BERKELEY POWER STATION

CENTRAL ELECTRICITY GENERATING BOARD

Welcome to Berkeley nuclear power station

Berkeley nuclear power station lies on the east bank of the River Severn midway between Bristol and Gloucester. At this point, the river is over a mile wide and is strongly tidal.

The construction site occupied some 96 acres but the final area now contained within the security fence is 43 acres.

The C.E.G.B's nuclear power branch initiated construction before handing responsibility to the Southern Project Group.

Building started in January 1957, and the station first supplied electricity to the national grid on 12th June, 1962.

The station has a net output of 276,000 kilowatts, the plant consisting of two natural uranium, carbon dioxide gas-cooled, graphite-moderated reactors supplying heat to 16 boiler units, eight boilers being associated with each reactor. Each of the four dual-pressure turbo-generators has a capacity of 83,000 kilowatts.

Each reactor core comprises a vertical cylinder 48 feet in diameter by 30 feet high built up from graphite blocks and containing 3,275 vertical channels; 3,265 channels contain uranium fuel and the remaining 10 contain graphite samples. The cylindrical steel pressure vessel containing the core is three inches thick and surrounded by a concrete biological shield.

The fuel elements are natural uranium rods 1.1 inches in diameter and 19 inches long sheathed in magnesium alloy. There are 13 fuel elements in each channel. Carbon dioxide gas at a pressure of 125 lbs./square inch transfers the heat produced in the reactor to its eight associated boiler units through five feet diameter ducts. Eight blowers, each connected to the outlet of a boiler, circulate the gas back into the reactor vessel.

The civil works for the reactors comprise two circular reinforced concrete rafts each 150 feet in diameter and 14 feet thick. The walls of the biological shields are 80 feet high.

For condensing purposes, six circulating water pumps, with a total capacity of 21 million gallons an hour, are installed in the circulating water pumphouse. Cooling water is drawn from the Severn 650 feet off-shore and a baffle wall has been constructed in the estuary to prevent recirculation of the cooling water.

The pressure vessel containing the reactor core is cylindrical with domed ends. It is 80 feet high and 50 feet in diameter and was fabricated on site from three inch thick steel plates.

The boilers are 70 feet high and 17½ feet in diameter. Each produces 204,000 lb. of steam an hour at two pressures—306 lbs./square inch and 62 lbs./square inch at 322°C.

Control of the station is from a central control room located in the turbine hall where all the major component controls are located.

making electricity is easy!

Making electricity is easy. All you have to do, as Michael Faraday discovered more than a century ago, is to rotate a loop of wire in a magnetic field. If you twiddle a paper clip between the jaws of a toy horseshoe magnet, you will generate a tiny current of electricity on the paper clip. The dynamo of a bicycle or a car generates electricity in the same way, but on a larger scale. And right at the top end of the scale, but still operating on the same principle, we have the power station, producing enough electricity to supply a whole town.

The difference between a bicycle dynamo and a power station is like the difference between climbing a local hill and climbing Everest, or between a child damming a tiny stream and a vast project like the Kariba Dam in Africa. In each case the principle is the same, but the sheer size of the operation makes a simple task become difficult and complicated.

A modern power station is huge and complex. It has to be in order to generate very large quantities of power with maximum efficiency. But it helps to make it more understandable if you remember that all it is doing is to repeat, in a very big way, just what you could do by twiddling a paper clip between the jaws of a toy magnet.

