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INDUSTRIAL ENERGY CONSERVATION

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OF THE

JOINT ECONOMIC COMMITTEE

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THURSDAY, JULY 28, 1977

CONGRESS OF THE UNITED STATES,
SUBCOMMITTEE ON ENERGY
OF THE JOINT ECONOMIC COMMITTEE,
Washington, D.C.

The subcommittee met, pursuant to notice, at 9:35 a.m., in room S-126, the Capitol Building, Hon. Edward M. Kennedy (chairman of the subcommittee) presiding.

Present: Senator Kennedy.

Also present: Jerry Brady, subcommittee professional staff member; William Morgan, professional staff member; Mark Borchelt, administrative assistant; and Charles H. Bradford, Stephen J. Entin, and Mark R. Policinski, minority professional staff members.

OPENING STATEMENT OF SENATOR KENNEDY, CHAIRMAN

Senator KENNEDY. We will come to order.

Our purpose today is to explore what might be called the last frontier of energy conservation, a vast, unexplored area filled with promise and potential.

A few simple facts indicate the size of this frontier. Fewer than 9,000 boilers at just 3,000 plants plus 6,000 industrial furnaces account for 16 percent of all the energy consumed in the United States. When you take the fact that about 45 percent of energy utilization is in industry, and about 85 percent of that comes from furnaces and boilers, you realize the enormous size and importance of this area of energy utilization. When we stop to think about it, industrial energy use may present the most attractive opportunity available to achieve energy savings.

We have already taken steps to bring maximum efficiency to the 120 million cars and trucks driven in the United States. We have taken steps to make the 45 million most common appliances energy efficient. And we have begun to set standards for the efficient use of energy in America's 102 million dwellings with various standards and requirements. In other words, we have already taken on the most difficult tasks which affect millions of people several times over. Incredibly, little has been said about the efficiency of just 9,000 boilers and 6,000 furnaces, even though they account for 16 percent of energy consumed.

The National Energy Act attempts to get at these energy users indirectly, first, by increasing the cost of fuel and, second, by forced conservation from oil and gas to coal, achieved with tax incentives. But these two Government policies do not insure energy efficiency. It can be argued persuasively that coal will actually be less efficient than oil or gas—the virtue of coal being that it is in adequate supply in the United States.

Of course, that does not affect the environmental kinds of questions which have been raised from the extraordinary expansion of the utilization of coal.

The question we will discuss today is whether the Government should attempt to do more to advance conservation in industry. Is it possible to set efficiency standards for boilers, furnaces, and motors in the same manner which has now been done for automobiles, appliances, and residences? Are there simple, universal standards of efficiency available, or is the field too complicated? Would standards and efficiency targets encourage or retard innovation?

Industrial energy efficiency has attracted the interest of a number of my colleagues in the Senate, particularly Senators Metzenbaum and Hart. Senator Metzenbaum has proposed performance standards and labeling for motors used in industry, thus insuring that manufacturers build energy efficient products. Senator Hart proposes amendments which would accelerate the production of electricity from industrial waste heat through cogeneration and he will be here today to testify about his bill.

The Industrial Energy Conservation Act, which I have introduced, is compatible with both of these bills. My bill focuses not on the efficiency of boilers, furnaces, and motors, as such, but on the total efficiency of the processes and functions in which this equipment is used.

A furnace may be efficient but it may be using a high quality, high temperature fuel to do work which requires only low temperature heat, it is this total process which must be addressed. Senator Metzenbaum's approach would insure that motors are efficient, Senator Hart's bill would increase the incentives for cogeneration which will have to be utilized if industry is to achieve any improved process efficiency eventually required under my bill.

Our hearing will begin with a panel consisting of three men who have been pioneer thinkers in this area, George Hatsopoulos, president of the Thermo Electron Corp. in Waltham, Mass.; Roger Sant, a consultant to industry and former Assistant Administrator of the FEA; and Charles Berg, an industrial engineer and former Chief Engineer of the Federal Power Commission.

But first, we welcome Senator Gary Hart from the State of Colorado.

Please proceed, Senator.

STATEMENT OF HON. GARY HART, A U.S. SENATOR FROM THE STATE OF COLORADO

Senator HART. Thank you, Mr. Chairman. Thank you for the opportunity to speak today on the subject of energy conservation in industry.

At the outset I wish to congratulate you, Mr. Chairman, on your effort to reduce energy waste in industrial processes. I stand with you in pursuit of much needed Federal legislation to reach the goals of minimizing energy wasted by industry.

I believe the need to reduce industrial energy waste is extremely important to our national energy picture. The daily amount of waste heat from industrial processes is roughly equivalent to 6 million barrels of oil, according to a study by Mechanical Technology, Inc. This waste heat is roughly three-fourths of our daily amount of imported oil. It is clear that this amount of energy is well worth saving. Unfortunately, however, the Government is doing very little to directly encourage conservation of industrial energy usage.

Perhaps it is reasonable that in the past the Federal Government has not established standards for industrial processes because of the difficulty of defining and comparing the energy efficiency in different firms and different industries. However, there are new processes and procedures that will allow the simple calculation of industrial process efficiency. Therefore, I strongly urge that such standards be developed and that we consider whether they should ultimately be mandatory, if industry does not take economically practical measures with reasonable speed to reduce energy waste.

The proposal that you are offering, Mr. Chairman, will establish energy conservation goals for the major energy users in the major energy using industries. Furthermore, addressing only three basic processes, raising steam, heating materials, and using electromotive power will cover most energy wastage by industry. The proposed Department of Energy will monitor the progress of industry to judge whether industry's efforts to install economically practical energy conservation equipment is proceeding well by 1980. If conservation is not proceeding quickly, then I would agree with the Senator that industry should be given additional incentives to speed up. At a bare minimum, I would consider a penalty for energy waste equal to the costs to other firms of providing a substitute for that energy wasted.

The Chairman's proposal will allow the Government to use newly developed techniques to judge whether energy is used wastefully. In the past, notions of energy efficiency were applied only to particular energy using devices, or to groups of devices in an isolated process. An attempt to reduce energy waste was then focused on reducing the amount of energy put into the process or increasing the output from the existing process.

However, new techniques are now developed to judge whether any additional work can be done with energy already used in a given process. To do additional work, heat which is developed for one process can be applied between stages, or after the process is completed, to another process. That additional process is work which is performed relatively free from an energy point of view.

As I understand your proposal, Mr. Chairman, you would establish standards for process efficiency. A firm could use a fuel in the most efficient engine in one process, yet rank poorly in the quality of energy usage. This would be due to a large amount of waste heat released into the atmosphere or into water as a byproduct. The process would rank poorly because the heat was in a form which could be used to fuel yet another process.

If the firm connected the heat released from the first process to a second process, such as, for example, generating electricity or heating a greenhouse, the heat then given off as waste would be in a form less able to perform further useful work. In this case the combined processes would compare favorably on the quality of energy usage, because a large portion of the potential work which could be done with the fuel was in fact employed.

It is clear that the use of process efficiency guidelines will encourage energy conservation far more than guidelines which would focus on a useage of energy in isolation. The process efficiency guidelines could cause firms to link together, essentially to share a common energy source. Alternatively, the guidelines could allow firms to expand in new and profitable directions.

I am particularly enthusiastic about your proposal for energy conservation standards for industrial processes because this relates so well to two pieces of legislation I have introduced. S. 1363, Cogeneration and Waste Heat Utilization Act, is designed to encourage the use of waste heat from one industrial process in yet another process, or to generate electricity. As I have already indicated, S. 1363 contains major provisions to provide economic incentives for the purchase of cogeneration equipment. It will establish new regulatory procedures for public utilities to replace the current ones which tend to hinder cogeneration.

In summary, the central thrust of S. 1363, Mr. Chairman, will be to establish a favorable regulatory climate and to increase the economic practicality of cogeneration investments. I view this bill as pulling energy conservation. I think that S. 1363 is extremely compatible with that proposed by the chairman, which pushes energy conservation.

The industrial energy conservation bill of the chairman establishes a Federal standard by which any firm can judge the energy efficiency of its major energy-using processes. The standard will represent a target for energy efficiency which is achievable by economically practical investments. A manager, who sees that his firm rates below the Government's energy efficiency targets, is also seeing a place where his firm can make a profitable investment.

In some cases, the manager may decide to invest in devices which reduce the energy used in making the firm's usual products. In other cases, the manager may decide to cogenerate—either to use wasted heat to produce other types of products, or to generate electricity which may be sold to the local power company. If we see that the managers of firms continue to ignore economically practical investments in energy conservation, additional incentives such as the noncompliance penalty may be necessary. The chairman's proposal, thus, can be viewed as pushing energy conservation.

In summary, my bill, S. 1363, breaks down traditional barriers to a major form of waste heat reduction. Mr. Kennedy's bill would monitor the progress of firms in effecting waste heat reduction and could eventually provide disincentives for unreasonable delay.

I have introduced another bill, S. 800, "Conservation and Solar Energy—Federal Buildings Act of 1977," which is designed to promote energy conservation in Federal buildings. Because the Government is our Nation's largest energy consumer, I feel it necessary and practical to set standards for energy efficiency in Federal buildings. This bill provides that Federal buildings over a certain size install all economically practical energy-saving techniques by 1990. This bill, in substantial part, was just adopted by the House Ad Hoc Energy Committee and the Senate Committee on Energy and Natural Resources. I would hope that we could have similar goals for the major industrial energy users.

In closing, I wish to reiterate that I strongly support Mr. Kennedy's effort to introduce process efficiency standards for energy-intensive industries.

I thank you for the opportunity to appear here this morning.

Senator KENNEDY. I thank you, Senator Hart. You have been a real leader in the Senate in this area. As you mentioned, I think these concepts are complementary, and the technology which has been developed to a really significant extent by researchers in my State, and the effectiveness of the evaluation of the utilizatiou of energy in these areas which have boilers and furnaces, and the establishment of standards can be extremely important.

You move toward tax credits as well as regulatory reforms to encourage industry. Do you think it is valuable to begin to set some targets as well for achievement in these areas?

Senator HART. Very definitely, and I think this is one of the advantages which you are offering, that it would enable the Government to establish energy efficiency standards against which industry and specific plants within those industries could judge the effectiveness of their operations.

That, as much as anything else, I think, would lead to the adoption of the kind of cogeneration type of techniques which the legislation which I have introduced proposes, and in that way I think the two bills are extremely complementary.

Senator KENNEDY. You are basically cautious, though, about what means should be enforced in reaching those targets.

Senator HART. That is right.

Senator KENNEDY. At least until we have more information and we see how the process works.

Senator HART. The Senator is exactly correct. There are enormous potential savings from cogeneration and the recapture of industrial waste heat. The technical experts say that a great deal of the waste heat can be recaptured, judging from the European experiences. They believe in the next 4 to 7 years we will have advanced the technology so exponentially that the potential for recapture is even much greater.

So, what I would do is move expeditiously but not dramatically so that we can take advantage of that advanced technology that we believe will be taking place, particularly if legislation of the sort you are proposing comes into being and gives incentives to plants and industry to figure out how much energy they are losing.

We would establish areas of studies to be done reasonably quickly. We would also encourage the advanced technology, which is on the verge of commercialization now. And third, we would give the incentives to industries and grants to State regulatory commissions to begin to establish the rate structures necessary to implement cogeneration.

Senator KENNEDY. You are satisfied, though, that in terms of the existing technology, that we begin to establish standards within industries?

Senator HART. Absolutely.

Senator KENNEDY. As you mentioned, there is a technology explosion now, and the movement is one which is new, and I think it has to be taken advantage of.

Senator HART. That is right. I agree completely. It is not as if we do not know how to do this. The Europeans are doing this. The Germans and others are recapturing enormous amounts of wasted energy. If we focus through your legislation and mine on as few as the top 20 industries, the savings would just be enormous, and it would have an impact on foreign policy, OPEC, and the rest.

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Senator KENNEDY. We will see later in the course of the morning that the savings in just the top 10 industries is dramatic in terms of what can be achieved here.

Could you tell us where the legislation stands now? You are very much involved in the marking up of the legislation.

Senator HART. I appeared before the Senate Energy Committee yesterday to speak on cogeneration. We are hopeful are that they will adopt the basic principles of my cogeneration bill in the legislation they are marking up now.

It is my understanding that they are taking testimony as the pre-recess period winds down, and that they will be in markup in mid-September. I am hopeful that the members of that committee will adopt the legislation I propose, and I would encourage the support of this subcommittee and its members for that.

Senator KENNEDY. Very good. Thanks very much.

Senator HART. Thank you.

Senator KENNEDY. Coming up in our next group of witnesses are Charles Berg of Buckfield, Maine, industrial engineer and former Chief Engineer of the Federal Power Commission; George N. Hatsopoulos, president, Thermo Electron Corp., Waltham, Mass.; and Roger Sant, consultant and former Assistant Administrator of FEA for Conservation, Washington, D.C.

