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ENERGY AND MINERALS

ENERGY

Introduction

There are adequate resources of brown coal and natural gas for Victoria to be completely self sufficient in these particular fuels. About 90 per cent of petroleum refinery input comes from Victoria's indigenous oil fields offshore in east Gippsland and more than 80 per cent of Victoria's electricity supply is produced by brown coal fired generating stations situated on the coal fields in the La Trobe valley. A further 5 per cent of Victoria's requirements are produced by hydro power stations in the north-eastern ranges.

About 10 per cent of Victoria's petroleum requirements are derived from crude oil imported from the Middle East and approximately 10 per cent of electricity is obtained from the Snowy Mountains Hydro-Electric Scheme in south-eastern New South Wales.

Natural gas is assuming an increasingly important role in the supply of energy in Victoria. Prior to 1969 there was a small but steady increase each year in the supply of towns gas comprising a blend of Lurgi gas from brown coal, refinery gas, tempered or reformed LPG, water gas, oil gas, and gas from black coal and coke. The blends varied in different parts of Victoria according to supply of feedstocks and type of gas making plant installed. Since 1969, however, the advent of natural gas has caused sales to increase very sharply.

Ministry of Fuel and Power

The Ministry of Fuel and Power was formed in December 1965 following the passing of the *Fuel and Power Act* 1965. This Act made the Minister for Fuel and Power responsible for determining the means by which the present and future supplies and sources of fuel and power in Victoria can best be developed and utilised. The Act also established the administrative machinery of the Ministry and made the Minister responsible for the State Electricity Commission of Victoria and the Gas and Fuel Corporation of Victoria. The broad terms of the Act also enable the Minister to deal with legislative and other problems concerned with the production and marketing of energy which may be referred to him by private oil and gas companies. In accordance with the provisions of the *Pipelines Act* 1967 the Ministry is also responsible for determining the routes of major pipelines conveying hydrocarbons throughout Victoria.

Brown coal

Location

Victoria's largest resources of fossil fuels which form the bulk of energy available in the State, are the huge deposits of brown coal, among the largest in the world, located in the La Trobe valley about 130 to 180 kilometres east of Melbourne in central Gippsland. Smaller deposits also exist in other areas

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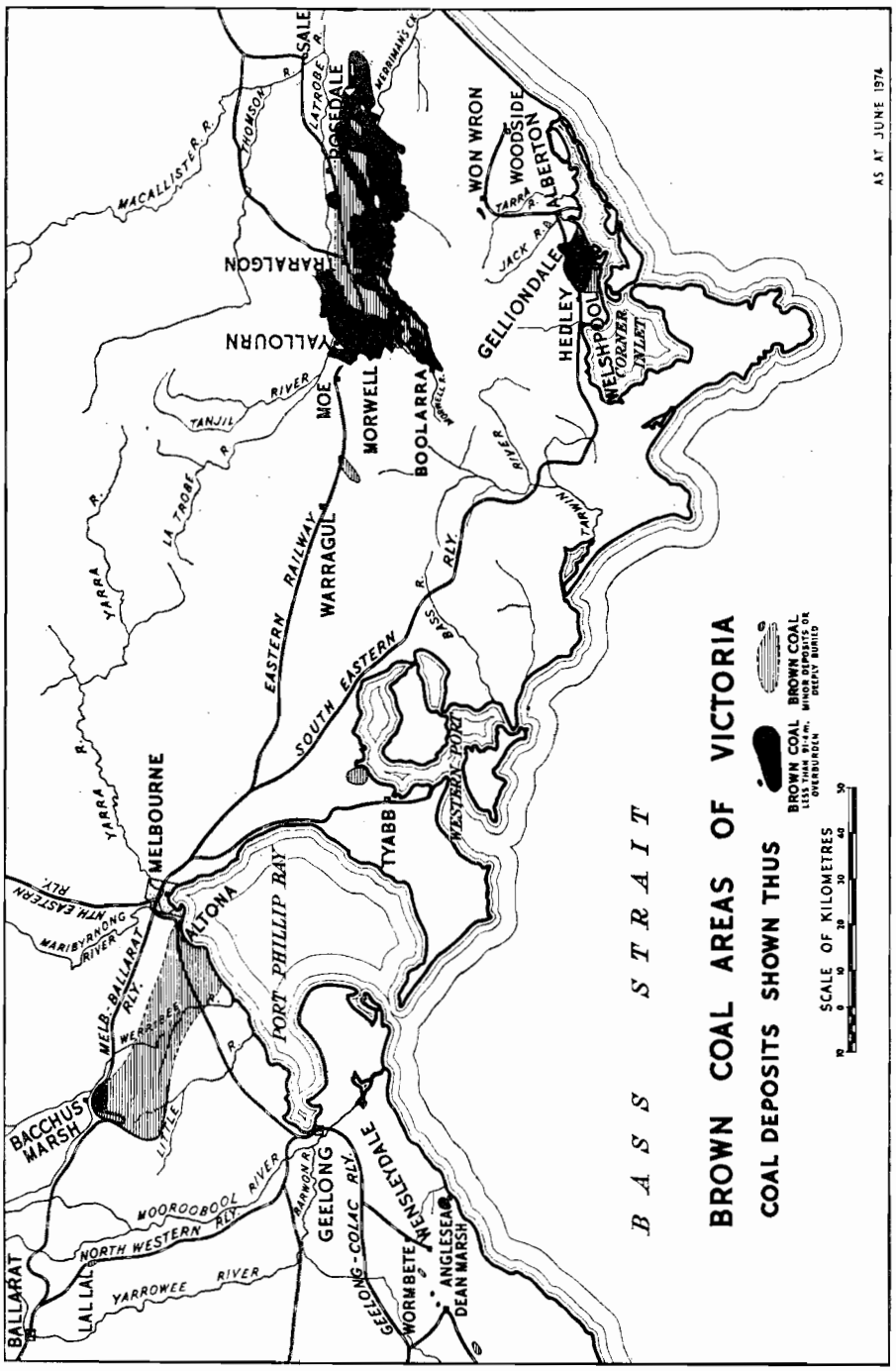

FIGURE 12. Brown coal areas of Victoria, June 1974.

in the south of Victoria at Gelliondale, Anglesea, Bacchus Marsh, and Altona but, although extensive, these do not compare in magnitude and importance to those in the La Trobe valley.

The brown coal seams in the La Trobe valley range from Eocene to Early Miocene in geological age and are thus between 20 and 50 million years old.

Reserves

The reserves of brown coal in Victoria, re-assessed during 1974, are set out in the following table:

VICTORIA—RESERVES OF BROWN COAL, 1974
(megatonnes)

Major coalfields	Proven geological reserves total	Readily recoverable reserves		
		Main areas	Marginal areas	Total
La Trobe valley—				
Yallourn–Maryvale	12,400	2,500	300	2,800
Morwell–Narracan	6,800	2,200	1,100	3,300
Loy Yang Flynn	21,300	3,400	1,300	4,700
Sub-total—main fields	40,500	8,100	2,700	10,800
Gormandale	4,000	400	200	600
Holey Plains–Coolungoolun	2,500	100	100	200
Other areas	17,900	30	..	30
Total La Trobe valley	64,900	8,630	3,000	11,630
South Gippsland—				
Gelliondale	1,300	200	200	400
Won Wron	2	..	..	..
Total South Gippsland	1,302	200	200	400
Total Central Gippsland	66,202	8,830	3,200	12,030
Other (Bacchus Marsh, Altona, and Anglesea)	500	100	100	200
GRAND TOTAL	66,702	8,930	3,300	12,230

In addition to the 66,700 megatonnes of proven geological reserves in Victoria, there are further inferred geological reserves of 47,000 megatonnes making an overall total of proven plus inferred reserves of 113,700 megatonnes. Of this total, 113,000 megatonnes are in central Gippsland with 108,000 megatonnes being in the La Trobe valley.

Recoverable reserves

About 35,000 megatonnes, or 54 per cent of the proved deposits, occur in areas where the overburden over the uppermost seam is less than 30.5 metres, while 62,000 megatonnes, or 95 per cent, is in areas with less than 91.4 metres of overburden. The inferred reserves of 43,000 megatonnes in the La Trobe valley are mostly deeper and less accessible with about 75 per cent occurring in areas with more than 30.5 metres of overburden. Thick coal seams occur close to the surface in two large areas. One of these is the Yallourn/Morwell coal field where the large, baseload power stations are located and the other is the Loy Yang coal field which is presently being evaluated for early use for power generation.

Electricity generation

The brown coal mined from the La Trobe valley deposits in central Gippsland is used to fuel the base load power stations providing over 80 per cent of Victoria's electricity. It is also the feedstock for the production of briquettes, a solid fuel made from brown coal by removal of most of the moisture and subsequent compression into different sizes of rectangular pellets for use as a fuel in industry and homes and to generate electricity principally at the peak load power station at Newport near Melbourne.

With its high moisture content and difficult burning characteristics brown coal is less suitable than black coal for power generation but there are ample supplies of it and it is conveniently located and cheap to mine.

Following the study by The Electricity Commissioners between 1918 and 1920, the practicability of using brown coal for the generation of electricity was confirmed. Following the formation of the State Electricity Commission of Victoria in 1921, work began on the excavation of an open cut at Yallourn for mining of brown coal for use in a power station to be built nearby.

