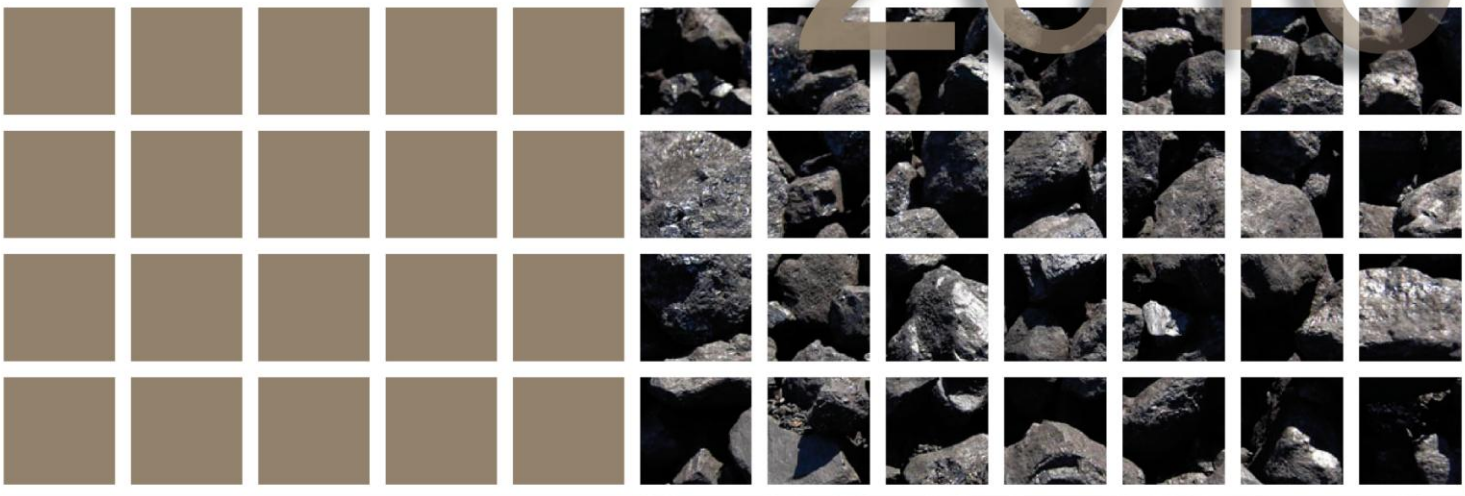
Australian Government

Department of Climate Change
and Energy Efficiency

Fugitive

emissions projections

2010



Published by the Department of Climate Change and Energy Efficiency

ISBN: 978-1-921299-24-7

An appropriate citation for this report is:
Department of Climate Change and Energy Efficiency 2010, Fugitive emissions projections (2010), DCCEE, Canberra, ACT.

This document is available on the Internet at the following address:
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December 2010

Australian Government
Department of Climate Change
and Energy Efficiency

Fugitive

emissions projections

Executive Summary

Key Points

- Fugitive emissions from fuels (the fugitives sector) accounted for around 7 per cent of Australia's total domestic emissions in 2009 at 39 Mt CO_2-e.
- Baseline fugitive emissions are projected to average 43 Mt CO_2-e per year in the Kyoto period (2008-2012), 46 per cent above 1990 levels. In 2020, fugitive emissions are projected to be 69 Mt CO_2-e, 97 per cent higher than in 2000.
- Fugitive emissions from coal mining account for the largest proportion of emissions in the sector, averaging 31 Mt CO_2-e per year over the Kyoto period and 48 Mt CO_2-e in 2020.
- Emissions from oil and gas extraction are expected to average 11 Mt CO_2-e per year over the Kyoto period and 21 Mt CO_2-e in 2020.
- Indicative baseline modelling suggests fugitive emissions will be around 83 Mt CO_2-e in 2030.

Baseline projection

- Greenhouse gas emissions from the fugitives sector are projected to average 43 Mt CO_2-e per year over the Kyoto period (2008–2012[1]), 46 per cent above 1990 levels.
- Fugitive sector emissions are projected to increase by 76 per cent (around 7 per cent per year) to 69 Mt CO_2-e between 2009 and 2020 as strong growth in international demand for Australia's energy resources continue to drive development of coal mines and oil and gas fields.

Table 1 Baseline fugitive emissions, Kyoto period average and 2020

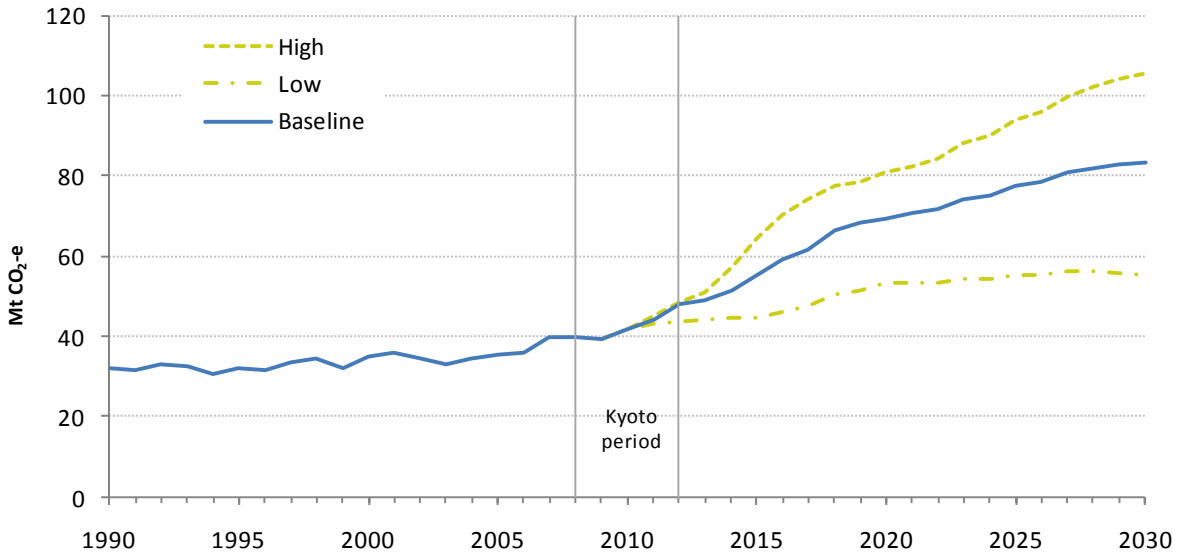
	1990	2000	Kyoto period average 2008–12		2020	
	Mt CO_2-e	Mt CO_2-e	Mt CO_2-e	Increase on 1990 (%)	Mt CO_2-e	Increase on 2000 (%)
Coal production	16	23	31	92	48	113
Oil and gas	13	13	11	-12	21	68
Total	**29**	**35**	**43**	**46**	**69**	**97**

Note: totals may not add due to rounding. Source: pitt&sherry 2009, WoodMackenzie 2010, DCCEE analysis.

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

- Fugitive emissions from oil and gas extraction are expected to continue to account for a smaller but growing portion of fugitive emissions in 2020 (at 31 per cent). Rapid development of oil and gas projects in northern Australia is projected to drive emissions growth of around 9 per cent per year from 2009 to 2020, faster than that in coal.

Figure 1 Baseline fugitive emissions, 1990 to 2030



Source: pitt&sherry 2009, WoodMackenzie 2010, DCCEE analysis.

- Fugitive emissions from coal mining are also projected to grow rapidly from 2009 (at around 6 per cent per year) to be 48 Mt CO_2-e in 2020. Development of new coal mines in response to significant export demand as well as a shift away from surface to underground mines is driving this growth in emissions.
- By 2030, total fugitive emissions are projected to be 83 Mt CO_2-e, with coal fugitives accounting for 59 Mt CO_2-e and oil and gas fugitives contributing 24 Mt CO_2-e.

Business-as-usual projection

- The business-as-usual projection indicates that without existing policies and measures, fugitive emissions are projected to have averaged around 47 Mt CO_2-e per year over the Kyoto Period, and 74 Mt CO_2-e in 2020.
- Policies and measures to reduce emissions in the fugitives sector involve abatement of gases released when fossil fuel deposits are exploited (supply side measures). These include flaring (which converts methane to carbon dioxide and water) and combustion of waste coal mine methane to generate electricity resulting in carbon dioxide emissions.

Impact of measures

- Since 2000, six policies and measures have been implemented to reduce emissions in the fugitives sector:

  - Greenhouse Challenge program
  - Greenhouse Friendly program
  - Clean Energy Initiative – Carbon capture and storage flagships
  - NSW Clean Coal Fund
  - Low Emissions Technology Demonstration Fund
  - Greenhouse Gas Abatement Program

- Some measures contribute directly to abatement in the sector, while others are aimed at research and development of new technologies with future abatement potential. In total, these measures are estimated to contribute to around 5 Mt CO_2-e per year of abatement over the Kyoto period and in 2020. For more details, see Appendix A.

