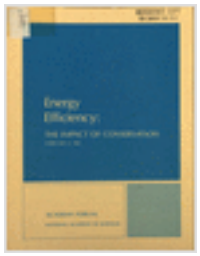

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ENERGY EFFICIENCY: THE IMPACT OF CONSERVATION

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FOREWORD

ROBERT R. WHITE
Director, Academy Forum

Although it has been recognized for some years that the profligate use of energy in the United States offers a large opportunity for energy conservation, the many techniques and efforts of conservation constitute for the population in general a new way of viewing the energy supply.

The codified experience with conservation indicates that projection of energy needs may be much too high and that the United States has far more freedom to choose energy sources than has been perceived. There has been speculation that as the United States creates, develops, and implements new methods of conservation, it becomes conceivable that this country can eliminate its need for imported oil.

This is the report of an Academy Forum on energy efficiency that focuses on the impact of conservation. It will be followed by another Forum on energy efficiency that will emphasize consumer economics and social response.

We wish to acknowledge support given to the development, presentation, publication, and dissemination of this Forum by the Department of Energy and the National Academy of Sciences.

INTRODUCTION

HARVEY BROOKS
Moderator

I first would like to introduce my fellow panelists. I apologize in advance if I don't do justice to their credentials.

Paul Craig is Professor of Applied Science, University of California at Davis. His research began in low temperature and solid state physics. More recently he has been concerned with energy policy. He was for a time with the National Science Foundation and the California Energy Council.

Joel Darmstadter is Senior Fellow at Resources for the Future, an economist specializing in the comparative study of energy use in industrial societies.

John H. Gibbons is Director of the Office of Technology Assessment. Originally a physicist in nuclear structure physics, since 1968 he has specialized in energy management and environmental impacts. He has carried out his work at Oak Ridge National Laboratory, in the Federal Energy Administration, and as Director of the Energy, Environment, and Resources Center of the University of Tennessee before coming to OTA in 1979.

Dale W. Jorgenson is Frederick Eaton Abbe Professor of Economics at Harvard. He is an authority in econometrics with recent specialization on energy and productivity.

Henry R. Linden is President of the Gas Research Institute and formerly of the Institute of Gas Technology. He is a chemical engineer with specialization on fossil fuel technologies.

Rene H. Males is Director of the Energy Analysis and Environment Division of the Electric Power Research Institute. Formerly a director of economic research for Commonwealth Edison, he has held several managerial positions with Commonwealth Edison.

Arthur H. Rosenfeld has been Professor of Physics at the University of California at Berkeley since 1963. Since 1975 he has been leader of the program on efficient use of energy at Lawrence Berkeley Laboratory.

Roger W. Sant is Director of the Energy Productivity Center of Carnegie-Mellon University, which is located in the Washington area. Prior to that he was entrepreneur and businessman with broad experience in energy-related industry. He was a member of the Stanford business faculty for several years.

Thomas E. Stelson recently stepped down as Assistant Secretary for Conservation and Solar Energy in the Department of Energy. He is a civil engineer, former Dean of Engineering at Georgia Institute of Technology, and now Vice President for Research there.

Robert H. Williams is Senior Research Physicist in Princeton's Center for Energy and Environmental Studies, specializing in conservation, solar energy, and cogeneration.

Before stating the four major questions that the panelists have agreed to address, I would like to make a few preliminary observations.

While it is true that future demand for energy in the United States will be determined both by behavioral changes and by improvements in

the efficiency with which energy services are provided, our focus in this Forum will be mainly on the latter.

This orientation is inspired by the belief that a major barrier to the reduction in the growth rate of energy demand is the public view of energy conservation as a program of austerity, hardship, and deprivation rather than as a potential opportunity for capital investment that could compete in hard economic cost-effectiveness terms with the importation of oil or with crash programs for the expansion of domestic energy supplies.

A related point is that energy waste is an economic concept, that what counts is not the use of energy per se but the total use of all resources in the provision of the consumer services that energy makes possible. If the cost of the other resources, including human labor or convenience, required to save a given amount of energy exceeds the value of the energy saved, then there is no waste.

One can legitimately argue that the energy saved may be wrongly priced or that a wrong value is placed on the other resources used in saving energy, but it is the matter of the value of all resources, if you will, the total social cost of providing a given level of energy services, that should be considered in the discussion of conservation policy. This will be the leitmotiv of the panel discussion.

With that background in mind I am proposing four general questions for consideration by the panel:

1. What is the realistic technical potential for energy efficiency improvement over the next 20 years and what is its approximate capital cost?
2. To what extent is this technical potential likely to be realized if market forces alone are relied upon to impel cost efficiency investments in all sectors?
3. To what extent is it feasible and desirable to supplement market forces with government-set economic incentives, and to what extent should public policy measures other than economic incentives be used to induce improvements in energy efficiency closer to their ultimate technical potential?
4. What are the national policy objectives that interact with energy conservation policy? What should be the specific goals of conservation policy in the light of these broader policy objectives?

Turning back then to question 1, what is the realistic technical potential for energy efficiency improvement over the next 20 years and what is its approximate capital cost? I'll call first on Roger Sant.

ROGER W. SANT: To get at the question I'd like to tell you a little bit about the current work we're doing, which sheds some light on the technical and economic potential to improve efficiency.

We have simply asked ourselves how much heat or how much cooling, how much mobility, how much comfort, if you will, people want and need for the next 20 years; that is, from now to year 2000.

Given that projection of needs, we have asked ourselves how would we provide those needs if all we did is supply them at the lowest cost. In other words, if we ignore all of the other energy objectives and simply look at providing all of those comforts, all of those energy services at the lowest cost, how would we do that.

We haven't been concerned with how much energy can we save. We really are indifferent as to whether we supply those needs through producing more oil or any other supplies versus improving end-use efficiency.

We look at the possibilities for improving the total system. One of the interesting things we've found is that in the system we now use for providing those services, energy is, in a cost sense, in the minority. It's now only costing about 40 percent of the cost of energy services. Sixty percent is nonenergy--the cost of equipment, the cost of labor, and maintenance and so on. So again we only look at what the system would look like if we provided all those energy services we need at the lowest possible cost.

Well, here are a few of the results we get. First, using 1978 as a base case, primary energy growth through 1990 would be negative; that is, in 1990 we would be using about 2 percent less BTUs even though we projected a 41 percent increase in the gross national product. And from 1990 to 2000 we would have only an 8 percent growth in energy use, less than 1 percent per year, with a further 33 percent increase in the GNP.

So that over the 20-year period, a least-cost energy services system would provide a 4 percent growth in GNP with only an 8 percent increase in energy use. The ratio of BTUs to gross national product would be about two-thirds of what it is now by 1990 and about 60 percent of what it is now by the year 2000.

The second result--and it's really the most interesting one to me--is that the cost of energy services currently used per capita would slightly decline over that period. The ability to substitute end use efficiency including the cost of the capital equipment necessary to do that, would more than offset the increase in unit fuel prices so that the fuel cost per capita would be down by about 30 percent by the year 2000 with the capital cost up about 25 percent.

If so--if that is accurate--that means that the inflationary impact of the energy sector is over. That from here on we are essentially looking at opportunities rather than a continuation of the problems we've had in the last decade.

Third, the fuel mix is rather interesting in this least-cost system. Imports, for instance, which has been our sort of paranoia over the last 7 or 8 years, would be down 53 percent by 1990 and almost gone by the end of this century. Natural gas would increase by about 17 percent in the 1980s and then decline 5 percent in the 1990s as it runs into real competition from coal and electricity. Electricity is down 2 percent in the 1980s but up 15 percent in the 1990s. And industrial coal would be up substantially throughout the period.

The capital requirements for the least-cost system would start out as being about what they are now--10 percent of GNP. They would decline to 6 percent of GNP in the 1990s, much less than what is conventionally predicted.

So the outcome of all of that to me is that we have every reason to think that the possibilities for providing the energy services to people at costs they can afford are immense, that the opportunities are much greater than the problems, and that in fact the self-interest of each of us in looking at providing those things at least cost will probably produce things that are very consistent with our social goals.

ARTHUR H. ROSENFELD: I'm going to follow a point of view very close to that of Roger Sant. The difference is that about a year ago Lawrence Berkeley Laboratory, where I work, and the Solar Energy Research Institute got together as part of a national study to come up with a conservation strategy; I was the chairman of the panel that worried about the building sector, and so what I'll tell you about is mainly our results there.

Now the numbers that I am going to give you are essentially a theoretical potential of what we would do in the way of cutting energy use if the United States behaves as a rational economic society. Nobody claims it does that, but we think it's interesting to see what might happen if we went that way. Later on we can decide about how you might get from here to there.

The technologies that we looked at were only those that are pretty much on the shelf now, things like storm windows for buildings, better refrigerators, a little bit of solar energy but not an awful lot, domestic hot water, and of course a lot of passive solar--such as new buildings with large windows facing the south--but nothing very fancy.

We got slightly lower energy-use results than Sant's continuing study, probably because we just got on the telephone and tried to collect a lot of information about how well retrofitted buildings are working, how well new buildings are working, and so on, and discovered that they seem to be doing extremely well.

The summary seems to be that in the building sector we can reduce energy use to about a half of what conventional wisdom predicts by the year 2000. That shouldn't be so surprising. If you think about the automobile sector, we had gas guzzlers at 14 miles per gallon in 1975; we expect 28 miles per gallon by 1985. That's a factor of two, so it's not surprising that buildings can do just as well.

Industries and utilities is Bob Williams' part of the discussion, so I'll avoid that for now.

In summary, buildings now consume a third of the United States' energy use, 14 million barrels a day. Conventional wisdom in the form of the Department of Energy says it will grow to 16 million barrels a day by the year 2000. We say we can cut it in half for a total investment of about $400 billion. That sounds like a lot of money, but in fact it's about the same amount we'll have to invest in new power plants and new synfuel plants if we don't learn to use energy a little bit better.

The way we got that result was to list all the technologies available and then calculate that point where the "cost of conserved energy" was as high as the current price of energy. And what do we mean by the cost of conserved energy?

Let me suggest you think for a second about our famous 1975 car, 14 miles a gallon, versus not the gas guzzler but the gas sipper of 1985 at 28 miles to a gallon. The car costs about a thousand dollars more, but over its 10-year life cycle it's going to save its happy owner about 3,500 gallons. So you invest a thousand dollars; you save 3,500 gallons. That's 30 or 35 cents a gallon. That's a lot better than going out and buying the stuff at $1.25 or so a gallon or buying synfuels at $2 or $3 a gallon.

So that's what we mean by the cost of conserved energy. Take the investment, take account of the interest rate, divide by the savings over the lifetime of the investment, and you have the cost. If it's cheaper than today's price, invest. That was our scenario.

ROBERT H. WILLIAMS: I would like to sketch some of the highlights of an analysis of the technical and economic potential for conservation carried out by me and by a colleague, Marc Ross, of the University of Michigan and the Carnegie-Mellon Energy Productivity Center. Our analysis is presented in a book that was just published, Our Energy: Regaining Control (McGraw Hill, 1981).

We looked not to the year 2000 but rather to the year 2010. In our analysis we assumed, for example, that the GNP would double in this period and that the basic institutional barriers to conservation investments would be eliminated. The elimination of energy supply subsidies, the decontrol of energy prices, and the levy of an energy tax are among the most important new policies that we identified as necessary to create an even-handed treatment of investments in energy efficiency and energy supply. We estimated that by the year 2010 energy demand in the United States under such conditions could be reduced to a level comparable to the level of U.S. domestic energy production last year; in other words, some 7 million barrels of oil equivalent per day less energy than we actually consumed last year.

Our estimate of the potential for fuel savings is considerably greater than that which was estimated by Roger Sant and his group. I haven't had the opportunity to compare our analyses in detail, so I can't tell you precisely why there are these differences; but I can identify some of the factors behind the difference.

