CHAPTER 18

ENERGY

Introduction

Australia is well-endowed with energy resources and is presently one of only five OECD countries that are net energy exporters. It presently supplies about two-thirds of its oil requirements from domestic sources and should be able to maintain this relatively favourable situation for some years at least.

Estimates of Australia's demonstrated economically recoverable resources of energy as at December 1984 are:

Brown coal	41.9 gigatonnes
Black coal	34 gigatonnes
Uranium	463 kilotonnes U
Natural gas	689 teralitres
Crude oil and natural gas liquids	407 gigalitres

Additionally, there are huge inferred resources of black coal amounting to about ten times the demonstrated figure quoted above but presently uneconomic, and resources of oil shale equivalent to about ten times the level of crude oil and condensate resources.

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, to try to minimise uncertainty for the future 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 attempt to ensure that an adequate supply of energy is available at all times;
- to facilitate the efficient use of energy in Australia and the efficient development of Australia's energy resources in response to the needs of domestic and overseas energy markets; and
- to ensure the benefits of energy resource development are shared equitably throughout the Australian community.
- in respect of uranium policy:
  - the Government will not permit the development of any new mines with the exception of Roxby Downs, if commercially feasible;
  - Australia's role in the nuclear fuel cycle and all future exports of uranium will be subject to the findings of an inquiry by the Australian Science and Technology Council (ASTEC);
  - the Government will not facilitate or be otherwise involved with uranium enrichment.

In establishing an appropriate framework within which Australia's energy industries can develop, the Government attaches key importance to the pricing and fiscal environment surrounding production, consumption and trade of Australia's energy resources. Realistic pricing of all energy resources is of fundamental importance in developing this framework. The policy of import parity pricing of indigenous crude oil has been, and is important in meeting the Government's policy objectives in the energy field generally and in the field of liquid fuels in particular. This is supplemented however by measures such as support for energy research and development. In this respect a total of $128 million has been committed to energy research and development through the National Energy Research, Development and Demonstration Program since its inception in 1978. The primary focus of the Program has been the co-ordination and support of research and development activity in Australia to achieve a full understanding of the extent and quality of Australia's energy 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.

The Government has indicated that a priority matter for its attention is reform of the existing arrangements for the taxation of energy and other extractive industries. It has expressed a preference for the replacement of the present complex system of Commonwealth

and State taxes, royalties, licence fees and other charges currently applicable to many extractive industries with more equitable and efficient profits-related taxes.

In a joint statement dated 27 June 1984 the Treasurer and the Minister for Resources and Energy announced details of a resource rent tax to apply from 1 July 1984 to offshore petroleum projects which have not yet reached the development stage (known as "greenfields" petroleum projects). The tax will be payable on those projects earning, before company tax, a minimum rate of return on project outlays equal to the long term bond rate plus 15 percentage points. Profit in excess of this threshold rate will be taxed at a rate of 40 per cent, additional to company tax.

The resource rent tax is intended to replace all existing excise and royalties on greenfields petroleum projects. It will be levied prior to company tax and be deductible for company tax. Deductions from resource rent tax are available for current and capital expenditure excluding payments related to debt and equity capital and for related exploration expenditure.

Enabling legislation for the resource rent tax is expected to be introduced into Parliament during the 1986 Autumn Session.

Advice and co-ordination

Institutional Arrangements

The Commonwealth Minister for Resources and Energy has portfolio responsibility for national energy policy matters, including the commercial development of hydrocarbon fuels and minerals.

The Department of Resources and Energy provides advice to the Minister on energy policy and provides support for a number of advisory bodies including the National Energy Research Development and Demonstration Council (NERDDC), the Australian Minerals and Energy Council (AMEC), the National Oil Supplies Advisory Committee (NOSAC), the National Petroleum Advisory Committee (NPAC), the National Fuels Emergency Consultative Committee (NFECC), and the Australian Coal Consultative Council (ACCC).

It is also responsible for implementation of action required from Australia's membership of the International Energy Agency (IEA) and for the national system of accounting for a control of nuclear materials under Australia's Agreement with the International Atomic Energy Agency (IAEA).

International Energy Agency

The International Energy Agency (IEA) was established in Paris in November 1974 as an autonomous institution within the framework of the Organisation for Economic Co-operation and Development. Australia joined the IEA in May 1979.

The Agency carries out the International Energy Program and the Long Term Co-operation Program. These programs aim to prepare member countries against risk of oil supply disruptions and to share remaining supplies in the event of a severe oil shortfall, to develop alternative energy sources and the more efficient use of energy including through co-operative research and development programs, and to promote co-operative relations with other oil-producing and oil consuming countries.

The main decision-making body of the IEA is the Governing Board. The Board meets as required at Ministerial level and several times a year at senior official level. The IEA has standing groups on Long Term Co-operation, the Oil Market, Emergency Questions, a Committee on Research and Development and an ad hoc group on International Energy Relations.

Research and Development

NERDDC

The National Energy Research, Development and Demonstration (NERD&D) Program has been established to stimulate the level of energy research, development and demonstration in Australia. Grants under the NERD&D Program are approved by the Minister for Resources and Energy who is advised by the National Energy Research, Development and Demonstration Council (NERDDC).

The Council consists of twelve members drawn from government, laboratories, private industry and tertiary institutions. It is supported by seven Technical Standing Committees covering all major areas of energy technology.

Government, industry and university research bodies are eligible to apply for grants under the NERD&D Program which is administered by the Department of Resources and Energy. From the start of the Program in 1978, $128 million had been committed by June 1985.

Further Commonwealth support for energy research, development and demonstration is provided through budget appropriations to Commonwealth agencies such as CSIRO, BMR and the Australian Atomic Energy Commission (AAEC), the Australian Industrial Research and Development Incentives Scheme, and Commonwealth funding of all Australian universities.

Commonwealth Scientific and Industrial Research Organization (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 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.), and the Division of Mineral Engineering at Clayton (Vic.).

Research on certain renewable sources of energy is carried out in the Institute of Biological Resources, Division of Water and Land Resources and the Centre for Irrigation Research.

AMEC

The Australian Minerals and Energy Council (AMEC) was established on 9 April 1976 by agreement between State and Federal mines and energy Ministers and replaced the former Australian Minerals Council. AMEC is principally a body for consultation on minerals and energy matters and provides a forum for Ministers to discuss policy issues of mutual concern and co-ordinate policy action. An AMEC Advisory Committee which is composed of the Departmental heads or their nominees provides for officer level consulation and information exchange. AMEC establishes committees, sub-committees etc, to undertake specific tasks and report back through its Advisory Committee as the need arises. At present, the following are in place:

- Co-ordinating Committee on Energy Conservation
- Standing Committee on Offshore Petroleum Legislation
- Sub-committee on the Development of Alternative Commonwealth and State Liquid Fuels Emergency Legislation

ACCC

The Australian Coal Consultative Council (ACCC) was established following a Coal Industry Conference in Canberra on 30 March 1983. Its terms of reference are to review and report from time to time on the economic and structural problems of the industry. The Council is a tripartite body, chaired by the Minister for Resources and Energy. Its membership comprises the New South Wales and Queensland Ministers responsible for the industry, coal mine proprietors, mining unions and the ACTU. The Australian Mining Industry Council has 'observer' status. The ACCC has met six times, most recently on 20 September 1985.

A National Research Group was set up at the November 1983 meeting which has undertaken seven Working Party reports examining particular problems of the industry. Five of these reports have been completed and considered by the ACCC. An Advisory Committee whose membership reflects that of the ACCC, meets more frequently (approximately monthly) and reports to the ACCC and through it to the relevant Federal and State Ministers.

The ACCC has been effective in developing a greater level of understanding of the industry's situation, particularly on industrial relations issues. This has led to the development of a labour adjustment package to meet the problems of the industry—particularly in N.S.W.

NOSAC

The National Oil Supplies Advisory Committee (NOSAC) was formed in 1983 by the amalgamation of separate Commonwealth/industry and Commonwealth/State bodies set up during the period of tight oil supply in 1979. Representatives of the Commonwealth Government, State Government energy authorities and major domestic oil producers and refiners meet in NOSAC about three times a year to review the situation and outlook for domestic and international oil supplies. Matters discussed include oil production, new oil and gas developments, imports, exports, stock levels, regional shortages, industrial relations, shipping, technical matters and government policies affecting the oil industry.

NPAC

Membership of the National Petroleum Advisory Committee (NPAC) is drawn from agricultural, general aviation, fishing, manufacturing, mining, shipping and transport industries, oil industry, trade union movement and motorists' organisations as well as Commonwealth, State and Territory Governments. The Department of Resources and Energy provides the Secretariat for NPAC. In accordance with the NPAC recommendations the Commonwealth Government has enacted the *Liquid Fuel Emergency Act 1984* and established with the States and the Northern Territory the National Fuels Emergency Consultative Committee.

NFECC

The National Fuels Emergency Consultative Committee (NFECC) chaired by the Commonwealth and comprising officials of the Commonwealth, States and the Northern Territory, was established in late 1983 to consult and advise Governments on matters relevant to the preparation for, and detailed management of, a national liquid fuels crisis; and to act as the prime channel of consultation between Governments in the event of such a crisis. NFECC meets three or four times a year in a programme of co-ordinated arrangements for managing a national fuel crisis.

Resources

Black coal

Black coal is currently second to petroleum products as the largest source of primary energy in Australia. 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.

Australia's inferred resources of black coal are very large, amounting to over 500,000 megatonnes (Mt). At 30 June 1985, Australia's demonstrated economic resources of black coal were estimated to total 54,105 Mt of which 33,998 were considered recoverable. These recoverable resources are located largely 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. Australian saleable black coal production in 1984-85 was 118 Mt.

For further details relating to the production of black coal in Australia *see* Chapter 16, Mineral Industry. Details about the nature and age of black coal are given in Year Book No. 64, pages 460 and 461.

Brown coal

Australia's measured and indicated resources of brown coal are estimated at 43,300 Mt, located principally in Victoria's Latrobe Valley (39,700 Mt). 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, the Esperance area of Western Australia and at Rosevale in the north-east of Tasmania.

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. Production of brown coal in Victoria during 1984-85 was 32 Mt. 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 1984-85, about 880 Mt of raw brown coal had been mined.

Energy research and development statistics

Estimates of the expenditure on energy R & D carried out in Australia during 1982-83, and classified by energy objective, are presented in the table below.

