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Energy for the Year 2000

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PREFACE

The Third International School on Energetics was devoted to the subject of Energy for the Year 2000. By this title we hoped to avoid discussion of such matters as the role of OPEC in raising oil prices. In one sense, therefore, our task was made easier; we could merely look into our crystal balls.

The choice of lecturers was made with the idea that no reasonable source of energy can be overlooked. We omitted detailed lectures on oil and natural gas because we took it as a given fact that we would continue to use as much of these fuels as we can get at a reasonable price.

To give us an overview we started the School by discussing U.S. energy policy and possible U.S. energy scenarios. As might be expected, there was some disagreement about the current energy program in the U.S., but little disagreement about the facts presented.

Various energy options were examined. They included nuclear power and the breeder reactor where the lecturers focused primarily on controlling various problems inherent in using fission power for energy production. There were lectures on coal--a source which will, hopefully, be used in more and more environmentally superior ways, and two sets of talks on solar energy--one a general survey and the other a detailed discussion of photovoltaics. The talks on solar energy were realistic about the current state-of-the-art and very optimistic for long-term research and application. Energy production using waves was a topic scheduled but was not presented due to illness. However, the lectures do appear in this volume as originally prepared.

Richard Wilson

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CONTENTS

8062617

ENERGY FUTURES: STRATEGIES FOR THE U.S.A.

Chauncey Starr
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THE STRATEGY ISSUES

Introduction

The recent history of U.S. energy policy does not reveal a consistent strategy behind our actions. There are many reasons for this, but outstanding is the fact that no clear popular view has emerged to support a comprehensive strategy for dealing with the mixed aspects of the U.S. energy problem.

We have instead dealt with the discreet issues on which a consensus appeared, such as a 55-mile-per-hour speed limit, mandatory auto efficiency standards, and new building standards. Similarly, long-term research and development programs have been initiated, particularly in solar energy. Policy in both these cases could go forward politically before settlement of the difficult issues of oil pricing, environmental standards for coal mining and use, or any of the many controversial aspects of nuclear power.

This piecemeal approach and preoccupation with the detail of short-term factors has failed to assure the long-term availability

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*Dr. Starr used materials from three reports in his lectures. The first is printed here, but due to copyright laws, we are unable to reproduce the other two. They were entitled, "Energy and Society" and "Energy Systems Options," and are contained in Current Issues In Energy, Chauncey Starr, Pergamon Press, New York, 1979.

of energy in the U.S. The means by which this objective should be reached continues to be the center of the U.S. energy policy debate.

The purpose of this talk is, first, to consider the ways in which the elements of the energy problem are generally understood, to question that understanding, and to pose alternative statements of the problem; and, second, to summarize specific aspects of energy and electricity supply and demand which relate to strategy alternatives.

Conventional Energy Analysis

Conventional analysis of energy issues presumes generally that economic cost-benefit analysis of the issues can produce a reasonable guide to optimum energy policies. Unfortunately, economic analysis appears to be limited to the effects of changes that are quite small relative to basic reference parameters, such as the effect of small changes in energy price or supply. Effects of this nature are referred to as marginal. The limitation of this type of analysis is that large nonmarginal changes are obviously more important, yet conventional extrapolations generally result in the misestimation of their effects.

In addition to the limitation that changes be small or "marginal," conventional analysis is also limited to those aspects of the problem that can be quantified. For example, the point that economists underestimate the social cost of energy supply has been a central tenet of environmental groups, and they are correct. But there is a corollary missed by the environmentalists--we similarly underestimate the social value of energy use. Neither has been well quantified. By looking only at marginal changes, we equate the benefits with the social value of the last unit of energy used, and, of course, this generally tends to be wasteful or frivolous, as well as the most costly unit.

Conventional energy analysis also frequently suffers from a static view of social values. Those values which we currently hold may change rapidly, as, for example, on the importance of environmental protection versus economic growth, or on the equitable control of resources versus unrestricted competitive opportunity. As a more familiar example, conspicuous, energy-consuming, large automobiles have suddenly been displaced as status symbols by the diesel Mercedes and the solar collector.

Complexity of Energy Issues

The mix of complex issues that goes into the formation of U.S. energy strategy includes the following:

Supply Issues

- The Geology and Geography of Energy Resources
- Supply Technologies and Alternative Sources
- Environmental Impacts and Public Risk
- Imported Fuel--Cost, Availability, and Supply Security

Demand Issues

- Conservation--Price Effects and Technology
- Energy Needs of the U.S. Economy
- Lifestyle Benefits of Energy Use

Political and Economic Issues

- Impacts of Energy Imports
- Equity and Distributional Effects vs. Aggressive Economic Growth
- Energy Producers--Size, Power, and Profit
- Demand Modification vs. Supply Modification
- Energy Policy in Conflict with Social Goals
- Energy Policy as a Surrogate for Social Policy

The length of the above list is a big part of the problem, because the array of feasible strategies does not contain any capable of resolving all these issues. Save for some possibility that a lucky long shot will occur (for example, a miraculous photovoltaic discovery or extremely large domestic oil and gas finds), no easy comprehensive solutions are visible. And those solutions which require personal sacrifices (President Carter's "moral equivalent of war") have not been judged politically salable to the American public--at least by the politicians.

