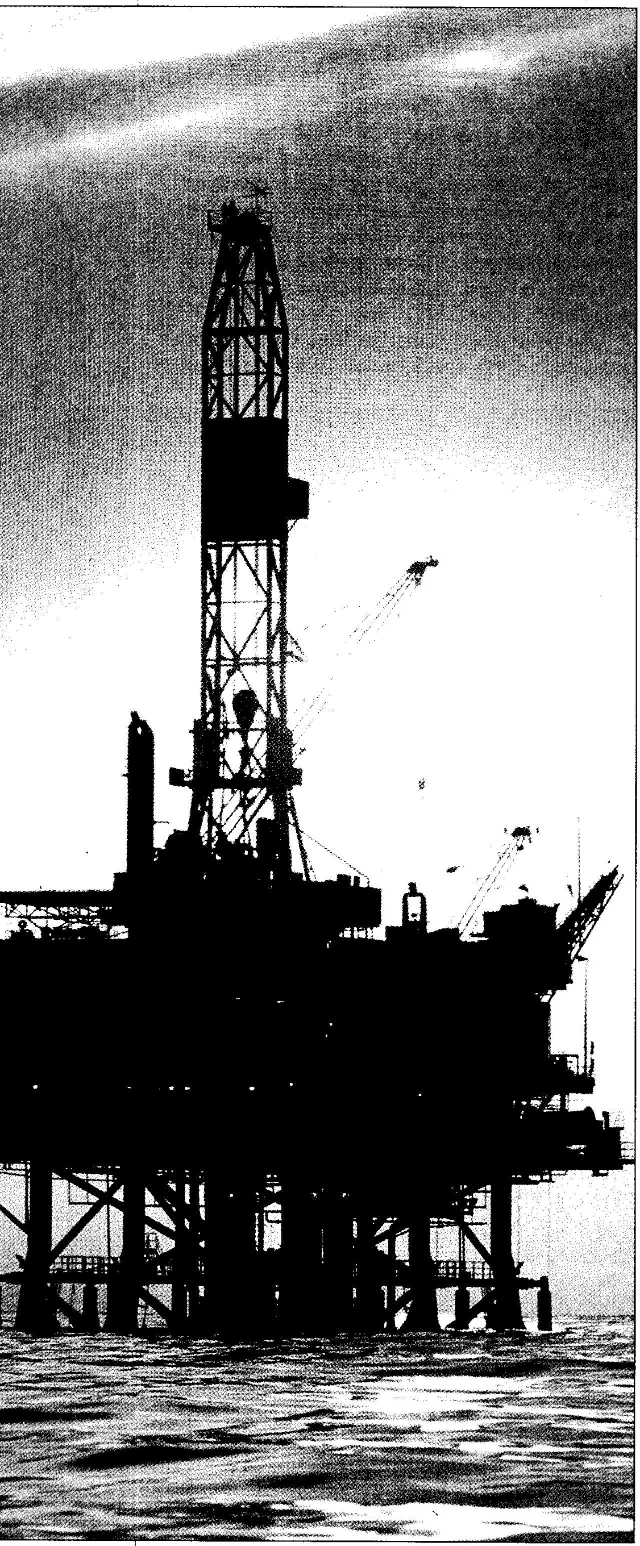

Off shore oil rig, Santa Barbara, CA. Image Bank

The Scope and Limits of Energy Policy

Energy is fundamental and necessary to all human activities. The reserves, such as hydrocarbons and uranium, are finite and the other supplies, such as sunlight, wind, and the like, are limited. To the degree that energy consumption depends in large measure upon population, economic activity, and lifestyles, in view of the limitations of the long-term supplies and potential environmental problems, it is necessary to develop and follow a consistent *long-term* energy policy using economic incentives for its implementation. The need to develop such a policy, without prescribing a *specific* policy, is here emphasized.

Introduction

Rider noted that "The subject of energy, in all its different ramifications, has generated an enormous amount of heat from politicians, environmentalists, regulatory bodies, economists, industry, physical scientists, the press, and ill-informed citizens" [1]. Indeed, much has been written about energy, especially since the OPEC

The authors are with the Energy Center, University of Oklahoma, Norman, OK 73019. Leon W. Zelby is Editor-in-Chief of IEEE Technology and Society Magazine.

