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Engineering Solutions to Recycling Problems

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Engineering Solutions to Environmental Problems

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SYNOPSIS: The environmental problems that we face today are largely associated with what we call the "good life." The "good life" consists of lots of leisure time, low cost of goods, lots of modern conveniences, etc. This means the convenience of prepackaged foods, throw-away containers, and all kinds of disposables. The free time gives us lots of time to travel, recreation, etc. We're able to afford it because we have mass production made possible primarily by electrical energy. We like to travel so we need lots of transportation: automobiles, airplanes, etc. Our income has gone up faster than our costs, and spendable income has increased. All of this is based on technology. The engineer helped create this situation which we have come to enjoy and he must now help the population to understand the situation that we have and to seek out ways to resolve this matter in an enlightened fashion, and help the population to understand it. Then we can all resolve the matter by setting priorities and weighing costs with benefits.

There are no quick and easy solutions to the problems we face in connection with our environment. Not only are the solutions generally rather complex and expensive, but the questions frequently are not well understood. It was recently stated that we are currently faced with a population which is demanding immediate answers each of his own liking to problems which have been with us for many years and are only now becoming apparent.

Within this framework and with our present judicial processes, misinformed and naive points of view may lead at best to expensive solutions to problems that may not be needed and may at worst actually aggravate an already difficult situation. Consider our present confusion regarding hasty conclusions on use of DDT, phosphates and leaded gasoline.

Most of our environmental problems relating to air and water, generally are related to the transformation of energy. Water pollution related to land runoff is not as directly related. It is, however, technically oriented. Our activities involve us in the process of transformation of energy. Consider the processes of cooking, heating, cooling, lighting, eating, transportation, all forms of mechanization and automation. All of these involve a process of taking energy in some form and converting it to a more usable or more convenient form. All of them have less than 100 percent efficiency and, hence, there is waste to be removed. The high level of prosperity, gross national product, and the so-called level of progress that we enjoy in this country, are traceable entirely to the high transformation and utilization of energy. All this is the basis of several branches of engineering and has always been recognized as basically a technically oriented matter. It must be apparent, therefore, that the scientific community must have native responsibility, to be informed and to understand the problems, to seek sound solutions and to inform and communicate with the masses. Thus, everyone should have a better understanding of the problems, of the nature of the solutions and the alternatives so that we may arrive at good timely solutions and a good set of priorities. There must be an honest evaluation of the cost and benefits to the end that we can maintain our environment in a clean and healthful condition without disregard for other problems, all within good economic sense.

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First of all, what about the need for power and energy in the United States. The December 1971 report of the National Academy of Engineering through its Committee on Power Plant Siting, indicates that the total energy requirements in the United States have doubled between 1950 and 1970, and will more than double again by 1990. It further reports the percent of this energy that will be used in the form of electricity is 25 percent in 1970, but will be 42 percent in 1990, rising to nearly 46 percent by the year 2000. Usage of electricity is, therefore, predicted to double between 1970 and 1980, as it has each ten years since 1950 and to reach six times the 1970 figure by the year 2000. They point out that energy is important in the production of the Nation's goods and services. The report brings out that the control of the economy is extremely difficult, and focusing that control on a single element is extremely complex. To do so may lead to unintended consequences and may even have its effects contrary to those intended.

The first thing the engineering community needs to do is to create a more general understanding of the interrelation of energy, particularly the electrical energy, and the operation of the economy. At the present time, there appears to be a conflict between the economic growth and environmental preservation. This conflict need not be a permanent condition. This is not to say that the need to improve the environment is not a pressing one. The nature of the problem is not well understood and the solutions are likewise afflicted. However, if we were to succumb to the temptation to improvise only partially thought-through measures, these could have a detrimental impact not only on the environment, but on our society as a whole. More sober research and understanding is needed to determine attainable environmental standards from the technical point of view, tempered by economic considerations with emphasis on benefit and related cost.

The increased use of electricity will be, in part, brought about because of the need to improve the environment. Consider the following:

A. Central Station energy conversion can be done at locations remote from population centers, where environmental impact will be less.

B. Central Station energy conversion can control the emission of pollutants more effectively and efficiently than nu-

merous small furnaces to provide electricity where electrical energy is the most advantageous form. Improvements in technology further reduce the environmental impact of Central Station electrical generation.

