australian energy

national and state projections to 2029-30

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ABARE is a professionally independent government economic research agency.

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foreword

In this report, ABARE presents its latest medium to long term projections of Australian energy consumption, production and trade. The analysis covers the period from 2004-05 to 2029-30, with a focus on the medium term to 2010-11. The projections update those presented last year for the same projection period and are prepared using ABARE's *E*$_4$*cast* model.

The medium term analysis is based on information from ABARE's regular survey of Australia's fuel and electricity sector and draws on ABARE's projections analysis of Australian commodity markets. It is hoped that this revised outlook will continue to assist industry decision makers and government policy makers to understand the trends and likely developments in Australia's energy industries to 2029-30.

Phillip Glyde
Executive Director
December 2006

acknowledgments

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glossary

bagasse	The fibrous residue of the sugar cane milling process that is used as a fuel (to raise steam) in sugar mills.
biogas	Landfill (garbage tips) gas and sewage gas. Also referred to as biomass gas.
coal byproducts	Byproducts such as coke oven gas, blast furnace gas (collected from steelworks blast furnaces), coal tar and benzene/toluene/xylene (BTX) feedstock. Coal tar and BTX are both collected from the coke making process.
conversion	The process of transforming one form of energy into another before use. Conversion itself consumes energy. For example, some natural gas and liquefied petroleum gas is consumed during gas manufacturing, some petroleum products are consumed during petroleum refining, and various fuels, including electricity itself, are consumed when electricity is generated. The energy consumed during conversion is calculated as the difference between the energy content of the fuels consumed and that of the fuels produced.
gas pipeline	Natural gas used in pipeline compressors and losses and
operation	leakage during transmission.
levelised costs of electricity	The costs of electricity generation calculated as the sum of input fuel, operating and investment costs expressed on a per energy unit basis.
natural gas	Gases that include commercial quality sales gas, liquefied natural gas, ethane, methane (including coal seam and mine mouth methane and gas from garbage tips and sewage plants) and plant and field use of noncommercial quality gas. In this report, natural gas also includes town gas.
petroleum	Crude oil and natural gas condensate used directly as fuel, liquefied petroleum gas, refined products used as fuels (aviation gasoline, automotive gasoline, power kerosene, aviation turbine fuel, lighting kerosene, heating oil, automotive diesel oil, industrial diesel fuel, fuel oil, refinery fuel and naphtha) and refined products used in nonfuel applications (solvents, lubricants, bitumen, waxes, petroleum coke for anode production and specialised feedstocks).

	In this report, all petroleum products are defined as primary fuels even though most petroleum products are transformed (refined). The distinction between the consumption of petroleum at the primary and final end use stages relates only to where the petroleum is consumed, not to the mix of different petroleum products consumed. The consumption of petroleum at the primary energy use stage is referred to collectively as oil, while the consumption of petroleum at the final end use stage is referred to as petroleum products. The one exception to this is liquefied petroleum gas (LPG). LPG is not included in the definition of end use consumption of petroleum because it is modeled separately.
petajoule	The joule is the standard unit of energy in electronics and general scientific applications. One joule is the equivalent of one watt of power radiated or dissipated for one second. One petajoule, or 280 terawatt hours, is the heat energy content of about 43 000 tonnes of black coal or 29 million litres of petrol.
primary fuels	The forms of energy obtained directly from nature. They include nonrenewable fuels such as black coal, brown coal, uranium, crude oil and condensate, naturally occurring liquid petroleum gas, ethane and natural gas, and renewable fuels such as wood, bagasse, hydroelectricity, wind and solar energy.
secondary fuels	Fuels produced from primary or other secondary (or derived) fuels by conversion processes to provide the energy forms commonly consumed. They include refined petroleum products, thermal electricity, coke, coke oven gas, blast furnace gas and briquettes.
total primary energy consumption	(Also referred to as total domestic availability.) The total (in energy units) of the consumption of each primary fuel in both the conver sion and end use sectors. It includes the use of primary fuels in conversion activities – notably the consumption of fuels used to produce electricity – and also includes own use and losses in the conversion sector.
total final energy consumption	The total amount of energy consumed in the final or 'end use' sector. It is equal to total primary energy consumption less energy consumed or lost in conversion, transmission and distribution.
town gas	All manufactured gases that are typically reticulated to consumers. These include synthetic natural gas, reformed gas, tempered liquid petroleum gas and tempered natural gas. In this report, town gas is included with natural gas.

units

metric units

J	joules
L	litres
t	tonnes
g	grams
Wh	watt-hours
b	billion (or 1000 million)

standard metric prefixes

k	kilo	10^3 (thousand)
M	mega	10^6 (million)
G	giga	10^9 (1000 million)
T	tera	10^{12}
P	peta	10^{15}
E	exa	10^{18}

standard conversions

1 barrel = 158.987 L

1 kWh = 3600 kJ

indicative energy content conversion factors

Black coal production	28.5 GJ/t
Brown coal	9.7 GJ/t
Crude oil production	37 MJ/L
Naturally occurring LPG	26.5 MJ/L
LNG exports	54.4 GJ/t
Natural gas (gaseous production equivalent)	40 MJ/kL
Biomass	11.9 GJ/t
Hydroelectricity, wind and solar energy	3.6 TJ/GWh

conventions used in tables

0.0 is used to denote a negligible amount.
Small discrepancies in totals are generally the result of the rounding of components.

summary

> In this report, ABARE presents its latest medium and long term projections of Australian energy consumption, production and trade, covering the period 2004-05 to 2029-30. The projections are prepared using ABARE's E_4*cast* model and update those published in October 2005 (Akmal and Riwoe 2005).

energy consumption

> Australia's rate of growth in primary energy consumption has tended to fall through time, from 5.0 per cent a year in the 1960s to 2.3 per cent a year in the 1990s. From 2004-05 to 2029-30 energy consumption growth is projected to continue to moderate (figure A).

> In the medium term – from 2004-05 to 2010-11 – Australia's primary energy consumption is projected to grow by 2.0 per cent a year, from 5593 petajoules in 2004-05 to 6311 petajoules in 2010-11.

> Over the full outlook period – 2004-05 to 2029-30 – primary energy consumption is projected to grow at an average rate of 1.5 per cent a year, reaching 8162 petajoules in 2029-30. Energy consumption per person is projected to continue to rise over the outlook period, from 275 gigajoules in 2004-05 to 319 gigajoules by 2029-30 (figure B).

fig A **annual primary energy consumption growth in Australia**

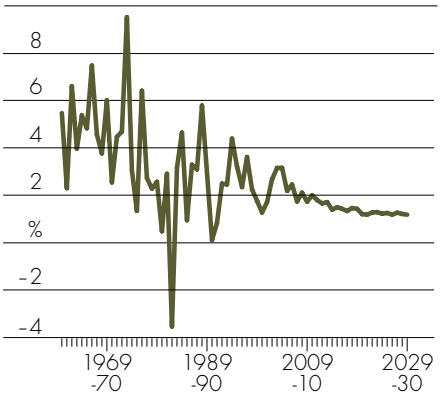
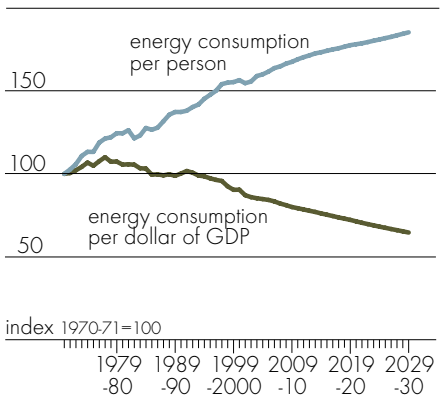


fig B **energy use in Australia**



> After remaining more or less stable during the 1970s and 1980s, Australia's aggregate energy intensity (measured as total primary energy consumption per dollar of GDP) fell by an average of 1.1 per cent a year during the 1990s, and is projected to continue to decline at around this rate from 2004-05 to 2029-30 (figure B).

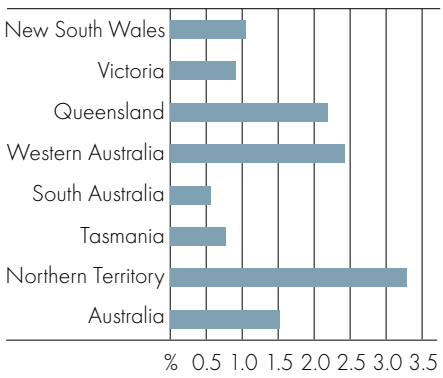
> At the primary energy level, fossil fuels provided around 95 per cent and renewables about 5 per cent of the energy consumed in Australia in 2004-05. Of the fossil fuels, black and brown coals provided 41 per cent, oil 34 per cent, and gas 20 per cent of primary energy consumed in 2004-05. Over the long term the respective shares of black and brown coal, and oil, are projected to fall to 36 per cent and 33 per cent by 2029-30, while the respective shares of gas and renewables are projected to rise to 25 per cent and 6 per cent.

> In *E_4cast*, the main drivers of energy consumption are industry activity, in the case of the energy intensive sectors, and in the case of the non energy intensive sectors, gross state product. The rate of growth in gross state product is assumed to be highest in Queensland, Western Australia and the Northern Territory and lowest in South Australia and Tasmania.

> By region, the projections of primary energy consumption reflect these assumptions. Primary energy consumption in Western Australia is projected to rise from 760 petajoules in 2004-05 to 1385 petajoules in 2029-30 (or by 82 per cent over the projection period). In Queensland it is projected to rise from 1319 petajoules to 2265 petajoules (or by 72 per cent), growing at a rate of 2.2 per cent a year (figure C). Currently, the third largest primary energy consuming state, Queensland, is projected to overtake Victoria in terms of total primary energy consumption in 2012-13, then New South Wales in 2017-18 to become Australia's largest consumer of primary energy.

fig C **primary energy consumption growth in Australia, by region**

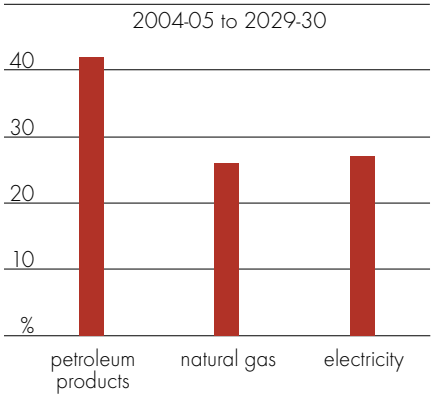
average annual growth, 2004-05 to 2029-30



> At the national level, final end use energy consumption is projected to increase from 3464 petajoules in

2004-05 to 5261 petajoules in 2029-30, an increase of 52 per cent over the projection period and an average rate of increase of 1.7 per cent a year. The final end use fuel mix will continue to be dominated by petroleum products, with its share of final energy consumption in 2029-30 projected at 47 per cent. Petroleum products are projected to account for 42 per cent of the increase in final energy consumption over the outlook period (figure D). The substitution away from petroleum products toward gas is projected to continue throughout the projection period, although this substitution is projected to occur at a faster rate in the medium term than over the longer term. The share of natural gas in final energy consumption is projected to increase to 21 per cent, while the share of electricity is projected to increase to 24 per cent.

fig D **contribution to growth in final energy consumption in Australia**



> Transport and manufacturing are the two largest consumers of final energy, followed by residential, commercial and mining. Mining is the only sector projected to greatly alter its share of total primary energy consumption over the projection period, from 5 per cent of total final energy consumption in 2004-05 to 10 per cent in 2029-30, reflecting a large number of energy intensive project developments assumed to take place over the projection period.

electricity generation

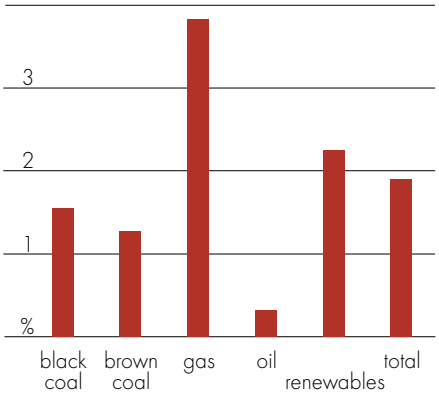
> Gross electricity generation is projected to rise from 907 petajoules (252 TWh) in 2004-05 to 1468 petajoules (408 TWh) in 2029-30. This represents an increase of 62 per cent over the projection period and an average rate of growth of 1.9 per cent a year.

> Little change is projected in the relative shares of electricity generated from fossil fuels or renewables over the projection period. In 2004-05, 93 per cent of electricity was generated from fossil fuels (coal, oil and gas), and 7 per cent from renewables such as hydro, wind, biomass and biogas. The

main projected change in the sector's fuel mix is an increase in the share of electricity generated from gas from 14 per cent in 2004-05 to 23 per cent in 2029-30. A corresponding decrease is projected in the share of electricity generated from coal (both black and brown) from 77 per cent in 2004-05 to 68 per cent in 2029-30. The share of renewables is projected to increase slightly, to 8 per cent by the end of the projection period.

