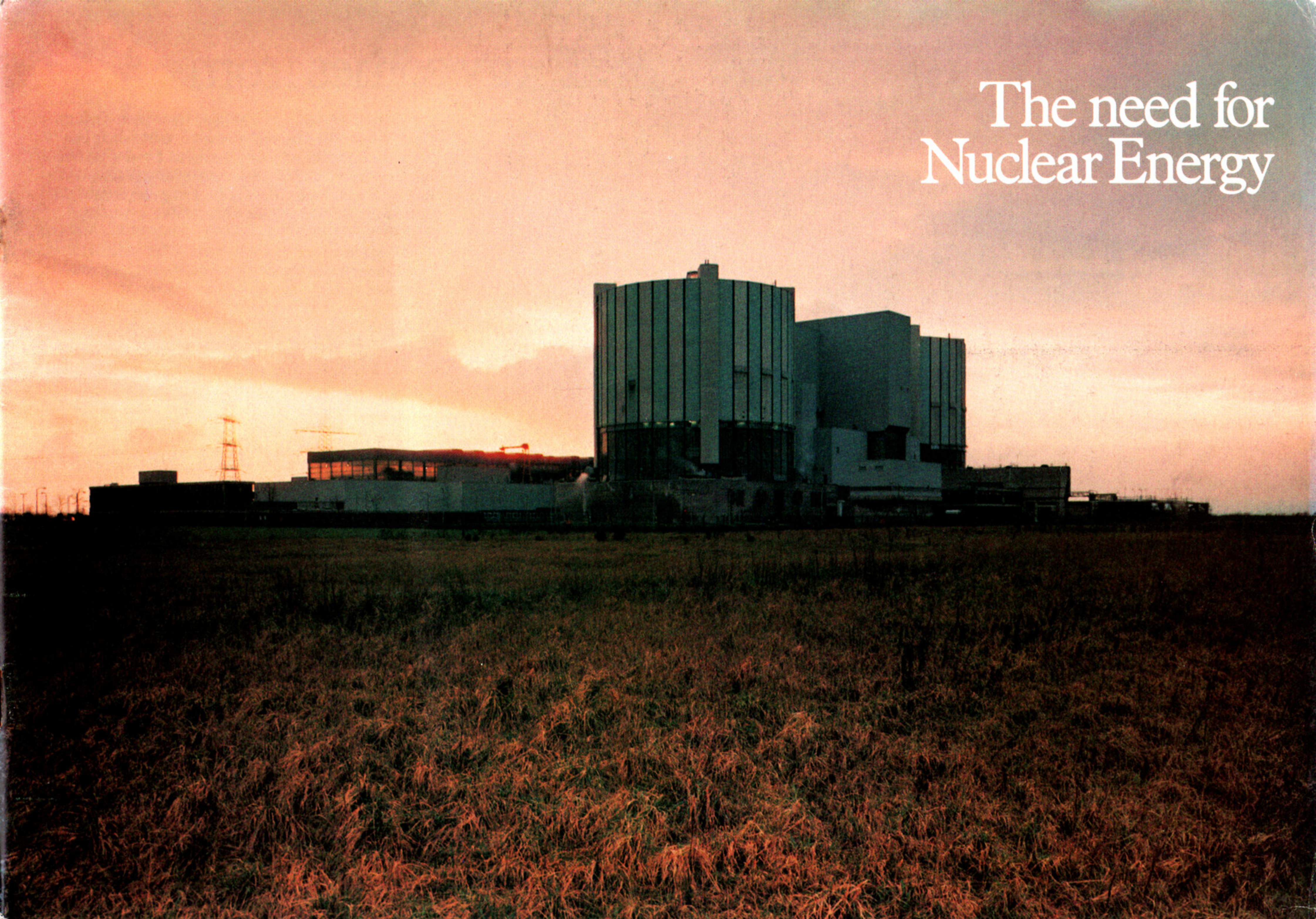
The need for Nuclear Energy



Where our energy comes from

If we work hard or play hard we become hungry. We need food to restore the energy we have used up. Food is the fuel our bodies need to keep going.

Our country is also a body that needs fuel to keep it going. It needs fuel to provide the energy for keeping warm, for moving about, for giving light, for making the things we need, for making household jobs easier, for entertainment and for much else.

As a community of people living together we could no more do without fuel than an individual person could do without food. If we had less than we needed we would be uncomfortable and if we had none at all we would die.

Just think for a moment what life would be like if we ran out of fuel or if we did not have enough for our needs. All sorts of things we take for granted would have to stop. We would not be able to travel by train, bus or car. Aircraft would be grounded. Factories would stop work. The shops would be empty. We would sit in cold rooms with no electric light and no television.

Life would slow down and our country would be like a body without food.

Today we get the fuel we need from a number of different sources. By far the greatest amount comes from coal, oil and gas. These are called fossil fuels because they were created by plants and other living matter millions of years ago.

Then there are the natural sources of energy, the fuel we get by harnessing water, wind and sun. At one time, when we needed much less fuel than we do now, water and wind were very important sources of power. Waterwheels supplied the power for factory machines and windmills ground the farmer's corn. But nowadays only a very small proportion of our energy comes from water power, hardly any from wind power and just a little from the heat of the sun.

The other important fuel is nuclear energy. Nearly one-seventh of all the electricity we use in Britain today comes from nuclear power stations. We would be in real trouble without them.

There is good reason for using all these different fuels. They all have advantages – but they all have problems too. When we consider what fuels to use we have to think very carefully and think for a long time ahead. Developing new sources of power takes huge amounts of money and sometimes many years. Making the wrong decisions could leave our country dangerously short of fuel in years to come.

You might think it would be sensible just to decide to use whatever fuel is cheapest now. But the cheapest fuel might soon run out – and then other fuels would be even more expensive than they are now and we should be worse off.

We also have to consider risks. Some fuels carry more risks than others of injuring us or damaging the world we live in. So we have to weigh up the advantages and disadvantages of each type of fuel when we plan for the future.

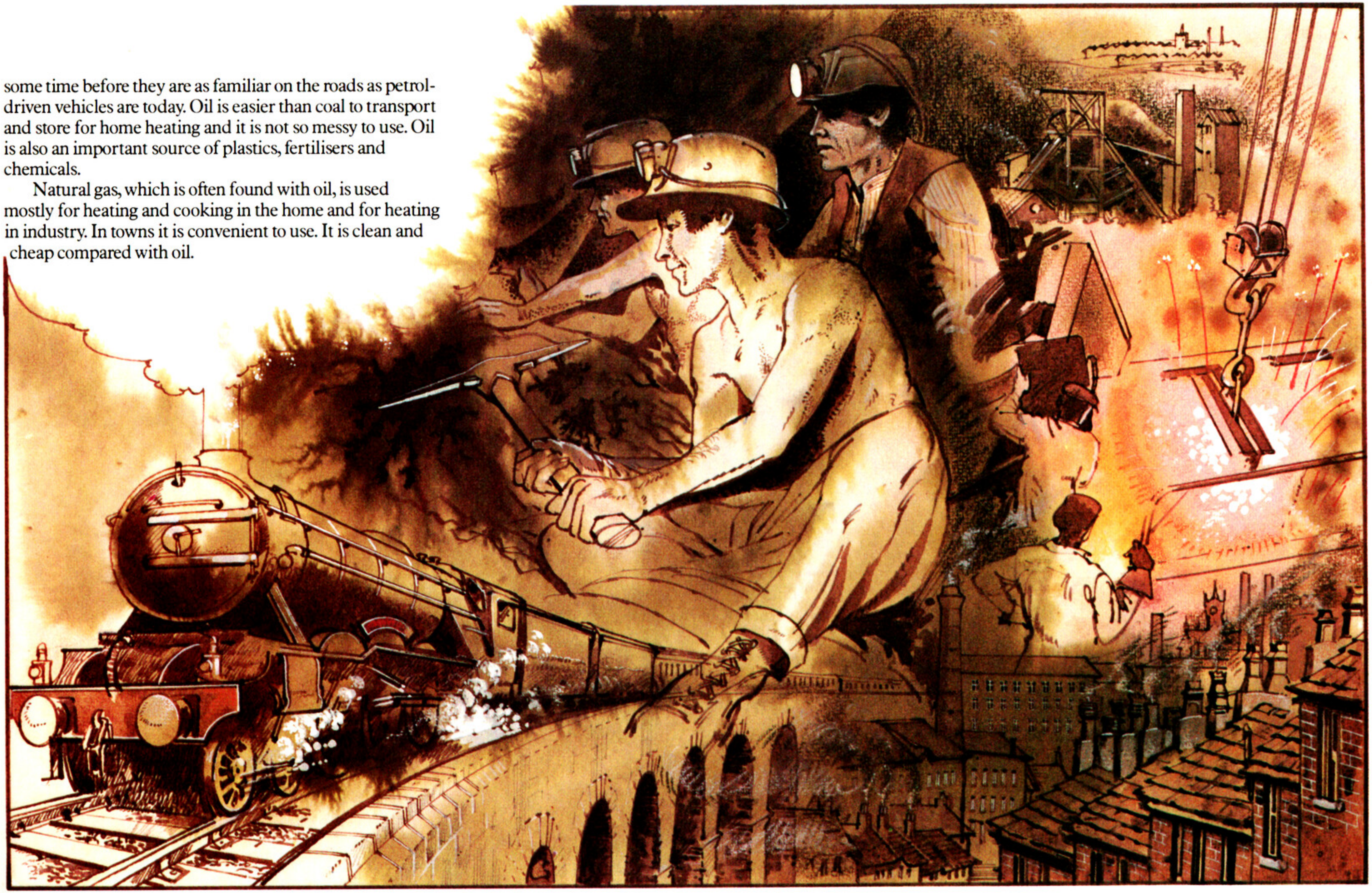
Fossil fuels – coal, oil and natural gas – are the fuels we use most today. Most of the electricity we use comes from the coal-fired power stations and coal is also used for furnaces in industry and for central heating in homes.

Coal is Britain's traditional fuel. We have been mining it for centuries. It was the fuel that made Britain a great industrial nation. A century ago, coal fired the furnaces of our iron and steel works. In the age of steam our railways ran on coal. Coal fires burned in our homes and millions of chimneys blew out smoke and soot to poison the air and blacken our buildings.

