

# Cost Curve for NSW Greenhouse Gas Abatement

*3 November 2004*

*Prepared for the NSW Greenhouse Office*

## **Preface**

This study was commissioned by the NSW Cabinet Office to help better understand the options for abating greenhouse gas (GHG) emissions within NSW. The intention is to identify areas where additional policy attention might best be brought to bear by providing an indication of both the magnitude and the likely total costs of these opportunities.

This study includes measures that could be deployed over a ten year horizon to 2014 that may require new or continued NSW policies. In consultation with the NSW Greenhouse Office, a broad array of GHG abatement measures were identified. Only the most speculative or small scale measures were removed from consideration. There are some additional intermediate term measures that have not been included in this report due to a lack of readily available information, such as improvements in performance of commercial vehicles and rail, and use of alternative refrigerants. Furthermore, additional abatement measures (or cost and performance enhancements to these measures) should be achievable over the longer term which are not included in this report. The cost and potential of such additional longer term measures would necessarily be more speculative.

As a quick snapshot, the study necessarily relies primarily on existing reports and analyses. The reports used in preparing this cost curve contain a variety of assumptions, and some of these are not fully consistent with each other. To allow for a reasonable basis of comparison, a number of assumptions were made by the authors of this study to normalise the available data. As such, there are limitations in the detail and accuracy of the conclusions drawn. Additional work to validate the conclusions will be beneficial as policy development progresses.

## Background

The NSW Government has long taken a leading role in addressing the challenge of global climate change through the development of effective and world-leading policies and programs.

These policies include:

- **NGGAS** - establishment of the NSW Greenhouse Gas Abatement Scheme for electricity retailers, which introduced a market mechanism requiring retailers to reduce the greenhouse gas intensity of the electricity they sell to a specified benchmark or pay a penalty for emissions above their target;
- **BASIX** - introduction of BASIX, which requires high levels of energy efficiency in the design of new housing;
- **LAND CLEARING** - introduction of requirements to manage land clearing;
- **ELECTRICITY PRICE & SERVICE REGULATION** – introduction by IPART of price and service regulation of network service providers specifically promoting demand management initiatives; and
- **EDUCATION** – introduction of a wide variety of educational initiatives, rating/labelling systems and facilitation activities by various government agencies.

In addition to enacted policies and programs, a wide variety of initiatives are currently underway within government including development of a Demand Management Fund and an Integrated Resource Strategy by DEUS, development of a State Environmental Planning Policy for energy project development by DIPNR and work by Cabinet Office to establish a domestic emissions trading program in Australia.

The NSW Greenhouse Office is developing a Greenhouse Strategy to reduce greenhouse emissions and adapt to climate change in NSW. Over the last several years, a large amount of work has been performed of direct relevance to a wide array of abatement measures. This strategy can build upon both the existing policies, and upon this wide array of existing analyses.

While extensive work has been performed in assessing many individual abatement measures, there has been relatively little work to integrate the results, and to adapt them specifically to NSW.

Accordingly, the Government's specialist greenhouse policy unit, the NSW Greenhouse Office, identified an opportunity to enhance the development of future policies by developing an integrated cost curve of NSW abatement measures. Development of the cost curve will facilitate identifying least-cost emission abatement options, provide a basis for prioritising proposed measures, and help assess the potential of the Government's overall strategy.

This study did not investigate the policy tools that would be needed in achieving the abatement measures.

## Key Findings

- 1. A wide array of measures could produce significant GHG abatement over the intermediate horizon to 2014 and beyond.** Several of these are summarised in Figure 1 and Table 1 (below). The abatement opportunities identified equate to some 51.9 MtCO<sub>2</sub>-e or about one third of current estimated NSW GHG emissions. These are measures that could be implemented under new or continued NSW policies. Additional measures (or cost and performance enhancements to measures identified in this report) should be achievable over the longer term. Such longer term measures, which are necessarily more speculative, are not included in this report.
- 2. A few abatement measures that appear to have particularly large potential and low or negative costs, warrant intensive policy and analytic consideration going forward.**

These are:

- a) Commercial, industrial, household, and automotive energy efficiency;
- b) Reduction in land clearing;
- c) Establishment of plantation based sequestration; and
- d) Industrial cogeneration.

- 3. A range of energy efficiency activities appear to have a negative cost, and would appear to merit implementation efforts regardless of their GHG abatement benefits.**
- 4. Geosequestration or carbon capture and storage, may warrant careful analytic attention for a variety of reasons:**
  - high longer term abatement potential;
  - the significant emphasis placed upon it by the Commonwealth government;
  - the high degree of technical uncertainty; and
  - possible relevance to near term generation decisions within NSW.
- 5. Most abatement measures have significant lead times or can only be deployed gradually over time, and would therefore require near-term start of implementation activities** to achieve their full potential within the 10 year timeframe considered in this study.
- 6. While there is cost and performance uncertainty with all measures, it is greater for some than for others.** Examples of areas with particular uncertainty include:
  - the ability to deliver large-scale geosequestration projects;
  - the ability to develop effective policies and programs to significantly influence commercial/industrial energy efficiency;
  - the ability to develop effective policies and programs to significantly influence automobile usage and purchasing patterns; and
  - the ability to achieve abatement from reduced land clearing.For many others, there do not appear to be significant technical barriers or uncertainties. Examples of these include wind project development, coal plant upgrade initiatives and some energy efficiency measures.
- 7. For some of the measures, there are already policies in place that should promote their implementation.** However, most of the measures, including those with low or no costs, would appear to require significant additional NSW policy and program

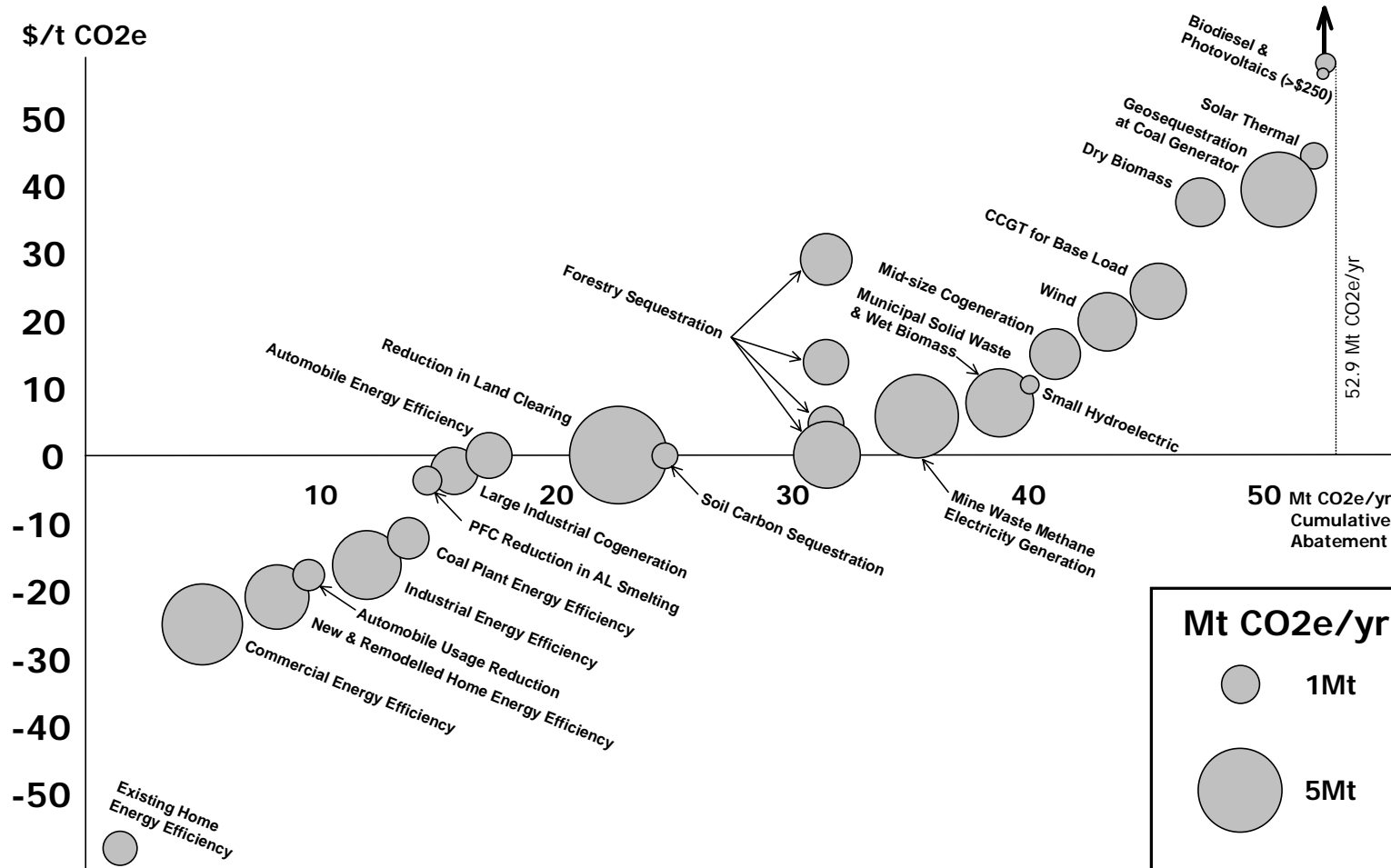
development.

