Replacing Hazelwood Power Station – Critique of Environment Victoria report

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Abstract

Hazelwood Power Station is Australia's most CO2 emission intensive power station. Replacing it with cleaner technology could reduce Australia's CO2 emissions by 12 to 16 Mt/a. Environment Victoria recently commissioned a report by Green Energy Markets Pty Ltd to consider options. But the report has a pro-renewables bias, avoids the best option (gas only), and contains many inconsistencies.

Comparing the 'renewables and gas' option against the 'gas only' option shows
Emissions saved per year: 12.2 Mt/a versus 11.8 Mt/a;
Capital cost: $6-$7 billion versus $2 billion;
Cost of electricity: $103/MWh versus $55/MWh;
CO2 avoidance cost: $64/t CO2 avoided versus $22/t CO2 avoided.

The renewables option for replacing Hazelwood is a poor one. It is high cost and yet yields only small extra emissions savings.

The significance of this analysis is:

- It highlights the pro-renewables bias endemic in activist environment NGOs.
- It highlights the irrational policy advice being provided to governments by such groups.
- Federal and Victorian governments should reject the renewables option and implement the 'gas only' option.
- The nuclear option would be even better if it was available.

Introduction

Hazelwood Power Station is Australia's most emissions-intensive power station. Environment Victoria, a "non-government environment group", contracted Green Energy Markets Pty Ltd to consider options for replacing Hazelwood Power Station. The report "*Fast-tracking Victoria's clean energy future to replace Hazelwood Power Station*" [1] was published by Energy Victoria in May 2010.

The project brief was (**bold** is my emphasis):

> *... to undertake an assessment into the options and opportunities for replacing the Hazelwood Power Station by the end of 2012. This report assesses a combination of clean energy technologies to replace the generation capacity provided by Hazelwood in a way that maximise emissions reductions, whilst also maintaining energy security and* ***minimising any increase in electricity bills****.*

Does it actually meet these criteria? The scenarios it considers are described as follows:

> ***Scenario 1 – Supply side only option:*** *this scenario involves bringing forward 1180 MW of combined cycle gas turbine plant running at 65 per cent capacity factor and 1500 MW of renewable generation (predominantly wind) at 30 per cent capacity factor; and*
>
> ***Scenario 2 – Supply side and demand side option:*** *this scenario involves bringing forward 970 MW of combined cycle gas-fired generation running at 50% capacity factor initially, then declining over time, as well as 1500 MW of renewables. It also incorporates additional residential, commercial and industrial energy efficiency options that replace around 25 per cent of Hazelwood's annual generation as well as 100 MW of Demand Side Management.*

I have reviewed the report and my findings are provided in the following sections.

In short, the report does not meet its stated aims and contains many inconsistencies. Importantly, the report does not consider the alternative of replacing Hazelwood with just combined cycle gas (dispensing with the renewables component).

I have attempted to resolve the main inconsistencies (to the extent I can without having access to their assumptions and calculations). I have recalculated the CO2 emissions, CO2 emissions avoided, capital cost, cost of electricity and cost of emissions avoided. I have added a scenario for the case for combined cycle gas turbine plant only (no renewables).

Lastly, I considered a scenario where nuclear power is available as an established and mature option in Australia. Although nuclear is not an option on the time scale needed for replacing Hazelwood, it is important to recognise that if we continue to delay in allowing nuclear to be one of the options for replacing coal power stations in Australia in the future, we will be restricted as to how much emissions avoidance is achievable, the cost of emissions avoidance, and the cost pressures that will be applied to natural gas in the future.

Main criticisms

My main criticisms of this report are:

1. The energy efficiency and demand side management initiatives included in Scenario 2 – 'Supply side and demand side option' should not be considered a 'replacement' of Hazelwood. They are applicable to the whole electricity system, to all generators, and should be considered in their own right, not as a way to try to make the replacement of Hazelwood by renewable energy appear better and cheaper than it actually is. For this reason, I have not considered Scenario 2 any further in this critique.

2. There are many inconsistencies in the report (see below for more on this).

3. The report overstates the emissions savings to be gained from a mix of wind power and gas turbines (see below for more on this).

4. The option that is clearly the best for the immediate replacement of Hazelwood, combined cycle gas turbines alone, was not considered (or if it was, the results are not presented in the report).

5. The report seems biased towards promoting a pro-renewable energy solution despite the much higher costs and negligible additional emissions savings. This is not an objective, scientific or transparent way to plan energy policy.

