Submission to

Australian Energy Market Commission Directions Paper – Reliability Frameworks Review

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1. Introduction

This is a submission for the Australian Energy Market Commission Directions Paper – Reliability Frameworks Review published 17th April 2018.

Summary

The electricity supply chain needs integrated inventory management systems to allow and support inventory policy.

Inventory is becoming part of the electricity supply chain. Investing in how to manage it will create opportunities for greater reliability, diversity and flexibility with reduced risk.

The Directions Paper currently does not include mention of inventory. I believe the Directions Paper should, at minimum, explicitly recognise that a choice is being made between continuing without inventory management systems or investing in inventory policy and management systems development.

While I have no doubt inventory is at times considered within the network I believe it is time to give it a higher profile in accordance with its increasing significance and impact.

Intent

This submission attempts the potentially impossible task of introducing an inventory management paradigm into an industry which has existed for more than 100 years without and a Directions Paper that doesn't currently make mention of inventory.

By implication this submission also seeks to change the level of abstraction in system design. Technical equivalence is recognised to assist policy evolution without hindrance from the system or the need for radical system redesign to implement policy change. Redundant technical requirements appear abundantly throughout the existing larger system, within rules, policy, and elsewhere. From a systems perspective, and my experience, they represent a huge barrier to evolution.

Structure

Narrative in nature, a picture not a linear argument, holistic in intent. Each short paragraph explores some implications of storage, and thus inventory, for some existing electricity network policy and management systems. It is by no means exhaustive. Individual dot points, collectively compelling. The effect of inventory is pervasive.

In three sections:-

- Introduction
- Narrative
- Suggestions

Interest

My stakeholder interests are those of a consumer with no affiliations or membership of any organisation with interests in energy, electricity, or politics. Simple interest and a sense there was something fundamental missing in the publicly visible debate.

2. Narrative

System Design Principles

A sound principle for systems design and development is to generalise. Decisions about how to implement technology and policy can be delayed as long as possible so that when they later change the effort for system redesign is minimised.

Conversely, if the system is not generalised, the effort of system redesign is a barrier to policy and technology change. The effort required for change includes overcoming the paradigms embedded within the system.

Generalisation is a process of abstraction. The absence of abstraction results in redundant technical and policy requirements within the system. Systems can be considered to have been designed at too low a level of abstraction.

The consequence of such system design is increased operating cost, lack of flexibility, and less than optimum outcomes.

Implications for Electricity Network

Electricity networks have evolved over more than 100 years with systems that instantaneously match supply to demand with supply capacity that can always meet or exceed maximum demand.

The advent of supply technology that is intermittent and storage which can be thought of as smoothly decoupling supply and demand presents a challenge to systems which have been designed at a level of abstraction that impedes their introduction.

Paradigm Constraint

From page 39 of the Directions Review ……….

> The second and arguably most fundamental challenge is that currently most variable renewable generation is non-dispatchable (at least in the absence of adequate storage capacity, for example, large banks of batteries). This means that AEMO cannot depend upon those types of generation to ramp up when, say, a shortage is emerging, because their availability is dependent on the weather. If the wind is not blowing, or if there is cloud cover when these plants are needed, they will not be able to provide a reliability-firming response if called upon. AEMO considers that with fewer synchronous generators in the supply mix, operating reserve margins are declining. At the same time, variability is increasing as described above, and so the amount of headroom required to prudently manage the power system is increasing.

While adequate storage is recognised as having some equivalence to dispatchable capacity the thought appears to be discarded.

My mental model suggests storage and synchronous generation are not mutually exclusive terms. Synchronous may have implications of a particular technology. The conflation of operating reserve and synchronous generation may be perceived as not technically neutral and act as a barrier to technical evolution

There is possibly an additional reason intermittent generation cannot be relied on to ramp up. Possibly because the position it occupies on the bid curve almost guarantees that it will always be fully utilised when available.

Reliability and Security

In any supply chain reliability and security can be achieved with an appropriate mix of available capacity and inventory defined by policy. To exclude inventory, as is currently occurring, is to limit options and evolution.

Inevitable Economics

Intermittent renewable generation has a very low marginal cost and a take or lose source. Renewable contains the implication that if it is not consumed today it is lost forever and if consumed today there is more tomorrow. This distorts the market bid curve resulting in renewables always being consumed first. The results of this fundamental of economics can only be changed by policy settings and market intervention.

The introduction of inventory to smooth supply in a network saturated with intermittent generation incurs a cost. At present the cost can reasonably be recovered by storing energy and releasing it during periods of peak demand.

