Flyers Creek Wind Farm Pty Ltd

Flyers Creek WIND FARM

Environmental Assessment

CHAPTER 15
Greenhouse Gas Assessment

15. Greenhouse Issues

This chapter of the Environmental Assessment addresses the importance of greenhouse gas emissions reduction generally and the role of the Flyers Creek Wind Farm project in Australia's efforts to curtail the emissions intensity of electricity generation.

15.1 Climate change science and greenhouse gas emissions

The issue of anthropogenic greenhouse gas emissions and their contribution to climate change has attracted significant global attention over recent times. Predicted future changes in climate are indicated to have significant physical, environmental, social and economic consequences for future generations over the 21st century. Accordingly, considerable global effort has been directed to assessing the nature and severity of such outcomes.

Fundamental to the understanding of the linkages between greenhouse gas emissions and climate change is an understanding of climate processes. The United Nation's Intergovernmental Panel on Climate Change (IPCC), established by the World Meteorological Organisation (WMO) and the United Nations Environment Programme (UNEP) in 1988, has provided the most comprehensive forum in relation to the issue and has brought together the findings of many leading scientists from around the world. Its main objective is to assess scientific, technical and socio-economic information relevant to the understanding of human induced climate change, potential impacts of climate change and options for mitigation and adaptation.

The IPCC has completed four assessment reports with a fifth assessment due for release in 2013-2014. They contain developed methodology and guidelines for preparation of national greenhouse gas inventories, special reports and technical papers. The Fourth Assessment Report findings were released during 2007, comprising the efforts of three separate working groups (WG 1 to WG 3).

In February 2007 as the first part of the Fourth Assessment Report process, the IPCC released the first in a series of documents, produced by WG1 and entitled, "*Summary for Policy Makers – Climate Change 2007: The Physical Science Basis*". Several key findings of the summary document are listed below in an abbreviated form. The summary and the WG 1 report from which the summary was derived are available via the internet at: www.ipcc.ch.

Human and natural drivers of climate change

- Global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values
- Carbon dioxide is the most important anthropogenic greenhouse gas and global increases in carbon dioxide concentration are due primarily to fossil fuel use and land-use change
- The global atmospheric concentration of carbon dioxide has increased from a pre-industrial level of about 280 ppm to 388.3 ppm in 2010.
- The annual carbon dioxide concentration growth-rate was larger during the ten year period from 2000 to 2010 when the average was 1.9 ppm per year than it has been since the beginning of direct atmospheric measurements (the 1960 to 2010 average was 1.4 ppm per year)
- Annual global fossil carbon dioxide emissions increased from an average of 6.4 Gt Carbon (23.5 Gt CO_2) per year in the 1990s to 7.2 Gt Carbon (26.4 Gt CO_2) per year in 2000-2005.
- The report indicates there is 'very high confidence' that the global average net effect of human activities since 1750 has been one of warming, with a radiative forcing of +1.6 (+0.6 to +2.4) W/m^2
- The carbon dioxide 'Radiative Forcing' increased by 20% between 1995 and 2005, the largest change for any decade in at least the last 200 years. 'Radiative Forcing' is a measure of the influence that a factor has in altering the balance of incoming and outgoing energy in the Earth-atmosphere system and is an index of the importance of the factor as a potential climate change mechanism. Positive forcing tends to warm the earth's surface.

Direct observations of recent climate change include the following

- Warming of the climate system is unequivocal
- January 2000 to December 2009 was the warmest decade in the modern scientific instrumental record of global surface temperature (since 1880)
- Observations since 1961 show that the average temperature of the global ocean has increased to depths of at least 3,000 metres and that the ocean has been absorbing more than 80% of the heat added to the climate system
- Global average sea level rose at an average rate of 1.7 mm per year over the 20th Century. The rate was faster over the period from 1993 to 2010, increasing at an average of 3.2 mm per year. There are uncertainties in the rate of sea level rise but high confidence that the rate of sea level rise has increased from the 19th to 20th century.

