Submission to AEMO on the

Draft 2025 Inputs, Assumptions and Scenarios Report (IASR) – Stage 2

Thanks for opportunity to make a submission to Draft 2025 Inputs, Assumptions and Scenarios Report – Stage Two.

Apologies for not addressing the individual items for discussion highlighted in the report. I felt it useful to reinforce, and hopefully clarify, the conceptual framework. Hopefully help remove a little mist from the crystal ball.

Network Development

Assumption:- The grid will evolve to maximise utilisation of zero short run marginal cost, raw material use or lose, more tomorrow (renewables), generators.

The network is evolving. I perceive in three stages.

- Historic composed of generators and loads.
- Current composed of generators, storage (inventory) and loads.
- Future composed of generators, storage (inventory), loads, and flexible demand.

I believe this framework should be part of the assumptions as the relative proportions of each network component type to achieve desired reliability changes as the network evolves.

Historically, average utilisation of the generator fleet has been relatively low, around 60%. With predominantly near zero marginal cost renewables there will be an imperative to maximise average generator utilisation. For renewables, utilisation may be measured as percent of available wind or sun. Capacity factors vary.

Storage, Generator Utilisation and System Reliability

Assumption:- Inventory (Energy) Management will be recognised as part of asset selection, operation, system reliability and asset utilisation.

Storage is described as firming renewables. A reaction to the intermittent and variable nature of renewables. The term firming may be hiding some of the broader implications of inventory (what's in storage).

Storage adds cost to the network which is currently recovered predominantly through price difference (arbitrage) between off-peak and peak demand. Inventory is the energy in storage.

- Effect of Inventory on Utilisation

  In typical supply chains inventory increases utilisation of upstream and downstream assets. Storage will increase generator and flexible demand capacity factors.

- Effect of Inventory on Reliability

In typical supply chains inventory is part of reliability. Simplistically "safety stock" has a similar effect to reserve capacity, albeit for a limited time. Inventory changes the desirable relative proportions of each component type in the network. Conceivably we will pay Snowy 2.0 to reserve some inventory in their vast storage in the same way we pay for reserve capacity.

- Storage Utilisation

  Storage utilisation can be both re-generator utilisation and throughput (inventory turns). For BESS throughput impacts asset life expectancy.

- Arbitrage

  Inventory is part of price discovery. When there is sufficient inventory in the system for reliable operation arbitrage reduces and may not be sufficient to cover storage cost.

  An effect of relying on arbitrage to cover storage cost is that storage and re-generation may not occur when arbitrage is insufficient. However, it may be that zero marginal cost renewables are curtailed as a result. A lost opportunity.

  An example of a different cost recovery is the London Metal Exchange model which has a charge for storing product in their stores. Paid for by increased production. Payment for storing stuff, much like diy storage establishments for household effects.

While individual generators compete to maximise individual utilisation there is a role at the system level to maximise network asset utilisation while maintaining reliability.

Investment in storage lags investment in generation and becomes a bottleneck. A more mature model may help relieve bottlenecks.

The effects of inventory impact not just the Integrated System Plan, they are pervasive through all aspects of AEMO, AEMC, AER and ESB. And probably some acronyms I don't know about. A significant paradigm shift for an industry that has had no need for significant energy storage for at least 100 years.

Flexible Demand, Generator Utilisation and System Reliability

Assumption:- Flexible Demand is a new class of load.

Assumption:- A grid operating mode where supply is the constraint rather than demand may emerge.

Assumption:- High asset utilisation is required as part of planning.

Hydrogen electrolysis can be characterised as flexible demand. It can ramp rapidly. It has a similar effect on increasing generator utilisation as inventory. With the advantage of revenue from hydrogen sales as well as being storable with feedback to re-generate electricity.

The reduction of viable economic utilisation of hydrogen electrolysers to 35% by the 2050's (page 71 of draft 2) introduces the enticing (to me) prospect of operating renewables generators at 100% utilisation of available wind and sun.

Currently the bottleneck in electricity grids is demand. There is a potential for the bottleneck to be supply. To vary flexible demand as generator output, inventory requirements and conventional demand vary, to balance the grid.

It is common for capital intensive process industries to switch between operating modes.

I sense, through a few hints in the assumptions and Plan, that this is understood. Demand Response is a temporary market precursor to a more holistic system. I perceive demand response as conventional demand which can be turned up/down/off slowly. Solar Divert is the household equivalent of flexible demand (eg an EV charger that varies charge rate in response to available rooftop solar change is already available). I believe the evolution of flexible demand, and its impact on grid operation, should be recognised explicitly. At least as a possibility. In particular, to complete the so far partial integration of Hydrogen into the Integrated System Plan.