At some level of storage that avenue is lost. Leaving inventory holding cost.

At present the total cost of ownership of fossil and renewable generation may be compared. At some point, when the necessary inventory policy is introduced, the comparison becomes between fossil generation and renewable with storage.

Forecasting and Planning Approaches

In general forecasts are created to support planning decisions.

In general there are materials and products, and there is capacity to produce.

Materials and products measured in each, litres, tonnes, etc. Capacity measured in hours of machine time.

In planning Electricity we find that since supply is directly coupled to demand we have no need to consider time or inventory. Thus, capacity is power (MW). Inventory does not exist in significant quantities.

Currently, it is only when payment is involved that we need to include time and consider the product to be energy (MWh). Inventory is also electrical energy.

In conventional planning terms Electricity Planning applies a finite capacity planning model to a flow. Energy availability is, currently, never a constraint.

There may be some useful experience available from the body of knowledge embedded in standard industrial forecasting, planning and scheduling approaches. Perhaps a bold claim, and certainly not a recommendation, it is possible to model an electricity supply chain in standard materials and capacity planning software. There is nothing unique about the electricity supply chain, however, the sequence in which planning can occur makes it distinct, which renders standard software clumsy and (in my opinion) unusable.

Just-In-Time Inventory Management

Simply, if its not full then fill it up.

However, for planning purposes, with variable demand, it is useful to know if storage is full or empty in some time frames. There is a well understood gap between just-in-time inventory management and planning systems in supply chains with variable demand.

In a market driven system with mixed generator types it is not always financially desirable for individual entities to always target full storage.

Storage and Inventory

The introduction of intermittent renewable generation has forced consideration that supply may not always be directly coupled to demand. The realisation that without storage (inventory) there may be times when there is insufficient supply capacity.

Within the planning (and rules) system there are "generators" and "loads". Existing storage is modelled as both generator and load. There is some limited consideration of time in supply contracts.

There is an interim arrangement in place whereby utility level storage greater than 5MW is registered as both generator and load. (page 56 of Directions Paper).

To be pedantic, storage is the container, inventory is what is contained in the container. Storage is more than generator or load, it is also how much energy (inventory) it currently holds.

Storage may provide for the storage of x MWh. Inventory may be some amount less than x.

In short, current forecasting and planning systems have few mechanisms for transparently and explicitly considering inventory.

A "storage" entity is required which contains "inventory".

The Changing Role of Storage

Storage within electricity networks is not a new concept. There has been storage present within the Australian electricity networks for many years.

Historically it provided for network stability as spinning reserve, and for generation during maintenance of other equipment.

More recently it has become seen as a mechanism for assisting in supply of maximum demand.

With the introduction of markets storage provides an opportunity for arbitrage.

It appears that storage has not yet been perceived as inventory.

Ultimately, with sufficient inventory in the system, supply and demand are decoupled such that both primary generation and price are relatively stable within the normal daily demand cycle.

Reserves

In the current definition Reserve appears to be limited to available but normally unutilised generating capacity and demand which can be reduced. Strategic Reserve recognises reserve with a long lead time.

Both of supply and demand reserve can be considered in the current planning models as available for an unlimited time. Though perhaps turning off a consumer for an extended period may result in a very high price for the privilege.

Inventory may be held in reserve. However, it is somewhat different in character to generation. There is a limited amount, it requires replenishment once consumed, and it may be available at short notice.

Similarly, demand turned off may be satisfied by “behind the meter” storage, which later requires replenishment.

While a holder of inventory may choose to contribute to the Strategic Reserve it is probably useful to know that the energy available is finite.

The concept of Strategic Reserve as currently interpreted appears to have been conceived around historically available technology without consideration of inventory.

I am uncertain whether that was the intent of the Finkel Review.

There are suggestions (page 152 of the Directions Paper) that a Strategic Reserve should be technologically neutral. A Strategic Reserve may be inventory or capacity regardless of technology.

Safety Stock

In conventional supply chains, with inventory, there is the concept of “safety stock”.

Finished product availability to meet demand is the result of both available capacity which may be utilised infrequently and safety or reserve stock.

Perhaps a difference between the Snowy Hydro view of the Strategic Reserve and other stakeholders (page 150 of Directions Paper) is in part explainable by the realisation that Snowy Hydro are embarking on creating a very large inventory. The magnitude of that inventory, plus the different rates at which it can be re-generated and replenished, suggest to me it already has the nature of a strategic resource.

Ultimately the network mix of generators and storage may evolve to the point where we pay Snowy Hydro to keep the storage full for most of time.

