# nuclear energy and the environment

This issue of the Bulletin contains a series of articles discussing various aspects of the interplay between the use of nuclear energy for electricity production, and the acknowledged need to protect the human environment, to conserve natural resources for the benefit of mankind.
This article, the keynote to the series, has been contributed by Dr. Glenn T. Seaborg, immediate past Chairman of the United States Atomic Energy Commission and now of the University of California, Berkeley, California.

In many of the discussions taking place today on the question of environmental quality there appears to be an acceptance – tacit or explicit – of a kind of exclusion principle between environmental quality and abundant energy. This principle is stated in extreme form by Garrett DeBell as "all power pollutes". Slogans such as this certainly have a legitimate purpose in drawing public attention to an important environmental problem and, on occasion, may even cause people to entertain second thoughts about purchasing an unneeded appliance. This is desirable. But there is also a danger that the approach which labels energy itself as "the enemy" may in fact be focussing attention on the wrong problem, and that it may even be counterproductive to the goal of a clean environment.

The argument for reducing total energy consumption goes something like this: the fact that we can acquire and apply energy so readily and cheaply (although at the expense of our environment) has led us to use it to support a burgeoning population with an increasing per capita consumption of goods and services, most of which result from environmentally harmful technologies and do not contribute to the quality of life. If, the argument continues, we cut back on our indiscriminate and unwise use of this energy, we will eliminate these technologies, find less harmful substitutes, and both man and nature will be much better off.

This premise has truth in it: we have indeed extracted and used energy sources in environmentally damaging ways. And we have developed and supported technologies that, we now recognise, detract from rather than contribute to the quality of life. There can be little argument on the principle that we should reduce wasteful and unnecessary consumption of energy. Fortunately, there appears to be a growing mood in our society to de-emphasize the "gadget culture" in favour of more durable values, and we are already witnessing certain countertrends that may affect the growth rate of energy consumption. These run the gamut all the way from driving smaller cars and using more mass transit to opting for the life-style of the rural commune. We may hope that these new social attitudes will reinforce the long-term historic trend of a decline in energy consumption per dollar of gross national product (GNP). It is essential, however, to consider the quantitative aspects of this question: how much saving in energy consumption can be effected if those uses that society can reasonably be expected to accept as non-essential are reduced or eliminated? What uses will survive all tests for essentiality, and what magnitudes of increases in these essential uses of energy are we likely to witness as the less-developed segments of the world's population move toward a position of relative affluence and as the population grows to the extent predicted in the coming decades?

One issue here is the question of what is to be considered non-essential. We may agree that we can live without electric toothbrushes, but are air conditioners non-essential? If we give up the electric toothbrushes but not the air conditioners how much energy will we save? It is a common misconception that the proliferation of electric-powered gadgets in the home accounts for our great demand for electricity. Actually, the intermittent use of these low-wattage gadgets contributes only a very small fraction of total demand. Rather, it is the use of air conditioners, electric heaters, and other large appliances – washers, dryers and television sets – that creates the bulk of the household demand for energy. In the United States 28 per cent of the increased household use of electricity in the past decade has been traced directly to air conditioning and space heating.

Thus, we must consider realistically our growing needs for energy. To do so is not, however, to advocate supporting an uncontrolled population growth or unlimited consumption of power. There must indeed be limits to the production and use of power, and to the ways that it is produced and applied, so that these can be circumscribed in terms of their overall impact on society and its environment. Most technologies, including energy systems, can be vastly improved if we are willing to pay the price, so that we can enjoy their social benefits by bearing a cost that was paid for previously in environmental abuse.

We must also strive to stabilize the world's population over the coming decades and eventually create what many scientific statesmen have been referring to as a "steady state society". Such a society – inevitably a highly technological one – would depend on adhering to a recycle philosophy, one that controlled the input, output, use and side-effects of all production, so that mankind would be operating physically in a closed system in which his man-made ecology is compatible with the natural ecology.

