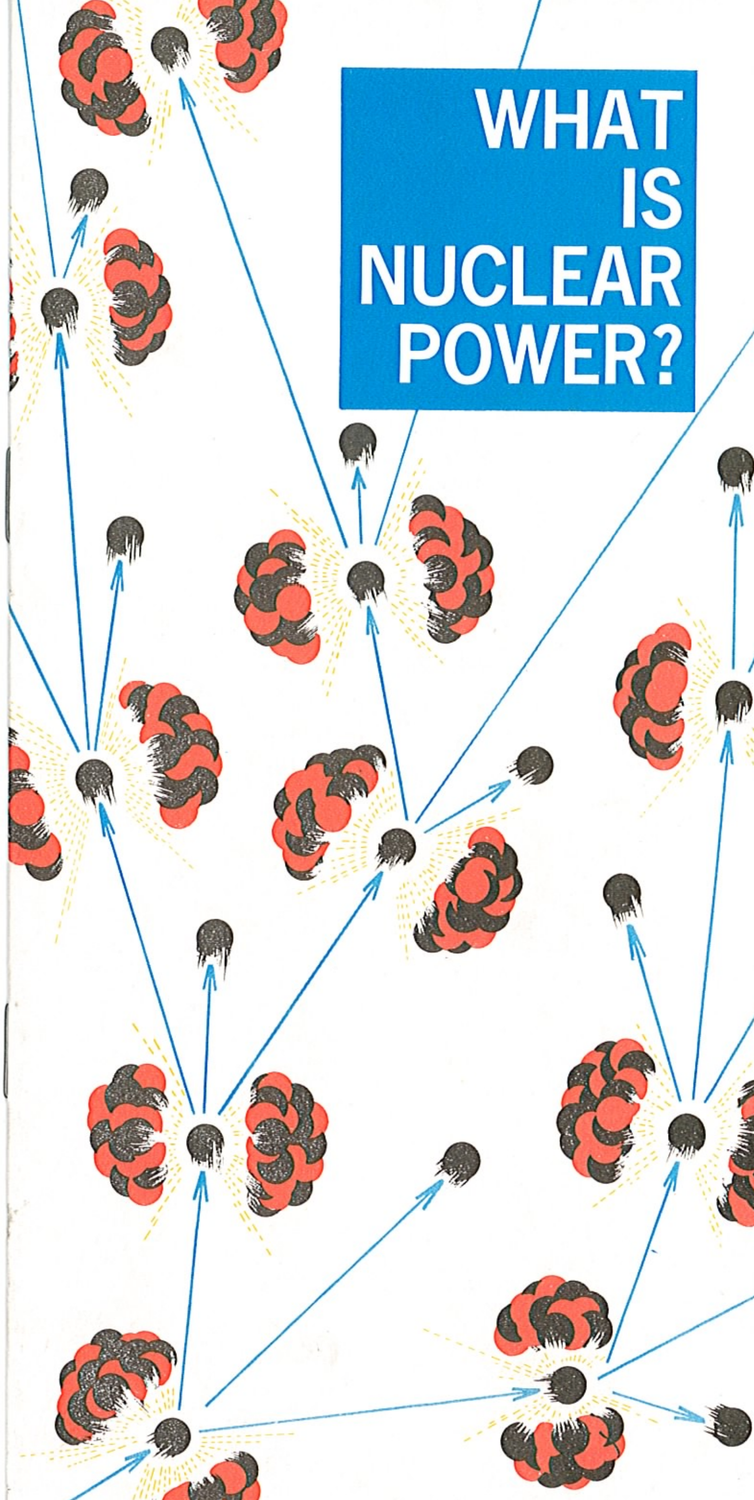
# WHAT IS NUCLEAR POWER?



