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Submission to: Select Committee on Wind Turbines

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Renewable energy sources – Economic impact

This submission addresses the peculiar design of the Renewable Energy Target (RET) scheme and in particular the impact of wind farms on other conventional electricity generators when considering "whole of life operation", often discussed as levelised power costs. This is examined by way of a comparison of wind power to other electricity generator types that supply electric power to two states in Australia.

Design of the Renewable Energy Target (RET) scheme

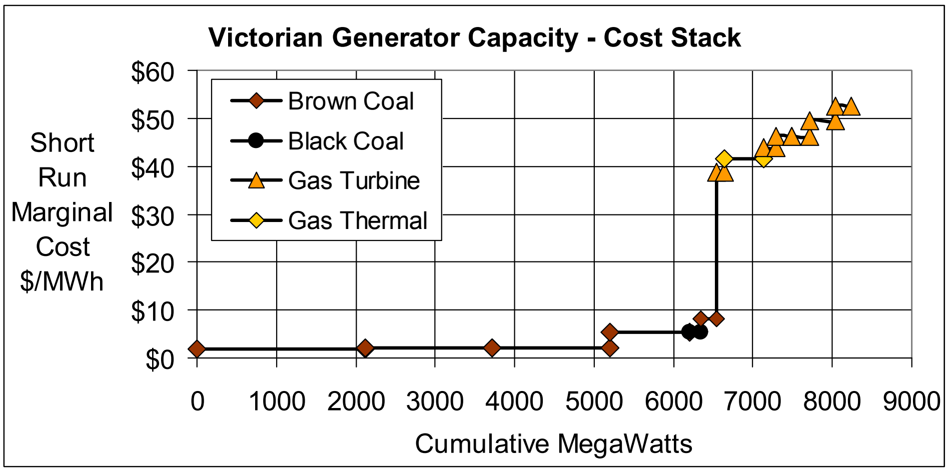
Many countries offer subsidies to renewables similar to our Renewable Energy Target (RET) scheme. The scheme is not very helpful for emission reduction. The payment of a subsidy to renewables has the peculiar structure that implies a higher carbon tax on the lower fossil fuel emitting generators - the opposite of the intention to reduce the use of the highest CO_2 emitters

Generators of renewable energy in Australia, in fact mainly wind farms with some small solar contribution, are paid a subsidy of $40 per megawatt hour (MWh) for electricity produced. This source of electricity displaces that generated from conventional power plants. This is an indirect equivalent of a carbon tax. If one MWh of electricity from black coal is displaced that stops the emission of one tonne of CO_2 so the carbon tax is $40 per tonne of CO_2. But for brown coal electricity with 1.5 tonnes of CO_2 per MWh the equivalent tax is $27 and gas turbines have equivalent taxes of $80 to $100, an increased tax for a lower emitter than the black coal generators!. The tax equivalents for these energy sources are shown in Table 1.

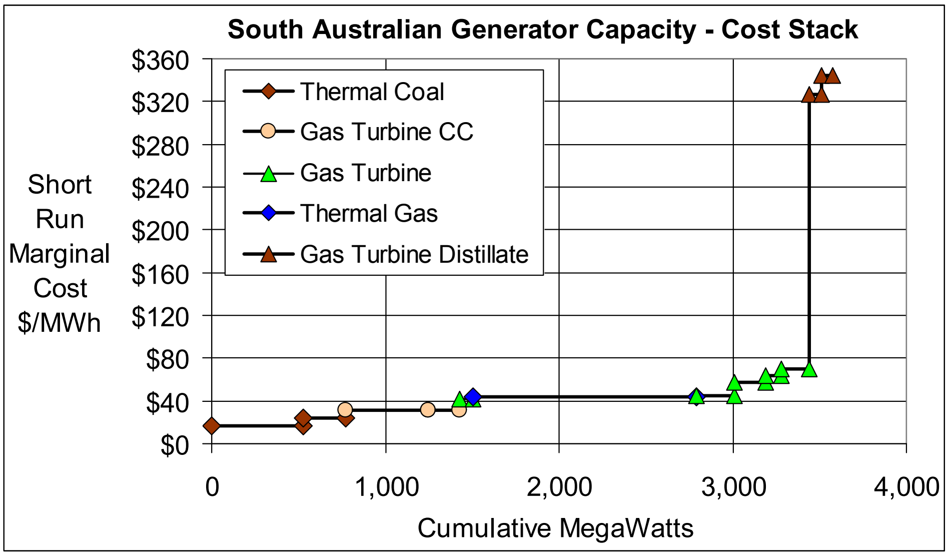
Table 1: Carbon tax equivalent for $40 per MWh subsidy paid to renewable generators

