# australian energy

## national and state projections to 2029-30

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# foreword

In this report, ABARE presents its latest medium to long term projections of Australian energy consumption, production and trade assuming no change in established policy settings. The analysis covers the period from 2005-06 to 2029-30, with a focus on the medium term to 2011-12. The projections update those presented last year for the same projection period and are prepared using ABARE's *E4cast* model. Since the 2006 energy projections, *E4cast* has been modified to include representation of solar electricity generation.

ABARE's practice in making these projections is to include only those policies that have been implemented at the date of publication. Policies that have been announced but not implemented have not been included in the projections. This means that the Australian Government's policies to introduce an emissions trading scheme and increase the Mandatory Renewable Energy Target to 20 per cent of electricity supply by 2020 have not been included. Further, the projections do not include the impact of climate change on economic growth.

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

Phillip Glyde
Executive Director
December 2007

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*$E_4$cast* has been developed with the financial support of the Australian Government Department of Resources, Energy and Tourism and the Australian Greenhouse Office. The projections of energy consumption, production and trade are prepared for the Department of Resources, Energy and Tourism.

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## boxes



## figures



## tables

# 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 operation* | Natural gas used in pipeline compressors and losses and 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.<br><br>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 gigawatt 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 | 28.5 GJ/t |
| Brown coal | 9.7 GJ/t |
| Crude oil | 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.

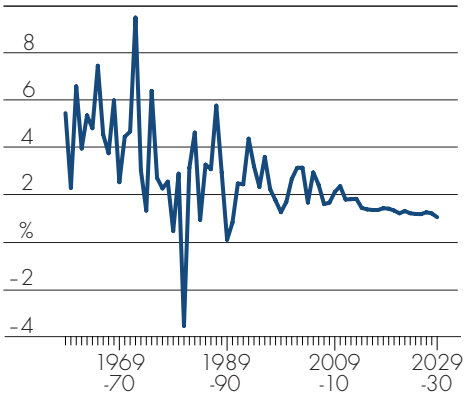
# summary

- Medium to long term projections of Australia's energy consumption, production and trade are presented in this report. These projections are made using ABARE's *E4cast* model for the period between 2005-06 and 2029-30, and update those published in December 2006 (Cuevas-Cubria and Riwoe 2006). Since the 2006 energy projections, *E4cast* has been modified to include an additional electricity generation technology, namely solar electricity.
- ABARE's practice in making these projections is to include only those policies that have been implemented at the date of publication. Policies that have been announced but not implemented have not been included in the projections. This means that the Australian Government's policies to introduce an emissions trading scheme and increase the Mandatory Renewable Energy Target to 20 per cent of electricity supply by 2020 have not been included. Further, the projections do not include the impact of climate change on economic growth.

## *energy consumption*

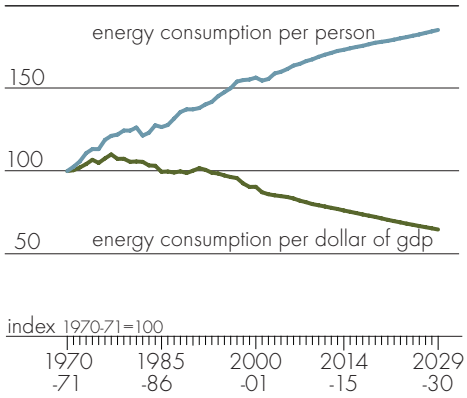
- The main drivers of energy consumption in the Australian economy are industry activity in the energy intensive sectors and gross state product in non energy intensive sectors.
- The growth in primary energy consumption in Australia has tended to fall through time, from 5.0 per cent a year in the 1960s to 2.3 per cent a year in the 1990s. From 2005-06 to 2029-30 energy consumption growth is projected to continue to moderate (figure A).

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



- Australia's primary energy consumption in the medium term is projected to grow at an average rate of 2.2 per cent a year, from 5688 petajoules in 2005-06 to 6479 petajoules in 2011-12.
- Over the full outlook period (2005-06 to 2029-30) primary energy consumption is projected to grow at an average rate of 1.6 per cent a year, reaching 8298 petajoules in 2029-30.
- Energy consumption per person is projected to rise over the outlook period (figure B), from 275 gigajoules in 2005-06 to 324 gigajoules in 2029-30.
- The aggregate energy intensity of the Australian economy, measured as total primary energy consumption per dollar of GDP, remained broadly stable over the 1970s and 1980s, and then fell by an average of 1.1 per cent a year during the 1990s. Over the projection period, energy intensity is projected to continue to decline at around 1 per cent a year on average from 2005-06 to 2029-30 (figure B).

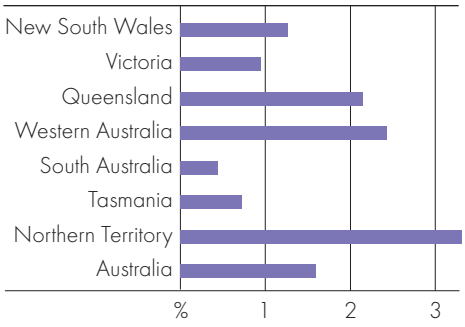
fig B **energy use in Australia**




- Fossil fuels play a dominant role in Australia's energy consumption. Fossil fuels represented around 95 per cent and renewables about 5 per cent of the primary energy consumed in Australia in 2005-06. Black and brown coal represented 41 per cent, oil 35 per cent, and gas 19 per cent of primary energy consumption in 2005-06. By 2029-30, the shares of coal and oil are projected to be 35 per cent each of total primary energy consumption. The shares of gas and renewables are projected to rise to 24 per cent and 6 per cent respectively of total primary energy consumption by 2029-30.
- While the Northern Territory is projected to have the highest annual growth rate in primary energy consumption between 2005-06 and 2029-30, Queensland is projected to have the largest increase in primary energy consumption in absolute terms. Primary energy consumption in Queensland

is projected to rise from 1372 petajoules in 2005-06 to 2284 petajoules in 2029-30, at an average rate of 2.1 per cent a year (figure C).

fig C **primary energy consumption growth in Australia, by region**
average annual growth 2005-06 to 2029-30

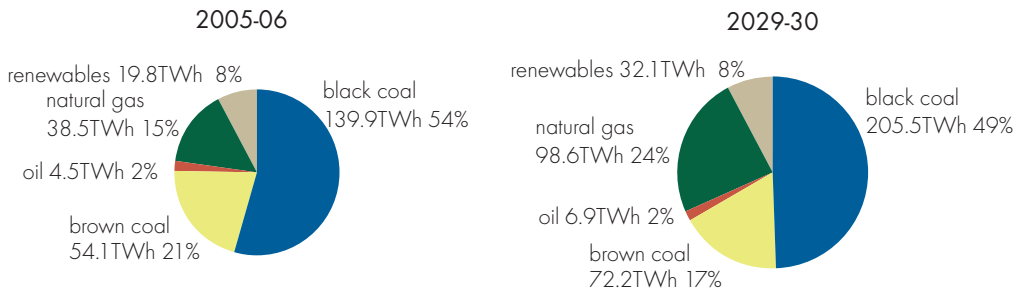



- Currently, Queensland is the third largest primary energy consuming state in Australia. Queensland is projected to overtake Victoria in terms of total primary energy consumption in 2009-10, and New South Wales in 2011-12, to become Australia's largest consumer of primary energy.
- Total final energy consumption in Australia is projected to increase from 3510 petajoules in 2005-06 to 5299 petajoules in 2029-30, growing by 51 per cent over the projection period, at an average rate of 1.7 per cent a year.
- Petroleum products (excluding naturally occurring LPG), are projected to remain the dominant source of final energy consumption in Australia throughout the projection period. However, the share of petroleum products in final energy consumption is projected to fall from 49 per cent in 2005-06 to 47 per cent in 2029-30. A projected decline in the transport sector's share in total final energy consumption from 39 per cent in 2005-06 to 36 per cent by 2029-30 is the main driver behind this decline in the share of petroleum products in the fuel mix. The projected fall in the transport sector's share of total final energy consumption reflects both car ownership saturation and the relative strength of the mining industry.
- Transport and manufacturing are the two largest consumers of energy at the end use stage, followed by the residential, commercial and mining sectors. Reflecting a large number of mineral and energy mining project developments assumed to take place over the projection period, mining is the only sector projected to expand its share of total final energy consumption. The mining sector's share of total final energy consumption is projected to rise from 7 per cent in 2005-06 to 12 per cent in 2029-30.

## *electricity generation*

- Gross electricity generation in Australia is projected to rise from 924 petajoules (257 TWh) in 2005-06 to 1495 petajoules (415 TWh) in 2029-30. This represents an increase of 62 per cent over the projection period and an average rate of growth of 2 per cent a year.
- In 2005-06, 92 per cent of electricity was generated from fossil fuels (coal, oil and gas), and 8 per cent from renewables, including hydro, wind, biomass, biogas and solar. The relative shares of fossil fuels and renewables in electricity generation are projected to remain broadly unchanged over the projection period, with both growing by 2 per cent a year. While existing policies to promote renewables have been included, these projections do not take into account potential policy initiatives that may be implemented over the period to 2029-30.
- Within the category of fossil fuels, the share of gas used in electricity generation is projected to grow from 15 per cent in 2005-06 to 24 per cent in 2029-30. A corresponding decrease is projected in the share of electricity generated from coal (both black and brown) from 76 per cent in 2005-06 to 67 per cent in 2029-30.
- Electricity generation from black coal is projected to grow modestly (figure D), increasing by around 66 TWh over the outlook period. This reflects a number of factors, including some existing base load capacity overhang and government policies encouraging a shift to less greenhouse gas intensive fuels.
- In contrast to black coal, electricity generation from natural gas is projected to grow strongly, from an estimated 39 TWh in 2005-06 to 99 TWh in

fig D **electricity generation in Australia, by fuel**



2029-30. Investment in peaking capacity and a number of policy initiatives, such as the New South Wales greenhouse gas abatement scheme and the Queensland Government's gas scheme, are expected to drive growth in gas fired electricity generation.

» Wind, biogas and biomass energy are projected to account for the majority of the increase in electricity generation from renewable sources over the projection period. The expansion in nonhydro renewables reflects the impact of a number of government policies, such as those mentioned above, as well as the Australian Government's Mandatory Renewable Energy Target scheme.

## *energy production and net trade*

» Total energy production in Australia, excluding uranium ($U_3O_8$), is projected to increase from 11 889 petajoules in 2005-06 to 21 778 petajoules by 2029-30, growing at an average rate of 2.6 per cent a year.