- These projections assume the Gorgon LNG project is developed with carbon capture and storage, reducing the potential emissions from production by around 2.7 Mt CO_2-e per year. The Australian Government has provided some funding to the project proponents Chevron, Shell and ExxonMobil to assist with trialling the sequestration technology aimed at reducing fugitive emissions from LNG extraction.

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. Methodology improvements to the estimation of fugitive emissions from coal have been incorporated, see Appendix C for further details.

- Over the Kyoto period, annual emissions from the fugitive sector are projected to average 3 Mt CO_2-e higher than the previous projection. Projected emissions from the sector in 2020 have been revised up by 9 Mt CO_2-e.

- Emissions from coal production are projected to average 3 Mt CO_2-e per year higher in the Kyoto period than estimated in the previous projection. In 2020, the coal fugitive emissions projection is 9 Mt CO_2-e higher than in the previous projection. These revisions are driven by higher coal production forecasts in response to strong international demand for coal and the availability of mine-specific emissions factors as reported under the *National Greenhouse and Energy Reporting Act 2007*.

- Projected average annual emissions from oil and gas extraction are 1 Mt CO_2-e lower than the previous projection over the Kyoto period and in 2020.

Contents

Figures

Tables

Introduction

This paper presents projections of greenhouse gas emissions from the Australian fugitive sector (fugitive emissions from fuels) and forms part of the 2010 emissions projections update.

The 2010 fugitive sector projection is a combination of a full update of the 2009 coal fugitive projection and a minor update of the 2009 oil and gas fugitive projection. It reflects new information regarding coal production forecasts and emissions, the timing of oil and gas projects and specific greenhouse gas abatement projects.

The coal fugitive model has been fully redeveloped in 2010 and incorporates new methodologies including for mine-specific emissions factors, production and emissions forecasting to 2020 (see Appendix C).

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

Fugitive emissions cover emissions of greenhouse gases associated with the production, processing, storage, transmission and distribution of fossil fuels such as coal, oil and natural gas. The sector also includes emissions from decommissioned (abandoned) underground coal mines.

The fugitive sector does not include emissions arising from combustion of fuel for energy purposes (accounted for in the stationary energy sector), combustion of fuel for transportation (accounted for in the transport sector), or emissions from the decomposition of organic waste in landfills (accounted for in the waste sector).

For the first time, production and emissions from the production of brown coal have been included in the projections due to improved data availability. This has had only a small effect on projected emissions but has resulted in significantly higher coal production than in previous projections. This is because production of brown coal typically has a low level of fugitive emissions associated with its extraction.

For the purposes of fugitive emissions measurement and projections, a distinction is made between waste coal mine methane and coal seam methane.

- Coal seam methane, which is deliberately extracted from coal seams with the objective of using it as a fossil fuel (combusting it for energy generation; injecting it into

conventional natural gas pipelines for distribution and combustion) is included in the oil and gas subsector.

- Waste coal mine methane, which is captured as a byproduct of coal mining is included in the coal subsector.

The capture (and combustion) of waste coal mine methane is considered to be an abatement measure as it would otherwise be a byproduct of the mining process, while combustion of coal seam methane is not as it is deliberately extracted for use as a fossil fuel and may be unrelated to coal mining itself.

Greenhouse gases arising in the fugitive sector include methane (CH_4), carbon dioxide (CO_2) and nitrous oxide (N_2O) (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 (CO_2-e), where the emission of each gas is converted to CO_2-e according to its global warming potential.

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

Recent trends – National Greenhouse Gas Inventory

The latest *National Greenhouse Gas Inventory (June quarter 2010)* (NGGI) estimates total fugitive sector emissions for 2009 at 39 Mt CO_2-e, accounting for around 7 per cent of Australia's total emissions. Almost three-quarters of emissions in this sector (29 Mt CO_2-e) are associated with coal mining, handling and decommissioned mines, with the remaining 11 Mt CO_2-e arising from production, processing and distribution of oil and natural gas.

Between 1990 and 1999, emissions in the sector remained relatively stable at around 32 Mt CO_2-e. However, since 2000 emissions have grown by nearly 25 per cent, an average of 2.7 per cent a year. Growing emissions have been the result of increased volumes of coal production. In addition, while production has increasingly come from surface mines (which have lower emissions on average than underground mines), increasing emissions intensity of underground coal production has more than offset this and has contributed to further increases in fugitive emissions from coal mines.

Oil and gas fugitive emissions have been falling on average in line with improvement in gas distribution infrastructure and lower emissions from flaring as more efficient processes and technologies are developed to limit the need to flare.

Emissions from decommissioned mines continue to increase on average, however the nature of these emissions results in significant variation from year to year.

Projections results

The projection of fugitive emissions shows rapid growth in the sector from 2010 onwards. From 2009 to 2020, emissions growth is projected to be around 7 per cent per year on average, around four times the historical average of 1.7 per cent.

Over the Kyoto period, fugitive emissions from fuels are projected to average 43 Mt CO_2-e per year, 46 per cent above the 1990 level. The increase is attributable to growth in coal production and emissions, with emissions from the oil and gas subsector 12 per cent lower than in 1990. By 2020, emissions from the sector are projected to increase to 69 Mt CO_2-e, more than double the emissions level in 2000. Both the coal and the oil and gas subsector contribute to the increase.

Indicative modelling suggests that fugitive emissions will be around 83 Mt CO_2-e in 2030.

Table 3 Emissions from the fugitives sector, Mt CO_2-e

	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 (%)
Coal production	16	23	31	92	48	113
Oil and gas	13	13	11	-12	21	68
Total	**29**	**35**	**43**	**46**	**69**	**97**

Note: totals may not add due to rounding. Source: pitt&sherry 2009, WoodMackenzie 2010, DCCEE analysis.

Trends in the fugitive projections

Over the period to 2020, fugitive emissions are projected to grow more rapidly than in the two previous decades. Increasing export demand for Australia's energy commodities is contributing to rapid expansion in both the coal and oil and gas subsectors resulting in new developments and projected higher emissions.

Australia is currently the world's largest exporter of metallurgical coal and second-largest thermal coal exporter and is expected to remain a major source of world coal supplies to at least 2030. Australia is also projected to play an increasingly important role in supplying world LNG markets to 2020. The International Energy Agency's *World Energy Outlook 2010* projects world coal demand will grow by 30 per cent between 2008 and 2020, while demand for gas will increase by 22 per cent over the same period.

Growth in domestic demand for energy commodities, by contrast, is projected to be slow compared with both historical rates and global demand growth. For example, between 2000 and 2010, domestic demand for coal grew by around 10 per cent in response to higher coal use for electricity generation and increasing combustion of coal for heat and steam. From 2010 to 2020, however, domestic demand growth is projected to slow to 2 per cent as most of

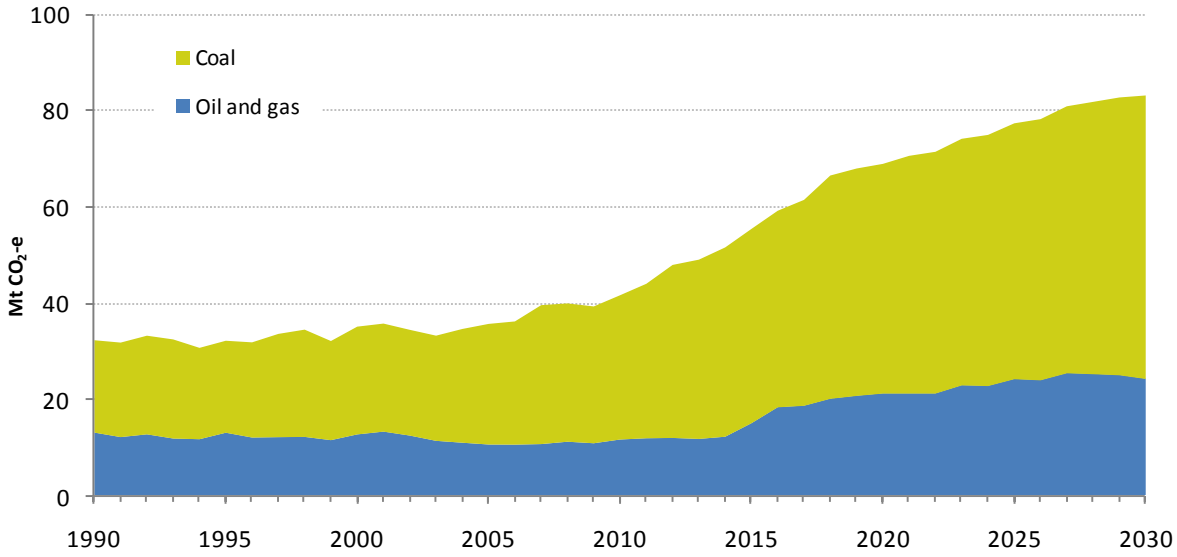
the increase in demand for electricity is met from renewable sources (see stationary energy for more details), before recovering to 22 per cent between 2020 and 2030.