C. Electrical energy can best use non-combustion energy sources; such as nuclear fission, falling water, nuclear fusion, and other forms under consideration, because they take advantage of the cost/benefits of large scale installations.

D. Environmental needs will require large applications of electricity; for example, in sewage treatment, dust collection, more pollution-free manufacturing methods, recycling of used materials, and so on.

E. Transportation presents at this time the chief air pollution control problem, but nuclear energy is not available for these energy requirements. Electricity then becomes one possible means of overcoming this problem.

To indicate the level of need for technical knowledge and understanding, to satisfy the demand for electricity, the electric utility business will need to install in the next 15 years the equivalent of about 650 plants of all types, each 1000 megawatt size. By the end of the period a new 1000 megawatt plant will need to be brought on line every week somewhere in the country.

At one time it was thought that nuclear power was to be the answer to our future expansion of generating capacity requirements. This came from the recognition of the problem of availability, mining and delivery of increasing quantities of fossil fuels. The nuclear plant has potential of essentially clearing up the problems of air pollution that have been associated with generating stations. However, it has made the age-old problem of thermal pollution more acute at the moment. One reason for this is that it has made possible larger single installations, thereby creating a larger heat dissipation problem at a given location. The nuclear plant was also supposed to have considerable economic advantage but the cost and productivity of skilled labor, quality control of equipment and material, and very strict safety measures have raised the investments in some cases beyond acceptable limits. Besides, there have been considerable delays in bringing units on line, adding further to the penalty associated with the nuclear plant. The delays and safety measures are the result, in part, of inadequate technical knowledge and understanding by many involved people.

Thermal pollution created by nuclear plants is partly attributed to the low steam temperatures at which the light water reactors operate. The advanced reactors using high temperatures will result in higher steam cycle efficiencies, thereby eliminating this comparative disadvantage. However, the need to reject 60 percent of the heat generated by a fuel because of metallurgical limitations on the initial temperature involved in the Carnot cycle, will continue as a problem until we get some new metals to permit economically feasible higher temperatures or until direct conversion cycles become feasible.

Today we are faced with essentially arbitrary restrictions prohibiting or severely limiting the discharge of heat into natural water systems in spite of the lack of evidence that heated discharge actually constitutes a pollutant on the aquatic ecosystem. Indeed, most investigations conducted to date show that this heat properly added and controlled has either no effect or has a beneficial effect on fish life. Current political motivations tend to force the indiscriminate use of evaporative cooling towers or some equivalent regardless of their environmental effects. Many of these solutions do not correct anything, they only change the form of the problem and add to the cost.

In particular, the fast breeder reactor was to have been the ultimate source for future power generation. This type of power plant creates a fuel as it operates, rather than consumes it, and operates at higher temperatures, which results in a higher thermal efficiency than the conventional nuclear plant. As early as 1944, Enrico Fermi recommended that the fast breeder reactor should be an important national goal. Technology has been slow in developing this concept, however, and there has been considerable resistance to further the expansion of nuclear technology for the generation of electricity. At this time it will be at least 1985 before the fast breeder reactor, even with sufficient commitment of funds at the earliest possible date, can have impact on the Nation's power generation. Technical knowledge has not been able to keep pace with the needs of technology.

So, this leaves us with the sometimes surprising fact that the majority of our electrical generation in the foreseeable future will be accomplished by essentially the present means. It is now estimated that by 1987 approximately one-third of the total amount of electricity generated will be by nuclear plants, and by the year 2000, 50 percent. This means that fossil fuel will increase by 2 1/2 to 3 times in the next 30 years. We are, therefore, faced with problems of emission control for which the techniques available at the present time are relatively crude and expensive. This is not to say there have been no technological advances made in this area. A great deal of attention has been given to it, but it takes from 3 to 10 years for a new development to become available, commercial and reliable.