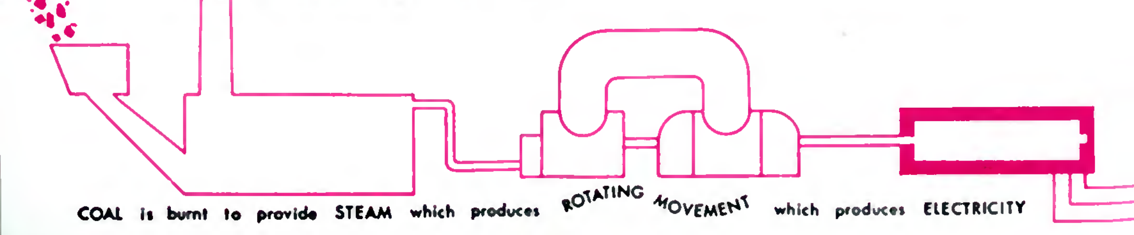
how a power station works

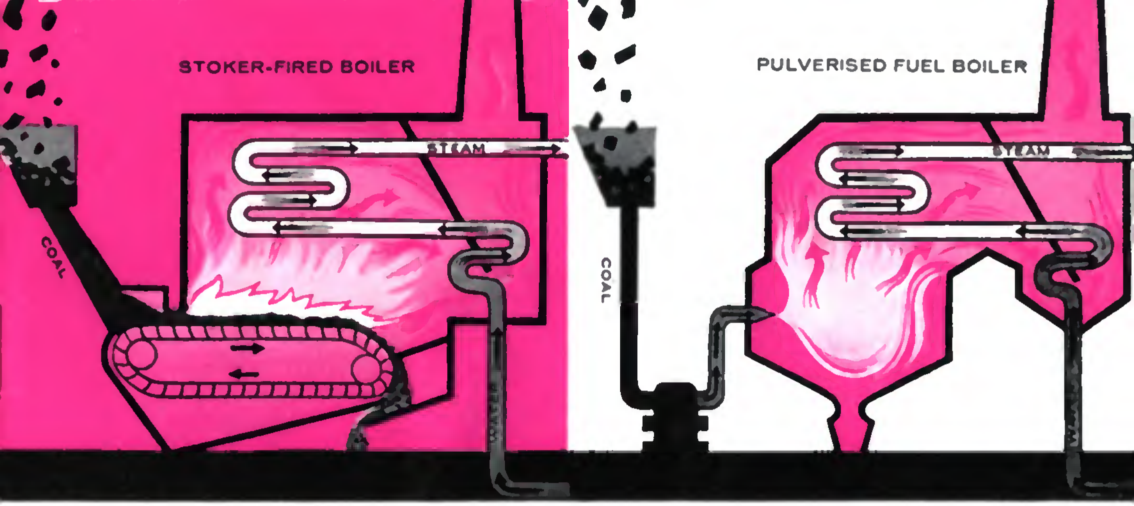
Instead of rotating a loop of wire between the poles of a magnet, you can get exactly the same effect by keeping the wire loop stationary and rotating the magnet. This is what is done in a modern power station. Either way, however, you have to start with a rotating movement.

In countries where there are large, fast-flowing rivers, generators can be rotated by water power. In this country we have to use steam power, which is obtained by burning coal or oil in a boiler, or by using the heat from a nuclear reactor. Whether we use water or steam, we convert their energy into rotating movement by means of a turbine, which is simply a modern version of the old water-wheel.

This gives us the pattern of the power station layout. We start with coal, which is fed into the boiler. From the boiler we get steam which is piped to the turbine. In the turbine the steam issues through nozzles, striking curved blades mounted on the turbine wheels and so making the wheels spin round.

The turbine shaft is connected to the generator shaft, on which is mounted a large magnet. So, when the turbine rotates, the magnet of the generator also rotates. Fixed round the generator are thick copper bars which act like the loop of wire in Faraday's original experiment. When the magnet rotates, electric current is generated in these bars—the current that is picked up and taken by overhead line and underground cable to light your house.





raising the steam

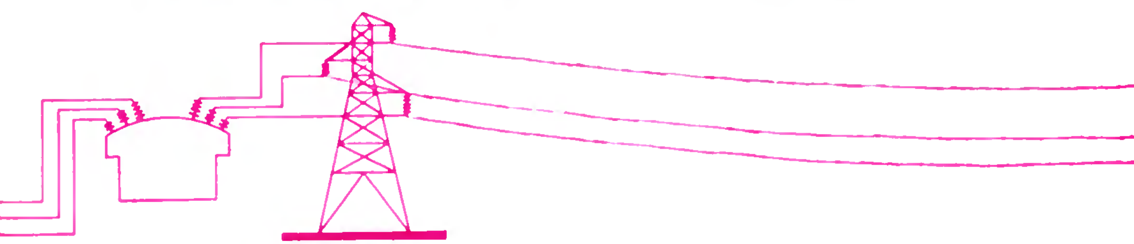
The boilers are the largest items of plant in a power station. They are large because they have to burn immense quantities of coal—as much as 20,000 tons a day on a big station. And they are complicated because the cost of coal is three-quarters of the cost of producing electricity, so the boilers have to be designed to make the best possible use of every ounce of coal they burn.

