CHAPTER 18

ENERGY

Introduction

Australia is an energy-rich country with major economically recoverable resources of coal and uranium; substantial resources of economically recoverable natural gas and significant, but more limited, resources of crude oil. Whilst there are no known deposits of heavy-oil or tar sands, there are extensive deposists of oil shale which are located primarily in Queensland. Thorium, solar, wave, hydro-power, wind, ocean thermal, wood, geothermal, tidal and crop resources also represent actual or potential energy sources.

Despite Australia's rich endowment of energy resources, it has not been insulated from the changing world energy situation. Indigenous oil supplies currently meet around two-thirds of Australia's oil needs with the prospect that, without further discoveries, the level of self-sufficiency will decline during the late 1980s. The remaining requirement has to be obtained from world markets at prices and conditions similar to those for any other oil importing country.

As at December 1981, estimates of remaining recoverable reserves of crude oil and natural gas liquids in commercial fields in Australia totalled 418 gigalitres (2.6 billion barrels), compared with about 297 gigalitres (1.9 billion barrels) which have already been produced. A further 154 gigalitres (967 million barrels) have been identified in deposists which are theoretically recoverable but considered uneconomic under present conditions or are awaiting further appraisal. About 78 per cent of Australia's proved and probable commercial liquid petroleum reserves are located in the Gippsland Basin around the South East corner of the continent.

Assessments made during 1980 and 1981 indicate that Australia's demonstrated economic recoverable energy resources total 1,353 exajoules (joules x 10^{18}) of which 58 per cent is accounted for by black coal, 26 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, 31 per cent of Australia's recoverable demonstrated economic energy resources (other than uranium) are located in Victoria, almost all of which is brown coal. Queensland accounts for about 40 per cent of national energy resources and New South Wales for 27 per cent; both these quantities being almost entirely black coal. Significant resources of natural gas are located in the Gippsland Basin (Victoria), the Cooper Basin (South Australia) and the North West Shelf (Western Australia).

In terms of world resources, Australia has about 19 per cent of the world's known low-cost uranium, 4.3 per cent of the world's coal, 1.2 per cent of the world's natural gas and about 0.3 per cent of the world's liquid petroleum resources. By comparison, Australia's population is about 0.3 per cent of the world total. This relative abundance, combined with substantial supplies of many raw materials, creates the opportunity for an expansion in energy exports and the development of energy intensive industries.

In recognition of the importance of energy resources to Australia's national wealth, policies have been developed to respond to the changing pattern of world energy supplies, in order to try to minimise uncertainty for the future and to take full advantage of the opportunities arising from the oil situation and to develop other energy sources which can substitute for oil in a wide range of uses, in both domestic and export markets. The basic aims of these policies are:

- to ensure that an adequate supply of energy particularly liquid fuels, is available at all times;
- to maintain a high level of self-sufficiency in liquid fuels, consistent with the economic utilisation of energy resources; and
- to promote the efficient development of indigenous energy resources, both for domestic use and for export to less energy rich nations.

More specific objectives, with particular relevance to the area of liquid fuels are:

- to encourage conservation through the efficient use of existing energy resources, with special emphasis on petroleum;
- to substitute petroleum based fuels by more abundant energy sources (e.g. coal, gas, etc);
- to encourage exploration for, and development of, conventional oil and gas resources; and
- to encourage research and development of alternative energy sources, including synthetic fuels.

The most significant measure adopted in pursuit of these objectives was the decision, taken by the Australian Government in August 1978, to raise the price of domestically produced crude oil to full import parity. In addition, a number of supplementary measures have been implemented in the areas of taxation policy, promotion of conservation and interfuel substitution, stimulation of exploration and development, support for energy research and development, improving preparedness for severe interruptions to oil supplies and active international co-operation.

In general, the Government believes that the supply of and demand for energy should be subject to commercial considerations in the market place and that the development of energy resources should generally continue to be the responsibility of private enterprise. Hence a primary emphasis has been on providing an appropriate economic framework in which Australia's energy resources might be developed and efficient energy use promoted.

The Australian Government's support of energy research and development (R and D) projects, through the *National Energy Research, Development and Demonstration Program,* is indicative of this approach to energy policy. Since the Program was introduced in 1978 it has committed $80.5 million to energy research and development in Australia. In accord with its view on the importance of commercial considerations in governing the energy market, the Program does not give financial assistance to projects to move to the commercialisation stage. The primary focus of the Program has been the co-ordination and support of R and D activity in Australia to achieve a full understanding of the extent and quality of Australia's resource base, and the development of appropriate technologies to enable these resources to be used to their fullest extent for the benefit of the Australian people.

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 an Emergency Oil Sharing Scheme (EOSS) to be activated in an emergency supply situation, an information system on the international oil market, regular consultations with the major oil companies, the promotion of relations with oil producing and consuming countries, and long-term co-operation in energy aimed at reducing dependence on oil. The IEA's long-term co-operation program includes the promotion of energy conservation, the acceleration of the development of non-oil energy sources and the encouragement of energy research and development projects.

The IEA's chief concern is to transform oil-dominated energy economies to a more balanced use of the major available energy sources, oil, coal, nuclear and gas, and to ensure energy efficiency is maximised. Principles for Energy Policy have been adopted to provide a framework to assist governments in the definition of national energy policies. Within this context, the IEA regularly carries out reviews of member countries' energy policies and programs.

The IEA adopted in May 1979 a set of Principles for IEA Action on Coal which emphasised the need to expand the production, trade and use of coal. It subsequently created a Coal Industry Advisory Board, composed of eminent individuals in the international coal industry, to offer expert advice to the IEA on the implementation of the Principles. Australia has three representatives on the Board.

The main decisions-making body of the IEA is the Governing Board. The Board meets annually at Ministerial level and more frequently at senior official level. 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 Energy, 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) the National Petroleum Advisory Committee (NPAC) 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).

Research and Development

NERDDC

The Department of National Development and Energy through the National Energy Office provides policy and technical advice on energy research, development and demonstration (R,D & D) and administers the National Energy Research, Development and Demonstration Program (NERD & D Program).

The National Energy Research, Development and Demonstration Council (NERDDC) was established in May 1978. It advises the Minister for National Development and Energy on the development and co-ordination of a national program of energy research and the disbursement of funds under the NERD & D Program. Council consists of twelve members drawn from government, private industry and tertiary institutions who are appointed by the Minister on the basis of established expertise in the energy field. It is supported by seven Technical Standing Committees (TSC's), covering all major areas of energy technology, which provide expert technical advice. The NERD & D Program is funded from the accrued funds paid to the Coal Research Trust Account under the provision of the *Coal Research Assistance Act* 1977 and from the Energy Research Trust Account for which funds are provided from a Departmental Appropriation for energy research.

1981-82 was the fourth full year of operation of NERDDC. During this year, a further $19.5 million was committed to energy research projects over a wide range of energy technologies. This brought the total committed to date under the NERD & D Program to around $80 million. NERDDC and its TSC's also assist the Department in monitoring scientific and technical progress and performance of projects being supported.

Commonwealth Scientific and Industrial Research Organisation (CSIRO)

Energy research within the Institute of Energy and Earth Resources is carried out with the objectives of improving methods of locating, evaluating, defining and characterising Australia's energy resources and of planning their development and effective use, consistent with the minimisation of environmental stresses. Divisions of the Institute engaged in energy research are the Division of Applied Geomechanics at Syndal (Vic.); the Division of Energy Chemistry at Lucas Heights (N.S.W.); the Division of Energy Technology at Highett (Vic.); the Division of Fossil Fuels at North Ryde (N.S.W.); the Division of Mineral Chemistry at Port Melbourne (Vic.); the Division of Mineral Engineering at Clayton (Vic.); the Division of Mineral Physics at North Ryde (N.S.W.), Lucas Heights (N.S.W.) and Port Melbourne (Vic.), and the Physical Technology Unit at Ryde (N.S.W.).