The estimate of manpower resources devoted to energy R & D in Australia during 1982-83 was 3,222 man years. Of this amount, business organisations accounted for 1,079 man years, general government organisations for 1,155 man years and higher education organisations for 988 man years.

More detailed statistics are contained in the ABS publication *Research and Experimental Development; Energy Production, Utilisation and Conservation, All Sectors, Australia, 1982-83* (8110.0)

ENERGY RESEARCH AND EXPERIMENTAL DEVELOPMENT(*a*), AUSTRALIA, 1982–83
DETAILS OF R & D EXPENDITURE BY ENERGY OBJECTIVE(*b*)

($'000)

Energy objectives(b)			*Sector of performance(d)*			
Energy codes	*Description*	*Total expenditure(c)*	*Business enterprises(e)*	*General government and higher education*	*Source of funds(f)* *Industry*	*Government*
	Production and utilisation of energy--					
513	Oil and gas—mining extraction techniques	818	n.p.	n.p.	70	748
111	—refining, transport and storage	3,586	2,620	967	2,633	953
112,523,533	—other	10,110	2,230	7,880	2,897	7,213
113,114,514,524,534	Oil shale and tar sands	7,991	n.p.	n.p.	425	7,566
512	Coal—mining extraction techniques	9,520	n.p.	n.p.	5,990	3,531
121	—preparation and transport	9,159	5,136	4,024	3,930	5,230
122	—combustion	5,113	2,808	2,305	2,873	2,240
211	—conversion	13,550	2,503	11,046	1,560	11,990
123,522,532	—other	8,114	3,449	4,665	2,867	5,247
131	Solar—heating and cooling	5,913	2,778	3,135	2,613	3,300
132	—photo electric	4,065	682	3,383	329	3,736
133	—thermal electric	1,377	431	946	469	907
141	Nuclear—non-breeder—light water reactor	1,850	—	1,850	1	1,849
142	—other converter reactor	—	—	—	—	—
143,511,521,531	—fuel cycle	13,980	n.p.	n.p.	736	13,243
144	—supporting technologies	387	n.p.	n.p.	n.p.	n.p.
145	—breeder	—	—	—	—	—
146	—fusion	7,714	n.p.	n.p.	n.p.	n.p.
151	Wind	862	283	578	301	561
152	Ocean	56	—	56	—	55
153	Geothermal	60	—	60	—	60
221	Biomass	6,929	2,644	4,285	2,497	4,432
154	Other sources and new vectors	2,615	2,100	515	1,871	745
	Conservation of energy—					
311	Industry	7,708	5,605	2,103	5,283	2,425
312	Residential and commercial	6,062	3,349	2,713	3,133	2,929
313	Transportation	13,939	8,356	5,582	6,837	7,102
314	Other	1,645	1,298	348	1,174	471
	Other energy R & D (including supporting technologies)—					
411	Electric power conversion	4,098	2,533	1,565	2,201	1,897
412	Electricity, transmission and distribution	3,031	497	2,534	535	2,496
413	Energy storage, n.e.c.	1,215	640	575	608	606
414	Energy system analysis	2,001	78	1,923	55	1,946
415	Other	3,316	245	3,071	221	3,096
	Total all energy objectives	**156,785**	**59,046**	**97,739**	**54,109**	**102,676**

(*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.

Petroleum

For a definition of petroleum, together with a brief description of recovery techniques and the history of the search for petroleum in Australia, *see* Year Book No. 64, pages 461 and 462.

Good prospects of further discoveries of petroleum are considered to exist in Australia, particularly in sedimentary basins off the north-west coast. Consistent with the existing pattern of discoveries, undiscovered oil is likely to be of the lighter type and more gas fields than oil fields will be found. Assessments by the Bureau of Mineral Resources, Geology and Geophysics indicate that there is a 50 per cent chance of finding at least another 286 gigalitres (GL) (1,800 million barrels) of crude oil in Australia. This compares with demonstrated economically recoverable resources of 240 GL (1,510 million barrels) and demonstrated sub-economically recoverable resources of 49 GL (308 million barrels) as at 31 December 1984.

PETROLEUM RESOURCES(a) AS AT 31 DECEMBER 1983

(*Source:* Department of Resources and Energy)

Basin	Crude oil GL	Gas condensate GL	LPG GL	Sales gas 10^9m^3
Demonstrated economic(b)				
Gippsland (Vic.)	205	20	46	171
Carnarvon/Canning (W.A.)	13	51	27	411
Eromanga (S.A./Qld)	11	—	—	3
Cooper (S.A./Qld)	4	7	13	82
Amedeus (N.T.)	6	3	—	16
Perth (W.A.)	1	—	—	4
Bowen/Surat (Qld)	—	—	—	2
Otway (Vic.)	—	—	—	—
Total	**240**	**81**	**86**	**689**
Demonstrated sub-economic(c)				
Gippsland/Bass (Vic./Tas.)	32	7	5	32
Bonaparte (W.A./N.T.)	9	7	3	229
Carnarvon (W.A.)	6	5	1	443
Eromanga (S.A./Qld)	2	—	—	1
Browse (W.A.)	—	8	—	97
Cooper (S.A./Qld)	—	1	2	24
Bowen/Surat/Adavale (Qld)	—	—	—	6
Total	**49**	**28**	**11**	**832**

(*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 Resources and Energy)

Year	Crude oil and Condensate ML	LPG (a) ML	Natural gas GL
1980-81	23,052	2,982	10,435
1981-82	22,378	3,033	11,550
1982-83	22,069	2,909	11,654
1983-84	26,828	3,132	12,098
1984-85	30,919	3,863	12,958

(*a*) Naturally occurring.

Crude Oil and Condensate

Indigenous production of crude oil and condensate reached a new record level in 1984-85, surpassing the previous record set in 1983-84. New wells came on stream in the Cooper/Eromanga, North West Shelf and Amadeus Basins and production from Bass Strait also increased.

Exports of crude oil from Bass Strait increased markedly during the year. Crude oil is now Australia's second largest mineral export earner after coal. During 1984-85 approximately 19 per cent of Bass Strait production of crude oil was exported. Main markets were the USA, Singapore and Japan.

Exports of condensate continued from the Cooper Basin and began from the North West Shelf in March 1985; currently about a third of condensate production is being exported. Self sufficiency in liquid fuels rose during 1984-85 to 95 per cent compared with 77 per cent in 1983-84.

Liquefied petroleum gas

Liquefied petroleum gas (LPG) is a valuable co-product of oil and gas production and petroleum refining. The major constituents of LPG are propane, propylene and iso- and normal-butane, which are gaseous at normal temperatures and pressures and are easily liquefied at moderate pressures or reduced temperature. Operations involving LPG are

expensive relative to other liquid fuels because LPG has to be refrigerated or pressurised when transported or stored. LPG is an alternative transport fuel for high mileage vehicles in capital cities as well as a petrochemical feedstock and a traditional fuel.

Identified economically recoverable resources of LPG at December 1984 of 86,000 megalitres (ML) are concentrated in Bass Strait, the North West Shelf and the Cooper Basin.

Production of naturally occurring LPG in Australia in 1984-85 was 3,842 ML, (3,082 ML Bass Strait and 739 Cooper Basin), virtually all being extracted from crude oil and natural gas from the Bass Strait fields. About 74 per cent of Australia's LPG production is exported (2,620 ML in 1984-85)—mainly to Japan. Domestic consumption of 1,261 ML in 1984-85 was met by 736 ML of product obtained from refineries with supply shortfalls being met by naturally occurring Bass Strait product.

North West Shelf Project

On 2 August 1985 the Joint Venture Participants (JVP) announced the successful com pletion of legal formalities for the export of Liquefied Natural Gas (LNG) to Japan from the North West Shelf project. The project is the largest single resource development project ever undertaken in Australia. Exports are to commence in October 1989 and will build up to six million tonnes a year from 1995, under take or pay provisions, until 2008. It is expected that some $50 billion, in dollars of the day terms, in export revenue will be generated. North West Shelf gas will be sold to five electricity and three gas utilities which supply a combined market of some 90 million people.

The project is estimated to cost a total of $12 billion. Of this, $2,100 million has been spent by the JVP for the supply of natural gas to the domestic markets of south west Western Australia, comprising the North Rankin 'A' platform, a 134 Km submarine pipeline, the onshore domestic gas plant and associated site engineering services. The State Energy Commission of Western Australia (SECWA) also constructed a 1,500 Km pipeline to serve the domestic markets.

The second phase, the export of LNG, currently estimated to cost $9.8 billion, includes an on-shore LNG plant ($3,500 million), two more off-shore production platforms, further drilling and pipelines, site engineering and the provision of infrastructure and housing in Karratha. Seven 125,000 m^3 LNG tankers ($2 billion) are in addition to this estimate.

The project operators, Woodside Offshore Petroleum, have already announced the letting of some contracts and it is expected that most major contracts for the LNG plant will be announced by mid 1986, with on-site labour expected to peak at around 4,800 in mid 1987, winding down to 1,750 for the operations phase to the end of the contract.

On 12 March 1985 it was announced that the domestic gas contracts had been successfully renegotiated alleviating a potentially serious revenue shortfall for SECWA. This involved, in part, the waiving by the Commonwealth of its share of domestic gas royalties in favour of the State.

The National Liaison Group (NLG) on the North West Shelf was subsequently established to serve as a forum for the exchange on information with a view to increasing Australian content in contracts and purchase orders for the project. It comprises representatives of the Commonwealth and State Governments, trade unions and industry associations together with the JVP. The Commonwealth Minister for Resources and Energy, is joint chairman with the W.A. Minister for Minerals and Energy. The aim of the NLG is to maximise Australian content consistent with cost, quality and performance criteria. The fundamental principle is that Australian industry should have a full and fair opportunity to compete in tenders for the project.

The North West Shelf project is one of national significance, with the potential for major impact on Australia's international trading position.

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; and
- the economic development of liquid fuel substitutes.

Import parity pricing provides the basis for the long-term security of supply for Australia and the continuous adaptation of the Australian economy to changing world energy prices.

The present pricing and excise arrangements are based on announcements made by the Commonwealth Government on 9 October 1984. Refiners pay and producers receive the appropriate import parity prices (IPP) for all liftings of indigenously produced crude oil.

