

## **Analysis of Carbon-Cost Abatement Potential of Australian Energy Technologies by 2030**

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### **ABSTRACT**

Australia's current level of emissions produced through electricity generation contributes 37 percent of the country's total emissions. As a result, implementing cost effective energy technologies with a low life cycle CO<sub>2e</sub> output is vital in reducing Australia's future greenhouse gas emissions. The viability of alternative energy technologies based on cost and capacity were assessed by producing a business as usual cost abatement graph for 2030, which shows the additional cost of saving one tonne of CO<sub>2e</sub> when compared to the continued use of coal and lignite for electricity production. In relation to lignite, coal and gas with carbon capture and storage technology; coal was established to be the most viable technology with a potential capacity of 103 TWh by 2030 and an average additional cost of \$30.8 per tonne of CO<sub>2e</sub> saved when compared to the base case. Wind energy was deemed to be the most viable renewable energy source with a total capacity of 26 TWh by 2030. Although the price range of wind (\$5 to \$58 per tonne CO<sub>2e</sub> saved), is slightly higher than other renewables including geothermal and biomass, it is expected that wind will be one of the leading renewable technologies as it is already well established in the current energy sector. Solar photovoltaic energy was established to be the least viable renewable technology due to a low capacity of 6 TWh by 2030 and a high price range of \$154 to \$462 per tonne of CO<sub>2e</sub> saved. However, it is expected that the high learning rates of solar PV and renewable subsidies will lower the future cost of solar. Nuclear energy, although cost effective at an average additional price of \$30 per tonne of CO<sub>2e</sub> saved does not present a viable alternative source of energy by 2030. This is due to current Government policy being opposed to domestic nuclear power.

### **INTRODUCTION**

Climate change induced by anthropogenic activities is of increasing concern to both governments and society. Between 1970 and 2004, human activities were responsible for an increase in global CO<sub>2</sub> emissions of 17 Gt (Pachauri & Reisinger 2007). Projections predict that a future economy built on fossil fuels and population growth will cause a 6.4 °C global average temperature rise by 2090 relative to 1980-1999 temperatures (Pachauri & Resinger 2007). As a developed nation, Australia has a responsibility to mitigate the impacts of climate change by drastically reducing its production of greenhouse gas (GHG) emissions. Depending on the outcome at Copenhagen, the Australian Government have set a potential 25 percent GHG reduction target for 2020 compared to 2000 emission levels (Department of Climate Change 2009a). With electricity generation being responsible for 37 percent of Australia's GHG emissions in 2007 (Department of Climate Change 2009b), it is evident that a reduction of GHG emissions in Australia is reliant on finding alternative low carbon output energy technologies.

By producing a cost abatement graph for Australia for different energy technologies, this paper aims to establish viable alternative energy sources based on cost and energy production potential by 2030. The graph will illustrate the additional cost required to save one tonne of CO<sub>2e</sub> emissions when compared to a base case of ongoing energy production from coal and lignite resources. The paper first outlines the methodology used to construct the cost abatement graph. Secondly, the results of costs and the capacity of each technology illustrated by the abatement graph are discussed.

## **METHODOLOGY**

To produce an abatement graph for potential energy technologies in Australia, the following steps were carried out.

- Calculating CO<sub>2e</sub> emissions;
- Calculating costs; and
- Calculating the potential capacity in Australia for each technology for 2030

Only energy production technologies that were considered likely to be viable in Australia by 2030 were analysed, including wind, solar, nuclear, geothermal, biomass and Carbon Capture and Storage (CCS) technology for coal, gas and lignite.

### **Calculating CO<sub>2e</sub> emissions**

To determine the CO<sub>2e</sub> emissions from each technology, the program Simapro version 7.1 was utilised (Ecoinvent Centre 2007, Centre for Design at RMIT and Life Cycle Strategies Pty Ltd 2009). SimaPro is a Life Cycle Assessment (LCA) program that calculates factors including emissions and material use over the entire lifecycle of a number of technologies. This program was used due to its adoption in industries, consultancies and universities in over 60 countries, making it the most widely employed LCA program in the world (Pré 2009). With regards to Life Cycle Inventories (LCI), both Ecoinvent and the Australian Unit Processes were selected. These inventories contain detailed data on emissions production and material use for energy technologies. It was assumed that all emissions calculated using both LCI's in SimaPro were accurate for Australian technologies.