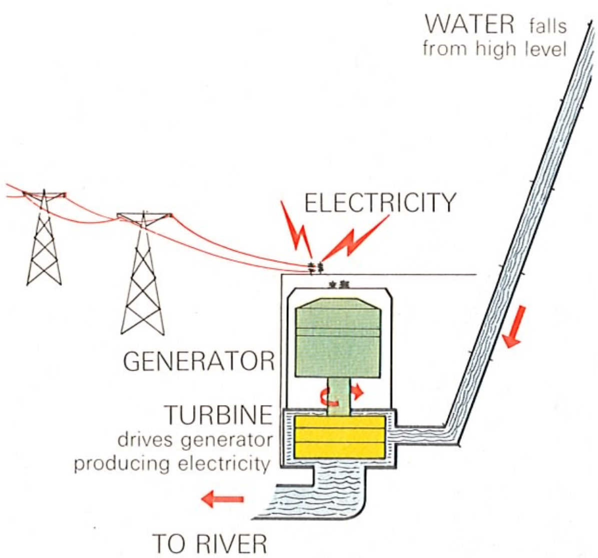
AUSTRALIAN ATOMIC ENERGY COMMISSION

# HOW IS ELECTRIC POWER PRODUCED?

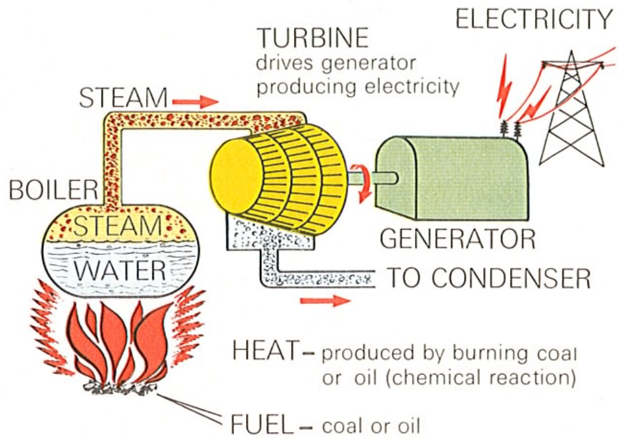
There are two main types of power stations generating electricity in Australia today. One uses water coming down from a high level to turn the turbine-generators. The other burns coal or oil to raise steam which turns the turbines. In a nuclear power station, steam spins the turbines, but the steam is raised by heat from a nuclear reactor—an atomic furnace.

This heat is produced by splitting atoms; the process is called fission. Millions upon millions of fissions per second are required to generate enough heat. By controlling the number of fissions, the required heat level can be maintained.

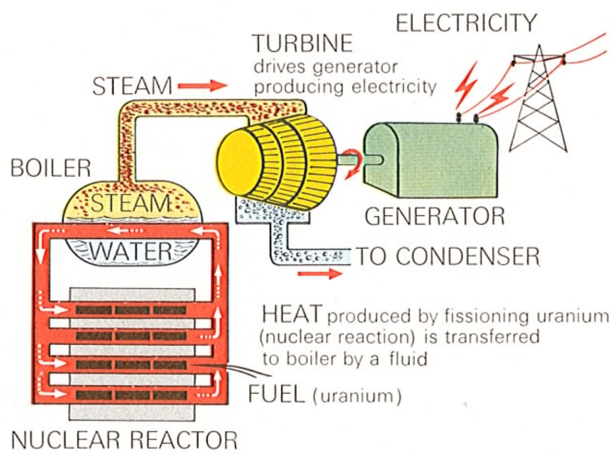
## Hydro-electric plant




## Thermo-electric plant

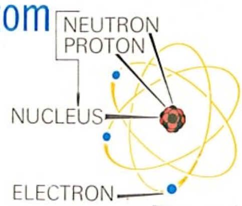



## Nuclear power plant



# THE ATOM, FISSION AND CHAIN REACTION

## Atom




The uranium 235 atom has in its nucleus
92 protons
143 neutrons
235

(There are also 92 electrons in orbit which play no part in the nuclear reaction.)

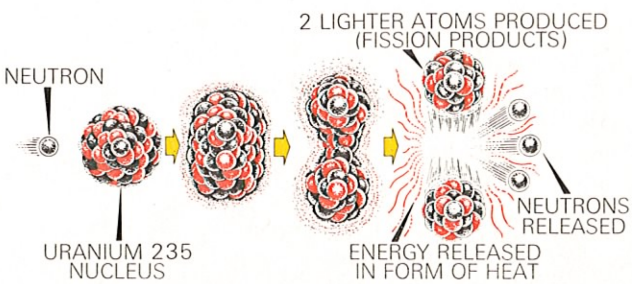
Everything is made up of atoms—the air, the earth, stars, man, a speck of dust. Atoms are minutely small, being about a hundredth of a millionth of an inch across. Each atom is made up basically of a cluster of protons and neutrons at the centre, forming its nucleus. Electrons orbit the nucleus, like planets around the the sun. Protons, neutrons and electrons are called "sub-atomic particles".

