.7	8,311.9	16,410.5
1972	4,282.0	11,068.5	7,660.3	12,030.0
1971	2,949.4	10,233.4	3,972.4	10,112.8
1970	4,360.3	8,721.3	3,796.0	10,465.2
1969	4,347.4	10,590.1	4,342.5	11,760.5
1968	8,046.1	10,839.6	5,269.7	15,633.8
1967	9,405.7	10,811.2	7,082.1	16,973.5
1966	10,003.6	13,546.3	9,248.1	19,486.0
1965	9,967.8	13,662.0	11,601.1	19,531.2
1964	13,166.1	16,999.6	15,791.6	25,065.8
1963	13,115.0	16,955.0	15,767.9	24,983.5
1962	13,948.6	17,350.2	16,210.1	26,093.7
1961	15,774.1	18,737.4	16,862.0	28,890.3
1960	16,101.0	18,723.0	17,113.7	29,207.1
1959	17,510.0	17,141.6	17,057.0	29,509.1
1958	17,521.4	17,416.2	17,037.4	29,712.7
1957	19,003.6	19,998.5	18,054.2	33,002.6
1956	18,669.9	19,645.5	16,423.6	32,421.8
1955	13,296.5	16,349.8	3,655.6	24,741.4
1954	7,415.9	9,776.8	--	14,259.7
1953	6,679.2	1,699.4	--	7,868.8
1952	5,676.6	33.4	--	5,700.0
1951	2,709.2	1.8	--	2,710.5
1950	2,270.2	--	--	2,270.2

Source: Enriching Operations Division, Oak Ridge Operations, U.S. Department of Energy.

(a) TVA directly supplies all of the power requirements of Oak Ridge and approximately 70% of the requirements of the Paducah plant. The remaining 30% at Paducah is supplied by Energy Electric, Inc. and Portsmouth is supplied by the Ohio Valley Electric Company.

electric energy consumption as a percentage of total U.S. sales of electric energy was also up slightly in FY1978 to 6.98%. The actual amount of electric energy consumed was 139.6 billion kWh in FY1978 for the Federal Government. This represents an increase of 4.2% over FY1977's electric energy consumption for the Federal Government. So, while energy consumption overall was declining for the Federal Government, its electric energy consumption was increasing.

Energy consumption figures for the Federal Government prior to the implementation of the Federal Energy Management Program are unavailable. There exist some estimates, made at various times in separate studies and reports[29], but the estimations are based on disparate assumptions and methods rendering them essentially incomparable. Therefore, figures from the FEMP annual reports are the only ones presented in this analysis.

Market Activities

Uranium Enrichment Facilities

Between 1943 and 1955, the Federal Government constructed three uranium enrichment facilities at a cost of $2.4 billion. A plant at Oak Ridge, TN, was constructed during World War II and the Paducah, KY, and Portsmouth, OH, facilities became operational in the early 1950s following the outbreak of hostilities in Korea.

The uranium enrichment process is a particularly electric energy intensive process. For example, during the peak period of 1957, the three enrichment plants consumed over 10% of total amount of electricity sold in the United States. However, by 1978 enrichment operations consumed under 2% of the total U.S. electricity sales. All of the power consumed by the Oak Ridge facility and approximately 70% of Paducah's requirements are supplied by the Tennessee Valley Authority (TVA). The remaining 30% of Paducah's requirements is supplied by Electric Energy Inc. (EEI) which was incorporated in 1950 by five private utility companies to supply power to the facility. The Portsmouth facility is supplied by the Ohio Valley Electric Corporation which was incorporated in 1952 by fifteen private utility companies just to serve the Portsmouth plant (Moody's Public Utility Manual 1979 pp. 704 and 1431).

The sales of energy to the enrichment facilities from 1950 to 1978 is listed in Table 37. Since the TVA supplied a large portion of this power at a low price, the public sector has received an incentive to consume electricity. The value of this incentive is included in the next section. It is also possible to argue that the cost of constructing these facilities was an indirect incentive to consume energy, especially because the facilities consume so much energy. However, if this cost were considered to be a consumption incentive, then, the cost of constructing all government buildings that consume electricity would be treated as an incentive to consume. This is not felt to be appropriate and the construction cost of the enrichment facilities is not considered an incentive to consume electricity.

Federal Project Public Sales

Most of the federal projects sell power directly to the public sector. Public sector sales include those to military installations, interdepartmental sales and other ultimate governmental consumers of electricity. A portion of these sales go to the various projects themselves which use the power to operate and maintain their facilities. Power used to operate locks should be counted in the transportation sector. However, there is no way to identify these sales separately, so they are included in public sector sales.

Federal project public sector sales, customers, revenues, and price for 1950 through 1978 are tabulated in Table G-4, Appendix G. If one compares the total federal project sales (Table 38) with sales made by TVA to the enrichment plants (Table 37), the significance of the enrichment sales becomes apparent. Comparing the lower federal project price for electricity with the average utility price for power provides the value of the price incentive to the public sector. An incentive value of $20.1 billion (1978 $) has been calculated.

CONCLUSIONS

During the period from 1950 through 1978, it is estimated that the Federal Government provided $39.2 billion (1978 $) in incentives to stimulate the consumption of electricity. The largest dollar amount of

TABLE 38. Estimated Savings to the Industrial Sector from Federal Project Electricity Sales 1950-1978

Year	Federal[a] Public Sales (million kWh)	Average[a] Federal Price (¢/kWh)	Average[b] Utility Price (¢/kWh)	Price Differential (¢/kWh)	Savings[c] (millions of current $)	Savings[d] (millions of 1978 $)
1978	23,499.9	1.46	3.42	1.96	460.6	460.6
1977	29,332.4	1.20	3.33	2.13	624.8	672.9
1976	29,353.7	1.14	3.06	1.92	563.6	645.9
1975	27,047.1	0.80	2.84	2.04	551.8	668.7
1974	25,026.5	0.60	2.51	1.91	478.0	632.4
1973	24,208.4	0.53	2.02	1.49	360.7	529.5
1972	19,690.7	0.50	1.88	1.38	271.7	423.6
1971	18,923.5	0.45	1.79	1.34	253.6	408.6
1970	21,167.8	0.40	1.70	1.30	275.2	462.3
1969	23,635.9	0.38	1.65	1.27	300.2	534.4
1968	25,868.3	0.39	1.66	1.27	328.5	615.9
1967	27,088.6	0.39	1.67	1.28	346.7	677.5
1966	26,936.7	0.38	1.71	1.33	358.3	720.2
1965	25,385.6	0.38	1.81	1.43	363.0	750.7
1964	30,139.4	0.38	1.82	1.44	434.0	912.7
1963	29,257.9	0.38	1.83	1.45	424.2	904.0
1962	32,317.9	0.37	1.86	1.49	481.5	1,038.6
1961	32,207.4	0.37	1.89	1.52	489.6	1,067.8
1960	32,039.2	0.37	1.96	1.59	509.4	1,122.2
1959	31,249.3	0.37	1.94	1.57	490.6	1,098.0
1958	31,818.3	0.38	1.97	1.59	505.9	1,141.3
1957	34,880.6	0.39	1.95	1.56	544.1	1,261.2
1956	33,180.6	0.40	1.91	1.50	497.7	1,194.5
1955	24,410.2	0.45	1.91	1.46	356.4	868.2
1954	13,784.9	0.44	1.92	1.48	204.0	495.1
1953	8,783.1	0.42	1.89	1.47	129.1	314.9
1952	6,406.7	0.46	1.89	1.43	91.6	225.2
1951	3,345.3	0.34	1.87	1.53	51.2	128.6
1950	3,115.0	0.32	1.92	1.60	49.8	135.0
Total						20,110.5

(a) From Table C-4, Appendix C, columns 2 and 6.
(b) Revenues divided by sales. Data from Edison Electric Institute, Historical Statistics of the Electric Utility Industry. Washington, DC, 1971. And Edison Electric Institute, Statistical Year Book of the Electric Utility Industry for 1978. Washington, DC, 1979.
(c) Price differential multiplied by sales.
(d) Inflated using the consumer price index.

incentive (see Table 39) came in the form of price incentives provided by the sale of inexpensive federal project power to ultimate customers. Power from federal projects is sold through many outlets and has impacted the price of electricity all over the nation. However, this market activity incentive is particularly important to those end-users of electricity that buy power directly from a federal project instead of through a utility supplied by a federal project. This incentive obviously has its impact primarily through price rather than the other demand determinants.

Disbursement incentives represented the second largest group. Grants provided by the Urban Mass Transportation Administration to improve transit systems has impacted the use of electricity. This incentive reduces the price of complementary goods, thus increasing electricity demand.

Research, Development, and Demonstration activities related to electric vehicles and energy storage will provide ways in which electricity can be used more efficiently. In the future, these activities are almost sure to stimulate the demand for electricity. These non-traditional government services have been provided at a cost of $242 million (1978 $). These incentives like the mass transit grants, reduce the price of complementary goods, thus increasing demand.

In terms of sector impacts, the public sector received the largest incentive to consume electricity. This is primarily the result of low cost TVA Power supplied to enrichment facilities. The industrial sector also received a large incentive to consume electricity through the availability of federal project sales. Similarly, the residential and commercial sectors benefitted from federal project power but to a much smaller extent. Finally, the transportation sector was a major recipient of federal incentives to stimulate the consumption of electricity.

TABLE 39. An Estimate of the Cost of Incentives Used to Stimulate the Demand for Electricity (Millions 1978 Dollars)

MAJOR SECTOR

Incentive Type	Residential	Commercial	Industrial	Agricultural	Transportation	Public	Total
Taxation	--	--	--	--	--	--	--
Disbursements	93.0I	--	--	--	6,865.5Pc	--	6,958.5
Requirements	--	--	--	--	--	--	--
Traditional Services	--	--	--	--	--	--	--
Nontraditional Services	--	--	--	--	242.4Pc	--	242.4
Market Activity	37.3P	15.8P	11,948.5P	--	--	20,110.5P	32,112.1
Total	130.3	15.8	11,948.5	--	7,107.9	20,110.5	39,313.0
Total P							32,112.1
Total Pc							7,107.9
Total							93.0

P = Pride determinant of demand
Pc = Price of complementary goods determinant of demand
I = Income determinant of demand

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VIII. CONCLUSIONS WITH RESPECT TO SOLAR ENERGY POLICY

The purpose of the analysis presented in this report is to identify and quantify federal incentives that have increased the consumption of coal, oil, natural gas, and electricity. An analysis of public incentives can form the basis of initial insights into the kind, quantity, and duration of incentives to stimulate the use of renewable energy resources. This chapter is intended as a device for presenting the policy questions about the incentives that can be used to stimulate desired levels of energy development. Decisions about incentives involve not only dollars, but also types of incentives, particular technologies, intended user groups and the timing of incentives.

The estimates of past incentives presented in this volume can be useful in framing new incentive programs in three ways. First, the rationales used to justify historical programs may be useful in arguing for new programs. Rationales of aid to infant industries, moving an industry along a learning curve more rapidly, and aiding particular social or geographical groups may be applicable to solar industries. Second, we identify the mechanisms used to provide incentives in the past. These tools for implementing governmental policies are basically tools that are available at present. Our research is one of the few attempts to develop a theory of how the government can give incentives, and to provide data on the efficacy of using various theoretically available "tools." Third, the data on historical use of various incentive types provide indicators of preference for one type versus another. These data can be guides to policy makers as they consider how to implement new incentive programs.

The conclusions about past incentives can be a guide in choosing the particular incentives that deserve careful consideration in the years ahead. It is intended as a point of departure in the process of achieving a national goal through the interaction of scientific inquiry and public debate. If it is socially desirable and technologically feasible to increase solar energy's share in the national energy budget, the paramount policy question is one of selecting an incentive strategy and determining the government's level of investment in it.

In the theoretical chapter we defined federal incentives for the consumption of energy as Federal Government actions whose major intent or major result is to stimulate energy consumption. The stimulus comes through changing values of variables included in energy demand functions, thereby inducing energy consumers to move along the function in the direction of greater quantity of energy demanded, or through inducing a shift of the function to a position where more energy will be demanded at a given price. The demand variables fall into one of six categories: (1) price of the energy form, (2) price of complements, (3) price of substitutes, (4) preferences, (5) income, and (6) technology.

The government can provide such incentives using six different policy instruments defined in the introductory chapter: (1) taxation, (2) disbursements, (3) requirements, (4) nontraditional services, (5) traditional services, and (6) market activity. We examined four energy forms: (1) coal, (2) oil, (3) natural gas, and (4) electricity. And we examined six energy-consuming sectors: (1) residential, (2) commercial, (3) industrial, (4) agricultural, (5) transportation, and (6) public.

Two types of analyses of incentive actions are presented in this volume. The generic chapter focused on actions taken in 1978 across all energy forms. The subsequent chapters traced the patterns of incentive actions, energy form by energy form, from the beginning of the 20th century, especially since 1950, to the present. In this summary chapter, the results of the previous chapters are presented by energy form, by incentive type, and by user group. Finally, the implications of these results for solar policy are presented in the last section of this chapter.

When all energy incentive actions taken during fiscal year 1978 were analyzed it was found that the overwhelming proportion of these incentives are classified as "incentives with non-energy related intent." Funds used to construct highways, operate government buildings, and transport government personnel have major influences on national energy consumption patterns. The Federal Government is the single largest energy consumer in the economy. However, the primary intent of these programs has little to do with shaping energy consumption patterns. Total non-energy intent incentives amounted to $28.8 billion in 1978. About 47% of these funds consisted of market activity to operate government buildings and to transport government personnel. Disbursements accounted for nearly 44% of these funds, and traditional and nontraditional accounted for over 9%. Incentives with energy related purposes amounted to $2.3 billion in 1978. Nearly 91% of these incentives were for oil consumption, with solar and other nontraditional energy forms receiving 8%, and the remaining traditional energy forms (coal, gas, and electricity) each receiving less than 1% each. Almost half (42.1%) of the incentives with energy related intents were in the form of tax exemptions, and more than a third (38.5%) took the form of market activity incentives. The remainder of the incentives are divided among disbursements (12.2%), requirements (5.0%), and traditional and nontraditional services (2.2% together). Thus, the 1978 spending patterns suggest a concentration of incentives with energy intent in taxation and market activity. The incentives with non-energy intent were concentrated in disbursements and market activity for the most part, and required almost fifteen times as much funding as the incentives with energy related intent. Since several purposes, both explicit and implicit, are served by these actions, it is not surprising to find higher spending levels.

Our analysis shows that the Federal Government has expended $170.4 billion for incentives to stimulate energy use. This figure, and all of the estimates below are the undiscounted sum of spending in relevant categories over the period 1950-1978 (unless some other period is specified), reported in constant 1978 dollars. (No discounting of incentives was done on the grounds that many incentives have cumulative effects over long time periods; they are public sector "investments" whose effects are felt over long periods of time in both the private and public sectors.) These expenditures are presented in Tables 40 and 41 according to energy form, incentive type, and user sector.

Energy Forms

As shown in Table 40, oil consumption received the largest share of incentive funds (75%), more than twice the share of any other energy

TABLE 40. An Estimate of the Cost of Incentives Used to Stimulate Energy Consumption, by Incentive Type and Energy Source (Millions of 1978 Dollars)

	Coal	Oil	Gas	Electricity	Total	Percentage of Total Incentives
Taxation		28,086			28,086	16.4
Disbursements		3,466	201	6,959	10,626	6.2
Requirements	10	80,414			80,424	47.2
Traditional Services		15,825(a)			15,825	9.3
Nontraditional Services	3030	75		242	3,347	2.0
Market Activity				32,113	32,113	18.8
Totals	3,040	127,866	201	39,314	170,421	100.0
Percentage of Total Incentives	1.8	75.0	0.1	23.1	100.0	

(a) Negative value of highway trust fund omitted ($60.6 billion).

