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Energy, Projects, Governance, Engineering

Submission to the The Standing Committee on the Environment and Energy on Modernising Australia's Electricity Grid

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DECLARATION

Resonant Solutions Pty Ltd is a company based in South Australia that consults and advises on technical commercial and contractual issues relating to energy systems at the MW scale – grid and offgrid, through project management, modelling, analysis and due diligence.

This is a company submission however to avoid any potential for conflict of interest, we declare that Graham Davies, the director of Resonant, was invited by and contributed to the Engineers Australia submission. Graham was active in EA discussion on the SA blackout and subsequent media releases and was invited to SA Government Forums to contribute discussion on its Energy Future.

Graham also Chairs the Sustainable Engineering Society (of Engineers Australia), and although the views expressed here are those of Resonant, they are largely consistent with those of the Society. The Society has not made a submission.

PREAMBLE

We congratulate and thank the Standing Committee on this initiative.

Our submission is framed around what we believe is best for the community (in line with the Engineers Code or Ethics), and is consistent with the Engineers Australia (EA) Climate Policy and Sustainability Policy.

We are fortunate in being able to be reasonably objective in our assessments of the various technologies to the extent we have been involved with all aspects of generation, demand management and grids as listed in our 'wiseGRID' slide below.

Whilst we support the intent of the Standing Committee, we do believe that to consider only the grid without due consideration of the future generation mix is limited. It is like considering a road network without analysing what vehicles are likely to use it, where they come from and where they are going.

As an example, a grid is not required (other than a local micro-grid) where a community bands together to supply self-generation. This is made possible primarily because a combination of PV, wind, bagasse, battery, waste gas, micro-hydro can provide the local generation.

We do believe that in this regard, the Finkel Review covers the electricity grid adequately. Having said this, the grid is that critical, that an additional assessment from another body gives weight to the debate about Australia's Energy Future.

We would also like to note that the discussion paper refers to wind and solar as asynchronous. This is not strictly correct, as synthetic synchronicity is now possible.

SUMMARY AND RECOMMENDATIONS

The NEM is a complex mix of generation, transmission, distribution assets. Although there is no current 'crisis', inaction would lead to increasing risks relating to reliability, affordability and emissions.

The objective of the inquiry is about "modernising the grid" in the context of technological, economic, regulatory and community issues that would deliver secure, reliable affordable and sustainable electricity. This report includes aspects of generation and demand (load) in order to consider the objectives holistically.

Probably the biggest single root cause of emerging problems is related to lack of leadership from elected politicians, which has manifested itself into sovereign risk and policy uncertainty. What is required is multi-partisan cooperation to work towards a future grid in the interest of all Australians, however if the politicians cannot agree on policy, there will still be progress, but it would lack the coherence required for an optimum affordable, reliable system that meets emissions reduction targets.

It is now evident that renewables, along with their ancillary services, offer the most secure, reliable and affordable way forward, even without a price on carbon. This has to be understood in the context that fossil fuel and coal generation is required for the foreseeable future but no further build (other than specific situations) should occur. Aging plants will be steadily decommissioned, and a properly managed phase out of fossil fuel is required as renewables ramp up.

The grid needs to be designed in such a way as to find the optimum mix of elements as expressed in the wiseGRID figure below in the context of its values (act in the interest of society as a whole), policies and regulations to achieve the most economic outcome.

It is unacceptable that there is mis-information presented to the general public, and a concerted education campaign should be undertaken to present the facts and evidence along with uncertainties to the general public.

There are 2 options that future NEMs can consider: a) become an efficient market mechanism – with overriding factors that are in the national interest (security, safety, health) and also recognising it is not a true supply/demand market because spot market proportional pricing is not passed onto the end user b) progressively re-nationalise the grid, though allowing for PPAs from Independent Power Providers (IPPS) on the basis it is an essential service and critical to Australia. Markets do not work well in dealing with security issues (eg. it would not be advisable to privatise the defence force) or far reaching plans (eg. the Snowy scheme would not have eventuated under privatisation).

