

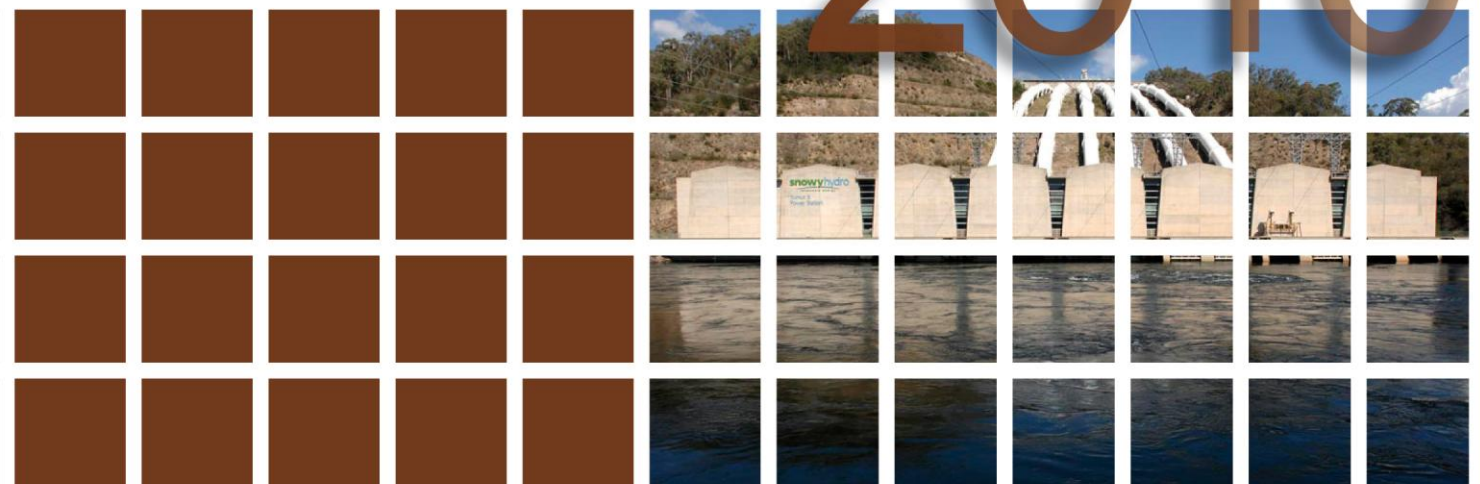


Australian Government
**Department of Climate Change
and Energy Efficiency**

Stationary energy

emissions
projections

2010



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December 2010



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**Department of Climate Change
and Energy Efficiency**

Stationary energy

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Executive Summary

Key Points

- The stationary energy sector accounted for more than 51 per cent of Australia's total domestic emissions in 2009 at 295 Mt CO₂-e.
- Baseline emissions from the stationary energy sector are projected to average 294 Mt CO₂-e per year in the Kyoto period, 51 per cent above 1990 levels. In 2020, stationary energy emissions are projected to be 332 Mt CO₂-e, 33 per cent above 2000 levels.
- Electricity generation accounts for the largest proportion of stationary energy emissions, projected to average 203 Mt CO₂-e per year over the Kyoto period and to be 213 Mt CO₂-e in 2020.
- Emissions from direct fuel combustion are projected to average 91 Mt CO₂-e per year over the Kyoto period and to be 119 Mt CO₂-e in 2020.
- Baseline indicative projections of emissions from the stationary energy sector suggest emissions will be around 402 Mt CO₂-e in 2030.

Baseline projection

- Greenhouse gas emissions from the stationary energy sector are projected to average 294 Mt CO₂-e per year over the Kyoto period (2008–2012¹), 51 per cent above 1990 levels.

Table 1 Baseline stationary energy emissions, Kyoto period average and 2020

	1990	2000	Kyoto period average 2008–12		2020	
	Mt CO ₂ -e	Mt CO ₂ -e	Mt CO ₂ -e	Increase on 1990 (%)	Mt CO ₂ -e	Increase on 2000 (%)
Electricity generation	129	175	203	57	213	22
Direct combustion	66	75	91	39	119	58
Total	195	251	294	51	332	33

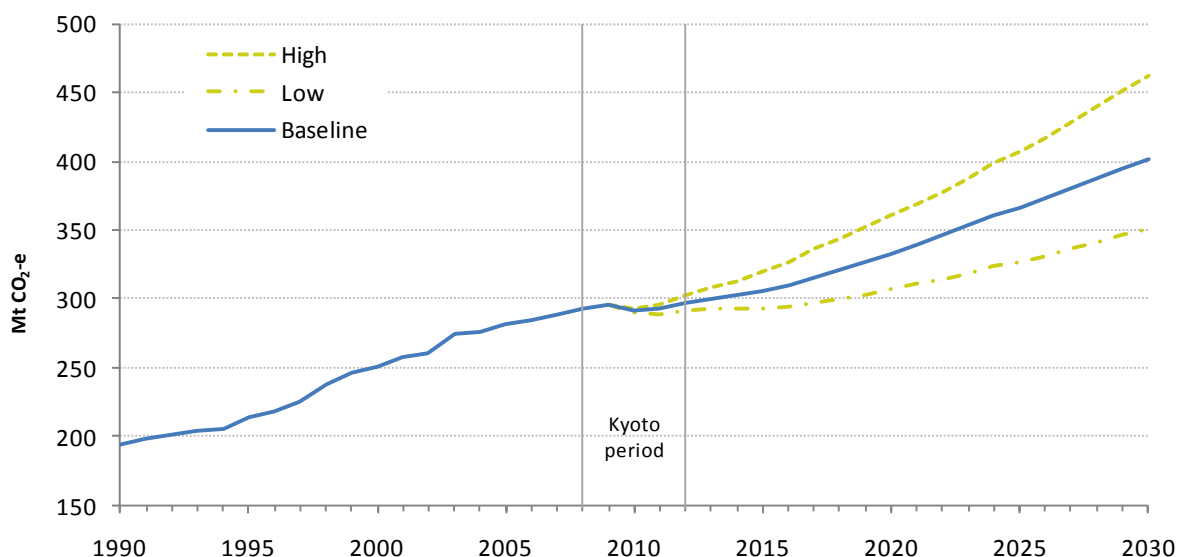
Note: totals may not add due to rounding. These 1990 emissions are consistent with Australia's assigned amount for the Kyoto Protocol, which differ to the latest National Greenhouse Gas Inventory (June Quarter 2010).

Source: SKM-MMA (2010), ACIL Tasman (2010), DCCEE analysis.

¹All years in this publication are Australian financial years, ending on the 30 June of the year quoted.

- Stationary energy emissions are projected to increase by 13 per cent between 2009 and 2020, to 332 Mt CO₂-e, mainly as a result of increased emissions from direct fuel combustion.
- The Renewable Energy Target and energy efficiency measures are the main drivers constraining growth in emissions from electricity generation to 0.3 per cent per year, or 5 Mt CO₂-e between 2009 and 2020. These measures continue to contribute to both slower demand growth and lower emissions intensity of electricity generation over the projections period.
- Emissions from direct fuel combustion are projected to increase by 34 per cent between 2009 and 2020 driven largely by expected growth in the minerals and energy sector.

Figure 1 Baseline stationary energy emissions, 1990 to 2030



Source: SKM-MMA (2010), ACIL Tasman (2010), DCCEE analysis.

Business-as-usual projection

- The business-as-usual projection indicates that without existing policies and measures, stationary energy emissions are estimated to have been around 323 Mt CO₂-e over the Kyoto period, and 416 Mt CO₂-e in 2020.
- Policies and measures in the stationary energy sector aim to both reduce demand for energy and encourage the use of cleaner energy sources. Measures aimed at increasing energy efficiency reduce the demand for electricity and other fuel combustion, while policies such as the Renewable Energy Target (RET) encourage the use of low-emissions energy supplies.

Impact of measures

- The abatement from more than 20 policies and measures aimed at reducing emissions from the stationary energy sector have been estimated for the current projection. However, the Renewable Energy Target and National Strategy on Energy Efficiency account for around three-quarters of total abatement in the Kyoto period and more than 85 per cent in 2020.
- The Renewable Energy Target (RET), including both the Large-scale RET and the Small-scale Renewable Energy Scheme, aims to induce more investment in electricity generation from renewable sources. Abatement from the target averages 9 Mt CO₂-e per year in the Kyoto period and 30 Mt CO₂-e in 2020.
- The National Strategy on Energy Efficiency measures including Mandatory Energy Performance Standards, more stringent building codes and the Energy Efficiency Opportunities program contributes an average 14 Mt CO₂-e of abatement per year in the Kyoto period and 42 Mt CO₂-e in 2020.
- Other policies and measures include the NSW Greenhouse Gas Abatement Scheme (2 Mt CO₂-e in 2020), the Victorian Energy Efficiency Target (2 Mt CO₂-e in 2020), and the Queensland Gas Target (4 Mt CO₂-e in 2020). Remaining measures not identified separately here contribute 6 Mt CO₂-e of abatement in 2020. See Appendix A for more details.

Changes from 2009 projection

- These projections reflect a full update of the projections released in Australia's Fifth National Communication on Climate Change to the UNFCCC in February 2010.
- Over the Kyoto period, annual emissions from stationary energy are projected to average 1 Mt CO₂-e lower than in the previous projection. Projected emissions from the sector in 2020 have been revised up by 11 Mt CO₂-e.
- Emissions from electricity generation are projected to average 2 Mt CO₂-e more per year over the Kyoto period than in the previous estimate. Average annual emissions from direct fuel combustion have been revised down by 3 Mt CO₂-e over the Kyoto period as a result of a technical reallocation of some diesel emissions to the transport sector.
- In 2020, electricity emissions are projected to be 2 Mt CO₂-e higher compared with the previous projection. Direct combustion emissions have been revised up by 9 Mt CO₂-e in 2020, mainly as a result of higher expected gas consumption for LNG production.
- Updated modelling has enabled the stationary energy projection to take account of detailed LNG production forecasts used to develop the oil and gas fugitive emissions projection. The inclusion of this information has led to increases in emissions from stationary energy.

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Introduction

This paper presents projections of greenhouse gas emissions from the Australian stationary energy sector and forms part of the 2010 emissions projections.

The 2010 stationary energy projection is a full update of the 2009 emissions projection. It incorporates modelling of the electricity and direct combustion subsectors by two external modelling consultants; ACIL Tasman and SKM-MMA. Where possible, the projection includes measures introduced by the Australian Government following the August 2010 election.

Two projections scenarios are provided, a baseline and business-as-usual (BAU). High and low sensitivity scenarios are also provided to indicate the level of uncertainty around key assumptions. The baseline projections have been developed on the basis of current policies in place and do not include the impact of a carbon price.

Coverage of the sector

The stationary energy sector is a subsector of the energy sector, which also includes transport emissions and fugitive emissions from fuel extraction.

The stationary energy sector includes the generation of electricity and the combustion of fuels for purposes other than transport. The non-electricity part of the sector is referred to as direct combustion.

Emissions from the electricity subsector are associated with fuels combusted to generate electricity, while emissions from direct combustion are associated with fuels combusted to generate energy used directly to generate mainly heat or steam. Direct combustion includes fuels used for energy industries such as petroleum refining and the manufacture of solid fuels, fuels used in manufacturing and construction industries such as steel furnaces and chemicals, and fuels used in the commercial and residential sectors such as gas heating, on-site diesel generation and farm machinery.

Table 2 Projections scenarios

Scenario	Description
Business-as-usual (BAU)	Emissions in the absence of Government abatement policies and measures
Baseline	Emissions given current policy settings
High/ low	Sensitivity scenarios around the baseline – determined by modifying key assumptions such as economic growth rates

Greenhouse gases arising in the stationary energy sector include methane (CH₄), carbon dioxide (CO₂) and nitrous oxide (N₂O) (for more information, refer to the IPCC guidelines). The individual and combined emissions of the greenhouse gases are expressed in terms of

carbon dioxide equivalence (CO₂-e), where the emission of each gas is converted to CO₂-e according to its global warming potential.

Electricity generation accounts for the largest share of emissions in the stationary energy sector, with direct fuel combustion in the industrial sector contributing most of the remainder and some smaller quantities of direct combustion in the residential and commercial sectors for cooking and heating.

