The Energy Crisis and Nuclear Power

Peter Hodgson

The scientific and technological advances of the present century have brought about an unprecedented increase in the standard of living of millions of the world's inhabitants. This has however created new problems that have recently come into prominence. We are acutely aware that the resources of the earth are finite, that we are using them up at an accelerating rate, and that many of our activities are polluting the earth to an unacceptable degree. If we persist along our present course we are heading for an irreversible disaster that will make our present worries pale into insignificance.

These problems are widely debated; books, articles and television programmes tell us about the threats to our fragile earth. Many organisations demand rapid action. It is recognised that the Church has a vital part to play in this debate, and indeed has already made important contributions. In many respects, however, it has failed to rise to the occasion, and does no more than repeat the errors and distortions of the media.

A basic requirement, generally not well understood, is that those who contribute to these debates should have a certain level of understanding of the basic scientific and technological facts. Without this it is almost impossible to say anything useful, and very easy to talk dangerous nonsense. It is thus necessary to begin by a brief summary of the present situation and, with this as a basis, to pass on to wider political and moral questions. It is convenient to begin with the energy crisis, a definite a clear-cut problem that faces us now. We all depend on energy in its various forms, and the amount available to us is directly related to our standard of living. Hundreds of millions of people are now living in the direst poverty because they do not have enough energy. Where are we going to get the energy to give them life, and to support us all in the next century?

The Gulf War has brought home to us once again the dangers of relying too heavily on oil, and there is increased understanding of the pollution hazards associated both with oil and with coal-burning power stations. Should we think again about nuclear power, or does it also have unacceptable hazards?

The problems of energy and the environment are by no means new. In ancient times the forests of the Mediterranean lands were cut down for fuel. Many parts of North Africa once supported large populations and are now desert. Later on, the forests of central and northern Europe were also cut

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down for fuel.

During the Middle Ages and the following centuries coal was increasingly mined and replaced wood as the major source of energy. The coal mines, with associated deposits of iron ore, made possible the Industrial Revolution. In the present century oil has replaced coal as the major source, but it is expected that world oil production will reach a maximum in a very few decades from now.

World population is increasing rapidly, at a rate that varies greatly from one country to another. But overall it is doubling every thirty or forty years. The energy consumption is rising even more rapidly due to improved living standards. Thus our energy needs are increasing while our oil production will soon begin to fall. Where are we going to get our energy in the next century? This is an exceedingly urgent problem that faces each country in one form or another.

There are two ways to tackle this problem, and both are needed. One is to stop the demand for energy from rising so rapidly, and the other is to increase energy production. Our standard of living is closely related to the energy supply. We need energy to cook our food and heat our homes as well as to make possible our transport, industry and communications. At present the richer nations of the world, mainly in Europe and North America, are using around ten or twenty times as much energy per capita as people in the poorer countries of Asia, Africa and South America. If this unbalance is to be redressed, world energy supply must be greatly increased.

We do however waste an enormous amount of valuable energy and much of it could be saved by conservation, restraint and increased efficiency. It is not easy to see how this can be brought about on a sufficiently large scale. Energy demand can be reduced by rationing or by increasing the price, and this would affect the poorer people. Some form of differential tariffs would be worth considering.

Energy conservation is essential, but it is not sufficient on its own. It cannot solve our problems, though it can make them more soluble. Even with the most efficient use of energy, we still need vastly more than we produce at present. Where is it to come from?

This is a highly complicated question that has to be tackled by each country, taking into account its natural resources. All possible energy sources must be considered and evaluated as objectively as possible taking into account their capacity, cost, reliability, safety and effects on the environment. An objective assessment means one that expresses the quantities concerned numerically as far as possible, so that they can be compared with each other. This is not always easy, but it can be done to some extent, and approximate numbers are far better than no numbers at all.

It is possible here only to sketch the more important considerations

governing our choice of energy sources. We need all the energy we can get, subject to the above criteria, and so it is necessary to exploit all sources to the limit. There is no single solution, and the optimum mix of energy sources varies from one country to another.

Our list of energy sources includes wood, coal, oil and its associated gas, hydro, nuclear, wind, solar, wave, tidal and geothermal. Some of these are relatively minor sources, very useful in some places for specialised purposes. But here we must concentrate on the major sources of power, those capable of providing the power for large cities and manufacturing industries.