### Functional unit and technology options

The functional unit used for each technology was 1 kWh. This provided a unit for CO<sub>2e</sub> emissions of kg per kWh and allowed the emissions from each technology to be compared. Due to the large number of energy technologies available in the Ecoinvent and Australian Unit Processes database, it was assumed that the technology with the lowest kg of CO<sub>2e</sub> emissions per kWh for each energy generation type represented the expected performance of Australian energy technology by 2030. Consequently, these technologies were chosen for use in the abatement graph. Emissions relating to the base case were calculated by using a scenario including emissions from coal and lignite from the Australian Unit Processes database.

### Researched emission outputs

Geothermal energy generation data in SimaPro is sourced from New Zealand, which relies on volcanic geothermal systems that are not present in Australia (AGEA 2009). As a result, geothermal emissions data produced by Simapro do not reflect the emissions produced by geothermal energy generation in Australia. Consequently, this data was unsuitable and was not used in the production of the

abatement graph. Instead, emissions data for geothermal energy generation was established by reference to relevant literature.

### Calculating costs

Costs for each technology were determined in Australian dollars per kWh in 2030 based on published literature and industry sources such as ACIL and McLennan Magasanic Associates. All costs included construction, operation and maintenance net present value dollars for 2008. Often the data collected was not in Australian dollars and was sourced before or after 2008. This problem was overcome by ensuring that:

- Foreign currencies were converted to Australian dollars using the average exchange rate for the year the data was sourced. Conversion rates were taken from the Reserve Bank of Australia (RBA) (2009a). In cases where published literature did not supply the year in which cost data was sourced, costs were assumed to be at the year of the literature's publication in a similar manner to Sustainable Development Commission (2005);
- Australian dollars for years preceding 2008 were converted into 2008 dollars through the inflation calculator from the RBA (2009b); and
- Australian dollars for the year 2009 were converted into 2008 dollars using an inflation rate of 1.2 percent (RBA 2009c).

The costs determined for each technology were based on a business as usual scenario and did not take into account changes in prices due to future policy changes, including the possible introduction of an Emissions Trading Scheme and renewable technology subsidies.

### Calculating capacity

To establish the capacity of each technology in 2030 for Australia, data from literature sources was acquired including the Energy Revolution Report (Teske, Vincent 2008). However for coal, lignite and gas Carbon Capture and Storage (CCS) technologies, the capacity was based on the following factors (HRSCSI, 2007):

- An emissions storage capacity of 115 million tonnes per year. This capacity was used for coal, lignite and gas;
- Emissions produced by each technology during operations;
- A capture efficiency of 95 percent for post combustion capture; and
- A reduction of energy outputs by 30 percent due to energy requirements of capture and storage.

The method used to take into account these factors for CCS technology capacities is shown by Equation 1.

$$\text{Capacity for CCS technologies (kWh/yr)} = \left( \frac{\text{Tonnes CO}_2\text{e storage capacity}}{1 \text{ year}} \times \frac{1 \text{ kWh}}{\text{Tonnes operational CO}_2\text{e produced} \times 0.95} \right) \times 0.7 \quad \text{Eq. 1}$$

Under a business as usual scenario, nuclear energy generation was found to have a capacity of zero watt-hours, as the technology is currently undeveloped in Australia and lacks bipartisan government support. However, Communications Director Simon Clark from the Australian Uranium Association stated that "in considering the composition of its long-term energy portfolio, it is appropriate for Australia to examine nuclear energy" (Clarke 2009, email). As a result, this report

analyses the nuclear energy potential in Australia, however it was assumed that a maximum of one nuclear power plant, based on the capacity of a small nuclear plant in France, would have the potential to be operational in Australia by 2030.

