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ENERGY CONSERVATION AND ENERGY DECENTRALIZATION: ISSUES AND PROSPECTS

Mark D. Levine[a] and Paul P. Craig[b]

A friend of ours recently spotted an unidentified flying object. As the UFO departed, our friend found a document that was inadvertently left behind. It was apparently a report on an evaluation of the energy problems of the earth, prepared by someone from an advanced civilization. We share with you the executive summary of the report because we find it to be of great interest:

> The evaluation of the policies and problems of energy on earth was a difficult and confusing assignment. I decided first to focus my attention on one country, the United States. The United States, though a declining economic power at this time, still produces and consumes more energy of all different types than any other nation of the world.
>
> My findings were so confusing to me that I decided to input the data base into our most powerful computer, JNYX. JNYX studied the data for some time. Its first readout was rather startling to me: "AFTER TEN HOURS OF ANALYSIS, I AM UNABLE TO UNDERSTAND THE INFORMATION. THE DATA ARE INCONSISTENT AND NOT SUBJECT TO RATIONAL ANALYSIS. PLEASE INSTRUCT." Never before has JYNX spent so much time with so little results.
>
> Back to my report. I have drawn the following conclusions from my brief story:

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First, there is a very strong belief--especially in the United States-- in economics as a means of allocating scarce resources such as energy. Thus, persons and nations with money are able to use as much energy as they wish while those with little money must be very frugal. Although this causes great problems for many nations and people, there is a widespread belief that the economic system is the most efficient way of distributing scarce resources. I can understand the logic of this idea, but I am greatly confused about the way that the economic principles are applied. For example, most people in authority in the large energy agency, the U.S. Department of Energy, believe that the least costly energy technologies that work well should be used. However, these same people support projects like synthetic fuels conversion and processing facilities that are extremely expensive. Furthermore, in their private lives they pay more than a dollar per gallon for gasoline when they could pay 30 cents per gallon to purchase a more efficient automobile.* An investment in energy conservation for a new house in Washington, D.C. is equivalent to paying 22 cents per therm of gas (versus gas costs of 34 cents per therm) and 1.5 cents per kWh electricity (versus 4.4 cents per kWh). Similarly, the Nation invests $2 billion to build a new power plant when it could have invested $1 billion in more efficient air conditioners and other equipment and used the remaining $1 billion for other purposes. To make this situation even more confusing, the same people who advocate using the economic system to obtain energy from the cheapest sources are also most in favor of $2 billion power plants. I cannot imagine an official of the Intergalactic Federation who would long survive advocating

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*An average car is driven 10,000 miles per year. A rough estimate for the cost of improving the efficiency of an automobile from 20 to 30 miles per gallon is five hundred dollars. The reduced expenditure for gasoline over the life of a car (about 100,000 miles) is thus $1670, made possible by an extra investment of $500. This is the equivalent of paying 30 cents per gallon of gasoline not used!

the waste of $1 billion on a purchase of a $2 billion piece of equipment. *This extraordinary conflict between a belief in economic rationality and behavior inconsistent with economic rationality is, I think, a root cause of major energy problems.* But it leaves me fully perplexed.

Second, there is considerable debate on the abundance of energy resources and how long they are likely to last. I scanned the literature and discovered that the estimates of resource availability varied by greater than a factor of 25. At the lower end of this estimate, the earth (and particularly the industrialized nations) will suffer terrible economic consequences within a decade. They are doing little about finding alternate energy sources, so I conclude that their leaders are not particularly worried about the scarcity of economic energy resources. There does exist a fringe group that speaks of the "limits of growth" and there are people who speak of "soft paths" and decentralized renewable energy systems and energy conservation. These people make some interesting points, but they do not exert very much influence in high government circles.

Third, I have been baffled by the oil situation in the United States and other countries. The United States acts curiously when it is threatened. Recently, many of its citizens were prepared to go to war because 50 of its people were captured by students in a far away country. And yet, when the United States is really threatened, as they are by the price increases and uncertain availability of world oil (controlled by an international oil cartel), they do very little. I have mentioned that an attempt is being made to produce liquid fuels from coal at very high costs. Yet there are large quantities of garbage distributed throughout the country that people pay money to remove and dump, when it could be converted into scarce liquid fuels at

a cost much lower than converting coal to liquid energy forms. But the garbage is dumped and the coal is dug up.

The problem of liquid fuels is apparently very serious. Many of their experts have predicted that there will be a severe oil shortage in less than ten years. These same experts have shown that a shortage of oil will cost the United States billions of dollars, will cause severe unemployment and have disastrous effects on the world economy. And some of the experts have shown ways that half of the oil imports could be conserved over the next ten years, at a cost of less than 60 cents per gallon of gasoline. What is the response? Mainly synthetic fuels at $2.00 per gallon or more, with little chance that it can be ready in significant supply short of twenty or thirty years. I do not understand why these people and their leaders are willing to court economic disaster and social upheaval when they apparently value their economic goods, material possessions, and social institutions so much.

