

INTRODUCTION

All over the world people are realising more and more clearly that the increase of population and the growth of industries are seriously threatening the environment. The more people there are, the more energy will be needed, and this means more factories, more power stations, and therefore more pollution. We are gradually poisoning the earth, and if it dies, then we all die. We just cannot go on like this. If we are to survive, there are limits to the growth of population and living standards, and if these are forgotten our planet will be poisoned forever. In addition there is the possibility of world-wide climate change, with effects that are difficult to foresee.

This book is concerned with all these problems that are of vital importance for everyone. We are all dependent on energy to cook our food, to make our clothes, to light and heat our homes, to drive our transport and communications and to provide power for our factories. How best can we obtain the energy we need, with the least damage to the environment? There are some energy sources that have been used since time immemorial, while others have been developed only in this century. All consume the resources of the earth to a greater or lesser extent and all affect our surroundings, the air we breathe, the water we drink and the food we eat. Can we obtain all the energy we need without polluting the environment to an unacceptable extent? And if not, can we reduce our energy consumption sufficiently to avoid catastrophe?

An attempt to answer these and related questions raises many scientific, technological, sociological, political and moral questions to which there are no easy answers. For example, how much of the earth's resources should we use for ourselves, regardless of the possible needs of future generations? Should we go on producing energy in ways that pollute the atmosphere? Should industrial companies be allowed to devastate the landscape? These and many similar questions are inter-related in many ways that differ from one country

to another. Most of them raise moral questions that have been insufficiently studied.

Considered simply as an academic exercise, these are very difficult and complicated problems. Any attempt to solve them in an objective way is however made far more difficult by the reactions of those likely to be affected by any decision. Manufacturing companies naturally want to concentrate on making and marketing their product with maximum profitability, and until recent years have not been much concerned about the effects of their activities on the environment. If it is proposed to establish a repository for noxious waste, no one wants it to be sited near their home, whatever assurances they receive concerning its safety. Increasingly, all such activities are regulated by laws, and public enquiries are often held to try to find the best course of action. Inevitably these are confrontational and lead to fierce controversies, invective and propaganda. It is usually easy to make an apparently impressive case both for and against any proposed development. All this makes it more than usually difficult to reach an objective judgement.

In such circumstances it is more than ever necessary to make clear from the start the principles and methods that will be used to try to answer these questions. It is not of course possible to give complete answers: there are many areas of legitimate disagreement and other areas where the best course of action can only be decided when more facts are available. It will become clear, however, that there are other areas where enough is known to show that some proposed solutions are certainly impracticable. The acceptance of such areas of established knowledge is a precondition for responsible discussion in the areas of legitimate uncertainty. Unfortunately, however, the force of propaganda has largely prevented the attainment of consensus in the areas of established knowledge so that much contemporary discussion is worse than useless. This naturally has serious implications for the future of our society, as it makes it much more difficult for Governments to reach responsible decisions.

How can it be ensured that the discussion of these problems takes place realistically, respecting what is already known? We can begin by accepting, at least provisionally, what has been written by real experts on each subject, that is people who have the necessary qualifications and have devoted years of study to the question. Especially useful are the reports of national and international committees of experts. This is a good beginning but it is not enough. Such documents often deal with only one or a few aspects of a problem or are concerned with a limited geographical area. They inevitably become dated,

and are not immune from political influence. We also have to be aware of the existence of pseudo-experts, that is people with sufficient scientific knowledge to give their writings a spurious authority, who pose as energy consultants and write very plausible but politically-biassed articles for pressure groups who use them to enhance the credibility of their propaganda.

