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LIMITING THE DEMAND FOR ENERGY: POSSIBLE? PROBABLE?

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Energy Conservation Schematized

Proposals to dampen growth in energy consumption usually have the two-fold objective of conserving finite resources and minimizing environmental damage. I will assume two conditions as governing the pursuit of these goals: first, that for the time span for which it makes sense to look ahead, any suppression of energy-consumption growth will not be brought about by a deliberate slowdown of economic growth in general, even though that may be an independent goal for other reasons and may ultimately be forced on us by resource stringency and environmental constraints; and second, that reduced energy use will conform to economic and not merely physical or engineering, efficiency criteria—so that simply to switch, say, from a conventional space conditioning setup to a heat-pump system featuring fewer Btu's of energy input per unit of effective energy output is unacceptable if the shift involves a net increase in total costs. Any such cost comparison should, however, include the environmental and other external costs traditionally left unaccounted for.

Just as it seems proper to reject socially costly ways of reducing energy use, so it is necessary to point out that there are ways in which reduced energy consumption is essentially a by-product, or, at best, only one element within a wider context of socially desirable policies. Thus, diminished reliance on large horsepower private passenger cars reflecting low load-factor usage would very likely yield significant savings in energy consumption, but such a change in transportation arrangements is apt to be necessitated by overriding needs of a more general sort rather than simply by efforts to cut down on fuel use.

To clarify the notion of energy demand dampening in terms of the two-fold objective mentioned at the outset, it may be useful to refer to the schematic outline of Table 1. The table distinguishes between the conservation of raw (or primary) energy resources, on the one hand, and energy as it is utilized by ultimate consumers, on the other. Table 1 also identifies the effect of various conservation practices on electric generating capacity, since much current controversy exists concerning the issue of power plant siting requirements.

Some of the items cataloged in Table 1, such as line 1, reflect a point already made—that some opportunities for energy conservation are largely dependent on other social and economic trends. As indicated, these refer to developments which, if they come about, could reduce energy consumption and do so for each column in the table. The desirability of those developments may, in fact, be reinforced by the need to conserve fuels and power but may be presumed to have such widespread economic and social implications that it would appear inappropriate to suggest them solely as energy conservation measures—as in the case of mass transit, or policies to dampen population growth or economic growth.

Other lines in Table 1 illustrate the fact that conservation at one stage of energy flows in the economy need not signify savings at another point. Improving the efficiency of central electric generating stations, referred to in line 2, yields raw energy savings (say, of coal, oil, or gas) without any necessary diminution in final electricity utilization or plant site requirements. In this example, even in the absence of reduced consumer demand, resources are conserved; the environmental costs of producing them (say, oil spills or acid mine drainage) are mitigated, as are the thermal and air pollution emissions at power plants. But the esthetic disruption arising from the presence of a power plant or transmission line remains.

Line 3 reminds us that offpeak energy use—turning on the electric clothes dryer at mid-day rather than during the hours of intensive power demand—may reduce the volume of required generating capacity without, however, reducing the quantity of raw energy needed for combustion or the amount of electricity consumed.

Line 4 reflects the fact that some forms of energy utilized by the consumer are judged to represent a lesser drain on primary energy resources than other forms. An example commonly cited suggests that by delivering heat to households from gas furnaces rather than

TABLE 1
A SCHEMATIC RUNDOWN OF ENERGY CONSERVATION PRACTICES

(ϕ = energy saving; x = no energy saving)

	Conservation of:		
	Raw energy resources	End-use energy consumption	Electric generating capacity
1. Reduced population and income	ϕ	ϕ	ϕ
2. Improved conversion efficiency (as in conventional electric generation)	ϕ	x	x
3. Better load balancing	x[a]	x	ϕ
4. Shift in end-use energy use towards form involving higher conversion efficiency (as in shift from electric heating to gas heating)	ϕ	x	ϕ
5. No shift in end-use energy form but shift in intermediate energy conversion towards a higher-efficiency technology (as in shift from conventional electricity generation to MHD or fuel cell)	ϕ	x	x[b]
6. More efficient end-use energy utilization in satisfying given "need":[c]			
(a) Improved end-use technical efficiency, as in shifting from incandescent to fluorescent lighting to furnish given degree of illumination	ϕ	x	ϕ
or, use of lower horsepower automobiles or mass transit to furnish given volume of passenger mileage	ϕ	ϕ	x[d]
or, more efficient household motors	ϕ	ϕ	ϕ
(b) Reduced heat and light needs via improved building design and insulation	ϕ	ϕ	ϕ[e]
(c) Eliminating "waste" (e.g., turning off unused lights, or raising summer thermostat when home is unoccupied)	ϕ	ϕ	ϕ[e]
7. Shift towards less energy-intensive end-use activities:			
(a) Where purpose of a given activity can be achieved without fuel or power use (e.g., walking instead of riding, communicating instead of traveling)	ϕ	ϕ	[f]