» Australia's exportable surplus of energy relative to consumption is projected to rise over the projection period. Australia's primary energy consumption was equivalent to 48 per cent of nonuranium energy production in 2005-06. This proportion is projected to fall to 38 per cent in 2029-30.

» Excluding uranium, black coal accounted for 69 per cent of energy production in 2005-06, in energy content terms. Exports of black coal are forecast to increase by 2.2 per cent a year to reach 386 million tonnes in 2029-30.

» In 2005-06, total gross output of natural gas in Australia was 1742 petajoules. The largest contributor to natural gas production was Western Australia, which accounted for 1011 petajoules or 58 per cent of total production. Natural gas production is projected to increase to 6135 petajoules by 2029-30, with Western Australia accounting for 71 per cent of this increase.

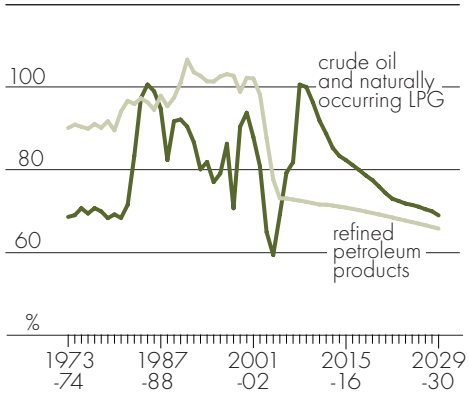
» Australia's production of liquefied natural gas (LNG) is projected to increase from around 12 million tonnes in 2005-06 to 24 million tonnes in 2011-12. By 2029-30, Australian LNG exports have the potential to reach 76 million tonnes, reflecting average annual growth of 7.8 per cent a year over the entire projection period.

» The combined production of oil (including crude oil and condensate) and naturally occurring LPG in Australia is forecast to increase strongly in the short term, from 1025 petajoules in 2005-06 to peak at almost 1600 petajoules in

2009-10, as new oil fields come on stream. However, as older oil fields mature and slowly deplete, total oil and naturally occuring LPG production is projected to fall gradually to 1340 petajoules by 2029-30.

» Australia's self sufficiency in oil and naturally occurring LPG, measured as the proportion of projected consumption of oil and naturally occurring LPG that is sourced from domestic production, is projected to peak in 2008-09, before falling steadily to 70 per cent by 2029-30 (figure E).

fig E **production to consumption ratios in the liquid fuels sector, Australia**




## *petroleum refining*

» In 2005-06 the proportion of petroleum products consumption sourced from domestic refineries is estimated to have been around 73 per cent. Assuming the Port Stanvac refinery remains closed and there is a 1.0 per cent a year growth in overall refinery output through efficiency improvements, this would result in refinery output increasing to a projected 1937 petajoules by 2029-30. The growth in consumption of petroleum products is projected to outpace the growth in refinery output over the longer term. As a result, the proportion of petroleum products consumption sourced from domestic refineries is projected to fall to 66 per cent over the projection period (figure E).

# 1

# overview of the *E4cast* model and key assumptions

## *E4cast* overview

The energy sector projections presented in this report are derived using ABARE's *E4cast* model. *E4cast* is a dynamic 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 economic growth 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 *E4cast* is provided in box 1. A detailed technical outline of the model is available on ABARE's website, www.**abare**conomics.com.

The model includes nineteen fuels, five conversion sectors, twenty-one end use sectors and seven regions (tables 1 and 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.

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

table 1 **fuel coverage in *E4cast***

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

table 2 **sector coverage in *E*$_4$*cast***

| *sectors/sub-sectors* | *ANZSIC code* |
|---|---|
| conversion | |
| coke oven operations | 2714 |
| blast furnace operations | 2715 |
| petroleum refining | 2510, 2512-2515 |
| petrochemicals | na |
| electricity generation | 361 |
| 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.

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 2007 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 five conversion sectors and twenty-one end use sectors.
- Fuel coverage comprises nineteen primary and secondary fuels.
- Results for all states and territories (the Australian Capital Territory is included with New South Wales) are provided.
- Detailed representation is provided of energy demand. The demand for each fuel is modelled 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.
- The current version of *E*$_4$*cast* covers the period 2005-06 to 2029-30.
- Demand parameters are estimated econometrically using historical Australian energy data.
- Business activity is generally represented by gross state product (GSP).
- Energy intensive industries are modelled explicitly, taking into account large and lumpy capacity expansions. The industries modelled in this way are:
  - aluminium
  - other basic nonferrous metals (mainly alumina)
  - iron and steel.
- Peak and offpeak electricity demands are modelled separately.
- The electricity generation module includes eighteen generation technologies – three peak and fifteen base load technologies.

*continued...*

box 1 key features of $E_4cast$ *continued*

- Key policy measures modelled explicitly are:
  - the Australian Government's Mandatory Renewable Energy Target scheme
  - the New South Wales Government's greenhouse gas abatement scheme
  - the Queensland Government's gas scheme and
  - the Victorian Government's renewable energy target scheme.
- Supply of natural gas (including coal seam methane and ethane) is modelled at the basin level, taking into account future gas discoveries and reserves growth. A total of fifteen sources of gas are represented in the model.

## *activity variable and growth assumptions*

Sector level energy demand within $E_4cast$ is primarily determined by the value of the 'activity' variable used in each sector's fuel demand equation. 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. When modelling energy demand in sectors that contain energy intensive industries (aluminium; other basic nonferrous metals; and iron and steel manufacturing), projected production from these subsectors is used as the activity variable. For industries characterised by large and lumpy capacity expansion, projected industry level output is viewed as a more relevant indicator of activity than gross state product.

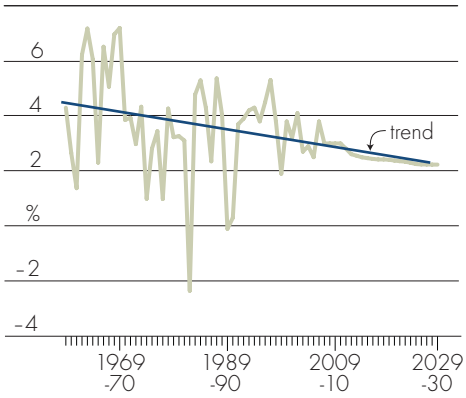
### national and state level economic growth

After growing by 2.9 per cent in 2005-06 (figure F), Australia's gross domestic product (GDP) increased by 3.3 per cent in 2006-07. Continued strong world demand for mineral resources and strengthening construction activity in Australia are assumed to support average growth in Australian GDP of 3.0 per cent a year over the medium term to 2011-12 (table 3).

Between 2011-12 and 2019-20 Australian GDP is projected to grow at an average rate of 2.5 per cent a year, reflecting a slowing in Australia's population and labour supply growth. Between 2005-06 and 2029-30, Australian GDP growth is assumed to average 2.6 per cent a year.

In the model, the national rate of economic growth is disaggregated into growth at the state and territory level by multiplying the national level figure by state and territory output elasticities that have been estimated using historical data from 1990-91 to 2005-06. The resulting assumed state and territory level growth rates are shown in table 3. Of the seven states and territories, Queensland and Western Australia are assumed to have the highest long term rates of economic growth, reflecting the continued growth of the mining sector in these states. Tasmania and South Australia are assumed to have the lowest rates of economic growth.

fig F **economic growth in Australia**
year on year




## *growth in energy intensive industries*

Australian aluminium production is assumed to increase modestly over the projection period as a result of efficiency improvements, from 1.9 million tonnes in 2005-06 to 2.1 million tonnes in 2029-30 (table 4).

For the other basic nonferrous metals sector, alumina production is used as the activity variable. Between 2005-06 and 2011-12 alumina production is assumed to increase by 37

table 3 **Australian economic growth, by region**

| | average annual growth | | |
|---|---|---|---|
| | 2005-06 to 2011-12 % | 2011-12 to 2019-20 % | 2005-06 to 2029-30 % |
| New South Wales a | 2.7 | 2.3 | 2.3 |
| Victoria | 2.9 | 2.4 | 2.5 |
| Queensland | 4.0 | 3.3 | 3.4 |
| South Australia | 2.3 | 1.9 | 1.9 |
| Western Australia | 3.9 | 3.1 | 3.0 |
| Tasmania | 1.7 | 1.4 | 1.4 |
| Northern Territory | 2.5 | 2.1 | 2.1 |
| Australia | 3.0 | 2.5 | 2.6 |

**a** Includes the Australian Capital Territory.

per cent to 24 million tonnes (table 4). Approximately 38 per cent of this increase is assumed to be accounted for by expansions in Western Australian alumina refineries – specifically, the Wagerup and Worsley refineries (table 5).

Between 2011-12 and 2029-30, alumina production is assumed to increase more strongly in Queensland than in Western Australia. Projected growth in production reflects expansions at the Yarwun alumina refinery and the startup of a greenfield plant based on the Aurukun bauxite deposits on Cape York Peninsula. China Aluminum Company (CHALCO) has proposed to develop these 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 (Copeland et al. 2007).

Over the full projection period, Australian alumina production is projected to increase by around 67 per cent to 30 million tonnes in 2029-30 (table 4). In the 2006 energy projections (Cuevas-Cubria and Riwoe 2006), alumina produc-

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

| | production | | | average annual growth | |
|---|---|---|---|---|---|
| | 2005-06 | 2011-12 | 2029-30 | 2005-06 to 2011-12 | 2005-06 to 2029-30 |
| | Mt | Mt | Mt | % | % |
| iron and steel | 7.9 | 8.8 | 9.1 | 1.9 | 0.6 |
| primary aluminium | 1.9 | 1.9 | 2.1 | 0.3 | 0.4 |
| alumina | 17.8 | 24.4 | 29.7 | 5.3 | 2.1 |

table 5 **alumina projects in Australia**

| project | location | capacity Mt | planned startup |
|---|---|---|---|
| Worsley refinery expansion | Bunbury, WA | 0.90 | 2011 |
| Wagerup refinery expansion | Darling ranges, WA | 1.80 | 2011 |
| Yarwun alumina refinery expansion (CAR Stage 2) | Yarwun, QLD | 1.40 | 2011 |
| CHALCO alumina refinery | Cape York, QLD | 2.10 | 2011 |
| QAL refinery expansion | Gladstone, QLD | 1.40 | early 2020s |

tion was assumed to grow more strongly – from 17.2 million tonnes in 2004-05 to 34.7 million tonnes in 2029-30. This change in assumption reflects lower expected production from expansions at the Worsley, Wagerup and Yarwun refineries, based on current industry information as compiled in Copeland et al. (2007).