The import parity prices are currently reviewed every six months (1 January and 1 July) or every two months if movements in the relevant parameters would result in a price change of $1 a barrel or more, and even more frequently if there are major changes in circumstances. The prices are based on the landed costs of Saudi Arabian light crude oil at the nearest refinery port to the producing area and then adjusted for domestic freight cost and quality differentials. The current import parity prices from 1 September 1985 are $265.88/kl ($42.25/barrel) for Bass Strait crude, $269.39/kl ($42.81/barrel) for Barrow Island, $269.18/kl ($42.77/barrel) for Cooper/Eromanga Basin, $258.78/kl ($41.12/barrel) for Jackson, $252.05/kl ($40.05/barrel) for Dongara, $273.11/kl ($43.40/barrel) for Bodalla SPL/Tintaburra, Bowen/Surat Basin, $260.02/kl ($41.32/barrel) for Canning Basin, $250.73/kl ($39.84/barrel) for Mt Horner, and $263.30/kl ($41.84/barrel) for Mereenie.

For projects which had reached the development stage on 1 July 1984 and new onshore projects, producers pay excise to the Commonwealth and royalty to the State (if onshore) or Commonwealth (if offshore). Excise is paid at a rate based on the annual level of crude oil sales from the producing area and is levied as a percentage of the Bass Strait IPP. Different excise scales are applicable to oil discovered before 18 September 1975 ("old" oil) and oil discovered on or after that date ("new" oil). An intermediate scale will apply to oil produced from "old" oil fields that were not developed as of 23 October 1984. The rates are given the following table.

CRUDE OIL PRODUCTION: EXCISE PERCENTAGES PAID AND PRODUCER RETURNS, AUSTRALIA

Annual production range	*Excise rate (Percentage of import parity price)*					
	'Old' oil		*Intermediate scale*		*'New' oil*	
Megalitres	*Marginal excise rate*	*Average excise rate*	*Marginal excise rate*	*Average excise rate*	*Marginal excise rate*	*Average excise rate*
0-50	—	—	—	—	—	—
50-100	5	2.50	—	—	—	—
100-200	15	8.75	—	—	—	—
200-300	20	12.50	—	—	—	—
300-400	40	19.38	15	3.75	—	—
400-500	70	29.50	30	9.00	—	—
500-600	80	37.92	50	15.83	10	1.67
600-700	87	44.93	55	21.43	20	4.27
700-800	87	50.19	55	25.63	30	7.50
Greater than 800	87	n.a.	55	n.a.	35	n.a.

Offshore projects in 'greenfields' areas, that is offshore areas not covered by production licences granted before 1 July 1984 and the permit areas from which they were drawn, will be subject to a resource rent tax. The tax will replace existing excise and royalty arrangements.

Crude Oil Allocation Scheme

The crude oil allocation scheme was designed 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 then 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 in Australia.

In June 1984, the Government announced that exports of Bass Strait crude oil which are surplus to domestic refiners' requirements would continue to be permitted until December 1984 together with exports of condensate. Government approval would be required for each export cargo.

In late 1984, the Government undertook a major review of the Crude Oil Allocation Scheme. Two discussion papers have been published and an announcement of the partial allocation arrangements to apply from 1 January 1985 was made on 9 October 1984. These

arrangements provide for all production from areas producing less than 50 kbd (thousand barrels per day) and the first 350 kbd of Bass Strait production to be allocated. Bass Strait production above this level is available for local sale or export at negotiated prices.

Pricing of liquefied petroleum gas (LPG)

The Commonwealth Government sets the price that the producers receive for LPG sold for automotive and traditional domestic, commercial and industrial users. Pricing arrangements which came into force on 28 March 1984 apply until the end of March 1987. Adjustments to the wholesale price are made on 1 October and 1 April each year on the basis of the average monthly export parity price of Bass Strait propane from 1 April 1984 to the month preceding the new price date, but increases are not allowed to exceed rises in the fuel and light component of the consumer price index for the latest six month period available prior to the adjustment date. The designated price on 1 April 1985 was $253.34 per tonne. These arrangements do not apply to non-traditional commercial, industrial and petrochemical users or exports. In these areas the price is determined by commercial negotiation.

Under the excise arrangements announced in 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 average return to producers on both domestic and export markets in excess of $147 per tonne. LPG from fields brought into production on or after 17 August 1977 is free from excise. Adjustments to the LPG excise rate are made on 1 April and 1 October each year.

A subsidy paid to households and commercial and industrial users in areas without access to natural gas, terminated on 1 October 1985.

The pricing arrangements will be reviewed early in 1987.

Oil shale

A description of the nature and location of Australian oil shale deposits is given in Year Book No. 67, page 468.

Major investigations into oil shale development are concentrated on the Condor and Rundle deposits.

A $US24 million feasibility study on the Condor project finished on 30 June 1984. The exclusive rights of the Japanese participants, Japan Australia Oil Shale Corporation (JAOSCO), to negotiate the future development of the project was terminated in September 1985.

Studies are proceeding on the Rundle project. Participants are Esso Australia, Southern Pacific Petroleum and Central Pacific Minerals.

Uranium

Australia has about 29 per cent of the Western world's low-cost uranium reserves. Deposits occur in the Northern Territory, Western Australia, South Australia and Queensland.

The major use for uranium is as a fuel in nuclear reactors. It is also used for power generation in atomic energy research programmes.

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 reach 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 announcements 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: Beverley (1969), Honeymoon (1972), Olympic Dam (1975), and in Northern Territory: Ranger (1969), Nabarlek (1970), Koongarra (1970) and Jabiluka (1971). These and other discoveries have led to substantial additions to Australia's reasonably assured uranium resources which now total 474,000 tonnes of uranium recoverable at less than $US80 per kg U.

The Mary Kathleen mine which had ceased operations in 1963, opened again in 1976. After mining and treating sufficient ore to meet its contractual commitments, the mine was closed in 1982.

The Ranger mine was authorised under Section 41 of the Atomic Energy Act in 1979, and commercial production at a planned rate of 3,000 tonnes yellowcake (U_3O_8) per annum commenced in late 1981. Development approval for the Nabarlek deposit was granted in early 1979 and mining commenced later that year. Production at a planned rate of 1,000 tonnes U_3O_8 per annum, commenced in 1981.

Following the election of a new Government in 1983 a complete review of all aspects of Australia's policies as they relate to uranium was instituted. This process was completed in November 1983, at which time the Government announced its policy on uranium.

The policy provides for the continuing operation of the existing Ranger and Nabarlek mines in the Northern Territory and the development of the Olympic Dam copper-uranium-gold deposit in South Australia. No other uranium mines will be permitted to proceed, but existing mines and the Olympic Dam project will be allowed to negotiate new contracts.

All exports of Australian uranium under existing and future contracts will continue to be subject to the most stringent safeguard requirements. In addition, exports of Australian uranium for end use in France will not be permitted until France ceases testing nuclear weapons in the South Pacific Region.

All uranium produced in Australia is exported in the form of yellowcake for use in nuclear reactors for the generation of electricity, and for the production of radioisotopes and radiopharmaceuticals. Australia's two producers have contracts with utilities in Japan, the Federal Republic of Germany, Republic of Korea, Finland, Sweden, Belgium, and the USA.

Contract tonnes for the period 1977-1996 exceed 55,000 tonnes U_3O_8. Exports for 1984-85 amounted to almost 3,400 tonnes U_3O_8 valued at about $A300m.

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 Resources 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 AAEC's current nuclear program includes radioisotope production and applications, environmental science (particularly in relation to uranium mining activities), provision of support for regulatory and international operations and waste management studies. The latter involves the construction of a non-radioactive pilot plant for the manufacture of full-sized blocks of SYNROC (a synthetic rock-like material used to immobilise high level radioactive waste from reactors. The AAEC is also participating in co-operative research programs with both Japan and the UK and Italy to investigate the properties of SYNROC and its abilities to immobilise high level waste.

The programs, structure and functions of the AAEC are currently under review. Particular attention is being given to ensuring that the functions and programs of the AAEC are appropriate to national requirements.

Current expenditure by the AAEC is of the order of $52 million a year. Staff totals some 1,088 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 radio-nuclides 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 Atomic Energy Act is the principal Commonwealth legislation in the nuclear field. As well as being the legislative basis for the AAEC, the Act provides for Commonwealth powers over uranium and nuclear materials, it was also used as the basis for the authorisation of the Ranger Uranium Mine.

The Government's policy is to introduce a package of new legislation to establish a successor to the AAEC, to repeal repressive and outmoded security provisions of the *Atomic Energy Act* and to give effect to Australia's international nuclear non-proliferation and safeguards obligations.

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

Thorium

Thorium is a radioactive mineral that is about three times as abundant as uranium, but occurs in fewer geological environments and in lower grade accumulation. Most of the world's resources of thorium occur in monazite, a complex phosphate recovered primarily for its rare-earth content. Primary thorium minerals are resistant to oxidation and form economically important placer deposits as well as hard-rock deposits.

In Australia, monazite is produced from titanium-bearing mineral sands on the east and west coasts. Other thorium occurrences are known, but are uneconomic. Australia currently supplies about 60 per cent of the world's traded monazite.

Exports from Australia of thorium and thorium-containing ores require the approval of the Minister for Trade under the Customs (Prohibited Exports) Regulations.

Solar Energy

Solar radiation is measured continuously on a routine basis by the Bureau of Meteorology at 28 stations throughout Australia. These stations also supply data on air temperatures, dewpoint and wind.

Like wind, and tidal and wave energy, solar energy 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. The particular properties are low intensity, geographic, seasonal and daily variations.

The use of solar energy for domestic hot water supply is well established commercially in Australia and the solar hot water systems industry production now has a value of about $44 million per annum. With a view to industrial application, advanced collectors have been designed which can produce steam. Currently however, there appear to be few applications of solar energy which are economically attractive to industry.

The use of passive solar design principles in housing is increasing as relatively low cost passive designs are developed. In the area of electricity generation, photo-voltaics are already viable in some small-scale specialist applications, for example, in navigation and communications stations. If costs are reduced, solar electricity may be increasingly used in the future, for remote homestead or community power supplies and for pumping of water. Solar cooling is not economic at this stage owing to high capital costs and low efficiencies.

Ocean thermal energy

In Australia, there has been virtually no assessment of the potential of the ocean thermal energy source 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 of considerable distance from the major power consumers in the south, and therefore unable to compete with coal based electricity.