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oil embargo, with a disappointingly large amount of it exhibiting either a lack of technical merit, or wishful thinking, or promotion of a particular political, economic, or social agenda [2].

What has been missing, except in rare and fragmentary instances, has been both a *balanced* view of the consequences of utilizing different sources of energy, and an objective examination of the uncertainties surrounding virtually all of the forecasts of supply, demand, environmental impact, and their social, economic and political significance.

The reason for this concern lies in that energy is THE fundamental commodity, a commodity with many different manifestations which are all intricately woven into our very existence: life and death, national and world economies, politics and social position, comfort and freedom of choice. Because energy is the *fundamental* commodity, and because it affects *everything*, it cannot easily be freed from controversy surrounding its production, transformation, and utilization. Every segment of global society has a different social, political, or economic viewpoint, and consequently its outlook on energy production and use will vary.

One would expect that with this pervasiveness and importance, governments at all levels would have placed energy high on their agenda. This need for some sort of an "energy policy" certainly has been noted more than once in recent times [3], yet little seems to have been accomplished.

This may well be due to the instinctive but not fully articulated realization that energy considerations do indeed permeate every act of any society, and in particular an advanced society, and that a truly comprehensive policy would be tantamount to *centrally planning the economy.* As has been especially evident over the last few years, those nations who have tried the great experiment of central planning have found it wanting. Using a rigorously detailed energy policy as a surrogate for rigid economic planning would most likely be no more constructive or successful. Therefore, except for the brief periods of gasoline and oil shortages, or occurrence of visibly obvious environmental incidents, energy policy has been virtually ignored.

There is a need for a thorough and comprehensive ventilation of the many issues involved in the formulation of an energy policy. There is also the need to recognize that formulation of an energy policy is substantially more complicated than addressing only few of its aspects, and recommending formats based on either purely economic considerations, or overweening protection of the environment, or either an overly optimistic or pessimistic view of energy supplies. Without a broad consideration of the very many issues and interests involved, and without provision of incentives which would encourage ready compliance, problems associated with formulation of an energy policy and use will not be successfully solved.

The incentives for compliance with any energy policy cannot be based solely on a set of laws and regulations, no matter how comprehensive. First, because these do not usually provide sufficient incentives even with attempts at continuous enforcement; and second, because of the need for stringent enforcement, costs may well become excessive. It follows that ANY suitable and workable energy policy for the long term must be based on incentives which would provide adequate freedom of choice, choice tempered by economic considerations rather than one directed by an increasingly complex web of laws and regulations.

An energy policy is clearly needed —but little has been accomplished

Paradoxically, although economic considerations would provide *an enabling mechanism* for an energy policy, the policy itself cannot be constructed *solely* on economic grounds — any more than it could be based on the use of only one or a few selected energy carriers; or on the expectations that new technologies will be developed to provide adequate supplies [4]. The fact that energy forecasts can vary from a low of 33 quads per year (about 35 EJ) to a high of 190 quads per year [5] (about 200 EJ per year) suggests that a different, broader and less subjective approach to energy policy is required. The approach should be descriptive rather than specifically prescriptive, an approach which takes into consideration such important factors as global population, aspirations of younger countries, and the rapidly growing worldwide interdependence in trade relations, transportation, communication, food supplies, social patterns and desires, environmental integrity, and others.

Conventional and widespread use of data on purely statistical basis in many of the analyses, and the tendency for extrapolations of past experiences using *linear* regressions, represent some of the factors which hamper the development of a realistic and "pursuable" energy policy. One of the reasons is that what *was*, may never happen again, and extrapolations, especially linear, rarely describe the changes which take place. For instance, until the beginning of World War II, energy use appeared to grow linearly, as is characteristic of initial exponential behavior; thereafter, however, its true exponential character became more obvious [6]. In spite of this now well recognized fact, there remains a disturbingly frequent tendency to use piecewise linear approximations and to extend them beyond the region of their respective validity [7].

Energy is *the* fundamental commodity and cannot easily be freed from controversy surrounding its production, transformation, and utilization.