Inconsistencies in the report

The report contains many inconsistencies. The numbers in the Executive Summary, Section 3 and Attachment 3 do not agree. Numbers in tables do not agree with related text. For example:

Page 12 states:

> *Hazelwood's power contribution to the NEM can therefore be summarised as follows:*
>
> *• Total generation – 11,770 GWh on a gross basis (effective capacity factor of 84 per cent). This needs to be reduced by the extent of its auxiliary electricity consumption (10 per cent) and its transmission loss factor (3 per cent). This means that 10,240 GWh per annum of generation needs to be replaced.*
>
> *• Contribution to meeting peak summer demand of 1350 MW on gross basis with 1175 MW after auxiliary power use and transmission losses.*
>
> *• Emissions intensity 1.37 tonnes/MWh on a gross basis (1.53 on a sent out basis after adjusting for auxiliary power use).*

But these figures do not agree with Attachment 3. Table 1 shows three different figures for the annual generation that must be replaced.

Table 1 – Hazelwood average annual generation in 2008, 2009

Item	Reference	GWh
Generation to be replaced (sent out)	Page 12	10,240
Hazelwood generation - net	Page 4, Attachment 3	10,301
Replacement generation	Attachment 3	10,392

When any of these figures are multiplied by the emissions intensity (1.53 t/MWh) the result does not match the total emissions figure quoted in the Attachment 3, which is. 16,166 kt/a. Multiplying the highest of these figures by the emissions intensity gives the total emissions as 15,900 kt/a. I suspect the 16,166 kt/a is the correct figure because it is derived from the 11,770 GWh (gross) generation multiplied by the gross emissions intensity (1.37 t/MWh). Therefore, I suspect the report has an error in the calculation of the 'sent out' energy. It appears, the report has understated the net energy that needs to be replaced. I calculate the sent out energy to be 10,566 GWh/a (see Appendix 2).

The peak capacity of the replacement generators is also understated. The report states 1350 MW (gross) of peak generating capacity is required to replace Hazelwood. I calculate 1500 MW (gross) is required. Why the difference? Figure 3 shows that Hazelwood provides 1600 MW peak power (gross). However, the report has used the average power output over the summer rather than the peak power output. Then this figure was reduced by 10% (allowance for the internal energy use) and also by 3% for transmission losses. However, transmission losses should not be deducted in calculating the 'sent out' power. It seems transmission losses have been deducted in calculating Hazelwood's net peak capacity, but not included when calculating the gross capacity of renewables and gas generators required to replace Hazelwood. The transmission losses from the wind farms would be higher than from the coal and gas power stations. The transmission losses from coal and gas should be similar. The transmission losses should not be included in the calculation of the capacity. I calculate, to replace the 1600 MW gross capacity of Hazelwood, we would need 1500MW gross capacity of combined cycle gas turbine if air cooled, or 1462 MW if water cooled. The report states the replacement capacity required is 1350 MW (gross). This significantly understates the peak capacity required to replace Hazelwood. (See Appendix 2 for basis of calculations.)

Emissions Savings overstated

The emissions savings that would be achieved from the proposed combination of wind power and gas turbines is overstated.

1. Combined Cycle Gas Turbines (CCGT) cannot back up for wind power on their own. A mix of CCGT and Open Cycle Gas Turbines (OCGT) would be required.

2. Both types will have to operate in a cycling mode and both will run at below their optimum output. As a consequence, both will produce higher emissions than they would if running at optimum output and if not cycling to follow the changing wind power output. [2], [3], [4]

3. The gas turbines will spend more time in start up, spinning reserve and cool down, than if they were not backing up for wind power.

4. The Kent Hawkins calculator provides some guidance on the additional fuel used and emissions involved in shadowing for wind power [3].

Calculations

Emissions Savings

I have recalculated the figures for Scenario 1 using what I believe are more realistic assumptions and inputs. I have also calculated the figures for the option with CCGT only (with no renewables). Appendix 1 compares the figures in the original Scenario 1, my revised Scenario 1, and the 'CCGT only' scenario. The following table compares the main results.

