Balancing Flexibility Whilst Decarbonising Electricity: the Australian NEM is changing

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Abstract

The current energy debate, both locally and globally, is how to reduce emissions while providing reliable and cost effective electricity. While the current Australian National Energy Market (NEM) has delivered reliable and secure energy for decades – it needs to change to meet the current challenges.

The majority of electricity on the NEM is generated by coal-fired plants with large CO2 emission profiles. This technology has also delivered the backbone of the grid, providing the services required for grid stability and strength; such as inertia, frequency control and fault current support. Fossil-fuel technologies have also, to date, underpinned the energy competitiveness of the Australian economy. However, with increasing penetration of variable renewable generation, it is becoming important to plan for and manage generation asset investment to track the least cost and highest reliability path to a low emissions future.

This work demonstrates how Carbon Capture and Storage (CCS) on fossil-fuel plants can play an important role to play in a portfolio of generation technologies.

Key Points

• In addition to supplying electricity, each power generation technology brings with it a different set of grid services and attributes such as – low emission power, firm capacity, inertia, frequency control, flexibility and fault current support.

• The National Electricity Market (NEM) consists of 5 state based grids that are only weakly interconnected and frequently operates at a more granular level than a nationally optimised system.

• The characteristics of the NEM plays a significant role in determining the value of an additional asset placed on the system.

• Each state grid will have unique asset requirements to ensure reliability and its characteristic generation profile will have a material impact on the overall NEM system.
• Fossil-fuel power generation with CCS has a crucial role to play to deliver the services required for deep decarbonisation in the long term if the lowest cost system is be achieved.

**Results:**
The NEM model developed for this study takes into account the grid services provided by the various electricity generation technologies together with simple energy balancing. It challenges current paradigms for understanding the total system cost for electricity supply. Conventional modelling approaches make simple comparisons using traditional metrics, like levelised cost of electricity (LCOE), which do not take into account the grid system requirements.

This model integrates hydro production data and demand data from the NEM with the output of Renewables Ninja. This resource simulates, for a given region, how current and future wind and solar PV assets would operate based on weather from previous years. This modelling safeguards the resilience of a grid by maintaining a minimum level of inertia and seeking to ensure that the operator has the frequency control tools needed to maintain a stable grid.

The model at the heart of the work reported here is MEGS – Modelling Energy and Grid Services. It is a regional electricity system model that ensures there is sufficient firm capacity to meet demand, while the grid operator has sufficient services to maintain grid supply and stability. The goal of MEGS is to explore scenarios around the least system-cost mix of generation that satisfies both a demand constraint and a grid services constraint.

Decisions made to meet short-term emissions targets (e.g: Paris 2030) can lock in higher costs and compromise Australia’s energy competitiveness in the long term. The lowest cost energy supply technologies change as NEM decarbonisation proceeds.

Figure 1 shows renewables costs increasing due to intermittency and curtailment. Inflexions for other technologies occur when their emissions limits are reached. At high decarbonisation levels, low-carbon dispatchable power like carbon capture and storage (CCS) will be required to deliver the required resilience for grid stability. It can also deliver the deepest decarbonisation ambitions at lowest cost. High penetrations of wind and solar PV will require companion low-carbon technologies, such as CCS, if they are to provide firm capacity that is available “on-demand”.

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1 Note: this renewables curve in a combination of solar and wind with some co-installed battery support.
In high renewables scenarios, existing fossil-fuelled power plant (especially black coal) will have to become increasingly flexible on a daily basis, see Figure 2. This is a new operating paradigm for coal assets on the NEM. It requires either new build or investment to upgrade existing plant to ensure they have such flexibility.

Conclusions:
The effectiveness of carbon abatement and the value to the system of a technology vary significantly according to how much of that technology is already on the system. This is most noticeable with the renewables (with storage) scenario with an exponential-like cost curve. The other technologies also have very marked inflexions. Hence no simple metric, which assumes linear behaviour and is independent of the grid (like LCOE), can adequately describe the benefit a technology brings.

Of the three scenarios modelled in this phase of the project, the renewables mix is the cheapest for the initial steps towards decarbonisation, at less than $80/tCO_2 abated.
However, its costs rapidly increase, as renewables find they suffer diminishing returns compounded by increasing costs of integration. Both the gas and the coal-CCS scenarios were cheaper at decarbonising the system beyond a 45% reduction in from today’s emission level.

To meet the reliability standard and ensure the lights don’t go out, PV and wind would need to either be coupled with an unfeasibly large volume of storage, or backed up by other firm, low-carbon capacity.

Given these conclusions, it is likely that a hybrid solution produces the least cost pathway to decarbonisation. Coal with CCS has a crucial role to play to deliver the services required for deep decarbonisation in the long term while being part of broader renewable and gas power generation portfolio – at least cost.

This ANLEC R&D commissioned study is an innovative modelling approach. It considers the grid system cost by recognising the importance of firm generation, the cost of balancing the system, and the required flexibility, while on the “pathway” to a lower emissions grid.