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PROCEEDINGS OF THE FIRST NATIONAL WORKSHOP

on

ENERGY EFFICIENCY EDUCATION THROUGH TECHNOLOGY TRANSFER

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Professor Karen C. Cohen
Massachusetts Institute of Technology
Rm 9-369
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Sponsored By

U. S. Department of Energy Division of Power Systems

in conjunction with

Massachusetts Institute of Technology's Project PROCEED

edited by Karen C. Cohen, Ph. D.

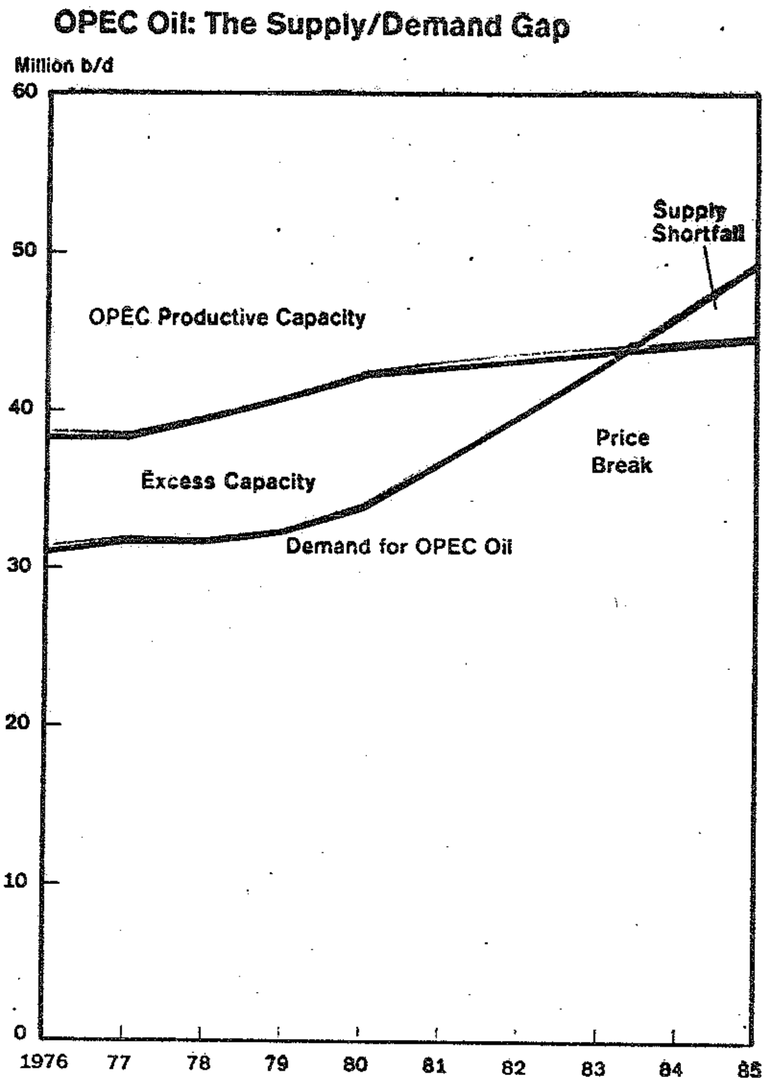
Professor Elias P. Gyftopoulos

ENERGY CONSERVATION EDUCATION: MAJOR CONSIDERATIONS

I would like to make a few remarks about the problems that might be included in a program of education regarding energy conservation.

Let me, before I start, define what I mean by energy conservation, because there are many interpretations. The meaning with which I will be using the words is the achievement of a task with equal or less cost than today, but using less energy. Things that do not satisfy this idea do not belong to the discussion that I will be having.

Now, there is no doubt that the problem of energy is extremely difficult and the discussions that are going on in our Congress reflect the