Table 2 – Comparison of main results from original Scenario 1, Revised Scenario 1 and Combined Cycle Gas Turbine (CCGT) Only

		Original Scenario 1	Revised Scenario 1	CCGT only
Hazelwood Generation – Net	GWh/a	10,301	10,566	10,566
Hazelwood Greenhouse Emissions	kt/a	16,166	16,166	16,166
Emissions from replacement generator	kt/a	2,580	4,003	4,332
Emissions saved per year	kt/a	13,586	12,162	11,834
Cumulative emissions saved by 2020	kt/a	108,687	97,299	94,670

In recalculating, I accepted as correct the report's figures for the gross generation, total annual emissions (16,166 kt/a), and emissions intensity (1.53 t/MWh). To calculate the net generation I did not include the 3% transmissions losses and I changed the capacity factor slightly (from 84% to 83.76%). Making these changes gives the Hazelwood net generation as 10,566 GWh/a. Note the emissions saved are less than stated for the original Scenario 1.

Costs

Table 3 compares the two options, wind and gas versus gas only, on the key criteria of capital cost, cost of electricity, emissions avoided and cost of emissions avoided. The basis of estimates is in Appendixes 3, 4 and 5.

Table 3 – Comparison of the wind and gas option and the gas only option on the basis of capital cost, electricity cost, emissions avoided and avoidance cost.

		Revised Scenario 1	CCGT only
Capital cost	$ million	$7,045	$1,913
Electricity cost	$/MWh	$103	$55
Emissions avoided per year	kt CO2/a	12,162	11,834
Emissions avoided per MWh	t CO2/MWh	1.15	1.12
Avoidance Cost	$/t CO2 avoided	$64	$22

Discussion

Replacing Hazelwood with wind and gas generators (Scenario 1) is only 3% better than the gas only option for the amount of emissions avoided. However, the wind and gas option (Scenario 1) is much more costly than the gas only option – see Table 3. The wind and gas option is 3.7 times the capital cost, 3 times the emissions avoidance cost, and, importantly for most people and industry, the cost of electricity is nearly double that of the gas only option. Thus, their stated criteria of "*minimising any increase in electricity bills*" is not satisfied.

On this basis it is clear that the wind and gas option should not be considered further. For currently available replacement technology in Australia, the gas only option is by far the cheaper option, and has only slightly (3%) higher emissions.

Nuclear option

I also considered a 'Nuclear' option. It is informative to consider this option because it demonstrates why we should not continue to delay the decisions to allow nuclear to be an option for new electricity generation capacity in Australia. Had the Hawke Government not banned nuclear from consideration during the *Ecologically Sustainable Development* work 20 years ago, we could have five operating nuclear power stations by now, be past the period of FOAK (first of a kind) costs, and have nuclear power providing clean electricity at a competitive cost. In this case our emissions from electricity generation would be near 20% lower than they are today. The clear message from this is we should not delay the decision to allow nuclear as an option for generating our electricity in the future.

If nuclear was an available option, replacing Hazelwood with nuclear would reduce emissions by 16 Mt/a. If the cost of electricity from nuclear power was the same as for the new nuclear power plants in Europe [5], the cost of electricity would be about $4/MWh (8%) more than the combined cycle gas plant option now, and much less as gas prices rise in the future. (Gas price is the main factor in the cost of electricity from gas generation, but fuel cost is a very small component of the cost of electricity from nuclear). Table 4 lists the key results:

Table 4 – Same as Table 3 but with nuclear option included on the assumption that nuclear is available now at the same cost as in Europe.

		Revised Scenario 1	**CCGT only**	**nuclear [1]**
Capital cost	$ million	$7,045	$1,913	$5,507
Electricity cost	$/MWh	$103	$55	$59
Emissions avoided per year	kt CO2/a	12,162	11,834	15,954
Emissions avoided per MWh	t CO2/MWh	1.15	1.12	1.51
Avoidance Cost	$/t CO2 avoided	$64	$22	$19

Implications for governments

The renewables option for replacing Hazelwood is a poor one. It is high cost and yet yields only small extra emissions savings.

The report demonstrates an obvious pro-renewables bias in the advice being provided to governments by the environment NGOs.

Such bias is causing irrational decisions that are forcing high cost electricity on Australia.

Federal and Victorian governments should reject the renewables option and implement the gas only option.

[1] Capital cost and electricity cost from NEEDS [5], p3, converted to A$ and escalated to 2010 $. http://www.needs-project.org/docs/results/RS1a/RS1a%20D14.2%20Final%20report%20on%20nuclear.pdf

Governments should recognise subsidising renewables is irrational and costly.