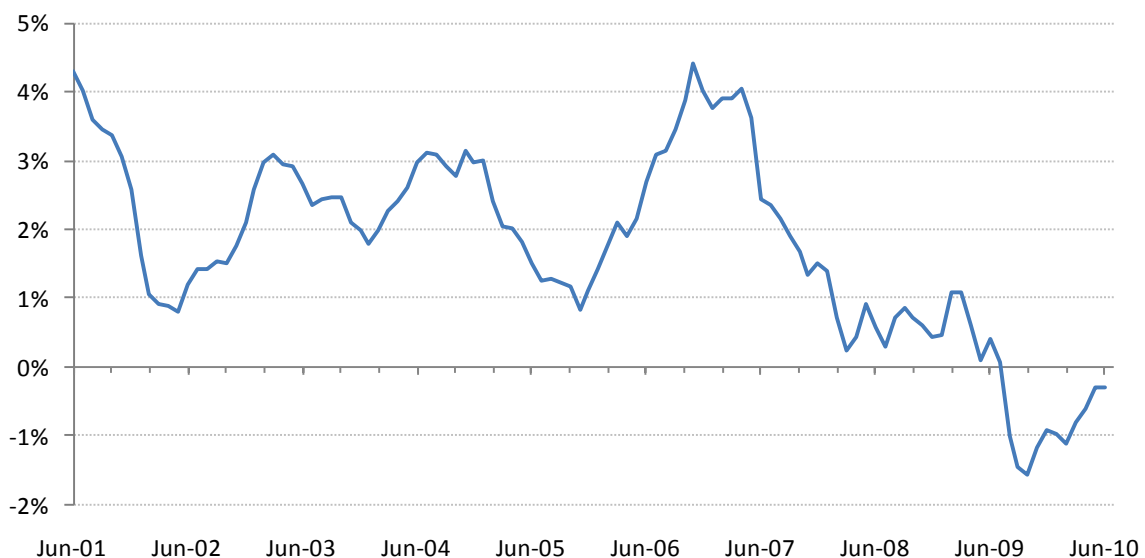
Recent trends – National Greenhouse Gas Inventory

The stationary energy sector is the largest contributor to greenhouse gas emissions in Australia, making up more than 51 per cent of the total in 2009². The sector is also the fastest growing with emissions increasing by more than 51 per cent since 1990 to 295 Mt CO₂-e.

Within the sector, *National Greenhouse Gas Inventory (June quarter 2010)* (NGGI) data indicates electricity generation accounted for the largest portion of emissions and emissions growth. Emissions from electricity generation were 207 Mt CO₂-e in 2009, an increase of 60 per cent since 1990. Direct combustion emissions were 89 Mt CO₂-e in 2009, 35 per cent higher than in 1990.

Growth in electricity generation since late 2007 (in the NEM regions) has been markedly slower than growth experienced in the preceding decade (see Figure 2). Following strong growth in electricity generation between 2005 and 2006, growth has slowed substantially, and since September 2008 has averaged around -0.2 per cent.

Figure 2 Electricity generation growth in the NEM, 12 month moving average

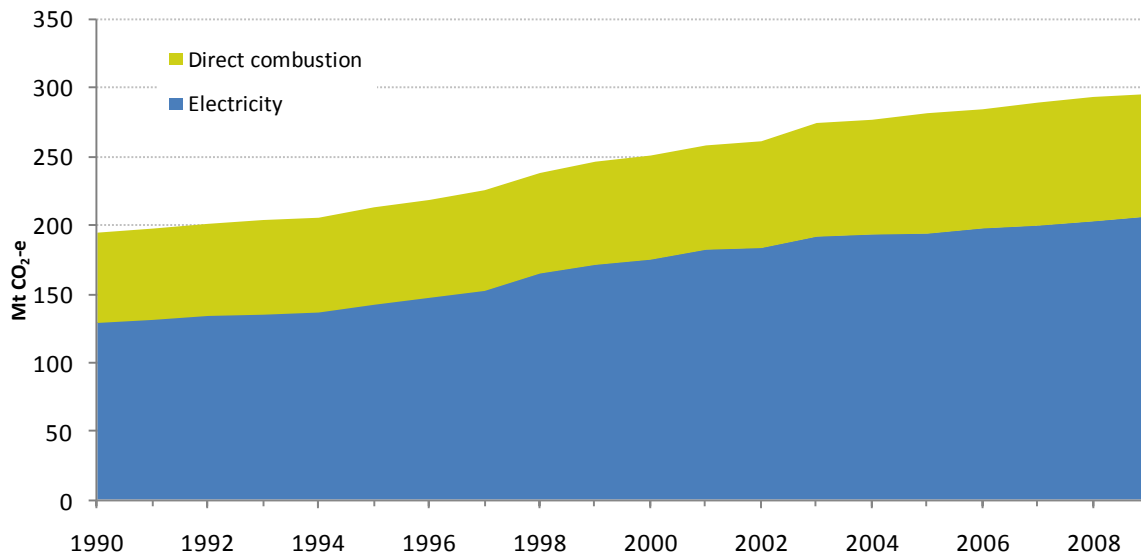


Source: AEMO (2010), DCCEE analysis.

² All years in this publication are Australian financial years, ending on the 30 June of the year quoted.

The most recent NGGI data suggests that while electricity generation is beginning to grow after experiencing negative average growth since early 2008, emissions are growing relatively slowly. Recent rain along the east coast of Australia has resulted in significant water flows in the snowy hydro regions and Tasmania and hydroelectric generation has increased. This has reduced the need for other more emissions intensive generators to produce and resulted in slower growth in emissions than in generation in recent months.

Figure 3 Stationary energy emissions, 1990–2009



Source: DCCEE analysis.

Black coal generation declined on average between 2008 and 2010, considered to be the result of increases in generation from natural gas and renewable energy, and declining overall demand. The Queensland Gas Scheme and Renewable Energy Targets are currently drawing more gas and renewable energy generators into the market, resulting in some declines in generation from black coal.

Nevertheless, total emissions from stationary energy continue to grow in line with increases in economic growth, population and industrial production. This is in response to increasing industrial activity driving growth in direct fuel combustion, particularly of gas.

Projections results

The projection of Kyoto period emissions shows a significant slow-down in emissions growth from the stationary energy sector compared with the historical trend. Average emissions growth from 2009 to 2020 is projected to be 1.1 per cent per year, substantially lower than the 1990–2009 historical average of 2.7 per cent annual growth. The combined effects of policies including the Renewable Energy Target and energy efficiency measures, and the impact of the global financial crisis are projected to result in stable emissions over the Kyoto period.

Table 3 Baseline stationary energy emissions, Kyoto period average and 2020

	1990	2000	Kyoto period average 2008–12		2020	
	Mt CO ₂ -e	Mt CO ₂ -e	Mt CO ₂ -e	Increase on 1990 (%)	Mt CO ₂ -e	Increase on 2000 (%)
Electricity generation	129	175	203	57	213	22
Direct combustion	66	75	91	39	119	58
Total	195	251	294	51	332	33

Note: totals may not add due to rounding. These 1990 emissions are consistent with Australia's assigned amount for the Kyoto Protocol, which differ to the latest National Greenhouse Gas Inventory (June Quarter 2010).

Source: SKM-MMA (2010), ACIL Tasman (2010), DCCEE analysis.

Emissions declined in 2010 and are expected to remain flat in 2011, rising again from 2012. Over the Kyoto period, stationary energy emissions are projected to average 294 Mt CO₂-e per year, this represents a 51 per cent increase over the 1990 level.

Trends in the stationary energy projections

Emissions are projected to be 332 Mt CO₂-e in 2020, 33 per cent higher than the 2000 level. After the Kyoto period, emissions are projected to increase in the absence of additional Government policies and measures.

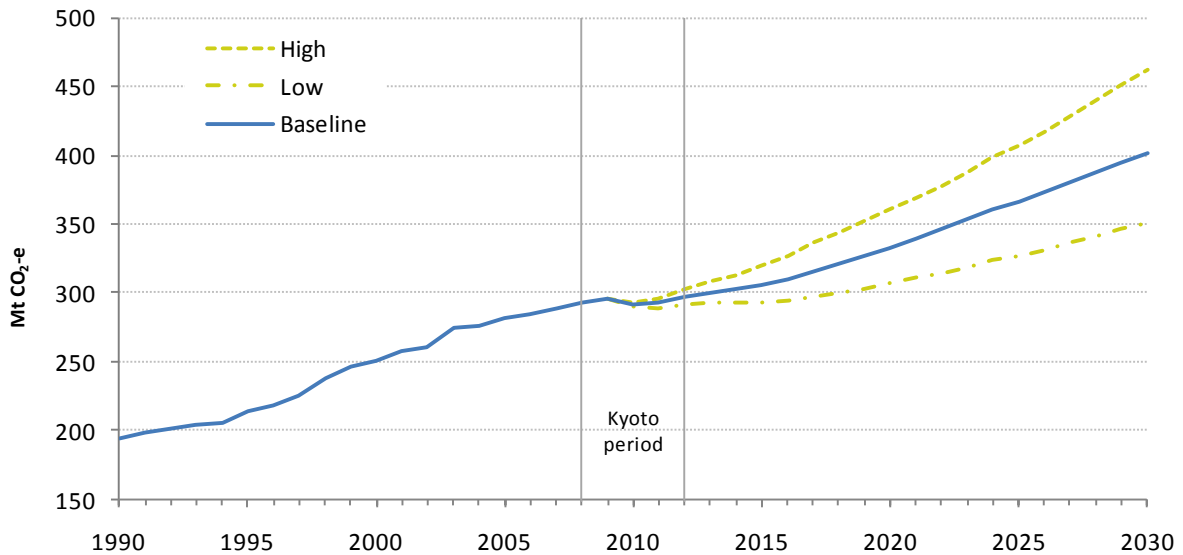
Baseline emissions are projected to increase at a slower rate than historical emissions. From 2009 to 2020, emissions growth is expected to average 1.1 per cent per year, down from 2.7 per cent between 1990 and 2009.

Between 2009 and 2020, emissions from stationary energy are projected to increase by 13 per cent, or 37 Mt CO₂-e. Emissions from both electricity generation and direct fuel combustion are projected to continue to rise to 2020 in the presence of current policies.

Historically, electricity emissions have grown at a faster rate than those from direct fuel combustion; however, this situation is projected to reverse between 2009 and 2020 as a result of increasing renewable electricity generation (driven by the Renewable Energy Target) and rapid growth in industrial fuel combustion.

Emissions growth from electricity generation is projected to be relatively slow as the Renewable Energy Target encourages low emissions sources of generation to meet growing electricity demand. However, strong economic growth and increased export demand for Australia’s mineral and energy resources are the primary drivers of higher emissions, especially in the direct combustion sector.

Figure 4 Baseline stationary energy emissions, 1990 to 2030



Source: SKM-MMA (2010), ACIL Tasman (2010), DCCEE analysis.

Indicative modelling suggests emissions from stationary energy will be 402 Mt CO₂-e per year by 2030. Both electricity demand and the direct use of fuels continue to increase.

Table 4 Stationary energy emissions, 1990 to 2030, Mt CO₂-e

	1990	2000	2009	KPA	2020	2030
Electricity generation	129	175	207	203	213	259
Direct combustion	66	75	89	91	119	142
Total	195	251	295	294	332	402

Note: totals may not add due to rounding. These 1990 emissions are consistent with Australia’s assigned amount for the Kyoto Protocol, which differ to the latest National Greenhouse Gas Inventory (June Quarter 2010).

Source: SKM-MMA (2010), ACIL Tasman (2010), DCCEE analysis.

Once installation of renewable generation capacity to meet the Renewable Energy Target is completed (currently projected to be by 2017), coal and gas-fired power generation is projected to rise to meet future increases in electricity demand. In addition, continuing expected demand for Australia’s energy and mineral commodity exports contribute to higher emissions from direct combustion.