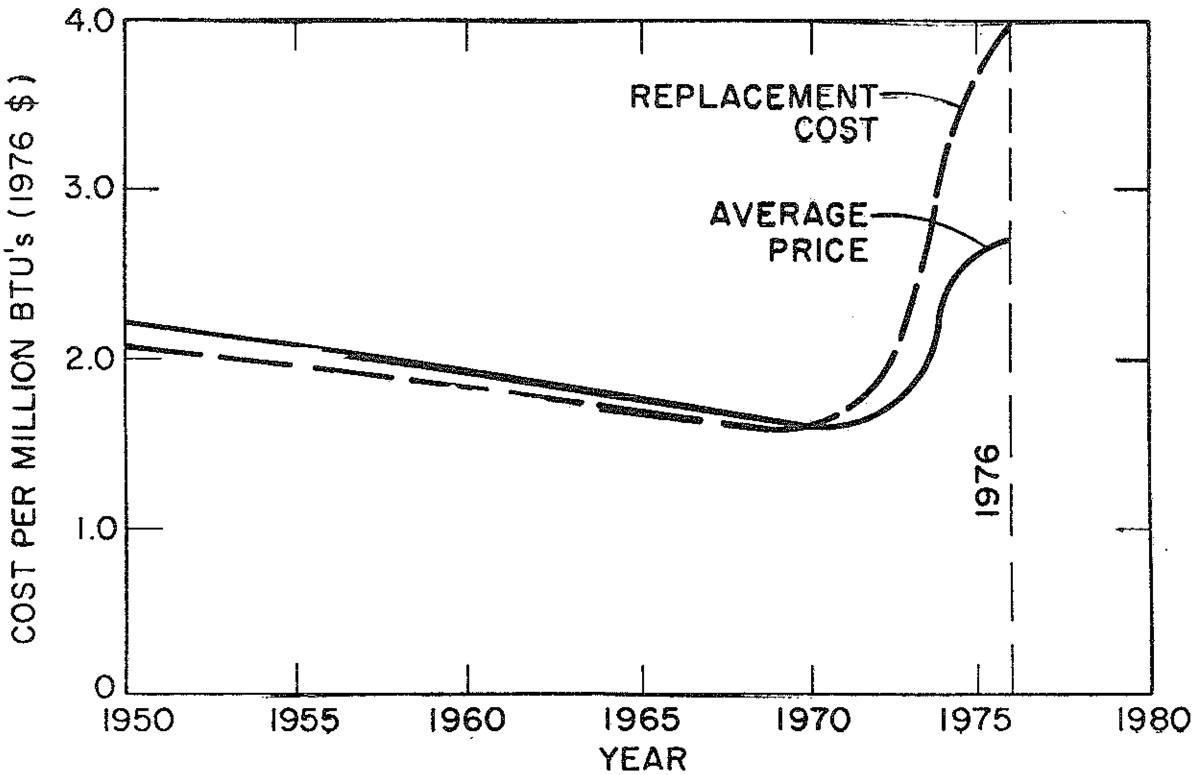
SLIDE 1

fact. It's not simply as Dr. Belding says that Washington works in peculiar ways. It is that the representatives of our people have a very difficult problem. They receive all sorts of conflicting information and they have all sorts of conflicting solutions to offer and, therefore, the need for education at the grass roots is a need indeed.

In a program of education one has to be as inclusive as possible. And you already heard, from Dr. Belding, a synopsis of the problem, especially about the resources. I would like to cast the same problem in a slightly different light than was already referred to.

It's not only so much that we are running out of the resources that we are currently using, especially the liquid and gaseous fuels, but that the rate at which we can provide them in the near future will be less than the demand. This was illustrated in the report that was issued by C.I.A. last April. For example, sometime around 1983 or 1984 oil will be produced at a rate that will be lower than the demand (Slide 1).

Other calculations may differ by one or two years or something like that, but that doesn't change the picture. The Workshop on Alternative Energy Strategies reached the same conclusion. You can use the graph on Slide 1 or a different type of graph, but the message is clear that



Aggregate Cost in Constant Dollars of Industrial Energy from 1950 to 1976; (Weighted According to Usage of Coal, Oil, Gas and Electricity in Industry).

SLIDE 2

there will be a shortage in the production of oil in a very few years from now.

