CHAPTER 18

ENERGY

Introduction

Australia is an energy rich country, with major reserves of coal and natural gas and substantial reserves of uranium. Australia's known reserves of crude oil are however small. While Australia is currently about 70 per cent self-sufficient in crude oil, this will decline, in the absence of new discoveries, to less than 20 per cent by the end of the century. Whilst there are no known deposits of heavy-oil or tar sands, there are extensive deposits of oil shale which are located primarily in Queensland. Thorium, solar, wave, hydro-power, wind, ocean thermal, wood, geothermal, tidal and crops resources also represent actual or potential energy sources.

Assessments made during 1979-80 indicate that Australia's demonstrated economic recoverable energy resources total 1,248 exajoules (joules x 10^{18}) of which 58 per cent is accounted for by black coal, 27 per cent by brown coal, 12 per cent by uranium with demonstrated oil and gas resources representing only 3 per cent of the total. On a state basis 32 per cent of Australia's recoverable economic energy resources (other than uranium) are located in Victoria, almost all of which is brown coal. Queensland accounts for about 36 per cent of national energy resources and New South Wales for 30 per cent (most of which represents black coal). Significant reserves of natural gas are located in the Gippsland Basin and the Cooper Basin and substantial reserves are known to exist on the North-West Shelf.

Australia's energy resources, combined with abundant supplies of many raw materials, create the opportunity for a large expansion in energy exports and the development of energy intensive industries. Despite this relative abundance, Australia shares the world-wide concern regarding the growing shortage of energy resources, and in particular oil resources. The energy problem is a global one and Australia is participating in discussion on energy with its industrialised partners within the International Energy Agency (IEA) and in other international fora, especially the United Nations and its agencies. The IEA has emphasised the need for measures to reduce levels of oil imports, to use oil more effectively and to develop alternative energy sources.

The immediate aim of Australia's energy policy is to reduce dependence on imported oil and ensure that secure and stable supplies of energy—particularly liquid fuels—are readily available. In the longer term, the aim is to develop a diversified energy base which will minimise dependence on liquid fuels.

These objectives are being pursued by pricing and tax policies, the pursuit of energy conservation and inter-fuel substitution, the encouragement of exploration and development, support for major energy development projects, the stimulation of energy research and development, and active international co-operation.

The most significant development in shaping the current energy policy was the decision, taken in August 1978, to raise the price of domestically produced oil to full import parity. This resulted in refiners—and hence consumers—paying prices for petroleum products which generally reflected the value of oil on the world market. The move to full import parity was implemented by the addition of a crude oil levy on local production. The proceeds of the levy accrue to consolidated revenue.

The Government's oil pricing policy provides a basic framework within which conservation, interfuel substitution, exploration and development and research into alternative fuels can be pursued. Significant gains have already been made in reducing consumption of petroleum products and in substituting coal and natural gas for oil-based fuels in both industrial and residential uses. The higher real price of oil has been important in encouraging an increase in exploration and development as well as the promotion of synthetic fuel production. For example, the first phase of the Rundle shale oil project is expected to produce about 200,000 barrels of syncrude per day by the early 1990s. The North-West Shelf project in Western Australia is another example of an important energy project in Australia. The project is expected to cost $8,000m and will provide a substantial proportion of Western Australia's energy requirements as well as being an important source of export income. The Western Australian State Energy Commission will be constructing a 1,500 km pipeline from Dampier to Perth to carry the gas to the south-west of the State. Natural gas provides an attractive alternative to crude oil products and the Government is anxious to extend natural gas pipelines to provide wider access to this energy source.

Advice and co-ordination

International Energy Agency

The International Energy Agency (IEA) was established in Paris in November 1974 as an autonomous institution within the framework of the Organization for Economic Co-operation and Development. (Australia did not seek membership at that time.)

In January 1979 Australia applied for membership. This application was accepted by the IEA Governing Board in March 1979, and Australia formally became the twentieth member of the IEA in May 1979. Other members of the IEA are Austria, Belgium, Canada, Denmark, the Federal Republic of Germany, Greece, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States of America. The Agency is supported by a permanent Secretariat headed by an Executive Director.

The objective of the IEA is to implement the International Energy Program as set out in the Agreement authorising the establishment of the Agency. This Agreement encompasses the development of a common level of emergency self sufficiency in oil supplies, establishment of common demand restraint measures, the creation of an Emergency Oil Sharing Scheme (EOSS) to be activated in an emergency supply situation, an information system on the international oil market and a framework for consultation with oil companies. The IEA is particularly active in energy research projects and is promoting closer relations with producer countries.

In October 1977 the IEA adopted a Group Objective of limiting oil imports to 26 million barrels per day by 1985. Principles for Energy Policy were also adopted which provide an international policy framework to assist Governments in the definition of national energy policies. In March 1979 IEA member countries agreed to reduce their demand for oil on the world market in the order of 2 million barrels per day, and in May 1979 adopted the Principles for IEA Action on Coal to boost, significantly, the use of coal. The Coal Industry Advisory Board was established in 1979 to provide practical advice to the IEA on the implementation of these Principles. Australia is represented on the Board. In December 1979, IEA Member Countries adopted a system of individual country oil import targets as an energy conservation measure.

In 1980 the IEA established a High Level Group on Energy Technology Commercialisation, composed of senior policy making officials, to implement the report of the International Energy Technology Group on the accelerated introduction of new energy technologies. This acceleration is aimed at enhancing production of alternative liquid fuels.

The IEA decisions which are binding on members are made by the Governing Board of the Agency. The Governing Board is composed of Ministers (or delegates) from member countries. The Management Committee composed of senior officials from each member country, carries out functions assigned to it in the Agreement or delegated by the Governing Board. Standing Groups have been established to monitor developments in Long-Term Cooperation, the Oil Market, Emergency Questions and Relations with Producers and Other Consuming Countries and Research and Development.

National Energy Office

Reviewing energy policy and providing policy advice on an ever increasing range of energy matters is a major task for the National Energy Office. It provides policy advice on energy pricing and taxation, and also provides departmental support for the National Energy Advisory Committee (NEAC) and the National Energy Research, Development and Demonstration Council (NERDDC), and contributed substantially to participation by the Department of National Development and Energy in the work of the Australian Minerals and Energy Council (AMEC).

National Energy Advisory Committee (NEAC)

The National Energy Advisory Committee was established on an interim basis in February 1977 and as a permanent committee in February 1978. Its functions include the provision of advice on Australia's energy reserves and on factors likely to influence the pattern of energy supply and demand, and future costs, in Australia; the assessment and development of our energy resources; and economy in the use of energy. The Committee is also required to offer advice on the balance of resources for research relating to the development of energy sources in Australia, and on development both here and overseas in respect of methods and technology associated with the production and distribution of energy.

The Committee consists of 18 members who have been selected with a view to covering a wide spectrum of expertise in the energy area, and appointed on the basis of the personal contribution which they can make to the work of the Committee, as distinct from any representational role they might otherwise perform. Since its inception, NEAC has published the following reports: *An Australian Conservation of Energy Program* (September 1977); *Australia's Energy Resources: An Assessment* (December 1977); *A Research and Development Program for Energy* (December 1977); *Motor Spirit—Octane Ratings and Lead Additives* (February 1978); *Electric Vehicles* (June 1978); *Exploration for Oil and Gas in Australia* (December 1978); *Fuel Economy Goals for Passenger Cars* (May 1979); *Efficient Use of Liquid Fuels in Road Vehicles* (July 1979); *Liquid Fuels—Longer Term Needs, Prospects and Issues* (December 1979); *Strategies for Greater Utilisation of Australian Coal* (May 1980) and *Natural Gas: The Key Issues* (June 1980).

Other Organisations

In May 1978 the then Minister for National Development announced the establishment of a further advisory body, the National Energy Research, Development and Demonstration Council. The Council advises the Minister for National Development and Energy on the development and co-ordination of a national program of energy research in Australia and the disbursement of funds under the National Energy Research Development and Demonstration Progam (NERD & D Program). The Council is supported by a secretariat within the National Energy Office of the Department of National Development and Energy.

For further details of the activities of NERDDC *see* Chapter 25, Science and Technology.

Resources

Black coal

Black coal is currently second to petroleum products as the largest source of primary energy in Australia. In geological terms it varies greatly in age, ranging from Permian to Miocene, or from about 225 million years to 15 million years of age. Within this range the Permian or oldest coal measures are of the highest quality. By world standards, in relation to her present population and consumption, Australia is fortunate in the availability of easily worked deposits of coal. The country's main black coal fields are located in New South Wales and Queensland, not far from the coast and from the main centres of population. Coal is a complex organic rock composed principally of carbon, hydrogen and oxygen, but also containing nitrogen, sulphur and other elements. It has formed from accumulated vegetable matter, which has subsequently undergone chemical and physical changes due to organic decay and to pressure and heat arising from burial. Coal also contains varying amounts of non-combustible materials such as silt and clay deposited as sediment among the vegetable debris: these contribute to the mineral matter content of coal which is related to coal ash. Most Australian coal deposits are classed as bituminous, but there is some sub-bituminous coal and a little anthracite. The bituminous coals have a wide range of properties: volatile contents range from high to low and, although ash tends to be high, the sulphur content is almost universally low.

Identified black coal resources amount to over 526,340 million tonnes which could yield more than half of this in saleable coal. Economically recoverable resources are currently about 20,000 million tonnes, almost all in the Sydney Basin in New South Wales and the Bowen Basin in Queensland. There are other coal bearing basins in New South Wales and Queensland, and small deposits are being worked in Western Australia, South Australia and Tasmania.

For further details relating to the production of black coal in Australia *see* Chapter 16, Mineral Industry.

