TRACKING PROGRESS TOWARDS A LOW CARBON ECONOMY

ClimateWorks AUSTRALIA

2. POWER

July 2013

Summary report available at www.climateworksaustralia.org/tracking-progress

About us

Five years ago, The Myer Foundation and Monash University realised that Australia needed a new approach to drive action on climate change. One that understood the interests of business, government and investors and was trusted to be an independent, credible advisor in Australia's transition to a prosperous low carbon future.

That's why they partnered to create ClimateWorks Australia - an independent, research-based, non-profit organisation committed to catalysing reductions in greenhouse gas emissions in Australia.

Since then, ClimateWorks has built a reputation as a trusted, credible and fact-based broker by working in partnership with leaders from the private, public and non-profit sectors.

With strong links to the US-based ClimateWorks Foundation, ClimateWorks Australia also benefits from an international network of affiliated organisations that support effective policies for greenhouse gas reduction.

TRACKING AUSTRALIA'S PROGRESS TOWARDS A LOW CARBON ECONOMY

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Executive summary

Recent Progress

The emissions intensity[1] of Australia's grid-supplied electricity generation has decreased, with strong reductions in coal generation. Total emissions have decreased by 13 per cent since its peak in 2008-09 to 2012-13.

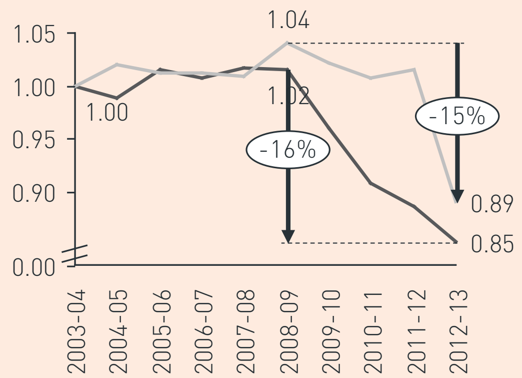
Demand: Australia's electricity demand reduced by 5 per cent between 2009-10 and 2012-13, contrary to previous expectations of continued growth in demand. This reduction of about 12,000 GWh is equivalent to eliminating Tasmania's annual electricity use in recent years.

Reductions in electricity demand have come primarily from a reduction in manufacturing output, increased uptake of distributed energy particularly solar PV, milder weather in the last 4 years leading to less heating and cooling, and improvements in energy efficiency in industry and buildings[2].

Renewables: Generation of electricity from large-scale renewables grew by 62 per cent between 2003-04[3] and 2012-13, led mostly by wind and a post-drought recovery in hydro. Renewables now generate 12 per cent of all electricity in Australia, up from 7 per cent a decade ago.

The Large-scale Renewable Energy Target (LRET) legislation requires that Australia generate 41,000 GWh of large-scale renewable energy by 2020. It has driven a surge in investment in wind power, with generation from wind energy growing from 214 GWh in 2003-04 to 7,744 GWh in 2012-13.

Exhibit 2.1: Generation of black and brown coal 2003-04 to 2012-13, index (ESAA 2005-2012, AEMO 2013)[4]



1 The volume of greenhouse gases emitted for each unit of electricity produced, e.g. tCO_2e / MWh of electricity produced.
2 More details on analysis in the Industry and Buildings sectors are presented in Reports 3 and 4 of the *Tracking Progress* series.
3 Data for this sector was not available for 2002-03.

Fossil fuels: Electricity generation from coal decreased by 14 per cent between 2003-04 and 2012-13. This shift has been driven by a combination of the LRET, the carbon price, increased gas generation and a reduction in demand for grid-supplied electricity. The reduction has been most pronounced in the last 4 years.

The historic growth in total emissions from electricity generation has stalled. While emissions from the sector grew steadily from 2003-04 and peaked in 2008-09 at 7 per cent above 2003-04 levels, this trend has since reversed, with a sharp fall in emissions of 13 per cent between 2008-09 and 2012-13.

Emissions from the sector are now almost 3 per cent lower than they were in 2002-03, after having increased steadily between 2002-03 and 2008-09.

What's driving down coal generation?

The reduction in coal generation has been most pronounced in the last 4 years. Since 2008-09, total coal generation has decreased by 16 per cent, mostly driven by a 16 per cent reduction of black coal generation, as well as a 15 per cent reduction in brown coal generation.

While black coal generation has been steadily declining since 2008-09, brown coal generation remained relatively stable until 2011-12. A sharp decrease (12 per cent) in brown coal generation was seen from 2011-12 to 2012-13.

Many factors contributed to this decrease, including flooding and industrial action at Yallourn, the introduction of the carbon price in July 2012 (which is expected to have impacted brown coal generators the most given their high emissions intensity), and continued reductions in electricity demand.

The steady decrease in black coal generation, however, suggests that black coal generators have been more heavily impacted by the softening demand for grid-supplied electricity and the increase in renewable generation.

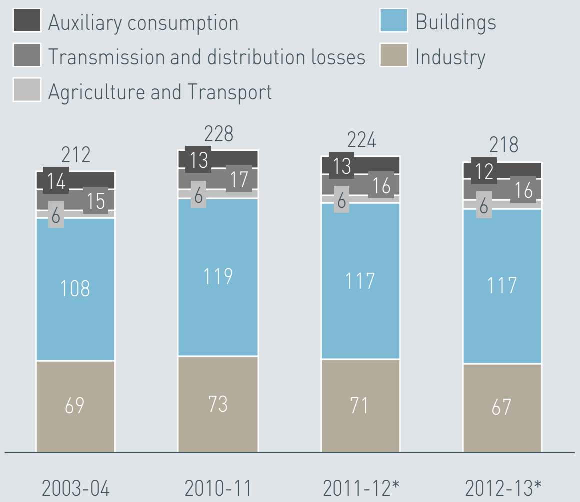
When demand for electricity drops, some power stations must reduce the amount of electricity produced. Renewables such as wind farms have a very low marginal cost (the cost to produce one unit of electricity, once the station is built), as they do not require fuel inputs which means they often take precedence over fossil fuel power stations.

4 2012-13 data is based on estimates using National Electricity Market (NEM) data. A detailed bibliography is available in the full Power report (Report 2) of the *Tracking Progress* series.

What has driven recent decreases in grid-supplied electricity demand?

Latest data suggests that reductions in demand for grid-supplied electricity have been primarily from decreases in industrial production, as well as from reductions in auxiliary consumption by coal power plants, a stabilisation in buildings electricity consumption and strong uptake of residential solar PV.

Exhibit 2.2: Estimated grid-supplied electricity use distribution, TWh (BREE 2012, ClimateWorks team analysis)



*More detail on this analysis is presented in Report 1: National Progress Report of the *Tracking Progress* series.

Outlook to 2020

Assuming the Renewable Energy Target is met, and if other abatement trends in the Power sector are sustained, Power sector emissions would continue to fall slightly to 2019-20 with new renewables more than meeting the additional demand for grid-supplied electricity[5].

Without any further emissions reduction activity in the Industry and Buildings sectors, higher demand for grid-supplied electricity from more industrial activity, growth in total building stock and increased use of appliances would put upward pressure on power sector emissions between now and 2019-20. In this case, if the emissions intensity of grid-supplied electricity were to remain constant at 2009-10 levels, emissions from the Power sector would grow by 32 $MtCO_2e$ between 2010-11 and 2019-20.

However, a range of factors are expected to see the Power sector reduce its overall emissions from 173 $MtCO_2e$ in 2012-13 to 171 $MtCO_2e$ by 2019-20, leading to a 11 per cent decrease in emissions intensity of grid-supplied electricity.

Demand: Existing policies and trends in the Buildings and Industry sectors are expected to keep demand for grid-supplied electricity low, with a net increase of 6 per cent in grid-supplied electricity demand expected between 2010-11 and 2019-20 (compared to 2012 forecasts of around 14% growth over the same period).

Renewables: The LRET is expected to continue to drive new renewable energy projects. Fewer than half of the projects currently in the pipeline would be required to meet the LRET, although implementing the projects needed to meet the LRET would require a significant increase in the rate of construction of renewable generation assets.

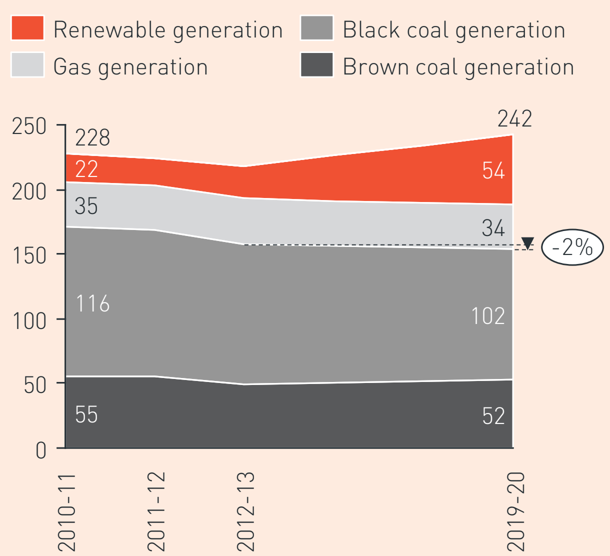
Fossil fuels: An increase in renewables and soft demand for grid-supplied electricity are expected to lead to a decrease in generation from coal and gas. If recent trends are sustained, generation from existing coal assets would further decrease by 2 per cent from 2012-13 to 2019-20 (see graph below).

If recent trends in abatement activity are sustained, around 32 per cent of the abatement potential identified in the *Low Carbon Growth Plan for Australia* for this sector would be captured by 2019-20.

Future demand for grid-supplied electricity, the availability of renewable technologies at reasonable cost, the carbon price and future fuel prices – in particular gas prices – are the key influencing factors that will determine whether current trends are sustained or can be increased.

(A Summary of changes to grid-supplied electricity generation mix from 2003-04 to 2019-20 is shown in Appendix 1).

Exhibit 2.3: Outlook for generation mix to 2019-20, TWh (ESAA 2005-2012, AEMO 2013, ClimateWorks team analysis)



5 This differs from emissions projections undertaken by the Australian Government. A detailed description of the differences is contained in Report 1: National Progress Report in the *Tracking Progress* report series.

Index of Progress

1. Overall sector

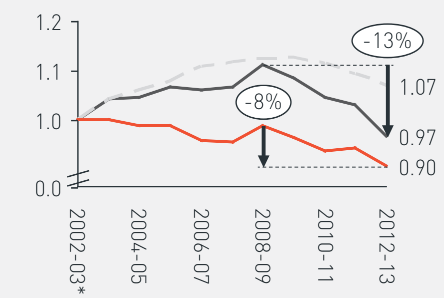
The index of progress for the Power sector illustrated here relates to progress in the generation mix of grid-supplied electricity. Progress relating to demand reduction in Buildings and Industry and the corresponding abatement achieved is addressed in the Buildings and Industry sector reports in the Tracking Progress series.

Recent progress

Emissions from electricity generation have started to decrease

The emissions intensity of Australia's power generation decreased by 8% from 2008–09 to 2012–13, with overall emissions decreasing by 13% since 2008–09

Change in emissions, generation and emissions intensity, indices (ESAA 2005-2013, AEMO 2013, ClimateWorks team analysis)



What factors influenced the abatement activity?

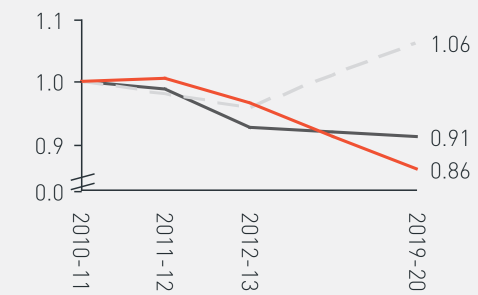
- Decrease in demand for grid-supplied electricity
- Renewable Energy Target
- Carbon price
- Prolonged drought reducing hydro generation

Outlook to 2020

Current trends could deliver 32% of the LCGP potential

A strong pipeline of renewable energy projects and slow growth in grid-electricity demand are expected to see overall power sector emissions decline by 2019–20

Change in emissions, generation and emissions intensity, indices (ESAA 2012-2013, AEMO 2013, ClimateWorks team analysis)



What factors will influence abatement activity?

- Grid electricity demand remaining soft
- Renewable Energy Target
- Carbon price
- Increase in gas prices

Change relative to historical levels & expectations

- No improvement or backwards
- Patchy or limited improvement
- Some improvement
- Moderate improvement
- Strong improvement

Legend

- Upside factors
- Downside factors

Share of potential identified in the Low Carbon Growth Plan (LCGP) that current trend would deliver

- No abatement captured
- Little abatement captured (1–25%)
- Some abatement captured (26–50%)
- Moderate abatement captured (51–75%)
- Significant abatement captured (>75%)

Legend

- Upside factors
- Downside factors

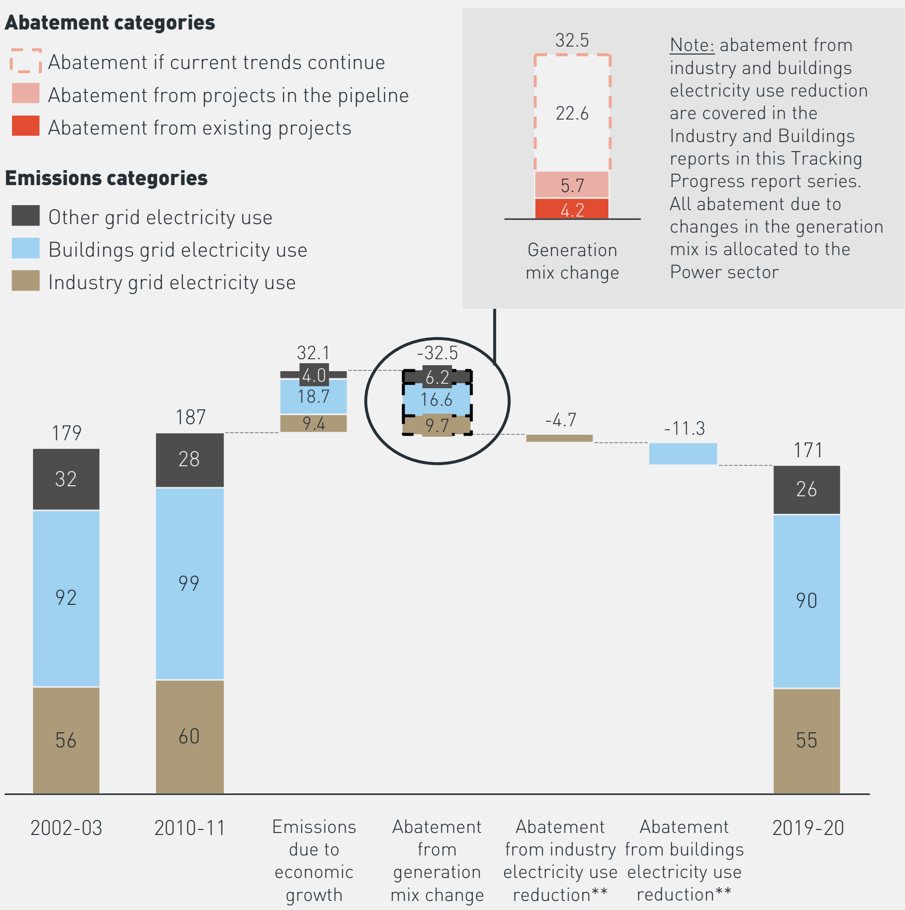
* No generation data was available for grid-supplied electricity for 2002–03, emissions intensity was assumed equal to 2003–04. Data in other sectors starts in 2002-03.

Between 2002–03 and 2010–11, emissions from grid-supplied electricity grew by only 4 per cent while generation grew by 12 per cent, due to strong improvements in average emissions intensity of electricity generation as a result of changes in the generation mix. With no further abatement activity beyond 2009–10[7], emissions would grow by 17 per cent by 2019-20, driven in particular by growth in demand in the Buildings sector.

If current trends are sustained, abatement activity would deliver 48.5 $MtCO_2e$ of emissions reductions, more than compensating for the growth in emissions and leading to an overall decrease in emissions of 9 per cent between 2010–11 and 2019–20. The largest contribution would come from changes in the generation mix, with a 32 $MtCO_2e$ reduction in emissions delivered by 2019–20 if the Renewable Energy Target is met and coal generation is further reduced. Demand reduction would contribute 16 $MtCO_2e$ of abatement simply by reducing the volume of electricity generated[8] if current trends are maintained (this abatement is allocated to the Industry and Buildings sectors).

The Buildings sector would contribute nearly three quarters of this abatement, in particular through reductions in electricity use per household and increased uptake of solar PV in the residential sector. Some demand reduction would also occur in the Industry sector through energy efficiency and an increase in off-grid electricity generation.

Emissions from the Power sector, $MtCO_2e$ (DIICCSRTE 2013a, ESAA 2011, ClimateWorks team analysis)



** Abatement allocated to the Industry and Buildings sectors

7 Abatement from 2009-10 to 2010-11 has been captured as abatement from existing projects in the graph above.

8 The impact of reduced demand on the generation mix is captured in the abatement from generation mix change.

2. Index of progress for each abatement category

Recent progress

GRID ELECTRICITY DEMAND

How much activity is happening?

Demand for grid-supplied electricity across Australia decreased by 5% between 2009–10 and 2012–13, contradicting strong growth projections

Shift in direction relative to strong historic increases

What are some key achievements?

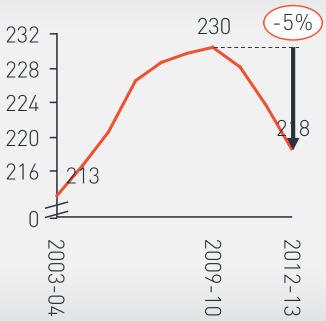
- National Electricity Market (NEM) demand in 2012–13 was 10% lower than was projected for this period in 2010
- Rapid uptake of small-scale solar PV has substituted up to 3 TWh of grid-supplied electricity in 2011-12

What factors influenced the activity?

