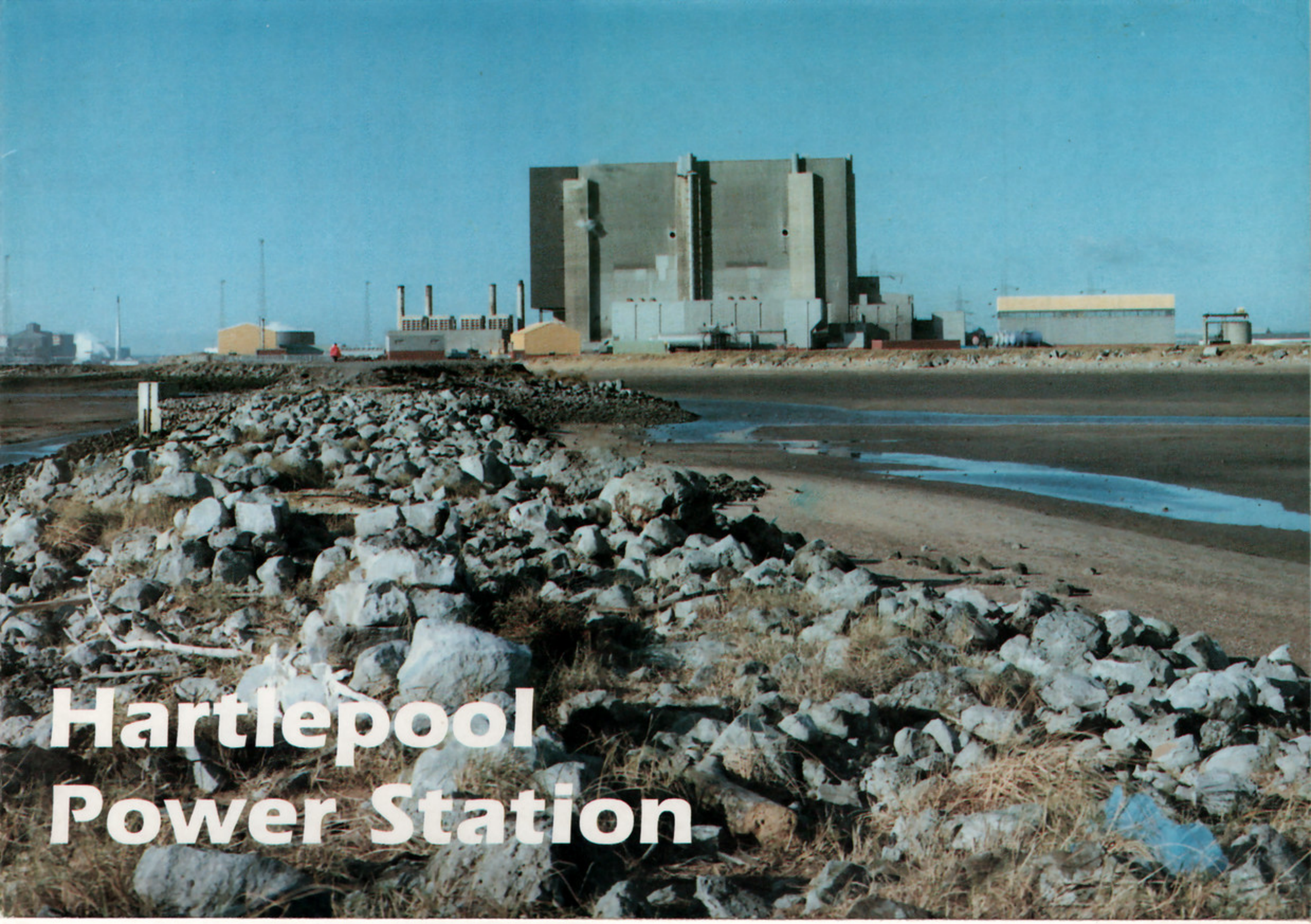
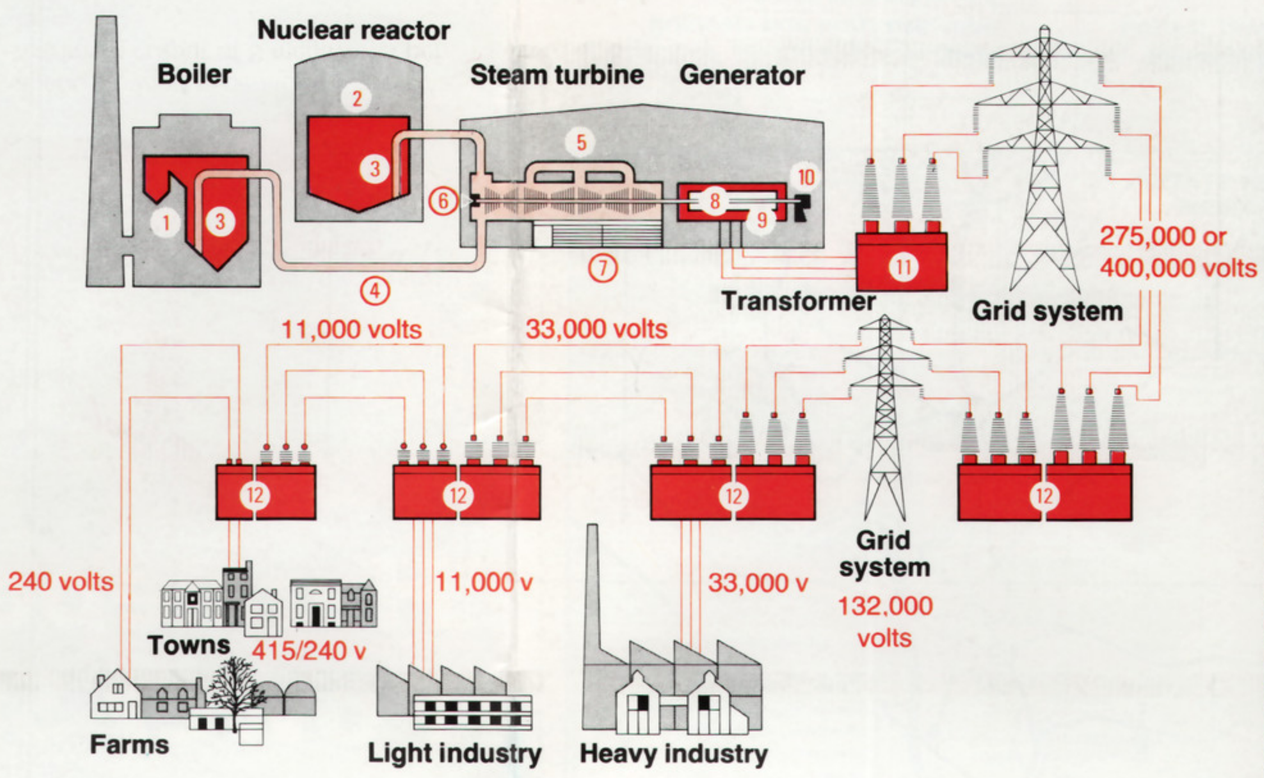

