Reducing CO_2 Emissions in Victoria

Delivery or Dogma?

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Background

Victoria has amongst the world's highest CO_2 emission rates for its power generation. This is largely due to the state's reliance on brown coal, its incumbent older technologies for converting the lignite to electricity, as well as Victoria's comfortable living standards and the associated energy usage per person. Additionally, Victoria has enjoyed a lower cost of electricity versus other states in Australia with its low cost generation capability, providing it with a competitive advantage in attracting industry investment, providing jobs and income for the State and its people.

In response to the climate change challenges, Victoria's state government, as well as other bodies, have made various proposals to reduce the CO_2 emissions, ranging from step-wise and economically sensitive to idealistic with little respect for the economic impact on individuals, businesses, or the State's low electricity cost competitive foundation.

Environmental Clean Technologies strongly believes that reducing our CO_2 emission rates is the right thing to do. Further, we believe this must be achieved in an economically responsible fashion. To that end, we have prepared a detailed report on some options available to the State, and will here summarise an alternative option to those discussed in the media and government, and compare these with some which have captured media attention in terms of costs, which are typically avoided in public discussion.

Summary

There have been a series of proposals to review the continued service of one of the State's oldest generating plants. Alternatives proposed or discussed include the very credible report by Environment Victoria proposing a combination of Gas and Wind power to cover the resulting power generation gap, as well as a more 'emotional' proposal to replace the full needs via Wind alone.

We have modelled three scenarios; the Environment Victoria proposal; a leading edge Black Coal power plant, consuming Black Coal Equivalent produced by dewatering Victoria's Lignite resources via the Coldry process; and Wind Power alone, and compared these against the status quo of the oldest Brown coal generator.

The analysis process followed closely the modelling approach as developed by ACIL Tasman in their authoritative report "The impact of an ETS on the energy supply industry". Our analysis compared these alternatives on the basis of a long-term complete cost of generation. This included capital cost coverage, operating and maintenance (both fixed and variable), as well as the costs of fuel required to drive their operations.

Finally, and very importantly when the reasons are driven by climate change challenges, the alternatives are compared on the basis of the CO_2 reductions achieved, and the cost for that reduction.

	Business as Usual	**Environment Victoria Plan** (Gas & Wind)	**Coldry-USC Solution**	**All Wind** (Reference Only)
Capital Cost to Build	n/a	$5.205 Billion	$3.903 Billion	$11.313 Billion
Generation Cost of Power ($/MWh)	$39.21 Base reference	$77.90 +99%	$44.40 +13%	$95.87 +145%
CO2 Intensity (t/MWh)	1.53	0.27	0.75	0
CO2 Emitted (t/y)	18,013,363	3,131,200 -83%	8,827,500 -51%	0 -100%
CO2 Mitigation Cost ($/t Co2)	n/a	$30.61	$6.66	$37.03

While the table above has followed a relatively comprehensive approach, the Wind power components lack a significant element. Wind generation is by definition a geographically distributed approach, being installed where available land and sufficient wind speeds match the needs. These do not tend to be located adjacent to an existing distribution infrastructure for electricity today, and so an allowance needs to be included for the installation of this required component. This is likely to be significant – typically 1/3 of the total capital expenditure – though has not been included, and so represents a further cost addition that needs to be considered on top of the above analysis for the Wind based alternatives.

Discussion

Victorian targets and constraints

Victorian targets for reduction of Greenhouse gas emissions have been set by the State Government via a range of measures and initiatives, and – as they relate to this paper – can be summarised as:

- "20% by 2020" – 20% reduction in emissions (vs. year 2000 levels) by 2020
- 0.8 tonnes per MWh – a cap on CO_2 emissions per MWh delivered for new fossil fuel power generation systems
- "4 million tonnes in the next four years"
- Prohibition of new conventional Brown Coal fired electricity generation
- Funding of further development of the CarbonNet CCS Hub project
- Support the Latrobe Valley to transition to a low-carbon economy

The Government also states: "Since 2005 the Government has committed $230 million in funding through the Energy Technology Innovation Strategy (ETIS) to investigate and trial more efficient brown-coal technologies."