Australian governments should implement the policy, legislative and regulatory changes necessary to allow nuclear power to be implemented at least cost (consistent with appropriate safety requirements) in the shortest practicable time.

References

[1] Green Energy Markets (2010). *Fast-tracking Victoria's clean energy future to replace Hazelwood Power Station*. Environment Victoria. http://www.environmentvictoria.org.au/sites/default/files/Fast-tracking%20Victoria%27s%20clean%20energy%20future%20to%20replace%20Hazelwood.pdf

[2] Lang, P, (2009), *Cost and quantity of greenhouse gas emissions avoided by wind generation.* http://bravenewclimate.files.wordpress.com/2009/08/peter-lang-wind-power.pdf

[3] Hawkins, K, (2010) *Wind Integration: Incremental Emissions from Back-Up Generation Cycling (Part V: Calculator Update).* http://www.masterresource.org/2010/02/wind-integration-incremental-emissions-from-back-up-generation-cycling-part-v-calculator-update/#more-7271

[4] Lang, P, (2010), *Emission cuts realities – electricity generation: Cost and CO2 emissions projections for different electricity generation options to 2050.* http://bravenewclimate.files.wordpress.com/2010/01/lang_2010_emissions_cuts_realities_v1a1.pdf

[5] NEEDS (2007) *Final report on technical, costs and lifecycle inventories of nuclear power plants*. http://www.needs-project.org/docs/results/RS1a/RS1a%20D14.2%20Final%20report%20on%20nuclear.pdf

[6] ACIL-Tasman (2009), *Fuel resource, new entry and generation costs in the NEM.* http://www.aemo.com.au/planning/419-0035.pdf

[7] Mills, A. et al, (2009), *The Cost of Transmission for Wind Energy: A Review of Transmission Planning Studies*. Lawrence Berkeley National Laboratories, Environmental Energy Technology Division. http://eetd.lbl.gov/EA/EMP/reports/lbnl-1471e.pdf

[8] ABARE, (2009), *Electricity generation; Major development projects – October 2009 listing* http://www.abare.gov.au/interactive/09_Listings/eL09_Oct/ , http://www.abare.gov.au/publications_html/energy/energy_09/EG09_OctListing.xls

Appendixes

Appendix 1 – Emissions saved calculations

		Original Scenario 1	Revised Scenario 1	CCGT only
Replacing Peak Summer Supply				
Hazelwood Generation – Net	MW	1,179	1,206	1,206
Replaced by:				
1. Gas – combined cycle	MW	1,133	581	1,206
2. Gas – open cycle	MW		581	
3. Renewable Generation	MW	45	45	
	MW	**1,178**	**1,206**	**1,206**
Replacing Energy Generation				
Hazelwood Generation – Net	GWh	10,301	10,566	10,566
Replaced by:				
1. Gas – combined cycle	GWh	6,450	3,312	10,566
2. Gas – open cycle	GWh		3,312	
3. Renewable Generation	GWh	3,942	3,942	
	GWh	**10,392**	**10,566**	**10,566**
Replacing Greenhouse Emissions				
Hazelwood Greenhouse Emissions	kt/a	16,166	16,166	16,166
Replaced by:				
1. Gas – combined cycle	kt/a	2,580	1,500	4,332
2. Gas – open cycle	kt/a		2,503	
3. Renewable Generation	kt/a	0	0	
	kt/a	**2,580**	**4,003**	**4,332**
Emissions saved	**kt/a**	**13,586**	**12,162**	**11,834**
Cumulative emissions saved	**kt/a**	**108,687**	**97,299**	**94,670**
Emissions Saved by Activity				
1. Gas – combined cycle	kt/a	7,555	3,567	11,834
2. Gas – open cycle	kt/a		2,564	
3. Renewable Generation	kt/a	6,031	6,031	
	kt/a	**13,586**	**12,162**	**11,834**

Appendix 2 – Calculation of capacity for substitute gas generator

Calculation of Replacement Gas Generator Capacity

Calculate Hazelwood Average Power		Original	Revised
Hazelwood capacity	MW	1,600	1,600
Auxiliary load		10%	10%
Transmission losses		3%	0%
Net capacity	MW	1,397	1,440
Capacity Factor		84%	83.76%
Average Power	MW	1,173	1,206
Hazelwood Generation - Net	GWh	10,278	10,566