Wind energy

Using data from Bureau of Meteorology wind stations, CSIRO has undertaken a continental wind assessment of Australia. In addition, a number of site specific wind resource assessments have been carried out by CSIRO and other bodies. Broadly, these studies indicate that while the bulk of the Australian inland has relatively low average windspeeds, some coastal and island localities have favourable wind energy resources, notably on the Western Australian, South Australian and Tasmanian coasts, in Bass Strait and on Lord Howe Island.

At present the use of wind energy in Australia is confined principally to mechanical windmills for water pumping and small wind electricity generators for remote areas.

It is unlikely that wind energy will be able to compete on a widespread and large scale with coal for electricity generation in Australia, but where wind resources are favourable,

wind turbines could find increasing application in remote areas which currently rely on diesel fuel for electricity production.

Two imported machines in the 20-55 kW range are currently being demonstrated on Rottnest Island in Western Australia, and another imported 55 kW machine is operating at Ballarat in Victoria. At the same time, two Australian manufactured wind turbines are also being demonstrated, one 60 kW capacity machine at Fremantle in Western Australia, the second, a 16 kW machine at Wodonga in Victoria.

Geothermal energy

Most of Australia's geothermal resources are of conduction-dominated type. A most extensive and well documented study in Australia of subsurface temperatures has been made in bore-holes in the Great Artesian Basin. In this basin, about 20 per cent of indexed water bores penetrate to depths greater than 1,000 m and since geothermal gradients are generally greater than 30°C/1,000 m, 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 of the Great Artesian Basin, the extrapolation of flow rates and temperatures to other sedimentary basins suggests it to be geologically reasonable. Economic and technical difficulties indicate that in the foreseeable future the potential 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 (BMR) that identified (demonstrated and inferred) geothermal resources are about 1 per cent of Australia's annual primary energy consumption. Undiscovered geothermal resources however 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 includes crops, wood, agricultural and forestry residues and animal wastes. Currently only two forms of biomass are used significantly as energy resources in Australia. These are firewood and bagasse, both converted to energy by direct combustion.

Approximately 2 megatonnes of firewood are used annually in Australia, equivalent in energy terms to 82.3 petajoules, or 2.6 per cent of Australia's primary energy demand. Production is expected to remain stable at about this level through the 1980s.

Bagasse is the fibrous residue remaining after extraction of the juice from sugar cane. It is the major fuel used in the sugar industry, providing 68.5 petajoules or 2.2 per cent of Australia's total primary energy demand.

Biomass also has a possible use as a source of liquid fuels for transport, particularly ethanol and methanol. Technologies are commercially available for converting biomass to liquid fuels. The major impediments to its current use are that it is not competitive with conventional fuels and generally vehicle modifications are necessary for satisfactory operation.

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 both 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 per cent of the energy used as liquid fuel in transport in 1977-78. This is a net figure taking into account the liquid fuel used in production. It does not take into account socio-economic considerations such as more profitable or socially desirable use of the land available for new crops. It must be considered as an upper limit only.

Recent studies have shown that, largely as a result of the cost of production of the feedstocks, liquid fuel from biomass is at major economic disadvantage compared to petroleum-based fuels, and is unlikely to be commercialised on a significant scale in the near future.

Electric power

Responsibility for public electricity supply rests with the State Governments which control electricity production and distribution through public authorities. The Commonwealth Government's major direct role in the electricity supply industry is its responsibility for the Snowy Mountains Scheme. Greater descriptive and historical detail about the various systems is contained in earlier issues of the Year Book.

Hydro-Electric Resources

With the exception of Tasmania, Australia is generally not well-endowed with hydro-electric resources because of low average rainfall and limited areas of high relief. Major hydro-electric potential is confined to Tasmania and the Great Dividing Range areas of Victoria, New South Wales and Queensland, with some small potential on rivers draining into the Timor Sea in Western Australia and the Northern Territory.

The practical potential of hydro-electric power in Australia has been estimated at 24,000 gigawatt hours (GWh) per year, of which about 60 per cent has currently been developed. In 1983-84, hydro-electric generation was 12,808 GWh.

At 30 June 1984 the installed hydro-electric generating capacity of 6,663 megawatts (MW) represented 21 per cent of total installed capacity.

Future hydro development will be mainly limited to environmentally acceptable sites in Tasmania, and to a lesser extent North Queensland, as most of the low cost resource elsewhere has already been developed. Although hydro-electric power stations will continue to be constructed into the 1990s and probably beyond, hydro's share of total generation will decline as increasing load is met mainly by coal-fired power stations.

Snowy Mountains Hydro-Electric Scheme

The Snowy Mountains Scheme is a dual purpose complex which supplies water for generation and irrigation. It is located in south-eastern Australia, and on its completion was 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 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, Victoria and the Australian Capital Territory as they pass through power stations to the irrigation areas inland from the Snowy Mountains.

A special article on the Scheme, written 20 years after the first diversion of water from the Snowy River to the Murray River in April 1966, appears at the end of this chapter.

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*
1978–79	90,857
1979–80	95,910
1980–81	100,782
1981–82	104,975
1982–83	105,933
1983–84	111,696

(*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 1984 there were 28 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 3 private franchise holders.

Most electricity distribution areas have been consolidated into county 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, 173 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 continues to administer the Rural Electricity Subsidy Scheme which terminated on 30 June 1982. Under the scheme, the rural electrical development of the State has now been virtually completed in areas where the extension of supply is economically feasible. Local electricity suppliers receive subsidies from the Authority towards the cost of new rural lines. At 30 June 1985 the Authority was committed to the payment of $46,924,963 in subsidies, of which $42,199,510 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 road accidents at night. Since the introduction of the scheme in 1964, subsidy has been approved in respect of some 2,325 kilometres of traffic routes throughout the State.

Generation and transmission

Of the State's electrical power requirements during the year ended 30 June 1984, almost all was generated in New South Wales (93.8 per cent by thermal fired power stations, 5.4 per cent from the Snowy Mountains Hydro-Electric Authority and 0.8 per cent by other hydro-electric stations). Interchange with other States and other small generating authorities in New South Wales was negligible.

Major generating stations. At 30 June 1984 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), 1,995 MW; Eraring, 2,640 MW; Wallerawang (near Lithgow), 1,240 MW. The total nominal capacity of the Electricity Commission's system as at 30 June 1984 was 10,665 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 500 kV, 330 kV, 220 kV, 132 kV, 66 kV and some 33 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 1984 there were in service, 4,199 circuit kilometres of 330 kV, 283 kilometres of 220 kV, 7,628 kilometres of 132 kV transmission lines and 282 kilometres of 500 kV transmission lines. There were also in service 5,156 kilometres of transmission line of 66 kV and lower voltages, and 512 kilometres of underground cable. The installed transformer capacity at the Commission's 187 substations was 34,366 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 15.3 MW), the North-West County Council (16.4 MW) and the New England County Council (5.7 MW). The aggregate effective capacity for the whole of New South Wales systems and isolated plants was approximately 10,702 MW at 30 June 1984, while the number of ultimate consumers at this date was 2,165,672.

Future developments

Future projects include the installation of 3,960 MW of coal-fired generating plant. 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 units is planned between 1985 and 1987 with Mount Piper to follow in the early 1990s.

Construction of a double circuit 500 kV transmission line between Eraring and Kemps Creek, west of Sydney is complete. A double circuit 500 kV transmission link operating initially at 330 kV 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 420). 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 five 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 (SEC)

The SEC is Australia's largest electricity supply authority and individual coal producer. It is a semi-government authority with the principal responsibility of generating or purchasing electricity for supply throughout Victoria. It may own, develop and operate brown coal open cuts and briquetting plants and develop the State's hydro-electric resources. It is required to meet, from its own revenue, all expenditure involved with operating its power and fuel undertakings and to provide for statutory transfers to the consolidated revenue of the State. In 1984-85 its revenue was $1,621 million. At 30 June 1985 it had total fixed assets of $7,631 million and a staff of 22,500.

The SEC was established by an Act of the Victorian Parliament in 1921 and now operates under the *State Electricity Commission Act 1958.* Since it began operating, the SEC has expanded and co-ordinated the generation, purchase and supply of electricity on a statewide

basis to the stage where its system provides almost all the electricity produced in Victoria and its transmission covers almost the entire population of the State. At 30 June 1985 it distributed electricity directly to 1.424 million customers and indirectly to a further 277,800 through 11 metropolitan councils which buy power in bulk for retail distribution under franchises granted by the Victorian Government before the SEC's establishment.

Existing electricity system

The SEC Act requires the SEC to apply the natural resources of the State. Of the State's recoverable fossil fuel reserves, brown coal represents 94.6 per cent, natural gas 2.6 and oil 2.8. The SEC therefore has committed itself to increasing the proportion of total Victorian requirements met with coal based energy.

Victoria's electricity system is based upon the State's extensive brown coal resource in the Latrobe Valley 140 to 180 km east of Melbourne in central Gippsland. It is one of the largest single brown coal deposits in the world, amounting to 108,000 megatonnes of which 35,000 are economically winnable.

The coal is young and soft with a moisture content of 60 to 70 per cent and occurs in thick seams from relatively close to the surface to a depth of several hundred metres. The coal can be won continuously in large quantities and at low cost by a specialised mechanical plant. The SEC's coal-fired power stations have been established near the coal deposits because the coal's moisture content would make the coal expensive to transport, every three tonnes of material including two tonnes of water.

The major brown coal-fired generating plants in the system are the 2,000 MW Loy Yang A, the 1,600 MW Hazelwood and 1,450 MW Yallourn 'W' power stations. Other brown coal-fired plants are Morwell (170 MW) and Yallourn 'D' and 'E' (340 MW). These stations are all located in the Latrobe Valley and generate 80 per cent of the State's electricity requirement.

Other thermal stations are Jeeralang (465 MW) gas turbine station in the Latrobe Valley and Newport 'D' (500 MW) gas-fired station in Melbourne. There are hydro-electric power stations in north-eastern Victoria: Kiewa (184 MW), Dartmouth (150 MW), Eildon/Rubicon/Cairn Curran (135 MW). Victoria is also entitled to about 30 per cent of the output of the Snowy Mountains Hydro-Electric Scheme and half of the output of the Hume hydro-electric station near Albury.

The SEC's total installed generating plant capacity at 30 June 1985 was 6,603 MW, including both capacity within the State and that available to it from New South Wales. In 1984-85 electricity generated by the SEC in its thermal and hydro-electric power stations and purchased totalled 27,339 GWh.