Let us assume that we shall reach the "steady state society", but let us also understand that we have much distance to cover before we reach that goal. Today's world is one in which two thousand million people are still hungry or suffer from various forms of malnutrition, where housing is grossly inadequate in many areas even in the so-called advanced nations, where urban systems and transportation systems must be re-vamped, and where environmental controls – many calling for additional expenditures of energy – will be required to reduce ecological stress. If we take all this into account we cannot help but realise that we still face several decades – perhaps a half-century or more – of inevitable growth before we can have a world in which a stable population (hopefully no more than 7 or 8 thousand million people) enjoys peace, stability and a broadly acceptable standard of living.

Most of our energy-intensive technologies were developed not simply because economic energy was available. Our streets are not crowded with automobiles because gasoline was cheap; we did not develop air conditioning merely because electricity was available at reasonable rates; we did not turn to the use of aluminium, cement and plastics only because we had the power to produce them. These technological developments occurred because they met needs perceived by society at the time. Some of these needs, we realize, are less essential than others; still, there were real needs that these technologies served and continue to serve. Many of the same needs are perceived today by economically-developing peoples. By and large, the populations that are energy-poor have no intention to remain so for any longer than poverty demands. Theirs is a world of unfulfilled dreams, of rising expectations for decent housing with adequate climate control, for good transportation, for useful consumer products. These demands are as natural as they are firmly held, and they are not likely to be dislodged by the affluent ones in the name of "environmental improvement". For us to label energy as "the enemy" when in fact energy holds the key to a better life for many of the world's peoples would be equivalent to labelling ourselves as "the enemy". There is nothing to be gained by creating this kind of a credibility gap between ourselves and the developing peoples, and in fact there is much to lose. We must recognize the legitimate needs of people for energy as well as for a good environment. Within limits, these goals are not incompatible. Energy is not the enemy; dirty energy is the enemy.