TABLE 1 (*Continued*)

(ϕ = energy saving; x = no energy saving)

	Conservation of:		
	Raw energy resources	End-use energy consumption	Electric generating capacity
(b) Shift towards consumption of goods and services containing less embodied energy (e.g., more steel, less aluminum, natural instead of synthetic fibers)	ϕ	ϕ	ϕ
(c) Tolerating increased discomfort (e.g., by limiting acquisition and use of various energy-using appliances)	ϕ	ϕ	ϕ
8. Shift towards less energy-intensive, but still economic, production practices (e.g., by waste heat utilization, or by change in product-output specifications, such as brown paper in replacement of white paper)[g]	ϕ	ϕ	ϕ

[a] Slight savings may accrue from not having to use inefficient peaking equipment.
[b] There may not be a saving in kilowattage, but perhaps one of site requirements.
[c] "Need" may have to be defined in physiological or normative terms.
[d] If the switch were to be electrified mass transit, electricity consumption (even if not energy consumption as a whole) would go up, and so, therefore, would electric generating capacity.
[e] The extent of the saving in electric generating capacity depending on whether electric heating or cooling is involved.
[f] Effect is unclear.
[g] Less proliferation of models and increased durability could also produce raw energy savings, provided the economic resources so freed are not diverted to other energy-intensive output.

through electric heating units, primary energy savings occur because the low-efficiency electric plant conversion stage is thereby bypassed. The fact that the conservation benefits of switching away from electric heat seem frequently to be overstated and the arguments for such a shift oversimplified doesn't alter the basic point of this example.

Line 5 is similar to line 2 insofar as it illustrates the effects of enhanced central station conversion efficiency.

The different components of lines 6 and 7 are those cited most frequently in discussions of dampening energy demand. Line 6 suggests examples of how given types of consumer needs might be accommodated with less energy (at both the primary and final consumption stages)—e.g., reduced fuel or power requirements for house heating and cooling by better insulation. Line 7 cites instances where reduced energy consumption presupposes a shift in expenditure patterns or life styles. Here, though, one can easily succumb to the imposition of value judgments. Thus, distributional changes in national expenditure patterns—e.g., more collective goods such as health services, fewer manufactured items—can bring about fuel and power savings. The temptation to play god is not easy to resist.[1]

Line 8 raises the possibility of energy conservation opportunities in production activity—a subject that has been very little explored (particularly in its cost implications) but is presently receiving serious attention (e.g., as part of a research effort under way at the National Bureau of Standards in Washington).[2]

Very often, the problems associated with energy consumption are of a particularly regional or localized nature—e.g., where to locate additional generating capacity for New York City. Clearly, regional conservation practices may not signify national energy savings and vice versa. For example, a regional limit to expanded electricity capacity and generation which induces industrial relocation simply shifts the burden of adjustment elsewhere, while, conversely, national energy savings achieved, say, by switching away from energy-intensive production (such as plastics or aluminum) obviously may have little or no impact within a given region.

One could broaden the conception of energy conservation reflected in Table 1 still further by alluding to opportunities at the raw-materials production end. Significant advances in petroleum recovery techniques, for example, can help stretch out energy supplies that might otherwise have been lost to society and, conceivably, make less pressing the need that would otherwise exist for energy-saving habits, say, in household, industrial, or transport usage. The development of new types of primary energy, among which tidal power is a theoretical possibility, falls into a similar category.