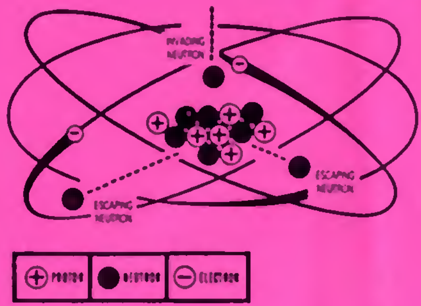
In most modern stations, before the coal is burnt, it is pulverised in mills which grind it finer than face powder. This powder, mixed with air, is blown into the furnaces, where it burns like a gas. Some older stations have stoker-fired boilers, the coal being fed into the furnaces on an endless steel belt.

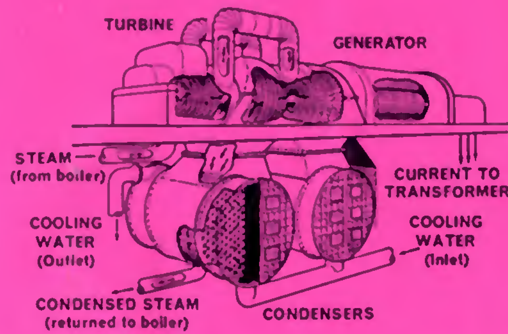
The walls of the furnace are lined with tubes containing water and the heat is so great that in a big boiler nearly 100 gallons of this water is boiled and turned into high-pressure, high-temperature steam every second.

The boilers have pre-heaters for both air and water, huge fans to provide an exactly-controlled draught, economisers, super-heaters and other devices to get the maximum heat at the lowest possible cost. They also have large precipitators which remove dust and grit from the flue gases before the gases are allowed to go up the chimney stack.

Power stations can burn low quality coals which would be difficult to market elsewhere. Much of this coal contains a high percentage of ash which is recovered, on pulverised fuel stations, in the form of a fine powder known as PFA. Many useful applications have been developed for PFA, including construction fill, road foundations, the manufacture of lightweight building blocks and aggregate, and as an additive to cement. Millions of tons have also been used to fill in old gravel pits and reclaim derelict land for agriculture.





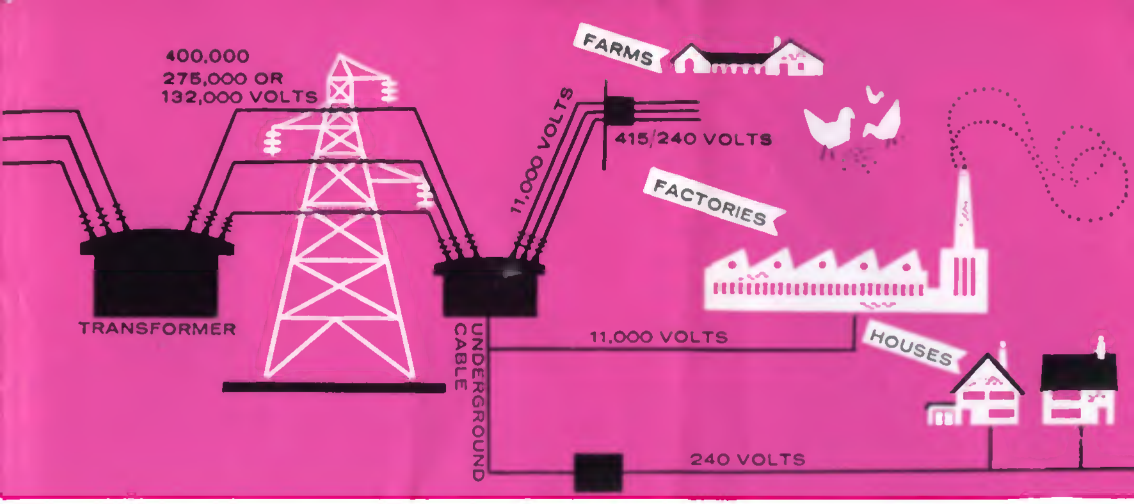


nuclear power stations

Nuclear power stations differ from conventional ones in using the heat from nuclear energy instead of burning coal or oil to boil water and generate steam. Having raised the steam the rest of the station follows the conventional pattern as far as turbines and generators are concerned.