Item (b) is worth discussing for the future, however, given action is required now, specific recommendations pertain to item (a) and include:

a) Review the NEM (including AEMC, NER, AER and AEMO) periodically to ensure it delivers effectively. Build in flexibility where possible, but balance that with long term consistency (a big challenge);
b) Develop a whole of system model that can do scenario planning and 'test' integration of all elements of the wiseGRID and new technologies;
c) Empower AEMO with strategic infrastructure decisions such as CST at Port Augusta, and other options such as grid scale batteries, pumped/hydro and/or interconnection. This could be achieved by setting up a 'strategic infrastructure group', that can build, own and operate where required. This is to offset limitations that arise form short term economic market benefits in which business typically operate;

d) The 30 minute settlement period is too long. Suggest making it 5 minutes (in line with bidding) or reduce both bidding and settlement periods;
e) A more suitable value for the FCAS and SRAS market needs to be established;
f) Supply of electricity for small scale distributed power needs recognition through an introduced market, where participating households/business can earn a feed in tariff related to peak demands (and assist in voltage droop etc);
g) Set up rules for Virtual Net Metering and or micro/mini-grids such that sections of the community can be self-sufficient if islanded from the grid. Micro/mini-grids typically consist of wind, solar, bio, waste gas, storage, control such that the community (or organisation) can take advantage of cheaper sources of energy;
h) Encourage grid connected distributed generation as a way to make the grid more resilient (ie N-n redundancy);
i) Have demand tariffs for voluntary participants that incentivise switching off (or time shifting) at times of peak demand or high spot prices. In other words reduce the "crazy" situation where electricity is generated at $14/kWh and on-sold at 35c/kWh for a non-essential or easily time-changed use (eg hot water, chillers, pool heating, HVACR (with safe hysteresis bands); desalination (RO),
j) Encourage and or stipulate smart meters to assist with implementation and management of the above items, demand management and any future developments;
k) Remove the term 'base load' and replace with more modern and accurate terms such as 'load profile', 'demand', 'minimum demand', 'maximum demand'.
l) AEMO are given the powers to direct a generator to be on standby and/or operate with appropriate notice, and the operator be compensated fairly for this service at agreed operating prices;
m) Ideally have multi-partisan support, but in the event of a standoff, AEMO/AEMC/AER are given the powers to act in the interest of the public;
n) Independent body to assess AEMO, AEMC, AER and not appointed by COAG – reporting directly to parliament;
o) State Governments given powers to direct a generator to 'switch on', that overrides AEMO in the event of a dispute.
p) Public display on a website of each generators output for each State in real time, along with each generators forecasts and bids; ie full transparency.
q) Undertake arms-length investigations into the blackout and all outages, blackstart capability, generation failures, powerline/tower failures; market manipulation;
r) Undertake a full risk assessment that considers what are acceptable outage times from the public perception, what demographics are more at risk (vulnerability), probability, consequences and mitigation options;
s) An independent authority is given the oversight of AEMO and is also responsible for clear and accurate communications to the public – including if necessary taking out 1 page public notices in all newspapers.

Resonant has expressed some ideas above, that are not fully articulated or detailed, and is thus happy to be contacted for further involvement.

REPORT BODY

1. OVERVIEW / FRAMING THE PROBLEM

The blackout in SA triggered many studies and investigations – as it rightly should, and this included the Senate Review, the Finkel Review and now the Modernising Grid Inquiry.

Despite much rhetoric, SA is not in a crisis regarding electricity with most consumers within the accepted limits of outages. Having said this, we believe that the NEM is failing customers and is due for an overhaul, if the NEM is to avoid reaching 'crisis' status.

Before going into solutions, it is critical to frame the situation.

There are 3 fundamental criteria: energy reliability and security, affordability and sustainability (including all externalities such as emissions, environmental degradation, adverse health). There are different views as to the relative importance of these requirements, but it would come down to the values of individuals. There is no clear right answer. Our view is that all externalities must be paid for by the producer of those externalities. This is fundamental to a level playing field and a 'live and let live' philosophy where you can do as you wish but not to the detriment of others.

Based on the above view, it can be deduced (and is consistent with EA policy) that there needs to be a price on carbon. We also believe that there should be a price on emissions relating to particulate matter, but accept this is more difficult to assess. Australia was a leader in tackling climate, but has now become a laggard. We believe it would be selfish and a 'tragedy of the commons' if Australia does not address climate seriously.