All atoms of a particular element have the same number of protons in the nucleus but the number of neutrons varies.

## Splitting the Atom (Fission)

Some atoms may split when they are bombarded by sub-atomic particles (such as neutrons). Only two elements have atoms suitable for producing nuclear energy. One is uranium occurring naturally in certain minerals; the other is the man-made element, plutonium. The type of uranium fissioned in nuclear power stations is uranium 235, so named because its nucleus contains 92 protons and 143 neutrons making a total of 235 particles. Naturally occurring uranium actually consists of two types—uranium 235 which can be made to fission and uranium 238 which is not fissionable. In every 100 lb of pure uranium only ¾ lb is uranium 235.

When the uranium 235 nucleus is hit by a neutron from outside the atom, the stray neutron becomes, so to speak, the straw that breaks the camel's back, and the uranium atom splits into two lighter atoms—and an average of two or three neutrons are shot out at high speed. Heat energy is created during the process.



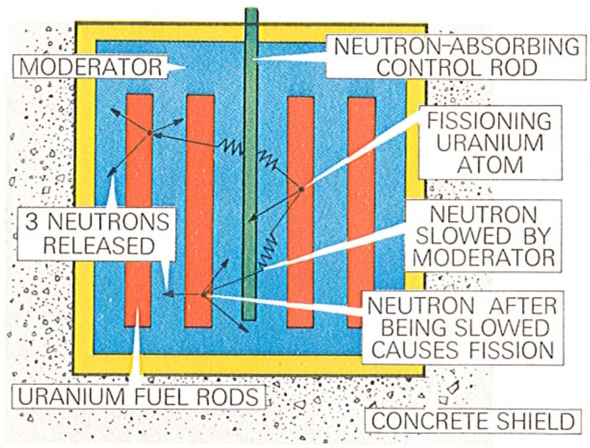



## Chain Reaction

The neutrons ejected by the uranium atom when it splits can now break up further uranium 235 atoms and release more neutrons and produce more heat. This is called a chain reaction and the process is illustrated on the front cover of this booklet.

To get heat on a commercially useful scale, millions and millions of uranium atoms have to be split every second. This large-scale splitting is done in a reactor. Very briefly, a nuclear reactor is a vessel in which enough uranium is placed for a chain reaction to become self-sustaining. The extent of the chain reaction is controlled in the reactor by special materials which absorb or "soak up" surplus neutrons and maintain the level of heat production, as required. To shut down the reactor, more neutron-absorbing material is inserted so that the chain reaction cannot be maintained and the fission process stops.

In the Australian Atomic Energy Commission's research reactor HIFAR at Lucas Heights, for example, cadmium rods operating like railway signal arms, are positioned in the heart of the reactor to control the number of free neutrons. To protect people from radiation, the reactor is enclosed in dense concrete.




Simplified arrangement of reactor showing chain reaction

The two or three neutrons released when a uranium 235 atom splits travel at a speed of about 10,000 miles per second. The most effective neutron speed to cause fission is about one mile per second. Materials called moderators are used in the reactor to slow down the neutrons. The most commonly used are carbon (graphite), water, and heavy water (about one part in every 6,500 parts of natural water).