Only around 10 per cent of production growth from new coal mines and expansions is expected to be consumed in Australia.

In the coal subsector, emissions have increased steadily since 1990 to be 29 Mt CO_2-e in 2009. Increasing demand for coal has resulted in new mine development over the period and emissions have similarly risen. Over the Kyoto period, coal fugitive emissions are projected to average 31 Mt CO_2-e per year, more than 90 per cent higher than in 1990.

This trend is expected to continue with more than fifty new mines and expansions to existing mines currently in the planning or development stages. Emissions from the coal subsector are projected to increase by a further 60 per cent between 2010 and 2020, to reach 48 Mt CO_2-e. This is 97 per cent above 2000 emissions, making coal sector emissions the fastest growing of all sectors since 2000.

Figure 2 Baseline fugitive emissions trends, 1990 to 2030



Source: pitt&sherry 2009, WoodMackenzie 2010, DCCEE analysis.

Emissions in the oil and gas subsector have remained relatively flat since 1990 despite rising production. Improvements in gas distribution infrastructure have reduced leakage and emissions from flaring have declined. Over the Kyoto period, emissions are projected to average 11 Mt CO_2-e per year, 12 per cent lower than in 1990. This trend is expected to change in the projections period as LNG (liquefied natural gas) production increases.

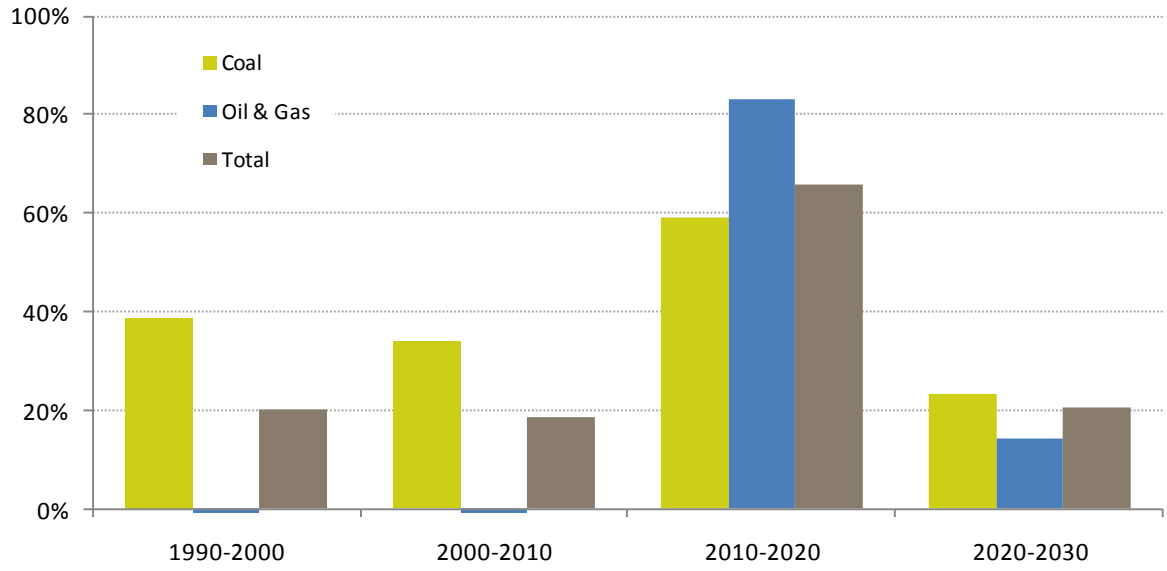
A number of new liquid natural gas (LNG) trains and other conventional gas projects are currently under development. In addition, production from unconventional gas projects such as coal seam gas and tight gas[2] is expected to increase. Overall, emissions from the oil and

[2] Tight gas is natural gas which is difficult to access because of the nature of the rock and sand surrounding the deposit, requiring high energy prices to make it financially viable.

gas subsector are projected to increase by more than 80 per cent between 2010 and 2020, to 21 Mt CO_2-e.

While unconventional gas projects are expected to contribute to the increase in production between 2010 and 2020, the impact of these projects on emissions is expected to be small compared with new LNG projects. Conventional extraction processes result in substantial quantities of emissions from venting CO_2 and entrained methane during acid gas stripping and flaring. Conversely, unconventional projects that produce LNG from coal seam gas are expected to produce very few emissions. Because coal seam gas has a very low CO_2 content, production of LNG from some fields may not require acid gas stripping, a major source of fugitive emissions. While these projects may have significant energy requirements for extracting the gas, resulting in higher direct combustion emissions, fugitive emissions associated with LNG production from coal seam gas are projected to be low.

Figure 3 Growth in coal and oil and gas emissions, 1990 to 2030



Source: pitt&sherry 2009, WoodMackenzie 2010, DCCEE analysis.

In the period 2010 to 2020, emissions from oil and gas are projected to increase for the first time since 1990 (figure 3) and to grow more rapidly than emissions from the coal subsector. Despite the rapid growth in oil and gas fugitives, these emissions are still expected to account for around only 30 per cent of total fugitive emissions in 2020 (figure 4). This is up from 23 per cent in 2014, but illustrates the large volume and growth in emissions from coal.

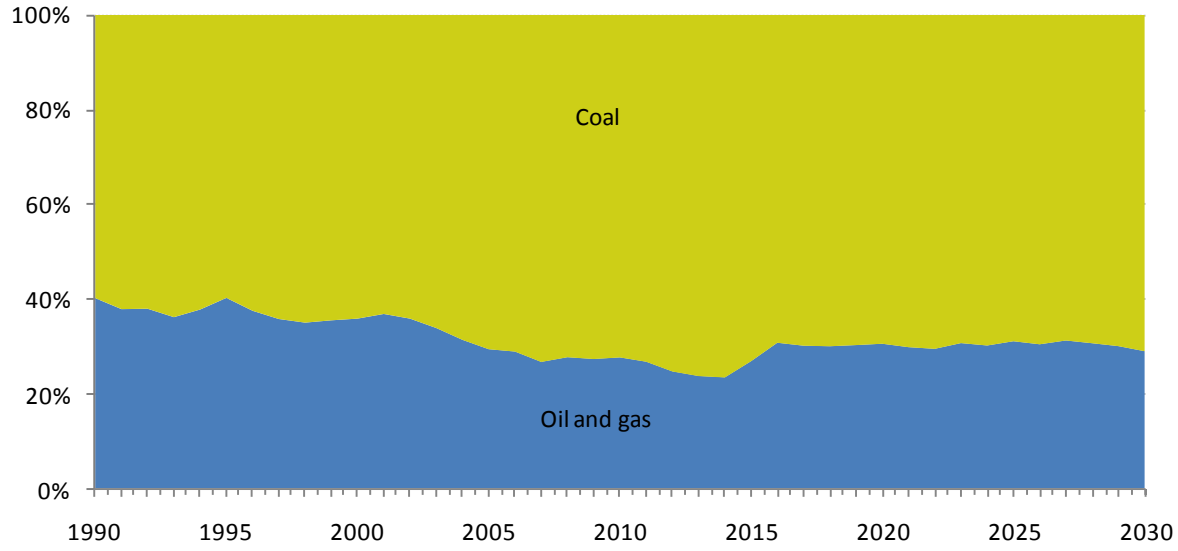
Table 4 Fugitive emissions, 1990 to 2030, Mt CO_2-e

	1990	2009	KPA	2020	2030
Coal production	16	29	31	48	59
Oil and gas	13	11	11	21	24
Total	**29**	**39**	**43**	**69**	**83**

Note: totals may not add due to rounding. Source: pitt&sherry 2009, WoodMackenzie 2010, DCCEE analysis.

The combined growth in coal and oil and gas subsectors results in total emissions growth in the fugitives sector of 76 per cent between 2009 and 2020. In 2020, fugitive emissions are projected to be 69 Mt CO_2-e, 110 per cent higher than in 2000.

Figure 4 Subsectoral trends, 1990 to 2030, share of total fugitive emissions



Source: pitt&sherry 2009, WoodMackenzie 2010, DCCEE analysis.