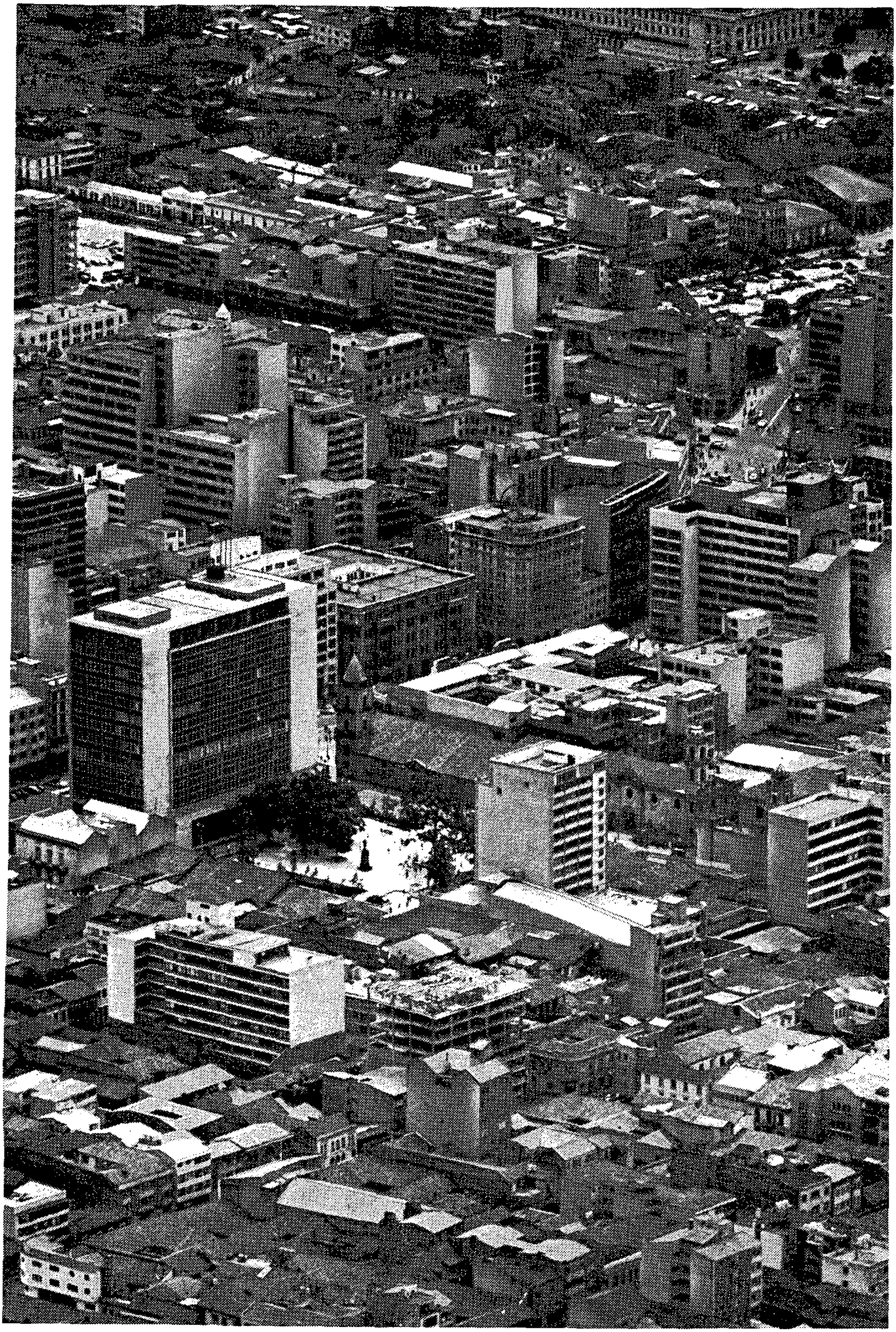
Consider these energy demands as they related to electricity, which represents an increasingly-large portion of our total energy picture. For all its growth, electricity still represents in the United States only about a quarter of the total primary energy consumption. And when the use of electricity grows, much of that growth is represented by a shift from the direct use of a primary energy source – a fuel such as coal, gas or oil. Some examples of this are the uses in industry of electrolytic and electromagnetic processes in place of heat processes, the use of electric furnaces in the manufacture of steel in place of the basic oxygen furnace, the use of electric heating in the home in place of oil or gas furnaces, and the use of electrically-powered rapid transit systems in place of the individual gasoline-burning automobiles.

Because electricity is a clean, convenient and versatile source of power the share of the total primary energy going into electricity in the United States has increased from about 8 per cent in 1920 to about 25 per cent today. It is projected that that percentage will rise to more than 30 by 1980, to 40 by 1990, and to about 50 per cent by the end of the century. What accounts for this forecast that by the year 2000 half of all the energy will be in the form of electricity? Certainly it is not the idea that every home will be loaded with electric toothbrushes. Rather, it is that on the home front the number of large appliances per home is growing, and also a larger fraction of the homes are being equipped with them. And in the industrial area tremendous growth in energy uses for the enhancement of our environment will be important. Among these are electrically-powered mass transit, sewage and water treatment plants, technologies to reduce air pollution from industrial plants and fossil-fuelled power stations, and recycle technologies.

Where is all this electricity going to come from? Most of it for the next three decades or so is going to be generated by the burning of coal. The transition to the use of nuclear power as the major source of electricity in the United States is not taking place overnight. The use of coal is growing and will continue to do so for some time. Today we burn more than 500 million tons of it annually. By the year 2000 we will be using more than 800 million tons – perhaps a thousand million tons – annually to meet coal's share of the approximately 2 million megawatts of electric capacity projected as our requirement for that time.

Now, the mining, shipping and burning of more than 800 million tons of coal per year in an environmentally acceptable manner is an enormous undertaking. And any responsible expert in the energy field cannot help but advocate that we put great effort into this task in the years ahead. We will have to devote great effort and considerable resources to improving mine safety, to the management of the environmental effects of coal mining and to those systems that can alleviate the problems associated with burning coal. Research and development must be advanced in the de-sulphurization of coal and its combustion products, in the gasification and liquification of coal, in "topping cycles" such as magnetohydrodynamics (MHD), in the operation of mine-mouth plants and other systems for improving the ways that coal is used.