Research on certain renewable sources of energy is carried out in the Institute of Biological Resources (Division of Plant Industry, Tropical Crops and Pastures, Water and Land Resources and the Centre for Irrigation Research) and in the Institute of Industrial Technology (Divisions of Applied Organic Chemistry and Chemical Technololgy).

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 19 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); *Natural Gas: The Key Issues* (June 1980); *Alternative Liquid Fuels* (July 1980); *Energy Conservation in Buildings* (December 1980); *Australia's Energy Resources 1980* (December 1980); *Motor Spirit: Vehicle Emission, Octane Ratings and Lead Additives—Further Examination* (March 1981); *Nuclear Power in Australia: Regulation and Control* (June 1981); *Renewable Energy Resources in Australia* (July 1981); and *Petroleum Products: Demand and Supply Trends in Australia* (June 1982).

Other Organisations

The *LPG Task Force* was established in 1978 to provide advice to the Government on development of the use of LPG as an automotive fuel. Its membership comprises representatives of bodies associated with the fuel supply and transport industries as well as Commonwealth and State Government. Among the matters considered are the development and adoption of nationally uniform standards and regulations for LPG vehicles, fuel composition and exhaust emission requirements, development of shipping and other infrastructure, public awareness of automotive LPG and demonstration through conversion of Commonwealth fleet vehicles.

Two committees with advisory responsibilities in regard to indigenous and imported crude oil supplies, petroleum stocks, refinery operations, and the distribution of refined petroleum products were formed in 1979. They are the *Oil Supplies Advisory Committee* (OSAC) which consists of Commonwealth officers and representatives of oil production and refining companies operating in Australia, and the *Commonwealth/State Oil Supplies Liaison Committee* which consists of Commonwealth, State and Territory officials with responsibilities for oil supply matters. The two committees usually meet in joint session. Meetings are held approximately every three months or more frequently as circumstances dictate.

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 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 black 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 economic black coal resources amount to over 549,000 million tonnes. Demonstrated economically recoverable resources are currently about 30,000 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

Australia's brown coal identified economic resources are estimated at 43,600 million tonnes. Nearly all are located in Victoria where demonstrated economically recoverable resources are about 36,200 million tonnes. Small deposits exist in other areas of south Gippsland, in south eastern Victoria at Gelliondale 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 large deposits are being tested in the Kingston area of South Australia and the Esperance area of Western 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.

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. By the end of 1982, about 800 million tonnes of raw brown coal will have been mined.

Energy research and development statistics

Estimates of the expenditure on energy R&D carried out in Australia during 1979–80, and classified by energy objective, are presented in the table below.

The estimate of manpower resources devoted to energy R&D in Australia during 1979–80 was 2,570 man years. Of this amount, business organisations accounted for 980 man years, general government organisations for 789 man years and higher education organisations for 801 man years.

More detailed statistics are contained in the ABS publication *Research and Experimental Development; Energy Production, Utilisation and Conservation, All Sectors, Australia, 1979–80* (8110.0)

ENERGY RESEARCH AND EXPERIMENTAL DEVELOPMENT(a), AUSTRALIA, 1979-80
DETAILS OF R & D EXPENDITURE BY ENERGY OBJECTIVE(b)
(\$'000)

Energy objectives(b)			*Sector of performance(d)*		*Source of funds(f)*	
Energy codes	*Description*	*Total expenditure(c)*	*Business enterprises(e)*	*General government and higher education*	*Industry*	*Government*
	Production and utilisation of energy—					
513	Oil and gas—mining extraction techniques	170	(*g*)	(*g*)	(*g*)	(*g*)
111	—refining, transport and storage	1,311	756	555	753	558
112,523,533	—other	5,278	(*g*)	(*g*)	(*g*)	(*g*)
113,114,514,524,534	Oil shale and tar sands	696	(*h*)1,593	(*h*)4,552	(*h*)1,636	(*h*)4,508
512	Coal—mining extraction techniques	4,961	2,169	2,793	1,653	3,308
121	—preparation and transport	5,523	3,865	1,658	3,385	2,138
122	—combustion	3,844	3,216	627	2,956	888
211	—conversion	7,761	2,285	5,476	1,183	6,578
123,522,532	—other	8,464	6,742	1,722	5,706	2,758
131	Solar—heating and cooling	7,224	3,103	4,121	2,925	4,299
132	—photo electric	1,800	521	1,279	596	1,204
133	—thermal electric	287	73	214	16	271
141	Nuclear—non-breeder—light water reactor					
142	—other converter reactor	18,558				
143,511,521,531	—fuel cycle		5,815	16,289	6,177	15,927
144	—supporting technologies					
145	—breeder	—				
146	—fusion	3,545				
151	Wind					
152	Ocean	907	278	629	174	733
153	Geothermal					
221	Biomass	4,091	1,704	2,387	1,486	2,605
154	Other sources and new vectors	1,283	668	615	434	849
	Conservation of energy—					
311	Industry	3,852	2,794	1,058	2,249	1,603
312	Residential and commercial	2,344	851	1,493	956	1,388
313	Transportation	4,775	3,502	1,273	2,551	2,225
314	Other	640	482	158	462	178
	Other energy R & D (including supporting technologies)—					
411	Electric power conversion	2,262	1,614	648	1,456	807
412	Electricity, transmission and distribution	3,182	1,888	1,294	2,054	1,128
413	Energy storage, n.e.i.	1,098	(*i*)	(*i*)	(*i*)	(*i*)
414	Energy system analysis	869	30	839	59	810
415	Other	2,503	(*j*)619	(*j*)2,982	(*j*)772	(*j*)2,830
	Total all energy objectives	**97,228**	**44,567**	**52,661**	**39,636**	**57,592**

(*a*) Refers to R & D activity predominantly directed towards producing, storing, transmitting, utilising and conserving energy. (*b*) The energy objective categories represent ultimate national needs rather than the immediate objective of the researcher or the organisation performing the energy R & D. (*c*) Includes expenditure associated with overhead staff providing indirect services to energy R & D. (*d*) The sector classification used is adapted from the guidelines specified by the OECD for use in the conduct of R & D studies. (*e*) Excludes enterprises in ASIC Division A—i.e. enterprises mainly engaged in agriculture, forestry, fishing and hunting. (*f*) In accordance with IEA practice, source of funds are classified as either Industry or Government. (*g*) Included with oil shale and tar sands (codes 113, 114, 514, 524, 534). (*h*) Comprises codes 513, 112, 523, 533, 113, 114, 514, 524, 534. (*i*) Included with other (code 415). (*j*) Comprises codes 413 and 415.

Petroleum

After World War II the Commonwealth Government actively encouraged petroleum 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 petroleum 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 of America and USSR. 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 is 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 pumping, gas lifting, gas injection or 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 will have 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 gas fields than oil fields will be found. Assessments by the Bureau of Mineral Resources, Geology and Geophysics in September 1980 of Australia's undiscovered petroleum as at 30 June 1980 indicate that there is an 80 per cent chance of finding, at least, another 150 million kilolitres (950 million barrels) of crude oil in Australia, and a 20 per cent chance of finding at least 600 million kilolitres (3,800 million barrels). The mean of the BMR estimate, which occurs at 34 per cent probability is, 420 million kilolitres (2,600 million barrels). This compares with demonstrated economic resources of 270 million kilolitres (1700 million barrels) and demonstrated sub-economic resources of 33 million kilolitres (208 million barrels) as at 31 December 1981. For further details see the National Energy Advisory Committee's Report No. 14, *Australia's Energy Resources 1980 (December 1980)*.