For one thing we have looked 10 years farther into the future, so that there is more time available for a turnover of existing capital stock. Also, we have assumed a levy of energy taxes that would be used to offset existing taxes. Furthermore, we have brought into the analysis some factors that are often overlooked in conventional energy modeling.

Consider the industrial sector. While we estimate that total energy demand could decline in other sectors with the policies we recommend, we expect that there would be slow growth in the industrial sector, something like a 5 percent increase in energy demand over this 30-year period.

This relatively slow growth in energy demand in the industrial sector would come about not just because of energy efficiency improvements, but also because of a number of other factors that complement the influence of rising energy prices.

One of these is that there is a slow but long-established trend in the U.S. economy away from goods production toward services production, with the result that goods production in the future can be expected to grow slightly more slowly than gross national product. And within the goods-producing sector there is an established trend away from basic materials-intensive activities toward much greater emphasis on finishing and fabrication of materials. In essence, the goods that consumers are buying today contain more value added and less basic materials. In the case of steel, for example, output today contains much more thinly rolled steel of special qualities compared to yesteryear, when the heavy steel rails represented a major component of production.

This trend away from basic materials' production, of course, should come as no surprise in a materials intensive society such as ours, where each day a person consumes on the average his weight in stuff--"stuff" being fuel, paper, steel, cement, and so on.

To wrap things up I'd like to say that while our study has targeted a much higher degree of energy savings than many other studies, we have still only scratched the surface of opportunity for technological innovation in energy efficiency.

While energy supply technology is quite advanced, the present state of technology for energy efficiency improvements is still very low on the learning curve. During the twentieth century, for example, the efficiency of central station power generation increased from about 4 percent at the turn of the century up to about 32 percent in 1960. The state of our knowledge about energy efficiency corresponds to where we were with electrical generation near the turn of the century.

BROOKS: Now I'd like to open up to questions from the audience or the panel.

GARY KAH, Program Analyst, Honeywell, Inc.: This is to anyone who wants to answer, but it's most closely related to Roger Sant's work in the energy services company concept among companies Honeywell is interested in. Do you see that as a substitute for market imperfections in a sense that were uncapturable in low-energy-cost days but will become profitable in a high-energy-cost future?

SANT: Yes. I think the most exciting steps may be institutional change rather than technological change in these two decades. One of those that is most exciting is the energy-services concept, in which someone would be responsible for selling consumers heat instead of selling fuel, and furnaces, and insulation, and controls. Some need is there to pull a system together such that the consumer gets the output of the best system possible rather than having to make those component choices themselves.

I think there will be a major shift in marketing. Even the utilities, instead of selling kilowatt hours, will be selling light; or gas companies, instead of selling therms, will be selling heat and cooling. So there should be opportunities not only for them but for

companies like yours to substantially shift away from selling hardware to selling services.

MYRON TRIBUS, Director, Center for Advanced Engineering Study, Massachusetts Institute of Technology: Dr. Rosenfeld, your discussion dealt with the trade-off between capital investment and energy saving, and I was curious to know how do you determine what the inherent additional cost is for a gas sipper versus a gas guzzler? Is there a trade-off?

ROSENFELD: There are two ways at arriving at the conclusion that the gas sipper costs a thousand dollars more than the gas guzzler. One is simply to ask what the speeches of the president of General Motors or Chrysler say, and they all say about a thousand dollars more in 1980 dollars.

A parenthetic remark: that's not just to conserve fuel. It's a better car. It's smaller, but it has a catalytic converter, and it doesn't make as much smog and so on. But you wrap all that together and you compare the two cars, and there's about a thousand dollars' difference.

The other way is to ask how much Detroit will have invested in new production lines between 1975 and 1985, and the answer is about $90 billion. If you divide that by the number of cars produced, you come to a thousand dollars a car. So I don't think that number is terribly far off. Do you want to make a comment that you think it's outlandish?

TRIBUS: I just don't understand the arithmetic. They normally produce new models, and over that period of time there would have been new models produced. The requirements for smog control and so forth are all there. I have difficulty seeing that there is an added cost in the car if we compare what would have happened otherwise, and so that was my question.

ROSENFELD: But many things about this car are new and expensive. One is the better environmental controls. They go to four or five forward gears instead of three. They make smaller engines, which require better machining and run at higher RPMs. The transmissions are better. They require radial tires.

BROOKS: It's really an upper-limit calculation. You're merely arguing that it ought to be smaller than that.

ROSENFELD: Of course, then I would be happier if instead of saving fuel at 30 cents a gallon it's down to 10 cents.

ROBERT L. HERSHEY, Science Management Corporation: We've heard various projections here. I wonder if each of the speakers would say what they mean in terms of the mix of fuels, of coal, oil, gas, and nuclear.

SANT: Actually, the softest part of the mix is oil. We just see oil falling out of the system very fast, because the world oil price

now is so high. We see electricity being relatively flat in the 1980s and starting growth again in the 1990s but at a very low rate. We see gas coming on very strong in the 1980s and then running up against some strong competition in the 1990s. We see industrial coal rising very rapidly and still being able to still meet environmental conditions.

It's quite a different mix than what we now have, and it's quite different from what our institutions seem to be projecting.

BROOKS: How much nuclear occurs in those projections?

SANT: Electricity is growing so slowly that it stands to reason there's not going to be very much nuclear, and there's not going to be very much coal except what's replaced of oil and gas-fired generation in place.

UNIDENTIFIED: I have a two-part question for Mr. Rosenfeld. He says that a new car would be a thousand dollars' expense. You trade in your 1975. My experience with buying an auto is that when you trade in, it's not a thousand dollars' difference, it's more like $4,000, even if it's a 1-year-old car.

And you haven't taken into consideration in your figures what happens when people drive smaller cars with less power: not being able to get onto the cloverleaf, the overturns, and a crash against a guardrail. Most of the guardrails for all of the interstates were made for the so-called gas guzzlers, and when a small car such as a Renault goes up against one, the driver usually instead of being seriously injured ends up positively dead. So how do you figure that type of cost into your calculations?

ROSENFELD: First, there's one part of your question I can answer. The other I can simply restate.

The part I can answer is that no one is suggesting in this analysis that you trade in your 1-year-old gas guzzler for the sipper. When you do these analyses for automobiles and appliances you assume that the old one wears out, and only then do you buy a new one. You are going to have to buy a new one anyway, and then the only difference we discuss is the extra cost for the catalytic converter and the gears and so on. And that's the number that we were discussing as a thousand dollars.

BROOKS: These are real prices?

ROSENFELD: Those are 1980 dollars, yes.

The other part of your question relates to the fact that there is some sort of a life-style difference as society moves to smaller cars. This is of course true. I mean, change in general is difficult. It's particularly resisted by those people who own either stock in gas guzzler manufacturers or gas guzzlers. Change is always difficult. There is nothing we can do about that except realize that it's difficult and not try to do it too fast.

One small comment, however. There are both positive and negative aspects to going to smaller, more fuel efficient cars. One of them is that if you run into a Mack truck, you're deader, I agree. On the other hand, because none of us likes to spend more than some fraction of our income on gasoline, there are other virtues of fuel efficiency. When my daughter asks to borrow the car tonight, instead of saying no, it's too expensive, I say sure, but use the Fiat. We get more miles that way, and that's a trade-off that will result in more deaths, but it's useful.

BROOKS: You really, though, haven't answered the question of the social cost of the higher accident rate, which I think is still a point.

FREDERICK W. LAWRENCE, Federal Energy Regulatory Commission: I have a question for Mr. Williams. I believe you indicated that the GNP of this country is going to grow more in the service industry and less on the heavy industries that are energy intensive.

Doesn't that mean that we will be importing energy in the form of basic bulk materials rather than in the form of energy itself?

WILLIAMS: It's the consumption of materials-intensive products that is slowing down, so that there is correspondingly slower growth in the demand for basic materials. Much of the growth in steel, for example, is going to be in the downstream areas--in fabrication and finishing parts of the industries rather than in the production of basic steel.

LAWRENCE: Is this on a worldwide basis?

WILLIAMS: I'm talking only about the United States. We're much closer to material saturation than many other countries are.

BROOKS: For example, the per capita steel consumption has been going down for quite a few years now.

UNIDENTIFIED: I'm with the House Energy Conservation and Power Subcommittee, and I have a question for Roger Sant. As you see oil falling off in the 1990s, what do you see picking up the slack in the liquid fuels for the transportation sector? Do you see synthesized liquid fuels from natural gas or coal?

SANT: Very little, frankly. The transportation sector in our numbers is down about 15 percent from here to there. That is, even though mobility services have gone up more than 50 percent, transportation fuel use would be down about 15 percent over that period of time.

Some of that may be in synthetic fuels, maybe as much as a million and maybe two million barrels a day in methanol, or some shale, or possibly some other things. But it isn't very much, and in fact, the transportation sector, contrary to myth, looks as though it could be one of the most flexible sectors of all in the sense of being able to export fuel from that sector to other sectors or to the world market.

So the total amount of oil consumption is what's really giving us the results, and it's just the high-mileage cars, and the high-mileage planes, and the high-mileage trucks that are doing that.

N. E. HAGER, Senior Research Associate, Armstrong World Industries, Inc.: Everything we do to save energy not only costs dollars but it also costs energy; that is, it takes energy to create the systems that we put in place to save energy. I'm concerned that our models on energy conservation are not paying enough attention to the energy cost, and that our conservation projections are going to turn out to be invalid. Can one of the panelists please comment on that?

ROSENFELD: Thanks. That's a very good question. It's one that thoughtful people always ask, and it's one to which I think there is a simple answer. If a measure pays for itself in dollars, it pays for itself about 5 to 10 times over in energy, and the reason is very simple; that what you're doing if you insulate your attic, for example, is you're saving the savings of your energy, gas, or oil.

The cost for insulating your attic is either for insulation or for labor, and the energy cost of nonenergy is only 10 percent on the average in this economy. So there is a general theorem, which is very important to understand; if something pays for itself in dollars, if you invest a dollar in energy conservation, only 10 percent, 10 cents out of that dollar will be for energy. The rest is just money that gets plowed back into the general United States economy.

RENE MALES: We're really getting into the next session. Dr. Rosenfeld's comment presumes that the energy prices are correctly equivalent for the various energy forms. If, in fact, there are different energy forms substituting for each other through conservation, then the calculation is considerably more complex.

ALBERT F. SCHMIDT, Westinghouse Electric: I'd like to direct my question to Mr. Sant.

In the original least-cost strategy I thought there were two major flaws, one being that it didn't address itself to the potential supply of energy in the future. You have indicated that gas use would significantly increase in the 1980s, but I'd be interested in hearing your projections on the supply of natural gas.

The other concern I had was that it looked good only when you compared one system to another, the fuel cost for one particular year; for instance, for natural gas what may look good at 50 cents per million BTU may not be so good at $3.80 a million BTU.

In your analysis did you take into account the future projections on the cost of the fuels?

SANT: Yes, that was a flaw in our first study. We were really just kind of testing the concept the first time around. This time we took fuel price projections into account. For lack of anything better, we took the Energy Information Agency's mid-range forecast and based the least-cost analysis on it this time; so the flaw before isn't there

this time except to the extent that the forecasts are unreliable, and they probably are.

So this time we really do get a dynamic effect of having gas come flowing out of the building sector and into the industrial sector, as we did before. But then as it comes into the industrial sector it starts to run out of opportunities, and it runs into real competition from coal and electricity in the 1990s, after it is deregulated, that we didn't get before.

So I think we're seeing a lot of what some of you criticized us for on the first go-around, but it didn't change it as much as some of you hoped.

BROOKS: You're assuming deregulation immediately in your projections?

SANT: No. EIA's price projections assumed deregulation of gas in 1985, as is now contemplated.

BROOKS: Henry Linden, would you like to comment on the supply situation for gas?