Yallourn open cut now covers over 860 hectares in area, is currently producing coal at the rate of about 12 megatonnes a year, and since 1926 has yielded a total of about 345 megatonnes. The highest grade remaining seams lie under the township of Yallourn which will be gradually dismantled in the 1980s and 1990s as the demand for fuel for the new Yallourn W power station, now under construction, increases.

In the late 1950s full scale production of brown coal began from a new open cut at Morwell, about 6 kilometres south-east of Yallourn, for use in the recently erected combined power station and briquetting factory complex. Working at several levels large dredgers, the latest capable of mining up to 1,900 tonnes an hour, have produced about 138 megatonnes from this open cut to date. Currently the rate of production is 14 megatonnes a year. The coal is taken by conveyor belts to the Morwell power station and to the Hazelwood power station. Up to 30 June 1975 a total of about 510 megatonnes of brown coal have been produced from open cuts in the La Trobe valley.

Other areas

In addition to being used as a fuel in power stations in the La Trobe valley brown coal is mined by open cut methods in two other localities in Victoria. The most important of these is at Anglesea about 130 kilometres south-west of Melbourne, where Alcoa of Australia Ltd excavates the coal for fuel in a 150 MW power station built by the company and commissioned in 1969. This station produces electricity for use at Alcoa's alumina smelter at Point Henry, about 56 kilometres from Geelong. The Angelsea field contains reserves estimated at 117 megatonnes and production is about a megatonne a year. About 0.2 megatonnes a year is also produced at Bacchus Marsh for industrial use by two private companies.

VICTORIA—PRODUCTION OF BROWN COAL
(megatonnes)

Period	Production	Period	Production	Period	Production
1926–1930	1.540	1956–1960	12.392	1969–70	24.316
1931–1935	2.485	1961–1965	18.611	1970–71	23.185
1936–1940	3.668	1966	22.138	1971–72	23.636
1941–1945	5.099	1967	23.765	1972–73	24.147
1946–1950	6.756	1968	23.345	1973–74	26.353
1951–1955	8.870	1968–69	23.504	1974–75	(*a*)26.320

(*a*) Only figures for State Electricity Commission of Victoria available for 1974–75.
NOTE. Figures in the table to 1965 are for five-yearly periods and are annual totals, averaged over each such period. Thereafter, annual figures are shown.

Briquettes

Briquettes are pellets of brown coal which have been compressed into various sizes capable of being transported and stored economically for industrial and domestic use. During the processing, the moisture in the brown coal is reduced from about 66 per cent to about 15 per cent, according to the source of the coal used. Coal from the Yallourn open cut can be made into briquettes relatively easily by drying and pressing finely crushed raw coal without any need for a binding agent in contrast to the coal from the Morwell open cut. The Morwell coal contains boiler fouling constituents and has poor weathering characteristics. Only coal from the Yallourn cut is now being used for the production of briquettes. The Yallourn briquette factory commenced production in 1924 and ceased in 1971. Manufacture continues, however, at the Morwell factory. Annual production reached a peak of 1.92 megatonnes during the mid-1960s but declined to 1.09 megatonnes in 1974–75.

Briquettes are also used as a feedstock in the production of char and could be used to produce oil from brown coal.

Electricity

The most widely used and extensively distributed form of energy supplied in Victoria is electricity. This is carried out by the State Electricity Commission of Victoria, a public utility formed by Act of Parliament in 1921. At 30 June 1975, the Commission, with 18,478 personnel and capital assets of $1,741m, distributed electricity to 1,160,000 customers throughout Victoria and to a further 261,000 customers through 11 metropolitan councils which purchase electricity in bulk for retail distribution. The State Electricity Commission and municipal networks comprise over 113,000 kilometres of power lines.

Electricity generation

The State Electricity Commission has expanded and co-ordinated the production and supply of electricity on a State-wide basis to the point where its system now produces all of the electricity generated in Victoria available for public supply.

The development of Victoria's electricity system is based on the utilisation for both power and fuel of Victoria's extensive brown coal resources in the La Trobe valley in central Gippsland, about 130 kilometres east of Melbourne, with supplementary development of the hydro-electric potential in north-eastern Victoria. Victoria is entitled to one third (New South Wales receives two thirds) of the electricity from the Snowy Mountains Hydro-Electric Scheme after the Australian Government's requirements for the Australian Capital Territory have been met. Victoria also shares with New South Wales the electricity generated at the Hume hydro station near Albury on the Murray River.

By far the greater part of Victoria's electricity is generated from brown coal, used mainly in its raw state. The coal is also manufactured into a high quality fuel in the form of briquettes, some of which is consumed in power stations.

Electricity generated in the State system or purchased by it totalled 17,033 million kWh in 1974–75. The system comprises a series of thermal and hydro-electric power stations. Inclusive of generator capacity both within the State and available to the Victorian system from outside the State, the total installed generator capacity at 30 June 1975 was 4,395 MW. The power stations are interconnected and feed electricity into a common pool for general supply.

The major station in this interconnected system is the 1,600 MW brown coal fuelled power station at Hazelwood, which alone generates nearly 50 per cent of Victoria's electricity. Other power stations in the interconnected system comprise

the three other base load power stations—Yallourn (which contributes 15 per cent), Morwell, and the first set of a new base load power station, Yallourn "W", and steam stations in Melbourne (Newport, Richmond, and Spencer Street) ; and hydro-electric stations at Kiewa, Eildon, on the Rubicon and Royston Rivers near Eildon, and at Cairn Curran on Eppalock Reservoir on the Campaspe River near Bendigo.

Generating projects

Yallourn "W"

Designed as a base load power station of 1,450 MW capacity, this station is being built in two stages at Yallourn West in the La Trobe valley. The station was originally planned to comprise only 2 × 350 MW units when approved by the Government in 1965. The first was commissioned during the winter of 1973 and the second during the winter of 1975.

In 1972 Parliament approved a proposal to extend the Yallourn "W" power station by the addition of two generating units. Each will have a capacity of 375 MW. The two new generators will be needed to meet the growth in Victoria's requirements after 1978. A third unit is scheduled to be commissioned in 1979 and a fourth in 1980. Site works commenced in 1975. The total cost of the station is estimated to exceed $400m.

The Yallourn "W" boilers are among the largest in the world designed for the combustion of raw brown coal. Each boiler is more than 80 metres high and contains 200 kilometres of steam tubing and 137 kilometres of water tubing. At full load each boiler can consume 600 tonnes of coal an hour.

Newport

A 1,000 MW regulating power station is planned to be built at Newport at the mouth of the Yarra River at an estimated cost of about $210m. It will be fuelled primarily by natural gas. Following an exhaustive inquiry, the Environment Protection Authority issued licences for the operation of the station. Appeals to the Environment Protection Authority Third Party Appeal Tribunal in 1974 and to the Environment Protection Appeal Board in 1974 were disallowed and the granting of the licences upheld. Conditions of the licences impose stringent controls on the operation of the station, and the Commission must observe all the conditions imposed.

Dartmouth

The construction of a new hydro-electric power station of one 150 MW generator is planned for Dartmouth in north-eastern Victoria. It will be operated in association with the irrigation storage now being built on the Mitta Mitta River. The station is scheduled for operation in 1979.

Loy Yang

In 1973 the Commission announced its intention to carry out an extensive investigation into the possible development of a new major base load generating project of about 4,000 MW capacity at Loy Yang in the La Trobe valley, to begin operating in the early 1980s.

The Parliamentary Public Works Committee was given the task of inquiring into the Commission's proposals, and began hearing evidence late in 1974. The plans include the development of a new open cut and two power stations, each of 2,000 MW, to meet Victoria's base load power requirements during the 1980s and early 1990s. The Loy Yang project on completion will have a greater generating capacity than the Snowy Mountains Hydro-Electric Scheme and produce six times as much electricity.