- Increase in solar PV uptake
- Higher electricity prices
- Milder weather
- Improved energy efficiency in Buildings and Industry
- Decreasing manufacturing output
- Population growth

Key metric

Electricity generation, TWh*



RENEWABLES

How much activity is happening?

Generation of large-scale renewables has grown by 62% between 2003–04 and 2012–13, led by an increase in wind and a recovery in hydro generation.

Renewable generation has grown substantially

What are some key achievements?

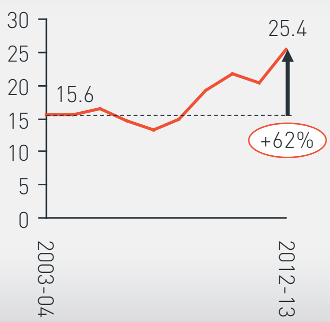
- Wind generation now accounts for 31% of all renewable generation, enough to power 1 million households
- Renewable generation now accounts for 12% of total grid electricity generation compared to 7% in 2003-04

What factors influenced the activity?

- Renewable Energy Target (RET) driving investment in new renewable capacity
- Drought conditions affecting rainfall and dam levels for hydro generation

Key metric

Renewable energy generation, TWh*



FOSSIL FUELS

How much activity is happening?

Generation from coal decreased by 14% between 2003–04 and 2012–13, and gas generation doubled

Shift to less emissions intensive generation has begun

What are some key achievements?

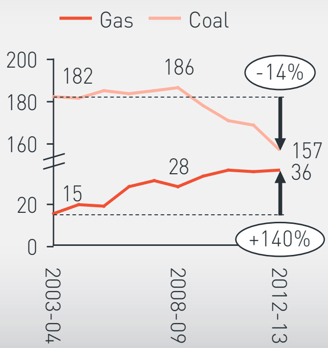
- Generation from coal decreased by 16% over the past 4 years, with decreasing utilisation rates leading a few coal generators to mothball some units
- Gas generation (OCGT & CCGT) more than doubled since 2003-04
- Fuel efficiency levels were maintained in coal generation assets, despite reduced utilisation which can affect efficiency

What factors influenced the activity?

- Decreasing electricity demand
- Fuel efficiency improvements are likely to have counterbalanced the impact of reduced utilisation on plant thermal efficiency
- Queensland Gas Scheme and GGAS driving growth in gas generation

Key metric

Generation from fossil fuels, TWh*



* Multiple data sources. See relevant section of this report for details.

Recent Progress

Change relative to historical levels & expectations

- No improvement
- Limited improvement
- Some improvement
- Moderate improvement
- Strong improvement
- Data unavailable

Outlook to 2020

Share of available potential that current trend would deliver

- No abatement captured
- 1–25%
- 26%–50%
- 51%–75%
- 76%+
- Data unavailable

Outlook to 2020

How much activity could happen?	What's in the pipeline?	What factors will influence the activity?	Key metric

GRID ELECTRICITY DEMAND

How much activity could happen?

Reduction in demand for grid-supplied electricity from manufacturing and residential buildings (including solar PV) expected to contain demand rise to 6% growth from 2010–11 to 2019–20

Current trends could capture 44% of the total abatement identified in LCGP

What's in the pipeline?

> Uptake of rooftop solar PV is likely to continue increasing in residential and commercial buildings, possibly generating 9 TWh in 2019-20

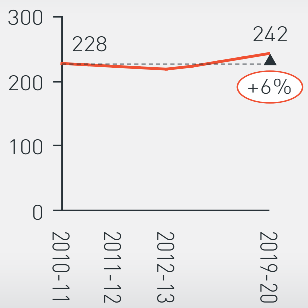
> Buildings and Industry are likely to become more efficient through energy efficiency initiatives and increased response to high electricity prices

What factors will influence the activity?

- Soft economic outlook
- Continued improvements in energy efficiency
- Continued increase in solar PV uptake
- Potential changes in electricity market rules
- Population growth
- Connection of new LNG plants in QLD to electricity grid

Key metric

Electricity generation, TWh*



RENEWABLES

How much activity could happen?

Meeting the Renewable Energy Target (RET) would more than double renewable generation by 2019-20

Current trends could capture 40% of the total abatement identified in LCGP

What's in the pipeline?

> There is twice as much renewable energy capacity in the pipeline as is needed to meet the Renewable Energy Target

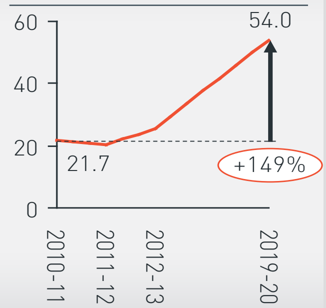
> Significant funding is being targeted at research and demonstration of new renewable technologies

What factors will influence the activity?

- Decrease in renewable technology costs
- Perceived uncertainty around the RET could defer investment
- Challenges in securing finance for new projects
- State planning regulations make it challenging to implement projects
- Rainfall and dam levels on hydro

Key metric

Renewable energy generation, TWh*



FOSSIL FUELS

How much activity could happen?

Expected future demand for grid-supplied electricity and increased renewables are expected to keep coal generation at 2012-13 levels

Current trends would deliver 20% of the LCGP potential for this sector

What's in the pipeline?

> There is no prospect of lock-in from new major coal projects before 2019-20

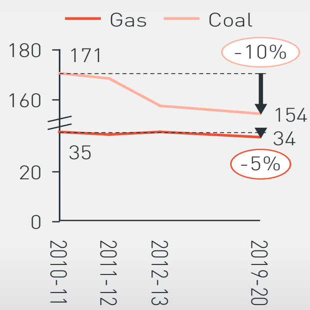
> Generation from black coal is expected to be the most affected, with a potential decrease in generation of 12% between 2010–11 and 2019–20

What factors will influence the activity?

- Demand decreasing further
- Higher carbon price could increase costs of fossil fuel generation
- Rising gas costs could impact on the profitability of gas vs coal generation
- Uncertainty around the carbon price could slow the displacement of coal

Key metric

Generation from fossil fuels, TWh*



2.1 Background

2.1.1 About the *Tracking Progress* project

Tracking Progress is the first national index of Australia's progress towards a low carbon economy. With increasing business and community focus on how best to transition to a low carbon future, it is critical to have a robust measurement and evaluation framework for low carbon activity. In order to understand how Australia is progressing towards our national emissions reduction targets, a good understanding of this activity – and the factors that are supporting or impeding it – is required. Building this evidence is critical for achieving an efficient, least-cost transition while maintaining our economic growth, competitiveness and prosperity.

The reports that make up this project provide an assessment of activity occurring across the Australian economy that reduces or avoids greenhouse gas emissions, pulling together all the available information and data across key sectors.

We have tracked and reported progress through our national progress report series covering Power, Industry, Buildings and Land-Use & Waste[9]. In addition we have produced a Special Report of factors influencing large industrial energy efficiency.[1]

No other research provides a national aggregation of data on the underlying investments and activity that lead to future abatement.

National measurements currently focus on actual emissions and energy use each year. This only reveals 'the tip of the iceberg' of abatement activity.

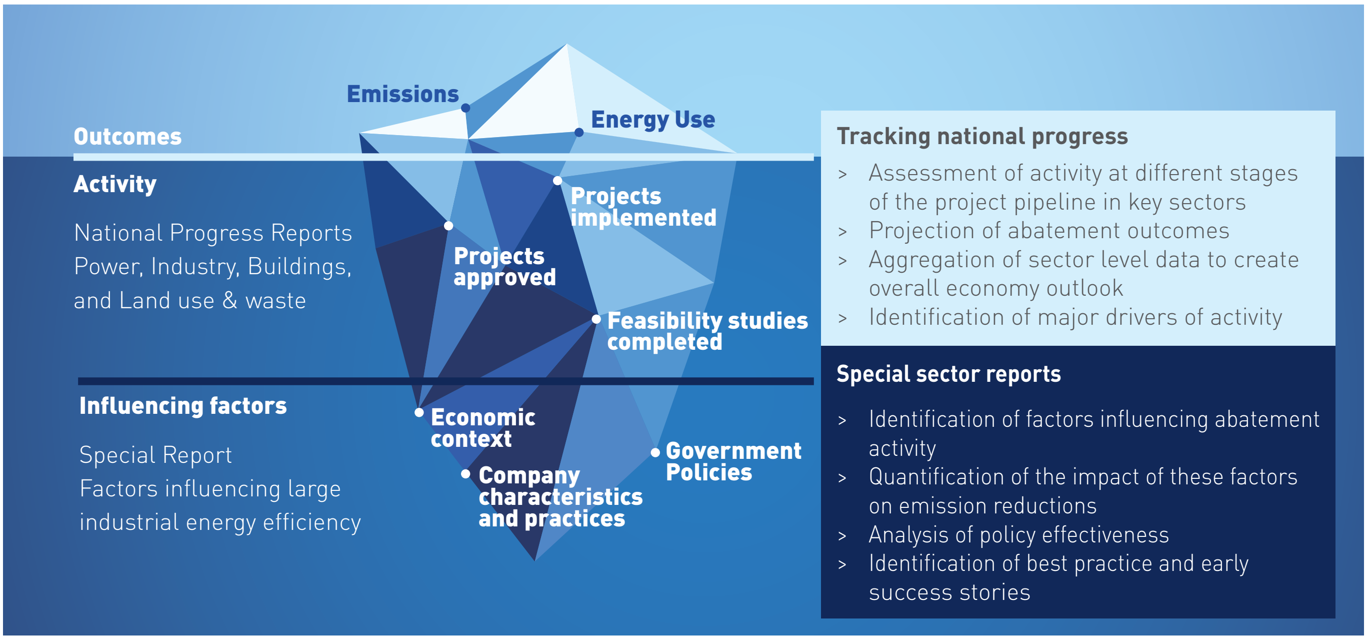
This series of reports reveals the hidden part of the story including:

LEVEL OF CURRENT ACTIVITY across key sectors of the economy. This includes activities that will deliver emissions savings in the future, some of which do not yet appear in national energy and emissions metrics but which are sufficiently advanced to make a known contribution to reducing future emissions.

FUTURE ABATEMENT that can be achieved if recent trends in abatement activity are sustained to 2019-20.

FACTORS INFLUENCING EMISSIONS REDUCTION ACTIVITY for large industrial energy efficiency – from broad economic influences to company specific factors – including an understanding of the common qualities of companies that achieve the most emissions reductions.

9 The Transport sector has not been assessed in the 2013 Tracking Progress report series but will be addressed in a future report series.



2.1.2 Methodology overview

This first *Tracking Progress* report series provides an assessment of Australia's progress in reducing emissions over the last decade (since 2002-03), and looking forward to 2019-20.

For each of the economic sectors included in the report series, we have undertaken an assessment of what activity is taking place to reduce emissions.

For each sector, we also provide analysis of the key drivers of activity based on interviews with relevant experts.

For the Special Report on large industrial energy efficiency, we combined qualitative information from an extensive interview survey with 47 companies with quantitative analysis of activity data to develop a deeper understanding of the drivers of energy efficiency activity in those companies. Similar analyses could be completed for other sectors in the future.

In each sector, abatement activity is measured over time using the following measures:

> **Emissions intensity**, namely the emissions in tonnes of CO_2e (carbon dioxide equivalent) per unit of output or other metric, for example emissions per ton of metal produced, or per dollar of GDP.

> **Energy intensity**, namely the amount of energy used per unit of output or other metric, for example energy per square metre of commercial building floor space. This measure was in particular used in the Buildings and Industry sectors to separate the impact of activities undertaken within the sector to reduce energy consumption, from the impact of changes in grid-supplied electricity intensity (which results from activity in the Power sector) on the overall sectoral emissions. Energy intensity can be equal to energy efficiency, or it can be a combination of energy efficiency and other factors.

> **Energy efficiency** refers to improvements in energy intensity from internal processes and operations. For example, the energy intensity of mining operations is influenced by the energy efficiency of the internal processes involved such as extraction and processing of ore, as well as external factors such as the grade of the ore and the depth at which it sits. Energy efficiency activity is regarded as any activity to identify, investigate or implement actions that reduce the amount of energy required to complete internal processes and operations.

> **Total emissions**, namely the total emissions in each sector and sub-sector in tonnes of CO_2e. Changes in total emissions result from changes in emissions intensity (which can be driven by abatement activity or structural factors), changes in underlying economic activity (e.g. changes in the level of economic activity, or changes in the structure of the economy such as a decline in manufacturing and a growth in mining).

This report series focuses on quantifying future emissions reduction activity based on observable abatement, rather than modelling or projections. This restricts its analysis to abatement from:

> Projects that have been implemented since 2009-10;

> Projects or activity underway in a sufficiently advanced stage such that emissions reductions in the future can be calculated from the planned volume of implementation; and

> Continuation of recent trends in abatement activity. In most sectors, the observable pipeline of activity does not yet extend to 2019-20 (e.g. investment pipelines are known to 2014-15 but not beyond). Accordingly, we have estimated the additional abatement that would occur between now and 2019-20 if the same rate of implementation of activity seen over recent years continued to 2019-20. This excludes possible new abatement from improved rates of penetration of activity or technological advancement. It restricts abatement levels to only that which would occur if the same rate of implementation observed in the past decade continued. It also implicitly assumes that similar amounts of attractive abatement opportunity could be found in the future compared to what was identified in the past. The implementation rate may be adjusted if there has been a clear directional shift in the trend in more recent years, or if the impact of changes such as new regulations that have been implemented is sufficiently certain but has yet to be reflected in observable trends (e.g. the Renewable Energy Target, which would require a significant increase in installation of new renewables in order to be met).

> This demonstrates how much abatement would be delivered by 2019-20 if current trends continued, and provides an indication of how much activity levels would need to increase in order to meet current or future national emissions reduction targets.

Exhibit 2.4 on the next page illustrates this as steps 2, 3 and 4. To compare the abatement observed with what is needed to achieve Australia's minimum national 5 per cent emission reduction target, the abatement is deducted from where emissions would have been if there was no abatement but simply the economic growth continued and the level of abatement remained at pre-2009-10 levels (e.g. emissions intensity does not improve). This is represented by Step 1 in the chart below. The 2009-10 reference year was chosen to allow a comparison of abatement activity with the opportunities to reduce emissions identified in the *Low Carbon Growth Plan for Australia*.

The resulting estimate of emissions in 2019-20 represents the volume of emissions that would occur if the economic and policy conditions that are observable today stay the same until 2019-20, and the rate of abatement continues at the same level (adjusted as described above).

At a whole-of-economy level, this National Progress Report brings together the results from each sector to provide an assessment of current progress towards meeting the current national bi-partisan minimum emissions reduction target of a 5 per cent reduction on 2000 levels by 2020.

At a sectoral level, the Tracking Progress report series assesses each sector's progress towards implementing the opportunities for emissions reduction identified in ClimateWorks' *Low Carbon Growth Plan for Australia* (see section 2.1.4), which would deliver a 25 per cent emissions reduction target domestically (427 $MtCO_2e$). This 25 per cent target aligns with the minimum target recommended by IPCC scientists for developed countries (IPCC 2007).

The assessment of progress includes:

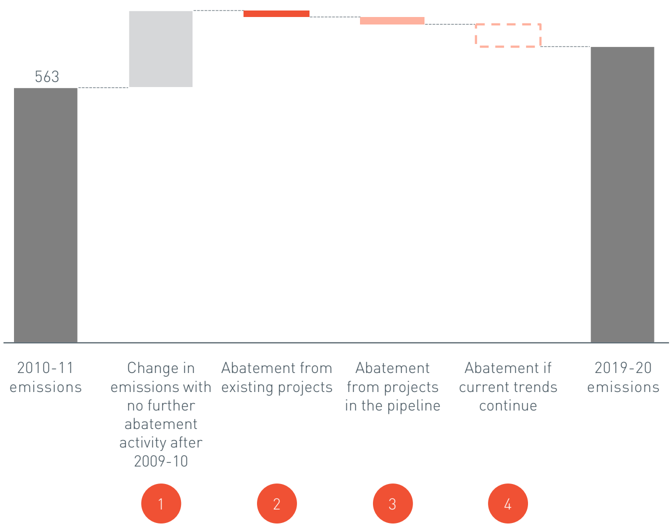
1. Recent progress
    a. Analysis of emissions reduction activity between 2002-03 and 2012-13 (or latest year with available data)
    b. Calculating a rating for each sector or activity. The rating is based on the degree to which activity to reduce emissions has increased or improved since 2002-03. We take into account the specific context of each sector – a 1 per cent growth in one sector or activity may be rated the same as a 10 per cent growth in another, depending on the opportunities available and other factors influencing activity. We also consider the change in total emissions for the sector, and reduce the rating if emissions have increased significantly despite improvement in emissions reduction activity.
2. Outlook to 2020
    a. Quantitative assessment of emissions reductions that will be achieved by 2019-20 from projects implemented since 2009-10
    b. Estimate of emissions reductions expected by 2019-20 from projects currently under way
    c. Estimate of emissions reductions that would be achieved by 2019-20 if recent trends in emissions reduction activity were to continue
    d. Rating of this future outlook according to how far (a), (b), and (c) gets each sector towards reaching the full available emissions reductions identified for each sector in the *Low Carbon Growth Plan for Australia* by 2019-20.
3. Comparison to targets and potential
    a. For the Overview Report, calculation of Australia's emissions in 2019-20 after subtracting all the emissions reductions identified in each sector report (including those already implemented, those expected from projects under way, and those that would be achieved by 2019-20 with recent trends). This number is then compared to 537 $MtCO_2e$, which represents Australia's 5 per cent emissions reduction target.

Estimate of how much more emissions reduction potential is available by 2019-20, by reference to the opportunities identified in the *Low Carbon Growth Plan for Australia* which assessed the least cost approach to achieving a 25 per cent reduction in Australia.