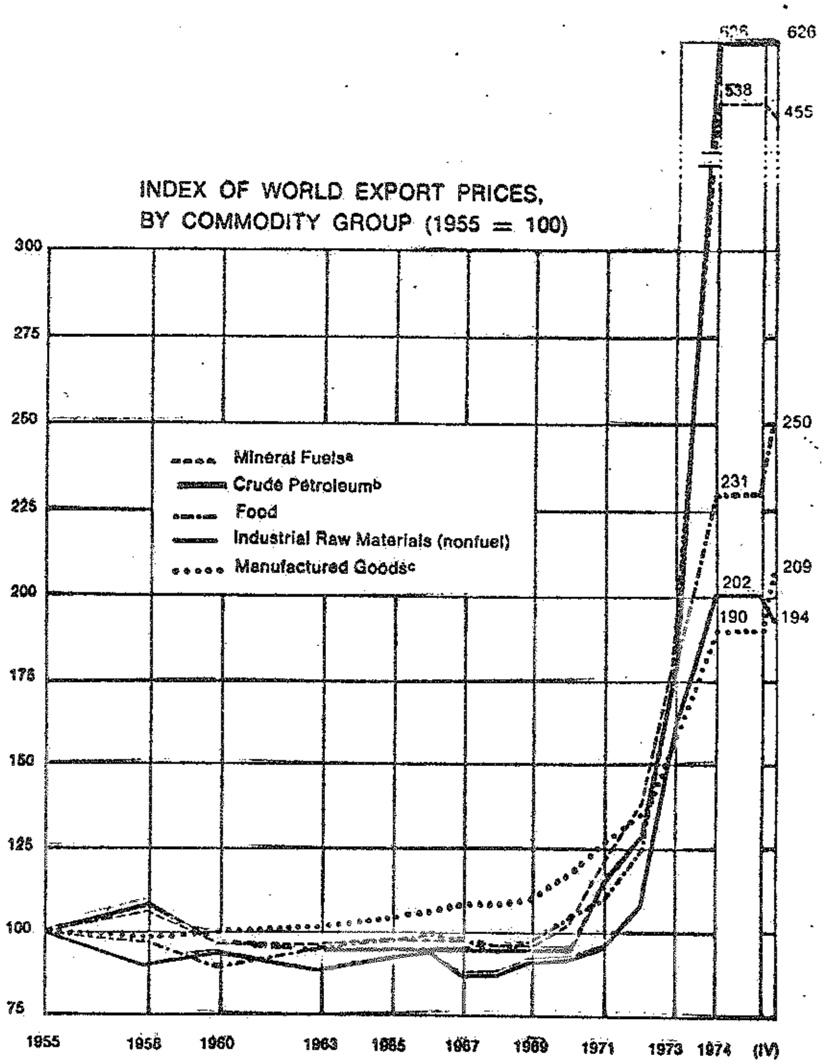
That in itself is not such a bad thing. In the past some energy sources were depleted and had to be replaced and were replaced. But today the situation is different from what we experienced in the past. The problem is that whatever alternatives we have for replacement are much more costly. There is nothing under the sun, including the sun, that will be able to replace the energy that we are currently using at a cost anywhere near or comparable to the cost we have been incurring so far.

This is illustrated by the trend in replacement costs of energy for industry (Slide 2). On this graph the dotted line illustrates the trend in the average replacement cost of energy used for manufacturing in the United States. The averaging is done over the percentages and energy forms used by U.S. manufacturers. We see from this graph that, in real terms, up to about 1970 the replacement cost of energy used in manufacturing was steadily decreasing. It was decreasing by 1.7 percent per year. In about 1970 this replacement cost started for the first time in our history going up, right now it's almost twice as large as it used to be back in 1950. This is much more important a change than the scarcity or the depletion of the fuel sources that we are currently using because that's what's going to affect and is affecting our economic well being.

Energy Form	Percent of Industrial Use [1976]	($ per Million Btu of Delivered Energy)		Ratio of Replacement Cost to Average Price
		Average Price	Replacement Cost	
Coal	18.0	$0.95	$0.95	1.00
Petroleum	29.1	2.32	3.32	1.43
Natural Gas	39.5	1.73	3.00	1.73
Electricity	13.4	7.62	10.55	1.38
Weighted Average	100.0	$2.55	$3.74	1.46

Average Price and Replacement Cost of Energy Used in Industry

TABLE 1



SLIDE 3

The replacement cost that I have used for each form of energy is shown in Table 1. For petroleum I have taken $3.37 per million BTU, for natural gas $3 per million BTU and for electricity $10.50 per million BTU, which is the same as 3.6 cents per kilowatt-hour.

As far as anybody can tell, in the future replacement costs will continue to rise. That to me is a real threat both to our economic well being and to the competitive position of our industry, because we may not be able to afford the energy we need for our activities and, therefore, we may have to stop using it. But to stop using energy would mean no heating in our homes, no jobs, et cetera. I believe that to a certain extent this will happen. The question that people like you that are involved in energy conservation ask is "Can we reduce as much as possible the negative effects of the higher cost of energy by means of energy conservation?" I believe that great opportunities exist for doing so.