Ian Dunlop (past coal/oil executive), considers the risk posed by climate to be severe, and that all fossil fuel burning would need to stop now to have a 90% confidence that we could meet the 2^0C Paris commitment. Indeed, the unprecedented storm event (particularly tornadoes), has an increased risk of re-occurrence as a result of climate change. We do however accept the Finkel trilemma proposition of equal value.

2. THE PROBLEM

A problem well defined is a problem half solved. We concur in general with the findings of the AEMO's report[1] and the Preliminary Finkel December Report with regards the SA blackout, however we would like to see the following:

1) An arm's length assessment of the blackout and AEMO's role. Self-assessment is always prone to bias or perceived bias;
2) A structural integrity assessment on the transmission towers (eg. maintenance, corrosion, geotech);
3) Modelling on whether there would be a state wide power outage now if the same weather event occurred and the same faults occurred, given that the changes to ride through settings, AEMO weather assessment procedures (ie under conditions of

severe or destructive storms continuous monitoring is necessary), implementation of synthetic inertia at Hornsdale have been implemented. To a certain extent, this has been shown that a similar event now would not result in a statewide blackout due to changes in settings, procedures for weather and FCAS/NSRAS.

4) Why AEMO had not put the settings in their specifications? From personal direct oversight of wind farms in the Philippines, the grid operator jointly tested settings for different modes of operation (max power output, reactive power control, voltage control).
5) Why was the failure rate of fossil fuel generators seemingly high eg. Port Lincoln, Flinders, Pt Augusta, 2xSRAS etc. Is this systemic?
6) If there had there been a 100MW – 600MW (eg. Alinta or CST), despatchable power generator at Pt Augusta (the other side of the failed transmission lines), what would have been the impact at the Eyre Peninsula and Olympic Dam?

In addition to the blackout, we would like to an arm's length assessment of the other outages and load shedding that occurred in SA on other occasions with a focus on:

7) Was there on any occasion a short fall of generator capacity, had it all been made available and was there any occasion when load-shedding was required?
8) What would be the cost implications of directing Pelican Point to be 'switched on', say 6 hours prior to the load shedding?
9) Why (and which) generators were not available at critical times?
10) Has there at any time been a gas shortage at any power station for technical reasons and also for commercial reasons?
11) With the improvements in AEMOs weather forecasting, how would that have affected outages?
12) Why has there been apparent generation withholding and why have there been many 'short bursts' of high prices over 5 minute intervals, that are then settled over 30 minute intervals. Is there any market manipulation? Are there any lessons to be learned from the California energy crisis[4]?

Our view, based on the information to date and notwithstanding the unprecedented weather, is that **the number and length of outages in SA (ie the sum of all outage time) has far more to do with market failure than any other reason.**

Whilst it is recognised that wind and solar PV are variable energy sources (VRE), they are also the lowest cost option of any generation, whether measured on a tenders[2], LCOE[3] or on correlation with household consumption relative to how much renewable energy is generated in the state[6]. The latter finding shows that there is a general correlation of relative decreased price with increased correlation.

As such it is imperative that a grid has a combination of generation types that offer cheapest generation when its available, but also reliability and FCAS, SRAS services that are fairly compensated.

Notwithstanding all the above, it is recognised, that the national grid is becoming more vulnerable particularly at the far ends as is the case of South Australia.

Based on the above, the problem appears to be a combination of a distorted market and lack of economic efficiency (ie insufficient competition), a skinny grid, insufficient authority to act in the public interest (without declaring a state of emergency as proposed by Frydenberg). The actual problem needs to be clearly defined based on some of the questions posed above.

3. DISCUSSION

Technologies are developing and improving all the time, and it is important to differentiate between "new technologies", and improvements to existing established technology (eg. PHES). In addition, what may be new to Australia, could already be proven overseas (as with the case of windfarms offering synthetic inertia or reactive power). We consider fossil fuels, nuclear, hydro, wind, solar PV, biomass and possibly solar thermal as established technologies. Grid scale batteries, synthetic inertia, supercritical coal with carbon sequestration, wave power and geothermal (in Australia) could be considered 'new'.

