ECASTAR

ENERGY CONSERVATION: AN ASSESSMENT OF SYSTEMS, TECHNOLOGIES AND REQUIREMENTS

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ECASTAR

Energy Conservation: an Assessment of Systems, Technologies And Requirements

BY

AUBURN UNIVERSITY ENGINEERING SYSTEMS DESIGN

SUMMER FACULTY FELLOWS

EXECUTIVE SUMMARY

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I. INTRODUCTION

ECASTAR presents a methodology for a systems approach display and assessment of the potential for energy conservation actions and the impacts of those actions. The U.S. economy is divided into four sectors -- energy industry, industry, residential/commercial and transportation. Each sector is assessed with respect to energy conservation actions and impacts. The four sectors are combined and three strategies for energy conservation actions for the combined sectors are assessed. The three strategies -- national energy conservation, electrification and diversification represent energy conservation actions for the near term (now to 1985), the mid term (1985 to 2000) and the far term (2000 and beyond). The assessment procedure includes input/output analysis to bridge the flows between sectors and net economics and net energetics as performance criteria for the conservation actions. The abbreviated 30 x 30 input/output analysis matrix developed in ECASTAR relates dollars, BTU's and labor to total industrial production. The matrix is thought to be the ideal size for energy policy analysis. A feature of the assessment methodology is the identification of targets of opportunity for large net energy savings and the application of technology to achieve these savings. In addition, citizen's actions for energy conservation are discussed. ECASTAR suggests areas and raises issues for detailed study.

Since BTUs and quads are referred to throughout this report, it may be helpful to include in this introductory page the precise meaning of these units of measure.

A BTU (British Thermal Unit) is the amount of heat required to raise the temperature of 1 pound of water 1°F.

Different fuels, when burned, release different amounts of heat. There are about 1,000 BTUs in a cubic foot of natural gas, 5,000 in a pound of wood, 13,000 in a pound of coal, 125,000 in a gallon of gasoline.

One BTU equals 251.9 calories, or 1,055 joules. A calorie is the metric unit of heat measurement: amount of heat required to raise the temperature of 1 gram of water 1 C. A joule is the amount of work done in 1 second to maintain current of 1 ampere in resistance of 1 ohm.

A quadrillion (quad) is 1 million-billion BTUs, or 970 billion cubic feet of natural gas, or 290 billion kilowatt-hours of electricity, or 170 million barrels of oil, or 40 million tons of coal. Approximately 75 quads of energy were required to meet the needs of the people in the entire United States in 1974.

2. CONSERVATION ISSUES

The meaning of the word conservation in "energy conservation" is an issue in itself. The ECASTAR definition of energy conservation is: The result of any action that improves the energy situation in the United States. Furthermore, the terms "energy conservation" as commonly used refer to using energy wisely and should not be confused with conservation of energy as used in the field of thermodynamics.

Each expert queried by the ECASTAR group used the word conservation to describe a different concept involving energy production or use. This is illustrated by considering the following issues where each issue uses the word conservation in a different context.

°Should the U.S. employ conservation by substituting plentiful energy resources for scarce energy resources?

°Should the U.S. employ conservation by curtailing end use of energy?

°Should the U.S. employ conservation by increasing the efficiency of energy-using devices?

°Can conservation be an important way of limiting OPEC power?

°Do you think that conservation will have a strong economic impact?

°Will the environmental impacts of conservation be significant?

°What political and social impacts might the U.S. expect conservation to have?

°Should the U.S. use a systems approach to formulate national energy conservation policy?

°Is energy conservation possible? Is it necessary, and is it worth the costs?

°Is electrification (an electric economy) a conservation strategy?

°Is diversification (a broad mix of energy sources) necessarily a conservation measure?

°Do you perceive any bottlenecks to the implementation of national energy conservation, diversification or electrification?

These are some of the issues raised and addressed in ECASTAR. The characterization of conservation is based on the mode of conservation under discussion. The three modes considered in ECASTAR are:

°Reduced consumption

°Increased efficiency

°Substitution for scarce energy resources

Reduced consumption affects the demand side of the energy equation. It can be effected either voluntarily or by mandate. In either case it may lead to changes in life style if continued over an extended period, although this is not necessarily the case. Reduced consumption may be instituted, even if the supply is sufficient, in order to extend the supply's lifetime.

Increased efficiency of energy utilization employs technology to increase the ratio of useful output to energy input. This may be viewed as obtaining more output for the same input, or the same output for less input. Another view sees increased efficiency as matching the quality of the energy input to the task, as in the case of using low quality waste heat for space heating or hot water heating.

The third mode of energy conservation involves substitution of energy forms such as coal or nuclear for oil or gas. In a more general sense this category of energy conservation can be realized by resource substitution at any point in the production or utilization sequence.

3. THE POLITICAL ECONOMY OF CONSERVATION

Political Economy

The political economy of the U.S. is that system which allocates the resources of society through the forces of the market and decree of the government. The principal agents are: the citizens, suppliers of resources and suppliers of final goods and services; labor unions, protectors of the rights of workers; and the government, the overseer of all and consumer of resources, goods and services. Contained in the system is the technological purview of the researcher and engineer. The political economy takes the psychological and social motivations of the people as constant. Clearly, an even more general system (e.g., anthropological) would consider these psychological and social motivations as variables.

Energy Economics

Two important notions in the decision-making of both consumers and producers are those of <u>substitution</u> and <u>elasticity</u>. Consider a general decision-maker (DM).

Substitution can simply be considered as a choice of raw materials, products, or processes which replace some previous choice. Scarcity implies substitutions. For example, the DM may substitute energy for material goods or services, energy form for energy form, output for output, or smaller amounts of any of the above for previously larger ones.

The degree to which a DM is responsive to changes in prices and available funds is called "elasticity." Price elasticity measures the ratio of a proportional change in quantity to a proportional change in price.

Cross price elasticity measures the proportional responsiveness of the quantity of one good to changes in the price of another.

Available funds elasticity measures the relative responsiveness of the quantity of a good to changes in the amount of funds available.

Elasticity, therefore, is an important gauge in measuring the effects of certain policies that alter energy prices and incomes. It, together with the phenomenon of substitution mentioned above, gives insight into the potential reactions of market forces and government actions in the area of energy conservation.

The macroeconomic aspects of energy economics are schematically represented by the Economic Actions-Impacts Flow in Figure 1. Because of the interdependence of the sectors, any action or policy taken in one arena has important impacts in many of the others. Implicit in the flow, for example, are the markets for specific goods and services, markets for specific types of labor and markets for money. From them come prices, wage rates and interest rates. These in turn are projected to the micro units for everyday decisions. An example in the energy industry is the current high interest rate structure which, with inflation, impedes large investments by utilities and oil companies.

The historic relationship of energy consumption to GNP has been strongly positive. Much of the debate over the "BTU theory of value" is related to the question of whether or not GNP should continue to grow, and if so, can energy consumption remain constant? Efforts to affect flows to and from the energy industry have significant implications on the distribution of wealth even if the total pie remains constant.

4. CONSERVATION: TOWARD FIRMER GROUND

History and Goals

There are two important facts in the history of economic-technical conservation. The first is that in an era of stable or declining real prices for energy ('50's, '60's) significant conservation gains have been achieved by many industries and many energy or fuel producers. The second is that while energy producers and industry were practicing efficiency, consumer energy use was being pushed up by rising sales of energy intensive goods and services. The time profile for the recent history of conservation contains three major periods. The first is the period of stable or declining real prices of energy brought about by government regulations, expanding supplies and economies of scale or efficiency. This period ended in the late '60's. The second period is one of gradually increasing energy prices due to general cost increases, government regulations on pollution and health, citizen involvement in environmental decisions, and weakening of the supply picture. The third period is identified with the 1973 embargo and its aftermath. It is characterized by escalation of energy prices, insecurity of sources, general recession, and a broad-based concern for a long range energy supply and consumption policy.

Contrast the achievements and failures of unsupervised energy consumption in the two examples:

°The chemical industry has reduced its energy consumption per pound of product by 50% from 1954 to 1971.

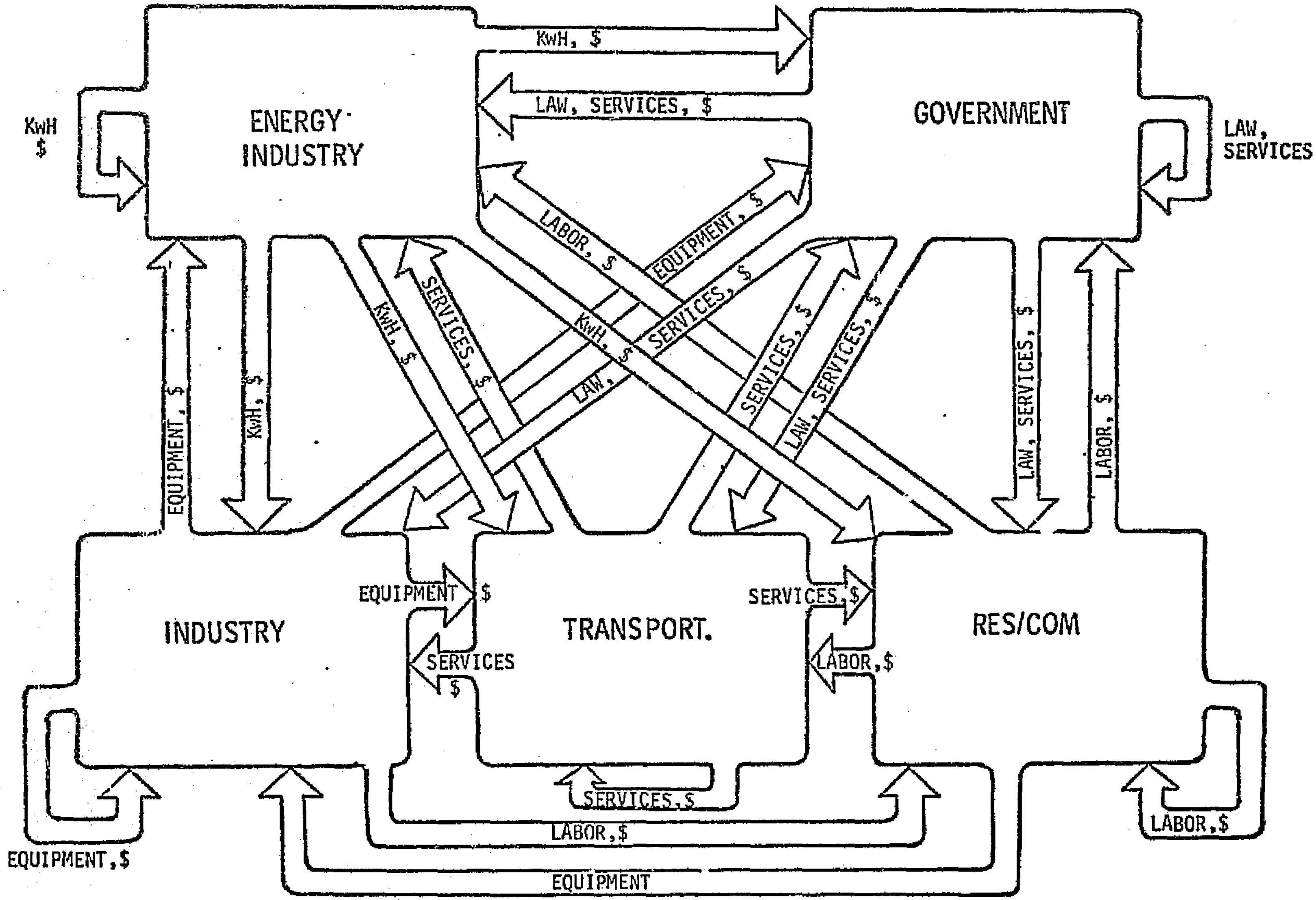

FIGURE 1. ECONOMIC ACTIONS -IMPACT FLOW

°The electrical utility industry has been forced to meet an ever increasing peak load problem which strains their capital resources and forces the use of inefficient peaking plants to meet consumer demand.