Understanding and attributing climate change

- The report stated that most of the observed increase in globally averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic gas concentrations. This is a strengthening of the position reported in the Third Assessment Report (IPCC, 2001). Discernible human influences now extend to other aspects of climate, including ocean warming, ocean acidification, continental-average temperatures, temperature extremes and wind patterns.
- Volcanic and anthropogenic aerosols have offset some warming that would have otherwise have taken place.

Projections of future changes in climate

1. For the next two decades a warming of about 0.20°C per decade is projected for a range of emission scenarios
2. Continued greenhouse gas emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would very likely be larger than those observed during the 20th century
3. Anthropogenic warming and sea level rise would continue for centuries due to time-scales associated with climate processes and feedbacks, even if greenhouse gas concentrations were to be stabilised. The magnitude of the climate carbon cycle feedback is uncertain but model studies suggest that to stabilise at 450 ppm carbon dioxide could require that cumulative global emissions over the 21st century be reduced from an average of approximately 670 Gt Carbon to approximately 490 Gt Carbon (about 30% reduction).

The above points provide a brief summary of selected findings of the IPCC forum. The IPCC findings represent a consensus opinion of a wide range of scientific specialists. While a degree of uncertainty is associated with the various predictions (as indicated in the IPCC document) the estimates could still under represent the full climate change consequences and government regulatory policy needs to allow for potential variation in the actual outcomes.

15.2 Level of global greenhouse emissions

Globally, annual greenhouse gas emissions have risen by 30% since 1990. The volume of carbon in the atmosphere is currently about 1,158 Gt and is projected to continue to increase substantially over the next 50 to 100 years. The increase in atmospheric carbon over time is primarily due to combustion of fossil fuels, coal, oil and gas (about 5,000 Gt carbon is estimated to be contained in the remaining reserves of these fuels) and to a lesser extent to the reduction in the earth’s biomass that temporarily stores carbon. Global actions have been initiated to address both of these contributions to the increased atmospheric carbon dioxide levels.

The increase in emissions corresponds to a progressive measured increase in atmospheric carbon dioxide currently about 388.3 ppm (2010 level), up from the pre-industrial level of about 280 ppm.

The World Resources Institute (WRI) has estimated that about 61% of global greenhouse emissions in 2000 came from energy use (WRI, 2006 in CSIRO, 2006).

While the magnitude and consequences of the future climate changes arising from greenhouse gas emissions are difficult to predict and are subject to ongoing review and debate, there has been a significant global response to the issue. Concerns over changes to climate patterns, more erratic weather conditions and biodiversity impacts and predicted longer term consequences have led to development of measures such as the Kyoto Protocol and emissions trading schemes.

There was a significant global response to the greenhouse and climate change issue with all but two of the Kyoto signatory countries ratifying the protocol. In December 2007, the new Australian Federal Government reversed the policy of the previous government, and also ratified the Protocol, leaving the United States as the only developed country not to have done so.

Increased global focus on the climate change issues and consequently response by governments has been influenced by recent events such as:

- Implementation of the Kyoto Protocol in 2007 following ratification by the countries responsible for 55% of the Annex 1 total emissions
- The IPCC's Fourth Assessment Reports, 2007
- Al Gore's film, '*An Inconvenient Truth*'
- Media reporting of extreme weather events and changes to weather patterns
- The Stern Report in 2006 indicating the economic consequences of inaction
- Development of emissions trading and carbon pricing schemes
- The Copenhagen Accord 2009, signalled that a concerted global effort to address climate change is possible

The above examples, amongst others, are causing State and Federal governments to more closely monitor the issues and further explore suitable responses including emissions mitigation, adaptation to climate change and economic restructuring.

15.3 Australia's greenhouse gas emissions and the government response

Australia's greenhouse gas emissions per unit of GDP are the fifth highest of any OECD country and among the highest in the world. It has been estimated that Australia contributed 0.6% of world's greenhouse emissions in 2005. In terms of greenhouse gas emissions per capita, Australia is ranked sixth (in 2006), at around 26.0 tonnes CO_2-e[1] per capita. The average amongst developed countries is 14.1 tonnes CO_2-e per capita well below Australia's contribution. Australia's per capita greenhouse gas emissions in 2009/2010 are indicated to be about 24.2 tonnes CO_2-e per person (a 1.8 tonne decrease from the 2006 estimation).

