Australian energy projections to 2029-30

Arif Syed, Jane Melanie, Sally Thorpe and Kate Penney

ABARE research report 10.02

March 2010

abare.gov.au

ISSN 1447-8358
ISBN 978-1-921448-66-9

Syed, A, Melanie, J, Thorpe, S and Penney, K 2010, *Australian energy projections to 2029-30,* ABARE research report 10.02, prepared for the Department of Resources, Energy and Tourism, Canberra, March.

Australian Bureau of Agricultural and Resource Economics

Postal address	GPO Box 1563 Canberra ACT 2601 Australia
Location	7B London Circuit Canberra ACT 2601
Switchboard	+61 2 6272 2000
Facsimile	+61 2 6272 2001

ABARE is a professionally independent government economic research agency.

ABARE project 1644

Acknowledgments

This report was undertaken with the support of the Australian Government Department of Resources, Energy and Tourism.

The authors appreciate the contributions of the following people, who assisted with various aspects of the project: Allison Ball, Alan Copeland, Clara Cuevas-Cubria, Trish Gleeson, Apsara Maliyasena, Paul Morris, Hom Pant, Jammie Penm, Andrew Schultz and Terry Sheales, all of ABARE. The authors are also grateful for the valuable input and comments provided by colleagues from the Department of Resources, Energy and Tourism, the Australian Treasury, and Geoscience Australia.

The preparation of this report also benefited from valuable insights and information provided by a range of agencies that participated in the consultation program. These include the Australian Energy Market Commission (AEMC); the Australian Energy Market Operator (AEMO); the Australian Energy Regulator (AER); the Energy Supply Association of Australia (ESAA); the New South Wales Department of Water and Energy; Primary Industry and Resources of South Australia (PIRSA); the Queensland Department of Mines and Energy; the South Australian Department for Transport, Energy and Infrastructure; Vencorp; and the Victorian Department of Primary Industries.

Contents

Boxes

Figures

Tables

Maps

Foreword

This report is an example of ABARE's ongoing commitment to providing information related to the Australian energy sector to support decision-making by industry, government and the broader community. Australian energy projections to 2029-30 provides long-term projections of Australian energy consumption, production and trade.

Since the previous long-term projections were published by ABARE in December 2007, significant developments have occurred that are likely to shape Australia's energy future. Concerns over climate change and energy security have given rise to new energy policy settings, both domestically and internationally. At the same time, the global financial crisis and the subsequent global economic downturn saw a significant contraction in energy demand and prices.

This report aims to encapsulate these recent developments in providing long-term projections of Australian energy consumption, production and trade for the period from 2007-08 to 2029-30. The results suggest that the Australian energy sector is at an important junction as it adjusts to a long-term growth trajectory within a carbon constrained economy. Even though Australia is endowed with vast renewable and non-renewable energy resources, the challenges inherent in this transformation are likely to be significant.

The dynamics of energy markets over the past few years clearly highlight the risks associated with any long-term forecasting. Further, technology is constantly evolving. Nonetheless, it is hoped the outlook presented here will assist decision-makers in delivering an efficient, secure and sustainable energy future for Australia.

Phillip Glyde
Executive Director
March 2010

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.
Coal by-products	By-products 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	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 non-commercial quality gas. In this report, natural gas also includes town gas (including synthetic natural gas, reformed gas, tempered liquid petroleum gas and tempered natural gas).
Gas pipeline operation	Natural gas used in pipeline compressors, and losses, operation and leakage during transmission.
Levelised cost	The total levelised cost of production represents the revenue per unit of electricity generated that must be met to break even over the lifetime of a plant.
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 278 gigawatt hours, is the heat energy content of about 43 000 tonnes of black coal or 29 million litres of petrol.
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). The distinction

between the consumption of petroleum at the primary and final end use stages relates only to where the petroleum is consumed, not to the mix of different petroleum products consumed. The consumption of petroleum at the primary energy use stage is referred to collectively as oil, while the consumption of petroleum at the final end use stage is referred to as petroleum products. The one exception to this is liquefied petroleum gas (LPG). LPG is not included in the definition of end use consumption of petroleum because it is modelled separately.

Primary fuels The forms of energy obtained directly from nature. They include non-renewable 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, electricity, coke, coke oven gas, blast furnace gas and briquettes.

Total final energy The total amount of energy consumed in the final or end use sectors. It is equal to total primary energy consumption less energy consumed or lost in conversion, transmission and distribution.

Total primary energy Also known as total domestic availability. The total of the consumption of each fuel (in energy units) in both the conversion and end use sectors. It includes the use of primary fuels in conversion activities, notably the consumption of fuels used to produce petroleum products and electricity. It also includes own use and losses in the conversion sector.

Units

Metric units

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

Standard metric prefixes

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

Standard conversions

1 barrel = 158.987 L

1 kWh = 3600 kJ

Indicative energy content conversion factors

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

Conventions used in tables

Small discrepancies in totals are generally the result of the rounding of components.

Summary

- In this report, ABARE's latest long-term projections of Australian energy consumption, production and trade are presented, with an outlook horizon of 2029-30. These projections are not intended as predictions or forecasts, but as indications of potential changes in Australian energy consumption, production and trade patterns given the assumptions used in the report.
- In undertaking these projections, ABARE included government policies that have already been enacted and those that can reasonably be expected to be adopted over the projection timeframe. On this basis, the Renewable Energy Target (RET) and a 5 per cent carbon emissions reduction below 2000 levels by 2020 have been incorporated in the projections, as well as other existing government initiatives.
- The design of the carbon emissions reduction target modelled in this report is consistent with the proposed Carbon Pollution Reduction Scheme (CPRS) as specified in the White Paper on the Carbon Pollution Reduction Scheme (CPRS) released on 15 December 2008 and amended on 4 May 2009.
- In November 2009, the Australian Government announced further measures related to assistance for electricity generators, households and energy-intensive trade-exposed industries under the proposed CPRS. These measures will clearly have distributional impacts and provide assistance to affected parties. However, it is unlikely that these measures will have a major effect on the behaviour of respective agents in the long run, given the incentives inherent in the CPRS for long-term structural adjustment to reduce the carbon intensity of the Australian economy.

Energy consumption

- Total primary energy consumption is projected to grow by nearly 35 per cent (or 1.4 per cent a year) over the projection period (2007-08 to 2029-30). This growth trajectory reinforces the long-term decline in the energy intensity of the Australian economy.
- Coal and oil will continue to supply the bulk of Australia's energy needs, although their share in the energy mix is expected to decline.
- In comparison, the use of gas (natural gas and coal seam gas) is expected to grow strongly by 3.4 per cent a year over the outlook period. This growth is driven primarily by the electricity generation sector and consumption of gas in liquefied natural gas (LNG) production.
- Supported by the RET, the share of renewable energy is projected to increase substantially to account for 8 per cent of total energy consumption in 2029-30. This implies an average annual growth rate of 3.5 per cent, with strong growth expected for wind energy.

- Higher projected growth rates in energy consumption in Queensland and Western Australia compared with other states are underpinned by relatively higher gross state product assumptions, combined with the high share of mining in economic output and the significant projected expansion of the gas sector, in particular LNG.
- The electricity generation sector and the transport sector are expected to remain the two main users of primary energy.
- While the mining sector contributed to only 5 per cent of primary energy consumption in 2007-08, it is projected to have the highest energy consumption growth rate over the next two decades. This reflects the expected recovery in global demand for energy and mineral commodities and the large number of mineral and energy projects (including LNG and coal seam gas) assumed to come on stream over the outlook period.
- Oil consumption in the transport sector is expected to grow steadily over the projection period at an average rate of 1.2 per cent a year, driven largely by economic growth. Within the transport sector, road transport is the largest contributor to energy consumption. Energy use in the road transport sector is projected to grow by 0.9 per cent a year on average over the period to 2029-30.

Electricity generation

- Gross electricity generation is projected to grow by nearly 50 per cent (or 1.8 per cent a year) from 247 terawatt hours in 2007-08 to 366 terawatt hours in 2029-30. This growth is dominated by gas-fired electricity generation. The share of gas in electricity generation is projected to increase from 19 per cent in 2007-08 to 37 per cent in 2029-30.
- In parallel with the increasing share of gas in the electricity fuel mix, these projections highlight the significant expansion in the use of non-hydro renewable energy resources. Wind energy is projected to account for the majority of the increase in electricity generation from renewable sources over the projection period, representing 12 per cent of electricity generation in 2029-30. Growth is also expected in other renewables, including solar energy, geothermal energy and bioenergy, but from a lower base.

Energy production and trade

- Total production of non-uranium energy in Australia is projected to grow by 87 per cent (or 2.9 per cent a year) over the projection period, driven by strong growth in gas and renewable energy, to reach 23 637 petajoules in 2029-30.
- While coal production is expected to continue to increase, with a projected growth of 1.8 per cent a year, its share in total energy production is expected to fall over the period to 2029-30.
- Production of coal seam gas (CSG) in Queensland and New South Wales is projected to continue its high growth trajectory and increase from 118 petajoules in 2007-08 to 2507 petajoules by 2029-30. It is expected that a significant proportion of this CSG will

be consumed domestically, supporting the projected growth in gas-fired electricity generation. From 2015 it is expected that coal seam gas will also be converted to LNG. There are currently several proposed CSG-LNG projects with a potential combined capacity of up to 43 million tonnes (2312 petajoules) a year by 2020.

- While the production of conventional gas (natural gas) is expected to decline in eastern Australia, strong production growth is projected in the western and northern gas markets as a number of major greenfield projects are developed.
- As the projected growth in energy production exceeds that of primary energy consumption, Australia's exportable surplus of energy is projected to grow over the projection period. In 2007-08, the ratio of Australia's primary energy consumption to energy production (excluding uranium) is estimated to have been 45 per cent. By 2029-30, this ratio is projected to fall to 33 per cent.
- Black coal, which includes both thermal and metallurgical coal, is projected to remain Australia's dominant energy export. The projected average annual growth rate of 2.4 per cent is based on expectations that global demand for coal will continue to increase in the period to 2029-30 as a result of increased demand for electricity and steel-making raw materials, particularly in emerging market economies in Asia.
- LNG exports are also projected to increase significantly. By 2029-30, LNG exports from the western market have the potential to reach 73 million tonnes (3986 petajoules), which reflects an average annual growth rate over the projection period of 9 per cent. The development of a number of greenfield projects, including the Gorgon LNG, Ichthys, Wheatstone and Browse projects, is assumed to occur over the projection period.
- With declining oil production and limited prospects for an expansion of refinery capacity, Australia's net trade position for crude oil and refined petroleum products is expected to weaken over the outlook period. Australia's net imports of liquid fuels are projected to increase by 3.3 per cent a year on average.

1 Introduction

This report represents ABARE's ongoing commitment to publish regular long range projections of Australian energy production and use, with the support of the Australian Government Department of Resources, Energy and Tourism. Since the previous long-term projections were published in December 2007, significant policy developments have taken place that have the potential to cause fundamental shifts in Australia's energy sector. In particular, concerns over climate change, and highly volatile energy prices have given rise to new energy policy settings, both domestically and internationally.

In the Australian context, these new policy settings revolve around the legislation of the expanded Renewable Energy Target (RET) and the proposed introduction of a carbon emissions reduction target, both of which are likely to have a significant influence on Australian energy consumption, production and trade patterns.

Another major event since December 2007 has been the global financial crisis and the subsequent global economic downturn. While this report is focused primarily on long-term trends, the weakened economic outlook has had an effect on short to medium-term economic growth trajectories, which has affected both energy demand and investment incentives.

The report aims to encapsulate these recent developments by providing an assessment of long-term projections of Australian energy consumption, production and trade for the period from 2007-08 to 2029-30. These projections are derived using ABARE's E_4cast model, which is a dynamic partial equilibrium model of the Australian energy sector.

In undertaking these projections, ABARE has included only the policies that have already been enacted and those that can reasonably be expected to be adopted over the projection timeframe. As such, these projections incorporate the RET and a 5 per cent carbon emissions reduction target. This scenario does not pre-empt any Australian Government decisions that may affect the final target and policy design, or any specific outcomes that may be achieved by a global commitment to reduce emissions.

Further, it should be recognised that the evolving dynamics of energy markets over the past few years have increased the complexity of long-term energy projections. There is significant uncertainty about technology, investment and government policies in the current environment. As such, these projections should not be considered as forecasts of the Australian energy future, but more as indications of what the future could be given the assumptions used. In setting these assumptions, ABARE consulted widely with stakeholders at both national and state levels.

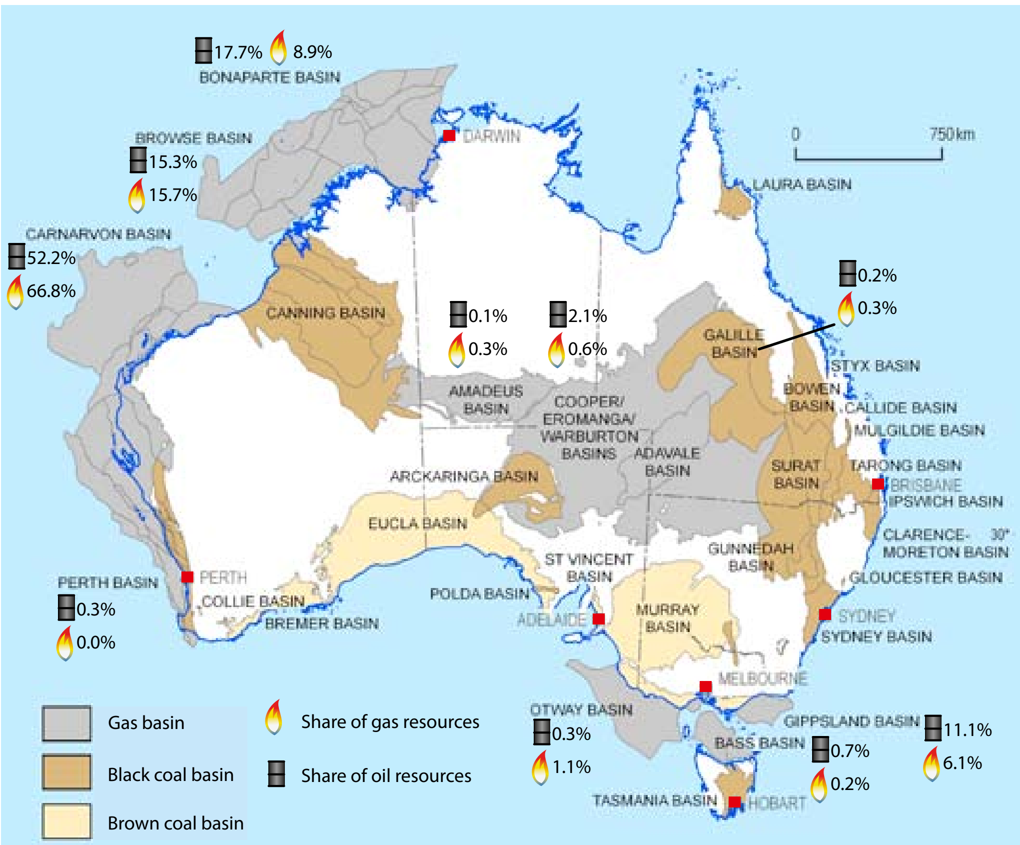
The report is structured as follows. In chapter 2 the changing energy policy context in Australia is described, with a focus on key policies that are likely to affect long-term energy trends. Chapter 3 presents the modelling framework used, as well as the key underlying assumptions. Chapter 4 provides the outlook for Australian energy consumption and electricity generation covering the period 2007-08 to 2029-30 and chapter 5 provides the long-term outlook for Australian energy production and trade.