Hartlepool
Power Station

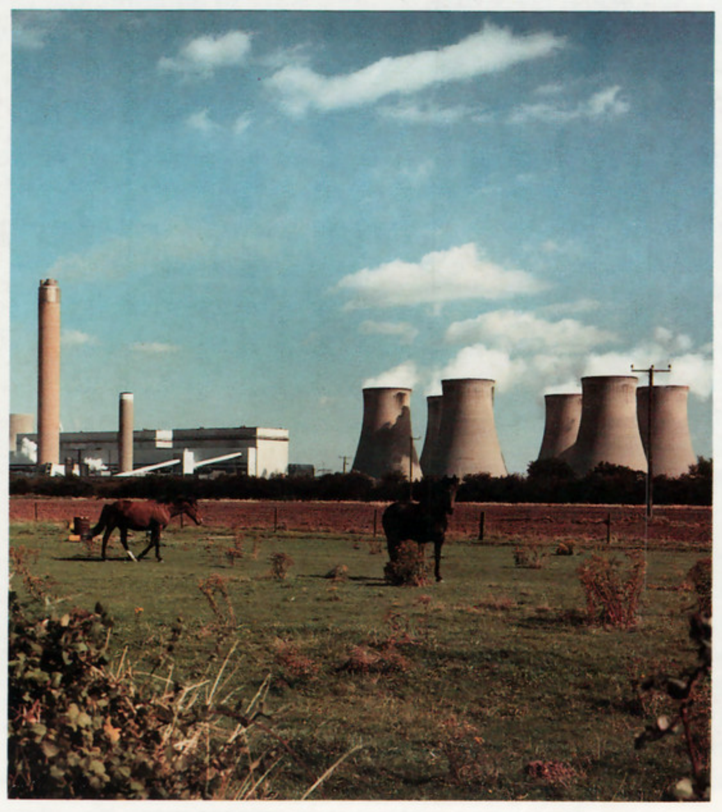
How electricity is made

In the majority of power stations coal or oil is burned in the boiler **1**, or carbon dioxide gas is heated in the reactor **2** of a nuclear power station, and the heat boils water circulating at high pressure in the boiler tubes **3** to create high-pressure steam **4**. The steam is taken by pipes to the turbine **5** where it is used to drive the shaft **6** at high speed. From the turbine, the steam enters the condenser **7** and passes over tubes containing cooling water. It is thus condensed back into water and creates a vacuum which helps improve the flow of steam through the turbine. The water is returned to the boiler under pressure by a series of pumps.

The generator consists of a rotor **8** and a stator **9**. The rotor (an electro-magnet made of a number of windings mounted on a shaft) is coupled to the turbine shaft so that it is turned at high speed and generates electricity in more windings that make up the stator. A small generator **10**, driven from the end of the rotor shaft, produces the current required to energise the rotor.

In the largest modern generators electricity may be generated at about 25,000 volts but for efficient transmission over long distances the voltage is increased by transformers **11**, to 132,000, 275,000 or 400,000 volts. The voltage is reduced again by other transformers **12** for distribution to consumers at suitable voltages - 33,000 volts for heavy industries, 11,000 volts for light industries and 240 volts for homes and farms.





Our energy needs

Energy is essential to the life we live - our jobs, our homes and our recreation.

More than half the energy used in Britain today comes from oil and gas but the reserves of these fuels are limited. On present prospects supplies of North Sea oil and gas will be declining in the 1990s and many experts predict an energy gap.

However, nuclear power is providing an increasing amount of electricity. Unlike fossil fuels, which have many other uses, uranium can only be used commercially for generating electricity. Electricity produced from nuclear power has been flowing into the national grid since Calder Hall was opened in 1956. Today the generating board operates 7 'magnox' nuclear power stations and 5 of the Advanced Gas-cooled Reactor, 'AGR' design. A pressurised water reactor (PWR) is under construction at Sizewell. Nuclear power stations have a first class safety record adding less than one per cent to the population's natural average annual radiation level. (less than the radiation from a single chest x-ray).

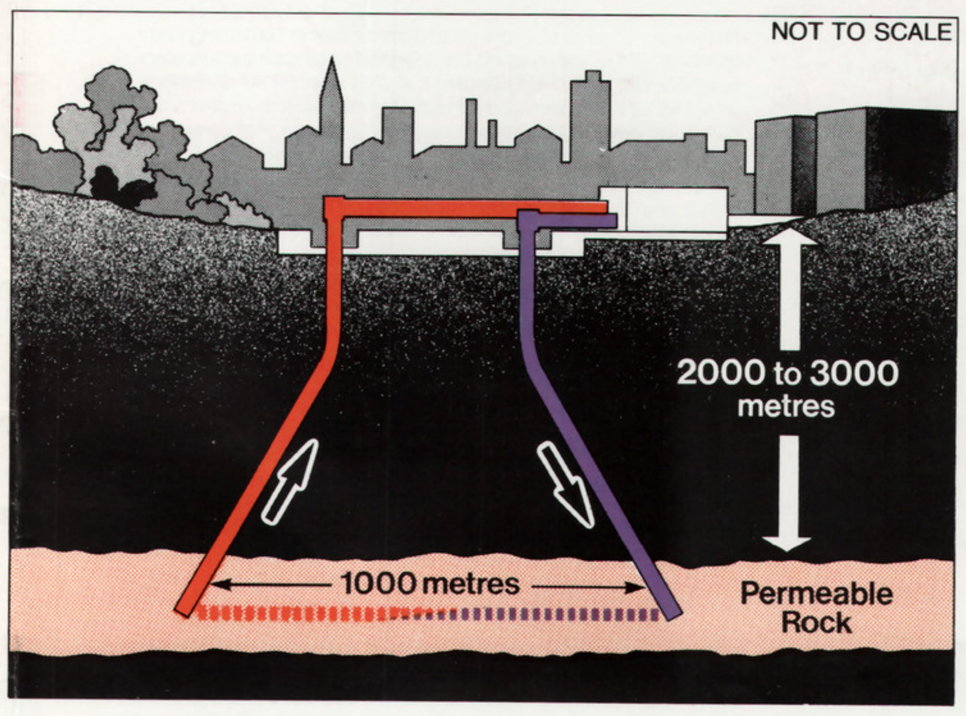
Carmarthen Bay wind turbine

The Generating Board is also exploring the potential of using renewable energy sources to produce electricity from the wind, waves, tides, sun and geothermal heat.