Behind the Meter

The Electricity Network is evolving from centralised continuous generation to distributed intermittent generation and storage.

With the introduction of roof-top solar came generating capacity which is “behind the meter”. The introduction of domestic batteries will also be “behind the meter”.

The same principle is being applied to storage which is coupled to large scale generators.

The aggregation of demand which is occurring creates what may be considered virtual meters.

In general the central network plan adopts a footprint which contains sufficient information to manage secure and reliable supply without being inundated with irrelevant detail.

At present that seems to be defined by the convenient physical meters and connection points.

Inventory Policy

In general inventory levels in any system are a matter of policy. Simplistically, the cost of holding inventory is balanced against the cost of changing supply rates, the cost of unutilised capacity, and the economic and political cost of being unable to supply.

The awareness that inventory is required to smooth intermittent supply as part of a guarantee to meet demand has not yet been translated into an inventory policy.

Current policy is an extension of existing paradigms requiring a level of excess continuous supply and zero inventory.

In a practical sense inventory is (almost) equivalent to unutilised available capacity.

A bit chicken and eggish. Without the inclusion of inventory in forecasting and planning models and thought processes it is unlikely an inventory policy will easily emerge. Without an inventory policy it is unlikely inventory will be included in the forecasting and planning model.

National Energy Guarantee and Inventory Policy

The National Energy Guarantee currently defines the technology required for a proportion of generation.

It can be seen as a necessary market intervention in the absence of an inventory policy.

Faced with competing technologies one can pre-empt a competitive outcome. Policies can be adopted at a level (of abstraction) which favours one or the other, or can be adopted at a level which allows equality of opportunity.

In some respects the National Energy Guarantee in its current form can be seen as a predictable outcome of a system which doesn't have mechanisms for managing inventory.

Conversely, the introduction of inventory and appropriate management systems would influence the National Energy Guarantee as it is currently conceived.

Storage and Generation

In the present scheme of things storage is typically coupled to specific generation, behind the meter.

At one extreme, with no intermittent generation, no inventory is required, as has been the system design and policy for more than 100 years.

At a different, hypothetical, extreme, with 100% intermittent generation, inventory is essential.

The inventory level required to maintain a given supply security and reliability increases with the proportion of intermittent generation. A sliding scale.

Thus, while it is possible to adopt a policy stating a given storage capacity in MWh is required for each MW of new intermittent generating capacity that would result in either today's new generation having to provide storage for generators not to be installed for many years or future generators having to provide storage for previously installed generators.

A more likely workable policy approach is to decouple generation and storage to allow, and manage, growth at different rates. Storage may be behind a different meter to generation.

Storage Business Models

It is conceivable that decoupled renewable generation and storage, and separation of storage and inventory concepts, will lead to storage business models which include "tolling storage". As a renewable energy generator I pay a storage owner to store my energy. A self-storage model. Ownership of the energy doesn't change. The owner of storage supplies storage.

This will challenge the flexibility of existing forecasting and planning models.

Demand Forecasting

The current approach of forecasting demand "at the meter" has successfully evolved to allow for the intrusion of weather patterns into local generation.

While it can be postulated that a similar evolution can occur in respect of local storage it can also be noted that storage hidden behind the meter can modify demand at the meter in ways not previously experienced.

In the current system demand is seen as instantaneous. Thus, simplistically, if its going to be hot tomorrow the demand at 4pm can be reasonably forecast, within limits.

However, with local storage, there will be a difference in that demand between if there has been three days of rain or three days of sun in the preceding days.

While forecasting "at the meter" is valid, as the extent of storage behind the meter increases so does the forecasting task become more complex and potentially less reliable.

At the same time there will be an averaging effect similar to that experienced by geographically dispersed wind generation where the local ups and downs average out across the whole network.

My crystal ball in this respect is murky and inadequate. I suspect that there is at least a period of time in the evolution of the network in which inventory levels have a significant impact on forecast accuracy adversely effecting planning decisions and reliability.

Electricity would not be unique in not knowing how much inventory is present at the ends of the supply chain. There is always cornflakes on the supermarket shelf due to a mix of capacity and inventory and the supermarket inventory is not known to the manufacturer.

A challenge is to find a flexible footprint which includes sufficient inventory transparency to provide reliable forecasting and planning.

Price Forecasting

Price forecasting is currently an outcome of demand forecasting and a bid curve.

Just as inventory decouples supply and demand so it decouples price and demand.

At the extreme, supply and price may be constant with inventory smoothing fluctuations in demand.