TABLE 41. An Estimate of the Cost of Incentives Used to Stimulate Energy Consumption, by Incentive Type and Sector (Billions of 1978 Dollars)

	Residential	Commercial	Industrial	Transportation	Agricultural	Public	Total	Percentage of Total Incentives
Taxation				24,130		3,956	28,086	16.4
Disbursements	415			10,211			10,626	6.2
Requirements	12,749	(a)	30,634 (b)	34,655		2,386	80,424	47.2
Traditional Services				15,825 (c)			15,825	9.3
Nontraditional Services			3,105	242			3,347	2.0
Market Activity	37	16	11,949			20,111	32,113	18.8
Totals	13,201	16	45,688	85,063		26,453	170,421	100.0
Percentage of Total Incentives	7.7	0.0	26.8	49.9		15.5	100.0	

(a) Requirement incentives for Commercial oil consumption included in Residential.
(b) Includes electric utilities and non-transportation agriculture incentives for oil consumption.
(c) Negative value of highway trust fund omitted ($60.6 billion).

form. The second largest share of federal incentives (23%) went to the promotion of electricity consumption. Coal received about 2% of the consumption incentive dollars, while natural gas received only 0.1%.

Incentive Types

As shown in the rows of Table 40, the largest proportion of incentives were in the form of requirements (47.2%). Market activity was the second most common incentive type (18.8%), with taxation a close third (16.4%). Traditional services (9.3%) and disbursements (6.2%) were roughly comparable in magnitude; nontraditional services accounted for just 2% of incentive costs. Note that in the cumulative estimates, incentives with energy intents are mixed with those with other intents, whereas these two types of energy incentives have been analyzed separately in the generic chapter.

Comparing these cumulative incentive figures to the single year estimates in the generic chapter, the relative roles of taxation, requirements, and disbursements appear to differ greatly. Taxation received greater emphasis in 1978 than in the average over all previous years. Requirements are larger in the cumulative estimates. Disbursements play a larger role in the 1978 estimates, but are found mostly in the category of incentives with non-energy intent.

User Sectors

Looking at the sectors (see Table 41), it is clear that transportation got the largest part, nearly 50% of all incentives. Large items are crude oil price controls, and aviation subsidies. (This estimate excludes federal highway programs, which have helped increase the use of motor fuel, but have collected more in highway user taxes than have been spent.) Industry has gotten the next largest allocation (26.8%), primarily from crude oil price controls and sales of government produced electricity at low prices. Government use of government produced electricity is another large item, which contributes to the public sector estimate of 15.5% of total incentives. The residential sector received just 7.7% of the incentive funds. The low estimate of incentives for the commercial and agricultural sectors is partly a data problem. Commercial use of oil could not be separated from residential oil use, and non-transportation agricultural oil use could not be separated from industrial oil use. The transportation estimate is complicated by the fact that some of it is really commercial, industrial, agricultural, and personal consumption activity. Only government transportation could be disaggregated from the totals.

Demand Determinants

Examples of the use of all of the demand determinants identified in the theory chapter are found in the empirical chapters. The largest determinant of demand has been price, principally through requirements (price controls for crude oil) and market activity (sales of electricity from federal projects). Technology determinants are next, the largest item being improvements in airports and aviation facilities. Income determinants, in the form of disbursements, and changes in the price of complements have had a minor role. Preference determinants of demand have had a small budgetary cost but involve federal programs with legal requirements, such as enforced switching to coal. The cost to a violator could be very high.

AN APPROACH TO SOLAR INCENTIVES

The analysis of historical use of incentives for traditional energy forms suggests a number of guidelines for solar policy. We do not expect history to repeat itself precisely, but neither do we expect historical patterns to be suddenly and widely disrupted. Thus, our examination of historical incentives used to stimulate the consumption of coal, oil, natural gas, and electricity suggests some guidelines and limits for the use of incentives to stimulate consumption of solar energy.

Several conclusions for solar policy are clearly related to the data we have assembled. That is, we suggest that direct analogues to historical policies may exist in some cases. Many of the programs which stimulated use of traditional energy forms were not directly energy programs, but had other purposes. As side effects, or second-order impacts, such programs as highway construction, port construction, and government use of energy have had powerful influences on national energy consumption patterns. A solar policy analogue is encouragement of solar power as an energy source in re-industrialization programs.

A major conclusion from this volume is that substantial incentives have been given to stimulate consumption of energy, $170 billion. Previous research has established that production incentives were also provided, amounting to $252 billion over the same period.(1) The historical incentive patterns suggest that it is not necessary to choose between supply-push and demand-pull strategies for stimulating new industries. The historical pattern in the energy sectors is to stimulate both sides of the market. In addition, the incidence of the incentive frequently is shifted from one sector to the other, making the distinction somewhat blurred.

Another important type of traditional action which government could consciously use to stimulate solar consumption is to specify solar space conditioning and electric power systems in selected government facilities. Such solar systems are cost competitive in a few installations at present. Furthermore, a dramatic decrease in cost as production increases (learning-curve phenomena) for some solar technologies (photovoltaics) could allow early Federal Government purchases in significant volumes, even at higher than competitive prices, to bring down costs in the future to the point that very widespread market penetrations will be possible. The Federal Government, as the single largest energy consumer in the economy, and as a major energy producer and major element of capital markets, can be very influential in shaping the future of solar energy through selective use of market activities.

More general guidelines for solar incentives also stem from this research. Traditional energy sources have been significantly stimulated by a variety of types of incentives given to both producers, as demonstrated in previous research,(2) and to consumers, as demonstrated by the estimates in this study. In order to compete well, solar energy will require similar governmental stimulation to overcome the cumulative effects of past stimulation of other energy forms and to offset on-going stimulation of other energy forms. The amount of spending on traditional energy forms, over $170 billion in consumption incentives and $252 in production incentives, may provide a rough guide to the magnitude of spending on solar incentives that will be required to achieve particular solar production targets.

NOTES - CHAPTER VIII

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APPENDIX A

ENERGY CONSUMPTION

(A SUPPLEMENT TO CHAPTER I)

APPENDIX A

LONG-RUN PATTERNS OF ENERGY USE

From the end of World War II until the early 1970s, the price of energy in the United States fell in real (constant dollar) terms, as it did in most of the other industrialized countries. The drop in real prices--combined with an average growth of real Gross National Product (GNP) of about 3.7% per year--led to an increase in energy consumption of about 5.5% per year, for an increase of about 200% over the two decades from 1950 to 1970.(1) From 1973 to 1977, in contrast, energy use grew by only 0.5% annually. This deviation from the historical growth rate, however, was caused equally by a reduction in the use of energy per unit of Gross National Product and by a reduction in the growth rate of the economy.(2)

THE VARIOUS FORMS OF ENERGY

Over time the relative contribution of the various forms of energy to total energy use has changed.(3) Figure A-1 depicts these changes over the last century. Prior to 1890, wood was the primary energy form. It was replaced by coal. Coal then retained half of the energy market until after World War II. Natural gas consumption jumped markedly in the post-war years until the early 1960s, and then leveled off. Oil's share of consumption has increased steadily until recently when it also became more stable.

In 1973, 47% of consumption was supplied by oil, 30% by natural gas, and 18% by coal--with the remaining 5% coming from hydroelectric, nuclear, and geothermal.(4) In February 1980, oil continued to supply 47% of the nation's energy, gas consumption was reduced to 25%, while coal consumption increased to nearly 20%, and hydro, nuclear, and geothermal consumption jumped to 8%.(5)

PATTERNS OF USE

Efforts to systematically separate energy uses into major categories such as transporting people and goods, space conditioning, and materials

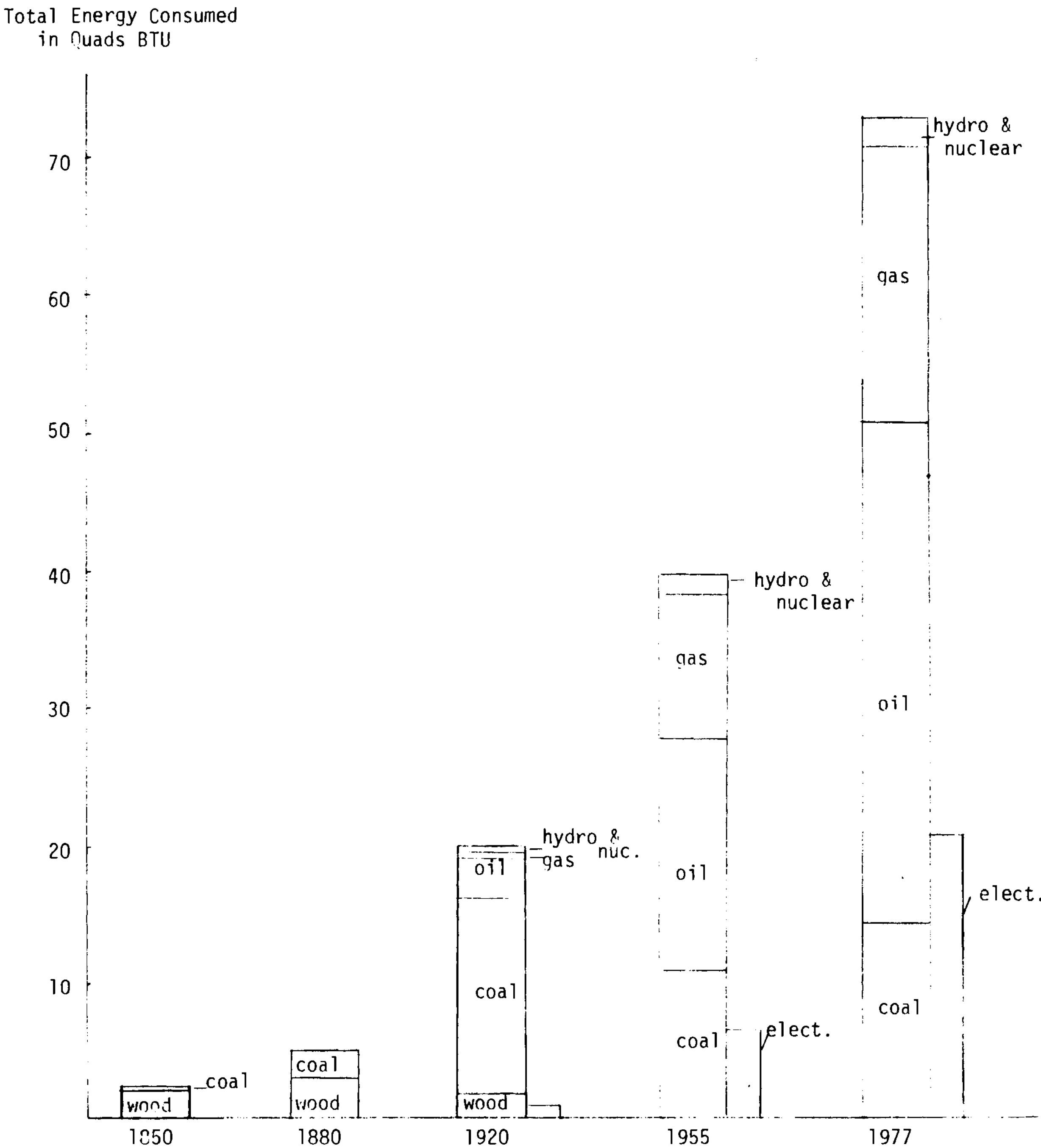

FIGURE A-1. Forms of Energy Consumption

Source: S. Sonenblum, The Energy Connection: Between Energy and the Economy. Ballinger, Cambridge, MA, p. 79, 1978.

processing have been undertaken only sporadically.[6] Figure A-2 is a breakdown of energy consumption by user, form, and use.

Figure A-3 shows the 1973 pattern of consumption by end-use sectors and consuming areas. In the industrial area, the largest end-use of energy is to furnish process steam. The automobile consumes 85% of the energy used for passenger travel. In the residential and commercial sector, space heating constitutes the largest functional requirement for energy.

Figure A-4 provides further breakdowns of energy consumption by sector and end-use. Unfortunately, after 1973, statistics gathered by the Federal Government have not routinely included these specifics.[7]

Finally, it is useful to look at the historical rate of growth in energy use. Between 1950 and the 1973 embargo, overall energy use jumped 3.5% per year. Within this period of rapid overall growth, individual fuels and end-use sectors grew at different proportions. Figure A-5, for example, shows that energy use in the residential and commercial sectors grew more rapidly than the average.[8] During the 1970s, particularly since the 1973-74 oil embargo, this situation changed. The right hand column in Figure A-5 traces the growth rates in energy use since the embargo. It shows a wide variation. Transportation use has grown at 1.7% per year, while industrial energy use has actually fallen by 1.2% per year.[9]

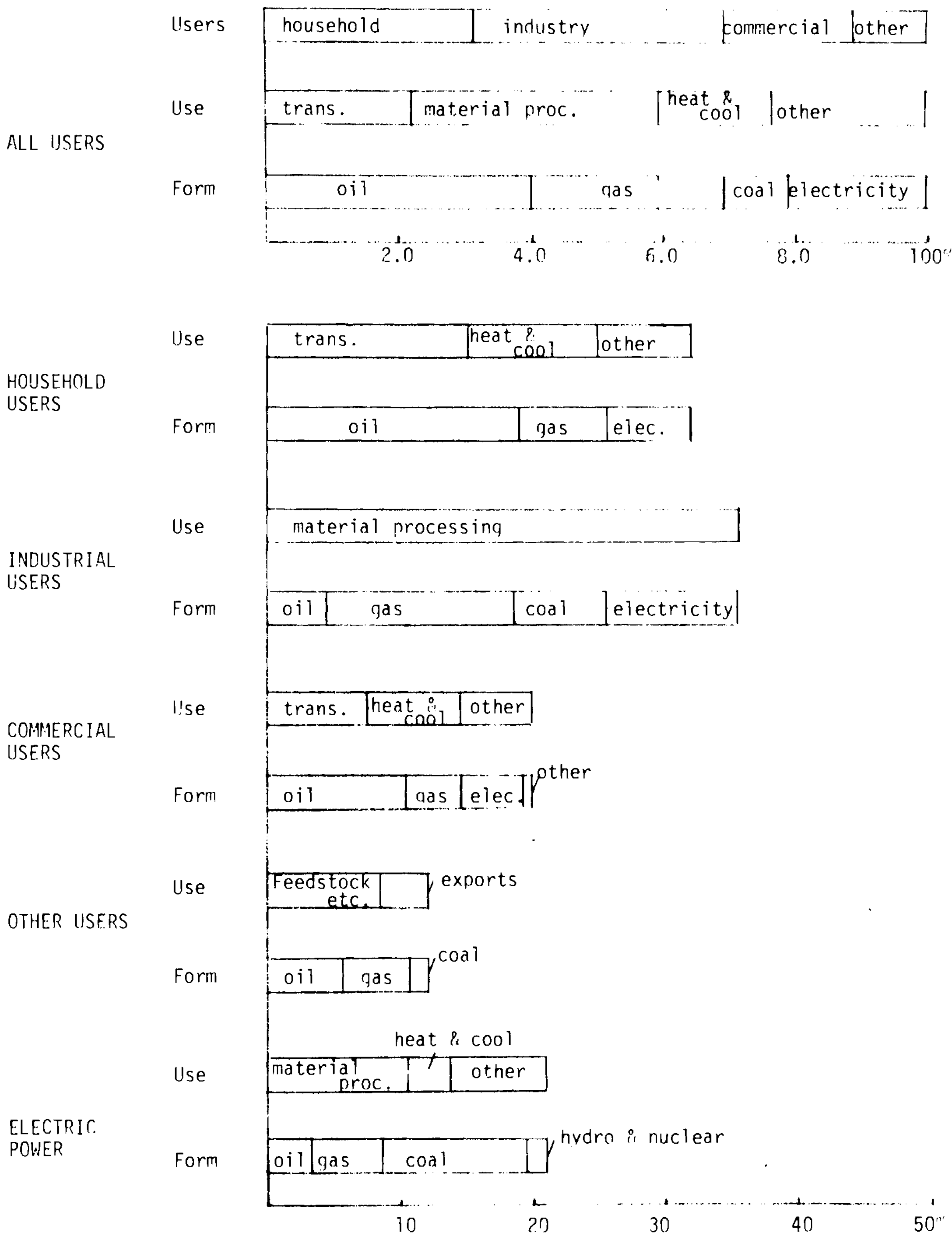

FIGURE A-2. Energy Consumption by User, Use, and Form 1970

Source: S. Sonenblum, The Energy Connection: Between Energy and the Economy. Ballinger, Cambridge, MA, p. 82, 1978.