Data used in this report to aggregate emissions across the Australian economy are drawn from the annual publication of the National Greenhouse Gas Inventory (NGGI). The most recent report contains national greenhouse gas emission estimates for the period 1989-90 to 2010-11, compiled under the rules for reporting applicable to the United Nations Framework Convention on Climate Change (UNFCCC).

Where more recent data is available, this has been included in the relevant sector chapter. The recent data is not comprehensive enough to allow all sectors to be updated beyond 2010-11 so we have used the 2010-11 year as a common comparison point for all sectors.

Exhibit 2.4: 4 steps followed to estimate the potential impact of abatement activity by 2019-20 (ClimateWorks team analysis)



2.1.3 Emissions profile

Description of the power sector

This report investigates emissions reduction activity from large-scale grid-connected electricity generation assets – both fossil fuel and renewables. It also examines electricity transmission and distribution networks across Australia. Grid-connected electricity is defined as electricity supplied by:

- the National Electricity Market (NEM), which covers Queensland, New South Wales, Victoria, Tasmania and South Australia
- the South West Interconnected System (SWIS), which covers Perth and other major population centres in the south west region of Western Australia
- the North West Interconnected System (NWIS), which covers the Pilbara region and other communities in the north west of Western Australia
- Scheduled, semi-scheduled and non-scheduled generators in the Northern Territory.

Small-scale solar power, other forms of distributed energy generation and off-grid electricity generation are addressed in the Buildings and Industry reports in the Tracking Progress series.

Data Sources

The primary source of data used in our analysis of recent progress is from the Energy Supply Association of Australia's annual publication of Electricity Gas Australia. This data is sourced from member companies, the Australian Energy Market Operator (AEMO) and the Independent Market Operator.

In section 2 of this report, 2012-13 generation of grid-supplied electricity was estimated using AEMO data from 1 July 2012 to 30 June 2013 for the National Electricity Market (NEM), which represents around 90 per cent of total grid-supplied electricity in 2011-12. Emissions from electricity generation in 2011-12 and 2012-13 were estimated using emissions intensity[10] of individual fossil fuel generation in 2010-11.

Company interviews

As part of the research completed for this chapter, 17 companies, including companies from the generation and networks businesses across Australia, were interviewed.

The respondents covered 49 per cent of Australia's total installed grid-connected generation capacity[11] and transmission and distribution network service providers in all those states supplied by the National Electricity Market.

In most cases, interviewees were energy or sustainability managers within the organisations.

The focus of the interviews included:

- Major emissions reduction or energy efficiency activities that have been undertaken
- Major emissions reduction or energy efficiency activities that are being considered
- Factors that may have driven past and recent activity
- Factors that may have inhibited further activity.

10 Emissions intensity of Australia's grid-supplied electricity refers to the amount of greenhouse gases emitted for each unit of electricity produced, e.g. tCO_2e / MWh of electricity produced.

11Please see section 2.1.3 for scope of Australia's total installed grid-supplied electricity.

Emissions profile

Emissions from the combustion of fossil fuels for the generation of grid-supplied electricity contribute a third of Australia's national emissions, representing 33 per cent of total emissions (N.B - does not equal 34 per cent due to rounding), or 187 $MtCO_2e$, in 2010-11 (see Exhibit 2.5).

This is comprised of emissions from electricity consumed in buildings (53% of grid-supplied electricity emissions) and industry (32%), with the remainder from consumption of grid-supplied electricity in other sectors (e.g. agriculture and electric-powered transport) as well as electrical losses in transmission and distribution networks and auxiliary consumption in power stations.

Exhibit 2.5: Breakdown of Australian emissions and sector coverage in 2010-11, % (DIICCSRTE 2013a)

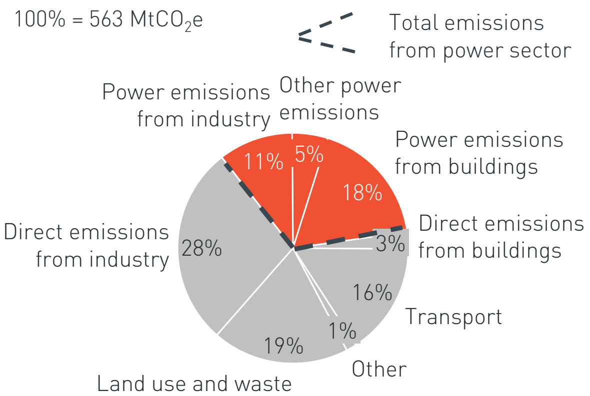
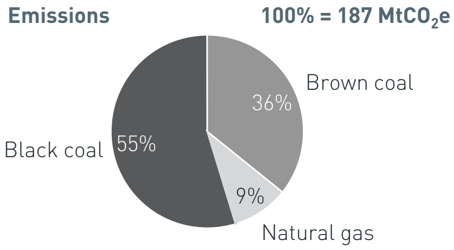
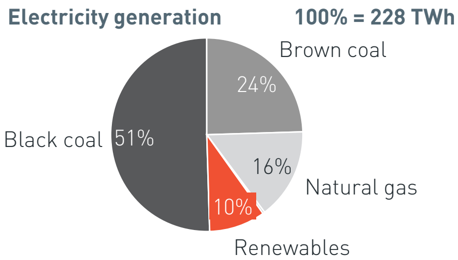


Exhibit 2.6: Breakdown of emissions and generation of grid-supplied electricity in 2010-11, % (DIICCSRTE 2013a, ESAA 2011, ClimateWorks team analysis)





Breakdown of the sector's emissions

The process of generating electricity from the combustion of fossil fuels releases greenhouse gases, primarily carbon dioxide (see Exhibit 2.6).

The emissions intensity of electricity generation differs for different fuel types. 91 per cent of the sector's emissions come from coal-fired generation that accounts for 75 per cent of total electricity generated in 2010-11.

In 2010-11, highly emissions-intensive brown coal accounted for 36 per cent of total emissions from electricity generation, despite producing only 24 per cent of all electricity generated. More than half of all electricity generation emissions came from black coal.

Gas generates electricity at a lower emissions intensity and therefore accounted for only 9 per cent of total emissions, despite generating 16 per cent of Australia's grid-supplied electricity.

How to read the greenhouse gas emissions reduction cost curve

The greenhouse gas emissions reduction cost curve, also known as a marginal abatement cost curve (MACC), summarises our estimate of the realistic volume and costs of opportunities to reduce greenhouse gas emissions in Australia.

Each box on the curve represents a different opportunity to reduce greenhouse gas emissions. The width of each box represents the emissions reduction potential that opportunity can deliver in 2020 compared to business-as-usual.

The height of each box represents the average net cost of abating one tonne of CO_2e (carbon dioxide equivalent) through that activity.

The graph is ordered left to right from the lowest cost to the highest cost opportunities. Those opportunities that appear below the horizontal axis offer the potential for financial savings even after the upfront costs of capturing them have been factored in. Opportunities that appear above the horizontal axis are expected to come at a net cost.

2.1.4 Opportunities to reduce emissions in the power sector

There is significant potential to further reduce emissions from electricity generation.

ClimateWorks' *Low Carbon Growth Plan for Australia*, released in March 2010, outlined a comprehensive economy-wide blueprint for how Australia could achieve an ambitious reduction in greenhouse gas emissions, while building a robust low-carbon economy. It identified the least-cost opportunities across the economy that would achieve a 25 per cent reduction in Australia's emissions below 2000 levels.

The Plan won the highly regarded Eureka Prize for Innovative Solutions to Climate Change and the Ethical Investor Award for Sustainability Research in 2010. The plan only assessed opportunities above the Australian Government's business-as-usual projections. ClimateWorks updated this analysis in 2011.

Based on detailed economic and policy analysis, the *Low Carbon Growth Plan for Australia* identified the actions required to reduce emissions, the barriers to their implementation, and their relative cost in six key sectors – Power, Forestry, Industry, Buildings, Agriculture and Transport.

The modeling excluded opportunities that would require a significant change to the business mix of our economy, or changes to our lifestyles, as well as opportunities with a high degree of speculation or technological uncertainty.

The Plan only assessed opportunities above the Australian Government's business-as-usual projections. This modeling was updated in 2011, to take into account changes since 2010.

The power sector can contribute around a third of the abatement required to reach a 25 per cent reduction target by 2020 in Australia.

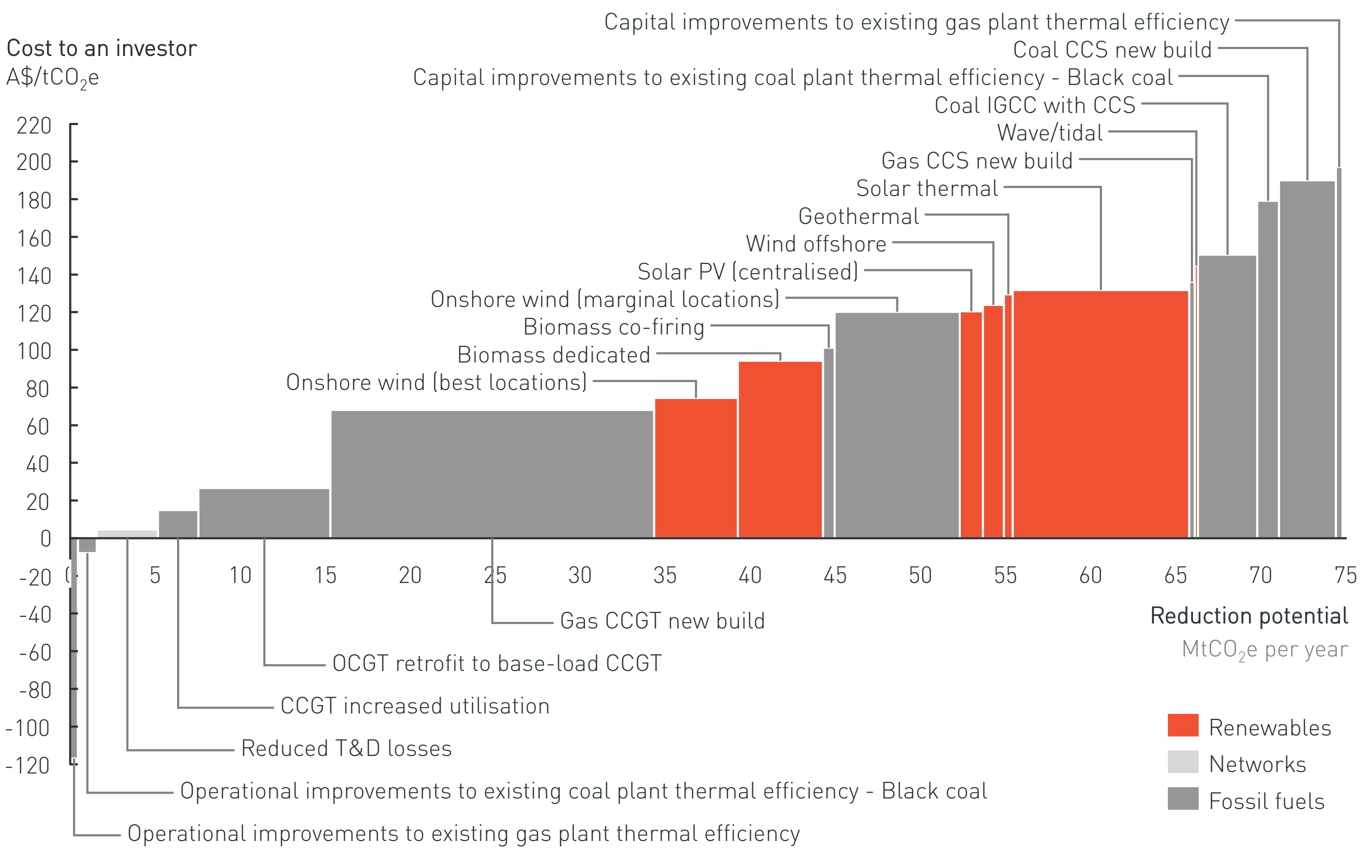
Most of these opportunities come at a net cost to investors, with an average abatement cost of \$88/ tCO_2e across all power sector opportunities. This means the opportunities identified require policy incentives, decreased technology costs or increased fuel prices before they can be attractive to investors.

Renewables

A significant proportion of the abatement opportunity in the power sector comes from increasing the generation capacity from renewables relative to fossil fuels. This may involve the early retirement of the most emissions-intensive generation assets and their replacement with lower emissions technologies.

Renewable sources of electricity include wind, solar PV, solar thermal, bioenergy, and geothermal. Technology costs have reduced significantly in recent years, lowering the overall cost of abatement.

Exhibit 2.7: Sectoral investor abatement cost curve (ClimateWorks Australia 2011)



Fossil fuels

Opportunities such as operational improvements to thermal efficiency of existing fossil fuel generation assets can offer net financial savings by reducing the amount of fuel used to generate a given amount of electricity.

Other emissions reduction opportunities identified for fossil fuel generation include increasing the use of less emissions intensive power plants relative to the higher emissions intensive power plants; switching to less emissions intensive fuel sources (from coal to gas), using some biomass in coal generation plants; and adopting carbon and capture storage technology when possible[12].

Others

ClimateWorks Australia's *Low Carbon Growth Plan for Australia* also considered other opportunities to reduce emissions in the power sector, such as reducing transmission and distribution losses, to reduce emissions by minimising electrical losses[13].

Energy efficiency improvements were also modelled in the relevant buildings and industry sectors where it was estimated that the resulting energy savings could contribute to a reduction in energy use of about one fifth compared to the business-as-usual scenario.

While there have been changes in economic and policy factors since the publication of the *Low Carbon Growth Plan for Australia*, the overall findings summarised above remain valid.

The exact size of each abatement opportunity may be different but the range of opportunities and their cost relative to other opportunities remain similar.

12 There is currently a high level of uncertainty on whether this technology will be available to contribute to significant emissions reductions by 2019-20.
13 Some of those opportunities are highly-capital intensive and are funded through network cost increases for consumers of grid-supplied electricity.

2.1.5 Historical context

Australia's electricity generation mix has historically been dominated by black and brown coal, accounting for around 80 per cent of the country's electricity generation throughout the 1990s. [3]

Note that the data presented in this section (section 2.1.5) covers all electricity generation in Australia, including grid-supplied and off-grid electricity generation, as historic data of grid-supplied electricity generation is not available. The scope of analysis and findings presented in later sections of this report is limited to generation of grid-supplied electricity only[14].

Grid-supplied electricity generation represented 90 per cent of all electricity generation in Australia in 2010-11, with off-grid generation making up the remainder. Off-grid electricity generation is not covered in this report. It is mostly powered by gas (80 per cent in 2011-12), oil (13 per cent), and biomass (6 per cent).

As shown in Exhibit 2.8 on the next page, Australia's electricity generation grew strongly in the 1990s in line with strong economic growth. Generation from black and brown coal consistently accounted for about 80 per cent of Australia's electricity generation mix, due mainly to the low cost and abundance of these fuel sources.

Since 2000-01, an increasing proportion of generation has come from natural gas. Electricity generation from natural gas increased from 9 per cent of the country's total generation in 1989-90 to 13 per cent in 2002-03. Renewable sources generated 8 per cent of total electricity in 2002-03, mostly from hydro-generation. Consequently, the share of generation from black and brown coal had fallen to less than 80 per cent in 2002-03.

Exhibit 2.9 on the following page shows that between 1989-90 and 2002-03, emissions from electricity generation grew by 43 per cent - following a similar trend to electricity generation (44 per cent).

The subsequent trends in the analysis period, from 2002-03 to 2012-13, will be discussed in later sections. Grid-supplied electricity generation will be addressed in this chapter while distributed and off-grid electricity generation will be addressed in the Buildings and Industry chapter.

14 Off-grid electricity generation and distributed electricity generation will be covered in the Buildings and Industry chapters (Reports 3 and 4)

Exhibit 2.8: Trend in electricity generation by fuel type for whole of Australia from 1989-90 to 2010-11, TWh per year (BREE 2012a)

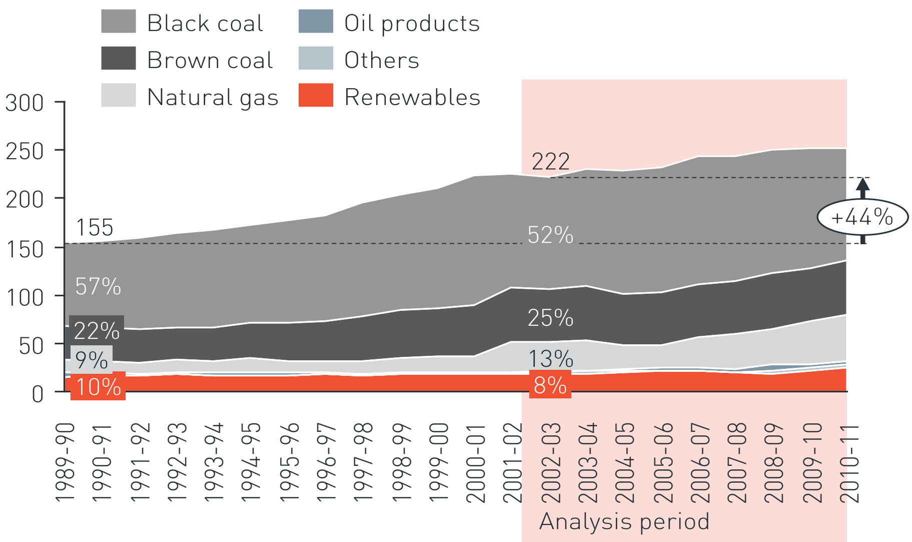
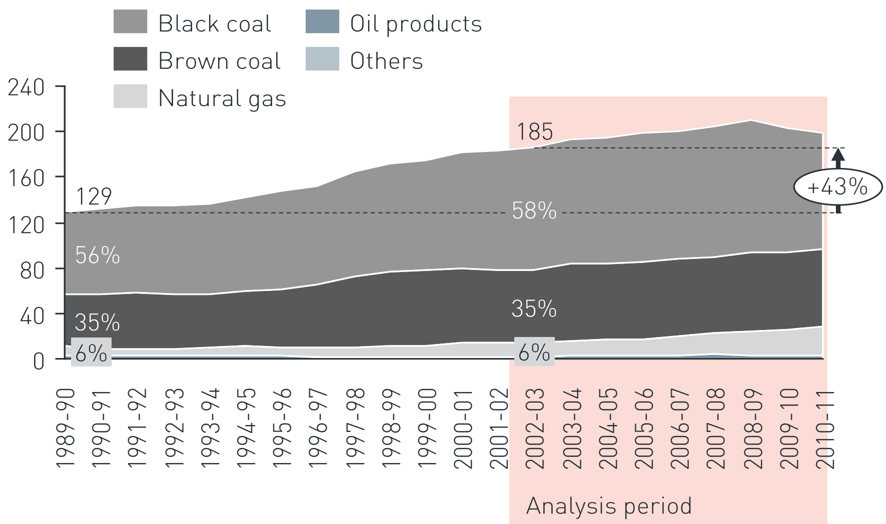


Exhibit 2.9: Emissions from electricity generation by fuel type from 1989-90 to 2010-11 , MtCO2e (DIICCSRTE 2013a)



2.1.6 Key interactions between abatement categories and between sectors

Emissions from grid-supplied electricity generation are mostly attributable to end-use demand for grid-supplied electricity from industrial activity and from commercial and residential buildings. Together, these account for almost 85 per cent of grid-supplied electricity use in 2010-11.