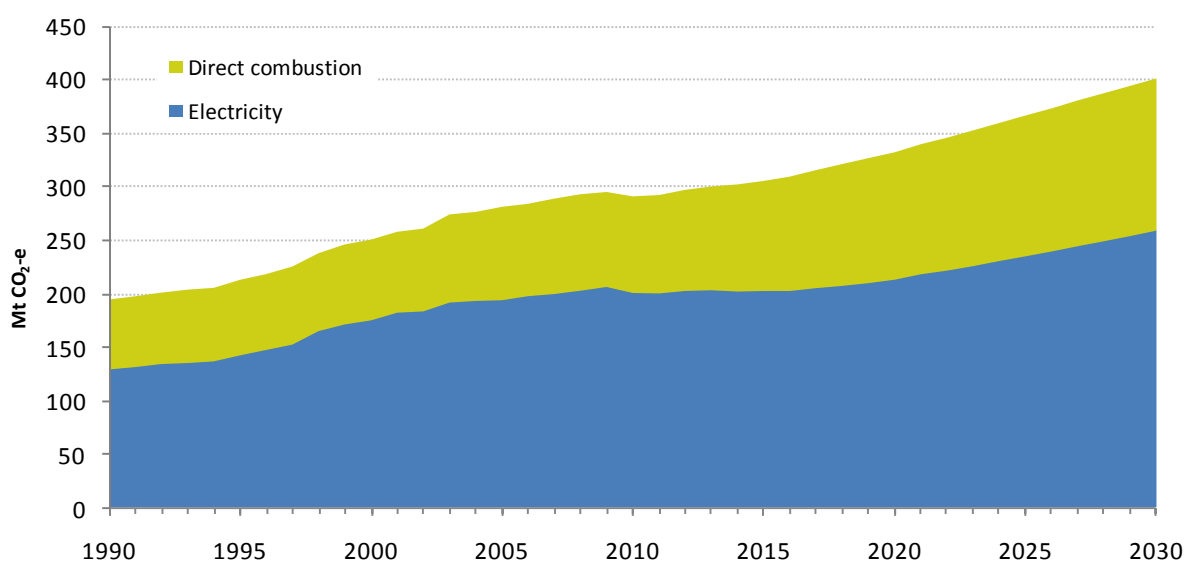
Main drivers of sectoral activity

Key drivers influencing emissions growth from the stationary energy sector include the structure and growth of Australia's economy, the fuel mix used in electricity generation and energy efficiency improvements across the economy. These factors affect the demand for electricity and its emissions intensity, as well as the demand for fuel for direct combustion.

The Renewable Energy Target is the main factor driving changes in the fuel mix for electricity generation to 2020. The target is projected to result in a significant increase in the proportion of electricity generated from renewable sources, lowering the average emissions intensity of electricity over time.

Other measures including those aimed at improving energy efficiency in the economy have the effect of reducing demand for electricity and other energy sources, potentially reducing the need for new investments. This can reduce energy prices and has a role in determining fuel mix.

Figure 5 Stationary energy emissions, 1990 to 2030



Source: SKM-MMA (2010), ACIL Tasman (2010), DCCEE analysis.

Strong growth in export demand for Australia's mineral and energy resources, such as Liquefied Natural Gas (LNG), iron ore and coal is the primary driver of growth in emissions from direct fuel combustion. Coal consumption for steel production and production of steam in other industrial applications as well as use of liquid fuels in activities such as petroleum refining and manufacturing industries are the other major sources of direct combustion emissions.

Business-as-usual scenario and measures estimates

There are more than 100 state and federal Government policies and measures aimed at reducing emissions from the stationary energy sector. Of these, around 20 have been estimated in the projections, the largest of which include:

- The Renewable Energy Target; and
- The National Strategy on Energy Efficiency

These two measures account for three-quarters of total abatement from stationary energy measures over the Kyoto period and around 85 per cent of abatement in 2020.

In total, stationary energy measures are projected to contribute an average of 29 Mt CO₂-e of abatement per year over the Kyoto period and 84 Mt CO₂-e of abatement in 2020. For more details, see Appendix A.

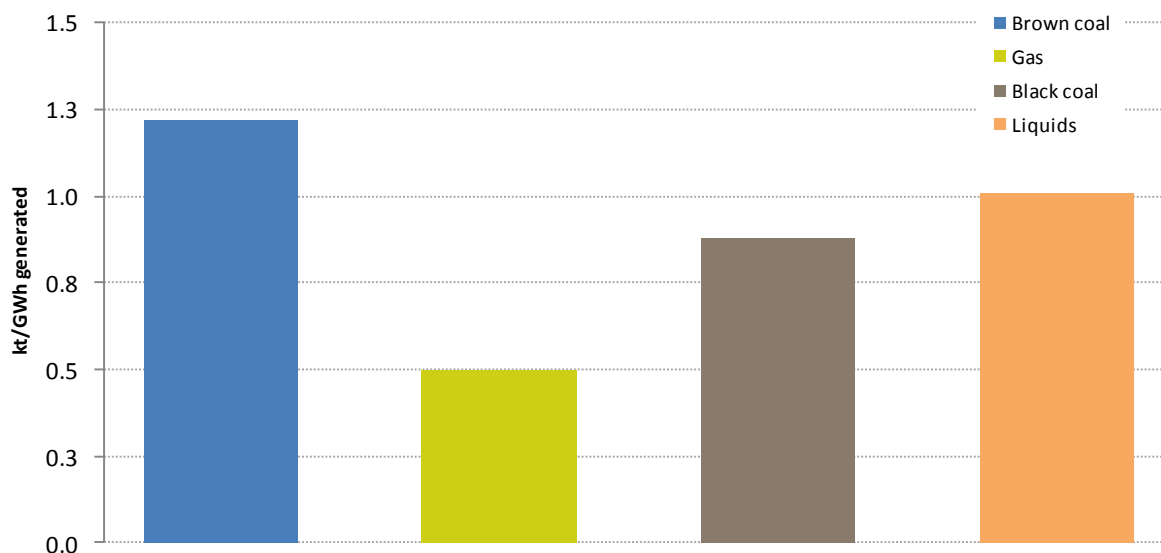
Electricity generation

Emissions from electricity generation account for more than two-thirds of total stationary energy emissions. The electricity subsector is split into two distinct categories: National Electricity Market (NEM) generation and non-NEM generation. The National Electricity Market accounts for around 87 per cent of electricity generation and almost 90 per cent of emissions from the subsector.

The NEM covers electricity on-grid generation and distribution in Queensland, New South Wales, Victoria, Tasmania and South Australia, as well as distribution in the Australian Capital Territory.

The emissions intensity of electricity generation is dependent on the fuel and technology used. Electricity generated from renewable sources has no associated emissions, while electricity generated from brown coal results in relatively high emissions. Emissions intensity also varies by the technology used for electricity generation. For instance, open cycle gas turbines (OCGT) have higher associated emissions than closed cycle (CCGT) for each unit of electricity generated because they are less efficient at converting the energy contained in the gas to electricity. The average emissions factor for electricity generated by each fuel is presented in Figure 6.

Figure 6 Average emissions intensity of electricity generation, by fuel, 2009



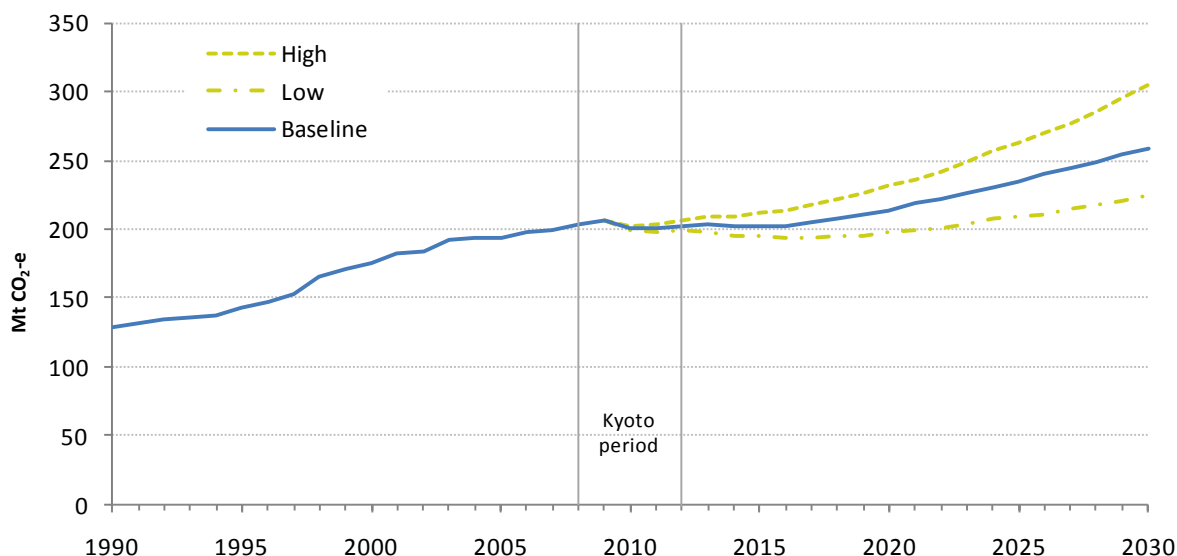
Source: SKM-MMA (2010), ACIL Tasman (2010), DCCEE analysis.

Trends in the electricity generation projections

Emissions from electricity are projected to average 203 Mt CO₂-e per year over the Kyoto period, 57 per cent above the 1990 level. Historically, emissions have been driven by population growth and increasing economic activity that has resulted in higher electricity

demand. The increasing availability and use of electrical appliances such as plasma televisions, air conditioners, game consoles and computers has contributed to demand growth.

Figure 7 Electricity emissions, 1990 to 2030



Source: SKM-MMA (2010), ACIL Tasman (2010), DCCEE analysis.

In 2020, electricity emissions are projected to be 213 Mt CO₂-e, 22 per cent above 2000 levels, and around 7 Mt CO₂-e higher than 2009 emissions. This relatively low growth in emissions is mainly the result of energy efficiency measures moderating demand growth and the Renewable Energy Target reducing the emissions intensity of electricity generation.

Table 5 Baseline electricity emissions, Kyoto period average and 2020

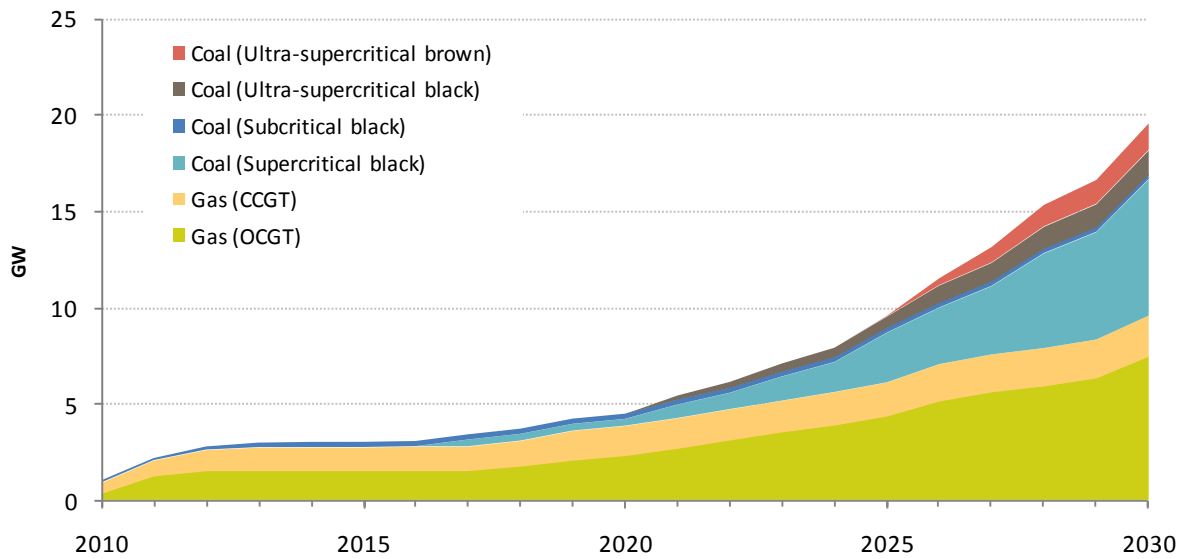
	1990	2000	Kyoto period average 2008–12		2020	
	Mt CO ₂ -e	Mt CO ₂ -e	Mt CO ₂ -e	Increase on 1990 (%)	Mt CO ₂ -e	Increase on 2000 (%)
Electricity	129	175	203	57	213	22

Note: totals may not add due to rounding. These 1990 emissions are consistent with Australia’s assigned amount for the Kyoto Protocol, which differ to the latest National Greenhouse Gas Inventory (June Quarter 2010).

Source: SKM-MMA (2010), ACIL Tasman (2010), DCCEE analysis.

Electricity demand is projected to grow by 16 per cent, or around 42,000 GWh between 2009 and 2020 as the Australian economy continues to grow and expand. In response to this growth, substantial new generation capacity is expected to be installed. Both renewable and fossil fuel capacity is projected to increase. More than three-quarters of the fossil fuel capacity installed to 2020 is projected to be gas. Investment is predominantly in open cycle gas turbines which have a higher emissions intensity than closed cycle gas turbines, but are relatively cheaper to build and can operate in response to peak electricity loads complementing the increase in wind generation.