Although it is not the cheapest fuel for generating electricity it is readily available at present. And we now have ways of cleaning the smoke before it is let out into the air. So coal must have a big part to play in providing the fuel we need for the foreseeable future.

Oil is the fuel we use for running buses, lorries and cars, for our aircraft and many of our trains. We use it also for home central heating, in industry and for generating electricity. Its most important use is for vehicles and aircraft because at present it is almost the only fuel we have for them. There are a few electric vans and cars but it will be some time before they are as familiar on the roads as petrol-driven vehicles are today. Oil is easier than coal to transport and store for home heating and it is not so messy to use. Oil is also an important source of plastics, fertilisers and chemicals.

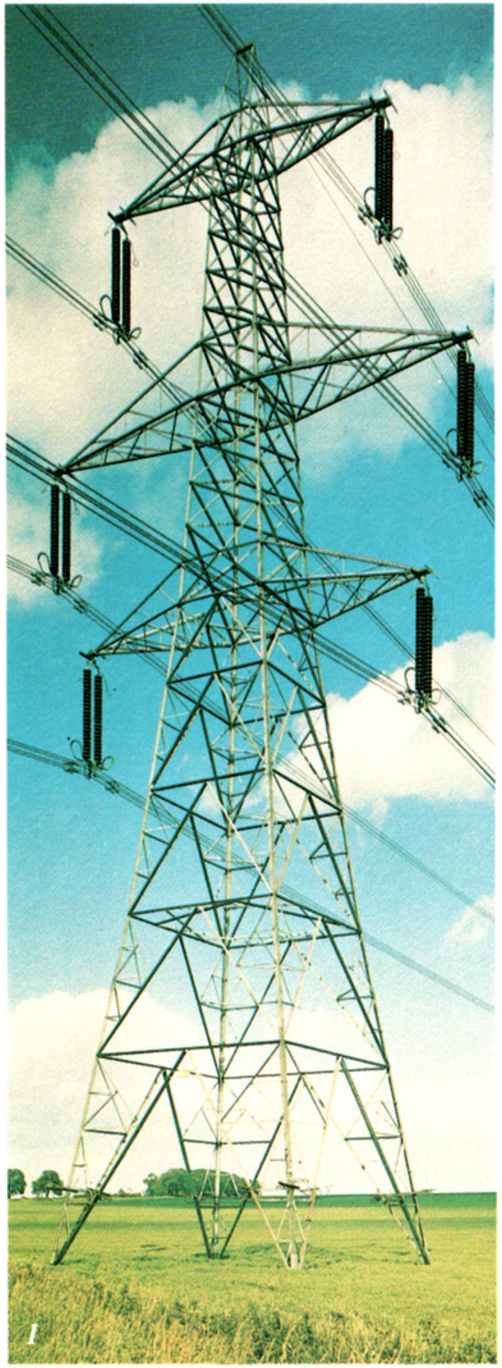
Natural gas, which is often found with oil, is used mostly for heating and cooking in the home and for heating in industry. In towns it is convenient to use. It is clean and cheap compared with oil.

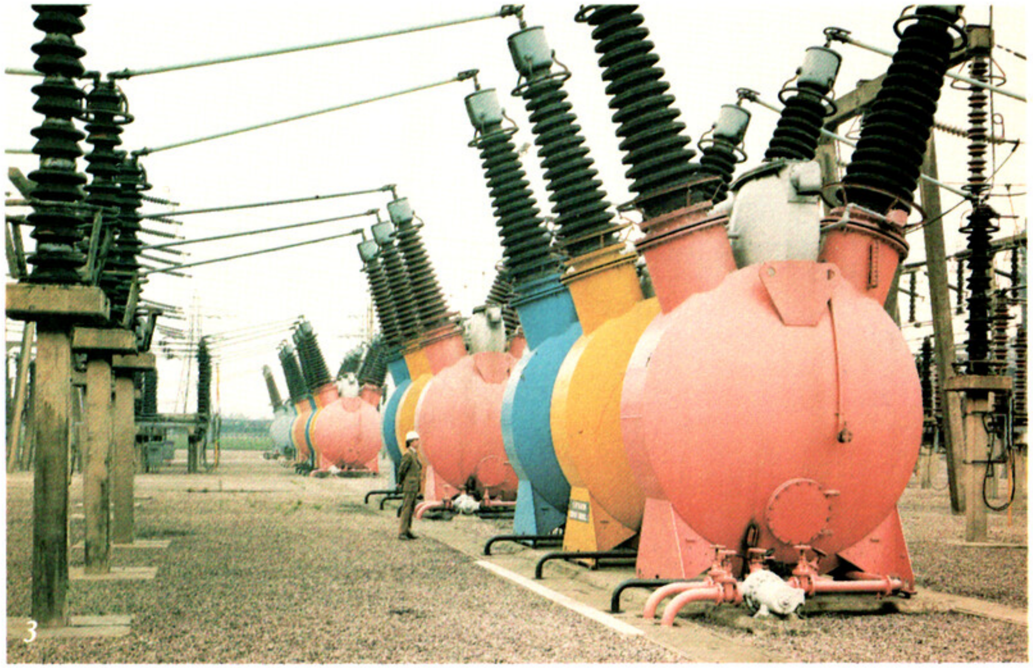


1. 400 kV suspension towers on the CEGB's Sizewell — Sundon transmission line. This view shows the cultivation of crops under and around the towers.

2. The CEGB's 1,980 MW coal-fired Drax power station near Selby in Yorkshire. Coal is delivered by rail and an average of 18 trains, each carrying 1,000 tons of coal, are required every day. The station has an 850ft chimney, the largest multi-flue chimney in the world and the tallest in Europe. Drax also has six 375 ft cooling towers.

3. Bulk oil circuit breakers in the 275 kV substation at Willington power station near Derby.



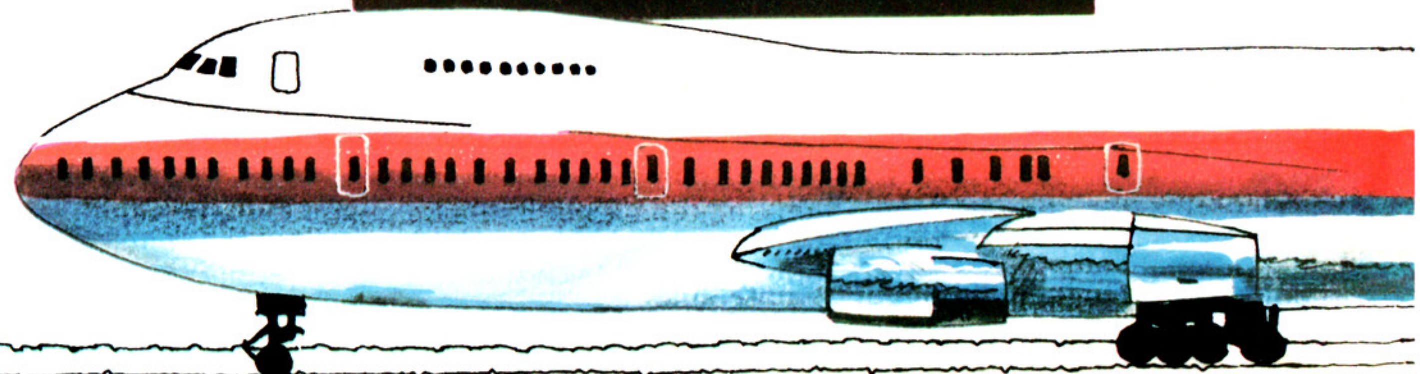


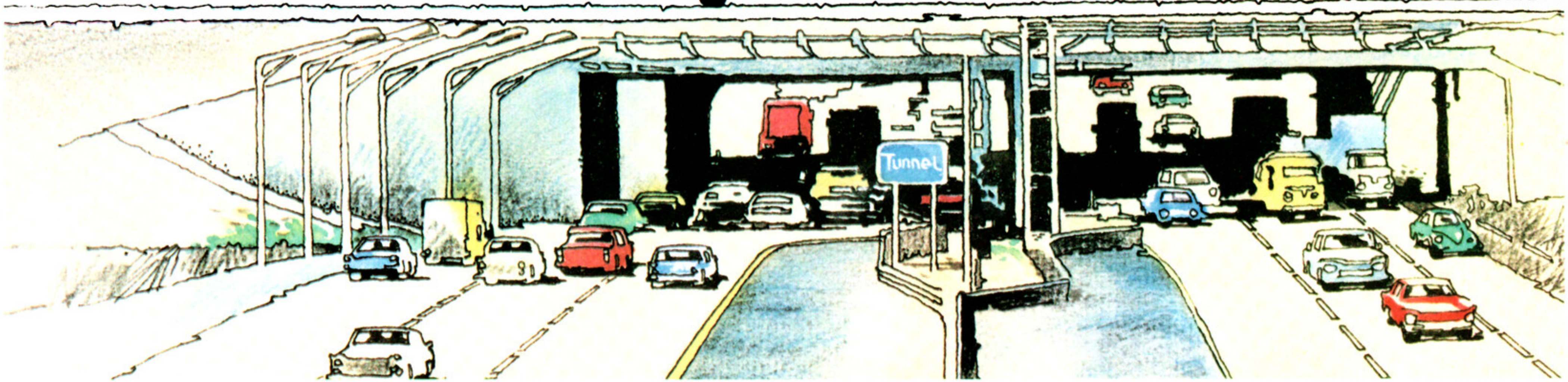
All these fossil fuels, though, have disadvantages. We know about the dangers of mining coal. About sixty men die and about five hundred are injured every year in Britain in coal-mining accidents.