LINDEN: The consensus is that we'll have some difficulty in selling the supplies of natural gas that are anticipated. Lower-48 conventional production is certainly not going to drop below 12 to 14 trillion cubic feet annually by the end of the century. Unconventional natural will add another 3 to 5. Canadian gas will certainly stay at 1 to 2, and then we have Alaskan gas.

So the consensus forecast without anything exotic, just natural gas from the North American continent, is 20 trillion cubic feet minimum for the rest of the century, maybe as much as 22 to 24. Supply is not the problem; it will be demand.

SANT: We got 24 TCF in 1990 and about 23 in 2000. I think it's a good question whether there will be greater competitive pressure than what we saw. But I think we can find some markets for it, Henry, if you can produce it.

JOEL DARMSTADTER: I think the framework that governs each of the three analyses that we have heard is basically one in which, at a given level of energy prices, conservation is pushed to the point of equivalence between the cost of an additional unit of supply and an additional unit of energy saved.

Now, since conservation is subject to the same economic constraints as other resources, one can, at least in principle, anticipate such a point of equivalence being reached--a point, that is, where having crossed that line of equivalence, one finds that it is cheaper to produce energy than to save energy.

The first question is whether one can roughly identify the general zone, in terms of years, when we might run into a problem of that sort. After all, the conservation barrel is no more bottomless than the oil barrel. Secondly, what does this tell us about the needed

initiation of policies today? Some supply sources have a long lead time measured in decades--look at solar photovoltaics, synfuels, fusion, or whatever. What's the implication for the kinds of supply initiatives that we ought to take today in order to provide reassurance that, as we approach that point of equivalence, we're not going to be up the creek on the supply side.

SANT: I'd love to answer, at least on the first.

Our assumption was you couldn't use any technologies that aren't now commercially available. So obviously we start to run out of potential by the time the 1980s are over, and the 1990s are a little thinner. But it's really kind of a silly assumption on our part to say no new technologies will come between now and then.

My sense is, much like Bob Williams, that we're down at an 8 or 10 percent second law efficiency for our total economy. There's no reason why that supply curve of conservation technologies won't continue. But it's clear that the 1980s are a catch-up period. There's a big bundle of opportunity that you use up because it's very cheap as a catch up.

In terms of what that means about a backup fuel, I just see so many technologies available that I'm not very persuaded that we're going to run out and need to subsidize a backup fuel. I think the scarcity mentality that's kind of forced us into doing some silly things really ought to stop, that there really are options out there now. I can find several scenarios that get close to the same results we get. So I'm not very persuaded by that long lead time argument.

UNIDENTIFIED: I have two questions. The first one is clarification from Dr. Sant. When he talked about the flat curve of energy demand, did he mean per capita demand or overall demand?

SANT: Overall.

UNIDENTIFIED: And the second question is to anybody on the panel. I saw some projections about the cost of getting minerals, indicating that you have to go deeper to try to get them, and so with the increase in energy demand, projections were as high as 10 percent.

How reasonable is it, and was this taken into account in your projections?

WILLIAMS: Could you clarify that second question?

BROOKS: He was asking really whether the increase in energy requirements for the minerals sector, due to the fact that you're getting lower and lower concentration ores, was properly taken into account in the projections, or what impact would it have on the projections?

WILLIAMS: It's certainly true that as time goes on we're going to lower and lower grade ores; but in the case of the industrial sector, where I think this is most important, one of the important factors underlying the growth in that sector is that it is becoming

increasingly less materials-intensive. We're going to lower and lower grade ores, but at the same time products are containing more value added and less basic materials inputs.

I'm not sure that answers your question, but I doubt that it's going to be a limiting factor in this time frame.

JORGENSON: I think it's important to be aware of evidence of what is actually happening to the costs of extracting minerals, since this is a question that's going to come up in a number of different contexts.

If you look at the recorded history of the industrialized era, which dates back about 200 years, a study of materials prices shows that prices of nonrenewable materials are falling in real terms, and that, of course, includes energy.

This study has recently been updated by an international consortium of scientists and they have found that even in the period since 1973, when we have confronted much higher energy prices, the trends in prices of the basic materials used in our society--copper, iron, and so on--have all been downward in real terms.

I think the answer to the question is that the effect of technical progress continuously outweighs the impact of the depletion of resources, and that has been true throughout industrial history, and it's true today, even with higher energy prices.

GERALD EHRENSTEIN, National Institutes of Health: I wondered if the question about carbon dioxide in the atmosphere has been considered in your projections. One might imagine, for example, that burning fossil fuels might in the long run come up against the limit of the carbon dioxide greenhouse effect. And if that were the case then other sources such as solar energy that would not involve that might be in some overall sense a better choice.

BROOKS: If I could just comment on that, I think one point that needs to be made is that most of the carbon dioxide projections are based on the old figures of the rate of increase in use of fossil fuels. You're now talking about a much flatter consumption rate for fossil fuel, which would almost certainly extend the carbon dioxide problem at least to the middle of the twenty-first century and probably beyond. Although your point may still be well taken in the long run, I think it does not really affect very much the next 30 years or so.

Does anybody else on the panel want to comment on that?

SANT: I want to say that we didn't take it into account. We took existing environmental regulations and met those, but we didn't impose any new regulations. We didn't try to impose our own judgment about whether CO_2 is going to be a problem or not a problem. We just left that kind of as is.

MALES: If I could get back to that question for Roger. Roger talks about the scenario for the future providing the services necessary. Does he consider in his analysis other services that are not provided today?

SANT: You know, I mean, that's a forecasting job--actually Dale Jorgenson's got a super model to try to do that. But I'd have to agree. We don't know. We do know something about it. We probably know as much as anybody. But I don't think we know as much as we need to know.

MALES: I think it is fair to guess that the new opportunities for conservation may be about a stand-off for new energy requirements. If energy services are utilized much more efficiently than before, it gives you more ability to purchase new energy services.

SANT: Yes, that's right. I think the one thing we can't take into account is what the long-term elasticity of demand for services is. We assumed that that it is not going to be affected much. Sure, people are going to change. Heat costs more than it used to, so they may cut down on their heat. But we didn't take that into account. We assumed it stayed at its current level.

BROOKS: Jack Gibbons may want to comment on this, but it's my impression that the demand panel of CONAES looked rather carefully for big increments of demand for energy resulting from new services and was not really able to identify anything like washing machines or air conditioners and so on that would generate new demands. The one possible exception might be large covered spaces.

MALES: In fact, Jack and I have discussed this before.

GIBBONS: Neither Rene nor I profess to be wizards, but we have had a running conversation, as I'm sure many of you have, about trying to anticipate the future in terms of new demands for electricity. I would only quote Niels Bohr who said that it's very difficult to make an accurate prediction--especially if it's about the future!

BROOKS: I think on that note we should turn to our second question: To what extent is the technical potential referred to in this first question likely to be realized if market forces alone are relied upon to impel cost-efficiency investments in all sectors? Rene Males is going to respond to that first and then Joel Darmstadter.

RENE MALES: It's important to say that we see two mechanisms through which the conservation options that have been discussed can be implemented. One of these is through market prices; the other is through regulation.

In the discussion that we had during our private deliberations, it was the consensus of the panel that price was the sensible way to go in implementing conservation technologies. Moreover, there was a consensus that the response to price is quite substantial.

There's a historical lesson to be learned. If we go back to the turn of this present century as a benchmark, prices for energy have actually declined since then. Yet, energy efficiency has improved by

about 50 percent. However, it's improved at an even faster rate during the last few years in which prices have increased.

Although there are no hard numbers as to how one could allocate energy savings from other factors versus price, the consensus was that maybe 70 or 80 percent of the impetus might come from the price.

But there are problems in implementing conservation through price. There are problems of equity among different customer classes, among different groups in the population. There are problems of transition. There are other effects, such as productivity. This issue will be discussed in the answers to question 4.

There are also problems in terms of the definition of the appropriate price, in terms of externalities, and in terms of market imperfections. My colleague Joel Darmstadter will discuss that in a moment. But there are also problems in just the definition of what the appropriate market price might be.

The economists in the panel, and I am not among them, would argue that the marginal or incremental price--that is, the cost of producing one more unit or one less unit of energy--is the right price to charge to get an efficient allocation in the economy of energy resources and other resources.

The question then becomes what is the correct marginal price for oil, natural gas, coal, or the produced energy form electricity? Which margin? How do we quantify it? And what are the other implications that go along with charging marginal prices, marginal costs?

Let me just use as an example the pricing of electricity. We have been studying at the Electric Power Research Institute the issue of marginal costing and pricing for electricity. We find that there are several definitional ways of calling something marginal. It can be either short run, basically the fuel cost associated with one increment or decrement of production. It can be long run, that is, the cost of building new capacity to serve an additional kilowatt hour in the longer-term future, or not building that capacity because there is no need for the service.

There's also the idea of the static, the perfect system and the cost associated with that at the margin. Or, alternatively, one can think of the dynamic system, the actual system that exists. Such a system has all the frailties of decisions made in the past because the signals to those who made those decisions were bad, or because the units didn't work out quite as they were originally expected to work.

In any case, there are multiple definitions that an economist would say are appropriate definitions of the margin. When we quantify the marginal cost of each of these definitions, the costs turn out with rather different numbers.

Similarly, we have the same problem of marginal cost definition on the price of oil. Is the marginal price the price that has been determined by OPEC, or the cost of raising oil domestically? Right now it would look like for the near term and even maybe for the longer term, based on some of the forecasts we heard a moment ago, the incremental barrel of oil will be one that's imported or not imported. That may be the appropriate price; but there is certainly reason for argument.

What are the policy implications? It seems to me that the policy implications of using market prices is that market prices will not be totally effective. That raises the next question that we'll have on our agenda: Are there supra-market measures that are necessary and desirable? It also raises other issues such as: Are there other objectives of the society, other goals, which may not be as well-served by marginal cost pricing? That leads to our fourth question.

Finally, there are implications for decision-making. I think it's clear that the marginal cost of energy today is higher than the prices that we're paying on the average, except perhaps for oil. This would say that there is room for substantial improvement to achieve economic efficiency based on correct prices leading to the implementation of the technologies discussed a few minutes ago.

BROOKS: What about the degree of responsiveness just to the present prices; in other words, to what extent will the decisions be economically rational even if you look at it in terms only of the present prices?

That was really the intent of that second question.

MALES: As I said to begin with, the panel agreed that about 70 to 80 percent of the potential discussed in answer to the first question could be made to occur through price motivation. Market imperfections and other problems, which Joel will talk about, will keep all of that improvement from being realized.

JOEL DARMSTADTER: Correct me if I'm distorting positions of two of you. In Roger Sant's scenario I think you indicated a moment ago you allow the process of phased deregulation of natural gas to take place, you assume the decontrol of oil that has now occurred; and that's consistent with what the government assumes in the Energy Information Administration report of this year. And the savings that you calculate are essentially guided by those assumptions without imposing additional taxes, surcharges, or market trends causing the prices to go much higher.

I believe in Bob Williams' analysis there is, in fact, the imposition of a surcharge, which in some sense is supposed to reflect the social cost of energy--not merely replacement values but something on top of that.

Well, to get to my question, Rene has indicated that the country's record in making progressively more economic use of energy is really not at all unimpressive, either during our long-term history or during the 1970s when, relative to GNP, energy use dropped about 1 1/2 percent per year. It dropped about 2 1/2 percent in 1980 according to preliminary reports.

Ten years ago, before prices were seriously injected into analysis of future energy needs, projected energy growth rates of something like 3 percent per year were common. That was the conventional prospect. Today, a convergence of outlook--centering around 1 percent per year or even a bit less--has emerged, and that would be consistent with the projections Roger Sant reported on. This would imply something like 95

quads in the year 2000 compared to, I think, 79 or 80 today. For example, Exxon and the Energy Information Agency, in their most recent analysis, conform to that sort of demand zone in the year 2000.

Now, the research reported on by Arthur Rosenfeld and Bob Williams, in answering the first question, indicates that both because of technical feasibility and cost-effectiveness even greater restraint than that is possible in the energy needed to meet our residential and industrial energy needs over the next 20 years.