Free Markets vs. Political Tension

Another aspect of conventional analysis is its assumption about how world energy markets work. It treats energy trade (principally oil trade) as if a free market exists. The attraction of this view is obvious. The economic description of such a market is most

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familiar to economists, and this model is a powerful analytical tool.

The free market view is clearly oversimplified and exaggerated. Certainly, even the strongest proponents of a free market recognize the existence of OPEC and the potential for using oil exports to influence political objectives. But what distinguishes the conventional view is an assumption that political decisions will bend to market forces, that is, that prices cannot be maintained at "artificially" high levels indefinitely.

The contrasting view is that we have a political world market, and that optimization from the seller's viewpoint does not mean maximizing only the present value of revenues, but includes influencing the foreign policy of the buyer. Lest we believe that political intervention of this sort is a recent or temporary effect, it is useful to recall that the U.S. has acted this way for a number of years in specific areas, for example, by trade embargoes with Cuba or by linking trade conditions with human rights policies. The point of these examples is not to critique such actions; it is rather common and that these policies have, in many cases, persisted for decades. The key issue for the U.S. raised by the political nature of the international market for fuels is the uncertainty of supply continuity, and the national security and economic vulnerability to a sudden and large reduction in supply.

Marginal Analysis vs. Supply Vulnerability

As an alternative to a policy based upon the premises of economic marginal optimization, it may be more important to the national interest to seek a policy which reduces both the likelihood and the effect of energy supply interruptions.

To some extent this position is exemplified by the decision made by several nations to create a strategic oil inventory. The U.S. has initiated such a reserve, recognizing that strategies should reflect the flexibility needed to deal with the political uncertainties.

But we failed to carry this understanding over to internal aspects of energy policy, despite painful evidence of the interruptible character of virtually all primary energy sources. In the past several years, shortages or interruptions of coal, natural gas, hydro, and nuclear power have occurred in addition to the oil embargo. It would be justifiable to subsidize high cost courses (and conservation) more aggressively to reduce the national vulnerability arising from dependence on any single source, either domestic or foreign.

On this basis, the U.S. would be wise to subsidize synthetic fuels from coal, oil shale, and liquid biomass fuels. If, as is occasionally alleged by proponents of these technologies, the lack of private industry commitment to these systems stems from the possibility that foreign oil producers can undercut their price, then Government support guarantees are appropriate. It may well be to the self-interest of the U.S. to pay $25/barrel for synthetic fuels rather than $20/barrel to OPEC, when the intangible costs of vulnerability to supply interruption are included.

We undertook our strategic oil reserve precisely because of the insurance it provides against interruption, yet the issue of electric utility reserve margin is rarely given the same consideration. In the past, the rule of thumb that developed was that a 20 percent reserve margin was roughly the desirable level to handle plant outages, maintenance, and uncertainty in demand due largely to the effect of extremes of weather. Today we have an added factor, supply uncertainty. Since the 1973 embargo, the United States has experienced several rather extreme weather conditions: the Western drought, which reduced hydroelectric availability, and Midwestern blizzards, which left coal barges stranded and coal stockpiles frozen solid. In both cases the high reserve paid off, as the less affected oil and nuclear capacity met the demand. The 1977 coal strike was another case of supply interruption, as is the current mandated shutdown of five nuclear plants for seismic analysis.

If we allow the implications of our intuitive understanding of supply vulnerability, we should consider policies to reduce this vulnerability by replacing insecure sources, such as imports, with more secure domestic sources, even at higher prices. The obstacles to such policies arise from several sources. First, and most apparent, is the ideologic and political opposition within the U.S. to policies which would accelerate either the rise in energy price or the expansion of coal and nuclear power, or early commitment (particularly with Government guarantees) to synthetic fuels from coal. This aspect, like the political component of the world oil market, is not quantifiable, but is quite clearly a primary obstacle to reductions of imported oil.

A second aspect of expanding domestic sources to reduce imports is the magnitude of the capital and other resource requirements needed to do so. A rough estimate is that to replace all oil imports with conservation, coal, nuclear, solar, oil shale, and other sources would require an investment of about $250-$500 billion. Currently, direct investments in the U.S. energy system are roughly 2 1/2 percent of GNP, or $50 billion per year, and conservation investments add to this unknown additional amount. But these conventional investment rates have merely sufficed to meet some demand increases and compensate for the depreciation of existing equipment. The investments of the past several years have not even been sufficient to hold oil imports constant.