While this study used the most relevant readily available information on cost and potential, additional information exists and will continue to be developed on many potential measures, and **GHG policy development should be flexible as new information becomes available.**

**Table 1: Abatement Measures**

Abatement Type	NSW Potential MtCO2e pa	Cost, \$/tCO2e	Key Assumptions
<b>Energy Efficiency</b>			
Commercial energy efficiency	4.6	-\$25	All measures with cumulative payback of 4 years or less at time of major refurbishment are implemented.
Industrial energy efficiency	3.4	-\$16	All measures with cumulative payback of 4 years or less at time of major refurbishment are implemented.
New and remodeled home energy efficiency	2.9	-\$20	40% reduction in GHG emissions achieved for new and remodeled homes
Existing home energy efficiency	0.80	-\$58	High efficiency appliances (e.g., refrigerators, dishwashers, lights) with less than 6.5 year simple payback at time of purchase are used. Does not include heating, cooling or water heating opportunities.
Automobile energy efficiency	1.5	\$0	10% improvement in average fuel economy of automobile fleet at no net cost
Automobile usage reduction	0.7	-\$18	25% of NSW households participate in a program similar to the National Travel Behaviour Change program
<b>Renewable electricity generation</b>			
Wind	2.4	\$20	Suitable sites found for 1000 MW of wind; cost based on 4% pa declines thru 2009; no RECs value; NEM pays \$40/MWh
Small hydroelectric	0.2	\$11	50 MW developed at existing dams without generation currently; NEM pays \$40/MWh
Photovoltaics	0.3	\$273	200 MW installed; 6% pa cost drop thru 2009; NEM pays \$40/MWh
Solar thermal	0.5	\$43	36MW solar preheat units are installed at 8 existing NSW coal units.
MSW and wet biomass	3.3	\$8	113 MW of generation developed; avoids fugitive methane emissions from landfill; NEM pays \$40/MWh
Dry biomass	1.7	\$38	200 MW of mainly bagasse with supplemental dry waste fuel; cost stable; NEM pays \$40/MWh
Biofuels - biodiesel and ethanol	0.1	\$265	350 million litres pa of biofuels substitute for diesel and petrol; current technology only.
<b>Lower emission fossil-fuel electricity generation</b>			
Large industrial cogeneration	1.6	-\$2	350 MW steam-matched industrial host, eg former ALISE proposal; \$4.50/GJ gas; \$400 /Kva network benefit; NEM pays \$40/MWh
Mid size cogeneration	1.8	\$16	13x30MW units, steam matched, \$4.50/GJ gas; \$400/kVA network benefit; NEM pays \$80/MWh incl. dist'n benefit
Combined cycle gas turbine for base load	2.2	\$25	500 MW CCGT operates as base load unit, avoids high efficiency new coal unit; \$4.50/GJ gas price
Mine waste methane electricity generation	4.9	\$6	120 MW of new capacity using mine vent air and methane drainage; 50 MW of cofiring at coal power stations
Efficiency upgrade for existing coal plant	1.2	-\$12	2% gains at major NSW coal generators at average cost of \$2m/MW; NEM pays \$40/MWh
Geosequestration at coal generator	4	\$40	Suitable depository available in/near NSW; major technology cost/performance gains by 2010.
<b>Industrial process</b>			
	0.6	-\$3	Intensive PFC management implemented at time of major aluminium smelter upgrade.
<b>Land use change and management</b>			
Reduction in land clearing	6.8	\$0	75% reduction from last 5 year averages reported in the 2002 National Carbon Accounting
Soil carbon sequestration	0.5	\$0	0.6 million hectares adopt practices increasing carbon uptake by 2 t per hectare, building up over 10 years
Seq – forestry	3.1	\$0	Plantations established where value exceeds the agricultural value of the land. ABARE's alternate evaluation based on a lower economic hurdle (i.e., exceeding farm profitability) produces higher potential. Potential average annual sequestration during 30 year establishment of sustainably harvested plantations.
	0.9	\$5	Incremental plantations over above estimate, established with an assumed \$5 / t CO2e revenue stream
	1.4	\$15	Incremental plantations over above estimate, established with an assumed \$15 / t CO2e revenue stream
	1.9	\$30	Incremental plantations over above estimate, established with an assumed \$30 / t CO2e revenue stream
<b>TOTAL</b>	<b>52.9</b>		

# NSW GHG Abatement Cost Curve to 2014



# APPENDIX 1 - Project Methodology

The study used the following methodology to identify, quantify and compare abatement measures available to NSW:

1. **IDENTIFICATION** – In consultation with the NSW Greenhouse Office, a broad array of GHG abatement measures were identified for consideration. Only the most speculative or small scale measures were removed from consideration.
2. **INVESTIGATION OF KEY OPPORTUNITIES** – Reviewing both public reports and confidential analyses available within government, the authors sought to identify and review at least one published document relevant to each measure that presented an estimate of the likely costs and quantity of available abatement. In general, the most widely acknowledged and most current available report was selected.
3. **NORMALISATION** - To provide an approximate estimate of the quantity and cost of abatement measures on a basis that allowed for reasonable comparison, the authors took steps to normalise the cost and potential abatement within NSW at a 10 year horizon. Normalisation steps taken are explicitly identified in Appendix 2.
4. **REVIEW OF ASSUMPTIONS & UNCERTAINTIES** - For each of the measures, critical assumptions and uncertainties were assessed qualitatively. Conclusions reached are summarised in Table 1 and further detailed in Appendix 2.

## Appendix 2 – Individual Abatement Measures

Appendix 2 provides additional details on each of the abatement measures included in the cost curve.

### 1) Commercial Energy Efficiency

#### **Primary References**

- “Energy Efficiency Improvement in the Commercial Subsector”, EMET, February 2004.

This publicly available report was commissioned by the Sustainable Energy Authority Victoria in support of the Council of Australian Governments Ministerial Council on Energy development of the National Framework for Energy Efficiency. The report presents a detailed economic analysis of a range of energy efficiency measures for several major commercial subsectors for new buildings, existing buildings undergoing major refurbishment, and for existing buildings not undergoing refurbishment.

- “Distributed Energy Solutions”, Sustainable Energy Development Authority, 2002.

#### **Brief description of abatement measure**

There is a wide array of well demonstrated and commercially available energy management measures for commercial buildings. These include improvements in insulation and other technical measures that improve a building’s thermal performance; use of more efficient design, controls and systems for heating, ventilation, and air conditioning; use of more efficient design, controls and equipment for lighting; use of more efficient equipment for water heating, lifts, and other service equipment. It also includes measures such as lower energy-consuming office equipment.

The primary source provides estimates of the cost and performance of energy management measures under a range of investment criteria. For the NSW abatement cost curve the investment hurdle scenario that was applied was to include all energy management measures that were cost effective based on a cumulative average 4 year simple payback.