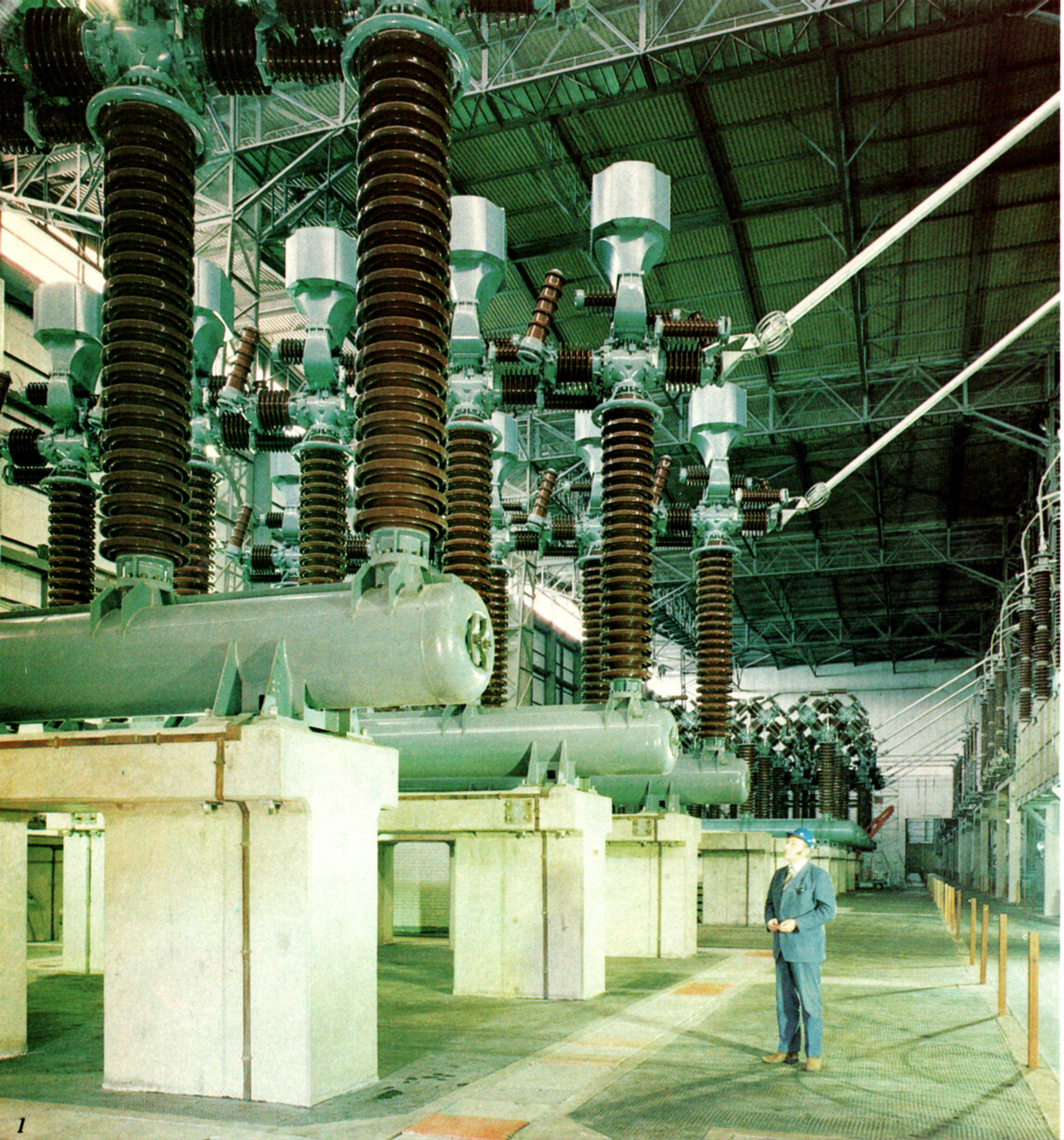
There are also hidden dangers in these fuels which may affect the lives of all of us. Inefficient coal, oil and gas fires and boilers pollute the air we breathe to such an extent as to cause diseases like bronchitis. We started to ban the burning of coal in open grates at home in 1956 and the air in Britain's towns has been much cleaner as a result. Buildings are no longer being blackened by soot.

Some scientists have quite a different objection to using coal and oil for fuel. When coal is burned as a fuel, many useful products are wasted in the smoke. Properly processed, this smoke or 'volatile matter', can provide ammonium sulphate for fertilisers, motor spirit, raw materials for plastics, man-made fibres, insecticides and disinfectants. All these are provided when coal is heated to make coke and coal gas as well as creosote and road tar.

It has even been suggested that one day we will be eating fossil fuels! No, not lumps of coal instead of potatoes or oil instead of gravy. But from oil we can get valuable protein, an important element of food. This is already being done to make animal feeding stuffs and oil can also yield food for humans.







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With millions more mouths to feed in the world every year, these scientists tell us, we are destroying badly-needed food when we burn coal and oil.

Even if fossil fuels had no disadvantages we would still have to be thinking of ways to replace them. We are using them up at a great rate and when they are gone they will not replace themselves. If we go on using coal at the present rate it may last another two or three centuries. But the North Sea oil wells, which can provide for our needs for the next few years, will start to run low in quite a short time. They may be very low in thirty years or so.

In other parts of the world there is already not enough oil to go round. We are lucky to have it now because it gives us time to think of something else. But unless we *do* think of something else a day will come when our cars and lorries run out of petrol.

1. Interior of the 400 kV indoor substation at Pembroke's 2,000 MW oil-fired power station in South Wales.

2. One of the two 500 MW turbo-generator units at Ironbridge B coal-fired power station in Shropshire. Both turbines are of the single shaft, five cylinder, reheat design.

What about the natural sources of energy, then – water, wind and sun? Whatever other problems there may be with them, they are never going to run out. The rivers and tides will always be flowing, the winds will blow and the sun will shine. That's why many people see them as the great energy sources of the future.

If only we can harness their boundless energy we can have all the power we could possibly want, for ever. No matter how much we use, these marvellous free sources of energy will always be there to serve us.

There'll be nothing to burn, no pollution of the air, no worries about what we might be doing to the climate. These natural forces must be the perfect answer to all our fuel problems!

So they may be, some time in the future. Countries which have swift-flowing rivers and waterfalls have already harnessed them to produce electricity. Niagara Falls, for instance, is not just a tourist sight. The Niagara River provides the power for a very big electricity generating station.

Where nature has neglected to provide Niagaras, engineers have built great dams to create waterfalls to operate power stations. We have some of these in our own mountain areas in Scotland; but most of our rivers are a bit too placid for this treatment.

Our best hopes of water power lie in the tides which wash our shores twice a day and the great waves which roll in from the Atlantic. We can get power from the movement of the tides by building power stations so that the rising and falling tides make the generator turbines revolve. We could also build structures to float in the sea and transform the movement of the great Atlantic rollers into energy to generate electricity.

The trouble is that we do not yet know how to do these things cheaply or simply enough. We know these things can be done and we know ways of doing them. But it may be many years before we can harness water so easily and neatly that it will again be an important source of power, as it was when water turned the wheels of weaving mills.

Wind has been a source of energy for many centuries. Wind power was harnessed to grind corn and pump water and propel ships across the oceans of the world. Some people think that windmills could be useful again and that we should even go back to sailing ships to save fuel.

Both windmills and sailing ships are nice to look at and it would be pleasant to think of them in use again. Big new windmills and cargo sailing ships have been built to try out these ideas. But even if we do find new uses for wind – or rather, go back to old ones – it looks as if wind will never be a very big source of energy for us.

Of all the natural sources of energy the sun is the one with the greatest possibilities for the future. Streaming away from that immense source of heat and light is all the energy we shall need for ever. If only we could find a cheap and simple way of using it we might never have to worry about fuel again.

We have made a promising start. Space travellers use solar panels which rely on heat from the sun and perhaps we can adapt the idea to everyday use. We can put solar panels on the roofs of our houses to catch the sun's rays and use them to heat water.

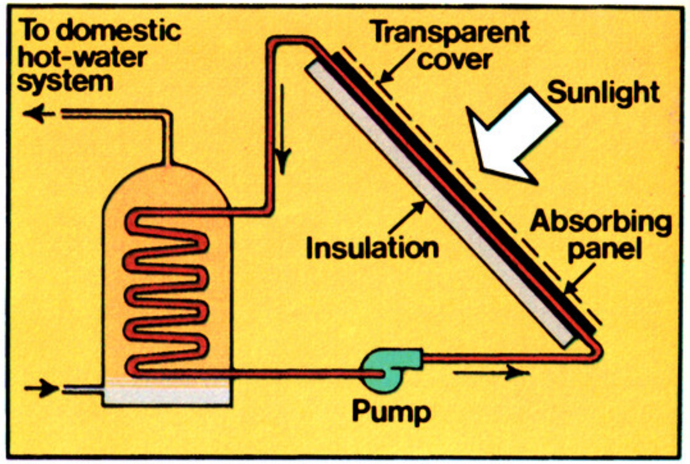
But so far all the ways of using solar energy we have invented are very expensive or not very effective. And of course it does not help us to know that there are many days when the sun does not appear – not to mention nights!

In order to find the best way to release and use the abundant energy the sun can give us, our scientists will have to work very hard for a long time and our Government will have to spend a vast amount of money. It will be money well spent and there is certainly a big future for solar power. But we will not get much energy from the sun for some years to come.

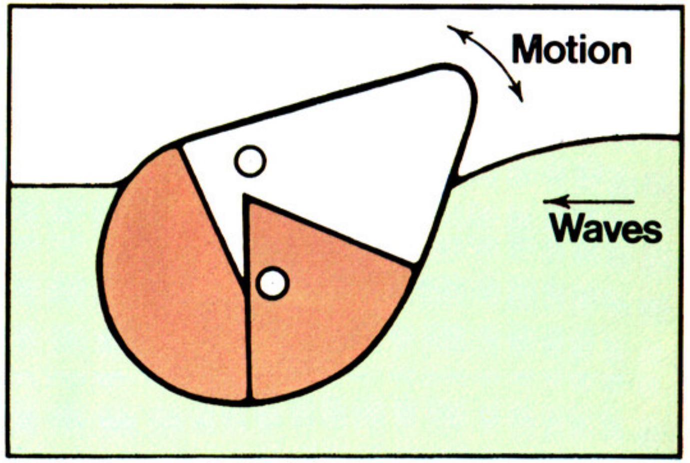
Another way in which we can seek help from the sun is to try to produce energy for ourselves in the same way that the sun gets its energy. This is by means of fusion, or melting things together under great heat. In the immense heat of the sun, light atoms are fused together to form heavier atoms. In the process an enormous amount of energy is released. If we could bring about a similar fusion of light atoms the energy released could provide us with almost unlimited power.

Research on fusion is going on in many countries, including Britain, but it will be years before we shall know whether we can employ a fusion process to generate electricity cheaply enough to be useful.