2 The Australian energy context

Energy resources and markets

Australia is endowed with abundant, high quality and diverse energy resources (map 1). The development of these resources has contributed to low cost energy, underpinned the competitiveness of energy-intensive industries and provided significant export income. Australia is one of the few OECD countries that is a significant net exporter of energy including uranium, coal, liquefied petroleum gas (LPG) and liquefied natural gas (LNG). Energy exports were valued at around $78 billion in 2008-09, which represented around 27 per cent of Australia's total exports of goods and services, and 40 per cent of Australia's total commodity exports.

map 1 Distribution of Australia's energy resources

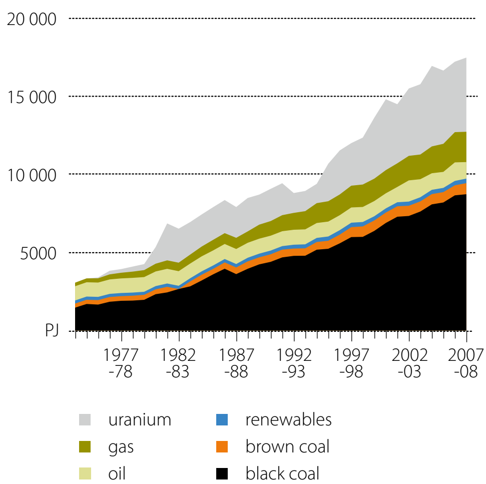


Source: Geoscience Australia.

Australia is the world's ninth largest energy producer, accounting for around 2.4 per cent of the world's energy production (IEA 2009a). Australia produces energy for meeting domestic energy consumption needs and for export. More than three-quarters of Australia's energy production is currently exported.

The rate of growth in Australia's energy production has been increasing over the past decade, driven largely by growing global demand for energy. Over the 10 years to 2007-08, energy production increased at an average annual rate of 3.5 per cent.

a Australian energy production



The main fuels produced in Australia are coal, uranium and natural gas (figure a). In 2007-08, Australia's energy production was dominated by coal, which accounted for 54 per cent of total energy production in energy content terms, followed by uranium (27 per cent) and natural gas (11 per cent). Crude oil and LPG represented 6 per cent of total production, and renewables represented 2 per cent.

Australian production of renewable energy has been dominated by bagasse, wood and wood waste, and hydroelectricity, which together accounted for 86 per cent of renewable energy production in 2007-08. Wind energy, solar energy and biofuels accounted for the remainder of Australia's renewable energy production.

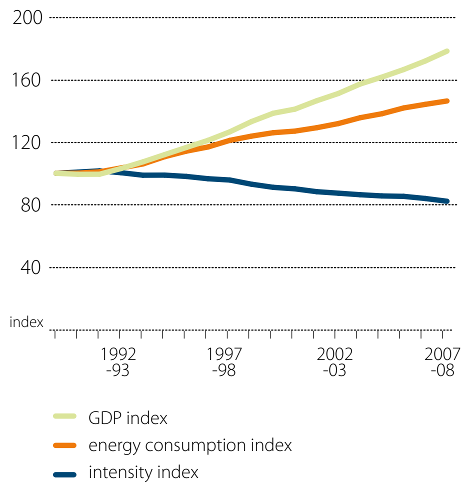
Australia is the world's twentieth largest primary energy consumer, and ranks fifteenth on a per person energy use basis (IEA 2009a).

Although Australia's energy consumption is growing, the rate of growth has been decreasing over the past 50 years. Following annual growth of around 5 per cent during the 1960s, growth in energy consumption fell during the 1970s to an average of around 4 per cent a year, largely as a result of the two major oil price shocks. During the 1980s, economic recession and sharply rising energy prices resulted in annual growth falling to an average of 2.3 per cent. Despite robust economic growth, annual average growth in energy consumption fell to around 1.9 per cent over the 10 years to 2007-08.

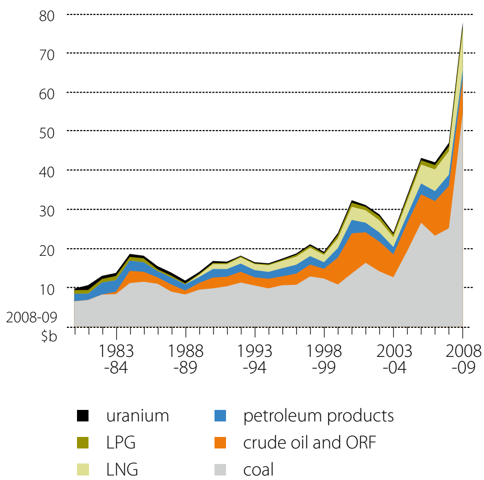
This trend indicates a longer term decline in energy intensity of the Australian economy, which can be attributed to two main factors (figure b). First, greater efficiency has been achieved through technological improvement and fuel switching. Second, rapid growth has occurred in less energy-intensive sectors, such as the commercial and services sector, relative to the more moderate growth of the energy-intensive manufacturing and processing sectors.

Australian primary energy consumption consists mainly of coal and petroleum. Black and brown coal account for the greater share of the fuel mix, at around 37 per cent, followed by petroleum products (36 per cent), natural gas (22 per cent) and renewable energy sources (5 per cent).

b Australian intensity of energy consumption



c Australian energy exports



The main users of energy in Australia are the electricity generation, transport and manufacturing sectors. Together, these sectors accounted for more than three-quarters of energy consumption in 2007-08. The residential and mining sectors were the next biggest consumers.

Over the past 20 years, domestic energy consumption has increased at a slower rate than production. Rapid growth in global demand for Australian energy resources has driven growth in domestic production. Consequently, the share of exports in Australian energy production has continued to increase.

Since 1987-88, the value of Australia's energy exports (in 2007-08 Australian dollars) has increased by an average of 7 per cent a year (figure c). Energy export earnings increased by 71 per cent in 2008-09 to reach close to $78 billion (ABARE 2009a). Coal is Australia's largest energy export earner, with a value close to $55 billion in 2008-09, followed by LNG ($10 billion) and crude oil ($9 billion).

While Australia is a net energy exporter, it is also a net importer of crude oil and refined petroleum products. In 2008-09, Australia's imports of crude oil and refined products were $28 billion.

Any future expansion of Australia's energy market, including access to new energy resources, will require investment in energy infrastructure. Additional investment will be required to replace aging energy assets and also to allow for the integration of renewable energy into existing energy supply chains.

The Asia Pacific Energy Research Centre released projections of energy investment requirements to 2030 in November 2009 (APERC 2009). APERC estimates that between US$414 billion and US$546 billion (in 2006 dollars) will be required over the period 2006 to 2030 for the energy sector as a whole. More than half of this is expected to be in resource extraction and around one-quarter in transportation including rail, pipelines and electricity transmission lines. Within the electricity sector, more than half of the required investment is in generation and a further 41 per cent in transmission.

Energy policy

Meeting growing demand for energy while providing a stable environment for energy sector investment poses some important challenges for the energy sector.

More broadly, the Australian Government has developed a suite of policies and programs aimed at creating a lower carbon economy. These policies and programs are designed to internalise the costs of climate change for Australian business and households through a fundamental shift in energy use and investment incentives.

The key elements of the government's strategy to reduce emissions are the Renewable Energy Target (RET) and the proposed carbon emissions reduction target.

Renewable Energy Target

A key policy driver that is likely to have a significant influence on the structure of the energy sector is the expanded Renewable Energy Target (RET). In 2008, the Australian Government announced a target of 20 per cent of Australia's electricity supply to be sourced from renewable energy by 2020. This is to be achieved through an expansion of the previous Mandatory Renewable Energy Target (MRET) scheme, increasing the legislated national target from 9500 gigawatt hours to 45 850 gigawatt hours in 2020, in addition to what would have been generated in a baseline without the policy. After 2020, the target will be maintained at 45 000 gigawatt hours until 2030, when it is expected that there will be a carbon price high enough to support renewable energy generation. This policy was legislated in mid-2009 with new targets to take effect in 2010.

The aim of the scheme is to accelerate the uptake of renewable energy for on-grid power generation and to contribute to the development of internationally competitive renewable energy industries. It is also designed to bring existing state-based renewable energy targets into a single, national scheme.

The Office of the Renewable Energy Regulator will oversee the implementation of the RET (ORER 2009).

Carbon emissions reduction target

The Australian Government released the White Paper on the proposed Carbon Pollution Reduction Scheme (CPRS) on 15 December 2008 (Australian Government 2008). This document sets out the government's policy for two components of its carbon mitigation strategy—the establishment of a medium-term target range for emissions reduction and the final design of the emissions reduction target. The White Paper allowed for two different scenarios:

- a 5 per cent emissions reduction target, which requires a 5 per cent reduction in emissions below 2000 levels by 2020
- a 15 per cent emissions reduction target, which requires a 15 per cent reduction in emissions below 2000 levels by 2020.

Both scenarios are based on the assumption that international emissions trading gradually expands, developed economies participate from 2010, developing countries join over time, and there is global participation by 2025. Under the 5 per cent emissions reduction target, a slower start to global greenhouse gas emission reductions and stabilisation of emissions in the atmosphere at 550 parts per million (ppm) are assumed. The 15 per cent emissions reduction target assumes a faster start and stabilisation at 510 ppm.

New measures for the emissions reduction target, including an expanded target, were announced on 4 May 2009 (Australian Government 2009a). In particular, Australia committed to a larger reduction in emissions of 25 per cent below 2000 levels by 2020, subject to a more ambitious international agreement involving all major emitters and consistent with stabilisation of emissions at 450 ppm or lower by mid-century.

Under all these scenarios, Australia's long-term target is to reduce emissions to 60 per cent below 2000 levels by 2050.

The CPRS aims to reduce emissions of greenhouse gases by placing a limit on aggregate annual emissions from all the covered types and sources of emissions and allowing carbon pollution permits to be traded, with the price of permits to be determined by the market.

The CPRS is proposed to be phased in on 1 July 2011 but is yet to be legislated.

In November 2009, the Australian Government announced further measures related to assistance for electricity generators, households and energy-intensive trade-exposed industries under the proposed CPRS. These measures will clearly have distributional impacts and provide assistance to affected parties to ease adjustment costs. However, it is unlikely that these measures will have a major effect on the behaviour of respective agents in the long run, given the incentives inherent in the CPRS for long-term structural adjustment to reduce the carbon intensity of the Australian economy. For this reason, these measures have not been explicitly considered in the modelling undertaken for this report.

Other initiatives

In addition to these key national policies, there is a wide range of other policy initiatives at state levels designed to deliver a lower carbon footprint. These include the Australian Government Clean Energy Initiative, energy efficiency initiatives, the New South Wales Greenhouse Gas Reduction Scheme, the Queensland Gas Scheme and the Victorian Renewable Energy Target.

Clean Energy Initiative

The Clean Energy Initiative announced by the Australian Government in May 2009 is designed to support the research, development and demonstration of low-emission energy technologies, including industrial scale carbon capture and storage (CCS) and solar energy (Department of Resources, Energy and Tourism 2009).

Under the CCS flagships program, support will be given for the construction and demonstration of large-scale integrated carbon capture and storage projects in Australia with a target to create 1000 megawatts of low emission fossil fuel electricity generation capacity.

Also part of the Clean Energy Initiative is the Solar Flagships Program which received funding to support the construction and demonstration of large-scale solar power stations in Australia with a target of 1000 megawatts of electricity generation capacity.

Under both programs, the commissioning of projects is expected to commence from 2015, following a competitive selection process, and subject to necessary financial, planning, engineering and regulatory processes and approvals.

Energy efficiency initiatives

Since 2004, the Australian and state and territory governments have coordinated national action on energy efficiency through the National Framework for Energy Efficiency (NFEE) which aims to increase the uptake of energy efficient technologies and processes across the Australian economy. In July 2009, the Council of Australian Governments (COAG) agreed on the National Strategy on Energy Efficiency (NSEE). The strategy aims to accelerate energy efficiency improvements for households and businesses across all sectors of the economy, to address climate change, reduce the cost of emissions abatement and improve the productivity of the economy. The NSEE addresses barriers preventing the optimal uptake of energy-efficient opportunities, such as split incentives and information failures. There are a number of programs already in place or in development by the Australian Government and state and territory governments to address energy efficiency (Sandu and Petchey 2009).

New South Wales Greenhouse Gas Reduction Scheme

The New South Wales Greenhouse Gas Reduction Scheme (GGAS) was implemented on 1 January 2003, and imposes enforceable annual greenhouse gas reduction benchmarks for electricity retailers and other liable parties. The Australian Capital Territory Government implemented a scheme that mirrors GGAS on 1 January 2005.

The annual greenhouse gas reduction benchmarks are set until 2012 and the NSW Government has committed to extending benchmarks until 2020. The initial benchmark was set at 8.65 tonnes of carbon dioxide equivalent (CO_2-e) per person for the year. Currently, the benchmark is set as a 5 per cent reduction in per person greenhouse gas emissions from the Kyoto Protocol baseline year of 1989-90 by 2007. This target will be maintained until at least 2012, which implies a target of 7.27 tonnes of CO_2-e per person in 2009 (Greenhouse Gas Reduction Scheme Administrator 2007). The introduction of the proposed CPRS will result in the termination of GGAS.

In November 2008, the NSW Government announced new energy efficiency targets to take effect from 1 July 2009. This will extend the scope of the demand side abatement element of GGAS beyond the introduction of the CPRS. The new targets will require electricity retailers to undertake energy efficiency activities or projects in business or residential buildings (Greenhouse Gas Reduction Scheme Administrator 2008).

Queensland Gas Scheme

The Queensland Gas Scheme was implemented on 1 January 2005 with the aim of reducing greenhouse gas emissions and supporting Queensland's gas industry. 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.

Amendments made to the Clean Energy Act 2008 on 1 July 2008 increased the requirement to 15 per cent in 2010 and up to 18 per cent by 2020 (Queensland Government 2009). The scheme will be transitioned into the CPRS proposed by the Australian Government.

Victorian Renewable Energy Target

The Victorian Renewable Energy Target (VRET) commenced on 1 January 2007 and requires 10 per cent of total electricity generation be sourced from renewable energy sources by 2016. Legislation has been passed in the Victorian parliament to transition the VRET to the Australian Government's expanded RET scheme from 2010.