"We must recognise the legitimate needs of people for energy as well as for a good environment..." Here, the city of Bogota, Colombia. Photo: UNESCO/P. Almasy



I think we can make significant progress in all this but, again, not without significant cost and effort.

Before I turn to nuclear energy and its problems and promise, let me mention the rôle of other power sources. I have not mentioned the use of gas or oil in our long-term generation of electricity because I believe they are bound to play a decreasing rôle in this use in the future. Their future lies more in their uses in transportation and as a source of synthetic products; and even should we discover substantial new reserves of oil and gas they will continue to grow proportionally more scarce and precious as our energy demands grow.

Hydro power, which today gives us less than 5 per cent of total electricity, will continue to provide only a small fraction of our power in the United States, because we have already developed most of our natural hydro power locations to their fullest capacity. From an ecological viewpoint there are just so many places where it is advisable to build dams and flood river valleys. Many believe that we have reached the limit of this development.

What of the other, more novel sources of power we are hearing about today? Geothermal energy — tapping the heat released deep within the earth — is one such source that is being used locally in some places in the United States and elsewhere. But even with the fullest development of such a source it is doubtful that geothermal steam could fill but a small fraction of total electric needs in the future. Of course, we should proceed with making as much use as possible of this "free" energy from inside the earth, but let us not deceive ourselves about its future potential.

The situation with regard to the use of solar energy may be more favourable. It may be possible to develop the technologies to concentrate, collect and store the enormous but low-intensity energy of the sun in a number of relatively cloudless areas, or even on solar cells orbiting in space, but it seems doubtful that we will see such technologies in large-scale use in this century unless massive governmental efforts are mounted on the problem.

Likewise, it would not be wise to set stock in the full-scale, widespread use of controlled fusion as a major source of electric power for the coming decades — perhaps not until well into the 21st century. I say this not because I do not have faith that we will eventually see controlled fusion as the ultimate source of power drawing on a virtually limitless supply of fuel — the heavy hydrogen of the oceans — but because I believe we must be realistic about the time span between the laboratory harnessing of fusion and all the necessary subsequent steps in engineering, testing, regulation and site planning that will be needed to see full-scale fusion power plants in wide commercial use. Considering, on the one hand, the difficulties and perhaps unpredicted pitfalls that we might encounter in these steps and, on the other, the enormous problems we might incur if we relied only on the burning of coal until controlled fusion came widely into use, I cannot agree with those critics of nuclear fission power who would have us abandon nuclear fission to risk a transition directly from coal to fusion power. The consequences of such a move could be disastrous — both environmentally and economically, and internationally as well as in the United States.

Bearing this in mind, let me move on to some thoughts on the future of nuclear power — a clean source of electricity characterized by the absence of noxious combustion products and a supply of fuel that will last for centuries when breeder reactors become operational. By the year 2000 we expect that nuclear power will be carrying at least half the load of the United States' total electric demand. We hope that midway to this point — by 1985 — we will see the fast breeder reactor in its first commercial use. The importance of such a nuclear system was stressed by President Nixon in his recent Message to Congress on Energy.

The future role of energy sources such as oil, says Seaborg, "lies more in their uses in transportation..." Here, a petrol refinery at Abadan, Iran. Photo: UNESCO/Michel Ménard

The President stated in that Message:

Our best hope today for meeting the nation's growing demand for economical clean energy lies with the fast breeder reactor. Because of its highly efficient use of nuclear fuel, the breeder reactor could extend the life of our natural uranium fuel supply from decades to centuries, with far less impact on the environment than the power plants which are operating today.