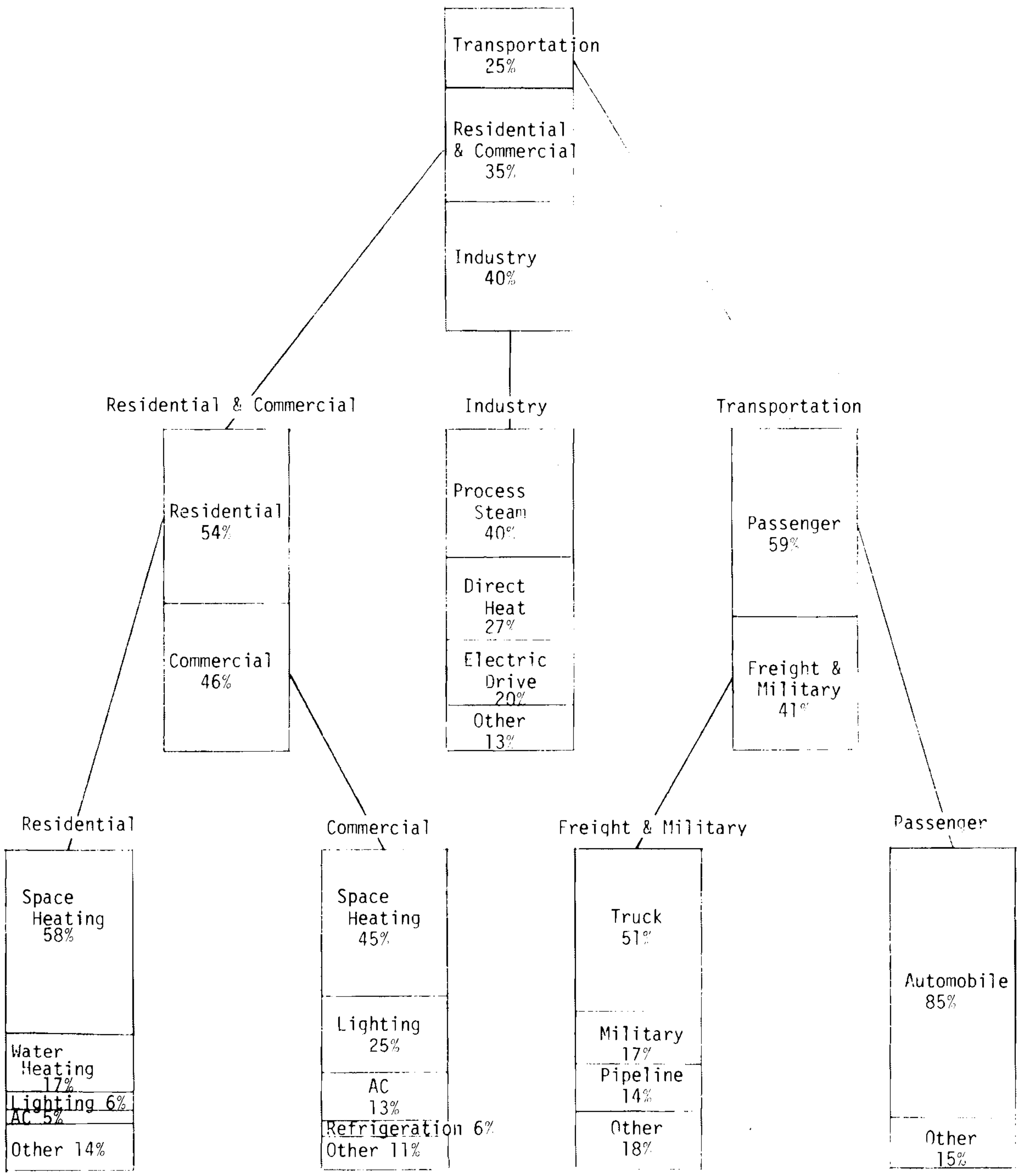

FIGURE A-3. 1973 U.S. Primary Energy Consumption By End-Use Sector and Major Function

Source: Hearings Before the Subcommittee on Advanced Energy Technologies and Energy Conservation Research, Development and Demonstration, Energy Demand, Conservation, Potential and Probable Lifestyle Changes, p. 86.

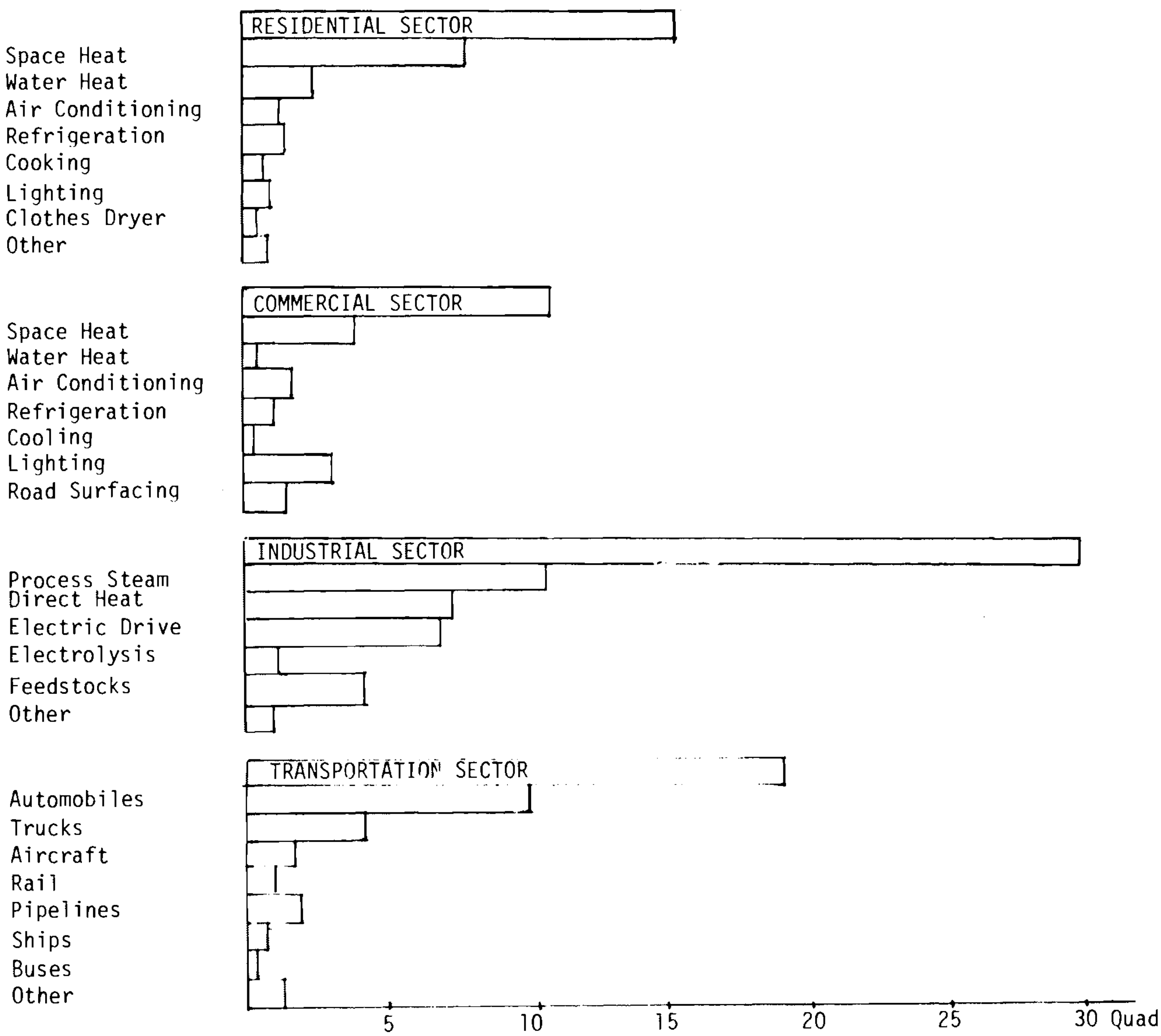

FIGURE A-4. Gross Energy Consumption, Estimated Distribution by Sector, and Detailed End Use, 1973

Source: S. H. Schurr et al., Energy in America's Future. Johns Hopkins University Press, Baltimore, p. 75, 1979.

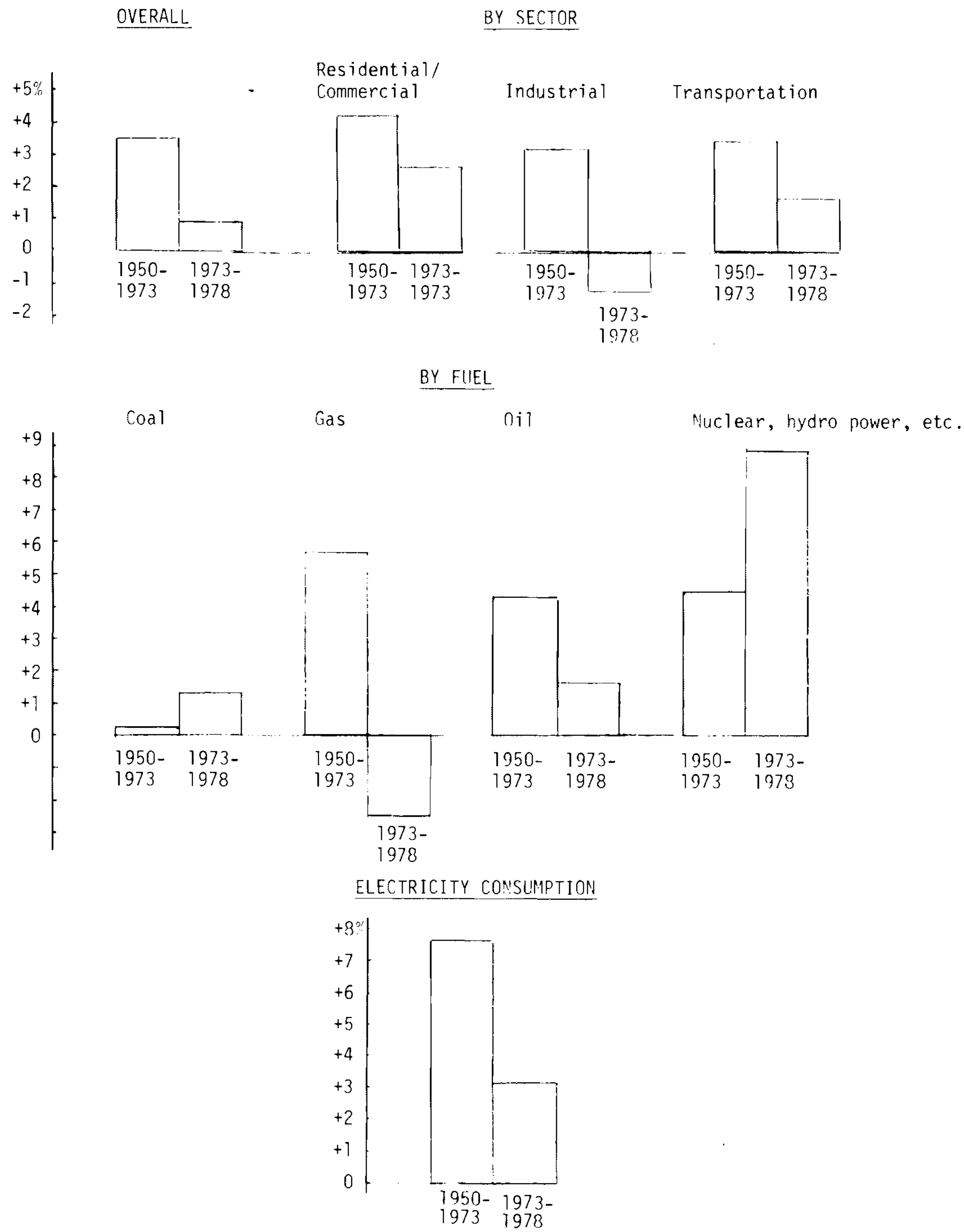

FIGURE A-5. Annual Energy Consumption Growth Rates (Percent per Year, Average)

Source: U.S. Department of Energy, National Energy Plan, p. 59, May 1979.

NOTES - APPENDIX A

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APPENDIX B

EMPIRICAL LITERATURE ON ENERGY DEMAND DETERMINANTS

(A SUPPLEMENT TO CHAPTER II)

APPENDIX B

Energy demand in the residential sector is affected by the set of variables shown in Table B-1. This table was constructed by including all of the variables revealed by our survey of the literature on residential energy demand. According to the literature, price, income, and preference are used extensively, with preference--and its several subtypes--being the one most extensively used. Demographic and climatic variables are included here since households have a degree of choice concerning matters such as household size and location. Advertising and other promotional activities fall into this category, although it is the changes in preference resulting from these activities that we are interested in here, not advertising or promotion in themselves.

COMMERCIAL

Energy demand in the commercial sector is affected by a set of unique variables. Energy consumed per square foot of floor space can vary from building to building by a factor of five.[1] Such large differences stem from the variety of activity and equipment in the buildings. Most of the differences, however, result from differences in the requirements for heating and cooling, which are affected by the physical characteristics of the buildings, by their occupants, and by their geographic location. In cold climates, for example, heating consumes the most energy and is followed by lighting, then cooling. In milder climates, cooling is likely to be more important than heating, and lighting, which is almost independent of climate, may exceed both. In some retail stores and schools, lighting is likely to be the most important use of energy, but in hospitals, hot water needs may exceed lighting requirements. Building design and materials also are an important source of differences in energy consumption. And since design and materials are influenced by building codes and zoning practices, these codes and practices will influence energy consumption. According to the Energy Information Administration, the availability of fuels is still another important determinant of energy use in the commercial sector.

TABLE B-1. Determinants of Residential Energy Demand

Determinant	References
Price of energy (own, substitutute forms)	(a), (b), (c), (d), (e)
Price of complements (appliance prices)	(a)
Income	(a), (b), (f), (c), (d), (e)
Preference	
Housing characteristics	(g), (d), (e)
Appliance characteristics	(a), (g), (d), (e)
Heating habits	(g)
Social and political factors	(g), (h)
Advertising	(d)
Demographic characteristics	(a), (g), (c), (d), (e)
Climate	(g), (d), (e)

(a) Energy Information Administration, Annual Report to Congress 1978, vol. 3. Government Printing Office, Washington, DC, p. 279, 1978.
(b) Energy Information Administration, Annual Report to Congress 1978, p. 280.
(c) F. M. Fisher and C. Kaysen, A Study in Econometrics: The Demand for Electricity in the United States. North-Holland, Amsterdam, pp. 4-5, 73-79, 1962.
(d) C. C. Mow, W. E. Mooz, and S. K. Anderson, A Methodology for Projecting the Electrical Energy Demand of the Residential Sector in California. Report for the Resources Agency of the California and the National Science Foundation by Rand, R-995-NSF/CSRA, pp. 6-7, March 1973.
(e) L. D. Taylor, "The Demand for Electricity." The Bell Journal of Economics, 6 (1):74-110, 1975.
(f) See S. Sonenblum, The Energy Connections: Between Energy and the Economy. Ballinger, Cambridge, MA, p. 85, 1978.
(g) J. Darmstadter et al., How Industrial Societies Use Energy. Johns Hopkins, Baltimore, p. 38, 1977.
(h) See S. Sonenblum, p. 88.

Table B-2 summarizes the types of variables that affect commercial energy demand levels. Preference variables are less important here than in the residential sector, but price variables and production relationships are more important.

INDUSTRIAL

Industrial energy consumption is relatively concentrated. Most of it takes place in a few energy-intensive industries: chemicals and allied products, primary metals, refined petroleum, paper and allied products, food and kindred products, and stone, clay, and glass products.[2] The reason for this concentration of energy consumption is that basic molecular alterations in processing tend to occur in a relatively few industries--chemical, metal, paper, and petroleum. The physical processes required to change molecular structure are usually more energy intensive than the processes required to combine materials.[3] Some, however, release energy; for example, polymerization of styrene to make polystyrene.[4]

TABLE B-2. Determinants of Commercial Energy Demand

Determinant	References
Energy prices	(a)
Availability of fuels	(a)
Economic conditions	(a)
Production relationships	(a)
Climate	
Building characteristics	
Type of activity in building	
Rate of technological change in energy using equipment	

(a) Energy Information Administration, Annual Report to Congress 1978, vol. 3. Government Printing Office, Washington, DC, p. 297, 1978.

The iron and steel industry is the largest industrial consumer of energy. In fact, the U.S. iron and steel industry uses more energy per ton of crude steel produced than that of any other country.(5) This high consumption per ton comes about because a relatively large proportion of the industry's capacity is provided by the energy-intensive, open hearth process, and a relatively small proportion by the basic oxygen process and electric furnace, which are more energy efficient.