Plant Type	t CO_2 per MWh	Carbon tax equivalent per t CO_2
Brown Coal	1.5	$27
Black Coal	1.0	$40
Gas turbine (open cycle)	0.5	$80
Gas turbine (combined cycle)	0.4	$100

The intention of having wind farms in the electricity supply system was to drive out the highest emitters of CO_2 but the cost structure of the electricity market is such that the coal burning power stations are the lowest cost generators and higher cost but lower carbon emitting generators became more vulnerable to being stood down. This is abundantly clear looking at the short run marginal costs of generation (see the figure below). These costs are the fuel needed with any additional variable operating and maintenance cost but no carbon tax to produce a MWh of electricity[1]. The cost stack orders the low to high marginal cost generators and gives a rough indication of which generators are dispatched as prices change with changing electricity demand. The order to a generator to start producing electricity is termed dispatch.



Up to 6,000MW of Victorian energy may be dispatched from cheap brown coal, but rapid changes or increases in demand cause a dramatic rise in costs as gas is called into action.



In South Australia, only 500MW comes from cheap coal and variations up to 1,000MW in wind power need gas turbines to follow the variations. Above 3,500MW of demand, the costs rise -- becoming 6 times as expensive as the most expensive Victorian electricity.

The rewards to the wind farms were thus likely to drive out the lower carbon emitters. However there are more complications. The generators put in bids for amount and price for energy supply. This is a bid stack from low to high price (different from the marginal cost stack). When the sum of the supply bids equals the demand, the price is set at the price of the highest bid. However with wind power, the supply amount and price is set at the point that matches demand less wind power. This is a distortion of the wholesale market price since the wind farms receive the RET subsidy. But this subsidy is paid outside of the wholesale market with the result that the wholesale market only presents the conventional generator price stack. The wind farms receive both the wholesale market price and the subsidy.

Levelised Power Costs:

A common starting point for many assessments of alternative electrical power technologies is levelised costs. Levelised costs are the $ per MWh cost appropriately discounted for building and operating a generating plant over an assumed financial life and duty cycle.

The problem with levelised costs is that there is no such basis in the operation of an electricity system. . There are three distinctions that must be made, first whether the power source is dispatchable, second the time characteristics of electricity demand and third the size of the demand in relation to the size of the operating generators supplying power.

Wind power is not dispatchable; it is accepted as and when generated. So wind power require a backup of dispatchable generators to compensate for the inherent variations in the supply of power. On the other side of supply is demand. Demand varies continuously over a twenty four hour cycle. It is different from state to state and, more generally, from region to region depending on climate, industry and spread of population. There are rough common characteristics with minimum load in the early morning and peak loads around breakfast, mid-day or dinner times. The ratio of these in Australia is the peak being about two to three times higher than the minimum. In Victoria the demand varies from 3,000 MW to 9,000 MW but with random demand variability of the order of 10s of MW per minute. So the power supply has to cope with changing demand. In general thermal power stations can cope with following demand variations at a rate of about 20MW per minute. But to complicate matters supply from wind power also varies unpredictably like that coming from demand and so increases the difficulty of matching supply with demand. South Australia is the extreme example with demand varying from 900MW to 3,000MW but with wind capable of contributing up to 1,200MW. The matching of supply and demand is essential not only for a stable transmission grid and constant voltage to avoid brown- and black-outs but also to provide frequency stability so that time clocks do not distort arrival and departure times of workers! Two examples of the performance of supply systems are shown in Table 2 below for Victoria[2] and South Australia[3].