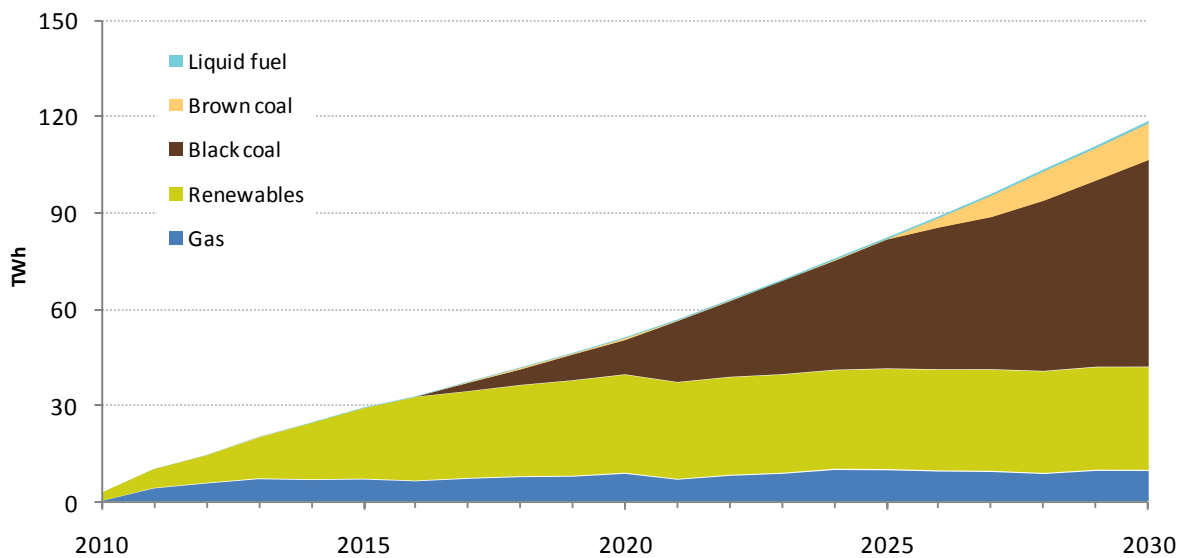
Figure 8 New thermal generation capacity installed, cumulative, 2010 to 2030



Source: SKM-MMA (2010), ACIL Tasman (2010), DCCEE analysis.

Without the changes in the fuel mix induced by the Renewable Energy Target and the Queensland Gas Scheme and improvements in generator efficiency, it is estimated this increase in demand would have led to an increase in emissions of around 39 Mt CO₂-e, significantly higher than the 7 Mt CO₂-e currently projected.

Figure 9 Electricity generation above 2009 levels, by fuel, 2010 to 2030

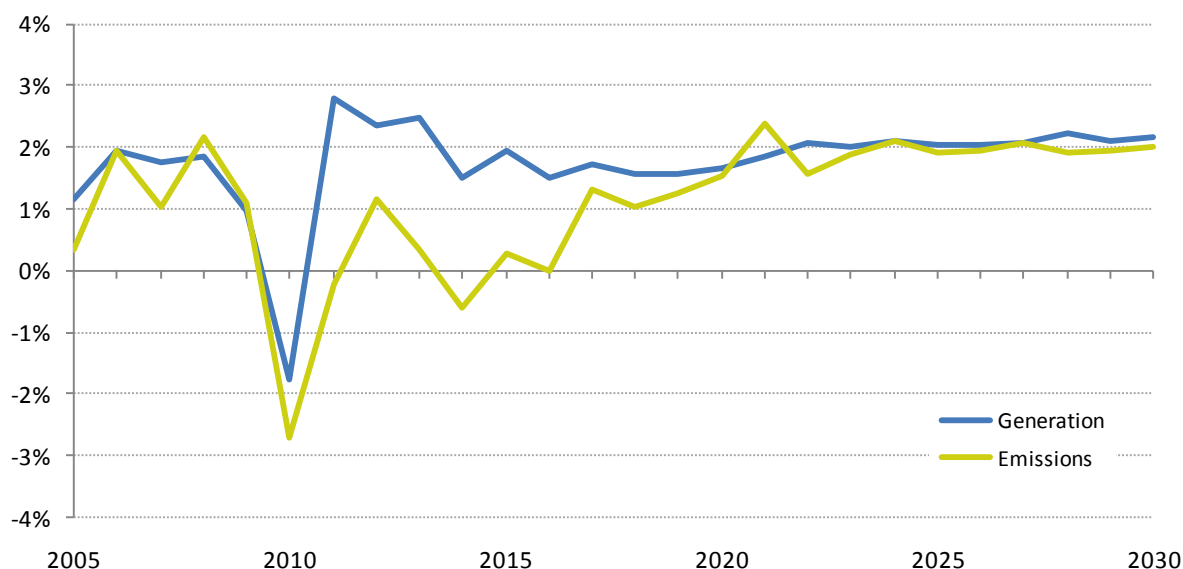


Source: SKM-MMA (2010), ACIL Tasman (2010), DCCEE analysis.

Emissions from electricity generation are projected to remain flat to 2016 as electricity demand growth is met largely by new renewable generation such as wind, as well as some gas. Figure 9 clearly shows the impact of the Queensland Gas Scheme and the Large-scale Renewable Energy Target, with the increase in generation from coal and liquid fuels close to zero between 2010 and 2016.

These two policies are projected to result in significant decoupling of emissions growth from electricity generation growth between 2010 and 2020 as shown in Figure 10. Historically, generation and emissions growth have been closely linked, with increasing generation resulting in higher emissions. Between 2010 and 2020, most of the increase in electricity demand is met by renewable energy sources, resulting in increasing generation but lower emissions growth than would otherwise have been the case. Small improvements in the efficiency of existing generators are also projected to occur over time.

Figure 10 Annual growth in emissions and generation, 2005 to 2030



Source: SKM-MMA (2010), ACIL Tasman (2010), DCCEE analysis.

From 2017 to 2020, emissions are projected to rise as investment in renewable generation capacity to meet the Large-scale Renewable Energy Target (LRET) is completed, and investment switches back to gas and high-efficiency black coal. In the absence of a carbon price, the modelling indicates that these two generation types are the most cost-effective to meet growing demand.

Table 6 Electricity emissions, by fuel, 1990 to 2030, Mt CO₂-e

	1990	2000	2009	KPA	2020	2030
Brown coal	42	62	64	62	62	71
Black coal	77	101	121	118	126	162
Gas	8	10	20	21	23	24
Liquid fuel	3	2	2	2	2	3
Renewables	0	0	0	0	0	0
Total	129	175	207	203	213	259

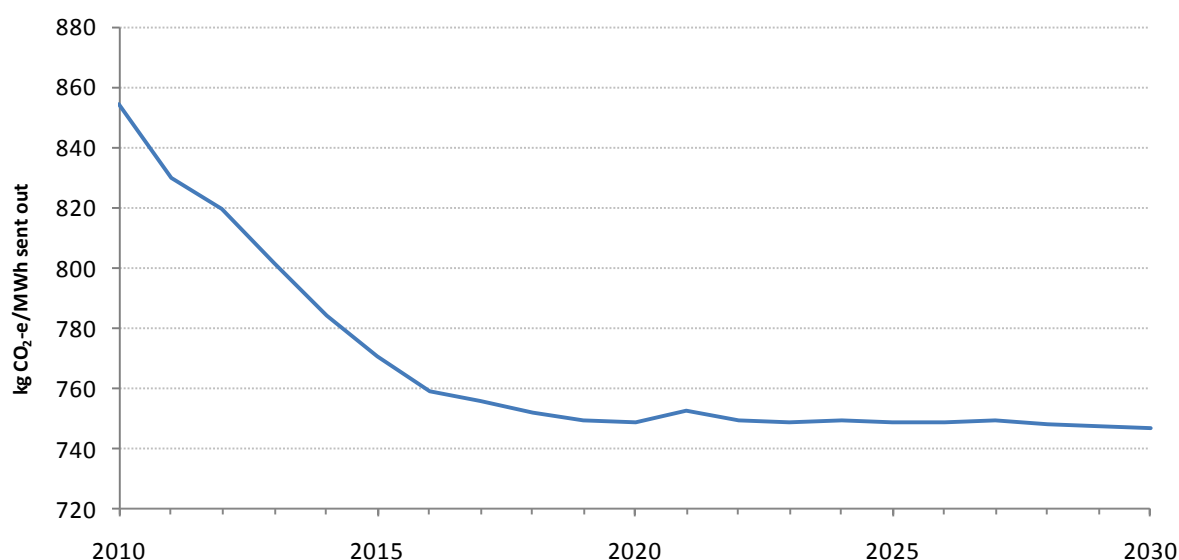
Note: totals may not add due to rounding. These 1990 emissions are consistent with Australia's assigned amount for the Kyoto Protocol, which differ to the latest National Greenhouse Gas Inventory (June Quarter 2010).

Source: SKM-MMA (2010), ACIL Tasman (2010), DCCEE analysis.

After 2020, emissions and generation increase at roughly the same rate as investment in renewable electricity generation slows. The average emissions intensity of generation remains relatively stable over the period from 2018 to 2030 (Figure 11), despite significant increases in the share of electricity generated from black and brown coal over that time. Ongoing efficiency improvements in black and brown coal generators contribute to this lower level of emissions intensity.

Past 2020, indicative modelling suggests that emissions from electricity generation will increase by a further 22 per cent to almost 260 Mt CO₂-e by 2030, 48 per cent above 2000 levels. As the LRET generation target remains at 41,000 GWh to 2030, investment in renewable generation slows rapidly after 2017 when the target is met.

Figure 11 Average emissions intensity of electricity generation, 2010 to 2030



Source: SKM-MMA (2010), ACIL Tasman (2010), DCCEE analysis.

Emissions from the use of gas in electricity generation have increased rapidly since 2000, with slight declines in emissions from brown coal over the same period. To 2020, all fuels except brown coal are projected to contribute to electricity emissions growth, with total emissions growth of 3 per cent.

While fossil fuel generation is projected to result in increasing emissions overall to both 2020 and 2030, the fastest growth in electricity generation is projected to come from renewables. Nevertheless, without further policy intervention, black coal is expected to remain the largest source electricity generation to 2030.

Between 2010 and 2020, generation from brown and black coal is projected to be relatively stable, resulting in the share of generation from these fuels declining from 75 per cent to 66 per cent. To 2030 however, generation from black coal is projected to increase as a result of new investment in high-efficiency black coal generators after 2017 to meet increasing electricity demand, while brown coal generation declines slightly. By 2030, electricity generation from coal is projected to recover to account for 71 per cent of the total.

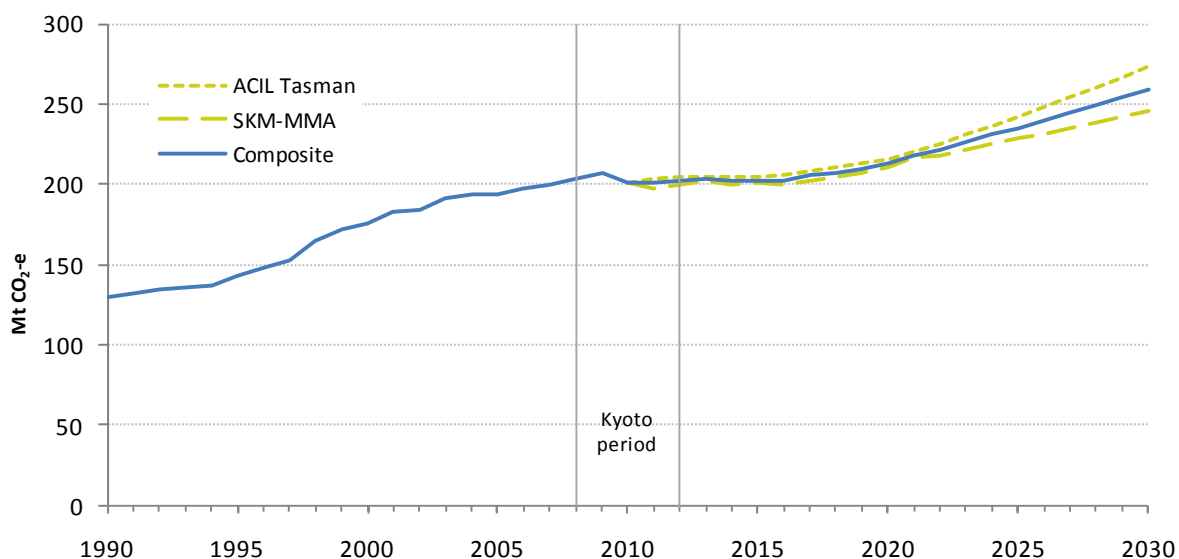
Modelling results

Two independent modelling groups were engaged to produce stationary energy emissions projections for the 2010 update. Both ACIL Tasman and SKM-MMA (formerly MMA) generated emissions projections for electricity and direct combustion subsectors.