We give an especially warm welcome to George N. Hatsopoulos a longtime personal friend, and Roger W. Sant, of course, who is here before the subcommittee frequently. We always value his testimony both here and otherwise. Your prepared statements will be included in the hearing record, gentlemen.

Mr. Sant.

STATEMENT OF ROGER W. SANT, CONSULTANT AND FORMER ASSISTANT ADMINISTRATOR FOR CONSERVATION, FEDERAL ENERGY ADMINISTRATION

Mr. SANT. Thank you, Senator. I am happy to be here to testify with respect to your efforts to take additional steps to make improvements in this area. It has been clear to many of us for some time that there is major potential for saving energy in industry by modifying equipment used in industrial processes.

George Hatsopoulos, three other colleagues, and I completed a study—if you will refer to Mr. Hatsopoulos' prepared statement—in which we determined that the potential for saving energy in industry is approximately 4.5 million barrels per day of oil equivalent by 1985. This is about 25 percent of the projected industrial energy use at that time—but even more striking to me—it is roughly equal to the vast amount of petroleum consumed by all automobiles in the current year.

Other analyses have confirmed that the savings potential is about this same order of magnitude. But to date it is difficult to demonstrate that industry is making progress at a rate necessary to achieve those numbers. Progress has clearly been made, however, and I do not wish to downplay the efforts of many outstanding companies that have used a great deal of creativity and dedication to find ways of saving money through saving energy. But the significant savings are yet to come and will only occur as a result of investing large amounts of capital that for several reasons are not being invested today. We found, for instance that industry would have to invest $125 billion to save the 4.5 million barrels we defined. But that $125 billion would replace an investment of $185 billion for an equivalent amount of new energy.

It is apparent that one of the major reasons efficiency investments are not taking place at a fast pace is that replacement costs of energy are currently being rolled into the average prices industrial users are paying.

The result is that the prices for industrial fuel are approximately one-third or more below the replacement costs now being incurred by energy producers. The cost of Alaskan gas for instance will likely be $4 per thousand cubic feet, while the average price being paid by industry today is $1.75. The price of industrial electricity is approximately 2.6 cents per kilowatt-hour while the cost of electricity from a new powerplant is about 3.6 cent per kilowatt-hour; over 40 percent higher. These examples illustrate that substantial waste is occurring just because industrial users are making decisions about how much energy to use at prices well below the price used to decide how much to produce.

The second barrier is that generally speaking, the industrial energy user must receive a 15-percent or better return on his investment in order to pay for his capital and/or keep up his growth rate. On the other hand, a regulated utility must only achieve a 10-percent rate of return on a new powerplant in order to pay for its capital costs because there is no competition. Normal market forces cause this result, but it may not be in the Nation's interest to, in effect, provide a subsidy for new powerplants. Incentives to industry or taxing of electricity are clearly called for to achieve a condition of economic equivalence.

As a result of these two economic barriers, large amounts of money are being invested in new energy supplies when it would be cheaper to invest in conserving energy at the industry level. This economic waste has been addressed by the President, and although I am not completely satisfied with those proposals, I am going to bypass discussion of those complex measures in order to get on to the more noneconomic barriers to saving industrial energy.

If one assumes that the economic problems mentioned previously are dealt with in some satisfactory way, there still remains a number of nonprice barriers that stand in the way of industrial energy users taking full advantage of the technical and economic potential to conserve. For instance:

Most large energy users perceive a fairly high risk in using waste process steam or waste heat to generate electricity. This perception exists even though the approach has been used, as Senator Hart has just testified, for years in both Europe and to a lesser degree the United States, but very few companies want to be the first one.

There is still insufficient information getting to plant managers and industrial engineers for them to make all of the appropriate modifications in their existing plants that are practical.

Industrial energy is often a small percentage of total cost and therfore saving energy does not receive the same attention that producing energy does from a producer.

And finally, there are man regulatory conditions that make it difficult to internally generate electricity, for instance, because the rules have been built up around central power stations. It is these kinds of barriers that I believe can be ably addressed by the Congress; supplementing rather than replacing some of the President's proposals.

For instance, each company that is now submitting energy efficency information under the FEA mandatory reporting system could be required to provide absolute efficiency calculations on operations for raising steam and heating materials since these two functions account for 62 percent of all industrial energy. By absolute efficiency, I mean to fully account for the quality as well as the quantity of energy used. And by quality, I mean to take into account something that all of us intuitively understand, that the quality of high temperature heat is higher than the quality of low temperature heat. I believe Mr. Hatsopoulos has clearly illustrated the practicability of making that measurement.

Based on the data that is collected, the Administrator of FEA might subsequently propose voluntary goals to be achieved by all of industry in those two functional categories. Those generic or cross-cutting goals should be set taking into full account the econonmic and technical characteristics of the various options that are now available for increasing industrial energy efficiency in those two functions. Perhaps at some time several years later the Administrator might make those standards mandatory if he could clearly establish the necessity of that step.

In addition, testing procedures could be established for all major items of industrial equipment and rules prescribed for labeling that equipment by the manufactures.

I believe that the sequence outlined is appropriate to our current knowledge. We clearly do not have enough information to mandate industrial efficiency standards today. We may never have sufficient information to do that but data could be gathered and goals could be established such that the further step of making those standards mandatory could be continuously evaluated. While I am confident that the absolute efficiency of each of these three major functions can be measured consistently, I am not confident that we are aware of all the exceptions that we should provide in order for those standards to become mandatory. Perhaps for another reason—that is, that progress is being made at such a satisfactory level—we might not ever have to to impose the mandatory feature.

I believe that even without the mandatory step, the potential savings from these actions would be in the range of 2 to 3 million barrels of oil equivalent per day by 1985—twice the throughput of the Alaskan pipeline.

In summary, Mr. Chairman, I believe that there is an opportunity to make a significant and needed improvement in the President's energy conservation package and place appropriate attention on industrial energy efficiency really for the first time. This approach should not be used as a substitute for the necessary changes in industrial energy prices that must indeed take place, or as a replacement for investment incentives, but rather to supplement these measures by encouraging faster adoption of the many economic and technical energy savings possibilities that currently exist. If this result is allowed to occur, the United States will not only find itself less dependent on foreign oil, but considerably more competitive in the world marketplace for goods that are produced with a high energy content. By bringing about the changes that are now justifiable in our industrial capital stock, we will be able to substantially reduce the upward pressure on energy prices.

Thank you very much, Mr. Chairman.

Senator KENNEDY. Thank you.

Mr. Hatsopoulos.

STATEMENT OF GEORGE N. HATSOPOULOS, PRESIDENT, THERMO ELECTRON CORP., WALTHAM, MASS.

Mr. HATSOPOULOS. Mr. Chairman, it is a privilege for me to be testifying on what I consider the most important aspect of energy conservation in this country; namely, that which deals with industrial use of energy.

In your opening remarks, you have stated that the opportunity for conservation in industry is enormous. In fact, it is the largest opportunity of all those that have been considered or proposed.

I think it would be appropriate to consider why has this enormous opportunity escaped the attention of people who are very much concerned with conservation, like the present administration.

Having followed the thinking of a lot of people in the Government who are committed to conservation, I find that what has impeded their taking a stronger stand on energy conservation in industry is the complexity of industry, the apparent complexity of the industrial processes.

It all goes back to the fact that until very recently there has not been a universal measure of efficiency that could encompass a very large fraction of the energy that is used in industry. Companies have been reporting to FEA on energy use, but their reports are based on the energy used per unit of product put out and it is impossible to relate a figure such as energy per ton of paper to a figure of energy per ton of steel, for instance. Even for one product, such as paper, the energy used per ton varies with the type of paper, one value for tissue paper and another for kraft paper. Faced with the enormity of numbers of articles produced by industry, until recently people considered it impossible to get hold of a measure that can compare or can give us an understanding of, first, how the various processes compare with with each other, and second, how they compare to what is the best that we could expect to achieve on an ideal basis.

In effect, it is the fact that we have not had a yardstick such as miles per gallon that we have for automobiles, that has impeded progress in this direction.

I would like to concentrate my remarks this morning toward the observation that such an efficiency measure has now been proposed, and that such a measure, if considered by Congress and the administration, could really be the starting of a new period in which energy conservation now can be handled in industry as well as it is handled now in automobiles.

I think this is basically the key to the discrepancy that you, yourself, mentioned in your opening remarks. We handled the automobiles, why can't we handle industry?

Now, as you very well pointed out, the majority of industrial use of energy is for producing steam, for processing purposes, and for producing heat. These two functions essentially cut across all of industry. They are used in petrochemicals as well as in paper. They are used in steel and in many other of the metallurgical processes. They encompass, right now, about 62 percent of all the industrial energy use.

Now, the proposed yardstick that I mentioned, which, by the way, is a new kind of development, essentially can measure the effectiveness of use in these two uses of energy in a meaningful way because, as Mr. Sant pointed out, it takes into account both quality and quantity.

Now, I would like to spend just a few minutes explaining these concepts. Most of the time when we talk about energy we talk about one measure; namely, the quantity of energy in Btu's. Very rarely has it been mentioned that energy possesses another characteristic; namely, the quality of energy. This characteristic is really representative of a fraction of the quantity of energy we have in hand or we need to use, which can be essentially converted into work. The fraction varies from very small all the way to unity, and it is the product of that fractional quality and the quantity that is of great physical importance.

The reason for that basically is that you can convert, you can exchange quantity for quality, and vice versa.

To give you a very simple example, the highest quality energy we have is electricity, for which the thermodynamic quality is unity. On the other hand, heat at low temperature is energy of low quality for which, depending on the temperature, the quality fraction could be 10 percent or 15 percent or 20 percent.

Senator KENNEDY. Why would not nuclear be the highest?

Mr. HATSOPOULOS. Well, nuclear has a thermodynamic quality as well equal to one, but the processes we know to convert nuclear energy into electricity are inherently inefficient, so by the time we make the conversion, we have a lot of losses, and we do not know how to do any better.

On the other hand, with electricity, which also has a quality of one, we know how to use the quality as well as the quantity.

As an example, let me cite the fact that you are——

Senator KENNEDY. Are you a teacher as well?

Mr. HATSOPOULOS. Yes; I am sorry.

Senator KENNEDY. No, no; you are explaining it very clearly to some lay people, which most of us are. There are a few exceptions on the subcommittee, but we are all basically generalists. So, we are following you along up to this point. I have a feeling we might get lost pretty soon.

Mr. HATSOPOULOS. I have been teaching thermodynamics at MIT for a number of years.

Suppose we want to heat this room and we need energy at low temperature, obviously, at around 70° or 80°, and we have a plug, so we want to use electricity for that. We could use an electric heater, which essentially takes a given quantity of energy from the plug, downgrades it, and heats the room.

Now, suppose this is a waste of quality, and the question has arisen, "Could we do any better?" The fact is that we can. We can exchange that quality for more quantity, and this is what a heat pump does. In essence, instead of converting one unit of electricity to one unit of heat, it converts one unit of electricity to two or three units of heat of low quality.

So, this example I use to illustrate the fact that quality does not have to be degraded if what we need is a low quality energy, but it can be exchanged for more quantity, and this is the key, essentially, to producing more efficient use of our energy resources.

When you take into account the quality as well as the quantity, you begin to be able to compare the use of energy for a boiler that has to raise the temperature of the steam to very high levels, or has to heat at high level, to that of a boiler that only needs to heat the stock, or to do the job at low temperature. Because now you are taking the ratio not only of the energy in and the energy out, but of the potential work included in the energy in and the potential work included in the energy out.

This is essentially the central idea of being able to come up with a universal yardstick which I feel can be very important for monitoring what we are doing; for comparing it with what is done in other countries in industrial processes, and for comparing one industry to another. Thus, we can get a feel for how much better we could do, and set goals for what we want to get, and set incentives, or set penalties, or whatever legislative action is deemed necessary.

But until we have the data presented in this form, it becomes completely unwieldy, and this is the key to the question.

Now, let me illustrate the point very simply. First of all, let me say that the procedure is really no more difficult than the procedure used for currently measured efficiencies, because the quality fractions are very well defined thermodynamically and can be simply tabulated.

To give you a couple of tables as an illustration, I have put down here the various quality fractions of heat. Each fraction depends on the temperature of the heat required. At 100° F, the quality is 3 percent, whereas at 3,000° F., the quality is 66 percent. Similarly, for steam, if we need steam at 30 pounds/in^2 pressure, the quality is 23 percent, whereas if we need it as 600 pressure, the quality is 38 percent. All these now bring heat, the various heating functions and the various steam functions, are evaluated by one universal absolute measure.

Similarly, with energy inputs we can identify quality factors. For gas and distillate oil, the factors are 1. For coal it is less because you take some energy to process the coal, and for electricity it is 1.

Similarly, we can have waste heat as our energy source. We can definitively identify the quality depending on the temperature at which this heat is available to us.

Using then, as a measure, not just the quantity of energy, but the product of the quality times the quantity, we can arrive at a universal and absolute efficiency measure which, if we could get the data from industry on what is the present practice, we could compare it to other countries and improved practices.

