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Some factors that would affect the retail price for 100% Australian renewable electricity

Ted Trainer

5 Dryandra St., Wadalba 2259, Australia

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ABSTRACT

The recent simulation by Lenzen et al. (2016) has significantly advanced the exploration of possible costs and implications of 100% renewable power supply for Australia. The analysis arrived at a probable production cost of around 20c/kWh. This discussion explores the possible implications for the resulting retail price of electricity. A number of factors in addition to those included in the original study are taken into account. Confident conclusions are not offered but the factors considered indicate that the retail price of electricity based on the mix of technologies the study assumed could be in the region of three to four times the price at the time of the study.

1. Introduction

The central issue for the analysis of 100% renewable energy supply is not whether this goal is possible, it is what the cost of the required amount of plant might be when provision has been made for the back up capacity required to enable supply through periods of low renewable energy availability. Numerous analyses have concluded confidently that 100% renewable electricity supply is possible without making any reference to the weather patterns in the regions under discussion and therefore these have been of little or no value.

Two groups have recently carried out the first analyses of the (more or less) total Australian power supply task based on detailed weather information. These find that the production cost of electricity taking into account capital, O & M, transmission costs and"fuel" would be c. 10 – 15c/kWh in one case and c. 20 − 30c/kWh in the other. However both these pioneering studies of this complex issue inevitably involve a number of assumptions and simplifying omissions. The following discussion attempts to consider this area in order to explore some implications firstly for the production cost of electricity and secondly for the retail price. The complexity of the issue and the scarcity of relevant information prohibits confident conclusions but it is evident that a thorough analysis is likely to arrive at a much higher retail price than the production cost which Lenzen et al. arrive at.

2. The two studies

Elliston, Diesendorf and MacGill (, 2012, 2013) deserve much credit for apparently being the first to attempt a national analysis based on actual weather data, recently made available by the Australian Energy Market Operator. Their general finding is that 100% renewable electricity supply can be achieved at a cost of around 10 – 15c/kWh. For coal-fired power the cost per kWh produced for plant plus operations and maintenance (O&M) and fuel is around 3c. (Lenzen et al., 2016, Table 1.) (Cost etc. statistics used here are for the 2014–2015 period.)

However the following discussion is based mainly on the more recent analysis by Lenzen et al., (2016), which concludes that the cost might be in the region of 20c/kWh, and possibly 30.3c under fairly common conditions. They say the scenario yielding the second figure "…comes close to what would be implemented in the real world". Both studies seek to determine the arrangement of generating units and transmission lines which would minimise the cost of producing sufficient electricity to meet demand with high reliability, given the weather patterns for the year 2010. The Lenzen et al. findings are set out in their Fig. 3 as a matrix of options that might be selected among, depending on the amount of biomass capacity within the system (…ranging from the present c. 1.7 GW to 15 times that amount) and the price put on carbon. The main plots giving results enable a production cost in cents per kWh to be read off for any combination of these two variables.

The reasons for working here with the Lenzen et al. analysis rather than that by Elliston, Diesendorf and MacGill (and associates later) include,

- The fact that Lenzen et al. do not select locations in advance but use an approach which in effect assumes that power stations can be set up everywhere to compete to sell their output according to their cost of production determined by the pattern of solar and wind energy at each of the different sites,
- The quite high dependence on wind in the EDM approach, up to

E-mail address: tedtrainertsw@gmail.com.

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58% of supply. (It is 68% in Riesz and Elliston, 2016.) Lenzen et al. provide references to support their working assumption that penetration above 30% is associated with increasing difficulties and costs.

- The somewhat simplified transmission system (understandably) assumed in the initial study. Lenzen et al. assess transmission provision necessary to connect each source to the existing grid pattern.
- Inclusion of geothermal in Riesz and Elliston, .) (2016) Lenzen et al. regard recent evidence ongeothermal as indicating that it is unlikely to be a significant contributor in the near future.
- The degree of dependence on CSP in view of evidence on its possibly limited contribution in conditions of poor DNI.
- Doubts re the energy and dollar costs of use of the biomass-gas-electricity path for backup. (The authors note that these are uncertain.)

3. The full real-world production cost?

There are several considerations complicating the drawing of implications from the Lenzen et al. production cost findings for the probable price firms and households would have to pay for electricity. This is not a criticism of the study given that it was a complex undertaking in a more or less unexplored field and therefore needed to confine its scope to set of crucial assumptions. Consideration was given to more elaborate conditions and variables that might best be left for subsequent inquiry. All of the fourteen causal factors identified below would tend to increase price. This aligns with the finding by Lovegrove, p. 109) et al. (2012) that in estimating CSP capital costs,"Large differences between original cost estimates and actual installed costs have been common."

Most of the following list of factors likely to raise the production cost above the value Lenzen et al. arrive at cannot be given a numerical value at this stage.