Attempting to achieve this substitution by the end of the century would require that we double our investments into energy systems during the next decade. This would represent a national peacetime investment less than half the military budget. President Carter's "moral equivalent of war" description is, indeed, accurate in describing the level of effort needed, if reduction of oil imports is the objective.

DEMAND AND SUPPLY PROJECTIONS

At present we do not have an extraordinary U.S. effort to accelerate alternative domestic energy sources which are technically feasible and almost economically affordable (even if not yet competitive). In the absence of such a program, our energy demand and supply projections continue to be based upon the criteria of commercial availability. Within the present conventional framework, the projections for the U.S. here presented assume the acceptability of oil imports and of expanding coal and nuclear power.

Demand Projections

Historically, the growth of our economy and energy have been closely coupled in both time and magnitude, as shown in Figure 1. In the future, the relationship between these factors can be expected to be modified to some degree by conservation, new technology, and changes in the relative size of the service versus the industrial sectors of our economy. A slow historical trend of reducing energy demand per unit of economic output is inherent in the relationship displayed in Figure 1. This was primarily motivated

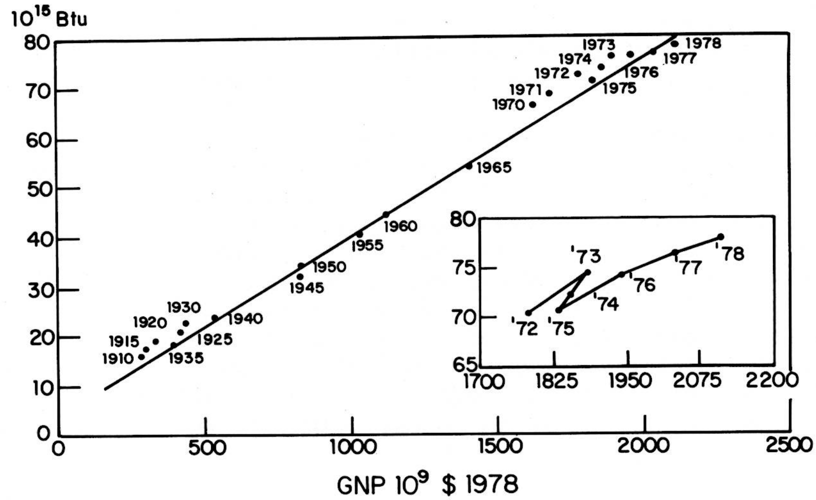

Fig. 1 Historical growth of energy use vs. economy

by the saving in capital cost of energy-converting and -using equipment which resulted from increased thermodynamic efficiency. The recent increases in primary fuel costs have motivated supplementary conservation efforts in addition to those in the historical trend, and in this paper, the term "conservation" refers to this supplement.

In recent years this strong relationship between energy and economic output (as measured by GNP) has continued despite the 1973 oil embargo and the recession of the mid-1970's. As Figure 2 illustrates, GNP and energy have been tightly linked.

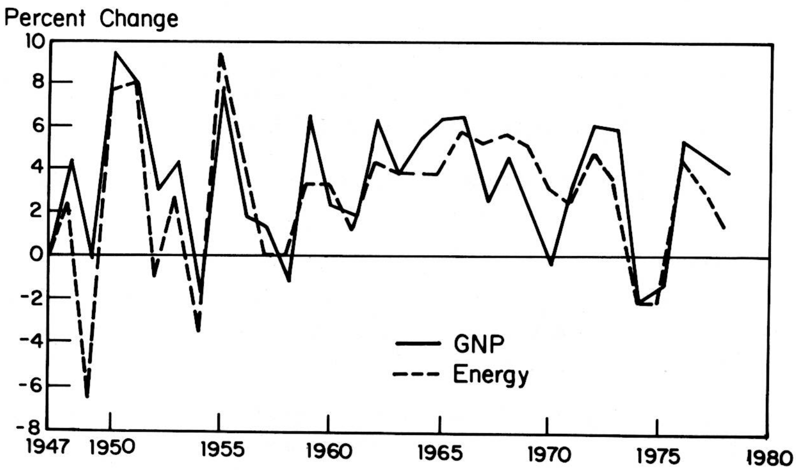

Figure 2. Changes in energy and GNP.

We expect the coupling of energy and economic growth to continue into the future, with the coupling coefficient depending on the course of the principal variables. Four important variables to consider in terms of future energy requirements are: the productivity of labor, employment level, the impact of conservation, and the energy required to meet national air and water quality goals. We know that the year 2000 labor force will be about 1 1/3 times the present, because most are already born. In this analysis we have assumed a 4 percent unemployment and a continuing trend of female participation.