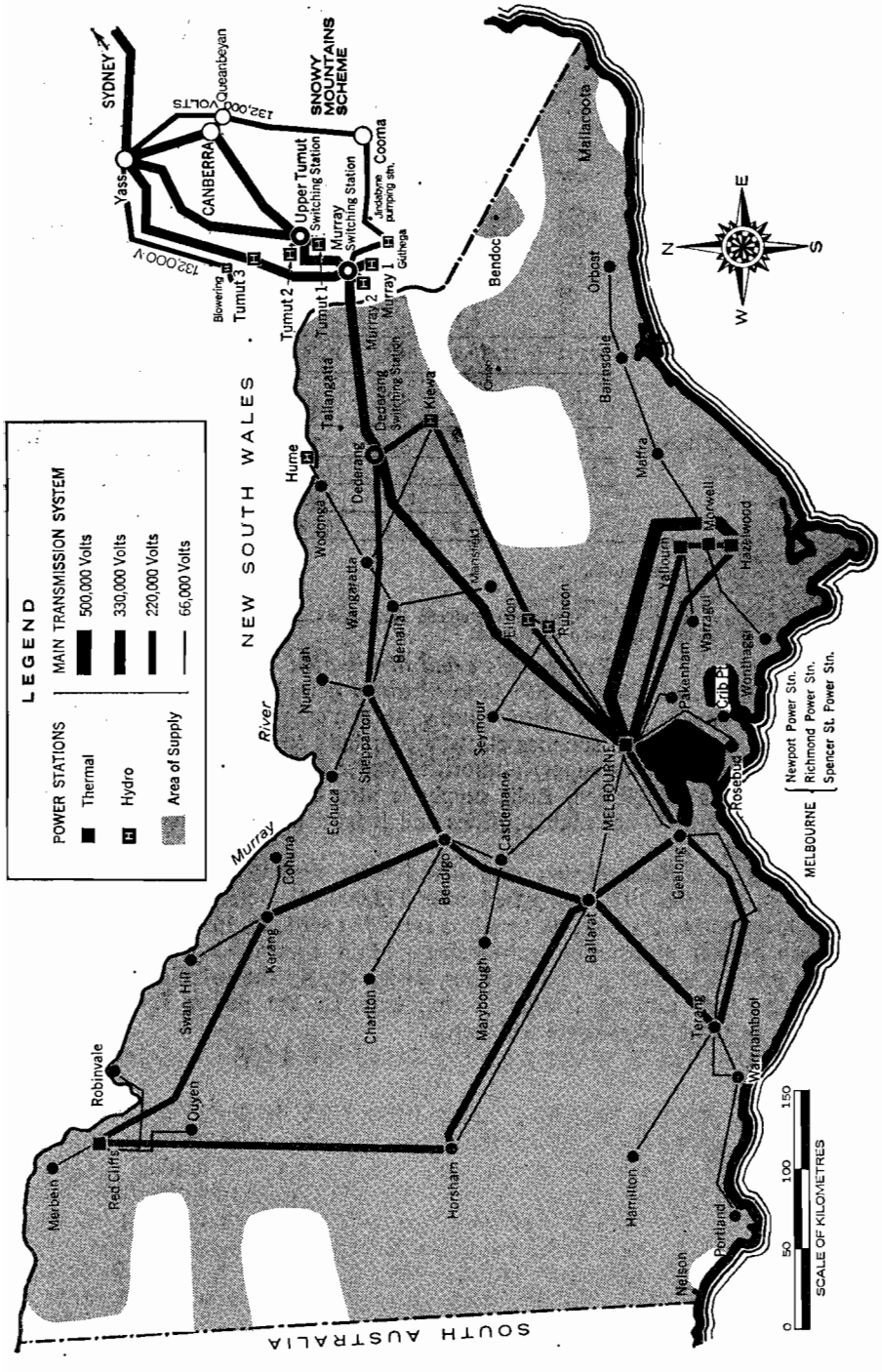

FIGURE 13. Victoria's main power transmission system, 30 June 1975.

VICTORIA—POWER STATIONS : LOCATION, RATING, AND PRODUCTION

Station	Maximum continuous rating (a)	Electricity production					
		1972–73		1973–74		1974–75	
		Quantity	Percentage of production	Quantity	Percentage of production	Quantity	Percentage of production
	MW	Mill kWh		Mill kWh		Mill kWh	
Thermal stations—							
Hazelwood	1,600	8,550.4	57.2	8,510.6	53.1	8,238.0	48.4
Yallourn	546	2,659.2	17.8	2,480.1	15.4	2,545.1	14.9
Yallourn "W"	350	4.8	..	1,475.1	9.2	2,409.0	14.2
Morwell	170	1,134.5	7.6	1,196.9	7.5	1,263.7	7.4
Newport	198	140.5	0.9	181.6	1.1	136.6	0.8
Spencer Street (b)	90	15.2	0.1	12.7	0.1	1.0	..
Richmond	38	5.2	..	7.2	..	0.1	..
Red Cliffs (c)	..	0.6	..	0.5	..	0.1	..
Total—S.E.C. thermal	2,992	12,510.4	83.6	13,864.7	86.4	14,593.6	85.7
Hydro stations—							
Kiewa (d)	183	286.1	1.9	452.0	2.8	451.9	2.7
Eildon (e)	135	306.4	2.1	320.7	2.0	539.1	3.1
Total—S.E.C. hydro	318	592.5	4.0	772.7	4.8	991.0	5.8
Total—S.E.C.	3,310	13,102.9	87.6	14,637.4	91.2	15,584.6	91.5
Net purchases	..	1,853.8	12.4	1,404.3	8.8	1,448.3	8.5
Total	3,310	14,956.7	100.0	16,041.7	100.0	17,032.9	100.0

(a) At 30 June 1974.
(b) Melbourne City Council station.
(c) Retired April 1975.
(d) McKay Creek, West Kiewa, and Clover.
(e) Eildon, Rubicon, Lower Rubicon, Royston, Rubicon Falls, and Cairn Curran.
Source : State Electricity Commission of Victoria.

Transmission and distribution

Electrification of Victoria has been virtually completed. Only some isolated properties in remote parts of Victoria are without a supply from the Commission's system. The Commission supplies electricity in bulk to the 11 municipal undertakings which operate as supply authorities under franchises granted before the Commission was established. Bulk supply is also being provided at present to several New South Wales municipalities and irrigation settlements bordering the Murray River.

The electrical transmission and distribution system in the State supply network at 30 June 1975 comprised over 113,000 kilometres of power lines, 4 auto-transformation stations, 26 terminal receiving stations, 169 zone sub-stations, and over 70,000 distribution sub-stations. Main transmission is by 500 kV, 330 kV, 220 kV and 66 kV power lines, which supply the principal distribution centres and also provide interconnection between the power stations. These four systems total 7,900 route kilometres.

The transmission of energy from Hazelwood is 500 kV.

Petroleum

Petroleum products were first imported into Victoria during the latter years of the nineteenth century. Initially the principal product was kerosene. However, with the advent of the motor car, the demand for petrol gradually replaced kerosene and it became necessary to construct bulk storage facilities (now known as tank farms). Victoria's first refinery was built at Laverton during the 1920s and closed in 1955. Three major refineries, Shell Co. of Australia at Corio near Geelong, Petroleum Refineries (Aust.) Pty Ltd at Altona, and BP Refinery (Westernport) Pty Ltd at Crib Point, currently satisfy almost the whole of Victoria's petroleum products requirements.

Development of Gippsland Basin oilfields

Indigenous crude oil in commercially recoverable quantities was first discovered in Victoria in 1967 when two oilfields were located between 51 kilometres and 80 kilometres offshore in about 80 metres of water in eastern Bass Strait.

An extensive exploration programme was carried out during the next few years and several important commercial fields were discovered. These are Marlin —natural gas and condensate, Halibut—crude oil, Kingfish—crude oil, Mackerel —crude oil, Tuna—crude oil and natural gas, and Snapper—natural gas and condensate. During the period 1967 to 1971 four of the fields—Barracouta, Marlin, Halibut, and Kingfish—were developed as an integral operation. Further development was carried out on the Marlin field. The Mackerel and Tuna fields are currently being developed.

The Barracouta oil reservoir, discovered during gas development drilling programmes in 1968 came on stream in October 1969, the Halibut field in April 1970, and the Kingfish field in March 1971. The crude oil from these three fields is stabilised at the Gippsland Gas Processing and Crude Oil Stabilisation Plant at Longford through extraction of the higher fractions—methane, ethane, propane, and butane. To the resulting stream of stabilised crude oil is added pentane extracted during the treatment of natural gas. The stabilised crude is then conveyed through a pipeline 188 kilometres long and 700 mm nominal diameter to Long Island Point where it is stored in eight 268,000 barrel capacity tanks. From the tank farm at Long Island Point the crude oil is then taken by tanker to refineries in Sydney and Brisbane and by pipeline to Victoria's three local refineries. The following table sets out the production of stabilised crude oil for the years 1971 to 1975 :

VICTORIA—PRODUCTION OF STABILISED CRUDE OIL

Year	Barrels during year	Progressive production at 30 June	Average B/D for year
1971	95,668,066	143,028,336	262,104
1972	103,262,110	246,290,446	282,136
1973	127,089,311	373,379,757	348,190
1974	126,656,461	500,036,218	347,004
1975 (*a*)	69,023,945	569,060,163	381,348

(*a*) To 30 June 1975.

The first shipment of Gippsland crude was made from the Long Island Point jetty late in March 1970.

The three Victorian refineries are now connected by pipeline to the Long Island Point Tank Farm and during the twelve months ended 30 June 1975 absorbed Gippsland crude oil at an average rate of 193,068 barrels a day, or about 55 per cent of the total available from the Gippsland fields.

VICTORIA—GIPPSLAND BASIN : RECOVERABLE TREATED HYDROCARBON RESERVES TO 30 JUNE 1975
(All figures are for products after processing)

Field (*a*)	Natural gas				Crude oil			Condensate and LPG initial reserves only	
	Initial 30 June 1975		Used 30 June 1975	Re-maining	Initial 30 June 1975	Used 30 June 1975	Re-maining	Con-densate	LPG
	Tcf		Tcf	Tcf	million barrels	million barrels	million barrels	million barrels	million barrels
Barracouta gas	1.856	1.857	actual ratio for each field unknown		..	actual ratio for each field unknown		28	66
Barracouta oil	0.001				25				
Marlin gas	2.720	2.763			..			71	129
Marlin oil	0.043				2				
Halibut	0.027				653			..	32
Kingfish	0.206				952			..	100
Mackerel	0.021		..	whole	256	..	whole	..	31
Tuna gas	0.392		..	whole	..	..	whole	10	20
Tuna oil	0.092		..	whole	84	..	whole		
Snapper	2.478		..	whole	..	..	whole	65	92
Flounder	0.166		..	whole	58	..	whole	8	17
Golden Beach (*b*)	0.100		..	whole	..	..	whole	..	..
Total	8.102		0.240	7.862	2,030	569	1,461	182	488

(*a*) Esso/B.H.P. fields.
(*b*) Golden Beach field of Woodside–Burmah.