Let us first look at some general economic aspects of these opportunities. Slide 3 is taken from a report of the United Nations. It shows the trend in the prices of various goods including energy. It expresses current prices in comparison with prices in 1955. The most important conclusion from this slide is that whereas the price of oil has increased by a factor of six, everything else (food, capital goods, and labor) has increased by a factor of two to three. We see then that an economic opportunity exists for replacing energy by other factors of production, such as labor or capital equipment.

If this slide were to be drawn for statistics available and pertinent to the United States (Statistical Abstracts, Department of Commerce) we would have found the following. In real terms, the cost of labor and the cost of capital equipment in this country over the past twenty years have remained practically constant within a few percentage points. By remembering the data in Slide 2 we conclude that as far as this country is concerned, the opportunity exists for substituting other factors of production for energy so as to achieve the same task with equal or less cost and less energy, namely by becoming more energy efficient.

So that's the economic opportunity. Let me now turn to the technical opportunity. I would like to ask: "Do we have the technology to become more energy efficient?"

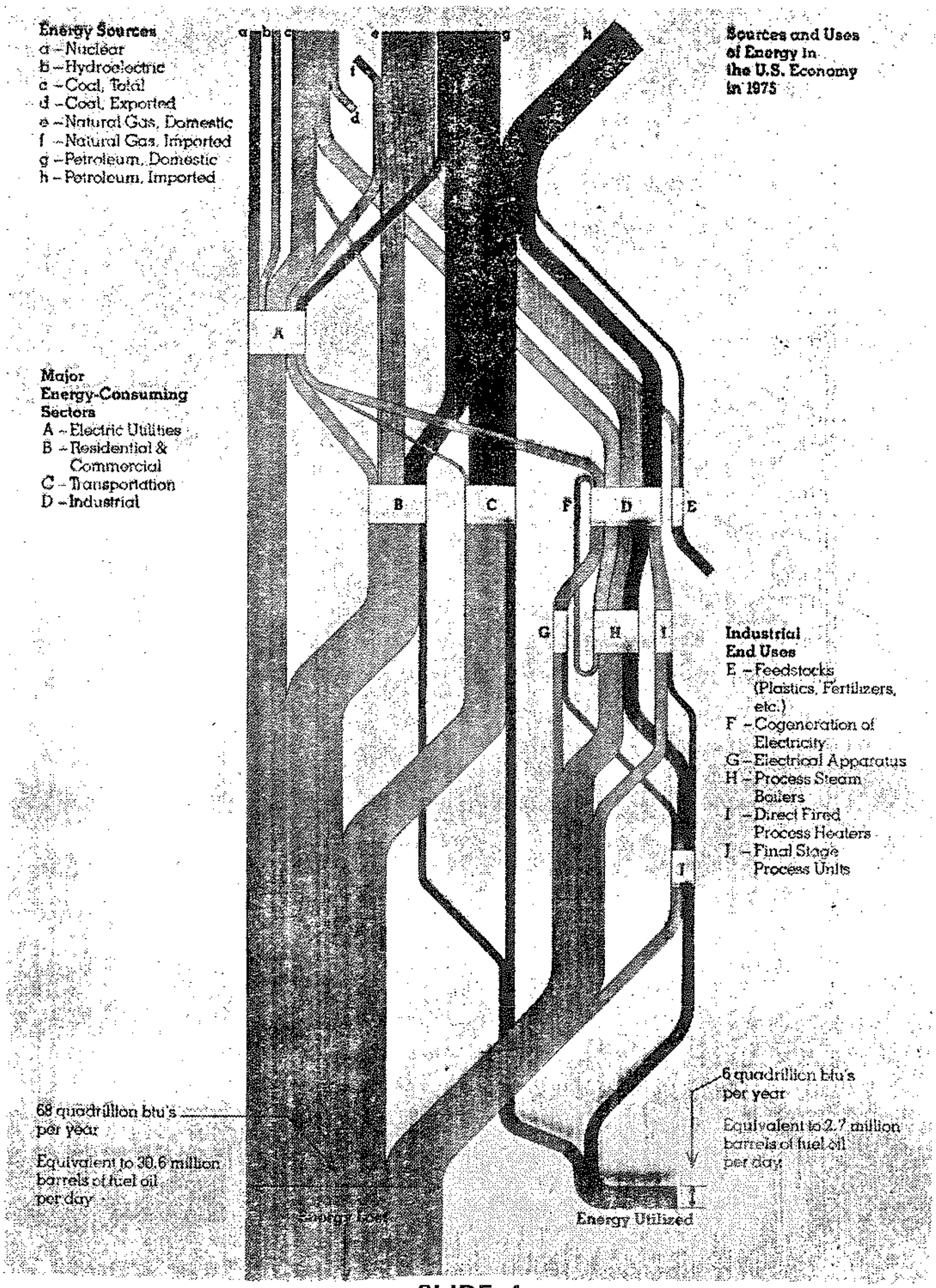
The answer to my question is an unqualified yes.