Much is presently being said about setting conservation goals. In particular, many efforts are being made to encourage conservation actions without mandating them. This report addresses the question of attainable goals in considerable detail. A characteristic of current conservation thinking is that most proposed changes involve isolated components or sub-systems of the larger energy supply and use systems. Little or no attention is given to assessing sweeping redesign of whole energy utilization systems and the integration of many proposed sub-systems into larger systems. This study looks at significant system redesign in the cross-sector examinations of (1) a policy of electrification of the nation's energy use and of (2) a policy of diversifying the nation's energy supply as widely as technology and economies allow.

Conservation opportunities and needs arise out of the context of present and future societal operations. The choice of an implementation method of a conservation goal is an altogether different study from that of identifying targets of opportunity for correctable waste. In particular, all conservation actions must be assessed from the point of application to the chain of raw materials to intermediate products, and through to consumer activities. There is good reason to believe that significantly more can be achieved in overall impact by attacking the end uses of products and energy instead of attacking just the obvious large consumers of energy. This is a point of crucial importance in formulating policy and illustrates the combined power of an engineering and economic systems analysis.

Some examples of conservation goals which industry and government see as attainable are:

°A 20% industry wide reduction in energy per unit of output by 1980 relative to 1972.

°A 40% improvement in automobile gasoline consumption by 1980 relative to 1974.

°A 40% reduction in energy consumption of new commercial buildings.

°A 20% improvement in the conversion of fuels to electricity (40% raised to 50% conversion efficiency) by 1977.

There is considerable tension between government and industry over establishing even voluntary goals, much less mandatory ones. There is evidence of resistance to setting goals and providing data to evaluate attainments. The conflict between long-term benefits and actions which complicate a product or weaken market potential is going to exist for some time. Many proposed mandated goals are double the industrial goals. Consumer action goals are also being considered, both voluntary and mandatory.

A point which should be emphasized is that conservation is motivated by some or all of the following:

°A conservation ethic or moral commitment to conservation

°Economic necessity

°Legislative decree or other government action

Conservation Accounting-Criteria

Acceptable conservation actions are those which meet certain criteria. Rather than these being absolute criteria, they are relative to conditions at the time, past history and projections of future needs. The view of the present and future is dependent on the recognition of the constraints on possible actions and on a body of feeling called conventional wisdom. One of the goals of assessment is to examine conventional wisdom and put a systematic structure into arguments pro and con. In today's condition with uncertainties about reserves and technology some of the criteria are:

°Imported oil is "more valuable" than domestic.

°Natural gas is "more valuable" than domestic oil.

°Oil is "more valuable" than coal for stationary uses.

°Oil has no substitute for transportation uses.

°Low sulfur fuels have an undetermined premium over high sulfur fuels.

°Coal is "less valuable" than almost any other source.

Most other criteria depend on subjective ranking of political and social goals. These criteria apply simply to substitutions of fuels. The idea is that conservation actions guard the more valuable fuel form. It is already apparent in this short list that present conditions and intentions are not rigorously compatible with these criteria. There is national conflict of opinion over the level of importation of oil. Natural gas is treated differently depending on whether it is compared to domestic or imported fuels and whether it is controlled by federal regulation. The obvious great value of oil is tied to the large transportation demand. However, the smooth functioning of a refinery dictates that products other than transportation fuels must be produced. This precludes reserving even this one fuel to its unique use. The same contradiction exists in the uses of natural gas.

°Net Energy Reduction Criterion

In the area of curtailing demand for energy or products in the hope of reducing energy consumption, any criterion must carefully specify the accounting boundary in determining if net reduction in energy use has been achieved. The goal of achieving a net benefit by some action directed at reducing consumption should be immediately suspect in that the economic repercussions may be larger than can be controlled. There are many ways of defeating a criterion requiring a net energy use reduction. One way is to replace an activity with another which is more energy intensive or contributes more demand in another area, thus leading to a net increase in energy consumption. As an example suppose demand for clothing is reduced by making clothes last longer. On the surface this saves energy in the energy intensive natural or synthetic fibers. It also saves some money for the consumer. However, almost everything the consumer might do with his savings leads to more energy consumption per dollar and generates fewer jobs per dollar. Just paying taxes is 15% more energy consuming than buying men's clothes.

It is not clear that a criterion requiring an action to generate a net energy reduction can ever be checked. Without further specification of actions initiated after the given action there is no way of guaranteeing that the net effect is known.

Strict net energy accounting can be applied to simple substitutions of materials, components, or subsystem with a view to increasing efficiency. There are no simple criteria to evaluate the full system substitution or strategy substitutions. In assessing a major systems change, for example a portable fuel alternative to petroleum, the impacts would be so wide-ranging that conservation could not carry enough weight to be decisive. Only narrowly defined actions can be successfully assessed with respect to a few sharp criteria. The larger actions will require impacts and modeling of the whole picture of economic and social changes for assessment.

°Economic Criteria

In the class of economic criteria two simple ones are to minimize initial cost or minimize life cycle costs. The conservation oriented criterion is life cycle costs. For those activities in which fuel costs are a large share of operational costs, it probably follows that reducing operating costs reduces fuel consumption. The same caution that applied to net energetics applies here. Careful definition of the boundaries of the system and the level of inputs and outputs is needed in order to make comparisons.

°Technical Criteria

The role of technical criteria, such as those in existence or some which might be defined to reflect peculiarities such as form value of fuels or declining reserves, is not clear. The realities of the present situation are that little attention is paid to technical recommendations.

A Method To Overcome Obstacles

Energy conservation is one of many highly prominent topics today.

It has certain features which complicate the organization of discussion, problem formulation, analysis, and decision making. The features include:

°Direct personal impact on everyone

°Impact on life style, income, security, aspirations

°Connections to the "they" in life: big government, big business, big politics

°Involvement of known and speculative science and technology

°Large scale involvement of environmental, safety and health issues

°Elements of the infinite: whole nation, whole world, all time

°Appeal to moral and ethical standards

°An element of crisis

°The transient nature of opportunities to correct the system

These features produce a reaction that can be described as conventional wisdom. Some of these conventional wisdoms are shown underlined below (with counterpoints mentioned also).

°Conservation is good. What if it causes unemployment, decrease in productivity and wages, or results in more energy intensive activities?

°There is a semi-infinite source of economic, safe energy accessible except for some solvable technical problems. Technology has been wrong or failed to deliver with increasing frequency. The scale of associated problems and impacts is growing faster than the scale of the technology.

°Conservation measures can be instituted individually. This ignores the facts of interfuel competition and the ripple effect of changes throughout the economy.

°Conservation measures should be mandated. Even gradually initiated mandatory actions create dislocations which seem to cry for more action but must be accepted for some time to assess their size and impact.

°Conservation can alleviate the energy crisis without decreasing national prosperity. The embargo and changing car buyer attitudes clearly indicate that reduced demand either voluntarily or involuntarily will slow growth and impede recovery.

°Conservation and environmental costs should be internalized. Major industry, utilities, and consumers actively resist accepting either type of cost. Decision makers fear the reaction of constituents should these costs be assessed.

°Conservation can be achieved by gradual alteration of present energy use patterns. There are much greater potentials in full redesign of the energy system by beginning transitions now before supplies restrict options. No mechanism exists in government for accomplishing a system redesign of any major system. No method exists for assessing large scale social engineering before the fact.

This body of partitioned thinking, plus the status quo with respect to existing laws, regulations, investments, and job spectra, constitutes the source of a priori constraints on planning for conservation.

A method must be found and applied which transcends the prejudgment characteristic of conventional wisdom, identifies alternate courses of action compatible with a priori constraints, evaluates their actions, and assesses their impacts in terms of a posterion constraints and criteria. An important element of an evaluation leading to concrete decisions (not just to a "study conclusion") is that the final criteria must spell out tolerable limits to compromises in the solution. A characteristic of the conventional wisdom is that it is intolerant of compromise. The ECASTAR methodology is an attempt to overcome these obstacles.

5. ECASTAR METHODOLOGY

The methodology for the ECASTAR study was based on a systems approach to develop, display and characterize the problem of energy conservation. A number of tools were used in conjunction with the systems approach employed. The primary tools were -- INPUT/OUTPUT ECONOMIC ANALYSIS, NET ECONOMICS and NET ENERGETICS.

The ECASTAR result consists of:

°A methodology for examining energy conservation

°Three illustrative assessments -- national energy conservation, electrification, and diversification

°Some insights into conservation problem areas

There are many considerations between the objective of ECASTAR - to assess the potential for and impacts of various energy conservation actions - and the result. Some of these considerations include:

°Establishing a data base on energy in the energy industry, industry, residential/commercial and transportation sectors of the U.S.

°Developing constraints and criteria for evaluating conservation actions

°Identifying energy conservation actions in each sector and classifying those actions with respect to conservation mode

°Relating energy conservation actions in one sector to reactions or manpower, material, money and energy requirements in another sector.

°Evaluating the energy conservation actions with respect to energy and economic performance criteria and constraints

°Evaluating social, technical, cultural, political, energy and economic impacts of energy conservation actions

°Displaying the result

The above considerations are examined individually below.

Data Base

The ECASTAR data base was generated from documents as well as interactions with consultants from the public and private sectors. These interactions totaled over 180. In addition 148 proposed pieces of Federal legislation and 682 State actions were reviewed to give background to ECASTAR. The 600 page appendix of ECASTAR constitutes a distillation of the information processed.

Constraints and Criteria

Some of the constraints and criteria are more flexible in their application than others. This flexibility depends on the ranking given to a constraint or criteria. The lower the ranking is the greater the flexibility. The ranking is a reflection of the importance society gives to the technical, social, economical, environmental, legal and political constraints and criteria. An inflexible statement of a constraint is that actions must not be unconstitutional. A flexible but highly ranked criterion or set of criteria relate to "life styles" to improve or lead to minimal degradation.

The following is a list of statements and questions relative to constraints and criteria:

°Statements

The study shall be confined to the U.S. economy but interactions with foreign economies shall not be neglected.

Federal and State laws germane to energy conservation must be considered. Those laws or regualtions blocking a beneficial conservation action must be noted. If the proposed energy conservation action is not unconstitutional, then consideration should be given to recommending a change in the law/s and/or regulation/s.

Existing and proposed energy conservation efforts, economic, technical and social, within the legislative and executive branches of State and Federal government must be considered.