I could go on and on with the contradictions that I have found in the energy policies of the United States. But I think at this point you can agree with me that there is no rational basis for the energy policy actions of the leading world power. I remain most perplexed by the belief in economic rationality combined with the irrational behavior of the people in their energy decisions and policy. Please inform if you wish continuation of the investigation.

II. Discussion of Energy Issues

The report from our extragalactic visitor has raised many important issues. They have several common themes: as oil resources are declining and severe shortages (caused by an inability of world productive capacity to keep pace with growing demand) are expected within the decade, the United States continues to waste energy in large quantitites. Extreme anomalies are present in our energy system and in the processes by which

decisions are made about energy: we spend vast sums of money to expand energy supply, when there are much better investments that can be made to increase the efficiency of energy use. We are, in effect, wasting our most valuable resources (time, labor, materials, and energy) in providing goods and services to our economy. This is, as our visitor has stated, an irrational way for us to proceed. We wish first to understand why this has come about in order to propose policy remedies for the problem.

A. Energy Decentralization, Values, Lifestyle, and Behavior

These issues lead directly to the theme of energy decentralization. Indeed, we believe that the theme of energy decentralization is in many ways a unifying concept that will clarify many of the difficulties that our observer had in understanding the U.S. energy system. Devices that use energy are distributed throughout the society; they are totally decentralized. They are not nearly as efficient as they could be or ought to be, given the high value of energy. Decisions about energy-using equipment are not and, in our society, cannot be made centrally. They result from a vast array of individual choices made by every person and every organization in our economy. Thus, though the Department of Energy official who is designing a synthetic fuels program may be seen from one perspective as producing plans that are inconsistent with the efficient production, allocation, and use of energy resources, it is his role as energy user that most forcefully points up the conflicts within our energy decision making process. He shares this role as an energy user with everyone else in the nation and, if he is typical, he is probably more irrational in his personal decisions about energy than he is in his professional decisions.

Decentralization from this perspective begins with technology as a means of improving our efficiency as we go about our business. But it is intimately related to institutions, for the innumerable decisions on energy using systems are made at every level--by individuals, by businesses and industry, by banks and other lending institutions, and by government. The primary challenge of implementing decentralization is that of changing the criteria by which the array of energy decisions are made.

The term decentralization has often been used to imply lifestyle changes. This is, in our judgment, a correct interpretation of the implications of energy decentralization. As the recognition of the scarcity and high value of energy spreads through society, people will learn to adapt their lives to changing circumstances. An example of one possible adaptation has to do with the American love affair with the automobile. Not too many years ago, a giant Cadillac was the ultimate symbol of success. The prestigous nature of this possession was enhanced if the owner replaced it every year with a new, and probably larger, model. No doubt these values continue in many parts of the country. But GM, our most profitable auto manufacturer, has recognized that a luxury car that appeals to the status seeking qualities of many Americans (especially American males) can be built small, be made reasonably efficient in its use of gasoline, and still provide its most important end product: status. And, incidently, it can provide transportation as well. In time, owning a super efficient automobile could come to confer status on its owner; indeed, in many circles, the possession of a large, wasteful automobile is regarded as a display of poor judgment rather than success. As the critical threat of oil import cutoffs grows, the possession of a gasoline wasting automobile may generally be seen as unpatriotic and a social

incentive to purchase efficient cars may emerge.

In this paper we are concerned with the present and the immediate future; we do not expect lifestyle and value changes to play a large and immediate role in changing our energy use characteristics. However, as the stresses on the energy system grow, as the inconveniences of over-consumption of energy (e.g., long waits for gasoline) are increasingly suffered, as our ability to conduct foreign policy becomes restricted (already clearly recognized in our dealings on the Middle East), and as uncertainty in energy price and availability increasingly interferes with countless business decisions, changes in values and lifestyles will of necessity take place. It is not a question of <u>if</u> these changes will occur; it is rather a question of <u>when</u> they will take place and if they will occur in time to avoid an otherwise extremely painful set of events. It is preferable that the adaptations occur in time to avoid great suffering and misery, especially since those least equipped to deal with economic adversity (generally the poor) are likely to bear the brunt of the suffering. But we know little about the time constants associated with basic changes in attitudes and behavior related to our use of energy.

We do, however, have considerable information about the technical and economic factors associated with improving the efficiency of energy use. And we have some knowledge about the decision making process that has directed our patterns of energy use. We now attempt to put this information to use in an attempt to explain the phenomena that our extra-galactic visitor found so "confusing" and so unyielding of "rational explanation."

B. Understanding the "Irrationality" the Consumers Energy Decision Making

One explanation for the seeming irrationality of our energy decisions is the low price of energy and its ample availability over the past decades. With very low energy prices, the consumer had little incentive to invest the time and effort to obtain information to improve his decisions. Furthermore, even though we are suddenly faced with rapid increases in energy prices, it takes time for people to change their habits and devote attention to learning about ways to reduce energy needs or obtain energy appropriate sources.

