Methodology for pricing health benefits of solar PV

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Rationale

According to the Electricity Industry Act 2000 No. 68 of 2000, Version incorporating amendments as at 15 February 2017 the ESC must have regard to the avoided health costs attributable to reduction in air pollution. An extract from the act states:

In determining a rate for the purposes of section 40FBA(a), the Commission must have regard to—

(a) prices of electricity in the wholesale electricity market; and

(b) any distribution and transmission losses avoided in Victoria by the supply of small renewable energy generation electricity; and

(c) the following avoided costs—

(i) the avoided social cost of carbon;

(ii) the avoided human health costs attributable to a reduction in air pollution.

However the ESC "found the causal chain was too lengthy and uncertain to reliably attribute a given quantum of health benefit with a given unit of output from distributed generation. As a result, we did not seek to add a monetary value for health benefit to the feed-in tariff".

This analysis seeks to remedy that situation.

Proposed methodology

The brown coal electricity generating fleet of Victoria is too small to make use of a direct epidemiological analysis. Instead the pollution output of the stations has been ranked within a study of 345 power stations in the USA. Based on this ranking, or percentile, the health costs of each of 4 pollutants within that study have been assessed. These costs have been applied to 3 specific power stations in Victoria, taking into consideration their actual generation. This analysis is based on a similar study by Jordan Ward and Mick Power[1] into the social cost of the now closed Hazelwood Power station. Use is made of their data but this analysis specifically excludes Hazelwood.

[1] Jordan Ward is a Frank Knox Memorial Fellow and Mick Power is a Gleitsman Fellow and an American Australian Association Fellow at the Harvard Kennedy School of Government. They come from a background in energy and environment policy and business in Australia and New Zealand.

The analysis has been applied to the three brown coal-fired power stations; Loy Yang A and B and Yallourn. See attached spreadsheet *Health cost of coal fired electricity.xlsx.* The population density in the nearby towns has been considered and compared with the US data.

The effects of four major pollutants, SO_2, NOx, PM_{10} and $PM_{2.5}$ emitted by these stations are quantified as follows:

1. The emission intensity of the power station is obtained from Ward [1], page 37. See tab *Revised Table B7 cell M9 – P11*. This is the volume of pollutant exiting the stack divided by the electricity produced. For example, Loy Yang A produces 3.17 kg of SO_2 for each MWh of electricity sent out. This is transferred to tab *Table B2 cell E10*.
2. From the distribution of emission intensity (Ward, Table B2, page 34) of US coal fired power stations it can be calculated that the above figure corresponds to a percentile of 36% for SO_2 (See comments in tab *Table B2*). The percentiles were calculated using the Excel Solver function).
3. Using a distribution [2] (NAS, Table 2-8, page 65) of health damages per ton of emissions of 406 US coal fired power stations, converting to metric units, the damages in \$/kg of SO_2 for the 5^{th}, 25^{th} and 75^{th} percentiles are calculated. This is done in *cells G11 – I14* for each station. See comments in tab Loy Yang A. Note only this tab is commented.
4. From the above, using the intensity (kg/MWh, *D4 – D7* for each station) and the damage (\$/kg, *G11 – I14*), the cost figures of these percentiles (copied to *E17 – E20*) in \$/MWh are calculated using the formulae in *M17 – M20*. The relationship between these costs and percentiles is quite linear. The 36^{th} percentile value for SO_2 from Loy Yang A is estimated as US\$14.63/MWh in this example.
5. This is repeated for each of the pollutants and summed in cell *M21*.
6. This is repeated for each of the power stations and the results are combined in tab *All stations, cells S13 – S15*.
7. In tab *All stations, cells P13 – P15* the annual output of each station is estimated. This is multiplied by Health cost per MWh *(S13 – S15*), is given in cells *U13 – U15* and totalled.
8. The total cost per annum is in *U16*.
9. Thus the final figure for the brown coal fleet is calculated in *U17* and *U18*.
10. The tab *summary* contains the above result which includes adjustments for exchange rates, inflation and factors as described below.