Industrial energy demands are considered quite sensitive to relative energy prices in the long run because industrial scale plants have more opportunities for substituting one energy form for another than do households, and because input cost minimization is a major concern of industries. As a result, industrial energy demands are more price elastic than residential and commercial energy demands.(6) As we have noted, unlike other sectors, industry is now using less energy than in 1973.(7) Industrial energy demand determinants are summarized in Table B-3. Prices, fuel availability, and the production relationships summarized above are the major determinants found in the literature.

TABLE B-3. Determinants of Industrial Energy Demands

Determinant	Reference
Prices (energy, substitute energy, labor)	(a), (b), (c)
Production relationships	(d), (e), (f), (c)

(a) D. Gujarati, "Demand for Electricity and Natural Gas," Public Utilities Fortnightly, p. 21, January 30, 1969.
(b) K. P. Anderson, Toward Econometric Estimation of Industrial Energy Demand: An Experimental Application to the Primary Metals Industry. The Rand Corporation, R-719-NSF, December 1971.
(c) W. E. Mooz and C. C. Mow, A Methodology for Projecting the Electrical Energy Demand of the Manufacturing Sector in California. Report for Resources Agency of California and National Science Foundation by Rand Corporation, Santa Monica, R-991-NSF/CSRA, January 1973.
(d) Energy Information Administration, Annual Report to Congress 1978, vol. 3. Government Printing Office, Washington, DC, p. 307, 1978.
(e) See S. Sonenblum, The Energy Connections: Between Energy and the Economy. Ballinger, Cambridge, MA, p. 86, 1978.
(f) J. Darmstadter et al., How Industrial Societies Use Energy. Johns Hopkins, Baltimore, p. 117, 1977.

TRANSPORTATION

Most of the energy consumed to move people and commodities from place to place by highway, air, rail, water, and pipeline is used in highway travel. In 1977, the net energy used in all modes of transportation accounted for one-third of the total net energy consumed in the U.S.[8] Since 1973, the energy used in transportation has grown in proportion to total energy use, but by less of a percentage than energy used in the residential and commercial sectors.

Industrial and commercial transportation requirements are met by rail, highway, water, and air modes. Each mode is subject to numerous federal and state regulatory agencies. For example, the Interstate Commerce Commission regulates rail, truck, and water transportation. The Civil Aeronautics Board and Federal Aviation Administration regulate air transportation. Other agencies have authority that cuts across transport modes as well. Regulatory programs are major determinants of the cost and conditions of the services offered by the different transportation modes and indirectly affect the energy consumption within each mode.

Transportation energy demand determinants are summarized in Table B-4. Many categories of determinants are involved, as many users make transportation decisions.

AGRICULTURE

Table B-5 lists the possible determinants of energy use in this sector. In the long run, fuel prices, capital costs of equipment, the energy efficiency of machines, production techniques, and the future outlook for agriculture will be important determinants of agricultural energy demands.

PUBLIC

Six million Federal Government employees used this energy in 490,000 buildings and in the operation of more than 500,000 aircraft and motor vehicles of all types. The 10 largest energy-using federal agencies accounted for over 98% of the energy consumed by the Federal Government.[9] These agencies, in order of energy use, with approximate percentage are listed in Table B-6. Relative to other sectors, the public

TABLE B-4. Determinants of Transportation Energy Demand

Determinant	References
Energy prices	(a)
Complementary good prices	(a)
Taxes	(b)
Regulation	Hypothesis
Transport system availability	Hypothesis
Technological change	(a)
Income and economic activity level	(a)
Taste	
Vehicle characteristics	(a), (c)
Geographic patterns	(d)

(a) Energy Information Administration, Annual Report to Congress 1978, vol. 3. Government Printing Office, Washington, DC, p. 321.
(b) J. Darmstadter et al., How Industrial Societies Use Energy. Johns Hopkins, Baltimore, p. 88, 1977.
(c) J. Darmstadter et al., p. 83.
(d) J. Darmstadter et al., p. 92.

TABLE B-5. Determinants of Energy Use in the Agricultural Sector

Determinant	References
Energy prices	Hypothesis
Complementary good prices	Hypothesis
Farming equipment	
Technological change rate	
Economic conditions	Hypothesis
Production relations	Hypothesis

TABLE B-6. Percentage of Energy Use by Agency

Department of Defense	80.4%
Department of Energy	5.0%
U.S. Postal Service	3.2%
General Services Administration	2.6%
Veterans Administration	2.3%
Department of Transportation	1.6%
National Aeronautics and Space Administration	1.3%
Department of Interior	0.7%
Department of Agriculture	0.6%
Department of Health, Education and Welfare (now HHS)	0.5%
Other	1.8%
	100.0%

(The remaining 56 agencies accounted for less than 1.8% of the total energy used by the Federal Government. Taken from the Federal Register, vol. 45, no. 23, p. 7500, February 1, 1980.)

sector was probably more concentrated in a relatively smaller number of decision-making bodies.

As well as being highly concentrated in a few agencies, most governmental purchases of energy were for fossil fuels. Table B-7 indicates that, in 1978, nearly all governmental procurements of energy were in nonrenewable forms. Indeed, oil and oil-based products directly accounted for 58.7% of all the energy consumed by the Federal Government.

Governmental, nontransportation purchases of energy are often included in the commercial sector in statistical sources. The economic determinants of energy use by the public sector are similar to those of the commercial sector. Public sector demands, however, may be influenced by a variety of social concerns not considered by the commercial sector. Government is in a position to consider issues of externalities, public goods, and equity, whereas commercial consumers are more likely to make decisions on economic grounds alone.

TABLE B-7. Fuel Use by Type in the Federal Government in FY-1978[a]

Fuel Type	Trillion Btu	Million Barrels of Oil Equiv.	Percentage
Jet Fuel	601.2	103.6	35.5%
Diesel and Petroleum Distillates	142.4	24.5	8.4%
Fuel Oil	177.1	30.5	10.4%
Gasoline	59.9	10.3	3.5%
Navy Special Fuel	7.9	1.4	0.5%
Aviation Gasoline	6.2	1.0	0.4%
Electricity	476.6	82.2	28.1%
Natural Gas	144.8	25.0	8.5%
Coal	67.0	11.5	4.0%
Other[b]	11.7	2.0	0.7%
Total	1694.8	292.0	

(a) Taken from Federal Register, vol. 45, no. 23, pp. 7499-7500, February 1, 1980.
(b) Other fuels include propane and purchased steam.

Federal agencies thus make two impacts on energy consumption patterns. First, in carrying out its programs, the government gives funds to agencies, which expend them on various goods and services, including energy. In a theoretical sense, agency income increases result in energy demand increases. Secondly, some federal actions may be addressed to other determinants of public sector demands at both federal and non-federal levels. Thus, analysts examining public sector uses of energy must account for both the direct costs of governmental energy purchases, and for the costs of federal programs whose effect is to encourage public sector use of particular energy forms at federal, state, and local levels. Possible determinants of public sector demands are listed in Table B-8.

TABLE B-8: Determinants of Public Sector Energy Demand

Determinant	Reference
Energy prices	Hypothesis
Availability of fuels	Hypothesis
Budget of agency	Hypothesis
Production relationships	Hypothesis
Heating and cooking equipment	
Building characteristics	
Type of activity	
Rate of technological change in energy using equipment	

NOTES - APPENDIX B

1. See S. Sonenblum, The Energy Connections: Between Energy and the Economy. Ballinger, Cambridge, MA, p. 88, 1978.

2. Energy Information Administration, Annual Report to Congress 1978, vol. 3. Government Printing Office, Washington, DC, p. 307, 1978.

3. Sonenblum, p. 86.

4. E. H. Hall et al., Evaluation of the Theoretical Potential for Energy Conservation in Seven Basic Industries. Battelle Columbus Laboratories, July 11, 1975.

5. J. Darmstadter et al., How Industrial Societies Use Energy. Johns Hopkins University Press, Baltimore, pp. 117-125, 1977.

6. D. Gujarati, "Demand for Electricity and Natural Gas." Public Utilities Fortnightly, pp. 21, January 30, 1969.

7. U.S. Department of Energy, National Energy Plan, p. 64, May 1979.

8. U.S. Department of Energy, p. 643.

9. Federal Register, vol. 45, no. 23, p. 7498, February 1, 1980.

APPENDIX C

INCENTIVE TYPES AND CONSUMING SECTORS: THEORETICAL LINKAGES

(A SUPPLEMENT TO CHAPTER II)

APPENDIX C

In this appendix, we offer some rudimentary hypotheses about probable linkages between incentive types and consuming sectors. That is, given sector characteristics, which incentive types are most likely to be used?

Incentive types are tools the government can use to influence the energy-consuming behavior of different user categories. These tools may have their primary effect on different determinants of demand. Market activity is likely to affect price and production relationships, while taxation is likely to affect both price and income.

Requirements may affect only price, while the primary effect of traditional and nontraditional services and disbursements may be through production relations. Our examples suggest that the primary effects of market activity, taxation, and requirements may be on price, while the primary effect of traditional and nontraditional services and disbursements may be on production relations.

Incentive types can be applied to the six consuming sectors. The sectors have particular characteristics. Some are more fragmented than others. They have more participants--more energy decision-making units. The more fragmented sectors are the residential, commercial, and transportation sectors. The public, industrial, and agricultural sectors are somewhat more concentrated.

Sectors also differ in the amount of energy they use and in how they use it. Major users in terms of quads of energy consumed are the industrial, transportation, and residential sectors. Commercial use stands somewhere in the middle, while governmental and agricultural use is relatively small. Industrial energy use is dominated by the need for process steam, direct heat, and electric drive, while the most significant use by the transportation sector is for automobiles and trucks. Most residential use is for space heating.

In the main body of the text we have quantified federal expenditures that have influenced the consumption decisions of sectors. What are some of the patterns that be found? We would like to present the following array of possibilities:

Alternative 1. The government may rely more on incentive types that affect price to influence the relatively more organized decision making that goes on in the concentrated sectors (government, industry, and agricultural), while relying more on incentive types that affect production relations in the case of the more dispersed sectors. The more concentrated sectors may demand this type of incentive and may have the political power to achieve what they seek.

Alternative 2. The opposite may be true. The government may rely more on incentive types that affect production relations to influence the concentrated sectors, while relying on incentive types that affect price to influence the behavior of dispersed energy consuming decision makers. This would be the case if politicians who represented the dispersed decision makers demanded this type of intervention, and if representatives of the more organized sectors would be willing to accept production relation incentives.

Alternative 3. There may be no pattern in the distribution of incentive types based on the number of decision makers in the consuming sector.

Alternative 4. The distribution of incentive types may be related to how much and for what purpose energy is used by the consuming sectors. Larger users (industrial, transportation, residential) may be the recipients of incentives geared toward the price of energy; smaller users (commercial, public, and transportation) may be the recipients of incentives geared toward production relations. This pattern could reflect the need for concrete incentives of large users and their political power in achieving what can be viewed as the more direct subsidy.

Alternative 5. Small users may receive the pure, related incentives, while large users may receive the production-related incentives. This allocation might be the result of programs designed by politicians to promote equity among consumption sectors.

Alternative 6. The allocation of incentives may be random and may show no relation to the amount or method of consumption.

A number of additional hypotheses about relationships between incentive types and energy-consuming sectors are offered below. These hypotheses are based on our knowledge of a wide spectrum of governmental policies. Tax incentives may be applied to any of the user sectors except for the public sector. Federal taxation of lower governmental units is prohibited by law, but taxes are often levied on each of the other sectors. The ease with which requirements are administered depends on the number of discrete entities of the sector in question. Economic sectors with very large numbers of discrete units pose formidable enforcement problems for an administrator of requirements. Thus, the residential sector is the least likely to be the subject of requirements programs, and the industrial sector is probably the most likely to be the target of such programs. Given the prevailing political ethics, it is not often acceptable to give disbursements to industrial or commercial entities. Subsidies or incentives to these sectors usually take other forms, so as to not be labeled as "giveaways" to big business. To be politically acceptable, disbursements to commercial and industrial entities do not require such extraordinary circumstances as those encountered with Chrysler and Lockheed. Thus, we are more likely to see disbursements for residential, agricultural, and public sectors than for commercial and industrial sectors. The transportation sector is also a favored recipient of disbursements. Mass transit systems are subsidized by the Federal Government, and much of the capital cost of transportation systems is financed through federal disbursements. Traditional services such as the use of roads and the postal system are available to all classes of energy users. However, nontraditional services are often given to industry, in the form of research and development, and for the promotion of commerce, perhaps as a way of compensating for the political unacceptability of disbursements to this sector. The residential sector also receives some nontraditional services, such as information about the characteristics of products and governmental programs. Special groups within the residential sector receive services tailored to those groups, such as the programs for veterans and for the poor. Governmental market activities increase energy consumption in the aggregate by creating a demand for goods and services which implies energy inputs. The residential sector is, by definition, excluded from the provision of such goods and services, leaving the commercial, industrial, transportation, and agricultural sectors as the recipients of such incentives.

APPENDIX D

ANALYSIS OF FEDERAL EXPENDITURES USED TO STIMULATE DEMAND FOR ENERGY

(A SUPPLEMENT TO CHAPTER III)

APPENDIX D

ENERGY DEMAND INCENTIVES WITH ENERGY RELATED INTENT

1. Department name: Department of Energy.

Agency name: none.

Budget line item: solar applications.

Description: for solar applications in 1980, principal objectives are to help accelerate the use of solar energy for cooling, passive solar for buildings, industrial processes, and agricultural purposes. Appendix, p. 373.

1978 expenditure, operating expenses, Appendix, p. 372, $101,700K; plant and capital equipment, Appendix, p. 375. $2,200K.

Incentive type: services, disbursements.

Demand determinant: own price lowered.

Most relevant energy form: solar.

User: public.

2. Department name: Department of Energy.

Agency name: none.

Budget line item: energy production, demonstration, and distribution; solar.

Description: the solar activity in this appropriation provides support for the use of solar technology in federal buildings and supports efforts to promote awareness of solar technology and to plan for orderly, early transfer of federally assisted solar technologies to the private sector. Appendix, p. 380.

1978 expenditure: $21,630K.

Incentive type: services, disbursement.

Demand determinant: own price lowered.

Most relevant energy form: solar.

User: public.

3. Department name: Department of Energy.

Agency name: none.

Budget line item: strategic oil reserve, planning, oil acquisition, and facility construction.

Description: the appropriation in this category provides for purchase of crude oil to be stored in the underground strategic oil reserve. Appendix, p. 381.

1978 expenditure: $897,148K.

Incentive type: market activity.

Demand determinant: preference variable enhanced.

Proportion energy related by energy form: 100% oil.

Energy-related expenditures by energy form: $598,420K oil.

User: all.

4. Department name: Department of Energy.

Agency name: Energy Information Administration.

Budget line item: entire budget.

Description: this agency provided information on energy supply and demand conditions. It is concerned with both near- and far-term predictions of energy supplies and demands. It provides an information network to collect and provide energy information to all energy users, to other governmental agencies, the Congress and to the public at large. Supply and demand information is intermingled in the activities of this agency, and one can argue that the output of the agency is a public good whose consumption is equally valuable to energy consumers and energy users. Thus, we cannot separate the supply-related expenditures in this agency from the demand-related expenditures. See Appendix, pp. 382-3.

1978 expenditure: $50,654K.

Incentive type: services.

Demand determinant: complement price lowered.

Proportion energy related by energy form: 100% oil.

Energy-related expenditures by energy form: $50,654K all energy forms.

User: all.

5. Department name: Department of Energy.

Agency name: Economic Regulatory Administration.

Budget line item: see below.

Description: a number of the regulatory activities of ERA are aimed at energy users. By setting prices and by compelling use of certain forms of energy, the ERA stimulates energy consumption. Specific types of programs are listed below. Appendix, p. 383.

BUDGET LINE ITEM	DOLLARS	ENERGY FORM
Coal Utilization	$ 4,055K	Coal
Utility Program Regulatory Intervention	$15,883K	Oil and Coal
Compliance	$38,499K	Petroleum and Coal
Regulation Development	$ 4,937K	Oil and Coal
Emergency Preparedness	$ 5,705K	Oil
Fuel Regulation	$ 5,500K	Oil and Natural Gas
Hearings and Appeals	$ 2,744K	Oil, Coal, and Natural Gas
Program Adminstration	$ 1,541K	Oil, Coal, and Natural Gas

1978 expenditure: see above.

Incentive type: requirements.