This explanation, while providing some answers to our dilemma, is not the entire story. We reach this conclusion by investigating behavior in the early 1970's, before energy prices began their precipitous rise. Back in 1970, a kilowatt hour of electricity cost about 75 percent as much as today (in constant dollars) and natural gas cost about 60 percent as much as today. At those prices, it would have made good economic sense for a new house in Washington, D.C. to have R-38 ceiling insulation, R-19 wall insulation, and double glazing, if the house was heated by natural gas, and substantially more insulation if the house was heated by electircity (Levine, et. al., 1979). Instead, in 1970 an average house in Washington, D.C. had less than R-9 insulation in the ceiling, practically no insulation in the walls, and single glazing.* Thus, back in 1970 the average new home purchaser chose not to make investments in energy conservation that would have saved $50 (1970 dollars) per year on fuel bills at a cost of less than $25 per year. We need to look beyond the low historical energy prices for a full explanation of the economically

irrational under-investment in increased energy use efficiency.

The relatively low total annual fuel bill (rather than the low per unit cost of energy) that prevailed for many years provides a second explanation for the behavior of consumers. In 1972-1973, total annual expenditure on gas and electricity was about $340 (in 1972 dollars) per household or about 3.5 percent of annual income for a middle class person. Perhaps $100 per year could have been saved by investing in simple and straightforward energy conservation measures in the home. This was apparently an insufficient savings to motivate the investment of time, labor, and money in energy conservation for a middle class home owner. For poor people during the early 1970's, the annual household energy bill is estimated to have been $280 (Newman and Wachtel, 1975). Although a smaller expenditure than that of wealthier households, the energy bill amounted to more than 10 percent of income for the lowest income groups. The lower income groups might therefore be expected to take the trouble to save $50 or $100 per year. However, there are two reasons why they did not do so: (1) most of the poor people do not own their own homes; they are therefore unlikely to invest in home improvements unless they are committed to remain in the same place for many years. There is little incentive for the property owner to invest in energy conservation, because it is invisible and cannot easily justify an increase in rent. (2) For the low income families that own their own homes, the availability of capital is so limited and the cost so high that they are precluded from making significant investments in energy conservation, even if the investment is paid back in one or two years. In short, the annual savings have historically either been so small (for the middle economic classes and above) or so difficult to achieve because

of borrowing limits (lower economic classes) that very little investment has been made in energy conservation.

Recent studies have shown another facet of this situation: the investment criteria used by consumers in their purchase of energy using equipment (furnaces, air conditioners, refrigerators, and houses) are notably different from the criteria used to invest income in, say, real estate or the stock market. In particular, consumers have typically required a return on investment of 40 to 100 percent in their purchase of equipment to improve energy end use efficiency (Hausman, 1979; Levine, et. al., 1980). The two explanations offered above--low historical energy prices and total fuel bills--may partly account for these results. A third factor, lack of information about cost effective energy conservation measures and lack of knowledge that sound investment criteria are applicable to purchases of energy using equipment, has certainly played a role in the decisions of tens of millions of consumers to pass up excellent opportunities to invest in energy conservation in favor of less desirable investments in other areas.

A fourth factor also plays a major role, particularly in explaining why very large improvements in energy end use efficiency are rarely purchased. This is the general unavailability of products of very high energy efficiency in the marketplace. Examples of the impossibility or difficulty of purchasing very energy efficient equipment abound. Refrigerators that use less than 40 percent of the energy of an average refrigerator, at an increase in first cost of 5 percent or less (and with a return on investment of 80 to 100 percent per year) can be produced with current technology (ADL, 1977). However, no manufacturer in this country is currently marketing such a refrigerator. Automobiles

that obtain about 45 miles per gallon are now commercially available (the Volkswagen Rabbit Diesel), but 95 percent of all cars sold in the United States obtain about half of this gasoline end use efficiency. (Here, at an extra cost of $1000 for a very efficient diesel engine, the effective cost of gasoline not purchased because of the energy conservation investment is 60 cents per gallon.) New houses could be tightly caulked to reduce heat loss through air infiltration and equipped with a mechanical ventilation system (fan and ducts) and a heat recuperator to recover heat. Such a house would use less than 60 percent of the energy used for space heating in a typical house. The energy conservation investment would be equivalent to paying 75 cents for each dollar of natural gas not used.)

These examples all have one thing in common: the energy efficient equipment that produces these large energy and dollar savings is not widely available in the market place. Thus, if a consumer wishes to purchase an extremely efficient refrigerator or house, he can only do so at enormous inconvenience to himself or not at all.