The lanes in Slide 4 show the flow of thermodynamic availability (not of energy) in the U.S. economy. The figure is different from similar figures that have been presented in many reports and have been published over the last few years. It leads to different conclusions than the conclusions about efficiency in manufacturing which are included in the national energy plan. Let me specifically address this last point. In the national energy plan it is stated that manufacturing in the United States is 75 percent efficient. In Slide 4, if you follow the lane corresponding to manufacturing you will find that, on the basis of availability, efficiency of manufacturing is about 13 percent.

Now, that does not mean necessarily that we are wasteful. As Dr. Belding said earlier, the economics of energy, capital equipment and labor in the past were such that that was the best way of using these factors of production and achieving the goals that we had in our society.

In Germany and Japan, either because of newer equipment or because they had faced higher fuel prices earlier than we did, the corresponding efficiency in manufacturing is about 18 percent instead of 13 percent.

The data in Slide 4 show the various types of fuels that are used in our economy and their availabilities, and the losses of availability in various processes. Here the word availability is used in the sense of thermodynamics. For example, fuels go into the electrical sector to produce electricity. That involves a certain inefficiency. Electricity is generated with an efficiency of about one third. Again, fuels are used for the generation of process steam. That involves certain inefficiencies. The thermodynamic efficiency of process steam raising in manufacturing is about 20 percent. Some of the fuels are used in high and low temperature



SLIDE 4

heating processes, in the chemical industry and other industries. These uses also involve inefficiencies.

Overall for our economy, the amount of availability that we need to carry on all our tasks is about 8 percent of that we consume. In more detail, the thermodynamic (availability) efficiencies of various uses of energy are as follows: residential and commercial space heating 6 percent, water heating 3 percent, air conditioning 5, automobile propulsion 10, steel production 21, oil refining 9, cement making 10, and paper is much less than 1. For the whole economy the efficiency is about 8 percent, and for manufacturing it's about 13 percent.

Now, what are the implications of disseminating this type of analysis of the energy use in our economy?

There are two. First and foremost that we have not reached the limits of efficient use of energy by any stretch of the imagination. There is a very large margin for improvement. To be sure, the realization that there is a large margin does not automatically provide us with the use of that margin. It will take hard work, a lot of money and many years. Nevertheless the margin does imply that working in the direction of improving the efficiency of energy utilization is not like knocking one's head against an immovable wall. I find this implication very challenging and stimulating in addressing problems of energy conservation. The second implication of the correct thermodynamic analysis is that it identifies the uses with the greatest inefficiencies and suggests methods that can yield large improvement.

As an illustration of these points, I will present first some examples of what can be done with existing technology.

Table 2 is a summary of energy savings and costs. Let me comment on the bottom line. This line represents estimates of how much energy we can save with existing technology by the end of the next decade, ten years or so from now. The technology that has been selected has a capital investment cost equal to or less than the capital investment required to produce equivalent amounts of energy from new supplies, energy that would be needed if the saving did not occur.

We estimate that we might save four and a half million barrels of oil per day compared to the demand for energy in manufacturing by 1987. Four point five million barrels of oil per day is about three Alaskan pipelines.

To bring about this energy saving, we must invest a lot of money. Our estimate is that the money that will be required over the next decade is about 125 billion dollars. I don't know if that sounds to you like a lot of money. It sounds like a lot of money to me. But the alternative requires even more money.