The transition to energy systems with minimal externalities (environmental damage, health effects, greenhouse gases etc.) is essential if we are to avoid creating a bigger problem than we solve. In this case the new technologies are likely to be in the area of renewables, storage, power electronic controls and demand management.

To date, it is known from experience in both Tasmania and South Australia, it is quite feasible to run with renewable penetrations at 100%. In the case of SA (which has an annual production of circa 45% renewables), it requires synchronous generation through the Heywood interconnector. Despite the recent blackouts, it is critical to realise that renewables per se were not the problem. It was demonstrated that ride through could occur many times as with the Waterloo Wind farm[1]. The blackout would likely have been averted with the new settings and AEMO procedures that are now in place. During the Torrens Island fire that also triggered the tripping of Pelican Point (a combined 600MW), wind and PV demonstrated that they were capable of this ride-through. In many cases, it appears there was surplus gas generation capacity that was not made available to the grid - particularly Pelican Point. Had this generation been switched on, the outages would likely have been minimal. The above is critical in understanding that the **NEM is failing largely because of a distorted economics, rather than for technical reasons**.

Having said this, the SA grid is more vulnerable and in the short term could do with more synchronous generation to be available eg. Concentrating Solar Thermal (CST), Pumped hydro (PHES), unmothball gas generation plants – electronic synchronous (synthetic) inertia and/or have interconnectors to NSW/Queensland. SA also is in the position,

where it is a net importer of energy from Victoria, so is in a position to increase generation capacity knowing there is a market.

Anticipating the future is not easy, and as a starting point, a robust grid model needs to be develop that can try out various scenarios. In addition, trials of technology that could be of benefit to Australia would be beneficial eg. CST, closed circuit pumped hydro, grid scale fast response batteries. Large interconnected grids are inherently more secure than a long 'skinny' grid as occurs in SA, Tasmania, North Queensland and parts of WA. In this instance, minigrids (or microgrids) would be highly beneficial – such that even if the national grid is down, the local community can still be up and running. This is analogous to a mainframe computer vs PCs. Many small generators are far more reliable than single large generators and a single transmission line (eg. Bass link). This is improves the N-n redundancy. For example, 5x100MW powerstations is far more secure and reliable (and even more efficient) than 1x500MW. Most importantly (and most difficult), is that new NEM rules receive bi-partisan support and political stability, while allowing flexibility for whatever arises in the future. It would be worth consideration to provide AEMO the powers to instruct and fund specific strategic infrastructure where it deems necessary (subject to clear guidelines) and a clear example of this is CST at Pt Augusta which provides, thermal, synchronous, despatchable power with black start capability at a point where the grid is more vulnerable.

Wind turbines can be designed to provide emulated inertia and governor response. Variable-speed wind turbines with power electronics can provide this type of service with a similar type of response to the conventional generation response5. Quebec has implemented emulated inertia (synchronous) generation on wind farms above 10MW, which has similar response characteristics as conventional generation[5].

Without a planned and economic grid transition, grid defection could occur in a few years when it would be economic to go off-grid. The recent heatwaves in Queensland and Sydney demonstrated that 1.5GW and 1GW of PV generation assisted the grid in averting further outages. An incentive for users to assist in reducing grid stress should be implemented, subject to limits of excessive feed-in causing grid instability.

Innovation has continually shown that it can improve reliability and reduce costs. The NEM should be designed to allow for connection in trial situations subject to suitable fault settings and 'safe' times. As has been shown with wind, PV, batteries etc. innovation has brought prices down. As an example, Hornsdale 3 has locked in 7.2c/kWh fixed for 15 years – this is now the cheapest form of new generation. PV is around 10-12c, but expected to overtake wind. SA has shown that renewables have caused wholesale prices to trend downwards[6]. What has happened in SA, is the large increase in renewables, as contributed to the situation where slow response power stations (eg. coal and to a lesser extent OCGT) have become less economic. What is required now is managing the demand profile by using load shifting (block shifting) storage and peaking plants.

New innovations already include – advancements in electronic synchronous generation and frequency control, hydrogen electrolysers with storage and fuel cells, electric

vehicles that can double as network batteries, linked microgrids of communities, demand/response, smart meters with remote control, virtual net metering, virtual power stations, municipal waste generation, waste to energy – and should be further progressed.