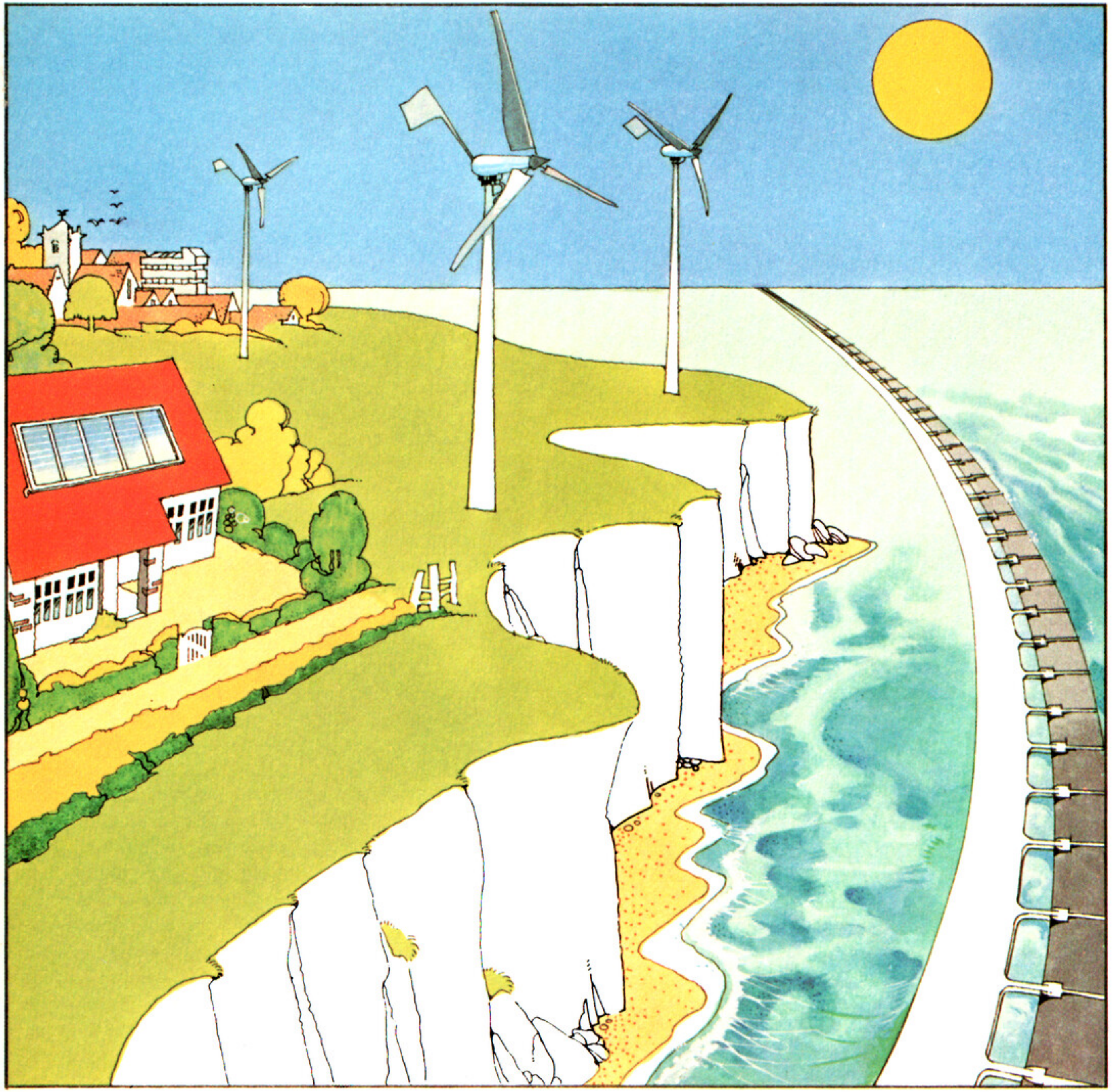
When we think about how much fuel we are going to



Heat-absorbing roof panels are already used in many parts of the world for boosting domestic hot-water temperatures. In this schematic arrangement, the transparent cover serves to retain the heat in the manner of a greenhouse. It is possible for over half the incident energy to be transferred to the circulating water, at temperatures up to 50°C



To absorb power efficiently from a wave, a float must have a front surface that moves with the water of the oncoming wave and a back surface that does not disturb the water behind. The cross section shown here is one that meets these requirements well. The float rocks about a central point and has a circular rear section with a front section that is partially circular, but merges into a plane section at about 15 degrees to the vertical in still water.



need in a few years' time and add up all the fuels of different kinds that we have, there's a gap to be filled somehow. One way to fill the gap would be to find more fuel. Another way, certainly cheaper, would be to reduce our requirements by economising. Most of the fuels we now use are going to become scarce in a few years time. Yet every year we demand more fuel than we used the year before.

If we made better use of the fuel we have we could save quite a lot of it. For instance, in many houses much of the fuel used for heating is wasted because the warmed air just disappears through cracks. Stopping up all the cracks, double-glazing the windows and lagging the loft and the hot water tank can save a useful amount.

There are many other ways in which fuel is wasted – driving cars faster than we need to, for instance, or flying big aircraft nearly empty. If we had to, we could manage on much less fuel than we use now without sacrificing anything we really need. Poorer countries would find it much more difficult to use less energy, however, because they use so little now. The difference these savings can make is important and worthwhile but they are unlikely to be sufficient in themselves. And economies will not alter the fact that the coal and oil we *do* still use can have harmful effects.

Nuclear Energy

One source of power that is important today as well as having a big future is nuclear energy. We use this to generate electricity in power stations. The fuel used is the metal uranium. When this is placed inside graphite blocks a process called nuclear fission takes place. Small pieces from the central parts of atoms fly off and bang into other atoms, which split up and release other small pieces to continue the process. All these collisions and splits give off energy in the form of heat. This heat turns water into the steam that drives the turbines of an electricity generator.

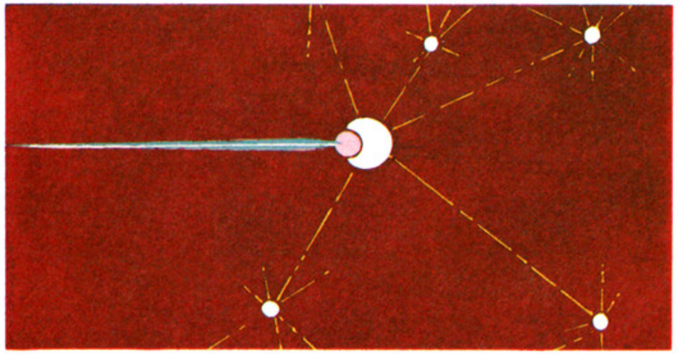
Uranium for nuclear power stations comes from mines in different parts of the world. Deposits of it which can be mined cheaply are limited. We know there are deposits of uranium in Britain but it is not of such good quality as the uranium we get from abroad.

If we continue to build nuclear reactors of the kind most commonly in use today, we may one day have difficulty in supplying them with the uranium fuel they need to keep going. However, a new type of nuclear reactor, called a fast reactor, has been developed. This uses only one kilo of uranium for every fifty or sixty kilos used by the present generation of reactors. In Britain we already have one fast reactor of the new type. If we build more reactors of this type we can make the world's supplies of uranium last very much longer.

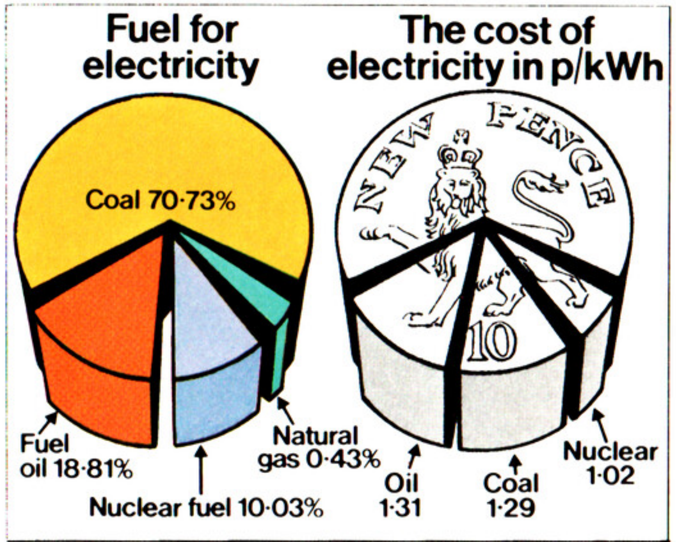
Like all other fuels, nuclear energy has its advantages and its problems. One important thing about it is that it is cheap, even though nuclear power stations cost a great deal of money to build. Electricity produced in nuclear power stations costs less than electricity from power stations burning coal or oil.

An even more important advantage of nuclear energy is that it does not damage health or poison the atmosphere. This does not mean that there is no risk attached to it. Of course it could do serious damage if it were used carelessly. But if it is used with proper care it does no harm to anyone.

The process called nuclear fission – splitting uranium atoms to produce heat – is one of the cleanest ways we know of releasing useful energy, provided it is carefully controlled. If we changed over from coal and oil to nuclear energy in power stations we could save hundreds of lives as well as a lot of money.



Nuclear Fission. *A neutron collides with a U-235 nucleus and causes it to split apart. Part of the energy that bound the nucleus together is released as heat, and other neutrons are ejected. These collide with other U-235 nuclei, thereby setting up a self-sustaining chain reaction.*



UK consumption in 1978-79. Total consumption of all fuels (left) was 118·15 million tonnes of coal or coal equivalent). Average costs (right) in 1978-79 for CEGB power stations commissioned since April 1965, including capital charges, interest, fuel and other operating costs. Nuclear refers to Magnox power stations.

The disadvantage of nuclear energy is simply that it *does* need very great care in all stages of the process. During and after fission the atoms give off streams of particles and rays. This is called radiation and it can cause burns and sickness to people who are exposed to too much of it.