Brown coal

About 99 percent of Australia's brown coal identified resources are in Victoria, where the total is estimated at 126,000 million tonnes. Nearly all are located in the Latrobe Valley where 105,000 million tonnes, are recoverable. Small deposits exist in other areas of south Gippsland, in south eastern Victoria at Gilliondale and in the south central region at Anglesea, Bacchus Marsh and Altona. Deposits are also known at many places along the southern margin of the continent, as far north as central Queensland, and a large deposit is being tested in the Kingston area of South Australia.

Because brown coal has a relatively low specific-energy value and high water content, its utilisation depends on large-scale, low-cost mining and negligible transportation costs in its raw state. However, as an energy resource, Australia's recoverable economic resources of brown coal are 1.6 times as large as the equivalent category of recoverable non-coking coal (based on thermal equivalents) and are equal to about 65 per cent of total recoverable demonstrated resources of black coal.

In Victoria the brown coal industry has reached a high degree of sophistication in mining, on-site development for power generation, briquetting and char manufacture. In a Victorian Government *Green Paper* published in 1977 the then Victorian Ministry of Fuel and Power estimated that by the year 2000–01, Victorian brown coal requirements will be between 724 and 1,036 thousand terajoules, or between about 79 and 113 million tonnes per year (production of brown coal in Victoria during 1977–78 was 30,512,000 tonnes). The brown coal deposits of the Latrobe Valley have been developed by the State Electricity Commission of Victoria (SECV) for the generation of electricity. In over a century of operation more than 600 million tonnes of raw brown coal have been mined. This represents less than one per cent of the proven geological reserves.

Oil

After World War II the Commonwealth Government actively encouraged oil exploration. The Bureau of Mineral Resources was able to provide much background information (mainly of the results of geological and geophysical surveys) to organisations participating in the search for oil and the State Mines Departments also afforded considerable assistance. The results of early efforts in the post war period were generally disappointing, but oil was struck at Rough Range, Western Australia, in 1953. Although the flow was short-lived, the discovery marked an important stage in the search, and provided a much needed stimulus for further exploration.

Petroleum is broadly defined as any naturally occurring hydrocarbon or mixture of hydrocarbons, whether in a gaseous, liquid or solid state (excluding coal). Nearly all petroleum occurs in sedimentary rock sequences which contain source and reservoir beds. Australian sedimentary basins that do contain petroleum are thought to be comparable in yield to overseas basins of the same type, but they lack the anomalously rich basins that are found in parts of the Middle East, the United States and Russia. The nature of Australian source rocks and the temperatures that they have undergone have produced lighter oils and a higher proportion of gas to oil than usual elsewhere in the world.

Recovery of oil, by means of wells drilled into a sub-surface reservoir, that relies solely on the natural expansion of reservoir gas and/or on the natural drive of reservoir water, is called "primary". "Secondary" recovery methods involve the artificial reinjection of gas and/or the injection of water. Many other techniques, referred to as "tertiary", may further improve recovery. In modern production, various techniques for enhanced recovery are applied more or less from the beginning to obtain the optimum economic result, hence the ultimate recovery of oil depends on cost (including royalty and levy) and price. No combination of these techniques, however, is capable of recovering all of the oil in a reservoir.

The proportion of gas recovered from gas reservoirs is generally higher than the proportion of oil recovered from oil reservoirs. The ultimate recovery of gas is sensitive to cost (including royalty) and price. These factors control the number of wells that may be drilled to develop the reservoir, the pressure at which the field is to be abandoned and the rate at which the field is to be produced. In terms of size, petroleum fields are not evenly distributed: large fields are few and they generally contain a major proportion of the total petroleum resources of a province. The large fields tend to be discovered early in the exploration of a province, and for this reason it is highly unlikely that the Gippsland Basin contains an oil field larger than Kingfish or that the Rankin Trend of the Dampier Sub-Basin contains a gas field larger than North Rankin.

Major prospects for new oil discoveries are in untested areas and it is likely that most of Australia's undiscovered oil will be contained in only a few fields. Extrapolation from known areas suggests that undiscovered oil will be of the lighter types and that more oil fields than gas fields will be found. The Bureau of Mineral Resources, Geology and Geophysics has estimated that there is an 80 per cent chance of finding, at best, another 150 million cubic metres (950 million barrels) of crude oil in Australia, and a 20 per cent chance of finding more than 600 million cubic metres (3.8 billion barrels). The mean of the BMR estimate, which occurs at 28 per cent probability is, 420 million cubic metres (2,600 million barrels). This compares with recoverable identified economic resources of 300 million cubic metres (1,900 million barrels) and identified sub-economic resources of 35 million cubic metres (320 million barrels). For further details *see* National Energy Advisory Committee's report *Australia's Energy Resources: An Assessment (2nd Ed.)*.

Most of Australia's identified resources of oil occur in the Gippsland Basin (Vic.), with smaller quantities at Barrow Island (W.A.), in the Cooper Basin (S.A.), Amadeus Basin (N.T.) and Surat Basin (Qld). The best prospects for further major discoveries of oil are probably in water deeper than 200 metres off Western Australia. In 1977–78 24,941,000 cubic metres of crude oil was produced in Australia.

Pricing of Australian Crude Oil

In June 1979 the Commonwealth Government announced new pricing arrangements for locally produced crude oil. Under these arrangements all oil is priced to refiners at the import parity price with the producers receiving an amount dependent on the rate of annual production of the producing field (or area). The return to producers from parity related oil, defined as either the first 953,925 kilolitres (6 million barrels) per annum produced from each field or a certain percentage of production (50% in 1980–81), depends on the rate of annual production of the producing field as follows:

- For fields producing less than 317,975 kilolitres (2 million barrels) per annum the producers receive the import parity price less a levy of $18.90 per kilolitre.
- For fields producing between 317,975 kilolitres (2 million barrels) and 2,384,813 kilolitres (15 million barrels) per annum the producers receive $67.07 per kilolitre, which they were receiving on 30 June 1979 for parity related oil, plus 25% of any increase in the import parity price since then.
- For fields producing more than 2,384,813 kilolitres (15 million barrels) per annum the producers receive $60.29 per kilolitre increased by the lesser of the percentage increase in the Consumer Price Index since the September quarter 1978 or the percentage increase in the import parity price after 1 July 1979.

Producers receive the controlled return for that part of their production which does not receive the higher parity related returns. Controlled returns received by the producers are based on the price applicable on 31 December 1978 ($14.66 per kilolitre for Bass Strait and $18.12 per kilolitre for Barrow Island) plus any increases in compensation for credit terms since then.

The import parity price is currently reviewed every six months (1 January and 1 July) and is based on the landed cost of Saudi Arabian light crude oil at the nearest refinery port to the producing field adjusted for domestic freight costs, quality differential and compensation for credit terms. The current import parity price, from 1 July 1980, is $173.08/kl ($27.50/bbl) for Bass Strait crude, $175.12/kl ($27.83/bbl) for Barrow Island and $178.86/kl ($28.42/bbl) for Moonie and nearby areas.

Crude Oil Allocation Scheme

The crude oil allocation scheme was introduced to stimulate the production of Australian crude oil by ensuring an outlet for this production. The allocation scheme first came into operation in September 1971. On 17 September 1980 the Minister for National Development and Energy announced the extension of the scheme, subject to some modifications, until 31 December 1984.

The scheme provides for the allocation of indigenous crude to refiner marketers based on their market share of most refined petroleum products sold or consumed in Australia. The major petroleum product that currently does not attract an allocation is fuel oil delivered direct into customer owned storages. However inland fuel oil sales are to be phased out from the list of products attracting an allocation over a two year period from 1 January 1981. By 1 January 1983 fuel oil sales will no longer make any contribution to a refiner's allocation of indigenous crude oil.

Another important modification to the crude oil allocation scheme is that from 1 January 1981 producers of crude oil who continue the sale of gas condensate (liquid petroleum produced in association with natural gas) may retain an equivalent volume of crude oil for their own use or disposal outside the allocation scheme. This unallocated crude oil available to producers is subject to the crude oil excise and import parity pricing arrangements. Condensate marketed separately from a crude oil stream is not subject to allocation and excise and is sold at free market prices.

The crude oil allocation scheme facilitates an equitable distribution, to the refiners, of indigenous crude oil priced at import parity.

For details such as government assistance in the discovery and mining of petroleum (including natural gas) in Australia *see* Chapter 16, Mineral Industry.

Natural gas

The remaining reserves of natural gas (sales gas) in Australia at 30 June 1980 are estimated to be 845.32 billion (thousand million) cubic metres (29.81 TCF). This is made up of 311.97 billion cubic metres (11.01 TCF) in fields or groups of fields which have been declared commercial and combines both Proved and Probable reserves together with 533.35 billion cubic metres (18.8 TCF) of theoretically recoverable reserves which are either geologically proved but uneconomic under present conditions, or are awaiting further appraisal and could be subject to major revision. There are also reserves of condensate and liquefied petroleum gas (LPG) which fall into the same categories. Details of the reserves of natural gas, condensate and LPG for the various geological basins are given below. The outer edge of the Northwest Shelf is considered to contain the bulk of undiscovered resources of gas (650 to 960 x 10^9m^3, or 23 to 34 TCF). Australia's demonstrated resources of natural gas (i.e. sales gas + condensate + LPG) are poorly distributed in relation to local markets. Most of the demonstrated resources are contained in only three areas—Gippsland Basin, Cooper Basin and the Dampier Sub-Basin of the Carnarvon Basin—and a high proportion of the total is offshore.