Refining

Due to the characteristics of Gippsland crude oil being different from those imported from the Middle East, the three Victorian refineries modified their refining processes and in some instances installed new plant. When the modification and expansion programmes were completed in 1971, the three refineries had the following respective production capacities, namely, Shell refinery at Corio—between 104,100 and 110,000 barrels a stream day, P.R.A. refinery at Altona—96,000 barrels a stream day, and BP refinery at Crib Point—50,000 barrels a stream day. In October 1973 the BP refinery at Crib Point further modified its plant to increase production capacity to 60,000 barrels a stream day. Shell Refining (Aust.) Pty Ltd also operates a lubricating oil plant at Corio which has a capacity of 2,200 barrels a stream day.

Each refinery also imports crude oils from the Middle East for the production of special oils, bitumen, asphalt, and certain other "heavy ends" products. The total refinery capacity in Victoria is approximately 263,000 barrels a stream day or about 30 per cent of Australia's total refining capacity.

Transportation

About 70 per cent of Australia's refined petroleum products are derived from Australian crude oils. The ratio of gasoline is much higher while that of bitumen, asphalt, and other "heavy ends" is very low. The three refineries in Victoria obtain crude oil feedstocks from both the Gippsland fields and from the Persian Gulf. They import wholly or partially refined products from either overseas or other States and export considerable volumes of wholly or partially refined products either to other States or overseas countries. Each refinery has its own tanker loading and discharging facilities and jetties. These are located at Crib Point for the BP refinery, at Williamstown and Newport for the P.R.A. refinery at Altona, and at Corio for the Geelong refinery. There is also a tank farm at Portland in the far west of Victoria for storage of refined products.

During the twelve months ending 30 June 1975, the three refineries obtained by pipeline 70,671,315 barrels of Gippsland crude and imported 4,137,000 barrels of crude oil from the Persian Gulf, making a total supply of 74,808,315 barrels of crude oil feedstocks. During the same period the refineries imported by ship 4,626,000 barrels of wholly or partially refined products from overseas or other States in Australia and exported by ship 25,243,000 barrels of wholly or partially refined products to overseas destinations such as New Zealand or the Pacific Islands and to other States in Australia.

Marketing

Motor spirit in two grades—98 octane (super grade) and 89 octane (standard grade)—and a wide range of other petroleum products are marketed in Victoria through a number of industry terminals and depots and 4,493 retail outlets (31 December 1974), the majority of which are operated by the nine major oil companies. Victoria had a capacity to store in bulk (30 June 1974) 703,036,000 gallons of crude oil and petroleum products at 22 installations in Melbourne (15), Geelong (1), Crib Point (1), Long Island Point (1), and Portland (4), including refineries.

The quantities detailed in the following table total 1,804,000,000 gallons or 26 per cent of the Australian total of the main petroleum fuels. The principal petroleum products marketed in Victoria's marketing area during 1974 were:

VICTORIA—PRINCIPAL PETROLEUM PRODUCTS MARKETED, 1974

Item	Quantity	Item	Quantity
	'000 gallons		'000 gallons
Aviation gasolene	3,637	Industrial diesel fuel—	
Motor spirit—		Inland	86,732
Super	654,827	Bunkers	20,774
Standard	131,012		
		Total	107,506
Total	785,839		
		Fuel oil—	
Power kerosene	3,148	Inland (*a*)	137,027
Aviation turbine fuel	85,158	Bunkers	131,042
Lighting kerosene	14,409		
Heating oil	100,651	Total	268,069
Automotive distillate—		Other petroleum fuels (*b*)	250,509
Inland	176,891		
Bunkers	8,568	GRAND TOTAL	1,804,385
Total	185,459		

(*a*) Excluding refinery fuel.
(*b*) Including refinery fuel.
Source : Petroleum Branch, Australian Department of National Resources.

Propane, butane (LPG), and ethane

While the three refineries in Victoria each produce LPG in varying quantities such production is only a fraction of the total produced. The largest LPG plant in Australia is operated by Esso and B.H.P. at Long Island Point, approximately 45 kilometres south-east of Melbourne.

Gas liquids comprising untreated propane, butane and ethane are extracted from natural gas and crude oil produced from the Gippsland fields and treated at the Gippsland Gas Processing and Crude Oil Stabilisation Plant at Longford. These products, in a mixed stream, are conveyed to Long Island Point through a pipeline 190 kilometres long and 250 mm in diameter. The Long Island Point Fractionation plant was erected between 1968 and 1970 and was commissioned in April 1970. Since that time it has been expanded by doubling the production capacity and more than tripling the storage capacity. At the present time a third processing train to further increase capacity is being installed. When this expansion programme has been completed the plant will be able to produce approximately 1,200,000 tonnes of LPG a year, together with sufficient volumes of ethane gas to supply two major petrochemical plants.

Almost all of the propane and butane is exported to overseas markets, principally Japan. Since the first loading was made at the Long Island Point jetty in July 1970 LPG carriers have been loaded continuously for destinations outside Victoria. About two thirds of the overseas shipments have been made to markets in Japan. Some has also been shipped to Argentina, Spain, and the Pacific Islands. The balance of the shipments have been made in small pressure carriers to ports around Australia. To 31 May 1975, 1,837,982 tonnes of propane and 2,430,557 tonnes of butane had been produced, making a total of 4,268,539 tonnes.

Ethane gas has, since 31 December 1972, been conveyed through a pipeline 79 kilometres in length and 250 mm in diameter to the Altona Petrochemical Co. Ltd, at Altona. It is also planned to supply this gas to Monsanto (Australia) Ltd in the Brooklyn–Footscray area.

Gas industry

The gas industry, one of Victoria's oldest energy industries, has been revitalised during the past six years as a result of the introduction of natural gas. It has changed from being operated by a large number of privately owned

companies and small municipal undertakings to being controlled by a single public utility—the Gas and Fuel Corporation of Victoria, a State instrumentality with a percentage of private shareholdings.

Gas and Fuel Corporation of Victoria

The Gas and Fuel Corporation was created by the *Gas and Fuel Corporation Act* 1950 which established it as a joint enterprise combining the State of Victoria with the shareholders of the Metropolitan Gas Company and the Brighton Gas Company. The purpose of the legislation was to provide the means for developing Victoria's brown coal resources instead of New South Wales black coal for the production of gas and to consolidate and rationalise the gas industry by providing for the takeover or absorption of other gas utilities. The new Corporation commenced operating on 1 January 1951 and by 1974, it had, through subsequent enabling legislation, become the sole authority for the distribution of reticulated gas throughout Victoria.

At 30 June 1975, gas was being supplied to 653,812 customers in Victoria through a network of approximately 13,500 kilometres of transmission pipelines and reticulation mains. About 98 per cent of the total supplied is natural gas.

Development of natural gas, 1965 to 1975

In February 1965, natural gas in commercially recoverable quantities was discovered in eastern Bass Strait in the Gippsland Basin about 20 kilometres offshore. The well, Barracouta, was the first offshore well drilled in Australian waters and Australia's largest gas discovery to that time. A second and even larger field, Marlin, was found a year later. These two events enabled natural gas to be commercially developed in Victoria. The partnership of Esso Exploration and Production Australia Inc. and Hematite Petroleum Pty Ltd (a wholly owned subsidiary of The Broken Hill Proprietary Co. Ltd) which discovered the fields, commenced a development programme immediately.

The initial step was the establishment of a marine terminal at Barry Beach in southern Gippsland, about 193 kilometres south-east of Melbourne and 145 kilometres west of the fields. This terminal, built between 1966 and 1968, became a general operational base for both exploration activities and the development projects, the most immediate of which was the fabrication of jackets and decks for the platforms from which the natural gas development wells and later, the crude oil wells, would be drilled.

Negotiations with the Gas and Fuel Corporation of Victoria for the sale of the natural gas to the State's gas utilities were virtually completed early in 1967 when agreement was reached on terms involving the payment, over a contract period of 20 years, of a fixed maximum price of 3.2 cents a therm and a minimum of 2.58 cents. A market for the gas was now assured. Further contractual arrangements were entered into during 1975 to provide for additional volumes of gas being supplied.

Certain legislative measures were also necessary to implement the development programme. First, the Victorian Government established the Victorian Pipelines Commission to lay a natural gas trunkline to Melbourne City Gate at Dandenong from Longford where the partnership was establishing a gas processing plant. The Commission later built the natural gas pipeline from Brooklyn to Geelong, but was dissolved and incorporated into the Gas and Fuel Corporation of Victoria on 1 July 1971.