Production in the Australian iron and steel sector is assumed to grow by 0.6 per cent a year over the projection period – from 7.9 million tonnes in 2005-06 to 9.1 million tonnes by 2029-30 (table 4). 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 major expansion in Western Australia's pig iron industry or the Australian steel industry is assumed to occur.

## *energy efficiency*

In the base year, the model uses empirically estimated energy efficiency parameters for end use sectors of the Australian economy. In addition, *$E_4$cast* incorporates energy efficiency improvements over time. End use energy efficiency improvements are represented by a decline in the demand for each fuel in a sector per unit of its output. The rate of end use energy efficiency improvement is assumed to be 0.5 per cent a year over the projection period for all fuels in non energy intensive sectors. In sectors containing energy intensive industries, the low capital stock turnover relative to other sectors is expected to result in a lower rate of energy efficiency improvement of 0.2 per cent a year. The rate of energy efficiency improvement is also assumed to be different in regions or sectors where greenhouse gas abatement policies are in place. For example, the New South Wales Government's greenhouse gas abatement scheme (discussed in box 2) is expected to accelerate the rate of efficiency improvement in the use of electricity in New South Wales. To incorporate this effect, a higher rate of energy efficiency improvement (0.7 per cent a year) is assumed for electricity use in New South Wales.

*$E_4$cast* also incorporates energy efficiency improvements in the electricity generation sector, reflecting expected technological developments over time. Thermal efficiency improvement rates are determined exogenously according to the maturity and capacity expansion rates of the electricity generation technologies modelled in *$E_4$cast*. These rates are based on data and assumptions used in ABARE's general equilibrium model, GTEM.

The thermal efficiency of natural gas plants is assumed to improve at a faster rate than coal fired plants because coal technologies are more mature. The thermal efficiency of natural gas generation is assumed to improve at a rate of 1.7 per cent a year from 2005-06 to 2009-10 (with the increased use of better technologies such as natural gas combined cycle plants). After 2009-10 the rate of thermal efficiency improvements in gas fired electricity generation is assumed to gradually fall (table 6).

table 6 **average annual rates of improvements in thermal efficiencies, by fuel, Australia**

| | black coal | brown coal | oil | gas |
|---|---|---|---|---|
| | % | % | % | % |
| 2005-06 to 2009-10 | 0.20 | 0.53 | 0.39 | 1.69 |
| 2010-11 to 2019-20 | 0.37 | 0.70 | 0.39 | 1.35 |
| 2020-21 to 2029-30 | 0.50 | 0.70 | 0.39 | 1.00 |

In comparison, the average thermal efficiency of black coal fired plants is assumed to improve at an average rate of 0.2 per cent a year from 2005-06 to 2009-10, and at a rate of around 0.4 to 0.5 per cent a year over the longer term as integrated gasification combined cycle and supercritical coal plants start coming on line.

## *energy production and trade*

In *$E_4$cast*, it is assumed that Australia's supply of black coal and oil will meet demand (export and domestic) at a given price level. The outlook for black coal exports is based on ABARE's recent assessments of the Australian coal industry (Copeland 2007a; Copeland et al. 2007; Fairhead et al. 2006). In the case of oil and naturally occurring LPG, domestic production is treated as exogenous, leaving the net trade in crude oil 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 (Copeland 2007b; Copeland et al. 2007). ABARE's outlook for coal, oil and LNG is discussed further in chapter 3.

The supply of brown coal and nontraded black coal (that is, black coal produced in states other than New South Wales and Queensland) is approximated using state specific price assumptions and an autonomous productivity improvement as the key determinants. For simplicity, the supply of other fuels such as biomass, biogas and solar power is assumed to be perfectly elastic, with supply increasing in response to demand.

Gas supply is represented in the model at the basin level and a total of fifteen alternative sources of natural gas, ethane and coal seam methane (CSM) are modelled (table 7). The supply outlook of gas is also determined by technical change parameters and estimates of reserves from Geoscience Australia (2006).

table 7 **gas supply basins in** *E*$_4$*cast*

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

The direction of interstate trade in electricity and natural gas is endogenously determined in *E*$_4$*cast*, 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 2007). 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 in gas pipeline and electricity interconnector capacity sufficient to meet trade requirements.

## *electricity generation*

The demand for both peak and offpeak (or base load) electricity is modelled explicitly in *E*$_4$*cast*. Annual electricity demand in New South Wales, Victoria,

Queensland, South Australia and Tasmania is split into peak and offpeak periods based on load duration curves, constructed using NEMMCO's half hourly demand data. As load characteristics are not readily available for other regions and states, the same load profile has been assumed for all regions and states.

The electricity generation module of *E4cast* includes eighteen generation technologies – three peak and fifteen offpeak (table 8). 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, diesel, biomass, biogas (landfill and sewage gas), solar, and wind plants. Biomass fuels include bagasse (the main biomass fuel), and wood and wood waste products. Since the 2006 energy projections (Cuevas-Cubria and Riwoe 2006), *E4cast* has been modified to explicitly model photovoltaic electricity generation technology. The projections for photovoltaic generation are based on existing photovoltaic generation, but do not include domestic photovoltaic panels, nor do they include planned expansions to photovoltaic generation capacity, such as the 154 MW Solar Systems plant planned for Victoria.

In *E4cast*, the future use of new generation technologies that are not currently used in Australia is based on the investment cost of each technology relative to those currently in use and future cost assumptions. The real cost of investing in electricity

table 8 **electricity generation technologies in** *E4cast*

| | |
|---|---|
| **black coal** | **natural gas** |
| 1 pulverised fuel | 9 peak |
| 2 integrated combined cycle | 10 offpeak |
| 3 integrated combined cycle with CCS | 11 combined cycle |
| 4 pulverised fuel super critical with CCS | 12 combined cycle with CCS |
| **brown coal** | **renewables** |
| 5 pulverised fuel | 13 hydro peak |
| 6 pulverised fuel super critical with CCS | 14 hydro offpeak |
| **diesel** | 15 wind |
| 7 peak | 16 biomass |
| 8 offpeak | 17 biogas |
| | 18 solar |

CCS Carbon capture and storage.

generation technologies (based on ABARE's general equilibrium model GTEM) is assumed to vary over time and incorporates the impacts of learning by doing and economies of scale. Though the model includes four technologies that incorporate carbon capture and storage technologies, in the absence of a greenhouse gas emissions trading scheme, carbon capture and storage is not expected to be used commercially over the projection period because of its relatively high cost.

Renewable energy is modelled to reflect the incentives provided by various government greenhouse gas abatement schemes. 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.

It is likely that a greenhouse gas emissions trading scheme will be introduced in Australia in 2010. However, at this stage, details of a future emissions trading scheme have not been announced. These projections do not include the potential implications for energy consumption, production and trade of such a scheme. Further, the recently announced renewable energy target that increases the renewable energy requirement under the existing Mandatory Renewable Energy Target scheme has not been included in these projections. Specific energy policies included in these projections are described in box 2.

## *$E_4$cast base year data*

Before employing *$E_4$cast* for this cycle of projections, the base year (2005-06) data in the model were updated using ABARE's historical energy statistics for 2005-06. 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 3. More details are provided in Donaldson (2007).

box 2 Government policies

The key policy measures modelled explicitly are:

- the Australian Government's Mandatory Renewable Energy Target scheme (MRET)
- the New South Wales Government's greenhouse gas abatement scheme
- the Queensland Government's gas scheme and
- the Victorian Government's renewable energy target scheme.

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 that there will be consistent progress toward achieving the additional 9500 GWh of renewable energy by 2010. It is assumed that this target is maintained until 2020. In *$E_4$cast*, the renewable energy target is modelled as a constraint on electricity generation. However, this requirement for renewable electricity generation is reduced in *$E_4$cast* to account for renewable technologies that are not explicitly modelled, such as solar water heaters.

It is assumed that about 23 per cent of the MRET target will be met by technologies that are not explicitly modelled in *$E_4$cast*. This is based on recent experience, using the number of renewable energy certificates created under the scheme as an indication of the renewable energy generated under MRET. In 2006, 19.9 per cent of renewable energy certificates were created by solar water heaters, slightly lower than the 2005 level of 20.4 per cent (ORER 2006). The renewable energy certificates generated by other technologies that are excluded from *$E_4$cast* have so far been negligible. 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.

*continued...*

box 2 Government policies *continued*

The Queensland Government's gas scheme is a key component of the Queensland Energy Policy announced in May 2000. The scheme currently requires electricity retailers and other liable parties to source at least 13 per cent of their electricity from natural gas fired generation. This requirement will increase to 18 per cent by 2020. The scheme is implemented in the model in an approximate manner, requiring the share of natural gas based electricity in Queensland to be greater than or equal to 13 per cent in 2005, increasing to 18 per cent by 2020. This target has been retained in the model for the period 2020-21 to 2029-30.

*$E_4$cast* also incorporates the New South Wales Government's greenhouse gas abatement scheme. The scheme requires electricity retailers and other liable parties to meet mandatory greenhouse gas reduction benchmarks. Currently, the benchmark is set as a 5.0 per cent reduction in per person greenhouse gas emissions from the 1989-90 level by 2007, implying a per person target of 7.27 tonnes of carbon dioxide equivalent ($CO_2$-e) in 2007. The scheme began on 1 January 2003, with a benchmark of 8.65 tonnes of $CO_2$-e for the year. Annual targets for the subsequent years follow a linear path to achieve the benchmark of 7.27 tonnes of $CO_2$-e per person in 2007. The target will be maintained at that level until at least 2020 (IPART 2007). 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 targeted per person emissions and state population.

In *$E_4$cast*, the Victorian Government's Renewable Energy Target scheme (VRET) is also explicitly modelled. This scheme commenced on 1 January 2007 and requires that 10 per cent of total electricity generation be sourced from renewable energy sources by 2016. The scheme is implemented in *$E_4$cast* in the same manner as the MRET scheme.

box 3 ABARE's energy statistics

ABARE's energy statistics are based 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 total Australian energy consumption. Each year, in around July–August, respondents are sent paper based surveys, requesting information on the quantity of fuels they produced and consumed 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 Resources, Energy and Tourism's Australian Petroleum Statistics
- Energy Supply Association of Australia
- Geoscience Australia
- state government departments
- Australian Customs Service.