Power station construction

Construction of the Loy Yang 'A' power station complex south-east of Traralgon in the Latrobe Valley was authorised by the Victorian Government in 1976. It is the largest single engineering project undertaken in Australia. Coal-fired, Loy Yang will provide base load electricity for the Victorian grid and almost double the State's generating capacity. The project nominally comprises two 2,000 MW power stations, Loy Yang 'A' and Loy Yang 'B' in eight 500 MW units. The first unit commenced commercial service in May 1984 and the second unit is scheduled to do so in November 1985.

Transmission and distribution

The distribution of electricity throughout Victoria has been completed, except for some isolated and remote areas of the State. Main transmission is by 500, 330, 220 and 66 kV transmission lines which supply the principal distribution centres and interconnection between generating sources.

Three 500 kV transmission lines, Australia's first, and six 220 kV lines link the Latrobe Valley stations with Melbourne and the State grid while three 330 kV lines provide the interstate link, two through the Snowy scheme. Bulk distribution of power throughout the main regional areas is by 220 kV lines to terminal stations which reduce the voltage to 66 kV or 22 kV for delivery to zone substations for further distribution. Feeder lines then deliver to distribution substations which in turn reduce the voltage to 415/240 volts for reticulation to individual customers. Some big industrial concerns take power at higher voltages.

The main transmission grid is currently being augmented to provide for increased power from the Latrobe Valley and to meet load growth in north-eastern and western areas of the State and the Mornington Peninsula.

Major development of the transmission system in 1983-84 included the completion of the first and second 500 kV lines from Loy Yang A power station to Hazelwood terminal station. In addition, the second 500 kV line between South Morang and Sydenham and the second 220 kV line between Geelong and Moorabool, were both completed during the year. Construction commenced on the Hazelwood to Narre Warren section of the fourth 500 kV line from the Latrobe Valley to Melbourne and construction is in progress on the 220 kV line from Moorabool to Ballarat.

QUEENSLAND

Organisation

The electricity supply industry in Queensland was restructured by Government legislation in 1984 by providing for the abolition of The Queensland Electricity Generating Board as from 1 January 1985, and the vesting of its assets and liabilities in The State Electricity Commission of Queensland. From that same date the name of the Commission was changed to the Queensland Electricity Commission. Under the terms of the *Electricity Act* 1976-1984 the Queensland Electricity Commission is the arm of Government responsible for co-ordination and regulation of the electricity supply industry in Queensland; for regulation of the use of electricity to ensure safety; and for generation and bulk supply of electricity. In addition the Commission determines bulk supply and retail prices for the supply of electricity, and is empowered to borrow money necessary for the purposes of the industry.

Electricity is supplied to consumers by seven Electricity Boards, namely:

The South East Queensland Electricity Board
The South West Queensland Electricity Board
The Wide Bay-Burnett Electricity Board
The Capricornia Electricity Board
The Mackay Electricity Board
The North Queensland Electricity Board
The Far North Queensland Electricity Board

Each of these organisations is constituted under the *Electricity Act* 1976-84 to supply electricity to consumers within its geographic area.

Electricity generation, transmission and distribution

During 1984-85 ninety-six per cent of the State's generation of 18,608 million kilowatt hours (GWh) was derived from coal-fuelled steam power stations. The hydro-electric stations located in North Queensland provided 3.2 per cent of the State's electricity needs with the remainder being produced by gas turbine and internal combustion generation using light fuel oil and natural gas. The Wivenhoe Pumped Storage Generating Station became fully operational during the year and produced 509 GW.h at times of peak system load while using 719 GW.h for pumping purposes. In addition a further 182.2 GW.h was purchased from private producers of electricity for redistribution to customers within the State wide interconnected system.

At 30 June 1985 the total generating capacity of the publicly owned power stations in the State was 4,816 megawatts (MW), comprising 3,946 MW of coal fired steam plant, 632 MW of hydro-electric plant, 178 MW of gas turbine plant and 60 MW of internal combustion plant. Details of the regional locations, types and capacities of the main power stations are listed in the following table.

QUEENSLAND POWER STATIONS—CAPACITY AND TYPE, 30 JUNE 1984

(*Source:* Department of Resources and Energy)

Location	*Type*	*Capacity (MW)*
	SOUTHERN REGION	
Swanbank A	Steam	396
Swanbank B	Steam	480
Swanbank C	Gas turbine	30
Tennyson	Steam	240
Bulimba	Steam	180
Middle Ridge	Gas turbine	60
Tarong	Gas turbine	15
Tarong	Steam	350
Wivenhoe	Hydro (pumped storage)	250
	CENTRAL REGION	
Gladstone	Steam	1,650
Gladstone	Gas turbine	14
Callide	Steam	120
Rockhampton	Gas turbine	25
	NORTHERN REGION	
Kareeya	Hydro	72
Barron Gorge	Hydro	60
Collinsville	Steam	180
Mackay	Gas turbine	34

At the end of June 1985 the transmission and distribution system within the State comprising 144,902 circuit kilometres of electric lines provided electricity to 981,608 customers. The main transmission voltages are 275 thousand volts (kV), 132 kV, 110 kV and 66 kV. The single wire earth return (SWER) system is used extensively in rural electrification and 43,598 kilometres of line for this system was in service at 30 June 1985.

Future development

A total of three 500 MW of generating capacity will be added to the system with the completion of three power stations now under construction. Progress at these stations is as follows:

- The second of Tarong Power Station's four 350 MW units was commissioned in June and all units are expected to be on line by the end of 1986.
- The two 350 MW generating units of the Callide 'B' Power Station are expected to be on line by 1989.
- The expected start-up date of the first of four 350 MW units at Stanwell Power Station is still uncertain and flexibility in scheduling work has been maintained to avoid overcommitment, while preserving the ability to supply new electrical loads as they arise.

During the past year the Government approved the acquisition of a number of coastal sites to be reserved for future power station development to reduce the likelihood of land use conflict. Four suitable sites have been secured for the development of power stations using sea water for cooling purposes. It is intended that these stations will be built over the next forty or so years.

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 owns and operates three major thermal power stations. These are located at Kwinana, Muja, and Bunbury and all use local coal to produce electricity. Kwinana power station also has the capacity to burn oil or natural gas. A small hydro-electric station is situated at Wellington Dam near Collie, and there are gas turbine generating units at Geraldton and Kwinana.

Power from the three major stations is fed to an interconnected grid system which supplies the electricity needs of 98 per cent of the State's population. The grid services the metropolitan area and the South West and Great Southern areas, including an area extending eastwards to Kalgoorlie and northwards as far as Kalbarri, some 100 km north of Geraldton. Kalgoorlie was brought into the south-west grid system in 1984 following construction of a 680 km transmission line from Muja, one of the longest radial feed lines constructed in Australia.

In areas too remote to utilise the interconnected grid system, diesel power stations are used. The Commission owns and operates 9 of these diesel stations. Of the remaining stations, 19 are owned by local authorities but operated by the Commission under the Country Towns' Assistance Scheme (CTAS).

The CTAS was introduced when steeply rising oil prices in the 1970s caused dramatic increases in country electricity prices. Under this scheme, the Commission operates the electricity undertakings but ownership remains with the shires which are required to raise the funds needed for capital works, including generating plant, distribution extensions and upgrading.

In areas supplied with power through the interconnected grid, or Commission owned and/or operated diesel power stations, uniform tariffs apply.

At 30 June 1985 the Commission's generating capacity from its interconnected grid system was 2,177 MW, while the capacity of its supply system in country areas was 171 MW.

The Commission is also the main supplier of gas in Western Australia. It operates an extensive gas reticulation system in the Perth metropolitan area and also makes supplies available at several country centres in the South West including Pinjarra, Bunbury and Albany. With the exception of Albany, where tempered liquefied petroleum (TLP) gas is fed into a local reticulation system, natural gas is the main gas fuel marketed by the Commission.

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 1983, the Electricity Trust operated a plant with a capacity of 2,090 MW, making it the most important authority supplying electricity in the State. There were approximately 584,000 ultimate consumers of electricity in the State, of whom 575,295 were supplied directly and approximately 9,200 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), a small station at Port Lincoln (9 MW), and one at Snuggery (75 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.

Future developments

To meet future demands, a Northern Power Station comprising two 250 megawatt turbo-generators and boiler units is being constructed on a site near the existing power station at Port Augusta and will be commissioned before 1987.

The preferred strategy of the Advisory Committee on Future Electricity Generation Options is:

- to implement an opportunity energy interconnection with the Victorian-N.S.W. system, for commissioning in 1989;
- to review in late 1985 the economics and need for an interim supply source in 1990. The review to be based on a third unit at the Northern Power Station, contract supply

from Victoria, or conversion of 400 megawatts at Torrens Island to coal firing; or
- to implement a local lignite-fired station when feasible and required (on current indications, 1993).

The South Australian Government is currently considering these options.

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). During 1967 the construction of a substantial oil fired thermal station with a capacity of 240 MW was approved, as a supplement to the continuing hydro development programme.

Output and capacity of hydro-electric system

At 30 June 1985 the generating system had an installed capacity of 1940 MW. The approved remaining works at the Pieman River Power Development, scheduled for completion in 1986, will increase the system installed capacity to 2,171 MW.

Work began in 1982-83 on the Gordon River Power Development Stage 2 but was halted by the Federal government refusing consent for the project to proceed.

The Hydro-Electric Commission in August-September 1983 began work on two smaller hydro power schemes in Western Tasmania. These are the King River Power Development scheduled for completion in mid 1990 and the Anthony Power Development which is expected to be commissioned 18 months later. They will add about 236 MW to the installed capacity of the system.

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's electricity supply requirements are met by a Snowy Mountains reservation of 670 GWh and the balance is provided by the Electricity Commission of New South Wales. The 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 1985 was 90,776. During the year 1984-85 the bulk electricity purchased was 1,763 GWh and the system maximum demand was 496 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.

In Darwin, the major electricity source is the oil fired Stokes Hill Power Station, with an installed capacity of 141 MW. A standby gas turbine is located at Berrimah. In Alice Springs, power is generated at the Ron Goodin Power Station which operates on dual fuel including natural gas. Installed capacity is 36.46 MW. Other Territory centres where power is generated by NTEC are diesel generating stations using distillate fuel.