### Modelling the abatement graph

Once data concerning emissions, costs and capacities of each technology option in Australia were collected, construction of the abatement graph took place. Equation 2 was utilised to establish costs required to abate one tonne of CO<sub>2e</sub> emissions. COT<sub>new</sub> represents the costs of the new technology, and COT<sub>base</sub> represents the cost of the base case technology. Regarding emission savings, CO<sub>2e</sub><sub>base</sub> - CO<sub>2e</sub><sub>new</sub> represents the tonnes of CO<sub>2e</sub> saved by each technology when compared to the base case of electricity production by black coal and lignite. As a result equation 2 illustrates the additional costs of each technology when compared to the base case to abate one tonne of CO<sub>2e</sub> emissions.

$$\text{\$ per tonne CO}_2\text{e saved} = \frac{\text{COT}_{\text{new}} - \text{COT}_{\text{base}}}{\text{kWh}} \div \frac{\text{CO}_2\text{e}_{\text{base}} - \text{CO}_2\text{e}_{\text{new}}}{\text{kWh}} \quad \text{Eq. 2}$$

For each technology, multiple costs were sourced from different organisations including McLennan Magasanic Associates and ACIL as discussed earlier. From this information, the average price of the technology could be represented by the cost bar, while maximum and minimum costs were represented by error bars.

The potential of each technology in Australia was based on its capacity for 2030 in TWh. Modelling of potential was achieved by adjusting the width of the cost bar relative to the capacity i.e. as capacity increases so does the width of the bar. The capacity of each technology was divided by a factor of ten to reduce the overall size of the graph.

## RESULTS AND DISCUSSION

Table 1 provides the costs required for each technology to produce 1 kWh of energy. Table 2 provides the emissions produced by each technology as well as the emissions savings when compared to the base case. Finally, Table 3 provides the energy capacity of each technology for 2030. Data provided in Tables 1 to 3 were used to produce the cost abatement graph as shown in Figure 1.

**Table 1** Costs of energy production for 2030 in 2008

Technology	\$2008 (per kWh)	Technology	\$2008 (per kWh)	Technology	\$2008 (per kWh)
Base case	0.037 <sup>e</sup>	Wind	0.042 <sup>c</sup>	Small Hydro	0.056 <sup>c</sup>
New Coal IGCC with CCS	0.062 <sup>c</sup>		0.051 <sup>c</sup>		0.065 <sup>c</sup>
	0.087 <sup>a,b</sup>		0.060 <sup>c</sup>		0.075 <sup>c</sup>
	0.049 <sup>e</sup>		0.102 <sup>a</sup>		0.134 <sup>a</sup>
New Lignite IGCC with CCS	0.077 <sup>a,b</sup>	Nuclear	0.077 <sup>d</sup>	Biomass	0.072 <sup>d</sup>
	0.049 <sup>e</sup>		0.069 <sup>c</sup>		0.040 <sup>c</sup>
GAS CCGT	0.048 <sup>c</sup>		0.065 <sup>e</sup>		0.060 <sup>c</sup>
	0.077 <sup>a</sup>		0.076 <sup>d</sup>		0.080 <sup>c</sup>
	0.061 <sup>d</sup>	0.531 <sup>c</sup>	0.071 <sup>d</sup>		
New Gas CCGT with CCS	0.109 <sup>a,b</sup>	Solar PV	0.343 <sup>c</sup>	Geothermal	0.049 <sup>c</sup>
	0.091 <sup>d</sup>		0.431 <sup>c</sup>		0.053 <sup>c</sup>
	0.063 <sup>c</sup>		0.209 <sup>d</sup>		0.059 <sup>c</sup>

- <sup>a</sup> Blesl et al., 2008. Assumes discount rate of 5 percent  
<sup>b</sup> includes a price of \$26/tCO<sub>2</sub> for transport and storage costs for 2030 in 2008 prices (Blesl et al., 2008)  
<sup>c</sup> McLennan Magasanic Associates 2006  
<sup>d</sup> ACIL 2008  
<sup>e</sup> ACIL 2009

**Table 2** CO<sub>2</sub>e emissions produced for each technology per kWh. And emissions savings when compared to the base case

Energy type	Name	CO <sub>2</sub> e (kg)	Emission savings (kg/kWh)	Emission Savings %
Base case emissions	Electricity high voltage, Australian coal based power production <sup>a</sup>	1.12		
Hydro small	Electricity, hydropower <sup>a</sup>	0.0062	1.114	99.446
Wind	Electricity wind power/ AU U <sup>a</sup>	0.00877	1.111	99.217
Nuclear	Electricity, nuclear, at power pressure water reactor/ FR U <sup>b</sup>	0.0067	1.113	99.402
Solar	Electricity, production mix photovoltaic, at plant/AU U <sup>b</sup>	0.0509	1.069	95.455
	Electricity, solar farm <sup>a</sup>	0.000743	1.119	99.934
Gas CCGT	Electricity, natural gas (turbine), Sent out/ AU U <sup>b</sup>	0.757	0.363	32.411
Biomass	Electricity, baggase, sugarcane, at sugar refinery/ BR U <sup>b</sup>	0.0163	1.104	98.545
New Coal CCS 95%	Electricity hard coal at power plant NORDEL with CCS <sup>c</sup>	0.16525	0.955	85.246
New Lignite CCS 95%	Electricity, lignite, at power plant/AT U with CCS <sup>c</sup>	0.072	1.048	93.571
New Gas CCGT CCS 95%	Electricity, natural gas (turbine), Sent out/ AU U CCS <sup>c</sup>	0.1357	0.984	87.884
Geothermal <sup>d</sup>		0.104	1.016	90.714