There is an overabundance of data, much of which is incomplete, often internally inconsistent, or based on limited studies. These data lend themselves to a variety of interpretations and extrapolations using sophisticated statistical techniques as an underpinning, interpretations which frequently reflect more the leanings of the interpreter than an objective evaluation of the available information. In this context, probably the best assessment of such use of statistics is the observation by Moore: "... a statistical approach can provide false clues as well as valid ones" [8].

Although energy is the fundamental commodity, and the total amount — to paraphrase Boltzmann — is finite, the processes of its conversion and uses, and the consequences of the uses seem to escape many who take energy for granted when readily available; and react vigorously when it suddenly is not so readily available as, for instance, during the well advertised and documented "gasoline lines" of the seventies.

Whatever the popular and prevailing view on energy, it is becoming increasingly evident that an energy policy, a well founded and adhered to long-range energy policy, is vitally needed for several reasons: to provide national security and political and economic stability independent of external pressures which may be applied as the sources of energy supplies change; to maintain the standard of living to which we have become accustomed even though this may very well call for a modification of lifestyles; and to preserve the integrity of the environment.

The policy must be flexible to allow for the different energy needs in the different sectors such as transportation, which relies heavily on liquid fuels; in household and industrial activities which rely heavily on electricity and different forms of hydrocarbons; or air and sea navigation, communications, and entertainment which rely so heavily on electricity; and the like. The policy must be sufficiently flexible to allow for variations in lifestyles which vary with income levels and personal tastes, locations, population densities, climates, and so forth. Each combination of these variables requires a different array of energy carriers and their uses. Particular combinations should be encouraged where they make sense because of overall system efficiency, or because of impacts on health and on the environment.

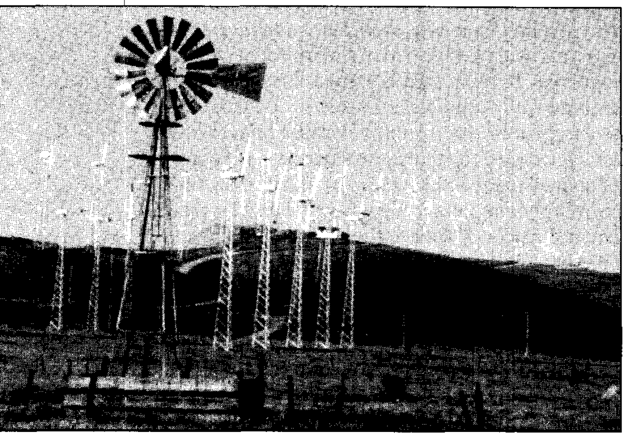
Scope

The scope of any energy policy formulation encompasses not only energy *sources* of all kinds but also energy *uses* from the most mundane household functions to the most sophisticated space probes. In addition, any energy policy affects social, political and economic activities of all, individuals as well as nations, none of which can exist without adequate supplies of energy carriers, whether they be twigs for an open fire or electricity generated by controlled release of the binding energy of the atom.

Although the immediate concern is *domestic* policy, that term is becoming increasingly archaic. It is now incontestably evident that energy uses or abuses, have global effects, cf. the "Butterfly Effect" [9]. The fact that concurrently there are societies which use the most sophisticated energy form currently known, electricity, along with those who use the most primitive, wood or dung burning, serves only to emphasize the range of the issues involved.

Availability of energy depends upon a large variety of sources which may be classified as "nonrenewable," "renewable," and "perennial." These range from the familiar and conventional such as the wind, wood, coal, oil, and gas to the less familiar such as some forms of solar energy, e.g., thermoelectric and photovoltaic, ocean thermal gradients, wind, and the like; the more "esoteric" forms of energy such as ocean waves, seiche, tides and geothermal; and finally, the frequently viewed with reluctance if not suspicion, nuclear fission and eventually (possibly) fusion.

The so-called nonrenewable sources comprise uranium and hydrocarbons; the so-called renewable sources, biomass in its many different forms; and the perennial sources, the many different manifestations of solar energy. It should be noted, however, that the distinction between "finite" or nonrenewable and "renewable" sources is often arbitrary and can be reduced to merely one of time scale. Biomass is renewable within months or years depending on whether one means cereals and grass or trees. Coal, oil, gas are "renewable" within thousands or millions of years. Furthermore, all of these are really carriers of energy with one of the fundamental differences among them being energy density, i.e., energy which they can produce per unit volume, per unit area, or per unit weight.


ind machines, Altamont Pass, CA.