Parties at interest to energy conservation should not be overlooked. Identification of those who gain and those who lose must be included in the study. Losses must be minimized.

Present energy conservation actions in industry must be considered. ECASTAR proposed actions must not lead to sudden disruptions in the industrial sector. The disruptions of primary interest are productivity, employment and dislocations of business and industries.

"Life style" changes must be determined for any anticipated energy conservation action. "Life style" changes should be minimized as much as possible if the change means a degradation of "life style". Furthermore any change in life style should be orderly.

Capital requirements must be determined for anticipated actions and the selection of actions must be financially feasible. Financial feasibility should be considered in terms of U.S. gross national product projections and capital reformation.

Energy conservation actions must consider energy resources availability. Fossil resources should be conserved using the following priority -- gas, oil, coal.

All proposed energy conservation actions must be evaluated in terms of a net energy savings.

All energy conservation actions must consider environmental impacts and these impacts must be minimal.

The time frames for energy conservation should be

near-term	1975-1985
mid-term	1985-2000
far-term	2000-

These time frames are stated on the fact that (1) energy systems are currently projected to 1985 with reasonable certainty, (2) energy conservation of immediate impact must be accomplished starting now and continuing through the present U.S. energy transition period, (3) the mid-term recognizes that any changes of the U.S. energy system beyond 1985 must be planned now and those changes will probably "buy time" for major changes based on technology around the year 2000.

°Questions

Does the action increase jobs, increase economic activity, lower costs, pay for itself, increase profits, stabilize energy supplies to the individual user, prolong usefulness of investment, encourage new investment, remove inconvenience, create a sense of security, enhance life style?

Does the action satisfy the needs for fuel in specialized forms, save certain fuels (not necessarily BTU's), impact immediately or in the very near term (e.g., 0 to 3 years), decrease dependence on unstable supplies, increase supplies, prevent profiteering, level supply with time, recognize resource limitations in making fuel choices, increase environmental strain, increase perception of danger, decrease uncertainty about technical and economic feasibility of options, subsidize technical or economic performance, recognize geo-political factors in fuel sources or fuel choices, distribute shortages equitably, increase direct efficiency, reduce unnecessary end-use, penalize selected end-uses and end-use patterns, satisfy legal constraints or achieve variance?

Does the action optimize the system, solve the problem instead of altering it, save energy and other resources on a net energetics basis, remove potential sources of a future energy problem, preserve economic and technical incentives, preserve economic and technical strength for future major redesign of the energy system, establish a foundation of knowledge and experience in advanced technology, preserve economic strength to meet major social demands, promote development of industries and infrastructures less sensitive to fuel form and supply, increase the stability, flexibility, and adaptability of the energy system, provide for the transition to the next generation of fuels and uses, increase reliable options, allow for alleviation and solution of problems of urbanization, distribute unavoidable impacts equitably?

Some of the user criteria questions relate to supplies of special fuels which depend on supplies of large volume products or supplies for non-fuel purposes or specialized end-uses. Natural gas is singled out immediately as having special non-fuel end-uses, and specialized clean fuel uses. Aviation fuels depend on the production in parallel of other transportation fuels which in turn depend on the production of unspecialized products like heating oil to compensate seasonal demand. Some inhouse electrical generation which indirectly saves oil or gas in turn depends on the need for coke and has attendant pollution problems.

In summary there are few if any strictly technical or strictly time independent criteria in the energy system or in conservation.

Identifying and Classifying Energy Conservation Actions

Various energy conservation actions germane to the four sectors were identified and screened to determine some of the major actions that might be taken. Some of these actions by sector include:

- °Energy Industry
  Coal gasification, in situ shale oil production, improved recovery techniques for oil and gas, importation of liquid natural gas, and deregulation of natural gas prices.

- °Industry
  Increased combustion efficiency, process improvement, and good housekeeping.

- °Residential/Commercial
  Reduce consumption and increase efficiency of buildings and systems for HVAC, reduce consumption and increase efficiency of domestic hot water systems, install heat pumps in 100% of electrically heated single family residences in period 1975-1985, use solar energy for space heating and cooling and hot water heating, and mandate standards for lighting in all new and existing commercial structures.

- °Transportation
  Substitute alternate fuels for petroleum, reduce demand for transportation, improve efficiencies in transportation systems, and change existing government regulations on transportation.

Relating Energy Conservation Sector Actions To Other Sectors' Requirements

Actions by sector were related to other sectors in two ways: (1) input/output analysis, and (2) considering actions in sets which constitute the scenarios or strategies of national energy conservation, electrification and diversification.

Input-output analysis was seen as a tool which would allow the group to evaluate the multiple impacts of either a specific conservation action or a set of actions occurring simultaneously in an economy. The tool was modified in a way that would permit the tracing of both labor and energy flows. Thus an action which originated in one industry but impinged on all industries could be systematically monitored. One novel use of the analysis was in the identification of conservation targets of opportunity. The pinpointed "targets" were intermediate interindustry product flows which, while not being large in terms of dollar flows, were nonetheless large in terms of BTU flows.

Evaluating Actions With Respect To Constraints and Criteria

NET ENERGETICS and NET ECONOMICS were considered in evaluating energy conservation actions. Net energetics accounts for initial energy use, life cycle energy use, and the embedded energy in manufacturing and raw materials including energy required for production and transportation. Net economics is the analog of net energetics and concerns life cycle cost. Life cycle cost combines first cost with the expected energy costs over the life of the system. The system with the lowest life cycle energy (or life cycle cost) is deemed the most effective system.

Related to the attempt to minimize effort or expense is the concept of waste. One might consider waste as the measure of how much effort and expense a process uses over its respective minimum. The problem of identifying waste may be reduced to evaluating alternate inputs to the process or to evaluating the size and character of the rejected streams of energy and materials. One principal reason for actual efficiencies never matching theoretical ones is that the constraints of time, materials, money and markets determine the system's operating point. Within the system, there are various forms of waste that may be identified. They are not all inclusive nor mutually exclusive. They are mentioned to depict some important problem areas. One can consider outright energy waste as that consumption which can be stopped with little or no expenditure of labor, capital or other costs. System waste may flow from the types of production and consumptive devices which employ energy, the forms in which energy inputs are utilized, and/or the failure to take into account the recycling potentials of the components of the system. Some of these may be easily correctable, but others may entail a complete restructuring of present systems.

Constraints and criteria have been discussed. Each action was examined against those constraints and criteria to determine the desirability of a particular action or set of actions.

Evaluating Impacts of Energy Conservation Actions

The group constructed the ECASTAR energy input-output matrix and used it to investigate the positive and negative aspects of impacts on the economy resulting from a conservation action or set of actions. The model uncovered material bottlenecks, potential labor shortages, and effective conservation actions.

Displaying The Result

ECASTAR and this summary constitute two displays of the results.

6. EXAMPLE OF INPUT-OUTPUT ANALYSIS

The ECASTAR energy input-output model consists of thirty sectors. Represented in this group of thirty are five energy producing sectors, fifteen manufacturing industries, two residential and commercial sectors, and eight service industries. The list of sectors is given in Table 1. The model is capable of tracing impacts of an action in three dimensions: dollars, BTU's of energy, and labor.

TABLE 1. INDUSTRY GROUPS CONTAINED IN THE ECASTAR INPUT-OUTPUT MODEL

Group	Group Title
1	Livestock, agricultural products, forestry products and related services (SIC 01-09)
2	Iron, nonferrous mining (SIC 10)
3	Coal mining (SIC 11-12)
4	Crude petroleum and natural gas (SIC 13)
5	Stone, clay mining, chemicals and fertilizer mineral mining (SIC 14)
6	New construction, maintenance and repair construction (SIC 15-16)
7	Ordnance and accessories (SIC 17-19)
8	Food and kindred products, tobacco manufactures (SIC 20-21)
9	Textiles, apparel, textile products (SIC 22-23)
10	Lumber, wood products, furniture (SIC 24-25)
11	Paper and allied products (SIC 26-27)
12	Chemicals and allied products (SIC 28)
13	Petroleum refining and related industries (SIC 29)
14	Rubber, leather products (SIC 30-31)
15	Glass, glass products, stone and clay products
16	Primary Metals (SIC 33)
17	Metal container, fabricated metal products (SIC 34)
18	Machinery (SIC 35)
19	Household appliances (SIC 363)
20	Electric lighting and wiring equipment (SIC 364)
21	Miscellaneous electrical machinery (SIC 36)
22	Motor vehicles and other transportation equipment (SIC 37)
23	Miscellaneous manufacturing (SIC 38-39)
24	Transportation and warehousing (SIC 40-47)
25	Communications, except radio and TV (SIC 48)
26	Electric utilities (SIC 491)
27	Gas utilities (SIC 492)
28	Water and sanitary services (SIC 494)
29	Wholesale and retail trade (SIC 50-52)
30	Other services, government enterprises (SIC 60-80)

Conservation Actions Considered

°A 30% increase in fuel efficiency applied to the chemicals and refined petroleum groups.

°A 40% reduction in fuel used in the transportation and warehousing group.

°Manufacturing of smaller automobiles using 25% less steel and rubber

°A communications/transportation trade-off.

Results of Input-Output Analysis

°Industrial Fuel Efficiency Action

Using advanced technology it was suggested that by 1985 fuel efficiencies can be increased by 30% in the chemical and petroleum refining industries. The impact on total BTU's purchased will be 30 times the proportion of transacted energy going for combustion purposes. A rough, conservative estimate for the chemicals and refining sectors is 70% [CAC-74]. Thus, the direct impact on total BTU's will be a decrease of approximately 20%.

If this reduction was achieved with no change in output there would be no major identifiable indirect impacts. As a result of this lower energy requirement, the amount available to other sectors would increase.

The use of advanced technology means that the transacted BTUs per dollar output value would be lowered. A majority of the output produced by the chemical and petroleum refining sectors is sold as inputs to other industries--not directly to final markets. Thus, the increased efficiencies obtained in these two sectors are distributed throughout the interindustry structure. An increase in the final demand for a product which has a large amount of embedded chemical product input implies that the overall product efficiency will increase, if the energy imbedded in the inputs is "charged" to the output sector. Through this accounting scheme, the combined impact of a change in final demand and the increased fuel efficiency can be assessed. Final demand, not total output, drives the demand side of the system. Total output is of interest primarily when actual output is less than estimated total output. To put it another way, knowing that the BTUs per dollar of chemical output has declined is of little value until you know where and how much of it ends up in other industries. A change of the energy accounting scheme helps identify energy flows, and particularly those that are "targets of conservation potential." The structure and composition of final demand are quite important when impacts of engineering actions are evaluated. An extreme example would be a process which cuts energy consumption by a large percentage. If this industry has a small, static level of final demand, the process improvement may not make even a marginal impact.

°Reduction In Freight Fuel Requirements Action

A 40% reduction in the transportation and warehousing group, which includes railroads, motor freight, air transport, and water transport, would imply savings of 1.74×10^{15} and 2.06×10^{15} BTUs in 1980 and 1985 respectively. For given prices of fuels, a 40% reduction of fuel use has the added impact of moderating the cost of transport and hence ultimately the cost of final goods and services.