REMAINING RESERVES AT 30 June 1980

	Declared Commercial			*Uneconomic at present*		
Basin	*Natural (Sales) Gas* 10^9m^3	*Condensate* 10^6m^3	*LPG* 10^6m^3	*Natural (Sales) Gas* 10^9m^3	*Condensate* 10^6m^3	*LPG* 10^6m^3
Bowen-Surat (Qld)	1.97	0.12	—	1.64	—	—
Gippsland & Bass (Vic./Tas.)	193.30	29.60	65.60	47.04	8.90	14.2
Cooper (S.A./Qld)	99.83	8.38	14.97	0.54	—	—
Perth (W.A.)	5.95	0.03	—	—	—	—
Carnarvon (Barrow Island) (W.A.)	10.92	0.45	0.09	—	—	—
Carnarvon-Browse-Bonaparte Gulf (W.A./N.T.)	—	—	—	458.00	65.43	59.1
Adavale (Qld)	—	—	—	0.59	—	—
Amadeus (N.T.)	—	—	—	25.54	1.54	3.8
Total	*311.97*	*38.58*	*80.66*	*533.35*	*75.87*	*77.2*

The following table shows the production of natural gas in Australia in recent years—

NATURAL GAS

Year	*Million cubic metres*
1974–75	4,633
1975–76	5,172
1976–77	6,093
1977–78	6,720
1978–79	7,686
1979–80	9,007

Oil shale

Oil shales are fine-grained elastic sedimentary rocks containing an organic material, kerogen (which is insoluble in ordinary petroleum solvents) and a minor proportion of soluble hydrocarbons (such as bitumen). To obtain oil from shale the kerogen must be heated to about 500°C. The kerogen then decomposes to produce a liquid hydrocarbon mixture (crude shale oil), gases, and a solid residue (spent shale).

Three types of oil shale deposit have been identified in Australia. They range in geological age from Cambrian to Tertiary. Marine deposits which cover thousands of square kilometres and are associated with limestone and marine shale are generally of low to medium grade. They include a comparatively small occurrence of Cambrian age at Camooweal in northwest Queensland, some small deposits of Permian age near Devonport in northern Tasmania and a very extensive deposit of Cretaceous age (including the Julia Creek deposit) in the Toolebuc Formation which underlies a large area of Central Queensland.

Lake deposits may extend over hundreds of square kilometres and may be hundreds of metres thick. They are generally of low to medium grade with average yields of up to about 100 litres/tonne. Lake deposits occur in a number of Tertiary basins in eastern Queensland including the Narrows Graben near Gladstone (containing the Rundle and Stuart deposits); the Duaringa Basin; the Hillsborough Basin near Proserpine (Condor); and the Yaamba, Rossmoya and Herbert Creek Basins near Rockhampton. Most of the lake deposits are in geographically favourable locations and for this reason appear to have the highest potential for exploitation.

Oil shales associated with coal seams are widespread in Permian and Jurassic strata in Queensland and New South Wales. The aggregate thickness of oil shale (generally up to 2 metres) and the real extent (tens of square kilometres) of individual deposits are small relative to the other types of deposit, but yields of oil are high (400–700 litres/tonne). Many of these deposits are unsuitable for open-cut mining because of thick overburden and extensive faulting. They are well situated geographically and several deposits of this type were mined by underground methods in New South Wales and Tasmania between 1865 and 1952. During early exploitation most of the shale oil was refined to produce lighting oils and waxes and many of the small rich deposits were worked out. In later production, mainly during the Second World War, the emphasis was on the production of motor spirit and oils.

Of the Australian oil shale deposits currently under consideration for development the Rundle project is at the most advanced stage of study. Research and engineering studies are under way and the developers plan to begin constructing a plant, to establish, before 1987, the economic and technical feasibility of producing oil from Rundle shale. A $1 million preliminary feasibility study is also in progress to assess how and when the Julia Creek project could be developed. If the study shows that a viable project is likely, $50 million may be spent on more detailed studies and on the construction of a pilot plant. Major exploration programs are under way at several oil shale prospects. Resources have been demonstrated at Rundle, Julia Creek and Yaamba and additional resources at Condor, Stuart, Duaringa and Julia Creek have been inferred on the basis of more limited drilling.

Uranium

Australia has about 17 per cent of the Western world's low-cost uranium reserves. The largest deposits are in the Northern Territory, with significant deposits in Western Australia, South Australia and Queensland.

The chief use for uranium is as a fuel for power generation in nuclear reactors and in atomic energy research programs. Relatively small quantities of uranium depleted in the fissionable U^{235} isotope are used for ballast, counterweights and balances in aircraft, radiation shielding, in alloys as a catalyst and glass colorant and in electrical components. The requirement for uranium in power generation is so much larger than the other uses that natural uranium can be regarded for most practical purposes as a fuel for nuclear power reactors.

At present there are no firm plans for the construction of nuclear power plants in Australia.

Uranium exploration began in Australia in 1944 at the request of the United Kingdom and United States Governments. Incentives were subsequently introduced to encourage exploration and about $225,000 was paid to 35 prospectors under a reward scheme introduced in 1948. A number of significant deposits were identified, particularly in the Katherine/Darwin region of the Northern Territory and the Mt Isa/Cloncurry region in Queensland. Exploration activity reached a peak in 1954.

In the period 1954–71 about 9,200 tonnes of uranium oxide concentrate was produced from five plants at Rum Jungle, Moline and Rockhole in the Northern Territory, Mary Kathleen in Queensland and Radium Hill in South Australia. Uranium requirements for defence purposes decreased in the early 1960s and uranium demand and prices fell rapidly, whereupon exploration for uranium almost came to a standstill.

A revival in exploration in the late 1960s was encouraged by the announcement in 1967 of a new export policy, designed to encourage exploration for new uranium deposits while conserving known resources for future needs in Australia. The renewed exploration activity which followed was very successful—major discoveries were found in South Australia (Beverly Deposit) at end of 1969 and in the Northern Territory (Ranger, Nabarlek, Koongarra, Jabiluka) in 1970 and 1971. These and other discoveries have led to substantial additions to Australia's reasonably assured uranium resources which totalled 299,000 tonnes of uranium.

Uranium production at the Mary Kathleen Mine resumed in 1976; production in 1979–80 was 710 tonnes of uranium.

On 25 August 1977 following consideration of the reports of the Ranger Uranium Environmental Inquiry, the Government announced its decision to allow development of the Ranger uranium deposit to go ahead, and to consider further development on the basis of stringent criteria concerning the environment and Aboriginal welfare in the region. Exports of uranium will be subject to the Government's nuclear safeguards and non-proliferation policies. The Ranger Uranium Mine received authorisation under the Atomic Energy Act in January 1979 and production of uranium concentrate at a planned rate of 2,500 tonnes of uranium a year is expected to commence in late 1981. Government approval was given to the Nabarlek project in March 1979 and mining of the high grade deposit was completed in late 1979. Production of uranium concentrate for the stockpiled ore commenced in June 1980 and is expected to continue for 10 years. The Commonwealth has also approved the development of the Yeelirrie uranium project in Western Australia under the Western Australia Uranium (Yeelirrie) Agreement 1978 between the Western Australian Government and the Western Mining Corporation. Full scale production of uranium concentrate from the mine is not expected to commence before 1985 at the rate of about 2,500 tonnes a year for ten years and 1,000 tonnes a year for a further twelve years.

For statistics relating to mineral exploration in Australia in recent years *see* the annual publication *Mineral Exploration, Australia* (8407.0).

The *Australian Atomic Energy Commission* (AAEC) was established by the Commonwealth Parliament under the *Atomic Energy Act* 1953 as a statutory body whose main functions are to facilitate the development of Australia's uranium resources and the utilisation of various forms of nuclear energy within the Australian economy.

Moving in its earliest days towards the planning and construction of a nuclear research establishment at Lucas Heights near Sydney, the Commission arranged for a nucleus of scientists and engineers to obtain training and experience through overseas attachments, mainly in the United Kingdom. By the late 1950s a research and development (R & D) program had been initiated at its research establishment.

The AAEC's activities are controlled by a Commission which is responsible to the Minister for National Development and Energy. The Atomic Energy Act provides for the Commission to consist of five Commissioners including a Chairman.

The Commission's current program places emphasis on the following areas: nuclear fuel cycle; energy research and assessment; radioisotopes and radiation; and international relations. The commission operates two nuclear research reactors 'HIFAR' 10MW thermal and 'MOATA' 100kW thermal at Lucas Heights.

Current expenditure by the AAEC is of the order of $25 million a year. Staff totals some 1,200 professional, technical, trade, administration and support personnel.

The AAEC participates in the activities of the Australian Institute of Nuclear Science and Engineering. The Institute, which has a corporate membership comprising the Commission and the Australian universities, is concerned with the awarding of studentships, fellowships and research grants, with the organising of conferences and with arranging the use of AAEC facilities by research workers within the universities and colleges of advanced education. The Australian School of Nuclear Technology, located at Lucas Heights, is a joint enterprise of the AAEC and the University of New South Wales. Courses are provided regularly on such subjects as radionuclides in medicine, radiation protection and nuclear technology. Participants have been drawn from Australia, New Zealand, Asia, Africa, Papua New Guinea and the Pacific region.

Thorium

Thorium is about three times as abundant in the earth's crust as uranium. However, because of the resistance of primary thorium minerals to chemical alteration, secondary thorium minerals are rare, thorium therefore occurs in fewer geological environments than uranium. The bulk of potentially exploitable resources of thorium occur in essentially lower grade accumulations than the exploitable resources of uranium. Most of the world's thorium resources occur in monazite, a complex silicate which is currently recovered primarily for its content of rare-earth oxides. Primary thorium minerals (including monazite) are resistant to oxidation and form economically important placer deposits. Large deposits occur throughout the world in beach and stream placers and also as hard-rock deposits in veins, sedimentary rocks, alkalic igneous rocks and carbonatites.

In Australia, by-product monazite in titanium-bearing minerals sands on the east and west coasts of the continent is currently the only economical source of thorium, although other occurrences of thorium minerals are known. Australia currently supplies about half of the world's monazite requirements.

The Commonwealth Government controls the export of thorium and thorium minerals under the authority of the Customs (Prohibited Exports) Regulations as amended from time to time by Statutory Rules. The export of minerals containing thorium and thorium compounds and alloys is prohibited without the approval of the Minister for Trade and Resources.