3 Methodology and key assumptions

The energy sector projections presented in this report were derived using ABARE's E_4cast model. E_4cast 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 a financial year basis.

The model includes a large number of variables and parameters that are used to approximate the interdependencies between production, conversion and consumption. As these are of critical importance to the results obtained, an outline of the key assumptions and model parameters are provided in this chapter.

The E_4cast model

The modelling framework developed by ABARE employs an integrated analysis of the electricity generation and gas sectors within an Australian domestic energy use model. The model represents two sets of conditions: quantity and competitive price constraints. The competitive equilibrium is achieved when all the constraints are satisfied. A simple schematic of the E_4cast model is provided in figure d.

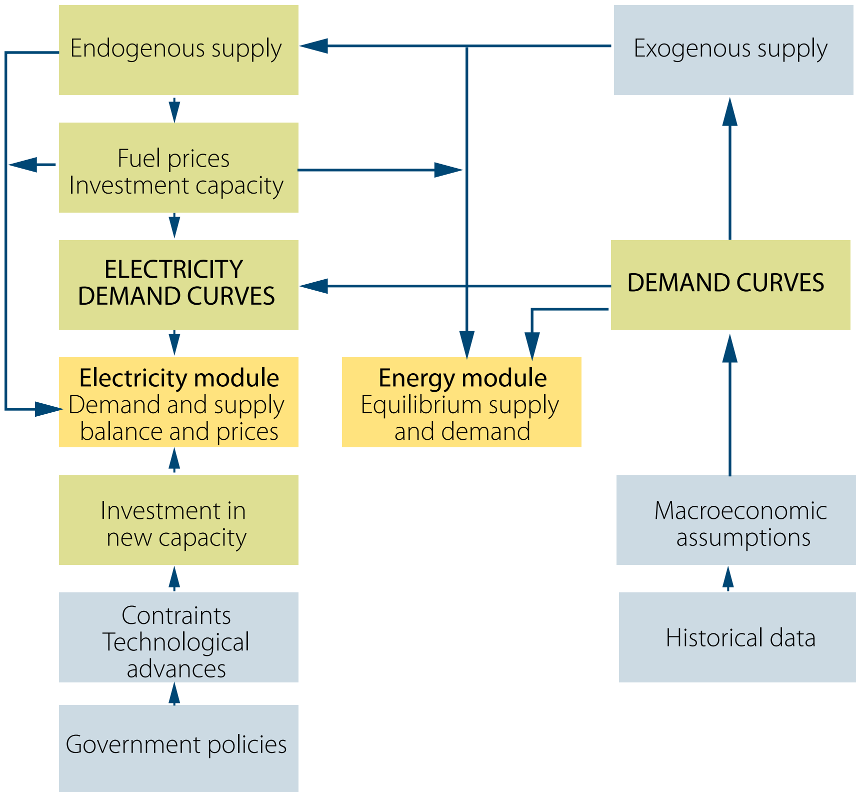
1 Fuel coverage in E_4cast

Black coal
Brown coal
Coal by-products
– coke oven gas
– blast furnace gas
Coke
Natural gas
Coal seam gas
Oil (crude oil and condensate)
Liquefied petroleum gas (LPG)
Other petroleum products
Electricity
Solar (solar hot water)
Solar electricity (solar photovoltaic and solar thermal)
Biomass (bagasse, wood and wood waste)
Biogas (sewage and landfill gas)
Hydroelectricity
Wind energy
Geothermal energy
Ocean energy

E_4cast incorporates ABARE's most recent commodity projections and current assumptions on the costs and characteristics of energy conversion technologies. A brief overview of the key features of the current version of E_4cast is provided in box 1. The model provides an outlook for the Australian energy sector that is feasible, where all quantity constraints are satisfied, and satisfies the economic competitive prices conditions (a competitive equilibrium is achieved).

The coverage of energy types and industries is shown in tables 1 and 2, respectively. The model includes 19 energy sources, five conversion sectors, 19 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

d Energy forecasting model



been estimated econometrically and incorporate own price, cross price, income or activity, and technical change effects.

In E_4cast, prices of energy sources used in electricity generation are determined within the model based on demand and supply factors, with the exception of oil where prices are determined in the world market.

The direction of interstate trade in natural gas and electricity is determined endogenously in E_4cast, accounting for variation in regional prices, transmission costs and capacities.

In E_4cast, over the medium term, upper limits on interstate flows of electricity and natural gas are imposed to reflect existing constraints and known expansions that are at an advanced stage of development. Beyond the medium term, it is assumed that any interstate imbalances in gas supply and demand will be anticipated, which will result in infrastructure investment in gas pipelines and electricity interconnector capacity sufficient to meet trade requirements.

box 1 Key features of E_4cast

In 2000, ABARE commenced development of its E_4cast 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 and provides a sound platform for the development and analysis of medium and long-term energy and greenhouse gas emissions projections. Key features of the 2009 version of E_4cast are outlined below:

- E_4cast is a dynamic partial equilibrium framework that provides a detailed treatment of the Australian energy sector focusing on domestic energy use and supply.
- The Australian energy system is divided into 24 conversion and end use sectors.
- Fuel coverage comprises 19 primary and secondary fuels.
- All states and territories (the Australian Capital Territory is included with New South Wales) are represented.
- Detailed representation of energy demand is provided. 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. This convention is consistent with the approach used by the International Energy Agency.
- The current version of E_4cast covers the period from 2007-08 to 2029-30.
- Demand parameters are established econometrically using historical Australian energy data.
- Business activity is generally represented by gross state product.
- Energy-intensive industries are modelled explicitly, taking into account large and lumpy capacity expansions. The industries modelled in this way are:
  - aluminium
  - other basic non-ferrous metals (mainly alumina)
  - iron and steel.
- The electricity generation module includes 17 generation technologies. Investment plans in the power generation sector are forward-looking, taking into account current and likely future conditions affecting prices and costs of production.
- Key policy measures modelled explicitly are:
  - the Australian Government's proposed carbon emissions reduction target
  - the Australian Government Renewable Energy Target
  - the Australian Government Clean Energy Initiative
  - the New South Wales Greenhouse Gas Reduction Scheme
  - the Queensland Gas Scheme
  - the Victorian Renewable Energy Target.
- All fuel quantities are in petajoules.
- Supply of natural gas is modelled at the state level.
- All prices in the model are real, in constant dollars of the base year, and are expressed in dollars per gigajoule. The base year is 2007-08.

For internationally traded energy commodities, crude oil, LNG and black coal of export quality, production is exogenous to the model and is drawn from ABARE's commodity forecasting capability.

2 Industry coverage in E_4cast

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
Basic chemicals	2520-2599
Non-metallic mineral products	26
Iron and steel (excludes coke ovens and blast furnaces)	2700-2713, 2716-2719
Basic non-ferrous metals	272-273
– aluminium smelting	2722
– other basic non-ferrous 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

Although Australia is a significant producer of uranium oxide, it is not included in the projections as it is not consumed as a fuel in Australia and, therefore, does not affect the domestic energy balance. A detailed assessment of Australia's uranium resources and outlook is provided in the *Australian Energy Resource Assessment* (Geoscience Australia and ABARE 2010).

E_4cast base year data

The base year (2007-08) data in the model are drawn from ABARE's Australian energy statistics (ABARE 2009b). These statistics are largely derived from ABARE's fuel and electricity survey. The 2007-08 data, as reported in the report, are the results of model calibration and classification and may not be identical to actual 2007-08 data. A brief description of the survey and ABARE's energy balance data is provided in box 2.

box 2 ABARE's Australian energy statistics

ABARE's Australian energy statistics are based on its fuel and electricity survey (FES), which is 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 October/November, 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 formation, 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.

From 2010, the FES will be replaced by the National Greenhouse and Energy Reporting System (NGERS) as the key mechanism by which Australian energy data are collected, and as a key input to ABARE's Australian energy statistics. NGERS implements a legal framework for companies meeting established thresholds to report their energy consumption and production and greenhouse gas emissions (Australian Government 2009b). NGERS reporting thresholds will be introduced in three steps, starting at 500 terajoules in 2008-09 to reach 200 terajoules by 2010-11. The FES will be run concurrently with NGERS in 2009 (to collect 2008-09 data), and subsequently the FES will be replaced by NGERS.

Key assumptions

There are a number of economic drivers that will shape the Australian energy sector over the next two decades. These include:

- population growth
- economic growth
- energy prices
- electricity generation technologies
- end use energy technologies
- government policies.

The assumptions relating to these key drivers are presented below.

3 Australian population assumptions

year	population million
2008	21.6
2020	25.3
2030	28.5

Source: ABS 2008, 2009.

Population growth

Population growth affects the size and pattern of energy demand. Projections for Australian population are drawn from the Australia Bureau of Statistics (ABS) and presented in table 3.

Economic growth

The energy projections are highly sensitive to underlying assumptions about GDP growth—the main driver of energy demand. Energy demand for each sector 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. However, for energy-intensive industries (aluminium, other basic non-ferrous metals, and iron and steel manufacturing), projected industry output is considered as a more relevant indicator of activity than GSP because of the lumpy nature of investment.

The GDP and GSP assumptions (table 4) were based on the modelling undertaken by the Australian Treasury for the 5 per cent emissions reduction target (Australian Government 2008). These were adjusted in the light of the revised GDP assumptions as presented in Mid-Year Economic and Fiscal Outlook 2009-10 in November 2009 (Australian Government 2009c).

In 2008-09, Australia's real GDP increased by 1.2 per cent, following growth of 3.7 per cent in 2007-08. Economic growth in Australia is expected to pick up in 2009-10 to average 1.5 per cent. As financial markets stabilise and global consumer and business confidence is restored, economic growth in Australia is expected to return to its longer term potential by 2010-11. GDP growth is expected to slow gradually in the latter part of the projection period to reflect a slowing in Australia's population and labour supply growth.

4 Australian economic growth, by region

	average annual growth, 2007-08 to 2029-30 %
New South Wales	2.7
Victoria	2.8
Queensland	3.2
South Australia	2.3
Western Australia	3.2
Tasmania	2.2
Northern Territory	3.0
Australia	2.9

Queensland and Western Australia are expected to have the highest gross state product growth rates over the period to 2029-30, reflecting to a large extent their substantial minerals and energy resource base, relatively high degree of export orientation and relatively higher population growth rates.

Real energy prices

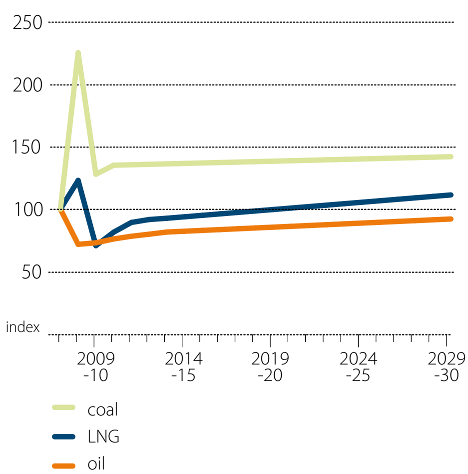
Energy prices affect the demand for, and supply of, energy. Assumptions for selected real international energy prices over the outlook period are presented in index form in figure e.

After significant declines in energy commodity prices in 2008-09 as a result of the global economic downturn, world prices for these commodities have started to recover in line with the improved outlook for a recovery in world economic growth. Over the medium term to 2015, it is expected that a strengthening in global demand, underpinned by the assumed economic recovery, will once again place upward pressure on energy prices, with significant volatility expected to remain.

In the longer term, energy price profiles will hinge on a number of factors including the amount of investment in additional production capacity, costs of production and technology.

Over the past few years, international thermal coal prices have generally followed a similar trajectory to oil and gas prices, as a reflection of inter-fuel substitution possibilities. In the medium term, thermal coal contract prices are assumed to remain above 2007-08 levels, supported by strong demand growth expected in countries such as China and India, combined with continuing infrastructure congestion in key exporting countries (ABARE 2010). Beyond the medium term, global thermal coal prices are expected to increase slowly in real terms, which reflects the higher costs associated with developing new mines being largely offset by the adoption of more advanced technology.

e Index of world real energy prices
2007-08 dollars



In the medium term, oil prices are assumed to recover, following their substantial decline in the second half of 2008, as a result of the economic recovery and higher oil demand (ABARE 2010). However, the long-term prospect for oil prices is much less certain. Key factors that are expected to drive long-term oil prices are the cost of developing remaining oil reserves, the level and timing of investment in production and refining capacity, and technological development in relation to alternative liquid fuels. The estimated capital and production costs for conventional oil sources have increased in recent years because of rising materials, equipment and labour costs (IEA 2009b). As a result, new oil projects are estimated to be uneconomic at a world price of less than US$70 a barrel.

While a rise in the marginal cost of oil production is expected over time, technological developments associated with non-conventional liquids, such as coal-to-liquids and second generation biofuels, have the potential to play a major role in anchoring oil prices below what would have been the case without these backstop technologies. The assumed development and entry of these technologies underpins the long-term price assumptions used in this report (figure e). However, there are uncertainties surrounding this price profile, particularly relating to the costs of alternative technologies and how these may evolve over time as a consequence of technological developments. Further, the costs of some of these technologies could also be affected by carbon emission pricing.

In relation to natural gas, LNG prices are assumed to follow a similar trajectory to oil prices in the long term, reflecting an assumed continuation of the established relationship between oil prices and long-term gas supply contracts through indexation in the Asia Pacific market, and substitution possibilities in electricity generation and end use sectors. In its 2009 World Energy Outlook, the International Energy Agency (IEA 2009b) flags a potential relaxation of this relationship as significant new gas supplies—including unconventional gas and LNG—come on line, thereby placing some downward pressure on gas prices. However, indexation is likely to remain the dominant pricing mechanism in the Asia Pacific region, where most of Australia's LNG trade will continue to occur (IEA 2009b).

Domestic coal and gas prices are determined in E_4cast through the interaction of changing demand and supply factors.