Australia's greenhouse gas emissions arise from a variety of sources and Figure 15.1 shows the contribution of the respective sectors of the Australian economy to total greenhouse gas emissions. It clearly indicates that 'stationary energy' accounts for the largest part of the total greenhouse gas emissions (approximately 53.9% in 2010 (Department of Climate Change and Energy Efficiency, 2010)). The largest sectoral growth in greenhouse gas emissions over the 1990 to 2010 period, of 95.2 Mt CO_2-e occurred in the stationary energy sector, which was driven in part by increasing population, household incomes and export increases from the resources sector.

[1] CO_2-e – tonnes of carbon dioxide equivalent

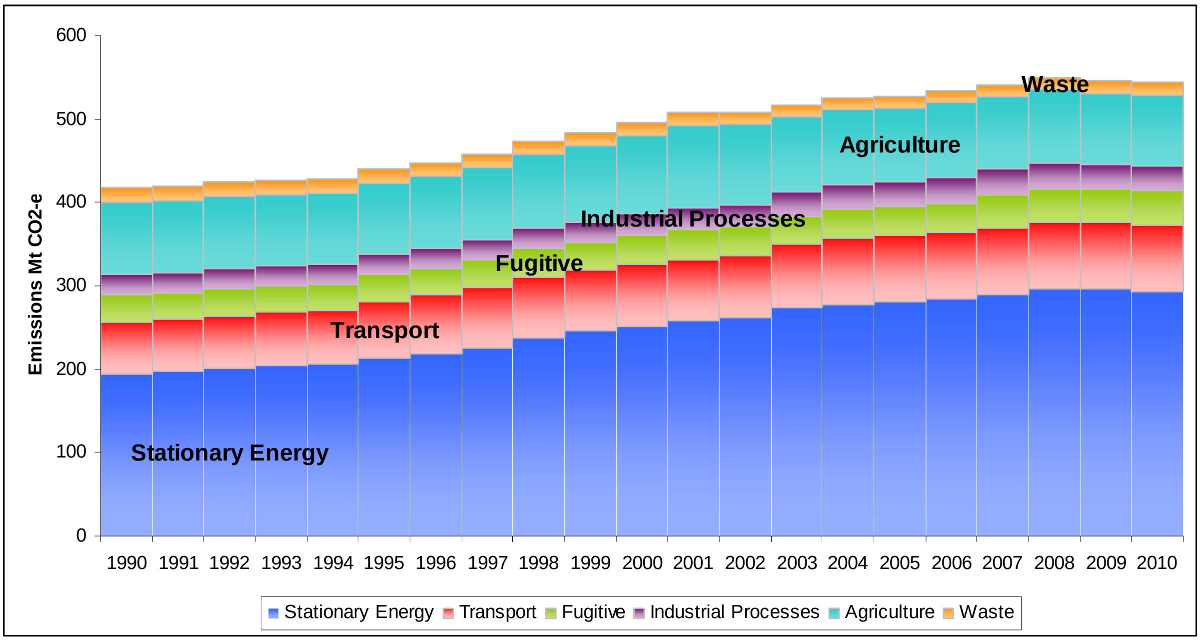

Figure 15.1 – Net CO_2-e emissions by sector, 1990-2010 (Source: DECC&EE, 2010)

The predicted changes in the levels of Australia's greenhouse gas emissions for respective contributory sectors from 1990 to the Kyoto Protocol target period of 2008 to 2012 are shown in Figure 15.2. The proportion of emissions from the stationary energy sector can be seen to be significantly increasing and has risen to approximately 51% above 1990 levels in 2010. Of the 51% increase, 70% is attributed to coal combustion, 21% to gas combustion and 9% to oil combustion.