Overall, it would appear a comprehensive approach to developing new technology, reducing CO_2 emissions, and Victoria "doing its bit" to deliver Climate Change improvement outcomes.

CO_2 Reduction – Delivery vs. Dogma?

Sustainability needs to provide for the intersection of the Three Pillars of Economy, Society and Environment – not Environment to the exclusion of all other objectives. A mature and complete discussion of alternatives must include consideration for the needs of:

- Society – electricity, reliably produced and available when required
- Environment – reductions in CO_2 generation
- Economy – electricity produced in an affordable fashion, done so reliably, without exposure to outages driven by poor winds (the Wind only scenario), without high levels of exposure to future trends in commodity pricing e.g. Natural Gas, and without squandering Victoria's long held competitive advantage

To engage in this discussion without consideration of all aspects – especially the economic impacts (which are intimately related to Society through provision of continued employment and the ability of consumers to pay their daily bills) – is not complete, and abrogates the responsibility for community leadership. Without continuing community support for change, change will cease. Community support for change will diminish with dramatically increased costs.

Options reviewed

In preparing this study, the scenarios were carefully selected to enable a reasonable comparison of options. An All-Wind scenario was also included to provide a comparison, even though this is not possible in practice due to base load generation exposures (since current technology for storing energy is not available for base load power).

The average power generation for Victoria's oldest power plant over 2008 and 2009 was 11,770GWh[1]. The scenarios to generate the replacement of this annual requirement were:

- Environment Victoria's "Fast-tracking Victoria's clean energy future to replace Hazelwood Power Station" report, prepared by Green Energy Markets, May 2010, containing a combination of 1500 MW of Wind generation capacity and 1130 MW of CCGT (Gas) capacity
- An All-Wind scenario (4.48 GW)

[1] Environment Victoria, "Fast-tracking Victoria's clean energy future to replace Hazelwood Power Station",

- A combination approach of Coldry Brown Coal dewatering technology, coupled with proven and modern high technology Ultra Super Critical (USC) pulverised coal fired power generation of 1445 MW capacity

Notes:

1. USC is in everyday use in Japan and China, and represents leading edge technology deliverable today in Australia. It is not an R&D technology yet to be proven, but rather something that today supports the energy consumption needs of millions of people.
2. Solar alternatives were not reviewed, as these technologies were rated as less preferable when compared on the basis of economics and effectiveness. ACIL Tasman's report "The impact of an ETS on the energy supply industry", page 12, provided Solar Thermal and Solar PV costs between $A200-240 per MWh – more than twice the cost of Wind power, with a cost of CO_2 abatement at $A128-162 per tonne of CO_2 avoided – around three times that of Wind. This compares very poorly to the alternatives explored above.

Method & Results

The following parameters were defined as providing the basis for comparison:

- Capital cost for the installation of each alternative
- Generation costs per MWh for each alternative
- CO_2 avoided in generating the required power per year
- Cost per tonne of CO_2 avoided

Costs were developed using the model defined through ACIL Tasman's report earlier referenced. That is:

Cost per Mwh = Cost allocated for the capital needs, allocated over the asset life

\+ Cost allocated for the Operations & Maintenance needs

\+ Fuels costs

Divided by the total MWh generated each year

For each technology, the Capital, Operations and Maintenance costs were estimated using a combination of ACIL Tasman's documented approach, as well as best available data for Wind Energy operational costs[2], USC capital costs[3] and ECT models for Coldry capital and operating costs.

For fuel costs, ACIL Tasman's data on Natural Gas long term mean pricing from 2008 and Brown Coal costs were used.

CO_2 reduction costs were calculated through first developing the CO_2 profile of each technology, then comparing the costs of electricity supplied and the CO_2 saved. Comparisons were made versus today's emissions profile and costs for the oldest generating asset.