To assess and relate these studies we can apply the criteria of internal consistency and conformity with known physical laws. This may indeed seem obvious but it is a common experience to find proposed solutions that conspicuously fail to satisfy this requirement. The importance of quantitative analyses cannot be sufficiently emphasised. Whenever any solution is proposed, it is essential to insist on numerical data, supported by statistical analysis. Without numbers, it is impossible to assess the importance of competing factors. Very often one finds general statements, based on a few events or qualitative data, making an apparently impressive case that collapses as soon as some numbers are introduced. The numerical data used may not be very accurate, but providing we have some measure of the likely uncertainty it is infinitely better than no data at all. Without numerical data, vital arguments are at the mercy of emotional propaganda. For example, we are exposed to many hazards in our everyday lives. Studies have shown, however, that people are often concerned about statistically negligible risks, while thoughtlessly exposing themselves to relatively serious risks.

Much of the discussion concerns what we should do now to bring about some desired result, or to avert some calamity, in the future. We are thus inevitably drawn into trying to predict what is likely to happen on the basis of our present knowledge, and such extrapolations are fraught with hazards. What will be the population of the world in fifty years' time? What will be the energy demand then? Will the future climate changes continue to follow the trends of the last few decades? Will some new energy source be discovered? No one knows the answers for certain, so we have to make the best estimates that we can. Many such estimates are quoted, and there are inevitably some inconsistencies among them, and these have been allowed to stand as a measure of the existing uncertainties.

A further difficulty is that in most cases the data required for a well-based decision do not exist, but if we wait until we have enough data it will be too late. Events will not wait for us; we have to decide now. In some cases it may already be too late. It may sound very reasonable and responsible to say that we must wait until we have enough evidence to be sure that we can make the correct decision, but in reality this is a totally unreasonable and

irresponsible way to behave. This is not an unfamiliar situation: most of our lives we have to decide what to do now on the basis of incomplete knowledge, and then live with the consequences. The option of doing nothing is often the most dangerous of all.

It must also be realised that not all problems have unique solutions. Energy can be provided in a number of ways, each with several advantages and disadvantages that have to be balanced against each other. The analogy of balance, however, is inappropriate because they are usually incommensurable. How can one balance cost against safety, or reliability against effects on the environment? This is one of the areas of legitimate debate, and people with different priorities may come to different conclusions. In addition, the energy needs and resources, to say nothing of the cultural values, differ from one country to another, leading to different decisions in similar situations.

It is particularly important to recognise that every energy source has its cost, not only in economic terms but in terms of safety and effects on the environment. There is no perfectly cheap, safe and harmless energy source. It is therefore highly misleading to call for perfect safety and then to argue that because a particular source is not perfectly safe, therefore it must be rejected. Although frequently heard, such demands are dangerous and irresponsible.

There is also the possibility of some new energy source that may transform the whole situation and solve all our problems. This is extremely unlikely, at least on the short term, and the deployment of a new energy source takes many decades before it begins to make a substantial contribution to world energy needs. There have been no fundamentally new energy sources since the discovery of nuclear fission about sixty years ago, and this is still far from being fully used. Nuclear fusion is still to be demonstrated as a viable option. Thus the only responsible way to tackle energy problems is in terms of known energy sources.

Finally, who is to make the decisions? In most cases it is the responsibility of Governments to formulate and implement an energy policy. This is not without dangers, as politicians are often concerned more with the next election than with the next generation. It takes five or ten years to build a power station, so the timescale of energy policies is much greater than the interval between elections in many countries. There is thus a serious danger that Governments will favour short-term solutions with the lowest cost, ignoring the harmful effects that may not appear for many decades. Governments are also very sensitive to the demands of pressure groups that frequently seek by

false and emotional propaganda to influence how people think and how they vote. This may force a Government to take decisions that it knows to be wrong in order to placate public opinion.

This tension between short-term and long-term solutions to problems is quite general. It is natural for politicians to seek solutions to the immediate problems and ignore long-term ones. They do not want to spend money on projects that will reap benefits only in the next generation; they want to gain votes by doing things with immediate results. This is a serious defect in our democratic system, and it would be wise to form an all-party body with the responsibility to look further into the future. The perspective of this book is certainly long-term, though short-term effects are also mentioned.

Some energy problems such as pollution are international, because emission of toxic gases in one country can cause damage in another. The economic effects of energy decisions are often felt world-wide. Such problems have to be tackled on an international level such as that of the United Nations.