The combined emissions of all other sectors has decreased as shown in Figure 15.2. However, of these other sectors, the transport sector has been the second greatest contributor to Australia's greenhouse gas emissions. The overall increase in Australia's greenhouse gas emissions would have been much greater if not for the significant abatement achieved through changed land use practices. However, as the change to land use practices is considered a once off abatement, if stationary energy emissions continue to grow at recent rates then Australia's target of 108% of 1990 emissions could be exceeded during the 2008 to 2012 period. Recent projections calculated in August 2009 by the Department of Climate Change show that Australia remains on track to meet its Kyoto obligations.

Electricity generation contributes a large part of the stationary energy emissions and in 2010 accounted for 69% of stationary energy emissions and represented 37% of total national emissions. Moreover, emissions from electricity generation increased by 50% between 1990 and 2010 (Department of Climate Change and Energy Efficiency, 2010) With continued growth in consumption and reliance on fossil fuelled electricity generation Australia's greenhouse gas emissions could rise further contrary to objectives to curtail global emissions growth.

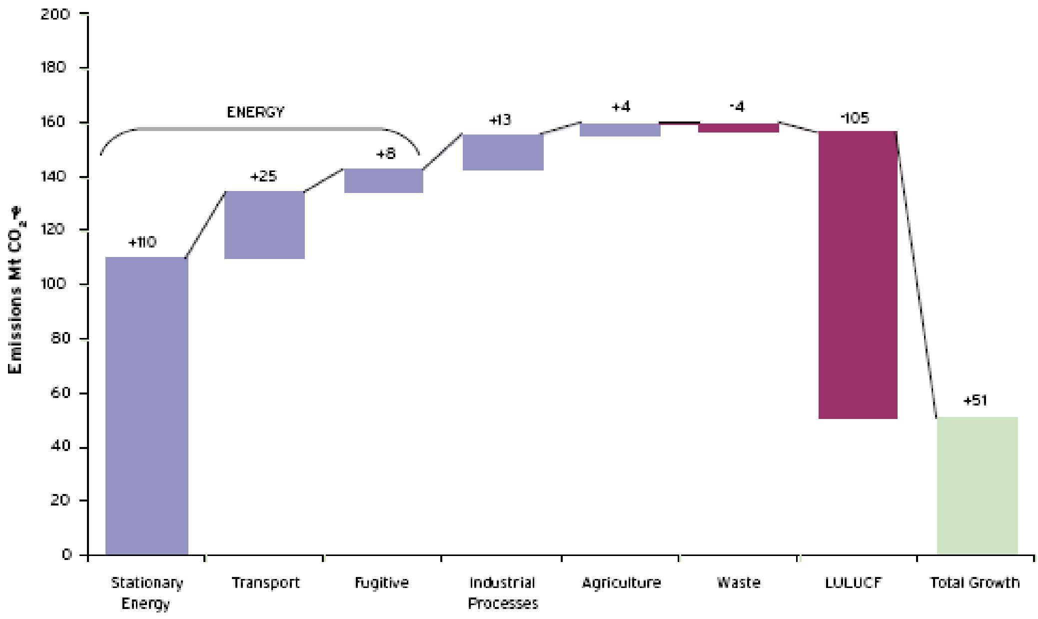

Figure 15.2 – Predicted changes in emissions from 1990 to the Kyoto Protocol target period of 2008–12 (Source: DECC, 2009)[2]

The Electricity Supply Industry's large contribution to Australia's greenhouse gas emissions means that it provides a key opportunity for significant emission reductions. The development of large scale renewable energy projects offers a means to reduce the carbon intensity of electricity generation. Wind and biomass fuelled generation both provide commercially available renewable energy technologies. Solar and geothermal technologies are also receiving significant attention for future deployment. However, solar energy is significantly more expensive than wind energy and geothermal 'hot rocks' technology has yet to be proven at commercial scale.

The Federal and State governments are exploring suitable responses including emissions mitigation, adaptation to climate change and economic restructuring. Such measures need to make significant progress in responding to the identified issues while recognising the need to maintain an efficient and productive economy that supports Australia's future.