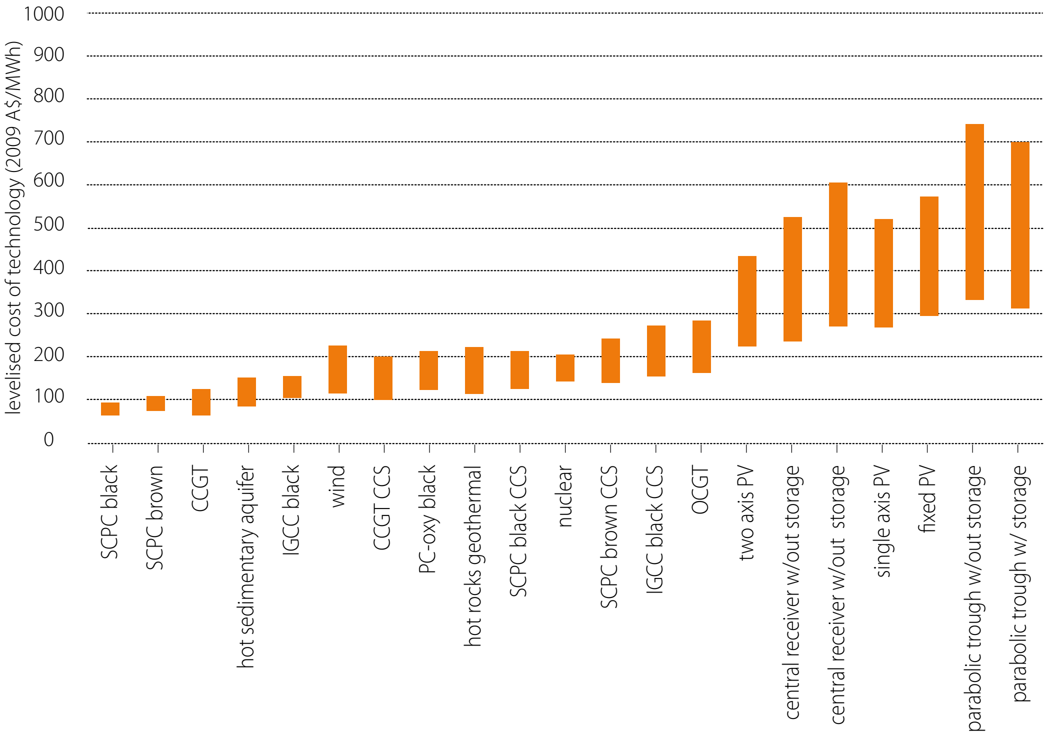
Electricity generation technologies

Australia has access to a range of different electricity generation technologies. This is likely to increase over time as new technologies are developed and the cost of some technologies falls. While a range of factors will affect which technology is used, the relative cost is important.

The Electric Power Research Institute (EPRI 2010) has recently assessed the status of different electricity technologies in 2015 and 2030.

This EPRI technology status data enable the comparison of technologies at different levels of maturity. However, market and system factors will have a significant impact on the technology mix in an energy system. For this reason energy market prices cannot be extrapolated from technology cost analysis. Market modelling is required to project potential electricity prices arising from market and investment outcomes. The levelised cost of technologies represents the revenue per unit of electricity generated that must be met to break even over the lifetime of a plant. These costs are in 2009 Australian dollars. The combined effect of uncertainty ranges in plant capital cost, fuel cost, project and site specific costs, and CO_2 transportations

f Technology ranking a, 2015
2009 prices



a EPRI levelised costs of technology estimates are based on simplified pro-forma costs; individual projects may lie outside this. Levelised costs of technologies include weighted cost of capital (8.4 per cent real before tax) and a notional allowance of 7.5 per cent for site-specific costs, and exclude financial support mechanisms, grid connection, transmission and firming (standing reserve requirements). Baseload technologies are assumed to have a capacity factor of 85 per cent.
Note: SCPC – coal (black and brown coal); PC-Oxy – pulverised coal with oxy-combustion; IGCC – integrated gasification combined cycle; CCS – carbon capture and storage; OCGT – open cycle gas turbine; CCGT – combined cycle gas turbine; EGS – enhanced geothermal systems; HSA – hot sedimentary aquifer; central receiver – solar thermal including central receiver and parabolic trough, all with and without storage; PV – solar photovoltaic including two axis, single axis and fixed.
Source: EPRI technology status data (2010).

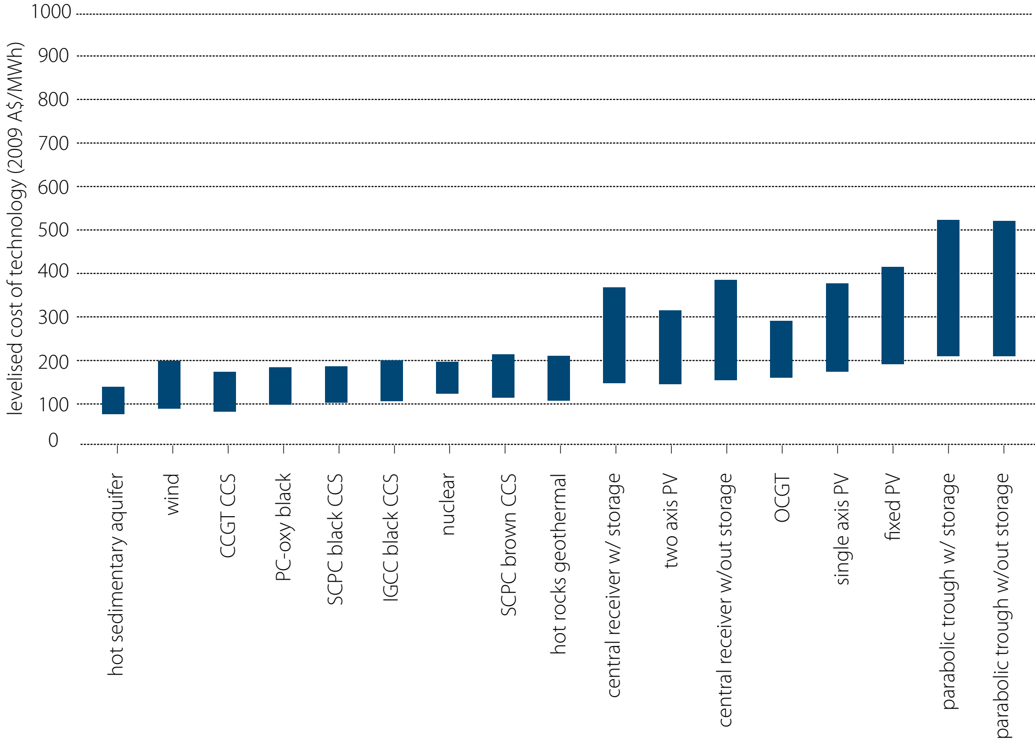
and storage costs are shown in figures f and g. These figures show how the relative technology costs change between 2015 and 2030 as learning and experience in technologies improves.

While these technology cost estimates were developed on the basis of generic plant configurations rather than on detailed plant designs or equipment and material costs, and are subject to uncertainty in relation to a number of factors, they provide valuable and comprehensive information on the relative costs of different electricity generation technologies in an Australian setting, and how these costs might change over time. Importantly though, these costs do not include the cost of any carbon price.

The relative costs of different technologies are more important than the absolute magnitude of these costs in determining their relative prospects in the electricity generation sector (merit order). The EPRI results show that, in the medium term, coal and gas without CCS will remain among the lowest technology cost options. Of the renewable energy technologies, wind is

g Technology ranking a, 2030

2009 prices



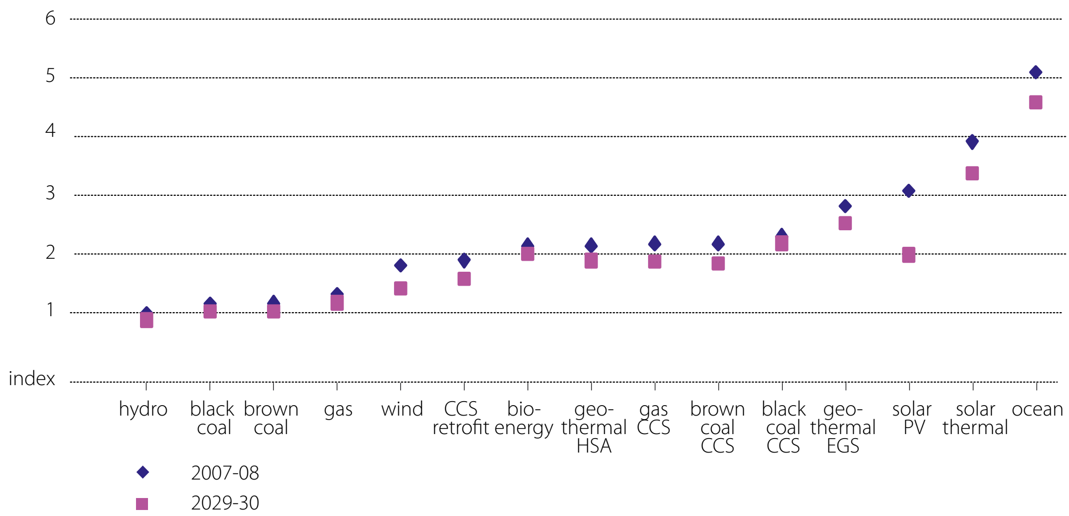
a EPRI levelised costs of technology estimates are based on simplified pro-forma costs; individual projects may lie outside this. Levelised costs of technologies include weighted cost of capital (8.4 per cent real before tax) and a notional allowance of 7.5 per cent for site-specific costs, and exclude financial support mechanisms, grid connection, transmission and firming (standing reserve requirements). Baseload technologies are assumed to have a capacity factor of 85 per cent.
Source: EPRI technology status data (2010).

one of the lowest cost options. Despite a significant decline in the costs of solar technologies expected in the future, the costs of these technologies are expected to remain relatively high over the coming years. The costs of geothermal electricity are shown to be competitive with those of other baseload technologies, although this technology is still at a demonstration stage.

For technologies that are not covered in detail by the EPRI data (ocean energy, bioenergy and the retrofitting of existing fossil-fuel plants with CCS technology), ABARE has drawn on a range of other sources (IEA 2008; Specker, Phillips and Dillon 2009; and National Energy Technology Laboratory 2009). There is considerable uncertainty regarding the absolute costs of these technologies. Further, not all units of existing power plants are amenable to be retrofitted with CCS technology. Key considerations include the unit's age and size, available space and access to geological storage.

The relative costs of all technologies represented in E_4cast are presented in figure h in an index form for the base year and 2029-2030. The relative costs of different technologies are more important than the absolute magnitude of these costs in determining their relative prospects in the electricity generation sector.

h Index of real levelised cost of electricity generation technologies excluding carbon emission costs



End use energy technologies

End use energy technologies affect the efficiency of energy use. These technologies are assumed to become more energy efficient over time through technological improvements. Further, the National Strategy on Energy Efficiency can also be expected to address non-market barriers to the uptake of energy efficiency opportunities.

The rate of end use energy efficiency improvement is assumed to be 0.5 per cent a year over the projection period for most fuels in non energy-intensive end use sectors. For energy-intensive industries, the low capital stock turnover relative to other sectors is assumed to result in a lower rate of energy efficiency improvement of 0.2 per cent a year.

Government policies

In this set of projections, the following key policies have been modelled explicitly in E_4cast:

- the Australian Government Renewable Energy Target (RET)
- the Australian Government's proposed emissions reduction target
- the Australian Government Clean Energy Initiative
- the New South Wales Greenhouse Gas Reduction Scheme
- the Queensland Gas Scheme
- the Victorian Renewable Energy Target.

The Renewable Energy Target (RET)

The RET requires extending the limit on the renewable electricity generation under the MRET scheme by more than four times, to 45 850 gigawatt hours by 2020. The target is then maintained at 45 000 gigawatt hours until 2030 when the scheme is scheduled to be phased out. Interim targets have been set by the Australian Government to ensure consistent progress toward the final target (table 5).

5 RET targets

year	GWh	PJ
2010	12 500	45.0
2011	14 825	53.4
2012	17 150	61.7
2013	19 050	68.6
2014	20 950	75.4
2015	22 850	82.3
2016	27 450	98.8
2017	32 050	115.4
2018	36 650	131.9
2019	41 250	148.5
2020	45 850	165.1
2021 to 2030	45 000	162.0

Source: ORER 2009.

In E_4cast, this policy intervention is modelled as a constraint on electricity generation; that is, renewable energy must be greater than or equal to the interim target in any given year. In the model, the RET target is met by a subsidy to renewables that is funded by a tax on non-renewable generators. This is endogenously modelled so that total renewable generation meets the target.

Carbon emissions reduction target

The emissions reduction target is modelled as a 'cap and trade' emissions trading scheme assumed to apply globally. The emission price is used as an exogenous assumption in E_4cast and is derived from the Australian Treasury modelling (Australian Government 2008), adjusted to reflect changes to the proposed CPRS announced by the Australian Government in May 2009, and the revised exchange rate assumptions presented in the Mid-Year Economic and Fiscal Outlook 2009-10 (table 6). However, in practice, the carbon price path will be determined by the world's carbon market, within which Australia will trade permits.

6 Carbon price assumptions

2007-08 dollars

year	5% emissions reduction target A\$/tCO_2e
2007-08	0
2011-12	8.9
2012-13	21.5
2019-20	28.2
2029-30	41.8

Emission prices are modelled as an added cost on fuels in the electricity generation sector and in end use sectors, hence affecting the net marginal cost of electricity generation and energy demand.

The Clean Energy Initiative

The Clean Energy Initiative is designed to support the research, development and demonstration of low-emission energy technologies, including industrial scale carbon capture and storage (CCS) and solar energy.

Under the CCS flagships program, support will be given for the construction and demonstration of large-scale integrated carbon capture and storage projects in Australia with a target to create 1000 megawatts of low emission fossil fuel electricity generation capacity.

Also part of the Clean Energy Initiative is the Solar Flagships Program which will support the construction and demonstration of large-scale solar power stations in Australia with a target of 1000 megawatts of electricity generation capacity. This was modelled using a direct subsidy from the government.

Under both programs, the commissioning of projects is assumed to commence after 2015.

NSW Greenhouse Gas Reduction Scheme

The New South Wales Greenhouse Gas Reduction Scheme requires electricity retailers and other liable parties to meet mandatory greenhouse gas reduction benchmarks. 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 effect, the price of carbon is internalised in state electricity supply decisions. However, it is assumed that the scheme will cease upon the commencement of the carbon emissions reduction target in 2011-12.

Queensland Gas Scheme

The Queensland Gas Scheme requires electricity retailers and other liable parties to source at least 13 per cent of their electricity from natural gas-fired generation. On 1 July 2008, the requirement was increased to 15 per cent in 2010 and up to 18 per cent thereafter. The scheme has been approximated in the model by requiring the share of natural gas based electricity in Queensland to be greater than or equal to 13 per cent in 2009 and 15 per cent in 2010. In effect, producers of gas based electricity receive a subsidy which is funded by all other generators. In the model, this scheme is terminated from 2011-12 with the introduction of the carbon emissions reduction target.

Victorian Renewable Energy Target

The Victorian Government's Renewable Energy Target (VRET), which requires that 10 per cent of total electricity generation be sourced from renewable energy sources by 2016, was implemented in the model from 2007-08 to 2009-10 before the legislated transition in 2010 into RET. In the model, generators of renewable electricity under RET receive a subsidy which is funded by all other non-renewable sources of power.

4 Energy consumption

This chapter presents the outlook for Australian energy consumption for the period 2007-08 to 2029-30 under the policy settings outlined in chapter 3. The projections cover primary energy consumption by fuel and sector. Final energy consumption by fuel and end use activity, and the outlook for electricity generation are also provided. The discussion focuses primarily on national trends, although key trends at state levels are also highlighted.

Total primary energy consumption

Total primary energy consumption growth has shown a downward trend since the 1970s, reflecting changes to Australia's economic structure and the effect of technological developments and government policies on energy efficiency in energy conversion and end use sectors. In the 1990s, energy consumption grew by an average annual rate of 2.3 per cent, followed by growth of 1.9 per cent a year in the 10 years to 2007-08.