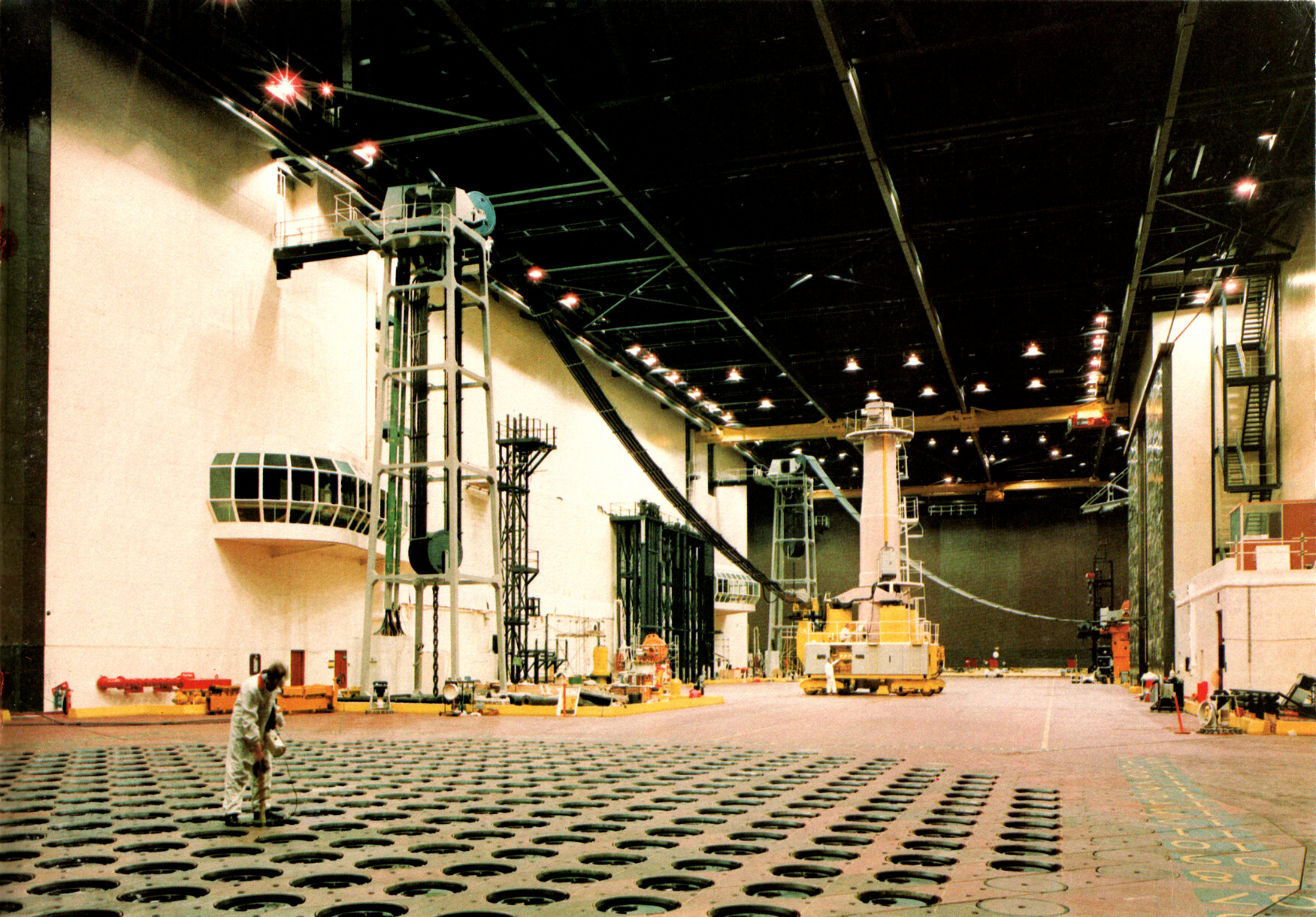
All the places where radiation occurs have to be protected by shields to prevent the radiation getting out. And all the people concerned with the process have to take special precautions to make sure that they do not become exposed to radiation. Obviously all this needs great care.

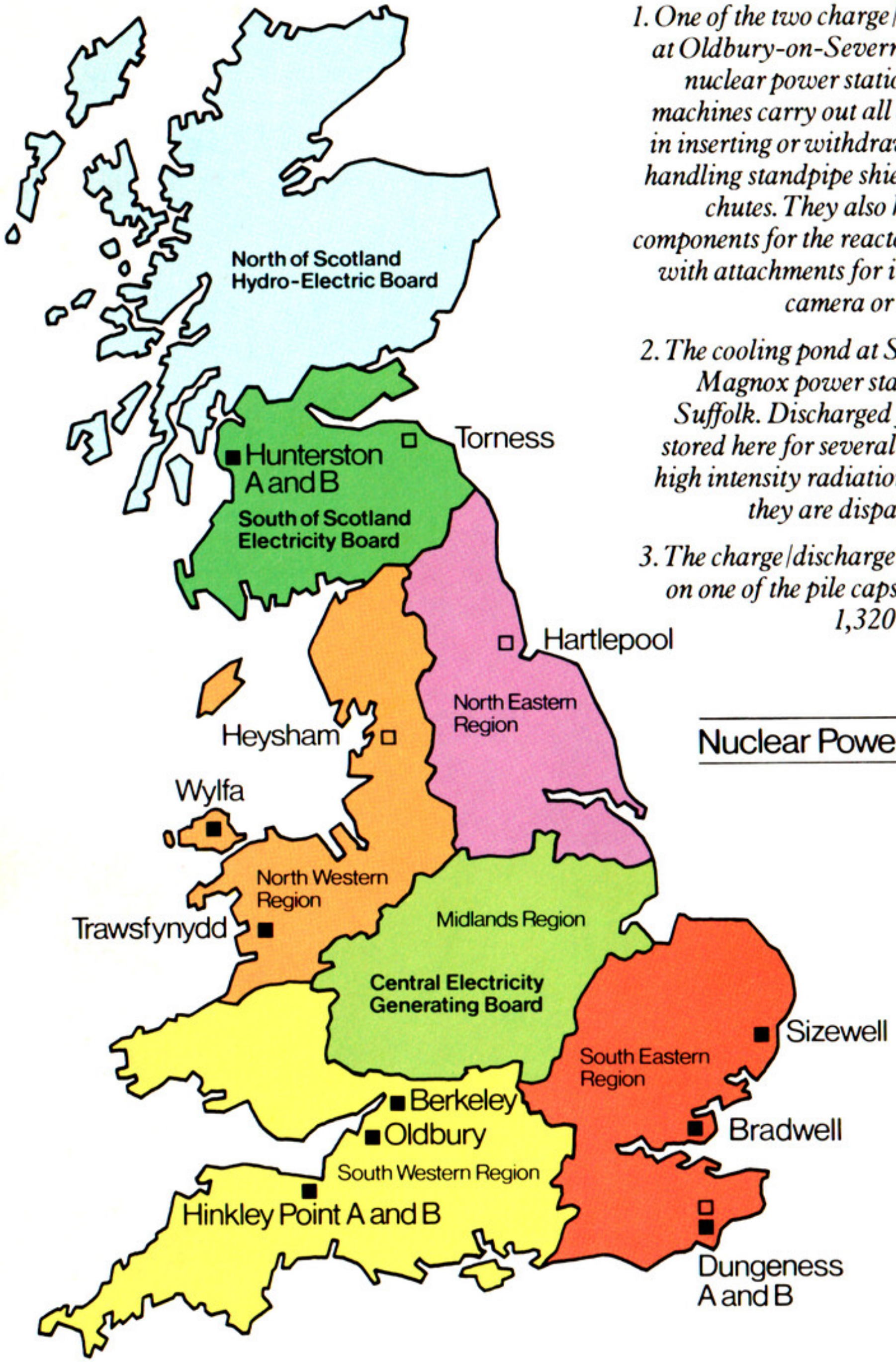
The same very great care is needed when the uranium fuel is exhausted and the waste matter that is left after reprocessing has to be disposed of. This waste is radioactive – that means that it gives off dangerous radiation. So it cannot just be thrown on to the nearest rubbish dump. It has to be put into containers that will prevent the radiation getting out and then taken to some place where it is never going to be dangerous – the bottom of an ocean, perhaps, or a long way underground.

Such waste remains radioactive for hundreds of years so the containers have to be able to hold it in safety long enough for it to become harmless.

All this presents many problems which have to be solved – what containers to use, for instance, and where to store them. At present highly active waste is stored as a liquid in containers made with two skins of stainless steel. Another idea is to make the waste material into blocks of glass, which does not rust, and to bury this deep underground.

One of the two reactors at Wylfa, 840 MW Magnox nuclear power station at Gwynedd (North Wales). On the pile cap floor is the single servicing machine used on both reactors for the maintenance of standpipe components. All routine fuelling operations can be carried out while the reactors are on full load.





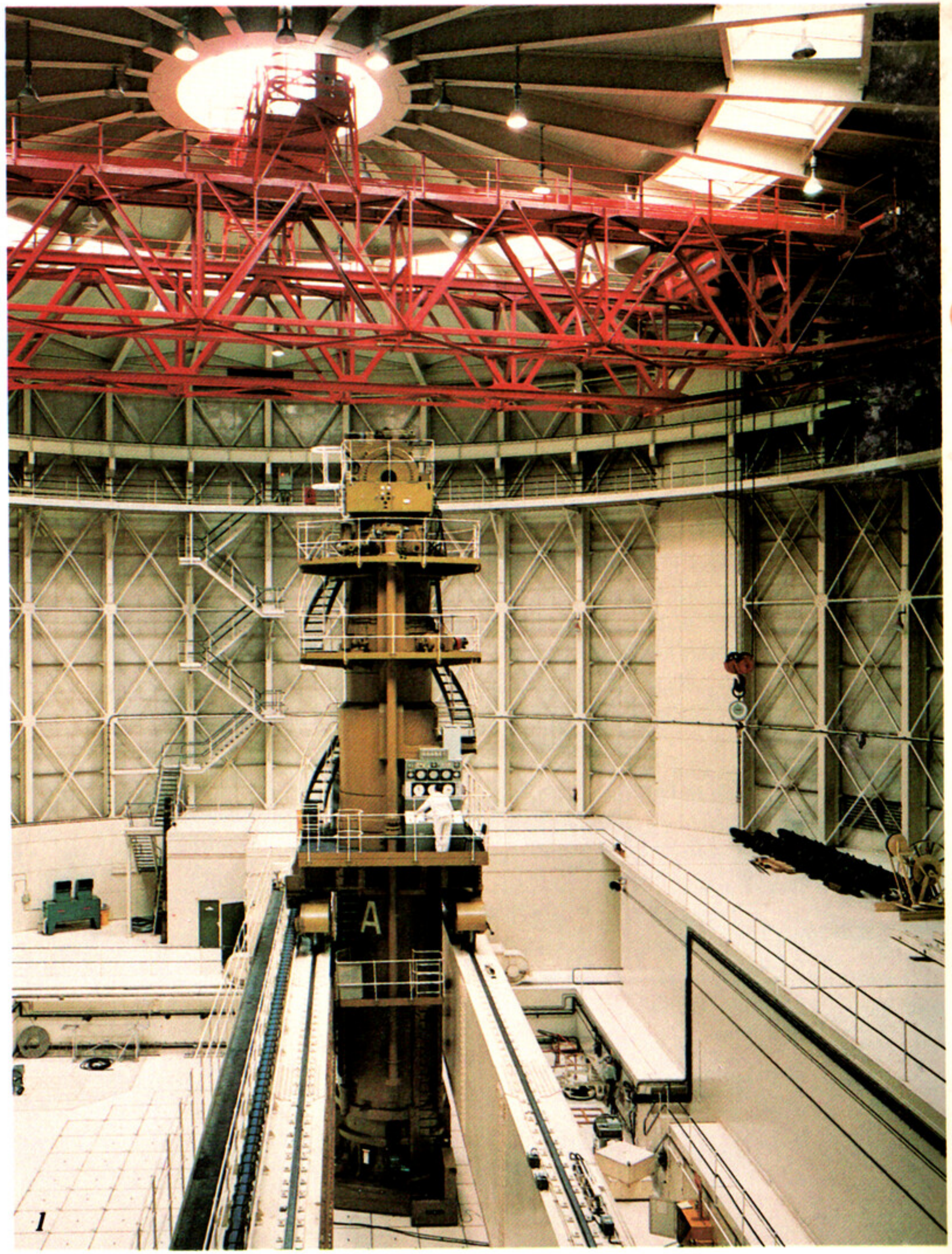
1. One of the two charge/discharge machines at Oldbury-on-Severn 600 MW Magnox nuclear power station. Both the 400 ton machines carry out all operations involved in inserting or withdrawing fuel, including handling standpipe shield plugs and charge chutes. They also handle all auxiliary components for the reactors and can be fitted with attachments for inserting a television camera or temperature probes.