Wind power looks the most promising technology. The Generating Board hosts 4 wind turbines at Carmarthen Bay in South Wales and plans to construct a 1 megawatt machine at Richborough in Kent. The Board is also proposing to build three prototype inland wind farms. These farms would each have about 25 wind generators with a total maximum output of 8 megawatts per farm.

If these initiatives prove to be successful it is estimated that up to 1000 megawatts of wind generation may be possible by the year 2004.

Harnessing wave power in the near future is going to be much more difficult and expensive than at first thought. To produce the same electricity as a 2000 megawatt power station a series of devices up to 60 miles long would be needed. Nevertheless the Generating Board is continuing research and development in the hope that in the long term it will prove economic.



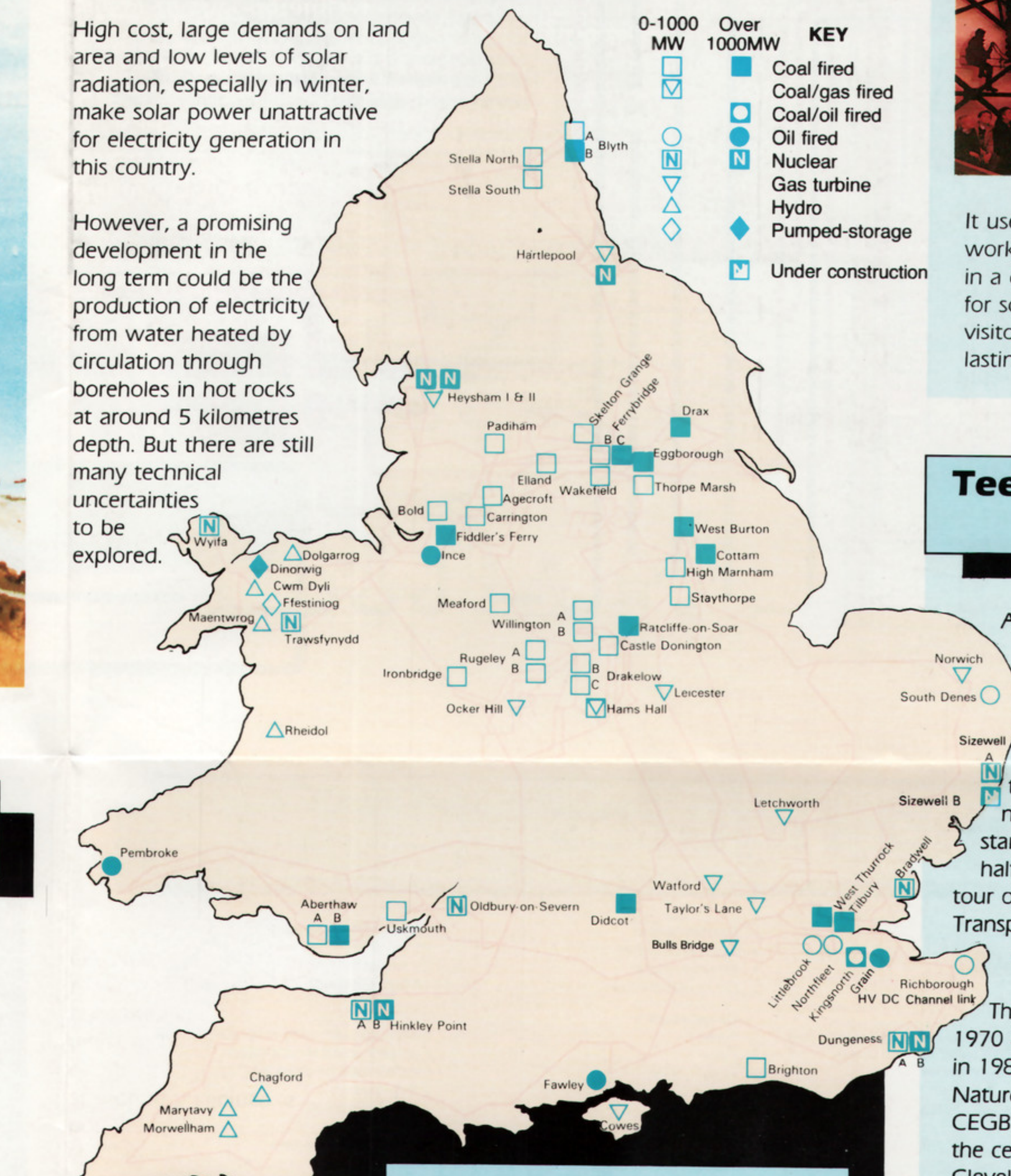
Meanwhile the Board is collaborating with the Severn Tidal Power Group and the Mersey Barrage Company in studying the viability of tidal schemes to be constructed and operated by the private sector.