Electricity sector emissions differ by an average of 3 Mt CO₂-e per year over the Kyoto period between modellers, after scaling results to the latest NGGI data.

Modelling results are also similar in 2020, with ACIL Tasman's projections of electricity emissions being 6 Mt CO₂-e higher than SKM-MMA's result of 209 Mt CO₂-e after scaling.

Figure 12 Electricity emissions projections by modeller, 2008 to 2030



Source: SKM-MMA (2010), ACIL Tasman (2010), DCCEE analysis.

Results show that the modellers broadly agree regarding trends in emissions from electricity generation to 2020. To 2030, uncertainty is higher and ACIL Tasman's projections indicate faster growth in emissions from electricity than those of SKM-MMA. However, both modellers' results forecast increasing emissions from 2020 to 2030.

Table 7 outlines the main drivers of emissions in the modellers' results, decomposing the growth in emissions between 2009 and 2020 into three factors. Each effect isolates the impact of that factor on the overall electricity emissions outcome by holding the other factors that influence emissions constant. Therefore:

- The generation effect illustrates the change in emissions that would have occurred had there been no change in the fuel mix or efficiency.
- The fuel mix effect indicates what the change in emissions would have been without increased electricity generation or improvements in efficiency.
- The efficiency effect illustrates how emissions would have changed had there been no increase in generation or change in the fuel mix.

Because the Renewable Energy Target and Queensland Gas Target are inducing changes in the fuel mix, and electricity generators become more efficient over time, the only factor that results in increasing emissions from the electricity subsector is higher electricity demand. Without the cleaner fuel mix and more efficient generation that occur by 2020, electricity emissions would be significantly higher than is currently projected.

While the proportion of generation that comes from cleaner sources increases between 2009 and 2020, the total volume of electricity required to meet demand increases. Were demand for electricity to grow more slowly, or even to decline, as a result of improvements in energy efficiency or other policies and measures, emissions growth would likely also be slower.

However, in reality each of the factors is interdependent. For example, with slower demand growth, there would also likely be less investment in new generation from cleaner sources.

Table 7 Effect of various factors on emissions, 2009 to 2020, Mt CO₂-e

	SKM-MMA	ACIL Tasman	Composite
Generation effect	43	34	39
Fuel mix effect	-31	-23	-27
Efficiency effect*	-8	-2	-5
Total	4	10	7

Notes: totals may not add due to rounding, the composite is the average of the two modellers. *Residual including generator efficiency. Source: SKM-MMA (2010), ACIL Tasman (2010), DCCEE analysis.

Modellers' results indicate that even though total electricity emissions outcomes are relatively close, the generation, fuel mix and efficiency effects for each modeller contribute differently to the overall result. For instance SKM-MMA projects a faster increase in electricity generation than ACIL Tasman, but also greater improvements in efficiency and a cleaner fuel mix. The 8 Mt CO₂-e difference in the fuel mix effect is the result of differing assumptions affecting generation under the Large-scale Renewable Energy Target (LRET). For more information on modelling of the LRET, see Appendix B.

Key uncertainties and sensitivity analysis

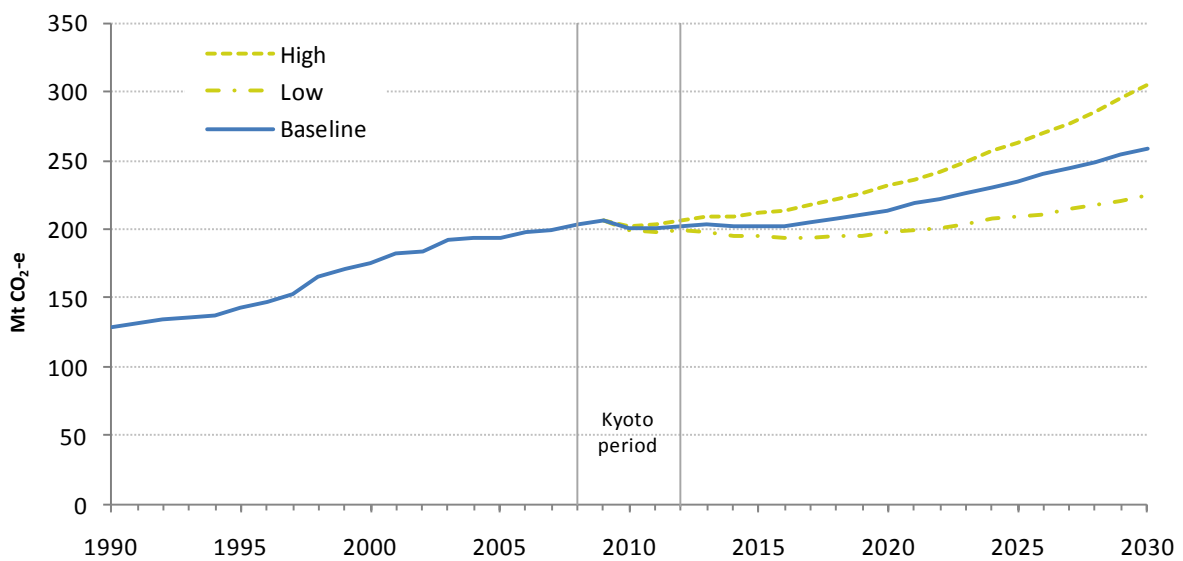
Emissions from electricity generation are sensitive to economic growth and population assumptions, changes in the overall energy efficiency of the economy, and changes to policy actions that affect either energy consumption or the fuel mix used for electricity generation. Changes in overall weather patterns are also important with warmer winters or cooler summers likely to reduce the demand for electricity and therefore also emissions.

Most recently, the global financial crisis resulted in a fall in electricity emissions as electricity demand fell and reduced the need for fuel combustion to generate electricity. Consistent with this, projections of electricity emissions are most sensitive to faster or slower economic growth than is assumed here. Growth that is 0.5 percentage points faster per year results in electricity emissions that are 7 per cent above the level currently projected for 2020.

Similarly, growth that is 0.5 percentage points slower per year results in emissions 6 per cent below the current projection in 2020. By 2030, these deviations increase to 15 per cent above and 12 per cent below the current projection.

Assumptions regarding population growth and autonomous improvements in energy efficiency have a less significant effect on overall electricity emissions. In total, higher economic and population growth, combined with lower energy efficiency improvements, results in emissions of 230 Mt CO₂-e in 2020, and 304 Mt CO₂-e in 2030. If economic growth and population growth are slower than currently assumed, and energy efficiency improvements faster, electricity emissions would likely be 197 Mt CO₂-e in 2020 and 224 Mt CO₂-e in 2030.

Figure 13 Electricity sensitivities



Source: SKM-MMA (2010), ACIL Tasman (2010), DCCEE analysis.

Direct combustion

Emissions from direct fuel combustion accounted for around 30 per cent of total stationary energy emissions in 2009. Growth in emissions from direct combustion has increased at an average rate of 2 per cent per year over the past decade, up from an average of 1.5 per cent per year between 1990 and 2000.

Table 8 Direct combustion emissions, Kyoto period average and 2020

	1990	2009	Kyoto period average 2008–12		2020
	Mt CO ₂ -e	Mt CO ₂ -e	Mt CO ₂ -e	Increase on 1990 (%)	Mt CO ₂ -e
Direct combustion	66	89	91	39	119
					Increase on 2000 (%)
					58

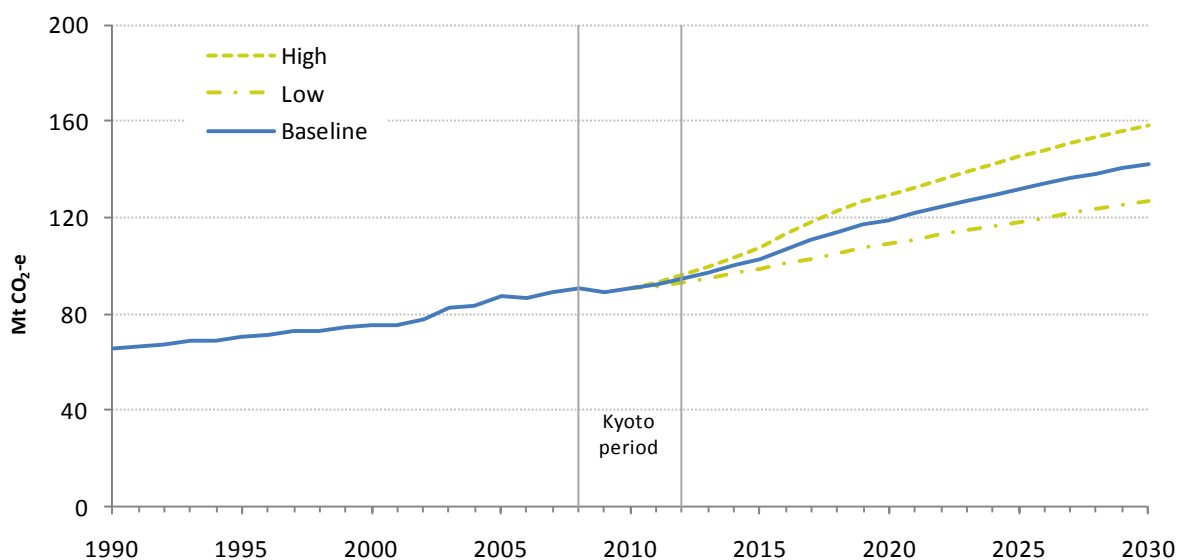
Note: totals may not add due to rounding. These 1990 emissions are consistent with Australia's assigned amount for the Kyoto Protocol, which differ to the latest National Greenhouse Gas Inventory (June Quarter 2010).

Source: SKM-MMA (2010), ACIL Tasman (2010), DCCEE analysis.

Trends in the direct combustion projections

Direct combustion emissions are projected to average 91 Mt CO₂-e per year over the Kyoto period, 39 per cent above 1990 levels. In 2020, emissions are projected to increase to 119 Mt CO₂-e, 58 per cent higher than in 2000.

Figure 14 Direct combustion emissions, 1990 to 2030



Source: SKM-MMA (2010), ACIL Tasman (2010), DCCEE analysis.

Growth in direct combustion emissions is projected to be around 3 per cent per year between 2009 and 2020, significantly higher than growth in electricity emissions and also higher than historical growth rates of 2 per cent per year. As a result, direct combustion's share of

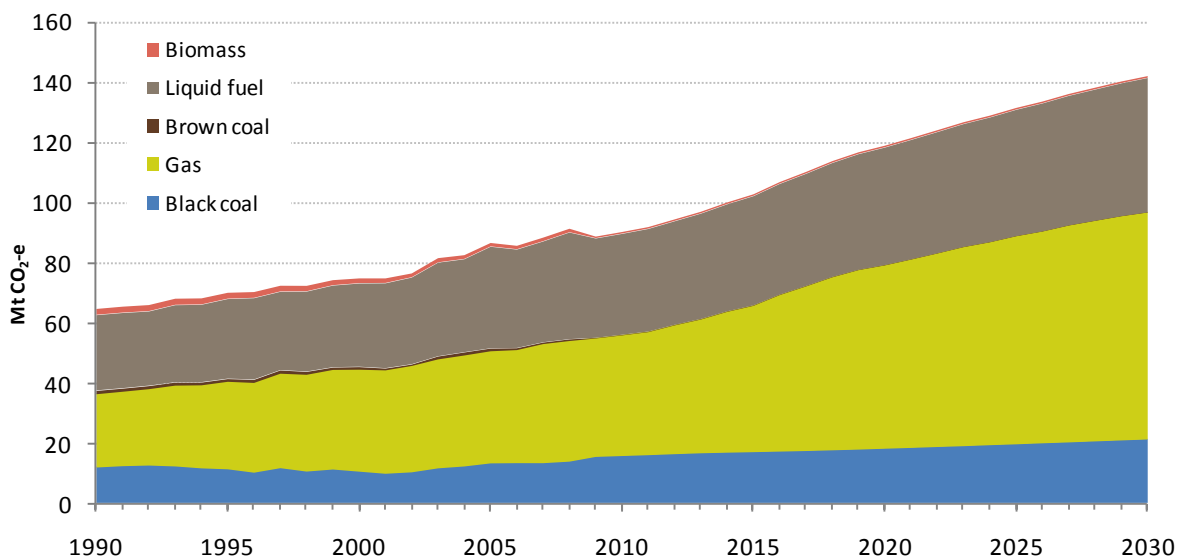
stationary energy emissions is projected to increase from 31 per cent in 2010 to 36 per cent in 2020.