The Principal Components of Energy Demand

So much, then, for a highly compressed conceptual treatment of the subject. I will now turn to some quantitative estimates of specific instances of energy consumption opportunities. These examples will range across several of the cases dealt with previously in the abstract, though they will focus primarily on energy-conserving possibilities among final consumers—essentially lines 3, 4, 6, and 7 of Table 1. These are also the examples most commonly singled out in current public debate.

To convey some notion of where significant potentials for energy savings may lie, it is useful first to recall what are the principal constituents of energy demand and their rates of increase. A small number of the identifiable end uses of energy account for most of the total energy consumption, as is evident from Table 2.

TABLE 2
MAJOR COMPONENTS OF U.S. ENERGY CONSUMPTION[3]

	Percent distribution of:		
	U.S. energy consumption, 1968	Changes in U.S. energy consumption, 1960-1968	Average annual percentage rate of change, 1960-1968
Transportation	24.8%	23.8%	4.2%
Space heating	17.9[a]	16.6	4.0
Process steam[b]	16.7	14.2	3.6
Direct heat[b]	11.4	7.9	2.8
Electric drive[b]	7.9	9.3	5.3
Feedstocks and raw materials[b]	5.5	6.2	5.1
Water heating	3.9	3.9	4.3
Air conditioning	2.5	4.7	10.1
Refrigeration	2.2	2.6	5.3
Cooking	1.3	0.7	2.2
Electrolytic processes[b]	1.2	1.2	4.7
All above	95.6	91.4	4.1
All other	4.4[c]	8.6	10.9
Total	100.0%	100.0%	4.3%

[a] Comprised of: residential space heating = 11 percent; commercial space heating = 6.9 percent.
[b] These items refer almost exclusively to industrial usage.
[c] Of which residential and commercial lighting = 1.5 percent.

One-fourth of nationwide energy consumption arises from fuels used in transportation. Transportation and space heating consume 43 percent of the total. Four major industrial demands for energy—process steam, direct heat applications, electricity for mechanical drive, and feedstock requirements—bring the figure to 85 percent. It is noteworthy that water heating, air conditioning, refrigeration, cooking, and lighting (not only in households but in commercial establishments as well) account for only 11 percent of U.S. energy consumption, even though one of these components—air conditioning—is growing far more rapidly than energy usage as a whole.

Another familiar aspect of the U.S. energy consumption pattern is the fact that energy delivered to ultimate users in the form of electricity has tended to grow at least twice as rapidly (around 7 percent annually) as energy consumed in other forms, chiefly gaseous or liquid. (Except for conversion to electric power, coal's only other significant market is the iron and steel industry.) As a result, the share of primary energy resources going into electricity generation has risen steadily—from 19 percent in 1960 to probably 26 percent or more now. This is important in a conservation context because of the inherently low efficiency (currently about 40 percent maximum) achieved in converting raw energy to electricity.

The items of Table 2 cut across the different end-use, energy consuming sectors of the economy. Regrouped by sector, they would show that, for recent years, U.S. energy consumption broke down as follows:

	A. Utilities treated as separate sector of consumption	*B. Fuels used to generate electricity ascribed to ultimate electricity users*
Residential	12%	20%
Commercial	9	15
Industry	29	40
Transport	25	25
Utilities	25	—
	100%	100%

A Look at Some Conservation Possibilities

This abbreviated picture of consumption patterns provides perspective on likely areas in which to seek possible energy conservation potentials. Savings opportunities would seem to lie especially in space heating, transport, and electricity conversion as major elements of a conservation strategy. In addition, industry accounts for a sufficiently large block of energy use to warrant evaluation of possible savings there, but the diffuse elements making up the industry aggregate make this a more elusive undertaking. To examine the conservation question more closely, I will discuss—at times critically—a recently released U.S. government study, which was coordinated and issued by the Office of Emergency Preparedness,[4] hereinafter referred to as the OEP Report.

The OEP Report evaluates what it terms "high payoff" conservation opportunities for three time spans: the short-term, 1972–1975;

the mid-term, 1976–1980; and the long-term, beyond 1980. Centering its summary findings on the year 1980—i.e., the approximate point at which the short- and mid-term efforts are judged realizable—the report states that the most significant conservation possibilities are these:

> the installation of improved insulation in both new and old houses and the use of more efficient air conditioners;
>
> a shift of intercity freight from trucks to rail, of intercity passengers from air to rail and bus, and of urban passengers from automobiles to motorized mass transit, along with an improvement in urban freight handling systems through consolidation and containerization;
>
> the introduction of more efficient industrial processes and equipment.