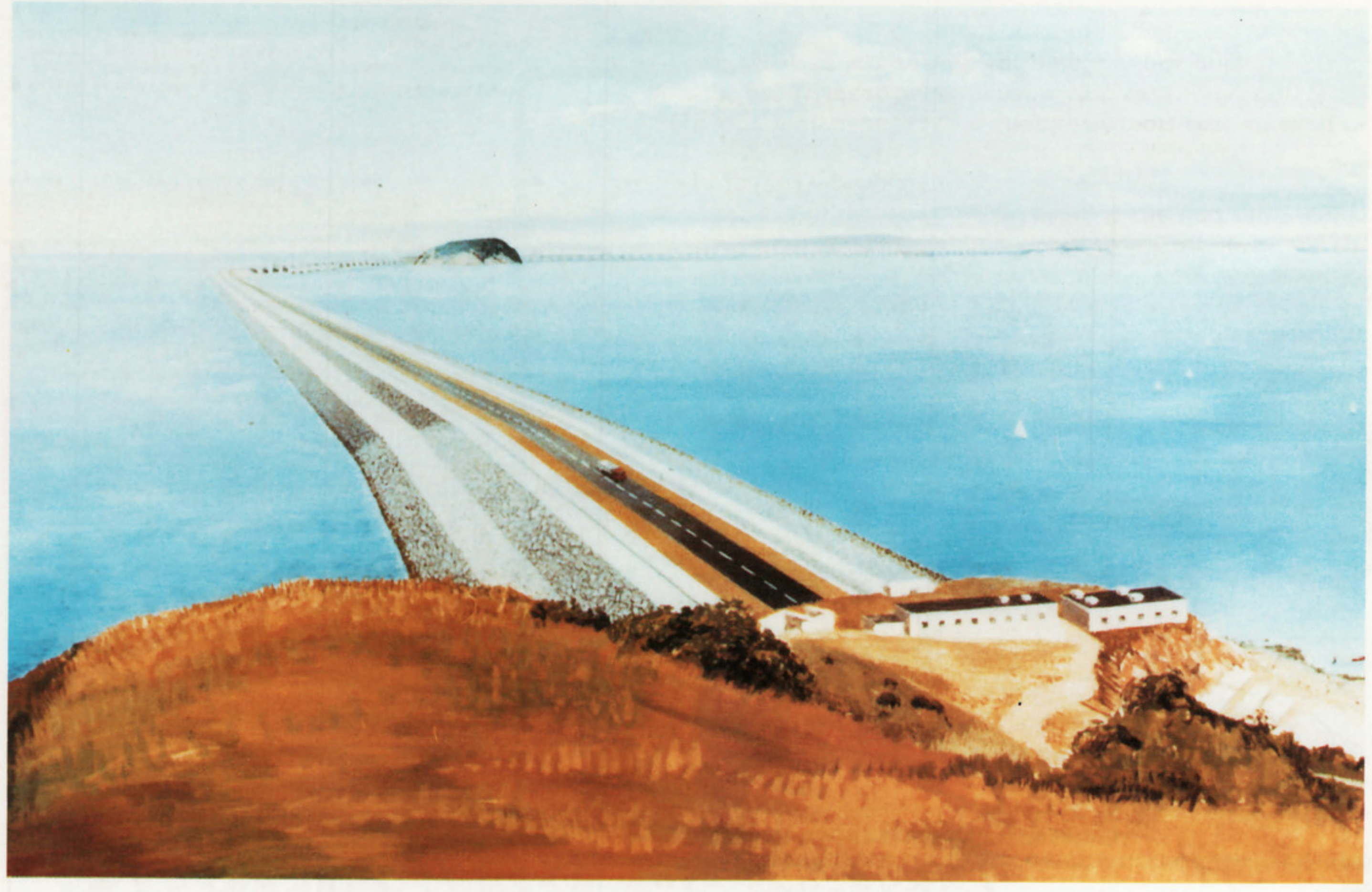
High cost, large demands on land area and low levels of solar radiation, especially in winter, make solar power unattractive for electricity generation in this country.

However, a promising development in the long term could be the production of electricity from water heated by circulation through boreholes in hot rocks at around 5 kilometres depth. But there are still many technical uncertainties to be explored.

So, to maintain our energy supplies we must

* use energy wisely, and the electricity supply industry is helping to show people how this can be done.
* continue to make the best use of Britain's coal, for example, by burning it efficiently in modern power station boilers.
* develop renewable energy resources, provided they are economic.
* maintain our use of nuclear power

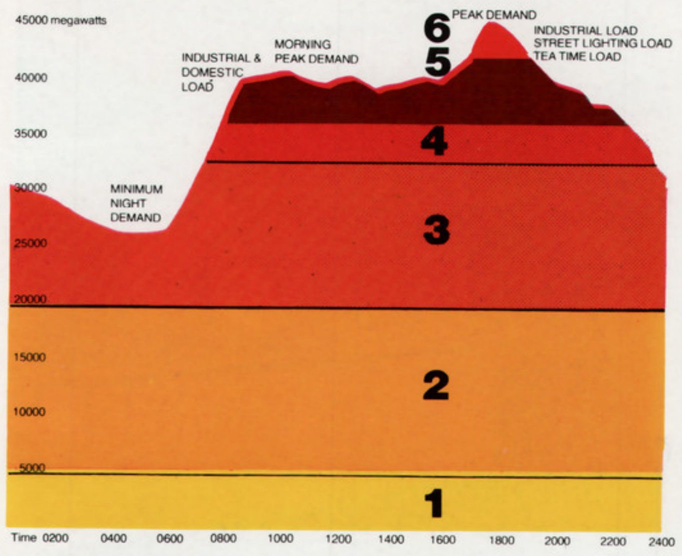




Artists impression of the Severn Barrage

Supply and demand

Typical winter day demand curve and how the CEGB might meet the demand



6 Pumped storage hydro electric plant - an 'instant' means of producing electricity to meet a peak in demand. Gas turbines can also be used for this purpose.
5 Old coal and oil fired plant.
4 Modern oil-fired plant.
3 Older coal-fired plant.
2 Modern coal-fired plant.
1 Nuclear plant.

Electricity is distributed over the National Grid transmission system which effectively links every power station with every consumer.

The National Grid is used to even out supply: for example by sending surplus electricity from one part of the UK to another part where there is exceptional demand. The demand for electricity varies widely during any 24 hour period. Electricity is an 'instant' product, it cannot be stored in large quantities at times of low demand, for use later during peak periods.

So the cheapest power stations are making electricity all the time, to meet basic demand. As demand rises, the more expensive stations have to be started up, on the instructions of the Board's Control Centre. It's also the job of control engineers to plan for sudden increases in demand, for example at the end of popular TV programmes.

It obviously makes sense to use the most cost-efficient stations to meet basic demand, and to reserve the more expensive stations for peak periods only.

Generations of Energy

Sited alongside Hartlepool power station is the CEGB's unique computer controlled audio-visual Energy Information Centre.

Opened in September 1985, the Generations of Energy exhibition uses the very latest techniques to tell the story of energy and electricity. Visitors are led by video guide through an historical journey tracing how energy resources such as coal, oil and uranium have been developed as fuels for electricity, the development of electricity and how it is produced, distributed and used today.

It uses sound, light, images and working models to present it's story in a dramatic way. The centre caters for school parties, families and casual visitors of any age with a presentation lasting about an hour. Entry is free.