Demand determinant: own price lowered for every item except coal utilization; in this program the coal demand curve is shifted out by adding a new group of customers who would otherwise burn oil.

Proportion energy related by energy form: see above.

Energy-related expenditures by energy form: see above.

User: industrial or all.

6. Department name: Department of Energy.

   Agency name: Federal Energy Regulatory Commission.

   Budget line item: entire budget.

   Description: the Commission's major objective is to ensure that the nation's consumers have adequate energy supplies at just and reasonable rates, while ensuring that energy producers have adequate rates of return which will provide sufficient incentives for increased production. Appendix, p. 385.

   1978 expenditure: $38,221K.

   Incentive type: requirements.

   Demand determinant: own price lowered relative to unregulated monopolist.

   Proportion energy related by energy form: 100%.

   Energy-related expenditures by energy form: electricity $15,854K; gas $19,293K; oil shale $3064K.

   User: all.

7. Department name: none.

   Agency name: Community Services Administration.

   Budget line item: 1978 Emergency Energy Assistance Program.

   Description: this program provided money to pay fuel bills of poor people, and to provide other types of crisis assistance (blankets, space heaters) during winter months. Appendix, p. 878.

   1978 expenditure: $158,076K.

   Incentive type: disbursement.

   Demand determinant: income increased.

   Proportion energy related by energy form: 100% oil.

Energy-related expenditure by energy form: $158,076K oil.

User: residential.

8. Department name: Department of the Treasury.

Agency name: Internal Revenue Service.

Budget line item: not applicable.

Description: see table below.

1978 expenditure: $800,000K revenues foregone.

Incentive type: taxation.

Demand determinant: income increased.

Proportion energy related by energy form: 100% oil.

Energy-related expenditures by energy form: $880,000K oil.

User: transportation.

TABLE D-1. Tax Incentives

Tax Incentive	Authority	$000	Energy Form	Economic Sector
Deductibility of non-business state & local gasoline, diesel, & motor fuel tanks	26 USC 164	880,000	Oil	Residential
Credit for excise tax on gasoline used on a farm for farming purposes	26 USC Secs. 6420, 39		Oil	Industrial
Credit for excise tax on gasoline used for non-highway purposes or by local transit systems	26 USC Secs. 6421, 39		Oil	Industrial Residential Transportation Public
Credit for excise tax on diesel fuel and special motor fuel used for farm or public transportation purposes or resold transportation	26 USC Secs. 6427, 39			Industrial Public
Exemption from manufacturers excise tax on trucks, buses, tractors for school buses, camper coaches, ambulances	26 USC Secs. 4061-4063 4221,4063		Oil	Industrial Residential Transportation
Exemption from excise tax on use for transit-type buses	26 USC Sec. 4483		Oil	Transportation

ENERGY DEMAND INCENTIVES WITH NONENERGY INTENT

1. Department name: not applicable.

   Agency name: all Federal Government.

   Budget line item: Federal Government domestic nontransportation energy use.

   Description: estimated nontransportation energy use by the entire Federal Government is reported below. These estimates were developed using the assumptions provided in Table D-2 which follows.

   1978 expenditure: $12.55 billion.

   Incentive type: market activity.

   Demand determinant: income of public agencies increased.

   Proportion energy related by energy form: 100%.

   Energy-related expenditure by energy form: (in billions)

Electricity	$10.94
Natural gas	$0.59
Oil	$0.81
Coal	$0.17
Other	$0.04
Total	$12.55.

   User: public.

2. Department name: all.

   Agency name: all on-budget agencies.

   Budget line item: Federal Government transportation energy use.

   Description: energy used by the government for transportation purposes has been estimated using budget figures on transportation expenditures by on-budget federal agencies. (Budget of the United States, 1980, p. 570 (Budget Line Item 400).) The amount of these expenditures ultimately passed through to energy producers has been estimated using input-output coefficients. The appropriate transportation output sector of the table was located and all energy sectors that provided input to the transportation output vector were used to estimate energy expenditures by the Federal Government. Each energy input coefficient multiplied by the government transportation budget figure provides an estimate of ultimate expenditure by the

TABLE D-2. Estimated Domestic Nontransportation Energy Expenditures by the Federal Government, 1977

	(1) Quads[a]	(2) $/Million BTU[b]	(3) Estimated Expenditure (Billions of $)[c]
Electricity	0.9405	11.63	10.94
Natural Gas	0.2805	2.11	0.59
Fuel oil	0.2640	3.08[1]	0.81
Coal	0.1320	1.30[2]	0.17
Other	0.0330	1.27	0.04
Total	-	-	12.55

Sources:

(a) Calculated from U.S. Department of Energy, Federal Energy Management Program, Federal 10-Year Buildings Plan, draft, n.d., p. 2-2.
(b) U.S. Department of Energy, Energy Information Administration, Annual Report to Congress, 1978 (DOE/EIA-0173/3), vol. 3, p. 62, (Industrial Coal) Table 18-1, p. 300; government is considered part of commercial sector by EIA.
(c) Column (1) x Column (2) x 10^{+9} (one Quad = 10^{15}BTU; hence Quads x $/Million BTU x 10^{+9} = $); total estimated expenditure is sum of entries in (3).

Notes:

(1) Distillate fuel oil price (residual oil price is 2.28; no data available on proportions of distillate and residual fuel oil use of Federal Government).
(2) EIA reports coal price as $33.98/ton; at 26.2 Million BTU per ton, this is equivalent to $1.30/Million BTU.

Federal Government on that type of energy through its procurement of transportation services.

1978 transportation expenditure: $15,444,000K.

1978 Energy expenditure:

Coal	$17,068K
Oil	643,955K
Natural Gas	58,227K
Electricity	110,671K
Total	$824,921K

Incentive type: market activity.

Demand determinant: income of public agency increased.

Proportion energy related by energy form: 100%, energy forms as above.

Energy-related expenditures by energy form: see above.

User: transportation.

3. Department name: none.

Agency name: all off-budget federal entities.

Budget line item: transportation energy use by off-budget entities.

Description: the methodology used above for on-budget entities is also used here. The data on transportation expenditures were compiled from the Appendix, pp. 1138-1152.

1978 expenditure by Energy Form:

Coal	$905K
Oil	65,787K
Natural Gas	4,523K
Electricity	3,613K
Total	$107,351K

Incentive type: market activity.

Demand determinant: income of public agency increased.

Proportion energy related by energy form: 100%, energy forms as above.

Energy-related expenditures by energy form: see above.

User: transportation.

4. Department name: Department of Transportation.

Agency name: Urban Mass Transit Administration.

Budget line item:

Description: disbursements to state and local agencies for capital and operating expenses of mass transit systems. Distribution of funds between capital and operating expense categories not available; allocation to energy not feasible. Appendix, pp. 737-39.

1978 expenditure: $3,004,142K.

Incentive type: disbursement.

Demand determinant: complement price lowered.

Most relevant energy form: oil.

User: transportation.

5. Department name: Department of Transportation.

Agency name: Federal Railroad Administration.

Budget line item: Northeast Corridor Improvement Program, construction.

Description: Appendix, p. 733.

1978 expenditure: $284,002K.

Incentive type: disbursement.

Demand determinant: complement price lowered.

Most relevant energy form: oil.

User: transportation.

6. Department name: Department of Transportation.

Agency name: Federal Railroad Administration.

Budget line item: grants to the National Railroad Passenger Corporation, operating grants.

Description. Appendix, p. 734.

1978 expenditure: $536,000K.

Incentive type: disbursement.

Demand determinant: complement price lowered.

Most relevant energy form: oil.

User: transportation.

7. Department name: Department of Transportation.

Agency name: Federal Railroad Administration.

Budget line item: Alaska Railroad Revolving Fund.

Description: "The Alaska Railroad is operated as a public enterprise activity of the Federal Railroad Administration. . . . The major activity of the line is transportation service. . . . To the extent possible programs are financed by revenues earned from the freight and passenger services. . . ." Appendix, p. 735. Three million dollars was appropriated from the general treasury in FY-1978; the remainder of the expenditure was recovered from users of the railroad.

1978 expenditure: $34,002K.

Incentive type: market activity, service.

Demand determinant: complement price lowered.

Most relevant energy form: oil.

User: transportation.

8. Department name: Department of Transportation.

Agency name: Federal Railroad Administration.

Budget line item: Railroad rehabilitation and improvement financing.

Description: the Secretary of Transportation uses these funds to buy redeemable preference shares from railroads to provide capital to preserve rail freight services; repayments by railroads to commence not less than six years later. Appendix, pp. 736-37.

1978 expenditure: $66,247K.

Incentive type: disbursement.

Demand determinant: complement price lowered.

Most relevant energy form: oil.

User: transportation.

9. Department name: Department of Transportation.

Agency name: Federal Railroad Administration.

Budget line item: rail service assistance.

Description: rail line subsidies; payments to states for planning, rail service subsidies, rail line purchases, rail property rehabilitation, subsidy of alternate mode transportation. Appendix, p. 782.

1978 expenditure: $99,185K.

Description: Loan guarantee/default payments.

1978 expenditure: $8,024K.

Description: other administration and special projects (states, National Railroad Passenger Corporation, services from other agencies).

1978 expenditure: $7,063K.

Incentive type: disbursements, services.

Demand determinant: complement price lowered.

Most relevant energy form: oil (total indirect $114,272K).

User: transportation.

10. Department name: Department of Transportation.

Agency name: St. Lawrence Seaway Development Corporation.

Budget line item: total obligations: $6,683K.

Description: this is a profit-making activity for the Federal Government; collections from users of the Seaway resulted in a transfer to the general fund of $1,000K in FY-1978.

1978 expenditure: $6,683K.

Incentive type: market activity.

Demand determinant: complement price lowered.

Most relevant energy form: oil.

User: transportation.

11. Department name: none.

    Agency name: The Panama Canal Commission.

    Budget line item: transit operations.

    Description: Appendix, p. 962.

    1978 expenditure: $165,250K.

    Demand determinant: complement price lowered.

    Most relevant energy form: oil.

    User: transportation.

12. Department name: none.

    Agency name: United States Railway Association.

    Budget line item: purchase of Conrail securities.

    Description: this association provides funds to Conrail to be used to rehabilitate plant and equipment, and to cover operating losses. No allocation between rehabilitation and operating loss uses is available; no allocation to energy forms is possible. Appendix, p. 1007.

    1978 expenditure: $425,000K.

    Incentive type: disbursement.

    Demand determinant: complement price lowered.

    Most relevant energy form: oil.

    User: transportation.

13. Department name: none.

Agency name: Washington Metropolitan Area Transit Authority.

Budget line item: total appropriation.

Description: the Federal Government provides an interest subsidy on outstanding bonds used to construct the Washington, D.C. Metro mass transit system. Other funds come from diversion of interstate highway construction funds to mass transit uses. Appendix, pp. 920-21.

1978 expenditure: $66,779K.

Incentive type: disbursement.

Demand determinant: complement price lowered.

Most relevant energy form: electricity.

User: transportation.

14. Department name: Department of Commerce.

Agency name: Maritime Administration.

Budget line item: entire budget.

Description: the appropriations in this category are for the construction and expenses incidental to the construction and reconstruction of ships and used ships.

1978 expenditure: $135,000K.

Incentive type: disbursement.

Demand determinant: complement price lowered.

Most relevant energy form: oil.

User: transportation.

15. Department name: none.

Agency name: Appalachian Regional Development Programs.

Budget line item: Appalachian development highway system.

Description: highway construction funds. Appendix, p. 79.

1978 expenditure: $155,944K.

Incentive type: disbursement.

Demand determinant: complement price lowered.

Most relevant energy form: oil.

User: transportation.

16. Department name: Department of Transportation.

Agency name: Federal Highway Administration.

Budget line items and 1978 expenditures:

Appendix, p. 715	Alaska Highway:	$1,135K
Appendix, p. 715	Off-system roads:	$65,166K
Appendix, p. 716	Access highways to public recreation areas:	$7,984K
Appendix, p. 716	Highway crossings:	$13,419K
Appendix, p. 717	Rural highway public transportation demonstration:	$2,731K
Appendix, p. 717	Forest highways:	$76K
Appendix, p. 717	Public lands highways:	$317K
Appendix, p. 718	Interstate highways systems:	$2,713,359K
Appendix, p. 718	Rural urban and small area transportation programs:	$1,586,182K
Appendix, p. 719	Urbanized area transportation programs:	$987,733K
Appendix, pp. 718-19	Bridge program:	$170,700K
Appendix, pp. 718-19	Emergency relief and bridges over federal dams:	$87,153K

1978 expenditure: $5,635,955K total.

Incentive type: disbursement.

Demand determinant: complement price lowered.

Most relevant energy form: oil.

User: transportation.

17. Department name: Department of Agriculture.

Agency name: Forest Service.

Budget line items and 1978 expenditures:

Appendix, pp. 208-09	Construction and land acquisition, road and trail construction:	$177,190K
Appendix, pp. 210-11	Forest roads and trails, construction of roads and trails, and maintenance of roads and trails:	$338,453K
Appendix, p. 216	Payments to states, National Forest funds, payments to counties, National Grasslands for school and road purposes:	$224,233K

1978 expenditure: $739,876K, total.

Incentive type: disbursement.

Demand determinant: complement price lowered.

Most relevant energy form: oil.

User: transportation.

18. Department name: Department of the Interior.

Agency: none.

Budget line items and expenditures:

Appendix, pp. 544-45	Payments to Coos and Douglas Counties, Oregon in lieu of taxes, used for schools, roads, highways, and bridges:	$1,856K

Description: highway construction funds. Appendix, p. 79.

1978 expenditure: $155,944K.

Incentive type: disbursement.

Demand determinant: complement price lowered.

Most relevant energy form: oil.

User: transportation.

16. Department name: Department of Transportation.

Agency name: Federal Highway Administration.

Budget line items and 1978 expenditures:

Appendix, p. 715	Alaska Highway:	$1,135K
Appendix, p. 715	Off-system roads:	$65,166K
Appendix, p. 716	Access highways to public recreation areas:	$7,984K
Appendix, p. 716	Highway crossings:	$13,419K
Appendix, p. 717	Rural highway public transportation demonstration:	$2,731K
Appendix, p. 717	Forest highways:	$76K
Appendix, p. 717	Public lands highways:	$317K
Appendix, p. 718	Interstate highways systems:	$2,713,359K
Appendix, p. 718	Rural urban and small area transportation programs:	$1,586,182K
Appendix, p. 719	Urbanized area transportation programs:	$987,733K
Appendix, pp. 718-19	Bridge program:	$170,700K
Appendix, pp. 718-19	Emergency relief and bridges over federal dams:	$87,153K

1978 expenditure: $5,635,955K total.

Incentive type: disbursement.

Demand determinant: complement price lowered.

Most relevant energy form: oil.

User: transportation.

17. Department name: Department of Agriculture.

Agency name: Forest Service.

Budget line items and 1978 expenditures:

Appendix, pp. 208-09	Construction and land acquisition, road and trail construction:	$177,190K
Appendix, pp. 210-11	Forest roads and trails, construction of roads and trails, and maintenance of roads and trails:	$338,453K
Appendix, p. 216	Payments to states, National Forest funds, payments to counties, National Grasslands for school and road purposes:	$224,233K

1978 expenditure: $739,876K, total.

Incentive type: disbursement.

Demand determinant: complement price lowered.

Most relevant energy form: oil.

User: transportation.

18. Department name: Department of the Interior.

Agency: none.

Budget line items and expenditures:

Appendix, pp. 544-45	Payments to Coos and Douglas Counties, Oregon in lieu of taxes, used for schools, roads, highways, and bridges:	$1,856K

Appendix, pp. 544-45	Payments to counties, Oregon and California grant lands, funds to be used as other county funds:	$106,045K
Appendix, pp. 544-45	Payments to counties, national grasslands for school and road purposes:	$440K
Appendix, pp. 544-45	Expenses, road maintenance:	$2,822K
Appendix, pp. 599	Bureau of Indian Affairs road construction:	$71,297K
Appendix, p. 576	Operation of the National Park system, construction of roads, trails, parkways:	$29,122K
Appendix, p. 215	Forest Service permanent appropriations, roads and trails for states, National Forests funds:	$66,012K
Appendix, p. 541	Oregon and California grant lands, construction acquisition, and maintenance of roads:	$7,543K

1978 expenditure: $285,137K, total.

Incentive type: disbursement.

Demand determinant: complement price lowered.