Drafting of legislation to regulate offshore exploration for, and exploitation of, oil and gas was expedited. After years of discussions between the Australian Government and all the States, the various enabling enactments applicable to each State and Australia were passed by the respective Parliaments in October 1967 and came into operation on 1 April 1968. Entitled the *Petroleum*

(*Submerged Lands*) *Act* 1967, this legislation provided for uniformity in granting offshore petroleum exploration permits and production licences, the imposition of royalties, and the laying of submarine pipelines. The Government also introduced the *Pipelines Act* 1967, Australia's first major attempt to regulate pipelines to convey oil and gas on shore.

During 1968 and 1969, Esso Australia Ltd as the operator for the Esso/B.H.P. partnership, erected two platforms in Bass Strait—one each over the Barracouta and Marlin gas fields, carried out a development drilling programme, and laid submarine and onshore pipelines to Longford where it built a gas treatment plant. The facilities at the plant comprise a twin-train, refrigerated absorption plant designed to process 400 million cubic feet a day of wet gas. It is capable of removing about 35 per cent of ethane and all heavier hydrocarbons.

Esso/B.H.P. are currently expanding the processing facilities at Longford by building a new plant which will be known as Gippsland Gas Processing Plant No. 2. Current design is for it to be capable of producing 300 million cubic feet a day of treated gas. It will be a cryogenic type whereas the existing plant is an absorption type. Construction began late in 1973 and was expected to be completed by the end of 1975. The expansion is required to meet expected peak demands of the Gas and Fuel Corporation of Victoria during the latter part of the current decade.

The Tuna field which contains both natural gas and crude oil is currently being developed and is expected to become operational near the end of the decade. A table outlining reserves can be found on page 329.

Distribution and conversion

Treated natural gas is conveyed from the Longford plant to the Dandenong City Gate through the Gas and Fuel Corporation's main transmission pipeline, 174 kilometres long and 750 mm in diameter. Natural gas first reached the metering and regulating station at Dandenong, known as the City Gate on 31 March 1969, and the Corporation commenced distributing natural gas to its customers in April 1969.

During the late 1960s the Gas and Fuel Corporation commenced the construction of a ring main around Melbourne initially to cope with normal expansion of gas supply to the rapidly developing suburban areas, and subsequently for the distribution of natural gas to its customers. The northern section of the ring main—82 kilometres long and 450 mm in diameter—passing through the eastern and northern suburbs, was completed late in 1969 and the 35 kilometre, 750 mm diameter southern section direct from the Dandenong city gate to West Melbourne came fully into operation in May 1970. Built at a cost of $11m, this 118 kilometre pipeline now forms an essential part of the Corporation's entire metropolitan distribution system and supplies gas to Geelong, Ballarat, and Bendigo and will provide supply to Seymour, Wangaratta, Benalla, Wodonga, Albury, and Shepparton by the winter of 1976.

The conversion of existing gas appliances in the Melbourne metropolitan area was completed in December 1970. In Geelong, conversion finished near the end of 1971, about five months after commencement. By the time conversion had been completed, the Lurgi plant at Morwell and the gas making plants at West Melbourne, Highett, Footscray, and Box Hill in the metropolitan area had closed down.

Following the laying of a 196 kilometre system to Ballarat and Bendigo during 1972 and 1973, the former city first received natural gas on 14 April 1973. The conversion programme involving over 36,000 appliances used by about 17,000 customers was carried out in these two cities and at Castlemaine and Bacchus Marsh by the Corporation's own staff during 1973 at a cost of about $1.6 m. A further 2,649 appliances owned by 934 customers were converted at Melton

during 1974. At 30 June 1975 a total of 1,375,000 appliances owned by 564,667 customers had been converted in Victoria. A further conversion programme will be carried out at Seymour, Benalla, Wangaratta, Wodonga, Albury, and Shepparton during 1976.

Gas supply areas

At 30 June 1975, there was a total of 637,783 customers receiving natural gas in Victoria. A further 16,029 customers were using other reticulated gases, mainly reformed LPG, making a total of 653,812 customers. The areas supplied with reticulated gas and the supplier concerned are shown in the following table:

VICTORIA—AREAS SUPPLIED WITH GAS AT 30 JUNE 1975 (*a*)

Supplier	Area supplied with	
	Natural gas	Other gases (*b*)
Public utilities—		
Gas and Fuel Corporation of Victoria	Bacchus Marsh	Ararat
	Ballarat	Benalla
	Bendigo	Colac
	Castlemaine	Hamilton
	Geelong	Horsham
	Lara	Kyneton
	Maffra	Portland
	Melbourne	Queenscliff
	Morwell	Seymour
	Sale	Shepparton
	Trafalgar	Stawell
	Traralgon	Wangaratta
	Warragul	Warrnambool
		Wodonga
Private suppliers—		
Esso Exploration and Production Australia Inc. and Hematite Petroleum Pty Ltd (B.H.P.)	Western Port North Geelong	

(*a*) Excludes Esso/B.H.P. plant use at Longford and Long Island Point.
(*b*) In addition the Gas and Fuel Corporation supplies Maryborough and Warracknabeal with bottled LPG, with on-site filling being used at the latter town.
Source: Victorian Ministry of Fuel and Power.

Liquefied petroleum gas is also supplied to over 100,000 customers from reticulation and cylinder by the Gas and Fuel Corporation and from cylinder by oil companies or subsidiary LPG marketing companies in accordance with the provisions of the *Gas Franchises Act* 1970.

Recent legislation

Through the provisions of the *Gas and Fuel Corporation (Geelong Gas) Act* 1971 and the *Gas and Fuel Corporation Act* 1972, the Corporation acquired the assets of the gas companies at Geelong and Queenscliff at a cost of approximately $5m. This was followed by the passing by the Victorian Parliament of the *Gas and Fuel Corporation (Colonial Gas Holdings Ltd) Act* 1973 and the *Gas and Fuel Corporation (Amalgamations) Act* 1973 which enabled the Corporation to acquire the assets of Colonial Gas Holdings Ltd including The Colonial Gas Association Ltd at a cost of approximately $19.4m. Early in 1974 the *Gas and Fuel Corporation (Powers) Act* 1974 was passed enabling the Corporation to acquire the Albury Gas Company Ltd at a cost of approximately $800,000. This latter legislation facilitated arrangements for laying a pipeline from Melbourne to Wodonga and Albury to supply the new growth centre and to provide gas for the country towns of Seymour, Wangaratta, and Benalla en route. A spur line will also be laid to Shepparton.

Production and sales

Since the Gippsland fields first came on stream in March 1969 the production of treated natural gas has increased markedly as shown in the following table:

VICTORIA—PRODUCTION OF TREATED NATURAL GAS (*a*)

Year	Quantity	Quantity
	mmcm	mmcf
1971	1,012.508	35,756.710
1972	1,202.882	42,479.756
1973	1,793.526	63,338.363
1974	2,241.743	79,167.139
1975 (*b*)	1,515.027	53,480.453
Total	7,765.686	274,222.421

(*a*) Includes sales, field and plant usage.
(*b*) For six month period 1 January 1975 to 30 June 1975.
mmcm : million cubic metres.
mmcf : million cubic feet.
Source : Australian Department of National Resources.

Sales rose sharply following the introduction of natural gas in April 1969. During the twelve month period ending 30 June 1968, the last full year before the introduction of natural gas, sales showed an increase of only 5.5 per cent over the previous year. Sales during the twelve month period ending 30 June 1974 increased by 58.4 per cent.

VICTORIA—SALES OF GAS

Year	Gas and Fuel Corporation			Colonial Gas Association		
	Sales in thousands of therms	Sales in gigajoules	Increase over previous period	Sales in millions of therms	Sales in gigajoules	Increase over previous period
			per cent			per cent
1970–71 (*a*)	178,669	18,848,929	37.5	35,365	3,730,879	51.6
1971–72	247,011	26,058,761	38.3	49,692	5,242,325	40.5
1972–73	337,911	35,648,381	36.8	64,607	6,815,803	30.0
1973–74 (*b*)	565,650	59,674,000	67.4	(*c*)	(*c*)	(*c*)
1974–75 (*b*)(*d*)	361,284	38,114,147	..	..	..	..

(*a*) Includes the undertakings purchased from The Gas Supply Co. Ltd from December 1970 and The Geelong Gas Co., acquired in June 1971, for the whole of the 1970–71 period.
(*b*) Includes Mt Gambier Gas Co. Ltd in South Australia.
(*c*) Incorporated into the Gas and Fuel Corporation.
(*d*) For six month period 1 July 1974 to 31 December 1974.
1 gigajoule = 9.479 therms.
Source : Victorian Ministry of Fuel and Power.

MINERALS

Mines Department

The traditional role of the Mines Department has been to promote the exploration of the mineral resources of Victoria, including oil, gas, and groundwater; to administer a system of leases and licences to enable extraction and to regulate extraction to ensure that it is carried out in an efficient and safe manner. The Department also carries out geological research and surveys for mineral resources, including fossil fuels, and publishes the results in geological maps and reports. In addition to assisting in mineral exploration these maps and reports provide basic information for soil surveys, land-use, and environmental surveys and engineering undertakings. They are also of assistance to educational institutions and the general public.

Mineral deposits in Victoria

Introduction

Victoria owes its rapid settlement and increase in population to the rich gold discoveries in the early 1850s. The discovery of gold, which attracted migrants in large numbers and led to their permanent settlement, reached its peak in 1856, with a production of 93,000 kg. Between 1851 and 1967, Victoria

produced over 2.4 million kg of gold or 40 per cent of the total for Australia, and the greater part of this production came from the Bendigo and Ballarat fields.