Solar energy

Solar energy is available to a varying extent, over the entire surface of the earth and because of this it is difficult to evaluate in the same terms as the more conventional, intensive energy sources. Like wind, tidal and wave energy, solar energy is renewable (in a sense, of course, it is inexhaustible) and shares with these energy sources a number of properties which make it both difficult and costly to collect, store and transform into useful work. Solar energy has the inherent characteristics of low intensity and of geographic, seasonal and daily variations.

The Bureau of Meteorology has at present 21 solar radiation stations at which detailed continuous routine measurements are made to standards recommended by the World Meteorological Organisation.

Solar energy is available in the form of low temperature heat when collected with commercially available flat plate collectors. Further thermal applications of solar energy are in the provision of low-medium temperature process heat for industry and heating and cooling of buildings. Economically successful use of solar energy in these applications will depend on the development of more cost-effective collectors, the careful design of overall systems for storage, transport and use of the energy collectors as well as the price of competing fuels.

As a source of electricity, solar energy may have further uses in supplying remote areas with small-scale electricity generation. Plant material resulting from photosynthesis may be a useful source of liquid and gaseous fuels for transportation and there are longer-range use possibilities for the hydrogen as both an energy source and energy carrier. The significance of the contribution likely to be made by solar energy between now and the end of the century will depend on a number of factors including research and development and the availability and price of alternative fuels.

Ocean thermal energy

Although the potential energy available from ocean thermal energy conversion (OTEC) is enormous, there are many problems to be overcome before it could become viable. These include the limited efficiency of the heat exchanges, the effect of micro-organisms and corrosion on underwater equipment and the economics of transporting power to land-based load centres. Many observers are pessimistic because of the complexity of these engineering problems and regard the potential of OTEC as speculative. In Australia, virtually no assessment of this energy source has been made. It has been suggested that tropical waters such as those off the Queensland coast would be suitable, but power generated from this area would be a considerable distance from the major power consumers in the south and not competitive with electricity based on coal.

Wind energy

There are a number of difficulties in assessing wind power as an energy resource, most of these stemming from the fact that wind resources are sources of actual kinetic energy and like the other forms of solar-derived energy, cannot be defined and measured in the same way as resources of chemical, nuclear, or potential energy. Available wind energy varies with the wind speed, which in turn varies with geographic location, height above ground, time of day and the seasons of the year. Even over a restricted area, the wind speed can be sharply influenced by topography, shelter, sea breezes and diurnal heating.

Apart from a program carried out in South Australia in the 1950s there has been no systematic assessment of the wind resources of Australia. Wind measurements are made, however, at various sites throughout Australia for climatological and meteorological purposes and the Commonwealth Scientific and Industrial Research Organization (CSIRO) is at present analysing data from existing weather stations in an attempt to better assess Australia's wind resources.

The effective recoverability of wind resources is limited by the need to transmit the power over long distances in Australia and by the fact that no satisfactory means of storing wind energy on a large scale yet exists. At present the use in Australia of this resource is confined to windmills for water pumping and small electricity-generating wind machines. These have been a useful small-scale alternative to conventional sources of energy in remote and isolated areas of Australia and will probably continue to be so in the future.

Future resource potential is almost entirely dependent on advances in technology which can make wind power competitive with conventional forms of power. In Australia there is not the same need for alternative means of large-scale electricity generation as in other countries because of our abundant coal resources. Most large-scale schemes depend on the conversion of wind energy to hydrogen for storage and distribution and there are many problems yet to be solved to make this a realistic proposition. It is unlikely that there will be large-scale use of this energy source in Australia before the end of this century.

Geothermal energy

Most of Australia's geothermal resources are of the conduction-dominated type. The most extensive and well documented study in Australia of subsurface temperatures has been made in boreholes in the Great Artesian Basin. In this basin, about 20 per cent of indexed water bores penetrate to depths greater than 1,000m and since geothermal gradients are generally greater than 30°C/1,000m, it is reasonable to assume that hot water can be obtained from such aquifers. Of the total number of indexed water bores, only a very small proportion have water temperatures greater than 100°C.

Australia's geothermal resources in other basins are probably comparable with that in the Great Artesian Basin, since the extraploration of flow rates and temperatures to other sedimentary basins is considered geologically reasonable. On a regional scale, it is unlikely that assessments of Australia's geothermal energy will change significantly, although it is possible that local areas of intense heat could be found.

In Australia, it has been estimated by the Bureau of Mineral Resources that identified (demonstrated and inferred) geothermal resources are about 1 per cent of Australia's annual primary energy consumption. This estimate, however, does not imply that these resources are economic, nor that they could be used for efficient electricity generation. Undiscovered geothermal resources may be many orders of magnitude greater than the above estimate.

Tidal energy

Tidal energy is a dispersed energy source derived from regular fluctuations in the combined gravitational forces exerted by the moon and the sun, at any one point on the earth's surface, as the earth rotates. The mean tidal range in the open ocean is about 1 metre, but under suitable hydraulic and topographical conditions, much higher tides than this build up in places around coasts, due to resonance. Because only two commercial tidal plants exist so far in the world, relatively little is known about the possible environmental impact of large-scale utilisation. It is unlikely, however, that tidal installations would be entirely without effect on the ecological life of bays and estuaries within their area of influence due, for instance, to silting and concomitant dredging.

Around Australia there are theoretically very large amounts of tidal energy available, especially on the north-west coast where the tidal range is as great as 11 metres and where the topography is suitable. The tidal potential of this region has been the subject of a series of investigations, including one carried out in 1965 on one of the most promising sites at Secure Bay. It was concluded that a minimum of 12 years' design and construction time would be required, although the cost of electricity at the site would be similar to that derived from conventional thermal stations. However, the long distances to potential markets result in a doubling of these electricity generation costs. Subsequent studies by the State Energy Commission of Western Australia have indicated that lead times and construction costs could be reduced but not sufficiently to make tidal energy economically attractive even if a suitable electricity consumer were nearby.

At present CSIRO has in hand a limited investigation of the tidal resources of Australia. Whatever the conclusions of this survey, the likelihood of early exploitation of this resource would appear to be less than in other countries, if only because of the long distances involved in transmission to population centres. In Australia, the major consumer regions are located along coastlines where the tidal range is very small.

Biomass

Biomass (matter of biological origin) can be utilised as an energy resource in a variety of ways. From the viewpoint of national energy priorities its major potential is as a source of liquid fuels for transport, particularly ethanol and methanol.

The CSIRO has recently completed a survey of the potential for the production of these fuels from agricultural and forestry resources in Australia. The resources considered were; potential new energy crops and forest plantations, as well as the residues from existing crop and forest production. In estimating potential new crop production, it was assumed that all land with suitable climate, soil and terrain for an energy crop would be available for energy farming; except land at present under crops or sown pastures.

The total biomass resources considered could provide a net liquid fuels output of 420 petajoules, 60% of the energy used as liquid fuel in transport in 1977-78. This is a net figure, taking into account the liquid fuel input into production, but not socio-economic considerations such as the possibility that there may be more profitable or socially desirable uses for the land available for new crops. It must be considered as an upper limit only. Largely as a result of the cost of the feedstocks liquid fuel from biomass is not currently cost competitive with petroleum-based fuels.

Ethanol from Sugar Cane

Crops under consideration as feedstocks for fuel ethanol production in Australia are sugar cane, cereal grains, cassava, sugar and fodder beet, and sweet sorghum. Starches and sugars from these crops can be converted by fermentation and distillation to ethanol using well established technology. Over 100 megalitres of ethanol for industrial and potable use is already produced each year from molasses, a by-product of the cane sugar industry. Up to 0.5 megalitres of this will be sold in a 10% ethanol blend with super grade petrol in Mackay for a 12 month marketing trial, commencing November 1980.

There is however little scope to increase production of molasses, and an expanded cane-based ethanol industry would need to use whole cane juice as feedstock. This is attractive because sugar cane has the highest yield of ethanol per hectare of the potential energy crops, averaging 7,000 litres. It has the added advantage that bagasse, the fibrous residue after crushing cane, can be used for the process heat, eliminating use of fossil fuel and substantially improving the energy balance for ethanol production.

There is considerable scope for expanded sugar cane production. Currently 355,000 hectares are used for growing cane. CSIRO has estimated that an additional 285,000 hectares could be used for cane production, but utilisation of most of this land would require the development of new irrigation and milling facilities. As an indication, this level of production would yield a net ethanol output equivalent to 7-10% of our current motor spirit needs.

Ethanol from Other Sources

Cereal and coarse grains (wheat, barley and grain sorghum) give much lower yields of ethanol per hectare, but much larger areas of land are available (11.6 million hectares), mainly in northern New South Wales and Queensland. Utilisation of much of this land would conflict with its present use as grazing land for sheep and cattle. Ethanol production from cereal grains yields a high protein by-product with potential for use as a human food additive or animal feed. The economics of a cereal based ethanol industry would depend heavily on whether markets would be available for the by-product.

Cassava is a tuberous crop with high starch content which grows in the same geographic regions as sugar cane but can tolerate poorer soil and lower rainfall. Cultivation trials on cassava are currently being conducted. The results suggest that cassava could well be grown as an ethanol feedstock in these areas, particularly on marginal agricultural land and land at present used for grazing. Cultivation trials are also being undertaken on sweet sorghum in Queensland and New South Wales, and on sugar beet in Tasmania.

Oil-seed crops

Owing to their poor compression ignition properties, ethanol and methanol are not ready substitutes for distillate as diesel fuel. On the other hand, recent research in Australia and overseas indicates that vegetable-oils give satisfactory performance as fuels in diesel engines, although further research is necessary to establish, for example, their effects on engine durability.

In 1979-80 oil-seed production in Australia totalled 558,000 tonnes, including safflower seed, sunflower seed, soybeans, rapeseed, linseed, cotton seed, peanuts and lupins. A total of 571,000 hectares was sown to oilseed crops. At one tonne/hectare rapeseed or sunflower would yield 435 litres of oil, equivalent to 380 litres of dieseline per hectare. CSIRO is gathering data on the scope for expanded production.