What is the cause of this deficiency in consumer products in a land that has greatest variety of products (more than 100 brands of toothpaste!) known to man? We don't know the full answer, but it is some combination of limited interest in energy conservation as a marketable commodity by manufacturers, wholesalers, retailers, and advertisers and little demand for energy conservation in consumer products by the purchasing public. While it is true that energy conservation has played a role in recent advertising, the claims of "energy efficiency" in most products (e.g., automobiles) are ludicrous when compared with the technical and economic opportunities for achieving high energy efficiency levels.

C. Understanding the "Irrationality" of the Energy Industry's Design Making

The discussion thus far has addressed only part of the issue raised by our extragalactic visitor who was baffled by the lack of economic rationality exhibited by the Americans who ostensibly believed in the economic efficiency of the marketplace. It attempts to account for the under-investment in energy conservation by the final consumer of products. But it does not explain why the energy industry is so eager to invest in large, centralized energy supply technologies when cheaper means are available to accomplish the same ends. We believe that this phenomenon is one of the fundamental but little recognized causes of our energy problems.

The decision maker on the new power plant costing $2 billion is the electric utility (and its regulators). This decision maker has choices to make among many different technologies but he considers only technologies that produce electricity. Although the electric utility's product is electricity, electricity is not what the consumer really wishes to purchase. The end user wants services such as refrigeration, air conditioning, and lighting which can be obtained through the use of electricity. If another energy source were available to produce the same end services at half the cost and no added inconvenience, the consumer would surely be satisfied to convert to the use of this new fuel. Thus, the electric utitity is primarily concerned with the cost and convenience (i.e., reliability, availability) of producing and distributing electricity; the consumer is primarily concerned with the cost and convenience of final services (refrigeration, etc.).

The implications of this dichotomy of interests between the electric utility and its customers are significant. The utility planner works on those things over which he has control--namely supply. Investments in energy conservation are not considered as part of the portfolio of projects that a utility planner evaluates. As a consequence, $2 billion is spent to purchase (but not yet operate) a new power plant when $1 billion would have purchased enough energy conservation to make the power plant unnecessary. And the utility customer, who has insufficient knowledge, incentives, and opportunity to invest in energy conservation, pays for his failure twice: first, in the use of more energy and second, in the use of more expensive energy (because new facilities to generate energy are more costly than the existing ones). The wasted billion dollars on the new power plant is hidden by being spread among all the customers of the electric utility, adding about $25 to the annual bill of a household whose utility serves 2 million customers.* The billion dollar waste occurs and is disguised not because of some nefarious plot to misallocate scarce resources or money by the utility but simply because the total is so widely scattered that no one would think of looking for it. They would not seek it because the waste occurs only in comparison to the costs of a wide variety of decentralized investment alternatives and neither the utility planner nor the regulatory agency

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*A 1000 MW(e) power plant meets the electricity demand of about 200,000 houses. If an electric utility has 10,000 MW(e) of baseload capacity the cost of an additional power plant is spread over about 2 million average customers. If one billion dollars is wasted in building a new power plant instead of investing in energy conservation, and the cost of capital to the utility is 5 percent real (i.e., 15 to 20 percent in current dollars), then an extra cost of $25 per year is borne by each utility customer. Note that in this example the average residential electicity customer would pay an additional $250 per year if he used electricity from the new power plant and were charged the cost of power from this plant!

evaluates energy supply projects in relation to projects that produce the equivalent services but entail no investment in supply.

As a result of pursuing the centralized rather than the decentralized projects, a billion dollars is wasted (for one new power plant) and until very recently no one even noticed. Further, the additional energy produced detracts from rather than contributing to our lives, because no new services are provided, environmental degradation is increased, and resources that could have been used productively are lost.

D. Recapitulation

We have attempted to explain the curious economic irrationality observed by our visitor as he analyzed the energy situation in the United States. We have identified five factors, each operating in different ways on different decision makers, and at (occasionally) times over the past ten years. These factors are:

1. Low unit price of energy (until mid-seventies)
2. Annual fuel bill a small percentage of disposable income.
3. Lack of consumer information about energy conservation opportunities and lack of knowledge about how to evaluate investments.
4. Lack of availability of highly energy efficient products.
5. The inability of energy supply firms to allocate their considerable resources to investments in energy conservation at the end use level.

The fifth factor, unlike the first four, accounts for the enormous investment in large, centralized energy supply projects. The first four factors are important in explaining the failure of decentralized energy projects to achieve anything near their potential during the past decade and before.

We now utilize this information to address energy policy issues confronting the Nation. We attempt to show how a strategy for enhancing the decentralized decision making process on energy can address the issues raised by the visitor and can be based on our understanding of the causes of the economic irrationality of the energy system.