An implication is that network equipment choice should not prevent modes of network operation other than the current dispatch model. A corollary of technology agnostic rules.

In terms of cost. An effective approach to reducing $/unit in capital intensive process industries is to increase asset utilisation and thus throughput without sacrificing reliability. With high fixed costs increase MWh to reduce $/MWh. The Plan should assume this is an aim.

Hydrogen will become more economical as the proportion of renewables in the network increases and the imperative to maximise generator utilisation due to the near zero marginal cost, raw material use or lose, more tomorrow (renewable) becomes more apparent.

Recent developments in desalination, in their infancy, suggest it may also satisfy the requirements of flexible demand. EV charging works well with household solar divert and will possibly be aggregated to grid level. It is conceivable that other examples will emerge.

Just as storage is being introduced after the need created by renewables has been fully recognised, so one may perceive that Hydrogen developments have been delayed until the need and role for flexible demand in an integrated renewables grid is fully recognised.

Standard Terms and Methods required to support Storage and Inventory

Assumption:- A common language inherited from supply chain methodologies will be required to replace some historical management artefacts as part of a paradigm shift associated with introducing inventory.

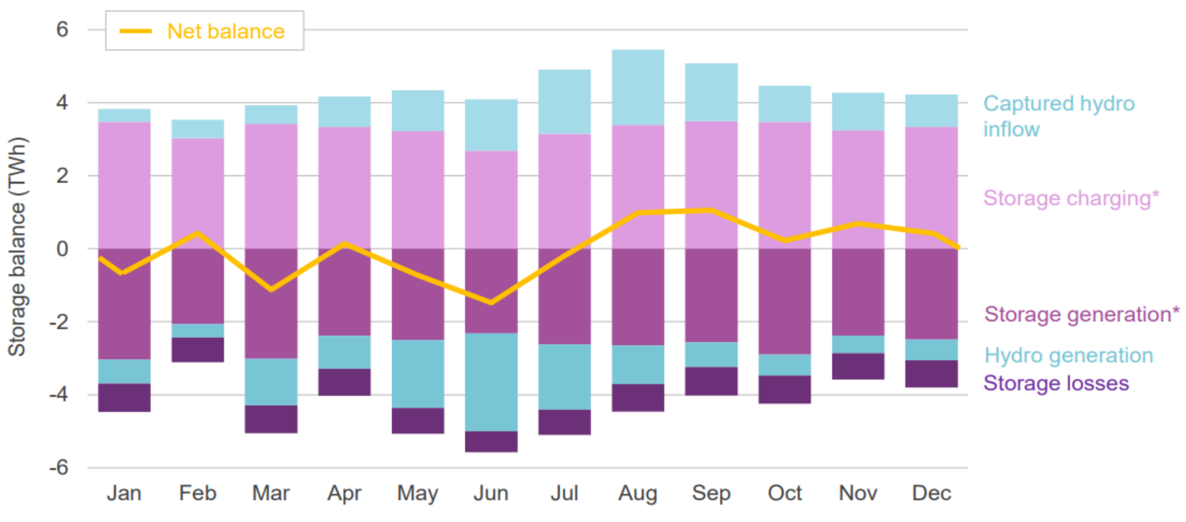
I believe the following terms should be added to the NER Glossary of Terms and referred to in all aspects of AEMO work, including the Plan. It is important at this stage of grid development to share common mental models. The concepts are more important than the labels.

- Power – standard scientific definition
- Energy – standard scientific definition
- Inventory – energy in storage
- Production – primary power or energy production
- Consumption – final power or energy consumption
- Regeneration – production from storage
- Self-Consumption – primary power / energy production that is directly consumed or stored in an end-user establishment (eg a house, or a factory).
- Flexible Demand – demand which can ramp rapidly enough to follow rapid changes in renewables generation.
- State of Charge – inventory in a battery as a percent of available capacity.

When I see a chart of fuel mix with “battery”, “solar”, “hydro”, “wind”, “black coal”, “gas”, etc I am confused. Such a chart is either ambiguous or inaccurate. For example, I don’t know if “solar” represents total solar, or solar less what was stored in battery or hydro, or even worse has it been double counted. Hydro is worse as it can be either primary generation or pumped storage. I don’t know what stage of the chain is represented.