Finally, it is important to note the gaps in such an analysis, namely:

- CO_2 generation intensity for USC has been (conservatively) assumed to be the same as current Black Coal technology as installed elsewhere in Australia. In reality, it should be better, but we are without basis for selecting another figure, so have taken a conservative approach – perhaps overly conservative.
- There are significant missing cost elements associated with Wind generation. The technology is necessarily geographically dispersed, requiring additional Electrical distribution infrastructure. This could add as much as another one-third to the capital costs, further escalating the delivered costs of power to consumers.
- There are risks associated with future escalation of gas pricing. The model uses a projected Long Term mean price of $6.5 per GJ of gas. While this may seem reasonable today based on Victorian pricing of around $5.5 per GJ, escalation pressures associated with

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[2] European Wind Energy Association report on the Economics of Wind Generation

[3] ACIL Tasman report on "Fuel resource, new entry and generation costs in the NEM"

international parity will be felt in the short term. As an example, Western Australia contracts have recently been let for long-term supply in excess of $8 per GJ. As more nations seek to mitigate their coal fired CO_2 exposures via gas generation, pricing will certainly escalate. Some reports have been sighted projecting $20 per GJ pricing into the next decade.[4]

Impacts in Victoria

Retail power bills have the cost of electricity generation built into them. These generation costs account for a significant portion of the overall bill, and so the impact of generation cost increases will carry through in entirety to the consumers – individual households, as well as employers across the state. Victoria's once strong manufacturing base would have its long-standing competitive advantage of manageable electricity costs further degraded, adding pressure to an already strained commercial sector of our economy.

Without doubt, there is community consensus for efficiency improvements and managing exposures to climate change. However, that commitment doesn't translate into a blank cheque. Achievement of results are expected to be at an affordable and reasonable cost and failure to do so may see community support for climate change measure being lost.

Environment Victoria's proposed model results in a near doubling of generating cost versus today ($39.21 / MWh increasing to $77.90 / MWh). In terms of CO_2 mitigation cost, this is $30.61 for each tonne of CO_2 avoided. We note that our cost calculations differ from those on page 6 of the Environment Victoria report. We are unable to explain how their report arrives at such figures given the ACIL Tasman referenced data we used bears out much higher calculations.

An "All Wind" scenario and those of Solar technologies would serve to increase further the electricity costs to the State, and cost even more for each tonne of CO_2 avoided.

The Coldry / USC alternative achieves comparable mitigation goals, costs $1.3 billion less in capital, reduces the electricity cost increases from +99% to a more manageable +13%, with CO_2 avoided at only $6.66 per tonne (nearly 80% less than the Environment Victoria proposal). This would deliver a reduction of more than 9 million tonnes of CO_2 (around half that emitted today from that power station), contributing significantly to the stated targets of "20% by 2020".

As the State Government has repeatedly indicated, continued further expenditures to develop viable CCS programs are underway. These are expected to consume many millions of dollars – if not billions when ultimately deployed. Coupling these efforts with technologies like Coldry that make such significant reductions enables those billions to be more effectively spent. If CO_2 emissions are decreased by half before they are captured, the capturing equipment and associated systems have far less work to do; can potentially be smaller and less costly and perhaps even avoided in all but extreme circumstances.

The Coldry / USC combination alternative is the most reasonable in terms of cost – capital as well as on-going generation cost – achieves significant reductions in CO_2 emissions levels, and maintains Victoria's competitive advantage as a low cost energy State. If the objective of Government climate change policy is to reduce CO_2 at the most reasonable cost, then Coldry / USC should logically garner serious consideration and significant support.

Global Application

Utilisation of brown coal for power generation is the least cost effective use of a potentially high value resource. The Coldry process delivers a low-moisture, stable, high-energy coal pellet. Victorian Lignite, once released from the burden of its inherent high moisture levels, forms one of the cleanest energy sources available. It is low in Ash, Sulphur and other hazardous pollutants associated with coals, and is located on land below minimal levels of overburden – meaning it is simpler and safer to extract versus deep offshore drilled alternatives.

With the water removed, the coal is perfectly suited to higher technology processes such as gasification, which are either coupled with yet higher efficiency power generation systems, or more

[4] David Archibald, "The Future of Energy in Australia," 20 July 2009

importantly, coupled with chemical process aimed at delivering liquid fuels, fertilisers or chemicals at much higher commercial value than realised today.

Coldry is thus a gateway technology delivering significant commercial benefits to Victoria in terms of income for the State, as well as jobs and skills for the population.