Following a change in the Federal Government in late 2007, Australia ratified the Kyoto Protocol in December 2007. The Australia Government has expressed its commitment to achieving the internationally agreed emissions target and has set a long-term emissions target of reducing greenhouse gas emissions by 60% below 2000 levels by 2050 (DECC&EE, 2010).

To further support the achievement of emission targets, the Rudd Government proposed a "Carbon Pollution Reduction Scheme", (CPRS) which had been planned for implementation after the end of the current commitment period of the Kyoto Protocol. The Rudd Government was unable to gain the support to introduce the CPRS and alternative strategies and timeframes for introduction of market mechanisms are currently being considered by the Gillard Government. Regardless of the mechanisms, there will essentially be a transformation of the national energy industry, driven by commercial instruments that effectively set an annual limit and/or price on carbon emissions. While wind farm projects will not be directly impacted by requirements to obtain carbon pollution permits, other electricity generators that are fossil fuel based are likely to be impacted. Such carbon pricing measures can potentially improve the viability of renewable energy projects and their competitiveness with traditional forms of generation.

[2] Land use, land-use change and forestry (LULUCF) refers to emissions and removals of greenhouse gases resulting from direct human-induced land use, land-use change and forestry activities.

Other Federal Government measures in place to support emissions reduction and increased renewable energy generation include the expansion of the Mandatory Renewable Energy Target (RET), investigation of Advanced Electricity Storage Technologies Program and Clean Energy Initiative (CEI) to mention but a few.

From early 2011, the current Renewable Energy Target (RET) Scheme will be separated into the Small-scale Renewable Energy Scheme (SRES) and the Large-scale Renewable Energy Target (LRET) Combined, the LRET and SRES is expected to deliver over 45,000 GWh/year by 2020 and this requirement level will remain through to 2030. The initiative has been estimated to deliver national greenhouse gas emission savings of up to 7.5 Mt/year.

Under the 'Green State' priority, NSW Government has set long term reduction targets of 60% cut in greenhouse emissions by 2050. The Government is committed to becoming carbon neutral and also to achieving 20% renewable energy consumption by 2020. This coincides with the Federal Government's expansion of the Renewable Energy Target from 9,500 GWh/year to 45,000 GWh/year by 2020.

Other initiatives promoted by the New South Wales government include the original introduction of the Green Power scheme and more recently, the NSW Greenhouse Gas Abatement and Energy Efficiency Schemes.

For 2006, the Independent Pricing and Regulatory Tribunal (IPART) have reported that emissions representing 11.6 million tonnes of carbon dioxide equivalent (tonnes CO_2-e) were abated under the NSW GGAS scheme. It also indicated that since the scheme began in 2003 almost 26 million tonnes CO_2-e have been abated under the GGAS scheme.

15.4 Wind energy technology and life cycle analysis of emissions

A life cycle analysis of the emissions arising from a development takes account of the emissions due to manufacture of component parts, construction activities, operations and maintenance and eventual decommissioning and disposal or materials recovery. Wind farm developments have the following life cycle emission characteristics:

- Greenhouse gas emissions for a wind farm on a life-cycle basis are 10 to 15 kg/MWh
- Only about one third of a wind farm's lifetime emissions occur during the operation of the wind farm (Table 15.1). These include auxiliary power from the grid when the wind farm is not generating and emissions associated with vehicles and plant used for operations and maintenance.
- About two thirds of life cycle emissions occur due to the manufacture, delivery and construction of parts that are used to build a wind farm. These emissions are likely to be from steel production, chemical processes, machining and assembly and transportation.
- Emissions from a wind farm are much lower than for most other electricity generating systems
- Where the wind farm displaces other fossil fuel generation systems there will be net savings in greenhouse gas emissions (Section 15.4).

An analysis of the greenhouse gas emissions for component phases of the Flyers Creek Wind Farm project over the project's lifecycle is provided in Table 15.1.

The life cycle analysis was conducted by reference to the Australian Greenhouse Office Emission Factors and Methods Workbook, European Wind Farm life cycle assessments and the typical equipment specifications for the project to determine the carbon dioxide equivalent emissions for each phase of the wind farm's life cycle.