- <sup>a</sup> Centre for Design at RMIT and Life Cycle Strategies Pty Ltd 2009  
<sup>b</sup> Ecoinvent Centre 2007  
<sup>c</sup> Using operational emissions from Ecoinvent Centre 2007 and a 95 percent capture rate (House of Representatives, Standing Committee of Science and Innovation 2007)  
<sup>d</sup> Emissions based on a weighted average of emissions produced from different plants including binary and injection (Bloomfield, Moore, Nielson 2003)

**Table 3** 2030 capacities for each technology

Technology	2030 Capacity (TWh)	Technology	2030 Capacity (TWh)
Coal IGCC with CCS 95% capture <sup>c</sup>	102.68	Hydro <sup>a</sup>	17
Lignite IGCC with CCS 95% capture <sup>c</sup>	81.48	Wind <sup>a</sup>	26
Gas CCGT <sup>a</sup>	129	Solar PV Farm <sup>a</sup>	3
Gas CCGT with CCS 95% capture <sup>c</sup>	129.57	Solar PV roof <sup>a</sup>	3
Biomass <sup>a</sup>	15	Geothermal <sup>a</sup>	14
Nuclear <sup>b</sup>	7.7		

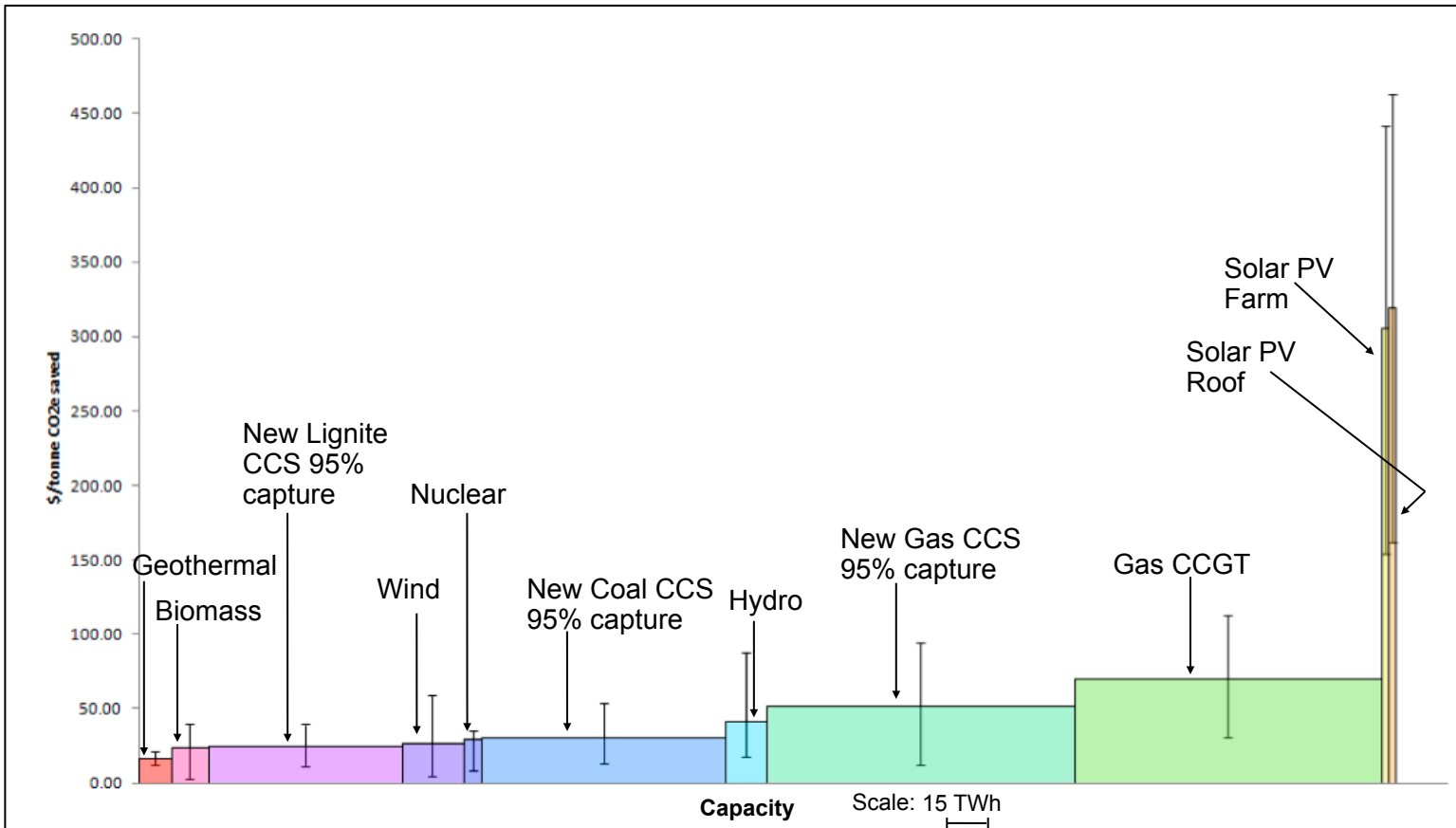
- <sup>a</sup> Teske, Vincent 2008
- <sup>b</sup> World Nuclear Association 2009
- <sup>c</sup> Calculated using equation 1