Between 2020 and 2030, fugitive emissions are projected to grow by a further 22 per cent or 15 Mt CO_2-e, with both coal and oil and gas subsectors contributing to higher emissions.

Main drivers of sectoral activity

Emissions in the fugitives sector are determined by the level of production of coal, oil and natural gas, and the emissions intensity of that production.

Production levels are driven by both export and domestic demand for these fuels; however export demand is by far the strongest driver of projected growth between 2010 and 2030. Demand is influenced by factors such as domestic and world economic growth, relative fuel prices (coal, oil, nuclear, renewables etc), the substitutability of various fuels, and national energy policies. For the purposes of this projection, a number of assumptions have been made:

- The Australian economy and the economies of Australia's main trading partners will continue to grow at recent historical average rates to 2030.
- Australia's coal, oil and natural gas supplies will retain their current competitiveness against other fuel sources in the baseline scenario.

The projections are also sensitive to assumptions regarding the timing and type of new project developments. Of the 44 new coal mines forecast to commence production between 2010 and 2020, 19 are expected to be underground mines and 25 to be surface mines. If more new production comes from surface mines and less from underground mines than assumed here, emissions would be expected to be lower than the current projection indicates.

Similarly, oil and gas developments are dominated by conventional LNG projects, which have high emissions overall, however some new LNG projects from unconventional sources (that produce fewer emissions) such as coal seam gas is forecast to contribute to increasing production also. Specific emissions intensities of new oil and gas developments will depend on the CO_2 content of the field in which the project is located. See Appendix D for further details.

These projections have also been developed on the basis of current policies in place regarding carbon pricing both in Australia and internationally. They illustrate expectations of Australia's fugitive emissions in the absence of a domestic carbon price.

The Australian Government has reiterated its intention to introduce a carbon price in Australia to reduce emissions and meet its 2020 targets. These projections assume current levels of global policy action on climate change. Consistent with the domestic policy assumptions, they do not include additional global action, such as actions to implement all of the Copenhagen Accord pledges.

International policy settings also affect Australian coal production because of the high proportion of coal exported. With global action on climate change consistent with commitments made in the Copenhagen Accord, demand for Australia's coal would be lower than these projections assume, while demand for gas is likely to be higher. It is uncertain to what extent these factors would offset each other.

The projections will be updated as domestic and international climate change policies evolve.

Business-as-usual scenario and measures estimates

Since 2000, six policies and measures have been implemented to reduce emissions in the fugitives sector:

- Greenhouse Challenge program
- Greenhouse Friendly program
- Clean Energy Initiative – Carbon capture and storage flagships
- NSW Clean Coal Fund
- Low Emissions Technology Demonstration Fund
- Greenhouse Gas Abatement Program

Some measures contribute directly to abatement in the sector, while others are aimed at research and development of new technologies with future abatement potential. In total, these measures contribute to around 5 Mt CO_2-e of abatement over the Kyoto period and in 2020. For more details, see Appendix A.

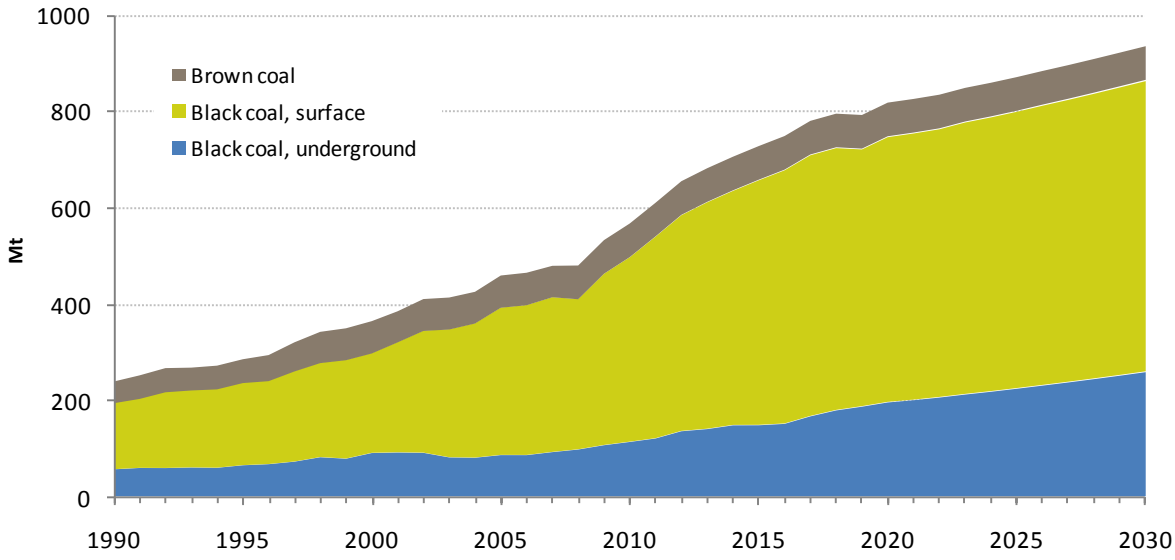
Coal

The coal fugitives subsector projection reflects a full update of the model. In 2010 the coal fugitive emissions model was redeveloped to enable more in-depth analysis of emissions by mine classification, region and status.

Emissions from coal mining depend both on the overall level of coal production and the level of production from underground emissions-intensive mines. Growth in emissions has also been moderated by the impact of a number of measures (see Appendix A for details). Since the introduction of the *National Greenhouse and Energy Reporting Act 2007*, the availability of mine-specific emissions factors has increased, rendering previous delineation of Class A "gassy" mines and Class B less "gassy" mines largely redundant.

From 2009 to 2020, the projection relies on mine-specific production data for both black and brown coal mines combined with basin-specific emissions factors to forecast emissions at a mine level. The total projection is the sum of these individual mine emissions projections. From 2021 to 2030, projections are based on trend analysis, as mine-specific data is considered to be less robust. These projections are done at the aggregate surface and underground mine levels.

Figure 5 Run-of-mine coal production, 1990 to 2030



Source: WoodMackenzie 2010, DCCEE Analysis.

The analysis presented for the coal fugitives subsector focuses mainly on emissions and production of black coal given its role in driving emissions and the declining importance over time of brown coal production and emissions. While brown coal accounts for 70 Mt (9 per cent) of total Australian coal production in 2020 its contribution to emissions is small (around 0.1 Mt CO_2-e or less than 1 per cent) in that year.

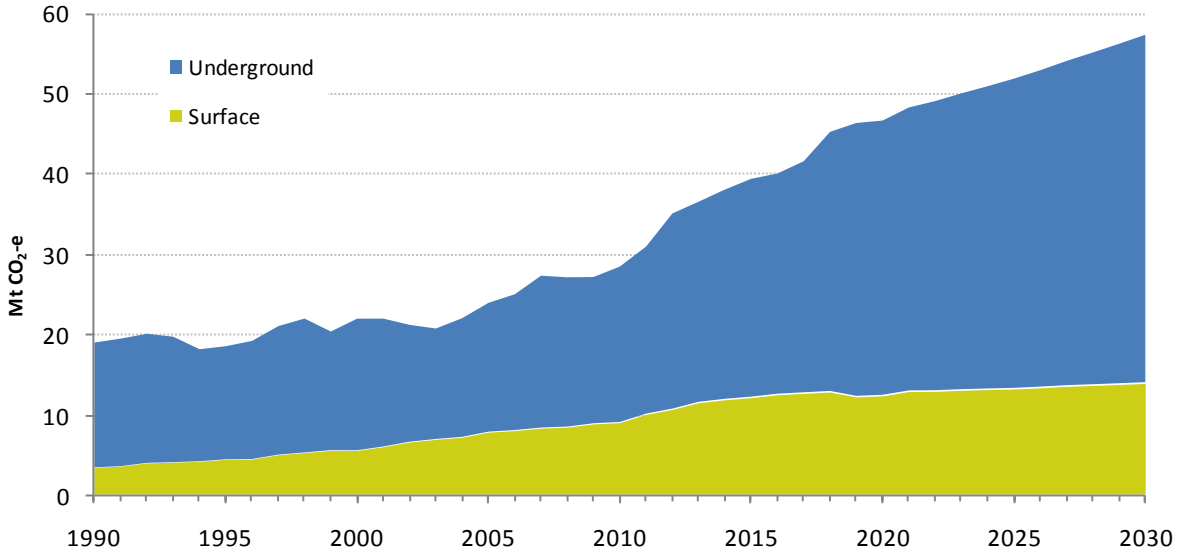
Fugitive emissions from the black coal sector are presented from underground mines and from surface mines, where underground mines are gassier than surface and therefore contribute most to both overall emissions and to growth in emissions.