Since prices cannot be explicitly estimated from the I-O model, some potential impacts can only be suggested. If fuel use in transportation decreases, what happens to transport prices? Would there be any shift to rail and water transport? There are many indirect impacts to be examined if any substitution is involved.

°Altered Automobile Requirements Action

As an example, the model was applied to the known data base of 1967.

In 1967 the automobile sector produced total output valued at 73.5 billion (1967) dollars. In producing that output the industry required over 6 billion dollars of input from the primary metals industry and over 1 billion dollars of input from the rubber and allied products sector. A 25% reduction in steel and rubber required by the transportation manufacturing industry would have resulted in a 3% decline in output from primary metals and a 1.5% decline in output from rubber and allied products. The direct energy impact would have been a reduction of $.3 \times 10^{15}$ BTUs.

These reductions imply a reduction in employment of 40,000 in primary metals and 13,000 in the rubber industry. Note that these numbers are rough estimates only. The level of aggregation used in the ECASTAR model does not permit a refinement in the estimates--one would have to utilize a larger I-O model.

A reduction in output of this magnitude would have caused subsidiary impacts in the economy. What would have happened to final demand as a result of a shift away from heavier cars? Suppose the value of transportation output stayed constant. Then the reduction in steel and rubber implies decreases in the final demands for all sectors included in the model. The cumulative effect of the reductions in primary metals and rubber would have amounted to .8% of 1967 GNP. This reduction would have been accompanied by a decrease of over 400,000 in total employment. The new levels of final demand imply new levels of output. This iterative process would continue until all the indirect effects were included.

The auto example shows the possibility of many potentially important indirect impacts. For example, if primary metals production is down and workers are laid off, what subsidiary impacts are likely to play havoc with the pattern of final demand? Sales of durable consumption items usually do not fare too well in sluggish times, nor do auto sales. If smaller cars are priced on a level with larger cars such that sales do not increase, the accumulation of inventories (excess supply) impacts on the production cycle. A 20% decline in auto sales will reimpact on primary metal production, this time with more force, as well as on all other sectors. It would be a mistake to peg economic growth solely with energy growth. While the two are casually related, there is no fixed relationship governing GNP growth. A recession brought about by adopting questionable actions in the name of conservation would be an extremely myopic and costly strategy.

°Communication - Transportation Trade-Off Action

The possibility of conserving energy by substituting communications for transportation was considered. What would happen to employment and BTU use if 1 billion dollars were shifted from the transportation and warehouse sector to the communications sector? Most of the substitution would originate in industry. The transportation-warehouse group included travel for business purposes. No other category, except possibly wholesale/retail trade, appeared to be directly impacted by the substitution.

Direct additional energy use in the communications sector would increase by 1.0×10^{12} BTUs. Energy saved in the transportation-warehouse group would be approximately 60.5×10^{12} BTUs, or a 60 fold savings. A one billion dollar increase for communications would imply an additional 44,000 jobs. A one billion dollar decrease in transportation would imply a loss of close to 54,000 jobs. The indirect effects would center on communication equipment manufacturing, fabricated metals, chemicals and allied products,transportation manufacturing, primary metals, petroleum refining, and stone, clay, and glass products. The indirect effect on the final demand for manufactured trucks and automobiles is a decline of nearly 25 million dollars; the indirect effect on wholesale and retail trade is a decline of 85 million. These effects together amount to a decline of over 10% of the initial output change. These indirect negative impacts are not offset by positive impacts accrued by increasing output in the communications sector.

The picture becomes more complicated if the structure of retail and wholesale trade is greatly altered. For this type of trade-off to make an imprint, a change in final demand far greater than 1 billion dollars is required. At higher levels the inputs needed by an expanding communications industry may well be the bottlenecks. The input-output model can be used to simulate alternative magnitudes of trade-offs--which would yield measurement of the indirect requirements. Growth in the communications sector has a different implication than does growth in the transportation sector. These changes would need to be examined closely. This is but one example which suggests that conservation can be achieved by altering the sector shares of GNP; thus altering the composition, not the size, of the economic pie. It is not clear that effecting a redistribution permits one to keep the same sized pie. The communications/transportation trade-off suggests that, primarily because of indirect effects, the pie would shrink, i.e. GNP would decline.

The four examples given above illustrate what can be done using an input-output analysis. ECASTAR does not give an in depth picture of indirect impacts but emphasizes the need to consider such impacts.

7. THREE STRATAGIES FOR CONSERVATION

The three strategies considered as energy conservation oriented are NATIONAL ENERGY CONSERVATION, ELECTRIFICATION, and DIVERSIFICATION.

7.1 NATIONAL ENERGY CONSERVATION - NEAR TERM (NOW - 1985)

The actions considered were as follows: (1) roll back the price of newly discovered oil; (2) force conversion of many power plants from gas and oil to coal; (3) freeze gasoline production for 3 years at 1972 levels; (4) mandate automobile mileage improvements; (5) require industry to improve energy efficiency; (6) require manufacture of household appliances with greater efficiency. The results, based on the Input-Output analysis technique, showed that considerable gas and oil would be saved by forcing switches to coal. However, the large scale switch to coal was shown to require greatly increased outputs from many other industries. These outputs (called indirect requirements) in turn required more energy. It was estimated that nearly 2.5 quads of additional coal were needed to produce these indirect requirements.

Also, the indirect requirements created more jobs. If the switch to coal use is the only action considered, the increase in projected employment is quite large. If the switch to coal is assessed in conjunction with actions (3) - (6), the indirect requirements and consequently increased employment are significantly less. This illustrates the Group's philosophy that the impacts of energy conservation can be both unexpected and large. Consequently, all actions must be carefully analyzed before they are implemented.

Each of the six actions is described and discussed in more detail in the succeeding paragraphs.

<u>Oil Pricing Proposal</u>

This action is to immediately lower the price of currently uncontrolled domestic "new" oil from $11.28 to an average of $7.50 per barrel, and over a period of time raise the price of controlled domestic "old" oil from $5.25 to $7.50 a barrel. Certain high recovery cost oils would be priced at an average $8.50 a barrel. In addition, an inflation and adjustment factor is included. Essential to the proposal is the satisfaction of two criteria;

°To increase domestic production

°To reduce the price of energy to the consumer

Increased Use Of Coal

This action provides for the utilization of coal in all power plants with existing coal facilities and for the conversion of sufficient natural gas fired plants to alleviate natural gas shortages. The FEA has reviewed the status of existing power plants and has found 155 boilers at 79 stations with a combined capacity of 25,000 MW which could be converted to coal without major modification. In addition it is proposed that a sufficient number of gas fired plants are converted to oil to overcome a deficit of 1.1 trillion cubic feet/year of natural gas.

These combined actions would reduce natural gas requirements in existing power plants from 3.4 to 2.3 MMCF/year, oil requirements from 527 to 505.9 million bbl/year and increase coal needs from 389.3 to 427.3 million tons/year. At $11/bbl for oil, the direct improvement in the balance of payments would be $233 million/year. One problem is that of obtaining sufficient coal supplies. Both power plant construction and mine development require significant lead times so that future coal requirements and availibility may be projected at least three years with a relatively high degree of accuracy. The scheduled startup of new fossil fuel-fired plants and the opening of new mines show no expected surplus of coal by 1977. However, it was found that an additional 31.4 million tons/year might be produced by 1977 if an aggressive development program were undertaken today. While this is still somewhat short of the 38 million tons/year required for all FEA conversions, it does indicate that the conversion process could be completed before 1980. In the interim period it may prove advantageous to import coal to alleviate any transient deficit.

Restriction Of Gasoline Use

During the period of the embargo in 1973 which was imposed on us by the OPEC countries, there was a short supply of most petroleum products. As a consequence, Congress passed the Emergency Petroleum Allocation Act in an attempt to ensure that all regions of the country were dealt with in an equitable manner by the oil industry. Allocation agencies or state energy boards had authority to implement these regulations. The EPAA expiration date is August 31, 1975, so these agencies are still in existence even though the embargo has been lifted and there are presently adequate supplies of fuel.

Because fuels are readily available, gasoline consumption is again increasing. This consumption would increase faster if oil is regulated at lower prices. To prevent higher rates of gasoline consumption, it is desirable to consider an action that would keep gasoline consumption at a fixed level equal to that of 1974. To achieve this fixed level implies that the allocation policies would have to be retained, i.e. the EPAA would have to be continued.

An auxiliary action that has a bearing on this is the possibility that regulations may be passed aimed at increased fuel economy for automobiles. Large fuel savings can be achieved by increasing fuel efficiency, but the automobile manufacturers must have lead times to realize improvements. Since it is believed that quite significant economies can be realized by 1978, it seems reasonable to continue allocation through that year. Further, allocation enforcement for three years may lead increasingly to public resentment. For these reasons, it is proposed that the allocation period should begin January 1, 1976, and run through December 31, 1978. Since the President of the United States must execute the program, it is intended that he should be given extraordinary powers to carry out this action. If it is found that a fixed level of gasoline consumption can be easily met, it would be desirable to give the President power to achieve further reductions in end use if possible. It is proposed that he would be allowed to achieve another 4% reduction in gasoline usage if feasible under recognized socio-economic constraints. In later discussion, the probable effects of this action will be studied.

Mandatory Automobile Efficiency

This proposal is to set minimum average miles per gallon requirements on the yearly production of autos manufactured as follows:

MODEL YEAR	MPG
1978	18.5
1979	19.5
1980	20.5
1985	28.0

Industrial Efficiency Improvement

Approximately 40% of all energy consumed in the United States is used by industry. Of this amount, approximately 70% (9 x 10^6 barrels/day) is consumed in manufacturing, and over 80% of the latter amount (22% of all U.S. energy) is used by the 2,000 largest energy consuming manufacturers.

Studies by the FEA have indicated (a) that very substantial savings of energy consumption per unit of product can be achieved by most industrial firms and (b) that over 27% improvement in energy efficiency per unit of output could be achieved by 1990 in six energy-intensive primary goods industries.

This action assumes that these industries could accomplish a voluntary 20% reduction in energy consumption by 1985. The program would be voluntary since many people feel that rising fuel costs will be sufficient incentive for industry to reduce consumption. In fact, many companies have already indicated that such reduction percentages are fully within their capability. This may be an understatement of their potential in view of the fact that several industries have already reduced their energy consumption by more than 7.5% by simply implementing non-captial intensive good housekeeping measures. The FEA estimates that approximately 2 x 10^6 barrels of oil equivalents/day (4.2 quad/year) can be saved if the 2000 largest energy consuming manufacturers improve their energy efficiency by 20% by 1981.

Although this reduction in consumption is believed to be well within the capability of most manufacturers, it is the general consensus that such savings can be attained only if the top management officials of each firm work diligently to achieve the objective of improving each firm's energy efficiency.

Since most of the non-capital intensive, good housekeeping type conservation measures have already been implemented in attaining the approximately 7.5% savings discussed above, the remaining reduction in consumption would require a capital commitment of varying degrees.

Energy Labeling And Efficiency Standards For Appliances

Energy used in the residential sector accounts for 19 percent of total energy consumed in this country. In 1970, 95% of residential energy consumption was for the following end uses: space heating (68%), water heating (15%), cooking (5%), refrigeration (3%), clothes drying (2%) and air conditioning (2%). Thus this area offers high potential for energy savings, and considerable attention has been focused on increasing the efficiencies of appliances to effect these savings.