Victoria is in a position to provide global leadership in the development of cleaner fossil fuel technologies. It is one of two locations globally where significant resources and skills have come to bear on brown coal technology development. While many nations around the world rely on brown coal for their fuel, delivering essential energy to their economies and population, it is only really Victoria and Germany that have invested in delivering technological innovation to this important fuel source. Without advancement in Coldry from Victoria, the range of nations around the world who today rely on brown coal for their staple fuel sources may be either deprived of the opportunity to reduce their own emissions, or worse, condemned to a cost of energy that outstrips their ability to pay should they be forced into lowering their emissions.

Victoria would benefit from our ability to provide high technology innovation and services to these nations, aiding them to improve themselves.

Steps to deliver

Step 1 would be the development and installation of a commercial module in the Latrobe Valley, logically located adjacent to existing power generation plants in the Latrobe Valley, and with ease of access to the better coal resources in the Valley. Following a short period for refinement and optimisation, expansion via replication of additional modules would then provide the required capacity to support the development of the USC project. Capacity expansion can be staged to match the consumption requirements.

Step 2 would encompass the development of the USC project, to be coupled to the Coldry facilities and mining infrastructure as a combination integrated unit.

The timetable to deliver the entire project would be of the order of 5 years or more to commencement of operation. If started now, the ability to deliver on the “20% by 2020” is greatly enhanced, as would be the opening of new opportunities within Victoria and globally.

Full Model Layout

	Capital cost (2008 ref) per kw	Fixed O&M per kw per yr	Fixed O&M plus CapCharge per kw per yr	Variable O&M per MWh	CapCharge per kw	CapCharge factor	Thermal efficiency (HHV, sent out)	Type	Price per unit	Energy content per unit	Price per GJ heat energy, $/GJ	Variable Fuel cost, $/mwh-e	Capacity factor	Generated cost, all components, $/mwh	Fuel consumption per yr per GW capacity	Capital cost per GW	CO2 emissions, mt/mwh
Brown coal	2,250	40	257	1.2	217	10.37	34%	Brown coal	3 $/mt	10.3 GJ/mt	0.29	3.08	84%	39.21	7,564,318 mt	2,250,000,000	1.53
Black coal (SC)	1,900	40	226	1.2	186	10.22	42%	Black Coal	70 $/mt	26.0 GJ/mt	2.69	23.08	93%	52.02	2,685,758 mt	1,900,000,000	0.75
CCGT	1,200	12.8	126	4.85	113.2	10.60	52%	Nat Gas	6.5 $/GJ	1	6.50	45.00	76%	68.84	45,926,988 GJ	1,200,000,000	0.40
Wind	2,526	5	248	1.5	243.0	10.39						0.00	30%	95.87		2,526,000,000	0.00
Black Coal (USC) + Coldry	2,702	40	300	1.2	259.9	10.39	46%	BCE	20 $/mt	24.0 GJ/mt	0.82	6.39	93%	44.40	2,656,565 mt	2,701,616,087	0.75

Detailed Comparison Table

	EnvVic plan (MW)	All Wind alternative	Coldry alternative
Brown coal			
Black coal (SC)			
CCGT	1,180		
Wind	1,500	4,479	
Black Coal (USC) + Coldry			1,445
Capex, million	5,205	11,313	3,903
Generated cost of reqd power	916,827,696	1,128,396,935	522,627,652
per mwh	77.90	95.87	44.40
% increase over base	99%	145%	13%
CO2 emitted, tonnes	3,131,200	0	8,827,500
Total Power generated, mwhr	11,770,000	11,770,000	11,770,000
CO2 emissions, mt/mwhr	0.266	0.000	0.750
CO2 of base case, tonnes		18,013,363	
Reduction, tonnes	14,882,163	18,013,363	9,185,863
%	83%	100%	51%
Annual cost per tonnes mitigated	30.61	37.03	6.66
$/mt CO2 reduced			
CO2 price, $/mt CO2 emitted	$ 25 /mt	$ 25 /mt	$ 25 /mt
New Generated cost, $/mwhr	84.55	95.87	63.15