Trends in the coal projections

Fugitive emissions from coal are projected to average 31 Mt CO_2-e per year over the Kyoto period, 92 per cent higher than in 1990. Emissions are projected be 48 Mt CO_2-e in 2020, 54 per cent higher than over the Kyoto period and 113 per cent above 2000 levels.

Production and emissions from coal production are projected to continue to increase as a result of continuing strong export demand for Australia's thermal and metallurgical coal. Australia is the world's largest exporter of metallurgical coal and is second only to Indonesia in the thermal coal export market[3]. Australia exports high-quality black coal (both thermal and metallurgical) for use in power generation and steel production. Australia also produces a large amount of brown coal (thermal) for domestic consumption in thermal electricity generation.

Figure 6 Coal production emissions, 1990 to 2030



Source: WoodMackenzie 2010, DCCEE Analysis.

Australia's black coal production is projected to grow at an average rate of 4 per cent per year between 2009 and 2020. Saleable production is expected to increase to more than 565 Mt in 2020, equivalent to nearly 750 Mt of run-of-mine production. Over time, the ratio of saleable production to run-of-mine production is declining as higher quality resources are mined out and lower quality deposits are exploited. This is resulting in increased mined volumes to achieve the same volume of coal sold.

[3] ABARES

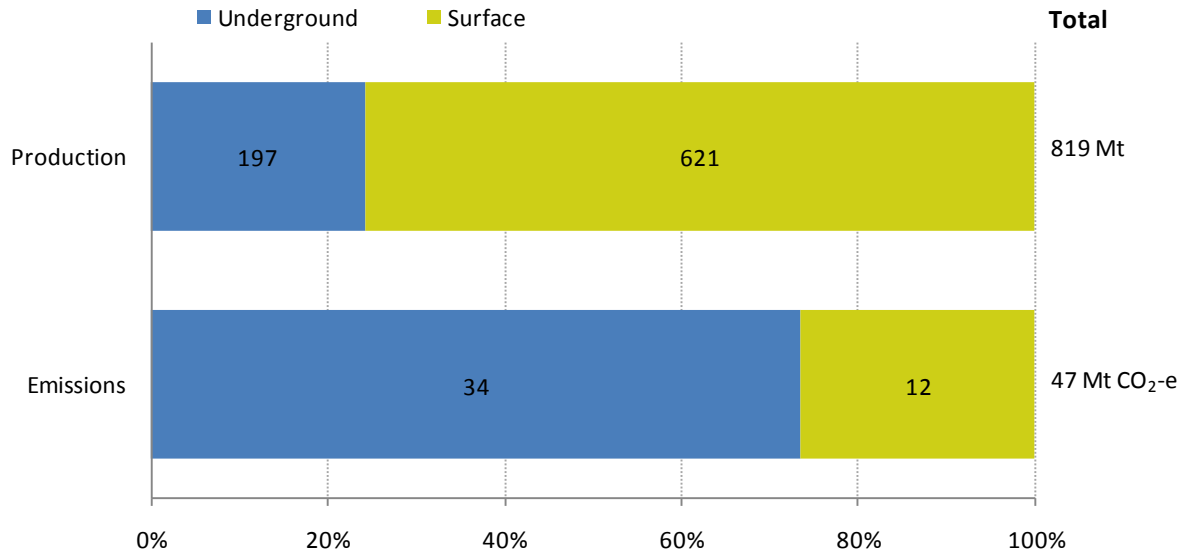
Table 5 Baseline coal fugitive emissions, Kyoto period average and 2020

	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 (%)
Underground	12	16	20	69	34	108
Open cut	3	6	9	179	12	125
Decommissioned	0	1	1	212	1	129
Total	**16**	**22**	**31**	**92**	**48**	**113**

Note: totals may not add due to rounding. Source: WoodMackenzie 2010, DCCEE analysis.

Between 2020 and 2030, black coal production is projected to grow by an average of 1.3 per cent per year. This is broadly consistent with the International Energy Agency's forecasts in the Current Policies scenario presented in the *World Energy Outlook 2010*. Emissions are projected to grow at the faster rate of 2 per cent per year as both mined volumes increase and the proportion of production from underground mines increases, despite declines in the average emissions intensity of coal mining overall.

Figure 7 Production and emissions from underground and surface mines, 2020



Source: WoodMackenzie 2010, DCCEE Analysis.

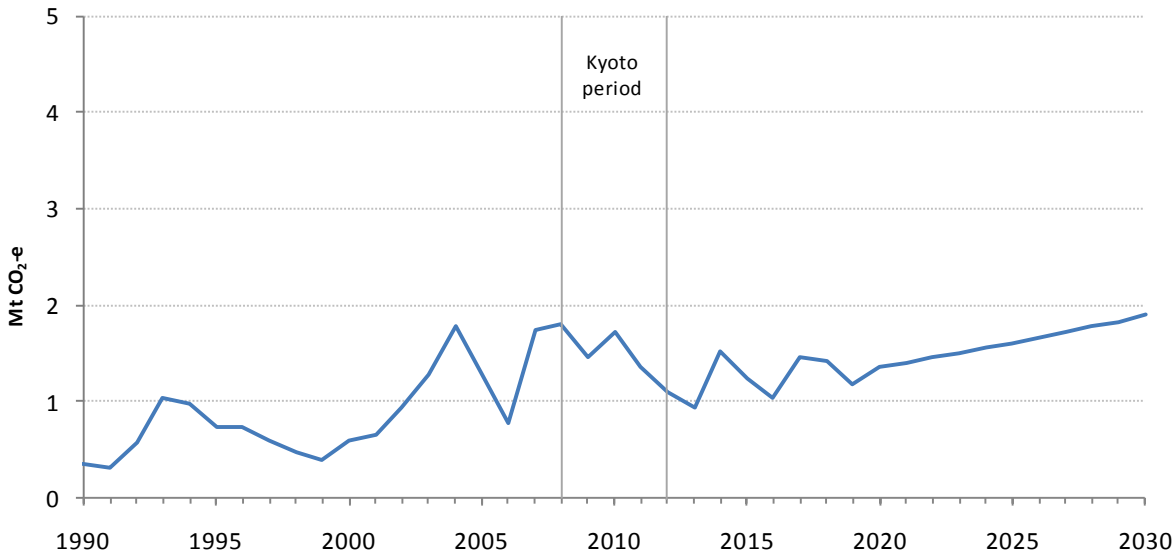
Coal production from the Galilee basin is projected to commence between 2020 and 2030 with two surface mines currently in the planning stages. The emissions intensity of this basin is currently unknown, but based on information about surface mines in currently producing basins, these projects are expected to have low emissions factors and therefore to have relatively little impact on the overall projections results.

While production from underground mines currently accounts for only around 20 per cent of the total, emissions from these mines are significantly higher per tonne of coal production. As a result, around 70 per cent of total coal production emissions come from underground mines.

This proportion is expected to increase over time as coal deposits close to the surface are depleted and producers exploit underground resources to meet demand.

Significant infrastructure expansions in both rail and port capacity indicate the coal industry considers export demand will remain strong. Between 2009 and 2020, Australian port capacities are projected to increase by more than 80 per cent as the Dalrymple Bay expansion is completed, the new Wiggins Island Terminal commences operation, replacing Barney Point and adding capacity at Gladstone, and the NCIG (Newcastle Coal Infrastructure Group) terminal at Newcastle ramps up. Port capacity is expected to increase from around 350 Mt per year currently to more than 630 Mt per year in 2020. Rail capacity is similarly expected to expand, bringing total rail capacity to more than 680 Mt per year by 2020. Available infrastructure and constraints have been incorporated into the overall projections.