Substitute capacity required for average power		**CCGT (AC)**	**CCGT (WC)**	**OCGT**
Average Power	MW	1,206	1,206	1,206
Auxiliary load[2]		4%	1.5%	1.0%
Transmission losses		0%	0%	0%
Net capacity	MW	1,256	1,225	1,218
Availability Factor		92%	92%	97%
Gross capacity	MW	1,366	1,331	1,256

Substitute capacity required for peak power		**CCGT (AC)**	**CCGT (WC)**	**OCGT**
Hazelwood Capacity, Gross	MW	1,600	1,600	1,600
Hazelwood Auxiliary Laod		10%	10%	10%
Gas Auxiliary Load		4.0%	1.5%	1%
	MW	1,500	1,462	1,455

[2] ACIL-Tasman (2009), Table 32, http://www.aemo.com.au/planning/419-0035.pdf

Appendix 3 – Capital Cost, Electricity Cost and Emissions Avoided Cost

Capital Cost	**MW**	**$/kW**	**$million**
Wind	1500[3]	$2,600[4]	$3,900
Transmission	1500[5]	$1,000[6]	$1,500
CCGT	750[7]	$1,275[8]	$956
OCGT	750	$918[9]	$689
Wind, OCGT & CCGT			**$7,045**
CCGT only – scenario not in original report	1500	$1,275	$1,913
Nuclear	*1565*	*$3,519*	*$5,507*
Electricity Cost	**GWh/a**	**$/MWh**	**$million/a**
Wind	3,942	$110[10]	$434
Transmission	3,942	$15[11]	$59
CCGT	3,312	$72[12]	$240
OCGT	3,312	$108[13]	$357
Wind, OCGT & CCGT	10,566	**$103**[14]	$1,090
CCGT only – scenario not in original report	10,566	$55[15]	$578
Nuclear	*10,566*	*$59*	*$618*
Hazelwood (assumed)		$30	
Avoidance Cost	**$/MWh**	**t/MWh avoided**	**$/t CO2 avoided**
Wind, OCGT & CCGT	$73	1.15	$64
CCGT only	$25	1.12	$22
Nuclear	*$29*	*1.51*	*$19*

[3] As per Original Scenario 1
[4] Average capital cost of recently commissioned Australian Wind farms (ABARE, 2009), http://www.abare.gov.au/publications_html/energy/energy_09/EG09_OctListing.xls
[5] Transmission capacity to transmit the full power output of the wind farms
[6] 'Rule of thumb' for the total extra cost of transmission and grid stability control attributable to wind power; Gene Preston, Nov 2009, pers. comm., http://bravenewclimate.com/2009/11/03/wws-2030-critique/ An alternative (lower) figure is 15% of the capital cost of the wind farms, i.e. A$390/kW, http://eetd.lbl.gov/EA/EMP/reports/lbnl-1471e.pdf , page xi
[7] 1500MW peak capacity of gas generation needed to replace Hazelwood's 1600MW peak capacity (see Appendix 2). I've assumed half this capacity will be provided by CCGT and half by OCGT. No allowance for Capacity Credit for Wind because is fact, and overbuild of gas will probably be required for the case where CCGT and OCGT have to back up for wind power (see Lang, 2010)
[8] Capital cost, CCGT (AC), 2010-11, ACIL Tasman, Table 35, http://www.aemo.com.au/planning/419-0035.pdf
[9] Capital cost, OCGT, 2010-11, ACIL Tasman, Table 35, http://www.aemo.com.au/planning/419-0035.pdf
[10] EPRI (2009), Table 7.1, p7-5 and p10-19. US$99/MWh = A$110/MWh @ conversion rate A$1 = US$0.90. http://my.epri.com/portal/server.pt?Product_id=000000000001019539
[11] Rule of thumb from Gene Preston (see previous foot note). Also, US$15/MWh from page xi here: http://eetd.lbl.gov/EA/EMP/reports/lbnl-1471e.pdf
[12] From Appendix 5
[13] From Appendix 5
[14] Total annual cost / GWh/a
[15] LRMC for CCGT (AC), CVIC, 2010-11 $54.66. Source ACIL-Tasman, Table 52, http://www.aemo.com.au/planning/419-0035.pdf

Appendix 4 – Calculation of CO_2 emissions intensities for CCGT and OCGT when backing-up for wind power.