We cannot expect to solve our problems with wood or oil, because they have passed or will soon pass their maximum capacity. Hydroelectric power is very important, especially in mountainous countries like Norway and Switzerland, but due to the availability of suitable rivers it can never provide more than about 10% of the world's energy. Tidal power is similarly limited by the rather small number of suitable river estuaries.

Geothermal energy is even more limited, as hot springs are found in few countries. Wave power is still in an early experimental stage and does not look very promising.

Wind and solar power need careful consideration. Windmills have been used for a very long time, and can provide power to grind corn or to generate electricity. Solar power is most efficient when it is used as a source of direct heat, as in the roof panels that heat domestic water. It is possible, but much less promising, to use it to generate electricity. Unfortunately wind and solar power are not reliable. When the wind drops and the sun no longer shines, no energy is available. They are also relatively costly and dangerous ways of producing energy, and have serious effects on the environment. Thus although they remain useful in certain circumstances, they cannot provide the large amounts of energy that the world needs.

We are therefore left with coal and nuclear as our possible major energy sources of the future. It is not at present a matter of choosing between them as for the next few decades both will be needed. It is nevertheless useful to compare them closely because the actual decision that faces each country is whether the next new power stations shall be coal or nuclear.

Coal is a familiar source of energy, and there are enormous deposits in many countries. Certainly coal has the capacity to provide large amounts of energy for several hundred years.

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The cost of coal power has been compared with that of nuclear power by detailed studies in many countries, and the figures vary between their being about equal to coal being about twice as costly as nuclear. This comparison is on the basis of the costs of mining the coal or uranium, constructing the power stations and delivering the electricity to the consumer, within the same financial assumptions about inflation and rate of return on capital.

This comparison does not however give the whole picture unless environmental considerations are also included. Coal power stations emit large quantities of poisonous gases that contribute to acid rain, and this affects all living things, from plants to ourselves. They also produce carbon dioxide that contributes to the greenhouse effect. A recent study evaluated the cost of the pollution due to coal power stations and concluded that if it were paid for, then the cost of coal power would be quadrupled. There has been much discussion about the imposition of a tax on coal power to allow for this. If this were done realistically, it would very greatly increase the price of coal power. Even then, the damage to the environment would still be there, unless the tax encouraged the use of an alternative source of power.

Safety is a most important consideration. Unfortunately no source of power is completely safe; all involve risks both to the workers and the public. These risks can be expressed by evaluating the number of people killed or injured in the course of generating a specified amount of electricity.

These include the casualties due to mining, transport and construction. One such study showed that the numbers of people killed in the course of generating a thousand megawatt years of electricity is about forty for coal, ten for oil, one for nuclear, three for hydroelectricity and five for solar and wind. For man-days lost due to injuries, the figures are 1000 for coal, 400 for oil, 8 for nuclear, 40 for hydroelectricity and 70 for wind and solar. These figures are subject to many uncertainties, but they remain useful guides. Coal is so dangerous because of the hazards of coal mining. Oil is dangerous because of oil rig explosions. Hydroelectric power is dangerous because of the possibility of dam bursts. Wind and solar, misleadingly called the 'benign renewables', are unexpectedly dangerous because of the very large number of units that have to be built to give the same output as a coal power station.

Coal power stations thus compare rather badly with nuclear from the point of view of safety, and the pollution they cause has already been mentioned. Nuclear power stations, on the other hand, have minimal effects on the environment.

These considerations led many countries, especially those like France that have no oil or suitable coal of their own, to embark on large programmes of nuclear power station construction. In many countries most of the electricity is now obtained from nuclear power. In France this figure is about 75%, and in many other countries it is around 50%. Nuclear has replaced coal as the major source of electricity in Western Europe. Worldwide, there are over 400 nuclear power reactors in twenty-five countries with a total generating capacity of 324 GWe. By far the largest nuclear power programme is in the USA, although it only produces about 16% of their electricity. In the UK, the figure is about 20%. The total number of operating years is now over 5600.