As a matter of fact, viewing the various uses of energy, one might well think of a canonically conjugate relationship between energy and time, a relationship which affects the expenditure of energy to save time but one which we all too often attempt to violate by the failure to include social and environmental costs.

There have been numerous calculations made of the availability and reserves of the nonrenewable sources; and new discoveries change those periodically [10]. Whatever the amounts, however, it clear that the reserves of hydrocarbons and fissionable materials are "finite" at today's prices. Given a major shift in the value society is willing to assign to energy resources (i.e., a major increase in price), vast new quantities would be added to reserves. In principle, the supplies of "nonrenewables" could be expanded if demand-driven prices were commensurate with the costs of extraction. In fact, this is exactly the problem with biomass, solar and other renewables today. Contrary to popular conception, biomass as an energy source is also finite in spite of its being renewable within a substantially shorter time than hydrocarbons. The reason for this limitation of biomass is that there is just so much arable land, part of which must be used for food production, with the amount of food needed dependent upon the size of the population [11] a point discussed further in the next section.

The different forms of solar energy comprise sunlight for use in thermoelectric and photovoltaic systems or concentrators to produce electricity, or in passive systems for heating space or fluids. Thermal gradients produced by the sun in the atmosphere produce winds, which in turn can be used to produce electricity or mechanical work directly in regions in which the prevailing wind speeds are adequate; and the temperature gradients produced in the ocean can be used for electricity production. Other indirect products of sun's energy like waves, can also be used for the generation of electricity.

Tides, differences in salinity, and geothermal outputs provide yet another possible set of energy sources suitable for the production of electricity. In addition, there probably are some currently unknown processes which could either lead to novel energy sources or to an increase in the efficiencies of conversion of current systems.

The spectrum of energy *uses* is even wider than that of its *sources*. Although thermodynamically all that is happening is conversion to heat and work, in practice this can range from simple uncontrolled combustion of wood or coal, to rigidly orchestrated electronic transfer on a minuscule flake of silicon. In between lie the myriad conversions required for producing and consuming food, and for transportation, commerce, safety, health and personal comfort.

In contemporary society, electricity has become the most important form of energy. It is used as a means of performing work and providing heat at sites remote from its generation, and as a method of controlling other forms of energy such as fossil or nuclear fuel conversion. The consequences and inconveniences of blackouts and brownouts clearly demonstrate contemporary society's utter dependence on electricity — without it, society as *we* know it would simply not exist.

To the degree that electricity has become one of the measures of technological advance, it is to be expected that its use will grow rapidly as the less developed nations strive to reach comparable status. If the world's supplies of energy are to be suitably husbanded, the energy policies of developed nations should include provisions for helping the less developed nations develop their respective industries by the most efficient means available.

It follows that issues affected by any energy policy will be as numerous as energy uses. They vary from personal in terms of particular lifestyles to geopolitical in terms international influences and pressures.

The problem in the past has been that energy issues have been treated anecdotally and as expediently as possible. Solutions were often logically inconsistent, and in all too many cases simply created a new (future) problem to replace the old. For example, in order to reduce hydrocarbon consumption, a complex series of regulations were enacted which attempted to control highway speed limits, foster one form of fossil fuel over another (but only for a few specific applications), and to mandate energy efficiency without examining the total system costs (e.g., the energy "cost" of producing energy efficient products and structures). Simultaneously, a major source of potential relief from hydrocarbon utilization, nuclear power, was left out of consideration or dismantled, and other "natural" sources such as biomass, and different forms of solar energy, either opposed by various interests or largely ignored.

One of the key issues affecting energy policies in the past has been that of "national security." A case in point was the siting of fueling stations for the British navy in the 19th and 20th century. Increasingly, however, and providentially today energy security cannot be viewed as purely military protection because it must make greater allowances for economic and commercial competitiveness than it does for the simple security of fuels for the military machine. With current levels of oil imports nearing 50%, however, it is possible that pressures on political or economic activities may be exerted by foreign suppliers, pressures which may not necessarily be in the best interests of our nation. Consequently, this factor constitutes an important aspect of any energy policy.