		CCGT	OCGT	Note
Emissions intensity at CF = 85%	t CO2/MWh	0.41	0.66	1
CO2 emissions % increases		21%	29%	2
Proportion of energy in wind shadowing mode		50%	50%	3
Emissions intensity (wind shadowing)	t CO2/MWh	0.45	0.76	4

Notes:

1. Table 41, CVIC, http://www.aemo.com.au/planning/419-0035.pdf
2. Kent Hawkins, Part V, Table 2, Wind CF= 28%, http://www.masterresource.org/2010/02/wind-integration-incremental-emissions-from-back-up-generation-cycling-part-v-calculator-update/#more-7271
3. Assumption (in effect I have halved the Kent Hawkins factors).
4. Calculated

Appendix 5 – Calculation of electricity cost for CCGT and OCGT when backing-up for wind power.

		CCGT	OCGT	Note
Electricity cost (sent out) at CF = 85%	$/MWh	$55	$86	1
Gas use & cost % increases		21%	29%	2
Proportion of energy in wind shadowing mode		50%	50%	3
	$/MWh	$60	$98	4
Lower CF increases fixed costs per MWh		20%	10%	5
Electricity cost (wind shadowing)	$/MWh	$72	$108	6

1. ACIL-Tasman, Table 52, CCGT (AC),CVIC, 2010-11 http://www.aemo.com.au/planning/419-0035.pdf
2. Kent Hawkins, Part V, Table 2, Wind CF= 28%, http://www.masterresource.org/2010/02/wind-integration-incremental-emissions-from-back-up-generation-cycling-part-v-calculator-update/#more-7271
3. Assumption (in effect I have halved the Kent Hawkins factors).
4. Calculated (intermediate step)
5. Assumption. The electricity costs are based on a capacity factor of 85% for all technologies (Refer ACIL-Tasman, Section 4.4, p81). However, in wind-shadow mode the CCGT and OCGT will run at much lower capacity factors. The Fixed costs must be spread over a smaller quantity of electricity sold. So the fixed cost share of the electricity cost must increase. Fixed costs are a relatively small component of the OCGT and somewhat higher for CCGT. I have not calculated these accurately and have simply assumed 20% and 10% for the sake of demonstrating the effect of these extra costs when gas is operating in gas shadowing mode as opposed to its optimum efficiency.
6. Calculated

Appendix 6 – Various comments on the Report

Efficiency improvements and demand side management should be considered as part of general improvements and shared between all power stations. They should not be assigned to one power station, e.g. Hazelwood. Therefore, I will not look further at Scenario 2. I will consider only Scenario 1.

Scenario 1.

All assumptions seem to be a stretch. For example:

1. Hazelwood is 1600 MW (gross capacity) and generates all that power at times during peak demand. However, Scenario 1 considers replacing Hazelwood with just 1350 MW (gross) capacity.

    - Page 11: "*Over the last two summer periods Hazelwood tended to operate at around 1350 MW. Hazelwood's output over the peak 2009/10 summer period has varied from less than 1000 MW to 1600 MW (refer to Figure 3).*"

    - Figure 3 shows that most of the time through the summer, 6 units (1200 MW) or 7 units (1400 MW) were operating and occasionally 8 units (1600 MW) were operating. So clearly, Hazelwood is capable of generating at 1600 MW when required. So we need to be able to replace the net equivalent of Hazelwood's 1600 MW of gross power.

    - I'd suggest a fair comparison would be to replace Hazelwood with plant of the same 'sent out' capacity.

2. The report states CCGT would produce only 27% of the emissions of Hazelwood.

    a. Page 14: "*Gas, while still a fossil fuel, is significantly cleaner than coal and when used in combined cycle mode for power generation produces only 27 per cent of the emissions of the Hazelwood Power Station*."

    b. However, this improvement could only be achieved if Hazelwood was fully replaced by CCGT alone. If wind power is in the mix, then Hazelwood would have to be replaced by a mix of CCGT and OCGT. With wind power in the mix, the gas power stations must cycle much more than they would if there was no wind power in the mix. The combination of requiring a mix of OCGT and CCGT as well as having to cycle them, would mean the emissions would be around 40% of Hazelwood's emissions rather than 27% (from the mix of CCGT & OCGT plant per MWh).

3. Emissions reductions are overstated on page 5 (Executive Summary), page 23 and page 35 (Attachment 3). The report does not allow for the fact that a mix of CCGT and OCGT is needed to back up for wind power, and does not allow

for the fact that CCGT and OCGT produce more emissions when they are backing up for wind power.

a. Page 23: "*This scenario would replace Hazelwood's current greenhouse emissions of 16.2 million tonnes per year with projects that would have annual emissions of 2.5 million tonnes, thereby reducing Victoria's emissions by 13.6 million tonnes*."

b. I calculate the emissions would be 4 Mt/a not 2.5 MT/a and reduce emissions by 12 Mt/a not 13.6 Mt/a.