Between 2009 and 2020, gas is projected to overtake black coal as the fastest growing fuel source and emissions source for direct combustion. Gas is already the largest single source of emissions from direct combustion. Most of the growth in gas consumption is projected to occur in the industrial sector as a result of expected growth in the mining sector and a number of new liquefied natural gas (LNG) projects (for more details, please refer to the fugitive sector paper).

Emissions from liquid fuels including petroleum (for uses other than transport) are also projected to grow rapidly (by 18 per cent between 2010 and 2020) in line with expected increases in activity in the manufacturing and construction industries. Non-energy mining industries including iron ore, gold, nickel and zinc production are also significant contributors to this growth. Since 2001, petroleum use in these industries has doubled, and with anticipated expansions in Australia’s commodity production, use is projected to continue to grow and contribute to rising emissions.

Combustion of brown and black coal and coke is restricted almost entirely to the industrial sector, while most biomass combustion occurs in the residential sector. Combustion of gas and liquids is dominated by the industrial sector, but the residential and commercial sectors contribute also.

Figure 15 Direct combustion emissions, by fuel, 1990 to 2030

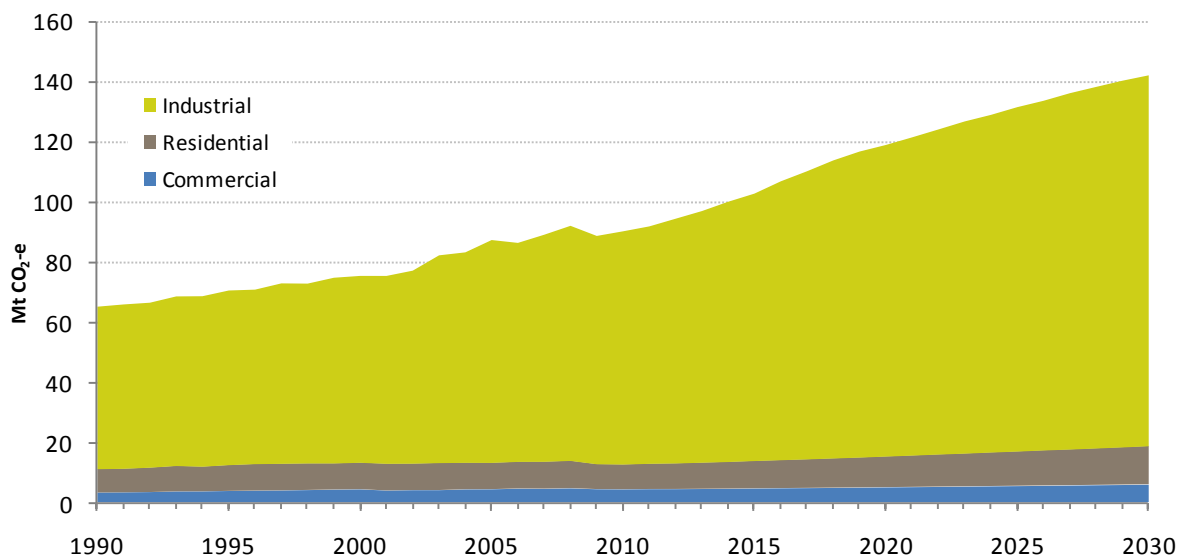


Source: SKM-MMA (2010), ACIL Tasman (2010), DCCEE analysis.

Gas and liquid fuel emissions are projected to continue to account for the largest proportion of residential fuel combustion emissions, constant at 95 per cent in 2009 and 2020. These fuels are used for cooking, heating and small-scale electricity generators (gas stoves and heaters, diesel generators) with the remaining 5 per cent of emissions coming from biomass (wood burning fires). Emissions growth to 2020 and 2030 in the residential sector is

projected to be fastest from gas combustion as electric water heaters are replaced with gas, or gas-boosted solar systems, and more homes switch to gas heating.

Figure 16 Direct combustion emissions, by sector, 1990 to 2030



Source: SKM-MMA (2010), ACIL Tasman (2010), DCCEE analysis.

The commercial sector contributes least to direct combustion emissions using only gas and liquid fuels for heating, commercial cooking and mobile generation (for example small refrigerated transport). Emissions from the commercial sector currently account for around 5 per cent of direct combustion and this is projected to fall to 2020 as a result of rapid growth in emissions from the industrial sector.

Modelling results

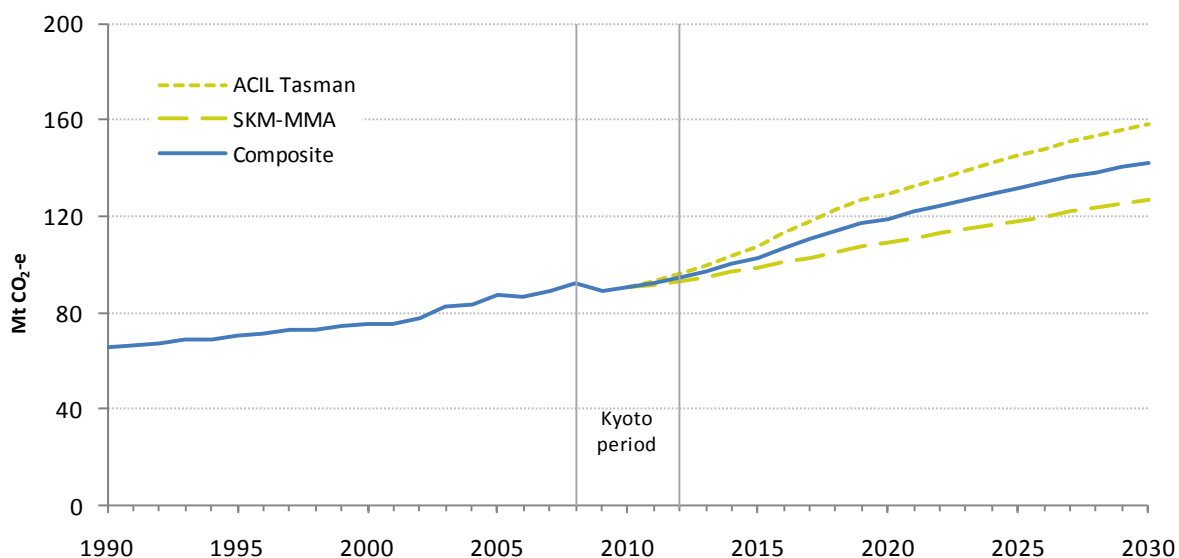
The same independent modelling groups were engaged to produce direct combustion emissions projections for the 2010 update as for electricity. Both ACIL Tasman and SKM-MMA (formerly MMA) generated emissions projections with direct combustion emissions varying by an average of 1 Mt CO₂-e per year over the Kyoto period between modellers, after scaling results to the latest NGGI data.

Modelling results vary far more in 2020, with ACIL Tasman's projections of direct combustion emissions being 20 Mt CO₂-e higher than SKM-MMA's result of 109 Mt CO₂-e after scaling.

The main difference between modellers is the projection of industrial energy consumption, with ACIL Tasman projecting faster growth in industrial consumption of gas and liquid fuels. This is largely the result of different views regarding the amount of new LNG and alumina production expected to be commissioned between now and 2020. ACIL Tasman's assumptions regarding LNG production growth and expansions of alumina capacity in Western Australia and Queensland are more optimistic than SKM-MMA's. Both LNG and

alumina production require substantial consumption of gas, resulting in ACIL Tasman’s emissions from direct combustion being higher than that of SKM-MMA.

Figure 17 Direct combustion emissions projections by modeller, 2008 to 2030



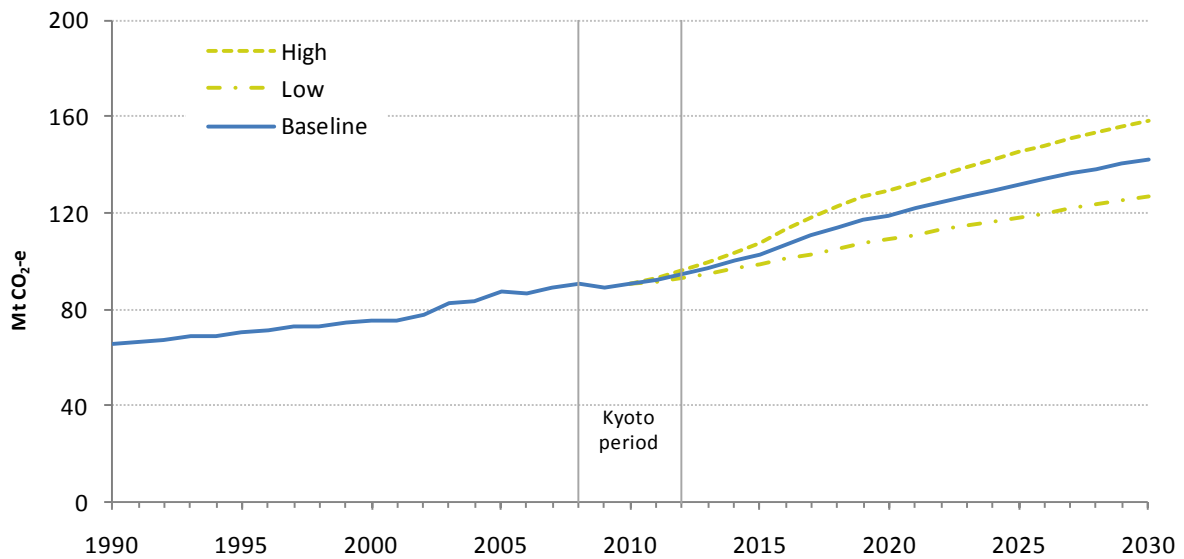
Source: SKM-MMA (2010), ACIL Tasman (2010), DCCEE analysis.

Key uncertainties and sensitivity analysis

Emissions from direct combustion are sensitive to economic growth and industrial activity assumptions, as well as changes to policy actions that affect energy consumption or the type and composition of industry in Australia.

Most recently, the global financial crisis resulted in a rapid fall in direct combustion emissions as some iron and steel capacity was shut down in response to low demand, reducing fuel combustion in that industry.

Figure 18 Direct combustion sensitivities



Source: SKM-MMA (2010), ACIL Tasman (2010), DCCEE analysis.

Direct combustion emissions are most sensitive to assumptions regarding growth in LNG production, the rate of alumina production growth, and fuel switching in alumina production from coal to gas. The baseline projection assumes alumina production grows to around 30 Mt by 2030 and LNG production increases fourfold in the same period.

Alumina production growth of 50 per cent between 2010 and 2020, and 30 per cent between 2020 and 2030 to 45 Mt, combined with fuel switching from coal to gas would result in emissions being 8 per cent higher in 2020 and 11 per cent higher in 2030 than is projected here. Slower alumina and LNG production growth would result in emissions around 10 per cent lower in both 2020 and 2030 than indicated here.

Appendix A – Measures

Table 9 Greenhouse gas abatement from stationary energy measures

Name	Kyoto period average (Mt CO ₂ -e)	2020 (Mt CO ₂ -e)
Clean Energy Initiative: CCS Flagship	Not estimated	2.3
Energy Efficiency in Government Operations	<0.1	0.1
Energy Efficient Homes Package: HIP	1.3	0.1
Greenhouse Challenge	<0.1	<0.1
Greenhouse Gas Abatement Program (GGAP)	0.8	1.0
Industry Greenhouse Program	0.2	0.3
National Strategy on Energy Efficiency	14.0	42.1
<i>Equipment Energy Efficiency (E3) Program</i>	6.3	20.3
<i>Energy efficiency requirements: Building codes</i>	4.2	11.8
<i>Mandatory disclosure requirements: Buildings</i>	<0.1	<0.1
<i>Framework Cool Efficiency Program</i>	0.1	0.4
<i>Phase-out of incandescent lighting</i>	1.0	1.9
<i>Phase-out of inefficient water heaters</i>	0.1	4.1
<i>Energy Efficiency Opportunities Program</i>	2.4	3.7
NSW Greenhouse Gas Abatement Scheme	0.7	2.1
<i>Greenhouse Gas Abatement Scheme</i>	0.7	0.9
<i>NSW Energy Savings Scheme</i>	0.1	1.2
Queensland Gas Scheme	2.2	4.3
Renewable Energy Target ³	8.8	29.9
<i>Large-scale Renewable Energy Target (LRET)</i>	8.5	26.3
<i>Small-scale Renewable Energy Scheme (SRES)</i>	0.2	3.7
Renewable Remote Power Generation Program (RRPGP) and Renewable Energy Commercialisation Program (RECP)	0.1	0.1
Solar Cities	<0.1	<0.1
Victorian Energy Efficiency Target and Energy Saver Incentive Scheme	0.2	1.6
Total	29	84

Note: totals may not add due to rounding. These 1990 emissions are consistent with Australia's assigned amount for the Kyoto Protocol, which differ to the latest National Greenhouse Gas Inventory (June Quarter 2010).