Teesmouth Field Centre

Also on the Hartlepool site is the Teesmouth Field Centre which is visited by thousands of school children each year.

To introduce people of all ages to Teesmouth and its ecology a nature trail is followed which starts at the field centre and takes half a day. Also undertaken is a tour of Teesmouth starting at the Transporter Bridge and ending at the field centre.

The original centre was opened in 1970 and moved to larger premises in 1984. It is leased to the Cleveland Nature Conservation Trust by the CEGB and grants to equip and run the centre are provided by Cleveland County Education Authority. Assistance is also given by the Nature Conservancy Council and local industry.

Information

The CEGB has a wide range of information available to the public including an 'Understanding Electricity' service (information and visual aids for schools) and an Energy Talks service (available free of charge to all types of organisations).

For further details write to the Public Relations Manager, CEGB, Beckwith Knowle, Otley Road, Harrogate HG3 1PS. (Tel. 0423 702742)

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Heat to steam

Coal, oil and nuclear power stations produce electricity in basically the same way — they use fuel to raise steam to turn a turbine to generate an electric current.
At Hartlepool, instead of burning coal or oil, heat generated by nuclear fission in the reactor cores is transferred by carbon dioxide gas to boilers to produce steam at high temperature and high pressure.

The diagram shows an Advanced Gas Cooled Reactor (AGR) and its associated 660 megawatt turbine. Hartlepool has two such units.

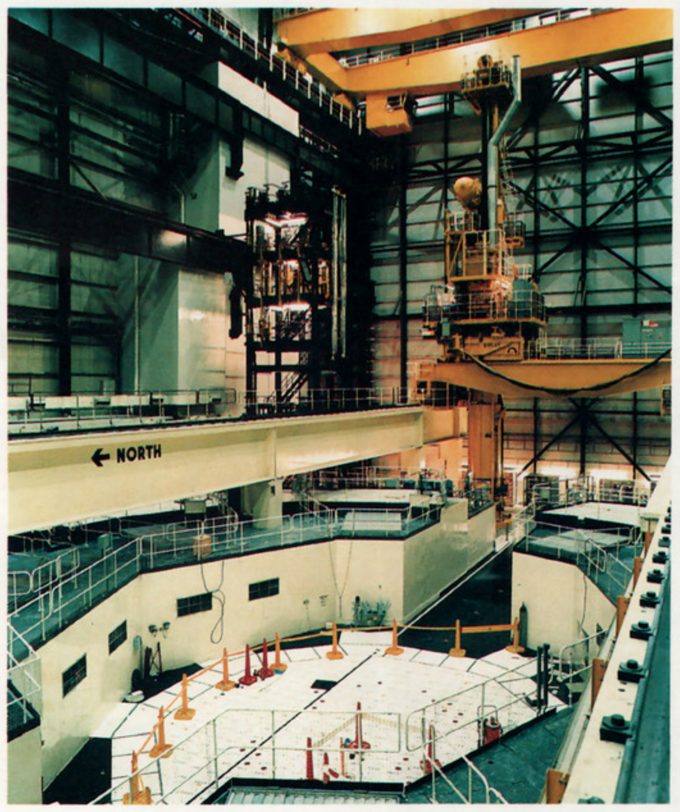
The reactor consists of a core (1) of graphite blocks containing vertical channels. 324 of the channels are designed to contain the fuel element assemblies (2) and their associated fuel plug units (3). 81 channels are provided for boron steel control rods (4) which absorb neutrons and are raised and lowered by electric motors (5). In the event of power failure, the rods will fall into the reactor under the action of gravity.

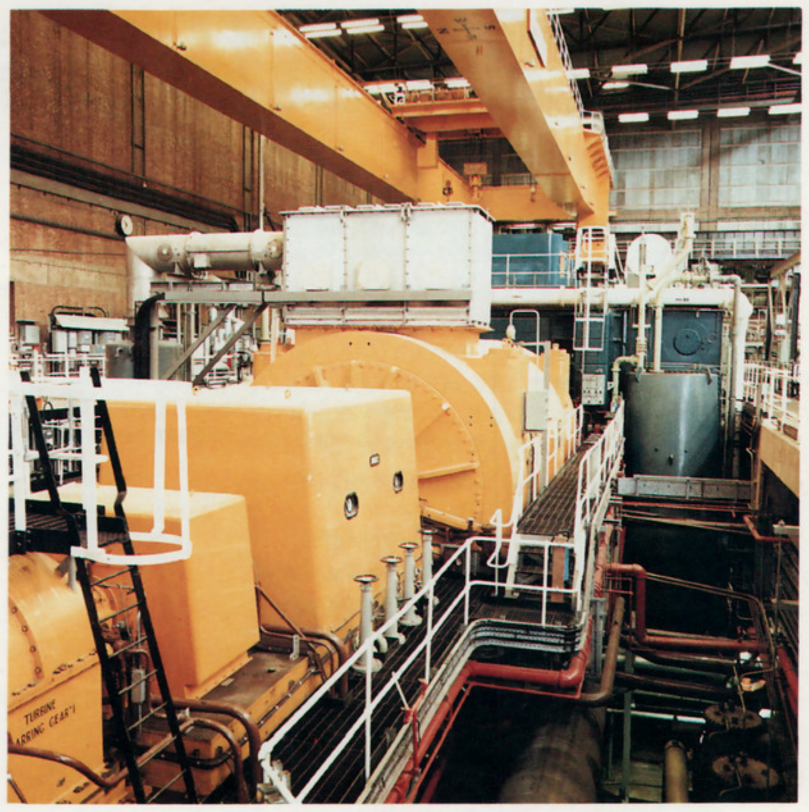
Some of the free neutrons produced by the enriched uranium in the fuel collide with the nuclei of other fissile uranium atoms. These nuclei disintegrate giving rise to further free neutrons and heat.