Moreover, there is little agreement on the harmful effects of the pollutants produced. A very great deal of knowledge, not opinion, is required. Particulate matter from stationary sources is capable of complete collection by electrostatic precipitators, but the three principal gaseous pollutants—carbon dioxide, sulphur dioxide and oxides of nitrogen—are not. A great deal of work still needs to be done to make commercially reliable systems. Consider, for example, a 1000 megawatt electric plant burning 9,000 tons of coal per day. It will produce and discharge in the same period 30,000 tons of carbon dioxide. This may be a significant pollutant, but the effect of carbon dioxide on our environment is not known. The same plant burning 3 1/3 percent sulphur coal generated 600 tons of sulphur dioxide per day. This could have a detrimental effect on human beings. We know very little about sulphur dioxide's effect on humans. Much experimentation to assist us in recovering sulphur has been going on and there is a constantly growing market. To date we have been using the technique of diffusing the sulphur dioxide concentrations to the air by the use of tall stacks. This is a simple solution but is not a permanent solution. Many systems for removal of sulphur dioxide from stack gases are being developed but the statements are repeatedly made by users that reliable commercial installations have not been developed. Nitrogen dioxide combines with water in the body to form nitric acid. The same plant will discharge 80 tons of nitrogen dioxide into the atmosphere each day. For the moment, the tall stack will diffuse it, but a great deal more research is necessary to develop means of capturing and converting it to a useful purpose or to dispose of it.

A very large problem today is to find and to mine adequate quantities of low sulphur fossil fuel and to transport it to the

places of use. Low sulphur coal east of the Mississippi is practically non-existent. This coal is in the west, and transportation becomes a real problem and extremely costly. Coal conversion, which is now receiving attention, may be an answer.

Natural gas produces about one-fifth of the electric energy produced at this time and is the cleanest form of conventional power generation. The natural gas production is actually expected to decline in the long run because of the pricing restrictions on the gas under government control; this has destroyed the incentive to locate new reserves. The liquification of coal is expected to be more expensive. It is expected this form of fuel will be restricted one day to non-power plant use. Availability of low sulphur oil is very low compared to the need, and imports will constitute an increasingly larger portion of the gas and oil being used in this country in the future.

In considering the total energy picture in this Nation and the world, there are two areas in which there is almost an immediate need for new technology if we are to fulfill our obligation of an abundant supply of energy. The first of these is methodology of permitting the use of available coal of a relatively high sulphur content within air quality standards. There must be long term arrangements for coal supply to meet forecast demands—supplies that will become useless if a practical and reliable method is not soon developed to handle the SO_2 problem. The other immediate need is in the nuclear field. While our uranium situation appears less critical with respect to time than fossil fuel, the need for the development of a fast breeder reactor is absolutely essential.

I hope it has become clear the solutions to those problems today that closely relate to our environmental quality are highly technical and cannot be solved by the simple solution of stopping the things we are doing now. As it was pointed out, also, in the report of the National Academy of Engineering, there are a great many matters which we will require for research and study by technical people. The path of improving existing technology and developing new but identifiable technology is a way to the future in the environmental fields. It will be the scientists and engineers that play the largest role in the solution of our problem. They will need to be instrumental in studying, researching, developing, and communication.

In conclusion, let me quote from some recent articles that appeared in Engineering Education. They are as follows:

> "Engineering has arrived at last, we have been recognized not only by the people, the politicians and the news media, but also by those members of the university community who call themselves humanists. At last, the liberal arts student wants a course which will help him learn something about the man who has a prime influence in his existence, the engineer. This is an important opportunity because what these students learn about engineering now will determine their attitude toward the engineer's work in the years ahead."
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> "While for one thing this is an age in which society, in general, and engineers, in particular, can no longer afford to have the universities turn out swarms of liberal arts students ignorant of engineering and biased against it. Out they go into a world plagued by problems, solutions and issues, many of which the technically illiterate are unprepared to cope with or even to grasp. This is one reason why I say contemporary liberal education needs us!"
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> "Another reason for the emphasis—our image has slipped badly with the public and especially with the non-technical segments of campus communities. We had better do something!"

And in this vein I would close, too. The technical fields have slipped badly. We have been accused of creating a monster, and I suggest to you that it is our responsibility as technical people, either in industry or in academic institutions, to set about immediately to correct this impression, and to assume our responsibility for providing the answers to environmental problems which are, in fact, after all technical problems which engineers can and should solve.

Albert Einstein has said—"The concern for man and his destiny must always be the chief interest of all technical effort."

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