The detailed FES data on energy consumption form the main building block on which energy consumption by region, industry and fuel type is estimated. 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, researchers 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

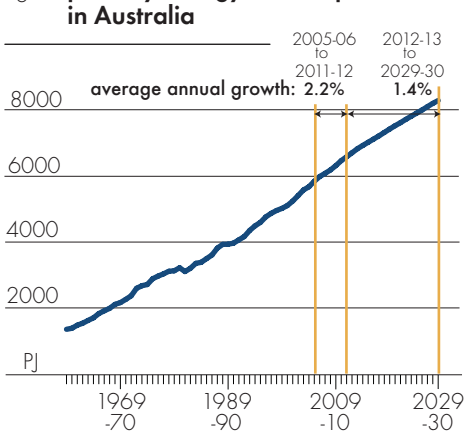
# energy consumption and electricity generation outlook

This chapter presents the outlook for Australian energy consumption, production and trade. It describes the projections of primary energy consumption in terms of fuel, regional and sectoral structures. Final energy consumption by fuel and sector, and the outlook for electricity generation are also discussed. The discussion focuses principally on national trends, although key trends at the state level are also highlighted.

The Australian Government has announced that it will introduce an emissions trading scheme in 2010. However, in preparing these projections, policies that have been announced but not implemented are not included in the model. For example, at this stage, details of the emissions trading scheme have not been announced or implemented and, therefore, such a scheme is not modelled in these projections. To the extent that an emissions trading scheme would impose a constraint on carbon dioxide emissions, total energy use and the relative contribution of different sources is likely to differ from the results presented below. Further, the recently announced renewable energy target that increases the renewable energy requirement to 20 per cent of electricity supply by 2020 under the existing Mandatory Renewable Energy Target scheme has not been included in these projections.

Detailed data on energy consumption, production and trade in Australia over the period 2005-06 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 2014-15 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 website (www.**abare**economics.com).

fig G **primary energy consumption in Australia**



## primary energy consumption

The rate of growth in Australia's primary energy consumption has tended to fall over time. During the 1960s, energy use increased at an average rate of 5.0 per cent a year (figure G). This fell to 3.9 per cent a year during the 1970s, prompted partly by the oil price shocks in this decade. The rate of growth fell further to average 2.3 per cent a year during the 1980s and 1990s.

Between 2005-06 and 2029-30 energy consumption growth is projected to continue to moderate. In the medium term – from 2005-06 to 2011-12 – Australia's primary energy consumption is projected to grow by 2.2 per cent a year (figure G), from 5688 petajoules in 2005-06 to 6479 petajoules in 2011-12 (table 9).

This represents the net outcome of countervailing 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 2005-06 to 2011-12 and a continuing strong demand for energy by energy intensive industries such as nonferrous metals. Downward pressures on future primary energy consumption include relatively high oil prices, government policies and energy efficiency improvements.

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

| | consumption | | | | average annual growth | |
|---|---|---|---|---|---|---|
| | 2005-06 | 2011-12 | 2019-20 | 2029-30 | 2005-06 to 2011-12 | 2005-06 to 2029-30 |
| | PJ | PJ | PJ | PJ | % | % |
| black coal | 1 634 | 1 734 | 1 848 | 2 105 | 1.0 | 1.1 |
| brown coal | 706 | 757 | 819 | 803 | 1.2 | 0.5 |
| oil | 2 022 | 2 274 | 2 528 | 2 944 | 2.0 | 1.6 |
| natural gas | 1 064 | 1 342 | 1 691 | 1 982 | 4.0 | 2.6 |
| renewables | 262 | 372 | 445 | 465 | 6.0 | 2.4 |
| biomass | 186 | 245 | 315 | 327 | 4.7 | 2.4 |
| biogas | 7 | 41 | 40 | 38 | 33.4 | 7.1 |
| hydroelectricity | 59 | 64 | 68 | 73 | 1.3 | 0.9 |
| solar [a] | 3 | 3 | 4 | 4 | 2.3 | 1.9 |
| wind | 7 | 18 | 19 | 23 | 18.5 | 5.4 |
| total | 5 688 | 6 479 | 7 332 | 8 298 | 2.2 | 1.6 |

**a** The actual numbers for solar are rounded off in the table.

The sensitivity of the primary energy consumption projections to assumptions about economic growth is analysed in box 4.

box 4 **sensitivity of results to changes in GDP growth assumptions**

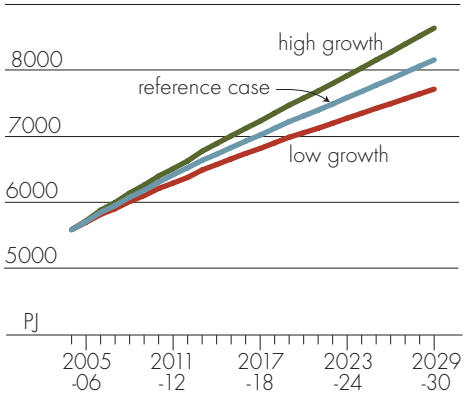
Australian energy consumption depends on a number of key factors, including economic growth, the output of energy intensive industries, end use efficiency improvements and electricity generation efficiency improvements. These latter parameters are considered to be relatively stable over time and, hence, energy consumption projections are relatively more sensitive to assumptions about economic growth. Because the outlook for Australia's economic growth is subject to some uncertainty, two alternative economic growth scenarios are modelled – a high growth scenario and a low growth scenario.

Under the 'high' and 'low' growth scenarios, average annual growth in GDP is assumed to be 10 per cent higher and lower respectively from 2005-06 to 2029-30 than in the projections presented above (referred to as the reference case).

Primary energy consumption under the 'high' growth scenario is 1.4 per cent (92 petajoules) higher than in the reference case by 2011-12 and 5.2 per cent (430 petajoules) higher by 2029-30 (figure H). 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 1.6 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 1.4 per cent a year over the projection period. By the end of the period, primary energy use is projected to be 4.8 per cent (399 petajoules) lower in the 'low' growth scenario than in the reference case.

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

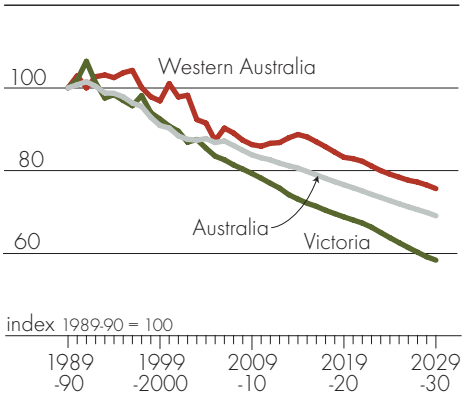


For the period from 2011-12 to 2029-30, primary energy consumption is projected to grow at an average rate of 1.4 per cent a year. Over the entire projection period, primary energy consumption is projected to grow at an average rate of 1.6 per cent a year, to reach 8298 petajoules in 2029-30 (table 9). This represents an increase of 46 per cent over the projection period.

### aggregate energy intensity trends

Australia's aggregate energy intensity (measured as total primary energy consumption per dollar of GDP) remained broadly stable over the 1970s and 1980s. It subsequently fell by an average of 1.1 per cent a year during the 1990s. Australia's energy intensity is projected to continue to decline by around 1 per cent a year from 2005-06 to 2029-30.

fig I **energy intensity trends**



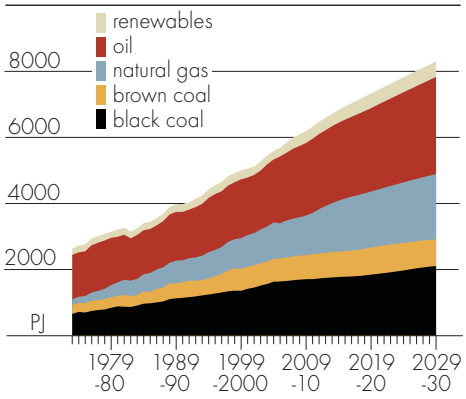

The trends in aggregate energy intensity index vary markedly between regions (figure I). For example, Western Australia's aggregate energy intensity is projected to fall by 1.7 per cent a year from 2005-06 to 2010-11 and then rise at an average rate of 0.4 per cent a year from 2011-12 to 2015-16, as new alumina projects come on stream. In Victoria, where economic growth is less dependent on major energy intensive projects, aggregate energy intensity is projected to decline by 1.5 per cent a year over the projection period.

## *primary energy consumption, by fuel*

At the primary energy level, fossil fuels currently provide around 95 per cent and renewables about 5 per cent of the energy consumed in Australia. Black and brown coals provide 41 per cent, oil 35 per cent, and gas 19 per cent of primary energy consumption (figure J). Over the long term, the shares of black and brown coal and oil are projected to account for 35 per cent each of total primary energy

consumption. The shares of gas and renewables in total primary energy consumption are projected to rise to 24 per cent and 6 per cent respectively.

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




Natural gas is projected to be the fastest growing fossil fuel over the projection period. Primary gas consumption is projected to rise by 4.0 per cent a year in the medium term and by 2.6 per cent a year over the full outlook period (table 9). Total primary demand for natural gas is projected to reach 1982 petajoules by 2029-30. Electricity generation accounts for 37 per cent of the total increase in primary gas consumption, while manufacturing is projected to account for 24 per cent, and the mining sector for 29 per cent. Factors driving the increase in gas consumption include the increasing availability of natural gas combined with national and state policy initiatives designed to encourage the use of lower greenhouse gas intensive fuels.

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 2908 petajoules by 2029-30.

The requirement for investment in the electricity sector, primarily in peaking capacity, and a number of policy measures that encourage the substitution away from coal into less greenhouse gas intensive fuels, are expected to be the main factors resulting in the slower growth of coal consumption than other fuels. These policy measures include the Australian Government's Mandatory Renewable Energy Target scheme, the Queensland Government's gas scheme and the New South Wales Government's greenhouse gas abatement scheme.

Australia's primary energy consumption of oil is projected to increase by around 920 petajoules to 2944 petajoules by 2029-30, or at an average rate of 1.6 per cent a year (table 9). Demand for products derived from oil for road, rail, air and sea transport is projected to be the main source of growth in oil consumption.

Reflecting the effects of existing policy measures to reduce greenhouse gas emissions, the use of renewables is projected to increase by 77 per cent over the next 24 years to 465 petajoules, or by an average annual rate of 2.4 per cent (table 9). In the medium term to 2011-12 the use of renewables is projected to grow at an average rate of 6.0 per cent a year. In particular, the use of biogas and wind energy is projected to grow strongly in the medium term, mainly due to the requirements for the increased use of renewables under the MRET scheme and availability of these resources.