4. Cost of replacing Hazelwood (page 29)

"…. The Australian Government's latest changes to the CPRS increased compensation to generators from $3.9 billion to $7.4 billion, which would likely nearly double Hazelwood's compensation to close to $2 billion.

At a $20 per tonne carbon price which is at the lower end of International Power's estimates of the cost of gas displacing coal[16], the carbon cost of Hazelwood's generation amounts to around $320 million per annum. This level of cost may be sufficient to deliver the 15 million tonnes of abatement under Scenario 2 and this cost could be shared between compensation to Hazelwood and support to new clean energy technologies.

If the cost was to be recovered from electricity consumers then electricity prices would increase by around $6 per MWh. This is equivalent to an increase in average household electricity bills of $36[17] per annum. There would be a need to moderately increase energy concessions to low income consumers to ensure that they are not disproportionately impacted by such a price rise.

To put the household impact into context, modelling by the Australian Government on the costs of implementing the CPRS indicated that electricity costs would increase by $30 per MWh by 2020, or $180 per annum per household, under scenarios involving 5 to 10% emission reduction targets by 2020. This is equivalent to one fifth of the Federal Government's modelled cost impact of the CPRS under the 5 to 10 per cent emissions reductions targets by 2020.

a. I calculate the electricity cost from Hazelwood would increase by $73/MWh for the Scenario 1 (Wind and Gas) or by $25/MWh for the gas only option. Page 10 of the report states: *Hazelwood currently supplies around 23 per cent of Victoria's electricity*. Therefore, the wholesale cost of electricity would increase by $16.80/MWh with the wind and gas option or by $5.75 with the gas only option.

b. The $6/MWh mentioned in the report seems to be the increase in the cost of electricity to Victorian customers due to the replacement of Hazelwood. I am not sure how this has been calculated.

Appendix 7 – Gene Preston on Capacity Factors and Reliability

This recent comment by Gene Preston on the BraveNewClimate web site contains some pertinent comments.

Gene Preston, on 20 May 2010 at 7.06 Said:

The above discussion about coal reliability is overly simplified. We need to make a distinction about annual peak, weekends, and low load periods of the year. The coal plant reliability is determined mostly by the FOR, forced outage rate, which could be as good as 95% (5% FOR) when the coal plant is needed most, during the peak load periods. Many maintenance problems can be deferred to the weekend when the load is less. This type of problem usually does not greatly affect the reliability. Then scheduled maintenance is scheduled for light load periods of the year when the plant is not needed. When you do a loss of load probability study, you will find that the greatest loss of load is during the peak load periods, not the lighter load periods. A plant failure during the lighter load periods usually has little consequence, provided the network is electrically stable for the loss of the largest generation within a geographic region. The annual capacity factor is mostly determined by demand for a coal plant. Coal can go into load following frequently and is dispatched after natural gas and before nuclear, which is even more base loaded than coal. Wind generation can cause gas and coal plants to be backed off because wind had a lower incremental energy cost than either gas or coal. Therefore adding more wind to a region will cause the capacity factor of coal to drop a little, especially when the wind runs during light load periods, which is does frequently. However because coal plants are difficult to dispatch they cannot be run back very far to accomodate wind. Because of the unpredictable nature of wind there must be kept on line a certain amount of gas and coal in the event wind is not sufficient. But there is only a certain amount you can swing gas and coal generators. Therefore as more and more wind is added it becomes more difficult to dispatch the total set of generators. Its possible to have some stablity problems with the network as wind is swinging from low to high levels. As you keep adding more and more wind you will reach a point where wind has to be dumped even if there are no transmission limitations. This is because the gas and coal generators cannot be swung enough to accomodate all the wind. Therefore wind is going to have an upper limit, probably no more than about 30% of the total energy. The only way to simulate the network to see how it work is in an hourly simulation model. That model can also be a montecarlo model considering random failures of both generators and line and even wind variability. Every once in a while the hourly model will run into difficulties that require dumping load. This is the only correct way to model the system.

Ref: http://bravenewclimate.com/2009/11/03/wws-2030-critique/#comment-67206