



Ausgrid

Some Realities of getting Power back into the Network

(Some Challenges for the Proliferation of Embedded Generation)

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Overview:

- A broader perspective on Embedded Generation.
- No Magic Answers Just trying to increase understanding of the diversity of issues – in the hope of contributing to more holistic, economically sound, and sustainable solutions.
- “Smart Grids” Lots of jargon, but we still need to transport Amps.
- Turning an old Paradigm upside down.
- Perception of Barriers
 - **The Customer.**
 - **Technical.**
 - **Economic.**
 - **Regulatory & Licence Compliance.**
- The GROWING effects and problems associated with Solar penetration and intermittency.
- Just what is the Driver for a proposed EG installation ?
This could really affect the outcomes.
- The Distribution Network can be the “Transport mechanism” that enables Distribution Generation Within the right Framework !

“Smart Grid” Be careful of the ~~Hype~~ Jargon

- How often have you heard ... *“Oh, the Smart Grid will make EG work”* ?
- There is a possible tendency (for those outside our industry, looking in) to misinterpret just what is “Smart”.
- Customers can’t (yet ?) plug their Generators into their iPhones, Home Cinemas, internet connections or Laptops.
- The “Core” Grid, or Network, still has to carry the current
It will still get hot, and will still need investment.
- The concept of the “Smarts” being a Data / Comms / Operational overlay for the Network that “does the work” could help with the understanding of some Embedded Generation issues.

Turning an old Paradigm “Upside Down”:

- The Distribution Network is not the “Source”, it is simply a “Transport Mechanism”.
- Historically, this “Transport” has been getting the energy from the source, to the load (ie, Customers), pretty much in one direction.
- This has been the basis of “traditional” Network Planning, Design, Investment, Protection, and Operation philosophies for a very long time
And has had a significant impact on current Licence requirements.
- **But, we can now have “Customers” becoming “Sources”**
- Concept of “positive” and “negative” loads, all time variant
hopefully diversifying in the long term.
- Popping up all over the place
- Multifarious combinations and permutations affecting Load Flows
- Distribution Networks will be a crucial, shared transport mechanism to handle the diversity of EG, integrate these sources, and will help to “enable” both the technology and the benefits.

Perception of “Barriers”

- There are a wide range of Issues (as opposed to Barriers) – for example ...
 - Just what does the Customer / Proponent want. Why are they embarking on EG ?
 - Safety, and operational.
 - Technical.
 - Network infrastructure and Customers’ installations.
 - Supply reliability, and security.
 - Economic.
 - Building, and development approval.
 - Network connection and backup Versus Energy “Retailing” or Trading.
 - Licence Compliance, Regulatory, NERs, the Market.
 - National / International Standards.
- Many issues may not have yet been tested, or worked through on enough occasions to make them “straight forward” ... or to be fed back into the evolution of Regulatory or Licence Compliance Frameworks.
- With some, under current Frameworks, the more you try to work through them, the more complex they seem to become.

Perception of “Barriers”

- Whilst in the short term, EG connection negotiations may seem complex, and simplification of these issues may take some time, they are only “issues”, and NOT “Barriers”.
- Ironically, throwing money at most of these issues can make them go away, but Customers and Proponents have financial constraints And so do we.
- It’s important to get the commercial construct and economic decisions correct, and avoid misunderstandings and confusion due to disguised or surrogate subsidies.
- And, our throwing of money at things is heavily regulated – from both a National, and State Jurisdictional perspective.

The Customer / Proponent:

- What do they want ?
 - Load requirements – both magnitude and timing.
 - How much will be offset by EG ?
 - Why do they want EG ? Environmental initiative, commercial venture, no choice ?
 - Islanded, or synchronised and in parallel ?
 - Any export ?
 - Network backup ?
 - Reliability and Security – As well as the Generator itself, they need to consider normal Network supply, Network Gen backup, their own electrical installation, fuel source (eg, gas supply), water supply and infrastructure etc for Tri-Gen.
- Are they able to provide the required EG characteristics and data for Load Flow and Planning analysis ?
- Are they aware of potential Voltage and Fault Level effects – not just a “Network” issue, but also within their own installation ?
Possible show stopper.
- Are they expecting significant safety, protection, synchronisation requirements ?
- Are they expecting Operating Agreements and Protocols ?