## *primary energy consumption, by state*

Reflecting assumptions about gross state product and the expansion of energy intensive industries, primary energy consumption in Western Australia is projected to rise from 808 petajoules in 2005-06 to 1437 petajoules in 2029-30 (or by 2.4 per cent a year over the projection period). In Queensland, primary energy consumption is projected to rise from 1372 petajoules to 2284 petajoules, growing at a rate of 2.1 per cent a year (table 10). Currently the third largest primary energy consuming state, Queensland is projected to overtake Victoria in terms of total primary energy consumption in 2009-10, and New South Wales in 2011-12, to become Australia's largest consumer of primary energy (figure K).

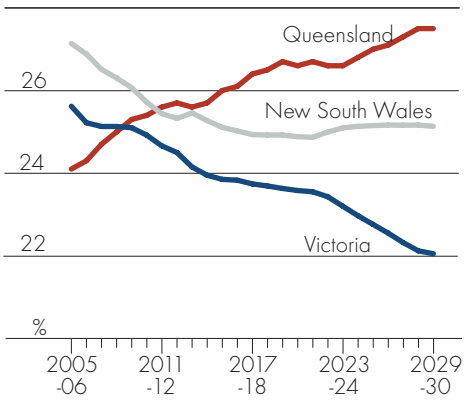
table 10 **primary energy consumption in Australia, by state**

| | consumption | | | | average annual growth | |
|---|---|---|---|---|---|---|
| | 2005-06 | 2011-12 | 2019-20 | 2029-30 | 2005-06 to 2011-12 | 2005-06 to 2029-30 |
| | PJ | PJ | PJ | PJ | % | % |
| New South Wales [a] | 1 544 | 1 648 | 1 828 | 2 086 | 1.1 | 1.3 |
| Victoria | 1 457 | 1 597 | 1 732 | 1 830 | 1.5 | 1.0 |
| Queensland | 1 372 | 1 658 | 1 954 | 2 284 | 3.2 | 2.1 |
| Western Australia | 808 | 992 | 1 208 | 1 437 | 3.5 | 2.4 |
| South Australia | 300 | 302 | 312 | 333 | 0.1 | 0.4 |
| Tasmania | 123 | 134 | 140 | 146 | 1.4 | 0.7 |
| Northern Territory | 84 | 146 | 158 | 183 | 9.8 | 3.3 |
| total | 5 688 | 6 479 | 7 332 | 8 298 | 2.2 | 1.6 |

**a** Includes the Australian Capital Territory.

Energy consumption in the Northern Territory is projected to grow at an average rate of 3.3 per cent a year to 183 petajoules by 2029-30 (table 10). This high growth reflects the expected expansion in the region's LNG export sector.

fig K **shares of Australian primary energy consumption** selected states




Growth in primary energy consumption in the other states is projected to be relatively low. This is particularly the case for South Australia and Tasmania. Reflecting the modest economic growth outlook, primary energy consumption in South Australia is projected to grow by just 33 petajoules, or 11 per cent, over the entire outlook period. In Tasmania, energy consumption is projected to grow at an average rate of 0.7 per cent a year. In Victoria energy consumption over the outlook period is projected to grow at a slightly higher rate of 1.0 per cent a year.

There are also significant differences in per person consumption of energy by state, reflecting factors such as the energy intensity of a state's industry structure and the significance of mining activities in gross state product. Australia's primary energy consumption of 5688 petajoules in 2005-06 is equivalent to energy consumption of 275 gigajoules per person at a 30 June 2006 population of 20.7 million (ABS 2006). On a regional basis, per person primary energy consumption in 2005-06 ranged from 397 gigajoules in the Northern Territory and 371 gigajoules in Western Australia to 191 gigajoules in South Australia and 216 gigajoules in New South Wales.

Primary energy consumption is projected to grow at a rate well in excess of population growth over the period to 2029-30. If Australia's population were to reach 25.6 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 8298 petajoules in 2029-30 would be equivalent to 324 GJ of energy consumed per person in that year. It is expected that state-based differences in primary energy consumption per person would persist.

## primary energy consumption, by sector

Of the 5688 petajoules of primary energy consumed in Australia in 2005-06 (table 11), electricity generation, transport and manufacturing consumed a total of 5006 petajoules. Primary energy consumption in these sectors is projected to grow by around 39 per cent to 6939 petajoules by 2029-30, accounting for 84 per cent of projected total primary consumption in 2029-30.

The electricity generation sector accounted for the largest share (45 per cent) of primary energy consumption in 2005-06. Notwithstanding the introduction of policies designed to reduce greenhouse gas emissions, coal is projected to remain the dominant fuel source in the electricity generation sector to 2029-30. This dominance reflects past investment in coal fired capacity, the suitability of coal for base load power generation, and coal's low cost relative to other fuels. 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 power generation sector is projected to rise from 2587 petajoules in 2005-06 to 3651 petajoules in 2029-30 (table 11).

table 11 **primary energy consumption in Australia, by sector**

| | consumption | | | | average annual growth | |
|---|---|---|---|---|---|---|
| | 2005-06 | 2011-12 | 2019-20 | 2029-30 | 2005-06 to 2011-12 | 2005-06 to 2029-30 |
| | PJ | PJ | PJ | PJ | % | % |
| agriculture | 86 | 93 | 101 | 112 | 1.4 | 1.1 |
| mining | 266 | 375 | 570 | 806 | 5.9 | 4.7 |
| manufacturing and construction | 1 056 | 1 217 | 1 299 | 1 400 | 2.4 | 1.2 |
| *petroleum refining* | *162* | *177* | *191* | *211* | 1.6 | 1.1 |
| electricity generation | 2 587 | 2 936 | 3 311 | 3 651 | 2.1 | 1.4 |
| transport and storage | 1 363 | 1 499 | 1 658 | 1 888 | 1.6 | 1.4 |
| commercial and services | 65 | 76 | 86 | 100 | 2.6 | 1.8 |
| residential | 192 | 207 | 228 | 257 | 1.2 | 1.2 |
| other [a] | 72 | 76 | 80 | 84 | 0.9 | 0.7 |
| total | 5 688 | 6 479 | 7 332 | 8 298 | 2.2 | 1.6 |

**a** Includes solvents, lubricants, greases and bitumen.

In the transport sector, road and air transport are projected to grow more strongly than other subsectors over the outlook period. As is currently the case, the transport sector is projected to remain heavily dependent on petroleum products. The total primary energy consumed in the transport sector is projected to increase from 1363 petajoules in 2005-06 to 1888 petajoules in 2029-30 (table 11).

In the manufacturing sector, the basic chemicals and other basic nonferrous metals subsectors are projected to increase their primary energy consumption. Moderate increases are also projected in all other manufacturing subsectors. Overall, total primary energy consumed in Australia's manufacturing sector is projected to rise from 1056 petajoules in 2005-06 to 1400 petajoules in 2029-30 (table 11).

The mining sector is projected to increase its share of total primary energy consumption from 5 per cent in 2005-06 to 10 per cent in 2029-30. This projected increase reflects the large number of mineral and energy projects (including LNG) assumed to come on stream between 2005-06 and 2029-30.

## *electricity generation*

Gross electricity generation in Australia is projected to grow over the outlook period by an average of 2.0 per cent a year, from 257 TWh (924 petajoules) in 2005-06 to 415 TWh (1495 petajoules) in 2029-30 (table 12).

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

| | generation | | | | average annual growth | |
|---|---|---|---|---|---|---|
| | 2005-06 | 2011-12 | 2019-20 | 2029-30 | 2005-06 to 2011-12 | 2005-06 to 2029-30 |
| | TWh | TWh | TWh | TWh | % | % |
| New South Wales [a] | 75.7 | 79.4 | 92.5 | 115.6 | 0.8 | 1.8 |
| Victoria | 59.3 | 68.7 | 80.2 | 87.8 | 2.5 | 1.7 |
| Queensland | 70.5 | 87.6 | 104.4 | 124.3 | 3.7 | 2.4 |
| Western Australia | 26.4 | 32.6 | 40.5 | 51.4 | 3.6 | 2.8 |
| South Australia | 9.9 | 11.5 | 12.8 | 15.4 | 2.5 | 1.9 |
| Tasmania | 11.4 | 12.9 | 14.0 | 15.0 | 2.1 | 1.1 |
| Northern Territory | 3.6 | 4.4 | 5.0 | 5.9 | 3.4 | 2.0 |
| total | 256.8 | 297.1 | 349.4 | 415.4 | 2.5 | 2.0 |

**a** Includes the Australian Capital Territory.

The projected growth in electricity generation varies between regions. In Western Australia, gross electricity output is projected to rise by 94 per cent over the projection period, from 26 TWh in 2005-06 to 51 TWh in 2029-30 (table 12). Queensland is projected to become Australia's largest producer of electricity, with production projected to increase by 76 per cent, from 71 TWh in 2005-06 to 124 TWh in 2029-30.

In the absence of potential new policy initiatives, the relative shares of fossil fuels and renewables in electricity generation are not likely to change significantly over the projection period. In 2005-06, 92 per cent of electricity was generated from fossil fuels (coal, oil and gas), and 8 per cent from renewables such as hydro, wind, biomass, biogas and solar. Within the category of fossil fuels, the key change projected over the outlook period is substitution away from coal fired generation towards gas. The share of gas in electricity generation is projected to grow from 15 per cent in 2005-06 to 24 per cent in 2029-30. A corresponding decrease is projected in the share of electricity generated from coal (both black and brown) from 76 per cent in 2005-06 to 67 per cent in 2029-30.

Electricity generation from black coal is projected to grow at an average rate of 1.6 per cent a year over the projection period (table 13). Electricity generation

table 13 **electricity generation in Australia, by fuel**

| | generation | | | | average annual growth | |
|---|---|---|---|---|---|---|
| | 2005-06 | 2011-12 | 2019-20 | 2029-30 | 2005-06 to 2011-12 | 2005-06 to 2029-30 |
| | TWh | TWh | TWh | TWh | % | % |
| black coal | 139.9 | 150.5 | 167.4 | 205.5 | 1.2 | 1.6 |
| brown coal | 54.1 | 60.1 | 68.7 | 72.2 | 1.8 | 1.2 |
| oil | 4.5 | 6.0 | 6.3 | 6.9 | 4.9 | 1.8 |
| natural gas | 38.5 | 54.3 | 77.6 | 98.6 | 5.9 | 4.0 |
| renewables | 19.8 | 26.3 | 29.4 | 32.1 | 4.8 | 2.0 |
| hydroelectricity | 16.5 | 17.8 | 18.8 | 20.3 | 1.3 | 0.9 |
| biomass | 1.1 | 2.3 | 4.1 | 4.2 | 12.4 | 5.6 |
| biogas | 0.3 | 1.9 | 2.0 | 2.1 | 34.7 | 8.1 |
| wind energy | 1.8 | 4.3 | 4.4 | 5.4 | 15.1 | 4.6 |
| solar electricity | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 |
| total | 256.8 | 297.1 | 349.4 | 415.4 | 2.5 | 2.0 |

from natural gas is projected to grow more strongly, at an average rate of 4.0 per cent a year, from 39 TWh in 2005-06 to 99 TWh in 2029-30. Growth in gas fired electricity generation is projected to be relatively stronger in the medium term, largely reflecting investment in peak capacity and the impact of a number of state and Australian government policy initiatives.