Several assumptions have been made when assessing the life cycle greenhouse gas emissions for the Flyers Creek Wind Farm.

- Flyers Creek Wind Farm will have 44 x 2.5 MW Wind Turbines with an operational life of 20 years and an approximate capacity factor of 35%
- The carbon dioxide balance is the only consideration in the life cycle analysis, no other environmental impacts are considered
- Inputs associated with feeding and accommodating the workforce associated with the wind farm have not been included in this study, as it is assumed that these emissions would have occurred regardless. No extraordinary emissions in this respect are identified.

Table 15.1 - Greenhouse gas emissions for project stages of Flyers Creek Wind Farm

Process	Emissions (tonnes CO_2-e)	% of total
Development planning	5	0.01
Material manufacturing	40,166	68.74
Materials Transportation	396	0.68
Site preparation earthworks	193	0.33
Clearing of vegetation and loss of sink	0	0.00
On-site construction and assembly	20	0.03
Operations & maintenance	17,245	29.51
Decommission, dismantle and remove	411	0.70
TOTAL	**58,436**	**100**

It is noted that while the emissions for component manufacturing, transport and construction are a significant part of the life cycle emissions, that if the wind farm were not built it would still be likely that other new generating plant would be constructed to meet increasing electricity demand. As will be discussed in the next section, the lifetime value of 58,000 tonnes of carbon dioxide emissions is completely offset within the first three months of wind farm operation. After this brief initial period, the wind farm is providing a significant net savings in greenhouse gas emissions.

Overall the emissions during the operations phase of the Flyers Creek Wind Farm are about one third of the project's life cycle emissions and as indicated in Figure 15.3 are low compared to fossil fuelled electricity generation.

15.5 Estimation of greenhouse gas emission savings for the Flyers Creek Wind Farm

Figure 15.3 clearly shows that generation from wind energy is associated with much lower greenhouse gas emissions than the various fossil fuel generation types (coal-fired power stations and combined cycle gas turbines (CCGTs)). Where wind energy displaces generation that uses fossil fuels then a net saving in emissions is achieved.

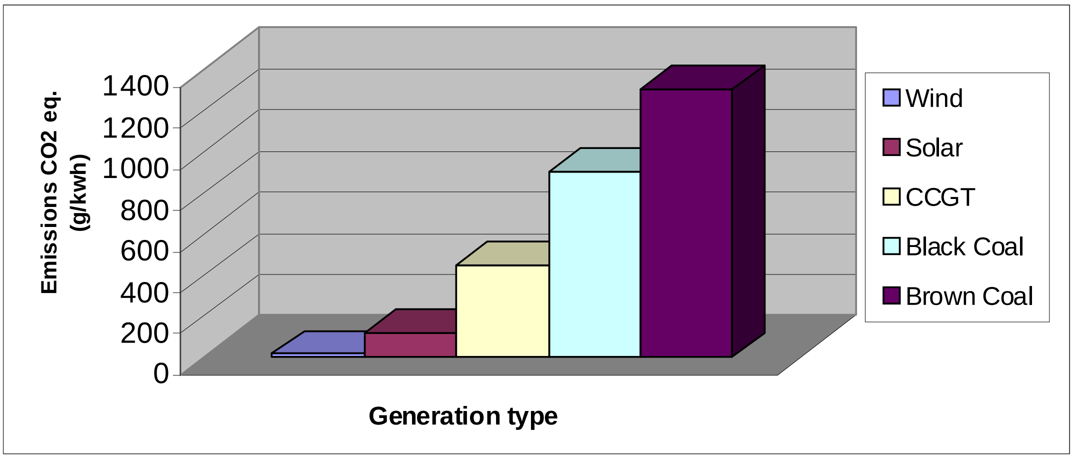

Figure 15.3 – Comparison of greenhouse gas emissions for different generation types (g/kWh CO_2 eq.)

