THE IMPACT OF TECHNOLOGY AVAILABILITY ON THE COSTS OF 100% RENEWABLE ELECTRICITY GENERATION SCENARIOS FOR AUSTRALIA

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Overview

With the majority of new investment in power generation now being in renewable technologies, future electricity markets with a high proportion of renewable generation appear likely. The Australian National Electricity Market (NEM) provides an interesting case study for analysis of high renewable scenarios. The NEM serves approximately 80% of the electrical load in Australia [1] over a wide range of distinct climate zones. As a relatively large but isolated system (without transmission connections to other grids), the NEM must manage the variability, uncertainty and other challenges associated with integrating highly variable and only somewhat predictablerenewable technologies internally.

Scenarios of 100% renewable energy have been previously modelled for the NEM [2, 3, 4, 5, 6]. However, there is significant uncertainty around the availability and future costs of some renewable technologies included in a number of these scenarios. In particular, in the NEM it is questionable whether proposed enhanced geothermal technologies will achieve commercial viability in the coming decades. There is also uncertainty around the degree to which the utilisation of bioenergy technologies may be limited due to competition with food production and other uses of land and water resources. This study aims to explore the potential impact these limitations may have upon scenario costs. This insight may help to guide the development of policy mechanisms to encourage commercialisation of certain technologies, if their presence or absence is found to have a significant influence on scenario costs.

Methods

The scenarios described in this paper are simulated using NEMO, a software package developed by one of the authors and previously described in detail [3]. This software package applies an evolutionary program to optimise the mix of generating technologies to meet hourly demand profiles over a year or more, to the required reliability standard, at lowest overall industry cost. The following technologies were included: Hot Sedimentary Aquifer (HSA) geothermal, Enhanced Geothermal Systems (EGS), utility scale photovoltaics (PV), wind power, Concentrating Solar Thermal (CST) with storage, existing hydro and pumped storage hydro (PSH) and turbines fuelled with biomass derived fuel. The capital and operating costs of each technology were based upon those projected for 2030 by the Bureau of Resources and Energy Economics in the 2013 Australian Energy Technology Assessment [7]. Hourly wind and solar profiles were applied, sourced from modelling by AEMO [6]. The following notable constraints were applied in the model in all scenarios. Annual hydroelectric generation was limited to historical levels at 12 TWh per year. Annual bioenergy generation was limited to 20 TWh per year (except where otherwise specified to be a lower limit). A maximum instantaneous non-synchronous penetration limit of 75% was applied (except where specified), and the NEM reliability standard (0.002% annual unserved energy) was met in all cases.

Results

Figure 1 illustrates the lowest cost generating mix for the seven possible combinations of synchronous technologies available. The lowest cost scenarios involve significant quantities of HSA geothermal, with the model finding this to be the lowest cost way to simultaneously meet the reliability and synchronous generation requirements. If the HSA technology is not available, but the EGS geothermal technology is available, costs were found to increase from an average of $68/MWh to an average of $74/MWh (around a 10% increase)[1]. Costs were highest in the scenario with only CST technology (no geothermal technologies), calculated at an average of $82/MWh (around a 20% increase). This indicates that commercialisation of enhanced geothermal technologies in the Australian market may have a value of around $1.6 to $2.9 billion per year, based upon the anticipated system cost reductions if those technologies are available at the predicted costs (assuming a 100% renewable power system). This may be achievable via a mix of targeted commercialisation policy support and appropriate market design to facilitate technology progress.

Figure 2 illustrates how system costs change as the amount of bioenergy available is progressively constrained. If CST and both geothermal technologies are available, reducing the amount of bioenergy available incrementally increases system costs from $68/MWh (where the optimal quantity of bioenergy generation is calculated to be much less than the 20TWh per year imposed limit) to $88/MWh (with no bioenergy being available). Although the bioenergy turbines operate as peaking plant (due to their high operating cost), their complete absence has a

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[1] All costs throughout are reported in real 2014 Australian dollars. As of mid December 2014, 1 AUD = 0.82 USD.

significant impact on scenario costs because they provide cost effective low capacity factor generating capacity. The influence on system costs is more extreme in the case where geothermal technologies are not available; if CST is the only synchronous technology available (aside from existing hydro resources) costs escalate from $78/MWh (with essentially unlimited bioenergy) to more than $140/MWh (with no bioenergy availability). However, it may be possible to achieve a lower cost outcome if the amount of storage at each CST plant were varied. These results indicate that it may be cost effective to introduce policy measures to support the availability of bioenergy technologies to a level of around 3-5TWh per year, at a value of 4 to 12 billion dollars per year, depending upon the availability of geothermal technologies. Even allowing only 0.1TWh per year of bioenergy is found to reduce system costs from $140/MWh to $108/MWh, a saving of almost $7 billion per year. This finding highlights the value of dispatchable low capital cost renewables with storable fuel.

Figure 1 - Generation mix for various combinations of synchronous baseload technology availability. Column labels indicate average scenario costs in $/MWh.

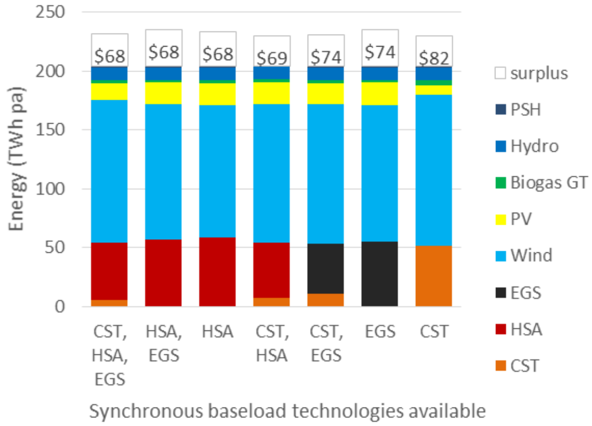
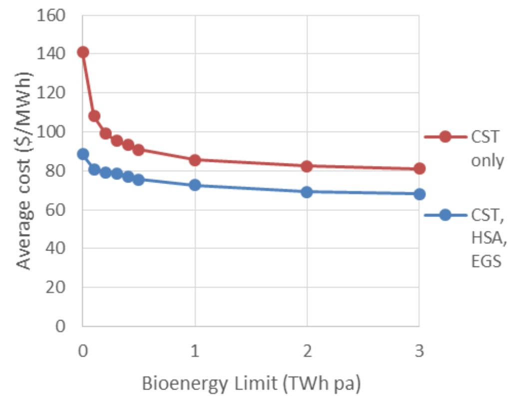


Figure 2 - Scenario cost as the amount of bioenergy available is progressively reduced



Conclusions

This modelling indicates that there could be significant system cost savings if geothermal technologies are available at the costs projected by the Australian Bureau of Resources and Energy Economics for the year 2030. These savings could amount to $1.6 to $2.9 billion per year in a 100% renewable power system. The cost savings from including a small amount of bioenergy are even higher, and could amount to 4 to 12 billion dollars per year from including 3-5 TWh pa of bioenergy (depending upon the availability of geothermal technologies). Even including only 0.1TWh per year of bioenergy could reduce system costs from $140/MWh to $108/MWh, a saving of almost $7 billion per year. This suggests that ensuring a small amount of bioenergy availability could be an important policy goal.

References

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