The impact of the Queensland Government's gas scheme is apparent in the projections for gas fired electricity generation for that state. Electricity generation from gas in Queensland is projected to increase by almost 80 per cent in the medium term to 2011-12. The projected growth in Queensland's gas fired electricity generation is assumed to be supported by, among other projects, Origin Energy's 1000 MW Spring Gully plant at Durham Downs. This combined cycle gas plant is proposed to commence production in 2008-09 (ESAA 2007).

The New South Wales Government's 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 gas fired electricity generation capacity is expected to continue throughout the projection period. Reflecting the impact of the scheme and growth in peak electricity demand, gas fired electricity in the state is projected to grow by 5.3 per cent a year over the projection period to 7.8 TWh in 2029-30.

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 3.4 per cent a year. At this rate, gas fired electricity generation will account for 81 per cent of the projected expansion in the state's electricity generation between 2005-06 and 2029-30. Another 14 per cent of the increase in Western Australia's electricity generation is projected to come from existing and new coal fired electricity generation capacity. New coal fired electricity generation capacity expected to come on line during the projection period includes the Bluewater project, which will be brought on line in various stages between 2008–12 and the Midwest project, which is expected to commence operation in 2011 (ESSA 2007). In the Northern Territory, almost all the growth in electricity generation is projected to be sourced from gas based generation technologies. Gas fired electricity generation in the Northern Territory is projected to grow by an average 3.0 per cent a year during the projection period.

The use of gas in the electricity generation sector commenced in Tasmania in 2002-03 after the completion of the Tasmanian Gas Pipeline that supplies natural

gas from Victoria (Longford) to Tasmania (Bell Bay) and the conversion of existing oil fired generating facilities at Bell Bay 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 67 per cent, providing approximately 1.5 TWh of electricity by 2029-30.

An assumed decline in investment costs associated with nonhydro renewable electricity generation technologies is projected to result in the expansion of nonhydro renewable fuels between 2005-06 and 2029-30. While there is an increase in absolute terms as a result of policy initiatives, the share of renewables does not change. Wind and biomass (mainly bagasse, woodwaste and bagasse cofired with woodwaste) are projected to account for the majority of the increase in electricity generation from renewable sources over the projection period. On a regional basis, availability of resources, such as wind, is assumed to be the main driver of renewables uptake. Around 97 per cent (or 3.4 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 85 per cent of the projected growth in the use of biomass for electricity generation is projected to occur in Queensland.

Solar electricity generation via photovoltaics is not projected to change significantly over the projection period from the 0.3 petajoules produced in 2005-06. This is because of the relatively high capital investment costs associated with solar electricity production, compared with other technologies.

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 assumed to be associated with the upgrading of existing equipment.

The total energy content of fuels used in electricity generation is projected to rise from 2587 petajoules in 2005-06 to 3651 petajoules in 2029-30 (table 11). Of this, the use of fossil fuels is projected to rise from 2477 petajoules in 2005-06 to 3387 petajoules in 2029-30, while the energy content of renewables used in electricity generation is projected to rise from 110 petajoules to 263 petajoules.

## *final energy consumption, by sector*

Total final energy consumption in Australia is projected to increase from 3510 petajoules in 2005-06 to 5299 petajoules in 2029-30, a rise of 51 per cent over the projection period and an average annual rate of increase of 1.7 per cent (table 14).

Mining is the only sector projected to significantly increase its share of total final energy consumption. This reflects a large number of energy intensive project developments that are assumed to take place over the projection period. The mining sector's share of total final energy consumption is projected to rise from 7 per cent in 2005-06 to 12 per cent in 2029-30.

Transport and manufacturing are the two largest consumers of final energy, followed by the residential, commercial and mining sectors. Growing at an average rate of 1.4 per cent a year between 2005-06 and 2029-30, the transport sector is expected to account for 30 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 39 per cent in 2005-06 to 36 per cent by 2029-30 (figure L). These projections for energy use in the transport sector are the main driver of the outlook for other petroleum products. Other petroleum products are projected to remain

table 14 **final energy consumption in Australia, by sector**

| | consumption | | | | average annual growth | |
|---|---|---|---|---|---|---|
| | 2005-06 | 2011-12 | 2019-20 | 2029-30 | 2005-06 to 2011-12 | 2005-06 to 2029-30 |
| | PJ | PJ | PJ | PJ | % | % |
| agriculture | 92 | 100 | 109 | 120 | 1.4 | 1.1 |
| mining | 235 | 320 | 447 | 660 | 5.3 | 4.4 |
| manufacturing and construction | 1 084 | 1 266 | 1 378 | 1 509 | 2.6 | 1.4 |
| transport | 1 371 | 1 508 | 1 668 | 1 899 | 1.6 | 1.4 |
| commercial and services | 243 | 289 | 350 | 434 | 3.0 | 2.5 |
| residential | 413 | 458 | 517 | 593 | 1.8 | 1.5 |
| other **a** | 72 | 76 | 80 | 84 | 0.9 | 0.7 |
| total | 3 510 | 4 018 | 4 550 | 5 299 | 2.3 | 1.7 |

**a** Includes solvents, lubricants, greases and bitumen.

the dominant source of final energy consumption throughout the projection period. However, the share of other petroleum products in the final energy consumption fuel mix is projected to fall from 49 per cent in 2005-06 to 47 per cent in 2029-30. (table 15)

Energy use in the transport sector is projected to grow relatively strongly, at around 2 per cent a year, in Queensland and Western Australia. In contrast, transport sector energy use in South Australia is projected to grow only modestly – by 0.1 per cent a year – over the projection period, reflecting modest economic growth prospects in that state. Energy use in the Victorian and New South Wales transport sectors is projected to grow at an average rate of 1.2 and 1 per cent a year, respectively.

Road transport is the largest energy consuming component of the transport sector (figure L). In 2005-06, road transport accounted for around 76 per cent of the energy used in the sector. With a share of 62 per cent in 2005-06, passenger motor vehicles were the largest energy consuming sector within road transport. 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

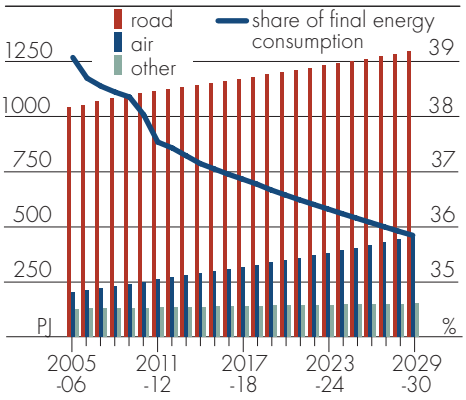
table 15 **final energy consumption in Australia, by fuel**

| | consumption | | | | average annual growth | |
|---|---|---|---|---|---|---|
| | 2005-06 | 2011-12 | 2019-20 | 2029-30 | 2005-06 to 2011-12 | 2005-06 to 2029-30 |
| | PJ | PJ | PJ | PJ | % | % |
| black coal | 175 | 194 | 194 | 193 | 1.7 | 0.4 |
| gasoline **b** | 602 | 609 | 610 | 610 | 0.2 | 0.1 |
| LPG | 97 | 131 | 147 | 183 | 5.1 | 2.7 |
| other petroleum products | 1 729 | 1 918 | 2 141 | 2 499 | 1.7 | 1.5 |
| gas | 565 | 694 | 808 | 941 | 3.5 | 2.1 |
| biomass | 150 | 163 | 178 | 197 | 1.4 | 1.2 |
| electricity | 792 | 916 | 1 078 | 1 282 | 2.5 | 2.0 |
| solar **a** | 2 | 3 | 3 | 4 | 2.7 | 2.2 |
| total | 3 510 | 4 018 | 4 550 | 5 299 | 2.3 | 1.7 |

**a** Solar water heating. **b** gasoline is a component within other petroleum products, hence not included in the total.

at an average rate of 1.9 per cent a year. The consumption of automobile gasoline in the road transport sector is a major component of final energy consumption. In 2005-06, 602 petajoules of gasoline were consumed at the end use stage (table 15). The consumption of gasoline is projected to increase modestly, at an average rate of 0.1 per cent a year over the projection period, with slightly faster growth in the medium term. This reflects car ownership saturation effects as Australia's per person income increases.

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




Energy use in the air transport sector (both domestic and international) is projected to grow strongly over the projection period, reflecting rapid 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 is projected to more than double to reach 453 petajoules in 2029-30 (figure L). As a result, the air transport sector is projected to account for over a quarter of the transport sector's use of petroleum products in 2029-30.

The basic nonferrous metal industries, including alumina, are the major consumers of gas at the end use stage. In total, the growth in basic nonferrous metal energy consumption is expected to account for around 47 per cent of the projected increase in manufacturing sector energy consumption between 2005-06 and 2029-30 (table 16).

The alumina industry's output is the activity variable used to model energy consumption in the other basic nonferrous metals sector. Reflecting an assumed 67 per cent increase in alumina production (table 4), energy consumption in the other basic nonferrous metals sector is projected to increase by 59 per cent to reach 514 petajoules by 2029-30 (table 16). This is equivalent to 45 per cent of the increase in energy consumption in the manufacturing sector over the projection period. Natural gas consumption in the other basic nonferrous metals sector

is projected to increase from 108 petajoules in 2005-06 to 199 petajoules by 2029-30. This is equivalent to around 48 per cent of the total increase in final energy consumption in the other basic nonferrous metals sector between 2005-06 and 2029-30.

Energy consumption in the aluminium smelting industry is projected to increase by 8 petajoules to 117 petajoules in 2029-30 (table 16), reflecting relatively modest growth in the production of primary aluminium over the projection period.

The projected growth in energy consumption in the iron and steel industry is also modest. Final energy consumption in this industry is projected to grow at an average rate of 1.0 per cent a year over the projection period, to 122 petajoules by 2029-30 (table 16). The use of gas in the iron and steel industry is projected to increase slightly from 26 petajoules in 2005-06 to 27 petajoules in 2029-30.