Figure 8 Emissions from decommissioned coal mines, 1990 to 2030



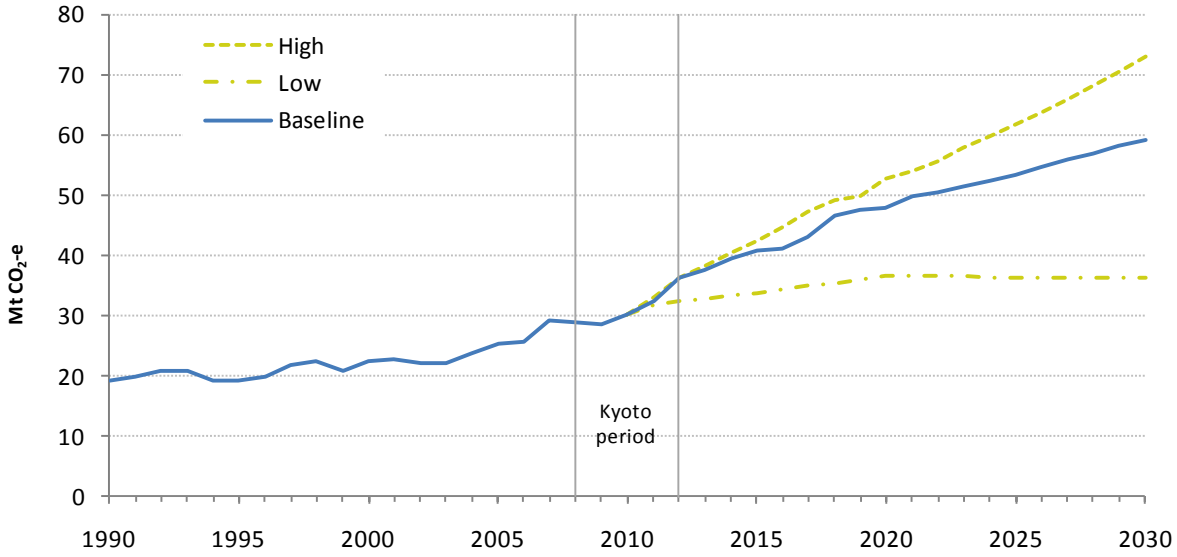
Source: WoodMackenzie 2010, DCCEE analysis.

Emissions from decommissioned underground coal mines are highly dependent on mine closures in particular years and the emissions intensity of mines that are closing. A number of gassy coal mines have closed in the past five years, resulting in peaks in emissions from decommissioned mines. Between 2009 and 2020, around 15 underground coal mines are expected to cease producing, resulting in emissions remaining between 0.5 and 1.5 Mt CO_2-e.

Key uncertainties and sensitivity analysis

As the high and low scenarios indicate (figure 9), uncertainty around coal subsector emissions are weighted to the downside. Emissions results are sensitive to both the aggregate level of production and the source of that production (underground or surface mines).

Figure 9 Coal sensitivities



Source: WoodMackenzie 2010, DCCEE analysis.

There are four main sources of uncertainty in the projections:

- Coal prices
- New mine developments
- Emissions intensity of new mines
- Mine closures

World coal prices are expected to remain above current long-term averages as a result of high global coal demand. Consequently, it is considered new projects currently in the planning stages are more likely to go ahead than not. Nevertheless, if average prices are lower than around $70 per tonne for thermal coal and $100 for metallurgical coal, coal production would be expected to be significantly lower than the current projection. In that case, emissions would similarly be lower.

The low sensitivity is based on the IEA's *World Energy Outlook 2010* projection of Australia's coal production in the New Policies scenario. This is consistent with an expectation that world coal prices would fall were global action on climate change sufficient to meet commitments made in the Copenhagen Accord.

The high scenario assumes Australia's coal production grows more rapidly than currently expected. This is consistent with an expectation that Australia would produce more coal if global economic growth and coal prices were higher than assumed here.

The number and type of mine closures affects emissions from decommissioned mines. If the lives of mines currently projected to close prior to 2020 are extended, the profile of emissions from decommissioned mines will be lower. However, given the small magnitude of emissions from decommissioned mines, this would not be expected to make a material difference to the projection.

Oil and gas

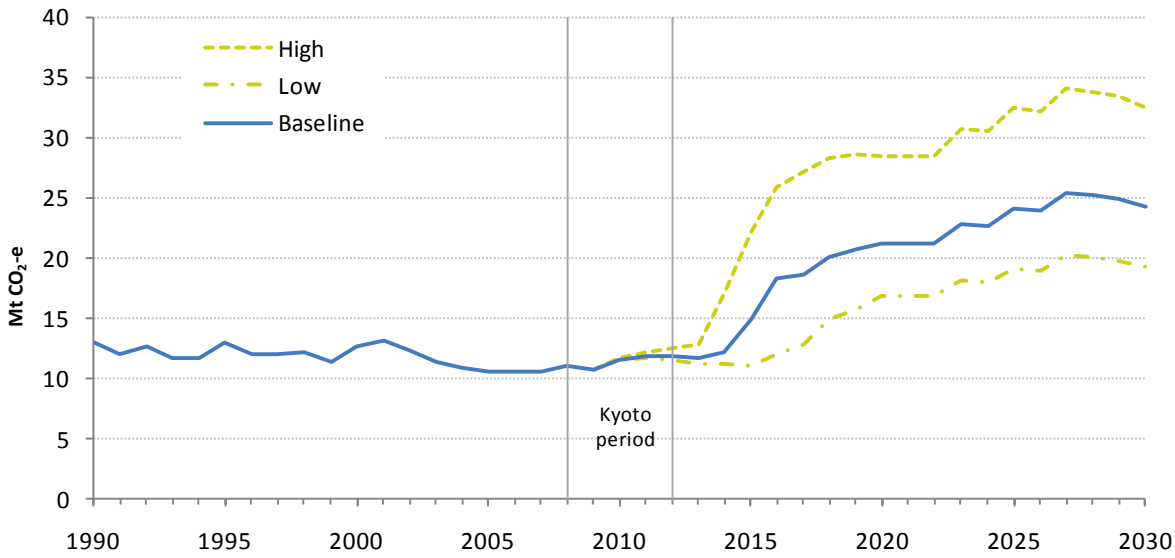
The oil and gas fugitives subsector projection reflects a partial update of modelling done in late 2009. Emissions from oil and gas extraction and processing fall into two main categories: uncontrolled sources from natural gas and oil including leakage, evaporation and accidental releases from distribution systems (such as gas pipelines); and emissions that occur from managed venting and flaring that are part of normal upstream production and processing operations.

Combustion emissions generated when fuel gas is used to power equipment and processes are included in the stationary energy sector so emissions from upstream oil and gas production and processing comprise mainly emissions from venting of carbon dioxide and methane from acid gas stripping, and from flaring.

Trends in the oil and gas projections

Fugitive emissions from oil and gas production are projected to be relatively stable to 2014, rising rapidly thereafter. Significant growth in export demand for LNG has encouraged the development of a number of new gas fields in Australia as well as substantial infrastructure to support exports.

Figure 10 Oil and gas fugitive emissions, 1990 to 2030



Source: pitt&sherry 2009, DCCEE analysis.

Over the Kyoto period, oil and gas fugitives are projected to average 11 Mt CO_2-e, 12 per cent, or 2 Mt CO_2-e, lower than in 1990, despite rising oil and gas production levels. This reflects improvements in gas distribution and a reduction in emissions from flaring. While some level of flaring is unavoidable, lower flaring emissions reflect improving technologies and efforts by producers to maximise financial returns and minimise environmental impacts from production by flaring as little as possible.

In the period 2009 to 2020, emissions are projected to grow by 96 per cent, to 21 Mt CO_2-e. New LNG projects including (but not limited to) Gorgon, Wheatstone and the Pluto expansion, driven by increasing global demand and gas prices are the main reason for this increase.

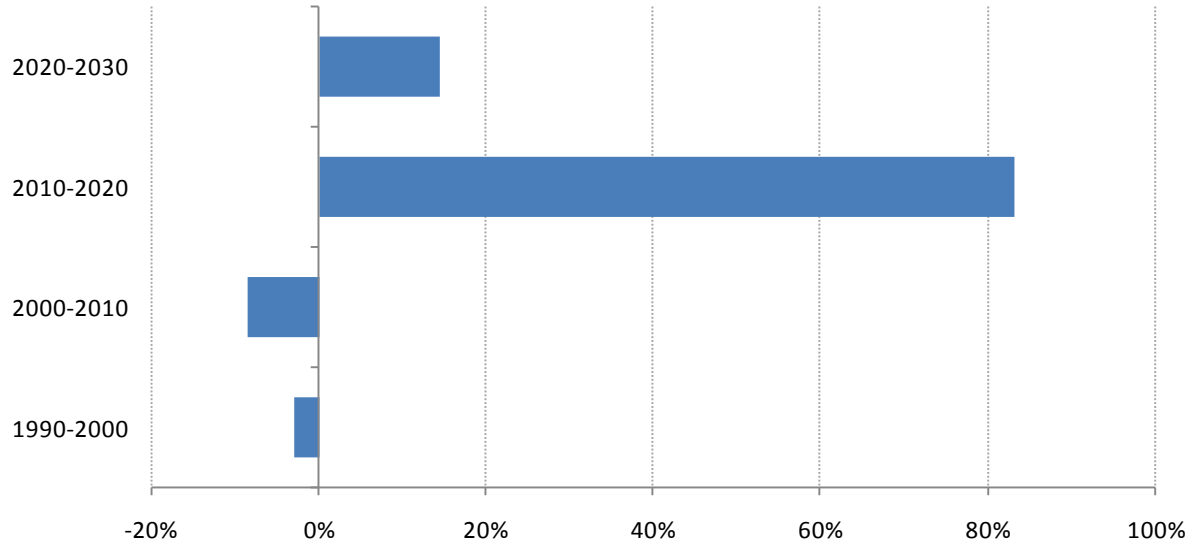
Table 6 Baseline oil and gas fugitive emissions Kyoto period average and 2020

	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 (%)
Natural Gas (leakage)	4	3	3	-20	3	22
Oil	0.5	0.5	0.4	-11	0.4	-34
Venting and flaring	8	9	8	-8	17	88
Total	**13**	**13**	**11**	**-12**	**21**	**68**

Note: totals may not add due to rounding. Source: pitt&sherry 2009, DCCEE analysis.