The proposed wind farm will have a nameplate capacity of approximately 110 MW depending on the electrical capacity of the turbine selected. For this assessment, a turbine with 2.5 MW capacity has been used as a representative turbine. Over a full year, annual electricity production of 342 GWh from the wind farm would provide the electrical power output equivalent to the annual consumption of 47,000 households. This has been based on a DECCW (2010) estimate that NSW households use an average 7,300 kWh annually. A larger wind turbine generator could be chosen for the project which would result in increased electricity production and greenhouse gas abatement

Additionally, the generation of electricity by the wind farm will deliver a significant benefit through savings in greenhouse gas emissions relative to fossil fuelled generation. While the wind farm is generating it will displace other electricity generators that compete for supply in the National Energy Market (NEM) as the generation must match supply every second of every day. Where the other generators produce electricity from fossil fuels and their production is fully or partly displaced by the wind farm's output, then there are net savings in the greenhouse gas emissions produced from the NEM's operations. The generators supplying the NEM are predominantly large coal fired power stations and to a lesser extent large hydro and gas fired generators. Queensland, Victoria and NSW have a high proportion of their electricity generation plants powered by burning coal.

Accurately estimating which form of generation will be displaced by a wind farm is not trivial, so to this end the NSW Department of Environment, Climate Change and Water (DECCW) developed an on-line tool to estimate the greenhouse gas emission savings as accurately as possible. The NSW DECCW wind farm greenhouse gas savings tool projected savings of approximately 305,000 tonnes of greenhouse gases per year would be obtained by the Flyers Creek Wind Farm. This is based on the wind farm becoming fully operational during 2013 with 44 x 2.5 MW turbines installed. This abatement is equivalent to removing approximately 70 000 vehicles from Australian roads each year or the planting of 447,000 trees and not harvesting them[3].

Emission savings of up to 305,000 tonnes of greenhouse gases each year represent about 6.1 million tonnes over a 20-year life compared to electricity produced by the NSW 'pool' of generators using a business as usual approach for modelling. On a daily basis, the Flyers Creek Wind Farm could on average offset emissions of up to 836 tonnes CO_2-e/day when operating. As mentioned previously, at this rate, operation of the wind farm will achieve more emissions savings than is involved in the production of the wind farm components, their transport to the site and construction and commissioning in about two months.

The land on which the wind farm is to be constructed is mostly cleared and used for farming and there will be only be very minor clearing of trees necessary to construct this project. Some of the grassland will be converted to access tracks but the net loss of greenhouse gas sink will be insignificant relative

[3] www.greenfleet.com.au

to savings achieved. Measures have been incorporated into the project to protect areas of ecologically significant vegetation and for tree planting at a number of locations, which to some extent offset the minor clearing involved for the site works during the project's construction.

15.6 Summary on project related greenhouse gas emissions

The electricity produced by the proposed Flyers Creek Wind Farm will be fed into the national electricity supply grid to provide a proportion of the community's power needs. Increased generation of electricity using wind energy will inevitably result in greenhouse gas emissions savings from electricity generation.

In respect to greenhouse gas emissions there is significant literature that shows that:

- Wind farms are one of the most benign forms of generation technologies with one of the lowest possible greenhouse gas impacts
- Wind farms have effectively no greenhouse gas emissions which results in significant greenhouse gas emission reductions compared to existing electricity generating plants
- Due to the nature of the wind turbine itself there is little opportunity to make other than very marginal gains in their greenhouse efficiency through changes in construction methods or transportation
- A recent report by the Climate Group has shown wind energy penetration of 17% in South Australia has resulted in a 7.5% reduction in greenhouse gas emissions from stationary electricity generation in that State in 2009 from 2008, on top of a similar reduction from the previous year.

The analysis presented in this Chapter shows that:

- lifecycle greenhouse gas emissions are of the order of 11 kg/MWh
- for the potential 44 turbines, net annual savings in greenhouse gas emissions of 305,000 tonnes/year is estimated to be achieved for the generation of electricity.
- 6.1 million tonnes of greenhouse gas emission savings will be achieved over a 20-year life

Construction and operation of the Flyers Creek Wind Farm will significantly assist in reducing the greenhouse gas emission intensity of NSW's electricity generation.