This action calls for the achievement of a 25% reduction in energy usage of new major energy consuming consumer products relative to their output by 1980 as compared to their usage in 1974.

Input-Output Analysis Of National Energy Conservation

Let S refer to actions relating to substitution of coal for oil and gas. Following the discussion of the six proposed actions, substitution refers to a 100% switch away from gas and a 50% switch away from oil to coal in generating electricity. Let E refer to actions directly impacting on industrial energy efficiency. The major action is a proposed 20% improvement in industrial energy use in the time frame 1985. Let C refer to actions which impact on the consumption sector. Included in this category would be mandated improvements in miles per gallon and home appliance operation efficiency.

The assessments of actions in sets S and E were made using the ECASTAR energy input-output model. Actions in set C were evaluated outside the context of the I-O model. The years 1967, 1980, and 1985 were selected in order to trace what the secondary impacts were likely to be. Each time period is analyzed separately.

°1967-The Base

Energy source requirements for 1967 are presented in Table 2. If the proposed actions which directly impacted on industry had been implemented in 1967, overall industry energy savings would have been approximately 12.5%. Note that industry includes mining, construction, manufacturing, and services. The direct impact of substitution is a shift in the source requirements. In 1967 over 3 additional quads of coal would have been needed. Substitution raises an interesting question. Was there the excess capacity to produce 3 more quads of coal? Would there have been sufficient quantities of inputs into coal mining -- water, steel, rail cars, employment? The magnitude of these secondary requirements determines how feasible the substitution is. Note also that since the ECASTAR model does not have a nuclear sector, some of the burden which falls on coal will be directed to alternative energy sources -- nuclear, for example.

The indirect impacts of substituting coal for oil and gas are substantial. In 1967 dollars, the substitution would have implied a billion dollar increase in coal production. To achieve this additional production almost 3/4 of a quad of additional energy would have to be used. Furthermore, the increased coal production would require:

primary metals output to increase by 2%

water output to increase by 1 1/2%

machinery output to increase by 1%

vehicle manufacturing (primarily rail) output to increase by 6%

transportation and warehousing output to increase by 3%

The implied indirect increases in manpower would be an additional:

45,000 for coal mining

27,000 for steel manufacturing

117,000 for transportation equipment

85,000 for transportation

While these estimates need to be qualified, given the aggregation inherent in the model, they nonetheless point out that major secondary impacts are likely to occur. These gains, moreover, are not offset by the decline in gas and oil allocated to electric utilities.

The direction and magnitude of the indirect impacts suggest that substitution may be more easily implemented when the economy is slack. Such substitution might well fuel an economic recovery. However, adopting substitution when the economy is rapidly moving towards full employment will necessarily increase competition for industry output. A trade-off in a growing economy, between energy substitution and other areas of growth, could well alter patterns of investment and consumption for years to come.

TABLE 2. COMPARISON OF ENERGY REQUIREMENTS UNDER VARIOUS CONSERVATION ACTIONS 1967

($x10^{15}$ BTU'S)

Action(s)		COAL	REFINED PETROLEUM	NATURAL GAS	TOTAL
Base	(1)	14.8	26.1	18.45	59.35
S	(2)	18.1	25.6	15.65	59.35
S and E	(3)	15.7	20.8	15.30	51.80
E	(4)	12.5	22.0	17.9	52.40

(1) Base Case-Bureau of Labor Statistics

(2) Substitution Actions (Coal for oil and gas as discussed)

(3) Substitution and industrial efficiency improvements

(4) Industrial efficiency improvements only.

TABLE 3. COMPARISON OF ENERGY REQUIREMENTS UNDER VARIOUS CONSERVATION ACTIONS 1980

($x10^{15}$BTU'S)

Action(s)		COAL	REFINED PETROLEUM	NATURAL GAS	TOTAL
Base Case	(1)	24.6	34.9	39.9	99.4
S	(2)	34.0	37.86	27.5	99.36
S and E	(3)	31.72	32.70	25.0	89.4
E	(4)	24.17	33 45	32.56	90.18

(1) Base Case-Bureau of Labor Statistics

(2) Substitution Actions (Coal for oil and gas as discussed)

(3) Substitution and industrial efficiency improvements

(4) Industrial efficiency improvements only.

TABLE 4. ADDITIONAL REQUIREMENTS ASSOCIATED WITH THE SUBSTITUTION STRATEGY 1980

Industry group	Additional output growth required %	Additional labor required 10^3
Primary metals	0.8	11.0
Water	1.0	0.6
Machinery	2.0	84.0
Transportation manufacturing	0.3	4.0
Transportation	2.3	92.0
Retail/wholesale trade	0.4	50.0
Chemicals and allied products	1.1	10.0

Implementing only the industrial efficiency standards would have produced an 11% reduction in overall energy use in 1967. The indirect impacts associated with efficiency improvements are far less than for substitution. The major drawback to a policy aimed only at increasing efficiency is that it may not reduce the energy requirement of oil and natural gas enough to curtail imports. This presents serious problems in the 1985 case -- where estimated natural gas requirements are over 40 quads.

°1980 Projections

Estimated energy demand by source for 1980 is given in Table 3. The 1980 base case was based on the Bureau of Labor Statistics projected estimates for 1980 and 1985. This case is very much like a historical growth extrapolation. While historical growth is unlikely to pace the future, it is nevertheless instructive to compare the effectiveness of conservation actions to this standard.

By 1980, if the substitution strategy had been followed, the additional requirement in coal production would be almost 10 quads. If both the substitution and efficiency strategies were followed, almost an additional 6 quads of coal would be needed.

The indirect requirements in terms of quads needed to produce the additional coal would be 2.4 quads for substitution only and 1.4 quads for both substitution and increased efficiency. Table 4 highlights the additional requirements which would be necessary to permit the substitution. Note that these projections are requirements above the 1980 projected output levels. A detailed analysis of each major industry's capacity to expand would be necessary to complement the assessment of substitution.

Those numbers should be compared relative to the projected growth of the input industries. Table 5 provides a perspective of what an additional 1% in growth implies. Employment estimates do not take productivity changes into consideration.

Table 6 presents energy requirements under the assumption natural gas demand is held constant at 1974 levels. Considerable quad savings can be brought about by accepting a 1.5% decrease in GNP relative to what it would have been for the 1980 base case. It has been pointed out in earlier chapters that a reduction in final demand will imply overall energy savings. Note, however, as final demand falls, so does GNP.

°1985 Projection

Tables 7, 8, and 9 summarize the energy and related input requirements for various cases in 1985. The S and E conservation program appears to save 11%, relative to the 1985 base case. However, to bring about the substitution, another 2.5 quads of indirect, imbedded energy would be required.

TABLE 5. PROJECTED OUTPUT GROWTH FOR SELECTED INDUSTRIES FROM 1967 to 1980

INDUSTRIES	1967 TOTAL OUTPUT ($ x 10^9)	1980 TOTAL OUTPUT ($x 10^9)	1967 EMPLOYMENT (x 10^3)	1980 EMPLOYMENT (x 10^3)
Primary metals	50.9	86.5	1350	2220
Water	2.8	4.0	46	59
Machinery	63.6	111.0	1390	4180
Transportation manufacturing	70.4	125.0	1950	3320
Transportation	46.8	75.6	2830	4060
Retail/wholesale trade	162.0	256.0	16150	25300
Chemicals	46.5	84.9	1001	1800

TABLE 6. COMPARISON OF ENERGY OUTPUT REQUIREMENTS UNDER VARIOUS CONSERVATION ACTIONS ASSUMING FINAL DEMAND FOR NATURAL GAS IS FIXED AT 1974 LEVELS

(x10^{15}BTU'S)

Action(s)	Coal	Refined Petroleum	Natural Gas	Total
Base (1)	26.1	38.5	30.1	94.7
S (2)	33.9	37.9	22.5	94.4
S and E(3)	31.7	32.6	20.4	84.7
E (4)	24.2	33.3	27.5	85.1

(1) Base Case-Bureau of Labor Statistics

(2) Substitution Actions (Coal for oil and gas as discussed)

(3) Substitution and industrial efficiency improvements

(4) Industrial efficiency improvements only.

TABLE 7. COMPARISON OF ENERGY REQUIREMENTS UNDER VARIOUS CONSERVATION ACTIONS

1985

($x10^{15}$BTU'S)

Action(s)	Coal	Refined Petroleum	Natural Gas	Total
Base core(1)	29.0	49.0	44.0	122.0
S(2)	41	48.3	33.0	122.3
S and E(3)	37.1	44.0	31.0	112.1
E(4)	28.6	46.2	41.7	116.5

(1) Base Case, Bureau of Labor Statistics

(2) Substitution action (coal for oil and gas as discussed)

(3) Substitution and Industrial Efficiency Improvements

(4) Industrial Efficiency Improvements Only

TABLE 8. ADDITIONAL REQUIREMENTS ASSOCIATED WITH THE SUBSTITUTION STRATEGY (1) 1985

Industry Group	Additional output growth required %	Additional labor required 10^3
Primary metals	1.8	14
Water	1.4	1
Machinery	3.2	1
Transportation Manuracturing	0.45	41
Traasportation	3.5	99
Retail/wholesale trade	0.7	71
Chemicals	1.5	12

(1) Substitution Strategy is switching 100% away from natural gas and 50% away from oil as discussed

TABLE 9. PROJECTED OUTPUT GROWTH FOR SELECTED INDUSTRIES FROM 1980 to 1985 (1)

Industries	1980 Total Output $ $x10^9$	1985 Total Output $ $x10^9$	1980 Labor $x10^3$	1985 Labor $x10^3$
Primary Metals	86.5	104.2	2220	2760
Water	4.0	4.5	59	65
Machinery	111.0	136.1	4180	5100
Transportation Manufacturing	125.0	144.0	3320	3800
Transportation	75.6	90.0	4060	4600
Retail/wholesale trade	256.0	300.0	25300	29600
Chemicals	84.9	104.0	1800	2200

(1) [illegible] of Labor Statistics

TABLE 10. COMPARISON OF ENERGY REQUIREMENTS UNDER VARIOUS CONSERVATION ACTIONS ASSUMING DEMAND FOR NATURAL GAS FIXED AT THE 1974 LEVEL
1984
($x10^{15}$BTU'S)

Action(s)	Coal	Refined Petroleum	Natural Gas	Total
Base(1)	33.2	48.9	32.9	115.2
S(2)	40.86	47.5	25.8	114.2
S and E(3)	38.0	41.0	23.2	102.2
E(4)	31.1	43.2	29.5	103.8

(1) Base Case Bureau of Labor Statistics

(2) Substitution action (coal for oil and gas as discussed)

(3) Substitution and Industrial Efficiency Inprovements

(4) Industrial Efficiency Improvements Only

TABLE 11. ESTIMATES OF SAVINGS FROM CONSERVATION ACTIONS IN SET C [a]

1985
($x10^{15}$BTU'S)

	Consumption of refined petroleum	Electricity consumption	Natural gas consumption	Total
1967 Base	10.7	1.2	4.4	16.3
1985 Estimated Base [b]	22.2	2.3	8.7	33.2
Savings[c] from actions in Set C	1.78	.24		2.02
Savings in coal				.75
Total Savings				2.77

a) Actions considered were 100% increased in MPG in 1985 and 25% increase in appliance operating efficiency in 1985.

b) Estimated by extrapolating 1967 base along historical growth curve.

c) Savings were computed by assuming standards affected 10% of the fleet of cars in 1985 and 25% of all appliances in 1985.