In spite of this, there is widespread opposition to nuclear power. After Chernobyl, some countries such as Sweden and Switzerland resolved to build no more nuclear power stations, and to close the existing ones as soon as possible. Subsequently they found that the alternatives are even more unacceptable, and so the policy is being quietly reversed.

The reasons for the opposition to nuclear power are of many different types. The power locked in the atomic nucleus first made itself known by the bombs on Hiroshima and Nagasaki, and the fear that a nuclear reactor could run out of control and blow up like a bomb is not far below the surface. Fortunately this is physically impossible, but Chernobyl showed that a hardly less catastrophic failure can occur.

Nuclear reactors are sometimes seem as symbols of all that is evil in the technological society: huge, menacing, inhuman. We prefer things to be small, friendly and beautiful. We are familiar with the dangers of coal and

oil, and they seem infinitely preferable to the unknown dangers of nuclear power. Better the devil we know.

The special characteristic that provokes most unease is the nuclear radiation, which we cannot see or feel until it has done the damage. The same applies to electricity, and we have got used to that; perhaps some day we shall get used to nuclear radiations.

It is not only nuclear power stations that produce nuclear radiations. They are all around us all the time. The cosmic rays that enter the earth's atmosphere from outer space, the rays emitted from radioactive rocks and from chemicals in our own bodies are all nuclear. We irradiate ourselves when we have a chest X-ray, or have radium therapy, or when a radioactive tracer is used in diagnosis. They all do us no detectable harm and provide a standard for us to judge the hazards of radiations from a nuclear reactor.

In a nuclear power station uranium undergoes fission and produces heat, leaving behind what are called fission fragments. After a time these accumulate and slow down the reactor, and so they have to be removed. To do this the spent fuel rods are taken out and processed to separate out the fission fragments from the remaining uranium. They constitute nuclear waste and are useless and highly radioactive.

The method of dealing with nuclear waste so that it is rendered harmless is now well understood. First it is stored above ground until most of the radioactivity has decayed, and then it is fused into an insoluble glassy substance, encased in stainless steel cylinders and buried underground in a dry stable geological formation. There is then no danger that the radioactivity will escape and return to the surface. Eventually the level of radioactivity will decay to the same level as the surrounding rocks.

Another category of nuclear waste comes from industries and hospitals using radioactive materials. This has a low level of radioactivity and it can be put into drums and safely buried on land or in the sea.

Radioactive material is easy to detect and measure, even in very small quantities, and so the whole process can be controlled to ensure that it does not cause any harm.

There is widespread and justified concern at the reports of increased numbers of cases of leukaemia around nuclear installations like Sellafield. It is known that intense nuclear radiations can cause serious injuries due to the destruction of the cells in the body. However the increased level of radiation around Sellafield is a very small fraction of the natural background radiation, so it is difficult to understand how it could be responsible. The natural background varies from one place to another, depending on the type of soil. In Cornwall, for example, it is about twice the national average, and yet the incidence of leukemia there is below the average.

If nuclear radiation is not the cause of the leukemia, then what is? It

should first be remarked that many surveys in other countries have found no significant evidence of increased incidence of leukaemia around nuclear sites. Furthermore, clusters of leukemia cases are found in other parts of the country where there are no nuclear installations. This suggests that there is some other cause. One possibility is that the leukemia is due to a viral infection that occurs when there is a large movement of population, as occurs when a large factory is built in a relatively remote area. Comparative studies of similar population movements not associated with nuclear power also show increased leukemia frequencies, which supports this hypothesis. Another possible cause is chemical effluents from nearby industries.

The nuclear reactors now in operation are thermal reactors in which slow neutrons cause fission in uranium 235, an isotope constituting only 0.7% of natural uranium. Uranium is quite widespread in the earth, usually in rather poor ores, and could become increasingly costly to mine in a few decades as the richer ores are used up.

It will then become economic to change to fast reactors which are able to use the uranium 238 that constitutes the remaining 99.3% of natural uranium. This will effectively increase the supplies of fissile material by a factor of about sixty. Already the energy stored in the spent fuel rods in Britain is equivalent to that in the North Sea oil. Prototype fast reactors are already in operation, and the technology is well understood, so it is likely that they will begin to take over the nuclear power production in about thirty or forty years.