Over the outlook period, growth in energy consumption is expected to continue to be moderate, with an average annual growth rate of 1.4 per cent from 5724 petajoules in 2007-08 to 7715 petajoules in 2029-30 (table 7). This declining trend in growth reflects a number of factors.

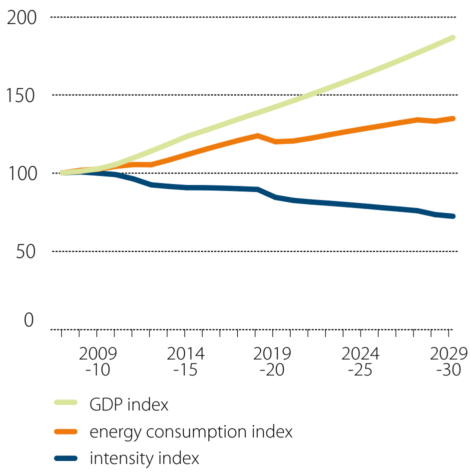
Between 2009-10 and 2019-20, significant policy measures are being introduced, namely the RET and the emissions reduction target, both of which are expected to lead to an increase in energy prices, and an associated dampening effect on energy demand. Partly offsetting this trend, economic growth in Australia is assumed to return to its long-term potential as world economic performance improves.

The final decade of the outlook period shows the most significant decline in the growth rate for energy consumption, which primarily reflects increasing carbon prices under the emissions reduction target and lower gross state product assumptions.

Aggregate energy intensity trends

Australia's aggregate energy intensity (measured as total domestic energy consumption per dollar of GDP) declined by an average of around 1 per cent a year over the past 20 years (Sandu and Petchey 2009). Over the next two decades, Australia's energy intensity is projected to decline by around 1.4 per cent a year, indicating a significant shift in Australia's economic structure (figure i). A major influence on this trend is the higher growth occurring in less energy-intensive sectors such as the commercial and services sector relative to more energy-intensive sectors such as manufacturing. Also driving this projected trend is improved efficiency through technological improvement and fuel switching.

Energy intensity trends



Primary energy consumption, by fuel

In 2007-08, non-renewables accounted for around 95 per cent of the primary energy consumed in Australia. Of the non-renewables, coal represented 37 per cent of primary energy consumed; oil, 36 per cent; and gas (including natural and coal seam gas), 22 per cent. Over the long term, the share of coal in total primary energy consumption is projected to fall to 23 per cent (table 7). In contrast, the share of gas (natural gas and coal seam gas) is projected to increase to account for one-third of primary energy consumption.

Gas is projected to be the fastest growing fossil fuel over the projection period. Gas consumption is projected to rise by 3.4 per cent a year over the outlook period, with total primary demand for natural gas projected to more than double to reach 2575 petajoules by 2029-30. This growth in demand is driven primarily by the electricity generation sector and the mining sector, and reflects the shift to less carbon-intensive fuels in a carbon constrained environment. Much of this growth is at the expense of coal. The growth in gas consumption is expected to be stronger in the period to 2020, consistent with the emergence of technologies with a weaker carbon footprint post-2020.

7 Primary energy consumption, by fuel (PJ)

			share (%)		average annual growth (%)
	2007-08	2029-30	2007-08	2029-30	2007-08 to 2029-30
Fossil fuels	5 447	7 125	95	92	1.2
Coal	2 124	1 763	37	23	–0.8
Black coal	1 514	1 311	26	17	–0.7
Brown coal	610	452	11	6	–1.4
Oil	2 083	2 787	36	36	1.3
Gas	1 240	2 575	22	33	3.4
Renewables	277	590	5	8	3.5
Hydro	44	46	<1	<1	0.2
Wind	14	160	<1	2	11.6
Bioenergy	212	340	4	4	2.2
Solar	7	24	<1	<1	5.9
Geo thermal	<1	20	<1	<1	18.4
Total	5 724	7 715	100	100	1.4

In 2007-08, around 5 per cent of energy consumption in Australia was sourced from renewable energy. With the implementation of RET, the share of renewable energy is projected to increase substantially to account for 8 per cent of primary energy consumption in 2029-30. This implies an average annual growth rate of 3.5 per cent, with strong growth expected to occur particularly in wind energy. Most of the expansion in renewable energy is projected to take place in the period to 2019-20 reflecting the implementation of the RET.

Overall, these results suggest that a 5 per cent emissions reduction target, combined with the RET, are likely to lead to significant changes to Australia's energy mix, characterised by a growing contribution from gas and renewable energy.

Primary energy consumption, by state

Primary energy consumption is projected to increase across all states over the next two decades. However, in line with assumptions about economic activity, energy resource endowments, economic structure and the significance of mining in the economic base, and state specific policy settings, growth in primary energy consumption is expected to vary across states (table 8).

Relatively higher gross state product assumptions, together with relatively high shares of mining in economic output and relatively high degrees of export orientation, are key factors underpinning the relatively higher energy consumption growth rates in Western Australia and Queensland (table 8).

8 Primary energy consumption, by state (PJ)

			share (%)		average annual growth (%)
	2007-08	2029-30	2007-08	2029-30	2007-08 to 2029-30
New South Wales	1 640	2 113	29	27	1.2
Victoria	1 362	1 495	24	19	0.4
Queensland	1 299	2 010	23	26	2.0
South Australia	302	374	5	5	1.0
Western Australia	860	1 383	15	18	2.2
Tasmania	126	147	2	2	0.7
Northern Territory	134	194	2	3	1.7
Australia	5 724	7 715	100	100	1.4

New South Wales and South Australia are expected to have more moderate growth in energy consumption, reflecting more modest economic growth prospects. In New South Wales, energy consumption is projected to rise from 1640 petajoules to 2113 petajoules, growing at a rate of 1.2 per cent a year (table 8). New South Wales remains the largest contributor to Australia's primary energy consumption over the period to 2030. Energy consumption in South

Australia is projected to increase at a rate of 1 per cent a year, with its share of total primary energy consumption remaining constant over the period to 2030 (table 8).

Victoria is projected to have the lowest growth in primary energy consumption, reflecting the significant effect of a carbon price on the costs of brown coal-fired electricity generation and other emission-intensive industries such petroleum refining and chemicals. In absolute terms, energy consumption in Victoria is projected to increase from 1362 petajoules in 2007-08 to 1495 petajoules in 2029-30.

Primary energy consumption, by sector

At the sectoral level, the main drivers of primary energy consumption are the electricity generation sector, the transport sector and the manufacturing sector. These sectors are projected to account for 57 per cent of the increase in primary energy consumption from 2007-08 to 2029-30.

The electricity generation sector accounted for the largest share (43 per cent) of primary energy consumption in 2007-08. Total primary energy consumption in the power generation sector is projected to increase from 2485 petajoules in 2007-08 to 3004 petajoules in 2029-30 (table 9). Over the projection period, the fuel mix in electricity generation is expected to gradually switch away from coal to gas and renewable energy, reflecting the combined effect of the emissions reduction target and the RET on the relative competitiveness of different energy sources. Further details about the electricity generation sector projections are provided below.

9 Primary energy consumption, by sector (PJ)

			share (%)		average annual growth (%)
	2007-08	2029-30	2007-08	2029-30	2007-08 to 2029-30
Electricity generation	2 485	3 004	43	39	0.9
Agriculture	96	139	2	2	1.7
Mining	270	996	5	13	6.1
Manufacturing **a**	1 118	1 302	20	17	0.7
Transport	1 456	1 896	25	24	1.2
Commercial and residential	298	377	5	5	1.1
Total	5 724	7 715	100	100	1.4

a Includes petroleum refining.

The transport sector (excluding electricity used in rail transport) absorbed one-quarter of primary energy consumption in 2007-08 and continues to rely heavily on oil. Consumption of oil and petroleum products in the transport sector is expected to grow steadily over the projection period at an average rate of 1.2 per cent a year driven largely by economic growth. However, the share of the transport sector in primary energy consumption is projected to fall marginally from 25 per cent to 24 per cent over the period to 2029-30, underpinned by high fuel prices and improvements in the fuel efficiency of vehicles.

The manufacturing sector is the third largest user of primary energy in Australia, accounting for a share of 20 per cent in 2007-08. This sector covers a number of relatively energy-intensive sub-sectors such as petroleum refining, iron and steel, aluminium smelting and minerals processing. While energy consumption in the manufacturing sector is projected to increase at an average annual rate of 0.7 per cent over the outlook period, the share of the sector in total primary energy consumption is expected to decline, which reflects a progressive structural shift toward less energy-intensive sectors under an emissions reduction target.

The mining sector, while contributing to only 5 per cent of primary energy consumption in 2007-08, is projected to have the highest energy consumption growth rate over the next two decades. This reflects the expected recovery in global demand for energy and mineral commodities and the large number of mineral and energy projects (including LNG and coal seam gas) assumed to come on stream over the outlook period. As of October 2009, there were 74 minerals and energy projects at an advanced stage of development on ABARE's major projects list, with total capital expenditure of around $116 billion (ABARE 2009c). These projects are either committed or under construction, and cover a wide range of energy, mineral mining, and mineral processing projects (map 2). This significant investment underway is a major driver of the expected expansion of the mining sector and associated growth in energy consumption over the projection period. By 2029-30 the sector is projected to account for 13 per cent or 996 petajoules of primary energy consumption.

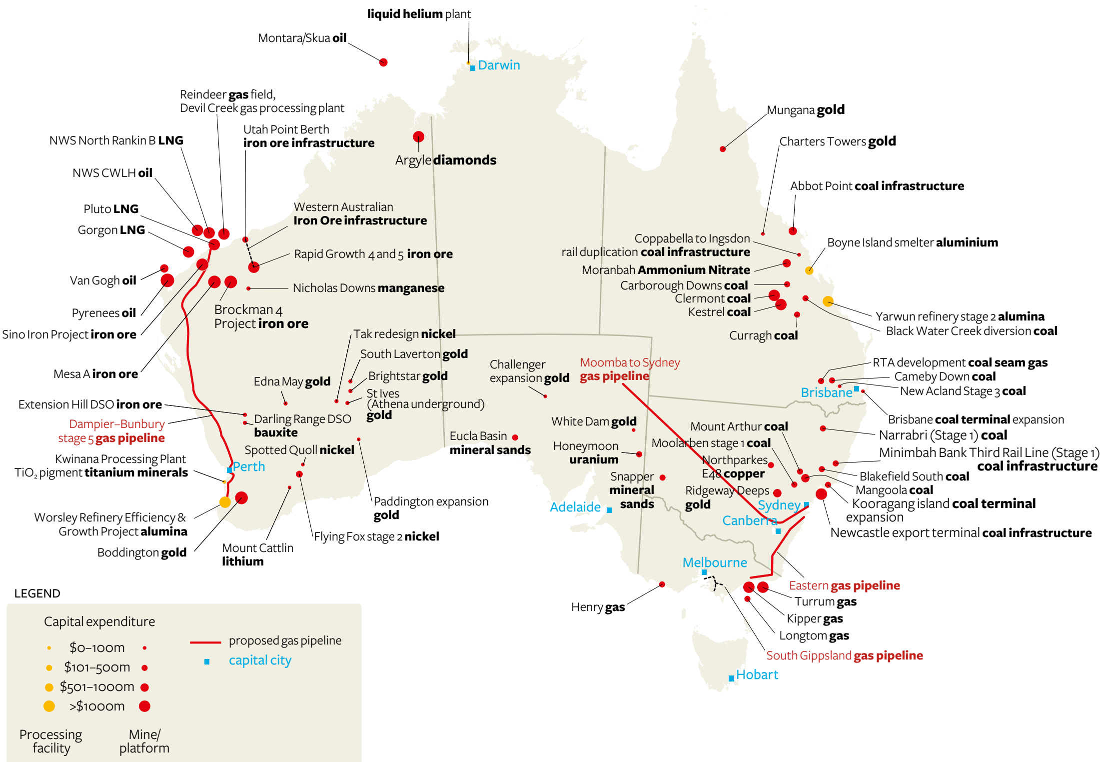
Electricity generation

Gross electricity generation in Australia is projected to grow over the outlook period by an average of 1.8 per cent a year, from 889 petajoules (247 terawatt hours) in 2007-08 to 1318 petajoules (366 terawatt hours) in 2029-30 (table 10).

The projected growth in electricity generation varies across regions, reflecting a number of factors including available technology, primary energy input availability and prices, capital cost and interregional transmission capacity. For states that are within the integrated National Electricity Market (New South Wales, Queensland, Victoria, South Australia and Tasmania), the figures provided in table 10 reflect electricity consumed as well as market determined electricity flows across regions.

New South Wales is likely to remain the largest producer of electricity in Australia. Nonetheless, relatively high growth rates in electricity generation over the period to 2029-30 are also expected in South Australia, with a growth rate of 3.4 per cent a year over the projection period. The dominant contributor to this growth is renewable energy (mainly wind energy), which is projected to grow at an average rate of 5 per cent a year. Gas-fired electricity generation is also projected to grow by 6 per cent a year.

map 2 Minerals and energy - major development projects
October 2009



10 Electricity generation, by state (TWh)

	2007-08	2029-30	share (%) 2007-08	share (%) 2029-30	average annual growth (%) 2007-08 to 2029-30
New South Wales	80	127	32	35	2.2
Victoria	52	64	21	18	0.9
Queensland	61	86	25	23	1.6
South Australia	10	20	4	5	3.4
Western Australia	29	46	12	13	2.1
Tasmania	12	17	5	5	1.6
Northern Territory	4	6	1	2	2.1
Australia	247	366	100	100	1.8

In Western Australia, gross electricity output is projected to increase by 59 per cent over the projection period, from 29 terawatt hours in 2007-08 to 46 terawatt hours in 2029-30 (table 10). Much of this expansion is driven by gas-fired electricity generation, which is projected to grow at an average rate of 2 per cent a year. At this rate, gas-fired electricity generation will account for 68 per cent of the projected expansion in the state's electricity generation between 2007-08 and 2029-30.

In comparison, electricity generation in Victoria is projected to grow at a rate below the national average. Electricity in this state is based mainly on brown coal. Under the emissions reduction target modelled in this analysis, a price on carbon emissions reduces the competitiveness of this power source relative to other less carbon-intensive fuels. As a result, unless Victoria builds its own low emission generation capacity, it is projected to become more dependent on imports from other regions to meet its electricity needs.

Under a policy setting that includes both the RET and a 5 per cent emissions reduction target, the relative shares of non-renewables and renewables in electricity generation are expected to change significantly over the projection period to 2029-30. In 2007-08, 93 per cent of electricity was generated from non-renewables (coal, oil and gas), and the balance from renewable energy sources. As a result of the incentives provided under the RET, the share of renewables is projected to increase to around 20 per cent by 2019-20. This reflects the effect of the RET, which requires a ramp-up of renewable energy in the period to 2020. After 2019-20, renewable electricity generation continues to increase, albeit at a slower rate.