To give you an example of a process, one of dozens that we have examined use this type of treatment. I have considered here the function of a typical furnace for hardening and tempering of steels which does use energy. The energy used for hardening is 260 Btu's per pound of steel, the energy used for tempering is 223, and the energy included in the fuel is 1,400 Btu's. These numbers are typical for such furnaces.

It you now calculate for the hardening and tempering functions the quantities required and the quality of the input energy that is available, then, you can just form the products of qualities and quantities and divide the output by the input and you come up with 19 percent.

Now, this 19 percent gives you a sound measure of what we are accomplishing versus the ideal, the ideal being 100 percent. Of course, we never get to that ideal, but it gives you an idea of how far we could progress. To illustrate that point I have shown here various options. This is the present practice for hardening and tempering, and this is 19 percent. If you improve the insulation of the furnace, you can get to 22 percent. Yet, if you had ideally perfect insulation which, of course, is unattainable in practice, you only can get to 31 percent.

Now, however, suppose you followed the approach that Senator Hart mentioned, and that you mentioned, that we combine these processes with that of producing electricity from the waste heat produced by the furnace.

Then—for the combined process now—the absolute measure of efficiency becomes 37 percent, even higher than what perfect insulation could achieve. So, you can begin to see now that this generalized approach can illustrate what can really happen in practice, because this 37 percent is practical, whereas this 31 percent was idealistic.

We can do even better, as you see here. For example, we could regenerate and, in fact, if we include all these practices together, we could improve the insulation plus regeneration, plus recuperation, plus waste heat recovery, and you then get up to 44 percent.

In effect, therefore, there are practical methods of getting the 19 percent to 44 percent, or doubling the efficiency. By the way, this is not a theoretical calculation. There are furnaces, with combined processes, overseas, in some selected places, that do accomplish that, and with new technology that Senator Hart pointed out, we can do even better than that.

Senator KENNEDY. What is the difference between recuperation and regeneration?

Mr. HATSOPOULOS. This is a technical difference. It is subtle. One relates to extracting the heat from the exhaust gases, and the other one is extracting the heat from the stock itself, because, for instance, if you take the billets and you quench them, you are able to extract some of the heat. Moreover, one relates——

Senator KENNEDY. The cogeneration would be both of those, is that right?

Mr. HATSOPOULOS. Well, usually the cogeneration falls under recuperation rather than regeneration. Regeneration implies that you take the heat and recirculate it, whereas with recuperation you recoup it and use it again, so cogeneration would fall under that term. This is just a jargon.

Senator KENNEDY. It is like a social relations course.

Mr. HATSOPOULOS. Yes; the point illustrated here is by combining all these things together you can begin to get more and more of this energy utilization, but to do that and to compare apples and apples, rather than apples and oranges, you have to have a unified approach to the subject, and when that is done, then everybody reports the same way, and the legislature and the administration can see where the target would be set, or whether we are approaching the target, or whether we need additional legislation for that.

Essentially, this is what I wanted to cover with you this morning. Thank you.

[The prepared statement of Mr. Hatsopoulos follows:]

Prepared Statement of George N. Hatsopoulos

Manufacturing industries in the United States presently use energy at a rate equivalent to about 12 million barrels of oil per day, more than twice as much as that used by the 100 million automobiles in operation in this country. Many studies conducted in the past 3 years by Federal as well as private institutions have shown that cost-effective investments in industry could, in 10 years, result in a rate of energy saving of about one-third of the present energy consumption. Such a conservation opportunity is by far larger than any other presently contemplated.

Yet, although definitive programs for energy conservation in automobiles and residences have been designed, proposed, and are now being considered by Congress, only a minimal and loosely-defined program has been proposed by industry. The reason for this deficiency is that no energy efficiency measure was available until very recently that would be applicable to any significant fraction of the large variety of industrial processes employed in the country. In other words, in order to design an effective energy conservation program for the U.S. manufacturing industry, we need a yardstick for measuring the efficiency of energy use in manufacturing that is equivalent to the miles-per-gallon yardstick used in transportation.

A yardstick that covers well over 50 percent of the energy consumed in manufacturing has now been proposed. Its application can have a profound effect on the ability of the Administration and of Congress to formulate an effective policy for energy conservation in manufacturing industries. I would like, therefore, to spend some time describing it.

About 60 percent of the energy consumed in industry is used to perform one or more of the following functions: the raising of steam to a given pressure and temperature; the heating of material to an elevated temperature; or, either of the above two functions in combination with the generation of electricity.

Associated with each of these functions is the energy input, E_1, such as that associated with fuel, and the energy that is associated with the output, E_2, such as the steam, the electricity or the heated materials.

The laws of physics and thermodynamics tell us that the absolute measure of how well we are performing the given functions as compared to the best that can possibly be done is not the ratio of E_2 divided by E_1, but the ratio of the work content, W_2, of the energy output divided by the work content, W_1, of the energy input.

Each quantity, W_2, and W_1, is a fraction, C_2 and C_1, of E_2 and E_1, respectively, and depend on the quality of the energy output and the energy input. This fraction is small when the energy is in the form of heat at low temperature and higher when the energy is in the form of heat at high temperature. The fraction is the highest, namely unity, when the energy is in the form of electricity.

Since the energy input and the energy output in industrial processes vary substantially in quality from one process to the other, the only way there is to compare "apples with apples" is to consider not only the energy quantities but also their qualities.

The qualities of all common energy forms are well establised by the laws of thermodynamics.

Each of the functions under consideration requires an amount of energy, E_2, of a certain quality, C_2. For a given level of production, the energy demand, E_2, can be readily calculated by means of standard procedures. Its quality, C_2, on the other hand, can be evaluated as follows:

If the function is generation of motive power or electricity,

$$C_2 = 1.0.$$

If the function is heating of stock at a particular temperature or raising of steam at a given pressure, C_2 will be as given in table 1.

The energy required by each of the functions in question is satisfied by consuming fuel, electricity, or recovered waste heat. For each fuel, the energy, E_1, is computed by using the heating value of the fuel. For electricity, the energy is the number of kWh consumed times 10,000 Btu per kWh because electricity is generated from fuels at a rate such that one unit of electrical energy requires about 3 units of fuel energy. For waste heat, the energy is found by considering changes in the energy content of the material that carries the waste heat.

TABLE 1.—*Quality C_2 of Energy Demand for Heating Stock and Raising Steam*

Heating of stock—Temperature (°F):	*Quality (C_2)*	Saturated process steam—Pressure (p.s.i.a.):	*Quality (C_2)*
100	0.03	30	.235
200	.11	50	.26
300	.17	100	.295
400	.22	200	.33
500	.27	400	.36
1,000	.42	600	.38
1,500	.53		
2,000	.58		
3,000	.66		
4,000	.71		

Qualities C_1 of different forms of primary energy and waste heat are listed in Table 2. For gas, distillate oil and electricity, C_1 is equal to unity. For residual oil and coal, C_1 is less than unity because some energy is required to prepare these fuels prior to combustion. For a waste-heat source at temperature T, C_1 is evaluated by the same method as C_2 for a heating function.

TABLE 2.—QUALITY C_1 OF ENERGY SUPPLIED BY VARIOUS ENERGY SOURCES

Fuels and electricity	Quality C_1	Waste heat at temperature, degree Farenheit	Quality C_1
Gas	1.00	500	0.27
Distillate oil	1.00	1,000	.42
Residual oil	.98	1,500	.53
Coal	.97	2,000	.58
Electricity	1.00	3,000	.66

For a number of specific examples which have been analyzed, we find that under present practices the efficiency (C_2E_2/C_1E_1) for the functions under consideration ranges between 0.15 and 0.25, and that, using only known technology these efficiencies can be substantially increased.

The function-related efficiency can be evaluated either for a single piece of equipment or for several pieces collectively. It can also be applied to equipment with different types of materials (outputs) being processed and several forms of energy being supplied. The energy-quality product for each output is evaluated as discussed above and the results are additive. Moreover, the energy-quality product for each of the energies supplied is computed as above and the results are additive. The overall efficiency is the ratio of the two sums.

It is noteworthy that the ratio E_2/E_1 instead of C_2E_2/C_1E_1 is commonly used as a measure of efficiency for industrial processes. Though well defined, the ratio E_2/E_1 neither reveals the enormous opportunities for energy saving in industry nor addresses the real causes of inefficiency. For example, based on E_2/E_1 the average efficiency of energy utilization in industry is about 75 percent, whereas the average value of the correct measure C_2E_2/C_1E_1 is a mere 13 percent. The value of 75 percent implies that there is little room for improvement but, in fact, the actual use of fuel can be greatly reduced.

An example of the use of the absolute measure of efficiency to an industrial process is given in Table 3. This example shows the absolute efficiency measure for hardening and tempering of alloy steel for both current practice as well as for several options for improvement.

Hardening and Tempering Process

EFFICIENCY OF CURRENT PRACTICE

Function: Heat parts to 1650° F; quench to 350°F reheat and hold at 1400° F, then cool slowly to room temperature.
Description: Gas-fired hardening furnace, oil-filled quench tank with cooling coil, and gas-fired tempering furnace.
Efficiency calculation:

C_1 for gas=1.0.
C_2 for stock at 1650° F=0.55.
C_2 for stock at 1400° F=0.5.
E_2 for hardening=269 Btu/lb.
E_2 for tempering=223 Btu/lb.
E_1 of gas fuel=1400 Btu/lb.

$$\text{Efficiency}=\frac{C_2E_2+C_2E_2}{C_1E_1}$$

$$=\frac{(0.55)(269)+(0.5)(223)}{(1.0)(1400)}$$

$$=\frac{259}{1400}=0.19$$

TABLE 3.—EFFICIENCY IMPROVEMENT OPTIONS

Conservation measure	Gas fuel used per pound of parts heat treated (per pound)	Energy saved (percent)	Efficiency (percent)
Present practice	1,400	(1)	19.0
Improved insulation	1,153	17.7	22.5
Perfect insulation	826	41.0	31.3
Improved insulation plus recuperators on the hardening and tempering furnaces	986	29.5	26.2
Improved insulation plus bottoming engine electricity	1,153 (2)(−496)	53.1	37.0
Improved insulation plus total process regeneration	728	48.0	35.5
Improved insulation plus total process regeneration plus bottoming engine for electricity	728 (2)(−127)	57.1	41.4
Improved insulation plus total process regeneration plus recuperation	582	58.5	44.5

[1] Baseline.
[2] Credit for fuel saved because the electricity generated by the bottoming engine need not be produced by a utility.

In conclusion, the newly proposed yardstick can be used not only to set goals for improvement, but also to provide guidance in formulating various policies, such as energy tax schedules, programs for investment tax credits, and efficiency standards.

Senator KENNEDY. Mr. Berg.

STATEMENT OF CHARLES BERG, INDUSTRIAL ENGINEER, BUCKFIELD, MAINE, AND FORMER CHIEF ENGINEER, FEDERAL POWER COMMISSION

Mr. BERG. Thank you, Mr. Chairman. I am very pleased to be here. Not only is George Hatsopoulos a former teacher, he was formerly my teacher.

Senator KENNEDY. We will see how well he taught you. Was he a good student?

Mr. HATSOPOULOS. He was.

Mr. BERG. In any event, I am here basically to testify in support of the fundamental notions you have advanced. I would like to focus my remarks on two aspects of the notions you have brought forth in your draft legislation. That is the reporting and the standards. I have prepared a statement; a very brief letter. It is a very brief summary, and I would prefer to testify from my notes rather than rely on that.

I believe reporting of energy data by major industrial users, where the reporting is done on a sound basis, certainly cannot do anything to impede progress toward energy conservation, and it may considerably accelerate it. The mere fact that the reporting will have to be considered may stimulate any in industry who have not considered it, to do so. I will point out I do not think that reporting of energy data would necessarily cause any extra administrative burdens or costs in industry, since most major firms, have instituted energy accounting systems, and, the most that a reporting system would do, I think, would be to introduce certain suggested thermodynamic criteria. I really do not see any problem there, and I think it could do some good.

On the issue of standards, however, I believe that standards of performance for industrial processes can be quite helpful in setting off something that Mr. Hatsopoulos alluded to. Something in which I believe; that is, a new wave of innovation in industrial processes. However, I believe that as one proceeds with standards, one should proceed with due caution.

I think it is necessary to appreciate, at the outset of the consideration of standards, the nature of industry. As Mr. Hatsopoulos pointed out, you raised the question of dealing with industry; basically, with performance requirements in building and transportation. You touched on several of the important aspects of comparison, but I feel you left one out. It is this:

When one deals with buildings, one should recognize that the purpose of a building has been well understood for at least 1,000 years; so the performance indicator for a building is understood instinctively.

The object of transportation is to get something from point A to point B, and it is fairly easy to arrive at a performance indicator that can be instructively understood.