> Electricity generation from black coal is projected to grow modestly (figure E), increasing by around 66 TWh over the outlook period. In contrast, generation from natural gas is projected to grow strongly, almost tripling to 92 TWh by 2029-30. Growth in gas fired electricity generation is projected to be particularly strong in the medium term, largely reflecting investment in peak capacity and the impact of a number of policy initiatives, such as the New South Wales greenhouse gas benchmarks and the Queensland 13 per cent gas scheme.

fig E **electricity generation growth in Australia, by fuel**
average annual growth, 2004-05 to 2029-30



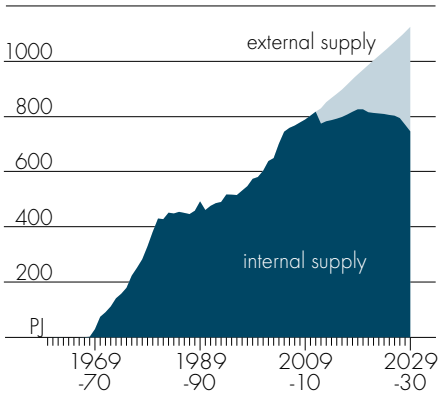
> Wind and biomass energy are projected to account for the majority of the increase in electricity generation from renewable sources over the projection period. This expansion in nonhydro renewables reflects falling investment costs and the impact of a number of government policies.

energy production and net trade

> Total primary energy production – excluding uranium (U_3O_8) – in Australia is projected to increase from 11 868 petajoules to around 22 350 petajoules by 2029-30, growing at an average rate of 2.6 per cent a year. As the projected increase in nonuranium energy fuels production exceeds the projected rise in primary energy consumption, Australia's exportable surplus of energy fuels as a proportion of consumption is projected to rise to 2029-30. Conversely, Australia's primary energy consumption represented 47 per cent of nonuranium energy fuel production in 2004-05. This proportion is projected to fall to 37 per cent in 2029-30.

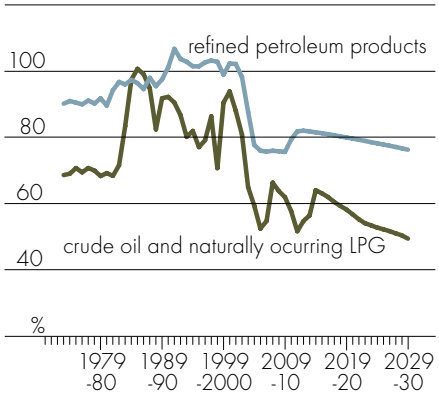
- In contained energy terms, black coal accounted for 74 per cent of total production of energy in 2004-05, excluding uranium. Over the outlook period, black coal exports are forecast to increase by 2.6 per cent a year to reach 438 million tonnes in 2029-30.
- The largest two natural gas producing basins in the eastern states are projected to have declining supplies over the outlook period. Natural gas production from the Gippsland basin is projected to peak in 2021-22 with 392 petajoules and decline thereafter by an average 4.7 per cent a year. Production from the Cooper–Eromanga basin is projected to decline to 183 petajoules in 2011-12. After this, production from Cooper–Eromanga is projected to decline sharply for the rest of the outlook, averaging a rate of decline of over 17 per cent a year.
- The decline in these two basins is partially compensated for by growing supplies from the Otway basin and coal seam gas (CSG). Gas production from the Otway basin is projected to increase from 42 petajoules in 2004-05 to a peak of 160 petajoules in 2011-12 and settle at around 110 petajoules from 2011-12 to 2019-20. After this, production from Otway is projected to fall to reach around 40 petajoules by the end of the outlook period. CSG currently accounts for more than 60 per cent of the Queensland gas market. Reflecting in part major supply contracts CSG production is projected to reach 339 petajoules by 2029-30, close to six times the amount produced in 2004-05.
- Total gas supply in the eastern Australian market is projected to increase more modestly than CSG production, by around 60 per cent over the 25 year projection period. This is a result of the offsetting effect of falling gas supplies from the mature Cooper–Eromanga basin and eventually from Bass Strait. Indeed, from 2012-13, gas demand in the eastern market is projected to outstrip local supply (figure F), providing an opportunity for supplies from outside the region to enter the market. By 2029-30, this market is projected to have grown to around 1124 petajoules.

fig F **gas supply and demand balance in eastern Australia**



> Australia's LNG production is projected to grow strongly over the outlook period, at an average rate of 7.7 per cent a year. LNG exports are projected to increase to 20 million tonnes by 2010-11 and 67 million tonnes by 2029-30.

fig G **production to consumption ratios for Australia's liquid fuels sector**



> The combined production of oil and naturally occurring LPG in Australia is forecast to increase only modestly over the outlook period, from 1133 petajoules in 2004-05 to 1340 petajoules in 2029-30. Consumption of liquid fuels, on the other hand, is projected to grow more strongly. As a result, Australia's self sufficiency in oil and naturally occurring LPG, measured as the proportion of liquid fuels consumption sourced from domestic production, is projected to fall from 59 per cent to 49 per cent over the outlook period (figure G).

petroleum refining

> Refinery output is projected to increase by 39 per cent over the projection period. However, this increase in output is outstripped by the increase in petroleum consumption, which is projected to be 42 per cent over the same period. As a consequence, the share of domestic production of refined petroleum products in liquid fuels consumption is projected to decrease from 78 per cent to 76 per cent over the outlook period (figure G), If it were assumed that new refinery capacity did not come on stream in the medium term, Australia's self-sufficiency in refined petroleum products could fall to around 70 per cent by 2029-30.

1

overview of the *E*$_4$*cast* model and key assumptions

E$_4$*cast* overview

E$_4$*cast* is a partial equilibrium model of the Australian energy sector. It is used to project energy consumption by fuel type, by industry and by state or territory, on an annual basis. Trends in real incomes and industry production, fuel prices and energy efficiency improvements are some of the parameters used to approximate the principal interdependencies between energy production, conversion and consumption. A brief overview of the key features of the current version of *E*$_4$*cast* is provided in box 1, while a detailed technical outline of the model is provided in Akmal et al. (2004).

The model includes eighteen fuels, twenty seven industry sectors, and seven regions (tables 1, 2). The demand functions for each of the main types of fuel (such as electricity, natural gas, coal, and petroleum products) have been estimated econometrically and incorporate own price, cross price, income or activity, and technical change effects. Manufacturing industry coverage includes wood, paper and printing; petroleum refining; chemical, rubber and plastic products; nonmetallic mineral products; iron and steel manufacturing; aluminium smelting; other basic nonferrous metals; and electricity generation. The transport sector includes road, rail, water (international, domestic), and air transport (international, domestic). Each state or territory – New South Wales, including the Australian Capital Terri-

table 1 **fuel coverage in *E*$_4$*cast***

black coal
brown coal
coal byproducts
– coke oven gas
– blast furnace gas
coke
oil (crude oil and condensate)
solar (residential solar hot water)
biomass (bagasse, wood and wood waste)
liquefied petroleum gas (LPG)
other petroleum products
electricity
– peak
– offpeak
hydroelectricity
wind energy
natural gas
coal seam gas
ethane
biogas (sewage and landfill gas)

box 1 key features of *E*$_4$*cast*

In 2000, ABARE commenced development of its *E*$_4$*cast* energy forecasting and analysis framework. The first version of the model was documented in Dickson et al. (2001). Since then, the model has been enhanced and refined in a number of directions, providing a sound platform for the development and analysis of medium and long term energy and greenhouse gas emissions projections.

Key features of the 2005 version of *E*$_4$*cast* are outlined below.

> *E*$_4$*cast* is a dynamic partial equilibrium framework that provides a detailed treatment of the Australian energy sector, representing energy production, trade and consumption in a comprehensive manner.

> The Australian energy system is divided into seven conversion sectors and twenty end use sectors.

> Fuel coverage comprises eighteen primary and secondary fuels.

> Results for all states and territories (the ACT is included with New South Wales) are provided.

> Detailed representation is provided of energy demand. The demand for each fuel is modeled as a function of income or activity, fuel prices (own and cross) and efficiency improvements.

> Primary energy consumption is distinguished from final (or end use) energy consumption. This convention is consistent with the approach used by the International Energy Agency (IEA 2004).

> The current version of *E*$_4$*cast* covers the period 2003-04 to 2029-30.

> Demand parameters are estimated econometrically using data for the period 1973-74 to 2000-01.

> Business activity is generally represented by gross state product (GSP).

> Energy intensive industries are modeled explicitly, taking into account large and lumpy capacity expansions. The industries modeled in this way are:

- aluminium
- other basic nonferrous metals (mainly alumina)
- iron and steel.

> Peak and offpeak electricity demands are modeled explicitly.

continued...

box 1 key features of E_4cast *continued*

> The electricity generation module includes seventeen generation technologies – three peak and fourteen base load technologies.

> Key policy measures modeled explicitly are:

- the Australian Government's Mandatory Renewable Energy Target scheme
- the New South Wales Government's greenhouse gas benchmarks scheme and
- the Queensland Government's cleaner energy strategy.

> Supply of natural gas (including coal seam gas and ethane) is modeled at the basin level, taking into account future gas discoveries and reserves growth. A total of sixteen sources of gas, including an external supply source for eastern Australia, are represented in the model.

tory, Victoria, Queensland, South Australia, Western Australia, Tasmania and the Northern Territory – is treated as a region.

Australia's exports of black coal and liquefied natural gas (LNG) are treated outside the model (exogenously), while net trade in oil and refined petroleum products is determined within the model (endogenously) from liquid petroleum production and consumption. Interstate flows in electricity and natural gas are also modeled.

activity or growth assumptions

The model results are particularly sensitive to the value of the 'activity' variable used in each of the fuel demand equations. The activity variable used for all non energy intensive sectors is gross state product (GSP), which represents income or business activity at the state level. The activity variable used for energy intensive industries (aluminium; other basic nonferrous metals; and iron and steel manufacturing) is industry output (production) at a state level. For industries characterised by large and lumpy capacity expansion, industry output is a more relevant indicator of activity than gross state product.

table 2 **industry coverage in E_4cast**

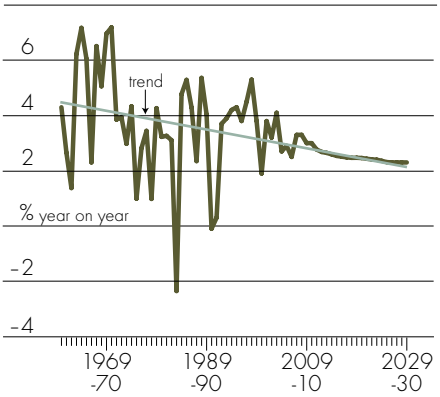
sectors/subsectors	*ANZSIC code*
conversion	
coke oven operations	2714
blast furnace operations	2715
petroleum refining	2510, 2512–2515
petrochemicals	na
electricity generation	361
fuel use in conversion	na
transmission losses	na
end use	
agriculture	division A
mining	division B
manufacturing and construction	division C
wood, paper and printing	23–24
chemical, rubber and plastic products	2520–2599
nonmetallic mineral products	26
iron and steel (excludes coke ovens and blast furnaces)	2700–2713, 2716–2719
basic nonferrous metals	272–273
aluminium smelting	2722
other basic nonferrous metals	2720–2721, 2723–2729
other manufacturing and construction	na
transport	division I (excludes sectors 66 and 67)
road transport	61
passenger motor vehicles	na
other road transport	na
railway transport	62
water transport	63
domestic water transport	6301
international water transport	6302
air transport	64
domestic air transport	na
international air transport	na
pipeline transport	6501
commercial and services	sectors 37, 66 and 67; divisions F, G, H, J, K, L, M, N, O, P and Q
residential	na
solvents, lubricants and bitumen	na

Source: Based on Australian Bureau of Statistics and New Zealand Department of Statistics, Australian and New Zealand Standard Industrial Classification, 1993 edition.

national and state level economic growth

Following growth of 2.7 per cent in 2004-05 (figure H), Australia's gross domestic product (GDP) rose by 2.9 per cent in 2005-06 (Penm 2006). Based on continued strong world demand for mineral resources and investment in resource related industries, Australia's short to medium term economic outlook remains strong; GDP growth is assumed to average 3.0 per cent a year over the medium term to 2010-11 (table 3).

fig H **economic growth rate assumptions for Australia**



Beyond the medium term, the annual rate of growth in GDP is assumed to moderate as Australia's population and labor supply growth slows. Over the full projection period – from 2004-05 to 2029-30 – GDP growth is assumed to average 2.6 per cent a year.