Although for a long time gold production dominated the mining industry, more recent mining activities have been characterised by progress in open-pit mining, particularly of construction materials and brown coal. At present, the bulk of mineral production is accounted for by fuels and non-metallic minerals.

Many other metallic minerals have been mined including (in order of value) tin, antimony, copper, molybdenite, and wolframite. Production of these minerals has been from small ore bodies or as a by-product of gold mining.

In contrast to the gradual decline in production of metallics, non-metallic production has increased steadily. Brown coal operations in the La Trobe valley rank amongst the world's major workings, and although coal had been mined from Yallourn North since 1889, major development was the direct result of strikes on the New South Wales coal fields shortly after the First World War. Since 1924, approximately 500 million tonnes of coal have been mined from Yallourn and Morwell.

Matching the increase in brown coal production is that in construction materials. The main products are road and concrete aggregates, sand for concrete, limestone for Portland cement, clay for paper filler, porcelain, brick and pipe, and gypsum for plaster and agricultural purposes.

Mineral provinces

Victoria can be divided into mineral districts or provinces. Each province is characterised by particular mineral associations, types of ore bodies, or age and lithology of the host rocks. Usually the provinces are separated from each other by major structural features. The differences between the provinces mainly relate to gold mineralisation, but there are also characteristic differences in the base metal deposits between some provinces.

Stawell province

This province is bounded on the east by a north-south faulted belt through Wedderburn. No fossils have been found in the province and a considerable thickness of sedimentary rocks as far west as the Glenelg River may be of Cambrian to lowermost Ordovician age.

The most important goldfield within this province is Stawell which has produced 38,900 kg. The gold occurrences are associated with quartzitic, talcose, and chloritic schists and greenstones. Some reefs were characterised by a high content of the sulphide minerals pyrite, arsenopyrite, and pyrrhotite. The other major goldfield in the province, St Arnaud, was characterised by the presence of galena and sphalerite in the quartz reefs.

Bendigo–Ballarat province

This province lies between Wedderburn on the west and the Cambrian Heathcote axis on the east and is essentially an area of strongly folded and faulted marine Ordovician sandstones, shales, and slates.

The primary gold deposits are largely confined to Lower Ordovician sediments and in contrast to those in the Stawell province, contain only a few per cent of sulphide minerals. This is by far the most important province in Victoria and includes the following reef mining fields: Bendigo (539,900 kg), Maldon (54,425 kg), Clunes (37,200 kg), Ballarat East (34,000 kg), Ballarat West (23,900 kg). The province was also the major producer of gold from alluvial and deep lead deposits with Ballarat being the most important field.

Warrandyte province

This province lies between the Heathcote axis on the west and the western edge of the Walhalla synclinorium in the east. The sediments within the province consist of Silurian and Lower Devonian marine sandstones, siltstones, shales, slates, grits, and conglomerates.

The characteristic mineral association within the province is gold-antimony and the province was a major producer of antimony. There are no major goldfields within the province, although one of the first Victorian gold discoveries was made at Warrandyte.

Walhalla–Woods Point province

This province is characterised by a swarm of basic to intermediate dykes (the Woods Point dyke swarm) intruding Silurian to Lower Devonian sediments. The reefs occur either along or sub-parallel to the dyke walls or in shears or fractures cutting across dyke bulges. Total production from the province is about 93,000 kg.

Mt Wellington province

This province includes the Upper Devonian to Lower Carboniferous volcanics and non-marine sediments extending north from Briagolong to Mansfield. The province is not well mineralised but a number of small copper occurrences are associated with red beds in the sequence.

Harrietville province

This province includes the Ordovician sediments lying between the belt of Upper Devonian–Carboniferous sediments and the metamorphic belt in eastern Victoria. Mineralisation is represented by gold-quartz fissure veins at Bright, Harrietville, and Dargo. Total production from reef mines has been about 12,300 kg.

Glen Wills province

This province coincides with the metamorphic belt of north-eastern Victoria. The most important goldfield is Glen Wills where the reefs commonly contain the sulphide minerals pyrite, arsenopyrite, galena, sphalerite, and chalcopyrite. Total gold production is estimated to be 12,700 kg.

Bendoc province

This province lies to the east of the Glen Wills province. No major goldfields are present but the province includes a silver-lead-zinc-copper province associated with the Snowy River Volcanics and some granitic intrusions.

Mineral occurrences

Aluminium

Bauxite, the only commercial source of aluminium, occurs in small quantities in the Mirboo North–Boolarra area of south Gippsland. Some forty occurrences exist, but only eight or so are of workable size. The bauxite is largely overlain by clay, sand, and gravel with intercalated brown coal. Formation of the bauxite probably took place after block faulting of the area, since the location and shape of deposits appears to be controlled by fault structures which have displaced gravels against Eocene basalt, and tuffs.

Alumina content of the bauxites is generally greater than 50 per cent, while silica and iron are generally less than 10 per cent.

Antimony

Victoria has been the principal source of stibnite (antimony sulphide) in Australia, most of the output coming from operations at Costerfield. Production was more than 24,000 tonnes of antimony metal between 1862 and 1951.

Two mines, Costerfield (22,400 tonnes antimony metal) and Ringwood (1,530 tonnes), have produced 98 per cent of recorded output. Stoping in the Costerfield mine extended to a depth of 300 metres. Deposits occur in dense, uniform, broadly folded mudstones of Silurian age and consist of short, steeply dipping branching veins averaging 15 cm in width. The Costerfield Reef extended to a depth of 180 metres, was 600 metres long, and consisted of quartz, stibnite and gold, the concentrate carrying 60 to 90 g/tonne of gold.

The Ringwood mine yielded about 3,500 tonnes of high grade ore between 1869 and 1892, from a west dipping lode on the east flank of an anticline.

Stibnite was mined at Coimadai, north of Bacchus Marsh, intermittently between 1887 and 1915 for 400 tonnes of picked ore and between 1942 and 1944 for 4,400 tonnes of low grade ore and 10 tonnes picked ore. Lodes consist of quartz-stibnite shear veins in sandstone and slate intruded by felspar porphyry.

Barium

Barite occurrences are associated with the Snowy River Volcanics, in eastern Gippsland, at Butchers Ridge, near Gelantipy, South Buchan, Gelantipy East, Canni Creek, and Mt Tara. The Butchers Ridge deposit is the only deposit to have been mined and occurs as a vein 150 metres long with an average width of 102 metres. The quantity mined appears to be much greater than the recorded figure of 70 tonnes.

Chromium

The only chromite to be worked in Victoria has been found in serpentinite on the Dolodrook River. Material on the Dolodrook consists of small blocks in serpentinite, broken by subsequent shearing, while a reasonable amount of blocky material, some lumps 1 metre in length, has been found in soil overlying the serpentinite. Chromite in this area contains from 45 per cent to 51 per cent chromic oxide, with a chrome-iron ratio greater than 3 : 1.

Black coal

Victoria has enormous reserves of Tertiary brown coal, but only a few small deposits of black coal. The latter occur in thick sequences of Lower Cretaceous sandstone and shale, and are known in South Gippsland, the Otway Ranges, and near Casterton. Seams in the latter two areas are mostly less than 30 cm thick, and all of the State's production has come from the South Gippsland area, particularly Wonthaggi, where production virtually ceased at the end of 1968.

Brown coal

Extensive Eocene–Miocene coal measures in the La Trobe valley contain some of the thickest brown coal seams in the world. Total thickness of seams, separated and subdivided by sandy clay beds, reaches a maxium of 300 metres. Thick seams also occur on the southern flanks of the Gippsland Hills, under the Werribee Plains between Melbourne and Bacchus Marsh, and on the eastern and northern flanks of the Otway Ranges. Reserves of brown coal in the La Trobe valley are very large and an almost unexploited field lies near Gelliondale in South Gippsland.

The reserves in the La Trobe valley have been determined by boring over an area of approximately 600 square kilometres, and production, which began in 1889, amounted to about 500 million tonnes by the end of 1975. Broad folding in the Yallourn, Morwell, and Rosedale areas has brought thick brown coal seams close to the surface. Mineable seams are the Yallourn (maximum thickness 100 metres), Morwell No. 1, (165 metres), Morwell No. 2 (55 metres), and Latrobe (145 metres). Three open cuts operate in the area, these being the Yallourn North Extension, Yallourn, and Morwell. Overburden average of the Yallourn and Morwell seams is 13 metres and 16 metres, respectively. The brown coals of the La Trobe valley range in moisture content from 50 to 70 per cent, calorific value varying from 5.8 to 11.5 MJ/kg. Estimates of economically recoverable coal are in the region of 12,000 million tonnes.

Other deposits of Tertiary brown coal occur at Anglesea, where reserves have been proved to be about 100 million tonnes. Here, brown coal is used for firing the power house which provides power for the aluminium smelter at

Point Henry, Geelong. Calorific value of this coal averages about 12.4 MJ/kg. Other deposits occur at Bacchus Marsh, where the seam is about 30 metres thick. At Lal Lal, brown coal has been preserved by subsidence of a small graben associated with the Parwan valley. At Wensleydale, the coal seam is 33 metres thick, and relatively high-grade coal occurs at Dean's Marsh.