III. Energy Policy Considerations

A. Higher Energy Prices and Energy Decentralization

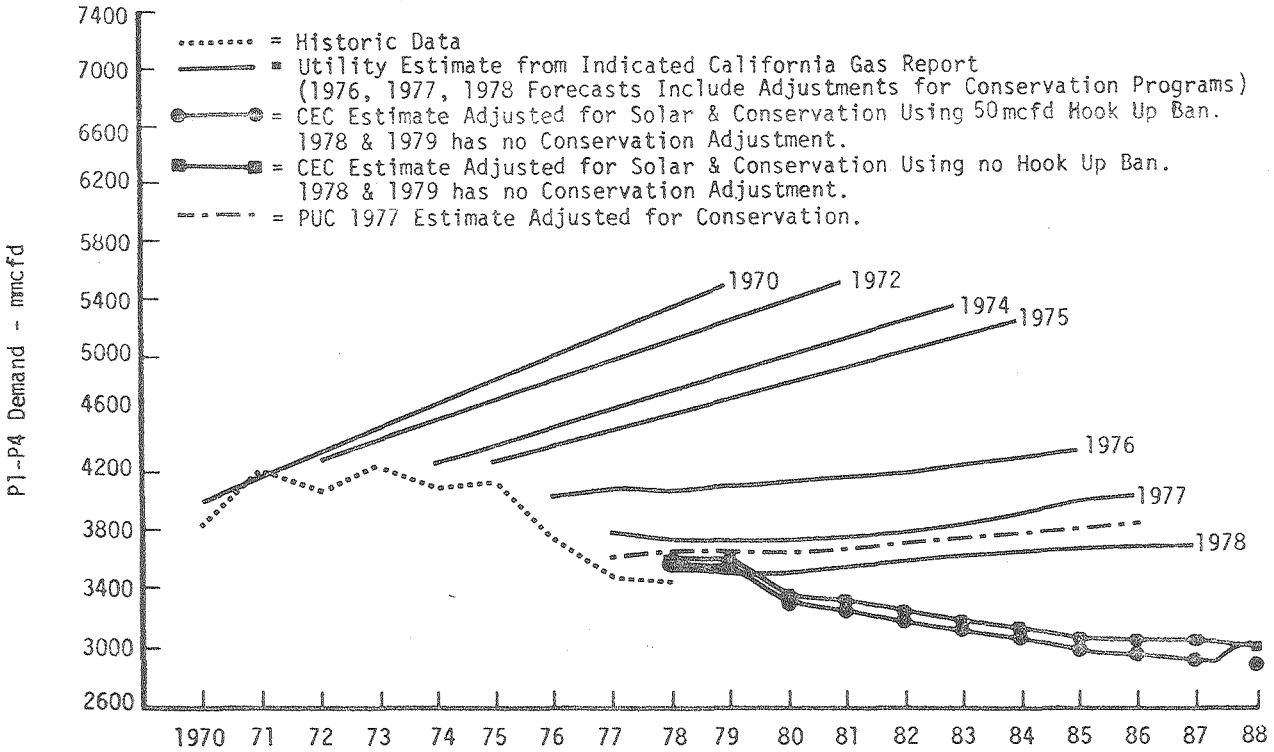
We have noted that higher energy prices alone will not cure our energy problems. We also recognize that they will help begin the cure. The effects of higher energy prices are already visible and are likely to become more visible during the eighties. Several key departures from past behavior of consumers, organizations, and governing bodies can be discerned from a careful assessment of recent developments in energy:

- The projections of energy demand growth have fallen, in many instances precipitously. (See Figures 1 and 2, which show the electricity and gas demand forecasts made for California by the California utilities and the California Energy Commission during sequential years in the 1970's for a striking illustration of this development.)
- The federal government has undertaken some major initiatives to bring about energy conservation, particularly in those areas where the market appears to work least well. The first of these activities was the mandated fuel economy for new automobiles. At present, the Department of Energy is promulgating energy performance standards for all new buildings and for residential appliances. *As a result of recent policy decisions, many of the standards (residential buildings, selected appliances) are being proposed at the cost effective level of energy conservation investment*! In fact, the possibility of setting the standards using marginal (rather than average) energy prices is