To explain what happens in a nuclear reactor certain terms are used which may not be generally understood. Some of the most common are:

ELEMENTS	ELEMENTS are chemical substances which cannot be broken down into other substances.
ATOMS	ATOMS are the smallest possible part of elements. They are so small that in a glass of water there are enough to provide millions of atoms for every square inch of the earth surface of the globe.
PROTONS NEUTRONS NUCLEUS	Each atom consists of PROTONS (positively charged particles) and NEUTRONS (uncharged particles), constituting the NUCLEUS which is surrounded at relatively vast distances by ELECTRONS (negatively charged particles).
NUCLEAR FISSION	NUCLEAR FISSION of uranium is the process whereby a free neutron is made to penetrate the nucleus so that it is caused to break up. This releases other neutrons and energy in the form of heat. How efficient this method is can be seen when one realises that a piece of uranium the size of a marble could produce as much heat as the burning of 50 tons of coal.



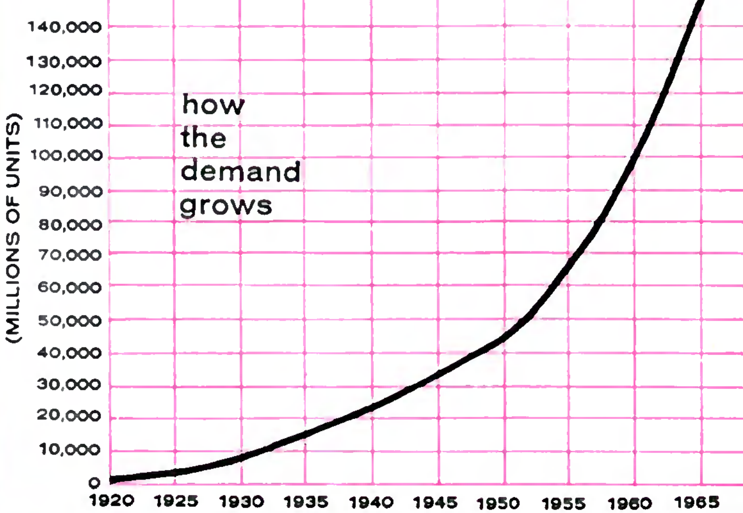
on to the grid

The power generated by a power station passes through transformers and on to the grid system. A transformer is a device for stepping the voltage up or down. It is more economical to transmit power at high voltages, so the output of the generators is stepped up for transmission over the grid, and stepped down again at substations before being fed to consumers.

The grid forms the arteries of our electricity supply system. It enables power to be generated where coal is cheapest, it helps to concentrate production at the most efficient power stations, and in the event of a breakdown at any one station it enables other stations to pick up the load.

As the demand for electricity has gone up, the C.E.G.B. has developed a 'supergrid' system, operating at 275,000 and 400,000 volts, compared with the 132,000 volts of the original grid system. These supergrid lines can carry much more power. One 400,000 volt line, for instance, carries as much power as three 275,000 volt lines or eighteen 132,000 volt lines. This means the increasing public demand for power can be met with far fewer lines than would otherwise be needed.

One line of pylons carrying 400,000 volt lines can transmit energy representing one ton of coal burnt every two seconds. In other words, that single overhead line is doing the same work as a stream of 10-ton lorries passing at the rate of one every 20 seconds!