If all the decisions are taken at the Governmental or super-Governmental level, then what is left for us to do? In the first place we can play our part in a democratic society and urge that responsible energy policies be followed. We can see that we are not misled by pressure groups and do what we can to reduce their influence. Secondly, we can examine our own life-styles and see if we can reduce our energy consumption and avoid polluting our surroundings.

Scientists and other qualified people have a special responsibility for, depending on their expertise, they have a greater insight into scientific matters. University scientists are particularly well-placed to contribute to the public debate on energy matters, as they are employed neither by the energy industry nor by a political organisation. It must however be admitted that most of the contributions of scientists to the energy debate are neither welcomed nor appreciated, thus allowing errors to flourish unchecked.

The first step in a study of energy problems is to estimate the energy need, and the second is to see how this need can be met. The need depends on the number of people and the energy that each needs. We therefore begin by studying in Chap. 1 the population of the world and the way it is expected to grow in the future, and also the energy consumption. Both the rate of change of population and the energy consumption vary greatly from one country to another, and these differences are a vital part of the energy crisis.

Having established the need, the next step is to see how it can be met. There are many sources of energy that have been used throughout history.

Until the present century, the most widely-used sources were wood, and then coal, followed by oil and natural gas from the middle of the last century. These three traditional energy sources are discussed in Chap. 1. All these energy sources consume material that cannot easily be replenished, in the case of wood, or cannot be replenished at all, in the cases of coal, oil and natural gas.

The information we have on existing and projected energy supplies from these sources indicates that they will increasingly be unable to satisfy our energy needs. Unless new energy sources are developed, there is the likelihood of a serious energy shortage in the not-so-distant future. Since it takes a long time to develop new energy sources, action must be taken now. This is the basis of the energy crisis.

A possible solution is to reduce energy demand by conservation measures, but this will not make available sufficient energy to meet world-wide needs. It is therefore a matter of urgency to look at all possible energy sources to see if they can provide the energy we need. A very attractive option is to use the renewable energy sources such as hydroelectric, wind, wave, solar and geothermal that are practically inexhaustible, and these are considered in Chap. 2.

For different reasons, these renewable energy sources seem unlikely to be able to supply all our future energy needs. Another energy source is the nucleus of the atom, in particular the fission of the nuclei of some heavy elements, and this is discussed in Chap. 3. Another possibility, not yet realised but of great potential importance for the future, is nuclear fusion, and this is also discussed in Chap. 3. The safety of the fission reactors is discussed in Chap. 4.

All these possible energy sources must be examined to see what contribution they can make to our energy needs. To do this as objectively as possible, they must be evaluated according to their capacities, reliabilities, costs, safeties and effects on the environment, and this is done in Chaps. 5 and 6. There are many other threats to the environment, and these are also considered in Chap. 6.

Faced with the energy crisis and the threats to the environment it is desirable to outline our future energy policy. Should we abandon nuclear power and develop the renewable sources? Should we replace our polluting fossil fuels power stations with nuclear power stations? Or is there perhaps some intermediate policy? These questions are discussed in Chap. 7.

It is not sufficient, or even possible, to decide in an objective way what is the best solution to the energy crisis. The very criteria that are used depend on decisions that may well vary from one country to another, such as how much we are willing to pay for safety and to reduce the harm to the environment. There

are many important issues where the scientific evidence is far from conclusive. Furthermore, even when the energy policy is agreed, there are still the political problems of putting it into operation. These are discussed in Chap. 8.

More fundamentally, all the problems related to our energy needs are moral problems, and the way we tackle them depends on our beliefs concerning the purpose of life. Are we free to plunder the earth to satisfy, not only our needs, but our pleasures and amusements, when poor people are starving? Should we care whether the pollution from our factories kills fish and trees in other countries? Do we have the responsibility not to bequeath to future generations a poisoned and exhausted earth? Our answers to such questions depends on our beliefs, and are discussed in Chap. 9.