FIGURE 1. GAS DEMAND PROJECTIONS FOR CALIFORNIA

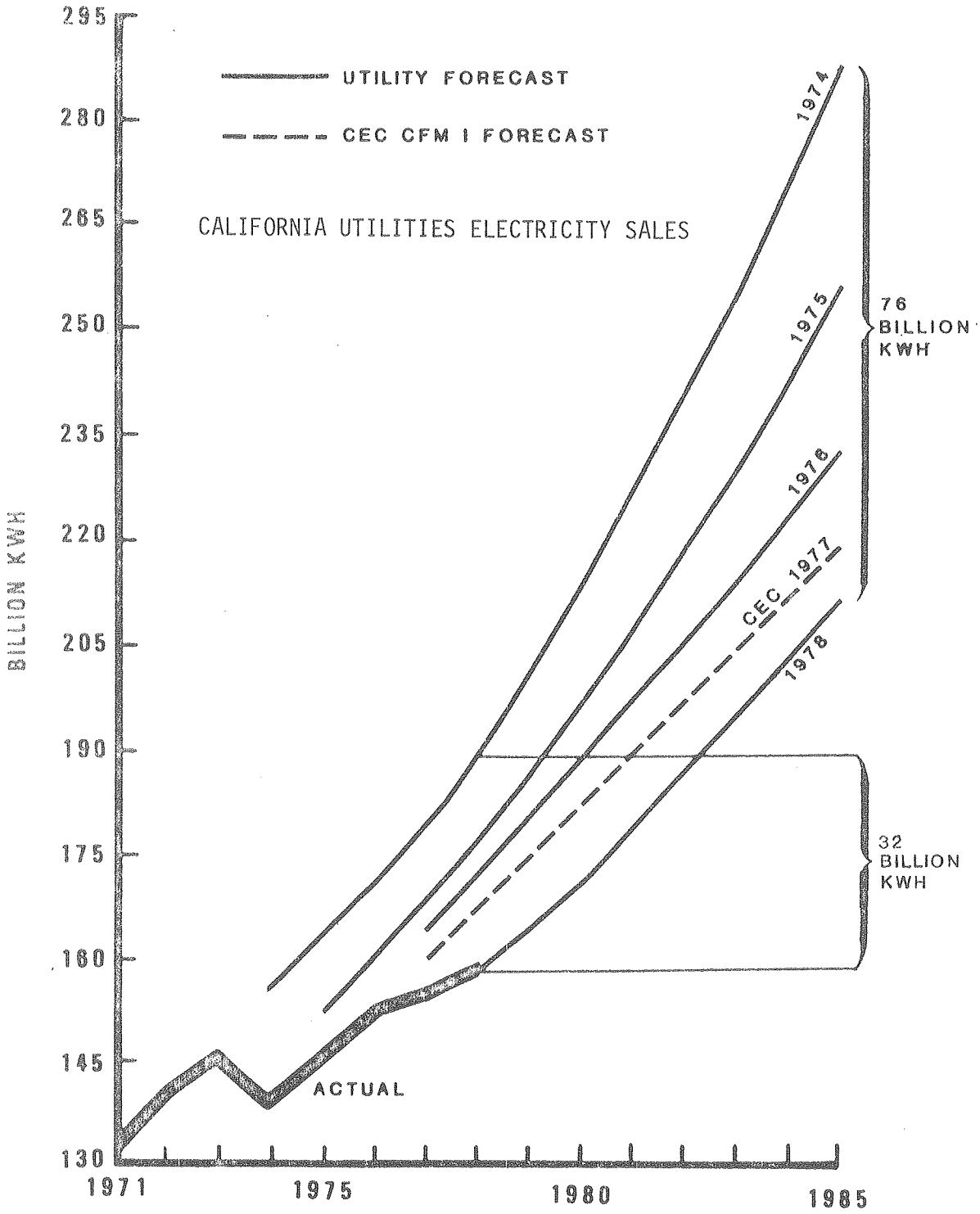
GAS DEMAND

Utility P1-P4 Demand Estimate Comparison
With Historic Demand, CEC and PUC Estimates*



*P1-P4 demand determined by using total send out plus curtailment less electric requirement less gas sent to storage. Source: utility estimates and historic data, California Gas Reports. 1976 electric demand determined from CEC Quarterly Fuels Report using natural gas and fuel oil use. CEC estimates from exhibits in PUC Case No. 10342.

FIGURE 2. ELECTRICITY DEMAND PROJECTIONS FOR CALIFORNIA



being investigated, and will be given serious consideration. If these standards are effectively implemented, substantial increases in energy conservation investments will occur throughout the Nation.

- Industrial energy demand has actually fallen in recent years, in response to increasing energy prices. The magnitude of the energy savings in the industrial sector is considerably greater than estimates made in the mid 1970's (widely accepted throughout industry) by the Conference Board (Energy Consumption in Manufacturing, 1974).

- Numerous state and local government agencies and private organizations have become extremely active in promoting energy conservation. A foremost example is the city of Davis, California, which, with a variety of local initiatives, reduced residential gas consumption 21 percent and residential electrical demand 13 percent from 1973 to 1977, during a period of population increase in the city. (See Vine, 1979, for an interesting account of how this was accomplished.) Other cities and counties (e.g., in California: Palo Alto, San Diego, and Santa Clara county) are attempting to achieve objectives similar to those of the city of Davis, often with innovative approaches.

- Industrial firms manufacturing and selling energy conservation measures and renewable energy systems have experienced rapid growth. Prominent examples of this growth can be found among manufacturers of home insulation (who were unable to keep up with demand for insulation during 1975 and 1976), heat pumps (a highly efficient way of providing space heat using electricity, with the industry experiencing very high growth rates during the past several years), solar heaters for swimming pools, and solar domestic water heaters. Other firms manufacturing multiple glazings, heat recovery systems for residential and commercial use, wind energy systems, co-generation facilities, and equipment for the direct burning of organic

wastes are certain to see significant growth during the 1980's.