It is well recognized that the U.S. is less energy efficient than other well developed nations such as those in western Europe or Japan by a factor of about 1.5 to 2.0 [12]. Although it has been claimed that an increase in energy efficiency, or reduction in energy intensity, would adversely affect the GNP and reduce the number of jobs, such claims are not borne out by data [13]. Although the relationship between energy consumption and GNP is real [14], it is much more complex than the different analyses imply, and structural elements other than levels of energy consumption could account for some of the differences in energy consumption among the industrialized nations.

The issue of personal lifestyles and individual freedom enter strongly into energy policy. For example, recycling is becoming increasingly important with the growing amounts of wastes, whether on an industrial, municipal or household scale, and problems associated with proposals for their disposition will have an effect on energy supply — either positive or negative. As recycling increases, there has yet to be a truly rigorous study performed of the net energy costs involved. It cannot be assumed that recycling automatically represents a positive contribution to energy utilization simply because some wastes can be used for energy production. There are, of course, many other examples of the impact of seemingly simple and beneficial activities that are influenced by, or influence the supply of energy.

Limits

In 1968, Hardin called attention to an important, probably the most important issue of contemporary existence, that of population [15]. It is, unfortunately, an extremely controversial and emotional issue. Sliepcevich [16], in a thoughtful and careful analysis, pointed out the interaction between population growth and energy consumption irrespective of the growth of the GNP on the global scale (see also [6] and [11]). Anticipating some of the current concerns about such environmental problems as the heating possibly due to the greenhouse effect, and environmental deterioration of any kind, he noted the limits of energy supply. This view was contradicted [17] though indirectly, using assumptions and extrapolations typical of many purely economic analyses.

The basic problem in many controversial issues, energy foremost among them, is that the extreme views, pessimistic or optimistic [18], appeal to the public more than the moderate and more reasonable approaches, possibly because of the techniques used by the communication media for the purpose of capturing attention. As a consequence, political response is often muddled and expedient as it attempts to respond to immediate problems rather than undertake fundamental changes which might not be well understood by the media or the public.

One can hardly overemphasize the impact on current energy policy — such as it is — of the need to simplify in order to communicate and dispel, or rectify, the distortions that so often result. Insofar as being alive is to be at risk, there are no totally safe alternatives. Nor, if the laws of thermodynamics are accepted, are there any methods of energy conversion or use that do not generate some sort of "waste." The public, however, has neither in its schooling nor in its "continuing education" by the media been prepared to deal with trade-offs and risk analyses — in energy or in any other matter.

To get a rough idea of the potential problems

The immediate concern is *domestic* policy, but that term is becoming increasingly archaic— energy uses and abuses have global effects.

which are likely to arise from profligate use of energy, it might be useful to make some sort of back-of-the-envelope type of estimate. The well developed nations use, on the average, approximately 200 million plus BTU (about 211 GJ/capita/year) per capita per year. It is not unreasonable to assume that as the less developed nations advance, as their respective industrial and commercial bases progress, *ceteris paribus*, the overall annual energy consumption may well reach 1000-1500 quads per year (about $1.1 - 1.6 \times 10^{21}$ J, i.e. over 1000 EJ versus current use of approximately 225 quads, i.e., about 240 EJ), assuming a comparable per capita consumption, a staggering amount indeed! As the less developed societies begin to grow, they *initially* will most likely use energy relatively inefficiently, and this ultimately will exacerbate the overall energy supply problem.

Conventional hydroelectric sources for the generation of electricity have just about reached their limit (about a total of 3 EJ available), whether in the developed or less developed nations. Tides and seiche are capable of producing some electricity but in limited quantities and only in some regions. Wave energy is generally useful for some very specific (and minor) uses such as buoys, although some envision large electric plants utilizing wave motion for the generation of electricity (a total of about 300 EJ from ocean currents, tides, and heat). In all these cases, net energy analysis, mandated by Congress [19], needs to be carried out to determine whether the utilization of these energy sources is worthwhile not from the economic but from the energy supply point of view. All too often, however, there is a paucity of information, and when information IS available, the net energy values vary substantially. If Howard Adler was correct, there are no energy sources which can provide net energy, if analyzed *ab initio* [20].