Looked at another way, the currently existing arbitrage opportunities which can accelerate the payback for storage reduce and disappear as the level of inventory increases.

There is conceivably sufficient inventory and capacity in Wivenhoe Pumped Storage to ensure a constant wholesale price within Queensland if that were seen as desirable.

What Are We Storing?

We are storing energy. However, when a renewable energy generator decides to store some energy, since the bid curve ensures renewable energy is consumed first any energy stored has to be supplied from additional generation. The renewable energy generator causes the non-renewable energy generator to increase output to fill storage. The non-renewable energy generator would never do that of their own accord as there are efficiency losses in storing energy and their energy inventory is held in coal or gas stockpiles.

The reverse occurs on regeneration. The renewable energy generator accepts the higher price at peak demand while the non-renewable generator is idle.

A form of gaming the system whereby the renewable energy generator has an advantage.

It is only when renewable energy is capable of supplying more than 100% of demand (even for short periods) that renewable energy is stored.

Distribution Network

It has been recognised (page 158 of the Directions Paper) that coordination of generator, storage and distribution investment is required.

Inventory management would be an input to that process. Distributed storage, and thus inventory, decoupled from generation, can significantly change distribution network capacity requirements.

Why Inventory?

Without inventory the proportion of renewable energy that can be supported in the generator mix is limited. With inventory there is a potential for a rational economic generator mix.

Without inventory management systems decisions on security and reliability are made by default.

Scary Thoughts

Just as with the introduction of renewables concerns about their intermittent availability are raised, so, when inventory is introduced to overcome the intermittency concerns about running out of inventory are raised.

But there is only a little equivalence. While we cannot control the weather, we can manage inventory as part of the supply chain.

It is simply a matter of system design.

Reality Check

Storage is becoming part of the electricity supply chain. It is disrupting the supply chain.

There is a choice to continue ignoring the presence of inventory until the effect is so disruptive a response is necessary or to introduce inventory policy and management systems in an ordered fashion.

At minimum there is a need to recognise that choice is being explicitly made rather than simply ignore the question.

Systems are Strategic

It is difficult to introduce a paradigm shift, such as the introduction of “inventory”, to a complex system.

For a concept so pervasive it is probably necessary to treat it as both a separate project and to include consideration of inventory in all rule change proposals. The difficulty is compounded by the number of organisations involved and a natural tendancy to revert to the status quo.

It is possible that in review the interim rule change for registration of storage as both generator and load, and all that lies behind it, spawns the need for a storage entity which acts as a spark to flow through all forecasting and planning systems.

Timing is difficult but there is no time like the present.

3. Suggestions

The following suggestions are intended to simply explore ways in which inventory, once identified as a useful concept, may be introduced into an existing system. They are by no means exhaustive.

Recognise Inventory as a Concept

When considering policy or rule changes include discussion of the impact of inventory.

At minimum the Directions Paper needs to explicitly state whether inventory will continue to be ignored or to be included as part of policy, market, and management systems design.

Inventory Policy

Create an inventory policy with consideration of how it interacts with other policies.

Inventory in Forecasting and Planning Systems

Explicitly include inventory in forecasting and planning systems. Separate “storage” and “inventory”. Introduce a “storage” entity. Object oriented designers will recognise a storage object inherits properties of both generators and loads with additional properties such as how much inventory there is in storage.

Energy (inventory) management should be integrated with Power (capacity) management.

Simplistically, create a Power plan (as currently) then check if there are Energy constraints that prevent the plan being implemented.

Market Mechanisms

Create and modify market mechanisms to support inventory management objectives.

Planning Footprint

Review the concept of the “meter”, and more explicitly “behind the meter”. This may include adoption of the concept of a (logical) Planning Footprint which is not bounded by meters and allows for aggregation (as will occur with virtual power plants) or disaggregation (as may be required to separate significant inventory from generation). The “meter” is virtual, and moveable. Aggregation may occur both within and outside the central forecasting and planning system.

Intermittent Generation and Inventory

While intermittent generation necessarily creates a requirement for inventory the amount required per unit of intermittent generation increases as the proportion of intermittent generation in the network increases. Their presence in the network should be allowed to change at different rates.

When considering policy measures it is essential that inventory and intermittent generation be decoupled.

Inventory as Reserve

Establish equivalence between generating capacity and inventory when considering Strategic Reserve and the Reliability and Emergency Reserve Trader (RERT) mechanism.

Prior to introducing that to current rule change proposals it is necessary to establish inventory as a concept within management structures.