In ABARE's previous long term energy consumption projections (Akmal and Riwoe 2005), GDP was assumed to grow at a rate of 3.3 per cent a year in the medium term, and 3.1 per cent a year from 2004-05 to 2029-30. Because economic activity is a key driver of energy consumption, assuming a lower rate of GDP growth has reduced the projected rate of growth in energy consumption in the projections presented here, particularly for the long term.

In the model, the national rate of economic growth is translated into growth at the state level by multiplying the national level figure by state and territory output elasticities that have been estimated using historical data from 1990-91 to

table 3 **economic growth in Australia, by state/territory**

	average annual growth		
	2004-05 to 2010-11 %	2011-12 to 2019-20 %	2004-05 to 2029-30 %
New South Wales [a]	2.4	2.1	2.1
Victoria	3.1	2.4	2.5
Queensland	4.2	3.3	3.5
South Australia	2.4	1.9	2.0
Western Australia	4.4	3.1	3.3
Tasmania	2.4	1.6	1.7
Northern Territory	4.1	2.3	2.7
Australia	3.0	2.5	2.6

[a] Includes the Australian Capital Territory.

2004-05. The resulting assumed state and territory level growth rates are shown in table 3. Out of the seven states/territories, Queensland and Western Australia are assumed to experience the highest long term rates of economic growth, and Tasmania and South Australia the lowest.

growth in energy intensive industries

Australian aluminium production is assumed to increase by around 11 per cent over the projection period, from 1.9 million tonnes in 2004-05 to 2.1 million tonnes in 2029-30 (table 4). Production is assumed to grow at a slightly faster rate over the medium term (0.5 per cent a year) than over the longer term (0.4 per cent a year).

In the other basic nonferrous metals sector, the activity variable used for the sector is alumina production. The Australian alumina industry is assumed to grow strongly over the projection period, particularly over the medium term. Production is assumed to increase by 47 per cent to 25 million tonnes in 2010-11 (table 4), with approximately 37 per cent of this increase accounted for by expansions in Western Australian refineries – specifically, the Pinjarra, Wagerup and Worsley refineries (table 5). The Alcan Gove alumina refinery expansion in the Northern Territory is assumed to add another 1.8 million tonnes a year to alumina capacity by 2007, more than doubling alumina production in the Northern Territory by 2010-11.

Between 2010-11 and 2029-30, several projects in Queensland and Western Australia have been assumed to proceed (table 5). In Western Australia, a second expansion of the Worsley refinery is assumed to occur in the mid-2020s. Alumina production is assumed to increase more notably in Queensland, reflecting expansions at the Comalco alumina refinery and the startup of a greenfield plant based on the Aurukun bauxite deposits on Cape York Peninsula. China Aluminium

table 4 **output of energy intensive industries in Australia**

	production			annual growth	
	2004-05	2010-11	2029-30	2004-05 to 2010-11	2004-05 to 2029-30
	Mt	Mt	Mt	%	%
iron and steel	7.8	8.6	11.5	1.6	1.6
primary aluminium	1.9	1.9	2.1	0.5	0.4
alumina	17.2	25.2	34.7	6.6	2.9

Company (Chalco) has proposed to develop the deposits and to build a new alumina refinery in the state. The 2.1 million tonnes a year project is currently at the feasibility stage and is scheduled for completion in 2011 (Haine et al. 2006).

Over the full projection period, Australian alumina production is assumed to double to 34.7 million tonnes by 2029-30, growing at a rate of 2.9 per cent a year (table 4). This increase in alumina production is higher than was assumed in ABARE's previous projections (Akmal and Riwoe 2005). Previously, alumina production was assumed to increase by 84 per cent in total over the projection period – from 17.2 million tonnes in 2004-05 to 31.5 million tonnes in 2029-30. This change in assumptions reflects greater production assumed for certain Alcan, Wagerup and Chalco developments, based on current industry information.

Modest expansion is assumed in iron and steel production. Production is assumed to grow by 1.6 per cent a year over the whole projection period – from 7.8 million tonnes in 2004-05 to 11.5 million tonnes by 2029-30 (table 4). In Western Australia, iron and steel production growth is assumed to be particularly low, with annual production at the end of the projection period assumed to be less than 1 million tonnes. This reflects the expectation that BHP Billiton's Port Hedland DRI plant – which was shut down in May 2004 – will remain closed over the projection period.

Rio Tinto's HIsmelt pig iron plant in Kwinana, Western Australia, was commissioned in late 2005 and is assumed to produce at its full capacity of 800 000 tonnes a year by 2010-11. Over the longer term, no further expansion in Western Australia's pig iron industry is assumed.

table 5 **alumina projects in Australia**

project	location	capacity Mt	planned startup
Pinjarra refinery efficiency upgrade	Pingarra, WA	0.60	2005
Alcan refinery expansion	Gove, NT	1.80	2007
Worsley refinery expansion – stage 1	Bunbury, WA	0.25	2008
Wagerup refinery expansion	Darling ranges, WA	2.10	2009
Comalco Alumina refinery – stage 2	Gladstone, Qld	1.40	early 2010s
CHALCO – stage 1	Cape York, Qld	2.10	2011
Comalco Alumina refinery – stage 3	Gladstone, Qld	1.40	mid 2010s
CHALCO – stage 2	Cape York, Qld	1.40	early 2020s
Worsley refinery expansion– stage 2	Bunbury, WA	1.00	mid 2020s

energy efficiency

Energy efficiency is assumed to improve over time across all end use sectors. Energy efficiency improvements are modeled exogenously in each fuel demand equation and can be made to vary by fuel, industry and region, in addition to over time. Energy efficiency assumptions in *E_4cast* are partly based on Akmal (2000), although they have been modified since that study to reflect recent ABARE research. Akmal (2000) estimated factor demand systems for Australian manufacturing, including labor, capital, energy and other intermediate materials. In that study, aggregate energy demand was found to be declining by 0.64 per cent a year owing to technical change. In order to estimate the factor demand relationships, Akmal (2000) used yearly historical data from 1973-74 to 1997-98. Since oil prices rose significantly during the mid-1970s to early 1980s, the estimated energy efficiency improvement rate during that period is likely to have been higher than may be expected for the future.

Energy efficiency improvement, represented by a decline in the demand for each fuel per unit of output, is assumed to be 0.50 per cent a year over the projection period for all fuels, although the rate of energy efficiency improvement is assumed to be different in regions or sectors where government greenhouse gas abatement policies are in place. For example, the New South Wales Government's greenhouse gas benchmarks scheme (discussed below) is expected to accelerate the rate of efficiency improvements in the use of electricity in New South Wales. To incorporate this effect, a higher rate of energy efficiency improvement (0.75 per cent a year) is assumed for electricity use in New South Wales.

In the case of energy intensive industries, a lower rate of energy efficiency improvement is assumed (0.20 per cent a year) in order to account for the relationship between energy requirements and production.

In the electricity generation sector, thermal efficiency rates also vary by fuel and over time. They are exogenously determined according to the maturity and capacity expansion rates of the electricity generation technologies modeled in *E_4cast*. The thermal efficiency of natural gas plants, for example, is assumed to improve at an average rate of 1.2 per cent a year. As a result, thermal efficiency of gas fired generation in Australia is projected to increase from 36 per cent in 2004-05 to 50 per cent in 2029-30. In comparison, coal technologies are more mature, therefore the coal fired plants are assumed to improve their thermal efficiency more modestly than gas fired plants. The average thermal efficiency of all black coal fired plants is

projected to increase from around 38 per cent in the base year to 41 per cent by 2029-30, improving at a rate of 0.4 per cent a year.

production and trade

In *E$_4$cast*, the supply structure of internationally traded fuels, such as black coal and oil, is represented by exogenously determined (real) price paths. In the case of black coal this implies that production will match demand (export and domestic) at a given price level. The outlook for black coal exports is based on ABARE's recent assessment of the Australian coal industry (Fairhead et al. 2006). In the case of oil and naturally occurring LPG, domestic production is treated as exogenous (leaving crude oil net trade to be determined endogenously in the model). Crude oil and LNG production projections are based on ABARE's most recent short to medium term outlook for the minerals and energy sector (Penm et al. 2006). ABARE's outlook for coal, oil and LNG is discussed further in chapter 3.

The supply of brown coal and nontraded black coal produced in states other than New South Wales and Queensland is approximated using state specific prices and an autonomous productivity improvement as the key determinants of supply. For simplicity, the supply of other fuels such as biomass, biogas and solar power are assumed to be perfectly elastic, with supply assumed to equate to demand at given prices.

Gas supply is represented in the model at the basin level and a total of sixteen alternative sources of natural gas, ethane and coal seam methane (including an external gas supply source for eastern Australia) are modeled (table 6). The supply outlook is determined by the price of gas, technical change and reserves. It is assumed that, while technical change lowers extraction costs and consequently wellhead gas prices, gas depletion and the resulting reduction in reserves would increase extraction costs and prices.

The direction of interstate trade in electricity and natural gas is endogenously determined

table 6 **gas supply basins in *E$_4$cast***

south eastern Australia
Adavale
Bass
Bowen/Surat
Cooper/Eromanga (natural gas)
Cooper/Eromanga (ethane)
Gippsland (natural gas)
Gippsland (ethane)
Otway
coal seam gas (Queensland)
coal seam gas (New South Wales)
external gas supply
north western Australia
Amadeus
Bonaparte
Browse
Carnarvon
Perth

in *E4cast*, accounting for differences in regional prices, transmission costs and capacities. Upper limits on interstate flows of both electricity and natural gas are imposed over the medium term. The limit on electricity flows broadly reflects interconnector capacities assumed in the latest NEMMCO Statement of Opportunities (NEMMCO 2005). Similarly, the limit on interstate natural gas flows is based on pipeline capacities to 2010-11. Beyond the medium term, it is assumed that any interstate imbalances in energy supply and demand will be anticipated, leading to infrastructure investment sufficient to meet trade requirements. To reflect this assumption, trade flows from 2011-12 to 2029-30 are not limited by current capacity in the model.

electricity generation parameters

The demand for both peak and offpeak (or base load) electricity is modeled explicitly in *E4cast*. The peak period is defined to extend from 7.00 am to 10.00 pm weekdays, covering 45 per cent of the year. Base load demand is assumed to cover the remaining time. The model incorporates load duration curves for New South Wales, Victoria, Queensland and South Australia, which were constructed using NEMMCO half hourly demand data. Total annual demand for each of these four states was found to be approximately equally distributed between the peak and offpeak periods. However, only 9 per cent of the electricity consumption that occurred during the peak period was generated using peak load technologies. The remaining 91 per cent of electricity consumption (covering both peak and offpeak periods) was generated using base load technologies. As fuel dispatch data are not readily available for other states, this same load profile has been assumed for all states.

The electricity generation module of *E4cast* includes seventeen generation technologies – three peak and fourteen offpeak (table 7). The peak technologies are peak gas, hydro and diesel. The offpeak technologies comprise six coal technologies – using both brown and black coal – three gas technologies, hydroelectricity, biomass, biogas (landfill and sewage gas) and wind plants. Biomass fuels include bagasse (the main such fuel), and wood and wood waste products. In *E4cast*, the real cost of investing in electricity generation technologies varies over time and incorporates the impact of learning by doing and economies of scale.

Renewable energy is modeled to reflect the incentives built into various government greenhouse gas abatement schemes, and the projected share of each renewable technology is affected not only by its own capacity constraints, but also

by those of other renewable technologies. Given the current small share of renewable technologies within total energy consumption and the evolving nature of these technologies, the projected share of any one renewable technology should be regarded as approximate.

Four government policies that affect energy consumption are explicitly modeled in *E4cast* – the Australian Government's Mandatory Renewable Energy Target (MRET) scheme, the Queensland Government's 13 per cent gas scheme, the New South Wales Government's greenhouse gas emissions benchmark scheme and the Western Australian Government's renewable energy target.

The MRET scheme requires the annual generation of renewable electricity to increase by 9500 GWh from 2000 to 2010. Interim targets have been set (commencing at 300 GWh in 2000) to ensure the target of 9500 GWh is achieved by 2010. In *E4cast*, the renewable energy target is modeled as a constraint on sent out electricity. The constraint is adjusted to account for renewable technologies that are not explicitly modeled, such as photovoltaics and solar water heaters.