References, Assumption & Derivations

References

1	ACIL Tasman, The impact of and ETS on the energy supply industry, 2008
2	ACIL Tasman, Fuel resource, new entry and generation costs in the NEM, 2009
3	Green Energy Markets / Environment Victoria, Fast-tracking Victoria's clean energy future to replace Hazelwood Power Station, 2010
4	European Wind Energy Assoc, The economics of Wind energy, 2009
5	ECT internal estimates
6	ECT research

Assumptions & Derivations:

Value	Category	Description	Reference	Source
2,250	Capital cost (2008 ref) per kw	Brown Coal	1	Table A3
1,900	Capital cost (2008 ref) per kw	Black Coal (SC)	1	Table A2
1,200	Capital cost (2008 ref) per kw	CCGT	1	Table A1
2,526	Capital cost (2008 ref) per kw	Wind	3	Derived from Table 9
2,702	Capital cost (2008 ref) per kw	Black Coal (USC) + Coldry	2 & 5	USC cost from ref1, Coldry plant data from ref5
40	Fixed O&M per kw per yr	Brown Coal	1	Table A5
40	Fixed O&M per kw per yr	Black Coal (SC)	1	Table A5
12.8	Fixed O&M per kw per yr	CCGT	1	Table A5
5	Fixed O&M per kw per yr	Wind	4	
40	Fixed O&M per kw per yr	Black Coal (USC) + Coldry	1	Table A5 - assumed same as per SC
257	Fixed O&M plus CapCharge per kw per yr	Brown Coal	1	Table A12
226	Fixed O&M plus CapCharge per kw per yr	Black Coal (SC)	1	Table A12
126	Fixed O&M plus CapCharge per kw per yr	CCGT	1	Table A12
258	Fixed O&M plus CapCharge per kw per yr	Wind	4 & 6	Derived using ACIL Tasman approach, and EWIA data
307	Fixed O&M plus CapCharge per kw per yr	Black Coal (USC) + Coldry	2 & 5	Derived using ACIL Tasman approach and ref1+ref5 data
1.2	Variable O&M per MWh	Brown Coal	1	Table A6
1.2	Variable O&M per MWh	Black Coal (SC)	1	Table A6
4.85	Variable O&M per MWh	CCGT	1	Table A6
1.5	Variable O&M per MWh	Wind	4	
1.2	Variable O&M per MWh	Black Coal (USC) + Coldry	6	Assumed consistent with SC
10.39	CapCharge factor	Wind/USC+Coldry	6	Using ACIL Tasman approach to absorb capital charge within LRMC
As stated	Thermal efficiency (HHV, sent out)	Brown, Black, OCGT	1	Table A8
46%	Thermal efficiency (HHV, sent out)	USC+Coldry	2	Table 36
3 $/mt	Fuel price per unit	Brown Coal	2	Table 26
70 $/mt	Fuel price per unit	Black Coal	6	International parity price less freight to port
6.5 $/GJ	Fuel price per unit	CCGT	1	Long term mean price
20 $/mt	Fuel price per unit	Black Coal (USC) + Coldry	2 & 5	Derived from Brown Coal pricing plus ECT modelled conversion costs
84%	Capacity factor	Brown Coal	3	pg12

Assumptions & Derivations (continued):

93%	Capacity factor	Black Coal (SC)	2	Table 32
75.7%	Capacity factor	CCGT	3 & 5	Derived from ref3 total generation required, less power provided by Wind generation
30%	Capacity factor	Wind	3	Table 7
93%	Capacity factor	Black Coal (USC) + Coldry	2	Table 32
1.53	CO2 emissions, mt/mwh	Brown Coal	3	Table 3
0.75	CO2 emissions, mt/mwh	Black Coal (SC)	1	Table 35
0.4	CO2 emissions, mt/mwh	CCGT	1	Table 35
0	CO2 emissions, mt/mwh	Wind	1	Table 35
0.75	CO2 emissions, mt/mwh	Black Coal (USC) + Coldry	5	This would be LESS than Black Coal SC, but ECT is choosing to be conservative with reduction projections in light of the Blk Coal SC estimate above
1445	Coldry alternative	Black Coal (USC) + Coldry	5	The power capacity required to meet 11770 GWhr at the noted efficiency

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