These three bundles of energy-saving possibilities, referring, respectively, to the residential-commercial sectors, to transportation, and to industry are said to yield reductions in demand in each of these sectors equivalent to 2.4 million barrels of oil per day (residential-commercial), 2.3 million barrels/day (transportation), and 2.6 million barrels/day (industry)—7.3 million barrels/day oil equivalent in all. The OEP Report uses the barrels-of-oil-per-day equivalent measure so as to be able to relate it more vividly to the major source by which a prospective shortfall of domestic energy supply by 1980 is expected to be met—by oil imports from other countries, principally the Middle East. The conventional picture of the situation at the end of the present decade shows the United States having to import 50 percent or more of its oil requirements by 1980, implying a volume of imports of over 10 million barrels/day. The indicated energy savings therefore represent some two-thirds of the projected import level, and approximately 16 percent of overall nationwide energy consumption foreseen for 1980. If this degree of energy-saving practice were then carried forward beyond 1980, it would mean that without realization of the still additional savings which the OEP says are possible over a more distant time span, the annual energy consumption growth rate might be reduced from, say, 4 percent to 3½ percent.

But note the principal OEP caveat: the mechanics of implementation and problems of user acceptance have received very little attention. We are dealing with a hypothetical and perhaps quite idealized notion—especially if the full range of estimated conservation opportunities were expected to be realized. However, as the OEP Report puts it: "it is pertinent to stress that a half or even a third of the 7.3 million [barrel/day] is a very significant input to programming a manageable solution to the energy crisis," even though conservation efforts cannot by themselves either eliminate the need for substantial imports or, given year-to-year increases in overall energy consumption, do more than delay by only a modest number of years the level of energy consumption estimated as being reached some time earlier without conservation. But "buying time" need not be scoffed at if it enables us to develop new programs and approaches to energy supply problems.

Let me now cite a couple of specific cases offering energy-conserving potentialities for the mid-term perspective. (These illustrations omit the important electric utility sector because the important energy-saving possibilities there are largely dependent on *longer*-term developments in new conversion technology—e.g., combined-cycle generating plants.)

Table 2 indicates the importance of space heating in U.S. energy consumption—some 18 percent of the national total. In residential uses only, it represents 11 percent of nationwide energy use; combined with residential air conditioning (so as to represent the function of "residential space conditioning") the figure becomes slightly higher—12 percent of the U.S. total or 60 percent of energy consumed by households. A significant opportunity for energy conservation in the residential sector lies in improved insulation, the net benefits of which (after allowing for the cost of financing such improvements) would include a reduction in winter fuel bills, summer cooling bills, and the size and capital cost of heating and cooling equipment. The OEP Report finds that improved insulation technology is readily adaptable to new houses, though the high initial cost makes unlikely any widespread introduction in existing houses. Tightened FHA insulation standards for new structures within the last two years have been directed to this conservation objective. Largely through improved insulation (better furnace maintenance is an ancillary measure), the OEP posits what it terms a "modest," but what, in fact, appears to be an exceedingly ambitious, 20 percent reduction in residential space heating and cooling requirements by 1980. This would represent a 2 quadrillion Btu energy saving—a bit over 2 percent of the projected level of national energy consumption; it is ambitious because a 20 percent reduction in overall residential space conditioning requirements implies what seems clearly to be an unrealistically large reduction in space conditioning requirements for new housing.[5]

Additional residential energy savings in water heating, refrigeration, cooking, lighting systems, and in air conditioning equipment are also believed to be possible. For example, many air conditioning units sold today are highly inefficient, the poorest requiring approximately 100 percent more power than the best for the same level of cooling—a disparity in no way attributable by price differences.