# HOW DOES A NUCLEAR POWER STATION WORK?

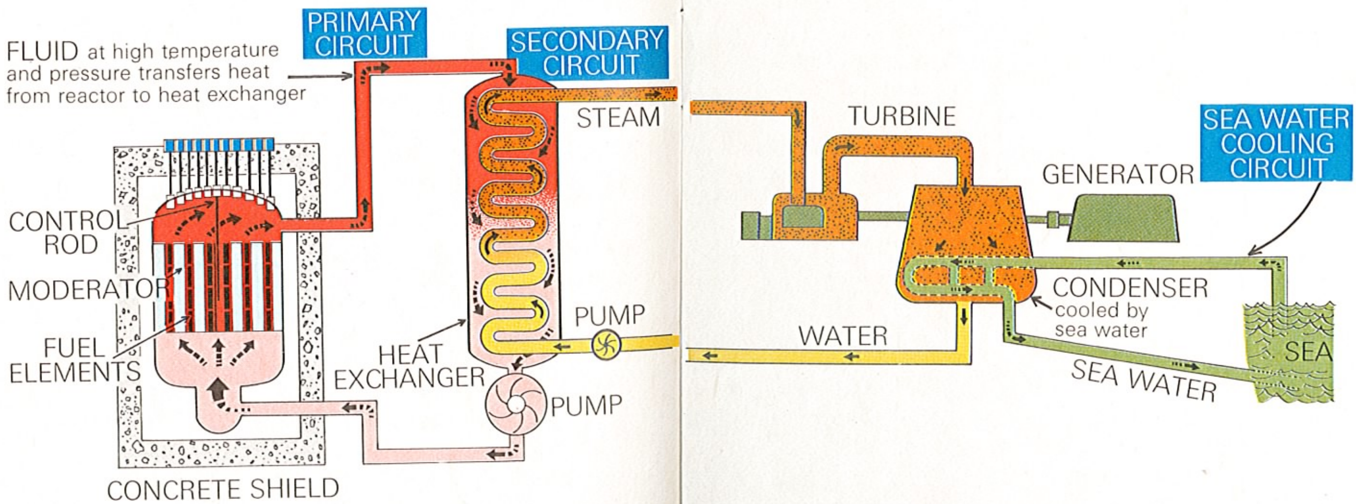
In a nuclear power reactor, uranium fuel replaces the coal or oil used in thermal power stations. Depending on the type selected, a nuclear power station producing 500 million watts of electricity (million watts = 1 megawatt), the size selected for Australia's first nuclear station, would require an initial fuel charge of 50 to 100 tons of uranium with a replacement rate of 20 to 50 tons a year. The fuel is loaded into the reactor in the form of rods or "elements" and a complete assembly of fuel elements, together with the surrounding moderator, is known as the reactor core.

A coolant gas or liquid is pumped through the core to remove and transfer the heat to a heat exchanger (equivalent to a conventional boiler) to produce steam. Immense quantities of heat are generated in nuclear reactors and the cooling system must be efficient and highly reliable.

Steam produced in the boiler drives a turbine-generator which, in turn, generates electricity. The spent or exhaust steam from the turbine is channelled into a condenser. Cooling water from the sea flows in tubes through the condenser to cool the steam and turn it back into water. This water, still warm, is pumped back into the boiler to begin the cycle again. The cooling water, after passing through the condenser, flows back to the sea. The two steam-producing circuits and the condenser cooling circuit are designed to prevent the fluids in the circuits coming into actual contact with each other. Thus, because each circuit is completely self-contained, no radioactive material from the reactor can be discharged into the sea.

Some nuclear reactors use uranium fuel in its naturally-occurring proportions. This is called "natural uranium".

Other reactor types use "enriched uranium". Here the proportion of fissionable uranium 235 to uranium 238 has been increased by special processing.




Generalised view of nuclear power station showing basic components

# HOW IS NUCLEAR FUEL PRODUCED ?

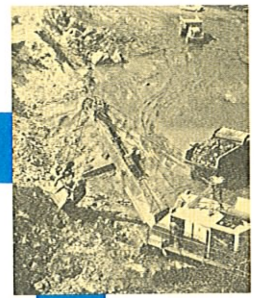
Uranium ore is the starting point in the nuclear fuel cycle. This particular mineral, Pitchblende, was mined in the Northern Territory and contains approximately 60% uranium oxide

Uranium has been mined already in Australia at Mary Kathleen in Queensland, at Rum Jungle and several other places in the Northern Territory, and at Radium Hill in South Australia. Uranium ore is usually treated in plants located near the mines. The product is "yellowcake"—a crude uranium oxide concentrate.

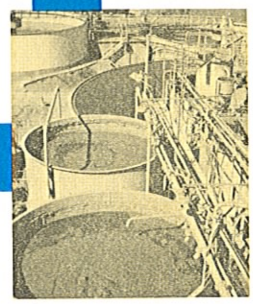
Uranium used in reactors must be extremely pure, and present-day processes are involved and costly. After chemical processing, pure uranium oxide is compacted and sintered into small pellets for use in nuclear fuel elements. The pellets are stacked and sealed in thin-walled metal tubes and, in a typical fuel element, a number of these tubes are assembled into bundles.