International Energy Agency projections indicate world gas demand will increase by around 1.6 per cent per year between 2008 and 2035 in the Current Policies scenario of the *World Energy Outlook 2010*. In line with this demand, the IEA projects Australia's natural gas production will grow by more than 4 per cent annually to 2035.

Figure 11 Oil and gas fugitive emissions growth, 1990 to 2020



Source: pitt&sherry 2009, DCCEE analysis.

Emissions projections presented here are based on an expectation that LNG will make up the largest proportion of the growth in production required to satisfy export demand. As a result, emissions are projected to rise at a faster rate than total natural gas production. Between 2020 and 2030, emissions growth is projected to slow but remain above historical levels.

As new discoveries and technologies are developed, unconventional gas sources and processing methods are beginning to emerge. For example in Queensland a number of

projects aiming to convert coal seam gas (CSG or CSM) from the Bowen and Surat basis to LNG are in the planning and development stages. With plans to export the LNG from the port of Gladstone, coal seam gas production is projected to be a fast growing industry but to remain a small contributor to total production to 2030.

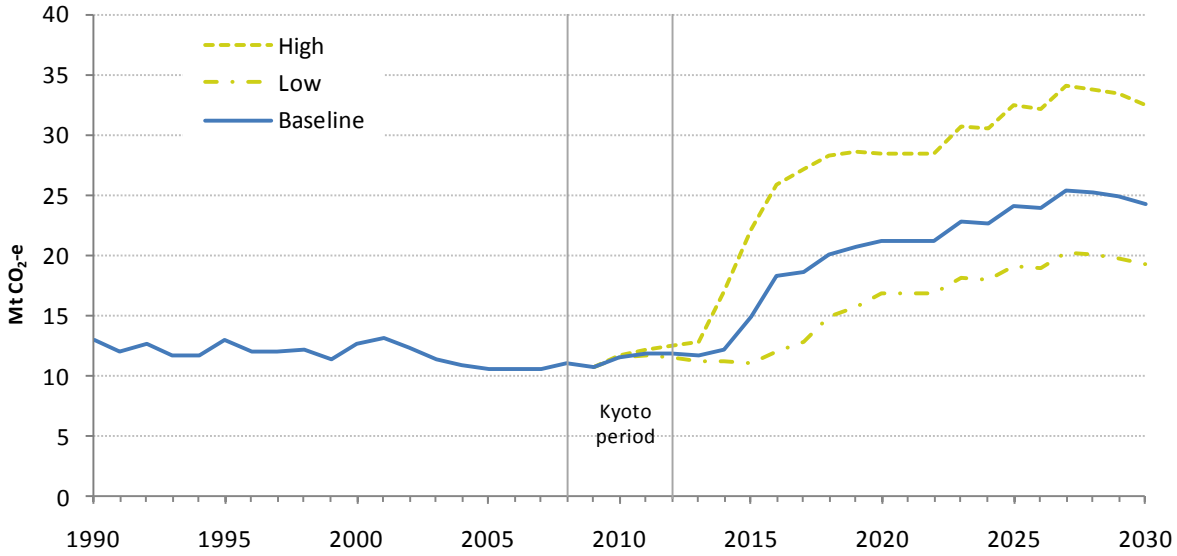
Crude oil production in Australia is expected to decline over the projections period as Australian oil fields mature and deplete, resulting in falling emissions from oil production. However, this decline will not be sufficient to offset emissions associated with the rapid development of natural gas production.

Key uncertainties and sensitivity analysis

The risks to oil and gas subsector emissions are weighted to the upside. Current projections are based on assumptions that commissioning of around five new LNG projects, including Gorgon will commence between 2013 and 2018. There is potential for as many as nine new projects or additional trains to commence production in this period.

Demand for LNG produced from these new developments is driven by exports demand from Asia. If world demand for LNG is stronger than currently projected, fugitive emissions from the sector may be higher as projects are developed more quickly. Conversely, if world demand for LNG is lower and world gas prices fall, fugitive emissions from oil and gas developments would also be expected to be below current expectations.

Figure 12 Oil and gas sensitivities



Source: pitt&sherry 2009, DCCEE analysis.

These projections assume the Gorgon LNG project is developed with carbon capture and storage, reducing the potential emissions from production by around 2.7 Mt CO_2-e per year. The Australian Government has provided some funding to the project proponents Chevron, Shell and ExxonMobil to assist with trialling the sequestration technology aimed at reducing fugitive emissions from LNG extraction.

Appendix A – Measures

Table 7 Greenhouse gas abatement from fugitive measures

Name	Kyoto period average (Mt CO_2-e)	2020 (Mt CO_2-e)
Clean Energy Initiative – Carbon capture and storage flagships	ne	ne
Greenhouse Gas Abatement Program (GGAP)	2.12	2.17
Greenhouse Friendly	0.09	0.02
Greenhouse Challenge	2.71	2.60
Low Emissions Technology Demonstration Fund	<1	0
NSW Clean Coal Fund	ne	ne
Total	**4.85**	**4.8**

Note: totals may not add due to rounding. ne – not estimated. Source: DCCEE analysis.

Clean Energy Initiative – Carbon capture and storage flagships

The $1.9 billion CCS Flagships Program will 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.

Insufficient information is available at this time to enable direct abatement from the program (of fugitive emissions) to be measured. This will be reviewed once details of projects are finalised. Some abatement from this program occurs in the stationary energy sector.

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.

Greenhouse Friendly

The Greenhouse Friendly program certified carbon-neutral products and services and approving abatement credits for sale on the voluntary market

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.

Low Emissions Technology Demonstration Fund (LETDF)

The objective of the LETDF is to demonstrate the commercial potential of new energy technologies or processes or the application of overseas technologies or processes to Australian circumstances to deliver long-term large-scale greenhouse gas emission reductions. The projects focus on the development of solar energy, innovative technologies for reducing emissions from the combustion of coal and the capture and storage of carbon dioxide emissions.

NSW Clean Coal Fund

The NSW clean coal fund provides $100 million to fund research, demonstration and commercialisation of clean coal technologies, and to increase public awareness of the importance of reducing greenhouse gas emissions through clean coal technologies. The program aims to reduce greenhouse gas emissions, encourage research and development, promote industry development and demonstrate technologies for adoption by the private sector.

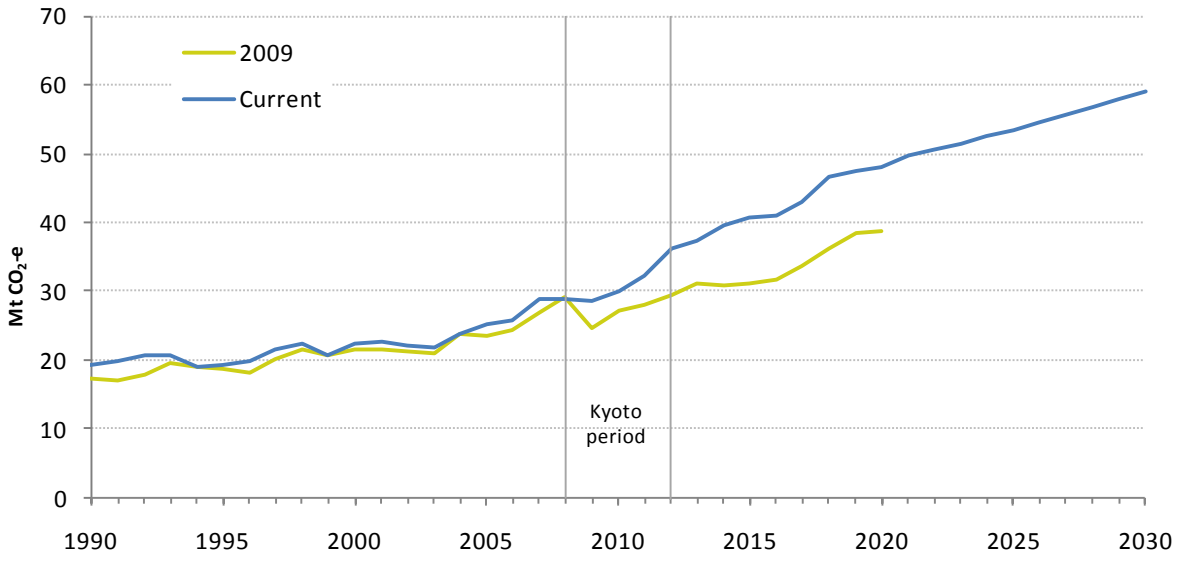
As a research and development program, direct abatement from this program is not measurable.