It is assumed that around 25 per cent of the renewable energy target will be met by technologies that are not explicitly modeled. The number of renewable energy certificates created can be used as an indication of the renewable energy generated under MRET. In 2003, approximately 15 per cent of the target was met by solar water heaters, rising to 25 per cent in 2004. The proportion of the target met by other technologies not explicitly modeled in *E4cast* was minor (ORER 2004, 2005). It is expected that wind and biomass (mainly bagasse, woodwaste and bagasse cofired with woodwaste) will provide most of the increase in electricity generated from renewable sources over the projection period.

table 7 **electricity generation technologies in *E4cast***

black coal	
1	pulverised fuel
2	integrated combined cycle
3	integrated combined cycle with ccs [a]
4	pulverised fuel super critical with ccs
brown coal	
5	pulverised fuel
6	pulverised fuel super critical with ccs
diesel	
7	peak
8	offpeak
natural gas	
9	peak
10	offpeak
11	combined cycle
12	combined cycle with ccs
renewables	
13	hydro peak
14	hydro offpeak
15	wind
16	biomass
17	biogas

[a] carbon capture and storage

The Queensland Government's 13 per cent gas scheme is a key component of the Queensland Energy Policy announced in May 2000. The scheme requires electricity retailers and other liable parties to source at least 13 per cent of their electricity from natural gas fired generation. The scheme commenced on 1 January 2005 and will remain in place until 31 December 2019. In the model, it is implemented through a requirement that the share of natural gas based electricity in Queensland be greater than or equal to 13 per cent through the projection period, although this requirement ceases to be binding by 2020.

The New South Wales Government's greenhouse gas emissions benchmark for electricity retailers and other liable parties began on 1 January 2003 with a benchmark of 8.65 tonnes of CO2-e. Annual targets for the subsequent years follow a linear path to reach a benchmark of 7.27 tonnes of CO_2-e by 2007. The target will be maintained at that level until at least 2012 (George Wilkenfeld and Associates 2002). The scheme is implemented in the model by requiring total emissions from state electricity generation to be less than or equal to the product of per person emissions and state population.

The New South Wales Government has stated that it would prefer not to extend the benchmark scheme beyond 2012, but to participate in a 'single national trading scheme'. However, in the absence of the latter, the Government would consider extending its benchmark scheme to 2020 (New South Wales Government 2004). Given the uncertainty about the future of the scheme, no policy is assumed beyond 2012 in this outlook.

In *E_4cast*, the Western Australian Government's renewable energy target for the South West Interconnected System (SWIS) is also explicitly modeled, assuming that the 6 per cent target for the SWIS will be achieved by 2009-10. The SWIS region accounts for around 56 per cent of total electricity generation in Western Australia (Government of Western Australia 2003). As electricity generation in *E_4cast* is modeled at the state level and not at the regional level, it is assumed that renewable electricity will account for at least 3.4 per cent (0.56 x 0.06 = 0.034) of Western Australia's total electricity generation in 2009-10. In 2004-05, renewable electricity accounted for 1.5 per cent of total electricity generation in the state.

E_4cast model rebase and definitions of energy statistics

Before employing *E_4cast* for this cycle of projections, the model was rebased using ABARE's historical energy statistics for 2004-05. ABARE's fuel and electricity

survey forms the basis for these statistics. A brief description of the survey and ABARE's energy balance data is given in box 2. More details are provided in Donaldson (2005).

box 2 ABARE's energy system statistics

ABARE's energy supply and disposal statistics are built on its fuel and electricity survey (FES), a nationwide survey of around 1400 large energy users and producers. The energy users surveyed account for around 60 per cent of Australian energy consumption. Each year, in around July–August, respondents are sent paper based surveys, requesting information on the quantity of fuels they produce and consume as well as the electricity they generated. These detailed energy statistics are integrated and reconciled with other databases and information sources. Supplementary data are collected from various sources, including:

- Australian Bureau of Statistics' international trade data
- ABARE's farm surveys database for the broadacre and dairy farm sectors
- Department of Industry Tourism and Resources' *Australian Petroleum Statistics*
- Energy Supply Association of Australia
- Geoscience Australia
- state government departments
- Australian Customs Service.

The detailed FES data on energy consumption forms the main building block on which to estimate comprehensive energy consumption by region, industry and fuel type. The consumption data are reconciled with readily available production statistics to provide a national energy balance.

ABARE's energy statistics are used by governments to assist in policy formulation, and by industry participants, academics and industry consultants. The survey is also a key element in meeting Australia's commitments to provide energy supply and demand information to international organisations such as the International Energy Agency, the World Energy Council and the Asia Pacific Economic Cooperation forum, and in developing Australia's National Greenhouse Gas Inventory.

2

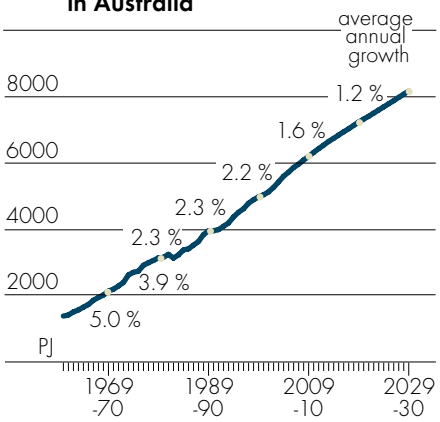
energy consumption and electricity generation outlook

In this chapter, the projections of primary energy consumption are discussed in detail, including projections by fuel, by region and by sector. Projected trends in energy intensity are also examined, followed by projections of electricity generation and a discussion of final energy consumption projections, by sector and fuel. Although the discussion focuses on national trends, key developments at the state level are also highlighted.

Detailed data on consumption, production and trade in Australian energy over the period 2004-05 to 2029-30, at the national level and for each of the states and territories, are provided in the statistical tables at the end of this report. For the projection years 2010-11 to 2029-30, the data are presented for five year periods. More detailed annual data on projected energy consumption, production and trade, are available on ABARE's web site (www.abareconomics.com).

primary energy consumption

fig 1 **primary energy consumption in Australia**



Australia's rate of growth in primary energy consumption has tended to fall over time. During the 1960s, energy use increased by an average 5.0 per cent a year (figure 1). The rate declined to 3.9 per cent a year during the 1970s largely as a result of the two major oil price shocks. During the 1980s, reflecting economic recession and sharply rising energy prices, the rate of growth fell further to average 2.3 per cent a year. Growth was maintained at this rate during the 1990s as real energy prices fell and economic growth was robust.

From 2004-05 to 2029-30 energy consumption growth is projected to continue to moderate. In the medium term – from 2004-05 to 2010-11 – Australia's primary energy consumption is projected to grow by 2.0 per cent a year, from 5593 petajoules in 2004-05 to 6311 petajoules in 2010-11 (table 8).

The growth rate of 2.0 per cent a year represents the net outcome of upward and downward pressures on energy consumption growth in the medium term. Upward pressures include the relatively strong assumed rate of GDP growth of 3.0 per cent a year from 2004-05 to 2010-11 and a continuing strong demand for energy by energy intensive industries such as iron and steel and basic nonferrous metals. In particular, the output of alumina (the main industry within the basic nonferrous metals sector) is assumed to grow at an average rate of 6.6 per cent a year between 2004-05 and 2010-11. Downward pressures include relatively high oil prices, government energy conservation measures, and autonomous energy efficiency improvements. The sensitivity of the primary energy consumption projections to assumptions on GDP growth, energy intensive industrial production and oil prices is analysed in box 3.

For the period from 2011-12 to 2029-30, primary energy consumption is projected to grow at a rate of 1.3 per cent a year on average, reflecting a lower assumed rate of GDP growth (2.5 per cent a year). Over the full period from 2004-05 to

table 8 **primary energy consumption in Australia, by fuel**

	consumption				average annual growth	
	2004-05	2010-11	2019-20	2029-30	2004-05 to 2010-11	2004-05 to 2029-30
	PJ	PJ	PJ	PJ	%	%
black coal	1 636	1 763	1 959	2 112	1.3	1.0
brown coal	688	710	756	798	0.5	0.6
oil	1 908	2 104	2 348	2 709	1.6	1.4
natural gas	1 102	1 391	1 743	2 063	4.0	2.5
renewables	260	343	423	481	4.8	2.5
– biomass	187	227	303	349	3.3	2.5
– biogas	7	39	38	37	34.1	7.1
– hydro	58	61	64	66	0.8	0.5
– solar	3	3	4	5	3.0	2.3
– wind	5	13	15	24	19.3	7.0
total	5 593	6 311	7 228	8 162	2.0	1.5

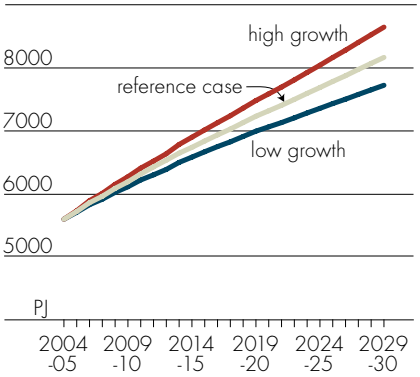
box 3 **sensitivity analysis**

In this section, the *E4cast* framework is used to explore the sensitivity of the primary energy consumption outlook to assumptions on economic growth and world oil prices. Three alternative scenarios are modeled – 'high' and 'low' economic growth scenarios, and a 'high oil price' scenario.

high and low economic growth scenarios

Primary energy consumption projections are particularly sensitive to the assumptions on economic growth. Under the 'high' and 'low' growth scenario, growth in GDP and the output of energy intensive industries is assumed to be 10 per cent higher and 10 per cent lower respectively from 2005-06 to 2029-30 than in the projections presented above (referred to as the reference case).

fig J **primary energy consumption in Australia under alternative scenarios**



Primary energy consumption under the 'high' growth scenario is 1.5 per cent (94 petajoules) higher than in the reference case in 2010-11 and 5.9 per cent (481 petajoules) higher by 2029-30 (figure J). Over the projection period, primary energy consumption is projected to grow at an average rate of 1.8 per cent a year in the 'high' growth scenario, compared with 1.5 per cent a year in the reference case. Under the 'low' growth scenario, primary energy consumption is projected to increase at an average rate of 1.3 per cent a year over the projection period. By the end of the period, primary energy use is projected to be 5.4 per cent (442 petajoules) lower in the 'low' growth scenario than in the reference case.

high oil price scenario

The outlook for world oil prices is subject to considerable uncertainty beyond the short term. The world trade weighted average oil price rose from US$41 a barrel in 2004-05 (in 2004-05 dollars) to US$55 a barrel in 2005-06. In 2006-07 world oil prices are assumed to average US$52 a barrel (in 2004-05 US dollars). Beyond this, oil prices are assumed to fall below US$40 a barrel by the early 2010s, reflecting expected increases in world oil production and an easing of

box 3 sensitivity analysis *continued*

demand in the medium term (Penm et al. 2006). However, oil prices could fall at a lower rate beyond the short term if the increase in world oil production over the medium term is slower than expected or if the currently high prices fail to moderate growth in world demand for oil. This possibility is modeled in a 'high oil price' scenario. In this scenario, world oil prices are assumed to average US$51 a barrel between 2006-07 and 2013-14, 29 per cent higher than under the standard assumptions (referred to as the reference case). From 2014-15 to 2029-30, oil prices are assumed to be the same in both scenarios, reflecting the assumption that global oil production and spare production capacity will have increased by that time.

Under the 'high oil price' scenario, oil consumption is projected to grow at a rate of 1.4 per cent a year from 2006-07 to 2013-14, compared to 1.5 per cent a year in the reference case. The change in oil consumption resulting from a change in the assumed oil price is projected to be highest in 2010-11. At this point oil consumption in the 'high oil price' case is 1.6 per cent (34 petajoules) lower than in the reference case. By 2013-14, this projected difference is only 0.8 per cent.

The relative insensitivity of the oil consumption projections to the assumed oil price reflects assumptions on the elasticity of demand for oil. This elasticity is assumed to be low for a number of reasons.

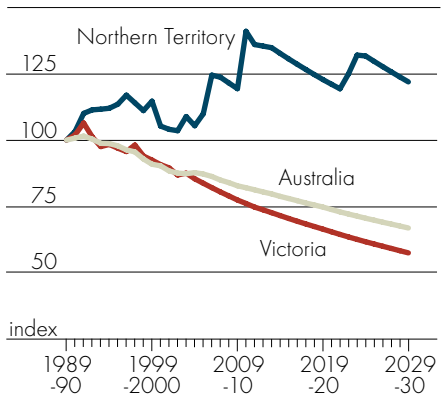
The price of oil paid by consumers does not reflect the full change in the crude oil price because of the mitigating effects of excise tax and refining and distribution costs. On the other hand, any changes in the price paid by consumers would not have a large impact on oil consumption, as most of Australia's oil is consumed as petroleum products by the transport sector, where the demand for petroleum products is relatively inelastic. No major changes in transport technology are assumed over the projection period, and the availability of alternative fuels such as biofuels is assumed to remain low relative to the supply of traditional petroleum products.