In industry, however, there are two aspects that make industry distinct. One is the complexity of industrial processes, and that in my estimation is the least important of the two. The other aspect is the mobility of industrial processes. I think that is more important.

I think if standards are to be used in the evaluation of industrial processes, one should try to maintain as the first criterion that they not interfere with the capacity of industry to innovate and adapt to new situations, particularly new situations in supplies of energy and raw materials. I feel the capacity of industry to adapt and innovate and come up with new processes is vital to the survival of what we call an industrial economy.

Senator KENNEDY. What are the areas that bother you the most with respect to these kinds of things?

Mr. BERG. I was about to come to that. As you pointed out, standards which would amount to prescriptive standards on design of equipment are inappropriate, and I am very happy to see that has been rejected as a notion.

The standard which you have been discussing, even some of those which Mr. Hatsopoulos has discussed here, applies to the class of operations known as unit processes. I see nothing at all wrong with requiring that a unit process, that is, steam raising in a boiler, be required to exhibit a certain efficiency. I see nothing wrong with moving the efficiency of a boiler from 75 to 90 percent, or moving the efficiency of reheating from 19 to 44 percent. That is one question that is very worthwhile addressing.

There is another question, however. It stems from a set of observations that I have made in my consulting practice. I find that in industrial plants such as tanneries, canneries, and small plastics plants, 30 to 40 percent more steam is generated than would actually be required if measures were taken to curtail the wasteful use of steam. It is one thing to raise the steam to the desired quality, and it is another thing to see that it is used properly. It is possible by focusing attention on the raising of the steam that one can actually divert the attention, the resources and the money that should be also focused, not focused instead, but also focused on the efficient use of steam.

In reheating it is one thing to devise a furnace that does efficient reheating. It is another thing to ask, "Do you want to reheat the steel to 2,300° at all?"

We have processes available—and by available I mean processes scientifically proven and tested in laboratories—that could be brought to commercial utilization—that to a large extent circumvent the requirement to reheat the material to that high temperature, and may even circumvent reheating it at all.

The ceramics industry is one where I think the examples are outstanding. I could quote my former colleague, David Kingery, at MIT, who has pointed out that much of the ceramics processing we do at 2,500° Fahrenheit and up could be replaced by processes operating at 200° or so.

It is one thing to gain the efficiency in a 2,500° furnace. It is another thing to eliminate the furnace.

Senator KENNEDY. How do you do that if the industry people do not understand that? How could we possibly do it?

Mr. BERG. All I am suggesting, Senator, is that when one proceeds to instituting standards for industry to follow, that one not inadvertently increase the comfort of ignorance on the part of those who do not understand it.

Now, there are people in industry who understand this quite clearly, but wherever you speak of imposing standards, you are speaking, no matter how you do it, of allocation of resources. I think it is worthwhile to keep that in mind as one proceeds along the line of imposition of standards.

Well, in brief, I see the energy crisis in the following way. I think that the industrial economies are faced with the sort of challenge—in the kinds of energy and the supplies of energy that they will be able to use—that could unstick the industrial resolution. I believe there are nascent processes that could be brought to industrial use and that should be brought to industrial use if the industrial economies are to continue to function satisfactorily.

I think standards that compel attention to the use of energy and raw materials in industry can be helpful provided that they do not divert attention from what I consider to be the more urgent task of preparing future processes for future use.

Before I close, I would like to make two suggestions. I do think incentives for capital investment in more efficient processes will also be helpful, and there is one other thing that I would like to suggest which I feel has been overlooked in legislation—that is that the Government, particularly in regard to——

Senator KENNEDY. You do not think there are enough incentives with the increasing costs of energy? Do you think we ought to add additional taxes or tax credits?

Mr. BERG. In my estimation, yes.

Senator KENNEDY. Thank you.

[The prepared statement of Mr. Berg follows:]

PREPARED STATEMENT OF CHARLES BERG

Gentlemen, I am pleased to have the opportunity to offer you my views on the legislation you are now considering. This legislation entails two provisions on which I especially want to comment. One of them is to establish a system of reporting for data on industrial use of energy, based upon the second law of thermodynamics. The other is a set of moves which culminates in the establishment of mandatory standards of efficiency for industrial processes.

As for the first provision, I do not see how this can detract from technical progress toward energy conservation in industry. While gathering and reporting data could impose extra administrative burdens and costs upon some operations, there are means to limit this effect. And, in any event, most major industrial consumers of fuel have already found it necessary to institute energy accounting systems from which the basic data could be extracted. I can imagine that a reporting system, properly founded on thermodynamics, might stimulate interest and innovative thought toward improving the efficiency of energy use.

However, when it comes to standards for efficiency, I wish to express certain doubts and to advise that if you proceed, to do so with caution. The discussion of standards that has been placed before you concentrates upon unit processes (e.g., steam raising, metal reheating, motor drive, etc.) rather than upon processes as a whole. It is the latter which should be addressed, rather than the former if one is to attain any significant part of the potential for improving the efficiency of fuel use in industry. For example, consider steam raising. There is certainly nothing rong with improving the efficiency of a boiler from (say) 75 percent to (say) 90 percent. This certainly will save fuel in generating steam. But, there are numbers of plants in which 30 to 40 percent more steam is generated than would be necessary if the proper modifications were made in the use of the steam. In many instances the overall fuel efficiency is determined not so much by how one generates steam, as by how one uses the steam.

Much the same is true of metal reheating. It is one thing to improve the thermodynamic efficiency of reheating metal to say 2350° F. It is quite another thing, and a more significant thing to determine whether the metal should be reheated to that temperature at all. There are processes, that can not be described in the limited space of this letter, by which much of the energy now conserved in reheating can be circumvented.

Now, a major problem with standards that focus upon the industrial unit processes that are sufficiently ubiquitous to be made subject to regulation, is that they tend to divert attention (and effort, and money) from the operation of processes as a whole.

In addition, the improvement of all the unit processes in a manufacturing process may not do a great deal of good. There are examples of processes in which each unit process operates at very high efficiency, but which never the less operate at low overall full efficiency. The most common example is the automobile. Each of the major components in an automobile—the engine, the transmission, the drive train, etc. actually works fairly efficiently. But because the transmission almost never permits the engine to operate at peak efficiency the system as a whole operates at considerably reduced efficiency. The mismatching that all lists automobile efficiency shows up in many other systems, including manufacturing systems in industry.

Finally I would like to point out that industrial processes are complex, and susceptible to rapid change. The former attribute is fairly well recognized. The latter attribute is less well recognized, but far more important. It is the capacity for industry to adapt, through invention and innovation, to the stimuli of energy problems that we will have to depend upon to maintain a healthy industrial economy.

We need new industrial processes if we are to survive on the limited quantities and types of energy and natural resources which we will be able to use in the future. To the extent that the imposition of standards on present day unit processes may divert attention from the urgent task of preparing future processes to operate on future resources, it will detract from urgently needed progress.

To concern one's self overly with standards for present day practices, in the face of the need for entirely new processes, would be rather like, as Professor Galbraith put it, optimizing the arrangement of deck chairs on the Titanic.

Senator KENNEDY. Mr. Berg, speaking of incentives, I would like to ask how would you begin evaluating what has been done already?

Mr. BERG. Senator, as Mr. Sant pointed out, there is an economic distortion with respect to energy production and energy efficiency. That is just a plain distortion. So, you could consider it an incentive or a distortion. It costs more to save energy in many cases than it does to produce new energy.

Mr. HATSOPOULOS. Not that it costs more—well, this is a different question.

Mr. BERG. In any event, there is one other thing. I believe that the Government could play a vital role of leadership in purchasing, and it has not picked up that role so far. I am speaking of purchases of new industrial equipment. The Government both purchases directly and underwrites vast amounts of capital equipment each year. The aerospace industry in this country consists largely of contractor-operated, Government-owned facilities. The Government could use those situations to great effect.

Senator KENNEDY. Could you elaborate on that point?

Mr. BERG. I would be happy to.

For example, if one of my fantasies were fulfilled and I were in charge of Defense Department purchasing for contractor-operated shipyard, one of the things I would like to see done would be to follow somewhat the approach that the Air Force took in developing numerically controlled machining.

If you take a forging operation in a shipyard, figure out what are the options for doing that forging and increased energy efficiency and economic efficiency, and then make an offer to buy forging furnaces that meet those criteria, I would be willing to bet almost anything that there would be tremendous research and large advances in forging furnaces.

Senator KENNEDY. Do you think it would obviously spill over significantly into other kinds of industries?

Mr. BERG. I believe it would. The Air Force put a total of $50 million into both the development and initial purchasing of numerical controlling machinery. It is an industry standard now. It is a highly valuable standard, and it was a good buy at $50 million.

Senator KENNEDY. Mr. Hatsopoulos, how do you respond to these observations of Mr. Berg?

Mr. HATSOPOULOS. I am quite aware, and in fact I have been preoccupied with a lot of these concerns that Mr. Berg has expressed, and I share them and I sympathize with him. It is true that one can conceive, and in fact in some cases new inventions have come about that replace the need for a boiler or for a furnace and so on.

There are two comments I want to make. First of all, I haven't found a way of handling such a thing, and I haven't heard anybody suggest one except maybe what I heard here today, through the purchasing power of the Government, which could be used. But a more direct way of comparing the new processes, which eliminate some functions from the old ones, is something that I would very much like to welcome, if anybody comes up with some ideas. I haven't heard any.

By the same token, however, I do not think that to impose or to aim for more efficient use even with the equipment we now have would discourage the invention of new methods. In fact, I think it would encourage it because, for instance, a manufacturer that uses process steam has to meet stringent requirements on the efficiency at which he produces that steam. Then, he is more likely to think of ways of altogether eliminating it.

In fact, to be honest with you, I think that the reason we have not made that much progress in eliminating a lot of these functions that are now inefficient was because it was the easier way out. We had energy so cheap and so abundant that we could use very cheap furnaces and very cheap boilers, and the incentive to come up with new ideas, such as those mentioned by Mr. Berg, was not there. If we now tell them, "Well, if you can't come up with a new process that eliminates the use of the furnace or the boiler, and if you think you have to, at least you have got to meet certain standards of efficiency," that could make it even more powerful, a more powerful incentive for many to come up with new processes.

So, I do not think that, although I fully sympathize that ultimately we do want to encourage new processes, I do not think that putting or enforcing higher efficiency, at least in the things we know how to do now, would deter that. That would be my only disagreement with Mr. Berg.

Senator KENNEDY. Mr. Sant, is there anything you want to comment on?

Mr. SANT. No. I think your statement would be right on the point. If they do not see that, we are really at the point. I think what we are trying to do is to have an opportunity to look at an index of efficiency, and I totally agree with what Mr. Hatsopoulos has said.

Senator KENNEDY. None of you has any problems in terms of the technology, that is, the standard, in terms of the furnaces and in terms of the boilers. It is just these other limitations.

Mr. BERG. That is right.

Mr. SANT. The measuring system. As they try to measure Btu's of outputs, there are so many outputs that no one quite knows how to standardize that. What is the unit of output for a steel industry? What this does is make it measurable on the same basis.

Senator KENNEDY. We have to move on here. We have a judiciary executive meeting that I have to go to, and I want to hear from our other witnesses. You have been very, very helpful, Mr. Hatsopoulos has mentioned this to me many times, and it is good to get it on the record. He is enormously dedicated and has been innovative.

Mr. HATSOPOULOS. Thank you very much.

Senator KENNEDY. Thank you.

Our next witness is Cravens L. Wanlass, inventor and research engineer of Tustin, Calif.

STATEMENT OF CRAVENS L. WANLASS, PRESIDENT, CRAVENS WANLASS CORP., TUSTIN, CALIF.

Mr. WANLASS. In order to save time, I would like to submit my prepared statement with attachments, and I have a few general comments which I think are pertinent with reference to the standard motor industry. I then will show that some improvements can be made.

The first of these comments is in relation to the work and to some of the library research which I did. It was evident that the electric motor consumed about a third more energy than the automobiles used in the United States. This is a point that we can discuss later.

The majority of all of the smaller electric motors are extremely inefficient in transmitting electrical energy to mechanical energy. They operate with approximately 30 to 60 percent efficiency, so as much as two-thirds of the energy is wasted. Additionally, present motors are that efficient—30 to 60 percent—only at a specific design point.

For example, if you were to use a 1-horsepower motor at a half-horsepower load, its efficiency would drop drastically. In industry, motors often are not used at their designed horsepower rating. Therefore, industrial efficiencies are even lower than could be anticiapted from laboratory studies.

Another item we discovered is that the number of electric motors in use is astronomical. It is in the order of at least 500 million motors rated at one-sixth horsepower or above, and probably closer to twice that, if adequate figures were available.

Another item to consider is that present electric motors have a very poor power factor. This means they put a greater demand on the electric-generating capacity of the generating companies than the motors' efficiency rating would indicate.

If you combine all these items, it is very evident that the present electric motor in use, particularly of smaller sizes, is a very inefficient device in all aspects. This is one of the things that interested me in conducting the work that I did on my own over the past 3 years.