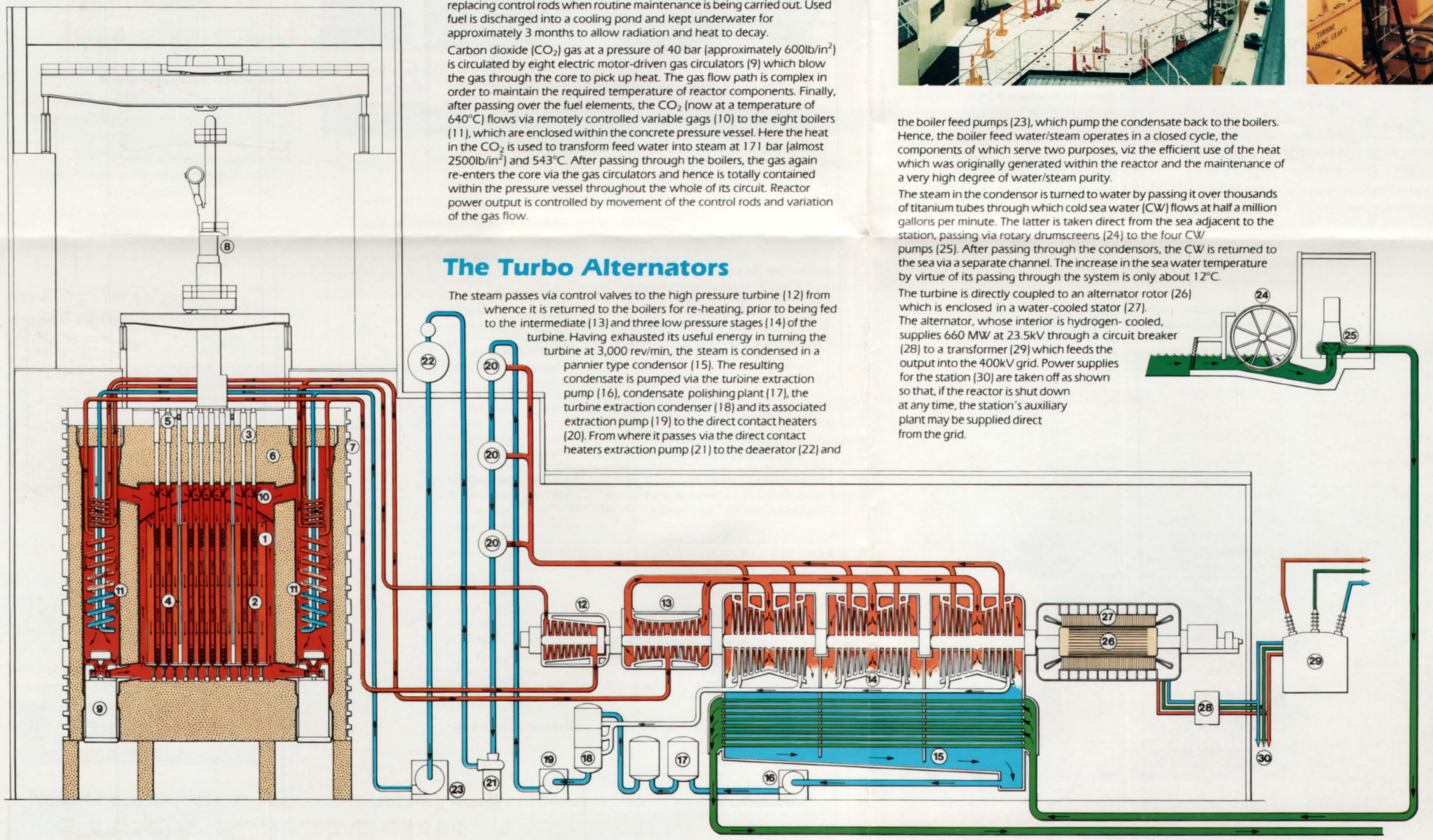
The reactor is contained within a pre-stressed concrete pressure vessel (6) which also acts as a biological shield. The vessel is pre-stressed by a continuous steel wire winding in each of 34 circumferential troughs (7) and by longitudinal steel tendons. The concrete is water-cooled and its interior is steel-lined. It is also protected from excessive temperatures by a system of insulation attached to the steel liner.

After the fuel has spent a long period in the reactor it is necessary to replace it. The refuelling is carried out, one channel at a time, by a fuelling machine (8) operating over the top of the reactor. This machine may also be used for replacing control rods when routine maintenance is being carried out. Used fuel is discharged into a cooling pond and kept underwater for approximately 3 months to allow radiation and heat to decay.

Carbon dioxide (CO_2) gas at a pressure of 40 bar (approximately 600lb/in^2) is circulated by eight electric motor-driven gas circulators (9) which blow the gas through the core to pick up heat. The gas flow path is complex in order to maintain the required temperature of reactor components. Finally, after passing over the fuel elements, the CO_2 (now at a temperature of 640°C) flows via remotely controlled variable gags (10) to the eight boilers (11), which are enclosed within the concrete pressure vessel. Here the heat in the CO_2 is used to transform feed water into steam at 171 bar (almost 2500lb/in^2) and 543°C. After passing through the boilers, the gas again re-enters the core via the gas circulators and hence is totally contained within the pressure vessel throughout the whole of its circuit. Reactor power output is controlled by movement of the control rods and variation of the gas flow.







The Turbo Alternators

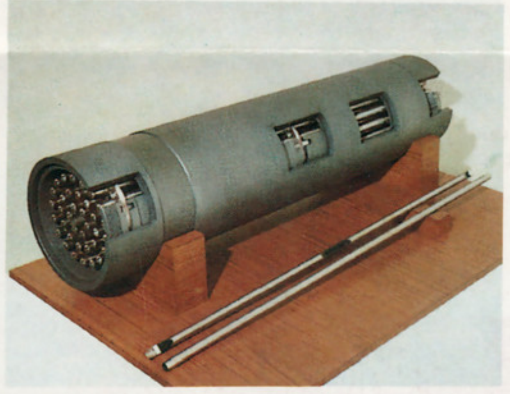
The steam passes via control valves to the high pressure turbine (12) from whence it is returned to the boilers for re-heating, prior to being fed to the intermediate (13) and three low pressure stages (14) of the turbine. Having exhausted its useful energy in turning the turbine at 3,000 rev/min, the steam is condensed in a pannier type condensor (15). The resulting condensate is pumped via the turbine extraction pump (16), condensate polishing plant (17), the turbine extraction condenser (18) and its associated extraction pump (19) to the direct contact heaters (20). From where it passes via the direct contact heaters extraction pump (21) to the deaerator (22) and the boiler feed pumps (23), which pump the condensate back to the boilers. Hence, the boiler feed water/steam operates in a closed cycle, the components of which serve two purposes, viz the efficient use of the heat which was originally generated within the reactor and the maintenance of a very high degree of water/steam purity.