Note the tab *All stations* also contains information from Environment Victoria. My analysis is independent of that but as can be seen the results are quite similar. Their data is in 1996 dollars so their 2018 figure is 2.63 c/kWh uncannily close to my calculation of 2.51 c/kWh. I would not go so far as to say that this level of accuracy is warranted but it provides a good sanity check of two separate approaches.

As a further check, two additional studies are listed in tab *All stations.* These are a European study and another US study. Both quote higher health costs than the methodology I have proposed.

Critical discussion

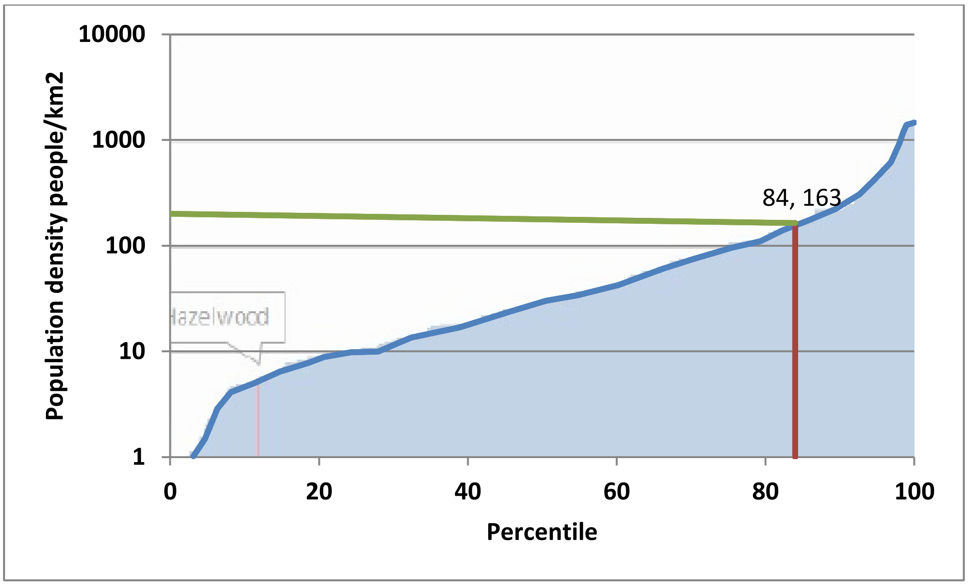
The analysis is necessarily imprecise but this is the nature of such a calculation. The following potential criticisms and replies follow:

The population density in the Latrobe valley is low.

A criticism which could be levelled at studies making use of US or European data is that those places have a higher population density than the Latrobe Valley. However this is not really the case. The towns of Moe, Traralgon and Yallourn lie between 4 and 7 km from the power stations. Moe has a population density [2] of 158 people/km^2 and Traralgon – Morwell 169 people/km^2.

A study of 345 US power stations puts the mean of about 163 people/km^{2}at about the 84th percentile [4]. So the data is for population densities mostly *lower* than that in the Latrobe Valley. The *Pop density tab* generates the percentile graph below[2].

Thus the data used in this methodology is representative of the conditions in the Latrobe Valley where the population density is above the median.



Not all power in Victoria is generated by Brown coal

An exact figure, when electricity is being exported and imported across state boundaries is not possible. Victorian generation was 78% from brown coal in 2018 from the Australian Energy Update [5]

Solar PV generated electricity does not necessarily displace coal powered generation

The only generation that has been retired has been coal partly as a result of increased penetration of renewables.

[2] Ward puts the population density of the Gippsland region, where Hazelwood is located, at 6.2 people/km in the regions surrounding the power stations. However the Gippsland region is mostly farmland and the majority of the population live in the vicinity of the power stations.

The benefit doesn't all go to Victoria

If the adjoining states in the NEM did not have similar uptake of solar PV then that would be so. However, since they do, the benefit flows both ways this is not a valid point.

The health benefit is negated by the increase in unemployment in the Latrobe Valley

Almost all transitions require adjustment. The transient hardship due to shutting down polluting power stations does not justify their continuation, just as continuing mining asbestos doesn't.