Energy consumption in the basic chemicals sector is projected to increase by 76 petajoules over the projection period to 252 petajoules (table 16), accounting for 18 per cent of the growth in total energy consumption in the manufacturing sector between 2005-06 and 2029-30.

table 16 **final energy consumption in Australia, by manufacturing subsector**

| | consumption | | | | average annual growth | |
|---|---|---|---|---|---|---|
| | 2005-06 | 2011-12 | 2019-20 | 2029-30 | 2005-06 to 2011-12 | 2005-06 to 2029-30 |
| | PJ | PJ | PJ | PJ | % | % |
| wood, paper and printing | 66 | 72 | 79 | 89 | 1.4 | 1.2 |
| basic chemicals | 176 | 201 | 223 | 252 | 2.2 | 1.5 |
| iron and steel | 95 | 116 | 118 | 122 | 3.4 | 1.0 |
| *of which natural gas* | 26 | 27 | 27 | 27 | 0.6 | 0.3 |
| basic nonferrous metals | 433 | 532 | 583 | 631 | 3.5 | 1.6 |
| *of which natural gas* | 112 | 173 | 197 | 204 | 7.5 | 2.5 |
| aluminium smelting | 109 | 112 | 115 | 117 | 0.4 | 0.3 |
| other basic nonferrous metals | 324 | 420 | 468 | 514 | 4.4 | 1.9 |
| nonmetallic mineral products | 108 | 118 | 126 | 138 | 1.6 | 1.0 |
| other manufacturing **a** | 206 | 226 | 249 | 277 | 1.6 | 1.2 |
| total manufacturing | 1 084 | 1 266 | 1 378 | 1 509 | 2.6 | 1.4 |

**a** Includes construction.

Wood, paper and printing is a relatively small energy consumer and is concentrated in three states, with New South Wales, Victoria and Tasmania accounting for 76 per cent of the sector's total energy use in 2005-06. Over the outlook period, energy consumption in the sector is projected to grow at an average rate of 1.2 per cent a year, reaching 89 petajoules by 2029-30 (table 16).

In 2005-06, nonmetallic mineral products accounted for 10 per cent of the manufacturing sector's total energy consumption. Gas and coal dominate the nonmetallic mineral product industry's fuel mix. In 2005-06 gas and coal had a combined share of nearly 80 per cent of the sector's energy use. Between 2005-06 and 2029-30, energy use in the sector is projected to increase by 30 petajoules, approximately 80 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 48 per cent in 2005-06 to 55 per cent in 2029-30.

In 2005-06, 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 14), with electricity consumption in the sector growing at a slightly faster rate of 2.7 per cent a year. In 2005-06, the commercial sector accounted for around 22 per cent of total electricity consumption and is projected to account for around 32 per cent of the increase in electricity use over the projection period. This compares with a share of 23 per cent of the projected increase in the residential sector's electricity use and a share of 27 per cent for the manufacturing sector.

Final energy use in the residential sector was 413 petajoules in 2005-06, 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 593 petajoules in 2029-30 (table 14). Electricity accounted for 53 per cent of residential sector energy demand in 2005-06 and gas accounted for 31 per cent. In 2029-30, these shares are projected to be 57 per cent and 30 per cent respectively.

# 3

# energy production and trade outlook

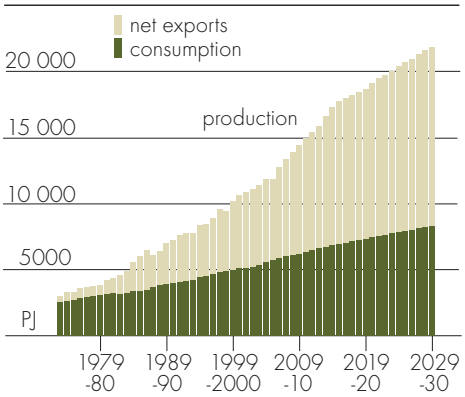
Excluding uranium, which is not used to produce energy domestically, the main fuels produced in Australia are coal, oil, gas and renewables. With the exception of crude oil and refined petroleum products, Australia is a net exporter of energy commodities, notably of black coal. In 2005-06, production of black coal was 8156 petajoules, or 69 per cent of total energy production (table 17). In physical terms, total coal production was 359 million tonnes, comprised of 286 million tonnes of black coal and 73 million tonnes of brown coal. Natural gas accounted for 15 per cent of total energy production, followed by crude oil and naturally occurring LPG (9 per cent) and renewables (hydroelectricity, wind, biomass, biogas and solar) at 2 per cent.

table 17 **energy production in Australia, by fuel**

| | production | | | | average annual growth | |
|---|---|---|---|---|---|---|
| | 2005-06 | 2011-12 | 2019-20 | 2029-30 | 2005-06 to 2011-12 | 2005-06 to 2029-30 |
| | PJ | PJ | PJ | PJ | % | % |
| black coal | 8 156 | 10 129 | 11 389 | 13 037 | 3.7 | 2.0 |
| brown coal | 704 | 755 | 817 | 801 | 1.2 | 0.5 |
| crude oil **a** | 900 | 1 351 | 1 139 | 1 078 | 7.0 | 0.8 |
| LPG **b** | 125 | 150 | 228 | 262 | 3.1 | 3.1 |
| natural gas | 1 742 | 2 626 | 4 619 | 6 135 | 7.1 | 5.4 |
| hydroelectricity | 59 | 64 | 68 | 73 | 1.3 | 0.9 |
| wind energy | 7 | 18 | 19 | 23 | 18.5 | 5.4 |
| biomass | 186 | 245 | 315 | 327 | 4.7 | 2.4 |
| biogas | 7 | 41 | 40 | 38 | 33.4 | 7.1 |
| solar energy | 3 | 3 | 4 | 4 | 2.3 | 1.9 |
| total | 11 889 | 15 383 | 18 638 | 21 778 | 4.4 | 2.6 |

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

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




Total production of energy in Australia is projected to grow at an average rate of 2.6 per cent a year. At this rate, Australian production of energy is projected to increase by 83 per cent to reach 21 778 petajoules in 2029-30 (table 17). Gas production is projected to rise from 1742 petajoules (43 550 gigalitres) in 2005-06 to 6135 petajoules (153 360 gigalitres) in 2029-30, constituting to 28 per cent of total energy production in 2029-30. At the same time, the combined share of crude oil and naturally occurring LPG is projected to fall to 6 per cent of total energy production. The share of black coal in total energy production is projected to fall from 69 per cent in 2005-06 to 60 per cent by 2029-30.

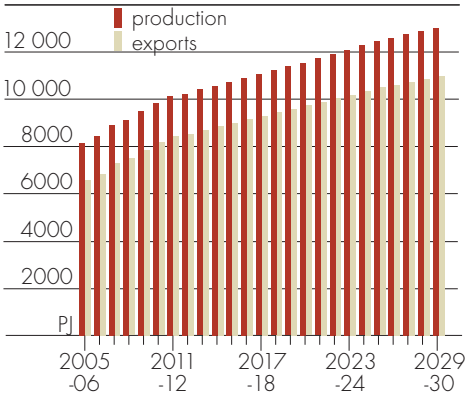
As the projected growth in nonuranium energy production exceeds that of primary energy consumption, Australia's exportable surplus of energy is projected to increase over the projection period. In 2005-06, the ratio of Australia's primary energy consumption to nonuranium energy production was 48 per cent. By 2029-30, the ratio of Australia's primary energy consumption to nonuranium energy production is projected to decline to 38 per cent (figure M).

## *black coal production and exports*

Increased mine and infrastructure capacity in Queensland and New South Wales is projected to support a 67 per cent increase in black coal exports over the projection period, from 6582 petajoules (231 million tonnes) in 2005-06 to 10 989 petajoules (386 million tonnes) in 2029-30 (table 18; figure N).

Black coal exports will be supported by the 13 million tonnes expansion of the Newcastle port coal terminal that was completed in March 2007. A number of additions to other Australian coal export infrastructure are also currently underway. The Blackwater rail system will be upgraded to support increased coal exports

fig N **black coal in Australia**




through Gladstone. Capacity at the Dalrymple Bay coal terminal near Mackay in Queensland will increase to 68 million tonnes in early 2008, in the project's first phase, and to 85 million tonnes by late 2008, in phases 2 and 3 of the project (Copeland et al. 2007).

Major thermal coal projects assumed to commence production over the projection period in Queensland include Rio Tinto's 12 million tonnes a year Clermont project and Ensham Resources' 8 million tonnes a year Ensham Central project. Major thermal coal projects expected to commence production in New South Wales include Centennial Coal's 10.5 million tonnes a year Anvil Hill mine, Felix Resources 13 million tonnes

table 18 **net trade in Australian energy**

| | net exports | | | net imports | |
|---|---|---|---|---|---|
| | black coal | LPG | LNG | crude oil and ORF | other petroleum products |
| | PJ | PJ | PJ | PJ | PJ |
| 2005-06 | 6 582 | 53 | 678 | 508 | 418 |
| 2011-12 | 8 454 | 47 | 1 284 | 209 | 489 |
| 2014-15 | 8 857 | 74 | 2 619 | 386 | 523 |
| 2019-20 | 9 599 | 111 | 2 928 | 553 | 600 |
| 2024-25 | 10 358 | 111 | 3 631 | 694 | 694 |
| 2029-30 | 10 989 | 111 | 4 153 | 794 | 804 |
| average annual growth rate | % | % | % | % | % |
| 2005-06 to 2011-12 | 4.3 | -1.9 | 11.2 | -13.8 | 2.7 |
| 2005-06 to 2029-30 | 2.2 | 3.1 | 7.8 | 1.9 | 2.8 |

a year Moolarben mine, Rio Tinto's 10.5 million tonnes a year Mount Pleasant project and BHP Billiton's 7 million tonnes a year Mount Arthur North project (Copeland et al. 2007).

Major metallurgical coal projects that are assumed to commence production during the projection period include the Belvedere mine in Queensland, with a capacity of 8–9 million tonnes a year, and the BHP Billiton Mitsui Alliance (BMA) Goonyella project in Queensland, with a capacity of 7 million tonnes a year (Copeland et al. 2007).

These projects are projected to drive an increase in black coal production of 60 per cent over the outlook period, reaching 13 037 petajoules by 2029-30 (table 17). 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.