Research is being undertaken at the AAEC Research Establishment, Lucas Heights, into all phases of fuel element manufacture. Studies in progress could lead to improved methods for producing nuclear-grade uranium oxide from Australian mine concentrates.

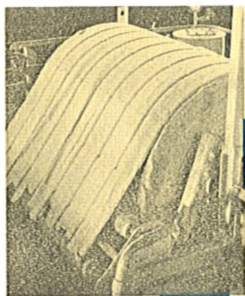
Uranium exploration



Open-cut mining

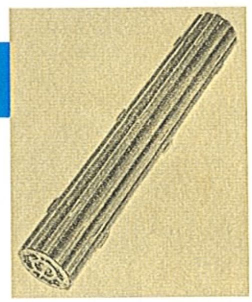


Uranium treatment



Crude concentrate —"yellowcake"

Fuel pellet manufacture

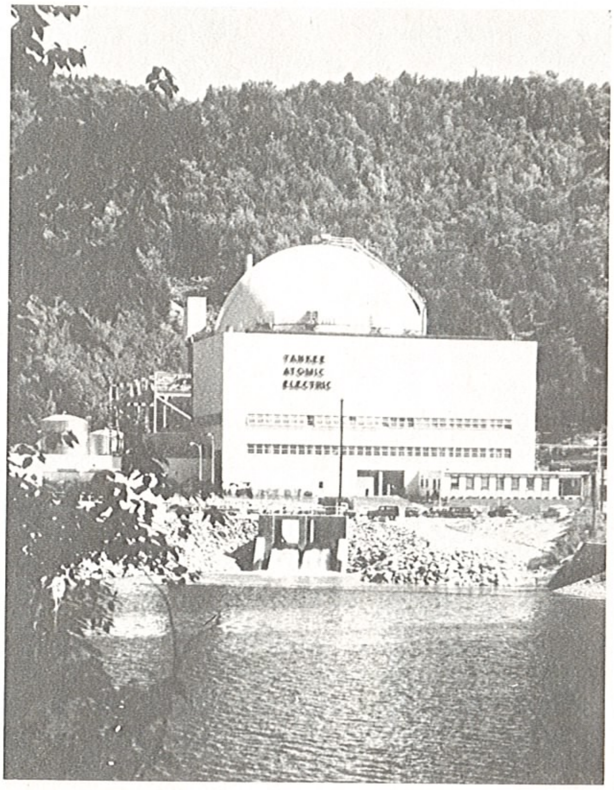


Typical fuel element

# ARE NUCLEAR POWER PLANTS SAFE?

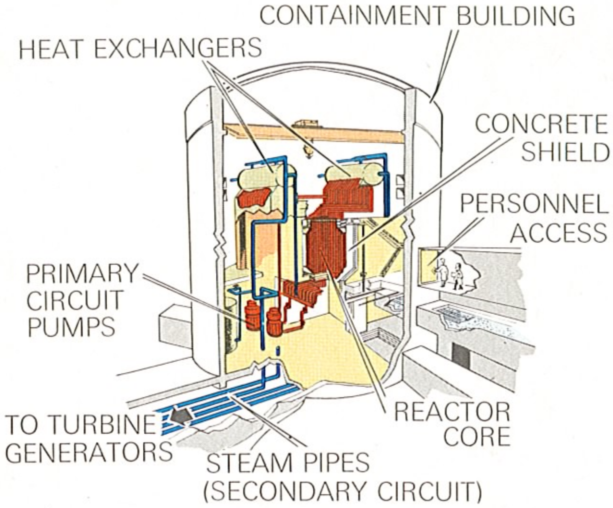
The atom is a completely new source of energy. Atomic energy was originally introduced to the world, not as a miracle of peaceful value but as a fearful weapon of war.

Because of the violent introduction of atomic energy to the world, the nuclear power industry has taken the most cautious approach in engineering history. Although this industry is relatively new, it has already logged millions of hours of operating experience overseas. There has never been a radiation injury to anybody in a commercial nuclear power plant, nor has there been any instance in which these power plants have affected public health or safety.