The challenge is to design NEM 2.0 (as referred to by Finkel) that allows for an efficient market (ie sufficient competition) that fairly rewards ancillary services (eg FCAS), and also has the powers to direct actions where the market fails the 'sensible test' (eg. switching on Pelican Point when it was determined there would be load shedding). NEM 2.0 should also address energy security issues such as what if fuel imports through the Singapore Straits were delayed due to conflict, what if facilities were sabotaged, what if there were cyber attack on control systems, is there too much dependence on a single asset that could go down. In addition, it appears that the market has already been beholden to demand on gas due to the extensive exports. This is an energy security risk.

We fully support the recent announcement to implement the concentrated solar thermal (CST) power station at Pt Augusta that already has multi-partisan support. We also support immediate action on Pumped Hydro (PHES), Grid scale fast response batteries, install more PV – particularly with batteries, restart mothballed gas power stations, reduce peak demand (in progress in SA through a government initiative), trial synthetic inertia (underway at Hornsdale). 2.5GW of PV in Qld and NSW assisted in reducing outages. Tasmania unfortunately put some wind farms on hold, and during the drought and Bass link failure, would have greatly assisted in energy security. South Africa had rolling load shedding a couple of years ago, but had 4GW of wind, solar PV and solar thermal installed and successfully reduced outages[3].

There is no credible evidence to indicate that renewables have contributed to outages any more so than conventional power (notwithstanding the settings).

One area that has not seen much coverage is risk analysis. It is essential that a full risk study be done (or at least be made public) that assesses what constitutes a credible risk, SFAIRP and ALARP principles in line with existing AS and ISO standards.

4. TRANSITION GENERATION

If there is one area that we question in the Finkel preliminary report, it is to do with the over emphasis of gas. Gas is intended as a transition fuel, and provides useful peaking generation with fast response OCGT and base load power with reasonable response through CCGT plants. This is expected to continue for quite some time.

Gas, however is potentially not as 'clean' as has been originally thought. Melbourne Univiersity has an extensive report that highlights fugitive methane (20-80x higher than CO_2). In addition, there Resonant have done research that has highlighted that 335PJ of gas (not converted) is lost. Information provided by the Office of the Chief Scientist in NSW (Justin Walker) indicates that this energy is a combination of re-injected, flared or vented gas. "page 20, of Guide to the Australian Energy Statistics 2015 it states the following: Gas production includes gas used by processing plants and gas transported in pipelines, but does not include gas re-injected, flared or vented."

We believe that this needs further investigation by NGERS or the Chief Scientist due to the potentially large amount of methane that could be emitted. This could critically affect the emissions intensity factors and the basis for gas as a transition fuel.

Furthermore, due to market forces with the export of gas and the likely increased bans on fracking, the security of gas supply and pricing is uncertain. This makes gas a security issue, and at the very least, Australians should be able to put reserves on what is required for local consumption. Renewables are highly competitive with gas[2,3], and are increasingly demonstrating the faster response of batteries, despatchability (CST, PHES, Biomass) and lower prices. Thus we believe (based on current technical and economic experience) that no new gas power stations are required, however if a full grid analysis and modelling shows this to be a cheaper, more reliable option then this should be considered.

5. CONCLUSION

Australia faces a shortfall of generation capacity due to aging coal-fired generators. "Clean coal" (is this analogous to 'safe asbestos' or 'humane slavery'?), is not a solution due to its emissions and higher costs[2,3] than renewables and long lead times for implementation, however any improvements in efficiency are desirable. Nuclear has not presented a feasible business case for Australia and whilst Gen IV and fusion show promise, the time scales for realistic implementation are too far into the future. There are mothballed gas powerstations that should be put into service, however new gas powerstations have a long lead time and there is already pressures on gas supply, so it would require specific justification for new OCGT or CCGT plants. For reasons above, there should be caution with expanding gas.

Energy efficiency (increased output for input) is always desirable. We prefer the term 'increased effectiveness' as this also incorporates switching off, less pampering, reduced gimmickry, reduction on pervasive billboards, reduced IT junk (around 2% of energy).