#### **Critical assumptions in source of primary analysis**

*Technical uncertainty:* The efficiency measures included in the primary source are technically well demonstrated and commercially available. No improvements in technology cost and performance appear to have been assumed, leading to a conservative estimate in the NSW GHG abatement cost curve.

*Market / economic uncertainty:* The primary source’s economic analysis includes assumptions about future energy prices. While these assumptions are inherently uncertain, they appear reasonable.

There is some prospect for specific projects to deliver network benefits that have not been included in either the primary source analysis or the cost curve estimate. To the extent that such benefits are achievable, the estimates presented here are conservative and overstate the cost of abatement.

*Program / policy uncertainty:* The primary uncertainty with respect to this abatement measure is the ability to develop policies and programs that would result in the take-up of cost-effective measures.

#### **Normalisation to NSW**

The analyses performed in the primary source are for all of Australia, not just NSW. Normalisation for the NSW GHG abatement cost curve was done by pro-rating the primary source results according to the population of NSW relative to Australia.

**Normalisation to ten year horizon**

The primary source estimated the deployment of energy management measures over a 10 year horizon between 2000 and 2010. While the start and end dates are different from those included in the NSW GHG abatement cost curve, no normalisation was made. The length of the time horizon is important, in that a key determinant of the cost of an energy management measure is highly dependent on whether the measure is applied in a new building (where cost is low), a major refurbishment, or to an existing building not undergoing refurbishment (where cost would be much higher).

**Normalisation for 'Business as Usual'**

The primary source analysis provides estimates of potential that are beyond BAU and no normalisation is needed. However, the costs and cost reductions are given for total energy management activities, including both those expected under BAU and the additional potential used in the cost curve. To normalise for this, a conservative assumption was used, specifically, that all implementation costs were associated with the additional GHG abatement potential, and not with BAU savings.

**Other normalisation**

The primary source analysis provides results in total energy savings, PJ pa. This was translated into GHG emissions potential by assuming that the savings were 75% in electricity and 25% in gas, based on current commercial energy usage.

**Implementation and timing issues**

Achieving the 10 year GHG abatement potential shown in the NSW GHG abatement cost curve would require an immediate start, as the savings increase cumulatively with the number of new buildings and major refurbishment to which the energy management measures are applied. Each year beyond the 10 year horizon considered in the cost curve estimates will deliver additional abatement, as the stock of commercial premises with energy management measures continues to increase.

## Appendix 2 – Individual Abatement Measures - *continued*

### 2) Industrial Energy Efficiency

#### **Primary References**

- “*Industrial Energy Efficiency Improvement Potential*” Powerpoint presentation, Energetics.
- “*Energy Efficiency Improvement Potential Case Studies – Industrial Sector*” March 2004, Energetics, March 2004.

These publicly available analyses were commissioned by the Sustainable Energy Authority Victoria in support of the Council of Australian Governments Ministerial Council on Energy development of the National Framework for Energy Efficiency.

The analyses provide estimates of total energy efficiency improvement potential, cost, and energy efficiency potential in excess of business as usual improvements. The analyses included only readily achievable energy efficiency measures which are currently commercially available, and was based on extrapolations of 4 to 8 audits in each of 11 industrial subsectors.

- “*Distributed Energy Solutions*”, Sustainable Energy Development Authority, 2002. This report is based on case studies of energy management opportunities at a variety of individual industrial sites performed. However, while the NFE report by Energetics is not specific to NSW, it is both more recent and more comprehensive.

#### **Brief description of abatement measure**

There is a wide array of demonstrated and commercially available energy management measures for the industrial sector. These include such areas as improvements as process optimisation and controls, improvements in combustion, boilers and heat recover, and use of variable speed drives.

The Energetics study provides estimates of the cost and performance of energy management measures under a range of investment criteria. For the NSW abatement cost curve the investment hurdle scenario that was applied was to include all energy management measures that were cost effective based on a cumulative average 4 year simple payback. Only opportunities which are readily achievable and commercially available currently were included.

#### **Critical assumptions in source of primary analysis**

*Technical uncertainty:* The industrial energy efficiency measures included in the Energetics study are technically well demonstrated and commercially available.

*Market / economic uncertainty:* The Energetics study’s economic analysis includes assumptions about future energy prices. While these assumptions are inherently have some uncertainty, they appear reasonable.

There is some prospect for specific projects to deliver network benefits that have not been included in either the primary source analysis or the cost curve estimate. To the extent that such benefits are achievable, the estimates presented here are conservative and overstate the cost of abatement.

*Program / policy uncertainty:* The primary uncertainty with respect to this abatement measure is the ability to develop policies and programs that would result in the take-up of cost-effective measures.

#### **Normalisation to NSW**

The analyses performed in the Energetics study are for all of Australia, not just NSW. Normalisation for the NSW GHG abatement cost curve was done by pro-rating the primary source results according to the population of NSW relative to Australia.

***Normalisation to ten year horizon***

The Energetics study estimated the deployment of energy management measures over a 12 year horizon. The estimates were prorated to 10 years for the NSW GHG abatement cost curve, based on an assumption that implementation is constant over the horizon. The time horizon is important, in that many energy management opportunities must be implemented at the time of major equipment or plant upgrades in order to be cost effective.

***Normalisation for 'Business as Usual'***

The Energetics study provides estimates of potential that are beyond BAU and no normalisation is needed. However, the costs and cost reductions are given for total energy management activities, including both those expected under BAU and the additional potential used in the cost curve. To normalise for this, a conservative assumption was used, specifically, that all implementation costs were associated with the additional GHG abatement potential, and not with BAU savings.

***Implementation and timing issues***

Achieving the 10 year GHG abatement potential shown in the NSW GHG abatement cost curve would require an immediate start, as the savings increase cumulatively with the number of new buildings and major refurbishment to which the energy management measures are applied. Each year beyond the 10 year horizon considered in the cost curve estimates will deliver additional abatement, as the stock of commercial premises with energy management measures continues to increase.

## Appendix 2 – Individual Abatement Measures - *continued*

### 3) New and Remodelled Home Energy Efficiency

#### **Primary References**

- “Summary of Cost Benefit Study for BASIX” Department of Infrastructure Planning and Natural Resources, July 2004.

This publicly available document summarises the study cited below. It provides cost and performance estimates for a BASIX 25% energy savings requirement. While the analysis upon which this document is based was undertaken prior to the final specification of the BASIX requirements, the summary provides an excellent qualitative and quantitative basis for the purposes of the NSW abatement cost curve.

- “BASIX – Building Sustainability Index An Economic Evaluation” The Allen Consulting Group, Report for Department of Infrastructure Planning and Natural Resources, 23 September 2003.

This document, which has not been publicly released, is the full analysis upon which the DIPNR summary is based. In addition to the analyses of the BASIX 25% energy savings requirement, it provides estimates of the BASIX 40% requirement.

#### **Brief description of abatement measure**

There is a wide array of demonstrated and commercially available energy management measures for the residential sector. These include improvements in insulation, building orientation, shading, heating, ventilation and air conditioning equipment, water heating, hot water usage, and appliances.

BASIX establishes a requirement to reduce energy use in new housing by 40%. The BASIX analyses estimate the household energy savings and costs of BASIX at 25% and 40% levels.

#### **Critical assumptions in source of primary analysis**

*Technical uncertainty:* The home energy efficiency measures included in the primary source are technically well demonstrated and commercially available. Some improvements in the cost of constructing an energy efficient house are explicitly assumed in the BASIX documents’ conclusions, and these appear reasonable.

*Market / economic uncertainty:* The BASIX documents’ economic analysis includes assumptions about future energy prices. While these assumptions inherently have some uncertainty, they appear reasonable.

There is some prospect for specific projects to deliver network benefits that have not been included in either the primary source analysis or the cost curve estimate. To the extent that such benefits are achievable, the estimates presented here are conservative and overstate the cost of abatement.

*Program / policy uncertainty:* There is low uncertainty with respect to this abatement measure, as BASIX has already been adopted.