Forests and Agricultural Residues

The rapid rate of depletion of fossil fuels is focussing attention again on wood as a renewable resource, and the potential production of fuels from agricultural wastes. Various fuels may be derived from wood, mainly methanol, ethanol and charcoal. Charcoal can be converted into fuel gas which is usable for a range of applications. Methanol can be produced by pyrolysis of wood and ethanol by hydrolysis and fermentation of wood cellulose.

Based on the definition and classification adopted by FORWOOD Conference, 1974, Australia's estimated productive forest area at 30 June 1978 was 43,825,000 hectares. Of this, plantations comprised 699,300 hectares (coniferous 655,100 and broadleaved 44,200 hectares). It is estimated that by 1984-85 total production and consumption in Australia will reach 1,442,000 tonnes in terms of primary energy consumer. This quantity represents 22.8 x 10^{16} Joules, an insignificant proportion of Australia's overall energy demand, although, especially in South and Western Australia, firewood has had some regional significance.

The 21MW Mount Gambier power station, in the centre of South Australia's most extensive forestry operations area, has operated since 1957 on wood fuels and a 3.2MW generating station at Nangwarry also uses wood.

Another aspect of wood utilisation which is under study in Australia is forestry residues as a source of fuel. Forest residues are the products left after logging, stems which are removed in silvicultural treatments and the as yet untapped resources of woodland classed as unproductive. Mill residues comprise bark, sawdust, shavings, defective section of the tree bole and off-cuts. It is estimated that the production of sawmill wastes in Australia is 3.5 million tonnes/year. After allowing for the quantities chipped for pulp and other uses, about 2 million tonnes would be available as fuel. Some of this would be included in the consumption of firewood by industry. Utilising the unknown volume of forest residues and unproductive woodlands involve problems of concentration and transport.

The immediate need however is for liquid fuels. It does not seem likely that ethanol from wood will be able to compete with that from other feedstocks which do not require hydrolysis. Methanol is more promising, and use of 15-16 million tonnes of wood to produce a net 4,400 megalitres of methanol may be possible. It is not clear whether methanol from wood could compete against methanol from coal or gas. Either of these options will have environmental consequences which will require thorough investigation before they can be considered.

Electric power

The information contained in this section relates to situations existing and projects contemplated, and may be considerably affected by changes in policy or plans, or by developments in the projects themselves. Greater descriptive and historical detail about the various systems is contained in earlier issues of the Year Book.

Hydro-Power

With the exception of Tasmania, Australia is not well-endowed with hydro-electric resources because of its generally low rainfall and limited areas of high relief. Its hydro-electric resources are confined almost entirely to Queensland, New South Wales, Victoria and Tasmania.

Currently the total installed capacity of hydro-electric generating plant is approximately 5,500 MW, which is about 25 per cent of the total installed capacity of the public electricity supply authorities and provides 20 per cent of the electricity generated owing to its lower use during off-peak periods. Although hydro-electric generating plant currently provides a significant amount of the electricity generated, its relative importance is expected to decline. Most of the economically favourable sites have been developed and only Tasmania and, to a lesser extent, north Queensland, have significant undeveloped resources. The relatively small resources remaining elsewhere may in time be developed for peak load power with or without pumped storage or as ancillary to water management projects. Examples of these respective types are the Shoalhaven Scheme in New South Wales and Dartmouth Dam in Victoria.

Hydro-electric power stations are characteristically high-capital-cost, low-running-cost developments and their economic feasibility compared with thermal stations utilising Australia's abundant resources of low-cost steaming coal is heavily dependent on interest rates and civil construction costs, both of which have increased appreciably in recent years. Tasmania's hydro-power potential is approximately half the total practical potential available in Australia. Currently about 50 per cent of Tasmanian practical potential, which has been estimated at 13,000 GWh/yr. has been developed and projects already committed will raise the proportion to 75 per cent by 1985.

The development of its hydro-power resources has resulted in Tasmania having had the lowest cost electricity in Australia for many years. In recent years, however, the price advantage of hydro-power over coal-fired thermal power has lessened due to the need to develop more remote sites, rising capital costs and high interest rates. Only Tasmania and Queensland have any significant amount of hydro-electric energy left to develop although there are useful amounts left in Victoria and New South Wales. Most of the Queensland potential is in high rainfall areas near Cairns and on the Burdekin River.

Snowy Mountains Hydro-electric Power Act 1949*

In July 1949 the Commonwealth Government established the Snowy Mountains Hydro-electric Authority (*Snowy Mountains Hydro-electric Power Act* 1949) and empowered it: to generate electricity by means of hydro-electric works in the Snowy Mountains area; to supply electricity to the Commonwealth Government (i) for defence and other purposes, (ii) for consumption in the Australian Capital Territory; and to supply the surplus to the States of New South Wales and Victoria.

The Snowy Mountains Act is supported by a detailed agreement between the States of New South Wales and Victoria and the Commonwealth Government with regard to the construction and operation of the Scheme, the distribution of power and water, charges to be made for electricity, and other such matters. The Snowy Mountains Council, established under the terms of the Agreement and consisting of representatives of the Commonwealth Government, the Authority and the States of New South Wales and Victoria, directs and controls the operation and maintenance of the permanent works of the Snowy Mountains Scheme for the control of water and the production of electricity.

Snowy Mountains Hydro-electric Scheme

The broad basis of the Snowy Scheme is to transfer waters, which would otherwise flow to the sea unharnessed, from the Snowy River and its tributaries to the inland system so that the water may be used for irrigation and to provide power. It involves two main diversions: the diversion of the Eucumbene, a tributary of the Snowy, to the Upper Tumut River; and the diversion of the main stream of the Snowy River at Island Bend and Jindabyne to the Swampy Plain River. These two diversions divide the scheme geographically into two sections: the Snowy-Tumut Development and the Snowy-Murray Development (*see* Plate 40, page 439). For purposes of both power production and irrigation it is necessary to regulate run-off, and this is achieved by the use of Lake Eucumbene (formed by the construction of Eucumbene dam) to control the waters of the Eucumbene and other storages to control the waters of the Murrumbidgee, Tooma, and Tumut Rivers for the Snowy-Tumut Development and of the Snowy and Geehi Rivers for the Snowy-Murray Development. For a description of the Snowy-Tumut and Snowy-Murray Development, and progress of the scheme, *see* previous issues of the Year Book.

* *See also* Chapter 15, Water Resources of this issue and the special detailed article in Year Book No. 42, pages 1103–30.

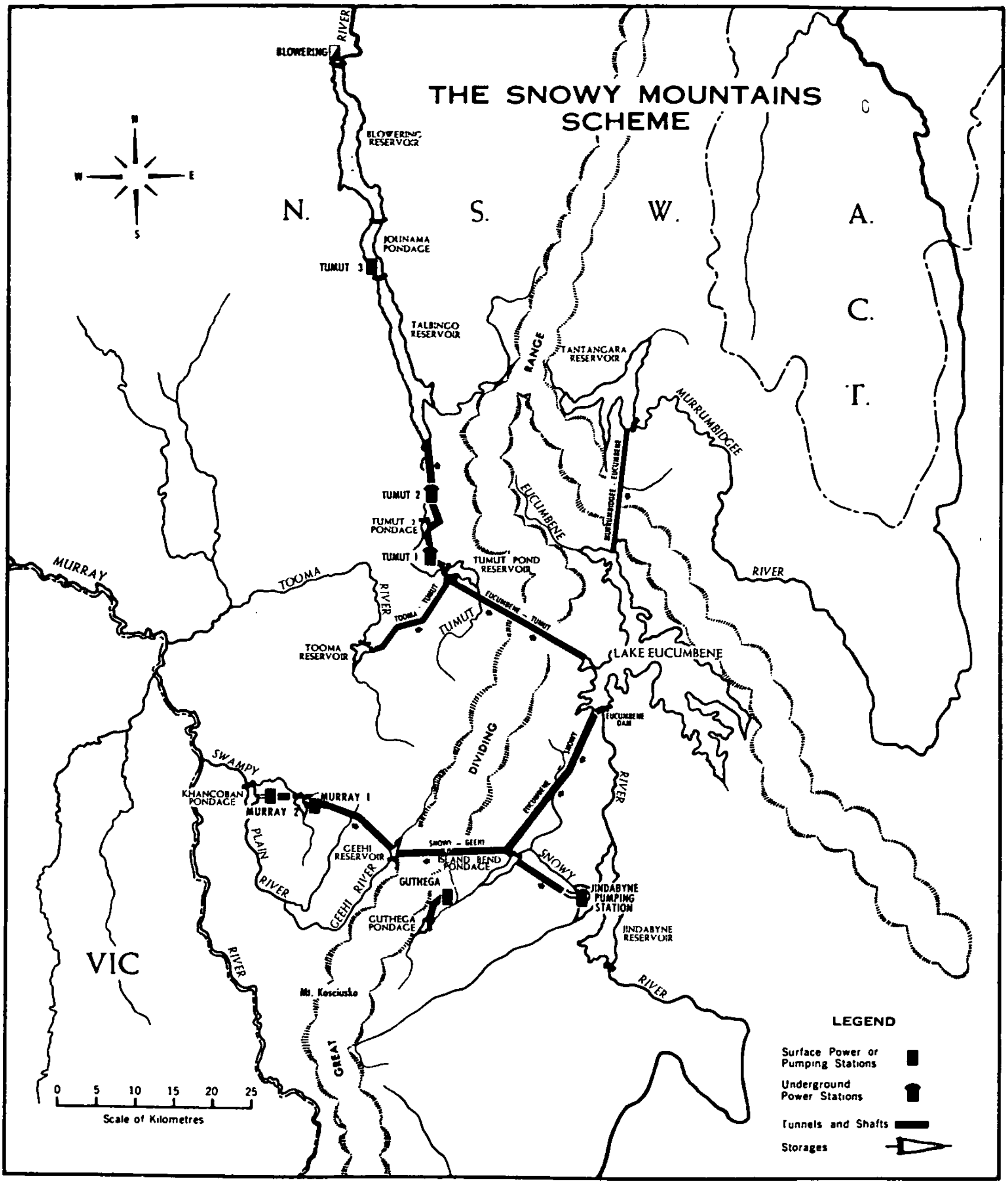

PLATE 40

Utilisation of power from scheme

The Snowy Mountains Scheme is situated about midway between the principal load centres of Sydney and Melbourne and is connected to those cities by 330 kV transmission lines. It is, consequently, in a position to take advantage of the diversity in the power requirements of these two load systems, a most important factor in so far as it affects the economy of operation of the supply systems of the two States. The average annual notified energy of the Snowy Mountains Hydro-electric Scheme is 5,129 GWh a year. The Commonwealth Government reserves 670 GWh for supply to the

A.C.T.; for convenience, the Commonwealth Government's requirements are drawn from the New South Wales transmission network by an exchange arrangement between the Commonwealth Government and the Electricity Commission of New South Wales. Electricity over and above that required by the Commonwealth Government is divided between the States of New South Wales and Victoria in the ratio 2:1.