The Customer / Proponent:

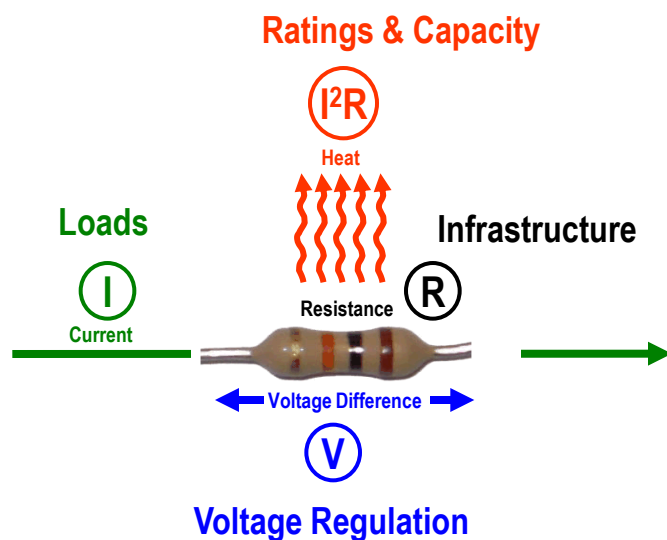
- Are they expecting likely restrictions on export magnitude, voltage swings and Power Factor, or the possibility of Trading Curtailment ?
- Do they know there may be significant costs associated with augmentation or reconfiguration of Network infrastructure, and provision of the connection – AND that there may be potentially long lead times ?
- Are they aware that each time their loads, timings, backup requirements, or connection configuration change, the Network response - and many other aspects of the negotiation, may change ? IT ALL TAKES TIME !!
- Do they understand the separation between “Network” and “Retail” issues, and the combined effects on their Financial model ?
- Are they aware of likely requirements for Comms, Data, Operational and Protection telemetry ?

Technical Issues – Absolutely Fundamental:

- Underlying concept of “Network Performance”.
- Numerous expectations, and “instruments” describing aspects of Network Performance:
 - **NERs.**
 - **Codes.**
 - **Licence Compliance requirements.**
 - **Design Planning Criteria.**
 - **Customer Charters.**
 - **Connection Agreements.**
 - **National / International Standards.**
 - **Internal Policies, Planning standards etc.**
- Fundamentally, the Network has to “work” – for all customers ...
When the EGs are running, AND when they’re not ...
(And presumably, the Network is required to provide backup supply) ...
At times of high loading, AND at times of low loading ...
When everything’s normal, AND during an emergency ...
Without causing problems for all the other customers.
- And, without requiring Network Operators to run around re-configuring and re-setting the Network each time the EG operating parameters change.

Technical Issues - Overview:

- That famous line from Star Trek
“You can not change the laws of physics”.



Ohm's Law:

- $V = I \times R$

And

- $W = V \times I$
 $= I^2 \times R$

(And... lets just leave $Z = R + jX$ out of it !!)

- So, infrastructure parameters, capacity and ratings, current, and voltage are all fundamentally tied together in a relationship bound by a really simple law of physics.
(Regardless of Regulation, Licence requirements, expectations, Politics, and economics)
- Combinations and permutations of multiple “sources” popping up within the Network will shuffle all of these relationships around.

Technical Issues – More Specifically:

- Voltage drop, rise, regulation, variability.
 - Voltage drop along the Feeders from source to consumption – variability, lack of predictability, may even change “direction” – local rise in vicinity of generation.
 - Voltage regulator settings along the Feeders, and possibility of reverse power flow.
 - On-Load Tap Changers and Line-Drop Compensation at the Zone Substations.
 - Fixed tap changers at the Distribution Substations.
 - What both the Proponent, and all other Customers experience, is an interaction between all of these.
- Loads, load flows, variability, thermal capacities (ratings).
 - Potentially huge number of combinations and permutations affecting load flows.
 - Network configuration. Normal or contingency scenarios.
 - Maybe not be much headroom, small increment can trigger major Network augmentation.
- Forecasting.
 - What were all the EGs doing at times of the seasonal peak loading ?
 - Can any “contribution” be relied on ? What will they be doing next year ?
- Fault levels.
 - Can affect the Proponent’s installation, AND Network assets, AND other Customer’s installations.
 - May not be much (or any ?) headroom. Again, small increment can trigger major Network rearrangements.

Technical Issues – More Specifically:

- Connection point.
 - Is it LV, somewhere along HV Feeder, dedicated Feeder back to Zone Sub, or Sub Transmission ?
 - Additional “challenges” associated with CBD Triplex Network.
- Ability of EG to “ride through” major Grid or Network faults.
 - Possibility of significant voltage dip resulting in multiple EG drop out. Will EG contribution be available when you most want it ?
 - Reset, restart, synchronisation, protection, stability issues etc.
- Power Quality (distortion of the Steady State waveshape).
 - Effect of background PQ on EG, and effect of EG on PQ seen by other customers.
 - Harmonics, voltage fluctuations / flicker / unbalance, transients etc.
- Losses.
 - Don’t want to unintentionally mitigate any environmental benefits achieved.
- Grid / Transmission Network stability.
 - Significant sudden changes to either loads or generation capacity.
- Solar (PV).
 - Both significant Penetration and Intermittency issues.
 - Forecasting, local voltage rise, harmonics, time variant – and lack of coincidence with local peak, inverters – and possible need for “curtailment”, in-feed tariffs, not reducing peak loads, may actually trigger investment – NOT defer.