Section 6.3 of the 2024 Integrated Systems Plan, and in particular Figure 22, reproduced below, provides a representation of the supply chain standard “opening inventory + in - out – losses = closing inventory” period calculation. It is valid for all timeframes (eg 6 minutes to years and everything in between) and all levels of hierarchy (parts can be summed to whole network). Part of Supply Chain Master Production Schedule. It should be adopted as a standard for planning, future operations, reporting, and reliability discussion. The note clarifying Pumped Hydro underneath the chart should be applauded.

Figure 22 Storage and hydro energy balances, NEM (TWh, 2040, Step Change)

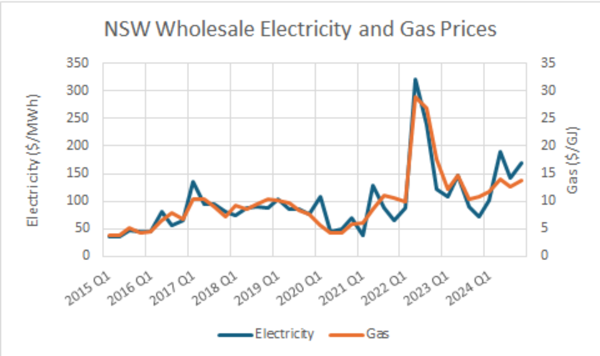


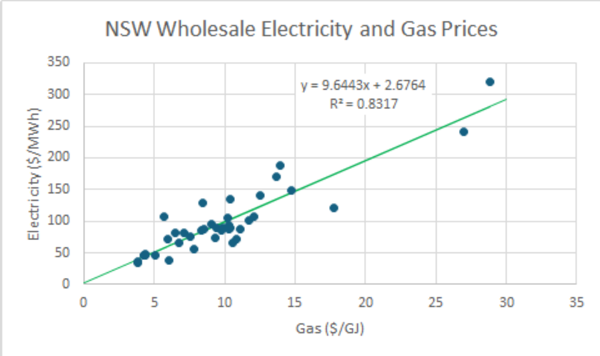
* Pumped hydro included as large-scale storage, not as hydro

Effect of Marginal Generator Raw Material Price on Electricity Price

Assumption:- Marginal generators will be progressively replaced by lower cost generators.

In the current generator mix gas price is the dominant driver of wholesale electricity price. Data from AER Quarterly Report. Gas is the marginal generator.





There is a limit below which the gas price cannot be squeezed.

Reducing gas volume consumed in electricity generation would have the same effect as reducing price. Thus, I see the current accelerated grid scale BESS developments in eastern states as likely to have some effect in reducing generation from gas (frequency of peaking and duration). And thus wholesale electricity price.

A useful assumption may be that in a grid with sufficient storage generation from the marginal generator (gas or whatever comes next when that is eliminated) will be reduced over time. A continuous improvement in generator mix. Our current mix suggests we may have got the chicken of renewables a little before the egg of storage. Both are necessary, neither sufficient.

Inflation

Assumption:- Low inflation generation will reinforce selection of low cost generation and influence generator mix.

Renewables are near zero short run marginal cost, there is no cost of raw materials. This in contrast to fossil generators which incur the cost of raw materials, diesel, coal and gas, to increase generator output. The cost of those raw materials increases over time. Fossil fuels are inflationary. Renewables are significantly less inflationary.

I imagine this would impact on network evolution.

Given energy cost ripples through the whole economy it is conceivable (at least to me) that in a future post pandemic world, with a predominantly renewables grid ,inflation would be very much lower than we have recently experienced.

Flexible Demand and Peaking Generator

Assumption:- Marginal generators may be replaced by flexible demand.

Given the revenue potential of flexible demand it is conceivable that generating capacity grows such that peaking generation, turned on when conventional demand exceeds supply, is replaced with flexible demand that is turned down when supply is insufficient.

Put another way. it may be more economic to operate an electrolyser at 95% utilisation than a peaking generator at 5% utilisation.

Overbuild of generating capacity relative to conventional demand to satisfy flexible demand and 100% renewables utilisation will create a more reliable, lower cost ($/MWh) grid.

The assumption that gas is required for peaking may not be true.

Market Design

Assumption:- Market Design is not a constraint on the Plan and will change.

There is an implied assumption that market design is not a constraint on the Plan. Market design will likely change radically when the economics boundary condition of zero marginal cost supply meets elastic flexible demand is encountered.

Market design will change to accommodate supply as the bottleneck.

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