<u>Julian Lawrence Second response to Post 2025 Market Design Issues Paper</u>

Conceptual Design for
Australian Wholesale Electricity Market

The increasing heterogeneity of electricity networks suggests opportunities for market and operations redesign.

Concept

A transparent wholesale electricity market is envisaged in which:-

- generator utilisation is maximised,
- prices are sufficient to allow reasonable profit,
- inventory is visible,
- extraordinary prices during peak demand and negative prices during minimum demand are avoided,
- demand elasticity is recognised,
- downward price pressure can occur naturally, without regulation,
- market constraints on operations are avoided,
- market flexibility is enhanced,
- reliability is explicitly included in market mechanisms

The critical market improvements are

- to recognise the role that inventory plays in price discovery.
- to respond to demand elasticity, and
- to recognise the positive effect of inventory on utilisation and network reliability

A trading floor approach, with two sided bids and offers, becomes feasible, and is proposed as more capable, (than the existing single sided merit order auction approach), of responding well to the additional market signals of inventory and demand elasticity.

The critical operational improvements are:-

- to recognise that storage contains inventory, which requires management, with the introduction of a storage entity and related real-time data requirements,
- to recognise that inventory decouples supply and demand,
- to explicitly manage energy as well as power,
- to recognise the role of inventory in reliability, and
- to recognise and manage demand heterogeneity.

Document Structure

The remainder of this document is aimed at expanding and explaining the above concept.

Market design is explored first, then Operations (Network Management) implications. Both are necessary, neither sufficient.

Interwoven are design concepts and implications followed by proposals.

Inventory

The introduction of variable intermittent renewables has necessitated the introduction of storage for network stability.

Inventory decouples supply and demand. Storage contains inventory which varies as the balance between supply and demand changes.

This is a departure from current operations where storage is considered as either supply or demand.

Inventory levels have an effect on price discovery in commodity markets. When inventory rises price falls. When inventory falls price rises. Variations in demand have less effect on supply utilisation. Price variation between peak and off-peak is reduced.

Price discovery in a market where inventory is present and visible is significantly different to a market in which inventory is invisible or non-existent.

At the extreme there may be sufficient inventory to completely smooth demand variations and maintain a constant level of supply, for inventory to rise and fall within its storage capacity limits. Price may be completely smoothed.

It is possible that the current price cap (a market intervention which is applied at high peak demand with a potential to create missing money) may become redundant.

Inventory and Reliability

Generation reliability in an electricity network is traditionally maintained through the presence of excess capacity (available but unutilised for long periods).

Within limits, inventory has a similar effect on reliability to excess capacity.

In conventional supply chains safety stock can be maintained. The minimum inventory required to guarantee acceptable reliability.

Market Implications

Beyond the immediate effect of inventory visibility on wholesale price discovery:-

- An ancillary market for safety stock is proposed which complements the existing reserve capacity market.

- Inventory may be traded as a result of different ownership of storage capacity and inventory.

Supply and Demand Heterogeneity

Prior to the introduction of renewables electricity generation was considered homogenous. The behaviour of different generator types was sufficiently similar.

Some heterogeneity exists through geography – generating capacity is defined by state with bi-directional transfers and different price outcomes.

Renewables are variable and intermittent. This required the separation of scheduled and semi-scheduled generation. Supply became heterogeneous

In addition renewables are near zero marginal cost. The raw material is use or lose, and there is more tomorrow (they are renewable). The resulting imperative to operate, which changed market behaviour, rendered supply heterogenous.

An outcome is a discontinuity in the market merit order bid curve, renewables are consumed first, fossil generators (in the absence of storage) become increasingly variable to maintain supply and demand balance. Prices move between higher peaks and more recently negatives (possibly due to the reluctance of coal generators to switch off for short periods in tension with the renewables desire to fully utilise available sun and wind).

Beyond that, price regulation through a maximum price at peak demand exacerbates the spectre of missing money where some generators cannot achieve full cost recovery.

Demand is currently considered homogenous.

A recent rule change has been the introduction of demand which can be reduced to bid into the market as supply. The advent of demand heterogeneity.

This is an important step change as the implied demand curve (price vs quantity) seen by the wholesale market is no longer vertical.

It is conceivable that as demand management becomes more sophisticated the extent of demand heterogeneity will grow and different demand signals may reach the wholesale market.

New Demand

Demand management is currently embarked on managing existing demand to create elasticity.

New demand, such as electric vehicles, may be managed in a way which increases elasticity.