Economic, Regulatory, Licence Compliance Issues:

- Current framework doesn't fully address or facilitate proliferation of EG.
 - **Combination of National Regulation and State jurisdictional Licence Compliance.**
- The NSW Licence Compliance, Design Planning Criteria underpin investment for “conventional” Network development augmentation
 - **Reliability, and Security Standard “N-1” classification for CBD, Urban, Rural Load Types.**
- But Do not (yet) provide a mechanism to proactively facilitate EG.
 - **Investment for the provision of “headroom” for either Capacity or Fault Level within appropriate precincts is not included in the current Frameworks or determination.**
- Each EG proposal is a one-off, multi scenario analysis to determine any “incremental” investment required.
 - **Many combinations of loads, ratings, configurations, and generation scenarios.**

Economic, Regulatory, Licence Compliance Issues:

- Complexity proliferates if there are multiple, separate EGs proposed.
 - What investment / augmentation is required for which EG connection ?
 - Order of connection, timing, who pays for what, cost sharing ?
 - Exponential increase in number of scenarios if each increment is to be individually determined.
 - General public should not underwrite investment for creation of “headroom” to facilitate EG.
- Most (all ?) will probably want Network capacity available as a backup.
 - Expectation that “bundles” of reserved capacity will be available when randomly needed.
 - Availability of spare capacity will likely fall with time, or will need specific investment to maintain ...
 - This is potentially a very significant Tariff issue, requiring the determination of appropriate Standby charges to cover the Network investment for these significantly under-utilised assets.
- Explore the concept of approved, proactive investment to “enable” the Network to facilitate the proliferation of EG.
 - Concept of both Capacity and Fault level “Headroom” that can be shared.
 - Approved methodology to allow investment, manage risks, ensure appropriate returns, and cost recovery.
 - Concept of sharing methodology to smooth out “lumpy” investment thresholds.
- Very different outcomes depending on whether Regulatory and Licence Compliance Framework change (and possibly associated Legislation)
 - Leads, facilitates, and is a driver for the proliferation of EG;
 - Or whether it lags and is reactive.

Economic, Regulatory, Licence Compliance Issues:

- Design Planning Criteria specifies the required Security Standard for Network supply to various Load Types For example:-
 - CBD N-1 No interruption.
 - Urban N-1 < 4 hours.
 - Rural N within best practice repair time.
- But doesn't (yet) include a Security Standard for backup supplies to EGs.
- Network backup supply for EG – at “N”, or “N-1” ?
 - An N-1 standby supply effectively gives an N-2 normal supply when the Generator is taken into account.
 - Issues include loss of return in Network investment, cost recovery, concept of “reserved” assets, apparent low utilisation, future investment to maintain reserve, incremental effects of base load growth, appropriate Tariffs.
 - Impacts on Network Operation and future Planning ... not inadvertently “consuming” the reserve.
- Are reliability and security expectations consistent ?
 - The Network supply.
 - The EG, its fuel supply, water plumbing etc
 - The customer's installation, switchboard.

Economic, Regulatory, Licence Compliance Issues:

- Questionable if EG will enable deferral of Network investment
 - Not very likely at a Distribution level whilst there is an expectation that Network will always be available as a backup. Long term aggregated or “rolled up” diversity Vs local constraints.
 - Uncertainty of individual, and aggregated, operational patterns - and effective dependability or reliability.
 - Any proposed deferral probably limited to consideration of rotating plant, not “Renewables”.
 - Risk of wide scale EG “drop out” in response to fault induced voltage dips ?
 - Will reliability and security of EG installations match what is required of the Network ?
- Current AEMC¹ (and other) issues / considerations likely to impact on EG.
 - Technical Standards, Carbon (CPRS²), Demand Side participation, Rule Change³ / RIT-D⁴ / DAPR⁵, SENES⁶.
- Multiple EGs, or “Precinct” scenarios
 - Considering the Network as an energy transport mechanism, and with an appropriate Regulatory and Licence Compliance Framework, shared Network capacity can provide the means of integrating and accommodating the “diversity” of EG, and enabling them to back each other up.

1 Australian Energy Market Commission.

2 Carbon Pollution Reduction Scheme.

3 National Electricity Rules.

4 Regulatory Investment Test for Distribution Assets.

5 Distribution Annual Planning Report.

6 Scale Efficient Network Extensions.

Just what is the Driver for EG ?