2029-30, primary energy consumption is projected to grow at an average rate of 1.5 per cent a year, to reach 8162 petajoules in 2029-30 (table 8). This represents an increase of 46 per cent over the projection period.

aggregate energy intensity trends

After remaining more or less stable during the 1970s and 1980s, Australia's aggregate energy intensity (measured as total primary energy consumption per

fig K **energy intensity trends**



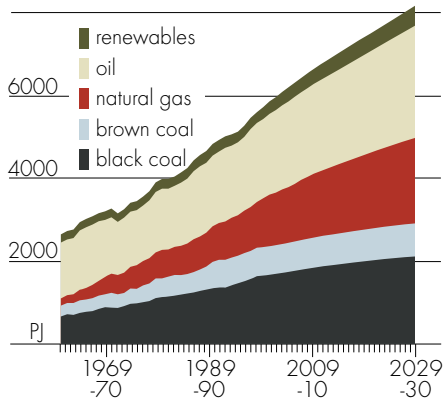
dollar of GDP) fell by an average of 1.1 per cent a year during the 1990s, and is projected to continue to decline at around this rate from 2004-05 to 2029-30.

Projected energy intensity trends vary markedly between regions (figure K). For example, the Northern Territory's aggregate energy intensity, which rose by 1.2 per cent a year during the 1990s, is projected to rise by 5.0 per cent a year from 2004-05 to 2010-11 as several large LNG and alumina projects come on stream. Beyond 2010-11, however, the territory's energy intensity is projected to fall at an average rate of 0.6 per cent a year. In Victoria, where economic growth is less dependent on major energy intensive projects, aggregate energy intensity is projected to decline by 1.6 per cent a year over the projection period.

primary energy consumption, by fuel

At the primary energy level, fossil fuels provide around 95 per cent and renewables about 5 per cent of the energy consumed in Australia. Of the fossil fuels, black and brown coals provide 41 per cent, oil 34 per cent, and gas 20 per cent of primary energy consumed (figure L). Over the long term, the respective shares of black and brown coal, and oil, are projected to fall to 36 per cent and 33 per cent, while the respective shares of gas and renewables are projected to rise to 25 per cent and 6 per cent.

fig L **primary energy consumption in Australia, by fuel**



Primary consumption of natural gas use is projected to rise by 4.0 per cent a year in the medium term and

by 2.5 per cent a year over the full outlook period, to almost double to 2063 petajoules by 2029-30 (table 8). This strong projected growth in gas consumption reflects strong expected increases in gas demand from the electricity generation, manufacturing, and mining sectors. Over the projection period, 32 per cent of the total increase in primary gas consumption is projected to be used for electricity generation and another 32 per cent for manufacturing, while mining is projected to account for 24 per cent of the increase in primary gas consumption. The incentives for industry to use gas include its increasing availability and policy initiatives such as the Queensland Government's 13 per cent gas scheme.

In contrast to the natural gas outlook, consumption of coal (both black and brown) is projected to rise relatively modestly over the outlook period – at an average rate of 0.9 per cent a year to over 2909 petajoules by 2029-30. This modest growth reflects the expected effect of a number of policy measures that encourage the substitution away from coal and into less greenhouse gas intensive fuels, including the Australian Government's Mandatory Renewable Energy Target scheme and the New South Wales Government's greenhouse gas abatement scheme.

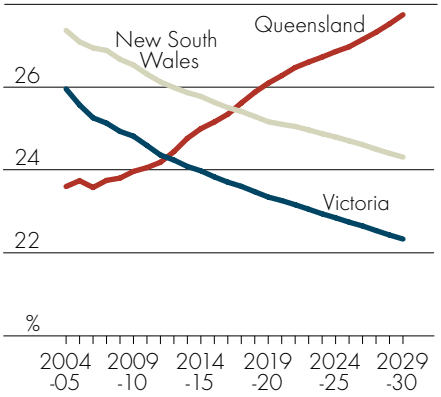
Australia's oil consumption is projected to increase by around 801 petajoules to 2709 petajoules by 2029-30, or by an average rate of 1.4 per cent a year (table 8). The increase in oil consumption reflects the continued expected growth in demand for products derived from oil for road, rail, air and sea transport.

The use of renewables is projected to increase by 85 per cent over the next 25 years to 481 petajoules, or by an average annual rate of 2.5 per cent (table 8). In the medium term to 2010-11 the use of renewables is projected to grow at an average rate of 4.8 per cent a year, primarily reflecting the effect of the Mandatory Renewable Energy Target and the New South Wales greenhouse gas abatement scheme. In particular, the use of biogas and wind energy is projected to grow strongly in the medium term (to 2010-11) – biogas at an average rate of 34 per cent a year and wind energy at a rate of 19 per cent a year.

primary energy consumption, by state

In *E_4cast*, the main drivers of energy consumption are industry activity (in the case of the energy intensive sectors), and in the case of the non energy intensive sectors, gross state product. The rate of growth in gross state product is assumed to be highest in Queensland, Western Australia and the Northern Territory

fig M **shares of primary energy consumption, selected states**



and lowest in South Australia and Tasmania. New South Wales and Victoria assumed to experience moderate rates of growth.

By region, the projections of primary energy consumption reflect these assumptions. Primary energy consumption in Western Australia is projected to rise by 82 per cent over the projection period, from 760 petajoules in 2004-05 to 1385 petajoules in 2029-30 (table 9). In Queensland primary energy consumption is projected to rise by 72 per cent, from 1319 petajoules in 2004-05 to 2265 petajoules in 2029-30. Currently the third largest primary energy consuming state, Queensland is projected to overtake Victoria in terms of total primary energy consumption in 2012-13, then New South Wales in 2017-18 to become Australia's largest consumer of primary energy (figure M).

Energy consumption in the Northern Territory is projected to grow at an average rate of 3.3 a year to 180 petajoules by 2029-30 (table 9). This high projected

table 9 **primary energy consumption in Australia, by state**

	consumption				average annual growth	
	2004-05	2010-11	2019-20	2029-30	2004-05 to 2010-11	2004-05 to 2029-30
	PJ	PJ	PJ	PJ	%	%
New South Wales [a]	1 531	1 661	1 819	1 984	1.4	1.0
Victoria	1 452	1 552	1 688	1 823	1.1	0.9
Queensland	1 319	1 518	1 886	2 265	2.4	2.2
Western Australia	760	965	1 196	1 385	4.1	2.4
South Australia	333	350	357	383	0.8	0.6
Tasmania	118	129	135	143	1.5	0.8
Northern Territory	80	137	147	180	9.3	3.3
total	5 593	6 311	7 228	8 162	2.0	1.5

a Includes the Australian Capital Territory.

growth reflects expected growth in the region's LNG export sector and the expansion of the Alcan Gove alumina refinery.

Growth in primary energy consumption in New South Wales and Victoria is projected to be relatively low. This is particularly true for Victoria where energy consumption over the outlook period is projected to grow at an average rate of 0.9 per cent a year (table 9). In Tasmania, energy consumption is projected to grow at a slightly lower rate of 0.8 per cent a year. Reflecting the modest economic growth outlook, primary energy consumption in South Australia is projected to grow by just 51 petajoules – or 15 per cent – over the entire outlook period.

Assessing these primary energy consumption projections in relation to population growth provides a greater perspective of the interstate differences in energy consumption. Australia's primary energy consumption of 5593 petajoules in 2004-05 is equivalent to energy consumption of 275 gigajoules per person at a 30 June 2005 population of 20.32 million (ABS 2006). On a regional basis, per person primary energy consumption ranged from 401 gigajoules per person in the Northern Territory and 384 gigajoules per person in Western Australia to 217 gigajoules per person in New South Wales and South Australia.

With total primary energy consumption projected to rise by 46 per cent from 2004-05 to 2029-30, primary energy consumption is projected to grow at a rate well in excess of population growth over this period. If Australia's population were to reach 25.60 million by 30 June 2030, as projected in the Australian Bureau of Statistics' population projections (ABS 2006), then the projected total primary energy consumption of 8162 petajoules for 2029-30 would be equivalent to 319 GJ of energy consumed per person in that year.

primary energy consumption, by sector

Around 45 per cent of the primary fuels consumed in Australia are used to generate electricity. Most of the remainder are used to produce energy fuels for the transport, manufacturing, mining, residential, commercial and agricultural sectors. Around 24 per cent of primary fuels are used to produce products for the transport sector (mainly oil based products), and 19 per cent for the manufacturing sector (mainly products produced from coal or gas, including coal or gas fired electricity). The generation, transport and manufacturing sectors together accounted for 4941 petajoules of the 5593 petajoules of primary energy consumed in Australia in

2004-05 (table 10). Primary energy consumption by these sectors is projected to grow by around 40 per cent to 6930 petajoules by 2029-30, 85 per cent of projected total primary consumption of 8162 petajoules in 2029-30.

Within the generation sector, the coal fired subsector is projected to remain the dominant consumer of primary energy to 2029-30, reflecting past investment in coal fired capacity, the suitability of coal for base load generation, and coal's relative low cost as a fuel for electricity generation. At the same time, the gas fired and nonhydro renewables subsectors are projected to increase their share of the electricity generation fuel mix, as government policies and increased competitiveness encourage substitution of gas and renewables for other fuels. Total primary energy consumption in the generation sector is projected to rise from 2538 petajoules in 2004-05 to 3576 petajoules in 2029-30 (table 10).

Within the transport sector, the main subsectors projected to increase their consumption of energy to 2029-30 are road and air transport. As is currently the case, this sector will remain highly dependent on fuels produced from oil. The total primary energy consumed by the transport sector in aggregate is projected to increase from 1346 petajoules in 2004-05 to 1871 petajoules in 2029-30 (table 10).

table 10 **primary energy consumption in Australia, by sector**

	consumption				average annual growth	
	2004-05	2010-11	2019-20	2029-30	2004-05 to 2010-11	2004-05 to 2029-30
	PJ	PJ	PJ	PJ	%	%
agriculture	92	101	111	122	1.5	1.1
mining	214	299	472	628	5.8	4.4
manufacturing and construction	1 056	1 232	1 359	1 483	2.6	1.4
– petroleum refining	148	163	181	199	1.6	1.2
electricity generation	2 538	2 819	3 209	3 576	1.8	1.4
transport and storage	1 346	1 473	1 646	1 871	1.5	1.3
commercial and services	65	77	89	104	2.7	1.9
residential	211	237	265	298	2.0	1.4
other **a**	69	73	77	81	0.9	0.7
total	5 593	6 311	7 228	8 162	2.0	1.5

a Includes solvents, lubricants, greases and bitumen.

Within the manufacturing sector, the main subsectors projected to increase their consumption of energy significantly are basic chemicals and other basic nonferrous metals. Moderate increases are also projected in all other manufacturing subsectors. Overall, the total primary energy equivalent of all fuels consumed by Australia's manufacturing sector is projected to rise from 1056 petajoules in 2004-05 to 1483 petajoules in 2029-30 (table 10).

Mining is the only sector projected to greatly alter its share of total primary energy consumption over the projection period, with mining's share of primary energy consumption projected to rise from 4 per cent in 2004-05 to 8 per cent in 2029-30. The projected increase in share reflects the large number of energy intensive mining projects assumed to come on stream between 2004-05 and 2029-30.

electricity generation, by fuel

Reflecting projected continuing strong demand for electricity in Australia, gross electricity output is projected to rise from 252 TWh (907 petajoules) in 2004-05 to 408 TWh (1468 petajoules) in 2029-30 (table 11). This represents an increase of 62 per cent over the projection period and an average rate of growth of 1.9 per cent a year.

table 11 **electricity generation in Australia, by fuel**

	generation				average annual growth	
	2004-05	2010-11	2019-20	2029-30	2004-05 to 2010-11	2004-05 to 2029-30
	TWh	TWh	TWh	TWh	%	%
black coal	141	154	180	207	1.5	1.5
brown coal	53	56	64	72	1.1	1.3
oil	4	4	4	4	0.8	0.3
natural gas	36	48	66	92	5.1	3.8
renewables	19	24	28	33	4.4	2.3
hydroelectricity	16	17	18	18	0.8	0.5
biomass	1	2	4	5	11.7	7.3
biogas	0	2	2	2	35.5	8.2
wind energy	1	4	4	7	19.3	7.0
total	252	287	342	408	2.2	1.9

Little change is projected in the relative shares of electricity generated from fossil fuels or renewables over the projection period. In 2004-05, 93 per cent of electricity was generated from fossil fuels (coal, oil and gas), and 7 per cent from renewables such as hydro, wind, biomass and biogas. The main projected change in the sector's fuel mix is an increase in the share of electricity generated from gas from 14 per cent in 2004-05 to 23 per cent in 2029-30. A corresponding decrease is projected in the share of electricity generated from coal (both black and brown) from 77 per cent in 2004-05 to 68 per cent in 2029-30. The share of renewables is projected to increase slightly, to 8 per cent by the end of the projection period.