In view of the significance of that statement and of the further development and use of nuclear power in general, it is essential that we review some of the problems connected with this source of electricity. I shall do this by attempting to place in perspective some of the doubts and apprehensions that are being emphasized today by the more vocal critics of nuclear power. There are three main lines of attack – other than the broad question of the need for such power. The three points raised concerning nuclear development involve the effect of low-level releases of radioactive effluents, nuclear safety and the possibility of major accidents, and the management of high-level nuclear wastes.

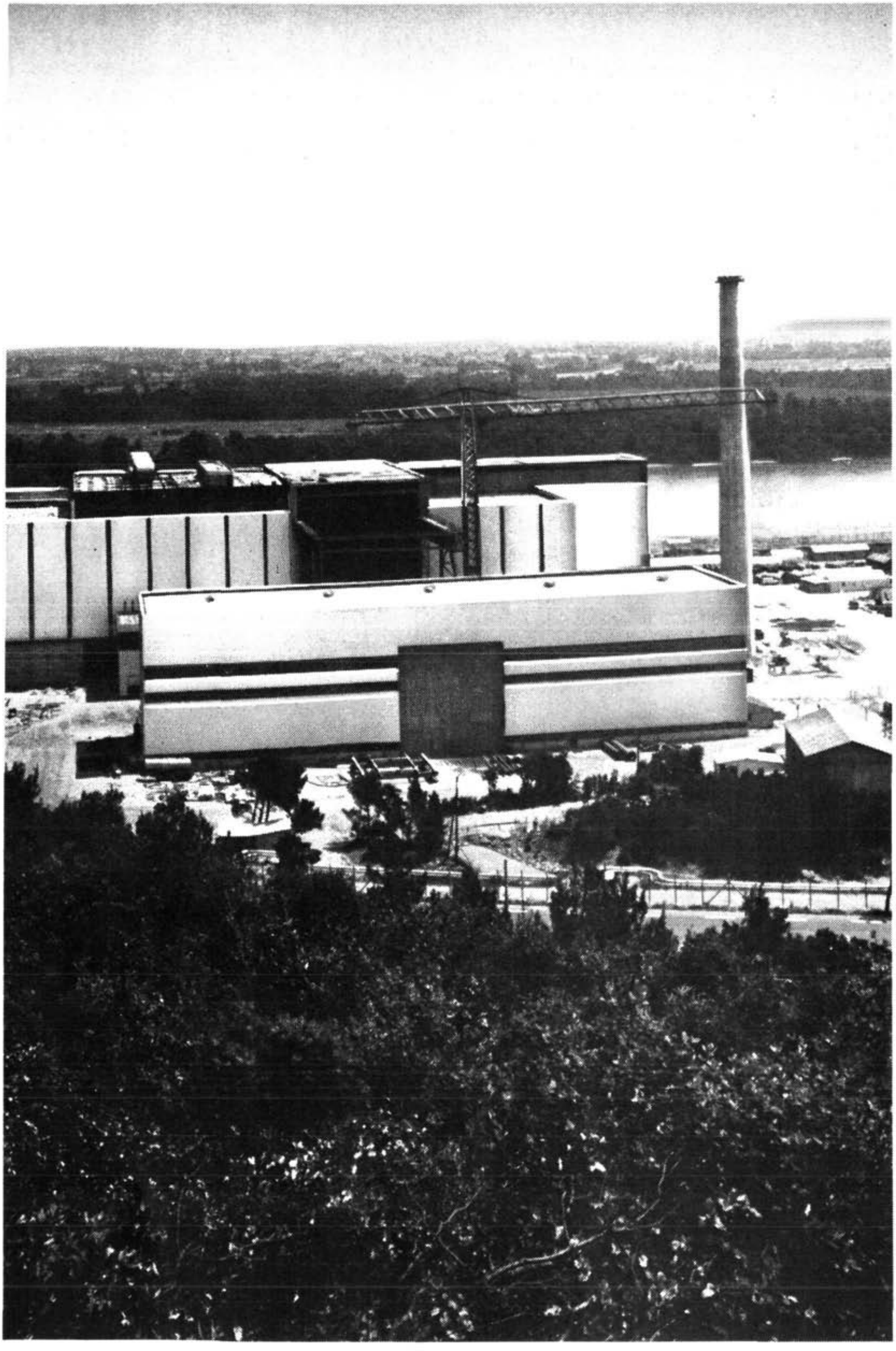
The concern on the first point, the effect of low-level releases of radioactive effluents, is already beginning to fade. It is being generally recognized that the operation of nuclear plants – even up to the number projected to be in operation in the year 2000 – will present the average person with only a fraction of the additional radiation that he receives from variations in his normal background – variations due to activities such as moving to a place of higher elevation, working in a building made of more naturally radioactive materials or taking additional jet flights in the course of the year. New operating criteria in the United States will guarantee that the average radiation exposure of the public due to the operation of all nuclear plants – even projected up to the year 2000 – will be less than one per cent of the average total background radiation.