Copper

The most important source of copper is in copper sulphide ores where it may be associated with other base or precious metals.

Although copper minerals have been reported from numerous localities in Victoria, few deposits have been worked and total production is estimated to be 3,640 tonnes of copper, most of which came from the Coopers Creek Copper Mine, 4 kilometres south-west of Walhalla. Copper mineralisation occurs along a fault zone, parallel to the western margin of a hornblende diorite dyke, and also disseminated within the dyke itself. The fault zone mineralisation varies from 1 to 3 metres wide and is reported to have contained 16 per cent copper. Gold, silver, platinum, palladium, and nickel sulphide were also reported.

Diatomite

The majority of diatomite occurrences in Victoria are of freshwater origin occurring in lakes associated with volcanic lava flows. The main deposits are those at Lillicur, Newham, Moranding, Redesdale, and Linton (Happy valley). Production is probably considerably greater than a recorded 44,000 tonnes to 1972. In these deposits, diatomite occurs as layers up to 3 metres thick between or beneath flows of basalt.

Fluorite

Fluorite production in Victoria, to 1971, was 5,240 tonnes, and all of this came from Pine Mountain, east of Walwa. The deposit occupies a steeply dipping fissure lode, extending for the greater part of its length along the contact of Upper Ordovician schist with porphyritic granite. The lode is from 1 to 1.3 metres wide and more than 120 metres long and contains between 60 and 70 per cent fluorite. Associated minerals are quartz, galena, and some sphalerite.

Gold

With only a few exceptions Victorian primary gold deposits are associated with quartz reefs intruded along fault planes. The reefs are largely confined to sediments and metasediments of Cambrian to Early Devonian age and to intrusives into these rocks. The greater proportion of production has come from reefs intruding Lower Ordovician sediments in west central Victoria, which includes the goldfields of Ballarat, Bendigo, Castlemaine, Clunes, Daylesford, and Maldon. Significant production has also come from quartz reefs intruding late Middle Devonian dykes in the Woods Point–Walhalla district.

The deposits are predominantly auriferous quartz reefs containing minor sulphides, commonly pyrite and arsenopyrite. Exceptions are the sulphide rich lodes of eastern Victoria which may contain up to 60 per cent of sulphides, the "Mundic" lodes of Stawell which may contain 40 per cent sulphides, and the stibnite rich gold-antimony veins of central Victoria.

The alluvial gold deposits of Victoria are largely related to events from the Eocene to the Pliocene periods when the eastern seaboard had a low relief, giving rise to considerable accumulation of gold bearing gravels in back-filled valleys. Some of these placer gravels were eroded away, while others were buried beneath lava flows to become buried placer deposits. About 60 per cent of Victoria's gold production has been from alluvial sources, and at Ballarat probably more than three quarters of some 620,000 kg came from such sources.

Gypsum

Gypsum is widely distributed in the north-west of Victoria, where it may occur as wind-blown dunes rising above the level of the plains, as lacustrine accumulations in topographic basins, as shallow buried deposits, and as deposits forming at the present time in shallow lakes.

Gypsum has been mined from Nowingie West, Cowangie, Swan Hill, Ouyen, Mildura, and Rainbow. Minor occurrences are mined at widely scattered places for use as a soil conditioner. At Nowingie West, up to 1 metre of gypsum underlies about 0.5 metres of soil. At Cowangie, gypsum covers an area of 100 square kilometres of low hills and flats to an average depth of 3 metres. Analyses of the deposits vary from 70 per cent to 99 per cent gypsum. To the end of 1974, Victorian production was approximately 2 million tonnes.

Lead—Zinc—Silver

Lead and zinc minerals are fairly widely dispersed in Victoria, but deposits are small and only 800 tonnes of lead ore were produced late in the nineteenth century. No zinc production has been recorded, although sphalerite (zinc sulphide) is the major constituent of some of the veins associated with shears in the granites of the Snowy River belt. Small but rich deposits of lead have been mined in east Gippsland, notably at Buchan, where small lenses and threads of galena, lead sulphide, with minor pyrite and gold, occur in limestone. They also occur at Mt Deddick where numerous parallel lenses of galena and sphalerite occur with quartz veins in crushed granite.

Silver generally occurs with lead sulphides in these areas.

Limestone

Principal centres of limestone production are Geelong, Lilydale, and Merrimans Creek. Lower Devonian limestone is quarried at Cave Hill, near Lilydale, 40 kilometres east of Melbourne, for production of lime. The deposit consists of bedded limestone forming a steeply dipping lens at least 1,200 metres long and more than 250 metres wide. Quality varies from 70 per cent to better than 96 per cent calcium carbonate. Magnesium oxide content is variable and patches may analyse as high as 17 per cent.

At Buchan, large reserves of limestone of Middle Devonian age occur. The Lower or Buchan Caves sequence consists of 250 metres of dolomite, dolomitic limestone, and almost pure limestone with practically no intercalation of non-carbonate rocks. The higher, Murrindal limestone, although containing intercalations of mudstone, is also of considerable thickness. Mineable reserves are probably more than 200 million tonnes for the Buchan Caves formation and 70 million tonnes for the Murrindal formation.

In the Rosedale–Sale area, Miocene limestone deposits outcrop on the flanks of the Baragwanath Anticline, at Longford, Merrimans Creek, and Darriman. Deposits generally consist of alternating beds of polyzoal limestone and sandy marls.

A thickness of the order of 20 to 25 metres of better than 78 per cent calcium carbonate material occurs at Merrimans Creek, where limestone is quarried for the manufacture of Portland cement. Dips generally range from 2° to 7° and limestone occurs at shallow depth for 20 kilometres along the strike west of Longford and for at least 5 kilometres on the south limb near Merrimans Creek. Calcium carbonate content ranges from 40 to 93 per cent.

In the Geelong area, more than 1 million tonnes per annum of Oligocene–Miocene polyzoal limestones are quarried at Fyansford and at Waurn Ponds for the manufacture of Portland cement.

Magnesium

Total output of magnesite amounts to approximately 4,500 tonnes, but dolomite production is very small. Most magnesite output has come from

deposits near Heathcote which consist of veins and nodules in decomposed diabase. The material assays 46.5 per cent magnesia.

Tertiary dolomitic limestone containing between 6.7 to 16.2 per cent magnesia has been mined on a small scale at Coimadai, but large reserves of high quality Middle Devonian dolomite occur at the base of the Buchan Caves limestone. A representative analysis shows 20.8 per cent magnesia, 30.2 per cent lime, 0.72 per cent silica, and 1.87 per cent alumina and iron.

Manganese and iron

The only iron ore produced in Victoria for iron production was 5,400 tonnes from Lal Lal in the 1880s. Limonite, however, was produced until recently from South Buchan for use in gas scrubbers. The largest iron ore deposit occurs north of Nowa Nowa but has not been exploited. This deposit, containing 5.5 million tonnes, is concealed, apart from a few broken outcrops of hematite along its western shear-margin. Bodies of similar nature, some manganese rich, outcrop sporadically over a distance of 15 kilometres along shear zones at the southern termination of the Snowy River Volcanic Belt. The ore at Nowa Nowa consists of massive and micaceous hematite at the surface, passing in depth to magnetite, with micaceous hematite, pyrite, and chalcopyrite. Iron content ranges from 45 to 68 per cent.

Farther north, higher manganese contents are encountered in iron ore deposits, and the "Iron Mask" assays up to 12 per cent manganese. Limonite is associated with Middle Devonian limestone at South Buchan. The deepest bore sunk on the largest deposit shows pyrite at the bottom and this may represent the primary iron mineral. This deposit is 1 kilometre long and 180 metres wide.

Molybdenum

Molybdenite was mined from a pipe-like ore body in porphyritic granodiorite at Everton near Beechworth. Almost all the recorded production of 325 tonnes was from this source. The deposits, which are 4 kilometres north-east of Everton, consist of several intrusions of porphyritic granodiorite intruding regionally metamorphosed slate and sandstone. Two molybdenite ore bodies occur in one of these intrusions, one close to the margin, and the other some distance from it. They form steeply dipping annular mineralised zones, each surrounding a barren core of quartz-biotite porphyry, intrusive into the granodiorite. Molybdenite has also been produced from Mt Douglas near Korong Vale where it occurs in thin, widely separated veins in granite, and as a by-product from the Thologolong wolfram mines.

Phosphate

Calcium and aluminium phosphates (wavellite and turquoise), have been recorded from several places in Victoria, but all production, which to 1926 totalled 16,270 tonnes, came from Phosphate Hill, near Mansfield. At this locality, dark grey to green, medium to coarse textured phosphorite is associated with cherts and fossiliferous shales of Lower Ordovician age, which have been folded, crumpled and faulted. Bulk sampling revealed an overall phosphoria content of 15 per cent, alumina content of 10 per cent, and lime content of 17 per cent.

Tin

Next to gold, tin is in terms of total production the most valuable mineral produced in Victoria. However, most of the Victorian output of 11,400 tonnes of tin concentrates, containing 73 per cent tin, to the end of 1968, was the by-product of gold-dredging of placer deposits in the Beechworth–Eldorado district. At Toora, 370 tonnes of concentrates were produced from a Tertiary placer preserved in a down-faulted graben. Small tonnages of tin concentrates

have been recovered from alluvial deposits at Chiltern and Rutherglen, while low-grade primary, cassiterite-bearing aplites and pegmatites were mined at Walwa.