It is conceivable that some new demand will be infinitely elastic. While currently expensive, hydrogen electrolysis can be controlled continuously between 100% to 0% very rapidly.

While pumping water is not infinitely variable it could well be configured to be variable and intermittent demand.

It is quite likely that demand will be developed that can mirror the variable intermittent nature of renewables in addition to the effect of inventory.

Demand will become increasingly heterogeneous.

The impact of an export hydrogen market on electricity pricing has not been explored. Market design will need to be aware of the potential for unintended cross subsidies between demand types and avoid the implications of potential market power of a large consumer.

Market Implication

Demand elasticity is an important signal for efficient price discovery.

Differentiation between scheduled and semi-scheduled demand is required to mirror supply and begin the introduction of demand elasticity signals into the wholesale market.

An integrated ancillary reserve market which includes a mechanism to balance future supply, demand and inventory requirements is required. A mechanism to achieve a network plan of full resource utilisation through market forces.

Capacity Implication

Having decoupled supply and demand through inventory, and established that both supply and demand are elastic, we have also established that:-

- At times supply will be underutilised (current outcome is average supply utilisation of around 80% of nameplate capacity)
- At times some demand will be unsatisfied (current outcome when reduced demand is equated to supply) and downstream activities are underutilised
- At times both generators and demand will operate at 100% utilisation while inventory varies.

It is useful to allow the bottleneck to move.

The desirable economically efficient outcome may be to utilise inventory to achieve 100% utilisation of both supply and demand resources.

We typically consider utilisation of nameplate generator capacity. While that is the constraint for fossil fired power stations, and 100% utilisation of generator capacity can be achieved, the constraint for renewables generators is the availability of sun and wind, which are intermittent and variable. This difference adds to other difficulties in comparisons, including how much excess generator capacity and inventory is required to achieve desired reliability. In this submission 100% utilisation of available sun and wind is considered the maximum renewables generator output.

Interestingly, if renewables generation is constrained to operate at less than 100% utilisation of available sun and wind, it would not be too perverse to consider the relief of the constraint to have the effect of releasing “free” renewable energy.

Imperative to Operate and Downward Price Pressure

In a 100% renewables network the imperative to operate which results from combined effects of the zero marginal cost, the use or lose raw material (sun or wind), and there’s more tomorrow (they are renewable), will have a more profound market impact than with experience so far of introducing renewables into the current mixed generator fleet.

Renewables competing with renewables creates an inexorable, never satisfied, downward pressure on prices.

The potential for "missing money" (marginal rather than full cost recovery) is forever present with zero marginal cost resources. Equally present is how to project the downward price pressure through to the end-user in good time, and thus through the whole economy.

Inventory Holding Costs

There is an efficiency loss of energy through storage. A subject too large for this submission. There are also costs associated with operating the storage facility.

Simply, consumption of inventory is always secondary to direct supply. The imperative to operate will naturally lead to filling inventory when capacities are in equilibrium – a desirable outcome of good market design.

With a mixed generator fleet, where renewables are consumed first, it is non-renewable energy which is stored. Total emissions become higher than otherwise.

Above 100% renewables (even for short periods) it is renewables which would be stored. As well as zero emissions there is a propagation of the zero marginal cost, which, depending on downstream market design, propagates through the whole economy.

Market Implication

The presence of inventory, the potential and desire to always generate, and to fill inventory for later release to the market, significantly changes the market dynamics.

While not a complete solution to "missing money" the not so subtle change allows timely decisions about under-utilisation rather than a sudden lack of permission to supply created at auction. A more flexible market.

Missing money occurs in all markets. Sadly, the ultimate economic response to long term excess supply is closure of some capacity. Similarly, the response to long term high prices is closure of some demand. Or, in the case of electricity, individual household rooftop solar.

Equally lack of supply can occur which in the long term increases prices and prevents the effect of zero marginal cost propagating through the market.

In a market that reaches equilibrium between supply, demand and inventory, with adequate transparency and information flows, there is an equilibrium between price and cost recovery.

Market Proposal

The conceptual proposal for market redesign is to progressively improve information flows, about inventory and demand elasticity, as the proportion of renewables and storage increases.

Progressively add or change ancillary markets to support the changed market dynamics.

At an appropriate moment move the wholesale market from the current merit order auction to a virtual trading floor (bid and offer) with the required information flows for operations to implement the outcomes.

Further develop the wholesale market with energy trading (MWh) making use of inventory.

Operations Implications

To derive the above market design there has been some iteration between market design and network operations requirements.