2. The cooling pond at Sizewell A 580 MW Magnox power station near Leiston in Suffolk. Discharged fuel elements can be stored here for several months to allow the high intensity radiation to die down before they are dispatched for processing.

3. The charge/discharge machine in position on one of the pile caps at Hinkley Point B 1,320 MW AGR nuclear power station.

Nuclear Power Stations in GB

■ Operating
□ Planned



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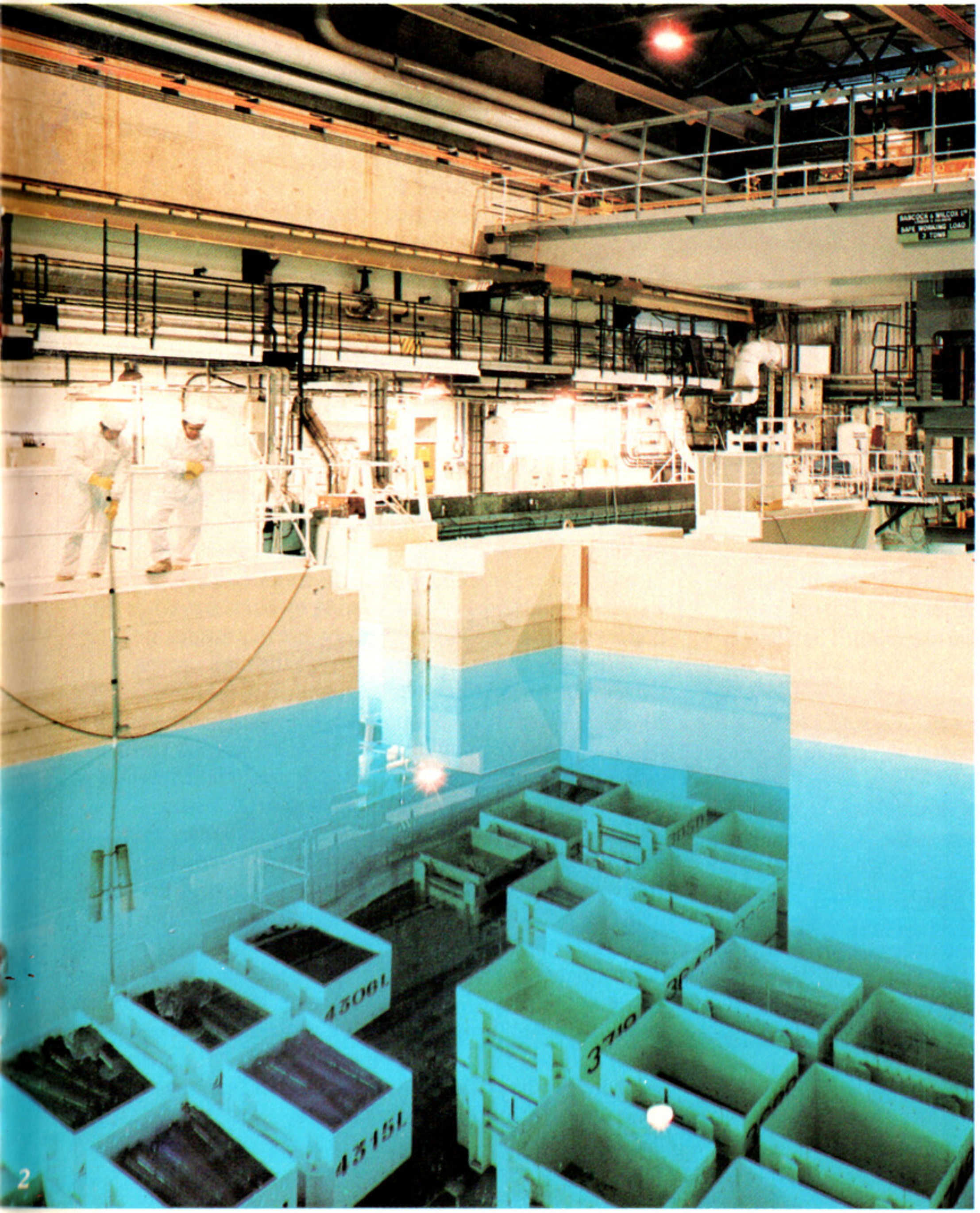

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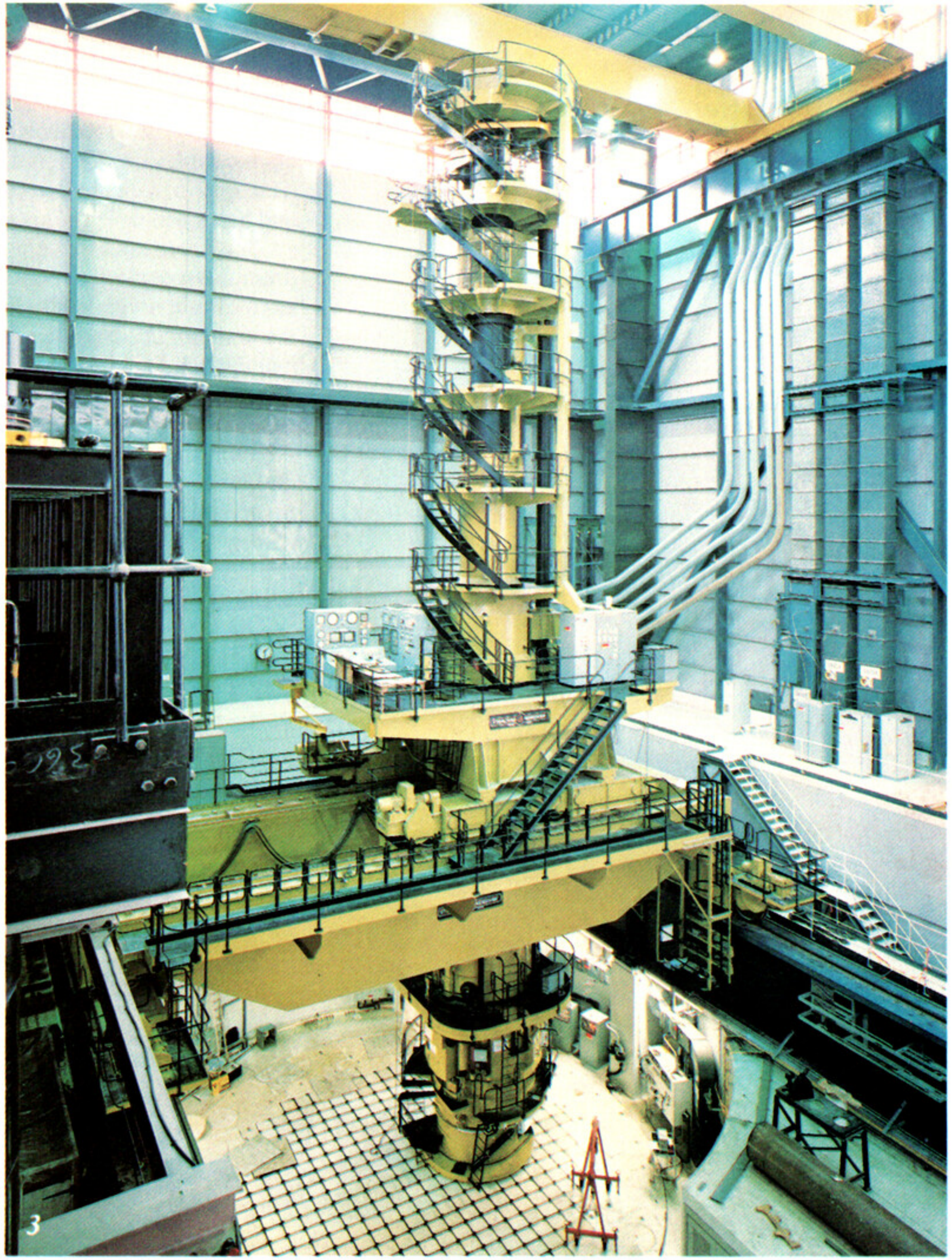

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One other matter in which great care is needed is in protecting the nuclear process and the fuel from attack by enemies or thieves. This does not mean that an enemy throwing a bomb at a nuclear power station could cause an atomic explosion. This could not happen. But of course any damage to a nuclear plant could allow radiation to escape and harm people in the area.