With reference to the motor I call the controlled torque^tm, not all people realize that this technology is developed and that it applies not only to the retrofitting of existing motors, but also to the manufacture of new motors. It is estimated that the retrofitting of approximately 200 to 250 million motors is possible, on refrigerators, air-conditioners, and other electrical devices.

In field tests, we have found an average savings of 30 percent in electricity consumed by a motor converted to the controlled torque^tm technology in comparison to the identical motor before conversion. If a 20-percent saving in electricity for all motors employed in the United States wers assumed, it would result in a savings of approximately 1.2 million barrels of oil a day. This is approximately equivalent to the Alaskan Pipeline oil delivery.

With respect to savings in plant capacity, the retrofit of 250 million motors should result in a reduction of electricity plant demand of approximately 50,000-megavolt amperes, or approximately $50 million of present plant capacity. Therefore, the process of retrofitting motors to the controlled torque™ technology is approximately 20 times as cost effective as it is to build new plants, just from a demand standpoint, in addition to the savings of energy which has been discussed earlier.

With regard to efficiencies of industrial processes, which is one of the main concerns today, the motor has a variety of applications, and I have just noted a few of these possibilities.

With respect to the retrofitting of existing motors, the conversion of industrial motors, both the single-phase or smaller motors and also the larger three-phase motors, shows great promise for energy savings. The single-phase motors can be retrofitted simply on location in a matter of minutes. Three-phase motors need to be taken to the shop, rewound, and put back into service. This process is more expensive but still very cost effective.

On new applications of the motor, we have developed a variable speed, variable torque motor, which gives flexibility in almost every aspect of the motor's performance characteristics. This was not possible before.

We have talked to a large chemical processing plant, and one of their biggest problems is the fact that they use large motors to pump their various fluids through a series of valves actuated by a computer control system. They have experienced considerable trouble with the valves, and in addition, the motors themselves are pumping against changing pressures resulting in an inefficient system. They are interested in a variable speed motor which will pump the fluids in different quantities without any valves at all. This is possible through application of the controlled torque™ technology. We have talked to industries using such pumping systems who have experienced similar problems, and we can be of significant help to them.

In addition, industry utilizes machines of variable-speed load, conveyors, et cetera. On a conveyor belt, load conditions often alternate between light and heavy, and yet the efficiency of the motor is very poor at the light load. In the controlled torque™ motor, the efficiency is maximized with every half cycle. Thus the efficiency of our motors can be as much as 70 percent greater than the efficiency of standard motors. In variable load applications, this type of motor is particularly useful.

Another likely application of the variable-speed motor is in an electric vehicle of any type. The motors currently used in electric vehicles are very inefficient, particularly at light load where most of the operation occurs.

For example, although a 50-horsepower motor is placed in a car, the need for power when driving along at a standard rate of speed requires only 7 to 10 horsepower. The 50-horsepower motor is extremely inefficient at the lower horsepower. In this particular application, our variable-speed motor would eliminate much of the vehicle cost in addition to increasing the range of the vehicle. We feel this motor would increase the range of the electric vehicle 50 percent or higher in this application.

There are almost innumerable applications for our new motors in industry, both from the standpoint of the actual manufacturing process that is employed, and also from the products into which we could incorporate this particular motor.

I have kept my comments as short as possible, because I know your time is important, and I think that it would be better to answer any questions you might have. Thank you.

Senator KENNEDY. Thank you, Mr. Wanlass.

[The prepared statement, with attachments, of Mr. Wanlass follows:]

PREPARED STATEMENT OF CRAVENS L. WANLASS

My name is Chris Wanlass. I am a research engineer and have previously been a director of an electronics laboratory for Philco-Ford, as well as a researcher for other major corporations. I appreciate this opportunity to describe to you the new motor which I have developed, called the Controlled Torque tm Motor, which I believe represents a significant energy-saving development in electric motor design.

Approximately twelve years ago, after leaving my position at Philco-Ford, I began research in energy-related electronics. Realizing that most areas of energy-production research were beyond my financial means, I looked to energy conservation, concentrating on devices which consume substantial amounts of electricity. My initial research revealed some very interesting facts:

Electric motors consume more energy in the United States than do automobiles;

The basic electric motor utilized today has not been substantially improved since the development of the electric motor in the 19th Century.

Recognizing the energy-saving potential improvements in electric motor design could have, I began to analyze the basic theories of the electric motor, drawing upon my substantial experience in electromagnetic theory. This theoretical exercise produced some favorable preliminary conclusions which I then incorporated into a test motor. The motor operated according to my expectations, displaying new and superior operational characteristics. Thus, the Controlled Torque tm Motor was born. The new motor is more efficient than standard motors in that it uses less electricity. It also runs cooler than conventional motors because a greater percent of the energy used by the motor is translated into work force rather than being wasted in heat production. This should mean that my motor will be more durable. The Controlled Torque tm Motor also has a variable peak efficiency, in contrast to the fixed peak efficiency of standards motors, so that its high efficiency is maintained over a wide range of work loads.

Subsequent investigation revealed that many existing standard single-phase motors possessed dual windings which were adaptable to operate as Controlled Torque tm Motors. Because of this fortunate circumstance, my invention can be utilized as a retrofit in many existing motors, as well as a design for the manufacture of new motors.

The energy-saving potential of the Controlled Torquetm Motor appears to be substantial. Field tests have shown consistent savings of approximately thirty percent (30%) in the amount of electricity consumed for essentially the same work done. The motor has been successfully field tested by Southern California Edison, the McDonald's Corporation, and others. If all motors currently in use incorporated the Controlled Torque tm design, this would translate into potential savings of the equivalent of over 1.2 million barrels of oil per day, assuming an average saving of about twenty percent (20%). This would approximate the expected daily production of the Alaskan North Slope Oil Field.

Implementation of the new motor would also lead to huge savings of electricity generating plant capacity. Indeed, if one assumes an approximate average savings of 100 watts per motor, then incorporation of the new design in 250 million motors throughout the United States (or ½ of the motors presently in use) would lead to plant capacity savings of 25,000 megawatts, or approximately 25 billion dollars based on today's cost.[1] If power factor correction associated with the Controlled Torque tm Motor is also considered, this savings could be in excess of 50 billion dollars.

Research to refine and expand the applicability of my motor design is continuing. We have just developed a method for retrofitting hermetically sealed motors which is the type of motor used in refrigerators. We are also in the initial stage of designing an electric car motor.

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[1] This assumes new construction cost of $1,000 per kilowatt of capacity. The number of motors is extrapolated from published estimates of over 50 million AC motors manufactured annually. The savings per motor will vary depending upon the size and efficiency of the motor being replaced. The plant capacity figures assume adequate capacity to operate all motors in the system simultaneously.

It is my understanding that these hearings are designed to focus on the possibilities for improving the energy efficiency of industrial processes. I think that the Controlled Torque tm Motor offers significant energy savings in this area. My technology can be readily incorporated into the manufacturing process for new multiphase industrial motors as well as the numerous small single-phase motors used in industry. Existing multiphase motors may be converted to the Controlled Torque tm design through a rewinding process, although "rewinding" is a more complex process than the "retrofitting" applicable to smaller single-phase motors. Large industrial motors are generally rewound periodically as they wear out, however, so that Controlled Torque tm rewinds may be incorporated into an existing motor maintenance practice with a minimum of extra expense.

Because my motor is more adaptable than conventional motors, it should also be able to save energy in a number of specialized industrial processes. Recently, for instance, we were approached by a major company which was having problems with a large chemical pumping system composed of motor-driven pumps and valves which opened and closed by fluid pressure. Because my motor is self-optimizing and can run at peak efficiency over a range of work loads, it appears that a new Controlled Torque tm Motor can be designed to power the entire system with varying motor speeds and eliminate the need for valves. This will eliminate the inherent inefficiency of having a motor pump fluid against unopened or partially opened valves, as well as involving the substitution of the more efficient Controlled Torque tm Motor.

Thank you again for providing me this opportunity to testify before your Subcommittee. I hope that my testimony today has not only provided you with useful information about the Controlled Torque tm Motor, but that it has also demonstrated the fact that individuals can make valuable contributions toward realizing the nation's energy saving goals. I will be happy to entertain any questions you might have and to demonstrate my motor for you if time permits.

Attachments:

Edison Co. Engineers Confirm Revolutionary Electric Motor Could Be Huge Energy Saver

Los Angeles.—Electric energy savings amounting to millions of kilowatt hours and lower electircity cost to consumers may be realized by nationwide use of a new electric motor design, according to initial tests conducted by Southern California Edison Company, the utility reported today (April 25).

Called a "Controlled Torque" (tm) motor, it was unveiled at a joint news conference called by Robert Batinovich, president of the California Public Utilities Commission, and Richard L. Maullin, chairman of the State Energy Commission.

The motor's potential was described by Glenn Bjorklund, manager of customer service staff of the Edison Company, and the inventor, C. L. (Chris) Wanlass.

The motor was developed by Wanlass, an Orange County scientist who has a wide background as research director for several major electronics firms around the country.

Demonstrations of the new motor concept were held recently at the Edison Customer Service Enginerring Laboratory in Rosemead for representatives of the California Public Utilities Commission and the State Energy Commission.

Initial tests indicate that major electric energy savings could result from widespread adoption of the new motor concept, engineers from the Edison Co. said. According to a study made last year for the Federal Energy Administration by Arthur D. Little, Inc., an independent research firm located in Cambridge, Mass., more than one-half of all electricity generated in the country is used to run electric motors in business, industry and residences.

Wanlass came to Edison to obtain independent testing of his energy saving concept, anticipating the utility's interest in conserving energy.

Edison's tests found efficiency improvements of at least 10 to 18% with motors converted to the Wanlass design.

The inventor believes greater efficiency increases are likely with newly-manufactured motors.

Tests were made on several single-phase, capacitor-start motors similar to those that would be used on swimming pools, furnace fans, refrigerators and air conditioners of sizes up to one horsepower. Each demonstrated significant electric energy savings.

Edison officials called the new concept a "significant conservation breakthrough which appears to offer something for everyone."

First, the motor *t*offer energy savings to the customers, because they would use less electricity, reducing the amount of kilowatt hours measured at the meter.

Second, the "power factor" of the motors is improved dramatically. This would reduce the amount of power a utility must generate to run the motor. Edison engineers found that in testing a one-horsepower blower motor the power factor increased from 61% to 99% in the Wanlass design.

Third, major gains could be realized in conservation and load management which, SCE said, are priority goals of the Edison Company, the Public Utilities Commission and the Energy Commission.

The Edison Company said it would cooperate with the Energy Commission in adopting regulations requiring that all new and replacement major residential appliances utilize such a new motor concept.

If the Energy Commission incorporated such standards, company officials estimate that in ten years the savings on the Edison system alone could amount to as much as a billion kilowatt hours, and the peak demand could be reduced by as much as 500 megawatts. Savings would increase each year as existing appliances were replaced.

Commercial and industrial applications could produce additional electric energy savings, and, if used throughout the country, the savings would, of course, be much greater, SCE pointed out.

In addition, the company said, the motors could help reduce the peak loading of electric generating equipment and thereby defer the need for costly added generating capacity required at times of heaviest electricity use.

Wanlass said he developed the new motor as a theoretical concept while searching for a way to increase efficiency and conserve energy. When he built the first one, he said it worked exactly as his mathematical calculations indicated it would. He then discovered that, in addition to manufacturing new motors with his design, it would be possible to convert many existing motors to the system.

Edison tests have concentrated on the conceptual application of this design as an electric energy saving idea. However, the specific cost/benefit relationship to a given application was not evaluated by Edison, a company official noted.

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New Energy Saving Wanlass "Controlled Torque tm" Electric Motor Revealed in California Public Utilities Commission Press Release of April 22, 1977

A major, billion dollar break-through for energy conservation in the form of a new motor will be the topic of a press conference called jointly by the California Public Utilities Commission and the energy resources conservation & development commission, the two state agencies most directly concerned with the energy crisis.

The new invention, called a "controlled torque" motor, was developed by scientist C. L. (Chris) Wanlass and has just been tested by Southern California Edison. Results have shown dramatic reductions in operating costs when conventional motors were converted to and replaced with smaller motors of the new design.

Wanlass estimates that if half a billion electric motors were converted to his design, the nation could save between one and 2 million barrels of oil a day, or roughly the daily production expected from the new Prudhoer Bay oil field in Alaska.

The press conference will include an comparative demonstration of a conventional motor and the new design, with metering devices to show relative efficiencies.

When: Monday, April 25.

Where: Room 1120, State Office Building, Los Angeles, Calif.

Who: Robert Batinovich, president, California Public Utilities Commission; Richard L. Maullin, chairman, Energy Resources Conservation & Development Commission; C. L. (Chris) Wanlass, inventor; and Glenn Bjorklund, manager, customer services staff, Southern California Edison.

