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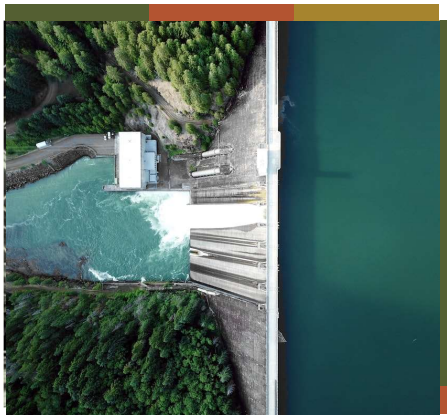

Qubist Energy Perspectives – June 2024

Electricity Transmission over Trunk Optic Fibre

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The "Impossible Build that we need to get done

We have a massive challenge ahead of us in transitioning our energy system to renewables. We need new generation to replace our aging thermal plant and renewables are the least-cost, most-investible option to build right now.

That creates several problems.

1. Renewable generation variability
2. Generation scheduling and dispatchability
3. Storage requirements
4. Output smoothing
5. System strength and stability.

But the biggest is probably getting the resources, specialist skills and equipment into the location they need to be, when they need to be there (probably 'yesterday').

We also have the challenge of managing risks from the exit and market power of the big coal-gas-retail portfolios of the major gentailers (i.e. AGL, Origin and EnergyAustralia)

Because:

a) The new generation needs to be in place before the old generation retires;
b) The big guys call the shots on the date that happens; and
c) They also benefit from running their other generation in the much higher prices in a supply constrained market,

so it becomes incredibly risky for new generation developers to build enough new generation capacity before the market actually needs it – because the big guys could extend (or get paid to extend) the operation of their coal plant and suppress prices for a few years to make recently commissioned renewables projects that are carrying more debt in the early years sweat.

...and put pressure on the new assets with a view to buy them up at highly favourable valuations due to the subdued wholesale markets.

It might sound a bit evil – but that's just how business and markets work – and we have received the benefits from our energy market working like this for the last 25 years or so.

So what are we doing to get it done?

To enable enough renewable generation to connect, we are building new transmission lines to bring in the energy from where the best renewable resources are.

The last time we did this was from about the 1960's when we moved our generation out of our cities (e.g. White Bay Power Station in Sydney) and into the coal fields (the Hunter Valley, Central Coast and Western power stations).

We built the transmission system back then and have been building more of it ever since to meet our needs. A lot of it is due for renewal after our Transmission Networks have and continue to manage the risk of keeping these very old assets in service by renewing the critical parts of lines and managing the criticality of older assets on the networks.

So, building the new transmission lines lets us gain the economies of scale by servicing targeted zones for renewable generation development and speed of renewables connection that we need to achieve.

It's a very good strategy, but it needs a lot of smart people, specialised equipment and skills and a whole lot of investment from both the public sector and private sector.

...and the rest of the world is doing something similar at the same time – so getting those people, skills and equipment takes longer and is more expensive.

Imagine a world without (as many) wires?

Right now, we are seeing a massive growth in data centre infrastructure, driven by increased rack power density, rapidly growing artificial intelligence (AI) processing demands, development economies of scale from locating far denser data centre environments on the same site footprint of a smaller facility from just a few years ago.

With single data centre loads rapidly escalating from 100MW to 250MW and up to GW scale there is an increasing convergence between energy markets and data processing because there are very few locations that could readily connect GW scale loads without substantial changes to the transmission system.

What if instead of moving electricity long distances between states, we moved the location of the energy intensive data processing instead?

Could we then make better use of our existing transmission assets by loading them up to higher utilisations by ramping up/down GW scale local processing loads in response to the energy market needs?

Would GW scale data centres be able to reduce/offset their grid connection costs against energy market services contracts and wholesale market revenue benefits?

How much of the 'impossible' task of building transmission infrastructure could we rationalise or push back to a more reasonable timeframe? (bringing substantial cost escalation, resource scarcity and specialist equipment lead time issues back into line.)

The flexibility of large loads has always been an important part of managing a power system. The scale of forecast data centre load, alongside the operation of data centres in geographically diversified portfolios means that data centres can provide substantial 'virtual' transmission, storage or interconnection services without the need for physical interconnection by transmission infrastructure.