Table 2: Performance of Electricity supply for Victoria and South Australia in 2012

Victoria	**Capacity power in MW**	**Generation energy in GWh**	**Average Supply MW**	**Utilisation (capacity factor)**	**% Generation of total GWh**
Coal	6,599	44,808	5,115	77.5%	85.4%
Gas	2,382	2,953	337	14.2%	5.6%
Diesel	0	0	0	0.0%	0.0%
Hydro	2,254	3,162	361	16.0%	6.0%
Wind	400	1,333	152	38.0%	2.5%
Total	11,635	52,440	5,986	53.4%	
South Australia	**Capacity power in MW**	**Generation energy in GWh**	**Average Supply MW**	**Utilisation (capacity factor)**	**% Generation of total GWh**
Coal	770	2,238	255	33.2%	17.1%
Gas	2,672	6,786	775	29.0%	51.9%
Diesel	270	12	1	0.5%	0.0%
Hydro	3	6	1	0.0%	0.0%
Wind	1,203	3,483	398	33.1%	26.6%
Solar PV	400	497	57	14.2%	3.8%
Other	16	55	6	39.2%	0.4%
Total	5,334	13,077	1,493	28.0%	

The fraction of supply and the utilisation (capacity factor) of the generators are shown in the last two columns of Table2,.

Victoria, with relatively little installed wind power draws 85% of it supply from brown coal burning power stations while gas turbines and a gas thermal generator along with hydro are used to match demand to supply and wind power variations. The utilisation of the coal source is 78% while gas is only 14% and this implies very different pricing with such differences in use.

South Australia, with less demand than Victoria and with a relatively large renewable sector, draws 30% of its supply from the latter and needs a quite different pricing for its coal and gas generators with their utilisation of around 30%.

The state or regional variations in supply and utilisation for electricity supply systems are not taken into account in estimates of levelised costs. This gives rise to misleading conclusions.

There is a good illustration of levelised cost estimates from the Energy Information Agency (EIA) in the United State[4] where assumptions are made for the capacity factors that are not based on regional electricity demand performance. This is shown below in Table 3, extracted from the EIA report. on levelized cost of electricity (LCOE) for new generation resources for 2019. The Australian states have very different values for capacity factors and the comparison shows the importance of analyzing the regional electricity system. .

Table 3. Estimated and measured Capacity Factors

Plant type	**Capacity factors**		
Dispatchable Technologies	**EIA***	**Victoria**	**South Australia**
Conventional Coal	85%	77.5%	33.2%
Natural Gas-fired			
Conventional Combined Cycle	87%	14.2%	29.0%
Conventional Combustion Turbine	30%		
Non-Dispatchable Technologies			
Wind	35%	38.0%	33.1%
Solar PV	25%		14.2%
Hydro	53%	16.0%	0.0%

*Energy Information Agency (United States)

Discussion

Wind as a non dispatchable power source cannot be considered without assumptions of amount of power supplied as a proportion of demand. None of the levelised considerations cover the size of plants and the transmission costs that are determined by industry and population concentrations. The comparison of South Australia and Victoria shows this explicitly. South Australia with 30% renewables (wind and solar) has exceeded the renewable energy target of supplying 20% of demand by 2020. In a small market, the consequence is no solid base load supply with 52% of supply coming from gas, a possibly expensive feedstock. Further, for times between midnight and sunrise, the steadiest part of the 24 hour demand cycle, demand is subject to wind, that is supply variability. The result is South Australia has amongst the highest retail electricity prices in Australia. Victoria, with a small contribution from wind power has achieved lower retail prices.

Thus there is no level playing field for assessing levelised generator costs. It is properly handled by modelling the supply system using the known electricity demand characteristics of the particular state or region.

The impact of non-dispatchable power is to change the life-times and capacity factors of dispatchable power supplies. This changes the electricity pricing needed to finance the investment in new generators and reduces the value of those generators already in the system.

Conclusions

The conclusions from the above are:

1. the RET scheme is badly designed with perverse levels of an equivalent carbon tax. While having no measurable effect on global atmospheric carbon dioxide levels some $2 billion is transferred annually from customers to suppliers

2. the total wind farm supply needs to be carefully matched to the relevant regional demand and behaviour of demand so that wholesale pricing is not distorted and

3. the whole-of-life costs of conventional electricity generators may be seriously altered by the variable power supply of wind farms.

The problems arising from the RET scheme and policy development from using “whole of life operation” or levelised costs for renewable energy sources are both the result of a failure to consider the operation of electricity supply systems.

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[1] ACIL Tasman 2007 Fuel resource, new entry and generation costs in the NEM
[2] NEM HISTORICAL MARKET INFORMATION REPORT 2013 Australian Energy Market Operator
[3] 2013 SOUTH AUSTRALIAN ELECTRICITY REPORT Australian Energy Market Operator
[4] Annual Energy Outlook 2014 **http://www.eia.gov/forecasts/aeo/electricity_generation.cfm**