Electricity generation from black coal is projected to grow by around 66 TWh over the projection period to 2029-30. In contrast, generation from natural gas in Australia is forecast to grow strongly, almost tripling to 92 TWh by 2029-30 (table 11). Growth in gas fired electricity generation is projected to be particularly strong in the medium term, largely reflecting investment in peak capacity and the impact of a number of policy initiatives, such as the New South Wales greenhouse gas abatement scheme and the Queensland 13 per cent gas policy.

The impact of the Queensland scheme is apparent in the projections for gas fired electricity generation in the state (table 12). Electricity generation from gas in Queensland is projected to increase by more than 50 per cent in the medium term to 2010-11. This expansion in the state's gas fired electricity includes, among other projects, Origin's 1000 MW Spring Gully plant at Durham Downs. The combined

table 12 **gas fired electricity generation in Australia, by state**

	generation				average annual growth	
	2004-05	2010-11	2019-20	2029-30	2004-05 to 2010-11	2004-05 to 2029-30
	TWh	TWh	TWh	TWh	%	%
New South Wales [a]	2	3	5	7	5.9	4.7
Victoria	3	4	7	10	5.6	4.6
Queensland	6	9	13	21	7.2	5.3
Western Australia	15	21	28	38	5.1	3.6
South Australia	6	7	8	10	1.9	1.8
Tasmania	1	1	1	1	2.2	2.3
Northern Territory	2	3	4	5	6.8	3.5
total	36	48	66	92	5	3.8

a Includes the Australian Capital Territory.

cycle gas plant is proposed to commence production in 2008-09 (ESAA 2006). This strong growth in gas generation is projected to moderate over the longer term, with growth in gas fired electricity generation in Queensland averaging 4.8 per cent a year from 2011-12 to 2029-30 (compared with 7.2 per cent a year over the medium term).

The New South Wales greenhouse gas abatement scheme is expected to provide economic incentives for investment in gas fired electricity in that state. The scheme's effect on the establishment of new infrastructure is expected to continue throughout the projection period, even if the scheme is not extended beyond 2012. Reflecting the impact of the scheme and growth in peak electricity demand, gas fired electricity in the state is projected to grow by 4.7 per cent a year over the projection period to 7.4 TWh in 2029-30 (table 12).

The use of gas for electricity generation in other states is also expected to increase. In Western Australia, gas fired electricity generation is projected to grow at an average rate of 3.6 per cent a year, accounting for 76 per cent of the projected expansion in the state's electricity generation over the projection period. Another 19 per cent of the increase in Western Australia's electricity generation is accounted for by coal fired power, projected to grow at an average rate of 1.8 per cent a year over the period. In the Northern Territory, almost all the growth in electricity generation is projected to be sourced from gas fired electricity plants. Gas fired electricity generation in the territory is projected to grow by an average 3.5 per cent a year (table 12).

The use of natural gas in the electricity generation sector commenced in Tasmania in 2002-03 after the completion of the gas pipeline from Victoria to Tasmania and the conversion of existing oil fired generating facilities at Bell Bay Tasmania to natural gas. Over the entire projection period the use of natural gas in the electricity generation sector in Tasmania is expected to increase by 75 per cent, providing approximately 1.3 TWh of electricity by 2029-30 (table 12).

Wind and biomass (mainly bagasse, woodwaste and bagasse cofired with woodwaste) energy are projected to account for the majority of the increase in electricity generation from renewable sources over the projection period. This expansion in nonhydro renewables reflects falling investment costs and rising availability factors. Around 97 per cent (or 5.4 TWh) of the estimated growth in wind energy over the projection period is projected to occur in Victoria, South Australia, Western Australia and Tasmania. More than 80 per cent of the projected growth in the use of biomass for electricity generation is projected to occur in Queensland alone.

Hydroelectricity generation is projected to grow only modestly over the outlook period, reflecting the limited availability of suitable locations for the expansion of large grid based hydroelectricity generation. Most of the projected expansion in capacity is expected to occur as existing equipment is upgraded.

Total fuel input for electricity generation is projected to rise from 2538 petajoules in 2004-05 to 3576 petajoules in 2029-30. Of this, the input of fossil fuels is projected to rise from 2438 petajoules in 2004-05 to 3308 petajoules in 2029-30, while the energy equivalent of the input from renewables is projected to rise from 100 petajoules to 268 petajoules. The average thermal efficiency for electricity generated from fossil fuels overall is projected to rise from 34 per cent in 2004-05 to 41 per cent in 2029-30. Increases in efficiency are projected for all fuels. For example, the thermal efficiency of black coal fired generation is projected to rise from 38 per cent in 2004-05 to 41 per cent in 2029-30, while the thermal efficiency of gas fired generation is projected to rise from 36 per cent to 50 per cent in 2029-30.

final energy consumption, by sector

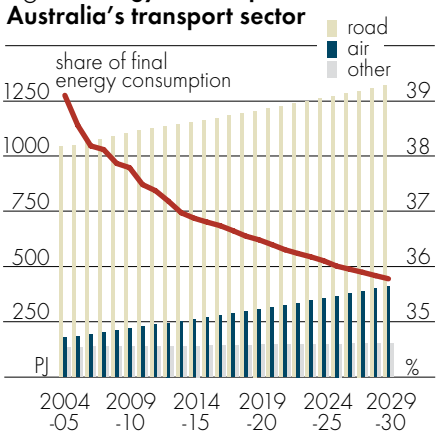
Transport and manufacturing are the two largest consumers of final energy, followed by residential, commercial and mining. Transport and manufacturing together account for 70 per cent of consumption, while residential accounts for 12 per cent, and commercial for 7 per cent. Mining is the only sector projected to greatly alter its share of total final energy consumption over the projection period – from 5 per cent of total final energy consumption in 2004-05 to 10 per cent in 2029-30, for the reasons already discussed in the primary energy consumption section.

Overall, final energy consumption is projected to increase from 3464 petajoules in 2004-05 to 5261 petajoules in 2029-30, a rise of 52 per cent over the projection period and an average annual rate of increase of 1.7 per cent a year (table 13).

Growing at an average rate of 1.3 per cent a year over the projection period, the transport sector is projected to account for 29 per cent (or 528 petajoules) of the total projected increase in final energy consumption. However, the share of the transport sector in total energy consumption is projected to decline over the period, from nearly 39 per cent in 2004-05 to 36 per cent by 2029-30 (figure N), with a corresponding increase in the share of mining.

Energy use in the transport sector is forecast to grow relatively strongly in Queensland (2.0 per cent) and Western Australia (2.1 per cent), tracking closely the assumed growth in gross state product in both states. In contrast, transport sector energy use in South Australia is forecast to grow only modestly – by 0.1 per cent a year – over the projection period, again reflecting modest economic growth prospects for that state. Energy use in the transport sectors of Victoria and New South Wales are expected to grow close to the national average, with a growth rate of 1.0 per cent a year in both states.

fig N **energy consumption in Australia's transport sector**



Road transport is the largest energy consuming sector within the transport sector (figure N). In 2004-05, road transport accounted for around 77 per cent of the energy used in the sector. With a share of 62 per cent in 2004-05, passenger motor vehicles were in turn the largest energy consuming sector within the road

table 13 **final energy consumption in Australia, by sector**

	consumption				average annual growth	
	2004-05	2010-11	2019-20	2029-30	2004-05 to 2010-11	2004-05 to 2029-30
	PJ	PJ	PJ	PJ	%	%
agriculture	99	108	118	130	1.4	1.1
mining	178	240	348	514	5.1	4.3
manufacturing	1 089	1 275	1 425	1 572	2.7	1.5
transport	1 354	1 482	1 655	1 882	1.5	1.3
commercial and services	243	292	361	450	3.1	2.5
residential	432	484	552	631	1.9	1.5
other **a**	69	73	77	81	0.9	0.7
total	3 464	3 953	4 537	5 261	2.2	1.7

a Includes solvents, lubricants, greases and bitumen.

transport sector. Energy use in the road transport sector is projected to grow by 0.9 per cent a year over the projection period. This growth is driven largely by energy use in the other road transport sector (mainly road freight), which is projected to grow at an average rate of 2.2 per cent a year.

Energy use in the air transport sector (both domestic and international) is projected to grow strongly over the outlook period, reflecting strong growth in private passenger demand for air transport. With a long term growth rate of 3.4 per cent a year, energy use in the air transport sector over the next 25 years is projected to more than double to 412 petajoules (figure N), accounting for almost a quarter of the transport sector's use of petroleum products in 2029-30. As a result of the strong growth in the air transport sector's energy use, the sector's share in total transport sector energy use is projected to increase steadily over the projection period.

energy consumption in other end use sectors

The outlook for gas is a key driver of total projected energy use, particularly the outlook for gas within the manufacturing sector. The main gas consumer within manufacturing is the basic nonferrous metals sector. This sector accounts for 43 per cent of the projected increase in manufacturing sector energy use over the projection period. Of this increase (206 petajoules), 62 per cent is accounted for by growth in gas use. There is, however, a significant difference in the outlook for the two major components of the basic nonferrous metals sector, alumina and aluminium.

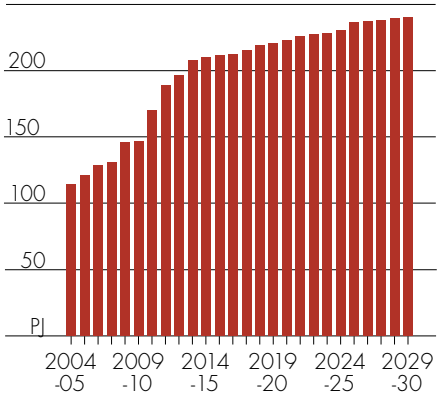
The alumina industry is the main component of the other basic nonferrous metals sector. Reflecting an assumed 102 per cent expansion in alumina production, energy consumption in the other basic nonferrous metals sector is projected to increase by 72 per cent to 476 petajoules by 2029-30 (table 14), accounting for 41 per cent of the increase in energy consumption in the manufacturing sector over the projection period. High project development activity in the alumina industry is assumed over the medium term in particular, and this is reflected in the other basic nonferrous metals sector's energy consumption. The sector's energy use is projected to grow at a rate of 4.5 per cent a year from 2004-05 to 2010-11. Almost 63 per cent of the increase in energy use over the outlook period in the sector is accounted for by gas use, which is projected to increase from 114 petajoules in 2004-05 to 240 petajoules by 2029-30 (figure O).

Energy consumption in the aluminium smelting industry is projected to increase by 6.8 petajoules to 128 petajoules in 2029-30 (table 14), reflecting relatively modest growth in the production of primary aluminium over the period. Electricity is

projected to continue to dominate the aluminium sector fuel mix over the projection period.

The projected growth in energy consumption in the iron and steel industry is also modest. Energy consumption in the industry is projected to grow at an average rate of 1.0 per cent a year over the projection period, to 115 petajoules by 2029-30 (table 14). The use of gas in the iron and steel industry is projected to grow modestly from 25 petajoules in 2004-05 to 27 petajoules in 2029-30.

fig ○ **gas consumption in Australia's other basic nonferrous metals sector**



Energy consumption in the basic chemicals sector is projected to increase by 115 petajoules over the projection period to 304 petajoules (table 14), accounting for 19 per cent of total energy consumption in the manufacturing sector in 2029-30. Energy consumption growth in this sector is projected to be the highest in Western

table 14 **final energy consumption, by manufacturing subsector**

	consumption				average annual growth	
	2004-05	2010-11	2019-20	2029-30	2004-05 to 2010-11	2004-05 to 2029-30
	PJ	PJ	PJ	PJ	%	%
wood, paper and printing	64	70	79	89	1.6	1.3
basic chemicals	189	232	264	304	3.5	1.9
iron and steel	90	109	112	115	3.1	1.0
.....*of which* natural gas	25	27	27	27	1.3	0.3
basic nonferrous metals	399	484	553	604	3.3	1.7
.....*of which* natural gas	120	177	227	246	6.7	2.9
aluminium smelting	121	122	125	128	0.1	0.2
other basic nonferrous metals	277	361	429	476	4.5	2.2
nonmetallic mineral products	111	121	132	145	1.5	1.1
other manufacturing **a**	236	258	285	315	1.5	1.2
total manufacturing	1 089	1 275	1 425	1 572	2.7	1.5

a includes construction.

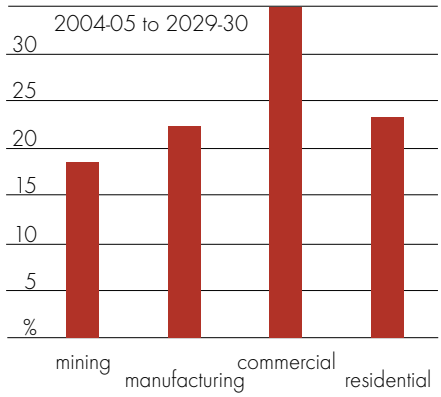
Australia, with an average growth rate of 5.3 per cent a year, followed by Queensland where energy consumption in the basic chemicals sector is projected to grow at a rate of 2.9 per cent a year.