Within the category of non-renewable energy, the key change projected over the outlook period is a substitution away from coal-fired generation to gas-fired generation. While coal is expected to continue to dominate the electricity fuel mix under the assumed policy setting, emission pricing will lead to a switch away from higher-emission energy sources for electricity generation. Coal-fired electricity (both black and brown coal) generation is projected to decrease at an average rate of 0.6 per cent a year over the projection period (table 11), leading to a fall in its share from 72 per cent in the base year to 43 per cent in 2029-30.

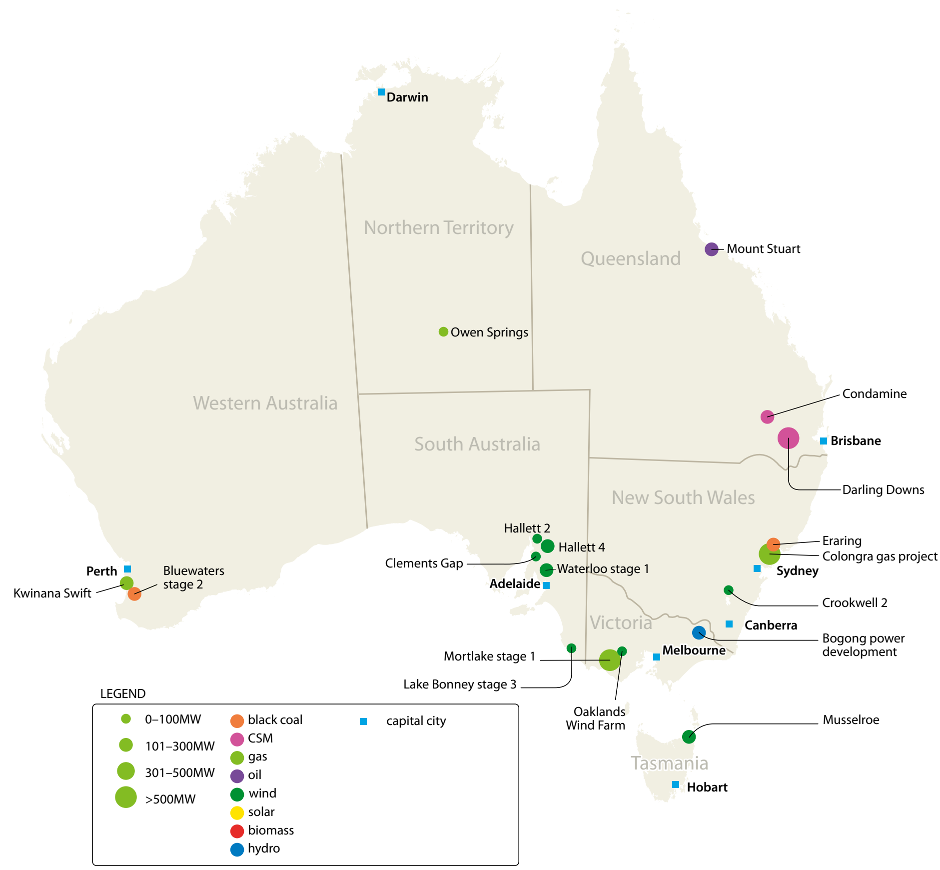
While these results imply the partial retirement or mothballing of some of the existing coal power plants over the outlook horizon, in reality there are some factors that may reduce the effect of emission pricing on these plants at least in the medium term. For example, hedging contracts and other financial considerations can be expected to provide some degree of insulation to these plants. Classified as a 'strongly affected industry' in the Carbon Pollution Reduction Scheme Green Paper, it is also possible that the industry could be granted different forms of assistance which are not taken into account explicitly in the modelling in this report.

The longer term role of coal is heavily dependent on technological developments related to carbon capture and storage. The timing for the deployment of carbon capture and storage (CCS) technologies hinges on the economic viability of this technology given emission prices. In the modelling, the deployment of carbon capture and storage technologies for new plants is not triggered to any significant extent because of their relatively high costs. Nonetheless, the modelling results suggest that, largely because of the development of subsidised projects, some coal-fired electricity generation with CCS may emerge by 2030. In addition, the significant global support to overcome technical and financing hurdles faced by CCS technologies (Global CCS Institute 2009) have the potential to bring forward the large-scale, commercial deployment of CCS technologies for electricity generation and other energy-intensive industries through accelerated cost reductions associated with learning by doing.

A large part of the decline in coal based electricity is taken up by gas-fired generation technologies. The share of gas in electricity generation is projected to grow from 19 per cent in 2007-08 to 37 per cent in 2029-30. This projected increase in gas-fired electricity generation is partly supported by its major share of currently committed electricity generation capacity (map 3). As of October 2009, gas and coal seam gas accounted for 60 per cent of the total capacity of advanced electricity generation projects in Australia (ABARE 2009d).

Gas-fired electricity generation is based on mature technologies with more competitive cost structures relative to many renewable energy technologies. As such, it has the potential to play a major role in the transition period until lower emission technologies become more viable. However, the cost competitiveness of gas as a fuel for electricity generation depends on gas prices.

map 3 Electricity generation - major development projects
October 2009



There is a range of perspectives on future gas prices. The modelling undertaken for this report suggests that domestic gas prices are likely to increase over the next two decades as a result of interactions between gas demand and gas supply. However, several factors could affect this outlook, including the renegotiation of existing long-term contracts, the lead time required to build LNG facilities on the east coast, the pace and level of development of the substantial coal seam gas resources, the extent of convergence in the eastern gas market and regional and global LNG markets, and developments in the regional and global LNG markets.

According to the International Energy Agency (IEA 2009b), under a reference scenario with no changes to existing government policy settings, gas prices are assumed to increase after 2015 in line with increasing demand and higher oil prices. However, the IEA also notes that the expected gas-to-gas competition in the Pacific region is likely to weaken the links between oil and gas prices and exert some downward pressure on relative gas prices.

Domestically, the Australian Energy Regulator also points to a number of factors in the east coast market that may reduce upward pressure on gas prices (AER 2009). These include the substantial volumes of 'ramp up' gas that are likely to be produced in the lead-up to the commissioning of coal seam gas–liquefied natural gas (CSG-LNG) projects, the large number of gas basins ensuring diversity of supply, relatively low barriers to entry, and an extensive gas transmission network linking producing basins.

The uptake of gas-fired generation technologies is apparent in a number of regions. Electricity generation from gas in Queensland is projected to more than double in the period to 2029-30. There are several coal seam gas-fired electricity generation projects underway to support this expansion. The recently commissioned coal seam gas-fired Braemar 2 power station and two other power stations under construction represent an addition of 1220 megawatts to electricity generation capacity in Queensland.

11 Electricity generation, by fuel (TWh) a

			share (%)		average annual growth (%)
	2007-08	2029-30	2007-08	2029-30	2007-08 to 2029-30
Fossil fuels	229	297	93	81	1.2
Coal	178	157	72	43	–0.6
Black coal	131	121	53	33	–0.4
Brown coal	47	36	19	10	–1.2
Gas	46	135	19	37	5.0
Oil	5	5	2	1	0.0
Renewables	18	69	7	19	6.4
Hydro	12	13	5	3	0.2
Wind	4	44	2	12	11.6
Bioenergy	2	3	<1	<1	2.3
Solar	<1	4	<1	1	17.4
Geo thermal	<1	6	<1	2	18.4
Total	247	366	100	100	1.8

a These figures represent total gross electricity generation output, covering both on-grid and off-grid principal generators, small generators, and non-scheduled generators. The figures for 2007-08 presented in this may not be identical to actual historical data as published in ABARE's *Australian energy statistics*. This is a reflection of model calibration.

The commissioning of the QSN link and expansion of the South West Queensland Pipeline in 2009 have created an interconnected gas pipeline linking Queensland, Victoria, South Australia, Tasmania and the ACT. This development is driven by the emerging coal seam gas industry in Queensland and is expected to support the growth of gas-fired generation in the other interconnected regions as well.

Gas-fired electricity generation is also projected to increase in Western Australia by an average of around 2 per cent a year over the projection period to 2029-30 with additional capacity coming on line in the next few years.

In parallel with the increasing share of gas in the electricity fuel mix, these projections highlight the significant expansion in the use of non-hydro renewable energy resources between 2007-08 and 2029-30. Wind energy is projected to account for the majority of the increase in electricity generation from renewable sources over the projection period. Wind is projected to account for 12 per cent of electricity generation in 2029-30. Within the renewable technology cluster, wind energy is a proven technology with relatively lower costs, notwithstanding the influence of site specific factors on these costs. While the projected growth in wind energy is spread across a number of regions, it is driven primarily by South Australia where a large number of wind energy projects are currently being developed (AER 2009).

Given Australia's large potential bioenergy resources, the potential commercialisation of second generation technologies using a new range of non-edible biomass feedstocks, and the RET, bioenergy has the potential to make a growing contribution to renewable electricity generation in Australia. However, this growth prospect is likely to be constrained to some extent by competition for bioenergy resources in industries, water availability, and logistical issues associated with handling, transport and storage.

Currently, Australia's bioenergy resources are dominated by bagasse (sugar cane residue), wood waste, and capture of gas from landfill and sewage facilities for generating heat and electricity. From 1989-90 to 2007-08, electricity generation from bioenergy grew at an average rate of 6 per cent a year and the share of bioenergy in total electricity generation also increased over that period, although modestly, to less than 1 per cent.

In these projections, bioenergy for electricity generation is projected to grow by 2.3 per a year over the period to 2029-30 but will still account for less than 1 per cent of electricity generated in that year. More than 60 per cent of the projected growth in the use of bioenergy for electricity generation is projected to occur in Queensland.

In comparison, solar energy is projected to grow at an average annual rate of 17 per cent, albeit from a low base. Electricity generation from solar energy in Australia is currently almost entirely sourced from photovoltaic (PV) installations. Electricity generation from solar thermal systems is currently limited to small pilot projects, although interest in solar thermal systems for large-scale electricity generation is increasing.

The high investment costs of solar technologies represent the most important barrier to their deployment. However, there is considerable scope for the cost of these technologies to decline significantly over time. The competitiveness of solar energy, and renewable energy sources generally, will also depend on government policies aimed at reducing greenhouse gas emissions. In this context, the RET, the Clean Energy Initiative and the proposed emissions reduction target are all expected to underpin the growth of solar energy in Australia over the outlook period.

Similarly to solar energy, Australia is considered to have considerable geothermal energy potential. However, Australia's geothermal resources are currently sub-economic because the commercial viability of geothermal technologies for electricity generation has not yet been demonstrated in Australia. Electricity generation from geothermal energy in Australia is currently limited to pilot power plants producing small amounts of electricity. Further, a major impediment to geothermal electricity generation in Australia is the distance of many of the resources from existing transmission lines or consumption centres.

Given the major investment in geothermal energy research, development and demonstration (RD&D) by both government and industry in Australia, it is considered likely that commercial scale geothermal power will become commercially viable over the outlook period. However, given the time required to achieve commercial viability, and the long lead time required to bring a geothermal power plant into operation, geothermal energy is not likely to play a significant role in electricity generation until the latter part of the outlook timeframe. In these projections, geothermal energy is projected to account for 1.5 per cent of electricity generation by 2029-30.

Hydroelectricity generation in volume terms is projected to remain broadly unchanged over the outlook period, reflecting the limited availability of suitable locations for the expansion of large grid based hydroelectricity generation and water supply constraints. Most of the projected expansion in capacity is assumed to be associated with the upgrading of existing equipment and small-scale schemes.

Final energy consumption, by fuel

Total final energy consumption, that is the total amount of energy used in end use applications, is projected to increase from 3733 petajoules in 2007-08 to 5019 petajoules in 2029-30. This is an increase of around 34 per cent over the projection period and an average annual rate of increase of 1.4 per cent (table 12). This compares with an average annual growth rate of 2 per cent in the 10 years to 2007-08. Electricity is projected to continue to grow strongly to meet energy demand in end use sectors. This will reduce the relative share of gas in final energy consumption by 2030, although the amount of gas consumption is projected to increase by 22 per cent between 2007-08 and 2029-30. Renewables are projected to have the fastest growth rate, with an average rate of 1.9 per cent a year over the projection period.

Final energy consumption, by sector

The main drivers of final energy consumption in the Australian economy are the transport and manufacturing sectors. In 2007-08 these sectors accounted for 39 per cent and 32 per cent of final energy consumption, respectively (table 13).

12 Final energy consumption, by fuel (PJ)

			share (%)		average annual growth (%)
	2007-08	2029-30	2007-08	2029-30	2007-08 to 2029-30
Black coal	151	153	4	3	0.1
Petroleum products	1 913	2 566	51	51	1.3
Gas	692	845	19	17	0.9
Renewables	172	262	5	5	1.9
Electricity	803	1 193	22	24	1.8
Total	3 733	5 019	100	100	1.4

Transport

With an average rate of growth of 1.2 per cent a year between 2007-08 and 2029-30, the transport sector is expected to account for 34 per cent (or 443 petajoules) of the total projected increase in final energy consumption. However, the share of the transport sector in total energy consumption is projected to fall slightly over the period, from 39 per cent in 2007-08 to 38 per cent by 2029-30 (table 13). These projections reinforce the downward trend in road transport fuel consumption growth over the past 30 years. Energy use in the transport sector is the main driver of the outlook for oil and oil-based products, which is projected to increase at an average annual rate of 1.3 per cent (table 12).

Within the transport sector, the road transport segment is the largest contributor to energy consumption. In 2007-08, road transport accounted for around three-quarters of the energy used in the sector, which in turn was dominated by passenger transport. Energy use in the road transport sector is projected to grow by 0.9 per cent a year over the projection period, driven largely by the freight transport industry. Automotive gasoline is the main fuel used in the transport sector and accounted for 650 petajoules in 2007-08.

Energy use in the air transport sector (both domestic and international) is projected to grow firmly over the projection period, reflecting rapid growth in private passenger demand for air transport. With a long-term growth rate of 2.3 per cent a year, energy use in the air transport sector is projected to increase to 454 petajoules in 2029-30. As a result, the air transport sector is projected to account for almost one-fourth of the transport sector's energy use in 2029-30.

The transport sector is highly dependent on oil-based petroleum products and this dependence is expected to continue over the projection period. In 2007-08, liquefied petroleum gas (LPG) and biofuels (ethanol and biodiesel) accounted for around 4 per cent and less than 1 per cent, respectively, of the transport fuel mix. There are a range of alternative low-carbon fuels that have the potential to complement or replace conventional oil in the longer term such as coal-to-liquids, gas-to-liquids and second generation biofuels. However, significant further research, development and demonstration would be required to allow these fuels to make a substantial contribution to meeting transport energy needs. Similarly, electric vehicles and hybrid electric cars are not expected to make a significant contribution to the road transport fuel mix by 2030.