PETROLEUM RESOURCES (a) AS AT 31 DECEMBER 1981

(*Source:* Department of National Development and Energy)

	Demonstrated Economic (b)				*Demonstrated Sub-economic (c)*			
Basin	*Crude oil* 10^6kl	*Condensate* 10^6kl	*LPG* 10^6kl	*Sales gas* 10^9m^3	*Crude oil* 10^6kl	*Condensate* 10^6kl	*LPG* 10^6kl	*Sales gas* 10^9m^3
Bowen-Surat (Qld) . .	1	—	—	2	—	—	—	2
Gippsland (Vic) . . .	244	29	62	196	—	—	—	—
Gippsland-Bass-Otway (Vic./Tas.)	—	—	—	—	18	9	9	39
Cooper (S.A./Qld) . .	12	8	15	95	—	—	—	1
Carnarvon-Canning (W.A.)	12	46	48	343	—	—	—	—
Carnarvon-Browse-Bonaparte (W.A./N.T.) . . .	—	—	—	—	5	16	20	200
Perth (W.A.)	1	—	—	8	—	—	—	—
Amadeus (N.T.) . . .	—	—	—	—	10	2	4	30
Total	**270**	**83**	**125**	**644**	**33**	**27**	**33**	**272**

(*a*) Based on the McKelvey classification which sub-divides resources in terms of the economic feasibility of extraction and their certainty of occurrence. (*b*) Demonstrated economic resources are resources judged to be economically extractable and for which the quantity and quality are computed from specific measurements and extrapolation on geological evidence. (*c*) Demonstrated sub-economic resources are similar to demonstrated economic resources in terms of certainty of occurrence but are judged to be sub-economic at present.

PETROLEUM PRODUCTION IN AUSTRALIA

(*Source:* Department of National Development and Energy)

Year	*Crude oil* $10^6 kl$	*Condensate (a)* $10^6 kl$	*LPG (b)* $10^6 kl$	*Natural (Sales) gas* $10^9 m^3$
1976	24.249(*c*)	n.a.	n.a.	5.929
1977	24.986(*c*)	n.a.	2.680	6.766
1978	24.426	.705	3.920	7.324
1979	24.532	.836	3.920	8.381
1980	21.325	.915	2.990	9.567
1981	21.790	1.140	3.210	11.268

(*a*) Commercial production of condensate. (*b*) Naturally occurring. (*c*) Contains condensate marketed as part of a crude oil stream.

Liquefied petroleum gas

Liquefied petroleum gas (LPG) is the most promising alternative liquid fuel for internal combustion engines in Australia in the short and medium term. The major constituents of LPG are propane, iso- and normal- butane, and propylene, which are gaseous at normal temperatures and pressures and are easily liquefied at moderate pressures or reduced temperature. In Australia the major sources of marketable LPG are crude oil and natural gas fields. LPG is also obtained as a co-product during oil refining and from petrochemical plants. Identified economically recoverable resources of 136,000 million litres are concentrated in Bass Strait, the North West Shelf and the Cooper Basin. In addition it is estimated by the Bureau of Mineral Resources, Geology and Geophysics, that there is an 80 per cent probability of future discoveries identifying a further 90 million litres of LPG. Production of naturally occurring LPG in Australia in 1981–82 was 3,027 million litres (about 85 per cent being extracted from crude oil and natural gas from the Bass Strait fields) most of which was exported to Japan. Most of Australia's 1981–82 consumption of LPG of 1,030 million litres was obtained from indigenous and imported crude oil processed at oil refineries around the country and as a by-product of the chemical industry.

Currently, of the major reserve basins, only Bass Strait is producing LPG at about 1.6 million tonnes per annum. The Cooper basin producers have announced their intention to proceed with a liquids scheme to recover LPG and condensate, to be on-stream in 1984. Annual output from the Basin could approach 500,000 tonnes by the mid 1980s. The North West Shelf Joint Venturers have announced firm plans to extract LPG from both domestic and export gas streams. Production of LPG from the North West Shelf, planned to commence in 1987, will be around 640,000 tonnes per annum and will be maintained at this level through the 1990s.

About 70 per cent of Australia's LPG production is exported (1.4 million tonnes in 1981–82) under relatively short term contracts. Exports could be expected to be diverted at relatively short notice to meet domestic needs, given sufficient incentive. On present analysis export of LPG from Australia would cease by the early 1990s.

Pricing of Australian crude oil

The pricing of Australian crude oil at import parity levels is fundamental to energy policy in Australia. Crude oil is a scarce and valuable resource and the Government considers that it should be competitively priced, to ensure that its usage recognises this value. Import parity pricing is considered essential to encourage:

- conservation of liquid fuels;
- exploration and development;
- substitution by more plentiful gaseous and solid fuels;
- the economic development of liquid fuel substitutes.

As a result import parity pricing provides the basis for the long-term security of supply for Australia and the continuous adaption of the Australian economy to changing world energy prices.

The present pricing and excise arrangements for locally produced crude oil are based on the June 1979 and earlier Commonwealth Government announcements. Producers receive the full import parity price for oil discovered after 18 August 1976 (new oil) and a return that varies according to the rate of annual production of the producing field (or area) for oil discovered before that date (old oil).

For old oil the producer return plus the excise (net of the applicable rebate) equals the import parity price paid by the refiner.

The return to producers from parity related old oil defined as the greater of:

- the first 953,925 kilolitres (6 Million barrels) per annum produced from each field; or
- a percentage of production (60 per cent for medium fields and 50 per cent for large fields in 1982-83).

Parity related production receives a return which depends on the rate of annual production of the producing field as follows:

- For small fields, that is those producing less than 317,975 kilolitres (2 million barrels) per annum, the producers receive the import parity price less an excise of $18.90 per kilolitre.
- For medium fields that is those producing at least 317,975 kilolitres (2 million barrels) but less than 2,384,813 kilolitres (15 million barrels) per annum, the producers receive $67.07 per kilolitre for Bass Strait and $67.63 for Barrow Island, the returns they were receiving on 30 June 1979 for parity related oil, plus 25 per cent of any increase in the import parity price since then.
- For large fields, that is those producing 2,384,813 kilolitres or more (15 million barrels) per annum, the producers receive $60.29 per kilolitre increased by the lesser of the percentage increase in the CPI since the September quarter 1978 or the percentage increase in the import parity price after 1 July 1979.

Producers receive a fixed return for that part of their old oil production which does not receive by the higher parity related return. Fixed 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 the 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 1982 is $223.12/kl ($35.46/barrel) for Bass Strait crude, $225.85/kl ($35.89/barrel) for Barrow Island, $210.66/kl ($33.48/barrel) for Dongara and $231.28/kl ($36.75/barrel) for Moonie and nearby areas. These prices are based on a $US32/bbl price for the marker crude, Saudi Arabian Light.

Royalties are paid to the relevant State Government for onshore production and are shared between the *Commonwealth and the State* under the *Petroleum Submerged Lands (Royalty) Act* 1967 in the case of offshore production.

Crude oil allocation scheme

The crude oil allocation scheme was introduced in 1965 to stimulate the production of Australian crude oil by guaranteeing a market for this production which was then a relatively expensive source of crude oil. The present allocation scheme first came into operation in September 1971. On 17 September 1980 the Minister for National Development and Energy announced the extension of this scheme, subject to some modifications, until 31 December 1984.

The scheme provides for the allocation of indigenous crude oil to refiner/marketers based on their market share of most refined petroleum products sold or consumed in Australia.

The only major petroleum product that currently does not attract a full allocation is fuel oil. 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 made to the crude oil allocation scheme was 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 for disposal. This producers' entitlement to crude oil is however 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 at the import parity price.