Whatever the maximum technical potential in energy savings, there's no doubt at all that because of imperfections in the system that we can identify, and because of inherent uncertainties, some slippage from an ideal target is almost inevitable.

Now, what are some of these impeding factors? Rene has discussed the question of marginal cost pricing. If you conclude that marginal cost prices would be substantially higher than prices now prevailing, and that marginal cost pricing can somehow be made to govern, you would increase your estimate of future savings.

If you felt, on the other hand, that marginal or replacement costs were lower and would in fact operate, then you would conclude the opposite.

However one regards the margin cost pricing issue, there are two sets of factors that clearly do impede the conservation response. One group relates to market imperfections. Another one relates to what have come to be called externalities or social costs.

Now, it's not at all hard to find evidence of market imperfections. Some of them are quite humdrum, though nonetheless real. Examples: cogeneration of industrial electricity and waste heat utilization, which is a very promising route, as Bob Williams has documented in great detail in some of his work, is clearly held back or has been held back by outmoded regulations governing electricity production. Renters are disinclined to introduce retrofit conservation investments in residences for obvious reasons. Master metering of apartment houses squelches the conservation impulse. Mortgage or money market terms may discriminate against conservation initiatives. Information to consumers on the payoff from conservation may be unavailable, intimidating, or confusing.

The externality question is trickier. Energy use imposes recognized costs on the nation and society as a whole that are frequently unpaid for. We render ourselves vulnerable to oil shocks abroad, but we fail to pay the premium that is necessary for, say, building a strategic oil stockpile.

Fossil fuel combustion may over the long run produce damaging climatic effect because of carbon dioxide release. A different, more immediate impact is acid rain.

Western resource development may have disturbing impacts on land and water.

The question becomes to what extent is it feasible and desirable to have such nonmarket phenomena--and there are others that we can think of in addition to the ones that I've illustrated--factored into energy supply and demand transactions through public intervention. And what,

if any, are some of the problems and the undesirable side effects if such intervention is to take place?

Well, that essentially slides into the second half of the program and particularly question 4, so I will cease with that observation.

BROOKS: I'd like, then, to open that up to general discussion.

CHRISTOPER WRIGHT, Carnegie Institution of Washington: Could you just clarify to what extent the panel's analysis makes certain assumptions about demography, numbers of population, and their distribution, other factors like that that are not amenable to market forces; and also to what extent you are making certain assumptions about not only population but also the market forces operating abroad or the lack of them; and finally, the relation between this analysis of energy and food production, because the green revolution seems to be quite energy intensive, and are there any indications that there can be increased efficiencies there and still produce the food we need?

ROSENFELD: I've got a very simple answer, and it's simpler because our model is simpler than Roger Sant's, but I'm very glad you asked the question.

Let me repeat that what the Solar Energy Research Institute-Lawrence Berkeley Laboratory study was trying to do was to see whether we're making the right relative investments in new supply versus improved effiency for cars or buildings or industry.

In that sense we didn't make any new demographic or economic assumptions whatsoever. What we did was to take the forecast in the 1979 Energy Information Agency's Annual Report to the Congress in which they made a lot of assumptions about the price of fuel, the increase in GNP, the demographic effects, the increase in housing size, and so on.

Whether we believed them or not, we used those numbers. We didn't change the price of fuel. We didn't change the predicted housing size. We didn't change anything. All we did was to change the unit energy consumptions of refrigerators, houses, buildings, and so on.

That's how we got down to a factor of a half, simply on the basis of pure technology. One can, of course, then go back and look at the more complicated world. I suspect what would happen is if you took a different value of growth of GNP or whatever, then of course the Energy Information Agency's estimates would go up and ours would go up, but I suspect the ratio would stay about the same.

So ours is independent of thinking about that sort of thing. What we just found is a pure ratio. It's about a half, and that's probably fairly stable.

BROOKS: One incidental observation, of course, is that if the GNP went up more, your investment rate would be somewhat greater, so your capital turnover would be faster, and your E over GNP would tend to go down slightly more. On the other hand, the energy consumption would tend to go up roughly in proportion to the GNP.

DARMSTADTER: I think in most of these exercises the demographic assumption adopted is essentially the mid-range of estimates prepared by the Census Bureau, which, I think, implies a long-term trend toward a stationary population in the United States by the middle of the twenty-first century, signifying a population growth rate of maybe 0.4 percent, less than half a percent per year over the next 30 or 40 years.

BROOKS: There is room for significant slippage there if the immigration problems and so on continue to be important.

DARMSTADTER: Correct.

MALES: Could I answer the other two-thirds of the question? I think the question is well posed, and I don't know whether anybody has the answer. The part of the question at issue is whether we have considered additional new energy applications, such as energy associated with the green revolution.

This was the thrust of my earlier question to Roger Sant. There are likely to be some new and dynamic energy intensive uses that we don't foresee. They may not even be in this country, but they would be reflected in the international energy market such as on the oil price. This would then affect our own markets.

BROOKS: But it does underline the importance of at least some insurance in the whole system.

THOMAS WOODS, Senior Policy Analyst, Gas Research Institute: One of the things in listening to your presentation and something that I recall that Bruce Hannon had noticed, and I remember from when Dennis Bakke presented the least cost, is that there was an indication that there was a savings; in other words, people had more money. But that money seemed never to have been spent.

Now, as I recall, when Bruce Hannon did some work looking at conservation, he found out in many ways it was sort of a zero sum game, because if the conservation was successful and saved us money, we didn't stick it away in the ground or put it in a sock; we went out and spent it. And when we spent it, we used more energy for other things.

Or is it, on the other hand, that what you do is you make the decision and say listen, the price of energy is high, and we're going to see to it that your investment--we want you to be at this level, but we prefer you to be at this level using the money to conserve energy; rather than using the money to pay Uncle VEPCO, you pay Uncle Hechinger's for your storm windows.

SANT: You know, that's a fun question I've argued with Bruce. It depends on whether you're trying to conserve energy or whether you're trying to get least cost. You see, there's a paradox at play that the environmentalists are starting to run into. Their conservation strategy produces economic growth. They didn't like it--I mean, that isn't what they had in mind.

Bruce is absolutely right. To the degree that you conserve or at least utilize cost efficient end use technology, you in effect lower the cost of service, or at least hold it such that you'll allow more economic growth. It's sort of the funny thing about the current statements by the new energy Secretary, that you can't conserve your way to economic growth. The fact is that conservation is what produces economic growth; so that in fact we may have a higher energy use in total through doing a good job in conservation than we would if we didn't. It's a neat paradox.

WOODS: As I recall when Dennis presented it, that $300 was a savings that was never spent.

SANT: Well, you see, it doesn't happen in an instant of time. You know, we're saying that instead of having a 30 percent real increase in the cost of services, you may be able to hold it even. So all that says is it's not going to have an inflationary impact on the economy.

That's different than what you're talking about. You're assuming that all of it happened at once, and we suddenly have this $80 or $100 billion in the economy that has to be spent. It doesn't happen that way. It happens gradually, and the effect is that you dampen the inflationary impact of the energy sector, which creates more growth.

WOODS: Then it strikes me that what you're saying is that if I don't conserve, you'll drop the building on me, and if I do conserve, you only drop the top 10 stories.

TRIBUS: It seems to me that Drs. Rosenfeld and Sant have raised an important point that has policy implications that come out of Darmstadter's comment, and I want to tie those together and ask a question.

Essentially out of Rosenfeld and Sant we get the perspective that if you spend your money to save energy, it's a bargain. There are opportunities, and you are well advised to do it.

Dr. Darmstadter speaks of the weaknesses or the imperfections of the marketplace that impede this; that is, people don't always know, the money markets don't always respond as they should, so there are a number of things.

Now, we are now dealing with a new administration that comes into office with great faith in the market forces and a great desire to cut the role of government; but if the market forces are sufficiently imperfect, even though in an ideal world we'd get the results we want, we may not.

And the question that the Moderator posed was: Will the market forces be adequate? If not, what should we do? And I'd like you, now that you've made the point so clearly, to comment on what can you do. I think that's a very important point to be discussed in this town at this time.

DARMSTADTER: I think you're stealing the thunder from the next set of questions that Harvey has posed for us.

BROOKS: I think we should take that up in the next session because it's really implied by the third question.

ROSENFELD: I'd like to make a comment on a technical basis about that, though. I'm going to take the point of view that market imperfections as seen by an economist belong after the coffee break, but the market imperfections as seen by a poor guy who's trying to get some retrofitting done have a minute in discussion now.

Let me say something very discouraging. Up until now I talked about what would happen if the United States behaved as a rational economic society.

Now, let me change hats. I work with a group which basically does research on improved efficiency. But to stay in touch with the real world we actually try to train house doctors and to retrofit commercial buildings and hospitals and schools and give advice to the California Building Industries Association and so on. And that's a very different world, and I would like to make a couple of very gloomy comments about that, if I may.

There is just no infrastructure today, and the first couple of examples I will give about that are the following. There are a number of utilities, private utilities as well as TVA and so on, who are out there trying to get homes retrofitted, and these utilities decided at first in making their plans that they would have spot checking on the quality of the retrofitting. That just didn't work, because what they found out, on the first few homes that they spot checked, was that the work was shoddy and the contractors didn't know what they were doing, and they were having to order up to 65 percent callbacks of the retrofitters.

So I know TVA has now decided that they have to inspect every single house, and I think finally they've got the callbacks down from maybe 30 percent to 20 percent, but it's pretty bad. Oregon's Pacific Power and Light has finally gotten their callbacks down from like 50 percent to 30 percent, but it's still pretty bad.

The same society that can learn to maintain cars, although rather inefficiently, can learn to fix buildings evenutally, but it's going to take training a lot of people. We need an army of trained house doctors, contractors, and so on, and we don't have them. And we can discuss all the economics we want, but if we don't get our act together enough to get trade schools to train people which side of the insulation goes down so the joints don't rot out, and if we can't train the Sears salesman on the difference between a kilowatt and a kilowatt hour (and that incidentally applies to the reporters) then we're in bad shape.

MALES: I hardly dare follow that comment, Árt, since it was so good. But I want to make the point that all of those actions that you talk about to help the market work more effectively are actions that have a cost. As such they have to be put into the calculus of whether conservation is worthwhile. That's sometimes not done. It is an important part of making markets work and in some cases extremely expensive, as you know from your experience.

BROOKS: That's why I'm a little bit surprised actually at Joel Darmstadter's figure of about 70 percent realization of technical potential. Art's story seems to say that unless there is some more vigorous training program, it's going to be more like 30 or 40 percent of the technical potential.

ROSENFELD: One serious point. These problems aren't terribly expensive ones. I make this point as an educator. We can get up to 70 percent, but we'll never get there until a required part of a technical vocational school education is to teach people to do this sort of thing, and until governments that go in for great policies about retrofitting and so on are willing to go out there and meter the buildings and find out if it's doing any good and why not.

SANT: We're looking at doing a thousand homes at a time, not one at a time, and the costs are 50 percent of what we project for one house at a time. So that there are economies of scale in just trying to rethink how we go about this task. It isn't necessary to sell one homeowner at a time if you can find a way to do it in quantity, so it's to the utilities' advantage, for instance.

BROOKS: There are also learning curves.

WILLIAMS: I'd like to make one comment about government intervention without getting into the details of question three. There are important things that the government can do. However, the worth of the government effort is not necessarily measured in dollars committed to federal program, because much of what needs to be done involves relatively low cost but very clever new policy initiatives. What is needed is not massive federal support for conservation, but well-directed efforts.

JORGENSON: I would take the liberty to disagree with the question. The question in this town at this time that we should be discussing is what to do after the market solution has been tried. My feeling is that that's going to be some distance down the pike, so what we ought to think about is what could be done in the way of trying the market solution.