The steam in the condensor is turned to water by passing it over thousands of titanium tubes through which cold sea water (CW) flows at half a million gallons per minute. The latter is taken direct from the sea adjacent to the station, passing via rotary drumscreens (24) to the four CW pumps (25). After passing through the condensors, the CW is returned to the sea via a separate channel. The increase in the sea water temperature by virtue of its passing through the system is only about 12°C.

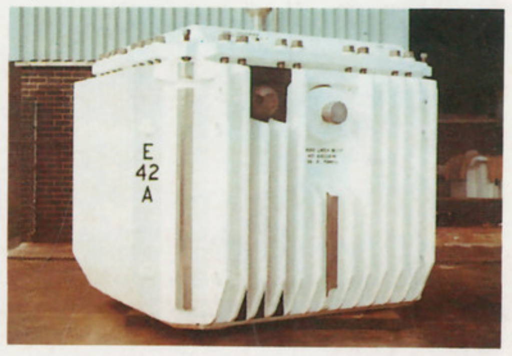
The turbine is directly coupled to an alternator rotor (26) which is enclosed in a water-cooled stator (27). The alternator, whose interior is hydrogen- cooled, supplies 660 MW at 23.5kV through a circuit breaker (28) to a transformer (29) which feeds the output into the 400kV grid. Power supplies for the station (30) are taken off as shown so that, if the reactor is shut down at any time, the station's auxiliary plant may be supplied direct from the grid.

FUEL

Hartlepool uses enriched uranium fuel in the form of cylindrical hollow pellets clad in stainless steel 'pins'. One fuel element comprises 36 pins supported inside a graphite sleeve and there are 8 elements per fuel channel.

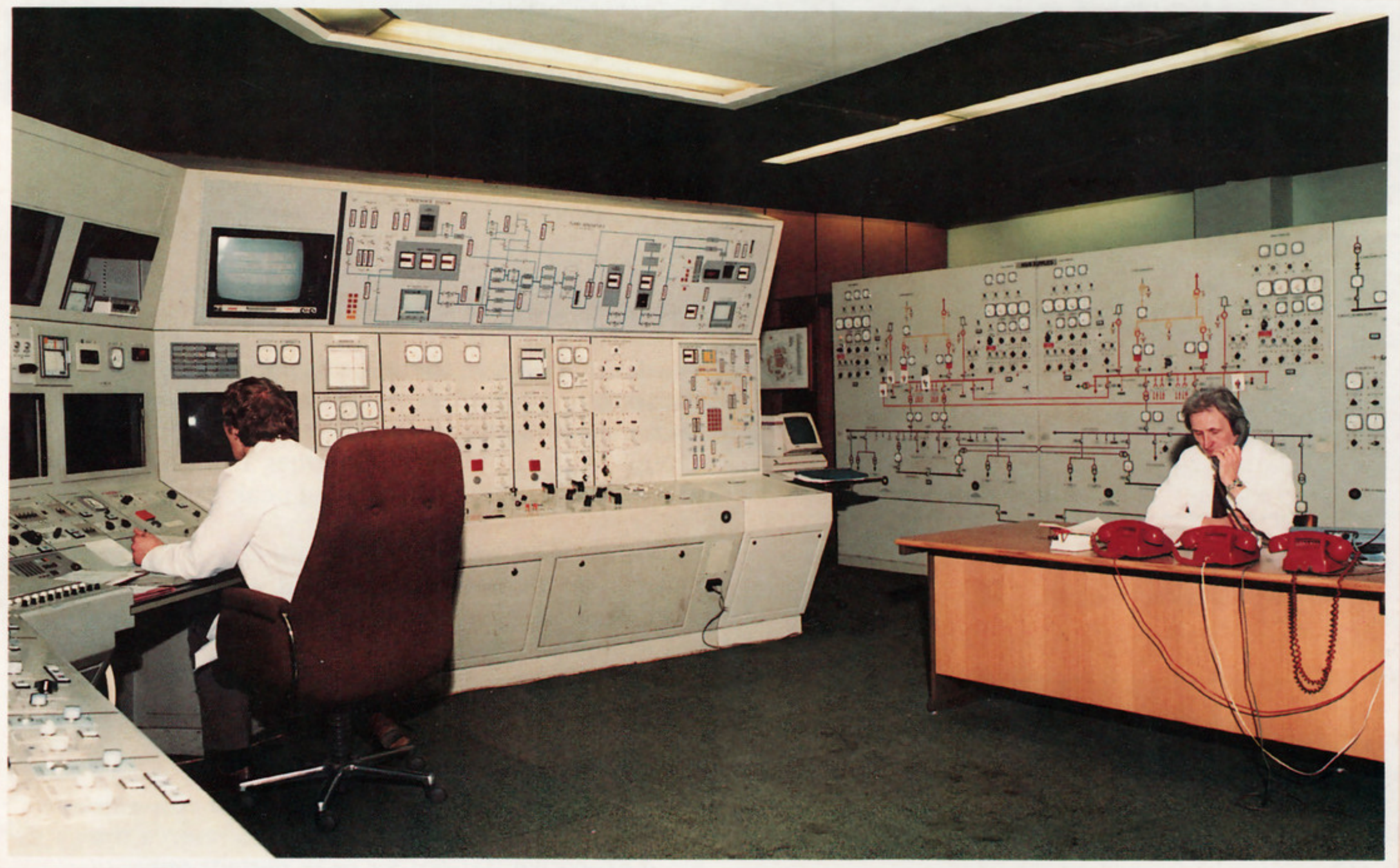


After use in the reactor the fuel is returned to the manufacturer, British Nuclear Fuels Ltd, for reprocessing. The fuel is loaded into special 'flasks', designed to rigorous international safety standards, for transportation to British Nuclear Fuels' Sellafield plant for reprocessing. The steel walls of each flask are 355mm thick giving full protection against the escape of radioactivity. They are designed to withstand a 9.75m fall onto a concrete surface, half-hour 800°C fire and 8 hours in 16m of water. There has never been a fuel flask accident involving the release of radioactivity. Their safety was demonstrated at the 100mph train crash experiment in 1984.