Inasmuch as the total earth's insolation provides about 90 EJ, assuming an average conversion efficiency of solar energy to electricity of about 10% (ocean thermal gradient converters claim 2% efficiency; photovoltaics, about 25% efficiency; windmills, about 25 – 30%) the total possible energy extraction from insolation would be, at best, about 9 EJ. Considering that the assumptions of the total insolation power and of efficiencies, as well as the use of the total surface of the earth, are obviously overly optimistic, it is clear that the sun alone, even when added to the hydroelectric, tide, and wave sources, cannot supply the energy consumption at the levels assumed — the total gross energy available from the various other "natural" sources, such as ocean heat, wind, tides, geothermal, hydroelectric, etc., is estimated at about 90 PJ [21]. It would not be inappropriate, therefore, to postulate that the earth's population constitutes a fundamental limit to any energy policy which asserts to provide "unlimited" supplies of energy once the so-called nonrenewable resources will have been exhausted.

Another limitation is that of environmental integrity. Proponents of various energy policies frequently proclaim the benefits of their choices without addressing the possible problems such choices may produce. Many advocates mix philosophic preferences with technological realities, and the arguments then become confusing and increasingly strident. Perhaps what is needed is a thorough "net environmental analysis" for each of the alternatives, as well as their combinations.

What is frequently ignored in the promotion of any of the singular form, source or carrier of energy is that each source exacts *some* toll from the environment, whether manifestly as in the production, transport and use of hydrocarbons, or more circumspectly as in growing, harvesting, converting and utilizing biomass. For example, nuclear energy, often represented as a "clean" energy source, is not nearly so clean when the path from the mine to the radioactive wastes is traced, a path which must include the environmental impacts of the enrichment process, and the large amounts of waste heat produced in the generation of electricity.

The products made from the various forms of biomass represent another category which is considered "clean." Yet, the use of ethanol in internal combustion engines produces carbon and nitrogen oxides as do fossil fuels, and also produces biomass wastes in its production which contribute little if any energy and will pollute as they oxidize.

Different forms of solar energy are also generally considered non polluting. Although it may well be likely that some of these contentions are true, to establish this as an unequivocal fact at least three attributes need be examined: the pollution generated in the production of conversion devices like windmills, photovoltaic cells, ocean thermal energy converters (OTEC), or the like; lifetimes of the devices; and the net energy, i.e., the energy produced by the devices over their lifetimes versus the energy required to produce and maintain or service the devices. Furthermore, a few demonstration windmills, or OTEC plants, might not have a significant impact on the environment but a number large enough to affect energy supply measurably might also have an environmental impact exceeding that expected by simple linear addition. For instance, having a large number of OTEC plants in regions of suitable ocean thermal gradients may well reduce these gradients to levels unacceptable for electricity production and render them proportionally less efficient ("diminishing returns") or even utterly useless [22]. A large number of windmills may well have an impact on the downwind weather and/or electromagnetic communications.

The use of hydrogen as a fuel, recommended by some [23], represents probably an energy carrier cleaner than most others, but even in this case there is the question of the "cleanliness" of the production process, of safety, and the integrity of the transportation and delivery system. Hydrogen is difficult to contain; it embrittles many metals, and the net energy required for its production is currently negative.

There are still many other types of energy sources such as active solar, or geothermal; use of municipal wastes, and so forth.

All energy sources, however, carry social, monetary and environmental costs which need to be compared more systematically and more objectively than has been the custom thus far [24]. Inasmuch as no single source can satisfy the diverse needs of society, a mix of fuels and delivery and conversion systems will remain necessary. Whether the current division of uses, e.g., liquid hydrocarbons for transportation, and electricity for space conditioning and cooking, is the most efficient way to utilize available energy resources is questionable.

The foregoing constitutes only some of the limitations of any energy policy. The recent growth in concern over carbon dioxide and its effect on the Earth's climate raises a new, and potentially unique, problem. Whereas other combustion byproducts, e.g., SO_x, NO_x, can be effectively neutralized, the cost to "trap" CO_2 would be enormous [25]. Furthermore, the question of what would be done with this CO_2, once isolated, has never been seriously addressed. Unless fossil fuel combustion is to be banned, carbon dioxide *will* be released in growing amounts as population and energy demands increase.