Pricing of liquefied petroleum gas (LPG)

In January and April 1980, the Government's decisions relating to the pricing of LPG were announced. The policy has been formulated against the background of relatively high proportions of domestically produced naturally occurring LPG being exported, in contrast to the need to import crude oil and some petroleum products to meet the demand for liquid fuels. The policy is designed to encourage the maximum efficient use of LPG in Australia, particularly in those areas such as automotive use, where LPG has a premium value. By this means Australia will reduce its dependence on imported oil and increase its security of supply.

To achieve this policy objective, the Commonwealth Government sets the price that the producers receive for LPG sold for automotive, domestic and traditional commercial/industrial uses at a level such that the resulting retail prices provide an incentive for its use as an automotive fuel, and do not cause undue hardship to other users. The policy is designed to maintain an approximate 50 per cent differential between LPG and petrol prices at retail level for motorists in the Melbourne market, with flow-on benefits to other locations. The level of indigenous supply of LPG is determined by the levels of production of crude oil and natural gas, of which LPG is a co-product.

The Government's LPG price scheme is not intended to apply to large scale new non-traditional commercial/industrial uses, exports or sales for petrochemical uses. In these areas, the price is determined by commercial negotation.

The price set by the Government for both naturally occurring and refinery produced LPG is determined at the lesser of $205 per tonne indexed to increases in the import parity price since 1 January 1980, and the export parity price. Until 30 June 1981, the index linked price applied, but following a significant fall in the world market price for LPG, the prices applying have been based on the export parity price. At 1 July 1982, the price was $220.09 per tonne.

Under the excise arrangements announced on 8 April 1980, producers of naturally occurring LPG from fields in production prior to 17 August 1977 pay excise at a rate equivalent to 60 per cent of the excess of the weighted average of domestic and export prices over $147 per tonne. Naturally occurring LPG from fields brought into production on or after 17 August 1977 remains free of excise.

A factor in the retail price of LPG and reticulation gas produced from LPG and naphtha is the subsidy of $80 per tonne introduced during 1980 for household users and commercial and industrial users in areas without access to natural gas. The subsidy is due for review by March 1984.

Oil shale

Oil shales are fine-grained Clastic 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).

In-ground demonstrated resources of shale oil are about 23,000 million barrels, at Rundle (2,650), Nagoorin (2,650) and Stuart (2,500) near Gladstone, Condor (about 8,200) near Proserpine, Duaringa (3,720) 100km west of Rockhampton, Julia Creek (about 1,500) Yaamba (1,630) near Rockhampton, and small deposits mainly in New South Wales, Queensland and Tasmania.

Three types of oil shale deposit have been identified in Australia. They range in geological age from Cambrian to Tertiary. Marine deposits, 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 Basin. 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 areal 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. Several deposits of this type were mined by underground methods in New South Wales 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.

A number of oil shale deposits are currently being studied with a view to commercial development, the most significant projects being Rundle and Condor. Research and engineering studies are under way to examine the economic and technical feasibility of establishing a commercial-scale plant at Rundle to produce syncrude.

Uranium

Australia has about 19 per cent of the Western world's low-cost uranium reserves. Deposits occur in the Northern Territory, Western Australia, South Australia and Queensland.

The chief use for uranium is as a fuel in nuclear reactors. It is also used for power generation 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, as a glass colorant and in electrical components. The requirement for uranium in power generation is so much larger than these other uses that natural uranium can be regarded for most practical purposes as a fuel for nuclear power reactors.

Consideration is being given to the establishment of a uranium enrichment plant, but at present there are no plans for the construction of nuclear power plants in Australia.

Uranium was first observed in Australia in 1894 but systematic exploration did not begin until 1944 following requests from the United Kingdom and United States Governments. 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. This initial phase of 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 (1969), Honeymoon (1972), Olympic Dam (1975)), and in the Northern Territory: Ranger (1969), Nabarlek (1970), Koongarra (1970), Jabiluka (1971)). These and other discoveries have led to substantial additions to Australia's reasonably assured uranium resources which now total 294,000 tonnes of uranium recoverable at less than US$80 per kg U.

Uranium production at the Mary Kathleen Mine resumed in 1976; production in 1981–82 was 935 tonnes U308.

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 arrangements and controls concerning the environment and Aboriginal welfare in the region. Exports of uranium are subject to the Government's nuclear safeguards and non-proliferation policies. The Ranger Uranium Mine received authorisation for development under the Atomic Energy Act in January 1979 and production of uranium concentrate at a planned rate of 3,000 tonnes U308 a year commenced 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 from the stockpiled ore commenced in June 1980; production in 1981 was 1,426 tonnes U308. The Jabiluka project received development approval during 1982 and production of up to 4,500 tonnes U308 per year could commence towards the end of 1986. The Commonwealth approved the development of the Yeelirrie uranium project in Western Australia in June 1979. The project will be developed and controlled 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 1985–86 at the rate of about 2,500 tonnes U308 a year for ten years and 1,000 tonnes U308 a year for a further twelve years. The Lake Way Project in Western Australia received development approval in January 1982 and could commence production in 1984. The Honeymoon project in South Australia received development approval in October 1981. Small-scale production is scheduled to commence in 1983 and full-scale production in 1985–86.

Since the Government's 1977 decision to proceed with the further development of Australia's uranium resources, Australian uranium producers have entered into commitments for the export of 44,000 tonnes U308 over the period 1981 to 1996 for electricity generation in Japan, the Federal Republic of Germany, the Republic of Korea, the United States of America, Sweden, Belgium, Finland and France. The value of exports under these contracts is estimated at $A3,500 million in 1982 dollars.

The *Australian Atomic Energy Commission* (AAEC) was established as a Statutory body by the Commonwealth Parliament under the *Atomic Energy Act* 1953.

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.

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 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 $38 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.

The Government announced on 5 June 1981 that to provide an appropriate basis for the development, regulation and control of nuclear activities in Australia significant changes are necessary to Commonwealth legislation on nuclear matters. The Government has decided to establish a new legal base for these purposes in consultation with the States by developing State legislation complemented as necessary by the Commonwealth legislation.

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

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 22 solar radiation stations, 18 of which have been operating since 1970. These make continuous routine measurements to standards recommended by the World Meteorological Organisation. They are supplemented by other measurements such as air temperature, dewpoint and wind, needed for many uses.

In the past, the lack of developed or potentially viable systems for collection, storage, transmission and utilisation and the problem of coping with the weather and seasonal fluctuations have contributed to a reticence to consider solar energy seriously, particularly for large-scale usage. Its future potential will depend largely on technological developments and the rate of escalation in fuel prices.

Solar energy is available in the form of low temperature heat when collected with commercially available flat plate collectors. These and other low grade heat applications for domestic and industrial use, together with solar building design, are technologies available now, eg in the solar hot water industry sales have now reached $30 million per annum. Collection of heat at higher temperatures to produce steam is a new direction in solar technology and its potential use lies in reducing the consumption of liquid fuels in industry.

As a source of electricity, solar energy in some specialist applications is already cost effective, e.g. solar energy is currently being used for navigation and communication purposes. It may also have further uses in supplying remote communities and mining townships. Technologies are available now for air conditioning in those areas where electricity costs are high, but research is needed to improve their efficiency and reduce high capital costs. In the medium to longer term, plant material resulting from photosynthesis may be a useful source of liquid and gaseous fuels for transportation and there are even some longer range plans to use hydrogen as both an energy source and energy carrier.

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 exchangers, 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. The first experimental plant, rated at 50 kW, commenced testing in the waters off the Hawaiian coast but little information on performance is yet available.

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.