Transmission over Trunk Optic Fibre (ToTOF)

Connecting these data centres to our transmission system is potentially very expensive if we do it conventionally.

...but what if we took advantage of the strong trunk data connections that GW scale data centre assets need to move that processing load around between states (or countries) to balance our power system from the demand side.

Coupled with the increasing co-location of batteries and potentially generation at the data centre sites, data centres could be the complementary flexible energy & data assets that digital and energy infrastructure markets need.

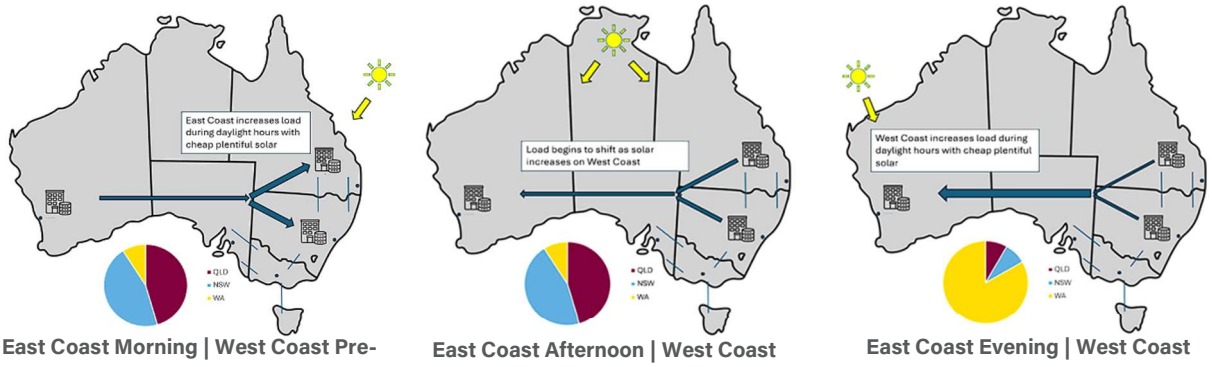
With increasing geographical diversity for energy intensive data centre processing (especially in applications where an increase to 100-200ms latency is not critical) GW scale data centres provide a novel solution to smoothing renewable energy output, reducing the level of battery or mechanical storage required and providing highly reliable and administratively efficient large scale operational, seasonal, and/or emergency demand-side load reduction and load increase responses into our energy market.

I have called it 'ToTOF' or Transmission over Trunk Optic Fibre because it could provide effective transmission services between markets with no electrical connection – but strong optic fibre links.

For example:

1. *What if we had a data centre on the east coast of Australia and one on the west coast?*
   Processing load could be passed from the NEM to the WEM to offload the east coast evening peak and serve the east coast evening data processing demand from the west coast data centre - with the afternoon solar and wind due to the time zone delay [See figure 1].
2. *What if a GW scale Sydney-Brisbane-Melbourne-Adelaide based data centre portfolio could be paid via the electricity market to ramp up/down processing demand automatically - in accordance with AEMO's dispatch instructions?*
   The flexibility of automatically moving processing demand to support the market suddenly gives AEMO another tool to:
   a) Suppress high/negative wholesale energy prices with automated up-down load regulation.
   b) Access a battery-like revenue stream that is incremental to the data centre asset that is paid for through the core data services.
   c) Provide GW scale 'virtual' interconnector capacity as required to manage the constraints on the power system (i.e. moving 500MW of processing in NSW and putting it in Qld gives a 1GW net effective transfer) [See figure 2].

Figure 1: Virtual transmission operation by shifting non-latency critical processing loads interstate



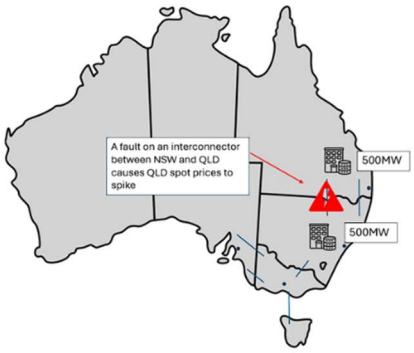
East Coast Morning | West Coast Pre-Dawn

East Coast Afternoon | West Coast Midday

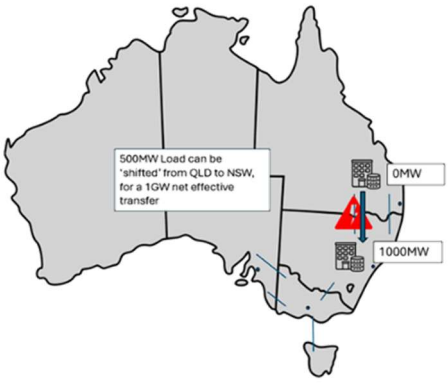
East Coast Evening | West Coast Afternoon

When expanded across a global portfolio, this concept could do the same for any international power system that has data centre processing loads that can be allocated to / away from Australia to smooth loads and stabilise grids worldwide.