Transportation is so large a component of national energy use that it, too, deserves major attention as a conservation possibility. Petroleum accounts for virtually all the fuel used in transportation; and automobiles are the principal component of transportation energy usage with 55 percent of the sectoral total. It is, of course, easy to document the enormous variability in transportation energy efficiency (measured in ton-miles or passenger-miles per gallon of fuel)—e.g., buses and trains exceeding the efficiency of cars in passenger traffic, the latter exceeding aircraft, and so on. (Not about to be criticized for incompleteness, the OEP Report includes a paddlewheel river steamer and the old Queen Elizabeth in its efficiency rankings.) But, just as it seems pointless to romanticize the way we moved about in a bygone era, so, too, long-run changes in altering the level, nature, or growth rate of transportation services involve rather intractable problems of technology and urban design. A variety of research and development projects in the fields of engine and propulsion modes, vehicle design, and traffic systems are underway. However, many of these are as much related to broad social and urban issues as to inefficient or excessive energy usage.

But even short of these longer-range goals the OEP Report claims to find ample potentiality for the realization of transport energy savings for the short- and mid-term time spans. Thus, over just a three-year period, the Report contemplates a 10 percent reduction in transportation energy use (a 2½ percent reduction of total U.S. energy consumption) by means of the following (unranked) measures:

Conduct educational programs to stimulate public awareness of energy conservation in the transportation sector;
Establish government energy efficiency standards;
Improve airplane load factors;
Promote development of smaller engines/vehicles;

Improve traffic flow;
Improve mass transit and intercity rail and air transport;
Promote automobile energy-efficiency through low loss tires and engine tuning.

And for 1980 the Report envisages a 21 percent energy use reduction in transport (a 5 percent reduction of the total projected U.S. energy use) through the additional deployment of the following:

Improve freight handling systems;
Support pilot implementation of most promising alternatives to internal combustion engine;
Set tax on size and power of autos;
Support improved truck engines;
Require energy-efficient operating procedures for airplanes;
Provide subsidies and matching grants for mass transit;
Ban autos within the inner city;
Provide subsidies for intercity rail networks;
Decrease transportation demand through urban refurbishing projects and long range urban/suburban planning.

Policies to Encourage Conservation

It would have been instructive to have these measures ranked according to some criteria of prospective effectiveness. Moreover, the listing is ambiguous as to the nature of the expected payoff from such general exhortations as "promoting" development of smaller engines, providing "support" to pilot implementation of internal combustion engine alternatives, and a number of other, equally imprecise, notions. (Banning cars from cities would probably obviate a number of other proposals.) Indeed, these quoted excerpts from the OEP Report blur over a useful, if somewhat arbitrary, distinction between the nature of specific energy-conserving actions, on the one hand, and some of the measures relied upon to effect these actions, on the other. Having cataloged several specific promising cases of conservation potential, it remains, therefore, to touch more explicitly upon the matter of feasibility and implementation.

One channel of implementation is clear from the very examples cited: educating and informing energy users of the economic advantages of energy-saving practices. Thus, if the increased initial cost of a residential or commercial structure can be more than offset over the life of a building by lower fuel and power bills, then it would seem possible to be able to alert people to their pecuniary self-interest, or, in doing so, at least to discover why stress on minimizing initial costs overrides such considerations. I have in mind such possible inhibiting factors as cash flows, capital market conditions, tax laws, and rapid writeoffs which may need investigating as to the way they may act as impediments to implementation.

Regulations governing the promotion of energy-using appliances seem a feasible approach to some aspects of energy conservation. Given the wide variations in the efficiency of air conditioning units, even at given size and price, a mandatory efficiency labelling requirement could make it possible for shoppers to reduce their total cost by being informed of these efficiency differentials. Manufacturers could be expected to respond to this new element in merchandising with traditional American competitive acumen.

Increases in the real price of energy—brought about by such things as pollution control costs and higher relative prices for domestic and imported primary energy sources—is another conceivable route to demand dampening. While education and regulation represent conscious policies to restrain energy use, the price route would simply reflect the influence of evolving market forces. "Conceivable" seems a more cautiously apt label than "obvious," since our whole historical experience has been one of low or declining real energy prices. We must therefore depend on rather abstract statistical analyses to tell us what might be energy users' response to rising prices. The tentative message spelled out by a number of such studies (particularly in electric power consumption) is that over the long term rising prices might indeed constitute a demand-restraining influence, though one about which we cannot at the present time speak with a great deal of certainty or authority.