- Why is EG being installed?
 - **Perceived commercial opportunity ?**
 - **“Incentives”? (is this just a skewed commercial issue ?)**
 - **Environmental initiative ? (regardless of cost ?)**
 - **No choice ? (to obtain approvals, consents, Green Ticks, ratings etc).**
- Driver needs to be transparent, and decisions made within the right commercial construct and framework.
- Maybe a “J Curve”, but needs to become commercially sustainable.
- Driver may well vary from one installation to another.
- Some of the issues are likely to vary according to the driver.
- Regulatory and Licence Compliance frameworks
 - **Not very likely to provide “public” funding for sheer commercial opportunities.**
 - **May support the progression of environmental / Government initiatives (Legislation ?).**
 - **Again, concept of both Capacity and Fault level “Headroom” that can be shared.**

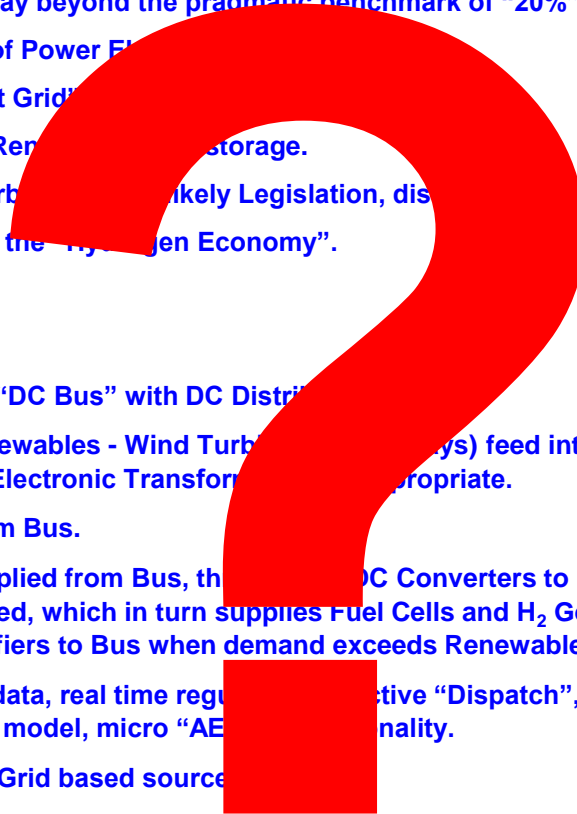
One view of “The Future”

- Assumes:

- Proliferation of EG (way beyond the pragmatic benchmark of “20%”).
- Increased efficiency of Power Electronics.
- The rise of the “Smart Grid”.
- Proliferation of both Renewable Energy and Energy Storage.
- Economic “shift” (Carbon Pricing, likely Legislation, disincentivising use of Renewables).
- A major step towards the “Hydrogen Economy”.

- The Vision:

- Concept of localised “DC Bus” with DC Distribution Networks.
- EGs (particularly Renewables - Wind Turbines, Solar PV, Hydro, etc) feed into Bus via Controllers and Rectifiers, DC/DC Converters, “Electronic Transformers” where appropriate.
- Demand supplied from Bus.
- Real time excess supplied from Bus, through DC/DC Converters to Electrolysers producing Hydrogen, compressed and stored, which in turn supplies Fuel Cells and H₂ Generators, feeding back through DC/DC Converters and Rectifiers to Bus when demand exceeds Renewables.
- Smart Grid provides data, real time regulation, selective “Dispatch”, Micro and Master Controllers, “Virtual Power Plant” model, micro “AE” capability.
- Minimal “traditional” Grid based sources.
- Distribution Networks provide the transport and integration.



“ With Tri-Generation, we can take Sydney off the Grid” ????

- Whilst it may, one day, be possible to really mitigate the energy coming into Sydney from the “coalfields” and have it offset by higher efficiency EG
 - I would suggest that it will never be feasible to “take Sydney off the grid”, or disconnect it from what we call the Distribution Network
 - Every customer has a source – or combination of sources and storage – that totally supplies and matches their time variant load.
 - And, be fully self sufficient for their reliability and security of supply requirements – and back themselves up.
- It is the “connection” to the Distribution Network, and the “Grid” that will
- Interconnect, or integrate, all of the time variant sources (albeit “local”) with all of the time variant loads.
 - Enable one customer without EG to still receive energy.
 - Enable another customer with EG to import any deficit.
 - Enable another customer with excess EG (at a particular time) to export the surplus which can get absorbed as some other customer’s deficit.
 - In other words – being interconnected is what will make it all work.

“Enabling” Embedded Generation

In the end, within the right framework, the Distribution Network can be the catalyst, the facilitator, that enables this new paradigm to work

Both the technology, and the benefits.