On the basis of reported costs for the development of new energy sources of oil, gas, coal and electricity from coal and nuclear power plants, our estimates for capital investment to produce an equivalent amount of energy from new supplies is about 170 billion dollars. So the alternative to energy conservation is much more expensive. We have also made an estimate of the total cost per unit of energy conserved versus that of energy produced from new supplies. We find that with investment in conservation the cost per unit of energy of the mix included in Table 2 would be 2.7 dollars per million BTU, as opposed to about 4.8 dollars per million BTU for new energy supplies. The numbers for both energy saved and energy supplied are high because they include a large fraction of energy in the form of electricity.

ENERGY SAVING TECHNOLOGY	1985 ENERGY SAVINGS IN MILLION BARRELS OF OIL PER DAY	CAPITAL COST		ENERGY TOTAL COST	
		CONSERVATION $ BILLIONS	ENERGY SUPPLY $ BILLIONS	CONSERVATION $10^6 Btu	ENERGY SUPPLY $/10^6 Btu
COGENERATION OF ELECTRICITY WITH					
- Process Steam	0.68	54.0	73.2	8.40	10.6
- High Temperature Processes	0.16	3.5	7.1	4.1	10.6
- Low Temperature Processes	0.18	18.6	24.6	8.9	10.6
ENERGY RECYCLING	1.13	9.5	14.2	0.8	2.7
ELECTRIC MOTORS AND OTHER ELECTRICAL PROCESSES	0.46	10.3	19.7	5.0	10.6
PROCESS MODIFICATIONS					
- Electrical	0.23	<10.0	10.2	7.8	10.6
- Nonelectrical	1.69	<20.0	21.4	1.0	2.7
TOTAL	4.53	<125.9	170.4	2.7	4.8

Summary of Energy Savings and Costs

TABLE 2

Now, the types of things that are used to bring about this energy conservation are known to most of you. They involve cogeneration of process steam or process heat and electricity, recycling of waste energy, and changes in manufacturing processes. We hope that the modules of Project PROCEED will bring out specific examples that illustrate both the technology and the economics of energy conservation, and the large energy and cost savings that can be achieved by combining processes (as in cogeneration) rather than by improving the energy efficiency of individual process components.

Another aspect of the correct use of thermodynamics is related to the long-term prospects for high end-use energy efficiency. Beginning ten years or so from now, suppose that we were able to improve the energy efficiency of our economy by one percentage point every two and a half years. Then, we could sustain an uninterrupted growth in real G.N.P. of three percent per year for the next three decades, and still consume no more energy than we do today. Even then, our overall end-use efficiency would be only twenty percent, about equal to that of the steelmaking process today.

The improvements in energy end-use efficiency suggested here are, in fact, not all that remarkable. They are still less than that accomplished over a comparable number of decades in improving the efficiency of electricity generation. This, of course, was the result of enormous and continuing commitments of resources to technological innovation--the same presciption that must be used for research and development of entirely new manufacturing processes.

Despite the economic and technical opportunities, energy conservation faces difficulties arising from politics and realities of everyday life. We hope that some of the modules of Project PROCEED will address these difficulties and discuss ways to overcome them.

Let me comment briefly on a couple of these difficulties. A utility, which is a regulated monopoly, is allowed about ten percent return on its investments (ROI). On the other hand, a manufacturer, who operates in the competitive market, usually requires a return on investment of about fifteen percent. So, when an investment in new electricty supply is contemplated, it is evaluated on the basis of about ten percent ROI. But, when an investment for energy conservation involving electricity is contemplated, it is evaluated at least at an ROI of about fifteen percent, though the conservation investment would accomplish the same result.

Actually, the gap between the two ROIs is even larger. Because of limited capital available to a manufacturer, investments are given priorities. First, the manufacturer must do things required by the Government--such as invest in anti-pollution controls. Second, he must secure his competitive position in the market by investing in expansion or improved production capacity. Then, he considers becoming an energy supplier by investing in energy conservation. Because the third type of investment is a relatively new activity and, therefore, an activity that is perceived as risky, it is given low priority or a high hurdle rate. The payback period required of conservation investments is usually two years or less. Such periods translate into ROIs of thirty percent or more.

Although this performance in our economy is understandable, it seems to me that an educational program in energy conservation should emphasize the need for a harder look at and change of investment priorities. Without a change, the unavoidable transition from the era of abundant and inexpensive energy to the era of limited and expensive energy might be more costly and painful than it need be.