Tax policy suggests itself as a wide-ranging means of encouraging more efficient energy use. Tax incentives, along with favorable loan terms, have been mentioned as ways to encourage improved insulation in homes. For industry, the OEP Report cites the possibility—it is at this point emphatically not a recommendation—of tax incentives to spur energy-saving recycling and reusing of component materials; and of energy use taxes to provide incentives for industry to upgrade processes and replace inefficient equipment. In contemplating this kind of policy measure, one wants to be sure that energy conservation is not being obtained at an increased total economic cost—in violation of one of the conditions mentioned at the outset. At the least, one wants to know that, if a less efficient use of aggregate resources is the result of the policy in question, the price is worth paying. Also, one ought to insure that tax measures imposed on different classes of users accord with standards of equity.

One could mention other proposals that seem to have merit—e.g., enhanced government research and development support for new energy systems, restructuring electric utility rates to dampen the peaks of the demand cycle, and subsidies and matching grants for mass transit. The list clearly could range over a broad spectrum of measures, from purely voluntaristic ones at one end to coercive restraints at the other—say, banning autos within the inner city, or curtailing "nonessential" electricity-using services at periods of peak demand. But my principal purpose is only to suggest a few of the diverse avenues of approach that we will probably be hearing a great deal about, and debating, from now on.

Summing Up

It is easy for someone burying himself in the energy conservation issue to come away with exaggerated notions of its efficacy. That is why it is well to recall the judgment offered earlier that, in sum total, those steps are likely to make modest, but not decisive, inroads into the energy problems confronting this country. (This would be particularly true if, as it apparently did in the space heating case, the OEP stretched the savings possibilities to the limit.) Figure 1 is a graphic portrayal of the possibilities, which shows that even the full range of long-term conservation practices in 1990 merely gets us down to the level of national energy consumption that would have occurred around 1982; or, alternately (by extending the curves beyond 1990), postpones for perhaps a decade the excess amount of energy consumed in the absence of conservation.[6] It would seem that efforts to cope with resource stringency and environmental problems depend on much more than just the kind of demand limiting actions we have been discussing here. But that does not negate the desirability of implementing conservation efforts, which economic rationality should prompt us to do in any case. If the adoption of energy-saving personal habits and commercial and industrial practices relieves us of (if only by postponing) some portion of the environmental burden and resource pinch, thus giving us somewhat greater maneuverability in fashioning prudent long-range energy strategies, the undertaking will have been worthwhile. There are even those who would argue that a