A $380 million natural gas pipeline from the Amadeus Basin natural gas fields in Central Australia to Darwin is currently under construction and is scheduled to be completed by December 1986 to coincide with the commissioning of the first gas turbine at the new Channel Island Power Station at Darwin.

Channel Island Power Station will use natural gas to generate electricity and will be the first power station in Australia to use combined cycle plant. A contract worth $75 million was signed on 2 September 1985 between the Northern Territory Electricity Commission and a consortium comprising the Marubeni Corporation, John Brown Engineering and Toyo Engineering for the supply of gas turbines and combined cycle plant with a generating capacity of 186 MW. Negotiations are continuing for the purchase of an additional 31 MW open cycle gas turbine to be installed in the future.

Under the terms of the contract the Marubeni consortium will supply five GEC Frame 6 gas turbines manufactured by John Brown Engineering, two heat-recovery steam generators (boilers) to be heated by exhausts from two of the gas turbines, one steam turbine and condenser, control equipment, transformers and auxiliary equipment.

In addition to Darwin, NTEC power stations at the regional centres of Katherine and Tennant Creek will be converted to natural gas fuel operation. Installed capacity at Katherine is currently 14.38 MW and at Tennant Creek 9.36 MW.

Many small communities in the Territory generate their own power using diesel-fired generating sets and responsibility for these operations has been transferred from the Department of Transport and Works to NTEC.

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 retail and wholesale trade, construction, transport and selected services industries.

The following table shows a summary of operations of electricity and gas establishments for 1983-84. Further details are available in the publication *Electricity and Gas Establishments: Details of Operations, Australia, 1983-84* (8208.0).

ELECTRICITY AND GAS ESTABLISHMENTS—SUMMARY OF OPERATIONS, 1983–84

State or Territory	Establishments at 30 June	Employment at 30 June			Wages and salaries	Turnover	Stocks		Purchases, transfers in and selected expenses	Value added	Fixed capital expenditure less disposals
		Males (No.)	Females (No.)	Total (No.)	($'000)	($'000)	Opening ($'000)	Closing ($'000)	($'000)	($'000)	($'000)
New South Wales											
Electricity	33	27,256	2,749	30,005	663,529	4,110,187	374,301	357,695	2,216,881	1,876,700	1,067,926
Gas	20	2,406	574	2,980	57,033	388,607	34,478	31,005	232,963	152,172	19,024
Queensland											
Electricity	12	11,374	1,465	12,839	278,725	2,095,702	123,742	143,135	910,606	1,204,489	1,019,047
Gas	7	620	122	742	14,091	87,233	8,315	8,325	44,737	42,506	5,813
Other States and Territories (a)											
Electricity	37	36,732	3,061	39,793	890,252	3,583,625	198,331	212,668	1,529,204	2,068,757	1,460,207
Gas	7	5,883	939	6,822	146,738	910,600	30,120	32,723	355,886	557,316	543,712
Australia											
Electricity	82	75,362	7,275	82,637	1,832,505	9,789,515	696,375	713,497	4,656,689	5,149,947	3,547,181
Gas	34	8,909	1,635	10,544	217,862	1,386,441	72,912	72,053	633,586	751,995	568,549

(a) Includes Victoria, South Australia, Western Australia, Tasmania, Northern Territory and Australian Capital Territory. At the end of June 1984 the number of establishments were: Victoria electricity 14, gas 1; South Australia—electricity 11, gas 2; Western Australia—electricity 7, gas 2; Northern Territory electricity 2 and Australian Capital Territory electricity 1, gas 1.

National Energy Survey

In June 1983 the ABS conducted a survey throughout Australia to obtain information relating to the numbers and types of selected domestic appliances held by households. Details were also sought from the relevant energy supplying authorities on the consumption of electricity and reticulated gas by households for the most recent 12 month period available.

The survey was conducted as part of the regular ABS population survey, which is based on a multi-stage area sample of private dwellings (houses, flats, etc.) and non-private dwellings (hospitals, hotels, motels, etc.) and covers about two-thirds of one per cent of the population of Australia.

For the purposes of this National Energy Survey certain types of dwellings were excluded, such as non-private dwellings, caravan parks, dwellings occupied by more than one household, and dwellings occupied by diplomatic personnel and by overseas residents. The survey identified a small number of households without electricity, and these were also excluded.

For each State a magnetic tape file is now available containing information from the National Energy Survey. An example of consumption data available is shown in the following table on Average Consumption of Reticulated Gas and Electricity by Households, by State and Capital City.

Further data relating to the survey can be found in ABS publications listed in the Bibliography at the end of this chapter.

AVERAGE CONSUMPTION OF RETICULATED GAS AND ELECTRICITY BY HOUSEHOLDS, BY STATE AND CAPITAL CITY(*a*), 1982–83

	Households with reticulated gas			*Households without reticulated gas*			
		Average annual consumption					
	Number of households	*Gas*	*Electricity*	*Number of households*	*Average annual consumption of electricity*	*Total households*	*Average annual electricity consumption*
	('000)	(MJ)	(MJ)	('000)	(MJ)	('000)	(MJ)
New South Wales	391.3	16,059	16,807	1,370.9	26,746	1,762.2	24,539
Sydney	*327.7*	*15,438*	*17,027*	*809.4*	*27,023*	*1,137.1*	*24,143*
Victoria	824.1	53,688	17,146	469.8	28,076	1,293.9	21,115
Melbourne	*707.1*	*54,620*	*17,437*	*214.7*	*27,761*	*921.8*	*19,842*
Queensland	102.4	9,570	14,314	678.0	23,275	780.5	22,099
Brisbane	*93.5*	*9,559*	*14,414*	*273.4*	*24,210*	*366.9*	*21,714*
South Australia	218.1	25,801	15,036	245.5	27,494	463.6	21,632
Adelaide	*206.9*	*25,861*	*15,105*	*128.2*	*28,245*	*335.1*	*20,132*
Western Australia	135.0	16,671	12,521	300.6	17,689	435.6	16,087
Perth	*129.4*	*16,796*	*12,607*	*188.8*	*18,146*	*318.2*	*15,893*
Tasmania (*b*)						138.0	33,861
Hobart (*b*)						*53.7*	*34,941*
Northern Territory (*b*)						33.3	27,295
Australian Capital Territory (*b*)						74.0	37,936

(*a*) Refers to Capital City Statistical Division. (*b*) Reticulated gas consumption not available.

BIBLIOGRAPHY

ABS Publications

Directory of ABS Energy Statistics (1107.0).

National Energy Survey: Household Appliances, Facilities and Insulation, Australia, June 1983 (8212.0).

National Energy Survey: Household Energy Consumption, Australia, June 1982-83 (8213.0).

Other Publications

Other organisations which produce statistics in this field include the Department of Resources 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.

THE SNOWY MOUNTAINS HYDRO-ELECTRIC SCHEME

(This special article has been contributed by the Snowy Mountains Hydro-Electric Authority)

In April 1966 the first diversion of water was made from the Snowy River to the Murray River, one of the many milestones in the Snowy Mountains Scheme. Twenty years later this article looks back at the development, construction and performance of the Scheme.

General description

The Snowy Mountains Scheme is a dual purpose hydro-electric and irrigation complex located in south-eastern Australia. 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 water, together with regulated flows in the Geehi and Tumut River catchments, generates mainly peak-load electricity for the States of New South Wales and Victoria and the Australian Capital Territory, as the water passes through power stations to the irrigation areas inland from the Snowy Mountains. The Scheme reached its designed capacity in 1974 after twenty-five years of construction.

Features of the Scheme

- Sixteen large dams
- 80 km of aqueducts
- Over 145 km of tunnels
- A pumping station
- Five surface and two underground power stations

which provide:

(a) a generating capacity of 3 740 MW; and

(b) 2 360 GL annually of water for irrigation in the Murray and Murrumbidgee rivers.

Broadly, the Scheme falls into two sections: the northern, Snowy-Tumut development; and the southern, Snowy-Murray development. Both developments are connected by tunnels to the Scheme's main regulating storage, Lake Eucumbene, on the Eucumbene River.

Snowy-Tumut development

The Snowy-Tumut development provides for the diversion of the Eucumbene, the Upper Murrumbidgee and the Tooma Rivers to the Tumut River, and for the combined waters of these four rivers to generate electricity in four power stations (Tumut 1, Tumut 2, Tumut 3 and Blowering) in their fall of 800 m before release to the Tumut River and thence to the Murrumbidgee River.

The trans-mountain tunnel system includes the Eucumbene-Tumut tunnel, connecting Lake Eucumbene with Tumut Pond reservoir. The normal function of the tunnel is to divert water through the Great Dividing Range from Lake Eucumbene to the Tumut River, but during periods of high flow in the Tumut and Tooma Rivers, water in excess of that required for operating the power stations along the Tumut River is diverted in a reverse direction through the tunnel to Lake Eucumbene for storage.

The total installed capacity in Tumut 1, Tumut 2, Tumut 3 and Blowering Power Stations is 2 180 MW. This section of the Scheme enables 1 380 GL of additional water to be provided over a year to the Murrumbidgee River. This water has enabled irrigation production to be increased and new areas to be developed in the Murrumbidgee Valley.

Snowy-Murray development

The Snowy-Murray development involves the diversion of the Snowy River, by a trans-mountain tunnel system, to the Geehi River, the diverted waters falling some 800 m and generating up to 1 500 MW in Murray 1 and Murray 2 Power Stations. Additional power is generated in the 60 MW Guthega Power Station which makes use of the rapidly falling water of the Upper Snowy River on the east of the Divide before it reaches the main tunnel system at Island Bend.