Ultimately, the main hope for the world's energy supply is that fusion reactors will prove possible. The basic physics is that nuclear particles called deuterons and tritons can fuse together with a large energy release. They will fuse provided the temperature is high enough, and the problem is to hold them together for long enough. Many experiments are in progress to see if the is can be done using high magnetic fields, for example in the JET (Joint European Torus) Laboratory at Culham near Oxford. Very encouraging progress has been made, and it is hoped that the next generation of machines will pass the break even point where more energy is produced than is used to run the machine. Since deuterons are found in ordinary water, and tritons can be made in the reactor, the energy available from fusion reactors is virtually limitless.

It is sometimes said that one of the great advantages of fusion reactors is that they produce no radioactivity. This is unfortunately untrue. There are of course no fission fragments, but the fast neutrons emitted from the reactor, which carry most of the heat produced, will inevitably induce radioactivity in the surrounding material. Some of my own research is devoted to finding ways of minimising this induced radioactivity. Recent studies show that it is likely that the radioactivity due to fusion reactors will be substantially less

than that associated with fission reactors.

After the problems of making fusion reactors have been solved, it will be a long time before fusion power becomes a reality. Preliminary studies are already in progress, but it will be several decades before the first fusion power station is built. Hopefully they will be contributing substantially to world energy needs in the latter half of the next century.

Thus it seems that nuclear power in its three main forms, thermal, fast and fusion, is well able to supply the foreseeable world energy needs. Whether it will is not just a matter of physics, technology and economics, but also of politics, and this will now be considered.

It might well be considered Providential that nuclear power was developed just in time to take over from oil as the main source of the world's energy. Coal, the only major alternative, is increasingly recognised to be seriously polluting, and the other energy sources, though important in various ways, are unable to produce energy in the quantities required.

Yet, instead of thanking God for this new source of energy, and devoting all our efforts to making it generally available, especially to the poorer countries of the world, we find widespread apprehension and determined opposition.

Initially, in the nineteen fifties, nuclear power was welcomed with enthusiasm. Scientists lectured and wrote articles explaining the new source of energy, and were assured of a hearing. The engineers mastered the technology of nuclear power and set to work to build nuclear power stations. In a few decades nuclear power was producing more than half the electricity of Western Europe, and there were large nuclear power programmes in many countries, especially in the United States.

As in any large new enterprise, there were mistakes due to ignorance and carelessness, and several serious accidents. But taken as a whole, the record of the nuclear industry has been very good, and nuclear reactors are quietly providing much of the power we need. It is undoubtedly here to stay, and will steadily increase its contribution to world energy needs in the future.

Why then such determined opposition? As already mentioned, some of the reasons are association with the bomb, the unfamiliarity of nuclear radiations, and the reports of leukemia cases near nuclear installations. Another reason is the sensationalism of the mass media. It is so much more interesting to read about radioactive horrors than the boring and unintelligible explanations of the scientists.

The accident at Three Mile Island and the disaster of Chernobyl certainly loom large in the public mind, giving rise to the fear that at any moment a nuclear reactor may run out of control, with deadly consequences. The Chernobyl disaster was partly due to a bad design and partly to operator

incompetence and flagrant disregard of the operating instructions. The reactor was designed to produce plutonium for weapons as well as power, and was built in a hurry. In certain operating regions it was thermally unstable, a feature that would never be accepted in the West. The political climate prevented the Soviet Union from making full use of international expertise in reactor design, and the pressure to build rapidly prevented internal protests.

On the evening of the accident the operators wanted to make an experiment at low power, in the unstable region. They were afraid that the reactor might automatically cut out and spoil their experiment, so they switched off the safety devices. To make their experiment they removed more of the control rods than permitted, and disaster followed. The design of the reactor should never have allowed such actions. It was a disaster that should never have happened, and it is attributable more to politics than to technology.

Politics is indeed one of the strongest forces behind the opposition to nuclear power. A coal strike brought down the Government of Mr Heath, but the subsequent attempt to bring down the Government of Mrs Thatcher failed, largely because of the nuclear power stations. If you want to maintain the political power of the coal miners, then you hate nuclear power.