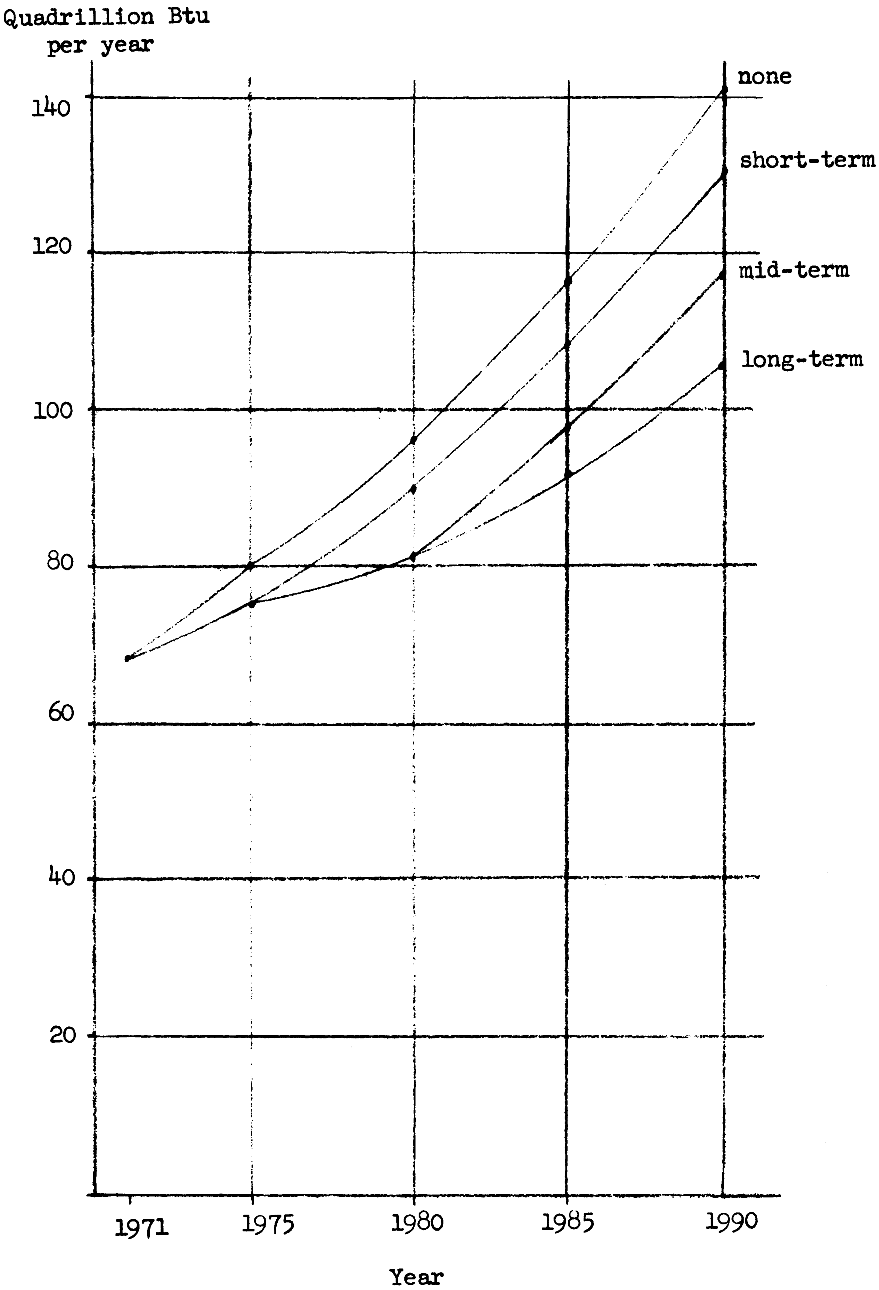

FIGURE 1
Idealized projections of energy consumption based on suggested conservation measures.

questioning of some of the excesses of our affluent society and a possible toning down of our frenetic lifestyles may have civilizing rewards of their own. Although this thought has a disagreeably sermonizing flavor, it may be a point worth pondering.

FOOTNOTES

* Senior Research Associate, Resources for the Future, Washington, D.C. Adapted from a talk presented at the Upper Midwest Council Conference on the "Outlook for Energy," Minneapolis, Minnesota, December 8, 1972.

[1] The nature of the spatial distribution of the population is one aspect of lifestyles having significant consequences for energy use and energy conservation possibilities. More scattered development means more transmission line losses, and more energy consumption for water and sewer pumping and for waste collection.

[2] Some persons perceive great virtues in switching from what they label "lower-power-productivity" industries (such as aluminum) to "high-power-productivity" industries (such as steel). *See,* B. Commoner, paper delivered to the American Association of the Advancement of Science, Philadelphia, Pennsylvania, December, 1971. While such shifts may curtail energy use, the question of whether such a shift is resource saving and environmentally benign from an overall perspective is far more difficult to answer. For example, steel production requires coal and iron ore mining and haulage, and blast furnace and coke oven operation; these include high, partially external environmental costs. Indeed, this example would logically favor switching away from "low-power-productivity" industries, often the most capital-intensive and most mechanized, to less capital-intensive, less mechanized, more labor-intensive industries. This is a mildly bizarre twist on the usual conceptions of economic and social development.

[3] Stanford Research Institute, Report to the Office of Science and Technology, PATTERNS OF ENERGY CONSUMPTION IN THE UNITED STATES (Washington, D.C.: Government Printing Office, 1972).

[4] Office of Emergency Preparedness, THE POTENTIAL FOR ENERGY CONSERVATION—A STAFF STUDY (Washington, D.C.: Government Printing Office, 1972).

[5] In this as in other cases, the OEP Report, creditable though it is in its comprehensive scope, is somewhat less than meticulous and discriminating in its specific analysis and calculations.

[6] THE POTENTIAL FOR ENERGY CONSERVATION—A STAFF STUDY, *supra* n.4, at 59.