We believe that due to the lower costs or renewables currently and the trends which predict a further rapid decline, it appears that renewables is the obvious choice for expansion. Specifically, wind and PV provide the lowest cost of generation and should be expanded rapidly across Australia including domestic PV and batteries. With immediate effect (and some is already on the cards), CST, PHES , grid scale battery, synthetic inertia should progress to implementation stage.

It is essential that greater control of the NEM operations are required to avoid manipulation[4] of the market for company gain in favour of what is a fair profit.
What is essential, is that gas generators be made available when 'destructive storms' are forecasts of low wind and high temperatures are predicted.

In summary, we believe that a rapid increase in renewables distributed around the country will provide the lowest cost most reliable form of electricity for Asutralia. In parallel with this expansion, coal generation can be progressively decommissioned, as Australia heads towards a zero carbon future.

[1] Australian Energy Market Operator, *BLACK SYSTEM SOUTH AUSTRALIA 28 SEPTEMBER 2016 THIRD PRELIMINARY REPORT Published: December 2016*. www.aemo.com.au/
[2] CSIR, Cost of new power generators in South Africa, October 2016, www.csir.co.za
[3] CSIRO, Australian Power Generation Technology Report, November 2015, www.co2crc.com.au
[4] University of Houston, Can Energy Markets Be Trusted? The Effect of the Rise and Fall of Enron on Energy Markets, J Weaver, October 2004, http://ssrn.com/abstract=471942
[5] I. Erlich et al., Primary frequency control by wind turbines, Proceedings of the IEEE Power and Energy Society General Meeting, Minneapolis, MN, July 2010.
[6] ANU, Household Energy Costs in Australia 2006 to 2016, Feb 2017, http://rsss.anu.edu.au

6. APPENDIX 1. FUGITIVE GAS

There is unaccounted for gas losses as reported by the Bureau of Resource Economics (BREE) and GeoScience Australia. With reference to the diagram below, 335PJ of gas energy is lost either as re-injected gas, flared gas or vented gas. Given that this is twice the total household consumption, it is critical to determine exactly what is happening with the gas. If it is all substantially burnt into CO_2 then it constitutes 10% of total gas supply 'wasted'. This loss should be aggregated into the emissions intensity factors. If however it were substantially vented (which we're sure it isn't) it would make gas more emissions intensive than coal. We trust that the office of the Chief Scientist can clarify this further.

AUSTRALIAN ENERGY FLOWS 2012–2013 (Petajoules)
SUPPLY
UTILISATION
Oil 787
LPG 95
Natural Gas 2439
Coal Seam Gas 282
Coal 11438
Uranium Oxide (U_3O_8) 4230
Hydro Electricity 66
Wind Electricity 26
Solar Electricity (14) Hot Water (13) 27
Biofuels 27
Bagasse (95) and Wood (89) 184
IMPORTS 244
IMPORTS 1160
STOCKS 76
IMPORTS 904
STOCKS 33
STOCKS 6
STOCKS 94
STOCKS 286
Refinery
Power Stn.
TRANSPORT 1515
Oil (1446) and LPG (42) 1488
Gas 3
Coal 6
Electricity 9
Biofuels 9
COMMERCIAL 319
Oil (27) and LPG (4) 31
Gas 51
Coal 1
Electricity 235
Solar 1
INDUSTRIAL 1682
Oil (478) and LPG (27) 505
Gas 590
Coal 131
Electricity 330
Bagasse and Wood 120
Biofuels 6
RESIDENTIAL 456
Oil (1) and LPG (16) 17
Gas 155
Electricity 218
Solar 12
Wood 53
OTHER 53
Lubes, bitumen and solvents 53
EXPORTS
LOSSES
Total end-use ~4024
Exports ~15433
Losses ~2121
Imports +2308
Stock change and discrepancies -331
Total Primary Energy 19601 =
NOTES:
A Includes transmission losses
• Numbers rounded to nearest PJ
• Sources: Bureau of Resources and Energy Economics, 'Australian Energy Supply and Consumption, 2012–13' and 'Energy in Australia 2014'.
Australian Government
Clean Energy Regulator