I will stop here and be happy to answer questions. Thank you for your attention.

DISCUSSION

MR. FRIEDMAN: Friedman, Consultant at D.O.E.

I remember reading a newspaper item that indicated that capital was plentiful, that banks had a lot of money but nobody to lend it to, and here we hear about a capital shortage. Is there a way of explaining that?

PROFESSOR GYFTOPOULOS: Yes, there is. It's a little involved but I will try.

The story is quite involved. You see, our industry operates with a certain debt to equity ratio. There is a certain fraction of money that they borrow and another fraction of money that they get from the stock market. This ratio has been established from past practices during which manufacturers were not in the energy supply business. At that time, whenever they wanted some energy they would go and buy it from the energy suppliers.

Now, because it makes sense both for them and for the nation, we are asking manufacturers to make investments beyond the regular ones and, in essensce, we are after a transfer of capital from the energy supply sector to the energy user sector. How will that come about? Suppose a manufacturer were to borrow money for energy conservation. That would increase his debt to equity ratio and, therefore, in the eyes of the banking community, he would appear as being on shaky financial grounds. As a result, bankers would increase the interest rate because a large debt to equity ratio implies a riskier company.

One might suggest that the manufacturer goes to the stock market. Money in the stock market is much more expensive than money from a bank. As you very well know on the average the price to earnings ratio for our industry right now is about seven. This ratio translates into a return on investment before taxes of 30 percent or higher. So that makes it difficult for a manufacturer to raise capital for energy conservation. It is a kind of vicious circle that results in an inconsistency. On one hand, you are absolutely right, that banks say they do have money but they are not asked for it and, on the other hand, manufacturers hesitate to ask for money because of the reasons that I explained.

In addition, there is another reason and perhaps it is an overriding one. It has to do with the great uncertainty that exists in our society about the whole energy problem and you can see that by reading the newspapers every day. Someone says, "Oh, there is no energy problem. So and so in Washington is manufacturing the problem. Wait for a little while, boost up prices, and the problem will disappear, and the economy will grow." Then they say, "No, no, stop what you are doing completely, reduce energy consumption and everything will be fine. Just take the soft path." And you can imagine why people, like you and me, are confused and uncertain. And when there is uncertainty about a new type of activity, the activity doesn't take place.

MR. MASSEY: Bob Massey, with the Department of Energy. Elias, when a company goes into an energy conservation project and compares that with other alternative uses of their capital, do you think they are taking into account the risk factors on energy conservation?

PROFESSOR GYFTOPOULOS: Yes. And that is translated into requiring a hurdle rate higher than that for regular investments.

Let me clarify that a little bit because I know that there is controversy about the statement that I just made, and no agreement. I would like to explain how I reached the conclusion about the higher hurdle rate.

In many conferences that I have attended I have heard representatives of manufacturers state that they would like to make investments in energy conservation, but these investments are costly. They further state that many investments have been made for which the payback is less than two years whereas those that remain require more than two years to pay back and, therefore, are given low priority. That's one source of my information.

Another source of information are the comments made by manufacturers on the voluntary targets proposed by the Department of Commerce and FEA. By reading the Federal Register I noticed that practically all manufacturers had commented that they want the payback period for energy to be less than two years.

Now, in fairness I must say that in other conferences, including the recent one that I attended in Tucson, Arizona, a large number of representatives of manufacturers stated that energy conservation investments are treated no differently than regular investments.

MR. LIBBY: Quint Libby from EPRI. I was just going to make the same sort of comment that Elias just made that the tendency to adjust the hurdle factor for energy conservation investments either up or down is not simple and in some cases the hurdle rate is less and in some cases higher than for other investments. It's based almost entirely on risk. I think Elias just said that it's not whether it's energy conservation or not, but rather how risky it is that determines what the hurdle rate is.

PROFESSOR GYFTOPOULOS: I would like to comment on that because it is relevant to what we are trying to do with Project PROCEED if we are successful. I understand that an investor or a manager should be very careful in his investments and, if the proposition is risky, to ask that it pay off faster so as to reduce, in some sense, the risk. That's perfectly understandable and that's how our economy works. However, if we are successful, and I hope we will be, in our efforts to conserve energy by using it more efficiently, we should recognize that for the next decade we are not talking about things that are far out, never tried before, and are just in the prototype stage. We are talking about technology that has been very well known and has been tried for many decades.