Externalities not included

Coal contains many toxic elements. These include mercury, arsenic, cadmium, lead and uranium. Although their concentration in the air emissions could be low, these settle on a wide area of farmland and may accumulate in farm produce. However these factors are outside the scope of this methodology.

Proportion of PV power represented by the FiT

Of the electricity generated by solar PV, only the fed-in portion is metered and subjected to a FiT. However the electricity generated also reduces apparent demand, by an un-metered amount. The fed-in electricity only represents part of the generation. For example an array might generate 7.5 MWh whilst the user exports 5 MWh. The avoided health cost should ideally reflect not just the fed-in electricity but total generation. Thus in this example, the FiT should be multiplied by 7.5/5 = 1.5. An estimate of this for Victoria is in tab *PV generation vs export* cell *C31*. Two parameters are required. I have used data from the Australian PV Institute [6]. The first is the average PV installation size. The second parameter is the typical annual export per kWp. The fact that at present generation can only be statistically estimated does not differ in principle to the way the consumption tariffs are calculated, based on wholesale price of electricity which varies according to the market and is dependent on the weather. This uncertainty is absorbed in an estimated average price. To a lesser extent it applies to distribution costs, in that some customers are at the end of long lines whereas others are near substations. The network cost is subject to this variation. These individual differences are absorbed in tariffs within one distribution area. In this methodology the situation is similar.

Conclusion

A FiT for solar PV has been estimated using data from reputable sources. The price is necessarily subject to the data used and assumptions made. However it does not differ in this regard to other electricity tariffs. Factors considered are:

1. The degree to which solar PV generation specifically abates coal generated electricity.

2. PV generated vs metered, exported electricity. This takes into account the fact that a proportion of the PV generated electricity is not exported but nevertheless abates coal fired generation.

The methodology estimates the health benefit of solar PV at 2.9 cents/kWh.

Appendix

A summary of the calculations in the spreadsheet *Health cost of coal fired electricity.xlsx* is given below.

	Loy Yang A	Loy Yang B	Yallourn	Data source
Emissions kg/MWh				Ward
SO2	3.17	2.72	1.69	
NOx	1.32	1.66	1.52	
PM10	0.23	0.18	0.27	
PM2.5	0.12	0.1	0.17	
Percentiles cf 405 US power stations				Ward
SO2	35.7	28.8	15.7	
NOx	30.1	48.3	39.3	
PM10	52.5	39.3	59.8	
PM2.5	37.9	29.5	52.3	
Health cost A$/MWh at percentile				NAS
SO2	$ 14.63	$ 11.06	$ 5.14	
NOx	$ 1.56	$ 2.50	$ 2.05	
PM10	$ 0.10	$ 0.06	$ 0.12	
PM2.5	$ 0.80	$ 0.57	$ 1.42	
Total	**$ 17.09**	**$ 14.20**	**$ 8.74**	
Output GWh/year				Environment Vic
	16763	7690	11381	35834
				Totals
	Health cost US$M			
	287	109	99	495
				Totals
Health cost cents per kWh				2.51
Adjustment of self consumption vs export			1.49	3.74
Adjust for prop brown coal generation			78%	2.90
Final health cost Aust cents per kWh				**2.90**

References

1. Cleaning up Victoria's Power Sector: the full social cost of Hazelwood power station by Jordan Ward and Mick Power, Harvard Kennedy School of Government February 24th 2015
2. The Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use, published by the US National Academy of Sciences, 2009
3. Methodology for valuing the health impacts of changes in particle emissions http://www.epa.nsw.gov.au/resources/air/healthpartemiss.pdf

4. Energy Information Administration (EIA) 2012 database of individual electricity generators. "Subbituminous coal". 345 unique plants were identified. From Ward [1] page 39
5. Australian Energy Update https://www.energy.gov.au/publications/australian-energy-update-2018.
6. Australian PV Institute, Installed PV generation capacity by State/Territory - downloaded data 25 Oct 2018 http://pv-map.apvi.org.au/historical#4/-26.67/134.12