Attachment:

Technical Summary of the Wanlass Controlled Torque tm Electric Motor

The Controlled Torque tm Motor has at least two windings per phase for either single-phase or polyphase motors. One of these windings, referred to as the main winding, is in series with the capacitor. The second winding is referred to as the control winding. For proper Controlled Torque[tm] operation, the inductance of the main winding must be considerably less than the inductance of the control winding, and the capacitor in series with the main winding must be large enough in value to maintain a capacitive power factor for the series LC circuit under all conditions of operation.

The control winding performs the following functions in the operation of the motor:

1. The control winding performs an important function in the starting of the Controlled Torque [tm] Motor in both single-phase and polyphase versions.
2. The control winding transfers some energy to the rotor under normal operating conditions, although the major energy transfer to the rotor takes place from the main winding.
3. The control winding performs an electro-magnetic function that controls the energy transfer from the main winding to the rotor of the motor.

The main winding of the motor performs the main energy transfer to the rotor. In this respect, the capacitor that is in series with the main winding performs the following functions:

1. The capacitor value determines the maximum possible energy transfer from the main winding to the rotor.
2. The value of the capacitor determines the maximum torque characteristics of a particular Controlled Torque [tm] Motor.
3. The value of the capacitor determines the output torque, and thus, the horsepower at which maximum efficiency occurs.
4. The capacitor allows the main winding to operate in the Controlled Torque [tm] mode.

A brief description of the operation of the Controlled Torque [tm] Motor follows:

When the motor is first energized, the rotor is at rest. The impedance reflected from the rotor to the stator is thus very low. Because of this, the volt-second capacity of the main winding is also extremely low. This results in most of the applied lined voltage being dissipated across the capacitor in series with the main winding. The net result is that the current through the main winding is limited by the series capacitor and the voltage across the capacitor. At the same time, the control winding which is connected directly across the input voltage has no limiting capacitor and thus a relatively large current flows through this winding of the motor.

As the rotor speed increases, two phenomena occur. The counter electromotive force ["EMF"] of the control winding increases rather rapidly as compared to that of the main winding because of the considerably larger number of turns associated with the control winding. This counter EMF reduces the energy transfer to the rotor from the control winding with a resultant decrease in the control winding current. The second effect of increased rotor speed is that the volt-second capacity of the main winding increases. This results in the voltage across the main winding increasing in magnitude. The net result is that the voltage across the series capacitor also increases, causing an increase in the energy transfer to the main winding. This process continues as the RPM of the motor increases, until, at rated RPM and load, the main energy transfer takes place through the main winding with lesser energy transfer taking place through the control winding. The control winding, in conjunction with the limiting energy transfer effect that the capacitor has upon the main winding, results in the motor operating extremely efficiently with minimum magnetic and copper losses over the operating torque range of the motor.

It should be pointed out that the operational aspects of the motor are such that the main winding/capacitor combination will only transfer energy to the motor as long as this circuit operates with the capacitive power factor. Energy transfer in the Controlled Torque [tm] mode cannot take place if the series LC main winding circuit is inductive. Therefore, if the motor becomes overloaded, the RPM will decrease such that the control winding will assume more of the load so that the main winding/capacitor combination may remain capacitive in power factor. Because of this condition, the maximum load that the motor is capable of operating is a function of the size of the capacitor. In addition, the maximum efficiency point of operation of the Controlled Torque [tm] Motor will occur at the load point where the main winding/capacitor circuit is at unity power factor. Therefore the value of the capacitor will determine the maximum efficiency load point of the motor. The optimum value of the capacitor will depend upon the load the motor is required to drive. Thus, the motor can be optimized to any given load from zero to maximum rated horsepower, if desired, by a proper choice of capacitor value.

If, on the other hand, the load requirements are not constant, then the capacitor values should be selected to provide for the maximum load that the motor will be required to drive.

If the load is very non-linear in nature, the Wanlass "step-optimized circuit" may be employed to provide even greater operating efficiency. This circuit automatically determines the correct value of capacitance under all operating conditions and incorporates this capacitance into the circuit. This "step-optimized" Controlled Torque tm Motor is capable of providing high efficiency operation under all operating conditions of line voltage and load while at the same time offering maximum useable torque and horsepower characteristics that are in excess of a standard induction motor of similar size and weight.

Senator KENNEDY. Mr. Wanlass, what is the conceptual aspect of this motor? Can you explain it without being too technical?

Mr. WANLASS. We find that the largest power losses of the motor are associated with transferring energy through the stator, the outside of the motor, into the rotor, which is the part that goes around. In this process, about 85 percent of the loss of the energy takes place. The additional 15 percent occurs in the bearings and other losses associated with the rotor.

What I attempted to do, therefore, was to see if I could do two things; decrease those stator losses under all cases, and, since those large losses are fixed, vary those losses in accordance with the amount of energy demanded from the motor.

For example, if you had a car with a 50-horsepower motor, you could vary the output horsepower. When you were cruising at highway speeds, using only 7 to 10 horsepower, the motor would not have all the losses associated with a 50-horsepower motor and would utilize the energy stored in the batteries much more efficiently.

In addition, we have found a way to transfer a high average energy capacity to the rotor without having high peak transfer. This cuts down all the magnetic and I^2r copper losses associated with motors, enabling the motor to work efficiently under all conditions.

We have brought a motor so that we can demonstrate the differences between the standard and the converted motor. In one case, we take one-twelfth as much current to operate the controlled torque tm motor as compared to the standard motor.

Senator KENNEDY. What is the application of this to all different motors? How could you vary it, from, say, a radio to a multisized kind of generator? How do you make that variation? Do you need a different widget for each one?

Mr. WANLASS. There is a controller which accompanies each motor. The retrofitting of standard motors is very cost effective. The parts cost is approximately $6 per horsepower to do this conversion, and it is applicable to any size motor.

The smallest we have converted is one-hundredth of a horsepower, and the largest we have personally converted is 40 horsepower. The controlled torque tm technology cuts electricity losses even in large motors by about 50 percent.

Senator KENNEDY. What kind of support are you getting from the Federal Government, or have you asked for it?

Mr. WANLASS. We did talk to Mr. O'Leary at the Federal Energy Administration. He has been very helpful and very enthusiastic. I think, however, the size of the organization causes it to move relatively slowly, but a definite interest is there. We have made some attempts to have the FEA test the motor, but this program is moving rather slowly. In general, however, Mr. O'Leary has been very cooperative.

We have had much less success with large motor manufacturers. For 2 years I attempted to interest them in the controlled torque ™ motor, even in a testing program. Without signing away all the rights I had to the motor, they were unwilling to do this. So, for 2 years, we accomplished nothing. We finally contacted Southern California Edison who agreed to test the motor. I thought their test results, if favorable, would change this, but it has not. The large manufacturers seem to have the "not invented here" principle, and they do not accept ideas from someone who is not part of the fraternity of electric motor manufacturers.

Senator KENNEDY. That would be a question.

Obviously, in terms of efficiency, I would think it would be very profitable to the manufacturers of motors.

Mr. WANLASS. Actually, it should be.

Senator KENNEDY. They see it as an additional cost and additional expense in terms of the initial processes?

Mr. WANLASS. In the standard controlled torque ™ motor, the regular production machinery they currently have could be utilized for the conversion process. In our variable-speed motor, additional tooling would be required.

I think some motors—namely the shaded pole motor—should be outlawed. Such motors are inherently only 20 percent efficient and should not be used; however, they are one of the most widely used motors today.

There is no additional cost that we can ascertain with respect to production of our motor when compared to a standard motor. The controlled torque ™ technology can produce greater horsepower than a standard motor of the same frame size.

Senator KENNEDY. Is part of it that it would be more expensive for producers, even though it might save the consumer some energy, and ultimately a good deal of savings, and is quite along with the national interests, or do you think it is something else?

Mr. WANLASS. It is to a degree the attitude that any change creates a trauma or a rocking of the boat. Objectively I think the cost of the motors' production per horsepower should enter into the producer's decision. However, the production costs of new controlled torque ™ motors should be no more than that of standard motors.

Senator KENNEDY. Just finally, in terms of the applications of the larger horsepower—you mentioned 40—does that become very complex, or——

Mr. WANLASS. No, the conversion is not complex in larger horsepower motors. We took a 40-horsepower motor, removed the windings and replaced them with our windings. It is not a difficult job. This is done quite regularly because the motors run into operating difficulties, and the controlled torque ™ conversion process could be done at the same time.

In larger horsepower motors, the increase in efficiencies is not as great, because the larger motors are inherently more efficient than smaller ones. However, any significant efficient increase would result in the savings of large amounts of energy since a large motor consumes more energy than a smaller motor.

Senator KENNEDY. How do you feel about establishing standards?

Mr. WANLASS. I think labeling the motor's average efficiency would be a good idea. For example, the automobile industry was required to label a car, "If you drive this car, you get so much per gallon; and if you pay so much a gallon, you will pay this much a year"—if the average consumer could look at a labeled motor where the efficiency were stated, for example, "If you operate this motor so many hours a day and so many total hours, it will cost you this much to operate it for a year"—the consumer could judge very quickly which was the more cost-efficient motor.

I think labeling would "force" the elimination of very inefficient motors. Labeled efficiency figures should use a weighted average, because otherwise the producer could state the peak efficiency point, and such information would not be helpful to the consumer. A labeled weighted average efficiency would be a substantial help to everyone, and I strongly suggest that such labeling be required.

Senator KENNEDY. Where is your motor?

Mr. WANLASS. It is right over here. It will take about 1 minute to set it up and to run it.

Senator KENNEDY. Could you do it quickly?

Mr. WANLASS. Yes.

This is an electric motor which we have never opened. We have modified this motor from the outside through the terminal box. By means of a switch, we can run it in a standard mode, and you can look at these meters to observe the consumption of electricity.

Senator KENNEDY. Perhaps you could explain to everybody.

Mr. WANLASS. I will read the meters aloud for you. The pump on the motor will make a little bit of noise.

We will show it in two modes, with the motor loaded to rated level and with the motor operating at no load and we will show the differences between the two modes. The motor consumes about 6.5 amperes and about 500 watts of power in what we call a standard mode.

We now shift it into the controlled torque tm mode; it consumes about 2.5 amperes and about 300 watts of power, or about a 40-percent decrease in power to drive the same load at the rated load of the motor. Thus, the current actually decreased by 60 percent.

Senator KENNEDY. How much would that motor cost?

Mr. WANLASS. If you bought this ¼ horsepower motor, it would cost about $40. To change it from standard to controlled torque tm technology would cost about $4 in parts.

Now, I will show it one more time, and in this case the savings are even more dramatic, because the standard mode current consumption is 6 amperes, and the wattage consumed is 250 watts. This power is necessary to operate the standard motor with no load at all.

When we put it in the Controlled Torque tm mode, the current consumed is half an amp, and the wattage consumed is about 60 watts. Here the Controlled Torque tm motor uses about one-twelfth of the current and about 20 percent of the power used to operate the standard motor.

To give you an idea of the inefficiency of the standard motor, it takes half as much power to operate the standard motor at no load as it does to operate the standard motor with a full load. This inefficiency is applicable across the board. The losses vary in accordance with the demand on the motor.

Senator KENNEDY. Thank you very much, Mr. Wanlass.

We hope there will be many ways that we can help you in terms of getting response and cooperation from the Federal Government. We will be glad to do it. Maybe we could write a letter to Mr. O'Leary again to again remind him of your testimony.

Mr. WANLASS. We appreciate that. The motor has been substantiated by a number of people who have independently tested it.

Thank you very much.

Senator KENNEDY. We appreciate it.

Mr. Willenbrock is the dean of the School of Engineering and Applied Science, Southern Methodist University.

Mr. Willenbrock.

STATEMENT OF F. KARL WILLENBROCK, DEAN OF THE SCHOOL OF ENGINEERING AND APPLIED SCIENCE, SOUTHERN METHODIST UNIVERSITY, DALLAS, TEX.

Mr. WILLENBROCK. I don't have a prepared statement, Mr. Chairman, but I would like to make comments on my own experience in the area of mandatory standards and discuss some of the implications that they might have for the present considerations.

First of all, I would like to state that there is no question in my mind of the importance of the industrial area, as a place where energy conservation needs to be considered. The panelists you have already heard identified both the physical and economic constraints, and also some of the problems of performance standards.

I would like to speak to some of the characteristics of mandatory standards and some of the problems that have come up in their application. My enthusiasm for mandatory standards has been tempered by the experience that although the objective of a mandatory standard was clear cut and desirable, there were many cases in which the results didn't work out well. When I was at the National Bureau of Standards, I was involved with fire safety standards. We developed a mandatory standard for children's sleepwear. As a result of this standard, there was a wide-spread use of TRIS, which was later found to be carcinogenic. This is an illustration of a side effect which can come from a well-meaning standard directed to a very specific purpose.

Previous witnesses have already spoken to the necessity of considering, in relation to energy utilization, both the inputs and the outputs of an industrial process. In metal processing, it is very important what you start with as well as what the end product is going to be. Thus it may not be valid to speak of kilowatt hours per pound of output. Very simple measures which have an attractiveness because of their simplicity just do not work when applied to actual situations. Many complexities are encountered in various industrial processes; there is a great diversity in these processes.