The rest of the emissions from grid-supplied electricity generation is attributable to transmission and distribution losses in electricity networks (7 per cent in 2010-11), auxiliary consumption[15] by electricity generators (6 per cent), transport electricity use (2 per cent) and agricultural electricity use (1 per cent). The associated emissions are referred to as 'Remainder of power emissions' in Exhibit 2.10.

In 2010-11, most of the emissions from Buildings, and more than a quarter of the emissions from Industry, came from centralised electricity generation, mostly fuelled by black and brown coal.

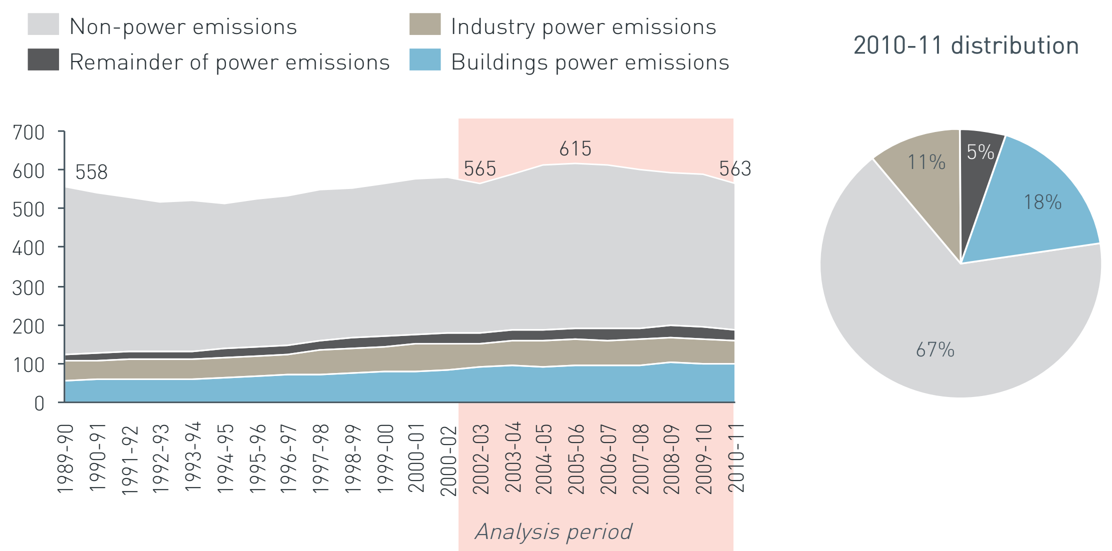
These fuels are extremely abundant in Australia but have a high emissions intensity, amplifying the emissions impact of electricity used in Buildings and Industry. his shows how closely linked Buildings and Industry emissions and Power sector emissions are. The emissions in those sectors will be strongly impacted by changes in the emissions intensity of grid-supplied electricity.

This is particularly true in the Buildings sector where grid-supplied electricity emissions represented 87 per cent of total emissions in 2010-11.

In addition, the emissions intensity of grid-supplied electricity generation will be strongly impacted by changes in demand for grid-supplied electricity in the Buildings and Industry sectors, both in terms of volume and shape throughout the day or year. These factors will influence which types of power generation plants are used to generate electricity.

15 Electricity consumed by the internal operations and processes of a generator for the purposes of electricity generation.

Exhibit 2.10: Trend in Australian emissions, $MtCO_2e$ (DIICCSRTE 2013a)



2.2 Recent progress

2.2.1 Overview

Recent data indicates an 8 per cent improvement in emissions intensity of electricity generation since 2008-09, due to an increased share of renewables. Overall emissions have also decreased by 13 per cent since its peak in 2008-09 due to a reduction in demand for grid-supplied electricity.

Between 2003-04 and 2008-09, electricity generation continued to grow but emissions increased at a lower rate. Since 2008-09, emissions from generation of grid-supplied electricity have decreased by 13 per cent, from a peak of 199 $MtCO_2e$ in 2008-09 to 173 $MtCO_2e$ in 2012-13.

Over the five years since 2008-09, grid-supplied electricity generation decreased by 5 per cent from 230 TWh to 218 TWh. Structural changes in the economy, distributed generation and energy efficiency activities in the buildings and industry sectors, partly driven by clean energy policies, have contributed to the decline in overall grid-supplied electricity demand.

This trend has meant that the emissions intensity of Australia's grid-supplied electricity has experienced a net decrease of 8 per cent from 2008-09 to 2012-13, from 0.87 tCO_2e/MWh to 0.79 tCO_2e/MWh. This has been driven primarily by the decrease of coal generation relative to renewable generation in the grid-supplied electricity generation mix.

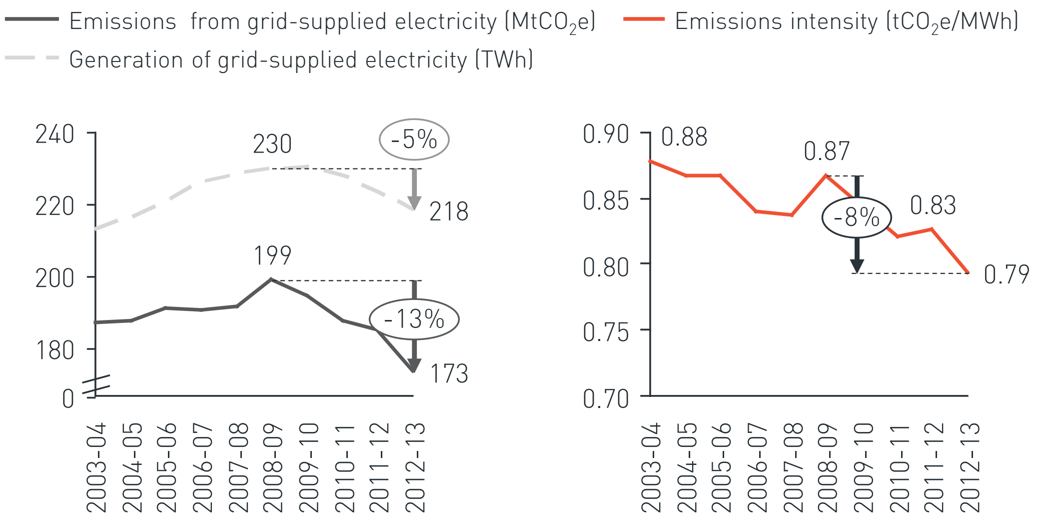
2.2.2 Grid-supplied electricity demand

Grid-supplied electricity demand across Australia has slowed significantly since 2006-07 and declined from 2009-10. This is the first time there has been a reduction in annual grid-supplied electricity consumption in the past decade.

Data from the National Electricity Market (NEM), South West Interconnected System (SWIS), and the North West Interconnected System (NWIS) shows that the growth in demand for grid-supplied electricity has slowed significantly from 2006-07 and actually decreased by 5 per cent from 230 TWh in 2009-10 to 218 TWh in 2012-13 (see Exhibit 2.12).

The recent decrease in demand for grid-supplied electricity is due to a range of factors such as the strong uptake of rooftop solar PV (driven by state-based feed-in-tariff schemes and rapidly decreasing technology costs), changing household and industry consumption patterns and structural changes to the economy, namely the closure of several large industrial electricity users. These are further discussed in the buildings and industry chapters.

Exhibit 2.11 Generation and emissions of grid-supplied electricity in Australia from 2003-04 to 2012-13 (DIICCSRTE 2013a, ESAA 2005-2013, AEMO 2013)*



* See data sources on page 12

2.2.3 Renewable energy generation

Generation from renewable energy sources increased by more than 50 per cent from 2003-04 to 2012-13, led by large increases in wind generation.

While overall demand for grid-supplied electricity has slowed, the volume and share of renewables has continued to increase. Generation from renewables grew by 62 per cent from 2003-04 to 2012-13, accounting for nearly 12 per cent of total generation in 2012-13, up from slightly more than 7 per cent in 2003-04.

Hydro generation, which is highly dependent on rainfall, decreased significantly during the 2006-2009 drought. Higher rainfall and dam levels in recent years have resulted in hydro generation returning to pre-2006 levels.

Exhibit 2.12: Generation of grid-supplied electricity in Australia, TWh by year (ESAA 2005-2013, AEMO 2013)*

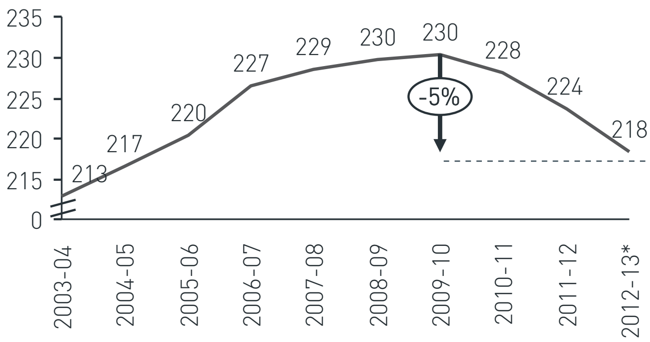


Exhibit 2.13: Generation of grid-supplied electricity by year, TWh (ESAA 2005-2013, AEMO 2013)*^

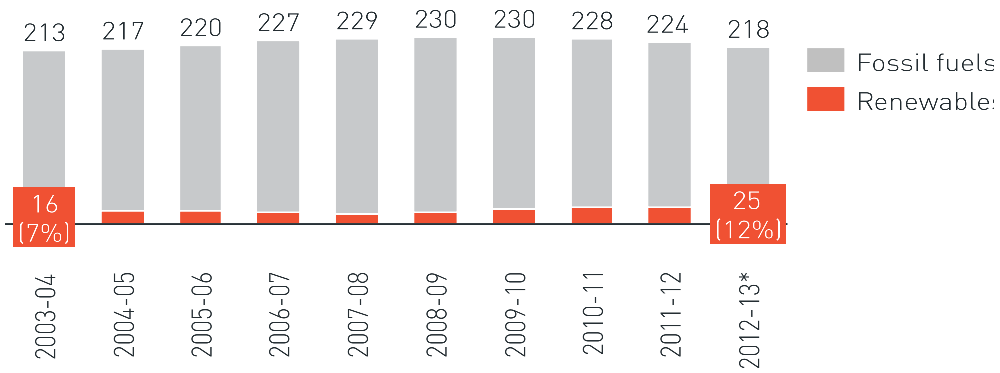
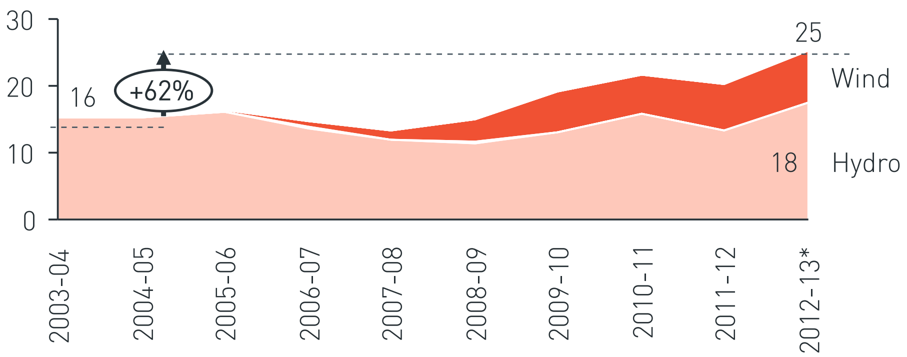


Exhibit 2.14: Generation from renewable technologies, TWh (ESAA 2005-2013, AEMO 2013)*^



*Generation refers to scheduled, semi-scheduled and large non-scheduled intermittent generators only. Hydro generation presented here does not include pump storage plants.
^ See data sources on page 12.

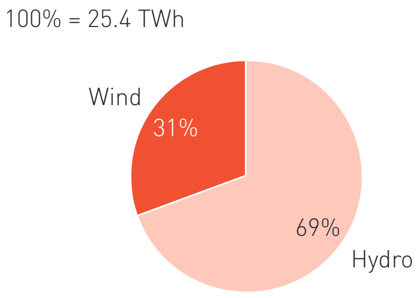
The increase in renewables has been largely driven by substantial increases in wind generation with wind contributing 31 per cent of all renewable energy generation in Australia in 2012-13.

There has been limited generation from large-scale solar to date. Small-scale solar is discussed in the buildings chapter.

The Australian Government's Large-scale Renewable Energy Target (LRET) has been the major driver for increased investments in new large scale renewable generation, mainly wind energy.

Since the inception of the RET in 2001, more than 35 million RECs have been created through wind generation, equivalent to 35 TWh of wind energy generated to date. The additional revenue generated through the sale of Renewable Energy Certificates (RECs) bridges the cost between renewable and fossil fuel generation.

Exhibit 2.15: Share of large scale renewable energy generation in 2012-13, % (ESAA 2013, AEMO 2013)*



Large Scale Renewable Energy Target

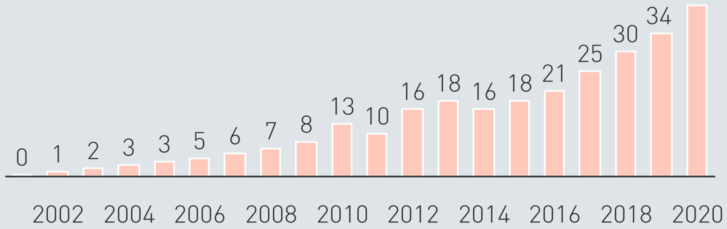
The Australian Government's Renewable Energy Target (RET) has been instrumental in driving investment in new renewable capacity. Since January 2011, the RET has comprised two components – the Large-scale Renewable Energy Target (LRET) and the Small-scale Renewable Energy Scheme (SRES).

The LRET provides a financial incentive to encourage the installation and operation of renewable energy power stations (excluding baseline generation from renewable capacity built before 1997), through provision of Renewable Energy Certificates (RECs) which provide an additional revenue stream to wholesale electricity prices through the sale of these certificates.

Electricity retailers are legally obliged to purchase and surrender a certain amount of certificates each year or incur a $65 penalty fee per certificate if there is a shortfall of large-scale generation certificates greater than 10 per cent of their liability.

Each certificate is equivalent to 1 MWh of renewable energy generated. The 2020 target for large scale renewable energy generation is 41,000 GWh, requiring increases each year as shown in the Exhibit 2.16.

Exhibit 2.16: Generation expected from LRET, TWh (DIICCSRTE 2013b)*



*Large-scale annual targets include adjustments that were made to account for the higher than expected number of certificates created in 2010 but do not include adjustments made to account for the use of waste coal mine gas as an eligible renewable energy source.

Renewables, a growing economic sector

More than $14 billion has been invested in renewables since 2009, while employment has almost tripled to 9,000 jobs.

Currently, 9,058 people are employed in the solar, wind and hydro sectors, including installation, generation and manufacturing, as well as their suppliers and services providers. This is more than half of all those employed in the entire electricity generation and supply sector (17,367 according to ABS Census 2011).

Note: Exhibits 2.17 and 2.18 include small scale solar PV. The output and abatement impact of small scale solar PV is addressed in Report 4:Buildings although the increase in uptake of small scale solar PV has played a major role in reducing demand for grid-supplied electricity, as discussed in section 2.2.2.

Exhibit 2.17: Investment generated by renewables*, m$ per year (BNEF 2012)

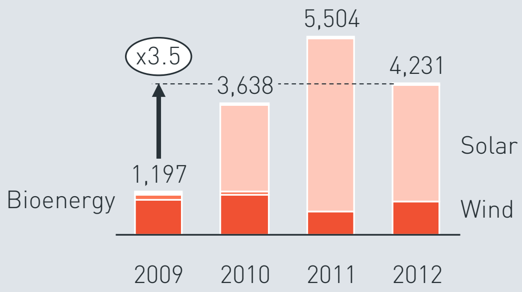
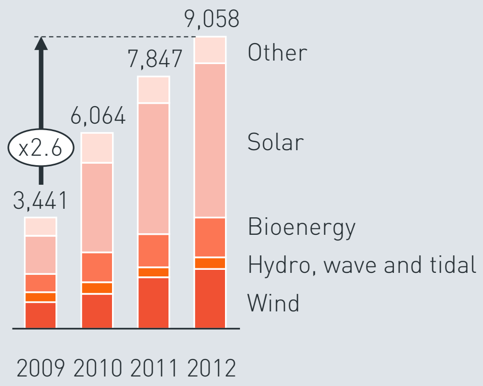


Exhibit 2.18 Identified jobs in the renewable sector, number per year (Australian CleanTech 2013)**



*Solar includes estimates for small scale PV investment (<100kW). Corporate and government R&D estimates are not included. There is no adjustment for reinvested equity. Estimates are included for undisclosed deal values
**The number of companies covered in this study has increased from 420 in 2009 to 1340 in 2012].