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.

Wind machines rated at 50 kW and 20 kW are currently being demonstated and tested on Rottnest Island in Western Australia and are expected to produce energy competitive with that produced by diesel power in the area and will provide valuable information for the assessment of energy from wind motors.

Future potential is almost entirely dependent on advances in technology which can make wind power competitive with conventional forms of power. However, 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. Therefore, it is unlikely that there will be large-scale use of this energy source in Australia 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 extrapolation of flow rates and temperatures to other sedimentary basins is considered geologically reasonable. The Great Artesian Basin extends mainly throughout Western

Queensland, which would limit its potential use to remote homesteads and small townships. Economic and technical difficulties suggest that in the foreseeable future the use of our geothermal resources will be largely restricted to hot water supply, for space heating and light industrial purposes.

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.

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.

In 1979, the CSIRO 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 460 petajoules, 65% 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.

Other energy crops

Other types of crops, which produce materials more amenable to conversion to fuel, may offer more potential. Crops at present being considered for this purpose include cereal grains, cassava and sugar cane. Cereal grains and cassava produce starch. The conversion of sugar and starch to ethanol is a well established and straightforward industrial process. The major problems, which also arise with large tree plantations, are that crop production for energy must also compete with alternative uses of the agricultural resources employed (land, labour, capital, water, fertiliser) and that there are alternative uses for these crops, including human food, animal foodstuffs and fibre. The CSIRO is at present investigating the possibility of growing sugar cane, cassava and cereal grains for fuel production on land not now used for crop production. Their results may give an indication of the potential for producing energy in this way.

Ethanol from Sugar Cane

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. 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 350,000 hectares are assigned 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. The major barrier to a fuel ethanol industry at present is the economics; the cost of production from cane is in the region of 60 cents per litre substantially higher than the cost of petrol.

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 long term engine performance and durability.

In 1980-81 Australia produced 447,000 tonnes of safflower, sun-flower, soybean, rapeseed, linseed, cotton seed and peanuts from 418,000 hectares sown to oil seed crops. This yielded a net 126,000 tonnes of vegetable oil allowing for import and export of seed, and compares to an estimated Australian consumption of 220,000 tonnes.

At one tonne/hectare rapeseed or sunflower would yield 435 litres of oil, equivalent to 380 litres of dieseline per hectare. The cost of production is believed to be around 60c/litre, almost twice the cost of dieseline. CSIRO is gathering data on the scope for expanded production, under Project Crop-fuel.

Hydrocarbon plants

A number of plants produce hydrocarbon-like compounds which can be extracted and converted to liquid fuels by a catalytic cracking process. A recent study under the NERDD Program indicates that the extracts would cost $116 to $196 per barrel of oil equivalent. None of these crops are presently grown commercially.

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 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^{15} Joules, an insignificant proportion of Australia's overall energy demand, although, especially in South and Western Australia, firewood has had some regional significance.

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. However, methanol from wood could not compete economically against methanol from coal or gas.

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.

In 1976 the World Energy Conference estimated Australia's gross theoretical hydro-electric capability at 53,500 gigawatt hours (GWh) per year. However, due to topography, economics or the committal of water for irrigation, only 22,500 GWh/year is considered to be capable of being ultimately developed.

Installed hydro-electric generating capacity in Australia is currently 6,250 MW which represents 24 per cent of the total installed generating capacity of public electricity supply authorities in Australia. This hydro-electric capacity generated 14,859 GWh in 1980–81 representing 16 per cent of total public electricity generation in Australia.

Future hydro development will mainly be confined to Tasmania, and to a lesser extent North Queensland, as most of the large lower cost sites have either been developed or are under development. By 1985 over 75 per cent of Tasmania's ultimate hydro potential would have been harnessed and with the exception of the Burdekin River in Queensland, Australia's remaining hydro potential will be confirmed to smaller more expensive sites.

Although hydro-electric power stations will continue to be constructed into the 1990s hydro's share of total generating capacity and electricity production will continue to decline as a result of the large expansion program for coal-fired power stations during this period.

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 Snowy Mountains Scheme is a dual purpose hydro-electric and irrigation complex located in south-eastern Australia and is one of the largest engineering works of its type in the world. It impounds the south-flowing waters of the Snowy River and its tributary, the Eucumbene, at high elevations and diverts them inland to the Murray and Murrumbidgee Rivers through two tunnel systems driven through the Snowy Mountains. The Scheme also involves the regulation and utilisation of the headwaters of the Murrumbidgee, Tumut, Tooma and Geehi Rivers. The diverted waters fall some 800

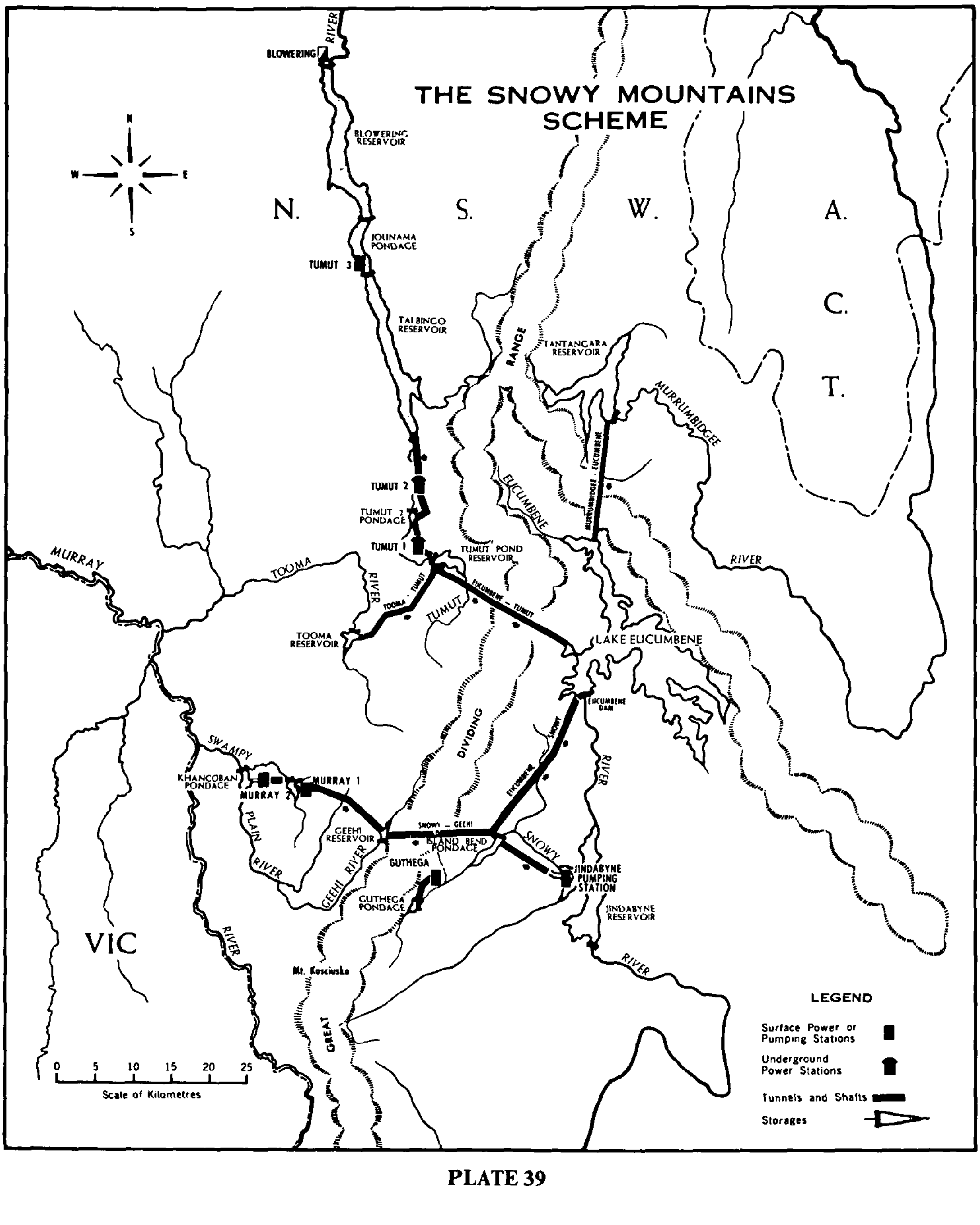
* *See also* Chapter 15, Water Resources of this issue and the special detailed article in Year Book No. 42, pages 1103–30.

metres and together with regulated flows in the Geehi and Tumut River catchments generate mainly peak load electricity for the States of New South Wales and Victoria and the Australian Capital Territory as they pass through power stations to the irrigation areas inland from the Snowy Mountains.