Thermodynamic measurements can be made with definitive results in many processes. Let me give an illustration of the complexities involved. Some work done a while ago at the National Bureau of Standards relates to how the efficiency varies with load in a boiler. A boiler can be very efficient at full load; but that isn't where it is operated at at all times. Frequently it is operated at three-quarters load, or half load. What are the efficiency characteristics at these loads? These characteristics will determine its energy consumption.

These are things that can be looked at, and the kinds of things that have to be looked at to realize the objectives you want to reach. It is easy to write a standard which doesn't have the result that you wish. A requirement that a boiler be very efficient at full load will not result in saving energy if it is operated at part load where its operating efficiency may be low.

Let me cite another example of a type of problem that can come up in some industrial situations. Let me describe a very specific case which relates to a steelmaking company. One steel manufacturer makes billets in Northern Illlnois, and then ships the billets to a hot strip mill in St. Louis. These billets are cooled down, sent to another geographical location, and then heated up again. The net effect is that much more energy is being used due to the geographical locations of the plants. These simple examples illustrate some of the complexities which arise in an actual situation. If a uniform performance standard is applled to all steel mills, this operation could be forced to close down.

When you seek some desirable objective, such as a decrease in the waste of energy, and you are considering processes which are as diverse as those in current industrial practice, so it is essential that the knowledgeable people talk together about how to proceed. At present, the institutional mechanisms don't exist for the necessary interchanges between representatives of the industrial sector and the public sector to do the complex of writing energy efficiency standards in an optimum fashion.

It is very difficult to settle technical questions and get good technical answers if operating in an adversary mode. The private and public representatives would have to work cooperatively in the development of standards.

Let me give an example of such a cooperative effort. Again, the example is in the fire safety area. One of the most difficult problems in fire safety is the toxicological effects of gaseous combustion products. Eighty-five percent of the people who die in fires die by asphyxiation. As more and more plastics are intoduced in the built environment, appropriate test methods and standards are needed to distinguish among various plastics and to keep those off the market whose combustion products are frightfully toxicological.

This particular research effort is being carried out in part at the Bureau and in part at universities. The research at the National Bureau of Standards is done with the assistance of a group of technical experts, engineers and scientists, from the plastics industry. There are six industrial experts supplied by the Society of Plastics Industries, a trade association that represents the major plastics manufacturers. The society has raised money to support the six people working at the Bureau.

This is a genuine cooperative effort. It is more likely to develop the best answer to particularly tough technical questions than if the industrial and Federal laboratory experts work independently and then try to merge their results. In this case, the very process of the technical development of the standard effectively guarantees the acceptability of the results. It is more likely to include all the aspects necessary for an optimum solution. I anticipate that there will be some very good test methods coming out which will be both effective and efficient.

Let me speak now to the characteristics of performance standards in areas such as energy utilization. First the measurement methods in the standards must be thermodynamically sound, and as Mr. Hatsopoulos has pointed out there should be concern for the quality as well as the quantity of energy involved. Considerable sophistication is needed to develop effective energy utilization indicators. They must also be based on unambiguous and simple measurement techniques.

Mr. Berg referred to the energy conservation standards in buildings. Writing energy conservation standards for buildings is relatively easy in contrast to industrial processes. The energy budget of a new building can be pretty well determined and there are good test methods available.

Now, let me describe some of the problems that come up in the application of performance standards for buildings. To insure compliance with a standard is the function of the building inspector. The building inspector is usually poorly equipped to measure the thermal characteristics of the wall. By visual techniques, he can usually determine whether a design standard has been complied with. In contrast, determining whether the thermal characteristics of a wall meet a performance-type standard is a much more difficult process.

Although performance standards are preferably in general, the practical mechanisms for their application in the building area are not available. Thus, there is a procedural failure in trying to accomplish the desired result.

Such problems are not impossible to solve. However, such considerations must be taken into account in the overall process of applying performance standards to increase energy efficiency.

Mandatory standards have also resulted in a number of side effects that have not been identified in advance. For example, there have been cases in the environmental pollution area where a company has terminated the use of a particular fuel in carrying out a process and has converted to electricity to meet environmental pollution requirements.

However, if the overall pollution of the company and the utility is considered, what is the overall impact? Is the change a positive one or a negative one?

Sometimes the net effect can be more pollution. However, now the pollution problem is that of the utility and not the pollution of the particular company.

I use these examples to indicate some of the difficulties which are encountered in the application of mandatory standards. I am not implying that mandatory standards should not be used in any case; rather, I wish to point out some of the complications in writing and applying them.

Senator KENNEDY. How do you come out on standards?

Mr. WILLENBROCK. My enthusiasm is tempered by experience. I have been involved with standards for a number of years.

Senator KENNEDY. Is it fair to industry to do voluntary rather than mandatory standards?

Mr. WILLENBROCK. I would hope that the voluntary system is given a real try because I feel that voluntary standardization is the best way. Mandatory standards, even if developed by a public agency with good technical competence, do not always take into consideration all the significant side-effects. The detailed industrial information is not available to the public agency standards writer. The optimum situation would be if the appropriate institutional mechanisms existed by which the people who have the different perspectives on the problem could work together to work out the solution in an effective way. That is why I cited the example of the toxicology standard being developed for the combustion products of plastics. That is the way to get the best answers. The thrust of my comments is that it is practically impossible to work out the best solutions in technical processes unless all the relevant experience and relevant knowhow is brought to bear. In some other countries, the processes used are better than ours. They are able to put the pieces together in such a way that they don't end up in an adversary mode.

There are many examples where there are major disagreements on technical issues, such as the seatbelt question in automotive safety, where the best solutions are not being reached. The available mechanisms are not appropriate to reach optimum solutions.

Senator KENNEDY. Could I ask Mr. Hatsopoulos if he would make a comment on it?

Mr. WILLENBROCK. Certainly.

Mr. HATSOPOULOS. On which part?

Senator KENNEDY. On the points that have been raised during the course of his presentation.

Mr. HATSOPOULOS. I think I very much sympathize with Mr. Willenbrock, the fact that when you are dealing with a complex situation, and certainly industrial processes are complicated, that the better cooperation you get, the better result you get.

I think that there is no way that the Federal Government can really be effective in promoting any conservation in industry without having the support and the cooperation of industry.

I think that, on the other hand, the Federal Government has a role to play in trying to bring out—well, the first step you should do is to try to bring out things in the open, and measuring, for instance, efficiency of certain industrial processes in a unified way is a method of bringing things into the open, so that then people can say, "Well, yes, but there is an exception to that," and so on, and you have time to report.

My main concern is that, although I have been preoccupied with industrial conservation from an overall picture, it does take a tremendous number of people to study a subject in order to bring out all the exceptions and all the difficulties, and that is why I would support a program in which there is a phasing in.

For instance, if you get a reporting period which we can iron out these problems in, so that the Federal Government can iron out these problems with industry and bring out the facts in a clear fashion, and do that before you rush into mandatory, I think it is sound. I think that is the sound approach to do it.

The fact is that in some cases we may find the answer 2 or 3 years down the line, or we may find out it is necessary to have some mandatory, and in some cases it is not necessary. But that cannot be prejudged, and therefore I support a step-by-step approach.

Mr. WILLENBROCK. Market forces, for example, do not accent safety.

Similarly, in the energy conservation area where there is an overriding national interest that has to be responded to, the question is: How can we respond to that interest in an optimum fashion?

I would agree with the statement Mr. Hatsopoulos just made. The best approach is one in which the cooperative effort in the exchange of information is maximized. Only after open discussions and voluntary agreements cannot be reached, should mandatory standards be employed.

Senator KENNEDY. The thing to mention in these areas like the boilers and the furnaces, with the utilization being of different phases, can you actually promulgate standards to measure, you know, the kind of efficiency in terms of conservation?

Mr. WILLENBROCK. Good standards can be developed. A simple requirement, for a boiler might be a requirement for high efficiency, measured at full load. However, if the boiler never operates at full load, the overall process could be very inefficient even though the boiler meets the standard.

Mr. HATSOPOULOS. My reaction is this, that the situation that we faced in the past was the information obtained was on a basis that resulted in so many thousands of noncomparable figures that you couldn't even begin to try to do it. I think by taking a more sound, scientific approach to the subject, there is a tremendous narrowing down of the ability to measure and compare, but that doesn't mean there will not be exceptions, and that doen't mean that we know exactly how big is the narrowing down that we can accomplish.

Therefore, in such a new step, I think the prudent approach would be how to get the information on this new basis and start looking at what can be accomplished with it. That would be my feeling.

Senator KENNEDY. Well, I think that what can be done legislatively is what we are interested in. It isn't the precise mandate, obviously, of the subcommittee, but how you get into a point of legislating, even voluntary requirements or goals in this area, that is obviously the question.

Mr. HATSOPOULOS. I have seen, Mr. Chairman, I have seen an amendment being prepared, and I think that it really moves in the right direction. I think it is tremendous, a tremendous step forward, this amendment.

Senator KENNEDY. Maybe we would have you take a look at the amendment, too.

Mr. WILLENBROCK. I haven't had the opportunity to see it.

Senator KENNEDY. We will send you one, and get your comments. Mr. Berg, is there anything you want to add to this general topic?

Mr. BERG. No, thank you.

Senator KENNEDY. The testimony has been very helpful. It is an area where the Congress is going to be moving on it, in the Senate, in the next few weeks. So we want to try to be constructive about it. This material will be useful to us.

I have some questions which I will submit to you in writing, and we will make the questions and answers part of the record. There are just a few, but they are technical kinds of questions.

The record will be kept open a few days for these responses. I want to thank you very much.

[The following questions and answers were subsequently supplied for the record:]

RESPONSE OF GEORGE N. HATSOPOULOS TO ADDITIONAL WRITTEN QUESTIONS POSED BY SENATOR KENNEDY

Question 1. I would like to get your thinking on the reporting system on energy utilization in the Energy Policy and Conservation Act. Is the system working right now?

Answer. I have no doubt that the reporting system of the Energy Policy and Conservation Act is working within the limits required by the law.

Because data are reported as averages over all manufacturers of the same classification, however, it is difficult to judge whether all reporting plants are making progress. I know that some enlightened companies are effectively pursuing excellent energy conservation programs, including zero energy growth, and I am concerned that perhaps they are masking the inefficiencies of poor performers.

Another shortcoming of the present system is that data are reported as energy per unit of product. Because of substantial differences in manufacturing processes even if the data were disaggregated it would be difficult to compare the effectiveness of fuel utilization of a plant with that of another.

These shortcomings could be partially overcome if the reporting system included data on the energy efficiency with which the functions of steam raising and stock heating are carried out in each plant. These functions are common to all manufacturing and the data can be helpful in establishing goals and standards.

Question 2. Why is it so important to have accurate reporting on energy use based upon second-law efficiency? Certainly it can be argued that reporting alone will do very little good.

Answer. I would most certainly agree that reporting alone will do very little good. Reporting, however, in a manner that provides an accurate picture of improvements of efficiency of energy use as time goes on, that suggests realistic goals for future improvements, and that allows comparisons even between dissimilar industries is important to planning for the energy and capital needs of our economy and for safeguarding the security and independence of the nation.

The question now arises, "How should we measure efficiency?"

One answer to this question is by the ratio of energy out of a process or machinery over the energy into that process or machinery. This is the so-called first-law efficiency. In some applications, such as generation of electricity, this efficiency is a sufficiently accurate description of how effectively energy is used, and of the ultimate margin for improvement.

In most applications, however, the first-law efficiency is grossly misleading because it is neither accurate nor indicative of the real opportunities to save energy. I can illustrate this point by considering an idealized boiler for low-pressure steam in which all the input energy goes into the water to make steam. The first-law efficiency of such a boiler is 100 percent, and we might be tempted to conclude that it cannot be improved. But to raise low pressure steam we can use low-temperature waste heat rather than raw fuel to fire the boiler and, obviously, save lots of fuel. This profitable change in input energy is intuitively understandable and yet not apparent from the first law efficiency result.

The misleading aspects of the first-law efficiency can be eliminated by using the so-called second-law efficiency. The second-law efficiency of the boiler of my example is about 20 percent and about 80 percent for suitably chosen waste heat. In addition, the second-law efficiency would disclose that the low efficiency associated with raw fuel is due to the fact that the high temperature heat of combustion is converted to low temperature steam, a highly inefficient conversion.

Many diverse examples can be given that illustrate the misleading conclusions that result from the first-law efficiency, and their elimination through use of the second-law efficiency.

Question 3. Could you say something about how wide spread reporting should be required, i.e. how many companies and what capacity equipment?

Answer. For steam raising, we propose that all plants with a capacity greater than 50,000 lb/hr be required to report. We estimate that this requirement would involve 7,000 to 9,000 boilers at about 3,000 sites and would cover about 75 percent of the fuel used for steam raising in manufacturing, about 7 Quads of fuel.