Table 10 describes the energy requirements if the final demand for natural gas was held constant at its 1974 level. At best a 16% reduction relative to the 1985 base case can be achieved -- at a cost of 1% in terms of GNP growth from 1980 to 1985.

Extreme care should be used when assessing these numbers. First, the proposed actions were made to impact immediately within any one year. A gradual scheduled shift would help moderate the impacts. Secondly, all the feedbacks were not assessed via an iterative procedure. Reaction to prices and output constraints was not built into the model. Finally, other energy sources were not fully accounted for.

It does appear, however, that because of the recent economic slump and the reluctance to deregulate natural gas, conservation aimed at increasing efficiency may help reduce consumption to approximately 104 quads by 1985.

Actions contained in set C were considered in the 1985 case only. Table 11 presents rough estimates of the savings brought about by these actions.

Summary

The previous tables characterized estimates of the effectiveness of a set of actions in an economy moving along a historical growth curve. Included with these numbers were estimates of some of the subsidiary impacts. While it was recognized that more refinement in the model is required, the model nevertheless uncovered certain areas which deserve close monitoring -- among them production in the transportation, primary metals, and machinery industries. Simulating the model under various sets of assumptions is necessary in order to assess the sensitivity of the economy to certain impacts. Some variables which deserve attention are: energy industry capacity, steel output, prices, GNP growth, unemployment, and aggregate demand. Impacts which result from a change in government spending should also be analyzed. This is particularly important if the government plans to underwrite research and development and technology assessment in the energy area. For example, the decision to go electric, using nuclear and coal as primary fuels, implies a host of direct and indirect impacts that need to be taken into account.

7.2 ELECTRIFICATION - MID TERM (1985 - 2000)

Electrification is a set of actions and/or policies that leads to an increasing proportion of total energy used in the form of electricity. The electric utility industry is a true energy delivery system in the precise meaning of the systems method. It is a major component of the energy picture today and of every scenario of the foreseeable future. As an energy system the utility industry is controlled completely by its system environment: fuel suppliers, equipment suppliers, governmental regulations, and consumption habits. In the mid-term, electricity is the major alternative to direct use of scarce fossil fuels. Electrification has been chosen for an assessment of conservation impact because it is almost the sole consumer of coal and nuclear power, and because electrical end use can be made to have higher overall efficiency than many present direct fuel uses.

The important actions within electrification examined here are those with the greatest impacts (coal and nuclear), the greatest technological requirements (peak shaving and transmission) and the greatest response from the decision makers (economic health and growth of utilities in an era of increasing energy costs).

Energy Industry Actions

Of direct interest in the electrification of the U.S. economy are subactions taken by the energy industry itself. These, together with the concurrent actions of the other sectors, will have significant impact on the domestic energy future. The major actions discussed in this section involve increased use of coal and nuclear fuels and the improvement of the operations of electric utilities.

°Increased Power Generation From Coal Action

The use of coal in the U.S. now and in the future represents an ideal subject for a systems study. The final form of a coal economy is not determined now because of the many developing technologies. All phases of the coal industry are under reassessment.

Fossil fuel power plant designs have shifted essentially 100% to coal in the last three years. There is strong support in Congress and FEA to mandate retrofits wherever possible of both power plants and process steam generators. This latter action is an outgrowth of the crisis atmosphere of the energy problem. In the long view, in an electrified economy, the retrofitting of the existing plants will be a minor factor. There is evidence that this retrofitting will be delayed slightly by the too slow expansion of coal supplies.

The largest requirement in conversion to coal is not the mining, trains, or equipment but environmental and health protection. This protection requirement begins at the mine with health, safety and reclamation and continues to the disposal of the varied combustion products such as ash, dust, sulfur compounds, toxic metals, carbon dioxide, and rejected heat. There is some sentiment, prompted again by the crisis, to relax environmental standards in order to facilitate the transition in the near term. This essential requirement of cleaning up the coal system is projected to add to the cost of coal-generated electricity and is the major obstacle to implementing coal conversion. Along with many other elements of the energy problem, the major design decisions necessary to determine an integrated system are awaiting some near-term and mid-term development results.

The scale of the materials handling problem associated with a coal electric economy is staggering. This is compounded by the simple fact that coal must be handled several more times in its fuel cycle than oil or gas. Thus the first area of awaited developments is in the transport of coal and all the associated by-products. The transportation problem is complicated by the dispersed sources of the fuel and its concentrated consumers. Materials handling is one of the factors driving coal conversion to liquid or gaseous form. Significant problems related to delivery, handling, and storage of coal can be expected as plant sites become more scarce. A key obstacle to retrofitting existing plants is the lack of space for stockpiles and even access to railroads. Some of these problems will be reduced or eliminated if economical conversion methods can be developed. Estimates of the time for large-scale availability of coal intermediates is post-1985.

An orderly development of a coal-electric system would suggest growth sufficient to meet base load growth (with nuclear) until intermediate processes are developed which can simplify the handling and pollution problems. Implicit in such a suggestion is that a systems approach should be applied in redesigning the energy industry to utility interface with all of the transportation, land use, and pollution constraints applied. The creation of very large scale coal-processing industries would generate an industrial base to rival the present petroleum refining industry. The relationship of this new intermediate industry to the fuel producers, utilities, and new diversified companies has not been specified. It is a possible horizontal integration for any company in the energy industry and a possible vertical integration for the utilities.

°Increased Use Of Nuclear Power Action

The success of the electrification strategy in energy conservation will depend to a large extent on the participation of the nuclear energy industry during the near time frame.

The justification for generating electricity from nuclear power is a matter of economics and the desire to conserve fossil fuels for other energy uses. The ratio of fuel cycle to total costs is lower for nuclear than for fossil power plants. Thus, fossil generated electricity is more sensitive to fuel price increases than nuclear. The energy content of the high grade uranium in the U.S. is about four times as great as that of oil, gas, and coal combined.

This action contemplates the growth of the nuclear energy industry in terms of Light Water Reactors (PWR's and BWR's), fueled with enriched uranium (no plutonium recycle) and the High Temperature Gas Cooled Reactors. The time frame considered for implementing nuclear power from LWRs and HTGRs is the present through 1985. The reason for selecting this time frame is that there is sufficient information regarding nuclear power growth without the necessity of introducing large uncertainties due to extrapolations.

One of the major obstacles to achieve the projected nuclear industry growth is nuclear plant delays and cancellations. The factors responsible for these delays are 1) equipment delivery delays, 2)equipment component failures, 3) construction labor and equipment manufacturer employees strikes, 4) rescheduling difficulties with associated facilities, 5) changes in regulatory procedures, 6) prolonged regulatory procedures, 7)legal changes at federal and local level, 8) challenges by intervenors at federal and local level, 9) material shortages, 10) low productivity of labor, 11) weather conditions, and 12) shortages of construction labor.

Capital cost escalation is in part responsible for some power plant cancellations. Costs have risen from $240/KWe for plants commissioned in 1969 to about $750 to $800/KWe in 1975 for plants scheduled for completion in the early 1980s.

°Improved Operation of Public Utilities Action

Since the action as stated is very complex, a basic distinction will be made at the outset. Although the two are very strongly interrelated, the technology and economics of utility operations are dealt with separately. Logically, the former is included in the latter.

The electrical utilities are facing many challenges resulting from rising costs of generator fuel and deteriorating load factor (average load/ peak load.) The load factor is particularly important because capital requirements are driven by peak loads, whereas revenues are derived from total load. This situation forces utilities to retain older, inefficient generators to meet peak loads, or to acquire relatively expensive new peak generators (typically simple cycle turbines inefficiently burning scarce fossil fuels) for peaking purposes.

Load-shaping technology is concerned with the maximization of the use of the more efficient base-load generators by minimizing load peaks through the applications of such technology as storage devices, power pools, shaping of a utility's load curve through cooperative action with affected customers. Indirect methods involve creating customer inducement to shift demand away from system peak, leaving to the individual customer control over the extent to which his particular load at system peak is reduced. Direct methods of load management vest a smaller degree of load choice in the customer, while giving the utility direct control over certain protions of its load. While the customer may retain some power to decide his load, once he does place a load on definable service, he relinquishes immediate control over the supply of electricity to that load.

Actions In Other Sectors

A strategy as broad as electrification involves significant interaction among the sectors. In this section, the most important actions in industry, transportation and residential/commercial will be considered.

°Industry Actions

The justification of electrification within industry is primarily a matter of shifting from direct fuel use. There are process areas which can make changes that decrease energy use, such as furnace technology in the steel refining industry.

The industrial sector is the largest user of electrical energy, accounting for 70 percent of consumption in 1972. The wide range of power uses, coupled with the relatively large blocks of power used by industrial customers, suggests many possible load management techniques. Three aspects of load leveling exist:

°Interruptible power

°Permanent shifting of loads to off-peak so that times of peak power use do not coincide with utility's peak demand

°Peak self-generation or storage of energy during off-peak periods for use in peak periods.

It is obvious that the extent to which these techniques (or some combination) are applicable to a specific industry must be determined by some in-depth analysis.

°Transportation Actions

Many important areas of impact are found in the transportation sector. These include fixed-rail systems, battery-operated systems and alternate fuels made from electricity.

°Residential/Commercial Actions

The principle change here is the adoption of heat pumps and limited thermal storage.

Conservation Feedback And Impacts

The question has been pending whether or not electrification implies conservation. This can be answered with reference to the three modes of conservation.

If electrification is built largely on coal and nuclear fuels, then it will achieve conservation through substitution for domestically scarce fuels.

Given the 60-70% energy conversion losses of power plants, the use of efficient electric devices such as the electric furnace, electric car and electric heat pump can partially make up for them.

If coal and uranium are in high demand due to the scarcity of other fuels and rigidities in production and conversion, then the price of electricity most likely will increase relatively more than other prices. This will cause a reduction in the consumption of electricity.

The major area of conservation appears to be that of substitution for oil (especially imported oil) and gas. Power plant conversion efficiencies apparently cannot be easily improved in both the technological and economic senses. The average coal and nuclear plants are respectively about 40% and 33% efficient. The rest of the energy is essentially lost in the present system. The degree to which these losses are made up by electric devices depends, of course, on how technically efficient they can become and how widespread their use. Conservation by curtailed end-use may be motivated by higher electricity prices, but will depend on a myriad of other forces. Although the latter are discussed in several other places throughout this report, no assumptions about them will be made here.

The major impacts of electrification in the energy industry itself are well-known. Among them are:

°Topographical disruption will result from strip mining and deep mining.

°Labor will shift to coal and uranium regions and to electric industry-related occupations.

°The transportation of fuels will be accomplished to a greater extent by improved railroad systems.