questions people ask

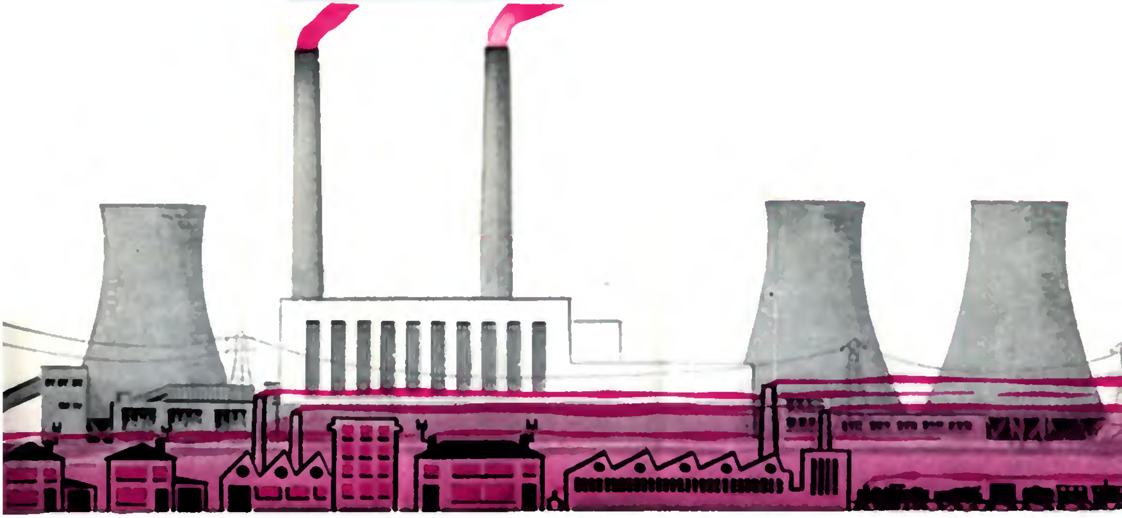
The answer to most of the questions people put to the Central Electricity Generating Board can be summed up in a sentence: the demand for electricity doubles every 9 or 10 years.

This has been the trend for fifty years, and there is no sign of it slackening off. This demand is decided by the public—not by the C.E.G.B. The housewife buys a new electric appliance, the works engineer buys a new electric-powered machine. They expect the C.E.G.B. to provide the power when they switch on. So the Board has to plan ahead to have the power stations and the transmission lines to provide the power the public will need.

To meet that public need, 10 years from now the C.E.G.B. must have doubled the generating plant and transmission line capacity it has at this moment.

That is why the Board has to go on building new power stations and new transmission lines. But it does try to reduce the effect of this expansion programme by building bigger and better—and therefore fewer—new stations and lines.

Inevitably, modern power stations and transmission lines are on a large scale and do make an impact on the countryside. But let us remember that without them we could not hope to sustain our modern standard of living—either in comfort and convenience in the home, or in productive efficiency in factory and office.

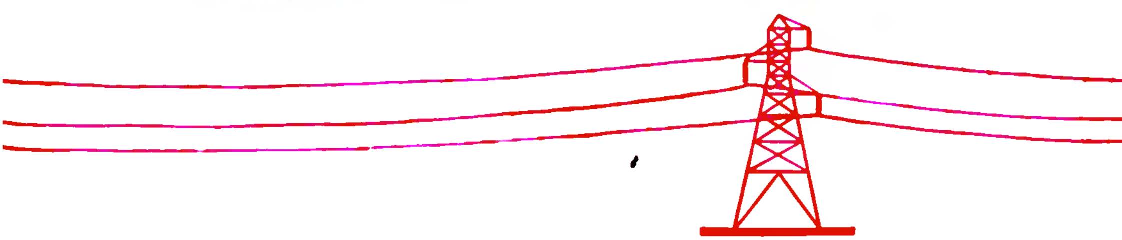


what about smoke from the chimneys?

Power stations burn coal more efficiently than anyone else, and make less smoke in doing so. Electricity-powered plant has largely replaced the old factory chimneys which belched forth black smoke, and electric heating is reducing the smoke from domestic chimneys, which were major contributors to 'smog'. So our power stations have done a great deal towards giving us clean air. Power stations burn the coal under expert supervision, and have special equipment to remove the dust and grit from flue gases. In modern stations, 99.3 per cent of the dust is removed in this way. Tall stacks and high gas emission speeds disperse any gas high in the air, where it cannot cause 'smog'.

what about the cost of electricity?

In spite of rising prices, modern power stations are getting cheaper to build—size to size. They are also more efficient, so they produce more electricity from each ton of coal. They need fewer men to operate them. In the past twelve years, the cost of living has gone up by two-thirds—but the cost of electricity has gone up only one-third. Bills are bigger, true—but that is because most people are using much more electricity.



why can't the lines go underground?