Figure 3 shows a base case total energy requirement of 157 quads in the year 2000, assuming a plausible projection of economic data and continuation of the historical relation to energy use. The trapezoidal box shows the range of projections which occur if the growth rate in the productivity of labor is varied between 0 - 2.3 percent per year and conservation is varied between 28-46

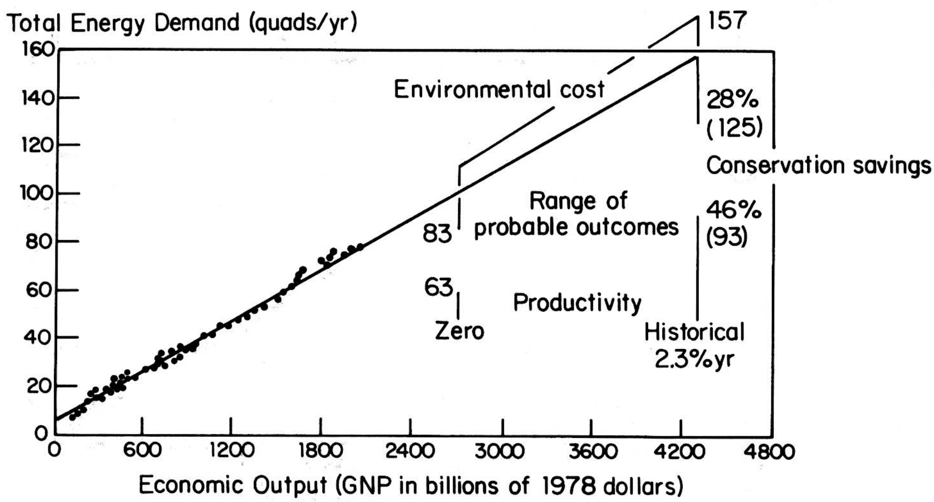

Figure 3. Projection of year 2000 energy and GNP.

percent savings from the year 2000 base case. It is expected that the pressure for environmental improvement will remain, and a 10 percent primary energy cost is estimated for this purpose.

There is a reasonable possibility that actual energy demand and GNP will fall near the top of this box. The lowest demand shown in the lower left-hand corner of the box indicates a year 2000 energy demand of about 63 quads, if 46 percent energy conservation could be achieved, and the productivity of labor were frozen at today's value, a combination that is possible but unlikely. Nevertheless, it is analytically correct that full employment could be maintained without increasing the present levels, if individual economic output is held fixed and conservation is pushed to its technical limit.

Based on the importance of modest planning for a surplus rather than a deficit, the upper right-hand corner of the box, which is equal to 125 quads, may be the prudent target. This assumes 28 percent conservation by the year 2000, 10 percent environmental clean-up cost, and historical growth in the productivity of labor. The 28 percent conservation savings appears to be an optimistic, yet achieveable, objective. It should be realized that, as a nation, we have been for many decades increasing the efficiency with which we use energy, and that conservation savings much in excess of 28 percent will require either massive economic investment or significant technical changes. Economic pressures alone may motivate the 28 percent conservation, as the cost of all primary fuels is expected to increase steadily.

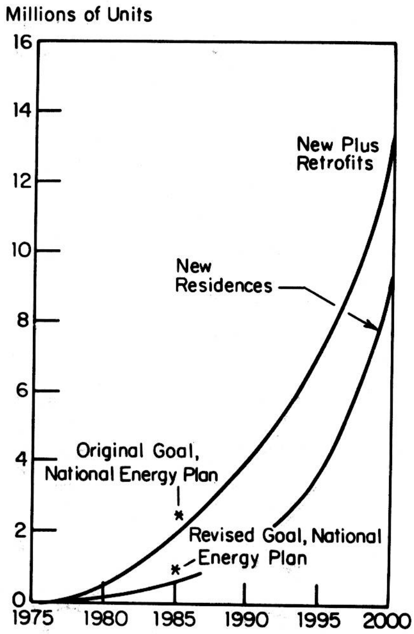

Figure 4. Solar heating of residences (installation rate).

Without going into a detailed discussion of how this future supply will be provided, it is valuable to examine the likely role for technologies currently under development, but not yet commonly in use. Of these sources, solar space and water heating is the technology furthest advanced. Space heating with solar is somewhat more expensive. An EPRI solar heating study analyzed the likely energy savings under several different rates of utilization. This is shown in Figure 4. As this figure indicates, an optimistic estimate is that 13 - 14 million residences would use solar heating in the year 2000, these out of about 106 million residences projected.

The conventional energy displaced by this solar heating is shown in Figure 5. As this study indicates, the fuel savings amount to about one quad. Thus, even if we installed solar heating in 60 or 70 million residences, the savings would be about 5 quads. This could make a significant impact on natural gas consumption, but it only one part of the answer to our supply problems.

In considering how fast new energy sources can contribute to supply, it is instructive to consider nuclear power as an example

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