Electrification will mean a proliferation of power plants. Some effects associated with these are:

°Pressure on money markets if the capital-intensive public utilities are not able to obtain internal financing.

°Siting problems caused by waste heat and other discharges into the surrounding air and water.

°Increased rights-of-way needed by transmission lines causing esthetic problems.

Recommendations For Electrification

°Create a more stable base for future coal, nuclear and hydro generated electrification of the economy, as an alternative to the direct combustion of scarce fossil fuels.

°Increase efficiency such that by 1985 the annual growth rates of electricity usage (KWh) and peak demand (KW) should be cut from their historical seven percent to no more than five percent and four percent respectively.

°By 1985 the average load factor should be improved from the present 62 percent to about 69 percent.

°Expand transmission system interconnections (power pools) to improve efficiency, reduce the requirement for inefficient peak-load generators and to maximize the use of installed capacity.

°Provide conservation merit awards and widespread publicity for those utilities which have taken positive actions to reduce inefficiencies in the generation, distribution, and end use of electricity.

°Perform an analysis of the potential for improving efficiencies of installed electric power generators, as well as improving state-of-the-art conversion efficiencies of new plants.

°Encourage mixed heating systems where the relative proportions of storage and direct heating are set to minimize capital plus operating costs, and to avoid the uneconomical design of a heat pump to supply peak heating demand on the coldest days of the year.

°Adopt an off-peak tariff for storage heating on a separate circuit with separate metering.

°Develop methods and equipment which would permit work on energized overhead and underground conductors to be performed rapidly with maximum safety to workmen.

°Initiate programs to improve communications and interchange of personnel between the academic community and the electrical utility industry.

°Perform extensive studies to determine relationship between energy price and the amount of energy used (elasticity studies). Studies should include: elasticity by class of service, and by states or appropriate regions of the nation.

°Develop detailed information on the cost of service by customer class and by time of day (for example: on or off peak.)

°Study the roles of the tax and regulatory systems in perpetuating or changing demand patterns by means of depreciation policies, depletion allowances, tax subsidies, zoning regulations, and building codes.

°Establish comprehensive research programs directed toward the development of understanding of the determinants of energy demand. This will shed the light on the factors which determine economic elasticities of demand, and also illuminate the relationship between energy use and standard of living.

°Support demonstration projects for cryoresistive 80° K systems.

°Establish applied research on properties of cryogenic materials (dielectrics; superconductors to operate above 12° K).

°Support engineering development of: improved cryogenic insulation; reliable installation techniques; efficient, more reliable and less expensive cryogenic refrigeration.

°Establish demonstration projects of AC & DC superconducting systems.

°Explore development of cryogenic terminal equipment.

°Use hybrid systems such as maraging steel flywheels for regenerative energy storage. This would save losses during braking downhill and/or to a stop. More important, it would help provide the added power needed for acceleration and going up grade. This means a smaller size requirement and also lower peak demand -- a vital factor concerning rates from the electric utility.

°To capitalize on electrification, the railroads could own and operate electric trucks and material-handling equipment at each terminal. In this fashion, they could move the goods to the customers' doors and thus capture freight business now handled by trucking firms.

°In the passenger realm, promote use of the auto train. In this manner, the passenger's automobile (perhaps electric) would go along with him. He would not refrain from riding the train simply because he needed his car at his destination.

°As an alternate and/or supplement to the above, the railroads could doubtless attract more passengers if they could provide a low-priced auto rental (probably electric) at each terminal. Again, the passenger would have the advantage of flexible automotive transportation at his destination without the expense and fatigue of the long driving trip on the highway. Furthermore, this would overcome the disadvantage of the short cruising radius of the electric automobile.

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7.3 DIVERSIFICATION - FAR TERM (2000 -)

Diversification is essentially a policy; its primary thrust is to maximize the total number of viable energy system types in every sector. Diversification, therefore, implies conservation through substitution for scarce energy resources. Its philosophical underpinnings reflect an awareness of social, political, environmental, and economic difficulties inherent in a program of energy system concentration and seeks systematically to avoid them.

Diversification, on the other hand, is not an overall energy conservation policy. It does not explicitly pursue methods for curtailment of energy use; it does, however, advocate that energy resources be used more wisely and to that extent is compatible with any program which emphasizes curtailment and greater efficiency.

Diversification implies a desire for the future development of a variety of sources, or at least a reduction in the uncertainties concerning a variety of sources, so that options for choice will be available when decisions need to be made. ERDA in its first National Plan echos this purview by suggesting that one of its goals will be to shorten the energy system maturation cycle from the historical 60 years to 30 or less.

Systems Approach To Diversification

Before a decision can be made as to the desirability of pursuing diversification, a systematic study of diversification should be undertaken. There are several requirements or aspects of diversification that must be studied. These include:

- °The fuel mix and end use patterns for various alternative diversification plans. The set of energy systems which make up a program of diversification should include:

Coal	Integrated systems
Oil	Photovoltaic
Natural gas	Solar thermal
Oil shale	Geothermal
Biomass	Hydro-electric
Waste	Thermal gradients
Nuclear fission	Solar heating/cooling
Nuclear fusion	Wind

- °The current status of diversification
- °The advantages and disadvantages of diversification (The impacts of diversification)
- °The constraints and criteria
- °The diversification actions and their controls
- °The means for implementing the chosen diversification strategy

Advantages

The fundamental justification for an energetic diversification program is reflected in the overall advantages which it offers. As will be seen in the sections below, these advantages are potentially enormous.

°Competition

A healthy economy presupposes vigorous competition. The diversification program lays a foundation for encouraging competition

between suppliers,

between utilities,

between energy hardward manufacturers, and

between producers of energy using equipment.

It may, if fact, be possible, through increased competitiveness, to effect a reduction in the cost of imported petroleum. This would follow if the world demand for OPEC oil declined; however, the potential results may be even more dramatic. A demonstration of the feasibility of a variety of alternate energy technologies could pose a potential economic challenge to OPEC nations, but more important for the near term, it would obviate arguments internal to some OPEC nations that running out of oil is tantamount to running out of energy altogether.

°Crisis Situations

Problem areas which could be favorably affected by diversification are those developing from:

Industry-wide labor disruptions. A multitude of industries makes it difficult to affect energy supplies nationwide.

Monopolistic practices and pressures. Diverse supplies and suppliers would foster competition.

Foreign embargos and price increases. Self-dependence is possible in the long run.

Shortages of specific fuel types. Shortages would have repercussions, but not of the magnitude we are presently experiencing.

Mechanical breakdowns with system-wide consequences. A complete breakdown in one energy supply would not necessarily affect other supplies.

Unforeseen impediments to technological development. Pursuing a single (or few) promising supply sources might not 'pan out', and would leave us with nothing for the future.

The first three crisis-related advantages listed above are political in nature and generally reflect a decentralization of the power base within the energy arena. The latter two listed advantages are derived from diffused technology.

°Local Energy Production

The potential for utilizing resources proximate to the point at which the energy will be used suggests at least three consequences:

Decreases transportation and transmission distances

Contributes to regional self-sufficiency

Feeds energy dollars back into the local economy

°Decentralized Plant Locations

Extravagant energy-producing schemes envisage massive developments of the resources within a concentrated area. Along with the other difficulties, this will cause rapid and extensive population buildups within the immediate area and is likely to result in hostility and major resistance among local citizenry. This, in turn, has the potential of impeding the progress of a development. Diversification, because of its emphasis on decentralization, lays a basis for the interruption of this trend.

°Long Range Energy Policy

Historically, little attention has been given to mid-term and far-term energy policy. Many proponents of mono-energy, near-term solutions have effectively shut the door on future alternatives since undue attention to immediate needs can deprive future alternatives of an adequate technological base. In this respect, a program of diversification can enhance the prospects for future energy development and long range energy policy.

°Environmental Overloads

A reasonable prospect exists for extensive environmental disruptions of a single type from a single energy source. There are very few, if any, energy systems which do not affect flora, fauna, air or water in some detrimental fashion, but by diversifying the nation's energy supplies it may be possible to spread out these effects and thereby reduce the overall magnitude of environmental impacts.

Major Criteria

There are three important criteria by which a diversification program should be judged:

°Encourage the use of a variety of energy systems. Those systems which use energy and those which produce it should be understood as an integrated whole. This does not imply arbitrary diversification, or diversification at any cost; it does entail overcoming major economic constraints.

- °Encourage the development of non-petroleum sources. This does not mean eliminating petroleum based energy systems, but it does mean using them more selectively.

- °Tailor an energy source to its use. Some of the factors which need to be considered are thermodynamic, geographic, demographic, biological and meteorological.

Major Constraints

For each alternative approach to diversification there is a spectrum of constraints. It is desirable to introduce an alternative into those situations where the constraints are minimal. Therefore, prudence dictates that it be ascertained what constraints might be encountered before an action is initiated. Most constraints are specific to an action; nevertheless, there are two gross factors which are likely to inhibit any sustained program of diversification or any action which tends to promote diversification:

- °Perceived cost ineffectiveness due to lack of economy of scale. Whether cost effectiveness does in fact prove to be an inhibitory factor is not the whole issue. The important thing is that industry may assume that it is. A great deal of recalcitrance to any kind of change derives from arguments that economic feasibility depends upon extensive and intensive concentration.

- °Vested interests of energy producers and energy related hardware manufacturers. It is likely, of course, that such industries can participate in, and can be initiators of, diversification. However, conservation industrial inertia would have to be overcome before diversification could be effected.

The Road To Diversification

The congress has taken a first step to examining diversification possibilities; PL 93-577 (the Federal Non-nuclear Energy Research and Development Act of 1974) constitutes a congressional mandate to explore a diverse array of potential energy sources. Section 3(a) of PL 93-577 states:

> "It is the policy of the Congress to develop on an urgent basis the technological capabilities to support the broadest range of energy policy options through conservation and use of domestic resources by socially and environmentally acceptable means."

Section 6 of PL 93-577, along with PL 93-438, requires that ERDA present to the Congress on or before June 30, 1975, with updating thereafter, a comprehensive plan for energy research, development, and demonstration.

The first such plan was delivered to Congress by Mr. Seamans on June 28, and is known as ERDA-48.

These first steps must be followed by others to select a diversification strategy that will permit man to satisfy wants and needs in harmony with nature.

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8. CITIZENS' ACTIONS

Citizens are consumers, and in such a role they are a vital cog in the energy machine. Consuming takes energy for direct actions such as traveling to work, going on vacation, using lights and appliances, and cooking. It also takes energy indirectly in producing consumer goods and providing an existence that is felt to be viable. In short, citizens use energy and they also have the potential to save energy. In fact, they must conserve energy if the nation is serious in its attempt to reduce foreign oil imports. But the task may not be easy. The majority of the seminar speakers for the 1975 Summer Faculty Fellowship Program, who incidentally were a representative cross-section of upper class Middle America, were quite sympathetic with energy conservation and the need to save. Hence, the need for a qualifying note--they were sympathetic, but only if it didn't mean a change in their life style. Is this possible? Can we, as citizens, indeed save significant amounts of energy without disrupting a consumptive life style?