## CAPACITY

From Figure 1, it is evident that Carbon Capture and Storage (CCS) technology for gas, coal and lignite represent the most viable technologies for 2030 when considering their potential capacities. When comparing these technologies, gas CCS provides the largest capacity of 129.57 TWh, while coal and lignite CCS have the potential to provide 102.68 TWh and 81.48 TWh respectively (Table 3). Although all three capacities were based on a total emissions storage capacity of 115 million tonnes per year (HRSCSI 2007), differences in capacity potential are due to larger operational CO<sub>2e</sub> emissions per kWh for coal and lignite when compared to gas, with coal producing 0.825 kg/kWh, lignite producing 1.04 kg/kWh and gas only producing 0.654 kg/kWh during operations (Table 2). As a result, increases in emissions per kWh will result in reductions of overall capacity for technologies employing CCS due to the limitations of storage capacity.

While an emissions storage capacity of 115 tonnes per year was used for each technology, the HRSCSI (2007) states that 115 tonnes per year is the total annual emissions storage capacity for Australia. Therefore this storage capacity will need to be divided among coal, gas and lignite technologies based on their total operational output in 2030. Because of this, the overall capacity of coal, lignite and gas CCS will be reduced when compared to the results show in Figure 1.

Nuclear energy represents the technology with one of the lowest capacities in 2030, with a total output of 7.7 kWh (Table 3). This was based on the output of one nuclear power plant in France with a annual output of 880 MW (World Nuclear Association 2009). Although this capacity is small, it is warranted under the current business as usual scenario. As stated by Penny Wong, the Minister for Climate Change and Water, “[the Labour Party] is opposed to nuclear power domestically” (ABC Sydney 2009). Therefore the only viable chance for nuclear power generation by 2030 is a change in Government policy in the next few years. Communications Director for the Australian Uranium Association, Simon Clark (2009, email), stated that “for nuclear energy to be introduced, a number of hurdles would need to be overcome, including an appropriate regulatory framework, bipartisan political commitment at the State and Federal level, as well as support from the majority of Australian people”. Consequently, until these barriers are overcome, the ability for nuclear to provide a significant supply of power to Australia and in turn help to reduce GHG emissions is limited.



**Figure 1** Cost-abatement graph featuring the additional cost per tonne of CO<sub>2</sub>e saved (compared to base case scenario) and potential capacity of various energy generation technologies by 2030.