Two of the main problems with high voltage transmission lines are insulation and heat. An overhead line uses air as an insulator—which is by far the cheapest method. An overhead line cannot heat up like a cable buried in the ground. Because of these two factors, it is much more expensive to put lines underground. Underground cable to replace the highest voltage lines would put up costs by more than a million pounds a mile. To put the grid system underground would increase everyone's electricity bills and divert men and materials from housing, roads, schools, private industry and other urgently-needed projects.

how about river pollution?

The water used in power station boilers is usually taken from the water mains. The river only supplies cooling water, which is pumped round the condensers and cooling towers. When discharged back into the river it will have been warmed up (but the C.E.G.B. works to very strict safety limits on this point, to protect fish life) and it will be rather cleaner, for it will have left a certain amount of sludge behind in the station's cooling ponds. The white foam sometimes seen is detergent discharged into the river higher upstream by drains and sewage works, and is largely household detergent which is still active. The power station's cooling system does not put detergent into the river, but it does churn up detergent put there by other people. Scientific investigations have shown that a power station can definitely help to improve the quality of river water.

why cooling towers?

Cooling towers are the most conspicuous feature of steam power stations. Why are they necessary?

The amount of energy we can extract from the steam that drives the turbine depends on the difference between the input and output temperatures. There are ways of increasing the input temperature of the steam; we can also lower the output temperature by rapidly condensing the steam from the turbine under vacuum in a condenser.

Large quantities of cooling water are needed for this, but an inland river does not provide enough. The same cooling water must, therefore, be used again and again, and cooling towers enable this to be done by getting rid of the waste heat.

facts
and figures
about
Berkeley nuclear power station

GENERAL

Number of reactors—2
Thermal output per reactor—595 MW
Number of gas circuits per reactor—8
Number of main turbo-generators—4
Net station electrical output—276 MW
Site area—43 acres

REACTORS

Fuel

Material—Natural uranium
Size of rods—19 in. by 1.1 in.
Fuel cans—Magnox
Number of rods per channel—13
Weight of uranium per reactor—231 tonnes
Systematic peak can temperature—440°C

MODERATOR

Material—Graphite
Number of fuel channels—3265 plus 10 sample channels
Dimensions—48 ft. diameter, 30 ft. high
Weight—1935 tons
Number of control rod channels—132
Fuel lattice pitch—8 in. (square)

Coolant

Material—Carbon Dioxide
Reactor gas inlet pressure—125 p.s.i.
Gas circuit pressure drop—7½ p.s.i.
Gas flow through reactor—6700 lbs/sec
Reactor gas inlet temperature—165°C
Reactor gas outlet temperature—345°C

Pressure Vessel

Shape—Cylindrical
Construction—Steel plate
Internal dimensions—80 ft. high, 50 ft. diameter
Thickness—3 in.

BOILERS

Type—Cylindrical pressure tube
Location—External
Construction—Steel cylinder 70 ft. high, 17 ft. 6 in. diameter. 1½ in. shell thickness
Feedwater temperature—77°C
H.P. steam conditions—306 p.s.i. 322°C
H.P. steam flow reactor—140,385 lbs./hour per boiler
L.P. steam conditions—62 p.s.i. 322°C
L.P. steam flow reactor—64,856 lbs./hour per boiler

MAIN TURBO-ALTERNATORS

Turbine—Horizontal, tandem-compound mixed pressure impulse
Alternator—83 MW output, 11.8kV 3000 r.p.m. hydrogen cooled 30 p.s.i.
Generator transformer—100 MVA, water cooled
Feed Heating Plant—Two L.P. bled steam feed heaters per turbine

CIRCULATING WATER SYSTEM

Pumps—Six centrifugal, vertical, squirrel cage, induction drive
Capacity/pump—58,300 gals/min at 41 ft. delivery head

The C.E.G.B. is responsible for generating the nation's power supplies and transmitting them over the grid system. From the grid the power is taken over by the area electricity boards who distribute it to the public. In effect, the C.E.G.B. is the manufacturer and wholesaler of power and the area boards are the retailers.

The South Western Region is one of five C.E.G.B. operating regions. It covers South Wales, the South West of England and a large part of Southern England.

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