There is also an international dimension to the opposition to nuclear power. Western Europe is heavily dependent on imported oil, so it could be brought to its knees by interrupting the oil supply. Nuclear power could gravely hinder this strategy, so it must also be attacked. Recent political developments have indeed undercut most of this strategy, but its effects remain.

These are some of the motivations behind the relentless media campaign against nuclear power, the continual scares about nuclear radiations, the spectre of nuclear accidents, and the hysteria about nuclear waste. On the other hand, there are optimistic stories about wind and solar power, which are relatively hazardous, unreliable and damaging to the environment.

There have been other major disasters like Bhopal, Piper Alpha, Torrey Canyon and Lockerbie, but it is never suggested that industrial development, oil power or air travel should be abandoned. Yet after Chernobyl several countries voted to phase out nuclear power, before finding this policy to be impracticable.

What is needed is simply a careful assessment, in each country, of its energy needs and the best ways of satisfying them, taking into account the capacity, cost, safety, reliability and effects on the environment of all possible power sources.

It is tragic that the campaign against nuclear power gravely hinders this

process. We are all the losers. If the correct decisions are not taken, energy is more costly, pollution is increased, the environment is destroyed and lives are needlessly lost. As always, the chief sufferers are the poor of the world. As the price of oil rises, they can no longer afford it and have to spend much of their time gathering fuel to cook their food. Valuable organic matter is burnt instead of being returned to the land, the soil is impoverished and becomes desert.

In Britain, our national priorities are distorted by what is called the nuclear debate. Large sums are spent on marginally improving the safety of Sellafield, whereas the same amount of money, spent for example on improving motorways, could save many more lives. There is strong opposition to the burial or sea disposal of low level nuclear wastes, but no proportionate concern about pollution by coal power stations and other industries. It is ironic that coal power stations emit more radioactivity than do nuclear, but that is never mentioned. Scientists who advocate more balanced policies cannot get a hearing. Environmentalists have yet to realise that of all power sources, nuclear has the least effect on the environment.

These arguments about relatively minor hazards of nuclear power distract attention from the really important problems concerned with how we are to obtain enough energy to maintain our standard of living into the next century, and, even more important, how we can help poorer countries. Some of the largest cities in the world are to be found there. How are they to get their energy without nuclear power? How can it be paid for, and how can the design and operation of those power stations be controlled so as to ensure safe operation without infringing their sovereignty?

The Churches could play an important role by encouraging objective studies that take full account of the scientific data. This was done by the Pontifical Academy of Sciences when it convened a meeting of experts at the Vatican in 1980 to study world energy needs and resources. The conclusions of this study were presented by the Holy See to the International Atomic Energy Conference in Vienna in 1982, and in his speech the Head of the Delegation, Mgr.Peressin, emphasised the urgency of the problem and recommended that 'all possible efforts should be made to extend to all countries, especially to the developing ones, the benefits contained in the peaceful uses of nuclear energy.' A further meeting on energy for survival was held in 1984. The concern about pollution by coal power stations and other industries. It is ironic that coal power stations emit more radioactivity than do nuclear, but that is never mentioned. Scientists who advocate more balanced policies cannot get a hearing. Environmentalists have yet to realise that of all power sources, nuclear has the least effect on the environment.

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Largely due to the influence of a prominent anti-nuclear campaigner, eminent in a non-scientific discipline, the Catholic Press in this country (with the honourable exception of *The Month* under the wise editorship of Mr Hugh Kay) failed to encourage informed discussion of the energy crises and nuclear power in the light of Christian principles. Instead, it has done little more than repeat the errors of the mass media, nearly always refusing a hearing to scientists when they tried to correct them. The Churches thus missed a great opportunity to contribute to the welfare of society, which they could have done simply by providing a forum for the truth.

An immense amount of damage has already been done. Eventually, as the effects of pollution become more evident, when our industrial competitors outstrip us with the help of cheap nuclear power, when poorer countries plunge further into famine because we have selfishly used up their oil and neglected to help them directly, then we will see clearly the effects of the antinuclear campaign. It is possible to ignore the realities of life for a while, but eventually there is an awakening, and the slower it is the greater the cost. Our children and grandchildren, if they survive, will suffer the consequences of our folly.

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