The reason why it may not be practiced in a particular location or in a particular manufacturing process today is because up to now or up to a few years ago it didn't pay to do so. It didn't pay to save natural gas when you could buy it at 20 cents per million BTU.

Why should one spend a dollar or two per million BTU to save 20 cents? It would have been socially and economically ridiculous to do so. But now things have changed. For the same technology, for the same procedure, the economics have changed. It is $3.00, so to speak, per million BTU of natural gas or whatever the price is versus one to one and a half for the equipment that will save it. Therefore, whereas in the past this technology didn't pay to be used, now it does pay to be used.

MR. MAXWELL: Maxwell from Charles County Community College

I understand you to say in summary that the three things you are advocating are, prevailing upon the investment community to change their thinking or habits on debt to equity ratio, for the manufacturers and also the utilities to change their investment in energy conservation over a long period of time, and then clearing up the confusion that exists today, as you pointed out, in the current newspapers.

PROFESSOR GYFTOPOULOS: Not quite. I am sorry. The three things that you mentioned are parts of the difficulty. I prefer that we have a good understanding of the problem. I believe that if we have a good understanding of the problem our society will respond.

For example, I believe that: (1) if manufacturers are really convinced that there will be a scarcity of oil sometime in the next decade, and that whatever alternatives they have for substitution would be much more expensive than what they pay today; and (2) if they fully recognized that there is a technological opportunity for becoming more efficient and that if they do it faster than their competitors they might reduce their costs and capture a larger fraction of the market, then they will respond to the job much faster and much more efficiently than if someone, whether from academia or from Washington, were to impose that type of development through strict rules and changes in the free market system of our society.

So that's why we are talking here about education and dissemination of information and hopefully good information rather than political decisions.

MR. MAXWELL: Thank you.

MR. FRIEDMAN: Friedman, again, Consultant, Department of Energy. Isn't industry accepting some financial help from the Government and aren't they waiting for that?

PROFESSOR GYFTOPOULOS: Yes, they are and some of that is necessary because of several factors that require that kind of help. Time does not permit me to elaborate on these factors. But as I understand it from discussions that I have held over several years, the greatest thing that manufacturers are expecting from Congress is to settle, to come up with a decision that they can believe will stick for a few years so that they know what they have to do. Think of it yourself. For example, right now Congress is debating an additional tax credit for investments in conservation of ten, twenty, or whatever percent. If you were in the process of buying a piece of equipment for energy conservation and you knew that there was some discussion in Congress that would make you save ten or twenty percent would you go ahead and order the equipment before the issue was settled in Congress?

So, my perception of what industry is expecting, in addition to financial help, is some certainty and some decision one way or the other. I believe that, once some energy plan is voted through Congress which has the appearance of being the plan for a number of years, we will see a faster rate of movement in the direction of greater efficiency than we are currently experiencing.

PROFESSOR TRIBUS: Elias has made a point worth expanding. Sometimes I think that the schools of engineering and the schools of business have combined inadvertently to destroy our technical competence and not to enhance it and the culprit, in my mind, is the return on investment calculation. When people get together to make a resource allocation decision, although they don't usually say it this way, they are involved in a three-way trade-off among three human characteristics: greed, impatience and fear.

By greed, I mean that for what they give they want as much as they can get. And by impatience, I mean they want it now rather than later. And by fear, I mean they want it without risk.

Unfortunately, the return on investment calculation only takes into account two of those, greed and impatience, it does not consider fear or risk. It is irrational to require a higher rate of return on investment, that is to be impatient, as a compensation for one's fear, because a higher rate of return requirement discounts future risks equally with future opportunities. It is a technique for painting yourself into the corner in the future.

What Elias Gyftopoulos is telling us is that he says to people, "Look, when you make this ROI calculation don't forget that it leaves out of account the fact you may not have a plant. You may not have fuel. You are not taking into account your risk considerations." And I say that when you try to take risk into account by raising the return on investment requirement, the so-called hurdle, you are being irrational. You are not taking into account risk at all. You may become hung in your risks.

When we teach people what to do about energy conservation, we must recognize that not only must we teach things that are known, but not known to everyone, but also things that are widespread but aren't true. We will have a challenge which goes beyond ordinary education, it is a challenge to make people understand that in doing what they have been taught to do they are behaving irrationally and they must substitute new ideas for old ones that are no longer appropriate.