We're of course all familiar with the fact that President Reagan has decontrolled the prices for petroleum. That of course continues an initiative of the Carter administration, so that has bipartisan support. In terms of scenarios for the very near future, as opposed to say 2 years from now or 3 or whenever, I think that there are a lot of things that could be done to impose a market solution, and there certainly is a federal role in some of them.

For example, natural gas is a candidate for decontrol. We currently have natural gas legislation in force that will continue price controls of the type that we've had in petroleum through 1987, and it's certainly possible to accelerate that schedule, not, unfortunately, without legislation. The President can't simply issue an edict tomorrow that natural gas prices are going to be

decontrolled. But in terms of going toward a market solution, that's obviously a political thicket that some member of the administration, perhaps the Secretary of Energy, will have to enter at some point.

A second area is the pricing of public utility services, and that's a very complicated issue, as Rene Males was suggesting. But there are at least two areas where you can think of very important initiatives that could be taken in the direction of a market solution.

First of all, we're still burdened with declining block tariffs. That's a technical term, but anybody who has an electricity bill recognizes the fact that if you buy more, you get a reduced rate. That, of course, induces inefficiency. Declining block rates are gradually being replaced by just the opposite, rising block rates, which ought to promote efficiency. This is an area where there is scope for further initiatives toward making the market forces effective in the conservation decisions of individuals and builders.

The third area related to the question of utilities is time of day of pricing. One of the most important opportunities is that given price incentives people will do things like heat the water in the middle of the night rather than when everybody else is trying to cook. That could produce very sizable real energy savings and is, therefore, a mechanism for introducing prices into the conservation decision that could have real and important impacts.

So my feeling is that in terms of the scenario for the immediate future, we're a long way from having to raise the question about what do we do after the market forces fail. We have a number of areas where market forces could be unleashed, just as the President has chosen to do in the area of petroleum. And I would conjecture that they could have very satisfactory effects.

DOUGLAS BULLEIT, Vice President and General Manager, Heery Energy Consultants: The first phenomenon we see demonstrated here is if you stand around long enough in a Forum like this, your question will get both asked and answered while you're on the floor.

But following on the heels of the last remark, I got up to say that I wasn't sure that I heard a direct answer to the original question; that was where the correct policy emphasis should reside. But it seemed to be that the consensus was that it was in the area of intensified market forces, which is certainly a rational point of view, but it places very, very heavy reliance upon correctness of pricing strategies.

Now, the strategy that seemed to be in favor among the panelists was incremental or marginal pricing. I was wondering what factor and how should replacement cost, which is the longer term extension of marginal cost, enter into this; that is, in a steady state system, marginal costs and replacement costs are the same, but in a system where substitutions are having to be made even now and certainly within the period we're talking about, the cost of replacing one form of energy with another in the consumer market has a direct bearing. Notwithstanding the semi-supportable optimism of the gas industry, many consumers are faced with that right now.

So if you're looking and weighing decisions and weighing substitutions on current prices and current marginal prices, how could and how should replacement costs of the alternatives enter the econometric models or whatever device you're using to set these prices?

BROOKS: Roger, I think you should respond to that because I think this really was taken into account.

SANT: The interesting thing is I used to be a big fan of marginal cost pricing until I ran the marginal cost case. And, you know, the supply curve of fuels is rather steep at this point, so if you get a real response from the efficiency end, you run right back down the supply curve to where your marginal cost is below the average price today, and that's a very quick response.

And I'm not so sure that our theory of marginal cost pricing stands up at all against the analysis at this point, so I'm not sure that the question is as important as you imply.

MALES: Let me just comment quickly that utility rate-setting is quite an arcane art, and I don't think there's enough time to discuss it here. EPRI is issuing the final report of the Rate Design Study this spring. I would suggest that we look to that for some hints as to what the problems and possibilities are in using marginal cost pricing.

I did also want to say I was not advocating marginal cost pricing. I was pointing out the problems and the issues of trying to impose economic theory that says that this would be the way in which to get the greatest economic efficiency. There are some good reasons to do that, but there are some problems associated.

And finally, I wanted to say that I differ with Dale Jorgenson in some minor details, again not worth discussing in detail here. The question of utility pricing because of the way it's regulated becomes very difficult to discuss in the normal competitive market.

ROSENFELD: I have a very brief remark about the marginal cost price business in our study. We spent a year on the study. Marginal cost pricing was a big waste of time. We started off with learned debates about were we going to cut off the conservation curve at 6 cents a kilowatt hour or 10.

We learned two things that were shocking. First of all, nobody studied the technology that's worth 7, or 8, or 9 cents a kilowatt hour; nobody is working there, so you can't buy the stuff, so it's irrelevant.

And secondly, by cutting off at 6, in our study we still ended up with 250 unused power plants in this country in the year 2000, so it was just silly. I mean, it's a nice intellectual effort, but in terms of serious saving of energy, take it from me it's irrelevant.

JIM BENSON, Institute for Ecological Policies: Over the last 5 years I've funded or managed about $2 million worth of energy studies. I haven't seen anything new coming out of energy studies for the last 3 or 4 years.

The conclusion that I think anyone would come to who pays attention to these studies is that there is no market price for these fuels, that what we're looking at is a political situation; that when the oil companies, that when the energy lobbies have enough influence to create subsidies for their particular type of activity, that's what sets the market. There's no such thing as a free market in the oil or the energy field.

As an example, does it make sense to build a synthetic fuel plant for $30 billion which would produce a millon barrels a day when the price of that oil, let's say conservatively, is going to be $65 a barrel? That means the consumers are going to be spending $24 billion a year to buy that oil. Why not put $30 billion into energy conservation where consumers will pocket $10 billion a year in energy savings instead of the oil company's $24 billion of household income?

You can run these things all the way through, and you find out that conservation and renewables, most of them, many of them, are cheaper, they create more employment, they can be done more quickly, they cut oil imports, they do improve the economy, and they're better on the environment.

The question that we ought to be addressing here is why aren't we doing conservation and renewables if they make sense?

Wilson Clark just published a study this week, I believe, that looks at the national security aspect of decentralizing the energy supply system. There's another benefit of conservation and renewables.

We don't have the political constituency for conservation and renewables, and I think it's kind of academic just to sit up there and talk about the finer points of economics when economics is defined and molded by the political process.

BROOKS: I really think that gets into question 3.

BENSON: I raised the point at this time so that it would be discussed when you got to questions 3 and 4.

JOHN HOFFMAN, Director, Strategic Studies, Environmental Protection Agency: We've got a lot of companies that have money, oil companies and people who because of the changes of prices have a lot of the capital of society. We have other institutions such as Chrysler, Ford, and General Motors, to put them in the right order, who need this money to make the kinds of investments that you're talking about.

Are the capital markets that exist today, in the opinion of the panel, sufficiently good to shift that capital where it's needed?

SANT: I don't know the answer to it. That's the question to ask. If you could expand the context in which the oil companies and utilities see their business, you'd have ample capital. There's enough to do the job. It's just redirecting it that will be the problem. But I don't know whether that will happen within normal market forces, and clearly that's the question of institutional inertia that I think penetrates so much of what we've been talking about.

I'm betting it will, but, you know, I don't know.

BROOKS: I'm going to make a slight modification of the agenda, and I'll explain why. The conclusion that I drew from the discussion of the first two questions is that given the present price structure, there are tremendous economic incentives in the sense that if people made all their decisions regarding energy consuming investments rationally, there is plenty of potential, and the real question is how big the lag is between what the economic incentives are and the realization of that potential. I think that Art Rosenfeld underlined that very well by his anecdote about the housing retrofits.

So the real question, I think, is: What steps can be taken in public policy that will accelerate the response of consumers, including industrial consumers, of course, to the price signals, and whether those price signals are marginal prices or average prices that may be important in the year 2000, but do not seem to be very important for the next 10 or 15 years. Even the average prices are high enough so that there are plenty of incentives for conservation.

So I would like to suggest that we orient the discussion really toward the second half of question 3: To what extent should public policy measures, other than economic incentives, be used to induce improvements in energy efficiency closer to their ultimate technical potential? The two panelists that are going to address that are Thomas Stelson and Henry Linden.

THOMAS STELSON: Clearly conservation is the fastest, cheapest, most environmentally acceptable energy opportunity. If the government activity, through regulatory research and development and other processes, can accelerate the economic potential of conservation, we can faster achieve a better balance and greater efficiency in overall energy systems.

What I would like to do is illustrate the enormous potential with a few simple examples from among the great many conservation possibilities. The one I would mention first is Emergency Building Temperature Restrictions (EBTR). This program can be looked upon as a regulatory curtailment system but actually isn't. There are the regulations that require thermostats to be under 65 degrees in winter and over 78 degrees in the summer.

The program has been in effect for more than 2 years, but for about a year has been unfunded. Not a penny has been spent for any form of compliance, yet a fairly accurate survey shows that compliance is between 80 and 85 percent; the principal category of noncompliance being restaurants. But the most interesting aspect is that the best estimate of the energy saving from this program, which costs nothing, is 400,000 barrels of oil a day. This is the goal of the $88 billion synfuel program in about a decade.

The reason it is such a successful, cheap regulatory and/or leadership policy is that it has significant economic benefit for certain elements of society, and they are highly cooperative in the compliance process.

The second example that I would mention is the Building Energy Performance Standards (BEPS), a congressionally mandated program to establish standards for building construction that would be a least cost for life cycle condition.

Now, it is pretty hard to fight with the kind of policy that would save energy and save consumers' money as well. A lot of good work was done; it was optimized; and clearly the system has a lot of merit--so much merit that many designers and builders use the system even though it has not come into law and effect. The reason it isn't in effect is that it brings together and perhaps eliminates a market imperfection, the imperfection being that builders of buildings generally don't pay the utility bills. So the savings accrue to one group of people, the building users, and the expenses are paid by another, the builders. Consequently, when this program came to a crucial stage, the congressional mandate was relaxed by a couple of years. We will need to wait to see how it moves in the uncertain future.

The savings from the BEPS program is about 20 quads in about 25 years, so it is a very significant program, reduces building energy use between a half and two-thirds, and is a least-cost scenario system.

These are two examples of the type of thing that the government can do in regulation.

As a last example I would like to show the power of knowledge and information because I think that is both the greatest opportunity and it is the least utilized opportunity.

In New England a little over a year ago there was a simple program called Low-Cost/No-Cost. It recommended 11 simple actions that a homeowner could take at a cost of perhaps $100 that would reduce the average energy consumption in a home by 25 percent. There was a careful analysis of the program's impact. In this analysis, 7 of the 11 items were thrown out because they weren't statistically accurate. The result is a very conservative analysis that showed that for every federal dollar expended during that one winter, consumers saved $26 of fuel costs. So it is a small but powerful program and illustrates one of the greatest opportunities of governmental effectiveness--that of improving energy understanding.

The Energy Extension Service and the Residential Conservation Service are informational type programs that have great potential on the informational, not the regulatory side of the cost-effective government energy conservation programs.

HENRY LINDEN: We have discussed the fact that energy efficiency improved even when prices of energy were falling and that energy efficiency improved even faster when prices of energy were rising, and that we have plenty of technology around today to make at least a 50 percent improvement in the end-use efficiency of the building sector. In the automotive sector we are well on our way toward this level of improvement, and we have good evidence that it will be cost-effective, technologically feasible, and marketable to get automotive efficiencies up to perhaps 40 or 50 miles per gallon by the end of the century, with gasoline consumption continually dropping. As Tom Stelson has observed, there is a lot of regulation that is indeed very beneficial, with some minor casualties like Chrysler.

However, the question, then, is why energy has become such an issue in governance, and particularly the United States. It is very likely that this is because the mark of good government is its ability to

prevent scarcity of essential commodities and, in fact, to promote abundance of essential commodities, and that the existing system of energy supply and distribution has failed us terribly on several recent occasions.