We believe that these activities are just a beginning. They provide a basis for some hope, but they offer little reason for complacency. Energy demand has a curious way of finding new ways to grow and investment in conservation, ways to decline. Nonetheless, there are some reasons to believe that we have begun early and very tentative steps toward energy decentralization.

Higher energy prices relate to energy decentralization by making energy a more visible commodity. In the past, energy was of little interest to most people. Now with a growing recognition that high prices of energy are likely to become even higher in the future, with a widespread concern about the availability of energy supplies, and with a serious international threat to the well-being of the Nation arising from energy imports, almost everyone is thinking about energy. Until now, centralized decision-making has led to centralized "solutions" to the energy problems. These solutions have not worked. Their failure has led to general acknowledgement of our energy dilemmas. This awareness will, of necessity, lead millions of people to make individual decisions about their use of energy. This, in our view, is a prerequisite of energy decentralization. The challenge is to make certain that these individual decision makers have access to the knowledge and the energy systems that can lead to more rational energy decisions.

B. The Role of the Federal Government in a Decentralized Energy Future

The federal government is the largest and most centralized organization in the United States. Energy decentralization implies countless

decisions by the smallest groups and at the local level. How then do decentralized energy decision makers and a centralized governing body coexist under a decentralized energy strategy? Or can they reasonably coexist?

We believe there is no necessary incompatibility between big government and little energy systems. The appropriate scale of a system, whether it is an organization or a technology, depends on numerous technical, economic, and social factors. Our stress on small-scale, decentralized energy systems derives from our sense that they are the best opportunities for our evolving energy system. It also stems from our sense that decentralizing important aspects of our decision-making process puts a large fraction of the responsibility to solve our energy problems where it belongs--on the individual. It does not, however, mean that big is bad, whether the "big" be government or technology. It does mean that we have gone much too far with many of our big systems and have thus missed extraordinary opportunities for making good energy decisions.

The primary role of the federal government is as a means of encouraging decisions that are cost effective when viewed from a societal perspective. It is, in this sense, essential that the federal government provide appropriate incentives for the Nation to make investments in new energy systems that provide a large return on the investment. This return needs to be measured in terms of economic benefits, improvements in the environment, and protection from economic disruption. Such incentives themselves do not differentiate between the scale of technology. However, under the present circumstances in which the decentralized energy solutions have been given little attention and the payoff from

their use is so large, appropriate government incentives ought to make clear the advantages of many of the decentralized energy systems. In this view, the government needs particularly to recognize the pervasive barriers to improving energy efficiency and take measures to counteract the forces interfering with rational decision making.*

A second role for the government, in our view, is a more active one of countering the powerful forces that impede our sense of rationality in energy decision making. The government is the only organization with sufficient size and authority to apply corrective measures to the marketplace when it fails to work properly. Thus, the use of energy efficiency standards can goad the market into responding as it should, if the standards are set at a cost-effective level of energy efficiency. And the standards, if applied intelligently, can spur a reluctant industry to make efficient products available. However, the standards are likely to be effective only if the population understands that they save both money and energy, as well as reducing critical social problems. And, for this understanding to become widespread, an enormous educational process is required.

Big industry is not likely to go away. Unfortunately, most of the political power exerted by the large energy industries is in favor of the large, conventional energy technologies that are, in our judgment, far less desirable than alternatives to them. (We do not expect the oil

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*Most of the barriers that interfere with good decision making on energy conservation apply as well to the decentralized uses of renewable energy resources. It is for this reason that we believe that an intensive effort to expand the use of efficient energy using devices will also in the longer term benefit small-scale renewable energy systems. This theme is worthy of considerable analysis, but is beyond the scope of this paper.

companies or the nuclear power industry to suddenly mount a massive lobbying campaign in favor of triple paned windows, R-48 attic insulation, or heat exchangers in houses.) To the extent that political power continues to influence the federal government to provide incentives for the wrong energy systems, we will see the government play a role antithetical to many energy needs of the Nation. To the extent that the government sees itself as playing a role in correcting imbalances in our energy system and recognizes that it can be an agent for positive change, the potential impact of government action in setting a context in which decentralized energy systems can reasonably compete with conventional systems is enormous.

C. Specific Policy Recommendations

We believe that a number of important policy measures are needed in order to translate the tentative beginnings in the direction of reduced energy use, decentralized energy technologies, and decentralized energy decision making. As stated above, we think that key centralized decisions by the federal government can work in concert with, and indeed encourage, decentralized energy decision making throughout the Nation. We discuss a few of these measures to illustrate the types of policy actions that can overcome or reduce to acceptable levels the energy problems discussed in this paper:

- Energy Efficiency Standards: The energy performance standards for consumer products (appliances, heating and cooling equipment) are important policy initiatives. The fact that some of them (residential buildings, some appliances) are based on economic criteria is highly desirable and has led to much tighter standards than would otherwise have been obtained. These standards are appropriate because of the extensive failures of the

market place in these areas, as documented in this paper. However, the approach now taken is just a beginning. There is a need to (1) make the remaining standards (e.g., commercial buildings, certain appliances) consistent with economic criteria, (2) provide strong incentives for industry to produce more efficient products that will meet much stricter standards (while still being economically sound investments), (3) extend the building standards from new buildings to existing buildings, where very large saving in dollars and energy are possible, and (4) ultimately base standards on marginal prices (the true cost of new energy supply), which is possible only when industry has responded to the need for products that are substantially more efficient in their energy use than at present.