There are ways that citizens can save energy, individually and in groups. The potential savings are significant, but the actual savings achieved may be quite small. The citizen needs to be motivated to save and to believe in a conservation ethic. Developing such an ethic is difficult, and perhaps not responsive to the shotgun approach now being attempted. Perhaps a future synopsis of the present situation will reveal that Americans failed in their post embargo attempt to conserve, and that the true course of action should have been one of synthesizing new societal structures that provide the maximum evolution of culture within the limitations of scarce energy resources.

Barriers To Conservation

A variety of barriers exist against citizens implementing an effective conservation program. Some of these barriers are discussed in the paragraphs below.

°Credibility Gap

Many people have indicated that perhaps one of the large barriers to obtaining significant savings in energy consumption is the credibility gap between producers and consumers. For example, the widely voiced opinion that the spiraling cost of gasoline is the result of a rip-off by the oil companies certainly does not enhance the conservation ethic.

°Consumptive Lifestyles

The lifestyles of American households are directly reflected by household energy users. For the past 25 years these developing lifestyles have been based on rising real incomes and stable or falling energy costs. Now that the tide has turned, rising energy costs must have an effect on lifestyles.

°Inverted Rate Structure

The existing utility rate structure obviously does not encourage conservation -- the more you use, the cheaper the rate. Perhaps significant savings might result if the rate structures were revised so that the rate was set higher for consumption above a specified level. In this case, consumers might watch their meter each month in an attempt to keep their consumption at a specified level.

°Fuel Costs

On the other hand, if fuel costs were to decline, consumption would probably return to the exponential growth curves prevalent prior to the embargo. Thus, low fuel costs are an obvious barrier to energy conservation.

°Initial Costs Compared To Life Cycle Costs

Consumer buying patterns are decidely affected by initial costs. A major consideration of one item over another is the initial cost of each. An appliance that is energy efficient, but costs more, is difficult to market simply because the consumer is not interested in or is unaware of life-cycle costing. Educating the consumer to the advantage of life-cycle costing may be a monumentous task, but one that is worthwhile from a conservation point of view.

<u>Conservation Incentives</u>

A variety of incentives for saving energy have been identified. Several of these are mentioned in the following sub-sections.

°Time To Develop Alternatives

One very important aspect of citizens' actions is that they represent a viable means of bridging the short term period until alternate energy sources become available.

°Scarcity Of Fuels

One obvious reason for conserving fossil fuels is to extend the lifetime of the finite supplies of these fuels so that they will continue to be available for unique uses for which they are suited.

°Reduction Of Dependence On Imports

Reducing consumption of oil and natural gas would result in a decline in imports of these expensive fossil fuels.

°Decreasing Environmental Pollution

Another problem emerging from the energy crisis is the apparent conflict between environmental protection and energy production. For example, burning coal creates numerous environmental problems, including air pollution resulting from the release of sulfur dioxide and particulates. Thus, by reducing consumption, there would be a reduction in particulates, carbon dioxide, and waste heat -- all of which are known to have environmental impacts.

Present Approaches

Actions by citizens to conserve energy may be individua' actions or group actions. They may be voluntary or mandated. So far, voluntary action has been encouraged through educational programs by citizen groups, State and local governments, and the Federal government. Educational programs based on economic aspects appear to be effective. Other programs, based on an appeal to a conservation ethic, appear to be accepted but not adopted.

One may force or mandate participation in conservation by enacting laws to accomplish some of the following kinds of actions:

- °Establish differential rate structures so that the base rate may be relatively inexpensive, but additional consumption is priced significantly higher. This escalator clause should encourage consumers to watch their meters and reduce consumption to stay within the base rate.
- °Force consumers to drive smaller cars or drive less by restricting gasoline consumption.
- °Encourage support of public transit by restricting parking.
- °Prohibit further use of ornamental gas lights and pilot lights.

The educational approach may turn out to be the most effective since any comprehensive proposal for energy conservation will include actions that will result in a change in life style.

Conclusion and Recommendations for Citizen's Actions

Several major ideas on energy conservation have been expressed in ECASTAR. First, a conservation action should be proposed or mandated only after it is properly assessed, i.e., a systematic study should be made to determine the requirements for, the alternatives to, and the impacts of implementing such an action. For example, consider that a consumer parks the car and rides his bicycle to work every day. Obviously, he is saving energy in the form of gasoline. On the other hand, a more detailed assessment should ask the question,"What does he do with the money he saves?" Whether he saves it or spends it, energy will be required to provide for the freed monies. If the consumer is armed with specific information, he can purposefully direct the money saved by bicycling so that he does realize a net savings in energy. The point is that he must be made aware of the possible impacts of not spending the savings wisely.

A second point concerns the comment made by many that the only way to have people conserve is to let prices rise. In other words, if gasoline prices rise sufficiently high, people will no longer be waiting in line to purchase this expensive commodity. However, before deciding to decontrol the price of oil and gas, one should try to assess the various impacts of such an action. For example, rising costs may indeed reduce consumption, but what about the effect on the poor? Since the percentage of their income spent on energy is greater, they are impacted much harder. In addition, there is probably very little they can do about reducing their consumption. Viable alternatives for dealing with the poor would need to be identified and assessed before the action is taken.

9. SUMMARY AND COMMENT

ECASTAR presents a methodology for a systems approach to energy conservation actions and their potentials and impacts in the United States. It was necessary for the ECASTAR group to choose from the broad spectrum of meanings for conservation. The first step in such a choice was to rank constraints and to choose a segment of conservation compatible with the highest ranked constraints. The constraints which were recognized as the most directly influencing the course of the United States' energy program were the present economic and technical conditions. It may seem trite to say that which will probably occur will do so because it is economically attractive and technically feasible. However, with a topic as personal and subjective as alterations of energy consumption patterns, a rigorous study of alternatives is not limited merely to those with quantitative performance criteria. It is clearly recognized that a systems approach to an economic and technical objective encompasses well founded goals aimed at establishing permanent equilibrium between man and man and between man and nature. Hence, the definition of energy conservation was: The result of any action that improves the energy situation in the United States.

Unresolved Issues

In the course of this study many unresolved issues facing the nation have been identified. However, solving the debate concerning these issues was judged to be outside the scope of the ECASTAR report. An identification and discussion of several of these important issues follows.

°Consumptive Lifestyles vs. Conservation Ethic

To a large extent, typical energy users are not aware that their homes, cars, businesses, and industries are wasting energy. This is partially true because energy has been too cheap.

°Environmental Standards vs. Energy Conservation

Some of the conflicts between energy conservation and environmental standards are obvious. Many of the environmental protection schemes either use more energy than before or rule out the possibilities of conservation modes.

°Capital Availability

The question of the availability of the capital required to install necessary environmental equipment and implement conservation measures simultaneously has not been answered. Some experts argue that capital is always available -- at a price. What is the price? Is the nation willing to pay that price?

°Decentralization And Vertical Integration vs Centralization

Past trends toward increasing centralization of energy generation have been accompanied by increasing controls. Many people feel that the time has come for a closer look at various schemes for decentralization.

°Fuel Rich Regions vs. Fuel Poor Regions

The recent enactment of a Louisiana law permitting the state the option of retaining 20% of their gas production for sale within the state rather than shipping the gas out of the state (with severance tax) points out a developing conflict between the energy producing states and the energy importing states. The resolution of this conflict requires careful assessment and considerable mediation.

°Supply vs. End Use Conservation

Energy conservation to most people means increasing efficiency or curtailing use. Increasing efficiency and good housekeeping measures result in a reduction in consumption with few lifestyle changes. Therefore, these conservation actions have considerable support. On the other hand, reducing consumption in the final demand sector may, even though it does not have public support, have potentially greater savings. The impacts of such actions must be assessed.

°Life Cycle Costing vs. Initial Cost

The American consumer, in general, is concerned only with the initial cost of an item. In the past he has been largely unconcerned with the operating cost or the lifetime of the appliance. In the future, the consumer must be made aware of life cycle costing and the benefits derived from paying the higher front end cost.

°Mandatory Savings vs. Voluntary Savings

Many people feel that the potential for reducing energy consumption is great but that voluntary actions may not produce these savings. Perhaps only mandated conservation actions will produce the desired savings.

°Labor Intensive vs Capital Intensive

In the past many labor intensive tasks have been replaced with expensive equipment because the life cycle costing revealed that buying and operating capital intensive equipment would be less expensive than employing a larger number of employees. As fuel costs rise, this trade off may flip the other way, i.e., labor intensive operations may be less expensive than operating expensive machinery with expensive fuel. The ramifications of this substitution need to be explored.

°Price Control vs. Free Market

The market system as it exists in the U.S. cannot be characterized as a purely competitive (or free) market. The energy market is no exception.

<u>Recommendations</u>

While there are many unresolved issues concerning energy conservation, the ECASTAR group recommends the following points.

°Provide Action/Impact Assessment

Many conservation actions have been proposed -- few have been subjected to a thorough analysis. A conservation action needs to be assessed before it is implemented.

°Establish Regional Energy Centers

The ECASTAR group recommends that regional energy study and analysis centers be established throughout the nation. The function of these centers would be to:

°Develop energy and energy conservation programs suitable for the region

°Coordinate national energy programs in the regions

°Advise State and local governments and provide feedback to the Federal Government

°Assess impacts of energy programs and actions

°Collect, analyze, store and disseminate national and regional data and information

°Coordinate and conduct studies and programs with all sectors of society and citizens' groups

If these centers were federally funded and freedom of action was encouraged, a different mix of people might become involved in the energy problem. Assembling inter-disciplinary groups of people interested in energy but having no vested interest in the problem might provide a fresh perspective for energy problems.

°Improve Technology Articulation With Government

The group urges that a climate be created which will enhance the articulation between persons and institutions directly responsible for technical inventions and those responsible for creating the laws of the society.

Issues dealing with energy supply and conservation are among our most contemporary examples of the interrelationships between technology, science and the political process. Unfortunately, it appears as if the communication links between the "technical inventors" (engineers and scientists) and the "social inventors" (legislators) are but weak and tenuous and in need of strengthening.

°Design Total Energy Systems

There are many other trends apparent in our society at this time which suggest that now is the time to look broadly at alternative energy systems. One area which perhaps needs to be given more attention from a systems analysis and technology assessment point of view is the design of total energy systems which are decentralized and which return autonomy in energy source to individuals or smaller institutional entities such as neighborhoods, cities or regions. Illustrative of such systems are the Modular Integrated Utility Systems (MIUS) which are presently being explored by Housing and Urban Development (HUD) and NASA. Developments in solar, wind, trash burning and other energy systems might produce (with additional R and D) very fruitful, economically feasible decentralized total energy systems for our future.

°Utilize Existing Systems Approach Expertise

As the results of the research and development and data collection program accumulate, the need for a way to integrate all this information becomes evident. Large systems planning is required. One way to organize this mass of data is to formulate a methodology for integrating the diversity of information from ERDA, FEA, the proposed regional energy centers, etc. This methodology could provide an integrated energy system that is badly needed by the country. It would help in establishing priorities for research funding, in formulating national energy policy, and in providing a constant iterative process for refining the data. The cooperation of organizations and institutions with expertise in the systems approach and technology assessment methodology would be needed to initiate such a program for long range planning for the nation.

10. PARTICIPATING FELLOWS

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Auburn University Engineering Systems Design
1975

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