For stock heating, we propose that all plants using more than 50 million btu/hr per plant be required to report. In these plants, only furnaces consuming more than 10 million btu/hr should be considered. We estimate that this requirement would involve about 10,000 furnaces at utmost 3,000 sites, and would cover about 5 Quads of fuel used in heating furnaces.

Because a number of plants have both large boilers and large furnaces, we estimate that the total number of reporting sites would be less than 6,000.

Question 4. I would like to ask tha panel what hope they have for voluntary targets of achievement in energy savings by industry. Under what circumstances, if any, would you be satisfied with voluntary energy targets? What should those targets look like and how would we know if they were achieved?

Answer. The answer to the first part of your question depends on the fate of legislation pending before Congress, and on the possible energy savings over the next decade. Assuming that President Carter's proposals for "replacement cost" pricing of fuels and additional investment tax credits are accepted, and defining the possible energy savings as those that require capital investments equal to or smaller than those necessary for development of equivalent new energy supplies, I would estimate that voluntary programs might achieve less than about one-half of the possible energy savings over the next decade.

I would be happy with voluntary targets if they were to be achieved about twice as fast as presently contemplated, and if the savings were expressed in terms of improved efficiency. I emphasize the use of efficiency as a yardstick because I believe that our goal should be to supply industry with all the energy needed for the manufacture of consumer products, provided that this energy is utilized as efficiency as known technology and economics permit.

Finally, with a good reporting system restricted to a number of widely used functions in manufacturing, such as steam raising and stock heating, I believe that over a period of a few years we will be able to set specific efficiency goals that can be easily monitored.

Question 5. Now would you give us some idea of how efficiency standards might work if we chose to move beyond voluntary targets? How could they be phased in? Would standards have to be universal, say to all boilers above a certain size or would some industries or companies have to be exempted?

Answer. Efficiency standards might be considered after data has been accumulated. In general, they should be phased in over a period of years.

Standards should not be universal but should be restricted to specific manufacturing functions that are amenable to easy evaluation and profitable improvement with known energy-saving technology.

Question 6. I know you have claimed, Dr. Hatsopoulos, that we could save ten Quads of energy through improved industrial efficiency, but we realize there are very real constraints on cogeneration. What is your estimate of where energy could be saved and in what quantity?

Answer. In arriving at our estimates of the amount of energy that can be saved in manufacturing by 1985, we have considered various practical constraints as well as benefits from an aggressive and coherent National Energy Policy. Moreover, we have used the criterion of cost equivalence. This means that we have considered only those energy savings that require capital investments that are smaller or equal than those needed for the development of new energy supplies (from source to consumer), and that result in a total cost of energy saved smaller than the replacement cost of energy.

Our estimated 10 Quads of energy savings comes from cogeneration (23 percent), waste heat recovery (25 percent), high efficiency motors (10 percent), and restructuring of manufacturing processes (42 percent).

Question 7. Would the standards apply—or should they apply—differently to say, an industry like atuomobiles which starts and stops its process than to glass making which is continuous?

Answer. I believe that we will be in a better position to answer this question after we have collected the necessary data.

Question 8. The efficiency of energy utilization in a specific process depends to some extent on climate. This dependence, however, can be easily accommodated in the formulation of the standards.

Answer. The efficiency of energy utilization in a specific process depends to some extent on climate. This dependence, however, can be easily accommodated in the formulation of the standards.

Question 9. What effect would different equipment, manufactured by different companies, have on efficiency standards?

Answer. Such differences should not have any effect on standards.

Question 10. If the National Energy Act becomes law, industry will be compelled toward conservation by higher energy costs and attracted by a tax incentive. In other words, we would already have a carrot and a stick. How much savings do you expect these two factors to bring about? Why should we add efficiency standards in addition?

Answer. To be sure, the carrot and the stick of the National Energy Act will be helpful in compelling industry to use energy more efficiently. As we have discussed in our policy paper, however, the provisions of the Act are not adequate for overcoming all the barriers that inhibit the adoption of cost-effective, energy-saving methods.

As we discussed in our paper, some of the barriers are non-economic and perhaps they could be overcome by additional efficiency standards.

Question 11. What would you think about making tax credits dependent upon compliance with energy efficiency standards?

Answer. I would be in favor of such a tax approach.

Question 12. Mr. Hatsopoulos, in my opening statement I said that 9,000 boilers and 6,000 furnaces accounted for 16% of the energy consumed in the U.S. Could you verify for me whether that statement is true?

Answer. I believe that the numbers that you gave in your opening statement are basically correct. The background information is contained primarily in the surveys carried out by FEA.

For 1975, FEA estimated that the number of boilers rated at more than 85,000 pounds of steam per hour was about 4,000 and consumed about 4 Quads of energy. We estimate that the number of boilers rated at more than 50,000 pounds of steam per hour were somewhere between 7,000 and 9,000 and consumed about 7 Quads of energy.

FEA also estimated that furnaces rated at more than 100 million Btu per hour consumed 3 Quads of fuel. Assuming the average rating of these furnaces to be 200 million Btu per hour, we find that 3,000 units belong to this category. Moreover, we estimate that the number of smaller furnaces, rated between 50 and 100 million Btu per hour, are about 3,000 and consume about 2.5 Quads of fuel.

Thus, as you suggested, boilers and furnaces rated at more than 50,000 pounds per hour and more than 50 million Btu per hour, respectively, account for at least 12 Quads or about 16 percent of the 70 Quads consumed in the United States in 1975.

Question 13. I have been considering a new bill on energy conservation which would base any penalty assessment on the replacement cost of wasted energy. It seemed to me fitting that the penalty be based on the true cost of providing the fuel wasted. Do you think that this is a feasible idea, and if so, how might it be applied. I have been thinking of stipulating that the additional replacement cost be $1.50 per million Btu's.

Answer. I presume that any new legislation, such as that which you are considering, would require that the waste be measured by an absolute standard based on the second law of thermodynamics. Then, I would agree that the penalty should reflect the cost of replacing the wasted energy.

To take an example, if the efficiency standard was set at 30% and a particular energy user in a given SIC category reports a 15% energy efficiency, then the penalty should reflect the fact that twice as much fuel is used than is actually required by the available efficient manufacturing process.

I think penalties based on a sliding scale and measured relative to an efficiency standard are probably the most equitable since they penalize the worst offenders proportionately more than the lesser offenders. Such measures could be administered through joint cooperation between agencies such as FEA and IRS.

It is very difficult for me to suggest a precise formula for evaluating equitable penalties because such a formula would have to take into account the difference between energy price that will be paid by industry and the cost for replacing that energy. This difference depends on legislation presently under consideration in Congress.

Question 14. Mr. Hatsopoulos, in the Energy Policy and Conservation Act, targets for industrial energy conservation are set based upon what is "economically justified." Could you discuss briefly the economics of replacing boilers and furnaces, when they will be replaced normally, and what are the economics of putting in new equipment over the next 8 to 10 years?

Answer. There are many ways of improving the energy efficiency of boilers and furnaces such as the use of recuperators, regenerators, economizers, waste heat recovery boilers, bottoming engines, and back pressure turbines. All these practices are economical even at present energy prices. Payback periods for the installation of such equipment range from 1 to 2 years for recuperators, economizers and waste heat boilers, 2 to 5 years for bottoming engines, and 3 to 6 years for back pressure turbines. The payback period varies within a range depending on the age of the existing equipment, location and other factors. In arriving at these figures, we assumed that the full cost of a new installation would be recovered by only the net fuel saving at current energy prices. The results are valid, therefore, even if relatively new equipment is replaced.

SENATOR KENNEDY. The subcommittee is adjourned.

[Whereupon, at 11:22 a.m., the subcommittee adjourned, subject to the call of the Chair.]

[The following information was subsequently supplied for the record:]

JAMES V. BYINGTON & ASSOCIATES,
ENERGY MANAGEMENT CONSULTANTS,
Jamestown, N.Y., August 5, 1977.

HON. EDWARD M. KENNEDY,
Chairman, Subcommittee on Energy, Joint Economic Committee, Washington. D.C.
In re: Industrial Energy Conservation

DEAR SENATOR KENNEDY: At the suggestion of U.S. Representative Stanley Lundine, New York, I am submitting the following observations and ideas concerning industrial energy conservation for your consideration.

As credentials, we are a private consulting firm which has for the past six years specialized in industrial development, expansion and retention efforts in the Great Lakes, Appalachia, and New England regions of the northeast. The bulk of our work has been dealing with industrialists on a one-to-one problem solving basis, and synthesizing solution responses in the design of joint public/private community programs.

From this direct exposure to industrialists' problems and concerns, we foresaw the need for a technical capability to assist manufacturers in identifying and applying cost effective energy conservation modifications to plant, equipment and operations. In late 1975, we designed a demonstration industrial energy conservation project to: (1) design and test several energy related analytical methodologies, (2) develop "payback" information required by the industrialist before committing to energy conservation investment, and (3) create a "Systems" approach to assist plants in industrial energy management on a volume basis.

In 1976, we initiated a project, funded by the Appalachia Regional Commission, to select ten "typical" industries in the Jamestown, New York area, to quantify heat loss from structures and equipment, to identify cost effective modifications that could be applied to reduce, convert, and recycle energy, to devise a community approach for transfer of methodologies to other areas, and to design a rationale for loan, grant, tax relief approaches to stimulate industrial energy conservation action.

In May of this year, we completed the ten plant analysis and the design of the energy management system. The results of the ten plant analysis exceeded our expectations. In summary, we identified modifications which would reduce energy consumption by approximately one-third for the ten plants, with gross payback on investment required being amortizable in less than ten years.

We have developed considerable insight into the obstacles and opportunities in industrial energy management from the Jamestown project, but more so from subsequent efforts to apply the "Industrial Energy Management System" through public agencies and through private individual plant contacts.

Following are comments concerning obstacles affecting energy conservation actions in the industrial sector. I have limited my comments to those institutional, technical and financial obstacles which are directly related to our experience and which I believe are most significant.

(a) Institutional Obstacles: Although energy costs and availability concerns exists, industrialists are not moving aggressively on energy actions (some indications are that they have reduced conservation action) pending crystallization of federal policies concerning investment incentives and fuel allocations regulations. As long as F.E.A. energy cost projections indicate "minor" increases in energy costs over the next fifteen years, it is unrealistic to expect industrialists to invest in cost avoidance energy modifications that are not competitive with other investment opportunitites. As long as utilities inform industrialists they have all the energy they need (which appears to be the case now) it will be difficult to stimulate action by concern for energy "availability". As long as energy allocation represents a possible method of controlling energy consumption, industrialists would tend not to reduce present levels of consumption for fear of "new" allocations being pegged to a lower level of consumption. For the above basic reasons, we can only expect limited industrial energy conservation until clear policy is established at the federal level which deals squarely with the contradictions that presently exist, and places the "energy crisis" in a perspective which is consistent with the industrialist's information.

(b) Technical Obstacles: The complex inter-relationship of energy conserving, recycling and conversion opportunities within industrial plants requires significant expertise. Unlike energy conservation in housing, office buildings, etc. which primarily deal with space heating/cooling, industries often contain equipment with consumes significant levels of energy which can be recovered and applied to other uses (such as space heating/cooling, air preheating, etc.). Although a recognized gap exists in conservation hardware/products which must be considered a high priority technical obstacle, I feel a very high priority should be assigned to the training of industrial energy technicians who are not only knowledgeable of complex energy matters, but are also capable of understanding the industrialist's motivations and constraints. There is, or will be, an urgent need for energy professionals, and a need for in-plant energy cooordinators who can initiate, implement, and monitor individual plant energy programs.

(c) Financial Obstacles: When a policy concerning industrial energy costs and availability is established, it is assumed the industrialist will be motivated by a "push-pull" combination of regulatory (allocations-conversion) and incentive (tax credits, etc.) program devices. Because energy suppliers have a motivation that can be considered inconsistent with conservation or appropriate energy use, and because utilities have monopoly positions that do not permit normal supply-demand forces to control price and consumption, the only workable solution appears to be the allocation of energy, particularly in the industrial sector. The F.E.A. energy cost projections appear to suggest this approach since prices by themselves, as estimated, would not encourage conservation or conversion to more abundant fuels.

Because of the diversity of industrial energy use, and the variations in individual plant budget scheduling, I would suggest financial incentives involve a minimum of bureaucratic processing and review as would be required on modification-by-modification basis. Rather, I would recommend a pegging of such incentives to actual energy reduction "at the meter" as compared to some prior unit consumption/unit product output levels. If in fact, the objective is energy consumption reduction, we can best rely on the dynamic ingenuity of the industrialist to find those methods which least interfere with his unique operating requirements, which at the same time reduce energy consumption to mandated allocation levels.

I hope the above comments are of some value to your committee. Please do not hesitate to contact me if we may be of further assistance.

Respectfully,

JAMES V. BYINGTON.

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