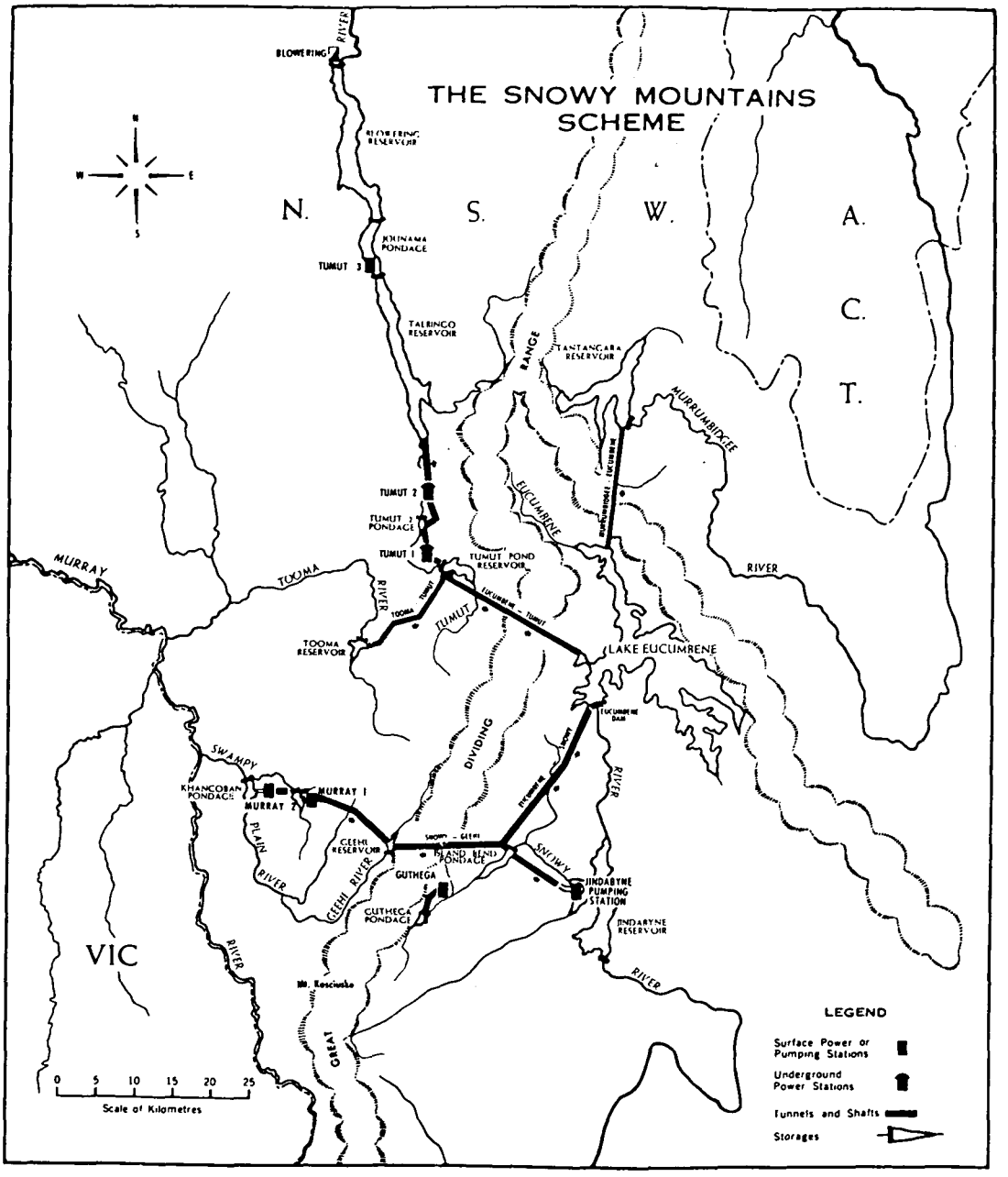
THE SNOWY MOUNTAINS SCHEME
N. S. W. A. C. T.
VIC
BLOWERING RIVER
BLOWERING RESERVOIR
KHANCOBAN PONDAGE
TUMUT 3
TALBINGO RESERVOIR
TANTANGARA RESERVOIR
MURRUMBIDGEE RIVER
EUCUMBENE RIVER
TUMUT 2
TUMUT 3 PONDAGE
TUMUT 1
TUMUT POND RESERVOIR
MURRAY RIVER
TOOMA RIVER
TOOMA RESERVOIR
TUMUT
LAKE EUCUMBENE
DIVIDING RANGE
SWAMPY PLAIN RIVER
KHANCOBAN PONDAGE
MURRAY 1
MURRAY 2
GEEHI RESERVOIR
GEEHI RIVER
BLAND BEND PONDAGE
SNOWY RIVER
GUTHEGA
GUTHEGA PONDAGE
JINDABYNE PUMPING STATION
JINDABYNE RESERVOIR
Mt. Kosciusko
GREAT DIVIDING RANGE
0 5 10 15 20 25
Scale of Kilometres
LEGEND
Surface Power or Pumping Stations
Underground Power Stations
Tunnels and Shafts
Storages

PLATE 38

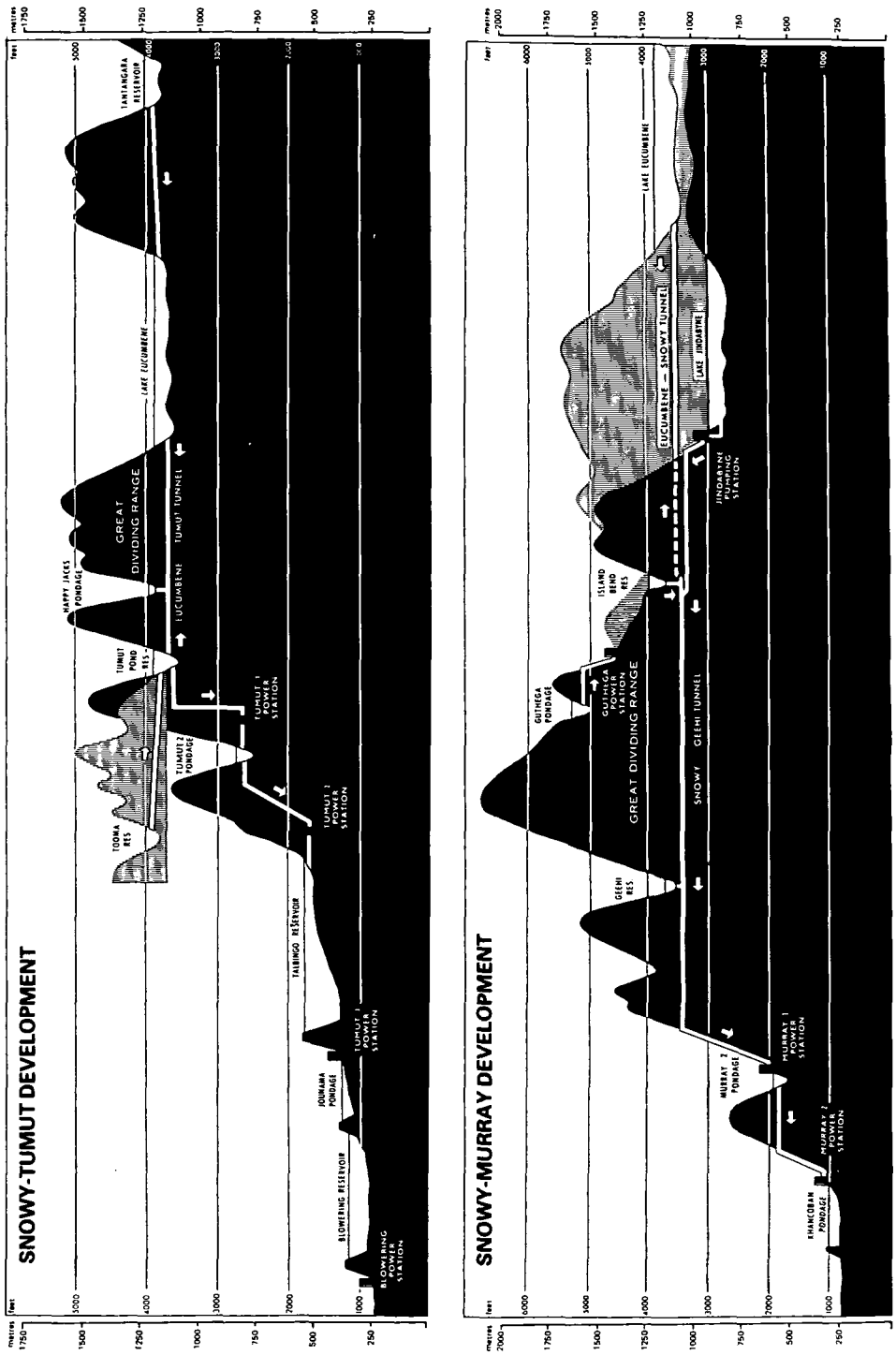
SNOWY-TUMUT DEVELOPMENT
metres
feet
TOOMA RES
TUMUT POND RES
HAPPY JACKS PONDAGE
GREAT DIVIDING RANGE
TARANGARA RESERVOIR
LAKE EUCUMBENE
EUCUMBENE
TUMUT TUNNEL
TUMUT 2 PONDAGE
TUMUT 2 POWER STATION
TUMUT 1 POWER STATION
TABBINGO RESERVOIR
JOUNAMA PONDAGE
BLOWERING RESERVOIR
BLOWERING POWER STATION
SNOWY-MURRAY DEVELOPMENT
GUTHEGA PONDAGE
GUTHEGA POWER STATION
ISLAND BEND RES
GEEHI RES
GREAT DIVIDING RANGE
SNOWY
GEEHI TUNNEL
EUCUMBENE – SNOWY TUNNEL
LAKE JINDABYNE
JINDABYNE POWER STATION
MURRAY 2 PONDAGE
MURRAY 1 POWER STATION
KHANCOBAN PONDAGE
MURRAY 2 POWER STATION

PLATE 39

An essential part of this development is the two-way Eucumbene-Snowy tunnel which connects the Snowy River with Lake Eucumbene. When the flows in the Snowy and Geehi Rivers exceed the needs of the Murray Power Stations, water from the Snowy River at Island Bend is diverted through this tunnel for storage in Lake Eucumbene. Low flows in the Snowy and Geehi Rivers are supplemented by diverting the stored water from Lake Eucumbene back through the same tunnel and delivering it to the trans-mountain tunnel system leading to the Murray power stations.

Additional water is supplied to the trans-mountain tunnel system near Island Bend by the Jindabyne project which pumps, from Lake Jindabyne, the run-off from the Snowy catchment downstream of Island Bend.

The Snowy-Murray Development enables 980 GL of additional water to be provided over a year, through the Hume Reservoir, to the Murray River for irrigation in the Murray Valley.

Construction

In 1947, a Committee of State and Commonwealth officers was formed to examine the development of the water resources of the Snowy Mountains area in the broad national interest. This followed previous single purpose proposals for using some of these resources which dated back to the early 1880s.