1. Lenzen et al. only take in capital, O&M, transmission and "fuel" costs. (It is assumed that the first of these includes interest charges.) Many more factors operate in practical situations and the Prietro and Hall (2013) study of the Energy Return On Energy Invested (EROI) of the Spanish PV system indicates that taking these into account can significantly increase the total energy costs and loss value. The study attempted to include as many of these as was reasonably possible and this resulted in a major downward revision of the commonly accepted PV EROI value. Similarly, for coal-fired electricity the above four dollar cost factors add to about 3c/kWh, but there are other dollar cost factors involved, including company tax and profit, and when all these are included the wholesale price is increased to about 8c/kWh. Thus, given the limited range of factors included an all-inclusive production cost figure associated with the Lenzen et al. simulation is likely to be well above the 20c figure it arrived at.
2. The cost assumptions made are commonly quoted estimated 2030 values. These are generally around one-third lower than present costs (and a challengeable 50% lower for CSP, see below.) Although often used the set involves assumptions regarding expected reductions and "learning curves" that are open to question, and various sources offer less optimistic estimates. For instance Wood, Mullerworth and Morrow (2012) and Hinkley et al. (2012) report that there was no fall in CSP plant capital cost as built capacity went from around 90 MW cumulative to around 1200 MW, i.e., despite around a twelve-fold increase in plant capacity built. EPRI (Table 1–7, 2009) states the same general view and expects no fall to 2025. Fig. 9. From Bolinger and Seel (2014) shows an increase in solar thermal cost over time. A report by the Electric Power Research Institute (2010) expects no fall in capital cost for PV, wind or CSP until at least 2025.
   For wind, the California Energy Commission (2014) does not necessarily foresee cost falls as this is a relatively mature technology. Continued falls for PV are commonly predicted and likely to occur but Feldman et al. (2014) report several estimates of tapering, indicating around 20% falls to 2040, as distinct from 33% by 2030 as assumed in the AEMO and AETA tables used in this study. There are reports that subsidies for Chinese module production are being phased out. CSP mostly involves relatively simple technology and well-established construction engineering suggesting that major cost-reducing breakthroughs here are less likely. The effect of increasing resource scarcity is also likely to add to construction costs in future. (See further below.)
   These considerations indicate caution re the optimism evident in the future capital cost figures Lenzen et al. have taken. However it should be recognized that in recent years there have been significant falls in various renewable technology costs, notably for PV and battery storage, and the expected continuation of this trend is likely to weigh against the other factors in this list.
3. As Lenzen et al. note, the cost figures used assume the exchange rate which held at the time they were made, i.e., the Australian dollar cost of the imported plant would be $1 A = $1US. The value of the $1 A has since fallen by up to 30% a times, meaning that the Australian dollar cost of renewable generating plant, which would be mostly imported, would be over 1.4 times as high as has been assumed.
4. Lovegrove, p. 22) et al. (2012) estimate that remote area construction of renewable plant would cost 10–20% more than the commonly quoted figures which assume construction at US and European locations. The maps Lenzen et al. provide show that most of the sites in Australia would be remote. Lovegrove et al. also say that the initial constructions would involve an additional perhaps 15% cost for technologies that have not previously been built in Australia.
5. Regardless of locational issues Australian construction costs seem to be considerably higher than overseas costs, due in part to poor productivity growth. (Freebairn, 2017.)
6. There is also a significant tendency for Australian construction projects of all kinds, let alone first of a kind projects, to significantly exceed initial cost and performance estimates. Infrastructure Australia (2013, p., 17) actually reports a general over-run of 40%.
7. The study did not attempt to take into account the embodied energy and related costs of generating or transmission systems. This was wise given the uncertainty and disputation in this field, especially for PV, and the apparently complete lack of evidence on the EROI for 100% renewable whole systems. This value is likely to be quite low, because a large amount of plant must be built to enable reliability through difficult periods. The case Lenzen et al. describe in Fig. 6 requires 162 GW to meet an average demand of 23 GW. Thus the EROI for individual renewable devices, commonly given as c.18 for wind, is not a meaningful guide to EROI values for whole systems. Trainer (2017) has attempted to estimate this value for the system Lenzen et al. describe. The figure arrived at, around 6, indicates that the sum of all other cost contributors might need to be multiplied by 1.17.
8. The year 2010 is unlikely to have been the worst ever for renewable generation. Examination of Bureau of Meteorology and AEMO data (ROAM Consulting, 2012a, 2012b) for 3 solar sites and 5 wind sites spread across central to eastern Australia shows that the average value over the three sites with the lowest solar radiation on record for each of the twelve months was 17+% below the 2010 figure. For wind the figure was 32% below the 2010 value.
9. The capital cost figures for an enthusiastic renewable building program beginning in the near future would be close to present costs, generally one-third higher than those anticipated for 2030 and used in the Lenzen et al. study. Thus even if costs fall to 2030 as assumed the average cost of plant built before 2030 would be around15% higher than those assumed.