Wood, paper and printing is a relatively small energy consumer and is concentrated in three states. New South Wales, Victoria and Tasmania accounted for 77 per cent of the sector's total energy use in 2004-05. Over the outlook period, energy consumption in the sector is projected to grow at an average rate of 1.3 per cent a year, reaching 89 petajoules by 2029-30 (table 14).

In 2004-05, nonmetallic mineral products manufacturing accounted for 10 per cent of the manufacturing sector's total energy consumption. Gas and coal dominate the sector's fuel mix; in 2004-05 gas and coal had a combined share of nearly 80 per cent of the sector's energy use. Between 2004-05 and 2029-30, energy use in the sector is projected to increase by 34 petajoules, 86 per cent of which is accounted for by gas. As a result, the share of gas in the sector's fuel mix is projected to increase from 52 per cent in 2004-05 to 60 per cent in 2029-30.

In 2004-05, the commercial and services sector accounted for around 7 per cent of total final energy consumption. The sector is particularly electricity intensive and is expected to be a major source of growth in electricity consumption over the medium to longer term. Over the projection period, commercial sector energy use is projected to grow by 2.5 per cent a year (table 13), with electricity consumption in the sector growing at a slightly faster rate of 2.7 per cent a year. In 2004-05, the commercial sector accounted for almost a quarter of total electricity consumption and is projected to account for around 35 per cent of the increase in electricity use over the projection period (figure P). This compares with a share of 23 per cent of the projected increase for the residential sector's electricity use and a share of 22 per cent for the manufacturing sector.

fig P **contribution to electricity consumption growth in Australia**



Final energy use in the residential sector was 432 petajoules in 2004-05, representing approximately 12 per cent of total final energy consumption. Over the projection period, the residential

sector's energy use is projected to increase at a rate of 1.5 per cent a year to around 631 petajoules (table 13). Electricity accounted for 51 per cent of residential sector energy demand in 2004-05 and gas accounted for 31 per cent. These shares are projected to increase over the period to 53 per cent and 33 per cent by 2029-30 for electricity and gas respectively.

final energy consumption, by fuel

The main final energy fuels are refined petroleum products, electricity and gas (table 15). In 2004-05, refined petroleum products accounted for 50 per cent of final energy consumption, electricity for 23 per cent, and gas for 18 per cent. The final end use fuel mix will continue to be dominated by petroleum products, with its share of final energy consumption in 2029-30 projected at 47 per cent. The substitution away from petroleum products toward gas is projected to continue throughout the projection period, although this substitution is projected to occur at a faster rate in the medium term than over the longer term. New growth in the use of natural gas is expected, with developments in the chemical, rubber and plastic products and basic nonferrous metals industries being the principal driving forces, particularly in Queensland, Western Australia and the Northern Territory. The share of natural gas in final energy consumption is projected to increase to 21 per cent, while the share of electricity is projected to increase to 24 per cent.

table 15 **final energy consumption in Australia, by fuel**

	consumption				average annual growth	
	2004-05	2010-11	2019-20	2029-30	2004-05 to 2010-11	2004-05 to 2029-30
	PJ	PJ	PJ	PJ	%	%
black coal	162	182	189	189	1.9	0.6
LPG	96	118	137	175	3.5	2.4
other petroleum products	1 640	1 801	2 010	2 318	1.6	1.4
gas	625	788	948	1 101	3.9	2.3
biomass	157	171	189	209	1.4	1.1
electricity	781	890	1 060	1 265	2.2	1.9
solar	3	3	4	5	3.0	2.3
total	3 464	3 953	4 537	5 261	2.2	1.7

3

energy production and trade outlook

Excluding uranium, which is not used domestically as an energy fuel, the main energy fuels produced in Australia are coal, oil, gas and renewables. With the exception of crude oil and refined petroleum products, Australia is a net exporter of energy commodities, notably of black coal. In 2004-05, in energy terms, production of black and brown coal was 8791 petajoules, or 74 per cent of total energy fuel production. In physical terms, black coal production was 284 million tonnes and brown coal production, 71 million tonnes. Natural gas accounted for 14 per cent of energy fuel production, followed by crude oil and naturally occurring LPG (10 per cent) and renewables (hydroelectricity, wind, biomass, biogas and solar) at 2 per cent.

Total production of energy fuels is projected to rise from 11 868 petajoules in 2004-05 to 22 350 petajoules in 2029-30 (table 16). This represents a rise of 88 per cent over the projection period and an average rate of increase of 2.6 per cent a year. The main projected change in production shares concerns gas, oil

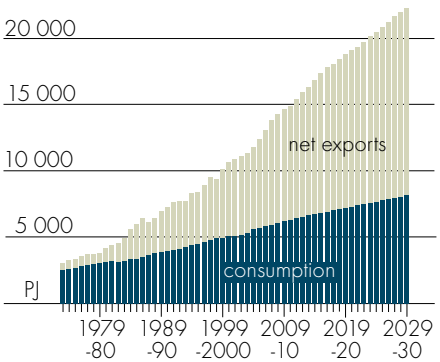
table 16 **energy production in Australia**

	production				average annual growth	
	2004-05	2010-11	2019-20	2029-30	2004-05 to 2010-11	2004-05 to 2029-30
	PJ	PJ	PJ	PJ	%	%
black coal	8 105	10175	11 875	14 390	3.9	2.3
brown coal	686	708	754	796	0.5	0.6
crude oil **a**	1 011	1 074	1 139	1 078	1.0	0.3
LPG **b**	123	142	228	262	2.4	3.1
natural gas	1 685	2 458	4 480	5 343	6.5	4.7
hydro electricity	58	61	64	66	0.8	0.5
wind energy	5	13	15	24	19.2	7.0
biomass	187	227	303	349	3.3	2.5
biogas	7	39	38	37	34.1	7.1
solar energy	3	3	4	5	3.0	2.3
total	11 868	14 899	18 899	22 350	3.9	2.6

a Includes condensate. **b** Naturally occurring LPG.

and coal. Gas production is projected to rise from 1685 petajoules (42 121 gigalitres) in 2004-05 to 5343 petajoules (133 578 gigalitres) in 2029-30, increasing its share in total energy fuels production to 24 per cent by 2029-30. At the same time, the relative share of crude oil and naturally occurring LPG is projected to fall to 6 per cent of total energy fuels production, and coal to 68 per cent.

fig Q **energy production and trade in Australia**

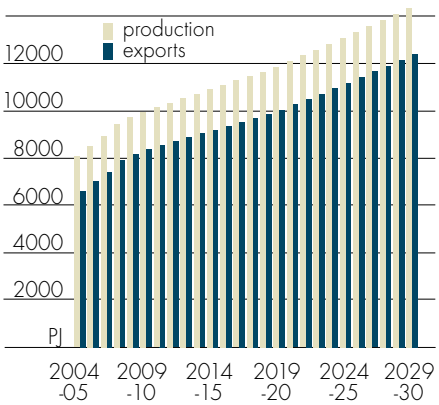


As the projected increase in nonuranium energy fuels production exceeds the projected rise in primary energy consumption, Australia's exportable surplus of energy fuels is projected to rise as a proportion of consumption to 2029-30. Conversely, Australia's primary energy consumption represented 47 per cent of nonuranium energy fuel production in 2004-05, and this proportion is projected to fall to 37 per cent in 2029-30 (figure Q).

black coal production and exports

Black coal is projected to remain Australia's dominant fossil fuel export over the projection period. In 2004-05, 81 per cent of Australian black coal (in terms of energy produced) was exported. Black coal exports are projected to rise by 88 per cent between 2004-05 and 2029-30, from 6591 petajoules (231 million tonnes) to 12 393 petajoules (435 million tonnes) (table 17; figure R). Australian thermal coal exports are forecast to increase by 7.4 million tonnes to 115 million tonnes by 2006-07, supported by a number of coal

fig R **black coal in Australia**



infrastructure developments currently under construction. Australia's metallurgical coal exports are forecast to grow by around 17 per cent to 146 million tonnes over the same period, driven by strong demand, particularly from China and India (Fairhead et al 2006).

Over the medium term, Australia's total coal exports are projected to grow at an average rate of 4.4 per cent a year, reaching 300 million tonnes by 2010-11. Beyond the medium term (between 2011-12 and 2029-30), coal exports are projected to increase by a further 50 per cent to 438 million tonnes in 2029-30.

This coal outlook incorporates new developments proposed for both the metallurgical and thermal coal sectors that are expected to expand production considerably over the projection period. Major thermal coal projects include Rio Tinto's 12 million tonne a year Clermont project in Queensland, Centennial Coal's 10.5 million tonne a year Anvil Hill mine in New South Wales and Ensham Resources' 8 million tonne a year Ensham Central project in Queensland. Metallurgical coal projects include the Belvedere coking coal mine in Queensland, with a capacity of 12 million tonnes a year, and the BHP Mitusi Alliance (BMA) Goonyella project in Queensland, with a capacity of 7 million tonnes a year (Haine et al. 2006).

table 17 **net trade in energy in Australia**

	net exports				net imports
	black coal	LPG	other petroleum products	LNG	of crude oil and ORF
	PJ	PJ	PJ	PJ	PJ
2004-05	6 591	51	-304	576	397
2010-11	8 532	49	-293	1 061	523
2014-15	9 197	87	-261	1 948	495
2019-20	10 034	118	-313	2 856	667
2024-25	11 178	118	-376	3 204	814
2029-30	12 393	117	-450	3 650	919
annual growth rate	%	%	%	%	%
2004-05 to 2010-11	4.4	- 0.4	- 0.6	10.7	4.7
2004-05 to 2029-30	2.6	3.4	1.6	7.7	3.4

Major additions to Australian coal export infrastructure are under way to support the planned increase in mine output. The most significant of these developments is expected at the Newcastle port coal terminal, where capacity is being expanded from 89 million tonnes a year to 105 million tonnes a year by early 2007. In Queensland the port of Gladstone coal terminal is being expanded to around 78 million tonnes a year by late 2007. The Blackwater and Goonyella rail systems will be upgraded to support increased coal exports through Gladstone. Capacity at the BMA Hay Point coal terminal in Queensland is also expected to increase to 44 million tonnes a year by early 2007. Capacity at the Dalrymple Bay coal terminal near Mackay in Queensland will increase to 68 million tonnes, in late 2007, in the project's first phase, and to 85 million tonnes by late 2008 in phases 2 and 3 of the project (Haine et al. 2006).

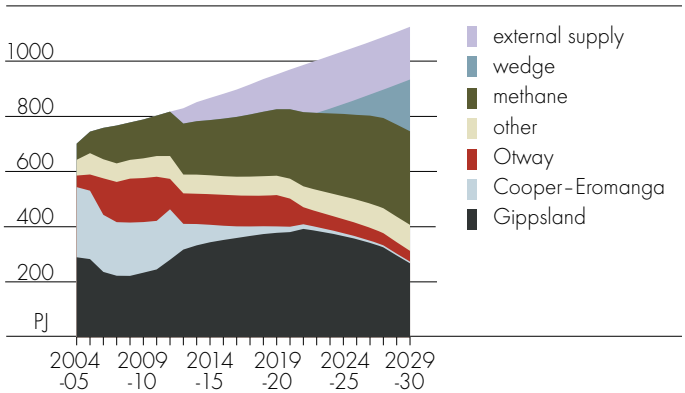
The positive outlook for exports is projected to drive an increase in black coal production of 78 per cent over the outlook period, reaching 14390 petajoules by 2029-30 (table 16). Black coal will continue to dominate Australia's energy exports (in energy content terms, excluding uranium), although LNG exports are also projected to increase strongly, as is discussed below.

natural gas production and LNG exports

In 2004-05, total gross output of natural gas in Australia was 1685 petajoules (table 16. Of this, 701 petajoules or 42 per cent was sourced from basins in the eastern states. The two largest producing basins in the eastern states, Gippsland and Cooper Eromanga, provided a total of 544 petajoules of gas or 78 per cent of the eastern gas supply. Production from Gippsland basin, which was the largest in 2004-05 with 290 petajoules, is projected to peak in 2021-22 with 392 petajoules and decline thereafter by an average 4.7 per cent a year (figure S). Production from the Cooper Eromanga basin was 254 petajoules in 2004-05 and is projected to decline to 183 petajoules in 2011-12. After this, production from Cooper Eromanga is projected to decline sharply for the rest of the outlook period, averaging a rate of decline of over 17 per cent a year.