Most relevant energy form: oil.

User: transportation.

19. Department name: Department of the Interior.

Agency name: Bureau of Land Management.

Budget line item: acquisition, construction, and maintenance, transportation facilities.

Description: Appendix, p. 540.

1978 expenditure: $21,507K.

Incentive type: market activity.

Demand determinant: complement price lowered.

Most relevant energy form: oil.

User: transportation.

20. Department name: none.

Agency name: Interstate Commerce Commission.

Budget line item: entire budget.

Description: this agency sets rates; grants operating authority; regulates mergers, acquisitions, and abandonments; and generates data on rail and truck overland transportation services. Appendix, pp. 927-929.

1978 expenditure: $64,767K.

Incentive type: service.

Demand determinant: complement price lowered.

Most relevant energy form: oil.

User: transportation.

21. Department name: Department of Commerce.

Agency name: National Oceanic and Atmospheric Administration.

Budget line item:

Mapping, charting, and surveying:	$41,660K
Basic environmental services:	$120,387K

Description: these activities of NOAA provide services which are necessary for the operation of sea and air transportation systems. Appendix, p. 244.

1978 expenditure: $162,547K.

Incentive type: service.

Demand determinant: complement price lowered.

Most relevant energy form: oil.

User: transportation.

22. Department name: Department of Defense.

Agency name: Corps of Engineers.

Budget line item: navigation, flood damage prevention, and shoreline protection studies.

Description: these activities provide services which are needed for operation of inland waterways transportation systems. Appendix, p. 347.

1978 expenditure: $40,852K.

Incentive type: services.

Demand determinant: complement price lowered.

Most relevant energy form: oil.

User: transportation.

23. Department name: Department of Transportation.

Agency name: Federal Aviation Administration.

Budget line item: entire budget.

Description: this agency operates air traffic control systems; administers flight standards program, medical programs, airport programs, and planning direction and evaluation of engineering and development programs for flight systems. In general, the agency provides services which are necessary for the operation for airborne transportation systems. Appendix, p. 700.

1978 expenditure: $1,622,700K.

Incentive type: service.

Demand determinant: complement price lowered.

Most relevant energy form: oil.

User: transportation.

24. Department name: Department of Transportation.

Agency name: National Highway Traffic Safety Administration.

Budget line item: entire budget.

Description: this agency provides safety rules and standards for vehicles, tires, and equipment used on vehicles. It also performs R&D activities and provides some assistance to state governments for similar activities. Appendix, p. 727.

1978 expenditure: $52,588K.

Incentive type: service.

Demand determinant: complement price lowered.

Most relevant energy form: oil.

User: transportation.

25. Department name: Department of Transportation.

Agency name: Coast Guard.

Budget line item:

Search and rescue on high seas:	$254,323K
Network of manned and unmanned aids to navigation:	$244,187K
Marine safety:	$120,711K
Enforcement of laws and treaties:	$142,826K

Description: this agency provides services which are necessary for the operation of waterborne transportation systems. Appendix, p. 690.

1978 expenditure: $762,047K.

Incentive type: service.

Demand determinant: complement price lowered.

Most relevant energy form: oil.

User: transportation.

26. Department name: none.

Agency name: Federal Maritime Commission.

Budget line item: entire budget.

Description: this agency licenses ocean freight commerce firms, establishes responsibility for pollution accidents, protects passengers on ocean transportation vessels, and regulates prices of ocean transportation. Appendix, p. 907.

1978 expenditure: $9,724K.

Incentive type: service.

Demand determinant: complement price lowered.

Most relevant energy form: oil.

User: transportation.

27. Department name: none.

Agency name: Civil Aeronautics Board.

Budget line item: entire budget.

Description: this agency sets standards for scheduled and unscheduled air transportation; it sets prices and tariffs for air transportation, and regulates competition. It conducts economic research analyses of the regulation and management aspects of air transportation, and undertakes activities related to international air tariffs and consumer protection. Appendix, p. 873.

1978 expenditure: $25,246K.

Incentive type: service.

Demand determinant: complement price lowered.

Most relevant energy form: oil.

User: transportation.

28. Department name: Defense.

Agency name: Corps of Engineers.

Budget line item: Navigation related expenses.

Description: The Corps of Engineers designs, constructs and maintains projects to provide navigable rivers at several sites, including those on the Mississippi River. (Interviews with Mr. Greene, Chief of Engineering, Corps of Engineers.)

1978 expenditure: $942,845K.

Incentive type: service.

Demand determinant: complement price lowered.

Most relevant energy form: oil

User: transportation.

29. Department name: none.

Agency name: Tennessee Valley Authority.

Budget line item: navigation expenses.

Description: TVA operates and maintains locks to ensure year around navigation.

1978 expenditure: not available, $7,103K in 1977.

Incentive type: service.

Demand determinant: complement price lowered.

Most relevant energy form: oil.

User: transportation.

PERSONS INTERVIEWED FOR GENERIC ANALYSIS

Mr. Greene
Chief of Engineering
U.S. Army, Corps of Engineers

Ms. Greenwell
Internal Revenue Service

Mr. Hixson
Tennessee Valley Authority

Mr. Joseph Holmes
Bureau of Indian Affairs

Mr. Chad Olsen
Budget Analyst
U.S. Forest Service

Mr. Jim Reed
General Accounting Office

APPENDIX E

GOVERNMENT PROCUREMENT POLICY

(A SUPPLEMENT TO CHAPTER III)

APPENDIX E

The Federal Government is the nation's largest single user of energy, accounting for 2.2% of the energy consumed in the United States in FY-1978.[1] The energy is used by six million government employees in 490,000 buildings and in operating more than 500,000 aircraft and motor vehicles of all types. The 10 largest energy-using federal agencies account for over 98% of the energy consumed by the Federal Government.[2] These agencies, in order of energy use are listed in Table E-1.

As well as being highly concentrated in a few agencies, most government purchases of energy are for fossil fuels. Table E-2 indicates that in 1978 all governmental procurements of energy were in nonrenewable forms. Indeed, oil and oil-based products directly accounted for 58.7% of all energy consumed by the Federal Government.

Prior to 1979, the United States Government had no systematic program to determine the cost effectiveness of its energy procurements. While some agencies--including OMB, GSA, DOD, and the VA--analyzed short- and medium-term costs of various energy sources, most decisions to acquire

TABLE E-1. Percentage of Energy Use by Agency

Department of Defense	80.4%
Department of Energy	5.0%
U.S. Postal Services	3.2%
General Services Administration	2.6%
Veterans Administration	2.3%
Department of Transportation	1.6%
National Aeronautics and Space Administration	1.3%
Department of Interior	0.7%
Department of Agriculture	0.6%
Department of Health, Education and Welfare	0.5%

(The remaining 56 agencies accounted for less than 1.8% of the total energy used by the Federal Government. Taken from the Federal Register, vol. 45, no. 23, February 1, 1980, p. 7500.)

TABLE E-2. Fuel Use by Type in the Federal Government in FY-1978[a]

Fuel Type	Trillion BTU	Million Barrels of Oil Equiv.	%
Jet Fuel	601.2	103.6	35.5%
Diesel and Petroleum Distillates	142.4	24.5	8.4%
Fuel Oil	177.1	30.5	10.4%
Gasoline	59.9	10.3	3.5%
Navy Special Fuel Oil	7.9	1.4	.5%
Aviation Gasoline	6.2	1.0	.4%
Electricity	476.6	82.2	28.1%
Natural Gas	144.8	25.0	8.5%
Coal	67.0	11.5	4.0%
Other[b]	11.7	2.0	.7%
Total	1694.8	292.0	

(a) Taken from Federal Register, Vol. 45 no. 23, 1 February 1980, pp. 7499-7500.
(b) Other fuels include propane and purchased steam.

energy for government use were made on the basis of immediate cost and availability.

As a result of the Energy Policy and Conservation Act, DOE, in late 1979 began to develop a systematic approach to energy procurement and conservation. It developed six energy management and planning programs. The goal was to "place the federal government. . . in the forefront of implementing energy conservation measures and implementing the use of solar and other renewable energy sources" by promoting design, construction, and operation of energy efficient buildings.[3] The government planned to accomplish this objective by (1) making life cycle cost analyses of energy used in federal buildings, (2) creating opportunities for the solar industry to provide improved energy systems, and (3) instituting a conservation program to reduce governmental consumption 20-40% by 1985.

Life-Cycle Cost Analyses. Effective January 23, 1980, DOE instituted a program to systematize energy-acquisition decision making. This program, based on life-cycle cost analyses, attempted to set guidelines for determining costs of various energy sources both for new federal buildings and for retrofitting old buildings. The calculation procedures are summarized in Table E-3. Standard assumptions and procedures in this program include the use of a 10% price discount for determining the cost of solar power and conservation, a 10% discount rate on future costs and benefits, and a standardized computer simulation model for comparative analyses. Although cost and availability still are the criteria for determining energy choices, the new regulations attempt to increase long-term energy planning and thereby stimulate conservation and use of solar power.

Creating Opportunities for the Solar Industry. On October 19, 1979, a program to create market incentives for solar technologies by showing federal confidence in solar power was initiated. Federal agencies could obtain grants to convert the heating and cooling of their buildings to solar power. In late 1979, preliminary energy audits were begun to find buildings suitable for retrofitting with solar energy panels. Then on December 7, 1979, a photovoltaic utilization program was announced. The purpose was "to stimulate and create confidence in the domestic photovoltaic industry" by converting federal buildings to photovoltaic electric systems.

What is the likely impact of this program? Photovoltaic cells have been commercially available for many years, but per-unit costs have limited their use. Private entrepreneurs have been discouraged from investing in photovoltaic technology as there is only a limited market for the relatively expensive cells currently available.

Government purchases of photovoltaic systems could give manufacturers the incentive to invest in automated production facilities, resulting in

TABLE E-3. Total Life-Cycle Costs

Total life-cycle costs, as calculated in the DOE Life Cycle Cost Analysis program, are the sum of the present values of:

(1) Investment costs less salvage--these are costs of design, engineering, purchase, and installation exclusive of sunk costs (investments prior to the year in which the LCC is conducted.) Investment costs are figured as 90% of actual total investment costs.

(2) Nonfuel operation and maintenance costs--these are costs incurred uniformly and annually over the study period. They are figured as the product of the base year recurring costs and an annually increasing uniform present worth factor (the present worth factor is based upon a 10% discount rate.)

(3) Replacement costs less salvage--those costs that are not uniformly incurred annually over the study period. They are figured as the product of estimated nonrecurring costs and an annually decreasing single present worth factor (this present worth factor is also based upon a 10% discount rate.)

(4) Energy costs--the costs of electricity, natural gas, distillate fuels, and liquefied petroleum gases are estimated for ten regions, at five-year intervals, and in the residential, commercial, and industrial sectors. Two methods are presented for estimating the costs of specific energy sources for specific federal buildings:

- (a) Base-year energy costs are weighted by increasing present worth factors (see (2) above), adjusted for region, fuel type, and year.
- (b) Year-by-year prices of energy are determined by multiplying estimated annual compound price growth factors by the price of energy in the previous year, beginning with the base year. These prices are then multiplied by present consumption volumes, and weighted by a decreasing present value.

(No guidelines are given on which estimation procedure is preferred.)

The study period is the lesser of the life of the building (without major overhauls) or 30 years.

For further details, see the Federal Register, vol. 45, no. 16 (Wednesday, January 23, 1980), pp. 5610-5646.

lower production costs. Lower costs, if passed on to consumers, could stimulate demand.[4] Data have been presented which suggest that the DOD could save approximately $560 million in energy costs over the 20-year life of photovoltaic cells if remote installations were shifted from conventional to solar power.[5] In turn, government purchases would increase production volumes and decrease per unit-costs as well as stimulate research in more efficient production techniques. Decreased per-unit costs would create markets for photovoltaic cells in the private sector and further stimulate production and price reductions. As the per-unit price of photovoltaic cells decreased, new sectors of the economy would find solar power an economical substitute for conventional energy. Through governmental purchasing, the per-peak-watt price of photovoltaic energy production could be reduced, perhaps from $15 to as little as 50¢ in 1978 dollars, and the movement from nonrenewable to renewable energy sources would increase.

Several problems with use of photovoltaic cells to generate electricity, however, have been noted.[6] While the government could perhaps reduce the per-unit cost of photovoltaic cells through its purchasing policy, the supportive technology necessary for peak performance of solar panels would be quite expensive. Indeed, even if the per-peak-watt price of solar electricity is reduced to $2-3 (the level, it is argued, that is required to stimulate private demand), the structures and mechanisms necessary to properly position the panels and store the collected energy might remain prohibitively expensive. Additionally, technical problems are encountered in the operation of photovoltaic panels. Solar panels function at peak capacity only in full sunlight at the optimum angle of incidence, and any cell in a series that is deprived of light would create a serious drain upon the efficiency of the panel. The energy produced through even optimal use of photovoltaic cells might be much more expensive than energy produced from fossil fuel sources. These costs, too, would fall directly upon the consumer and would not be distributed through general utility price hikes.

Additionally, there are social costs incurred by directly providing solar energy. Each home or business using solar power would have to be positioned toward the south in order to enjoy the full benefits of the sun, or have ground space available for separate collector facilities. Legal difficulties would develop over access to unobstructed sun light, and trees, tall buildings, and homes would have to be spaced far enough apart to allow access to direct sun light. Social costs, then, could be high. Whether governmental purchasing policy and technological developments could overcome these obstacles is uncertain.

Federal Consumption Reductions. Under Executive Order 11912,[7] as amended by Executive Order 12003,[8] and by operation of Section 301 of the Department of Energy Organization Act (42 U.S.C. 7151), the Secretary of the DOE is responsible for ten-year energy consumption reduction plans that will reduce energy consumption by 20 to 40% by 1985. Agencies also have to "prepare for sudden fluctuations in energy price and supply." DOE is currently drawing up guidelines to assist agencies in meeting these goals.

An analysis of Tables E-1 and E-2 suggests that meeting the 20-20% reduction energy consumption goals in such a short time is highly problematic. Not only is energy consumption highly concentrated, but the Federal Government also consumes large quantities of oil products, especially jet fuel. In times of perceived military inferiority, reductions by DOD--the single largest consumer, with 80.4% of total consumption--are unlikely. Even if all other federal agencies reach the 40% reduction goal by 1985, DOD still will be consuming a predominant portion of governmental energy procurements and aggregate governmental energy consumption may fall very little. Governmental conservation can only have significant consequences for energy markets if DOD also meets conservation requirements.

In addition, the 20-40% energy conservation goal applies to transportation, industrial production, and services as well as to buildings. Federal procurement policy regarding buildings is still in its infancy. Before 1979 there were no systematic attempts to regulate energy acquisition by federal agencies. For transportation, guidelines have been presented, but there has been no implementation.

Production and service uses of energy have yet to be added. In summary, the Federal Government has a long way to go in implementing its conservation and renewable energy consumption policies.

Some would question whether the government should consciously use its market activities for the purpose of influencing national energy-use patterns. They would argue that the government is a consumer, and like other consumers in the market should act to protect its economic interests. Government, for example, has a public trust to guard taxpayers money: it should not squander its resources by purchasing overpriced or unavailable energy supplies. Just as there should be no discrimination to achieve other social ends in the purchase of goods and services by the government, so there should be no discrimination by energy forms in the purchase of power. Factors that should dominate purchasing decisions are price, availability, quality, and other considerations that affect market calculations.

These arguments are important and must be considered. It is possible that the portion of government purchases by energy form reflect careful market calculations. However, it is also possible that many of the decisions by the government to purchase energy have been made on the basis of outmoded standard operating procedures.[9] Such decisions may be based on inertia and on past practices that are not being carefully analyzed in light of recent changes in the energy supply situation.

It is therefore reasonable to argue that a careful, forward-looking reckoning by government purchasing agents of relative fuel prices, adequacy and availability of supply, and quality of service, as well as other factors, should be undertaken. Given national policy goals of reducing reliance on foreign oil, a more conscious procurement policy in regard to energy forms may be necessary.

The size of the government's market activity incentives to energy consumption, both direct and indirect, suggests that the government may have at its disposal a powerful tool for shaping national energy-use patterns. If the government is serious about reducing oil imports and increasing renewable energy use, it must consider the implications of its own market activities in the energy area. As of FY-1978, market activities did not lend credence and support to the stated government goals. The programs discussed above begin to reshape government market activities in directions consonant with the goals of conservation and solar use. More extensive reshaping may be necessary, however--an issue future research must concentrate on.