Electricity generation and transmission

NEW SOUTH WALES

Electricity Commission of New South Wales and electricity supply authorities

The main function of the Commission is the generation and transmission of electricity, which it sells in bulk to distributing authorities (mainly local government bodies) throughout a large part of the State, to the Government railways and to certain large industrial consumers. As the major generating authority, it is also responsible for the development of new power sources except in the Snowy Mountains region.

The retail sale of electricity to the public is, in general, carried out by separate electricity supply authorities. At 30 June 1980 there were 27 retail supply authorities throughout the State, comprising 23 electricity county councils (consisting of groups of shire and/or municipal councils), 1 city council, 1 shire council, and 2 private franchise holders.

Most electricity distribution areas have been consolidated into country districts consisting of a number of neighbouring local government areas grouped for electricity supply purposes and administered by a county council comprising representatives elected by the constituent councils. Of the 205 cities, municipalities and shires in New South Wales, 198 are included in one or other of the 23 electricity county districts.

The Energy Authority of New South Wales (Incorporating The Electricity Authority of New South Wales)

The Electricity Development Act, 1945, confers broad powers on the Energy Authority to co-ordinate and develop the public electricity supply industry. The functions of the Authority include the promotion of the use of electricity, especially its use for industrial and manufacturing purposes and for primary production. Technical advice is given to retail electricity supply authorities on various aspects of their activities such as the framing of retail electricity tariffs, public lighting and the standardising of materials and equipment.

The Authority administers the Rural Electricity Subsidy Scheme under which the rural electrical development of the State has now been virtually completed where the extension of supply is economically feasible. Under the subsidy scheme, local electricity suppliers receive subsidies from the Authority towards the cost of new rural lines. At 30 June 1980 the Authority was committed to the payment of $43,123,011 in subsidies, of which $37,363,374 had been paid. Further details of the operation of the scheme are given in Year Book No. 56, page 956.

The Authority also administers the Traffic Route Lighting Subsidy Scheme, which provides for financial assistance to councils towards the cost of installation of improved lighting on traffic routes traversing built-up areas with the objective of reducing the incidence of night road accidents. Since the introduction of the scheme in 1964, subsidy has been approved in respect of some 1,816 kilometres of traffic routes throughout the State.

Generation and transmission

Of the State's electrical power requirements during the year ended 30 June 1980, almost all was generated in New South Wales (93.9 per cent by coal fired power stations, 0.2 per cent by internal combustion plants, 3.6 per cent from the Snowy Mountains Hydro-electric Authority and 1.6 per cent by other hydro-electric stations). Net interstate exports of electricity accounted for the remaining 0.7 per cent.

Major generating stations. At 30 June 1980 the major power stations of the State system of the Electricity Commission of New South Wales and their nominal capacities were as follows: Liddell (Hunter Valley), 2,000 MW; Munmorah (Tuggerah Lakes), 1,400 MW; Vales Point (Lake Macquarie), 2,195 MW; Wangi (Lake Macquarie), 330 MW; Tallawarra (Lake Illawarra), 320 MW; Wallerawang (near Lithgow), 740 MW; Pyrmont (Sydney), 200 MW. The total nominal capacity of the Electricity Commission's system as at 30 June 1979 was 7,737 MW. The greater part of the Commission's generating plant is concentrated within a one hundred and eighty-five kilometre radius of Sydney.

Major transmission network. The retailing of electricity to 97 per cent of the population of New South Wales is in the hands of local distributing authorities, which obtain electricity in bulk from the

Commission's major State network. This network of 330 kV, 132 kV, 66 kV and some 33 kV and 22 kV transmission lines links the Commission's power stations with the load centres throughout the eastern portions of the State, extending geographically up to 650 kilometres inland.

At 30 June 1980 there were in service; 3,672 circuit kilometres of 330 kV and 6,959 kilometres of 132 kV transmission lines (including 298 kilometres operating for the time being at 66 kV). There were also in service 4,917 kilometres of transmission line of 66 kV and lower voltages, and 523 kilometres of underground cable. The installed transformer capacity at the Commission's 173 substations was 26,446 MVA.

Separate systems and total State installed capacity. Several local government bodies operate their own power stations and generate a portion of their requirements which is supplemented by interconnection with the system of the Electricity Commission. Of these, the more important are the Northern Rivers County Council (installed capacity 28.75 MW) and the North-West County Council (15 MW). In addition, a private company operates small stations supplying the towns of Ivanhoe and Wilcannia. The aggregate effective capacity for the whole of New South Wales systems and isolated plants was approximately 7,805 MW at 30 June 1979, while the number of ultimate consumers at this date was 1,939,596.

Future developments

Future projects include the installation of 7,160 MW of coal-fired generating plant over the next eight years. The installation of an additional 500 MW unit is nearing completion at Wallerawang. Four 660 MW units are being installed at Eraring Power Station on the central coast and will be commissioned progressively for full commercial service over the period 1982–1984. At Bayswater Power Station, which is situated in the Hunter Valley, construction has commenced on four 660 MW units for commissioning over the period 1985–1986. Two 660 MW units are planned for Mount Piper Power Station which is located on the western coalfield near Wallerawang. Commissioning of the Mount Piper units is planned for 1987.

Construction of a double circuit 500 kV transmission line between Eraring and Kemps Creek, west of Sydney has commenced. This transmission line will initially operate at 330 kV but operation at 500 kV is planned in 1984. A double circuit 500 kV transmission link will be constructed from Bayswater Power Station to Mount Piper Power Station and thence to Marulan where it will be interconnected with the existing transmission system between the Snowy Mountains and Sydney.

Hydro-electricity

The greater part of the hydro-electric potential of New South Wales is concentrated in the Snowy Mountains area (*see* Snowy Mountains Hydro-electric Scheme, page 438). Apart from this area, major hydro-electric stations are in operation at the Warragamba Dam (50 MW) and Hume Dam (50 MW). In addition, there are six smaller hydro-electric installations in operation in various parts of the State. A pumped-storage hydro-electric system to produce 240 MW has been installed as part of the Shoalhaven Scheme in conjunction with the Metropolitan Water Sewerage and Drainage Board.

VICTORIA

State Electricity Commission of Victoria

Established under earlier legislation and currently operating under the provisions of the *State Electricity Commission Act* 1958, No. 6377 as a semi-government authority, the principal function of the Commission is to generate or purchase electricity for supply throughout Victoria. The Commission may own, develop and operate brown coal open cuts, and briquetting plant and develop the State's hydro-electric resources. The Commission is required to meet from its own revenue, which it controls, all expenditure involved in operating its power and fuel undertakings and to provide for statutory transfers to the Consolidated Revenue fund of the State.

Since it began operating in 1921 the Commission has expanded and co-ordinated the generation, purchase and supply of electricity on a State-wide basis to the stage where its system generates almost all the electricity produced in Victoria (which has an area of 228,000 sq km) and the transmission network covers practically the entire population of the State. As at 30 June 1980, the Commission had gross fixed assets of $3,214 million, employed 20,383 persons, had a total income of $726 million and, during the preceding twelve months, had increased sales of electricity by 3.3 per cent.

Victoria's electricity system is based on the utilisation of the extensive brown coal deposits in the La Trobe Valley in Central Gippsland, about 140 to 180 km east of Melbourne. Total geological resources of brown coal in the La Trobe Valley are estimated at 107,800 megatonnes and, of this quantity, about 30,000 megatonnes are economically winnable and 12,200 megatonnes are readily recoverable using present mining techniques.

In 1979–80 the output of brown coal from the Commission's three open cuts at Yallourn, Yallourn North and Morwell totalled 31.6 megatonnes of which 27.9 megatonnes were used in the Commission's power stations. A further 3.4 megatonnes were used to produce 1.3 megatonnes of briquettes and 0.30 megatonnes was sold to the public. Sales of briquettes to the public totalled 666,000 tonnes, producing an income of $13.1 million and 565,000 tonnes were used as fuel in power stations.

Electricity generation transmission and supply

In 1979–80 the Commission generated in its thermal and hydro-electric power stations, or purchased 21,843 GWh. The total installed generating plant capacity at 30 June 1980 was 5,210 MW, inclusive of the capacity both within the State and available to Victoria from New South Wales.

The power stations are interconnected and feed electricity into a common pool for general supply. The major generating plant in the interconnected system is the 1,600 MW Hazelwood base load, brown-coal-fuelled power station near Morwell in the La Trobe Valley, which alone generates nearly half of Victoria's electricty. Other brown coal power stations in the interconnected system comprise the established base load stations at Morwell and Yallourn and the partially completed Yallourn 'W' station. Peak load thermal stations are located in Melbourne (Newport, Richmond and Spencer Street and at Jeeralang in the La Trobe Valley). Hydro-electric stations are located at Kiewa, at Eildon, on the Rubicon and Royston Rivers near Eildon and at Cairn Curran. All generators for public supply within Victoria are owned by the Commission except Spencer Street Power Station, which remains the property of the Melbourne City Council although operated as a unit of the interconnected system.