The Scheme was completed in 1974 with an installed generating capacity totalling 3,740 MW and an annual average output of over 5,000 GWh. An average of 2,300 GL of water per year has become available in the Murray and Murrumbidgee Rivers as a result of the Scheme. The electrical output of the Scheme is distributed to the Commonwealth (670 GWh/year) and to the States of New South Wales and Victoria which share the remainder of the output of the Scheme on a two-thirds/one-third basis respectively.

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.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TALBINGO RESERVOIR
RANGE
TANTANGARA RESERVOIR
MURRUMBIDGEE
MURRUMBIDGEE - EUCUMBENE
EUCUMBENE
TUMUT 2
TUMUT 2 PONDAGE
TUMUT 1
TUMUT POND RESERVOIR
MURRAY
TOOMA
RIVER
TOOMA - TUMUT
EUCUMBENE - TUMUT
TUMUT
TOOMA RESERVOIR
LAKE EUCUMBENE
EUCUMBENE DAM
DIVIDING
SNOWY - EUCUMBENE
SWAMPY
KHANCOBAN PONDAGE
MURRAY 1
MURRAY 2
PLAIN
RIVER
GEEHI RESERVOIR
SNOWY - GEEHI
ISLAND BEND PONDAGE
SNOWY
GEEHI RIVER
GUTHEGA
JINDABYNE PUMPING STATION
GUTHEGA PONDAGE
JINDABYNE RESERVOIR
RIVER
Mt. Kosciusko
GREAT
0 5 10 15 20 25
Scale of Kilometres
LEGEND
Surface Power or Pumping Stations
Underground Power Stations
Tunnels and Shafts
Storages

PLATE 39

Electricity generation and transmission

The following table shows details of thermal and hydro electricity generated in Australia during recent years.

ELECTRICITY (a)—THERMAL AND HYDRO

Year	Million kWh
1975-76	76,597
1976-77	82,522
1977-78	86,095
1978-79	90,857
1979-80	95,910
1980-81	100,782

(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.

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 1982 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 175 cities, municipalities and shires in New South Wales, 172 are included in one or other of the 23 electricity county districts.

The Energy 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 wise 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 1982 the Authority was committed to the payment of $44,816,063 in subsidies, of which $38,924,304 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 at night road accidents. Since the introduction of the scheme in 1964, subsidy has been approved in respect of some 1,866 kilometres of traffic routes throughout the State.

Generation and transmission

Of the State's electrical power requirements during the year ended 30 June 1982, almost all was generated in New South Wales (86.1 per cent by coal fired power stations, 10.1 per cent from the Snowy Mountains Hydro-electric Authority and 1.2 per cent by other hydro-electric stations). The remaining 2.6 per cent was supplied by various sources, including interchange with other States and other small generating authorities in New South Wales.

Major generating stations. At 30 June 1982 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; Eraring, 660MW; Wallerawang (near Lithgow), 1,240 MW. The total nominal capacity of the Electricity Commission's system as at 30 June 1982 was 9,196 MW. The greater part of the Commission's generating plant is concentrated within a 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 330kV, 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 over 650 kilometres inland.

At 30 June 1982 there were in service; 3,808 circuit kilometres of 330 kV and 7,126 kilometres of 132 kV transmission lines (including 298 kilometres operating for the time being at 66 kV). There were also in service 4,385 kilometres of transmission line of 66 kV and lower voltages, and 517 kilometres of underground cable. The installed transformer capacity at the Commission's 167 substations was 27,722 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 13 MW) and the North-West County Council (17 MW). The aggregate effective capacity for the whole of New South Wales systems and isolated plants was approximately 9,229 MW at 30 June 1982, while the number of ultimate consumers at this date was 2,086,303.

Future developments

Future projects include the installation of 6,600 MW of coal-fired generating plant over the next six years. Three additional 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. Two 660 MW units are also planned for Mount Piper Power Station which is located on the western coalfield near Wallerawang. Commissioning of the Bayswater and Mount Piper units is planned between 1985 and 1988.

Construction of a double circuit 500 kV transmission line between Eraring and Kemps Creek, west of Sydney is proceeding. This transmission line will initially operate at 330 kV but operation at 500 kV is planned late in 1983. 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 474). 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 June 1982, the Commission had gross fixed assets of $4,763 million, employed 21,891 persons, had a total income of $1,088 million and, during the preceding twelve months, had increased sales of electricity by 5.0 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 11,000 megatonnes are readily recoverable using present mining techniques.

In 1981-82 the output of brown coal from the Commission's three open cuts at Yallourn, Yallourn North and Morwell totalled 36.3 megatonnes of which 33.4 megatonnes were used to produce 1.0 megatonnes of briquettes and 0.21 megatonnes was sold to the public. Sales of briquettes to the public totalled 591,000 tonnes, producing an income of $14.5 million and 347,000 tonnes were used as fuel in power stations.

Electricity generation transmission and supply

In 1981-82 the Commission generated in its thermal and hydro-electric power stations, or purchased 26,331 GWh. The total installed generating plant capacity at 30 June 1982 was 6,344 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 40 per cent of Victoria's electricity. Other brown coal power stations in the interconnected system comprise the established base load stations at Morwell and Yallourn and Yallourn 'W' station. Peak load thermal stations are located in Melbourne (Newport, and Spencer Street) and at Jerralang in the La Trobe Valley. Hydro-electric stations are located at Kiewa, at Eildon, and at Dartmouth, also 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 two 330 kV transmission lines which also allow for a two-way interchange with New South Wales.

At 30 June 1982 the electrical transmission and distribution system in the State supply network comprised 114,057 kilometres of overhead lines and 4,150 kilometres of underground lines. There are 4 auto-transformation stations, 26 terminal substations, 186 zone substations and 89,311 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 3,763 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 273,800 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 1982 the Commission had 1,342,700 retail customers excluding bulk sales, and the income derived was $871 million. There were 1,149,700 domestic, 81,300 industrial and 110,000 commercial consumers. In country areas electricity was supplied to about 81,300 farms. Sales of electricity during the period, including bulk supplies totalled 20,418 GWh and produced total income of $1,056 million.

Current and future development

Power station projects currently under construction are Yallourn W, Stage 2 and Loy Yang in the La Trobe Valley. 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 500 MW natural gas fired power station at Newport came into operation in 1981. A hydro-electric station with one 150 MW unit built at Dartmouth in conjunction with S.R. & W.S.C. Dam commenced operations early in 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.

QUEENSLAND

Organisations

The State Electricity Commission of Queensland's main functions are to plan and ensure the proper development and co-ordination of the electricity supply industry throughout the State; to enforce safety regulations; to control electricity charges: to raise capital for development and to administer the *Electricity Act* 1976-1982 which regulates the electricity supply industry in Queensland.