Appendix B – Changes from 2009 projection

In 2010, the coal fugitives projection model has been redeveloped. The model now projects fugitive emissions from solid fuels using mine-specific emissions factors and production forecasts. Emissions from different types of mines are identifiable separately. Emissions from brown coal mines are now also incorporated despite their low emissions intensity. The model is fully consistent with NGGI data however there has been a substantial upward revision in emissions since the 2009 projections for a number of reasons:

- Higher expected production, combined with higher emissions intensity of coal mining on average has resulted in an upward revision in coal fugitive emissions of around 9 Mt CO_2-e in 2020. Production forecasts have been revised up mainly as a result of a faster recovery in global demand following the financial crisis and a return to normal operation at a number of mines in Queensland following cyclones early in 2010. The projection is consistent with production forecasts from WoodMackenzie and ABARES.
- Around 5 Mt CO_2-e of the total increase is due to higher production forecasts, with a further 5 Mt CO_2-e attributable to a slower decline in emissions intensities than was expected in the previous projection. However a smaller proportion of production in 2020 is expected to come from underground mines than was the case in the previous projection, which reduces the expected increase in emissions by 1 Mt CO_2-e.
- The results reflect more complete data sets as well as new information obtained during the year that has allowed what are considered more accurate forecasts to be developed.

Figure 13 Coal fugitive emissions, comparison with 2009 projection



Source: WoodMackenzie 2010, DCCEE analysis.

The oil and gas projection is 1 Mt CO_2-e lower over the Kyoto period and in 2020. This is the result of updated NGGI data.

Appendix C – Methodology

From 2009 to 2020, the projection relies on mine-specific production data based on Wood Mackenzie's Coal Supply Service forecasts, which is consistent with ABARES' most recent coal production forecasts to 2014-15. This is combined with mine-specific emissions factors to project emissions at a mine level. The total projection is the sum of these individual mine emissions projections.

In addition, following the incorporation of data collected under the *National Greenhouse and Energy Reporting Act 2007* in the NGGI for 2008, mine-specific emissions factors have become available for a much larger proportion of mines. These mine-specific emissions factors have been combined with the Wood Mackenzie production data to project emissions at the mine level.

The oil and gas sector was modelled by pitt&sherry in late 2009. A partial update has been undertaken to ensure the projections are consistent with the most recent NGGI data and project information.

Appendix D – Key Assumptions

World thermal coal prices are assumed to average above $65 per tonne over the projections period and metallurgical coal prices above $100 per tonne in line with strong world demand for energy resources and consistent with ABARES forecasts published in *Australian Commodities*, March Qtr 2010. World gas prices are assumed to average $8 per gigajoule over the period in line with pitt&sherry, *Projected Fugitive Emissions from Oil and Gas, 2010-2020,* 2009.

Table 9 provides an indication of the assumptions regarding the profile of new mines commencing production between 2010 and 2020.

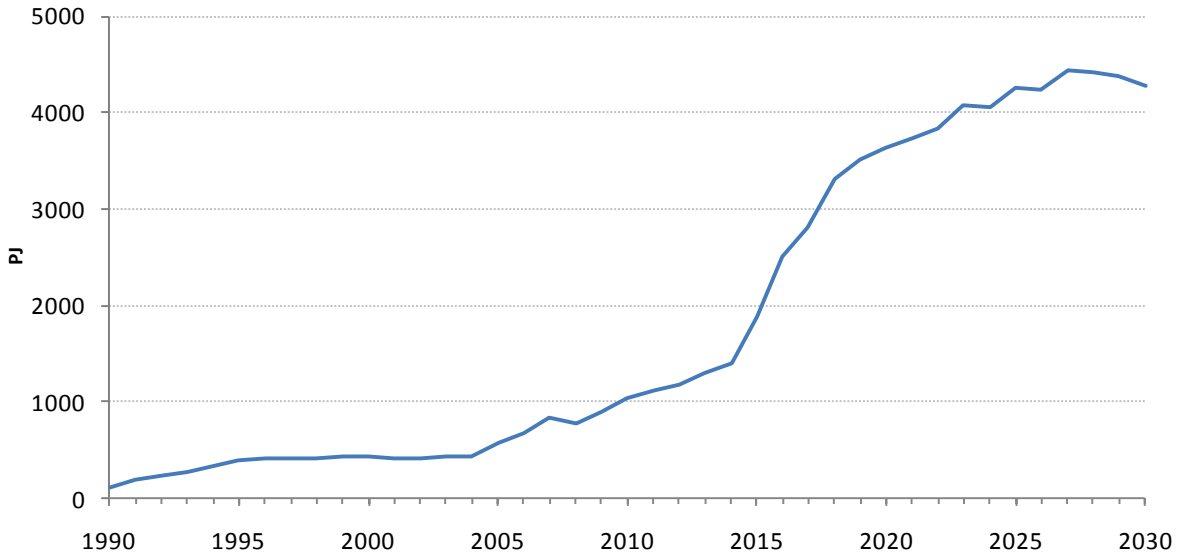
Table 8 Run-of-mine coal production, 2010, 1015 and 2020, Mt

	2010	2015	2020
Black coal - underground	115	150	200
Black coal - surface	385	510	550
Brown coal	70	70	70
Total	**570**	**730**	**820**

Source: Wood Mackenzie Coal Supply Service Ltd (2010), DCCEE analysis.

Three oil and gas projections were developed by pitt&sherry in 2009: a high, best, and low estimate of production and emissions. The oil and gas fugitive projection is based on the average of the best and low scenarios, leading to the production forecast shown below.

Figure 14 LNG production, 1990 to 2030



Source: pitt&sherry 2009, DCCEE analysis.

CSG is assumed to account for around 15 per cent of LNG production by 2020 and 20 per cent by 2025. The remaining production is assumed to come from conventional sources.

Appendix E – References

Australian Bureau of Agricultural and Resource Economics 2009, *Australian Energy Statistics – Australian Energy Update 2009,* Canberra.

Australian Bureau of Agricultural and Resource Economics 2010a, *Australian commodities – March quarter 2010*, Canberra

Australian Bureau of Agricultural and Resource Economics 2010b, *Australian commodities – September quarter 2010*, Canberra

Australian Government 2010, *Australian National Greenhouse Accounts: Quarterly Update of Australia's National Greenhouse Gas Inventory June Quarter 2010*, Department of Climate Change and Energy Efficiency, Canberra.

pitt&sherry 2009, *Projected fugitive emissions from oil and gas*, November

International Energy Agency 2010, *World Energy Outlook 2010*, IEA Publications, Paris, November.

WoodMackenzie 2010, Coal Supply Service.

Appendix F – Glossary

ABARES	An Australian Government economic and scientific research agency Australian Bureau of Agricultural and Resource Economics and Sciences.
Brown coal	Lower ranking types of coal used almost exclusively as fuel for electric power generation and with a very low energy density
Black coal	Higher ranking types of coal used for steel production as well as electricity generation and with a higher energy density than brown coal
Coal seam gas (CSG)	A form of natural gas deliberately extracted from coal beds and used as an energy source
Coal seam methane	The methane extracted as part of coal seam gas
Decommissioned mines	Abandoned underground mines whose economically viable coal resources have been exhausted
Fugitive	Uncontrolled or escaping to the air In this context as a result of mining or other extraction activities
IEA	International Energy Agency
LNG	Liquefied natural gas
Metallurgical coal	Coal suitable for making steel; includes coking coal and PCI coal
Run-of-mine production	Total volume (tonnage) of coal extracted from a mine prior to cleaning and classification
Saleable production	Amount (tonnage) of coal extracted that can be sold after cleaning and classification
Thermal coal	Coal used as fuel for electric power generation. It is also referred to as steaming coal
Tight gas	Natural gas which is difficult to access because of the nature of the rock and sand surrounding the deposit, requiring high energy prices to make it financially viable
Waste coal mine methane	Methane which is a byproduct of coal mining Coal seam methane that is not deliberately extracted for energy production but occurs as a waste product from coal mining