The decline in the two largest producing basins in the eastern states is partially compensated for by growing supplies from the Otway basin and coal seam gas (CSG). Gas production from Otway, a relatively new and promising gas province, is projected to increase from 42 petajoules in 2004-05 to a peak of 160 petajoules in 2011-12 and settle around 110 petajoules from 2011-12 to

fig S **gas supply structure in eastern Australia**



2019-20. After this, production from Otway is projected to fall to around 40 petajoules by the end of the projection period. With current production of about 49 petajoules, CSG already accounts for more than 60 per cent of the Queensland gas market. Reflecting in part major supply contracts, the production of CSG in Queensland and New South Wales is projected to increase from 58 petajoules in 2004-05 to 146 petajoules by 2010-11, accounting for about 18 per cent of the entire eastern Australian gas market. Over the entire outlook period, CSG production is projected to reach 339 petajoules by 2029-30.

Total gas supply in the eastern Australian market is projected to increase more modestly than CSG production, by around 60 per cent over the 25 year projection period. This is a result of the offsetting effect of falling gas supplies from the mature Cooper–Eromanga basin and eventually from Bass Strait. Indeed, from 2012-13, gas demand in the eastern market is projected to outstrip local supply, providing an opportunity for supplies from outside the region to enter the market. By 2029-30, this market is projected to have grown to around 1124 petajoules.

In 2012-13, production from such an external supply source is assumed to commence with 56 petajoules and is projected to grow by at least 13 per cent a year over the subsequent decade to reach 190 petajoules in 2022-23. Production is projected to continue at least at this level for the rest of the projection period. For the period after 2022-23, the gas supply sourced externally and that sourced from CSG are considered minimum levels. These two combined minimum levels of supply are insufficient to meet the gas demand gap in the eastern region. There is a further 17 petajoules in 2023-24, growing to 187 petajoules in 2029-30, which

would be required in order to fully meet demand (as indicated by the grey area in figure S). This additional demand could conceivably be sourced from either the external supply or from CSG.

Production of gas in Western Australia and the Northern Territory is projected to increase from 984 petajoules in 2004-05 to 4280 petajoules by 2029-30, growing at an average rate of 6.4 per cent a year. About 93 per cent of the additional gas production in the two regions is accounted for by assumed developments in the LNG sector.

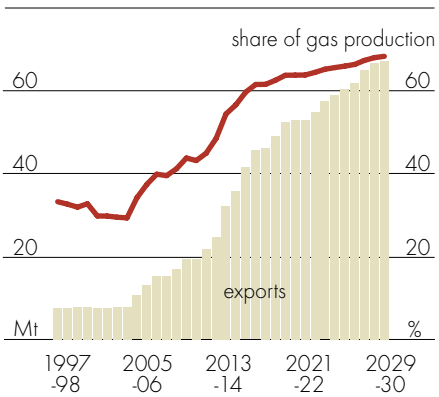
LNG exports

Australian LNG exports are expected to increase significantly in the short to medium term, supported by growth in existing markets and new regional markets, such as China and the north American west coast. Australia currently has two LNG export projects, the North West Shelf, with annual supply capacity of around 11.7 million tonnes from four trains and the Darwin LNG project with a capacity of 3.24 million tonnes a year. The Darwin project and a fifth train in the North West Shelf are expected to be the main contributors to LNG export growth over the medium term. LNG exports are forecast to rise to around 20 million tonnes by 2010-11.

The Darwin LNG plant began production in February 2006 and will supply LNG to Japan for the next seventeen years. Site work on the 4.2 million tonne a year North West Shelf fifth train started in July 2005 and exports from the project are scheduled to commence in late 2008.

LNG is projected to be Australia's fastest growing energy export over the outlook period, growing at an average rate of 7.7 per cent a year (table 17). By 2029-30, LNG exports are projected to reach 67 million tones (figure T). Several projects that are currently in the planning phase have been included in these projections. The Gorgon LNG, Pluto, Pilbara LNG and Browse projects are assumed to go ahead, as well as possible additional trains at the North West Shelf and Gorgon.

fig T **Australia's LNG exports**



The Gorgon LNG project on Barrow Island in Western Australia moved to the front end engineering development (FEED) phase in July 2005 and a final investment decision on the $11 to $15 billion project is expected in early 2007. Production is planned to commence in 2010, with a capacity of 10 million tonnes a year.

Total domestic gas production is projected to grow strongly, at an average rate of 4.7 per cent a year. Nevertheless, LNG production is projected to increase its share in total domestic gas production, from 34 per cent in 2004-05 to 68 per cent by 2029-30. The mining sector's use of natural gas will be largely driven by the strong projected growth in LNG production. Consumption of natural gas in the mining sector is projected to increase from 133 petajoules in 2004-05 to 363 petajoules by 2029-30, growing at an average rate of 4.1 per cent a year. The great majority of this increase is projected to occur in Western Australia, with a share of 73 per cent, and another 18 per cent of the increase is projected to occur in the Northern Territory.

petroleum refining and oil production

The outlook for domestic oil production and the outlook for the end use consumption of petroleum products are key drivers of Australia's demand for imported liquid fuels. Domestic oil production is largely driven by world oil prices and the impact these have on exploration activity, in addition to geological factors.

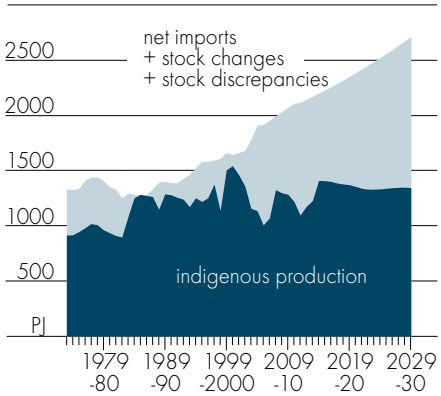
ABARE currently forecasts real oil prices in the short term to remain at around the high levels experienced in 2005-06. In 2005-06, real oil prices (in world trade weighted terms) averaged US$55 a barrel, up from US$41 a barrel in 2004-05. The world trade weighted oil price is forecast to be US$52 a barrel (in 2004-05 US dollars) in 2006-07 (Penm et al. 2006). Beyond the medium term, ABARE projects oil prices to fall to below US$40 a barrel and to remain at around this level for the rest of the projection period.

In 2004-05, domestic production of oil and naturally occurring LPG represented 59 per cent of Australia's total liquid fuels consumption (figure U). This is forecast to increase to nearly 66 per cent in 2007-08, as new projects reach full production, including Woodside's Enfield project, which began production in July 2006 and is expected to produce an extra 100 000 barrels a day at full capacity. The majority of Enfield's production is expected to be exported, however, since the development is located in the Carnarvon Basin, close to Asian markets and remote from the regions of high demand in Australia.

A large part of current Australian oil production is sourced from mature oil and gas provinces. The latest available estimates of oil reserves for the Bonaparte, Browse, Carnarvon and Gippsland basins are 587 gigalitres at the 95 per cent level of probability (Geoscience Australia 2005). However, many prospective areas offshore are yet to be fully explored. Australia has about 40 offshore basins that exhibit signs of hydrocarbon potential and around half of them have not been explored (Australian Government 2004).

ABARE bases its estimate of Australia's long term undiscovered resources partly on a 2000 study by the US Geological Survey (USGS) of world long term ultimate undiscovered potential oil resources. Using a 1995 data set, the USGS assessed potential undiscovered oil resources in the Bonaparte, Browse, Carnarvon and Gippsland Basins to be 1758 gigalitres at a 50 per cent level of probability, and 530 gigalitres at a 95 per cent level of probability.

fig U **Australia's oil and LPG production and net imports**



Taking account of the resources that have been discovered in these basins since the US study, the ultimate undiscovered potential in these four basins is reduced to 1423 gigalitres at a 50 per cent level of probability, and 195 gigalitres at a 95 per cent level of probability. At the 95 per cent level of probability, the ultimate remaining oil resources (identified, inferred and undiscovered) for the four basins are estimated by ABARE to be 782 gigalitres. In *E_4cast*, suppliers develop a small proportion of this resource base every year in response to price signals, and bring that production to the market, resulting in a projected long term level of indigenous production of crude oil and condensate of around 1078 petajoules by 2029-30 (table 16).

Reflecting the current estimates of reserves, after reaching a peak in 2007-08, Australian oil production is projected to fall by 0.3 per cent a year over the rest of the projection period. Domestic production of naturally occurring LPG is projected to increase at a rate of 3.1 per cent a year, reaching 142 petajoules by 2010-11 and 262 petajoules by 2029-30 (table 16).

The combined production of oil and naturally occurring LPG in Australia is forecast to increase only modestly over the outlook period, from 1133 petajoules in 2004-05 to 1340 petajoules in 2029-30. Consumption of liquid fuels, on the other hand, is projected to grow more strongly from 1908 petajoules in 2004-05 to 2709 petajoules by 2029-30. As a result, Australia's self sufficiency in oil and naturally occurring LPG is projected to fall from 59 per cent to 49 per cent over the outlook period (figure U).

The demand for liquid fuel imports is not only determined by domestic production and end use consumption of petroleum products, but also by domestic petroleum refining capacity. For a given domestic production and consumption outlook, petroleum refining capacity constraints will result in lower oil imports and, simultaneously, higher imports of refined products.

The refining industry also uses petroleum products as an energy input to convert oil feedstock into a range of petroleum products. Around 6.0 per cent of gross refinery output is used on site in the conversion process, in addition to small quantities of natural gas and electricity.

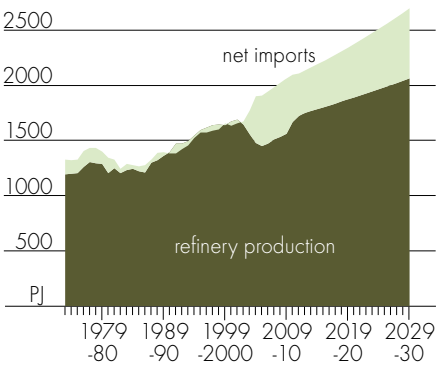
Gross refinery output in Australia, including that of petrochemicals, is projected to increase from 1482 petajoules in 2004-05 to 1670 petajoules in 2010-11, growing at an average rate of 2.0 per cent a year.

To achieve this increase, new investment in refining capacity will need to occur in the medium term, reflecting a consistent increase in the domestic consumption of petroleum products and an improvement in the economics of petroleum refining in Australia. In the projections, this new investment is assumed to occur around the period 2010-11 to 2012-13, when a 5 per cent increase in capacity is assumed. Combined with an assumed 1.0 per cent a year growth in overall refinery output through efficiency improvements, this would result in a projected average rate of growth in refinery output of 2.0 per cent a year over the whole projection period, together with a temporary fall in imports of refined petroleum products as the new capacity comes on stream.

Refining capacity and refinery output are assumed to continue to increase by about 1.0 per cent a year beyond 2012-13. Refinery output is projected to increase to 2066 petajoules by 2029-30, representing a 39 per cent increase over the projection period. However, this increase in output is outstripped by the increase in petroleum consumption, which is projected to be 42 per cent over the same period. Consequently, the share of domestic production of refined petroleum

products in liquid fuels consumption is projected to decrease from 78 per cent to 76 per cent over the outlook period (figure V). If it were assumed that new refinery capacity did not come on stream in the medium term, Australia's self sufficiency in refined petroleum products could fall to around 70 per cent by 2029-30.

fig V **Australia's petroleum products production and net imports**



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conclusion

Australia's primary energy consumption is projected to grow by an average 1.5 per cent a year from 2004-05 to 2029-30, with stronger growth forecast over the medium term to 2010-11. National energy consumption growth is projected to largely reflect energy consumption trends in Queensland, Western Australia and the Northern Territory. These trends will depend on growth in gross state product and future developments in energy intensive industries. By 2017-18, Queensland is projected to become the largest primary energy consuming state. Australia's energy consumption will continue to be dominated by coal and oil, although natural gas use is projected to increase its share in the fuel mix. Renewables are projected to grow strongly over the projection period, but not sufficiently to significantly increase their share in energy consumption.

Electricity demand is projected to grow moderately over the projection period, with coal fired generation continuing to supply the great majority of domestic electricity needs. By the end of the outlook period, 70 per cent of electricity generation in Australia will be sourced from coal fired plants, with gas fired plants supplying another 23 per cent.

Despite a strong projected growth in the supply of coal seam gas, consumption of gas in eastern Australia is projected to surpass local supply by 2012-13, providing an opportunity for supplies from an external region to enter the eastern market. By 2029-30, gas demand in eastern Australia is projected to exceed supply by 377 petajoules – this additional demand could be met by an external source or coal seam gas production in eastern Australia.

A moderate increase in domestic production of refined petroleum products is projected over the outlook period. However, liquid fuels consumption and net imports of crude oil and LPG are projected to grow more strongly. As a consequence, Australia's self sufficiency in refined petroleum products is projected to fall from 78 per cent to 76 per cent over the outlook period.

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10.06

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Australian Government Department of Transport and Regional Services

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