The Queensland Government has decided to amalgamate the functions of the Commission and the Queensland Electricity Generating Board. Enabling legislation is to be introduced as soon as possible, however, as an interim measure the Government has dissolved the Generating Board and appointed the Commission to perform the duties of that Board.

The Queensland Electricity Generating Board is responsible for generation and main transmission. It operates the State's major power stations and supplies, via its Statewide transmission network, energy in bulk to the seven distributing boards whose responsibility it is to distribute electricity to consumers in their respective areas. These boards are The South East Queensland Electrictity 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, The Capricornia, The North Queensland and The Far North Queensland) also operate small internal combustion stations in their respective areas

Electricity generation, transmission and distribution

Over ninety per cent of the State's generation is derived from steam power stations fuelled by black coal. Hydro-electric stations located in North Queensland provide around 5 per cent, depending on rainfall in the catchment areas, 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 1981–82 totalled 13,171 million kWh. In addition 182 million kWh were purchased in bulk from other producers of electricity for redistribution to consumers.

At 30 June 1982 the total generating capacity of the publicily-owned stations in the State was 3,591 MW, comprising 3,246 MW of steam plant, 132 MW of hydro-electric plant, 163 MW of gas turbine plant and 50 MW of internal combustion plant.

The regional locations, types and capacities of major publicly-owned power stations in Queensland are: Southern Region—Swanbank A (steam) 396 MW; Swanbank B (steam) 480 MW; Swanbank C (gas turbine) 30 MW; Tennyson (steam) 240 MW; Bulimba (steam) 180 MW; Middle Ridge (gas turbine) 60 MW. Central Region—Gladstone (steam) 1,650 MW; Gladstone (gas turbine) 14MW; Callide (steam) 120 MW; Rockhampton (gas turbine) 25 MW. Northern Region—Kareeya (hydro) 72 MW; Barron Gorge (Hydro) 60 MW; Collinsville (steam) 180 MW and Mackay (gas turbine) 34 MW.

The electrical transmission and distribution system within the State comprised 125,592 circuit kilometres of electric lines and at 30 June 1982 supplied approximately 873,500 customers. 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 33,933 kilometres of line for this system of distribution was in service at 30 June 1982.

Future development

There are four major generation projects being developed and under construction in Queensland and when completed will increase the installed generating capacity by 4,000 megawatts.

The Wivenhoe Pumped Storage Hydro Electric project when completed in 1984 will consist of two 250 MW pump/turbine generating units and will require the construction of 107 route kilometres of 275 kV transmission lines and one substation with a total transformer capacity of 624 MVA.

The Tarong Power Station will consist of four 350 MW generating units and the expected commissioning dates for each of these are May 1984, May 1985, February 1986 and November 1986. To connect this power station to the main transmission network will require the construction of 331 route kilometres of 275 kV transmission lines and 3 substations with a transformer capacity of 2,000 MVA.

The Callide "B" Power Station, expected to be completed by 1989, will consist of two 350 MW generating units and will involve the construction of 290 route kilometres of 275 kV transmission lines and installation of transformers with a capacity of 800 MVA.

The fourth power station is to be sited at Stanwell (24 km south-west of Rockhampton) and is expected to be producing energy by 1990. The power station will consist of four 350 MW generating units and will necessitate construction of almost 400 kilometres of 275 kV transmission line.

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 1981, the Electricity Trust operated plant with a capacity of 2,090 MW, making it the most important authority supplying electricity in the State. There were approximately 568,000 ultimate consumers of electricity in the State, of whom 559,052 were supplied directly and approximately 8,700 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 (1,280 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 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 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 are gas turbine generating units at Geraldton and Kwinana. 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 Kalbarri, some 100 km north of Geraldton. The Commission also owns and operates diesel power stations at Esperance, Fitzroy Crossing, Halls Creek, Kondinin, Kununurra, Onslow and Port Hedland.

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 1982 the Energy Commission's generating capacity from its interconnected grid system was 1,782 megawatts, while the capacity of its separate supply systems in country areas was 91.62 MW. During 1981-82 the Energy Commission synchronised the second 200 MW coal-fired generating unit at Muja Power Station, completing the Stage C extensions. This allowed the East Perth Power Station to be retired from normal service. Construction is now underway to duplicate the Stage C extensions with a power station that 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.

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 on the North-West Shelf 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. Construction has commenced on the first section of 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 a transmission interconnection to the Eastern Goldfields 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 1982 are: number of electricity customers 463,586, gas customers 107,995 in the metropolitan area; 5,742 in manufactured gas systems; electricity generated for interconnected system 5,488 GWh and 166 GWh for Country Towns' Assistance Scheme; natural gas supplied 1,358 GWh, manufactured gas supplied 35.8 GWh; fuel used for electricity generation included 3,012,406 tonnes of coal, 85,017 tonnes of fuel oil and 559 tonnes of distillate.

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 and the Gordon-below-Franklin Scheme, approved in July 1982. The Pieman Scheme which commenced in 1973 will add 385 MW to the grid and the Gordon-below-Franklin Scheme will provide a further 172 MW.

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 GWh'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 1982 was 83,138. During the year 1981-82 the bulk electricity purchased was 1,602 GWh and the system maximum demand was 485 MW.

NORTHERN TERRITORY

The Northern Territory Electricity Commission is a Statutory Authority operating under the *Northern Territory Electricity Act* 1978 (as amended to date), with responsibility for generation, distribution, transmission and sale of electricity in the Northern Territory. The Commission's responsibilities also include electrical safety and inspections.

In Darwin, the major electricity supply source is Stokes Hill Power Station, with an installed capacity of 141 megawatts, and standby gas turbines are located at Berrimah and Snell Street, with a combined capacity of 40 megawatts.

In the major centres of Alice Springs, Tennant Creek and Katherine, diesel power stations generate power with a capacity of 36.76 megawatts (Alice Springs), 7.8 megawatts (Tennant Creek) and 14.36 megawatts (Katherine). As additional sets are being installed at Alice Springs, provision is being made for dual firing in view of the forthcoming supply of natural gas from Palm Valley.

A new power station at Yulara (Ayers Rock Tourist Village) will be commissioned in September 1982 with an installed capacity of 2.6 megawatts. Tennant Creek's total capacity will rise to 9.6 megawatts by October 1982 with the installation of a sixth set.

The Commission operates a number of smaller diesel stations, by an agency arrangement, in the following smaller townships—Pine Creek (.95 MW), Elliott (.536 MW), Mataranka (.4 MW), Larrimah (.2 MW), Ti Tree (.318 MW), Borroloola (.56 MW), Newcastle Waters (.116 MW) and Timber Creek (.2 MW).

Many small communities in the Territory generate their own power using diesel fired conventional generating sets. The Department of Transport and Works has responsibility for the installation and maintenance of power generation in Aboriginal settlements, which comprise the greater majority of these small outlying communities.

Electricity and gas establishments

The census of electricity and gas industries covers distribution as well as production and is conducted as a component of the ABS's integrated economic statistics system. This system has been developed so that data from each industry sector conform to the same basic conceptual standards thereby allowing comparative analysis between and across different industry sectors. The results of this census are therefore comparable with economic data collections undertaken annually for the mining and manufacturing industries and periodically for the wholesale trade, retail trade and construction industries.