#### **Normalisation to NSW**

The BASIX documents are specific to NSW, and no normalisation is necessary.

#### **Normalisation to ten year horizon**

The BASIX documents provide an estimate of total GHG abatement over the first ten years of BASIX, assuming a 25% energy savings requirement. Assuming that implementation is constant

over that horizon allows calculation of the per annum abatement in year 10. Notably, each additional year brings additional abatement, as new houses are built.

***Normalisation for 'Business as Usual'***

BASIX is designed to achieve reductions from business as usual, and no normalisation is needed.

***Other normalisation***

The BASIX documents provide estimates based on a 25% BASIX requirement. These results were directly scaled up to 40% for the purposes of the cost curve.

***Implementation and timing issues***

The potential of this emissions abatement measure should be achieved under existing NSW government policy, as BASIX has been adopted. Each year beyond the 10 year horizon considered in the cost curve estimates will deliver additional abatement, as the stock of compliant households continues to increase.

## Appendix 2 – Individual Abatement Measures - *continued*

### 4) Existing Home Appliance Energy Efficiency

#### **Primary References**

- “Energy Efficiency Improvement in the Residential Sector”, EMET, April 2004.

This publicly available report was commissioned by the Sustainable Energy Authority Victoria in support of the Council of Australian Governments Ministerial Council on Energy development of the National Framework for Energy Efficiency. The report presents a detailed economic analysis of a range of energy efficiency measures for several major energy uses in existing housing.

#### **Brief description of abatement measure**

There is a wide array of well demonstrated and commercially available energy management measures for existing housing. Among those best suited to implementation in existing houses are the application of more efficient appliances such as refrigerators, dishwashers, and washing machines, and the use of higher efficiency lighting. This measure assumes that high efficiency appliances with less than a 6.5 year simple payback at the time of purchase are used.

There are additional abatement opportunities for existing homes that are not included in this measure, including use of more efficient heating and cooling equipment and water heaters. In this regard the quantification of the abatement potential in existing housing is conservative.

#### **Critical assumptions in source of primary analysis**

*Technical uncertainty:* The efficiency measures included in the primary source are technically well demonstrated and commercially available. No improvements in technology cost and performance appear to have been assumed, leading to a conservative estimate in the NSW GHG abatement cost curve.

*Market / economic uncertainty:* The EMET report’s economic analysis includes assumptions about future energy prices. While these assumptions are inherently uncertain, they appear reasonable.

There is some prospect for energy management to deliver network benefits that have not been included in either the primary source analysis or the NSW GHG ACC estimate. To the extent that such benefits are achievable, the estimates presented here are conservative and overstate the cost of abatement.

*Program / policy uncertainty:* The primary uncertainty with respect to this abatement measure is the ability to develop policies and programs that would result in the take-up of cost-effective measures.

#### **Normalisation to NSW**

The analyses performed in the primary source are for all of Australia, not just NSW. Normalisation for the NSW GHG abatement cost curve was done by pro-rating the primary source results according to the population of NSW relative to Australia.

#### **Normalisation to ten year horizon**

The EMET study estimated the replacement of appliances over a 10 year horizon, and no normalization is needed.

#### **Normalisation for ‘Business as Usual’**

The EMET study provides estimates of potential that are beyond BAU and no normalisation is needed.

#### **Implementation and timing issues**

Achieving the 10 year GHG abatement potential shown in the NSW GHG abatement cost curve would require an immediate start, as the savings increase cumulatively with the number of new buildings and major refurbishment to which the energy management measures are applied. Each year beyond the 10 year horizon considered in the cost curve estimates will deliver additional abatement, as the stock of commercial premises with energy management measures continues to increase.

## Appendix 2 – Individual Abatement Measures - continued

### 5) Higher Efficiency Automobiles

#### **Primary References**

- "Green Vehicle Guide" [www.greenvehicleguide.gov.au](http://www.greenvehicleguide.gov.au), Commonwealth Department of Transport and Regional Services and the Australian Greenhouse Office.

This publicly available document provides information on environmental performance for a full range of automobiles available in Australia.

- "Study on Factors Impacting on Australia's National Average Fuel Consumption Levels to 2010", Report to AGO, June 1999.

This public available document was produced for the Australian Greenhouse Office to help establish a target for negotiations with automobile manufacturers regarding fuel efficiency targets to be achieved by 2010.

#### **Brief description of abatement measure**

This measure involves improving the average fuel economy of the automobile fleet by 10%.

#### **Critical assumptions in source of primary analysis**

*Technical uncertainty:* There is little technical uncertainty, as there are automobiles commercially available in each class that already have consumption below average consumption for the class, and additional savings are available by shifting between classes.

*Market / economic uncertainty:* Fleet purchasing decisions and other consumer choice are the prime determinant of fleet average fuel economy. There is considerable uncertainty regarding the value of amenity attributes between different models within a class, and between classes. There is also uncertainty regarding the financial value of fuel savings due to the substantial uncertainty in oil prices.

*Program / policy uncertainty:* A primary uncertainty with respect to this abatement measure is the ability to develop policies and programs that would result in the take-up of lower consumption vehicles, both by fleet purchasers and other consumers.

#### **Normalisation to NSW**

The total Australian automobile GHG emissions reported in the National Greenhouse Gas Inventory were prorated to NSW based on relative population.

#### **Normalisation to ten year horizon**

The estimate is based on 10% savings from 2002 emissions levels. No normalisation was made, although total automobile usage and GHG emissions are expected to rise over the horizon. Accordingly, the estimate used can be viewed as conservative.

#### **Normalisation for 'Business as Usual'**

The fuel economy of the automobile fleet continues to improve. However, there continues to be a significant range of consumption levels between automobiles in each class, and no normalisation was made.

#### **Implementation and timing issues**

As the average automobile age is under ten years in NSW, implementation within the 10 year timeframe should be achievable.

## Appendix 2 – Individual Abatement Measures - continued

### 6) Automobile Usage Reduction

#### *Primary References*

- Greenhouse Gas Abatement Program Award Announcement, Australian Greenhouse Office.

This document summarizes the National Travel Behaviour Change Program (NTBCP), which was awarded GGAP funding of \$6.5 million. The NTBCP is a joint program involving governments of the ACT, Queensland, South Australia and Victoria.

- "The Greenhouse Abatement Potential of Travel Behaviour Change Initiatives. Report by Transport SA, in conjunction with Transport WA for the National Greenhouse Strategy Measure 5.3 Taskforce.

This public available document was produced for the National Greenhouse Strategy.

#### *Brief description of abatement measure*

This measure involves replacing some car usage by modes such as walking, cycling, public transport and ride sharing. The NTBCP anticipates that the program will result in a reduction of more than 3 billion car kilometres travelled and over one million tonnes of greenhouse gas emissions in the Kyoto period.

#### *Critical assumptions in source of primary analysis*

*Technical uncertainty:* There is no significant technical uncertainty.

*Market / economic uncertainty:* Economic factors do not appear to be the driving element in the NTBCP. The Transport SA report indicates that travel behavioural change deliver a positive but unquantified benefit cost ratio. The value used in the cost curve is arbitrarily chosen to indicate a slightly negative cost per ton of abatement.

*Program / policy uncertainty:* The primary uncertainty with respect to this abatement measure is the ability to develop policies and programs that would result in the anticipated behavioural changes.

#### *Normalisation to NSW*

The NTBCP estimate is given in terms of total abatement and number of participating households. For the cost curve, this value was prorated to NSW based on an assumed number of households, specifically, 25% of households in NSW.

#### *Normalisation to ten year horizon*

No normalisation was made.

#### *Normalisation for 'Business as Usual'*

No normalisation was made.

#### *Implementation and timing issues*

None evident.

## Appendix 2 – Individual Abatement Measures - *continued*

### 7) Wind Electricity Generation

#### **Primary References**

- "Distributed Energy Solutions: Cost and Capacity Estimates for Decentralise Options for Meeting Electricity Demand in NSW" Sustainable Energy Development Authority, February 2002.

This publicly available document was produced by SEDA for consideration in the IPART Demand Management inquiry. It summarises a variety of SEDA analyses performed across a range of energy options.