Source: SKM-MMA (2010), ACIL Tasman (2010), DCCCE analysis.

³ Includes GreenPower

Clean Energy Initiative – Carbon capture and storage flagships

The \$1.9 billion CCS Flagships Program aims to accelerate the deployment of large scale integrated carbon capture and storage (CCS) projects in Australia and is expected to fund between 2 and 4 projects. The Program includes funding of \$200 million from the Education Investment Fund (EIF) to support research infrastructure partnerships between the Flagship applicants and eligible research institutions.

Energy Efficiency in Government Operations Policy

Energy Efficiency in Government Operations (EEGO) aims to improve energy efficiency, and consequently reduce the whole of life cost and environmental impact of Government operations, and by so doing, lead the community by example.

EEGO comprises three major elements:

- Annual reporting of energy performance by agencies
- Portfolio energy intensity targets
- Minimum Energy Performance Standards (MEPS) for office government buildings, appliances, vehicles.

Energy Efficient Homes Package: Home Insulation Program

The Home Insulation Program was part of a stimulus package to relieve Australia from the impact of the global financial crisis. Commencing in July 2009, it provided up to \$1600 for the purchase and installation of insulation by owner-occupiers and an increased insulation rebate under the Low Emissions Plan for Renters. From 2 November 2009, the rebate declined to \$1200 in order to reduce demand. The program closed in February 2010.

Greenhouse Challenge

The Greenhouse Challenge program was a joint voluntary initiative between the Australian Government and industry. Its objective was to encourage abatement; improve greenhouse gas management; improve emissions measurement and monitoring; and strengthen government/industry information sharing. Some projects were also funded under GGAP; the abatement from these projects has been attributed to the GGAP program and is not counted here. Challenge participation was mandatory for entities claiming over \$3 million in fuel tax credits.

Greenhouse Gas Abatement Program (GGAP)

GGAP was a competitive grants program established in 2001 and designed to reduce net emissions by supporting activities likely to result in substantial emissions reductions or offset emissions. A number of grants were issued for projects that generated electricity from coal mine methane in the coal fugitives subsector. No further grants are being offered.

Industry Greenhouse Program

Under the program, Victorian EPA licensees that are medium to large energy users were required to:

- review their energy bills to calculate their energy use and associated greenhouse gas emissions; greenhouse gases produced by an industrial process (such as chemical manufacture or water treatment) were also calculated;

- conduct an energy audit to Australian standards;
- identify best practice options and determine payback periods;
- prepare an implementation plan for items with a payback of three years or less;
- report on implementation and annual emissions as part of annual reporting to EPA.

National Strategy on Energy Efficiency (NSEE)

The National Strategy on Energy Efficiency is designed to substantially improve minimum standards for energy efficiency and accelerate the introduction of new technologies through improving regulatory processes and addressing the barriers to the uptake of new energy-efficient products and technologies. It aims to encourage and support innovation in energy efficient technologies and approaches Short paragraph outlining each measure.

NSW Greenhouse Gas Abatement Scheme and NSW Energy Savings Scheme

NSW Greenhouse Gas Abatement Scheme is a Government initiative that requires liable parties (electricity retailers and large electricity users who choose to participate) to meet mandatory annual targets for reducing or offsetting greenhouse gas emissions from the production of electricity that they supply or use.

The NSW Energy Savings Scheme requires electricity retailers to meet annual energy savings targets by investing in projects through obtaining and surrendering energy saving certificates that demonstrate energy savings for households or businesses.

Queensland Gas Scheme

Requirement for electricity retailers to source a minimum percentage of their electricity from eligible gas-fired electricity provided above a baseline production amount. The target increases from 13% in 2008 and 2009, to 15% in 2010 and not more than 18% for any year after 2010.

Renewable Energy Target

The Renewable Energy Target is designed to deliver on the Government's commitment to ensure that 20 per cent of Australia's electricity supply will come from renewable sources by 2020. In ten years time the amount of electricity coming from sources like solar, wind and geothermal will be around the same as all of Australia's current household electricity use.

The RET expands on the previous Mandatory Renewable Energy Target (MRET), which began in 2001.

Electricity retailers must acquire and surrender Renewable Energy Certificates equivalent to their liability or pay the Renewable Energy Shortfall Charge.

In January 2011, the RET scheme was separated into two parts – the Small-scale Renewable Energy Scheme (SRES) and the Large-scale Renewable Energy Target (LRET). Abatement from all Government programs that lead to the creation of small-scale renewable energy certificates (for example the Renewable Energy Bonus Scheme – Solar Hot Water Rebate) is incorporated in the SRES estimate.

GreenPower abatement is also included in this estimate. GreenPower aims to facilitate the installation of new renewable energy generators beyond mandatory requirements. Energy retailers who sell GreenPower are required to surrender Renewable Energy Certificates for the quantity of electricity sold under the program. This is in addition to retailers' Renewable Energy Target obligations.

Renewable Remote Power Generation Program (RRPGP) and Renewable Energy Commercialisation Program (RECP)

The RRPGP provides assistance to households and communities not close to the main grid to reduce reliance on fossil fuels, particularly diesel. It supports over 30 major projects, and more than 9000 small scale installations, including 170 in indigenous communities.

Solar Cities

The Solar Cities program was designed as a one-off series of trials to capture information about energy use across a variety of Australian communities. The information will be analysed to see how different members of a community can best reduce energy consumption, and how governments, industries and individuals can support wise energy use.

Victorian Energy Efficiency Target and Energy Saver Incentive Scheme

The Victorian Energy Efficiency Target (VEET) scheme, which commenced on 1 January 2009, aims to encourage the uptake of energy efficient technology, initially in the residential sector. The VEET scheme imposes a liability on large electricity and gas retailers in Victoria to contribute to energy efficiency measures by acquiring and surrendering Victorian energy efficiency certificates (VEECs). A penalty will be imposed on entities that fail to surrender sufficient VEECs to meet their liability. Accredited persons are eligible to create VEECs for prescribed activities undertaken at residential premises. Each VEEC created represents one tonne of carbon dioxide equivalent (CO₂-e) abated by a prescribed activity.

Additional measures

Measures not identified separately here are considered to be fully overlapping with an existing program, not additional business-as-usual activities, not fully developed in terms of policy design, or too small to measure.

Feed-in tariffs and many other renewable energy measures fully overlap with the Renewable Energy Target (LRET and SRES) and are therefore not estimated here separately.

Appendix B – Renewable Energy Target modelling

Modelling results for the Large-scale Renewable Energy Target are dependent on a combination of modelling assumptions.

While the overall emissions (from the electricity generation subsector) of the two modellers are similar, the drivers of these emissions outcomes differ. The interaction between electricity demand (driving generation) and the price of Renewable Energy Certificates (RECs) (affected by long run renewable energy generation costs) is an important driver of investment in renewable generation capacity.

Table 10 provides a broad overview of the key factors that affect the level of renewable generation in each modeller's results. Individually, differences in each factor would be expected to have a relatively small effect on the modelling outcomes, however as these factors interact in the modelling, the outcomes regarding investment in renewables under the LRET are quite different.

Modelling by SKM-MMA show the LRET certificates created are sufficient to meet the target, while ACIL Tasman's modelling indicates there is a substantial shortfall in generation. The combination of lower electricity generation growth, lower wholesale and REC prices in the early years of the scheme, higher capital costs of wind and geothermal and the lower rate of capital cost decline in ACIL Tasman's modelling result in the LRET target not being met.

Table 10 Factors affecting LRET modelling outcomes

	SKM-MMA	ACIL Tasman
Electricity generation growth, 2010 to 2020	24%	18%
Combined wholesale electricity price and Renewable Energy Certificate price	Higher decreasing over time	Lower increasing over time
Capital cost of wind generation	Lower	Higher
Rate of capital cost decline per year	0.5%	0.2%
Long run marginal cost of geothermal	Economic before 2020	Not economic
Proportion of electricity generated from renewable sources	20%	15%
Outcome	Sufficient certificates generated over the life of the LRET to meet target	Target not met in generation or certificates

Source: SKM-MMA (2010), ACIL Tasman (2010), DCCEE analysis.

The composite emissions outcome presented here is an average of the results of each modeller engaged. The sensitivity of results to uncertain assumptions such as the rate of decline in capital costs of technologies demonstrates the value of engaging multiple modellers to understand the range of possible outcomes. The range of assumptions indicates

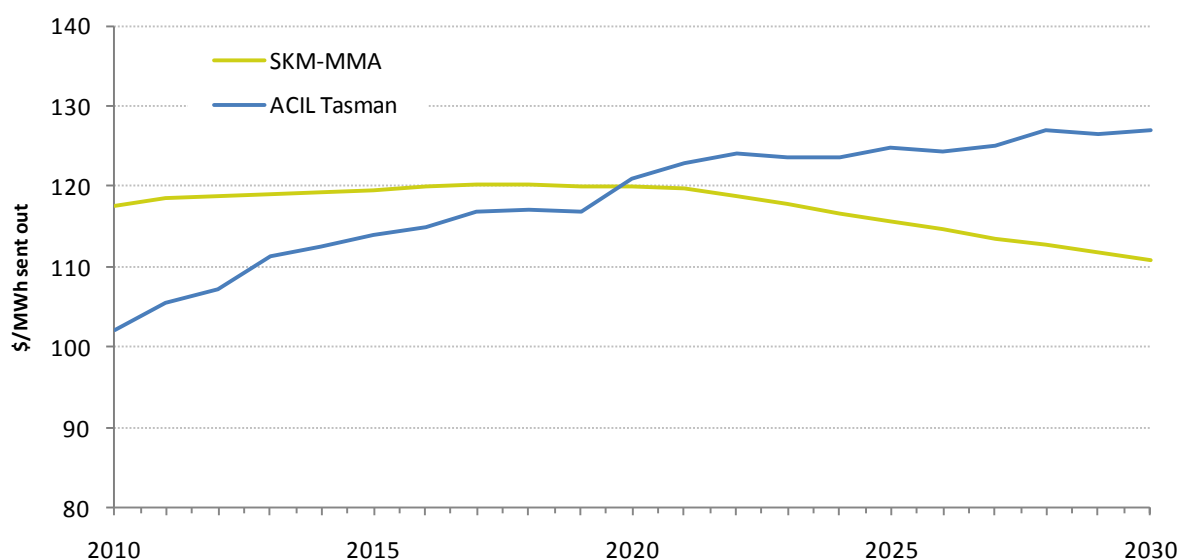
the inherent uncertainty involved in projecting the future, in this case regarding the future costs of renewable energy.

The baseline modelling assumes current RET design settings as set in the RET scheme legislation and associated regulations. In June 2010, the Commonwealth Parliament passed legislative amendments to prescribe independent, biennial reviews of the operation of the RET scheme, including the underpinning acts and regulations, from 2012. The Government is also committed to introducing a carbon price which would act as a further subsidy for renewables.

Detailed results and assumptions

The sum of the wholesale electricity price (\$/MWh) and the price of a Renewable Energy Certificate (REC) (equivalent to 1 MWh of renewable electricity generation) indicates the effective revenue to a renewable generator from generating 1 MWh of electricity (Figure 19⁴). The price of a Renewable Energy Certificate (REC) is the additional revenue received by renewable generators over fossil fuel generators.

Figure 19 Effective revenues to renewable electricity generators



Source: SKM-MMA (2010), ACIL Tasman (2010), DCCEE analysis.