This gets us to the absurdity of equating energy and oil, and the focus on liquids as the primary issue in government policy. And this then leads to the question why government intervention always allocates a scarcity of liquid fuels to the transportation sector, which is the very sector where liquid fuels are absolutely essential, and why there is not a more sensible approach to the management of real or imaginary oil shortages or oil supply interruptions. This also impinges on the synthetic fuels issue.

I believe that any government intervention in fuel efficiency should focus on form value of the various energy forms. One of the greatest heresies is to express all energy in the form of a million barrels a day, because the form values of electricity, gaseous fuels, liquids, and coal and of nuclear energy and hydropower in fossil equivalents are quite, quite different.

My contribution to this discussion is to point out that if, indeed, the issue of scarcity and fears of scarcity revolve around liquids, a very simple form of government intervention in fuel efficiency would be to make sure that we displace liquids from all in stationary heat energy uses and use them only at their highest form value for transportation and petrochemical requirements, and that we substitute in all stationary uses other energy forms that are more abundant or cheaper or more reliable.

Another form of beneficial government intervention, in addition to what Tom Stelson pointed out--and I do want to add to his list automotive fuel efficiency standards that have held an umbrella over the automobile manufacturers while they are adjusting to high fuel prices in a highly competitive market--is technology development.

If you look at the history of federal intervention in technology and technology related issues, it is a glorious history. The basic systems of transportation and the improvements in agricultural technology are all products of government intervention and subsidies, and there is really no fundamental reason why this intervention cannot continue to be beneficial. To simply say that it will not work because the government is not its own customer as it was in the defense-related developments, is just too easy a way to get around it.

So we do really have two basic federal forms of intervention that I would advocate, namely, continued technology development over a very broad spectrum that avoids unnecessary distortion of market forces and initiatives to displace the use of liquids for stationary heat energy users with other energy forms.

WILLIAMS: A market-oriented strategy is not necessarily a free market strategy. A market-oriented strategy should involve government initiatives aimed at making markets work better.

There are two alternative ways that are usually considered for doing this. One is to compensate for market imperfections. For example, to compensate for the large subsidies given for energy supply,

the suggestion is often made that we should also provide large subsidies for energy conservation.

An alternative strategy is to try to eliminate the market imperfections. Instead of providing the new subsidies on the demand side, one could try to get rid of the subsidies on the supply side. This approach appears to be particularly important for conservation, because conservation investments are usually not well suited for targeted incentives, because the technologies required for energy end uses involve multipurpose and changing approaches in highly diverse situations.

I can illustrate with a few examples some of the problems with targeted incentives. One problem is unintended side effects. This problem is very well illustrated by the recent cancellaton by the Tennessee Valley Authority of its zero interest loan program for housing retrofits. According to a recent Electrical World article one of the major reasons behind the cancellation of the program was some analysis that showed that between 1975 and 1979 the percentage of new houses built in the area without attic insulation increased from about 4 1/2 percent up to about 17 percent. Apparently the builders in the area realized that it wasn't necessary to install the attic insulation because homeowners could install it later with the benefit of this zero interest loan.

Another problem with targeted incentives is that they really cannot be applied to activities that serve multiple purposes. An example from the solar energy area illustrates this point. There are government subsidies for solar heating of houses via rooftop collectors, but there is no comparable subsidy for passive solar technology. And yet in many instances, passive solar technology is inherently more promising. But the attitude of the government in this regard is correct, because passive solar systems serve more than one purpose. The windows on south-facing walls serve as both solar collectors and as windows. Why should the government be subsidizing individuals to install fancy window systems?

And finally, a case could be made that targeted incentives tend to stifle innovation. The reason for this is that in order to qualify for a targeted incentive, an activity has to be fairly well defined.

Consider a heat recuperator for an oven that dries the paint on beer cans. This represents a very well-defined activity that could qualify for a tax credit. But suppose that as an alternative a fundamental change in the process of drying the paint is introduced. One of the ideas in this regard is to have "tuned paints," i.e., paints that are tuned to dry on exposure to flashes of ultraviolet light of a particular frequency. This particular innovation involves much greater savings than putting a heat recuperator on a gas oven. Yet, this innovation is not well defined as an energy conserving activity per se, because it serves many functions. It is aimed at improving industrial productivity overall.

In light of these kinds of difficulties, I think it is desirable to have energy conservation policies aimed at making markets work better by getting rid of the imperfections that exist now instead of trying to introduce policies that compensate for existing imperfections.

UNIDENTIFIED: What I gather from what you say, given the present political climate in this country with an emphasis on getting government intervention out of the marketplace, is that it would be politically consistent to talk as much about desubsidizing as about deregulating.

BROOKS: I think that is a good point. I wonder whether anybody would care to really quantify the question of subsidy for energy supply.

WILLIAMS: I can just give you a few numbers from 1977 that come out of reports done recently by Battelle Pacific Northwest Laboratory and by the General Accounting Office. These are subsidies not for energy supply generally, but subsidies that are aimed at the routine provision of energy. In the case of investor-owned utilities, the number is on the order of $2 billion a year; for publicly owned utilities it is on the order of $1 billion a year; government activities such as NRC regulatory costs and enrichment services and subsidies for hydroelectric and transmission facilities, on the order of $0.6 billion a year; and for the oil and gas industry, on the order of $3 billion a year.

BROOKS: How does that compare with the total sales of those industries?

WILLIAMS: I don't have those numbers right here.

BROOKS: It still seems to me like a fairly small percentage to sales.

MICHAEL L. TELSON, Energy Analyst, Committee on the Budget, U.S. House of Representatives: My question regards the 1978 Public Utility Regulatory Policies Act (PURPA), and the program it set up to basically prohibit discrimination from electric utilities on purchasing power that would be offered to them by potential cogenerators.

About a year ago, FERC came out with regulations implementing the program whereby utilities were almost required to purchase power from companies that might have some excess power, and they would be required to pay the avoided cost, essentially, to the utility.

I wondered if the panel thinks that this was a good idea in general as a way of encouraging energy efficiency, and secondly, if they think that government intervention was a necessary way of having this occur.

SANT: From what I can tell, it has really stimulated the cogeneration proposals that are now starting to be developed, and I would think it will really stimulate cogeneration. But I think that the interesting thing is it is starting to create some animosity, of course, on the utilities' side. They are saying, you know, why should I be forced to take this stuff? I didn't plan for it. How can I be expected to run my business?

And I think that it raises even a larger question of why do we regulate utilities at all? You know, why do we even consider utilities

a monopoly, at least the generating side of utilities? So if you once accept the fact there is competition for utility generation, which is implicit in the FERC ruling, that there is something out there that competes with centrally generated electricity, why do we have a monopoly?

So my feeling is that it will generate the better question, which will lead us more to a market question about when we build a generating plant, we had better know we can sell the power from it.

STELSON: I think PURPA is a tremendous example of a very low-cost, very effective governmental action that stimulates innovation and energy efficiency, and it is self-balancing in that respect.

For example, I just reviewed last week a $110 million entirely private investment in cogeneration with a biomass source. Of course, they picked the weakest utility area to cogenerate in because that is where you have the greatest avoided cost and maximum return on investment.

You design your system so you help the weakest utility and thereby provide self-balancing. Furthermore, you search for the most efficient alternate in a decentralized system because you make the most money from that kind of development.

The great asset of the utility is that it has the grid. It is a unique monopoly. It would be very unsuitable for everybody to get into the grid business. The time may come when the utilities' main job is running the grid, not generating power. Just providing a service in balancing the total system would be a tremendous advantage. PURPA is the key element in moving in that direction.

LINDEN: I fully agree with the benefits of PURPA. Clearly this ranks as one of the very positive federal interventions in energy conservation, and much of Roger Sant's least-cost energy strategy does, in fact, assume very widespread substitution of central commercial power with cogenerated power. But I do want to caution about too much enthusiasm for turning electric utilities into mere distribution companies, because I happen to know the plight of their equivalents on the gas side. The lack of vertical integration of a utility system robs it of opportunities to capture the benefits of the increased profit potential from the generating or producing sector thanks to, for example, deregulation, and puts them into somebody else's pocket. Lack of control over the price and supply of a utilitity's basic commodity can also cause problems with state regulatory commissions that approve the rates of the distribution companies and may squeeze margins very hard, especially in a period of rapidly rising costs.

So I want to caution about too much enthusiasm for divestiture of the generating sector from the electric utilities.

BROOKS: It certainly is also true that if there are large economies of scale in the generating sector, there are still some aspects of natural monopoly present. So it isn't quite as clearcut a case, I think, as implied.

WILLIAMS: I would like to say one thing about PURPA and cogeneration. On the one hand, I am very pleased with the PURPA rules. But on the other hand, there is one major remaining problem in that area. While PURPA makes cogeneration interesting both to industrial users and to third parties, it discriminates against utility ownership of cogeneration systems. There are many circumstances in which utility ownership of on-site cogeneration systems makes a great deal of sense. I think it is desirable to look at the existing rules to make them more neutral with regard to ownership than they are at the present time.

BROOKS: I think we will take one more question from back there if it is short.

UNIDENTIFIED: A little bit convoluted, but it is to Mr. Stelson, since he is the only one who has mentioned people in this. Nowhere has the question of recycling as a way of saving energy been brought into this, and yet we have an excellent model in terms of the throw-away beer can which constitutes 1 percent of all the electricity in the United States. All voluntary programs run by the aluminum companies at best are recycling one-third of these cans. In the places where there have been mandatory laws, the recycling rate is 90 percent, with a substantial saving in energy.

My question is how does one get the government more deeply involved in recycling as a form of energy conservation?

STELSON: The government already is somewhat heavily involved in recycling, and especially since last summer in areas like municipal waste. There are large new government programs that impact the market for recycled energy and materials. Aluminum is probably the best example of energy conservation in recycling. There are a lot of materials where it is questionable whether you save any energy although you may save other things such as natural resources.

For example, paper is one of the areas where it is really questionable as to whether any energy is saved by simple recycling. Technological development to reduce energy use would probably be a much better investment. Recycling materials is an intriguing area, and I think it is one where government leadership can be effective. I would expect a steady movement of the government into recycling, and especially in those sectors where there is the greatest promise.

LINDEN: Reynolds Metals recycles 60 percent of its aluminum cans, and it is not anywhere disproportionate, as you point out, between states where it is mandatory and where it is not.

BROOKS: It seems to me that the bottom line of the discussion on this question is that the one area of government intervention that almost all the panelists would agree on is desirable is interventions that in fact enhance the operation of market forces, and I think the examples that were cited are all in that direction.

Now we must move on to question 4: What are the national policy objectives that interact with energy conservation policy, and what should be the specific goals of conservation policy in the light of these broader policy objectives? The first commentator is Paul Craig.

PAUL CRAIG: Well, I would begin by asking the question of how much conservation should be our policy goal? A general principle that has appeared many times has been that we should conserve up to the point where the investment leads to minimum social cost. But we don't agree on what kinds of price to use, we don't agree on how to measure benefits. We worry somewhat about who benefits and who is hurt by particular problems, and we worry about social costs.

As a starting point, however, we can compare conservation investment with supply, and we could do the conservation investment if it is cheaper, and we should also be aware of the environmental costs.

Let me say something about those. A one-time investment in insulation in something under a million homes provides about as much energy as a large coal-fired power plant produces, and it does it indefinitely, and it costs a lot less. There is no strip mining associated with it, and a typical western power plant would require about a square mile per year of strip mining. There is no acid runoff. There is no boomtown effect. There are fewer transmission lines. There is no carbon dioxide problem associated with that power plant that wasn't built, ever.

Or if you fill your gas tank with oil from oil shale, it takes about a half ton of rock per tankful and costs perhaps $2 per gallon. Compare that with a modern diesel or stratified car that pollutes less and costs less for the benefit, the benefit being transportation.

And I will observe that there are a lot of technologies for making these more efficient cars so that they are just as safe as the big cars. There have been a number of projects developed to demonstrate that this can be done. It is not clear that the smaller cars necessarily need to be more dangerous.