#### **Brief description of abatement measure**

Wind farms are being extensively developed in Australia. SEDA has identified 1000 MW of wind farm potential in NSW. However, there has been little development to date within NSW due to a less attractive wind regime than in other states. The electricity generated directly replaces NEM generation, which is predominantly coal fired.

#### **Critical assumptions in source of primary analysis**

*Technical uncertainty:* Wind power generation is well demonstrated both in Australia and internationally. Wind energy technology has consistently shown cost and performance improvement during the past decade, and the outlook is for more of the same. However, the SEDA analysis does not assume any improvements. Given the strong track record and clear outlook for continued improvements, the cost curve estimate is based on continued 5% per annum declines in installed costs over the coming decade.

*Market / economic uncertainty:* There are several significant market/economic uncertainties for NSW wind. First, a critical assumption is the value of Renewable Energy Certificates under the Mandatory Renewable Energy Target scheme. However, it appears unlikely that NSW wind projects would be able to achieve significant REC value, given the availability of more economic competitors. Second, the value of generation in the National Electricity Market (assumed to be \$40 / MWh for wind and other electricity generation options) is uncertain. Third, the discounted value of wind relative to dispatchable generation has not been factored into the SEDA or cost curve estimate. For the cost curve, the real return on assets assumed for wind and other electricity generation options was 10%, in contrast with the 15% assumed by SEDA. Finally, no provision has been made for the cost of network connection, which may be significant where existing capacity is inadequate.

*Program / policy uncertainty:* The Mandatory Renewable Energy Target and the NEM provide a policy framework under which significant commercial investment decisions such as these would be made.

#### **Normalisation to NSW**

The primary source is specific to NSW, and no normalisation is necessary.

#### **Normalisation to ten year horizon**

None required.

#### **Normalisation for 'Business as Usual'**

None required.

#### **Implementation and timing issues**

Development of wind generation has a relatively short lead time and could be readily accomplished within the 10 year timeframe.

## Appendix 2 – Individual Abatement Measures - *continued*

### 8) Small Hydro Electricity Generation

#### **Primary References**

- "*Distributed Energy Solutions: Cost and Capacity Estimates for Decentralise Options for Meeting Electricity Demand in NSW*" Sustainable Energy Development Authority, February 2002.

This publicly available document was produced by SEDA for consideration in the IPART Demand Management inquiry. It summarises a variety of SEDA analyses performed across a range of energy options.

#### **Brief description of abatement measure**

SEDA has identified a number of existing dams where hydroelectric generators could be installed.

#### **Critical assumptions in source of primary analysis**

*Technical uncertainty:* Small hydro generation is well demonstrated in Australia and internationally.

*Market / economic uncertainty:* See the discussion under wind electricity generation.

*Program / policy uncertainty:* See the discussion under wind electricity generation.

#### **Normalisation to NSW**

The primary source is specific to NSW, and no normalisation is necessary.

#### **Normalisation to ten year horizon**

None required.

#### **Normalisation for 'Business as Usual'**

None required.

#### **Implementation and timing issues**

Development could be readily completed within the 10 year timeframe.

## Appendix 2 – Individual Abatement Measures - *continued*

### 9) Photovoltaic Electricity Generation

#### **Primary References**

- "Distributed Energy Solutions: Cost and Capacity Estimates for Decentralise Options for Meeting Electricity Demand in NSW" Sustainable Energy Development Authority, February 2002.

This publicly available document was produced by SEDA for consideration in the IPART Demand Management inquiry. It summarises a variety of SEDA analyses performed across a range of energy options.

#### **Brief description of abatement measure**

This measure involves generation of renewable electricity by using photovoltaics, displacing NEM generation. 200 MW of new photovoltaics was assumed based on the total output of current PV manufacturing facilities globally.

#### **Critical assumptions in source of primary analysis**

*Technical uncertainty:* PV technology is well demonstrated, both in Australia and internationally. PV technology has consistently shown cost and performance improvement during the past two decades, and the outlook is for more of the same. However, the current cost remains very high, and even with continuing cost declines of some 5% per annum, the outlook is for continued relatively high costs.

*Market / economic uncertainty:* See the discussion under wind electricity generation.

*Program / policy uncertainty:* See the discussion under wind electricity generation.

#### **Normalisation to NSW**

The primary source is specific to NSW, and no normalisation is necessary.

#### **Normalisation to ten year horizon**

None required.

#### **Normalisation for 'Business as Usual'**

None required.

#### **Implementation and timing issues**

Implementation could be readily completed within the 10 year timeframe.

## Appendix 2 – Individual Abatement Measures - *continued*

### 10) Solar Thermal Electricity Generation

#### **Primary References**

- Project description of Macquarie Generation/Solar Heat and Power Liddell development, Solar Heat and Power Pty Ltd.

This document summarizes the solar thermal preheater implemented by Solar Heat and Power for Macquarie Generation's Liddell Power Station.

#### **Brief description of abatement measure**

This measure involves establishing solar thermal collectors at existing coal power station sites, allowing for the partial substitution of coal. The cost curve assumes one 36 MW facility is established at each of 8 coal generating units in NSW.

#### **Critical assumptions in source of primary analysis**

*Technical uncertainty:* The SHP approach does not appear to have significant technical uncertainty other than the ability to achieve cost reductions.

*Market / economic uncertainty:* The value of the thermal energy depends on the value of the displaced coal, which has some uncertainty.

*Program / policy uncertainty:* The Mandatory Renewable Energy Target and the NEM provide a policy framework under which significant commercial investment decisions such as these would be made.

#### **Normalisation to NSW**

No normalisation is necessary.

#### **Normalisation to ten year horizon**

**None** required.

#### **Normalisation for 'Business as Usual'**

None required.

#### **Implementation and timing issues**

Plant upgrades can be readily implemented within the ten year horizon.

## Appendix 2 – Individual Abatement Measures - *continued*

### 11) Municipal Solid Waste and Wet Biomass Electricity Generation

#### **Primary References**

- "Distributed Energy Solutions: Cost and Capacity Estimates for Decentralise Options for Meeting Electricity Demand in NSW" Sustainable Energy Development Authority, February 2002.

This publicly available document was produced by SEDA for consideration in the IPART Demand Management inquiry. It summarises a variety of more in-depth SEDA analyses performed across a range of energy options.

#### **Brief description of abatement measure**

There are currently several major efforts within NSW to divert municipal solid waste and wet food/agricultural waste from traditional landfills and recover energy and other resources. Three examples include the Global Renewables Ltd UR-3R plant at Waste Service NSW' Eastern Creek site; Collex's Woodlawn Bioreactor outside of Goulburn; and Environmental Infrastructure's plant at Camelia.

Diversion of MSW and wet agricultural waste from landfill to such energy recovery facilities provides two distinct GHG abatement benefits. First, the electricity generated directly replaces NEM generation, which is predominantly coal fired. Second, the diversion of waste from landfill eliminates the fugitive emissions of methane that would otherwise occur. The latter is particularly significant, given the high greenhouse potency of methane.

#### **Critical assumptions in source of primary analysis**

*Technical uncertainty:* There have been a number of efforts to develop energy recovery from MSW and wet waste, and the technology remains to be fully commercially demonstrated at scale. However, given the advance of recent projects, it is highly likely that suitable technology will be demonstrated well within the ten year time frame of the cost curve, and the primary source's estimates appear not unreasonable. Actual cost and performance data for existing projects are proprietary.

*Market / economic uncertainty:* Among the key factors determining the economic performance of MSW projects is the tipping fee foregone. The primary source's economic analysis assumed that the fuel would have zero cost. However, it is likely that facilities may be paid to receive waste. For this reason, the estimate in the cost curve is conservative.

Given recent project developments, the cost curve estimate assumes that 75% of technical potential can be developed, rather than the 50% assumed in the primary source analysis.

There is some prospect for specific projects to deliver network benefits that have not been included in either the primary source analysis or the cost curve estimate. To the extent that such benefits are achievable, the estimates presented here are conservative and overstate the cost of abatement.