CASE STUDY: AUSTRALIA'S LARGEST WINDFARM

AGL is one of Australia's leading integrated renewable energy companies with 30% of its generation portfolio consisting of renewable capacity. Most of its investment in renewable energy is in hydro and wind generation.

What:

Comprised of 140 3MW wind turbines and fully operational since January 2013, Macarthur Wind Farm is currently the largest wind farm in the southern hemisphere and represents an investment of approximately $1 billion, the largest single investment in renewable energy in Australia since the Snowy Hydro Scheme.

How:

> Through a joint venture with Meridian Energy, AGL engaged the Vestas / Leighton Contractors consortium to construct the Macarthur Wind Farm.

> The site was chosen for its large landholdings, landowner commitment, community support, wind resource and proximity to the existing transmission grid.

> Over the course of the 2.5 years construction phase, AGL worked with the local community* and local government to allow the wind turbines to be constructed with little impact on local residents. As part of its community engagement, AGL also undertook independent noise monitoring tests to confirm that the Macarthur Wind Farm complied with noise limits set out by the Victorian Government.

> This community engagement process has been important to the successful completion of the Macarthur Wind Farm.

Why:

AGL is Australia's largest private owner and operator of renewable energy assets and the Macarthur Wind Farm represents an important company asset.

* Image supplied by AGL ©

What was saved:

> The 420MW wind farm is estimated to produce approximately 1.2TWh of electricity a year – equivalent to the electricity usage of more than 220,000 average Victorian households. It will reduce greenhouse gas emissions by more than 1.7 million tonnes every year, equivalent to taking more than 420,000 cars off the road.

"We hope that this [Macarthur Macarthur Wind Farm Community] fund will provide enduring positive benefits through grants that enable the community to participate in the benefits the project will bring."*

Michael Fraser,
CEO & Managing Director, AGL

"We appreciate some community members have been concerned about wind farm noise levels so we wanted to make sure it was operating correctly from the start. Over 40,000 hours of noise monitoring has been conducted at Macarthur, which is well beyond the amount of noise monitoring required in the Planning Permit. The independent AECOM Assessment demonstrates that the Macarthur Wind Farm operates well within the Planning Permit requirements."

Scott Thomas,
Group General Manager Power Development, AGL

* The Macarthur Wind Farm Community Support Fund is a $100,000 fund established by AGL and Meridian Energy dedicated to local community projects during the construction period of the Macarthur Wind Farm.

2.2.4 Fossil fuel generation

Emissions from fossil fuel generation have decreased by 13 per cent since 2008-09, due to a decrease in both black and brown coal emissions.

Emissions from fossil fuels have decreased by an estimated 13 per cent from its peak in 2008-09 to 2012-13 (Exhibit 2.19). This was driven by reduced demand for grid-supplied electricity, the increase in renewable generation and a shift in fossil fuel mix towards lower emissions assets.

Exhibit 2.20 shows a 16 per cent decrease in coal generation and a 28 per cent increase in gas generation since 2008-09 resulting in an overall 10 per cent decrease in generation across all fossil fuel generation between 2008-09 and 2012-13.

Exhibit 2.21 shows that the greater proportion of gas and shift to more efficient coal plants also reduced the overall emissions intensity from fossil fuel assets.

Exhibit 2.19: Emissions from fossil fuel assets, $MtCO_2e$ (DIICCSRTE 2013a, ESAA 2012, AEMO 2013)*

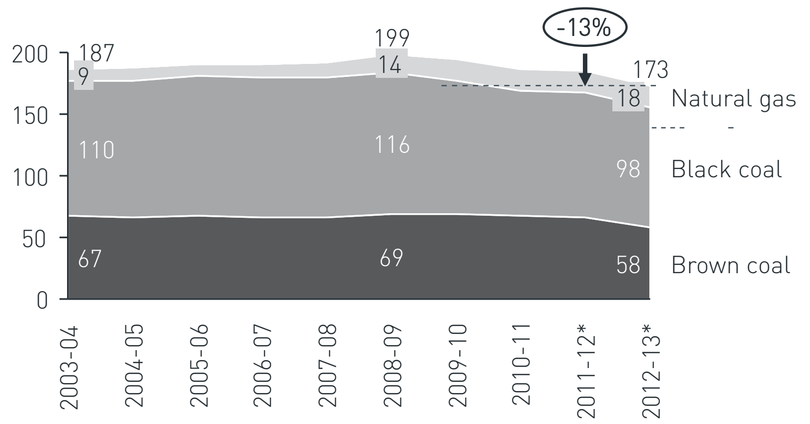


Exhibit 2.20: Generation from fossil fuel assets in Australia, TWh (ESAA 2005-2013, AEMO 2013)*

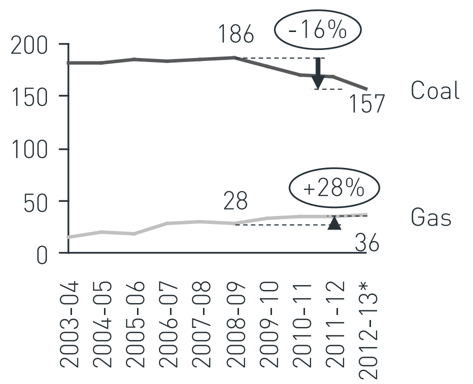
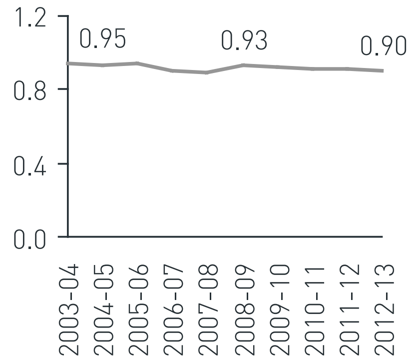


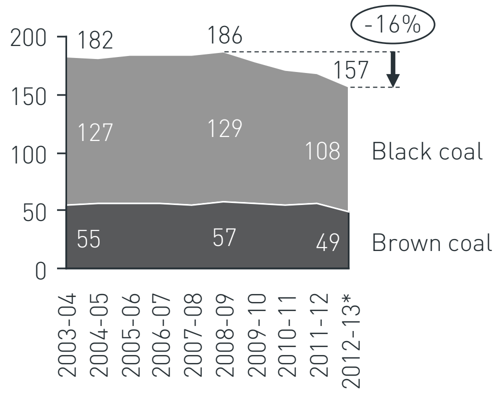
Exhibit 2.21: Emissions intensity from fossil fuel assets, tCO2e/MWh (ESAA 2005-2013, DIICCSRTE 2013a)*



* See data sources on page 12.

Slowing demand for grid-supplied electricity and increasing renewable generation has driven down coal asset utilisation to an average of 62 per cent, causing some units to be switched off or 'mothballed'.

Exhibit 2.22 Generation from coal, TWh (ESAA 2005-2013, AEMO 2013)*

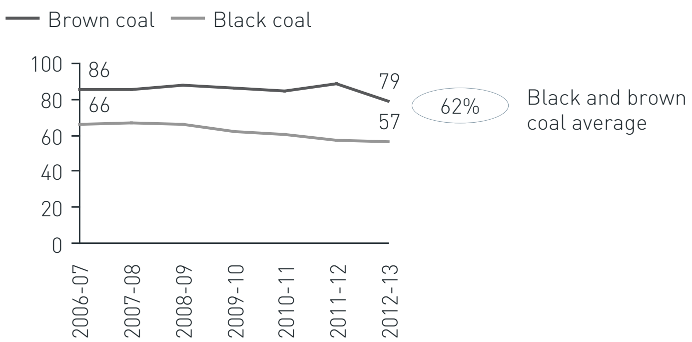


Generation from coal assets has decreased steadily over the last four years, decreasing by 16 per cent since 2008-09.

The decrease in generation from coal assets does not correspond to a reduction in capacity, but instead to a decrease in the utilisation of the existing assets. Overall, the utilisation rates[16] across all coal generation assets in 2012-13 amounted to an estimated 62 per cent. In particular, the utilisation rate of black coal power plants was down to 57 per cent.

This utilisation rate is approaching the minimum economically viable utilisation rate for coal assets, according to ClimateWorks Australia's recent interviews with companies in the industry (refer to page 12 - Company Interviews).

Exhibit 2.23 Average utilisation rate of existing assets, % (ESAA 2005-2013, AEMO 2013)*

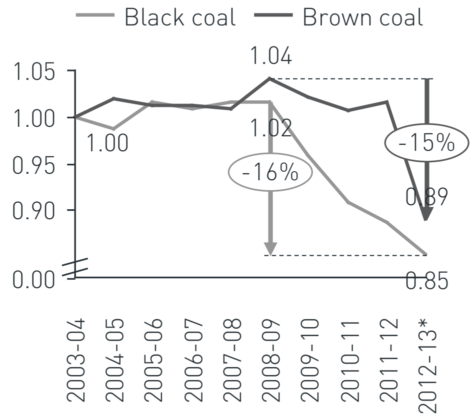


* See data sources on page 12

Black and brown coal generation declined by similar amounts. While black coal has decreased steadily since 2008-09, brown coal generation and utilisation rate experienced a sudden drop in the last financial year, probably driven by flooding at Yallourn and the introduction of the carbon price.

As seen in Exhibit 2.24, black coal generation reduced by 16 per cent between 2008-09 and 2012-13 while brown coal generation decreased by 15 per cent over the same period.

Exhibit 2.24 Generation of black and brown coal, index (ESAA 2005-2013, AEMO 2013)*



The decrease in black coal generation has occurred steadily since 2008-09 while brown coal generation remained relatively stable until 2011-12. A sharp decrease (12 per cent) in brown coal generation was seen from 2011-12 to 2012-13. Many factors contributed to these decreases, including operational constraints, the introduction of the carbon price in July 2012, and continued reductions in demand for grid-supplied electricity. Yallourn closed two of its four units due to flooding for the period June to October 2012, during which there was a 2 TWh reduction in generation output (compared to the

16 The utilisation rate of a power plant corresponds to the ratio of hours operated in a year over total hours in a year. It represents the share of time that the power plant is used to generate electricity.

same period in 2011), equivalent to about 25 per cent of the total reduction in brown coal generation from 2008-09 to 2012-13. Other factors, including industrial action and a recent fire incident at Yallourn, could also have contributed to further decreases in brown coal generation. The carbon price is also expected to have impacted brown coal generators - which have an average emissions intensity of 1.2tCO_2e/MWh- more strongly than black coal generators -which have an average emissions intensity of 0.9tCO_2e/MWh.

The steady decrease in black coal generation, however, suggests that black coal generators have been more heavily impacted by the softening demand for grid-supplied electricity and the increase in renewable generation[17].

Those significant decreases have led several coal generators to mothball 2,300 MW of capacity.

A total of 2,300 MW of coal-fired power capacity has recently been mothballed, at least temporarily. Discussions with generators and industry experts indicate that this is due to competition from less emissions intensive generators.

According to experts and companies interviewed, this situation has been influenced by the recent decreases in demand for grid-supplied electricity and the introduction of the carbon price which have played a part in driving marginal generation costs upwards.

Decreasing utilisation rates do not appear to have had a negative impact on fuel efficiency of coal generators due to selective closures of least efficient units and other incremental efficiency improvements.

Companies in the sector have reported that coal-fired generating units run most efficiently at near full capacity – more than 90 per cent for brown coal and more than 75 per cent for black coal.

This means that reductions in utilisation rates could be expected to lead to reductions in the fuel efficiency of generators. However, analysis of the fuel efficiency of brown and black coal generation assets suggests that the impact has been very limited (see Exhibit 2.25).

In fact, black coal fuel efficiency remained stable since 2008-09 and brown coal only slightly decreased since 2010-11 (when utilisation rates started declining).

Exhibit 2.25 Thermal efficiency of fossil fuel generation assets, GJ elec. sent-out / GJ fuel input (%) (CER 2012)

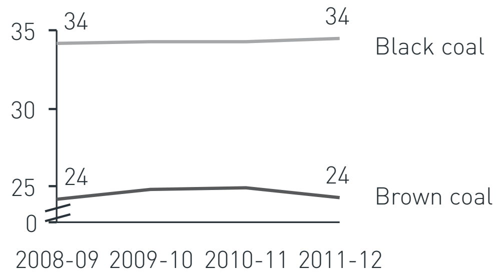


Table 2.1: Recent coal capacity mothballing announcements (ClimateWorks team analysis)

State	Power station	Fuel type	Capacity mothballed	Year started	Comments
NSW	Munmorah	Black coal	620 MW	1969	Last generated in Aug 2010
QLD	Swanbank B	Black coal	125 MW	1973	
QLD	Tarong	Black coal	700 MW	1985	Withdrawn for at least 2 years
SA	Playford B	Brown coal	240 MW	1960	Last generated in Feb 2012
SA	Northern	Brown coal	520 MW	1985	Moved to summer operating pattern
VIC	Morwell 3	Brown coal	75 MW	1962	

17 Experts mentioned other factors – such as water restrictions associated with drought conditions in Queensland in the summer of 2007-08 – may have further contributed to decrease in black coal generation, even though this does not appear to have impacted overall generation numbers. Drought pressures can constrain the amount of coal fired electricity generation due to the considerable amounts of water normally required in the cooling towers and boilers of coal fired power plants.

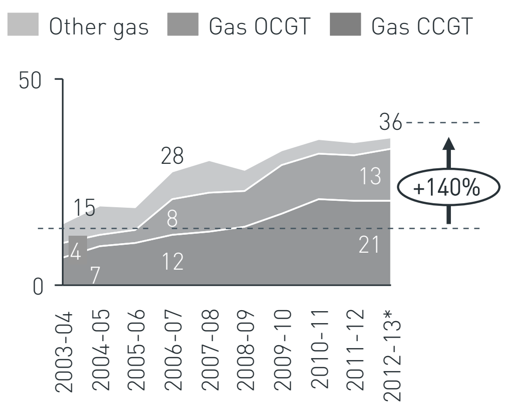
This is likely due to the selective closures of less efficient units and increased utilisation of newer, more efficient plants, such as Tarong North and Kogan Creek using "supercritical' high temperature technology.

It may also reflect other efficiency improvements counterbalancing the impact of reduced utilisation. For example, some black and brown coal generators have indicated in recent interviews for this research that they have started to use better quality coal in their operations, which allows them to improve the efficiency of generation and reduce their overall emissions intensity. In some cases this can be achieved by extracting coal from different sections of the mine, while in others it may be more complex and involve investigating the relative moisture content of various coal suppliers. Other generators mentioned upgrades to turbines, which led to improved efficiency. These turbine upgrades have been completed where the resulting increase in productivity more than offsets the cost of implementation.

Gas generation has more than doubled since 2003-04, due to a growth in coal seam gas production and the Queensland Gas Scheme and a continued increase in peak demand of grid-supplied electricity.

Generation from gas assets has been increasing steadily in the last nine years, more than doubling between 2003-04 and 2012-13 (see Exhibit 2.26). The strong growth in gas generation has been driven by open cycle gas turbines (OCGT) and combined cycle gas turbines (CCGT). OCGT plants are less efficient but more flexible than CCGT plants, which means they are often used to generate electricity to meet peak demand (see page 31) under short time frames, whereas CCGT plants are used to meet baseload or intermediary demand. Emissions from gas fired electricity generation have grown at a slower rate,

Exhibit 2.26 Generation from gas, TWh (ESAA 2005-2013, AEMO 2013)*



* See data sources on page 12

doubling from 9 $MtCO_2e$ in 2003-04 to 18 $MtCO_2e$ in 2012-13 (see Exhibit 2.19). This is due to the larger increase in CCGT which is less emissions intensive.

The increased gas generation corresponds to a strong increase in gas capacity, with OCGT and CCGT capacity both having more than doubled between 2003-04 and 2012-13 (see Exhibit 2.27).

The majority of new CCGT capacity was introduced in Queensland, with some new capacity in NSW.

This reflects the growth in coal seam methane production in Queensland, the impact of the Queensland Gas Scheme[17] and the impact of the Greenhouse Gas Reduction Scheme[18] in NSW.

The introduction of new OCGT capacity is likely to have been driven by the steady increase in peak demand.

Interviews with industry participants also indicate that increased uptake of renewable energy have contributed to new OCGT capacity, which can be used to regulate some of the variability associated with renewable generation.

Exhibit 2.27 Installed capacity of gas assets, total GW (ESAA 2005, ESAA 2012)

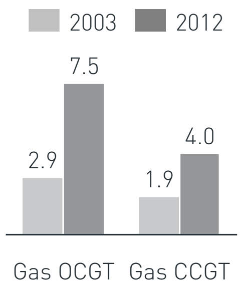
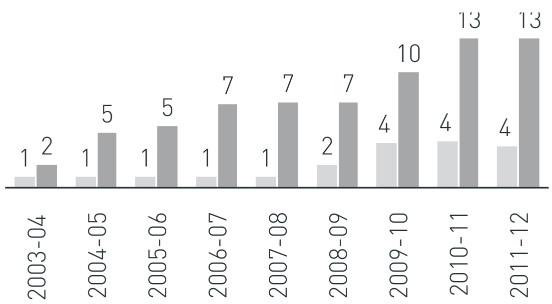


Exhibit 2.28: Gas fired electricity generation in NSW and QLD, GWh (ESAA 2005-2013)



17 The Queensland Gas Scheme was established in 2005 and requires Queensland electricity retailers to source 15 per cent of their electricity from gas fired generation

18 The Greenhouse Gas Reduction Scheme commenced in 2003 and allows for electricity generators to create abatement certificates for electricity generated at emissions intensity lower than that of the designated NSW pool coefficient (i.e. the average emissions intensity of the generation pool in NSW) as well as efficiency improvements to a generating system.

Peak demand and baseload demand

As illustrated in Exhibit 2.29, baseload demand is the amount of electricity required the majority of the time and represents minimum demands of grid-supplied electricity as a result of residential, commercial and industrial uses.