The market must allow operations to function well while operations must support market mechanisms. Ideally neither should be constrained by technology at this abstract level.

The important outcome for operations is that the disruptive, destabilising, effects of renewables are accommodated in market design and network operating systems.

Rather than trying to make renewables behave like fossil generators through market (and operational) constraints it is feasible to have renewables behave like renewables. Create a virtue out of necessity.

The Storage Entity

A new entity, “storage”, will be implemented. This will require AEMC rule changes for data collection through the AEMO real time (SCADA) control system.

The minimum data required is:-

- Storage capacity (MWh)
- Available Inventory (MWh)
- Operating State (Generating / Storing)
- Available Generating Capacity (MW)
- Current Generating Utilisation (MW)
- Available Storing Capacity (MW)
- Current Storing Utilisation (MW)

In a similar way to there being a minimum capacity for a generator to be considered part of the network (>30MW ?) there will be a minimum storage capacity for consideration.

Simply, the equivalent of Pelican Point would be “sorry, the upper dam is empty”.

Distributed Generation and Inventory Behind The Meter

Significant storage currently hidden “behind the meter” should be captured in the storage entity and exposed to the market as inventory regardless of plant design or external contractual arrangements.

Aggregation of Distributed Resources

There are various efforts occurring to aggregate household and other distributed generation and storage resource. For market participation aggregators must supply both aggregate generator capacity and storage capacity information to generator and storage entities.

Demand Heterogeneity

Differentiation between scheduled and semi-scheduled demand is required within the operations plan.

The Operations Plan

The Operations Plan will include inventory where it is useful for the time periods displayed (minutes, hours, days, months, weeks, years) in the plan.

Thus, each time period has

- Opening Inventory (MWh)
- Supply (MW or MWh)
- Demand (MW or MWh)
- (Transfers) (MW or MWh)
- Closing Inventory (MWh)

The plan is visible to the market, as is the plan now.

Forecasting

The role of forecasting supply, a difficult task for renewables, becomes less critical when renewables are allowed to operate at 100% utilisation of available sun and wind to satisfy conventional (forecast scheduled) demand, fill inventory, and satisfy semi-scheduled demand.

Detailed Design and Modelling

Electricity networks belong to the class of capital intensive commodity industries with the addition of being a natural monopoly. Physically, electricity is a single, undifferentiated, high volume, product.

This submission is a conceptual design only. It has been derived from first principles, from the application of principles commonly applied in other commodity markets and supply chains. Derived from an un-siloed, multi-discipline, approach.

There is no detailed design. It is sufficient at this stage to establish that a trading floor is a viable alternative to merit order auction and can provide desirable outcomes.

No modelling has been undertaken due to lack of resources.

Barriers

A barrier to change may occur due to business cases for capacity and storage having been based on current market design. That may apply more to storage than generating capacity due to the perceived long term ability to selectively take advantage of arbitrage between off-peak and peak. The opportunity for arbitrage reduces as the total storage capacity in the network increases. The golden goose ceases to lay.

Barriers may exist due to the organisational structures surrounding the electricity network which fragment disciplines and decision making.

A barrier also may exist due to the current operations and market stack having been designed with the benefit of more than 100 years of established practice and become the dominant design throughout the world. However, this proposal is considered no more earth shattering than the initial move to current market mechanisms.

Implementation

It is quite possible that the presence of large scale storage in a market could be tested reasonably soon in Queensland where operation of Splityard Creek (500MW, 5000MWh pumped storage) has recently been transferred to CleanCo, the Queensland Government renewable energy company.

The necessary operations changes will be required regardless of market changes. Implementation can commence before 2025.

Summary

A simplistic view of the above proposal is that electricity management should move from predominantly managing Power (MW) to more explicitly managing both Power (MW) and Energy (MWh) with consequent possible changes within the market.

Also to recognise the potential role that demand management can play through the whole system.

The implications of those requirements ripple through (from top down system design) the whole market and management structure.

Even if the market is not redesigned in this way operations should be, lest they inhibit further network and market development.

The design is expressed as an opportunity rather than a response to pressures on the existing market and operations. Alternatively, it could be viewed as a version of "necessity is the mother of invention".

Who Am I

I'm a retired Systems Thinker with experience in Operations and Inventory Management plus Integrated Systems Design at high level in commodity industries. Several years ago, I wondered why Splityard Creek (Qld 500MW, 5000MWh pumped storage) is capable of considerable smoothing supply but is unutilised.

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