*Program / policy uncertainty:* There is relatively low uncertainty with respect to this abatement measure, as waste driving policies favouring resource recovery have already been adopted in NSW.

#### **Normalisation to NSW**

The primary source is specific to NSW, and no normalisation is necessary.

#### **Normalisation to ten year horizon**

The primary source assumes that 50% of the available technical potential will be implemented. However, it is possible that over a 10 year horizon, a higher proportion of MSW is diverted from

landfill to resource recovery facilities. Accordingly, the 75% estimate contained in the cost curve is reasonable.

***Normalisation for 'Business as Usual'***

MSW resource recovery has significantly higher customer costs than landfill disposal. Accordingly, the abatement measures are in excess of the business as usual that would likely result without NSW policy.

***Implementation and timing issues***

A number of MSW resource recovery facilities are already under development or in operation. Development of additional facilities should be readily feasible within the 10 year timeframe.

## Appendix 2 – Individual Abatement Measures - *continued*

### 12) Dry Biomass Electricity Generation

#### **Primary References**

- "*Distributed Energy Solutions: Cost and Capacity Estimates for Decentralise Options for Meeting Electricity Demand in NSW*" Sustainable Energy Development Authority, February 2002.

This publicly available document was produced by SEDA for consideration in the IPART Demand Management inquiry. It summarises a variety of SEDA analyses performed across a range of energy options.

#### **Brief description of abatement measure**

There has been some NSW development of bagasse electricity generation, some use of forestry wastes as a supplementary fuel in existing coal generators, and some additional efforts to develop dedicated forestry waste-based electricity generation. The electricity generated directly replaces NEM generation, which is predominantly coal fired.

#### **Critical assumptions in source of primary analysis**

*Technical uncertainty:* Power generation using dry biomass is well demonstrated. There is some potential for efficiencies and costs to decrease over time, but no such improvements are assumed in the primary source.

*Market / economic uncertainty:* The primary source notes that there may be some prospect for fuel costs to be negative, as the power generator would be providing a waste disposal service. It is unclear whether such facilities would be paid to receive waste. For this reason, the cost curve estimate is modified from the primary source to indicate a small negative fuel cost.

There is some prospect for specific projects to deliver network benefits that have not been included in either the primary source analysis or the cost curve estimate. To the extent that such benefits are achievable, the estimates presented here are conservative and overstate the cost of abatement.

*Program / policy uncertainty:* The Mandatory Renewable Energy Target and the NEM provide a relatively clear policy framework under which significant commercial investment decisions such as these would be made. However, there has been considerable debate about the type and extent of forestry wastes that are appropriate for biomass generation.

#### **Normalisation to NSW**

The primary source is specific to NSW, and no normalisation is necessary.

#### **Normalisation to ten year horizon**

None required.

#### **Normalisation for 'Business as Usual'**

None required.

#### **Implementation and timing issues**

Development of dry biomass generation could be readily accomplished within the 10 year timeframe.

## Appendix 2 – Individual Abatement Measures - *continued*

### 13) Biofuels – Biodiesel and Ethanol for Transport Fuel

#### **Primary References**

- "Appropriateness of a 350 Million Litre Biofuels Target" Report to the Australian Government Department of Industry Tourism and Resources, CSIRO, ABARE, BTRE, December 2003.

This publicly available document was produced to examine the economic, environmental, and regional impacts and industry viability of maintaining a Commonwealth Government objective to increase production of biofuels to at least 350 ML by 2010.

#### **Brief description of abatement measure**

Currently about 60 ML p.a. of transport biofuels are produced in Australia, substituting for petroleum products. Production is projected to increase to 115 ML by 2010. This abatement measure assumes that production is further increased to 350 ML by 2010. The additional biofuel production would come primarily from ethanol derived from energy crops (i.e., sugar and cereal grains).

#### **Critical assumptions in source of primary analysis**

*Technical uncertainty:* Production of biodiesel and ethanol from renewable sources is well demonstrated. New technology is under development that may deliver cost and performance improvements, but only demonstrated technology is included in the estimate.

*Market / economic uncertainty:* The net cost of biofuel is highly dependent on the cost of the petroleum products that are displaced, and on foregone production of agricultural commodities.

*Policy uncertainty:* The Commonwealth Government has several policies that directly effect the prospects for biofuels. These include changes in fuel excise taxes, biofuels production grants, and biofuel capital grants.

#### **Normalisation to NSW**

The total Australian GHG abatement estimated in the CSIRO report was prorated to NSW based on relative population.

#### **Normalisation to ten year horizon**

None required, based on assumption that production remains constant from 2010.

#### **Normalisation for 'Business as Usual'**

None required, as the abatement was estimated as in excess of projected levels.

#### **Implementation and timing issues**

Development of additional biofuels capacity could be readily accomplished within the 10 year timeframe.

## Appendix 2 – Individual Abatement Measures - continued

### 14) Large Industrial Cogeneration

#### **Primary References**

- "Distributed Energy Solutions: Cost and Capacity Estimates for Decentralise Options for Meeting Electricity Demand in NSW" Sustainable Energy Development Authority, February 2002.

This publicly available document was produced by SEDA for consideration in the IPART Demand Management inquiry. It summarises a variety of SEDA analyses performed across a range of energy options.

#### **Brief description of abatement measure**

A few large industrial cogeneration projects (300 to 450 MW) have been proposed in NSW in the past decade, none of which have proceeded to date. Industrial cogeneration would reduce GHG emissions relative to coal fired generation due to both the lower GHG intensity of the fuel used (natural gas), and the higher conversion efficiency.

#### **Critical assumptions in source of primary analysis**

*Technical uncertainty:* Industrial cogeneration technology is well demonstrated.

*Market / economic uncertainty:* There are several significant market/economic uncertainties for large industrial cogeneration, including the following: 1) the existence of a suitable host for the project, which has a significant thermal requirement. While there have been several advanced proposals, the future interest and timing is uncertain; 2) the cost of the fuel used (e.g., natural gas), as well as the value of the fuel savings from the thermal host; 3) the value of network benefits, which are site-specific.

*Program / policy uncertainty:* The NGGAS and the NEM provide a relatively clear policy framework under which significant commercial investment decisions such as these would be made, although NGGAS concludes in 2012. The framework for achieving network benefits is not well developed. It is possible that environmental licensing policy and fees for new generation may be revised over time to place higher value on local and regional air pollutants such as particulates and nitrogen oxides. If analyses of environmental impacts support large new fees, this may have a material impact on the relative cost of cogeneration, particularly as most prospective sites would be located within the Sydney metropolitan air basin.

#### **Normalisation to NSW**

The primary source is specific to NSW, and no normalisation is necessary.

#### **Normalisation to ten year horizon**

None required.

#### **Normalisation for 'Business as Usual'**

None required.

#### **Implementation and timing issues**

Development could be readily completed within the 10 year timeframe, assuming that a large thermal host become available during the horizon.

## Appendix 2 – Individual Abatement Measures - *continued*

### 15) Mid-size Cogeneration

#### **Primary References**

- "Distributed Energy Solutions: Cost and Capacity Estimates for Decentralise Options for Meeting Electricity Demand in NSW" Sustainable Energy Development Authority, February 2002.

This publicly available document was produced by SEDA for consideration in the IPART Demand Management inquiry. It summarises a variety of SEDA analyses performed across a range of energy options.

#### **Brief description of abatement measure**

A large number of potential sites for small commercial/industrial cogeneration sites in NSW have been identified by SEDA over the past several years. Prospective sites are highly diverse, including hospitals, food processing, with high demands for thermal energy. Industrial cogeneration would reduce GHG emissions relative to coal fired generation due to both the lower GHG intensity of the fuel used (natural gas), and to the higher conversion efficiency. The generated electricity directly replaces NEM generation, and further benefits from avoiding network losses.

#### **Critical assumptions in source of primary analysis**

*Technical uncertainty:* Small cogeneration is well demonstrated in Australia and internationally.

*Market / economic uncertainty:* A critical assumption is the cost of the fuel used (e.g., natural gas), as well as the value of the fuel savings from the thermal host. There is also uncertainty in the extent of network benefits that can be achieved. Network benefits that have not been included in either the primary source analysis or the cost curve estimate.