Discussion

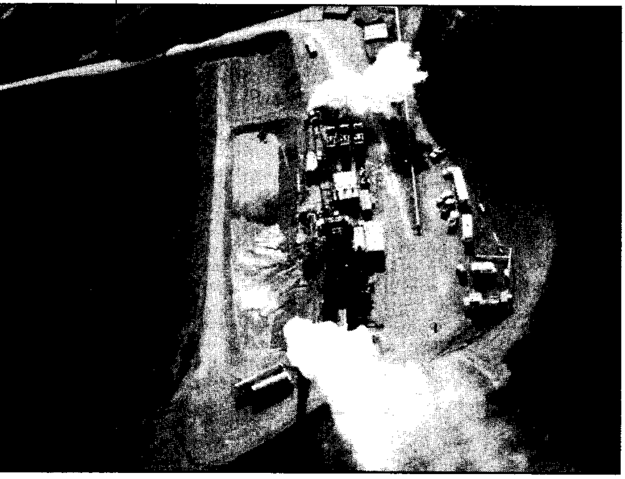
The preceding sections attempted to highlight a few of the considerations that would underlie any attempt at formulating a "traditional" *national* energy policy, that is, one which dictates the fuels that are to be favored, where they will come from, what one does with wastes, and similar proscriptions. In view of this enormous complexity — which grows daily as society changes — it must first be determined whether indeed these "traditional" objectives might themselves require reconsideration. Today, any energy policy must of necessity address *global* issues because of the availability of certain energy carriers in some locations, and materials for their conversion in others; because of the effect of energy production and uses on transnational environment and ecology; because of the economic impacts of energy carrier extraction and transfers.

No energy policy should be put in place, for example, which has even the appearance of denying the less developed nations an opportunity to improve their standards of living to levels comparable to those of the developed nations. Even if the less developed nations do not reach full parity in industrial production and per capita energy consumption with the developed nations, one can certainly acknowledge that space conditioning alone, i.e., heating and cooling, will rapidly become more widely used, a factor which will require very substantial amounts of energy.

No matter how one looks at the situation, energy supplies — at least those to which we have become accustomed such as hydrocarbons, wood and uranium — have limits, either in availability or in the environmental loading that their use incurs. Malthus proposed an interesting idea, but identified the wrong commodity — the limiting factor does not appear to be food supply, but rather energy supply. The critical need now is to develop a much wider constituency that recognizes the importance of energy supply and use, in order to begin the difficult task of adaptation and modification which will be necessary to maintain acceptable living standards with perhaps somewhat different practices. It is only this recognition which will make any energy policy successful and viable.

Conclusions

Energy is a commodity, a commodity more important than currency, for at least two reasons: first, the naturally occurring resources which are available for conversion to useable forms are diminishing relative to the demand. Second, unlike any other commodity, it is a necessary component of every act of every person for every moment of life. Unfortunately, its subtlety is not generally appreciated or even well understood, hence energy policies formulated *strictly* in economic rather than energetic terms have been the rule in the past [26].



Geysers power plant, California.

As a consequence of its utterly fundamental character, energy policy may well be "too important to be left to politicians." What are the alternatives? Is anything truly immune from the increasingly short-term focus of the political process? Perhaps a body similar to the Federal Reserve Board (FRB), a body which is somewhat more insulated from political pressure and lobbying than the executive or legislative branches, could be set up [27]. This body would guide energy uses through a series of linkages to the taxation and banking systems. Although the formulation of any energy policy should not, as discussed above, be based on purely economic considerations, it is clear that the use of economics in the implementation of a policy represents a powerful tool, a tool substantially better, more reliable, and more efficient than a set of laws and regulations [28].

Clearly, such an "Energy Board" (EB) would have to understand not only all aspects of energy production, transport and end use, but also be aware of the associated problems of environmental management, international political relationships, and economic development. Moreover, since the energy and environmental systems are global in character, similar boards or agencies would have to be set up in most, if not all, countries, and they would have to interact periodically as do the currency commissions and regulators. The challenge, if anything, would be even greater than that currently borne by the financial regulators.