13 Final energy consumption, by sector (PJ)

	2007-08	2029-30	share (%) 2007-08	share (%) 2029-30	average annual growth (%) 2007-08 to 2029-30
Agriculture	103	148	3	3	1.6
Mining	266	540	7	11	3.3
Manufacturing	1 207	1 376	32	27	0.6
Transport	1 465	1 908	39	38	1.2
Commercial and residential	692	1 048	19	21	1.9
Total	3 733	5 019	100	100	1.4

Manufacturing

The manufacturing sector is the second largest energy end user in Australia, with minerals processing—mainly iron and steel making, alumina refining and aluminium smelting—contributing to the relatively high energy intensity of the sector. Over the past 10 years, the manufacturing sector has grown relatively slowly such that its share of total final energy consumption remained largely constant at around 32 per cent. In these projections, the manufacturing sector as a whole is projected to grow at 0.6 per cent a year in the period to 2029-30, supported by growth in the economy and ongoing global demand for resource based energy-intensive output. However, the projected growth rate is well below the average for all sectors (1.4 per cent). This reflects the continuing long-term structural shift in the Australian economy toward the commercial and services sector, which is further reinforced by an emissions reduction target. By increasing the cost of energy, emission pricing provides incentives to reduce the energy intensity of the economy. As such, the share of manufacturing in final energy consumption is projected to decline to 27 per cent by 2029-30. Within the manufacturing sector, lower growth in energy consumption is expected for the relatively energy-intensive sub-sectors.

Final energy consumption in the iron and steel industry is projected to grow at an average rate of 0.7 per cent a year over the projection period, to 136 petajoules by 2029-30 (table 14). This is partly underpinned by new projects such as the recently completed upgrade to the Port Kembla steelworks and the planned Australian Iron and Steel project in Queensland.

Energy consumption in the non-ferrous metal industries, including aluminium smelting and other non-ferrous metals, is expected to increase by 0.5 per cent a year over the period to 2029-30.

Mining

Reflecting the development of a large number of mineral and energy mining projects assumed to take place over the projection period, mining is projected to increase 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 2007-08 to more than 11 per cent in 2029-30 (table 13), growing at an average annual rate of 3.3 per cent. This growth is slower than the rapid growth

14 Final energy consumption, by manufacturing subsector (PJ)

			share (%)		average annual growth (%)
	2007-08	2029-30	2007-08	2029-30	2007-08 to 2029-30
Wood, paper and printing	69	81	6	6	0.8
Basic chemicals	184	165	15	12	–0.5
Iron and steel	118	136	10	10	0.7
Non-ferrous metal products	503	560	42	41	0.5
Other manufacturing	334	434	28	32	1.2
Total	1 207	1 376	100	100	0.6

experienced in recent years, reflecting, in part, an assumed 0.5 per cent a year reduction in the energy intensity of mining industries.

Nonetheless, the projected growth in energy consumption in the mining sector is robust compared with projected growth in other sectors. This is driven by the substantial increase in the relatively energy-intensive production of liquefied natural gas (LNG). Over the period 2007-08 to 2029-30, the production of LNG is set to grow at an average rate of around 9.5 per cent a year. The outlook for the LNG sector is discussed in more detail below.

Commercial and residential

The commercial and residential sector comprises wholesale and retail trade, communications, finance, government, community services, recreational industries and households. In 2007-08, the commercial and residential sector accounted for around 19 per cent of total final energy consumption and is projected to grow to 21 per cent by 2030. 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, energy use in this sector is projected to grow by 1.9 per cent a year (table 13).

Given population growth assumptions, household income, energy prices and lifestyle choices are the main variables affecting energy consumption in the residential sector. Energy is a relatively small component of household expenditure (ABS 2007). Further, current pricing arrangements, particularly for electricity, do not provide strong time and cost-reflective price signals to residential energy consumers. For these reasons, a high degree of responsiveness to prices has not generally been observed. However, the Council of Australian Governments (COAG) has committed to a national rollout of smart meters (meters that allow energy consumers to see the real time cost of their energy consumption) where the benefits outweigh the costs. This is designed to foster more effective demand side management and enhanced demand side response.

Agriculture

Agriculture holds a minor share of final energy consumption with a share of less than 3 per cent in 2007-08. Over the outlook period, agricultural energy use is projected to increase by 1.6 per cent a year (table 13), which reflects, in part, an assumed reduction in the energy intensity of agriculture of 0.5 per cent a year. Petroleum products are the main fuel used on farms, accounting for more than 90 per cent of the total fuel mix.

5 Energy production and trade

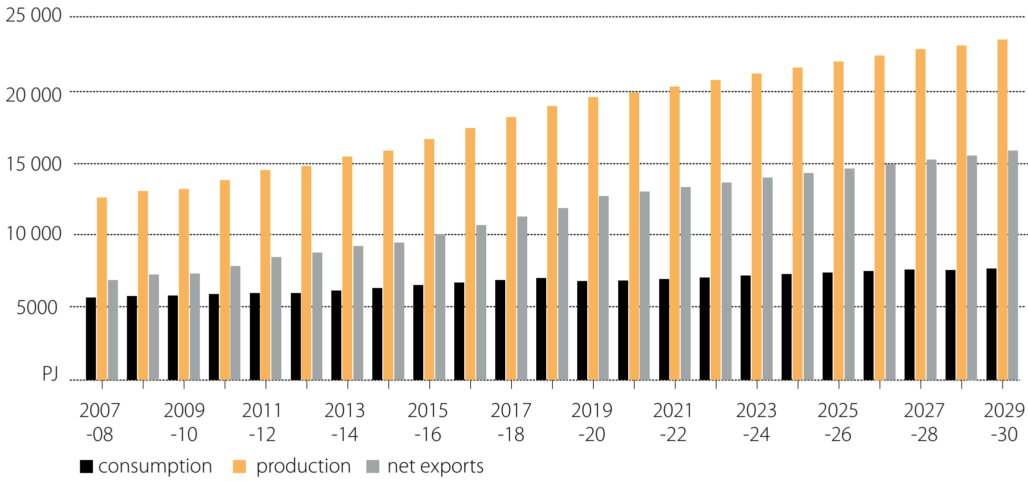
The main sources of energy produced in Australia on an energy content basis are coal, uranium and gas. With the exception of crude oil and refined petroleum products, Australia is a net exporter of energy commodities. In 2007-08, production of coal was 9306 petajoules, or 74 per cent of total energy production (excluding uranium). In physical terms, total coal production was 426 million tonnes. Gas accounted for 16 per cent of total energy production, followed by crude oil and condensate and naturally occurring LPG (8 per cent) and renewables (hydroelectricity, wind energy, bioenergy and solar energy) at 2 per cent. Although Australia is a significant producer of uranium oxide, it is not included in the projections as it is not consumed as a fuel in Australia and, therefore, does not affect the domestic energy balance.

Total production of energy in Australia (excluding uranium) is projected to grow at an average rate of 2.9 per cent a year over the projection period, slightly lower than the growth rate in the 10 years to 2007-08. At this rate, Australian production of energy is projected to increase by 87 per cent to reach 23 637 petajoules in 2029-30 (table 15). Gas production is projected to increase from 2040 petajoules (41 975 gigalitres) in 2007-08 to 8505 petajoules (174 979 gigalitres) in 2029-30, or 36 per cent of total energy production. At the same time, the combined share of crude oil and naturally occurring LPG is projected to fall to 3 per cent of total energy production. The share of coal in total energy production is projected to fall from 74 per cent in 2007-08 to 59 per cent by 2029-30.

15 Energy production, by fuel (PJ

			share (%)		average annual growth (%)
	2007-08	2029-30	2007-08	2029-30	2007-08 to 2029-30
Fossil fuels	12 394	23 047	98	98	2.9
Coal	9 306	13 875	74	59	1.8
Black coal	8 696	13 423	69	57	2.0
Brown coal	610	452	5	2	–1.4
Oil	945	425	7	2	–3.6
LPG	103	243	<1	1	4.0
Gas	2 040	8 505	16	36	6.7
Renewables	277	590	2	2	3.5
Hydro	44	46	<1	<1	0.2
Wind	14	160	<1	<1	11.6
Bioenergy	212	340	2	1	2.2
Solar	7	24	<1	<1	5.9
Geo thermal	<1	20	<1	<1	18.4
Total	12 671	23 637	100	100	2.9

j Energy balance



As the projected growth in non-uranium energy production exceeds that of primary energy consumption, Australia's exportable surplus of energy is projected to increase as a proportion of consumption over the projection period. In 2007-08, the ratio of Australia's primary energy consumption to non-uranium energy production is estimated to have been 45 per cent. By 2029-30, the ratio of Australia's primary energy consumption to non-uranium energy production is projected to fall to 33 per cent (figure j).

Black coal production and exports

Black coal, which includes both thermal and metallurgical coal, is projected to remain Australia's dominant energy export, accounting for around 49 per cent of the total growth in Australian energy exports over the projection period. The projected annual growth rate of 2.4 per cent is built on expectations that global demand for coal will continue to increase in the period to 2030 as a result of increased demand for electricity and steel-making raw materials, particularly in emerging market economies in Asia. Australia, with its abundant reserves of high-quality coal, has the potential to contribute significantly to meeting this increased demand, subject to adequate investment in mine and related infrastructure development. By 2029-30, Australian black coal exports are projected to reach 12 112 petajoules, equivalent to around 450 million tonnes (table 16 and figure k).

Black coal exports will be supported by the expansion of infrastructure and mining capacity in New South Wales and Queensland over the projection period.

In New South Wales, port capacity could increase by as much as 100 million tonnes with upgrades to the Kooragang Island and Newcastle Coal Infrastructure terminals.

16 Net trade in energy (PJ)

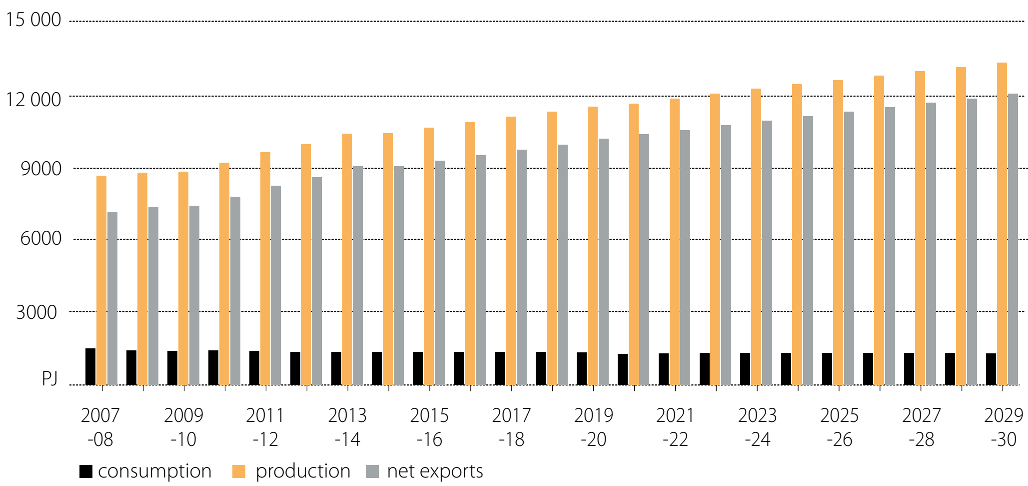
	2007-08	2029-30	average annual growth (%) 2007-08 to 2029-30
Black coal	7 182	12 112	2.4
Oil a	–1 075	–2 211	3.3
LPG	41	92	3.8
LNG	800	5 930	9.5
Total	6 947	15 922	3.8

a Includes crude oil, other refinery feedstock and petroleum products.

In Queensland, the Abbot Point Coal Terminal could be expanded to handle 110 million tonnes a year and the proposed Wiggins Island terminal near Gladstone has a potential capacity of 80 million tonnes a year. The increased port capacity in Queensland will be supported by upgrades to rail infrastructure including the Goonyella to Abbot Point Expansion Project and the Surat Basin Rail.

Thermal coal mines in New South Wales that could add to increased production capacity include Xstrata's Mangoola mine (10.5 million tonnes a year), Felix Resources' Moolarben mine (20 million tonnes a year) and Rio Tinto's 8.5 million tonnes a year Mount Pleasant Project. In Queensland, increased thermal coal production over the next 20 years could be supported by the development of the Galilee Basin. Currently three projects are under consideration,

k Black coal balance



including Alpha, Kevin's Corner and China First. These projects could each produce in excess of 30 million tonnes a year when in operation.

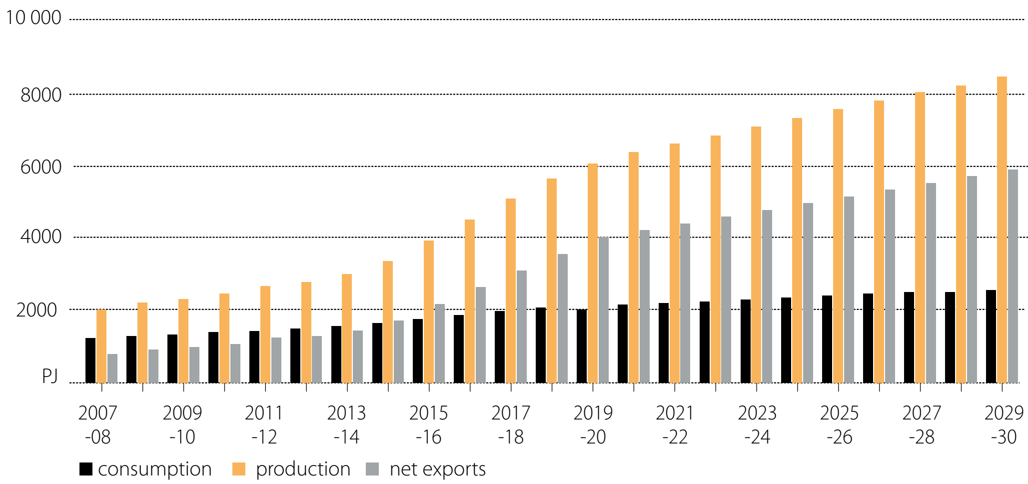
Major metallurgical coal projects in Queensland that are assumed to commence production during the projection period include the Belvedere coking coal mine, with a capacity of 9 million tonnes, and the BHP Billiton Mitsubishi Alliance's (BMA) Caval Ridge (5.5 million tonnes) and Daunia (4 million tonnes).

Natural gas production and LNG exports

Australia has significant volumes of natural gas that are increasingly being developed for domestic use and for export as LNG (Geoscience Australia and ABARE 2010). In 2007-08, total gross output of natural gas in Australia was 2040 petajoules (table 17), including LNG. On a regional basis, the largest conventional gas resources are located mostly off the north-west coast of Western Australia, with natural gas production in the western gas market totalling 1091 petajoules or 53 per cent of total national production in 2007-08. Gross gas production in the eastern and northern markets is estimated to have been around 691 and 257 petajoules, respectively, in 2007-08.