In regards to renewable energy technologies, Figure 1 illustrates that wind provides the highest capacity of 26 TWh for 2030, while solar PV on both roofs and as a solar farm provides the lowest capacity of 3 TWh respectively for 2030 (Table 3). The high capacity of wind when compared to other renewable sources may be due to a number of reasons including the technology being well established as a renewable source at the present time. Furthermore a large portion of Australia is suitable for wind energy due to high wind speeds across the coast of Victoria, New South Wales, Tasmania and the south-west coast of Western Australia (CSIRO 2006) which also improves the capacity of wind power in Australia. By contrast, reasons for the expected low capacity of solar PV for 2030 for a business as usual scenario includes the high costs attributed to solar PV technology of \$0.209 to \$0.431 per kWh (Table 1). Although this is presently the case, solar has the potential to provide a high capacity of electricity due to the elevated levels of solar radiation (5.5 to 6.75 kWh/m<sup>2</sup>/day), especially in the northern part of Australia (CSIRO 2006). Furthermore, potential improvements in technology and future cost subsidies will also improve the potential for an increase in capacity of solar PV by 2030.

The capacities of hydroelectricity, geothermal and biomass energy generation were found to be 17 TWh, 14 TWh and 15 TWh respectively (Table 3), presenting each of these technologies as viable alternative energy sources for Australia. Although their individual capacities are low when compared to CCS energy technologies, the combined capacity of all renewable technologies provides a capacity of 78 TWh per year. This overall capacity, and the low emission outputs of these technologies, indicates that renewable energy as a whole provides a prospective future alternative to reduce Australia's GHG emissions.

## **COST**

The additional price to abate one tonne of CO<sub>2e</sub> emissions of each technology, when compared to the base case, provides an accurate indicator of the potential of each technology to reduce GHG emissions in an economically viable manner. For this report, a price under \$50 per tonne CO<sub>2e</sub> saved is considered to be economically feasible.

From the cost-abatement graph (Figure 1), it is evident that the cost to abate one tonne of CO<sub>2e</sub> emissions using solar PV technology is significantly greater than other technologies analysed. An average additional price of \$305 per tonne CO<sub>2e</sub> saved for a solar PV farm and \$320 per tonne CO<sub>2e</sub> saved for solar PV roof panels. Since emissions saving for solar PV are between 95 percent and 99.9 percent when compared to the base case (Table 2), this high price range is most likely due to the cost of solar technology under a business as usual scenario for 2030. As can be seen in Table 1, the cost of solar energy generation falls in the range of approximately \$0.2 per kWh to \$0.5 per kWh, which is two to five times greater than the majority of costs found for other technologies. In addition, the error bars on the abatement graph, which represent variability of the price needed to save a tonne of CO<sub>2e</sub>, illustrates that prices for solar PV can range from \$154 to \$462 per tonne of CO<sub>2e</sub> saved for a business as usual scenario (Figure 1). With future changes to government policy and technology improvements, it is unlikely that the maximum price for solar PV will occur in 2030. However, it is also evident that prices will not fall below additional \$154 without the implementation of government incentives or subsidies. The high learning rate of solar technology is also likely to decrease the cost of photovoltaic technology in the coming years, making it probable that the cost of solar photovoltaic technology will have decreased considerably by 2030. As a result of this, solar photovoltaic technology is expected to be cost-competitive with other energy generation technologies in the future (Kantner et al. 2009).

Despite the high costs for solar PV energy generation, all other renewable energy technologies have an average additional cost below \$50 per tonne CO<sub>2e</sub> saved (Figure 1), thus making them cost competitive with the current base case technology of coal and lignite power generation. Standout technologies, as observed from the cost-abatement graph (Figure 1), were found to be biomass and geothermal energy generation. The additional costs to offset one tonne of CO<sub>2e</sub> for biomass and geothermal technologies were found to range from \$3 to \$40 and \$12 to \$22 respectively (Figure 1). These variations in price are well below the \$50 dollar range per tonne of CO<sub>2e</sub> saved (Figure 1), suggesting that geothermal and biomass are viable technology alternatives to the base case energy production. Wind and hydroelectricity also presents a viable energy alternative in terms of costs, with prices for wind ranging between \$5 and \$58 per tonne of CO<sub>2e</sub> saved, and prices for hydroelectricity ranging between \$18 and \$88 per tonne CO<sub>2e</sub> saved (Figure 1). Although the maximum prices for wind and hydroelectricity energy generation exceeds \$50 per tonne CO<sub>2e</sub> saved, it is expected that technology costs by 2030 are more likely to decrease than increase as a result of technological learning (IEA 2000). This has the potential to increase the cost-competitiveness of these technologies.