The following table shows a summary of operations of electricity and gas establishments for 1980-81. Further details are available in the publication *Electricity and Gas Establishments, Details of Operations, Australia, 1980-81* (8208.0)

ELECTRICITY AND GAS ESTABLISHMENTS—SUMMARY OF OPERATIONS, 1980-81

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)	Fixed capital expenditure less disposals ($m)
New South Wales—											
Electricity	34	26,641	2,726	29,367	457.2	2,307.2	124.0	164.5	1,132.6	1,215.2	646.8
Gas	25	2,497	589	3,086	47.0	192.1	18.0	18.5	99.5	93.1	14.9
Victoria—											
Electricity	14	18,198	1,314	19,512	309.9	1,571.6	73.1	82.6	596.5	984.7	593.2
Gas	1										
Queensland—											
Electricity	11	10,412	1,356	11,768	178.1	1,018.2	48.7	63.9	558.2	475.3	351.9
Gas	7	604	110	714	9.1	53.0	3.9	5.6	26.4	28.3	5.2
South Australia—											
Electricity	13	5,392	365	5,757	90.7	362.6	20.2	23.7	143.6	222.6	70.0
Gas	2										
Western Australia											
Electricity	9	5,397	376	5,773	107.6	416.4	39.7	42.5	224.5	194.7	161.9
Gas	2										
Australia(*a*)—											
Electricity	86	66,516	5,954	72,470	1,139.2	5,621.1	310.1	382.3	2,652.3	3,041.1	1,838.6
Gas	38	8,497	1,501	9,998	151.0	692.9	44.1	48.2	286.3	410.7	104.3

(*a*) Includes Tasmania, Northern Territory and Australian Capital Territory. At the end of June 1981 there were 2 electricity and 1 gas establishment operating in Tasmania; 2 electricity establishments in the Northern Territory and 1 electricity establishment in the Australian Capital Territory.

Note: For Victoria, South Australia and Western Australia, electricity and gas establishments are bracketed together; the figures shown against Electricity cover both.

National Energy Survey

In November 1980 a survey was conducted throughout Australia to obtain information about the number and type of selected domestic appliances held by households. It was undertaken as part of the regular population survey which is based on a multi-stage area sample of private dwellings (houses, flats, etc) and non-private dwellings (hotels, motels, etc) and covers about two-thirds of one per cent of the population of Australia. For the purposes of the National Energy Survey certain types of dwellings, such as non-private dwellings (e.g. hospitals, motels, hotels), caravan parks and dwellings occupied by more than one household, or diplomatic personnel or persons from overseas holidaying in Australia, were excluded.

The following table shows households by major appliances and facilities. Further data relating to the National Energy survey are published in *National Energy Survey: Household Appliances, Facilities and Insulation, Australia, November 1980* (8212.0)

HOUSEHOLDS BY MAJOR APPLIANCES AND FACILITIES, NOVEMBER 1980

('000)

	N.S.W.	*Vic.*	*Qld*	*S.A.*	*W.A.*	*Tas.*	*N.T.*	*A.C.T.*	*Australia*
Electric refrigerator	1666.1	1242.3	710.3	441.2	407.1	131.7	29.4	69.6	4697.7
One door electric refrigerator (*a*)	1031.4	833.7	429.2	277.4	268.0	94.0	19.9	37.0	2990.5
Two door electric refrigerator (*a*)	773.8	492.6	353.1	203.4	178.0	41.3	14.0	36.7	2092.9
Non-electric refrigerator	5.4	*	8.5	*	3.1	*	*	—	21.6
Deep Freezer	690.2	503.9	333.1	206.8	180.9	76.9	18.2	28.6	2038.7
Stove	1377.8	1001.5	602.4	377.2	344.6	117.7	25.5	45.3	3892.0
Separate oven	278.5	242.1	109.0	63.8	64.4	14.6	3.2	24.2	799.9
Hotplate only	11.8	3.7	4.9	*	*	*	*	*	25.4
Microwave oven (*b*)	71.8	33.6	25.4	12.6	14.9	2.8	*	3.2	165.6
Electric frypan/skillet (*b*)	682.6	401.6	359.1	185.5	161.4	68.2	14.3	30.9	1903.5
Vertical grill (*b*)	166.9	103.2	50.8	50.6	28.5	14.6	2.6	6.0	423.2
Crockpot (*b*)	82.6	40.4	44.6	26.7	20.5	8.1	3.2	4.4	230.4
Dishwasher	227.9	190.5	108.4	39.4	39.5	14.2	3.4	17.4	640.7
Washing machine—									
Automatic	995.1	764.1	368.6	194.4	193.7	69.0	20.4	56.0	2661.3
Other	526.4	359.5	300.5	218.4	178.8	59.3	7.8	9.5	1660.1
Total	*1521.6*	*1123.6*	*669.0*	*412.8*	*372.5*	*128.3*	*28.2*	*65.5*	*4321.4*
Clothes drier (*c*)—									
Rotary	625.0	488.7	198.4	133.2	80.5	61.4	8.8	30.8	1626.9
Cabinet	76.0	60.6	11.6	28.6	10.3	5.2	*	2.8	195.4
Total	*701.1*	*549.3*	*210.1*	*161.8*	*90.8*	*66.6*	*9.1*	*33.6*	*1822.3*
Hotwater system—									
Shared	38.1	36.2	15.8	4.2	8.0	*	*	*	104.6
Non-shared	1584.6	1204.4	683.3	432.0	398.9	130.7	28.0	68.8	4530.6
Total	*1622.8*	*1240.5*	*699.1*	*436.2*	*406.9*	*131.7*	*28.6*	*69.4*	*4635.1*
Central heating	53.7	152.1	3.6	13.7	10.9	4.9	*	10.2	249.6
Oil heater	200.0	184.5	15.4	78.2	93.0	45.7	*	18.2	636.5
Fixed electric heater	192.7	329.6	30.5	65.4	31.6	49.2	2.4	40.3	741.6
Gas heater	189.6	633.4	10.6	135.2	61.8	10.5	*	7.0	1048.5
Woodfire/solid fuel heating	247.8	259.7	53.5	97.3	104.4	62.1	2.0	10.9	837.8
Portable heater	1400.2	858.4	511.2	368.5	308.2	115.6	4.7	56.1	3622.9
Air-conditioning	453.2	323.1	103.1	224.6	156.1	*	15.6	11.4	1288.3
Wall insulation (*d*)	138.6	185.0	52.4	32.6	17.2	16.7	2.8	6.2	451.4
Ceiling insulation (*d*)	541.8	654.0	97.4	227.9	154.2	47.8	11.1	48.8	1783.1
Swimming pool—									
With filter	142.5	102.0	55.9	29.8	45.3	5.0	4.2	4.9	389.4
No filter	9.4	12.0	2.9	*	*	*	*	*	27.9
Total	*151.9*	*114.0*	*58.8*	*30.3*	*47.0*	*6.1*	*4.3*	*4.9*	*417.3*
All Households	**1676.7**	**1249.0**	**722.5**	**443.0**	**412.8**	**133.4**	**30.1**	**69.7**	**4737.3**

(*a*) Refers only to external doors. (*b*) Included only if used more than once a week. (*c*) Where a household owned more than one drier, only the one used most often was counted. (*d*) Excludes households in flats and mobile and improvised dwellings. * Subject to sampling variability too high for most practical uses.

REFERENCES

Because the supply and use of energy involves aspects of so many different activities, energy statistics appear in a wide range of ABS collections and a correspondingly wide range of ABS publications. In order to assist those involved in discussions of energy topics to locate the information available in the ABS that may be of relevance to a particular topic a Directory of ABS Energy Statistics (1107.0) has been issued.

Other organisations which produce statistics in this field include the Department of National Development and Energy, the Joint Coal Board, the Australian Institute of Petroleum, the Electricity Supply Association of Australia and the Bureau of Mineral Resources, Geology and Geophysics. State Government departments and instrumentalities also are important sources of energy data, particularly at the regional level, while a number of private corporations and other entities operating within the energy field also publish or make available a significant amount of energy information.