Facts and figures

Capacity	
Gross electric output:	2×666 MW(e)
Net electrical output:	2×622 MW(e)
Net thermal efficiency:	41.4%
Fuel Elements	
Material:	Hollow UO_2 pellets, stainless steel clad
Type:	36 pin cluster in graphite sleeve
Pin diameter (Pellet O.D.):	14.48mm (0.57in)
Inner sleeve diameter:	191mm (7.5in)
Element length:	1041mm (41in)
Number of elements per channel:	8
Enrichment	
Inner zone:	first charge: 1.4%, feed 2.3%
Outer zone:	first charge: 2.1%, feed 2.9%
Cores	
Moderator or reflector material:	Graphite
Mean diameter of active core:	9.3m (30.5ft)
Active core height, cold:	8.2m (27ft)
Diameter of fuel channel:	269.9mm (10.625in)
Number of fuel channel:	324
Diameter of control rod channel:	114mm (4.5in)
Number of control rod channels:	81
Lattice pitch (square):	457.2mm (18.0in)
Reactors	
Reactor heat:	1,500 MW(t)
Reactor gas inlet temperature:	287°C
Mean channel gas inlet temperature:	318°C
Mean channel gas outlet temperature:	651°C
Total gas mass flow at reactor outlet:	3,613kg/sec (7,965lb/sec)
Reactor coolant:	CO_2
Weight of uranium:	120 tonnes per reactor
Mean fuel rating including graphite heat:	12.5 MW(t)/TeU
Discharge irradiation:	21,000 MWd/TeU
Pressure Vessels	
Material:	Concrete, re-inforced and pressurised, lined with mild steel
Internal diameter:	13.1m (43ft)
Internal height:	18.3m (60ft)
External diameter:	25.9m (85ft)
External height:	29.3m (96ft)
Design gas pressure:	44 bara (644psig)
Circulators	
Type:	Centrifugal with integrated canned motor
Drive:	Constant speed electric motor
Flow control:	Variable inlet guide vane
Speed:	2,970 rev/min
Gas Pressure at circulator outlet:	41 bara (600psia)
Gas temperature at circulator outlet:	287°C
Motor input power:	38.2 MW(e) per reactor
Number of circulators:	8 per reactor
Boilers	
Type:	Helically wound, integrally finned pod boiler
Number of pods units per reactor:	8
Gas inlet temperature:	640°C
Gas outlet temperature:	278°C
Heat transferred to steam per reactor:	1,530 MW(t)
Superheater outlet header pressure:	171 bara (2,485 psia)
Superheater outlet temperature:	543°C
Steam generation per reactor:	486kg/sec (1,072lb/sec)
Reheater inlet header pressure:	41 bara (609 psia)
Reheater inlet temperature:	343°C
Reheater outlet header pressure:	39 bara (571 psia)
Reheater outlet temperature:	539°C
Reheater steam flow per reactor:	440kg/sec (972lb/sec)
Turbine Generators	
Gross electrical output:	666 MW(e)
HP cylinder TSV pressure:	160 bara (2,315 psia)
HP cylinder TSV temperature:	538°C
IP cylinder TSV pressure:	37 bara (543 psia)
IP cylinder TSV temperature:	538°C
Mean condenser vacuum:	731mm Hg (28.79in Hg)
Final feed water temperature:	157°C
Power factor:	0.86



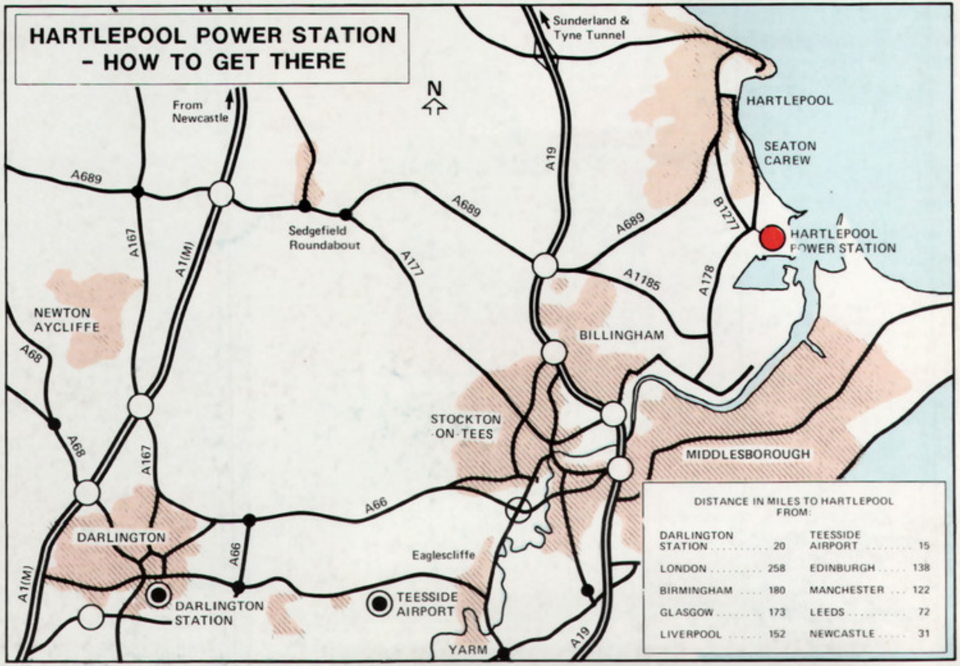
Hartlepool power station is situated near Seaton Carew on the Tees Estuary which is four miles south of Hartlepool and five miles north east of Teeside in the county of Cleveland. The station is one of the Central Electricity Generating Board's five advanced gas-cooled reactor (AGR) nuclear power stations.

The design of the power station was a development of the magnox nuclear power stations which first supplied electricity in 1962. When at full power the two 660 megawatt units at Hartlepool are able to supply almost twice the maximum power demanded for the County of Cleveland.

Hartlepool's first reactor/turbine unit supplied electricity to the national grid on August 1st. 1983. The second unit followed on October 31st. 1984 and both have since made significant contributions to electricity supplies.

Since construction was started, Hartlepool power station has provided over 20,000 man-years of work with much of the work force coming from the Teeside area.

In addition, the power station provides secure employment for over 700 people most of whom live locally. These include scientists, engineers, maintenance, mechanical, electrical and instrument craftsmen, health physics, personnel, canteen, administration and cleaning staff.



DISTANCE IN MILES TO HARTLEPOOL FROM:

DARLINGTON STATION	20	TEESSIDE AIRPORT	15
LONDON	258	EDINBURGH	138
BIRMINGHAM	180	MANCHESTER	122
GLASGOW	173	LEEDS	72
LIVERPOOL	152	NEWCASTLE	31