Conversely, peak demand represents the maximum demand for grid-supplied electricity at any one time. For example, on very hot days in summer when people turn on/up their air conditioners at the same time of the day (i.e. maximum demand for grid-supplied electricity may occur between 3pm and 6pm in a specific location).

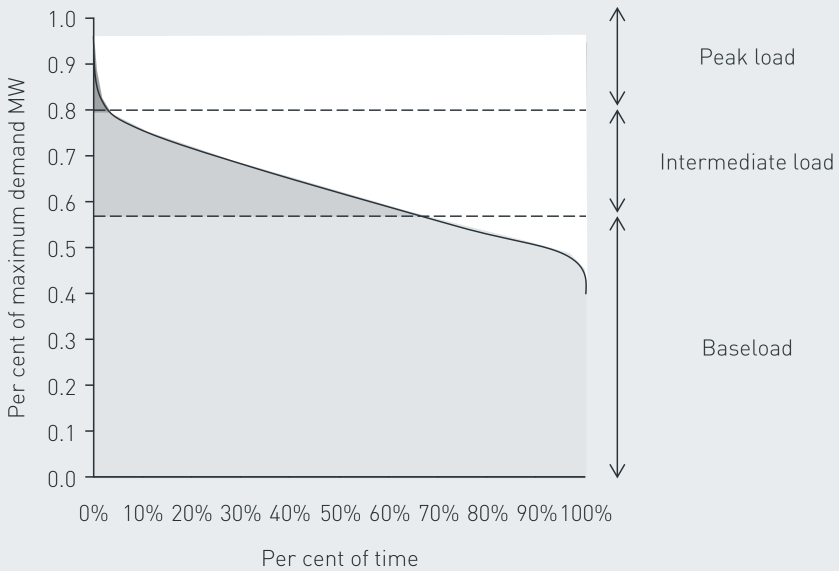
As illustrated in Exhibit 2.29, the peak periods (i.e. when more than 80 per cent of the maximum demand on the electrical system) only occur less than 10 per cent of the time.

The maximum demand in the National Electricity Market (NEM) has grown by 1.8 per cent since 2005 (AEMC 2012) despite overall demand for grid-supplied electricity falling since 2008-09.

Baseload demand is typically met by coal generation or combined cycle gas turbines (CCGT). These generators are designed to operate at constant production levels and are therefore more economical to operate continuously. They generally have low generation costs as well.

Occurrence of peak demand, however, can be highly variable and additional generation has to be sent out in a relatively short span of time to ensure that the reliability of the electrical system is maintained. As such, flexible 'peaking' generation such as hydro and open cycle gas turbines (OCGT), which can be cycled up and down to match rapid fluctuations in the system, are typically used to meet peak demand.

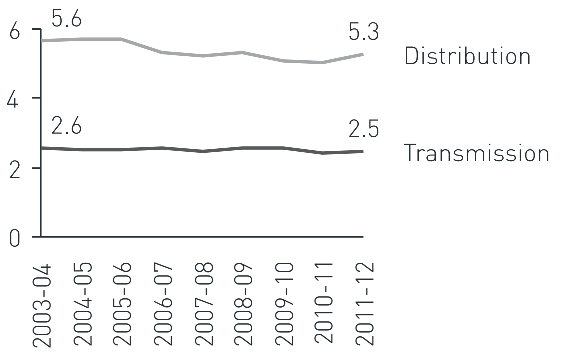
Exhibit 2.29: Illustrative load duration curve



2.5 Network efficiency

Efficiency levels in electricity networks have remained stable over the last decade with transmission losses stabilising at around 2.5 per cent, while distribution losses reduced slightly to 5.3 per cent.

Exhibit 2.30: Electricity losses in T&D system*, GJ lost / GJ sent-out (%) (DRET and Energeia 2013)



*Note that distribution losses are estimated based on responses provided by individual distributors and the number of respondents may differ from year to year

Transmission losses have remained stable at around 2.5 per cent for the analysis period.

Network businesses have indicated in recent interviews for this research that significant changes in efficiency, such as increasing line voltages, would not be economically viable on the basis of savings from reduced electrical losses alone. Interview participants suggested that transmission networks are designed and operated at the economically optimum level of energy efficiency allowed by the regulatory framework.

Distribution losses have slightly decreased in the last decade from 5.6 per cent in 2003-04 to 5.3 per cent in 2011-12. Distribution losses are more than twice the size of transmission losses, due to the lower voltage used and the more dispersed nature of distribution networks.

Interviews with distribution companies suggest that some improvements have been made, by increasing the voltage of selected parts of the distribution network. However, the primary driver behind these opportunities was to meet higher loads, rather than to minimise electrical losses.

It is worth noting that many factors impact on the electrical losses experienced in distribution networks, such as external temperature, load carried, and the location of generators relative to end consumers.

2.3 Outlook to 2020

2.3.1 Overview

Projects in the pipeline and forecasts of demand for grid supplied electricity suggest that recent trends are likely to continue, with soft demand, more renewables and gas expected to drive emissions down until 2019-20.

Initial analysis suggests that the various trends which have been emerging in the past few years will continue to 2019-20:

> Growth in demand for grid-supplied electricity across Australia is expected to be slower than originally projected, with a 6 per cent growth expected from 2010-11 to 2019-20, compared to 14 per cent growth in demand previously projected for the same period[19]. Estimates of demand for grid-supplied electricity have been presented from 2010-11 to 2019-20 as this was based on analyses in the Buildings and Industry sectors (see Reports 3 and 4) where data more recent than 2010-11 was not available. This is equivalent to 11 per cent growth in demand for grid-supplied electricity from 2012-13 to 2019-20[5]

> Renewable energy generation is expected to reach 54 TWh in 2019-20, in line with the Renewable Energy Target plus existing hydro generation; this is more than double 2012-13 renewable generation of 25 TWh

> Gas generation is expected to decrease by a further 6 per cent between 2012-13 and 2019-20

> Coal generation is expected to decrease by a further 2 per cent between 2012-13 and 2019-20 with most of the decrease coming from black coal generation

The combination of these trends is expected to lead to an improvement in emissions intensity of 11 per cent by 2019-20, and a 1 per cent reduction in overall grid-supplied electricity emissions from 173 $MtCO_2e$ in 2012-13 to 171 $MtCO_2e$ in 2019-20.

In order to deliver the equivalent of the full potential identified in ClimateWorks' *Low Carbon Growth Plan for Australia*, emissions from electricity generation would have to decrease by a further 58 per cent, to 72 $MtCO_2e$.

Exhibit 2.31: Estimated emissions from generation of grid-supplied electricity to 2020, MtCO2e (ClimateWorks team analysis)

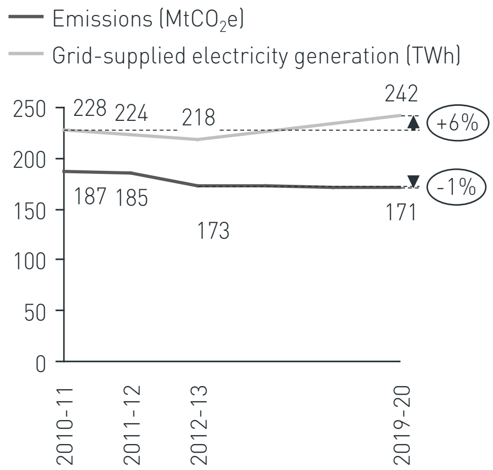
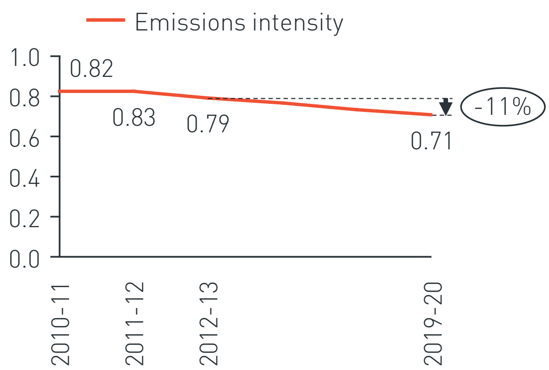


Exhibit 2.32: Estimated demand and emissions intensity of grid-supplied electricity to 2020, tCO2e/MWh (ClimateWorks team analysis)



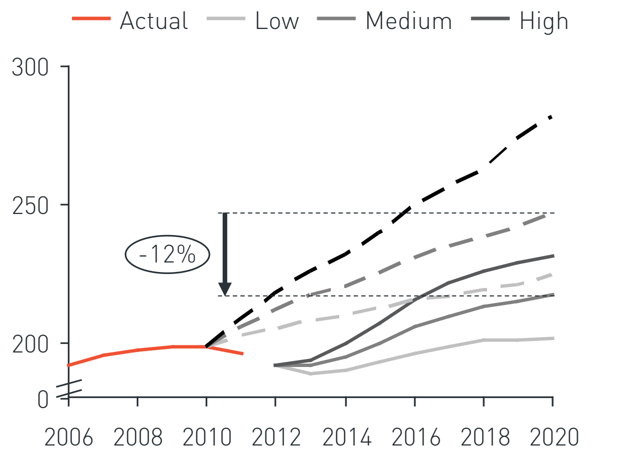
19 Projections previously made in 2012 were based on the "medium scenario" in the Australian Energy Market Operator's 2012 National Electricity Forecasting Report for the National Electricity Market, the "expected scenario" in the Independent Market Operator's 2012 Electricity Statement of Opportunities for the South West Interconnected System, and the "medium energy demand scenario" in SKM MMA's Modelling the Renewable Energy Target Report for the Climate Change Authority for grids in NT and Mt Isa

2.3.2 Grid-supplied electricity demand

Forecast of demand for grid-supplied electricity to 2019-20 remains low.

Falling demand for grid-supplied electricity has been the key factor driving recent emissions reduction in the power sector. Since 2010, forward projections of demand for grid-supplied electricity have been continuously revised downwards to reflect recent trends (see Exhibit 2.33).

Exhibit 2.33: Demand forecast for electricity in the NEM, TWh by year (AEMO 2010, AEMO 2012, AEMO 2013)



The latest 2013 projections[20] forecast soft increases in coming years to 2019-20. Demand for grid-supplied electricity in the National Electricity Market is expected to grow by 10 per cent from 2012-13, following significant declines in the past two years, while demand in the South West Interconnected System is expected to grow by 15 per cent from 2012-13.

Based on our analysis of recent trends in consumption of grid-supplied electricity in the buildings and industry sectors[21], we expect demand for grid-supplied electricity in these sectors to increase by 7 per cent from 2010-11 to 2019-20. In addition, the expect decreases in coal generation would lead to a 9 per cent decrease in auxiliary consumption, from 13 TWh in 2010-11 to 12 TWh in 2019-20 (see Exhibit 2.34).

Combining this with other growth in demand for grid-supplied electricity[22], we expect Australia-wide demand for grid-supplied electricity to increase by 6 per cent from 2010-11 to 2019-20. [8]

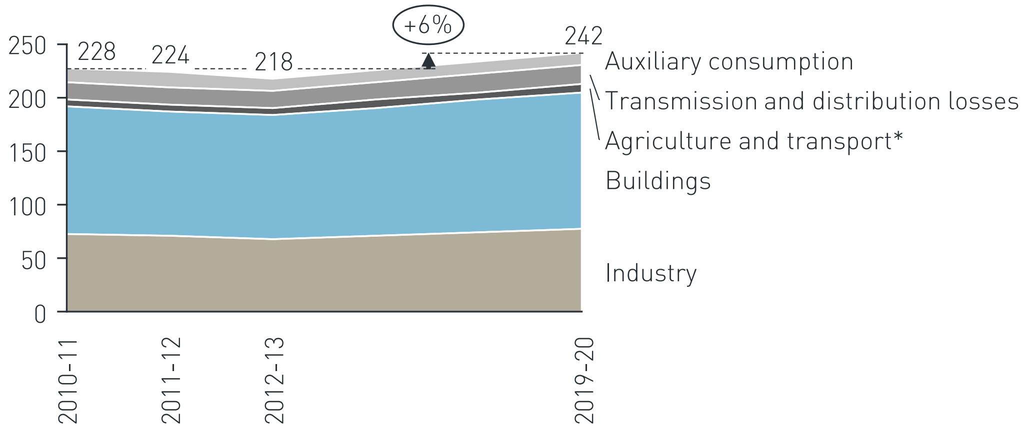
This aligns broadly with the latest preliminary medium forecasts released by the Australian Energy Market Operator in 2013 for the National Electricity Market and the Independent Market Operator's 2013 medium forecasts for the Wholesale Electricity Market for the South West Interconnected system, as well as the medium energy demand scenario modelled by SKM MMA for other grids (e.g. Northern Territory) in *Modelling the Renewable Energy Target Report for the Climate Change Authority (2012).*

20 Most recent projections of demand for grid-supplied electricity are the National Electricity Forecasting Report released by the Australian Energy Market Operator in July 2013 and the Electricity Statement of Opportunities released by the Independent Market Operator in June 2013.

21 Estimates of demand for grid-supplied electricity have been presented from 2010-11 to 2019-20 as this was based on analyses in the Buildings and Industry sectors (see Reports 3 and 4) where data more recent than 2010-11 was not available..

22 Other demand for grid-supplied electricity includes the agriculture and transport sectors, as well as transmissions and distribution losses in the electrical system. See Technical Appendix for further details.

Exhibit 2.34: Forecast of demand for grid-supplied electricity in Australia, TWh by year (ClimateWorks team analysis)



*Note that Tracking Progress scope for buildings and industry accounts for about 90 per cent of grid electricity consumption. Other grid-supplied electricity includes grid electricity consumption in agriculture, transport, transmission and distribution losses, and auxiliary consumption.

2.3.3 Renewable energy generation

Fewer than half of the projects currently in the pipeline would need to be implemented in order to meet the Australian Government's Renewable Energy Target (RET).

There are currently 23 GW of known renewable projects in the pipeline, 87 per cent of which are wind, and another 7 per cent in large-scale solar.

In order to understand how many projects are likely to reach completion by 2019-20, we analysed the likelihood of completion of projects in the pipeline, by looking at the current status of wind projects which entered the pipeline between 2005 and 2011, as shown in Exhibit 2.36.

For both wind and large-scale solar, the majority of projects are in the proposed stage. At the proposed stage, there is high uncertainty about the likelihood of completion, with only about 8 per cent of projects proposed between 2005 and 2011 having reached completion.

The likelihood of completion increases sharply when projects reach the advanced planning stage (about 25 per cent of projects proceed to completion within five years), and even more when they are categorised as under construction (58 per cent of projects proceed to completion within five years). While this analysis looked at progression of projects over a five year period, most of the projects that reached completion did so in a shorter period of time: about 3 years from proposed and advanced planning stages and less than 2 years from the construction stage.

Based on this rate of progress, it can be estimated that all projects currently under construction, plus a small number of projects in advanced planning with announced construction start dates, will be completed by 2014-15.

These projects equate to 1.7 GW of new capacity. Assuming average utilisation rates[23], this is equivalent to 4.7 TWh additional renewable generation in 2014-15. Together with existing renewable generation that is eligible under the RET, this represents 89 per cent of the generation expected for the RET in 2014-15 (30 TWh, see Exhibit 36).

Extrapolating the current pipeline status beyond 2014-15 is unreliable, given the high uncertainty surrounding early stage projects and the fact that many projects implemented by 2019-20 are likely to be projects that are yet to be proposed, as the total pipeline has been growing steadily since 2003.

Instead, a comparison of the total additional generation required to meet the RET by 2019-20 with the current pipeline of known proposed projects shows that less than half of the projects currently in the pipeline, equivalent to 25.8 TWh of renewable generation, would be required to meet the RET (see Exhibit 2.35).

This indicates that the physical capacity exists to meet the RET, with more than enough suitable sites and project proponents. However, industry participants indicate that other factors could hinder new renewable projects. They point to reductions in demand for grid-supplied electricity as making it more difficult for renewable energy project developers to secure power purchase agreements and planning regulations in some states placing restrictions on wind farm developments.

Given that the RET is a legislated requirement, this report assumes that these factors would not impede the RET being met by 2020. Accordingly, if rainfall levels remain relatively stable until 2020, renewable energy generation in 2019-20 is estimated to reach 54 TWh. This would equate to current renewable generation levels more than doubling from current levels.

23 See Technical Appendix for details on average utilisation rates.

Exhibit 2.35: Capacity of existing renewable energy generation projects in the pipeline, GW by status as of 2012 (ESAA 2012)

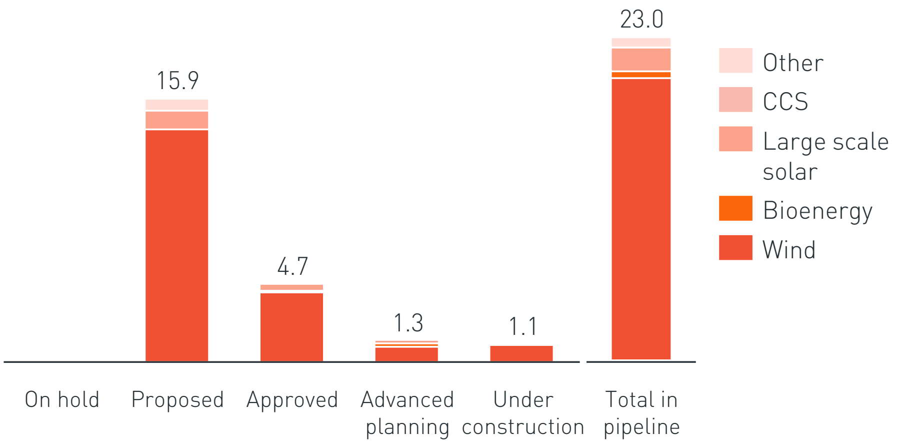
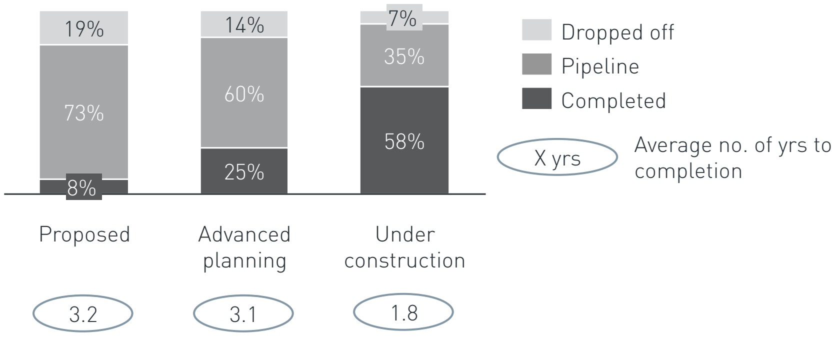


Exhibit 2.36: Likelihood of completion of wind projects, 2005-2011, GW (BREE, ClimateWorks team analysis)



There is substantial potential to go beyond the RET; however this would necessitate a significant increase in construction of renewable projects.