Many critics of nuclear power plants have shifted the focus of their attacks to the matters of nuclear safety and the potential of accidents. Years of research and development in nuclear safety are overlooked or brushed aside, outstanding safety records are ignored, and continued upgrading and innovation in the development and management of nuclear technologies are rarely mentioned, as they focus primarily on hypothetical catastrophes or a few isolated mishaps that did not harm the public. What the nuclear critics view as a technology leading to an inevitable catastrophe is actually a technology which poses less risk to the individual than almost any activity he engages in, or is inadvertently a part of in his daily life in modern society.

All this does not mean that there is never going to be a failure or accident among the growing number of nuclear plants being built. Of course there are going to be some failures and mishaps at nuclear plants in the future. However, nuclear technology – which due to its origin and nature has been managed with more care and integrity from its inception than any other technology – continues to improve in terms of health and safety considerations. In fact, if all our other life-sustaining technologies – such as those involving the management of our food, air and water – were judged by criteria equivalent to our nuclear standards, in the light of today's attitudes we would probably be fearful of eating, breathing or carrying on any of our normal activities. Nuclear technology is far ahead of any other field in its concern and care for environmental and health matters.

As a concluding thought along these lines, let me add a few words about another subject that nuclear critics dwell on, that is, the disposal of atomic waste. Particular attention is

The fast-breeder reactor is expected to play a growing rôle in nuclear energy programmes in the 1980s. Here, a general view of the construction of the Phénix fast breeder at Marcoule, France. Photo: Commissariat à l'énergie atomique



being given today to the management of high-level radioactive waste from nuclear power plants. A great many years of research, development and thoughtful planning have gone into the systems now proposed for the management of nuclear waste. When the spent fuel from a nuclear power station is removed to be shipped to a fuel reprocessing plant it is transported in containers that have been most rigorously designed and tested. Among those tests which prove those containers' capacity to withstand severe accidents and maintain their integrity are drop tests from towers and helicopters onto concrete pads, and exposure to high-temperature fire for hours.

At the reprocessing plant, after the valuable plutonium, unburned uranium and certain useful fission products are removed, the remaining waste is stored in underground tanks. But in future this is not going to be its final resting place. For more than a decade the US Atomic Energy Commission has been developing systems for converting this liquid waste to solids which occupy only a small fraction of the liquid's volume. The AEC has also developed a method for burying such solid waste in underground salt formations which are dry and the most geologically-stable areas known to man. Special equipment has been designed and built to handle the containers of this solid waste and to bury them at a depth of about 1000 feet, far from any underground water.

Many thoughtful people have had questions and criticisms about nuclear power. With respect for their sincerity, for their integrity and their spirit of co-operation, the US Atomic Energy Commission has conferred with and co-operated with thousands of individuals and organizations — conservationists and environmentalists, businessmen and lawyers, local and state officials, scientists and laymen. From these exchanges have come greater understanding, important compromises, and what I believe will be solid steps leading to better nuclear power, the source of electricity upon which the world will depend to an increasing degree in the future.