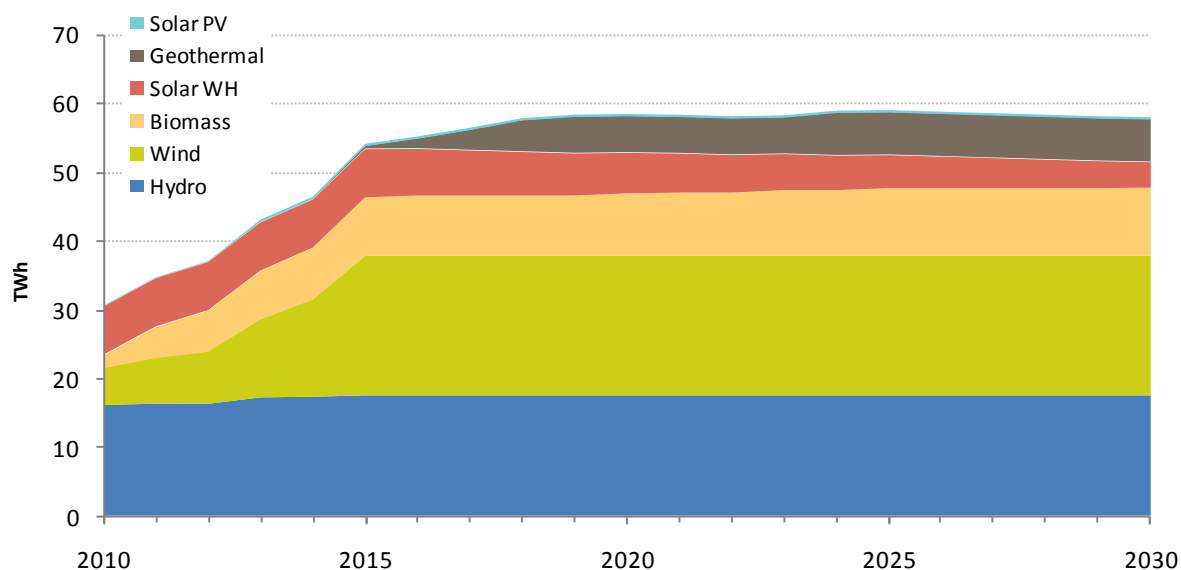
SKM-MMA

- Electricity generation grows by 24 per cent between 2010 and 2020, resulting in wholesale prices increasing from \$53/MWh in 2010 to \$63/MWh in 2020. REC prices start at \$70 and decline over time to \$50 in 2030.

⁴ The electricity wholesale price varies by region and time of day. Figure 12 is a simplified representation of revenues that accrue to a generator in a year. Revenues are comprised of a notional national average wholesale price received by renewable and fossil fuel generators plus the Renewable Energy Certificate price received.

- High revenue to renewables in the early years of the scheme and the advantage of investing early to receive more years of REC revenue encourages faster investment in wind.
- Assessed and assumed capital costs of wind installations are around \$2300/kW installed, and capital costs are assumed to decline at 0.5 per cent per year. Geothermal is assumed to be economically viable but is limited to 6000 GWh of generation per year before 2030.
- The cost of wind installation is below the expected revenue of the project (blue line in Figure 19) for long enough that sufficient investment occurs in wind generation to meet the majority of that required under the LRET. The long run marginal cost of geothermal generation makes it economic at all effective revenue levels so all geothermal is installed up to the available limit.
- As a result, investment in renewable generation is sufficient to meet the LRET and emissions growth is relatively slow.
- Figure 20 shows the split of renewable generation as modelled by SKM-MMA. The largest increase in generation comes from wind.

Figure 20 Renewable generation by fuel, SKM-MMA, 2010 to 2030



Note: PV - photovoltaics, WH - water heaters
Source: SKM-MMA (2010).

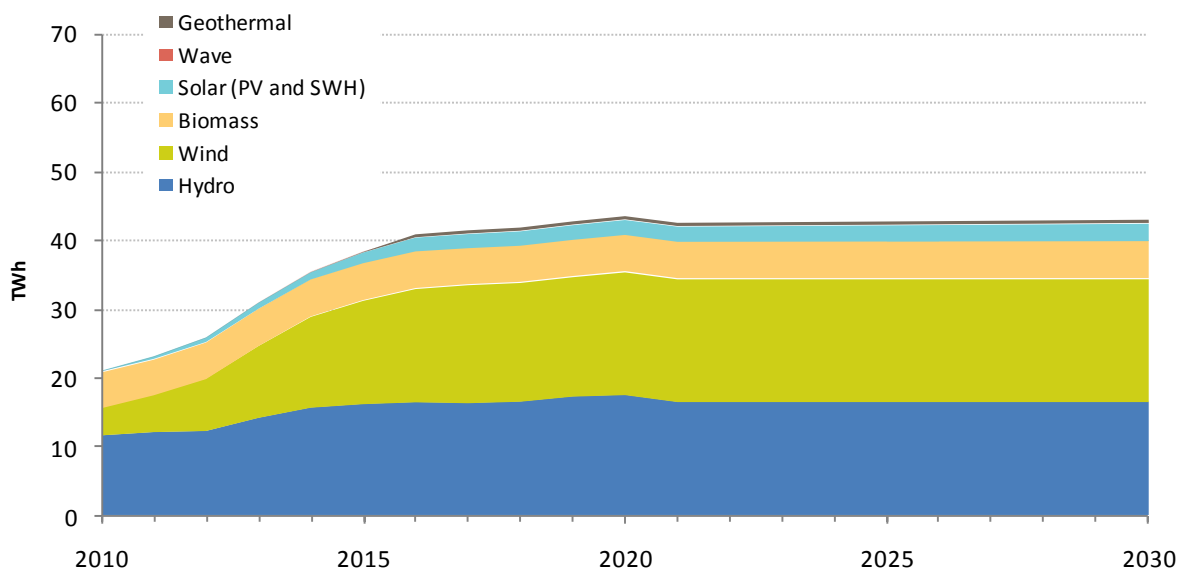
ACIL Tasman

- Electricity generation grows by 18 per cent between 2010 and 2020, resulting in smaller increases in wholesale prices from \$45/MWh in 2009 to around \$55/MWh in 2020. REC prices increase from \$60 in 2010 to peak at \$70 in 2016, before falling again over time.
- Limited investment in renewable generation occurs to 2012, reflecting the level of new capacity that is committed or under construction that ACIL Tasman expects to enter the

market in this period. Renewables (mainly wind) are rapidly developed between 2013 and 2016 while expected revenue over the life of the project is above the long run marginal cost. Post 2016, investment slows rapidly because the number of years remaining in the LRET is not sufficient to generate the REC revenues required to make investment profitable.

- Assessed and assumed capital costs of wind installations are around \$2700/kW installed, and capital costs are assumed to decline at 0.2 per cent per year. Geothermal is not economically viable in the projections period.
- The long run marginal cost of geothermal is such that no geothermal capacity is installed. The long run marginal cost of wind is such that investment is economic mainly between 2013 and 2016 (some investment occurs in marginal years) but this is not sufficient to meet the LRET generation requirement.
- As a result, investment in renewable energy (mainly wind) is not sufficient to meet the LRET and emissions growth is faster compared with generation growth.
- Figure 21 shows the split of renewable generation as modelled by ACIL Tasman. The largest increase in generation comes from wind; however generation is not sufficient to reach the 20 per cent target.

Figure 21 Renewable generation by fuel, ACIL Tasman, 2010 to 2030



Source: ACIL Tasman (2010).

Appendix C – Changes from 2009 projection

The 2010 stationary energy emissions projections reflect a full update of the projections released in *Australia's Fifth National Communication on Climate Change* to the UNFCCC in February 2010 (referred to here as the 2009 projections). Two modellers were engaged to provide updated projections based on the most recent economic growth forecasts, population forecasts and commodity outlooks. The results are fully consistent with the latest NGGI data.

Over the Kyoto period, annual emissions from stationary energy are projected to be largely the same as in the previous projection, averaging 1 Mt CO₂-e per year lower. However projected emissions in 2020 have been revised up by 11 Mt CO₂-e.

Electricity emissions have been revised up in the Kyoto period and in 2020, reflecting mainly higher emissions in the near-term and therefore a higher starting point for emissions growth. Over both the Kyoto period and in 2020, emissions are projected to average 2 Mt CO₂-e per year more than in the 2009 projection.

Direct combustion emissions have been revised down in the Kyoto period but up in 2020. Some diesel emissions previously allocated to direct combustion in mining have been reallocated to the transport sector, resulting in emissions averaging 3 Mt CO₂-e lower per year over the Kyoto period than was previously expected. However, expected growth in the sector has been revised up significantly as a result of higher expected gas consumption for LNG production. This has led to the projection of 2020 emissions being 8 Mt CO₂-e higher than in the previous projection.

Overall, in the Kyoto period, projected higher emissions in the electricity subsector are offset by lower direct combustion emissions. While in 2020, emissions from both subsectors are projected to be higher.

Appendix D – Methodology

Two modellers (ACIL Tasman and SKM-MMA) were engaged to undertake general equilibrium modelling of the stationary energy sector in 2010.

Each modeller was provided with historical emissions data as well as descriptions of, and where possible energy savings from, policies and measures and then used independent models to project emissions from the electricity and direct combustion subsectors.

SKM-MMA used their electricity market model, *Strategist*, in conjunction with their renewable energy model *REMMA*, gas market model *MMAGas* and a model of energy end use by customer class *MOSED* to determine electricity generation, direct use of energy and emissions by fuel.

ACIL Tasman undertook broader economy-wide modelling as well as electricity market and direct combustion modelling in their analysis. Again, four models were used: a gas market model *GasMark*, an economy-wide model *Tasman Global*, electricity market model *PowerMark LT* and a renewable energy model *RECMARK*.

These results were calibrated to the most recent National Greenhouse Gas Inventory data and an average of the results was taken. The result is the best estimate of emissions from the stationary energy sector.

Appendix E – Key Assumptions

Stationary energy emissions are most sensitive to assumptions around economic growth and population growth. These assumptions are detailed in Table 11. Sensitivity analysis was conducted around these assumptions, with variations of:

- an increase/decrease in the economic growth rate of 0.5 percentage points per year in each year of the projections
- an increase/decrease in the population growth rate of 0.1 percentage points per year in each year of the projection period
- an increase/decrease in the autonomous rate of energy efficiency improvement of 0.1 percentage points per year in each year of the projections around the baseline assumption of a 0.5 percentage point per year improvement.

Other assumptions were left to the discretion of individual modelling groups, recognising that a number of variables are inherently uncertain and that variation in these assumptions is valuable in providing a range of potential emissions outcomes.

Table 11 GDP and Population assumptions

	2010 to 2020	2020 to 2030
GDP (average annual percentage growth)	3.0	2.6
Population (average annual percentage growth)	1.4	1.3

Source: Treasury (2010a,c).

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Appendix G – Glossary

<i>Abatement</i>	Refers to emissions reductions made beyond that which would have been achieved in the business as usual scenario.
<i>Baseline</i>	Emissions given current policy settings.
<i>Business as usual (BAU)</i>	Emissions in the absence of Government abatement policies and measures.
<i>Black coal</i>	Higher ranking types of coal used for steel production as well as electricity generation and with a higher energy density than brown coal.
<i>Brown coal</i>	Lower ranking types of coal used almost exclusively as fuel for electric power generation and with a higher energy density than brown coal.
<i>Capital cost</i>	The upfront cost associated with an investment.
<i>Direct combustion subsector</i>	Emissions associated with fuels combusted to generate energy used directly to generate mainly heat or steam. Includes fuels used for energy industries such as petroleum refining and the manufacture of solid fuels, fuels used in manufacturing and construction industries such as steel furnaces and chemicals, and fuels used in the commercial and residential sectors for purposes such as gas heating, on-site diesel generation and farm machinery.
<i>Fuel mix</i>	The proportional contribution of each fuel type (coal, gas etc) to the overall level of energy use.
<i>Electricity generation subsector</i>	Emissions from the combustion of fuels to generate electricity.
<i>GDP</i>	Gross domestic product
<i>GWh</i>	Gigawatt hour
<i>High scenario</i>	A ‘high emissions’ scenario applying plausible high emission assumptions to the ‘baseline’ scenario.
<i>Kyoto period</i>	The 5 year Kyoto Protocol reporting period, 2008–2012.
<i>Kyoto period average (KPA)</i>	The Kyoto period average refers to the average of emissions over the 5 year Kyoto Protocol reporting period, 2008–2012.
<i>Low scenario</i>	A ‘low emissions’ scenario applying plausible low emission assumptions to the ‘baseline scenario’.
<i>LRET</i>	Large-scale Renewable Energy Target
<i>LNG</i>	Liquefied natural gas
<i>PEFO</i>	Pre-election Economic and Fiscal Outlook
<i>Marginal cost</i>	The cost of producing or consuming an extra unit of fuel.
<i>Measures</i>	Refers to past, current or committed Australian, State/Territory or local government policy actions that have an impact on greenhouse gas emissions, causing them to deviate from the BAU path after the base

	year of 1990.
<i>Mt CO₂-e</i>	Mega tonnes of carbon dioxide equivalence.
<i>MWh</i>	Megawatt hour
<i>NEM</i>	National Electricity Market
<i>NGGI</i>	National Greenhouse Gas Inventory
<i>RET</i>	Renewable Energy Target
<i>REC</i>	Renewable Energy Certificate
<i>Sent out</i>	The volume of electricity distributed to the network after generator efficiency losses and own electricity use has been accounted for.
<i>SRES</i>	Small-scale Renewable Energy Scheme
<i>Stationary energy sector</i>	Includes the generation of electricity and the combustion of fuels for purposes other than transport.
<i>TWh</i>	Terawatt hour