175 MW Yankee nuclear power station, Rowe, Massachusetts, U.S.A.

Because of the way in which a nuclear power reactor is built it cannot explode like an atomic bomb.




An example of a nuclear power station layout showing some basic components

Nuclear power reactors have a large number of in-built safety and automatic warning systems to guard against every possible failure or rise in radioactivity. The in-built safety systems are evaluated and tested carefully at the design stage, and must meet rigorous testing programs after construction. Only then can the power plant be "started up".

Any release of radioactivity from the plant will not exceed very low levels predetermined by both the State and Commonwealth Health Authorities. Set limits would be similar to those which have operated since 1958 at the AAEC Research Establishment at Lucas Heights, near Sydney, where two nuclear research reactors have been in full-power operation since 1962.

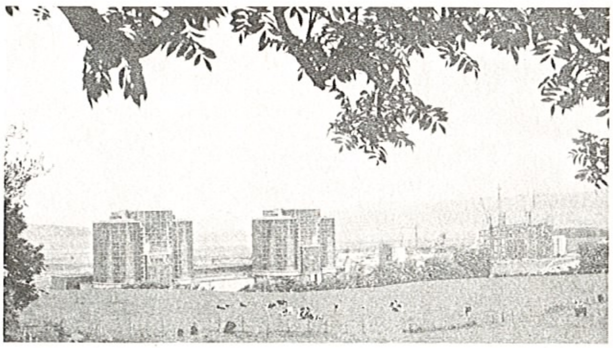
# SITING

A power plant is best situated close to the area of electrical demand. Good rock foundations are an advantage, and it is best to have space for the development of the site and for any future extensions which might be required.

An ample supply of cooling water is one of the major factors. All large power plants generating electricity with steam—whatever the fuel — need large amounts of cooling water. This water is not used up—it is merely borrowed from the sea, pumped to the plant, circulated through steam condensers, and then returned to the sea as clean, clear and as uncontaminated as when it entered. The slight increase in temperature that occurs is quickly dissipated on return to the sea.

A nuclear power station located at the high water mark on a coastline with a minimum tidal movement would reduce pumping costs, pipelines, and so forth and ensure a plentiful supply of cooling water.

Nuclear power stations do not require extensive fuel storage and handling plant. Instead of huge conveyor networks to carry fuel, or scores of rail trucks arriving every day at a coal-burning station, a month's supply of fuel (1 to 4 tons a month average) can be delivered by ordinary road transport.



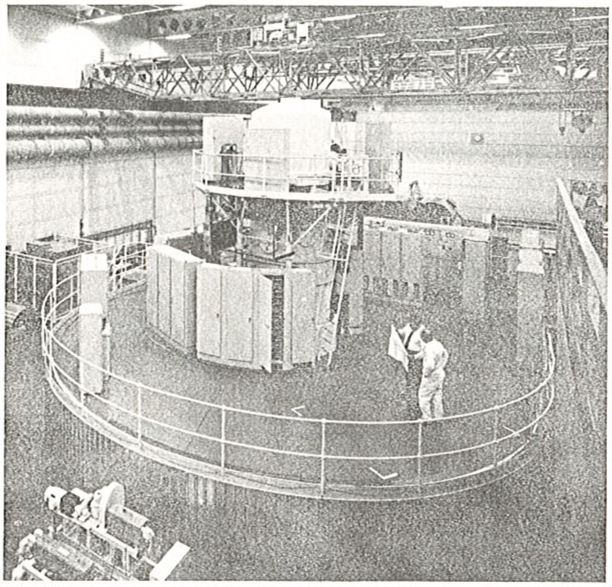
300 MW Hunterston "A" nuclear power station, Scotland. Hunterston "B", under construction(right),is designed for an output of 1,250 MW

The Commonwealth Government proposes to build Australia's first nuclear power station at Jervis Bay, some 120 miles south of Sydney by road. The site, Murray's Beach, is ideal for the supply of water and is flat and reasonably close to existing roads and power distribution systems. Geophysical and geological surveys show that the rock foundation for a power plant and associated services is most suitable.



# CONSERVATION

More and more people are becoming concerned over the need to conserve our natural assets—clean water and clear skies; animal and plant life. Nor can we afford to squander consumable resources, such as minerals, without regard to the future. Nuclear power can help in both these aspects.