It is sometimes thought that enemies might try to steal uranium from nuclear power stations in order to make atomic bombs with it. There is no likelihood of this because the uranium used in power stations is not suitable for making bombs; it is not of sufficiently high quality. All the same, these possibilities, remote as they are, make it necessary to protect nuclear power stations with extra care.

Now that we have looked at all the main sources of the fuels we need to keep our country healthy, pleasant and prosperous, and our people well fed and warm, we can see why nuclear energy is so important to us.

Oil is getting scarce in the world and so it is getting more expensive all the time. And, although we can and will have to increase our supply of coal, both oil and coal will run out more quickly, the more we use them. The same is true of natural gas.

Energy from the sun, and perhaps from wind and water, will not be able to fill our needs for fuel for many years to come. And we do not yet know what it will cost to put these forces to work.

We could save a lot of the fuel we use today, nearly a quarter of it perhaps, by using it more carefully and economically. But still our need for fuel will increase because we keep finding new uses for it.

For at least the next twenty years or so only nuclear energy and coal can provide abundant fuel at prices we know we can afford.

Even though we need nuclear power, some people think that it is too risky to use. "Carelessness costs lives" is a saying that is true of almost any human activity and it is certainly true of nuclear energy. Should we do without it,

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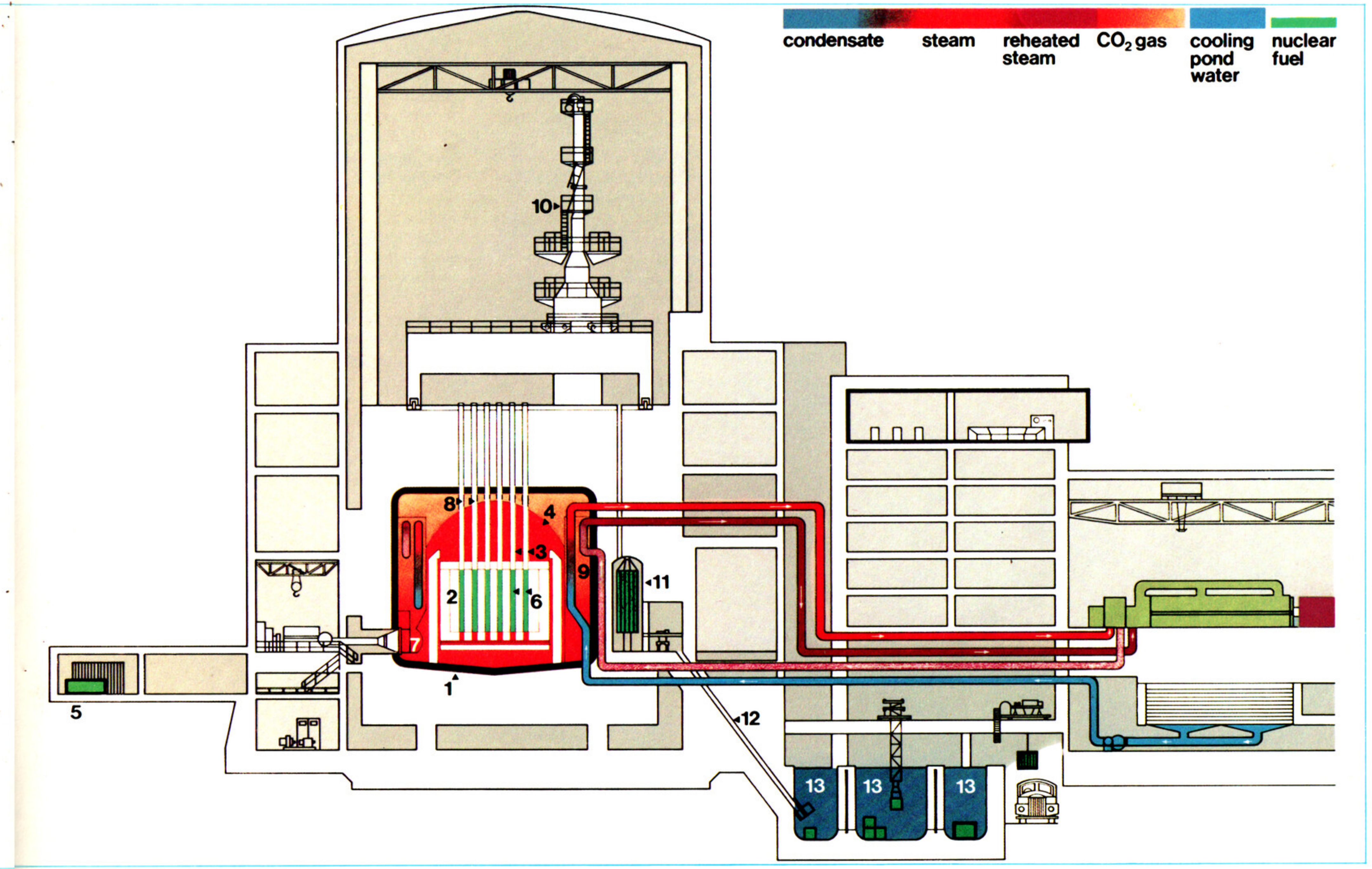
The first Advanced Gas-cooled Reactor (AGR) came into operation in 1976 at Hinkley Point 'B' power station, Somerset. The illustration shows an AGR of this type. The reinforced-concrete, steel-lined pressure vessel 1 contains the reactor, boilers and ancillary equipment. The reactor consists of the moderator 2 – a core of pure graphite constructed from thousands of separate graphite blocks and containing numerous vertical channels 3 – surrounded by an inner pressure cylinder 4. The enriched uranium dioxide fuel which is used in the reactor is kept in a new fuel store 5 until required. It is in pellet form and is sealed in stainless steel cans forming a Fuel 'Pin'. A cluster of 36 of these pins is arranged in a graphite sleeve to form a 'Fuel Element'. Eight of these fuel elements are tied together to form a fuel stringer, one of which 6 is placed in each vertical channel of the core. Nuclear fission takes place in the fuel elements and the heat liberated is carried away by streams of carbon dioxide gas (CO_2) under high pressure. The gas is pumped by gas circulators 7 up through the vertical channels in the moderator, passing round the fuel stringers and leaving by ports 8 to enter the boilers 9 at the top, where it heats water to produce steam.

Once the steam has been through the high pressure stage of the turbine it is reheated in the boiler before passing through the remaining stages (as in a conventional power station). And again, after the steam has done its work in the turbine, it is passed into a condenser where it is condensed back to water and returned to the boiler.

A refuelling machine 10 is used to position and remove the fuel stringers in the reactor and the fission process is controlled at a desired level of activity by moving control rods (not shown) containing boron-steel, a neutron-absorbing material, in or out of the graphite core. The spent fuel stringers when removed from the reactor, are stored in a special chamber 11 for about a week. They are then dismantled and the separate fuel elements are lowered down a chute 12 into a pond of water 13 where they remain until their radio-activity has decreased sufficiently for them to be removed from the power station.



then, even though we need it, in order to avoid any risk of carelessness causing deaths?

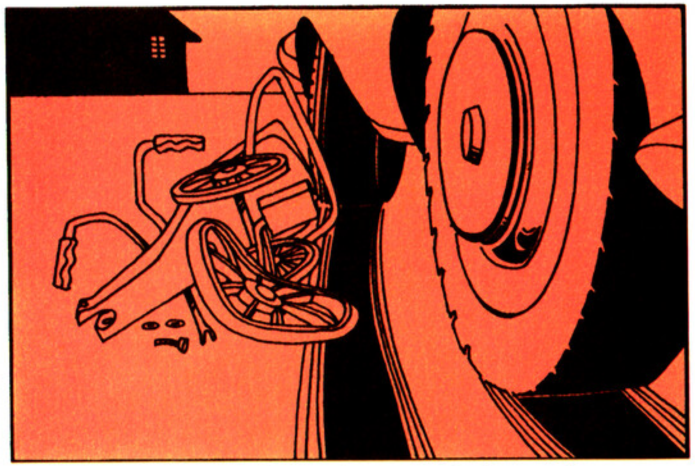
If nuclear energy were the only form of risk there was, that might be a sensible thing to do. But of course it is not the only form of risk we have to consider. There are risks everywhere.

At home you risk falling over and hurting yourself. There are serious risks in crossing the road on the way to school. At school there are risks of catching an illness from someone, risks of being injured playing games.

There are risks in driving a car, risks in flying an aircraft, risks in eating butter, risks in keeping a dog. There are, as we have seen, very serious risks in digging coal and burning coal, oil or gas as fuel.

If we list all the risks we can think of life may seem very dangerous. Yet the fact is that most of us live happily enough to a ripe old age. So the risks of life are not really too terrible if we are sensible and careful.

When we think about the risks of using nuclear energy the sensible question we have to ask is this: is the risk worth taking for the benefit it brings? Or could we get the same benefit some other way for less risk?



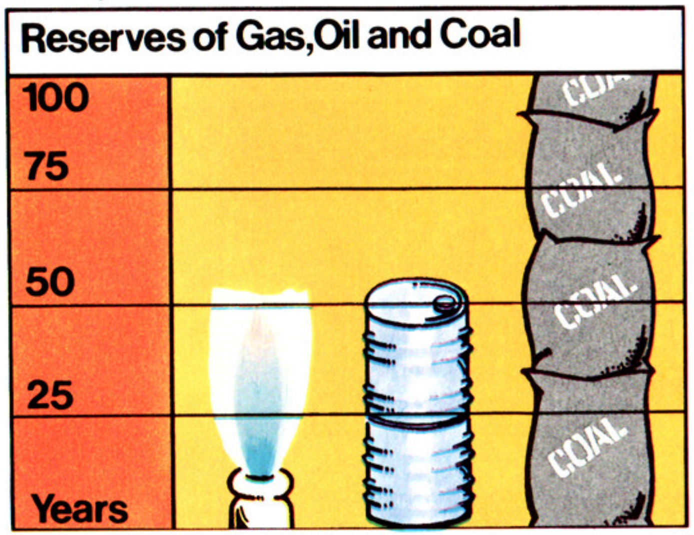
It's the same question we have to ask about using cars, which kill thousands of people every year. We go on using cars because of the great benefit and convenience they bring, even though we know there is a risk. Instead of deciding not to use cars, we look for ways of reducing the dangers of using them. By making people drive more slowly and take more care, for instance.

Scientists have worked out that you have something like a hundred and eighty times as much chance of being in a car accident as you have of suffering harm from an accident at a nuclear reactor if you live within 25 miles of one (if you live more than twenty-five miles away the risk is even less than that).