The costs of lignite and coal energy generation with CCS technology were found to have average additional costs below the \$50 per tonne CO<sub>2e</sub> abated price, with prices of \$25 and \$31 per tonne of CO<sub>2e</sub> saved respectively (Figure 1). Variability in cost of these two technologies is also near or below the \$50 range, with coal prices ranging from \$13 to \$53 per tonne of CO<sub>2e</sub> saved and prices for lignite ranging from \$12 to \$40 per tonne of CO<sub>2e</sub> saved. When analysing the cost of gas with CCS technology it is evident that prices relative to coal and lignite CCS technologies are high (Figure 1), with an average additional price of \$52 per tonne of CO<sub>2e</sub> saved and a price range of \$27 to \$74 per tonne of CO<sub>2e</sub> saved (Figure 1). This suggests that coal and lignite energy production may be better suited to employ CCS technology. Furthermore, gas energy production without the use of CCS technology was found to be less viable, with observations from the cost-abatement graph indicating an increased

additional average price of \$70 (Figure 1). This high price can be attributed to the low emissions savings achieved of just 32 percent (Table 2).

In terms of cost, nuclear energy also provides an economically viable alternative to the base case scenario. The average price of nuclear is \$30 per tonne of CO<sub>2</sub>e saved with a maximum price of \$36 per tonne CO<sub>2</sub>e saved. Although these additional costs are low, as discussed above, the capacity of nuclear in 2030, following a business as usual scenario, is not expected to be sufficient to provide a large portion of Australia's population with electricity by 2030.

## CONCLUSION

An Australian cost-abatement graph for 2030 featuring the potential capacities and additional costs to abate one tonne of CO<sub>2</sub>e emissions, compared to a base case scenario of coal and lignite energy production, was constructed for a number of alternative energy generation technologies. Technologies that were deemed suitable for analysis included solar photovoltaic, hydroelectricity, geothermal, wind, nuclear, biomass and carbon capture storage (CCS) for coal, lignite and gas.

CCS for coal, lignite and gas were found to have the greatest energy generation capacities and, based only on capacity, are the most viable for use in Australia. While this is the case, the emission savings from these three technologies ranges from approximately 87 percent to 93 percent and therefore do not perform as well as renewable technologies, which have emission savings in the 99th percentile. Additionally, when considering energy generation using coal, lignite and gas with CCS technology in 2030, the overall limited storage capacity for Australia must be considered. Data obtained for the cost-abatement graph assumed an emissions storage capacity of 115 tonnes per year for each of these technologies, however this figure represents Australia's total annual storage capacity. Consequently, if a mix of these energy generation technologies were utilised, the capacities of coal, lignite and gas energy generation with CCS technology would reduce.

In regards to nuclear energy, it was established that it is not a viable source of energy for 2030 due to the government's current policy of no domestic nuclear power generation. Because of this, although nuclear is cost competitive and provides an emissions saving of 99.4 percent it does not have the potential to provide an alternative energy source to lignite and coal by 2030.

Analysis of renewable technologies yielded varying results. Energy generation by geothermal, biomass, wind and hydroelectricity technologies were found to have low, competitive costs, while solar photovoltaic technology was found to be two to five times more expensive than all other technologies. In addition, solar photovoltaic technology was found to have a considerably small combined capacity of just 6kWh. However capacities and costs are expected to improve by 2030 as a result of technological learning. While geothermal, wind, biomass and hydroelectricity generation were found to have lower capacities than fossil fuel generation with CCS technology, the use of all four technologies together provides a sufficient energy output and is a viable alternative to current coal and lignite energy generation. Although this is the case, other limiting factors such as variable resources and slow technological advancements in Australia currently impede the immediate implementation of these technologies, particularly for geothermal and hydroelectricity technologies.

## ACKNOWLEDGEMENTS

First and foremost, we would like to thank Dave Collins for allowing us the opportunity to undertake this study. His resourcefulness and inspiration has been invaluable throughout the study. We would also like to thank our group mentor, Tim Grant, for his knowledge and patience in taking the time to assist our group. We also thank Patricia Boyce who provided invaluable information regarding cost estimation for technologies. A special mention also goes to Terry Teoh, Simon Clarke and William Young for their assistance.

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