*Program / policy uncertainty:* The NGGAS and the NEM provide a relatively clear policy framework under which significant commercial investment decisions such as these would be made, although NGGAS concludes in 2012. The framework for achieving network benefits is not well developed. It is possible that environmental licensing policy and fees for new generation may be revised over time to place higher value on local and regional air pollutants such as particulates and nitrogen oxides. If analyses of environmental impacts support large new fees, this may have a material impact on the relative cost of cogeneration, particularly as most prospective sites would be located within the Sydney metropolitan air basin.

#### **Normalisation to NSW**

The primary source is specific to NSW, and no normalisation is necessary.

#### **Normalisation to ten year horizon**

None required.

#### **Normalisation for 'Business as Usual'**

None required.

#### **Implementation and timing issues**

Development could be readily completed within the 10 year timeframe.

## Appendix 2 – Individual Abatement Measures - *continued*

### 16) Combined Cycle Gas Turbine for Base Load

#### **Primary References**

- “The Long Run Marginal Cost of Electricity Generation in NSW” Report to the Independent Pricing and Regulatory Tribunal, Intelligent Energy Systems, April 2004.

This publicly available document was produced for IPART to assist in developing regulated retail tariffs for electricity in NSW. To this end, among other things the report estimated the cost of incremental generation using new combined cycle gas turbine and new black coal generating plants.

#### **Brief description of abatement measure**

In developing future electricity supplies in NSW, a choice can be made between new gas generation and new coal generation. Use of combined cycle gas turbines (CCGT) would reduce GHG emissions relative to coal fired generation due to both the lower GHG intensity of the fuel used (natural gas), and the higher achievable conversion efficiency. This measure assumes a 500 MW generator is developed.

#### **Critical assumptions in source of primary analysis**

*Technical uncertainty:* Both CCGT and coal generation are technically well demonstrated and commercially available. Incremental improvements in cost and performance continue to be achieved, but none were assumed for the purposes of the abatement cost curve.

*Market / economic uncertainty:* One significant market/economic uncertainty for this abatement measure is the relative cost of the fuels under consideration (i.e., natural gas and coal). The cost curve assumes a fuel cost of about \$4.50 / GJ for gas and \$1.30 / GJ for coal.

*Program / policy uncertainty:* The NGGAS and the NEM provide a relatively clear policy framework under which significant commercial investment decisions such as these would be made, although NGGAS concludes in 2012. It is possible that environmental licensing policy and fees for new generation may be revised over time to place higher value on local and regional air pollutants such as particulates and nitrogen oxides. If analyses of environmental impacts support large new fees, this may have a material impact on the relative cost of CCGT.

#### **Normalisation to NSW**

No normalisation is necessary.

#### **Normalisation to ten year horizon**

None required.

#### **Normalisation for ‘Business as Usual’**

None required.

#### **Implementation and timing issues**

A CCGT could be readily developed within the ten year horizon.

## Appendix 2 – Individual Abatement Measures - *continued*

### 17) Electricity Generation Using Coal Mine Waste Methane

#### **Primary References**

- "BHP – Abatement and Utilisation of Methane in Mine Ventilation Air Exhaust," and "Envirogen – Waste Mine Gas Power Station at Bellambi Colliery" and "Waste Coal Mine Gas to Electricity Using Gas Engines at Teralba (NSW and North Goonyella (QLD), Greenhouse Gas Abatement Program Rounds 1 and 2 project announcements, Australian Greenhouse Office.

These project announcements summarize three GGAP awards: to install a specialised combustion device and steam cycle electricity generator using very low concentration of methane from West Cliff colliery in the Illawarra; and to install engines to generate electricity using mine waste methane at Teralba on the Central Coast and Bellambi on the South Coast. The GGAP awards are for between \$5.30 and \$6.60 / t CO<sub>2e</sub>.

- "Distributed Energy Solutions: Cost and Capacity Estimates for Decentralise Options for Meeting Electricity Demand in NSW" Sustainable Energy Development Authority, February 2002.

This publicly available document was produced by SEDA for consideration in the IPART Demand Management inquiry. It summarises a variety of SEDA analyses performed across a range of energy options.

#### **Brief description of abatement measure**

There are currently several major efforts to capture coal mine waste methane and use it for power generation, either in dedicated engines or as a supplemental fuel in existing coal power stations. Three examples that have received GGAP awards are given above.

Capture and use of waste methane provides two distinct GHG abatement benefits. First, the electricity generated directly replaces NEM generation, which is predominantly coal fired, with lower emissions methane. Second and more significantly, the processes reduce the fugitive emissions of methane that would otherwise occur. The latter is particularly significant, given the high greenhouse potency of methane.

This measure assumes that an additional 150 MW of generation using coal mine waste methane is developed.

#### **Critical assumptions in source of primary analysis**

*Technical uncertainty:* Coal mine methane recovery and electricity generation is technically demonstrated, particularly for relatively higher concentration mine drainage projects. Very low methane concentration projects are less well demonstrated, but the technology continues to improve with no apparent challenges. There is some uncertainty regarding the total economic potential.

*Market / economic uncertainty:* The actual cost of a coal mine waste gas project are both site specific and proprietary, and accordingly, there is some uncertainty in the cost estimates.

*Program / policy uncertainty:* The NGGAS and the NEM provide a relatively clear policy framework under which significant commercial investment decisions such as these would be made, although NGGAS concludes in 2012.

#### **Normalisation to NSW**

The SEDA assessment is specific to NSW, and no normalisation is necessary.

**Normalisation to ten year horizon**

No normalisation needed.

**Normalisation for 'Business as Usual'**

The three GGAP projects noted above all appear to be proceeding, and have been omitted from the total potential.

**Implementation and timing issues**

Development of additional facilities should be readily feasible within the 10 year timeframe.

## Appendix 2 – Individual Abatement Measures - *continued*

### 18) Existing Coal Power Plant Efficiency Improvement

#### **Primary References**

- "Liddell Efficiency Investment Boost" Macquarie Generation, 5 May 2004 project announcement.

This media release summarizes Macquarie Generation's plant efficiency upgrade for the Liddell Power Station, including costs and performance improvement.

- "Distributed Energy Solutions: Cost and Capacity Estimates for Decentralise Options for Meeting Electricity Demand in NSW" Sustainable Energy Development Authority, February 2002.

This publicly available document was produced by SEDA for consideration in the IPART Demand Management inquiry. It summarises a variety of SEDA analyses performed across a range of energy options.

#### **Brief description of abatement measure**

This measure involves upgrading major systems to improve efficiency and production of existing power stations in NSW. One example is the upgrade performed by Macquarie Generation at its Liddell Power Station, involving replacement of the turbines and production control systems.

#### **Critical assumptions in source of primary analysis**

*Technical uncertainty:* Plant upgrades such as those undertaken by Macquarie Generation are well demonstrated. There is uncertainty as to the extent of opportunity at other NSW power stations, although that would be well understood by their respective State Owned Corporations. The cost curve assumes that upgrades can be implemented at the five largest NSW generators and achieve a 2% improvement in production for a fixed amount of fuel consumption, consistent with the SEDA assessment. The Liddell project reported a 3% increase, but is the oldest of the five stations and accordingly may have had greater opportunity for improvement.

*Market / economic uncertainty:* The cost of implementation is dependent on plant-specific opportunities. For the purposes of the cost curve, it was assumed that the upgrades could be achieved at the same cost per unit of improvement as was reported for Liddell. The SEDA assessment estimated substantially lower costs than reported by Macquarie Generation.

*Program / policy uncertainty:* The NGGAS and the NEM provide a relatively clear policy framework under which significant commercial investment decisions such as these would be made, although NGGAS concludes in 2012.

#### **Normalisation to NSW**

No normalisation is necessary.

#### **Normalisation to ten year horizon**

None required.

#### **Normalisation for 'Business as Usual'**

None required.

#### **Implementation and timing issues**

Plant upgrades can be readily implemented within the ten year horizon.