Generation in thermal stations is supplemented by supply from the Commission's hydro stations in the mountains in the north-east of the State and by entitlements from the Snowy Mountains Hydro-electric Scheme in south-eastern New South Wales (one third of output after provision for the Commonwealth Government's needs) and the Hume Power Station on the Murray River boundary with New South Wales (half of output). The Snowy Mountains Scheme is linked to the Victorian system by nine 330 kV transmission lines which allow for a two-way interchange with New South Wales.

At 30 June 1980 the electrical transmission and distribution system in the State supply network comprised 110,776 kilometres of overhead lines and 3,852 kilometres of underground lines. There are 4 auto-transformation stations, 26 terminal substations, 180 zone substations and 84,059 distribution substations. Transmission is mainly by 500, 330, 220 and 66 kV lines which supply the principal distribution centres and provide interconnection between the power stations. The total route length of the 500, 330 and 220 kV lines is 3,739 kilometres.

The Commission sells electricity retail in all Victorian supply areas except for eleven Melbourne metropolitan municipalities. These municipalities purchase electricity in bulk from the Commission and retail it to approximately 271,800 customers within the municipalities concerned under franchises granted by the Victorian Government before the Commission was established in 1921. Bulk supply is also provided to several municipalities in New South Wales and to a number of towns and areas bordering the Murray River.

Complete electrification of the State has virtually been achieved and only a few remote areas do not receive supply. At 30 June 1980 the Commission had 1,295,100 retail customers excluding bulk sales, and the income derived was $578 million. There were 1,106,800 domestic, 81,200 industrial and 105,600 commercial consumers. In country areas electricity was supplied to about 77,800 farms. Sales of electricity during the period, including bulk supplies, totalled 17,932 GWh and produced total income of $704 million.

Current and future development

Power station projects currently under construction are Yallourn W, Stage 2 and Loy Yang in the La Trobe Valley; Newport in Melbourne and Dartmouth in north-eastern Victoria. Yallourn W is designed as a 4 unit, base load station of 1,450 MW capacity fuelled by brown coal. The first two 350 MW units are now in commission. The second two units, each of 375 MW capacity, are scheduled to begin operating in 1981 and 1982. The Commission is erecting a 500 MW natural gas fired power station at Newport to come into operation in 1981. A hydro-electric station with one 150 MW unit capacity is being built at Dartmouth in conjunction with the dam currently under construction to come into operation during 1981. The largest project is a major base load generating complex of about 4,000 MW capacity at Loy Yang in the eastern part of the La Trobe Valley, planned to come into service progressively from 1984. A new coalfield is being opened for this development. At Jeeralang, near Morwell, a 225 MW gas turbine station has been constructed and a second station of 240 MW capacity will be put into service progressively during 1980.

QUEENSLAND

Legislation

Queensland's electricty supply industry is regulated by the *Electricity Act* 1976-1980. This Act deals with the organisation and regulation of the generation, transmission, distribution, supply and use of electricity in Queensland and with matters of safety associated with these functions.

State Electricity Commission of Queensland

Its main functions are to plan and ensure the proper development and coordination of the electricity supply industry throughout the State, to enforce safety regulations, to control electricity charges, to raise capital for development, and to administer all electricity supply legislation.

Organisation

Generation and main transmission are functions of the Queensland Electricity Generating Board. It operates the power stations and main transmission lines in the interconnected grid supplying energy from Cooktown to the New South Wales border and west to centres such as Winton and Julia Creek.

The Queensland Electricity Generating Board supplies energy in bulk to seven distributing boards whose responsibility is the distribution of electricity to retail consumers in their respective areas. These boards are the South East Queensland Electricity Board, the South West Queensland Electricity Board, the Wide Bay-Burnett Electricity Board, the Capricornia Electricity Board, the Mackay Electricity Board, the North Queensland Electricity Board and the Far North Queensland Electricity Board.

Four of these distributing boards (the South West Queensland, Capricornia, North Queensland and Far North Queensland) also operate small internal combustion stations in their respective areas.

Electricity generation, transmission and distribution

Ninety-four per cent of the States generation is derived from steam power stations fuelled by black coal. Hydro-electric stations located in North Queensland provide 5 per cent, with the balance being generated by gas turbine and diesel power stations using light fuel oil. The Roma diesel power station also uses locally produced natural gas. Electricity generated by the public supply authorities in Queensland in power stations during 1979-80 totalled 11,355 million kWh. A further 138 million kWh were purchased in bulk from other producers of electricity for re-distribution to consumers.

At 30 June 1980 the total generating capacity of all public supply authorities in Queensland was 3,040 MW, comprising 2,696 MW of steam plant, 132 MW of hydro-electric plant, 49 MW of internal combustion plant and 163 MW gas turbine plant.

The southern-central electricity network is served by the following steam power stations: Swanbank 'A' (396 MW), Swanbank 'B' (480 MW), Tennyson (240 MW), Bulimba (180 MW), Gladstone (1,100 MW) and Callide (120 MW). Gas turbine stations at Middle Ridge (60 MW), Swanbank 'C' (30 MW), Rockhampton (25 MW) and Gladstone (14 MW) also serve the southern-central network. The northern electric network is supplied by a steam power station at Collinsville (180 MW), hydro-electric stations at Kareeya (72 MW) and Barron Gorge (60 MW) and a gas turbine station at Mackay (34 MW).

The electrical transmission and distribution systems within the State comprised approximately 113,623 circuit kilometres of electric lines at 30 June 1980. The main transmission voltages are 275 kV, 132 kV, 110 kV, 66 kV and in certain areas 33 kV and 22 kV. The single wire earth return system is used extensively in rural electrification and nearly 27,400 kilometres of line for this system of distribution was in service at 30 June 1980.

At 30 June 1980 the total number of electricity consumers was 816,000.

Future development

Construction of the power station at Gladstone in Central Queensland is well advanced. When complete, this station will consist of six 275 MW steam sets and one 14 MW gas turbine set. The first four steam sets and gas turbine set are fully operational. The remaining two sets are due for completion in early 1981 and 1982 respectively.

Over $50 million has been spent on construction of the Wivenhoe Pumped Storage Hydro Electric Project on the Brisbane River. The power station will consist of two 250 MW pump turbine units, to be commissioned in 1983, at an estimated cost of $180 million. Contracts have been placed for the major plant items comprising turbines, pumps and generators, and construction is underway on the major civil works associated with the project.

Work on the 1400 MW power station, comprising four 350 Mw sets, being constructed on the Tarong coal field is advancing on schedule. Civil works associated with the project are well underway and contracts have been let for major construction works and plant items with a total value of about $270 million. The first set is programmed to commence service in mid 1984, the second in mid 1985, the third and fourth in early and late 1986, respectively.

SOUTH AUSTRALIA

Electricity Trust of South Australia

In 1946 the assets of the Adelaide Electric Supply Co. Ltd were transferred to a newly-formed public authority, the Electricity Trust of South Australia, which became responsible for unification and co-ordination of the major portion of the State's electricity supply and which took over the powers previously vested in the South Australian Electricity Commission. In addition to the powers specified in the Adelaide Electric Supply Company's Acts, 1897–1931, the Trust may supply electricity direct to consumers within a district or municipality with the approval of the local authority; arrange, by agreement with other organisations which generate or supply electricity, to inter-connect the mains of the Trust with those of other organisations; and give or receive supplies of electricity in bulk.

Capacity and production

Of the total installed capacity in South Australia at 30 June 1979, the Electricity Trust operated plant with a capacity of 1,690 MW, making it the most important authority supplying electricity in the State. There were approximately 551,000 ultimate consumers of electricity in the State, of whom 542,500 were supplied directly and approximately 8,500 indirectly (i.e. through bulk supply) by the Trust. Its major steam stations are Osborne (240 MW), Port Augusta Playford 'A' (90 MW) and Playford 'B' (240 MW), and Torrens Island (880 MW). The Trust also operates a turbo-generator station at Dry Creek (156 MW) and a small station at Port Lincoln (9 MW).

The two main fuels used by the Trust are sub-bituminous coal from Leigh Creek for the Playford power stations at Port Augusta and natural gas from the Gidgealpa-Moomba field for the Torrens Island and Dry Creek stations.

WESTERN AUSTRALIA

State Energy Commission of Western Australia

On 1 July 1975 the Government of Western Australia combined the State Electricity Commission and the Fuel and Power Commission to form a new organisation known as the State Energy Commission of Western Australia. The new Commission is specifically charged with the responsibility for ensuring the effective and efficient utilisation of the State's energy resources and for providing its people with economical and reliable supplies of electricity and gas.

The Commission operates coal-burning power stations at East Perth, South Fremantle, Bunbury and Muja and a coal and oil-burning station at Kwinana. A small hydro-electric station is situated at Wellington Dam near Collie and there is a gas turbine generating plant at Geraldton. A uniform tariff electricity supply is provided from these stations through an interconnected grid system to the Metropolitan Area and the South-West and Great Southern Areas, including an area extending to Koolyanobbing and northwards as far as Binnu beyond Northampton. The Commission also owns and operates diesel power stations at Esperance, Fitzroy Crossing, Halls Creek, Kondinin, Kununurra, Onslow, Port Hedland and Roebourne.

Small electricity supply systems too remote to be connected to the grid system or supplied from the Commission-owned diesel stations are still controlled by local government authorities but are being assisted through an agreement whereby the local generating plant and distribution system is operated by the Commission under a subsidy arrangement known as the Country Towns' Assistance Scheme. Under the scheme, the Commission undertakes to operate, maintain, replace or upgrade plant and supply equipment as necessary. At the present time there are 29 country towns supplied under the provisions of the Country Towns' Assistance Scheme.