- Pricing: We believe that marginal cost pricing, combined with effective and fair taxes on windfall profits, is extremely desirable and will provide a significant boost to many decentralized energy systems. To be fair, the windfall profits tax should apply to all of the increased profits derived from the difference between average and marginal prices. We recognize, however, that marginal cost pricing, even with the difference in revenue between average and marginal prices of energy rebated to the American people, is not likely to be politically acceptable. A second best alternative is to base key energy policy decisions on marginal prices (e.g., conservation standards, incentives for new technologies that compete at the end user level against average prices when new supply competes against marginal prices). The government needs to make people aware of the rapid escallation in energy prices and the expectation of continued price rises. Even more importantly, the government needs to inform people how these prices can rationally influence their decision making on energy. Thus, even without marginal prices but with a serious educational campaign, many of the effects of marginal prices could be felt.

- New technology: If our case for decentralized energy technologies is accepted, then a new and important role for the government in

fostering new technologies emerges. This involves an evaluation of which technologies can pay off (and, as we have suggested, handsomely) in the near term followed by an intensive government role in facilitating their production and sale. We have suggested numerous new technologies that can increase energy efficiency by large amounts at substantial cost savings to the consumer. For some industries, incentives may be useful, to share the risk of sluggish market. For other industries, standards are needed. Standards with updates stated well in advance can strongly encourage the development of new products that are much more frugal in their use of depletable energy resources than the technologies that are replaced. A strong government role in evaluating and certifying the performance of these new technologies could also greatly promote their acceptance.

- Institution building: No institutional mechanisms for economic tradeoffs to be made between investment in energy supply and in increasing energy efficiency. As we have seen, the fact that the electric utility could evaluate only alternative supply options (thus excluding all demand moderating technologies) leads to an enormous squandering of valuable resources. This argues for an extension of the role of traditional energy supply companies into the markets spawned by energy demand technologies. Such an approach clearly requires new institutions or changes in old ones. The most striking example of such changes that are needed are the public utility commissions or public service commissions in each state. These commissions have great influence over all matters dealing with <u>electricity</u>. If their responsibility extended to matters dealing with the services provided by electricity, they could (under the proper framework) more effectively influence energy demand. This is but one example of numerous innovations that are needed to foster a more rational approach to decision making on energy.

IV. CONCLUSION

We have presented views of the seemingly paradoxical nature and irrationality of the energy system and the decisions that determine its evolution. An economic approach to energy decisions, while widely espoused and generally believed to be the underpinning of our system, appears not to be functioning in very important areas. The result is enormous waste of economic and intangible resources to produce energy that could be effectively replaced by energy conservation at low costs. This inefficiency in the economic system is, in our judgment, far greater than is recognized either by the public or by "experts." It has led to an over-investment in centralized energy systems and has discouraged the use of decentralized systems that could contribute significantly in the near term to a lessening of our energy problems. There are some signs that the situation is changing, albeit rather slowly. High prices and the widespread recognition of the seriousness of our energy problems have contributed to an increasing involvement of individuals in energy decisions profoundly affecting their future. To achieve an evolution of the energy system in which decentralized technologies (and, in the near term, particularly technologies that improve the efficiency of energy use) play an important role, the government must act forcefully. This action needs to recognize and be responsive to the powerful discriminatory effect of the economic system, as it is presently constituted, against investments in energy conservation.

REFERENCES

1. California Energy Commission, Biennial Report, 1979.

2. J. Hausman, Individual Discount Rates and the Purchase and Utilization of Energy-Using Durables, Spring 1979, Bell Journal.

3. M. D. Levine and D.B. Goldstein, Chapter 4 and Appendix A in Economic Impacts of Proposed Building Energy Performance Standards, Pacific Northwest Laboratory, October, 1979. (See also BEPS data base, Series VI, to be published in an LBL report by M. D. Levine, et. al., Analysis of Energy Performance Standards for New Residential Houses.)

4. Arthur D. Little, Energy Efficiency of Refrigerators, 1977.

5. D. Newman and D. Wachtel, "The American Energy Consumer," Ballinger Press (Cambridge, Massachusetts), 1975.

6. E. Vine, Planning for an Energy Conserving Society: The Davis Experience, Lawrence Berkeley Laboratory, February, 1979.

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