Figure 2: Virtual interconnector capacity and automated inter-regional arbitrage using a flexible data centre portfolio



Inter- regional arbitrage opportunity due to physical transmission constraint



1GW of virtual interconnector capacity deployed by shifting data centre processing load

Why Australia is the place to do this from

Australia has the best resources of the cheapest form of generation that we have today – solar. We are also on the other side of the world in latitude and in the other hemisphere to Europe and North America.

So, our summer sun can meet their evening and nighttime processing loads as well as providing a level of strategic energy security to Europe in case they run short of oil/gas/coal again. That was expensive for everyone.

Our geographical isolation also brings valuable physical security and importing the worlds processing lets us concentrate high skill data processing & optimisation jobs as a cornerstone 'knowledge' export industry and allow us to punch well above our weight in addressing global emissions.

Sister sites in a secure allied country like the UK (North Sea Wind), US (Inland solar/wind) or Canada (hydro/solar) would provide round the clock coverage for renewable flexible data processing and providing virtual ToTOF.

What's more, capacity can also be built off grid in Australia on long term fixed price renewables contracts to lock in long term price certainty for direct supply from our world's best solar resource and our other renewables.

Nuclear might also make economic sense in the future when the technology has been proven and global deployment has brought costs and delivery risk down to a competitive and repeatable level.

Qubist brings together the cross disciplinary and cross-market expertise in electricity markets, transmission infrastructure, telecommunications, generation and energy storage needed to help our clients realise the hidden value of their assets.

Our people understand digital and physical infrastructure and networks needed for large data centres from a 'dollars and sense' perspective alongside the technical drivers and delivery challenges.

Please reach out if you have a bold vision that we can help you turn into reality.

Qubist – a different way of viewing solutions

Our Story

We have been advising the Australian infrastructure sector since 2018 under the Qubist brand, but we have been working together for over a decade more in the former Evans & Peck utilities and environment team.

We bring a genuine concern for our clients and our people. We truly value integrity and independence above all else in how we work and the advice we give. This allows clients to trust us to guide their most challenging initiative and resolve the wicked problems that emerge for infrastructure owners.

That is what we do best– view things differently.

Our People

Our energy team has been involved in every major reform to the Australian Energy Market since the formation of the NEM inn 1998. From transmission networks, distribution, generation, renewables and storage, they have planned, reviewed, financed, operate, optimized and maintained the infrastructure.

We understand the past– as well as the future

Our team understands your business because there is a good chance that we have sat in your position as board member, senior executive, general manager, project manager, asset manager, regulatory manager, development manager, commercial manager, contractor, contract manager, procurement manager and more. *We have been there- and have earned 'our scars of success;*

Qubist people are curious and multidisciplinary, which brings you advisors with far more integrated experience and a team that can better foresee client issues before they become big issues.

Our Results

We don't like to brag- but if we have to, we have plenty to talk about.

Our people were the team that advised NSW Treasury and prepared the vendor due diligence for the very successful $36b long term lease transactions forTransGrid , Ausgrid and Endeavour Energy. We have subsequently been sought out to advise on the vendor side (Ausgrid) and buyer side (Endeavour Energy) on the subsequent minority equity stakes in these assets.

Our team members have managed $10b+ transport and energy asset portfolios. They have been the WA Govt independent reviewer on a 4 hour, 2.8 GWh battery initiative to transition coal generation out of the South West Interconnected System. They have advised TNSP's, Generators and Infrastructure owners on commercially negotiated transmission scale microgrids.

Whether it is energy infrastructure, commercial and transaction advice, strategy or delivery we have 'runs on the board' and the results and repeat clients to attest to what we can do- *differently*

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