Fuel-changing machine in position on top of the 100 MW, SGHWR nuclear power station, Winfrith, Dorset, U.K.

A nuclear power station is clean and quiet. It gives off no smoke or fumes, no dirty effluents. It requires no big fuel storage and handling areas—no coal dumps and conveyors, no trainloads of coal, no oil tankers.

The nuclear station, though it is large, can be designed and landscaped to harmonise with the surroundings. It causes a minimum of disturbance to plant and animal life. To build up our knowledge of the Jervis Bay environment, continuous measurements are being made, for example, of the air, water, beach sands, soil, and marine life in the bay and ocean. These checks will continue so long as the plant exists. State and Commonwealth Departments of Health and conservation authorities will be closely involved throughout.

As a new source of power, nuclear energy will also delay the depletion of the coal, oil, and natural gas resources which are so valuable to the metallurgical and chemical industries.

# WHY NUCLEAR POWER?

- It is clean, safe and efficient in operation.
- Annual fuel requirement would be 20 to 50 tons weight. A nuclear power station, therefore, can be sited independently of fuel supplies.
- Costs of electricity from large nuclear stations are competitive with coal, oil or hydro in some areas. Nuclear electricity will continue to become progressively cheaper.
- Does not pollute the atmosphere or environment.
- Known uranium ore deposits are extensive.
- Used nuclear fuel, after reprocessing, can be returned to the reactor or stored for future use.
- Some fission products, such as radioisotopes, have important applications in medicine and industry.
- Will assist Australia to gain the benefits of a new and advanced technology while, at the same time, offering new opportunities to develop further our engineering experience.
- This new technology will help Australia to train and hold many highly-competent scientists and engineers who might otherwise leave the country.



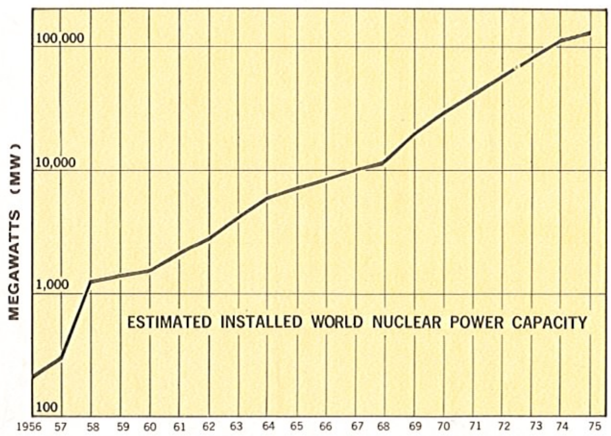
# THE FUTURE

In 1965-66, electricity generated by nuclear means became cheaper in many parts of the world than electricity generated by conventional means.

At the beginning of 1970 there were 84 nuclear-fuelled power reactors operating in 15 countries throughout the world with an aggregate generating capacity of approximately 13,000 megawatts of electricity. By 1980 it is estimated by the International Atomic Energy Agency that more than 300,000 megawatts, or about one-eighth of the world's total generating capacity, will be nuclear.

Australia's first nuclear power station at Jervis Bay, south of Sydney, will be the forerunner of many nuclear plants to be built in this country. In the future, not only could they generate large quantities of electric power more cheaply than conventionally-produced power, but they might also make possible the establishment of large metallurgical centres—e.g., for iron and steel in North-Western Australia, and for aluminium at Gove, Northern Territory. They could also provide fresh water for our cities and for industry, by desalting sea-water.

In addition to playing an important role in our national development, nuclear power will allow us to utilise fully all the benefits of this new technology and truly enter the Atomic Age.




The above graph, based on International Atomic Energy Agency figures shows the rise in estimated installed world nuclear power capacity from 1956 to 1975

# JERVIS BAY NUCLEAR POWER STATION PROJECT

Murray's Beach, the site selected by the Commonwealth Government to build Australia's first nuclear power station, is on the southeast tip of Jervis Bay, about three miles directly east of the Royal Australian Naval College and about 120 miles south of Sydney, by road.

The Commonwealth Government has assigned overall responsibility for the project to the Australian Atomic Energy Commission. The AAEC is acting in close consultation with the Electricity Commission of New South Wales, which will take the power from the completed station directly into the New South Wales grid.

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