The additional potential identified in ClimateWorks' *Low Carbon Growth Plan for Australia* represents a further 36 TWh of renewable energy generation required in 2019-20, equivalent to more than double the new renewable generation that will be provided to meet the RET.

It could, however, nearly be met if all projects that are currently in the pipeline were to be implemented by 2019-20, which confirms that it is likely there is enough potential in Australia to meet this level of renewable generation by 2019-20.

However, implementation of renewable projects would have to significantly accelerate in the coming years to achieve this full potential. In particular, investing in further new capacity could be challenging given soft demand for grid-supplied electricity and lower wholesale electricity prices.

Exhibit 2.37: Potential and required new renewable generation (2014-15 to 2019-20), TWh (BREE, ClimateWorks team analysis)

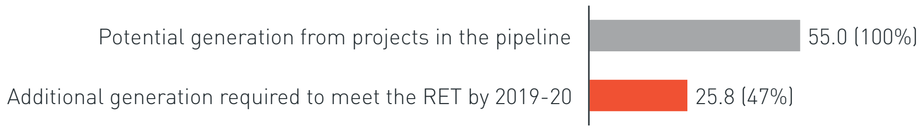
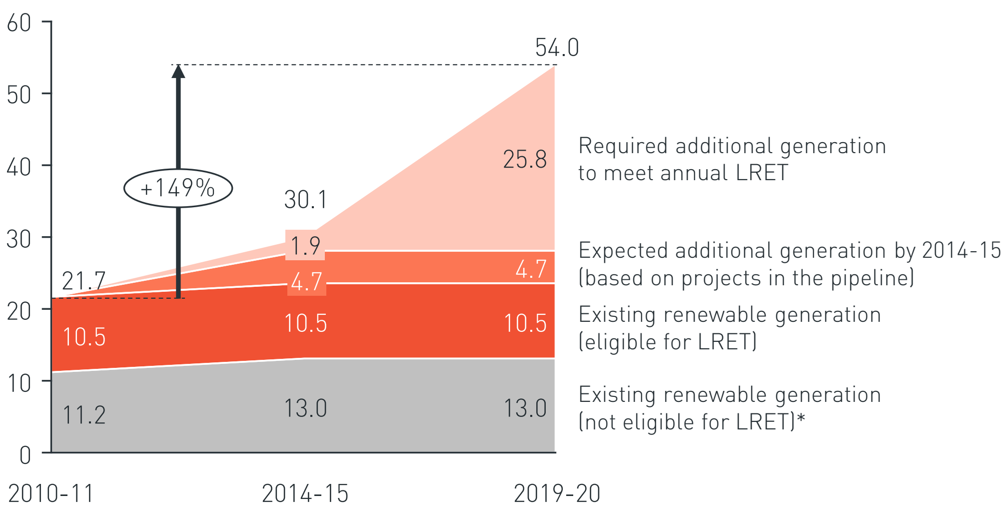


Exhibit 2.38: Potential generation from renewable energy to 2020, TWh (DIICCSRTE 2013b, ClimateWorks team analysis)



* Existing renewable generation (not eligible for LRET) is assumed to be 13 TWh equivalent to the long term average of hydro generation in the past decade

3.4 Fossil fuel generation

Most new fossil fuel projects in the pipeline are gas, meaning there are currently no major new coal generation assets proposed.

There is more than 34 GW of fossil fuel capacity currently in the pipeline, significantly more than the 23 GW of renewable projects currently in the pipeline. The vast majority (83 per cent) are gas generation projects; predominantly gas open cycle gas turbine projects.

No new coal power stations are currently in advanced stages of the pipeline (i.e. advanced planning or under construction), which means that there is unlikely to be any new coal generation assets built in the near term. The only coal projects currently approved or under construction are expansions or refurbishments to existing coal plants (e.g. Muja, Eraring, Mt Piper).

Industry experts indicate that projects at earlier stages of the pipeline are unlikely to go forward in the current context. Some power companies have also mentioned that their climate change strategies exclude the development of any greenfield coal plants, while others have indicated that the reputational risks perceived by institutional lenders make it difficult to finance a new coal-fired power station.

The majority of the fossil fuel projects in the pipeline are gas open cycle gas turbine plants, which are used only infrequently to meet peak demand[24]. These plants are expected to contribute small amounts to overall generation and hence emissions.

With the slow growth in demand for grid-supplied electricity, it is unlikely that major combined cycle gas turbine projects (generally used to meet baseload demand[25]) will come online in the short term.

Uncertainty surrounding future gas prices, particularly in the eastern states and the challenges companies face in securing long term gas supply contracts, are likely to further hinder the financing of new large combined cycle gas turbine projects.

Company interviews have indicated that the preference for open cycle gas turbines is also due to a perception that there will be an increased role for gas in the future to help balance the variability introduced with higher renewables penetration.

Coal generation is expected to continue to decrease due to competition from less emissions-intensive generators.

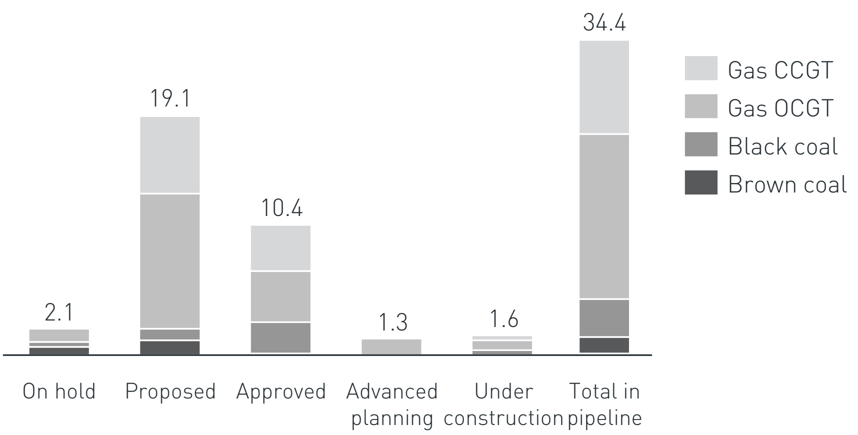
The increase in renewable energy generation (driven by RET) is expected to be greater than the overall growth in demand for grid-supplied electricity, meaning that achieving the RET will lead to reductions in total fossil fuel generation.

This will lead overall coal generation to reduce by a further 2 per cent from 2012-13 to 2019-20. The impact is expected to be greatest on black coal generation, with a 6 per cent reduction from 2012-13 to 2019-20.

As there has not been a sustained trend in brown coal reduction, and 2012-13 contained unusual circumstances such as the flooding at Yallourn and the existence of a fixed carbon price, we have based our analysis of future fossil fuel generation mix on 2010-11 and 2011-12 data.

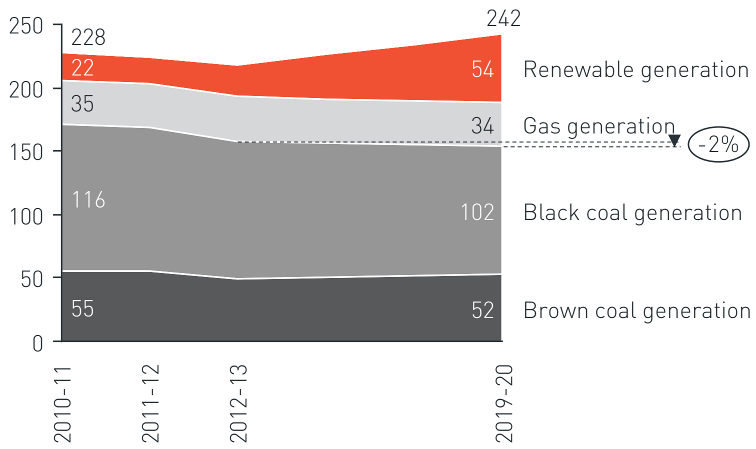
Given potential rises in gas prices (see section 2.4.4) and a potential decrease in demand for grid-supplied electricity in Victoria, our analysis assumes that gas and brown coal generation decreases by 5 per cent from 2010-11 to 34 TWh and 52 TWh in 2019-20 respectively.

Exhibit 2.39: Capacity of existing fossil fuel generation projects in the pipeline, GW by status as of 2012 (ESAA 2012)



24 See page 31 for further information on peak demand
25 See page 31 for further information on baseload demand

Exhibit 2.40: Potential generation mix to 2019-20, TWh (ESAA 2012-2013, AEMO 2013, ClimateWorks team analysis)*



Gas generation decline is likely to be limited given that:

> there will be continued need for peaking generation,

> demand for grid-supplied electricity is expected to continue to grow in Western Australia (which represents about a third of today's gas generation in Australia), and

> new CCGT plants recently built in NSW and QLD will likely be sheltered from gas price increases in the short term due to long term gas supply contracts.

With 54 TWh delivered by renewable energy, the remaining demand was assumed to be met by black coal generation. Black coal is assumed to be more strongly impacted by the softening demand for grid-supplied electricity, decreasing by 12 per cent from 2010-11 to 2019-20. This is in line with trends observed between 2008-09 and 2011-12 of steady decrease in black coal generation.[26]

However, significant increases in gas prices and greater growth in demand for grid-supplied electricity could see some of the mothballed coal capacity coming back online to replace gas generation (see section 2.4).

There is currently a high level of uncertainty around future grid-supplied electricity demand, influenced by factors including future levels of production in the manufacturing and mining sectors, uptake of distributed electricity generation in commercial and residential buildings, and whether the new LNG production plants which are expected to be developed in Queensland will connect to the grid.

Decrease in coal generation could also be driven by emissions reduction targets set by power generators themselves. For example, Energy Australia, which generates 10,500 GWh of electricity per year from its Yallourn coal fired power station, equivalent to approximately 19 per cent of Victoria's electricity needs, has a goal to reduce its emissions by 60 per cent below 1990 levels by 2050.

The full potential modelled in the *Low Carbon Growth Plan* would require coal generation to further decrease substantially to 42 TWh, a further reduction of 73 per cent, and be replaced with less emissions intensive gas generation or renewable energy, or new coal generation plants with Carbon Capture and Storage (CCS) systems.

26 Whilst brown coal has also reduced significantly in the last year, some unusual factors have contributed to this decrease. On the other hand, trends in black coal generation decrease have continued steadily since 2008-09. Assuming a high reduction in black coal generation as opposed to brown coal generation results in less improvement in overall emissions intensity of grid-supplied electricity.

*See data sources on page 12

There remains the potential for further efficiency improvements in fossil fuel power plants.

There is also further potential for increased efficiency of fossil fuel power plants. Thermal power plants are designed to optimise efficiency at the time of commissioning for the expected level of output.

While existing assets are likely to have considered efficiency improvements as part of regular maintenance or operational activities, recent and future changes in utilisation rates could move existing plants away from their expected load outputs, creating opportunities for optimising the plant at varying or different loads.

As their operating environment becomes increasingly challenging, the key driver for companies to implement efficiency improvements is the potential to reduce costs.

Anecdotal evidence suggests that in cases where fuel costs are particularly low, such as brown coal, efficiency opportunities appear less attractive than they may otherwise which can reduce the incentive for generators to pursue efficiency improvements.

Power companies are now participating in the Energy Efficiency Opportunities (EEO) program, which may lead to identification of more energy savings opportunities than standard maintenance practices may identify.

Several companies interviewed reported that they had already identified additional opportunities through the early EEO assessments performed with cross-functional teams.

2.3.5 Network efficiency

Transmission and distribution network service providers have indicated that the scope for efficiency improvements in electricity networks is likely to be limited.

Distribution networks are subject to Minimum Energy Performance Standards (MEPS) in their procurement of new transformers. Interviews with distribution companies have indicated that these will provide the most likely opportunity to reduce losses through existing networks, as other opportunities, such as increasing network voltage, are likely to come at a very high cost and are typically done to meet other objectives.

Distribution networks are also subject to variability in loads introduced by distributed and renewable energy generation throughout their networks. Distribution companies have indicated that with increasing uptake of distributed energy generation, network losses may increase, as reactive power needs to be supplied to parts of the network where distributed energy generation is high.

Electricity network businesses have recently been exempted from the Energy Efficiency Opportunities (EEO) Program. The Regulatory Impact Statement and consultation with stakeholders and companies indicated that the costs of extending the EEO program to electricity networks would outweigh the value of electrical losses that could be saved.

CASE STUDY: IMPROVING EMISSIONS INTENSITY IN COAL GENERATION

Who:

Delta Electricity is one of the largest electricity generators in the National Electricity Market (NEM), supplying up to 12% of the NEM's electricity needs. Delta Electricity operates around 3,700 MW of black coal generation capacity across three black coal generators in New South Wales (Mt Piper, Wallerawang, and Vales Point B).

What:

Improving the emissions intensity of coal inputs.

How:

> Delta Electricity's geographically diverse operations means that different sites often receive coal with variable greenhouse gas emissions profiles and energy contents.

> Black coal can contain relatively variable levels of moisture, hydrogen, sulphur, nitrogen and oxygen, which can vary the energy output but not the greenhouse gas emissions per tonne of coal.

> As part of its investigations into emissions factors (i.e. amount of greenhouse gas emissions produced per unit of electricity generated) of its individual power plants (which is required under the National Greenhouse and Energy Reporting (NGER) scheme, Delta electricity's sustainability team has analysed the carbon content of different black coal supplies used in its generation.

Why:

> Improving the emissions intensity of coal fired power stations can be financially attractive and can be achieved by varying the quality of fuel input used.

> Fuel costs can represent around two thirds of the operating costs in black coal generation. As such, minimising the amount of coal required to generate each unit of electricity can provide financial savings for coal generators.

> In many cases, however, generators may be limited by the long term coal supply contracts they have committed to or may not be aware of alternative sources of coal that are economically available.

What could be saved:

> Delta Electricity has now begun to consider the quality of black coal in its purchasing decisions, with the aim of prioritising coal with a higher energy to emissions ratio, and this will have an impact on future coal supply contracts.

> Delta's analysis suggests that the most efficient coal could have 2% fewer emissions than the least efficient coal, which is equivalent to 48kg fewer emissions per tonne of coal.

"Delta Electricity is constantly looking for ways to reduce costs and increase the efficiency or emissions intensity of its plants. With a price on carbon, using coal with a higher energy to emissions ratio delivers the same amount of electricity at lower cost. Lowering the emissions intensity of our coal now makes business sense and we will consider these in future coal purchases."

Justin Flood, Manager Sustainability, Delta Electricity Australia

2.4 Factors influencing future activity

2.4.1 Overview

The main factors affecting the future emissions intensity of grid-supplied electricity are future demand for grid-supplied electricity and the availability of renewable or low emissions technologies at a competitive cost.

In recent years, declining demand for grid-supplied electricity and the increase in renewable generation have contributed to the downward trend of emissions and emissions intensity for electricity generation.

Demand for grid-supplied electricity will be strongly influenced by a range of factors, but early signs indicate that demand is not likely to recover significantly in the future.

The future of renewable energy generation and fossil fuel generation depends on factors that can interact quite heavily to determine the relative profitability of different generation technologies. This will in turn determine which generators are used and the emissions intensity of grid-supplied electricity.

As technology evolves, the cost of renewable generation technologies is likely to fall. Australian Government funding support could further reduce the cost of implementation of renewable technologies in Australia, making renewable generation more financially attractive compared to fossil fuel generation.

Potential rising fuel costs and a carbon price will further reduce the relative profitability of fossil fuel generation. Similarly, should costs of other low emissions technologies fall (e.g. energy storage technologies, CCS), these technologies may play a role in improving the emissions intensity of electricity generation in Australia.

Should current trends continue, growth in renewable energy generation will continue. This, coupled with soft demand for grid-supplied electricity, will see significant reductions in fossil fuel generation.

All of these are expected to lead to reductions in the emissions and emissions intensity of electricity generation in Australia.

2.4.2 Grid-supplied electricity demand

Future demand for grid-supplied electricity will depend highly on economic growth and the uptake of distributed generation and energy efficiency opportunities.

Falling demand for grid-supplied electricity has been the key factor driving recent emissions reduction and is likely to continue to play a major role into the future.

In the past few years, the Australian Electricity Market Operator has made downward revisions (see Exhibit 2.33 on page 32) to its annual electricity forecasts for the National Electricity Market. These annual electricity demand forecasts are modelled on a number of factors. These key factors are:

1. **Electricity prices** - Electricity prices may rise in the near future, although electricity users have already started to put in place measures to reduce their electricity consumption and to minimise their exposure to rising prices. This trend is expected to continue in the future, through increased uptake of distributed generation technologies, such as cogeneration in commercial buildings or industrial facilities. Consumers' responsiveness to electricity price rises, however, can be complicated and may reduce the rate of change or even reverse it if electricity prices stop rising.
2. **Economic growth** - There has already been a weakening of the manufacturing sector in Australia. The high Australian dollar and other macroeconomic factors are expected to continue to affect the profitability of manufacturers. Given that the industrial sector makes up more than 30 per cent of Australia's total consumption of grid-supplied electricity, changes to industrial production will have a major impact on Australia's electricity demand, particularly any changes to aluminium smelting activity. (Note: The aluminium smelting industry consumed 29 TWh of electricity in 2009, equivalent to about 13 per cent of Australia's total electricity consumption in 2009 (Australian Aluminium Council 2009).