## *natural gas production and LNG exports*

In 2005-06, total gross output of natural gas (including natural gas from coal seam methane projects) in Australia was 1742 petajoules (table 19). On a regional basis, the largest contributor to natural gas production was Western Australia, which produced 1011 petajoules or 58 per cent of total production. Gross gas production in the eastern states and the Northern Territory is estimated to have been around 652 and 79 petajoules respectively in 2005-06. Gross gas production in the Northern Territory includes gas imported from the Joint Petroleum Development Area (JPDA) in the Timor Sea for LNG production.

At present the two largest producing basins in the eastern states are Gippsland and Cooper/Eromanga. In 2005-06, these two basins provided a total of 449 petajoules of gas, around 70 per cent of the eastern states' gas supply. Over the projection period, gas production from the Cooper/Eromanga basin is projected to decline to 10 petajoules. In contrast, supplies from the Gippsland basin are projected to increase to 381 petajoules by 2029-30.

Gas production from the Otway basin is projected to increase from 62 petajoules in 2005-06 to a peak of 146 petajoules in 2010-11, before settling at 115 petajoules by 2029-30.

Production of coal seam methane (CSM) in Queensland and New South Wales is projected to increase from 93 petajoules in 2005-06 to 218 petajoules by 2011-12, accounting for 32 per cent of the eastern Australian gas market. By 2029-30, CSM production is projected to reach 529 petajoules. It is assumed in these projections that all CSM produced in the eastern states gas market will be consumed domestically.

The positive outlook for natural gas production from coal seam methane projects is projected to result in the eastern gas market remaining in balance over the projection period. By 2029-30, total gross natural gas production in the eastern states is projected to be around 1089 petajoules (table 19).

In 2005-06, gross natural gas production (including imports from the JDPA in the Timor Sea for LNG production) in the Northern Territory is estimated to have been 79 petajoules. By 2029-30, gross natural gas production in the Northern Territory is projected to reach 718 petajoules, growing at an average annual rate of 9.6 per cent. Gas supply to the northern market (excluding LNG exports) is projected to meet demand over the outlook period, increasing from 31 petajoules in 2005-06 to 135 petajoules in 2029-30.

table 19 **Australian gas production and reserves to 2029-30, by region**

| | production | | average annual growth 2005-06 to 2029-30 | demonstrated resources [a] initial |
|---|---|---|---|---|
| | 2005-06 | 2029-30 | 2029-30 | |
| | PJ | PJ | % | PJ |
| *eastern gas market* | 652 | 1 089 | 2.2 | 16 850 |
| conventional gas | 559 | 560 | 0.0 | 11 411 |
| coal seam methane | 93 | 529 | 7.5 | 5 439 |
| New South Wales | 10 | 102 | 10.1 | 102 |
| Queensland | 83 | 427 | 7.1 | 5 337 |
| *western gas market* | 1 011 | 4 327 | 6.2 | 128 650 |
| *northern gas market* [b] | 79 | 718 | 9.6 | 27 229 |
| Australia | 1 742 | 6 135 | 5.4 | 167 291 |

**a** As at 1 January 2005 for conventional gas. Proved plus probable reserves as at end 2006 for coal seam methane.
**b** Production includes imports from the JPDA in the Timor Sea.

Gross natural gas production in Western Australia, including LNG, is projected to grow strongly, at an average rate of 6.2 per cent a year, to reach 4327 petajoules in 2029-30 (table 19). The demand for natural gas in Western Australia is projected to be fully satisfied over the projection period by Western Australian natural gas production, exclusive of LNG exports. Natural gas supplied to the Western Australian market is projected to increase from 380 petajoules in 2005-06 to 758 petajoules in 2029-30.

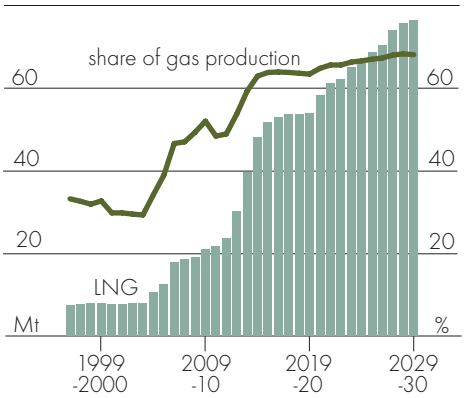
## LNG exports

Australia currently has two LNG export projects, the North West Shelf, with annual capacity of around 11.9 million tonnes from four trains, and the Darwin LNG project, with a capacity of 3.5 million tonnes a year. A fifth train at the North West Shelf and the Pluto LNG project are expected to be the main sources of LNG export growth over the medium term. LNG exports are forecast to rise to around 24 million tonnes by 2011-12.

Beyond the medium term, growth in LNG exports is projected to be supported by the development of a number of greenfield projects, including the Gorgon LNG, Pilbara LNG and Browse projects. Additional trains at the North West Shelf and Darwin are also assumed to contribute to the growth in LNG exports. By 2029-30, LNG exports have the potential to reach 76 million tonnes (figure O), reflecting an average annual growth rate over the projection period of 7.8 per cent.

In the second half of 2007, Santos announced a proposal for the construction of an LNG facility at Gladstone in Queensland. It indicated that 3 to 4 million tonnes of LNG produced at this facility per year would be exported and that feedstock for this facility would be sourced from Santos' CSM projects in the Bowen and Surat Basins. The timing of this announcement has precluded the inclusion of this proposal in the projections of Australian CSM production and LNG exports.

fig O **Australia's LNG exports**



Production of LNG is projected to increase its share of total Australian natural gas production from 39 per cent in 2005-06 to 68 per cent by 2029-30.

## *petroleum refining and crude oil production*

The outlook for domestic oil production and for end use consumption of petroleum products are key drivers of Australia's demand for imported liquid fuels. In addition to geological factors, world oil prices have a major influence on the level of global and domestic oil production. While oil prices are expected to remain high in the short term as the global oil market remains tight (Copeland 2007c), prices are assumed to decline over the medium to long term as new oil production capacity comes on stream and investment in nonconventional oil resources takes place.

A large part of current Australian oil production is sourced from mature oil provinces. The latest available estimates of commercial and recoverable oil reserves (which include reserves of crude oil, condensate and LPG) for the Bonaparte, Browse, Carnarvon and Gippsland basins are approximately 900 gigalitres at the 50 per cent level of probability (Geoscience Australia 2006). 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 these have not been explored (Australian Government 2004).

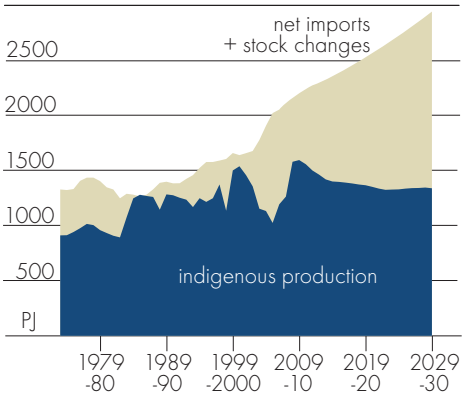
ABARE bases its estimate of Australia's long term undiscovered resources partly on a study by the US Geological Survey (USGS) of world long term ultimate undiscovered potential oil resources. Using a 1995 data set, the USGS assessed potential undiscovered oil resources in the Bonaparte, Browse, Carnarvon 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 (US Geological Survey 2000).

In order to ensure consistency across different data sources, only estimates based on the 50 per cent probability level have been used when calculating resource estimates included in the *$E_4$cast* model. Taking account of the resources that have been discovered in the Bonaparte, Browse, Carnarvon and Gippsland basins since the USGS study was undertaken, the potential undiscovered resources in these four basins are estimated, by ABARE, to have been reduced to approximately 1360 gigalitres at a 50 per cent level of probability.

Combining potential undiscovered resources (calculated from the USGS geological survey), and commercial and recoverable reserves (as identified by Geoscience Australia), the ultimate remaining oil resource is estimated by ABARE to be approximately 2260 gigalitres at the 50 per cent level of probability, as of January 2005.

In *$E_4$cast*, suppliers develop a small proportion of the resource base every year in response to price signals, and bring that production to the market. However, the reserves in existing and subsequently new oil fields are assumed to deplete as oil is extracted. The outcome of these two effects is that indigenous production of crude oil and condensate declines from the peak of 1451 PJ in 2009-10, to 1351 PJ in 2011-12, and in the long term, to 1078 petajoules by 2029-30 (table 17 and figure P).

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




Domestic production of naturally occurring LPG is projected to increase at a rate of 3.1 per cent a year, reaching 150 petajoules by 2011-12 and 262 petajoules by 2029-30 (table 17). The combined production of crude oil and naturally occurring LPG in Australia is forecast to increase modestly over the outlook period, from 1025 petajoules in 2005-06 to 1340 petajoules in 2029-30.

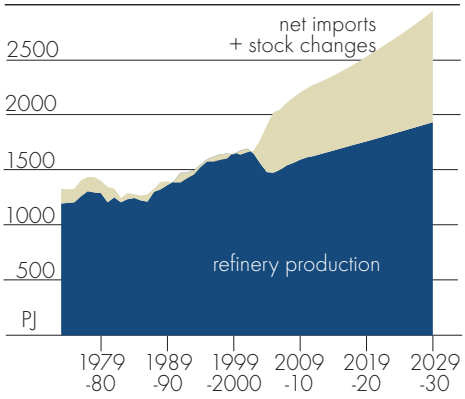
Consumption of liquid fuels (including LPG), on the other hand, is projected to grow more strongly from 2022 petajoules in 2005-06 to 2944 petajoules by 2029-30 (figure P). The projected supply–demand gap for liquid fuels in Australia is expected to widen because a significant proportion of the growth in domestic production of crude oil and naturally occurring LPG will be concentrated in the Carnarvon Basin, in the north west of the country. As a result, it is assumed that this supply of crude oil and naturally occurring LPG will largely be exported to Asia for processing, as opposed to supplied to the domestic market. The ability of domestic production of liquid fuels to meet domestic demand will thus be lower than implied by the simple comparison of aggregate production and consumption (figure P).

The demand for petroleum product 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 crude 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. It is assumed that 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.

Following the mothballing of the Port Stanvac refinery in South Australia in 2003, it is assumed that no new major additions to Australia's refining capacity will be made over the projection period. However, ongoing investment in efficiency improvements is assumed to be sufficient for gross refinery output in Australia, including that of petrochemicals, to increase from 1479 petajoules in 2005-06 to 1937 petajoules in 2029-30 (figure Q).

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




The growth in consumption of petroleum products is projected to outpace the growth in refinery output over the longer term, rising by a projected 1.6 per cent a year. As a result, the proportion of petroleum products consumption sourced from domestic refineries is projected to fall from 73 per cent to 66 per cent between 2005-06 and 2029-30.

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