NOTES - APPENDIX E

1. See the Federal Register, vol. 45, no. 23, pp. 7498-7512, February 1, 1980.

2. 45 F.R., pp. 7498-7512.

3. 41 F.R. 15825 (April 13, 1976).

4. See B. Commoner, The Politics of Energy. Knopf, New York, 1979, pp. 34-35.

5. Commoner, p. 36.

6. S. McCracken, Commentary, pp. 61-67, November, 1979.

7. 41 F.R. 15825, April 13, 1976.

8. 42 F.R. 37523, July 20, 1977.

9. See F. Thompson and R. Williams, "A Horse Race Around A Mobius Strip: A Review and a Test of Utility Maximizing and Organizational Process Models of Public Expenditure Decision." Policy Sciences, pp. 119-143, November, 1979.

APPENDIX F

U.S. ELECTRIC UTILITY DATA BY REGION AND SECTOR
1950 AND 1978

(A SUPPLEMENT TO CHAPTER VII)

APPENDIX F

In this appendix, regional electricity sales, number of customers, revenues, and current and constant dollar prices are tabulated. The presentation of regional data highlights the substantial regional differences in these factors. The data are shown for two years, 1950 and 1978, so that growth and other changes within a region and between regions can be noted. Data are presented for the total electric utility industry and for the residential, commercial, industrial, and railroad and railway sectors.

The data for these tables come from the Edison Electric Institute (EEI). The regional breakdown used by EEI is the U.S. Bureau of Census geographic divisions. However, because EEI has historically presented data on Alaska and Hawaii separately, they have continued to do so to maintain their historical series. The Bureau of Census includes Alaska and Hawaii in the Pacific Region. Puerto Rico is almost always ignored in energy statistics compilations. The states that are included in each of the nine regions on the tables are listed below.

1. New England Region:
   Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut,
2. Middle Atlantic Region:
   New York, New Jersey, Pennsylvania,
3. East North Central Region:
   Ohio, Indiana, Illinois, Michigan, Wisconsin,
4. West North Central Region:
   Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas,

5. South Atlantic Region:
   Delaware, Maryland, District of Columbia, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida,
6. East South Central Region:
   Kentucky, Tennessee, Alabama, Mississippi,
7. West South Central Region:
   Arkansas, Louisiana, Oklahoma, Texas.
8. Mountain Region:
   New Mexico, Arizona, Utah, Nevada, Montana, Idaho, Wyoming, Colorado,
9. Pacific Region:
   Washington, Oregon, California

TABLE F-1. U.S. Electric Utility Sales, Revenues, Customers, and Price by Region[a] 1950 and 1978

Region and Year	Sales (billion kWh)	Total Customers (thousands)	Revenues (millions $)	Price[b] (Current $) (¢/kWh)	Price[c] (1978 $) (¢/kWh)
New England					
1978	74.77	4,833.2	3,391.6	4.54	4.54
1950	13.84	3,087.5	353.4	2.55	6.91
Middle Atlantic					
1978	251.22	13,685.9	11,482.0	4.57	4.57
1950	58.04	9,531.1	1,154.8	1.99	5.39
East North Central					
1978	378.98	16,255.6	13,571.6	3.58	3.58
1950	64.11	9,476.1	1,226.0	1.91	5.18
West North Central					
1978	137.10	7,145.0	4,807.2	3.51	3.51
1950	18.19	4,353.7	431.6	2.37	6.42
South Atlantic					
1978	337.90	14,323.0	12,232.1	3.62	3.62
1950	33.04	5,500.6	604.0	1.83	4.96
East South Central					
1978	197.21	5,786.2	5,412.8	2.74	2.74
1950	22.68	2,716.3	261.9	1.15	3.12
West South Central					
1978	264.84	8,951.9	7,897.8	2.98	2.98
1950	18.47	3,902.1	363.2	1.97	5.34
Mountain					
1978	101.23	4,330.4	3,007.8	2.97	2.97
1950	10.02	1,488.6	166.5	1.66	4.50
Pacific					
1978	266.01	11,935.6	7,631.8	2.87	2.87
1950	42.16	4,930.2	525.1	1.25	3.39
Alaska and Hawaii					
1978	8.58	421.0	418.2	4.87	4.87
1960(d)	1.99	203.9	53.3	2.68	5.90

Source: 1978 data from EEI (Ref. 1, pp. 33, 38, 45)
1960 data from EEI (Ref. 2, pp. 28,34,40)
1950 data from EEI (Ref. 2, pp. 30-32)

(a) Bureau of Census geographic divisions.
(b) Revenues divided by sales.
(c) Inflated using the consumer price index.
(d) 1960 was the first year data was reported for Alaska and Hawaii.

TABLE F-2. U.S. Electric Utility Residential Sales, Revenues, Customers, and Price by Region[a] 1950 and 1978

Region and Year	Sales (billion kWh)	Total Customers (thousands)	Sales per Customer (kWh)	Revenues (millions $)	Price[b] (Current $) (¢/kWh)	Price[c] (1978 $) (¢/kWh)
New England						
1978	28.72	4,329.5	6,634	1,430.6	4.98	4.98
1950	3.88	2,678.0	1,449	141.9	3.66	9.92
Middle Atlantic						
1978	76.67	12,175.2	6,297	4,206.3	5.49	5.49
1950	12.14	8,116.3	1,496	413.7	3.41	9.24
East North Central						
1978	114.73	14,700.2	7,805	4,974.3	4.34	4.34
1950	14.76	7,907.8	1,866	427.5	2.90	7.86
West North Central						
1978	53.85	6,284.0	8,569	2,133.9	3.96	3.96
1950	5.94	3,554.7	1,671	193.5	3.26	8.83
South Atlantic						
1978	134.43	12,764.3	10,532	5,443.6	4.05	4.05
1950	8.33	4,651.9	1,791	237.4	2.85	7.72
East South Central						
1978	64.92	5,117.7	12,685	2,040.9	3.14	3.14
1950	5.09	2,250.5	2,262	104.3	2.05	5.56
West South Central						
1978	85.54	7,788.6	10,983	3,123.0	3.65	3.65
1950	3.97	3,121.9	1,272	142.5	3.59	9.73
Mountain						
1978	31.46	3,765.3	8,355	1,160.1	3.69	3.69
1950	2.80	1,245.1	2,249	72.2	2.58	6.99
Pacific						
1978	85.88	10,487.6	8,189	2,714.6	3.16	3.16
1950	10.11	4,006.3	2,524	198.7	1.97	5.34
Alaska and Hawaii						
1978	2.96	363.1	8,152	154.0	5.20	5.20
1960[d]	0.80	172.3	4,643	24.9	3.11	6.85

Source: 1978 data from EEI (Ref. 1, pp. 33, 38, 45)
1960 data from EEI (Ref. 2, pp. 28, 34, 40)
1950 data from EEI (Ref. 2, pp. 30-32)

(a) Bureau of Census geographic divisions.
(b) Revenues divided by sales.
(c) Inflated using the consumer price index.
(d) 1960 was the first year data was reported for Alaska and Hawaii.

TABLE F-3. U.S. Electric Utility Commercial Sales, Revenues, Customers, and Price by Region[a] 1950 and 1978

Region and Year	Sales (billion kWh)	Total Customers (thousands)	Sales per Customer (kWh)	Revenues (millions $)	Price[b] (Current $) (¢/kWh)	Price[c] (1978 $) (¢/kWh)
New England						
1978	22.56	466.71	48,338	1,084.6	4.81	4.81
1950	2.26	368.71	6,129	80.9	3.58	9.70
Middle Atlantic						
1978	66.64	1,385.35	48,103	3,660.6	5.49	5.49
1950	12.78	1,307.28	9,776	357.4	2.94	7.97
East North Central						
1978	77.98	1,452.50	53,687	3,351.9	4.30	4.30
1950	9.86	1,078.51	9,142	283.4	2.87	7.78
West North Central						
1978	36.48	802.58	45,453	1,361.9	3.73	3.73
1950	4.07	535.61	7,599	119.1	2.93	7.94
South Atlantic						
1978	83.21	1,453.28	57,257	3,414.3	4.10	4.10
1950	5.56	611.11	9,098	149.7	2.69	7.29
East South Central						
1978	27.93	613.77	45,506	878.1	3.14	3.14
1950	2.22	252.39	8,796	47.4	2.14	5.80
West South Central						
1978	59.92	1,030.66	58,137	2,069.0	3.45	3.45
1950	4.21	442.33	9,518	107.2	2.55	6.91
Mountain						
1978	32.30	527.04	61,286	1,080.8	3.35	3.35
1950	2.48	180.87	13,711	51.1	2.06	5.58
Pacific						
1978	71.17	1,361.68	52,266	2,678.0	3.76	3.76
1950	7.01	689.37	10,169	137.5	1.96	5.31
Alaska and Hawaii						
1978	2.58	54.84	47,046	135.2	5.24	5.24
1960[d]	0.43	29.59	14,532	15.5	3.60	7.93

Source: 1978 data from EEI (Ref. 1, pp. 33, 38, 45)
1960 data from EEI (Ref. 2, pp. 28, 34, 40)
1950 data from EEI (Ref. 2, pp. 30-32)

(a) Bureau of Census geographic divisions.
(b) Revenues divided by sales.
(c) Inflated using the consumer price index.
(d) 1960 was the first year data was reported for Alaska and Hawaii.

TABLE F-4. U.S. Electric Utility Industrial Sales, Revenues, Customers, and Price by Region[a] 1950 and 1978

Region and Year	Sales (billion kWh)	Total Customers (thousands)	Sales per Customer (thousands kWh)	Revenues (millions $)	Price[b] (Current $) (¢/kWh)	Price[c] (1978 $) (¢/kWh)
New England						
1978	21.64	19.96	1,084.2	768.2	3.55	3.55
1950	7.21	18.76	384.3	113.7	1.58	4.28
Middle Atlantic						
1978	94.74	87.51	1,082.6	3,013.4	3.18	3.18
1950	27.73	38.94	712.1	296.9	1.07	2.90
East North Central						
1978	172.52	62.09	2,778.5	4,761.5	2.76	2.76
1950	34.18	34.18	1,000.0	411.0	1.20	3.25
West North Central						
1978	42.96	30.39	1,413.6	1,189.3	2.77	2.77
1950	6.51	15.58	417.8	79.0	1.21	3.28
South Atlantic						
1978	109.23	64.28	1,699.3	2,996.9	2.74	2.74
1950	17.31	28.35	610.6	181.8	1.05	2.85
East South Central						
1978	100.82	38.23	2,637.2	2,374.4	2.36	2.36
1950	14.32	10.73	1,334.6	90.4	0.63	1.71
West South Central						
1978	109.07	89.86	1,213.8	2,429.4	2.23	2.23
1950	8.63	31.19	276.7	81.6	0.95	2.57
Mountain						
1978	33.89	29.01	1,168.2	662.5	1.95	1.95
1950	3.70	15.57	237.6	28.8	0.78	2.11
Pacific						
1978	94.38	42.62	2,214.5	1,964.6	2.08	2.08
1950	19.48	41.43	470.2	121.6	0.62	1.68
Alaska and Hawaii						
1978	2.88	0.71	4,056.3	120.1	4.17	4.17
1960(d)	0.71	1.06	669.8	11.4	1.61	3.55

Source: 1978 data from EEI (Ref. 1, pp. 33, 38, 45)
1960 data from EEI (Ref. 2, pp. 28, 34, 40)
1950 data from EEI (Ref. 2, pp. 30-32)

(a) Bureau of Census geographic divisions.
(b) Revenues divided by sales.
(c) Inflated using the consumer price index.
(d) 1960 was the first year data was reported for Alaska and Hawaii.

TABLE F-5. U.S. Electric Utility Railroad and Railway Sales, Revenues, Customers, and Price by Region[(a)] 1950 and 1978

Region and Year	Sales (million kWh)	Total Customers	Sales per Customer (million kWh)	Revenues (millions $)	Price[(b)] (Current $) (¢/kWh)	Price[(c)] (1978 $) (¢/kWh)
New England						
1978	21.0	1	21.0	1.51	7.17	7.17
1950	28.7	5	5.7	0.30	1.05	2.85
Middle Atlantic						
1978	3,233.0	11	293.9	134.38	4.16	4.16
1950	3,139.2	30	104.6	30.85	0.98	2.66
East North Central						
1978	405.0	5	81.0	12.20	3.01	3.01
1950	1,374.8	36	38.2	16.44	1.20	3.25
West North Central						
1978	36.0	3	12.0	0.84	2.33	2.33
1950	174.2	11	15.8	1.78	1.02	2.76
South Atlantic						
1978	322.0	4	80.5	11.68	3.63	3.63
1950	476.5	10	47.7	4.67	0.98	2.66
East South Central						
1978	0	0	0	0	--	--
1950	59.5	4	14.9	0.49	0.82	2.22
West South Central						
1978	20.0	1	20.0	0.28	1.40	1.40
1950	55.2	7	7.9	0.35	0.63	1.71
Mountain						
1978	0	0	0	0	--	--
1950	157.9	5	31.6	0.93	0.59	1.60
Pacific						
1978	297.0	4	74.3	9.18	3.09	3.09
1950	415.1	37	11.2	3.30	0.79	2.14
Alaska and Hawaii						
1978	2.0	1	2.0	0.06	3.00	3.00
1960(d)	0	0	0	0	--	--

Source: 1978 data from EEI (Ref. 1, pp. 33, 38, 45)
1960 data from EEI (Ref. 2, pp. 28, 34, 40)
1950 data from EEI (Ref. 2, pp. 30-32)

(a) Bureau of Census geographic divisions.
(b) Revenues divided by sales.
(c) Inflated using the consumer price index.
(d) 1960 was the first year data was reported for Alaska and Hawaii.

TABLE F-6. U.S. Electric Utility Public[a] Sales, Revenues, Customers, and Price by Region[b] 1950 and 1978

Region and Year	Sales (billion kWh)	Total Customers (thousands)	Sales per Customer (thousand kWh)	Revenues (millions $)	Price[c] (Current $) (¢/kWh)	Price[d] (1978 $) (¢/kWh)
New England						
1978	1.58	15.9	99.37	99.5	6.30	6.30
1950	0.39	10.5	37.14	15.2	3.90	10.57
Middle Atlantic						
1978	9.79	37.8	258.99	462.1	4.72	4.72
1950	2.08	26.5	78.49	51.7	2.49	6.75
East North Central						
1978	13.08	40.5	322.96	463.6	3.54	3.54
1950	2.43	31.7	76.66	43.3	1.78	4.82
West North Central						
1978	3.54	27.6	128.26	116.4	3.29	3.29
1950	0.86	13.3	64.66	16.4	1.91	5.18
South Atlantic						
1978	10.32	41.0	251.71	354.5	3.44	3.44
1950	0.91	18.3	49.73	18.5	2.03	5.50
East South Central						
1978	3.26	16.5	197.58	112.7	3.46	3.46
1950	0.63	14.3	44.06	9.3	1.48	4.01
West South Central						
1978	8.14	42.6	191.08	243.3	2.99	2.99
1950	1.08	15.7	68.79	13.8	1.28	3.47
Mountain						
1978	3.19	8.5	375.29	94.46	2.96	2.96
1950	0.34	4.2	80.95	5.57	1.64	4.44
Pacific						
1978	11.26	41.6	270.67	245.1	2.18	2.18
1950	1.42	21.0	67.62	20.4	1.44	3.90
Alaska and Hawaii						
1978	0.16	2.3	69.57	8.5	5.31	5.31
1960(e)	0.05	0.9	55.56	1.3	2.60	5.73

Source: 1978 data from EEI (Ref. 1, pp. 33, 38, 45)
1960 data from EEI (Ref. 2, pp. 28, 34, 40)
1950 data from EEI (Ref. 2, pp. 30-32)

(a) Includes street and highway lighting.
(b) Bureau of Census geographic divisions.
(c) Revenues divided by sales.
(d) Inflated using the consumer price index.
(e) 1960 was the first year data was reported for Alaska and Hawaii.