3. **Energy efficiency and demand management** - With improvements in technology and recent government initiatives, buildings and appliances have become more energy efficient, as have industrial processes and equipment, thus reducing demand for energy, including grid-supplied electricity.
4. **Solar PV uptake** - As detailed in the buildings chapter, there has been a rapid uptake in solar PV over the last four years. Our analysis of activity in the buildings sector indicates that small scale rooftop solar PV may increase to 9 TWh by 2020. This is equivalent to a three-fold increase of the generation from rooftop solar PV in 2010-11 and is likely to significantly offset demand for grid-supplied electricity in the future. In particular, as a result of improved energy efficiency and increased solar PV uptake, residential grid-supplied electricity demand is expected to decrease between 2010-11 and 2019-20.

2.4.3 Renewable energy generation

Future costs of low emissions generation technologies

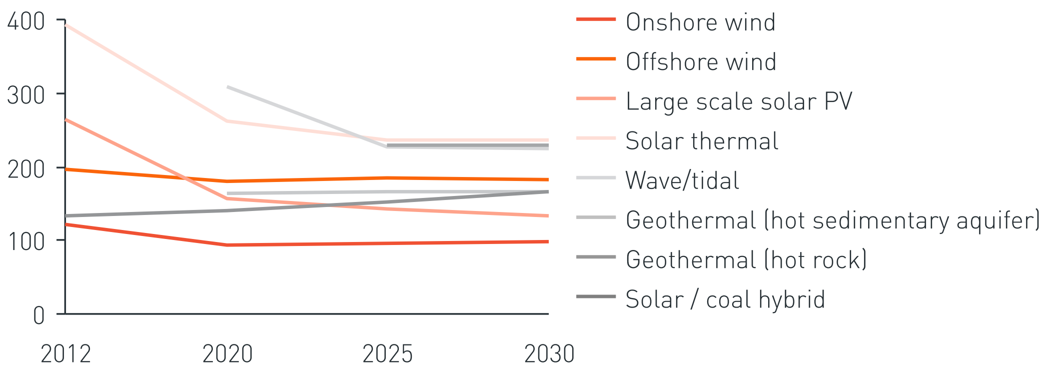
As costs of renewable technologies go down, they are likely to play an increasingly significant role in Australia's renewable energy mix[27].

Wind and hydro are expected to continue to play a strong role in Australia's renewable energy mix, particularly onshore wind, which is expected to remain one of the cheapest renewable technologies to 2030. Much of the hydro capacity has already been installed and will continue operating for years to come.

The emergence of large scale solar will depend greatly on how quickly the cost of technology comes down. The Bureau of Resources and Energy Economics estimates that the cost of large-scale solar PV will decrease rapidly to 2020 and beyond, becoming the second cheapest renewable technology by 2030.

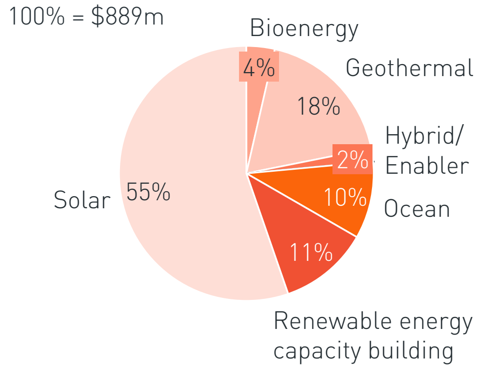
In addition, 55 per cent of Australian Renewable Energy Agency (ARENA) funding has gone into solar projects, which could further drive investments and installations of this renewable technology. Service providers have also seen strong interest in pre-feasibility and site assessments for potential solar projects (see Exhibit 2.42).

Exhibit 2.41: LRMC of key power generation technologies over time, $/MWh (BREE 2012b)



27 While increasing the proportion of renewable energy in the electricity generation mix would be likely to deliver improvements to the emissions intensity of grid-supplied electricity generation, there are additional costs associated with the operation of the electricity system with more renewable energy. This relates particularly to variable generation sources, such as wind and solar PV, which are likely to be the largest source of renewable energy in the near future. The 100 per cent renewable scenario modelling undertaken by the Australian Energy Market Operator identifies some of the underlying costs associated with a higher proportion of renewable generation.

Exhibit 2.42: ARENA funding by low emissions technologies, % (ARENA 2012)



Interviews with industry have indicated strong interest in hybrid systems, for example solar-wind hybrid systems, which have attracted two per cent of ARENA funding. However, the cost of solar-coal hybrid technologies is projected to rise slightly to 2030..

The emergence of energy storage technologies at a competitive cost will also be a key determining factor in the uptake of many of these emerging technologies. Energy storage solutions will play a key role in 'smoothing' the variability associated with renewable energy generation.

Other emerging technologies, such as geothermal and tidal, are at very early stages of development (mostly pilot or testing phases) and their potential in Australia's future energy mix is yet to be determined.

The development of these emerging renewable technologies will depend greatly on investment both here and overseas. Australia is typically a technology taker, which means the cost of these technologies domestically is heavily influenced by international research and development progress.

Interviews with companies have also indicated that due to the long-life nature of these emerging generation assets, a high level of certainty around key policies, such as the Renewable Energy Target and carbon price is required.

Australian Government funding

Australian Government funding for renewable generation projects is provided through:

The **Australian Renewable Energy Agency (ARENA)** has $3.2 billion of funding to provide grants support research and development, demonstration, commercialisation and deployment in renewable energy.

The **Clean Energy Finance Corporation (CEFC)** has $10 billion to provide loans or other investments in renewable energy, low emissions and energy efficiency projects.

The **Clean Technology Program (CTP)** has $1.2 billion to provide grants to support the development and early stage commercialisation of clean energy technology.

The **Carbon Capture and Storage Flagships Program** and others have contributed $2 billion to support the research and development and demonstration of carbon capture storage technology.

Note: The Government has recently announced reduced funding and deferrals for the Clean Technology Fund and the Carbon Capture and Storage Flagships program – mostly affecting unallocated money.

2.4.4 Fossil fuel generation

Fuel prices

Gas prices are widely expected to increase significantly in the medium to long term, which could have a major impact on the profitability of gas generation compared to coal generation.

Gas prices are projected to rise sharply, to around $12/GJ in 2030, particularly with the development of LNG export markets in the eastern states. Given that gas generation has grown significantly in recent years and the fossil fuel generation project pipeline is dominated by new gas plants, this sharp rise in prices could have a significant impact on future fossil fuel generation in Australia.

Our estimate of the generation mix of grid-supplied electricity in 2019-20 assumes a 6 per cent decrease in gas generation from 2012-13 to 2019-20, driven mostly by reductions in gas generation in NEM (with the exception of QLD). As gas prices in WA are unlikely to see similar sharp rises, gas generation in WA is expected to remain relatively stable.

Interviews with experts, however, indicate there is a high level of uncertainty around future gas prices in the eastern states which translates into uncertainty surrounding the future role of gas in Australia's electricity generation mix. In particular, higher gas prices and the ability to secure long term gas contracts at favourable prices will influence company decisions around new gas generation capacity.

Should gas prices increase significantly, there could be a larger shift away from gas generation, possibly towards cheaper coal fired generation. Conversely, should gas prices remain at approximately $4/GJ and with a carbon price of about $30/tCO$_2$e, gas generation could be more financially attractive than black or brown coal generation by 2019-20.

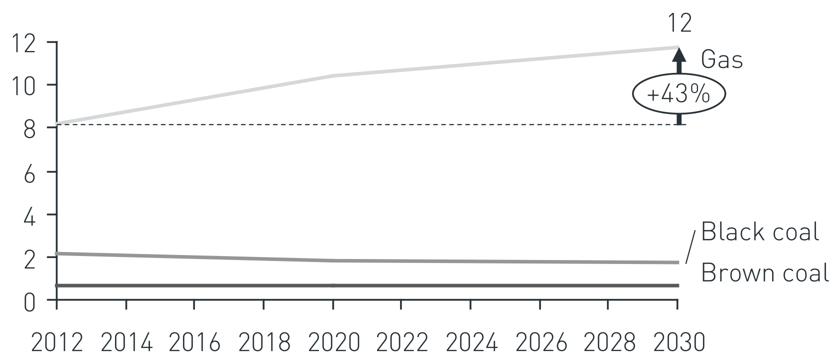
With a low carbon price, brown coal will continue to be the cheapest fossil fuel. The Bureau of Resources and Energy Economics has estimated brown and black coal prices will remain relatively stable to 2030.

Given the number of coal assets that have been mothballed (but not decommissioned), potential rises in gas prices could undermine the business case for new gas power plants and increase the costs for existing gas generation assets.

This could prompt increased utilisation of existing coal fired power stations, particularly if there is a high level of uncertainty around the existence and level of the carbon price.

This could lead to an increase in emissions intensity of fossil fuel generation and possibly an increase in emissions intensity of overall electricity generation, depending on the level of penetration of renewables.

Exhibit 2.43: Expected prices for fossil fuels, $/GJ (BREE 2012b)



Carbon price

The carbon price is expected to further impact on the competitiveness of fossil fuel generators compared to renewable energy sources.

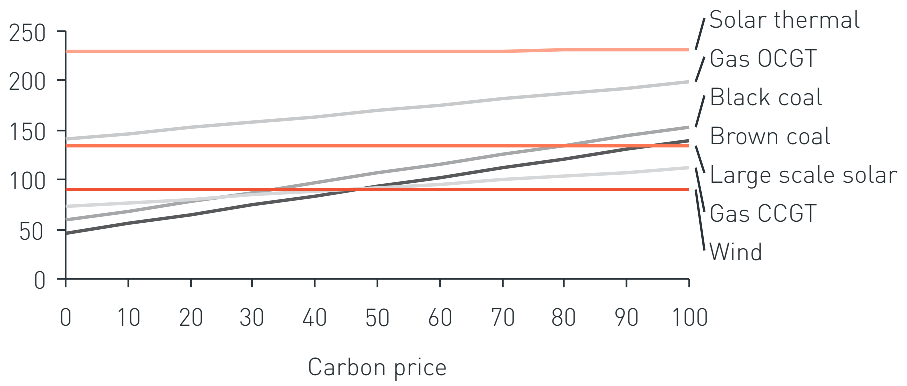
The carbon price is likely to reduce the competitiveness of black and brown coal generators in comparison to lower emissions technologies, such as gas or renewables. Exhibit 2.44 shows the impact of different carbon prices on long run marginal costs (the overall cost of generation per unit) used for weighing investment decisions.

In 2020, combined cycle gas turbine plants could become increasingly attractive relative to black and brown coal generators due to their lower emissions intensity. Based on Bureau of Resources and Energy Economics' analysis of Australian Energy Technology Assessments, combined cycle gas turbine plants would become more attractive than black coal generators with a carbon price between $20-30 a tonne. It would take a carbon price of between $40-50 a tonne to make combined cycle gas turbine gas plants competitive with brown coal.

Wind also becomes more attractive than black and brown coal generators, as well as combined cycle gas turbine gas plants with a carbon price between $30-50 a tonne.

However, discussions with experts and companies have indicated that more certainty around the level and longevity of the carbon price will be required to drive long-term investment decisions around generation projects, particularly since these projects have a relatively long lead time.

Exhibit 2.44: Carbon price impact in 2020 on LRMC of fossil fuel generation, $/MWh sent-out (BREE 2012b, ClimateWorks Australia 2011)



2.4.5 Network efficiency

National Electricity Market

Regulatory obligations for electricity network businesses currently prioritise supply reliability over investment in lowering carbon emissions.

Consultation with industry suggests that transmission and distribution networks have little scope to further improve network efficiency in an economically efficient manner within current regulatory requirements.

There may be some scope to improve efficiency in the lower voltage parts of distribution networks. However, interviews with industry indicate that distributors are unlikely to give active consideration to reducing electrical losses or emissions reduction in the near term, while improving efficiency remains secondary to maintaining network reliability and security.

Network businesses are required to consider network losses for proposed major network improvements. However, the overall regulatory framework and the value placed on network reliability, is such that loss reduction remains secondary to maintaining supply stability and reliability.

Networks have incentives to meet system reliability standards – they are heavily penalised if these standards are not met – but there are no incentives to actively reduce losses beyond current regulatory requirements.

Whilst not specifically targeting loss reduction, projects focused on improving reliability can sometimes have the additional benefit of reducing network losses.

Networks have also indicated they are focused on minimising capital investments, as recent increases in electricity prices have been largely attributed to high network costs.

Given that interviews with network businesses have indicated that efficiency improvements are likely to be very capital intensive, it would appear that the opportunities for significant future reduction in network losses will be limited within the current regulatory framework.

External factors

External factors can have a significant influence on the efficiency levels of electricity networks.

Network losses are also heavily influenced by external factors such as weather, load, and the location of generators relative to the consumers they have to reach. These factors are largely beyond the control of electricity networks, making it difficult to influence efficiency levels to some extent.

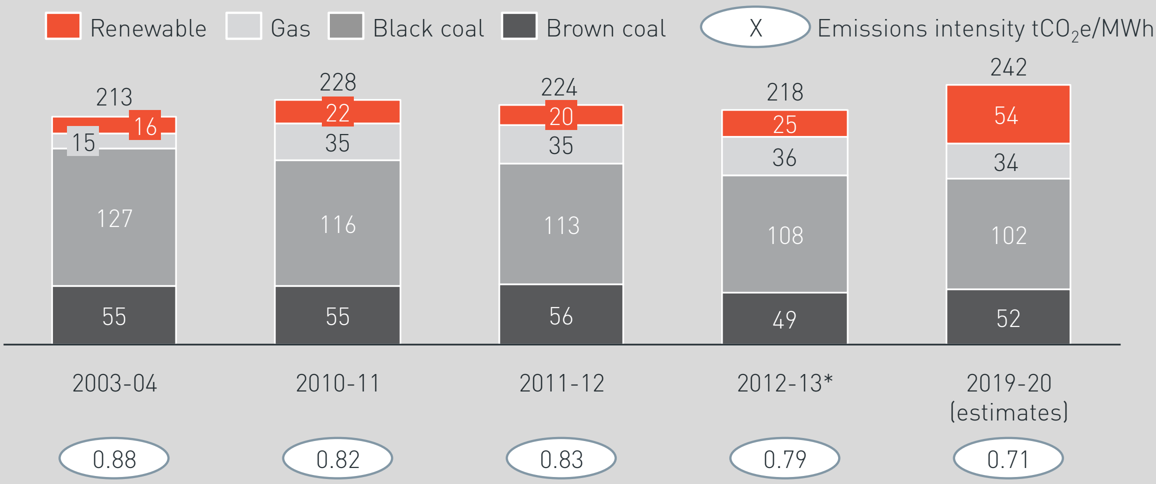
Data gaps and limitations

Data issue	Comment
Variable scope of datasets[28]	> There is a rich source of granular up-to-date data available for the National Electricity Market. > Similar data, however, is less easily accessible for the South West Interconnected System (SWIS),the North West Interconnected System (NWIS), and the Northern Territory. > A number of nationally aggregated datasets are available, but using these for analysis can be difficult as it is not always clear what the detailed scope of these datasets are. > For example, BREE's Australian Energy Statistics data publishes electricity consumption and generation in centralised grids and off grid while AEMO's data covers only the National Electricity Market.
Variable timeframes of datasets	> Some sources tend to publish data by financial year, while others tend to publish by calendar years, which can make it difficult to compare data between sources.

28 Our analysis in this report reconciles a number of datasets which may influence the conclusions and findings presented

Appendix 1

Summary of grid-supplied electricity generation



*2012-13 electricity generation was estimated using NEM data from 1 July 2012 to 31 May 2013, while 2011-12 and 2012-13 emissions from electricity generation were estimated using emissions intensity of individual fossil fuel generation in 2010-11

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Glossary

Auxiliary consumption: electricity consumed by the internal operations and processes of a generator for the purposes of electricity generation

CO2: carbon dioxide

CO2e: carbon dioxide equivalent (used to describe how much global warming a given type and amount of greenhouse gas may cause, using the functionally equivalent amount or concentration of carbon dioxide as the reference)

CTIP: Clean Technology Investment Program

DIICCSRTE: Commonwealth Department of Innovation, Industry, Climate Change, Science, Research and Tertiary Education

DRET: Commonwealth Department of Resources, Energy and Tourism

EEO: Energy Efficiency Opportunities program

Emissions intensity: the amount of emissions produced for each unit of output or other metric

Energy efficiency: improvements in energy intensity from internal processes and operations.

Energy efficiency activity: any activity to identify, investigate or implement actions that reduce the amount of energy required to complete internal processes and operations.

Energy intensity, the amount of energy used per unit of output or other metric

GGAS: Greenhouse Gas Abatement Scheme

GHG: greenhouse gas (defined in the Kyoto Protocol to include four greenhouse gases (carbon dioxide, methane, nitrous oxide, sulphur hexafluoride) and two groups of gases (hydrofluorocarbons and perfluorocarbons)

GJ: giga joules

GW: giga watt (one billion watts)

kW: kilo watt (one thousand watts)

LNG: liquefied natural gas

LRET: Large-scale Renewable Energy Target

Mt: mega tonne (one million tonnes)

MtCO2e: million tonnes of carbon dioxide equivalent

MW: mega watt (one million watts)

MWh: mega watt hour, a unit of energy in particular electricity, equivalent to the work done by one million watts for one hour

RET: Renewable Energy Target

Solar PV: solar photovoltaic

SRES: Small-scale Renewable Energy Scheme

SREC: Small-scale Renewable Energy Certificate

TWh: tera watt hour (one million mega watt hours)

Utilisation rate: the ratio of hours operated in a year over total hours in a year. It represents the share of time that the power plant is used to generate electricity

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