When we come to compare the risks of using different fuels we find that uranium for nuclear energy is the safest of them all except for natural gas. These risks cannot be measured exactly but when we have taken account of all the possible dangers we find that making electricity with nuclear energy is one of the safest ways we know of supplying the energy we need. And it is the way that carries the least danger of polluting the atmosphere.

So to be on the safe side we ought to be using *more* nuclear energy instead of oil.

When we think about the possible risks of using this fuel or that, we have to think also of the risks of running seriously short of the fuel we need.



We know there are risks in mining coal, drilling for oil or building nuclear power stations. But if we ran badly short of fuel we could be sure that even more people in our country would suffer and that some of them would certainly die.

Nuclear energy helps to make sure that we never do go short of fuel. Life would be safer and fuel would be cheaper if we produced more of our electricity in nuclear and coal-fired power stations and used more electricity as fuel.

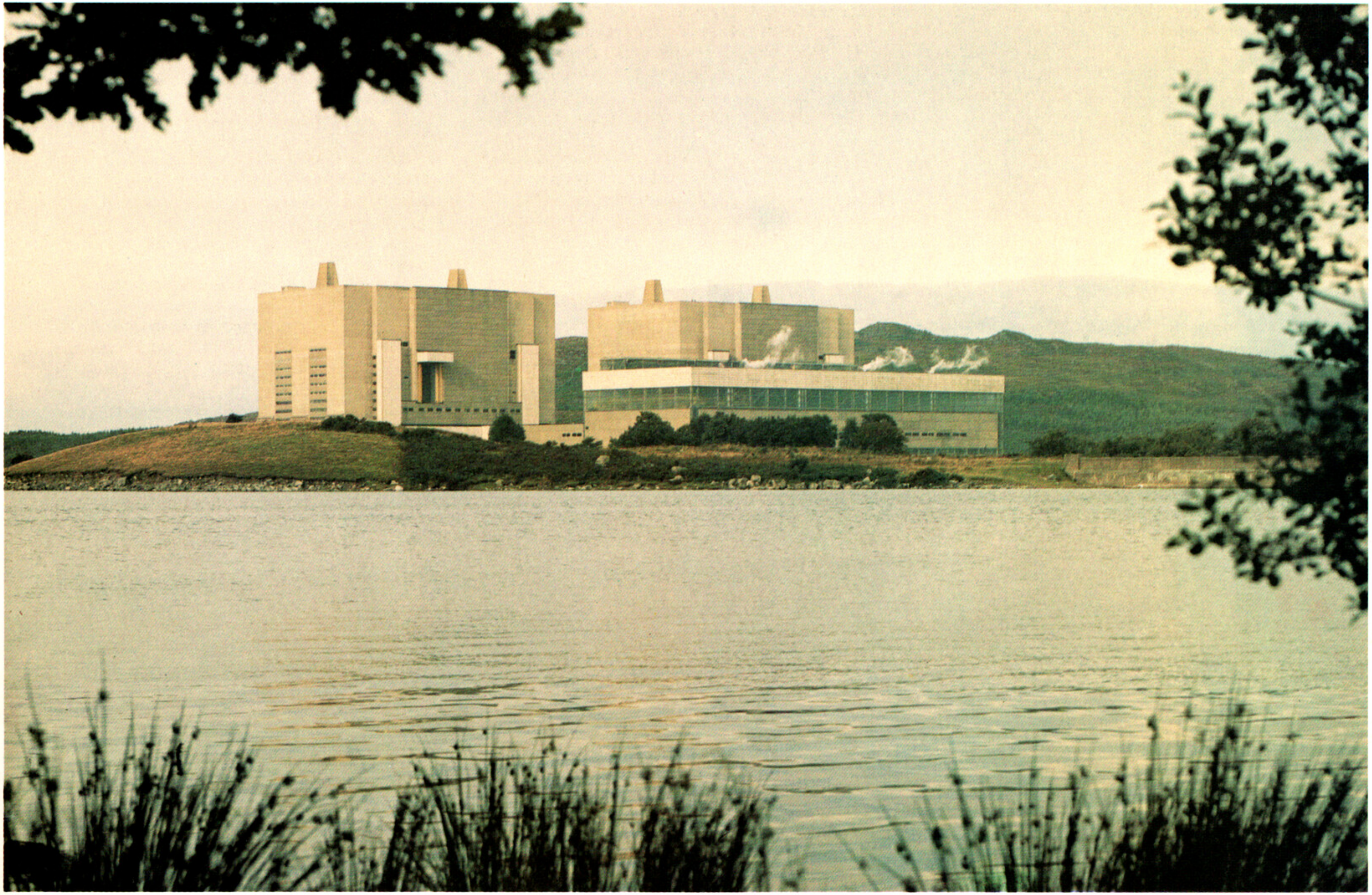
If we did that we should not only be helping ourselves; we should be helping the rest of the world as well. Poor countries need much more fuel if they are to develop and give all their citizens a good life. We could help them by selling more of our oil to other countries and using less ourselves. In Britain clean, safe nuclear energy and coal can safeguard our electricity supplies over the years when oil begins to fade out.

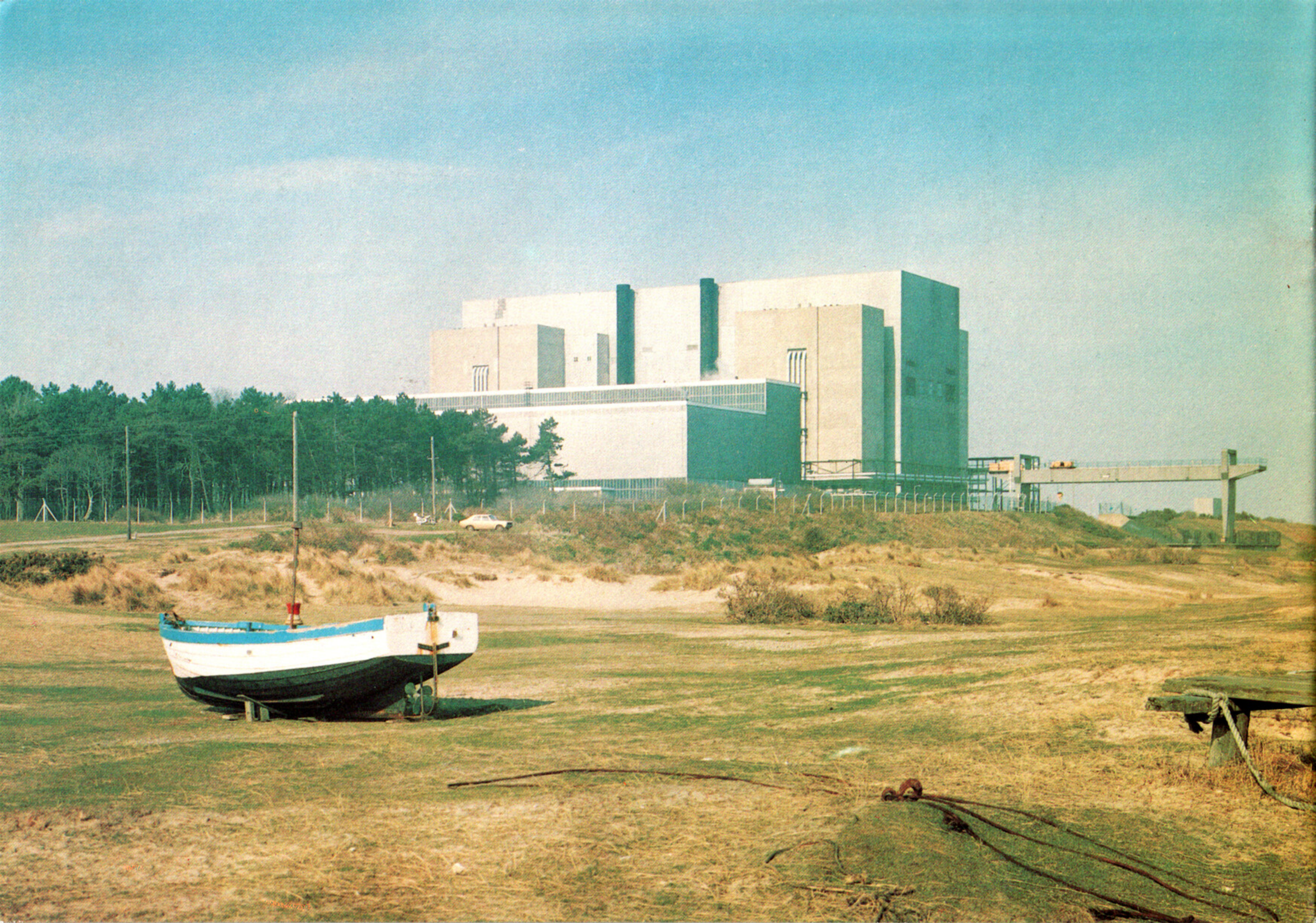
Nuclear energy makes it possible for all countries to have as much fuel as they need. We can have as much as we want and still help other countries to have as much as they want.

In the past many wars have come about because countries which have not had enough of the things they needed have gone to war to try to take them from other countries. Anything that helps to spread prosperity throughout the world can be a great force for peace.

This is what nuclear energy can do. It was first harnessed to make bombs in wartime. But now its immense force can be used, not to make weapons of war, but to help nations live in peace and plenty.

This 500 MW Magnox power station is on the northern shore of Trawsfynydd lake in Merionethshire. This was the first nuclear station to be built inland and the first to use a lake for obtaining cooling water. As the station site is situated within the Snowdonia National Park in North Wales special consideration was given to blending buildings into their surroundings.





Note for teachers:

UNDERSTANDING ELECTRICITY is an educational information service sponsored by the electricity supply industry in the United Kingdom and the Republic of Ireland for school and college use. Its aim is to improve the knowledge of young people about basic electrical principles and their practical applications and to provide background information on the use of electricity in commerce, agriculture, horticulture, industry and the home.

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Sizewell A 580 MW Magnox nuclear power station near Leiston in Suffolk. This was the first nuclear station in Britain to incorporate both reactors in one structure. The aluminium clad building has a reactor at either end with the control block, common equipment and fuel handling plant located between the reactors. A cooling pond, common to both reactors, is at the rear of the building, while the turbine hall is at the front.

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