The Commonwealth Government passed the *Snowy Mountains Hydro-electric Power Act* in 1949 which gave the Snowy Mountains Hydro-electric Authority the responsibility for the final investigation, design and construction of the Snowy Mountain Scheme, one of the largest single engineering works ever to be undertaken in Australia up to that time. The enterprise was established as 'a milestone towards full national development' and in serving the dual purpose of satisfying the need for increased generating capacity following World War II and diverting the Snowy River inland to the dry west was greeted with enthusiasm by the people of Australia.

One of the earliest tasks of the Authority was to obtain detailed survey, hydrological and geological information in steep, mountainous terrain. The analysis of this information together with advances in technology and the higher than anticipated growth in demand for electricity led to changes to the Scheme as originally proposed by the Commonwealth-States Committee. The main diversion of Snowy River water to the Murray River was made at a higher level as a consequence of the availability of dam sites and a pumping station was installed at Jindabyne for diversion of water from its lower reaches. A pumped storage project was incorporated at Tumut 3 and a number of proposed power stations were incorporated into single larger stations. In all there was a reduction in the number of power stations from 16 as originally proposed to 7 and an increase in generating capacity from 2 820 MW to 3 740 MW.

Besides the gathering of technical data, the early problems of the Authority were the establishment of stores, workshops, laboratories, offices and accommodation. Initially building materials needed to be brought from overseas in meeting priorities for post war construction. Communications needed to be developed over the area as well as road systems, camps and townships. Some 1 600 km of roads were constructed and townships and main camps established at over 100 locations. Community services and amenities were also a need for the construction and associated forces which numbered over 7,300 personnel at the peak of construction in 1959.

Initially, the design of major works was undertaken by the United States Bureau of Reclamation while appropriate staff were recruited from within Australia and overseas and younger engineers were trained by the Bureau.

In the early projects of the Scheme a major change was made in the construction management of large civil engineering works. Whereas works had been traditionally constructed by day labour in Australia, the contractual system was adopted. This led to the introduction into Australia of large overseas firms which has no doubt been of great benefit to construction in Australia. Overseas contractors using Australian and New Australian labour surpassed previous world tunneling records on many occasions. Electrical and mechanical plant was also supplied by contract to Authority specifications and at the time of construction, certain features of the Murray 1 and Tumut 3 Power Stations were of the largest attempted in the world.

Significant advances were also made in the use of rock bolts to reduce concrete lining of tunnels and underground structures.

Throughout construction a high standard of safety measures was employed and construction was renowned for the lack of industrial disputes. Undoubtedly, much of the credit for the construction of the Scheme was due to the leadership of the late Sir William Hudson K.B.E. who was Commissioner of the Authority from 1949 to 1967.

Although the Scheme was constructed at a time when the question of the effect of public works on the environment was not such a public issue as it is today this is not to say, however, that environmental aspects were not considered during design and construction. A high priority was given to soil conservation techniques and significant achievements were made in this field as well as in the protection of natural assets of the area. Under present conditions, when major environmental impact statements would be required, progress on the Scheme could have been delayed while some of the issues were resolved.

Generation commenced from the Scheme in February 1955 with the completion of the 60 MW Guthega project; and Eucumbene Dam, providing the main storage for the Scheme, was completed in May 1958.

The first transmountain diversion of water via the Eucumbene-Tumut Tunnel to the Tumut River was made in June 1959. On 1 May 1962, the Upper Tumut Works were declared in full operation marking the completion of the Tumut 1 and 2 Power Stations (600 MW), the Tooma-Tumut and Murrumbidgee-Eucumbene Diversions and the accumulation of sufficient water in Lake Eucumbene to provide regulation of water over dry periods.

Blowering Dam, which was constructed by the Authority for the State of New South Wales to regulate releases from the Scheme to the Tumut River for irrigation, came into service in May 1968 and the 80 MW Blowering Power Station began operation in August 1971. In April 1966 the first diversion of water was made from the Snowy River to the Murray River with the commissioning of the first two units at Murray 1 Power Station, and the Snowy-Murray Development was declared in full operation on 1 July 1970.

The Scheme reached its designed capacity of 3,740 MW in August 1974 when the last unit of the 1,500 MW Tumut 3 project was brought into service.

Snowy Mountains Hydro-Electric Power Act

This Act, passed in 1949, established the Snowy Mountains Hydro-electric Authority, and empowered it to provide hydro-electric works in the Snowy Mountains Area. The Authority was also empowered to supply electricity to the Commonwealth Government (i) for defence purposes, (ii) for consumption in the A.C.T. and (iii) to supply to a State, or to a State Authority, electricity not required for defence purposes or for consumption in the A.C.T.

Certain resolutions were adopted in July 1949 between Ministers of the Commonwealth and States with respect to the development and use of the water resources of the area for the generation of electricity, for the provision of water for irrigation and the sharing of water between the States. However, it was not until August 1959 when works of the Scheme were well advanced that a detailed Agreement between the States of NSW and Victoria and the Commonwealth Government was incorporated in the Act and joint legislation enacted by the States 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 Agreement also resolved differing opinions as to the constitutional powers of the Commonwealth Government with regard to the water resources of the Snowy Scheme. Under the provisions of the agreement the Commonwealth Government made a reservation of 670 GWh from the energy output of the Scheme of just over 5,000 GWh per annum, the remainder being shared between the States of New South Wales and Victoria in the ratio 2:1.

Operation and maintenance

Under the terms of the 'Agreement', the Snowy Mountains Council was established. One of the main duties of the Council is to direct and control the operation and maintenance of the permanent works of the Authority for the control of water and production of electricity. The Council consists of eight members; the Chairman and Deputy Chairman representing the Commonwealth, two representatives appointed by the State of New South Wales, two representatives appointed by the State of Victoria and the Commissioner and one other member appointed by the Authority. Since the first meeting in 1959, the State representatives have been appointed from the respective Electricity and Water Commissions.

Directions by the Council are carried out by an Operations Engineer and two Assistant Operations Engineers appointed by Council. The Operations Engineer is nominated by the Authority and an Assistant Operations Engineer is nominated by each of the Electricity Commissions of New South Wales and Victoria.

Operation of the Scheme with appropriate provision for maintenance is coordinated through a series of interlocking operating plans with the objective of optimising the use of water for irrigation and electricity production within legal and physical characteristics of the

Scheme. The plans are prepared by officers of the Authority and the Electricity and Water Commissions for consideration by Council.

Daily operation of the Scheme is scheduled from a Works Operation Centre in Cooma with the main State Electricity Control Centres at Richmond in Victoria and Carlingford in New South Wales. Instructions for operations are passed from the Works Operations Centre to Regional Control Centres located within the Scheme for physical implementation.

Releases from the Scheme into the Murray River come under the control of the River Murray Commission which apportions the water between New South Wales, Victoria and South Australia. Most of the water released into the Tumut River is used by New South Wales for irrigation in the Murrumbidgee Valley.

At the end of June 1985, the number of personnel employed in the Operation and Maintenance of the Scheme was 727, comprising 657 Authority personnel, 47 from the Electricity Commission of NSW and 27 from the State Electricity Commission of Victoria. Under the 'Agreement', the generating stations of the Scheme are manned by Electricity Commission personnel.

Performance of the Scheme

In the formative years of the Scheme, there were critics of its long-term economic viability in view of projected reductions in the cost of production from thermal plant as a consequence of increases in thermal efficiencies and the construction of large thermal plants adjacent to coalfields. As events have proved, the investment in the Scheme for hydro-electricity generation alone has been of great value. This arises firstly from the fact that a large proportion of the costs of hydro works are in the civil works such as dams and tunnels, etc., which have extremely long economic lives compared with thermal plants, and the fact that the operational costs are relatively low, whereas thermal plant have continuing fuel costs which are subject to the effects of changing economic conditions.

In 1984-85, the average cost of energy production by the Scheme was 2.1 cents per kilowatt hour being less than half the cost of electricity sold to bulk consumers by the Electricity Commission of New South Wales and Victoria in that year.

The connection of the Scheme since 1959 by 330 kV transmission lines to the electricity systems of New South Wales and Victoria has also been of significant economic advantage. This has enabled sharing of reserves and the interchange of electricity between New South Wales and Victoria to their mutual advantage in optimising system costs.

Extensive use has also been made of the power and pumping stations of the Scheme to provide spinning and fast reserve for both States from interrupting pumping, partially loaded units, changeover from synchronous condenser operation and the ability to start hydro units quickly with consequent savings in fuel costs of thermal plants.

When the Scheme reached its designed capacity of 3,740 MW in 1974, this figure represented 33 per cent of the capacity of the combined New South Wales, Victoria and Snowy systems, and during shortages of thermal generating plant the Scheme has been called upon to operate at the limit of the diversion capacity available.

The Scheme was designed to produce peak electricity, and good flexibility exists on a short-term basis although it is not able to replace base load generation for prolonged periods. Some increase in the diversion capacity of the Scheme may have been of advantage, but channel capacity of the rivers below the outlets of the Scheme as well as irrigation considerations limit prolonged, high discharge operation.

Because of the high degree of regulation of water available through Lake Eucumbene, a firm minimum release of water equivalent to 85 per cent of average releases is available each year. This release not only allows firm planning for electricity production but also for irrigation.

The regulation of water provided by the Scheme played an important part to mitigate the effect of very severe droughts in 1967-68 and in 1982-83 in the irrigation areas of south-eastern Australia. In 1982-83, the storage in the Scheme was reduced to 18 per cent of capacity and natural inflows to some irrigation catchments were described as being substantially below those previously recorded over some 100 years of available records.

The Scheme, however, has not been without its problems, the most significant of which was a collapse of an unlined section of the Eucumbene-Snowy Tunnel in 1970.

Major electrical and mechanical plants have performed well, but as some of this equipment has been in operation for 30 years, the time has come where replacements can be necessary. This situation also applies to communication and control systems where arrangements are in hand for replacement with high technology systems now available.

Conclusion

It may still be too early to assess the true significance of the construction of the Snowy Scheme particularly in regard to the inland diversion of waters. However, the Scheme has demonstrated its value in producing peak hydro-electricity, in conjunction with generating plants of predominantly thermal generators, and the objective of increasing regulated supplies of water to the Murray and Murrumbidgee Valleys.

Construction of the Scheme has also brought new skills to Australia and greatly enhanced the recreation facilities in the Snowy Mountains area. The social impact of the Scheme on the region has also no doubt been significant on the increase in size and prosperity of towns serving the area.