At 30 June 1980 the Energy Commission's generating capacity from its interconnected grid system was 1,437 megawatts, while the capacity of its separate supply systems in country areas was 127.5 MW. Since then (August 1980) the Energy Commission has synchronised another 200 MW coal-fired generating unit at Muja Power Station, being the first half of the Stage C extensions at Muja. The second 200 MW unit is due to come on stream about August 1981. Plans are now in hand to duplicate the Stage C extensions under what will be known as Muja Stage D. This will give Muja a capacity of 1,040 MW by mid-1985 making it the Energy Commission's biggest power station.

Meanwhile work is proceeding on the conversion of two 120 MW units at Kwinana Power Station from oil to dual coal/oil firing. This project, due for completion in April 1983, follows the successful conversion in 1979 of two 200 MW units at the station from oil to dual coal/oil firing. Another venture with which the Commission is involved is the Dampier to Perth natural pipeline project. Gas to be drawn from the massive offshore reserves in the North-West will overcome restricted supplies presently available at Dongara, and is expected to reduce W.A.'s dependence on oil from about 70% to about 45% by the mid-1980's. The Energy Commission will be responsible for the purchase of gas at Withnell Bay, near Dampier, for sale to customers in the Pilbara and South-West of the State. The Commission will design, finance, construct and operate the 1,500 km onshore pipeline to Perth and Wagerup.

The Commission is also studying various possible alternative methods of supplying power to remote areas of the State. Projects in this regard include the testing of wind powered electric generators on Rottnest Island and solar power plants at Meekatharra and at the Commission's Northern Gas Depot at Ballajura. The integration of separate power generation facilities in the Pilbara and a hydro-electric power station at the Ord Dam are also being considered.

Natural gas is reticulated in most areas of the Perth metropolitan region and in Pinjarra, simulated natural gas (SNG) is reticulated in the Bunbury area, and tempered liquefied petroleum gas (TLP) is reticulated in Albany.

Some details of the Commission's activities for the year ending 30 June 1980 are: number of electricity consumer accounts 419,490 and gas consumer accounts 99,711; electricity generated 5,229 GWh; gas sold 1,106 GWh equivalent; fuel used for electricity generation 2,720,738 tonnes of coal, 127,706 tonnes of fuel oil, and 69,619,760 litres of diesel fuel.

Sales for the year ending 30 June 1980, compared with those for the preceding year, show an increase of 8.5 per cent for electricity and 7.5 per cent for gas.

TASMANIA

A considerable part of the water catchment in Tasmania is at high level. The establishment of numerous dams has created substantial artificial storage which has enabled the State to produce energy at a lower cost than elsewhere in Australia and in most other countries. Another factor contributing to the low cost is that rainfall is distributed fairly evenly throughout the year with comparatively small yearly variations. Abundant and comparatively cheap supplies of electricity played an important role in attracting industry to Tasmania. For information on hydro-electric development in Tasmania prior to the establishment of the Hydro-Electric Commission in 1930, *see* Year Book No. 39, pages 1192–3.

Hydro-Electric Commission

The Commission was created in 1930, taking over the activities of the Hydro-Electric Department and the existing small hydro-electric installations. Development initially concentrated on hydro-electric generation feeding into a State-wide power grid (King Island from 1951 and Flinders Island from 1968 are outside the grid and are supplied by diesel generators). Unusually low rainfall during 1967 severely restricted the State's generating capacity and prompted the construction of a substantial oil-fired thermal station with a capacity of 240 MW. This station, completed during 1974, is used as required.

Output and capacity of hydro-electric system

For information on the development of the Tasmanian generating system *see* Year Book No. 61, pages 984–985.

The generator capacity of the Tasmanian system was: hydro, 1,540.4 MW; oil-fired thermal, 240 MW; and diesel, 2.0 MW. Two generators in the Gordon River Hydro-Electric Scheme, Stage 1, were commissioned during 1978, increasing generating capacity by 288 MW. The hydro system's sustainable long-term average loading is estimated at 854 MW.

The current development program involves construction of a system based on the Pieman, Murchison and Mackintosh Rivers in Western Tasmania; these works, which were commenced in 1973, will add 385 MW to the State's power grid.

In October 1979, the Commission released a report which recommended to the Government that an integrated hydro development on the Lower Gordon, King and Franklin Rivers in south-west Tasmania be developed. Other viable alternatives to meet the State's forecast demand for electricity from 1990 to 2000 investigated included a separate development of the same three rivers, a coal-fired thermal station and importation of electricity from Victoria by an underwater cable. The recommended hydro development was planned to add 172 MW to average output in 1990 and a further 168 MW (average) in 1995. The estimated cost of electricity generated from this scheme was under half the cost of that obtainable from a coal-fired station and only 40 per cent of that obtainable via a Bass Strait link with Victoria. In July 1980 the Government set aside the H.E.C. recommendations in favour of a smaller hydro scheme on the Gordon River above its junction with the Olga River. This would leave untouched, the waters of the Franklin River. State Parliament was expected to make the final decision around November 1980.

AUSTRALIAN CAPITAL TERRITORY

The supply authority is the A.C.T. Electricity Authority which took over the functions of the Canberra Electric Supply Branch, Department of the Interior, on 1 July 1963. Supply was first made available in Canberra during 1915 and was met from local steam plant. Connection to the New South Wales interconnected system was effected in 1929. The Authority electric supply requirements are met by a Snowy Mountains reservation of 670 GMh's and the balance provided by the Electricity Commission of New South Wales. Locally-owned plant consists of 3 MW diesel alternators which are retained as a standby for essential supplies. The total number of ultimate consumers at 30 June 1980 was 78,945. During the year 1979–80 the bulk electricity purchased was 1,454 GWh and the system maximum demand was 412 MW.

NORTHERN TERRITORY

Since 1 July 1978, the responsibility for the generation and distribution of electricity has been under the control of the Northern Territory Electricity Commission, a statutory body which came into operation with the establishment of Self Government in the Northern Territory.

The major electricity supply source in Darwin is the Stokes Hill Power Station which is an oil-fired steam power station with an installed capacity of 141 MW. There are also standby gas turbines with a combined capacity of 40 MW.

Alice Springs, Pine Creek, Katherine, Mataranka, Larrimah, Tennant Creek, Elliott and Tea Tree are supplied by diesel power stations. At Alice Springs the generating capacity is 30.8 MW, Katherine is supplied by an 8.5 MW diesel station while Tennant Creek Power Station's capacity is 6.4 MW.

Other power stations operated by the Commission are: Pine Creek (950 kW), Mataranka (400 kW), Elliott (340 kW), Tea Tree (170 kW) and Larrimah (110 kW). Nhulunbuy is supplied by generators operated by the mining company.

Other communities and Aboriginal settlements in the Territory generate their own power.

ELECTRICITY (*a*)—THERMAL AND HYDRO

Year	*Million kWh*
1974–75	73,933
1975–76	76,597
1976–77	82,522
1977–78	86,095
1978–79	90,851
1979–80	95,910

(*a*) Figures represent estimates of total electricity generated by public utilities, factories generating for their own use, and factories supplying electricity for domestic and other consumption.

Electricity and gas establishments

For electricity and gas, the basic census unit is an exception to the general concept of the standardised unit. Because of the nature of the activities of electricity and gas undertakings, the single operating location basis is not suitable. The establishment unit used consists of all locations, including administrative offices and ancillary units which are mainly concerned with the production and/or distribution of electricity or gas and which are operated by the undertaking in the one State. The use of this concept is one of the reasons for the number of electricity and gas establishments since 1968–69 being considerably less than in previous years. The other main reason is that until 1967–68 a number of electricity generating stations operated by enterprises principally for their own use were included. However, as from 1968–69, these generating stations have been included in the Electricity Census only if sales and transfers of electricity exceeded $100,000 in value.

ELECTRICITY AND GAS ESTABLISHMENTS—SUMMARY OF OPERATIONS, 1977-78

State or Territory	Establishments at 30 June	Employment at 30 June: Males (No.)	Females (No.)	Total (No.)	Wages and salaries ($m)	Turnover ($m)	Stocks: Opening ($m)	Closing ($m)	Purchases, transfers in and selected expenses ($m)	Value added ($m)	Rent and leasing expenses ($m)	Fixed capital expenditure less disposals ($m)
New South Wales—												
Electricity	47	24,709	2,323	27,032	314.7	1,483.8	107.2	131.6	726.7	781.5	3.8	249.1
Gas	21	2,345	511	2,856	31.6	111.5	12.7	13.6	43.4	69.0	0.4	11.1
Victoria—												
Electricity	13 }	15,622	1,390	17,012	198.2	885.0	44.8	51.6	298.4	593.5	3.9	237.9
Gas	1 }											
Queensland—												
Electricity	11	8,984	929	9,913	116.0	622.3	30.1	35.7	355.4	272.5	1.3	180.3
Gas	7	596	108	704	6.8	30.4	1.7	1.9	13.2	17.4	0.2	2.1
South Australia—												
Electricity	10 }	5,764	330	6,094	73.1	234.1	17.9	18.6	74.7	160.1	0.2	53.9
Gas	2 }											
Western Australia—												
Electricity	11 }	5,232	392	5,624	68.9	259.5	21.3	22.4	100.1	160.6	-	89.0
Gas	2 }											
Australia(a)—												
Electricity	96	60,271	5,046	65,317	766.8	3,386.3	213.7	255.4	1,520.4	1,907.6	7.9	828.6
Gas	34	7,715	1,367	9,082	99.7	388.5	31.4	31.5	144.5	244.1	2.6	55.1

(a) Includes Tasmania, Northern Territory and Australian Capital Territory. At the end of June 1978 there were 2 electricity and 1 gas establishment operating in Tasmania; 1 electricity establishment in the Northern Territory and 1 electricity establishment in the Australian Capital Territory.