## Appendix 2 – Individual Abatement Measures - *continued*

### 19) Geosequestration at Coal Power Plant

#### *Primary References*

- "Costs of Renewable Energy and CO<sub>2</sub> Capture and Storage" John Davison, IEA Greenhouse Gas R&D Programme.

This document provides an economic assessment of the long term outlook for carbon capture and storage using geosequestration.

- "Carbon Sequestration R&D Overview" US Department of Energy Office of Fossil Energy, 2004.

This document provides an overview of the R&D objectives for the US geosequestration program.

#### ***Brief description of abatement measure***

Carbon capture and storage (CCS) involves capturing carbon dioxide released during combustion at a power plant, transporting it to a suitable location, liquifying it, and placing it into storage. It is anticipated that CCS may be applied at existing or new power stations. However, it is expected to be more economic when developed in conjunction with a new power plant that allow for purer CO<sub>2</sub> exhaust gases.

#### ***Critical assumptions in source of primary analysis***

*Technical uncertainty:* CCS is technically immature and commercially speculative. While individual elements of CCS have been demonstrated, and some small amount of CCS occurs currently, systems are not commercially available and costs are very high. In addition to uncertainties regarding the long term cost and performance of CCS generally, there is uncertainty as to the existence of suitable storage facilities in or near NSW, and none have been identified to date. In contrast, potentially suitable storage has been located to serve Victorian generation and in other parts of Australia.

*Market / economic uncertainty:* opportunities. For the purposes of the cost curve, it was assumed that CCS R&D will deliver abatement at around the midpoint of the expected levels suggested by the US Department of Energy R&D program through 2015. This is a highly speculative assumption.

*Program / policy uncertainty:* The NGGAS and the NEM provide a relatively clear policy framework under which significant commercial investment decisions such as these would be made, although NGGAS concludes in 2012.

#### ***Normalisation to NSW***

No normalisation is necessary, other than to note that a suitable storage site has not been identified for NSW.

#### ***Normalisation to ten year horizon***

It is unclear whether CCS technology will become available within the ten year horizon, particularly given the long lead times for new plant construction.

#### ***Normalisation for 'Business as Usual'***

None required.

#### ***Implementation and timing issues***

It is unclear whether technology can be developed to a suitable level to allow construction of a new integrated base load / carbon capture and storage power plant.

## Appendix 2 – Individual Abatement Measures - *continued*

### 20) Reduction in Land Clearing

#### **Primary References**

- “Greenhouse Gas Emissions from Land Use Change in Australia: Results of the National Carbon Accounting System 1988-2001,” Australian Greenhouse Office, August 2003.

This document contains the estimate of emissions from land clearing between 1988-2001.

- “Native Vegetation Reform Implementation Group” Final Report 2003.

This document contains the advice a government established group to the NSW Premier of on management of native vegetation.

#### **Brief description of abatement measure**

Land clearing releases the carbon stored in vegetation. This measure involves reduction in land clearing. While the government’s policy is to end broadscale land clearing, there remains a process by which land clearing can be requested and approved by land holders. The cost curve assumes that 75% of average land clearing emissions over the past 5 years is eliminated.

#### **Critical assumptions in source of primary analysis**

*Technical uncertainty:* While land clearing is widely accepted as resulting in the release of GHG, the accounting has been subject to considerable uncertainty.

*Market / economic uncertainty:* Eliminating broadscale land clearing is expected to provide a variety of benefits beside GHG reduction, including improved water quality, soil retention, and salinity control. The zero value used in the cost curve estimate was chosen to indicate a balancing of costs and benefits.

*Program / policy uncertainty:* The Government’s native vegetation reform policy provides a basis for achieving this measure, although the direct application to GHG abatement is not fully clear.

#### **Normalisation to NSW**

The estimate of emissions is specific to NSW.

#### **Normalisation to ten year horizon**

None made. The estimated abatement is the average annual net increase in sequestration during a 30 year establishment of sustainably harvested plantations. No net increase in sequestration would occur in subsequent years.

#### **Normalisation for ‘Business as Usual’**

None made.

#### **Implementation and timing issues**

Land clearing reductions can be readily implemented within the ten year horizon.

## Appendix 2 – Individual Abatement Measures - *continued*

### 21) Soil Carbon Sequestration

#### *Primary References*

- “Soil Carbon Sequestration” Analysis from NSW Greenhouse Office, October 2004,  
This unpublished analysis contains an estimate of the potential for increased soil carbon sequestration through the adoption of changes to agricultural practices. It is based on several reference documents including:
- “The impact of tillage on changes in soil carbon density with special emphasis on Australian conditions – A review of published studies” by Frank Valzano, Brian Murphy and Terry Koen. AGO in preparation NCAS Technical Report TR 43.

#### ***Brief description of abatement measure***

The amount of carbon sequestered in agricultural land depends on a variety of agricultural practices. This measure involves increasing the adoption of land use changes that can be implemented immediately with no net cost to the farmer. Examples include changing from conventional tillage with stubble burning to stubble retention and heavy grazing; changing from heavy grazing to medium grazing. This measure assumes that the changes would increase carbon uptake over a ten year period by about 7.3 t CO<sub>2</sub> per hectare, over a total of about 0.6 million hectares.

#### ***Critical assumptions in source of primary analysis***

*Technical uncertainty:* While agricultural practices are recognised as having an impact on soil carbon sequestration, the accounting is subject to considerable uncertainty.

*Market / economic uncertainty:* The intention of the estimate is to identify changes in agricultural practices that have no net cost to the landholder. However, there is uncertainty regarding the value of agricultural production and the change in that value resulting from revised practices.

*Program / policy uncertainty:* The primary uncertainty with respect to this abatement measure is the ability to develop policies and programs that would result in the take-up of measures..

#### ***Normalisation to NSW***

The estimate of abatement is specific to NSW.

#### ***Normalisation to ten year horizon***

None made, as the estimate is intended to represent gradual accumulation of soil carbon over a ten year horizon, assuming an immediate change in practices. No net increase in sequestration would occur in subsequent years.

#### ***Normalisation for ‘Business as Usual’***

None made, as the estimate is for incremental abatement.

#### ***Implementation and timing issues***

The agricultural changes are intended to be readily implemented within the ten year horizon.

## Appendix 2 – Individual Abatement Measures - *continued*

### 22) Forestry Sequestration

#### *Primary References*

- “An Assessment of the Potential for plantation development in NSW” ABARE and BRS report to the New South Wales Plantations Taskforce Steering Committee on Plantation Capability and Suitability, August 2001.

This document was commissioned by the NSW Plantations Taskforce Steering Committee to among other things, assess the economic and environmental potential for plantations, in support of policy development.

#### ***Brief description of abatement measure***

Establishing plantations on cleared or agricultural land increases the take-up of carbon by vegetation. This measure assumes that plantations are established in all areas where the value exceeds the profits of farm business. The report provides estimate for sequestration potential under three scenarios of carbon credit values, \$0, \$5, \$15 and \$30 / tCO<sub>2</sub>e. Notably, the report authors also provided an alternate evaluation based on a higher economic hurdle (i.e., exceeding farm profitability), which produced a lower estimate of potential abatement.

#### ***Critical assumptions in source of primary analysis***

*Technical uncertainty:* The establishment of plantations is well demonstrated and commercially mature. However, there is uncertainty regarding the rate of uptake (e.g., due to water availability) and retention (e.g., losses due to fire) at any site.

*Market / economic uncertainty:* The economic analysis of area suitable for plantation establishment is subject to assumptions about the value of forestry and agricultural products, and of farm business profitability and the economic behaviour of landholders, all of which are uncertain.

*Program / policy uncertainty:* The NGGAS and the Government’s forestry sequestration policies provide a relatively clear policy framework under which significant commercial investment decisions such as these could be made, although NGGAS concludes in 2012. Whether these policies are adequate to meet the needs of landholders is unclear.

#### ***Normalisation to NSW***

The ABARE/BRS report is specific to NSW.

#### ***Normalisation to ten year horizon***

None required.

#### ***Normalisation for ‘Business as Usual’***

None required.