Two additional points are worth mentioning. Unlike economic systems, one cannot declare "energy bankruptcy" with impunity: the slate cannot be wiped clean through legal procedures and one cannot start anew with a court-appointed trustee. When certain energy supplies become exhausted, it is not at all evident that substitutes will be immediately available in the quantities and forms to which we have become accustomed. The second is that, whether concerns with environment are valid or not — be they pollutants or greenhouse effect — it would be more prudent to follow the safer, the more cautious procedure as we do, say, in accident prevention such as providing seat belts or air bags, or in health related issues: practice prevention.

Is such an approach to energy and environmental husbandry unrealistic? Probably!

We currently suffer a shortage of Plato's philosopher-kings, but in their place we would need to gather the "best and brightest" of our natural, health, and social scientists, environmentalists, soldiers, and lawyers. The powers to impose selective energy taxes [29], and other fiats, would be indeed formidable and the main challenge would be to develop the consensus necessary for effective and significant implementation.

When all is said and done, energy policy is unquestionably more important than our fight against disease, drugs, crime. Energy is THE backbone of our complex society and it is a commodity to which we must pay increasing attention as ours, and the world's, demands on its use increase.

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[25] P. Passel, "Cure for greenhouse effect: The cost will be staggering," *New York Times*, p. Y1, Nov. 19, 1989 cites the projected costs of curbing pollution contributing to the greenhouse effect vary from a low of $800 billion to a high of $3.6 trillion.
[26] L. W. Zelby, *Alternative Energy Sources*, T. N. Veziroglu, Ed. Ann Arbor, MI: Ann Arbor Science, 1979, pp. 4955-4962.
[27] L. W. Zelby, *Alternative Energy Sources*, T. N. Veziroglu, Ed. Washington, DC: Hemisphere Pub., 1983, pp. 247-254.
[28] As the FRB checks interest rates and money supply to control inflation or stimulate the economy, or the like, the EB would use taxation to encourage a prudent or desirable energy use. For example, instead of setting specific fuels or efficiencies for automobiles and trucks, it could establish a tax structure which would encourage, say, greater fuel economy and less polluting fuels. To encourage "cleaner" generation of electricity, it might separate generation and distribution functions [cf. legislation introduced by Sen. J. Bennett Johnson to amend the Public Utility Holding Company Act of 1935 to create corporate entities called Exempt Wholesale Generators], and establish some sort of rate structure which would reflect the real costs of electricity, i.e. including all social costs, and would encourage conservation. This arrangement might provide incentives to use less polluting energy sources and to conserve energy, yet would leave adequate freedom of choice which laws and regulations do not.
[29] L. J. Carter, "Energy policy: independence by 1985 may be unreachable without Btu tax," *Science*, Vol. 191, pp. 546-548, Feb. 13, 1976. T&S

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range problems and to problems with strong probabilistic components. For example, it has been perfectly clear for many years that petroleum supplies are approaching exhaustion in a matter of decades. Because of the long lead times involved in making the necessary adjustments (of whatever type we choose) it is essential that large scale research and development projects be initiated immediately, and that serious conservation measures be implemented now.

The market mechanism for stimulating these steps would of course be a steady and significant rate of increase in the price of oil. But there is no really major research and development effort (the United States government has actually reduced funding in this area over the last decade), and conservation efforts, while significant, have been of a modest and sporadic nature. The reason, in part, may be that, for the past decade, oil prices, fluctuating on the basis of short term developments, have reflected no sense of urgency. Thus we see for example that, after a significant increase in automobile mileages per gallon following the oil price hikes of the seventies, there has been little improvement over the past decade. There seems to be little reason, left to its own devices, why the free market should make adjustments to deal with such problems as the greenhouse effect or acid rain. Indeed we have seen that the corporations that are in principle market driven, have strongly resisted efforts to cope with these problems. While arguing that "the facts are not all in" about acid rain and the greenhouse effect, they have not been conspicuous advocates of accelerated research efforts to obtain those facts.

Problems such as these are not going to be dealt with adequately by all of us acting independently to further our own self interests. What is needed is collective action on a national and international level to defend the long term interests of all of humanity. Massive resources must be allocated to a great variety of research and development projects (many of these might themselves be small scale efforts). The force of law must be applied to protect the environment that we all share. Bringing this about will not be easy. Human history is replete with examples of the dangers of bureaucracy and the abuse of power by government officials. The challenge is great — but meet it we must. T&S