Tungsten

All the wolframite occurrences in Victoria are small deposits associated with quartz veins and reefs near the margin of granite bodies, or in pegmatites associated with tin. Mineralisation is associated with the middle Palaeozoic granites of Eastern Australia.

Most of Victoria's wolfram concentrates came from Mt Murphy, 60 kilometres north-east of Benambra, where wolframite is found in quartz veins up to 1 metre thick, in slate and metamorphosed sandstone, near the margin of a granitic intrusive. Two wolfram-quartz reefs in granite have been worked at the Womobi mine at Thologolong, east of Albury. Wolframite is the dominant mineral, but sulphides of iron, copper, molybdenum, and bismuth are also present. Ore treated averaged 1.0 per cent wolframite. Scheelite, the other important tungsten ore, is rare in Victoria.

Uranium

A few radioactive occurrences have been reported from Victoria, all being deposits derived from granites, mineralisation within granite, or within dykes transecting granite.

At Mt Kooyoora, near Inglewood, torbernite has been identified from a superficial ironstone overlying granite. Torbernite has also been identified from the mullock dumps of the Meerschaum and Gentle Annie Mines at Glen Wills. Other radioactive occurrences have been investigated in the Lake Boga granite and in dykes in or near the Dargo granite on Bulgoback Creek. The metamorphics around the Moliagul–Wedderburn areas are reported to show some anomalous radioactivity.

Mining and quarrying production

The mining and quarrying production of Victoria from lands occupied under the Mines Act and the Extractive Industries Act is recorded by the Victorian Mines Department, and from other lands by the Australian Bureau of Statistics. The production from both sources for the years 1971–72 to 1973–74 is shown in the following table:

VICTORIA—MINING AND QUARRYING PRODUCTION

Particulars	1971–72		1972–73		1973–74	
	Quantity	Value	Quantity	Value	Quantity	Value
	'000 gm	$'000	'000 gm	$'000	'000 gm	$'000
Metallic minerals (*a*)—						
Gold bullion	208	(*b*) 223	148	(*b*) 138	75	(*b*) 81
	tonne		tonne		tonne	
Antimony concentrate	96	n.a.	..	..	..	..
Antimony ore	n.a.	n.a.	n.a.	n.a.	2,318	57
Bauxite	..	..	4,222	36	6,669	57
Copper concentrate	..	..	..	..	..	..
Copper ore	..	..	..	..	..	..
Iron ore	123	1	596	3	466	3
Lead concentrate	..	..	..	..	..	..
Tin concentrate	30	42	10	20	9	26
Wolfram ore	..	..	12	n.a.	..	..
Non-metallic minerals—						
Diatomite, refined	4	(*c*)	14	(*c*)	538	7
Fireclay	17,274	53	22,658	56	38,484	80
Fluorspar	380	22	1,700	79	874	49
Gypsum	42,063	128	43,694	154	49,825	149
Kaolin, refined	20,918	526	13,809	671	27,856	1,493
Kaolin, unrefined (*d*)	13,683	34	10,714	41	1,623	21
Limestone (*e*)	2,158,991	n.a.	2,162,770	n.a.	2,424,380	n.a.
Other clays	2,106,382	1,754	2,186,698	1,858	2,736,979	2,524
Silica	98,791	316	109,019	339	141,832	460

VICTORIA—MINING AND QUARRYING PRODUCTION—*continued*

Particulars	1971–72		1972–73		1973–74	
	Quantity	Value	Quantity	Value	Quantity	Value
Fuel minerals—						
Briquettes	1,328,630	11,280	1,228,005	9,173	1,163,922	11,011
Coal, black						
Coal, brown (*f*)	23,630,467	25,706	24,121,155	23,763	23,253,577	27,823
	'000 cub m		'000 cub m		'000 cub m	
Crude oil	16,356	n.a.	18,190	n.a.	20,712	n.a.
Liquefied petroleum gases (*g*)—						
Commercial butane	662	n.a.	988	n.a.	929	n.a.
Commercial propane	576	n.a.	798	n.a.	1,123	n.a.
	million cub m		million cub m		million cub m	
Natural gas (*h*)	1,097	n.a.	1,473	n.a.	1,998	n.a.
Other derivatives (*g*)—						
	'000 cub m		'000 cub m		'000 cub m	
Commercial ethane	3,087	n.a.	27,436	n.a.	40,620	n.a.
	'000 tonnes		'000 tonnes		'000 tonnes	
Construction materials—						
Sand	5,619	8,004	6,659	8,945	7,788	11,068
Gravel	3,486	2,121	3,633	2,401	4,858	4,307
Crushed and broken stone	16,057	32,908	15,805	31,985	17,499	35,373
	tonne		tonne		tonne	
Dimension stone	13,066	200	14,515	284	10,937	217
	'000 tonnes		'000 tonnes		'000 tonnes	
Other quarry products	3,053	2,484	3,180	2,758	4,201	3,686

(*a*) See subsequent table for assayed content.
(*b*) Includes gold subsidy of $9,101 in 1971–72, $36,361 in 1972–73, and $18 in 1973–74. Gold subsidy payments ceased at the end of December 1973.
(*c*) Under $1,000.
(*d*) Excludes unrefined kaolin used in producing kaolin at or near mine.
(*e*) Excludes limestone used as construction material.
(*f*) Excludes brown coal used in production of briquettes : 1971–72 : 3,632,000 tonnes ; 1972–73 : 3,199,000 tonnes ; and 1973–74 : 3,101,000 tonnes.
(*g*) Excludes manufactured liquefied petroleum gases and other derivatives from petroleum refining.
(*h*) Includes commercial gas and gas for field usage.
Source : Victorian Mines Department, Australian Department of National Resources—Fuel Branch, and Australian Bureau of Statistics.

VICTORIA—ASSAYED CONTENT OF METALLIC MINERALS

Metal or element and mineral in which contained	1970–71	1971–72	1972–73	1973–74
Alumina (tonne)—				
Contained in bauxite	3,373	..	1,977	2,819
Antimony (tonne)—				
Contained in antimony concentrate	93	n.a.	..	..
Contained in antimony ore	259	n.a.	n.a.	110
Total antimony	352	59	n.a.	110
Copper (tonne)—				
Contained in copper concentrate	18	..	..	..
Contained in copper ore	22	..	..	..
Total copper	40	..	..	..
Gold (gm)—				
Contained in antimony ore	..	..	..	158
Contained in antimony concentrate	19,035	1,586	..	..
Contained in copper concentrate	715	..	..	..
Contained in gold bullion	163,076	191,970	141,054	67,783
Total gold	182,826	193,556	141,054	67,941
Iron (tonne)—				
Contained in bauxite	390	..	310	209
Contained in iron ore	172	71	322	280
Total iron	562	71	632	489
Lead (tonne)—				
Contained in lead concentrate	1	..	..	..
Palladium (gm)—				
Contained in copper concentrate	1,757	..	..	.
Platinum (gm)—				
Contained in copper concentrate	1,190	..	..	..
Silver (gm)—				
Contained in copper concentrate	5,412	..	..	..
Contained in gold bullion	218	8,305	3,732	n.a.
Total silver	5,630	8,305	3,732	n.a.
Tin (tonne)—				
Contained in tin concentrate	3	18	7	7

Source : Victorian Mines Department and Australian Bureau of Statistics.

VICTORIA—COAL PRODUCTION AND VALUE (*a*)

Period (*b*)	Black coal		Brown coal	
	Production	Value	Production	Value
	tonnes	$'000	tonnes	$'000
1926–1930	678,901	1,786	1,539,917	386
1931–1935	479,606	888	2,484,461	512
1936–1940	330,118	568	3,666,671	712
1941–1945	290,872	818	5,090,974	1,052
1946–1950	158,798	722	6,755,137	2,404
1951–1955	145,838	1,590	8,868,202	7,186
1956–1960	102,512	1,050	12,389,332	11,302
1961–1965	53,418	599	18,607,269	16,605
1966	36,089	497	22,132,593	20,064
1967	32,581	251	23,758,913	20,686
1968	26,736	209	23,339,331	21,555
1968–69	13,312	105	23,499,703	20,879
1969–70	407	6	24,310,900	22,131
1970–71	20	(*c*)	23,180,539	22,975
1971–72	..	..	23,630,467	25,706
1972–73	..	..	24,121,155	28,555
1973–74	..	..	26,354,577	31,532

(*a*) Value of output at the mine. This is essentially the unit selling price of the commodity, less any unit transport costs from the mine or associated treatment works, multiplied by the production. Where a commodity is transferred to another location for further processing without being sold, the unit value is based on production costs plus an allowance for overhead and profit.
(*b*) Figures for five-yearly periods are annual averages.
(*c*) Under $1,000.

Further references, 1965–1975; Mining in Victoria, 1964; Underground water, 1964; Groundwater in Victoria, 1969; Victorian clays, 1970; Brown coal, 1971; Minerals in Victoria, 1970; History of the Mines Department, 1970; Natural gas and crude oil development, 1972; Mineral exploration, 1972; Geological Survey of Victoria, 1975; Mineral exploration, 1975; Extractive industries, 1975

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