Gross natural gas production, including LNG, in the western market is projected to grow strongly, at an average rate of 7.1 per cent a year, to reach 4968 petajoules in 2029-30 (table 17 and figure I). This is underpinned by increasing demand in the domestic market and increasing global demand for LNG.

I Gas balance



17 Australian gas markets (PJ)

	2007-08	2029-30	share (%) 2007-08	share (%) 2029-30	average annual growth (%) 2007-08 to 2029-30
Eastern market					
Production					
Conventional	574	353	28	4	-2.2
Coal seam gas	118	2 507	6	30	14.9
Total	691	2 861	34	34	6.7
Western market					
Production	1 091	4 968	53	58	7.1
Northern market a					
Production	257	677	13	8	4.5
Australia	2 040	8 505	100	100	6.7

a Includes Joint Petroleum Development Area (JDPA).

Growth in LNG exports will be supported by the development of a number of greenfield projects, including the Gorgon LNG, Ichthys, Wheatstone and Browse projects By 2029-30, LNG exports from the western market have the potential to reach 73 million tonnes (3986 petajoules), reflecting an average annual growth rate over the projection period of 9 per cent.

A striking feature of the gas outlook in the eastern gas market is the increasing contribution of coal seam gas (CSG) to the gas production profile (table 17). In 2007-08, CSG accounted for around 6 per cent of total gas consumption in Australia and 80 per cent in Queensland. Production of CSG in Queensland and New South Wales is projected to continue its high growth trajectory, increasing from 118 petajoules in 2007-08 to 2507 petajoules by 2029-30, when it would represent 88 per cent of gas production in the eastern gas market. A significant proportion of this CSG will be consumed domestically, supporting the projected growth in gas-fired electricity generation, particularly in Queensland and New South Wales. The substantial projected expansion of CSG in Queensland suggests that gas flow patterns may also change, with relatively less gas flowing north from Victoria and more gas flowing south from Queensland (AEMO 2009).

From 2015 it is expected that coal seam gas will also be converted to LNG. There are currently a number of CSG-LNG projects being planned around Gladstone (ABARE 2009c); however, some of these projects may not proceed for several years. Some may confront changes in economic conditions or may be targeting the same market opportunities. However, if all these projects were developed over the medium term, they would have a potential combined capacity of up to 43 million tonnes a year by 2020.

The significant gas resource base is capable of meeting both domestic and export demand over the next 20 years and beyond.

In 2007-08, gross natural gas production in the Northern Territory (including imports from the JDPA in the Timor Sea for LNG production in the Northern Territory) is estimated to have been 257 petajoules. By 2029-30, gross natural gas production in the Northern Territory is projected to reach 677 petajoules, growing at an average annual rate of 4.5 per cent. Gas supply to the northern market (excluding LNG exports) is projected to meet demand over the outlook period, increasing from 57 petajoules in 2007-08 to 93 petajoules in 2029-30. This growth will be underpinned by gas consumption necessary for conversion of natural gas to LNG at the Icthys processing plant and increased use of gas for electricity generation.

Crude oil production and net imports

Geology, combined with world oil prices and exploration activity, has a significant influence on the level of domestic oil production. A large part of current Australian oil production is sourced from mature oil fields with declining reserves. The latest available estimates of recoverable oil resources are approximately 8414 petajoules (1431 million barrels), located mostly in the Carnavon and Gippsland basins (Geoscience Australia and ABARE 2010). However, Australia has many prospective offshore areas that are yet to be drilled and explored. Adding to Australia's oil resources, there are substantial resources of condensate (16 170 petajoules) and LPG (6210 petajoules) associated with the major gas fields on the North West Shelf and in the Browse and Bonaparte basins.

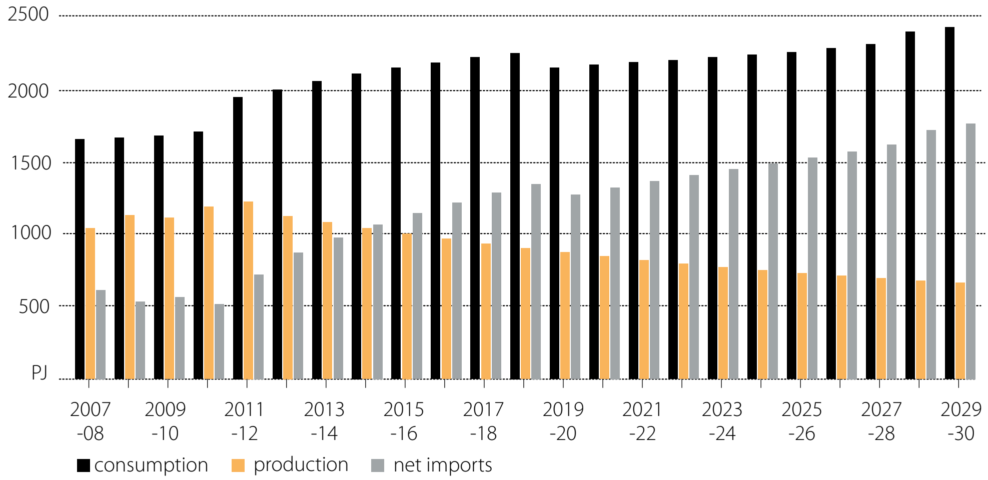
In 2007-08 Australia's crude oil production was equivalent to around 70 per cent of refinery feedstock, meaning that Australia was a net importer of crude oil. However, around 62 per cent of Australia's crude oil and condensate production were exported primarily to oil refineries in Asia.

In the projections it is assumed that suppliers will 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 is projected to decline from 945 petajoules in 2007-08 to 425 petajoules by 2029-30 (table 15).

Domestic production of naturally occurring LPG is projected to increase at a rate of 4 per cent a year, reaching 243 petajoules by 2029-30 (table 15). The combined production of crude oil and naturally occurring LPG in Australia is forecast to decline over the outlook period, from 1048 petajoules in 2007-08 to 668 petajoules in 2029-30.

Consumption of liquid fuels (excluding petroleum products), on the other hand, is projected to continue to increase from 1667 petajoules in 2007-08 to 2443 petajoules by 2029-30 (figure m). This gap between supply and demand is exacerbated by a significant proportion of the growth in domestic production of crude oil and naturally occurring LPG being concentrated in the Carnarvon and Browse Basins, in north-western Australia. As a result, it is reasonable to assume 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. As a result, the ability of domestic production to meet domestic demand is likely to be lower than implied by the simple comparison of production and consumption.

m Oil and LPG balance



The demand for petroleum product imports is determined by domestic oil production and end use consumption of petroleum products, and also by domestic petroleum refining capacity. Australia's refining capacity is not expected to expand given increasing competitive pressures from larger refineries in South-East Asia in particular. For a given domestic production and consumption outlook, petroleum refining capacity constraints may 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. Around 6 per cent of gross refinery output is used on-site in the conversion process, in addition to small quantities of natural gas and electricity.

With declining oil production, Australia's net trade position for liquid fuels is expected to worsen, with net imports increasing by 3.3 per cent a year over the projection period (table 16).

6 Conclusions

The outlook presented in this report represents a significant turning point from ABARE's previously published projections. The current projections show that Australian energy consumption will continue to grow over the next 20 years, albeit at a lower rate than experienced in the past 20 years, as a result of a range of market and policy drivers.

However, the expected transformation in the Australian energy landscape is even more evident in the composition of the energy mix. Driven by policies designed to move Australia toward a low emissions economy, these projections point to a shift to low emission technologies over the outlook time frame. With the RET and a 5 per cent carbon emissions reduction target, non-renewables are expected to account for 92 per cent of Australia's primary energy mix in 2029-30. This represents a decline from their overall share in 2007-08 (95 per cent).

Within the non-renewables category, there is expected to be a marked increase in the use of gas (natural gas and coal seam gas), primarily for electricity generation (the largest user of primary energy), and LNG production. Gas-fired electricity generation is based on mature technologies with competitive cost structures relative to many renewable energy technologies. As such, it has the potential to play a major role as a transitional fuel until lower-emission technologies become more cost effective.

Notwithstanding the bullish outlook for gas, renewable energy is projected to have the strongest growth prospects. Within this cluster, the largest expansion is expected to apply to the lowest cost and relatively mature renewable energy technology; namely, wind energy. However, the results also support a small but growing contribution from solar energy and geothermal energy. Much of this growth will be driven by the RET and other government initiatives, which are designed to accelerate the development and deployment of renewable technologies.

The transition to a low carbon economy will require long-term structural adjustment in the Australian energy sector. While Australia has abundant and diverse energy resources, this transformation will need to be underpinned by significant investment in energy supply chains to allow for better integration of renewable energy sources and emerging technologies into energy systems. While the energy market framework has been assessed as generally capable of supporting this transition, changes to market settings within the framework will be required (AEMC 2009). It will therefore be critical to ensure that the broader energy policy framework continues to support cost-effective investment in Australia's energy future, and timely adjustments to market settings in response to emerging pressures and market developments.

References

ABARE 2010, *Australian commodities*, March quarter, vol. 17, no.1, Canberra, http://www.abare.gov.au/publications_html/ac/ac_10/ac10_March_a.pdf

ABARE 2009a, *Australian commodities*, December quarter, vol. 16, no.4, Canberra, http://www.abare.gov.au/publications_html/ac/ac_09/ac09_Dec_a.pdf

ABARE 2009b, *Australian energy statistics*, Canberra, July, http://www.abare.gov.au/publications_html/data/data/data.html

ABARE 2009c, *Minerals and energy: major development projects – October 2009 listing*, Canberra, November, http://www.abare.gov.au/publications_html/energy/energy_09/ME09_Oct.pdf

ABARE 2009d, *Electricity generation – major development projects – October 2009 listing*, Canberra, November, http://www.abare.gov.au/publications_html/energy/energy_09/EG09_Oct.pdf

APERC (Asia Pacific Energy Research Centre) 2009, *APEC Energy Demand and Supply Outlook*, 4th edition, Institute of Energy Economics Japan, Tokyo, November, http://www.ieej.or.jp/aperc/2009pdf/Outlook/Outlook_Volume_II_4E.pdf.

Australian Bureau of Statistics (ABS) 2009, *Australian Demographic Statistics,* March 2009, catalogue 3101.0, September.

—— 2008, *Population Projections,* Australia, 2006-2101, catalogue 3222.0, September.

—— 2007, *Australian Social Trends, 2007*, catalogue 4102.0, August.

Australian Energy Market Commission (AEMC) 2009, *Review of Energy Market Frameworks in light of Climate Change Policies*, Final Report, October, Sydney. http://www.aemc.gov.au/Market-Reviews/Completed/Review-of-Energy-Market-Frameworks-in-light-of-Climate-Change-Policies.html

Australian Energy Market Operator (AEMO) 2009, *Gas Statement of Opportunities- for Eastern and South Eastern Australia*, December, http://www.aemo.com.au/planning/0415-0004.pdf

Australian Energy Regulator (AER) 2009, *State of the Energy Market*, Commonwealth of Australia, Melbourne. http://www.aer.gov.au/content/index.phtml/itemId/732297

Australian Government 2009a, *New Measures for the Carbon Pollution Reduction Scheme*, http://www.climatechange.gov.au/minister/wong/2009/media-releases/May/mr20090504.aspx

—— 2009b, *National Greenhouse and Energy Reporting*, http://www.climatechange.gov.au/government/initiatives/national-greenhouse-energy-reporting.aspx

—— 2009c, *Mid-Year Economic and Fiscal Outlook 2009-10*, Canberra, http://www.budget.gov.au/2009-10/content/myefo/html/prelims.htm

—— 2008, *Carbon Pollution Reduction Scheme: Australia's Low Pollution Future*, Canberra, December.

Department of Resources, Energy and Tourism 2009, *Clean Energy Initiative,* http://www.ret.gov.au/Department/Documents/CEI%20Fact%20Sheet%20(13%20May%2009).pdf

Dickson, A, Thorpe, S, Harman, J, Donaldson, K and Tedesco, L 2001, *Australian Energy: Projections to 2019-20*, ABARE research report 01.11, Canberra.

EPRI (Electric Power Research Institute) 2010, *EPRI technology status data,* February, http://www.epri.com.

Geoscience Australia and ABARE 2010, *Australian Energy Resource Assessment*, Canberra, March, http://www.abare.gov.au/publications_html/energy/energy_10/energy_10.html.

Global CCS Institute 2009, *Strategic Analysis of the Global Status of Carbon Capture and Storage*, http://www.globalccsinstitute.com/downloads/Status-of-CCS-WorleyParsons-Report-Synthesis.pdf

Greenhouse Gas Reduction Scheme Administrator 2008, *GGAS Newsletter*, issue 10, December, http://www.greenhousegas.nsw.gov.au/Documents/Newsletter_Issue10_Dec08.pdf

Greenhouse Gas Reduction Scheme Administrator 2007, *GGAS – Summary of the scheme*, Sydney, August, http://www.greenhousegas.nsw.gov.au/documents/FS-Sch-Summary-02.pdf

International Energy Agency (IEA) 2009a, *World Energy Balances*, 2009 edition, IEA online data services, OECD, Paris.

__ 2009b, *World Energy Outlook*, OECD, Paris, November.

__ 2008, *Energy Technology Perspectives: Scenarios & Strategies to 2050*, OECD, Paris.

National Energy Technology Laboratory 2009, *Extending the CCS Retrofit Market by Refurbishing Coal Fired Power Plants*, US Department of Energy.

Office of the Renewable Energy Regulator (ORER) 2009, *RET – The Basics*, http://www.orer.gov.au/publications/ret-overview.html

Queensland Government 2009, *Queensland Gas Scheme,* April, http://www.dme.qld.gov.au/Energy/gasscheme.cfm

Sandu, S and Petchey, R 2009, *End Use Energy Intensity in the Australian Economy*, ABARE research report 09.17, Canberra, November http://www.abareconomics.com/publications_html/energy/energy_09/energy_intensity.pdf

Specker, S, Phillips, J and Dillon, D 2009, *The Potential Growing Role of Post-Combustion CO_2 Capture Retrofits in Early Commercial Applications of CCS to Coal-Fired Power Plants*, EPRI.

RESEARCH FUNDING ABARE relies on financial support from external organisations to complete its research program. As at the date of this publication, the following organisations had provided financial support for ABARE's research program in 2009-10. We gratefully acknowledge this assistance.

02.09

AusAID

Australian Fisheries Management Authority

Australian Government Department of Climate Change

Australian Government Department of the Environment, Water , Heritage and the Arts

Australian Government Department of Resources, Energy and Tourism

CRC Plant Biosecurity

CSIRO (Commonwealth Scientific and Industrial Research Organisation)

Dairy Australia

Department of Primary Industries, Victoria

DN Harris and Associates

European Commission

Fisheries Research and Development Corporation

Fisheries Resources Research Fund

Forest and Wood Products Australia

Grains Research and Development Corporation

Grape and Wine Research and Development Corporation

Horticulture Australia

International Food Policy Research Institute

Land and Water Australia

Meat and Livestock Australia

National Australia Bank

OECD

Rural Industries Research and Development Corporation

The Treasury