Conservation has equity implications. There are capital outlay requirements. We have to worry about low income groups, especially during the transition period when we are catching up with the increase in prices. We need finance mechanisms. We need to decide who is going to work on these finance mechanisms. Will it be utilities? Will it be other groups? Will it be some kind of a combination of groups? We need to ask whether the environmental offset that comes about from conservation might not constitute a commodity that can be sold to the highest bidder, thereby yielding another source for funds that can be used for conservation investment, perhaps a revolving fund.

We need to be concerned about life-styles of people. If we invest in strip mining and oil shale plants instead of conservation, we are going to be installing some of the most expensive, capital intensive projects ever put in to certain parts of the country such as the Rocky Mountains.

We need to be concerned about risk. The future is uncertain. Most of the conservation investments decrease risk. A tight house, for example, is livable even if there is a fuel shortage. A strategic

petroleum reserve of a given size will last longer if the cars are efficient. Furthermore, conservation can be put in more rapidly than the supply options. So we have flexibility.

The amount of conservation that I think we should go for is the amount that is cost-effective, and one of the things we have learned here is that we can hold our energy use at about the same place as it is now out to the end of the century.

But what should government be doing? Well, government is needed to provide stability, assure national security, be concerned with equity issues. In my view, government should assist industry, especially regulated industry, to shift in to the service corporation mode. That will largely be done at the state regulatory level. The government should assure that decisions that involve the government will be carried out with the least environmental and social impact. That means the government should not be putting taxpayers' money into expensive supply when conservation is cheaper. In particular, the government should not be putting money into synfuel plants. It is going to cut down economic growth. It is going to decrease national security. It is going to hurt the environment. Why are we doing it?

And then lastly, as what I consider to be the major outlay area for the federal government in the conservation area, and in fact, almost the only outlay area, the federal government should be supporting underlying research on the kinds of technologies that we will need after this decade of the 1980s when new technologies are going to carry us much further. We don't know how far, we have had a few hints, but probably a long way if experience to date is any kind of a guide.

So the federal government has a long-term obligation in basic research where the results of the research are not readily capturable by any company, and the federal government, in my view, has a major role in near-term activities designed to help to overcome institutional barriers. Educational programs are one of the best examples of this.

JOHN H. GIBBONS: I thought about three national energy policy statements one might be able to make that certainly interact with conservation policy, and then I thought of just a few comments relevant to conservation activities. Let me try them out on you.

First, a national policy objective could be stated as follows: we should provide a system of energy supply and utilization that in combination delivers energy-related goods and services at the least cost in terms of economy, national security, and environment.

When you apply that to relevant conservation activities, it means:

(a) put to work existing methods because conservation is one of our few feasible options for the 1980s, and we must move rapidly during this decade.

(b) find less costly ways to provide energy-related goods and services. That is Dr. Craig's point about the promise of research.

(c) give special emphasis to displacing oil imports, for obvious national security and international economic reasons.

(d) choose options with the least net adverse environmental impacts.

The second national policy might be stated that we should assure the protection of equity across regions, across economic status, and also with due consideration to future generations, that is, the issue of sustainability.

What does that have to do with conservation? One example would be that we would help especially impacted people to become less dependent on energy, by helping fix their house, rather than getting them more hooked on energy via energy stamps.

This policy objective is related to the question often phrased, "Doesn't energy conservation only buy us a few years in the long-term trend to high energy demand?" Such a question presumes indefinite growth of demand. Conservation might also be considered as reducing the amount of energy required per year to sustain a given level of goods and services whenever that year comes about.

A third national policy objective would be to provide for a system of energy supply and use that is robust and resilient. That implies diversity of supply, flexibility of use, a satisfactory degree of self-reliance, and one in which no major single component contains a substantial risk of failure, i.e., risk distributed through the entire system.

One rhetorical phrase is: Why don't we keep our inefficient energy use systems so that in case of emergency we can tighten our belt without much pain? The analogy is that I should go around each day burning dollar bills steadily so that in case I need some cash I can stop burning my dollar bills.

A decentralized, diverse, and high efficiency system of supply and use matches this objective. Paul Craig has given you plenty of information to show that it would have inherent resilience.

Within this context, then, neither energy supplies, per se, nor energy productivity (conservation), per se, constitute national energy policy goals. They are both strategies to be employed in meeting those goals or ends. Neither supply nor conservation has inherent economic virtue.

It is interesting to note that the so-called supply-side economics, as applied to energy, does not simply say, "We must supply more energy." It opts, rather, to supply energy-related goods and services at least cost to the consumer and to the nation. We should choose, therefore, the best combination of energy strategies to attain those desired ends of our goods and services.

DALE JORGENSON: I am going to rephrase the question before us, as phrased by our chairman in the following way: How much energy conservation should we have?

It is obvious that this is an extremely difficult question to answer, and it is difficult because it involves not only the question of cost of conservation and cost of alternative energy supplies, but also the fundamental question of the value of energy to the consumer.

Now, of course, energy consumption is not an end in itself. Energy is used to produce energy services like heating and lighting, and of course, used to produce other goods and services. And its value is the result of a balance between the costs and the benefits, so that when we

say that we should have a conservation policy that achieves minimum cost, that in itself doesn't answer the basic question of how much we ought to have, because that involves balancing the minimum cost that is achieved by conservation against the benefits.

So what I would like to do is to address the question of what the benefits are of conservation and what the costs are, and phrase the question in this way. Is it possible that we could go too far? Could we have too much energy conservation? For example, if we kept energy consumption at the same absolute level today for the next 20 years, would that result in negative effects from the social point of view?

The answer to this question, as I suggested, is very complicated, but let's look at what the consequences of higher energy prices are. Higher prices are, of course, what would have to accompany flat energy consumption. If we don't achieve it by higher energy prices, we will have to achieve it by quantitative restrictions that are even more harmful than high prices.

We now have a period of history dating from 1973 when we can examine the consequence of higher energy prices, and we can see that higher energy prices are very costly from the social point of view. From the benefit side, energy consumption is curtailed. We are all very impressed by the amount of conservation that has taken place.

But if we look at some of the other aspects of what has happened to our economy since 1973, we find that one of the impacts of higher energy prices has been that capital accumulation has been depressed. We have had a slower growth in capital during the period from 1973 to the present than during any time since the Great Depression.

Second, employment is stimulated. That sounds like a benefit, but the mirror image of rapid employment growth is labor productivity growth at the slowest rates, again, since the Great Depression. So we have had a period of very poor economic performance.

The third, and to my mind, most insidious effect of higher energy prices is that in fact they depress the growth in productivity itself. Let me be very precise about what I mean. Productivity here is defined now as output per unit of all inputs, both capital and labor--the capital that is employed and used in production as well as the people and the time that is involved. Since 1973, productivity growth has been insignificant, and that is a very familiar fact to many people in this audience. By comparison, productivity rate in the post-war period as a whole grew at more than 1 percent per year, which was a very important component of the 3.5 percent annual increase in our real standard of living. At a 3.5 percent increase we get doubling of the standard of living roughly every 20 years. And of course, with productivity gone, that period of 20 years for doubling of the real standard of living increases substantially.

The same trends are observable throughout the industrialized world. Japan, which was growing at double digit rates before 1973, is now down in the range from 5 to 7 percent. Germany, which used to grow at 5 to 6 percent, is now down in the range of 2 to 3 percent.

So the conclusion is that higher energy prices or restrictions on the quantity of energy available directly reduced welfare. The first effect has been through the reduction of energy consumption; energy

does produce the benefits that we are familiar with--energy services in the form of heating and lighting, for example. Second, higher energy prices do reduce capital formation. And finally, they stifle productivity growth. Therefore, the effect of prices that are too high is a very, very serious matter.

What is the moral of this story? Should we maintain prices at levels that are much lower in order to stimulate energy consumption? Well, it seems paradoxical to say so, but in fact, the price controls lead to inefficiencies in energy use that in fact dominate the effects that I have just described.

For example, if you look at the impact of energy price decontrol, again, a Carter administration policy that was put on an accelerated schedule by the Reagan administration, we can find that the inefficiencies are so great that there will be, as a result of the elimination of price controls, a net social benefit, and that social benefit is going to show up as faster growth and higher increases in the standard of living.

So the moral of the story is not that we should attempt to maintain prices at an artificially low level, but rather, that it is very, very important to get prices right. To do that we have to take into account not only the supply side, the cost, if you like, and to achieve a minimum cost strategy, but we also have to think in terms of the benefits of energy consumption; they are very substantial.

We still have a long way to go to get the prices right, as I suggested earlier in the discussion. In particular, the frontier is wide open for improvements in the pricing of natural gas, and most important, for electricity. So the overall conclusion is not that we ought to maintain prices at a low level, but that we should make a very serious attempt to get the prices right and use both market forces and government intervention for that end.

BROOKS: I would like to ask a question because I think there was one point in your presentation I didn't fully follow. I didn't see what the intervening factor was that made the decontrol of oil prices economically beneficial, despite your earlier theorem.

JORGENSON: The matter is indeed a little bit complex, but I can explain it, I think, fairly simply. As a result of oil price controls, people had an incentive to purchase energy at prices that were well below the costs that prevailed in the world market. We had controlled prices in the United States and we had world market prices to confront. We allowed the consumers to average the two and thereby to consume oil at prices that were below the world market prices. That led to a dramatic growth in imports of petroleum. We are all familiar with the tremendous increase in energy vulnerability due to the increase in petroleum imports.

But of course we had to pay for those imports and how did we do it? We did it by exporting on a scale that is staggering the imaginations of people who thought that the U.S. competitiveness in world markets had been lost forever. Since 1973, we have had the most dramatic growth in exports in U.S. economic history. That has occurred

in sectors that we are all familiar with, agriculture being a leading one, but it has also occurred across the board, in manufacturing, even in services. And the point is that those exports are goods that are more valuable than the energy that people were consuming at these controlled, depressed prices. If these exports had been diverted into domestic use instead of used to pay for these excessive oil imports, they would have made everybody better off, raised the level of consumption, and raised the level of investment so as to stimulate the rate of growth.

So the moral of the story is that, as I said, the first thing to do is to get the prices right.

ANDRES LIEBENTHAL, Energy Economist, World Bank: I would like to ask mainly Professor Jorgenson, but anybody else who would care to comment, what is the right price of energy? Basically what I am asking is, is there any reason for arguing that the optimal price that would lead to the optimal amount of energy conservation would be different than the price that would result from the deregulation of oil and gas, that is, the market price?

JORGENSON: I think you could make the following argument. This used to be very popular, but it seems to be diminishing as the years go on. Since certain energy sources are depletable--not all of them are, of course, there are many renewable energy sources--we ought to save these depletable sources for future generations. There is only a finite amount and there is an infinite stream of future generation who will live on this globe, and therefore it is necessary to preserve petroleum for the future.

The line of argument that that leads to, of course, is that OPEC has done us a great favor by instituting a price system in the world petroleum market that will lead to dramatic conservation of petroleum. The argument that I would make against that, since I do not regard this as a reasonable position, is that there is absolutely no reason why, on the grounds of the existence of a depletable source, that we ought to conserve for future generations.

First of all, it is important to remark on the fact that if they have any luck at all they will be a lot richer than we are. They will be considerably more affluent, maybe not twice as affluent in 20 years, but say in 40 years.

Second, if history is any guide, the costs of the materials and energy that are produced even from depletable sources will be cheaper than they are to us in real terms. This may not be very plausible in the case of energy, given our recent experience. But if you take a somewhat longer time perspective--and that is what is important for these intergenerational comparisons--then I think it is clear that the real price of energy has gone down, the real price of materials has gone down, and again, the prices of those depletable sources are in fact going to be cheaper to them than they are to us.

So my basic conclusion is no, that there is no reason not to use market prices, that in fact, there are no externalities of this type that ought to be brought to bear.

BROOKS: Well, also there are, of course, many of the theories of resource economics that suggest that the optimal rate of depletion of depletable resources is indeed the market rate.