TABLE F-7. U.S. Electric Utility Street and Highway Lighting Sales, Revenues, Customers, and Price by Region[a] 1950 and 1978

Region and Year	Sales (million kWh)	Total Customers (thousands)	Sales per Customer (thousand kWh)	Revenues (millions $)	Price[c] (Current $) (¢/kWh)	Price[d] (1978 $) (¢/kWh)
New England						
1978	800.0	9.79	81.72	67.8	8.48	8.48
1950	255.1	2.78	91.76	12.0	4.70	12.74
Middle Atlantic						
1978	2,170.0	19.65	110.43	177.8	8.19	8.19
1950	785.9	5.05	155.62	29.5	3.75	10.16
East North Central						
1978	2,870.0	15.71	182.69	145.8	5.08	5.08
1950	642.4	6.97	92.17	17.6	2.74	7.43
West North Central						
1978	1,187.0	9.03	131.45	57.2	4.82	4.82
1950	283.9	4.51	62.95	7.9	2.78	7.53
South Atlantic						
1978	1,897.0	15.66	121.14	111.4	5.87	5.87
1950	261.9	3.29	79.61	8.9	3.40	9.21
East South Central						
1978	1,357.0	7.60	178.55	56.7	4.18	4.18
1950	123.6	2.18	56.70	3.2	2.59	7.02
West South Central						
1978	1,337.0	5.98	223.58	49.8	3.72	3.72
1950	152.1	3.11	48.91	3.4	2.24	6.07
Mountain						
1978	607.0	4.78	126.99	34.0	5.60	5.60
1950	96.7	1.55	62.39	2.7	2.79	7.56
Pacific						
1978	2,486.0	31.85	78.05	143.5	5.77	5.77
1950	374.0	4.30	86.98	9.0	2.41	6.53
Alaska and Hawaii						
1978	92.0	1.85	49.73	5.6	6.09	6.09
1960[d]	38.0	0.70	54.29	0.9	2.37	5.22

Source: 1978 data from EEI (Ref. 1, pp. 33, 38, 45)
1960 data from EEI (Ref. 2, pp. 28, 34, 40)
1950 data from EEI (Ref. 2, pp. 30-32)

(a) Bureau of Census geographic divisions.
(b) Revenues divided by sales.
(c) Inflated using the consumer price index.
(d) 1960 was the first year data was reported for Alaska and Hawaii.

<u>NOTES - APPENDIX F</u>

1. Edison Electric Institute. *Statistical Yearbook of the Electric Utility Industry for 1978*. Washington, D.C., 1979.

2. Edison Electric Institute. *Historical Statistics of the Electric Utility Industry*. Washington, D.C., 1971.

APPENDIX G

FEDERAL PROJECT ELECTRICITY DATA
1950-1978

(A SUPPLEMENT TO CHAPTER VII)

APPENDIX G

In this appendix, tabulation of federal project electricity data during 1950 through 1978 is presented. The tables show federal project sales, number of customers, sales per customer, revenues, and price in current and constant dollars for the residential, commercial, industrial, and public sectors.

The data was derived from annual federal publications titled Statistics of Publicly Owned Electric Utilities in the United States. This data was published by the Federal Power Commission until the formation of the DOE whose Energy Information Administration now publishes the document.

The tables include only federal project sales to ultimate customers which excludes project sales for resale. Projects under the jurisdiction of the Southeastern Power Administration, Southwestern Power Administration, Alaska Power Administration, Tennessee Valley Authority, Bonneville Power Administration, the Bureau of Indian Affairs, and the Western Area Power Administration are included in the tabulation.

There are certain problems with the data that must be considered. Not all of the federal projects reported their data every year. Whenever possible other sources were used to fill in the missing data or extrapolations were made. The data presented in the "ultimate consumers" category is broken into residential, commercial, industrial, and other categories in the source document. The "other" category was determined to be primarily interdepartmental sales and sales to government agencies and was used to approximate federal project sales to public agencies. Also, in 1960, the FPC modified their reporting form. Prior to 1960, the commercial and industrial ultimate consumer information was presented in a single category. This data between 1950 and 1960 was broken into the separate categories based on other information sources where available or extrapolations.

TABLE G-1. Federal Project Residential Sales, Customers, Revenues, and Price 1950 - 1978

Year	Sales (million kWh)	Total Customers	Sales per Customer (kWh)	Revenues (thousand $)	Price[a] (Current $) (¢/kWh)	Price[b] (1978 $) (¢/kWh)
1978	107.53	8,266	13,008	1,882.7	1.75	1.75
1977	100.57	7,991	12,585	1,736.0	1.73	1.86
1976	93.63	7,552	12,398	1,552.0	1.66	1.90
1975	90.75	7,300	12,432	1,216.0	1.34	1.62
1974	81.42	7,079	11,502	1,081.0	1.33	1.76
1973	77.61	6,785	11,438	1,024.5	1.32	1.94
1972	74.19	6,424	11,549	981.3	1.32	2.06
1971	67.07	6,116	10,966	881.2	1.31	2.11
1970	61.79	5,866	10,554	810.4	1.31	2.20
1969	60.89	5,730	10,627	796.8	1.31	2.33
1968	56.07	5,587	10,036	734.8	1.31	2.46
1967	53.54	5,526	9,689	692.9	1.29	2.52
1966	51.81	5,431	9,540	669.5	1.29	2.59
1965	50.06	5,316	9,417	642.7	1.28	2.65
1964	48.00	5,198	9,234	614.8	1.28	2.69
1963	45.77	5,094	8,985	587.8	1.28	2.73
1962	43.76	4,992	8,766	561.2	1.28	2.76
1961	41.55	4,922	8,442	534.8	1.29	2.81
1960	41.81	4,944	8,457	536.1	1.28	2.82
1959	39.17	4,874	8,037	498.7	1.27	2.84
1958	34.80	4,716	7,379	452.6	1.30	2.93
1957	33.72	4,732	7,126	442.0	1.31	3.04
1956	31.88	4,628	6,889	426.2	1.34	3.22
1955	30.51	4,573	6,672	410.1	1.34	3.26
1954	28.52	4,563	6,250	384.9	1.35	3.28
1953	27.50	4,717	5,830	386.2	1.40	3.41
1952	43.67	4,545	9,608	447.3	1.02	2.51
1951	50.84	4,785	10,625	488.1	0.96	2.41
1950	43.32	4,824	8,980	504.8	1.17	3.17

Source: DOE/EIA (formerly the FPC) 1950 through 1978.

(a) Revenues divided by sales.
(b) Inflated using the consumer price index.

TABLE G-2. Federal Project Commercial Sales, Customers, Revenues, and Price 1950 - 1978

Year	Sales (million kWh)	Total Customers	Sales per Customer (kWh)	Revenues (thousand $)	Price[(a)] (Current $) (¢/kWh)	Price[(b)] (1978 $) (¢/kWh)
1978	56.93	3,413	16,680	1,346.3	2.36	2.36
1977	88.22	3,084	28,606	1,706.0	1.93	2.08
1976	67.44	2,930	23,017	1,227.0	1.82	2.09
1975	66.68	2,700	24,696	1,273.0	1.91	2.31
1974	60.10	2,536	23,699	750.0	1.25	1.65
1973	61.51	2,322	26,490	728.1	1.18	1.73
1972	64.38	2,074	31,041	687.8	1.07	1.67
1971	49.86	1,930	25,834	595.4	1.19	1.92
1970	31.04	1,770	17,537	511.8	1.65	2.77
1969	28.88	1,672	17,273	531.4	1.84	3.28
1968	25.23	1,567	16,101	461.1	1.83	3.43
1967	35.04	1,481	23,660	511.2	1.46	2.85
1966	33.43	1,375	24,313	480.2	1.44	2.89
1965	31.23	1,270	24,591	447.6	1.43	2.96
1964	28.77	1,166	24,674	413.9	1.44	3.03
1963	26.39	1,064	24,803	383.2	1.45	3.09
1962	23.90	959	24,922	350.8	1.47	3.17
1961	20.32	853	23,822	309.6	1.52	3.32
1960	18.06	850	21,247	289.9	1.61	3.55
1959	15.16	828	18,309	252.0	1.66	3.72
1958	11.95	808	14,790	215.8	1.81	4.08
1957	11.73	806	14,553	213.1	1.82	4.22
1956	10.87	789	13,777	202.9	1.87	4.49
1955	10.09	758	13,311	190.0	1.88	4.58
1954	9.94	750	13,253	184.4	1.86	4.51
1953	9.28	725	12,800	175.3	1.89	4.61
1952	15.74	723	21,770	226.4	1.44	3.54
1951	23.88	707	33,777	317.3	1.33	3.34
1950	16.11	719	22,406	249.7	1.55	4.20

Source: DOE/EIA (formerly the FPC) 1950 through 1978.

(a) Revenues divided by sales.
(b) Inflated using the consumer price index.

TABLE G-3. Federal Project Industrial Sales, Customers, Revenues, and Price 1950 - 1978

Year	Sales (million kWh)	Total Customers	Sales per Customer (million kWh)	Revenues (millions $)	Price[(a)] (Current $) (¢/kWh)	Price[(b)] (1978 $) (¢/kWh)
1978	48,922.3	61	802.01	538.0	1.10	1.10
1977	47,018.7	61	770.80	397.2	0.84	0.90
1976	45,012.0	61	737.90	382.4	0.85	0.97
1975	47,363.7	62	763.93	290.1	0.61	0.74
1974	46,180.5	74	624.06	226.1	0.49	0.65
1973	43,880.8	73	601.11	189.0	0.43	0.63
1972	42,222.5	72	586.40	170.3	0.40	0.62
1971	43,556.7	69	631.26	170.6	0.39	0.63
1970	46,577.2	65	716.57	156.3	0.34	0.57
1969	43,166.9	64	674.48	138.6	0.32	0.57
1968	40,717.8	73	557.78	129.4	0.32	0.60
1967	38,114.8	78	488.65	120.3	0.32	0.63
1966	34,844.9	76	458.49	108.8	0.31	0.62
1965	33,339.8	74	450.54	103.6	0.31	0.64
1964	29,399.6	75	391.99	91.5	0.31	0.65
1963	25,865.8	75	344.88	81.3	0.31	0.66
1962	21,856.1	69	316.76	70.3	0.32	0.69
1961	23,307.5	68	342.76	71.1	0.31	0.68
1960	23,995.7	68	352.88	71.6	0.30	0.66
1959	22,359.3	71	314.91	68.1	0.30	0.67
1958	21,220.3	70	303.15	62.6	0.30	0.68
1957	21,767.2	70	310.96	61.3	0.28	0.65
1956	19,638.5	67	293.11	54.9	0.28	0.67
1955	17,085.5	66	258.87	47.7	0.28	0.68
1954	15,734.4	66	238.40	45.4	0.29	0.70
1953	13,682.3	78	175.41	41.8	0.31	0.76
1952	13,307.7	97	137.19	43.8	0.33	0.81
1951	12,593.2	120	104.94	34.2	0.27	0.68
1950	10,623.8	113	94.02	26.9	0.25	0.68

Source: DOE/EIA (formerly the FPC) 1950 through 1978.

(a) Revenues divided by sales.
(b) Inflated using the consumer price index.

TABLE G.4. Federal Project Public Sales, Customers, Revenues, and Price 1950 - 1978

Year	Sales (million kWh)	Total Customers	Sales per Customer (million kWh)	Revenues (millions $)	Price[(a)] (Current $) (¢/kWh)	Price[(b)] (1978 $) (¢/kWh)
1978	23,499.9	418	56.22	344.06	1.46	1.46
1977	29,332.4	428	68.53	351.22	1.20	1.29
1976	29,353.7	457	64.23	333.66	1.14	1.31
1975	27,047.1	394	68.65	216.27	0.80	0.97
1974	25,026.5	413	60.60	150.02	0.60	0.79
1973	24,208.4	398	60.83	127.99	0.53	0.78
1972	19,690.7	391	50.36	97.71	0.50	0.78
1971	18,923.5	391	48.40	86.04	0.45	0.73
1970	21,167.8	382	55.41	84.60	0.40	0.67
1969	23,635.9	377	62.69	89.94	0.38	0.68
1968	25,868.3	355	72.87	100.90	0.39	0.73
1967	27,088.6	272	99.59	106.21	0.39	0.76
1966	26,936.7	238	113.18	102.97	0.38	0.76
1965	25,385.6	226	112.33	97.22	0.38	0.79
1964	30,139.4	210	143.52	114.14	0.38	0.80
1963	29,257.9	193	151.60	111.98	0.38	0.81
1962	32,317.9	183	176.60	118.35	0.37	0.80
1961	32,207.4	197	163.49	120.56	0.37	0.81
1960	32,039.2	189	169.52	119.93	0.37	0.82
1959	31,249.3	197	158.63	117.11	0.37	0.83
1958	31,818.3	170	187.17	121.07	0.38	0.86
1957	34,880.6	165	211.40	136.91	0.39	0.90
1956	33,180.6	162	204.82	132.07	0.40	0.96
1955	24,410.2	158	154.49	110.28	0.45	1.10
1954	13,784.9	158	87.25	60.62	0.44	1.07
1953	8,783.1	149	58.95	36.84	0.42	1.02
1952	6,406.7	146	43.88	29.65	0.46	1.13
1951	3,345.3	131	25.54	11.28	0.34	0.85
1950	3,115.0	129	24.15	10.03	0.32	0.87

Source: DOE/EIA (formerly the FPC) 1950 through 1978.

(a) Revenues divided by sales.
(b) Inflated using the consumer price index.

APPENDIX H

FEDERAL FUNDS FOR RESEARCH DEVELOPMENT AND DEMONSTRATION RELATED TO ELECTRIC POWERED TRANSPORTATION

(A SUPPLEMENT TO CHAPTER VII)

TABLE H-1. Battery Research and Development in the Departments of Defense and Energy

FY	Mercury[a]	Lithium[b]	Silver[c]	Thermal[d]	Ammonia[e]	Other	DOE Battery R&D	Total Battery R&D
1962	337		673	201	121	1,381		2,713
1963	257	248	891	264	127	953		2,740
1964	1,147	515	914	86	303	1,195		4,160
1965	834	268	1,122		300	536		3,060
1966	1,005	376	1,254	306	65	822		3,828
1967	619	391	2,128	157	46	925		4,266
1968	520	723	2,627		63	1,429		5,362
1969	1,440	806	995		35	1,666		4,942
1970	2,830	245	714			1,256		5,045
1971	1,852	403	215	10		1,158		3,638
1972	1,530	323	565	6	1,015		3,439	
1973	933	398	440			1,005	500	3,276
1974	902	561	740	5		612	1200	4,020
1975	1,010	428	928	5		301	3,400	6,072
1976	552	215	459			184	15,600	17,010
TQ[f]	133	83	29			160		405
1977	1,242	556	1,157	130		76	16,500	19,661
1978	550	587	988	467		294	23,600	26,486
1979	1,363	642	166	265		318	25,500	28,254
1980	565	359	166	55		548	33,000	34,6943

Sources: Power Information Center, Franklin Institute, Science Information Services Organization, Philadelphia, Pennsylvania, Data telexed September 15, 1980.
Division Records, DOE Office of Electric Energy Systems, Advanced Conservation Technology.

(a) Includes R/O expenditures on mercury; cadmium; nickel; magnesium battery research.
(b) Lithium Battery Research.
(c) Silver and Zinc Battery Research.
(d) Thermal Battery Research and Development.
(e) Ammonia Battery Research and Development
(f) The Fiscal Year Code TQ denotes funding for 1 July 1976 to 30 September 1976, due to change in Government Fiscal Year, Transition Quarter.

TABLE H-2. Electric and Hybrid Vehicle Research, Development and Demonstration Funding (in thousands of dollars)

Year	EHV Work Under AAPS Program(a)	EHV Work Under Public Law 940-413(a)	Department of Defense(b) Army EHV Work	Total
1966			385	385
1967			17	17
1968				
1969	50		120	170
1970	595			595
1971	1,149			1,149
1972				
1973	235			235
1974	558			558
1975	600			600
1976		1,893		1,893
TQ				
1977		21,210		21,210
1978		29,460		29,460

(a) U.S. Environmental Protection Agency, Office of Air and Waste Management, Alternative Automotive Power Systems Division, Alternative Automotive Fuels and Power Systems Research and Development Programs summary of Fiscal Obligations, Ann Arbor, Michigan: Internal Document, June 1974. John Heywood, Henry Jacoby, Larry Linden, The Role of Federal Research and Development on Alternative Automotive Power Systems, Report to Office of Energy R&D Policy, National Science Foundation, November 1974.

(b) Power Information Center, Franklin Institute, Sciences Information Services Organization, data telexed September 15, 1980, assembled from administrative records submitted to Power Information Center.

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