GIBBONS: I will take a little difference with my esteemed colleague, Professor Jorgenson. Many technologists claim that economists are the world's foremost technology optimists. If you assume that the past is a prologue of the future, that past trends will inevitably continue into the future, then he is right. As a technologist I can't be that optimistic.

Let me add that if you just make your energy-related investment decision based on present market price of energy, then you will not make the economic decision because if your investment (e.g., a refrigerator) is going to last, let's say, 20 years, you should be thinking about the average price of energy that you are going to be paying during that period of time, not just what you are paying today.

So even in terms of your own self interest, you ought to be looking at the margin, not just at present market average cost.

A second point: if you look beyond your own individual self-interest and think about national self-interest, then there are external costs of energy, especially on oil. We have to keep the navy in the Indian Ocean in large measure to protect the flow of oil to the United States. There are other "external" costs that are associated and therefore need to be factored into the process. This is where the role of government comes in--to complement the market.

Therefore, if you make your decision for conservation based on present, market price, deregulated or not, I think it is the wrong decision.

CRAIG: I will make a remark that is on the same subject. It is a subject of economics where fortunately we now know, after the last few years, anybody can be an expert, so I will be, too.

There have been a number of econometric studies that suggest that if we didn't have an OPEC monopoly, the world oil price would be very much below the present world price.

Now, most people today don't think that OPEC is about to collapse, but it certainly might, and so that is a legitimate subject for concern. There is, I think, a legitimate role of the U.S. government to provide some kind of price stability so that people who have to make investments of their own money will have a reasonably secure price horizon to look at.

Second, there is a point to which Jack Gibbons alluded that there are national security costs. A very fascinating study by the Institute of Gas Technology suggested that the value of a marginal barrel of oil to the United States might be in excess of $100 per barrel, which is to say substantially more than twice the present cost.

Now, both of those argue that there is a legitimate national role to provide some kind of stabilization, but there is a very major policy issue that I will not begin to try and address in the limited time here, as to how that responsibility ought to be met.

LINDEN: In regard to treating history as the basis for projection, I do want to raise a point with Dale Jorgenson's thesis, namely that we do not have a representative data base since the industrial revolution because you could take the view that much of the growth of population and affluence worldwide was indeed the result of underpriced basic commodities until the present and, in particular, of underpriced post-World War II hydrocarbon resources that have created a false trajectory that is not sustainable in a system where we must eventually approach a totally renewable steady state economy.

So I don't think this is a good data base to look at this period of tremendous influx of subsidies to the world economy in the form of costs way below replacement levels for the most essential of all of our commodities.

BROOKS: I think I have to give Dale a minute to respond to that.

JORGENSON: I have to respond in terms of an example.

The first book on energy economics that was ever published was a book by William Stanley Jevons, who was a distinguished economist of the nineteenth century. This was a book about the coal trade and it is a story about how people had been exploiting low-cost coal and having an unsustainably high rate of growth because of that fact, and it was all going to come to an end very shortly because of the exhaustion of coal.

Well, that was a century ago, and my feeling is that this is a very useful example in providing historical perspective that may be useful today.

DAVID MOULTON, Executive Director, National Energy Efficiency Coalition: I wondered if the panel could integrate some of the remarks that have just occurred in the last 10 minutes in the sense that if there is a national security premium that we should be paying because we suffer from dependence that hurts us economically, how can a homeowner expect to be treated under that kind of thinking?

Professor Jorgenson mentioned the fact that rising prices have a benefit and a cost in the sense that it diverts capital. Again, from the homeowner's perspective, rising prices on the one hand give me a stronger signal to conserve, but at the same time, take out of my pocket the capital I was going to spend on investing in insulation and put it in someone else's pocket. It diverts capital somewhere else just when I need it the most.

And in the sense that there is a national security problem that possibly you could put a price on--I know that Bob Williams in his book discusses the fact that this could justify a $2 a gallon tax on gasoline--are there alternatives that won't have this aspect of diverting capital out of my pocket in order to respond either to conservation or to be patriotic in reducing our oil use? And I am thinking in particular, for example, we are commonly using government investment tax credits to encourage one thing or another, is that not a government intervention alternative that is not inconsistent with market forces but which helps me as a consumer respond to rising prices

by getting the capital back to me so that I can do that as quickly and as efficiently as possible?

JORGENSON: I think that is a very complicated question, and let me just respond to one aspect of it. I think that the $100 a barrel petroleum kind of argument is essentially an argument about what would happen if we all experienced, say, rolling blackouts. The losses would be very dramatic and very large. We have actually been through a situation like that in early 1974, so we know that it is pretty inconvenient; those losses are indeed very dramatic. But it seems to me that rather than attempt to deal with this by means of pricing, we ought to do what we have suggested here a number of times, namely, reinforce the natural instincts of the private sector.

What has happened in the period after the Iranian revolution is the growth of private stocks on a scale that staggers the imagination. Most of our competitors on the world oil market, on the demand side, the other industrialized countries, have very substantial stocks that are government controlled or government mandated relative to our own. We have utterly failed either to create a strategic reserve ourselves on an appropriate scale, or to provide incentives or mandatory restrictions that would reinforce the incentives just in terms of the possibility of a profit from increased prices during a shortage, that would naturally prevail in the private sector.

It seems to me we could go a lot farther in that direction before considering these draconian measures of doubling the price of petroleum.

GIBBONS: I think your question also gave part of the answer. One of the rationales for providing tax credits for insulating attics is the argument that that will hasten our move toward a better match of the efficiency of energy use in the United States and the price it now commands. As it stands now, we are dreadfully out of balance.

There is an interesting engineering generality that is very important here. If you look at the total cost to own and operate a house, an automobile, a refrigerator, and many other energy intensive items, you find that the total cost to own and operate is very insensitive, over a rather appreciable range, to the energy efficiency of that unit.

So the perfectly informed private market incentive is to make a choice in the region of the minimum total cost. The national incentive, however, is to move all the way across as far as you can, across that shallow minimum to where the actual total cost starts to rise significantly.

It is in that nudging across a shallow minimum that one finds the rationale for a lot of govenmental or public action. I call it mutual coercion, the best practice of a democracy.

SIDNEY HARRIS: I am a government employee. Last year I attended a gasahol hearing in the House Rayburn Building. You just talked about government help, government intervention in making a decision. In the 15 years I have worked with the government, and reinforced by the Washington hearing, I have yet to see the government make the right

decision at the right time. Yet between the free market and self interest, everyone on the panel seems to be pushing toward, to back me up, I hope the federal government will make the right decision. I am just wondering whether you gentlemen might be realizing, you are whistling in the dark.

STELSON: I think your pessimism is only partially well founded. There are lots of right decisions made at the right time. Perhaps the impression that I have given, which is erroneous, is that energy conservation is a finely tuned economic situation with narrow differences that are difficult to perceive, and that conditions don't drive the economics strongly one way or another. That is completely false. There are millions and millions of conservation opportunities where the cost per barrel of oil equivalent is $2 or $3 or $4 or $5. They are outstanding bargains by the crudest kind of analysis, and you don't have to worry about being careful. It is so clearcut that it is beneficial that you can't possibly make a mistake.

Consequently, the bulk of energy conservation achievement is not governmental, but individual. That is why the current conservation achievements, a reduction in the last year of something like four times the original government prediction is because there wasn't that confidence in the intelligence of the American people to see a bargain and take advantage of it.

Intellegent people are great resources that are now driving conservation efforts.

BROOKS: But I think your statement does suggest the question, if conservation is such a good bargain, why should the government subsidize it?

STELSON: And the answer is they don't provide much subsidy. The key right now to conservation is not economics; it is knowledge. Knowledge is several times more important than economics at the present time.

HARRIS: But what I want to clarify is that the government siphons off or makes such a wrong decision that it is almost impossible or it isn't worth the time and effort to go for a lot of things that are conservation. I believe personally in high technology, and yet I know that the synfuel plant is up to $30 billion down the drain.

As far as tax credits go, it would do more for more fuel efficient cars, instead of trying to hold on to the gas buggy or the gas guzzler. You can't do it because of high taxes and everything else. You are being bled on it; no matter which way you turn, you are being bled. And we have got these monumental decisions where a few self-interest groups keep things going. What I remember is Henry Ford II and Leonard Woodcock coming arm in arm down to the Senate floor and telling that big cars is the way to go. I mean, I just think we have got so much that rolls up against us.

DARMSTADTER: Just one brief comment.

Tom Stelson, reverting to something he suggested earlier, said that the problem is not economics but information.

I would like to suggest very simply and quickly that information and education are not costless resources. Take the care of the Building Energy Performance Standards (BEPS), which represents an extremely ambitious effort on the part of the federal government, here in Washington, to set minimum energy performance standards for a large variety of buildings, for every region of the country. Even though such an initiative may appear to be a relatively "costless" effort, it does nevertheless exact an enormous drain of personnel and resources; it would surely generate inefficiencies, and, conceivably, misallocation of resources, all of which ultimately have to be recognized to be a cost of conservation.

STELSON: I think you can look at BEPS at two levels. You can look at it as an imposed regulatory system. You can look at it as the best new information building energy systems that is available in the country, and people are using it widely without the regulatory backing.

BROOKS: The gentleman there, and then this will have to be the last question.

GARY KAH: I am somewhat intrigued with the format of this Forum in that we have been dealing with the questions of government interventions and government roles. But to my knowledge, there are but two of the distinguished panelists that have had government service stints, Dr. Stelson and Dr. Sant.

What is the expected output of this Forum in terms of taking the message to the current administration, to some of the new people on the Hill? We are facing a period right now with budget formulation for 1982 and beyond. We are looking at an 1981 budget rescission time. The President himself has several times claimed that conservation is not the way out of our energy problems.

Where do we go from here as an audience and as a panel with some voice in the Washington scene?

BROOKS: If I might respond to that, you missed one person, namely Jack Gibbons, who has a very key position in the Congress, probably a more key position from the standpoint of influencing policy in this direction than many others.

But the answer is that is not the purpose of this Forum other than to inform those parts of the audience who influence government decisions.

DAVID HACK, Energy Economist, Congressional Research Service, Library of Congress: My question is for Dr. Jorgenson. There seems to be a clear national anxiety that we are probably using too much energy in some sense, and an equally clear national anxiety that we are using too little labor, as shown by our unemployment rate. Yet historically we have subsidized and regulated the price of energy downward, as you

pointed out earlier, and we still are taxing the cost of labor upward through the Social Security tax.

My question would be if we cannot hope to increase the relative factor proportion of labor through draconian increases in energy taxes or prices, is there anything we can do to increase the relative factor proportion of labor by measures that might attempt to get the price of labor right?

JORGENSON: I think you have really put your finger on what I think is the critical policy issue. Once we get the prices right, which is the first priority, the second question is what do we do with the consequences, which will be decreased productivity growth, reduced energy consumption and all the rest.

I think the answer to that is that we have to reduce the burden of taxation on both labor and on capital, and I emphasize that it is both, not just one, and that there are tax measures which would do that. But of course, all taxes ultimately fall on one or the other. So if you are talking about a reduction of taxes on both capital and labor, you are talking about a large tax cut that has to be balanced, as we know from reading the newspapers, by spending cuts. And of course, that is enough for another Forum.

BROOKS: I think we are drawing to a close. Let me try to make just a couple of points. First, I think there is a general consensus that getting the prices right is important, that market forces are a very important element in getting the right balance between conservation and supply in our future energy policy.

The second point is that there are certainly some forms of government intervention that are desirable, but apparently the most desirable ones are those that make the market work better. There is much less unanimity about those that are designed to, say, diddle with the market, as it were.

And I guess really those are the two main messages I personally have gotten out of this discussion. First, is the fact that conservation has a tremendous potential. There is argument as to whether the forecasts of zero growth in total energy consumption, or a modest growth like an average of 1 percent a year, is the most likely or optimal path; but it is somewhere, I think, in that range.