ARCMesh Pty Ltd Submission on ElectraNet PADR – 31st August 2018

ARCMesh gives its approval for this Submission to be published in its Entirety

Introduction

ElectraNet has sought submissions from Industry Participants and Interested Parties in the ElectraNet Regulatory Investment Test process for their recently released South Australian Energy Transformation (SAET) Project Assessment Draft Report (PADR) which found constructing a new, high capacity interconnector between South Australia and New South Wales would provide economic benefits.

ARCMesh Pty Limited is one of the parties registered with Electranet in their associated consultation process and has attended the consultation sessions held in Adelaide during the last month and is an active participant in that consultation process.

ARCMesh is pleased to provide this submission on ElectraNet's PADR, as part of the consultation process. It is based on the material that has been made available by ElectraNet, ARCMesh's own very extensive investigations of an HVDC VSC interconnection from South Australia to Queensland; detailed investigations by ARCMesh's consultants, advisers, global equipment suppliers, international TSO's with HVDC experience and experienced contractors; CIGRE and IEEE-PES publications and technical-economic information, together with discussions with a range of experts across Australia, Europe, China, Africa and North America.

ARCMesh has undertaken comprehensive technical-economic investigations and studies over the past 18 months which have also contributed to extensive expert knowledge base for this submission. Given the short time (i.e. less than two weeks) from the release of partial details of the ElectraNet studies and the deadline for closure of submissions, combined with the extensive body of ARCMesh studies and associated detailed expert consultant reports, ARCMesh has adopted a focussed, but summarised approach to presenting this submission to the ElectraNet PADR. This comprises presenting our comments under the following key categories and for each category presenting "dot point" summaries of ARCMesh's contribution, together with a preliminary assessment for each key category of a conservative estimate of the economic impact on ElectraNet's assessment of the costs and benefits for either Electranet's preferred option "SA – NSW 330kv interconnection option C 3(i)" and/or ElectraNet's SA-Qld HVDC interconnection option B. Finally a summary table is provided that concludes, that based on ARCMesh's assessments, there are reasonable ground for ElectraNet to reassess the relativity of these two options , including their ranking, taking into account ARCMesh's submissions' including a variant of ElectraNet's option B, more closely aligned with ARCMesh's SA-Qld HVDC VSC interconnector.

Should ElectraNet need further details of any of ARCMesh's detailed investigations and studies, beyond the summaries and dot points in this submission, ARCMesh would be please to consider ElectraNet's requests, noting some of ARCMesh's material is confidential.

Contents of ARCMesh Submission – Key Categories

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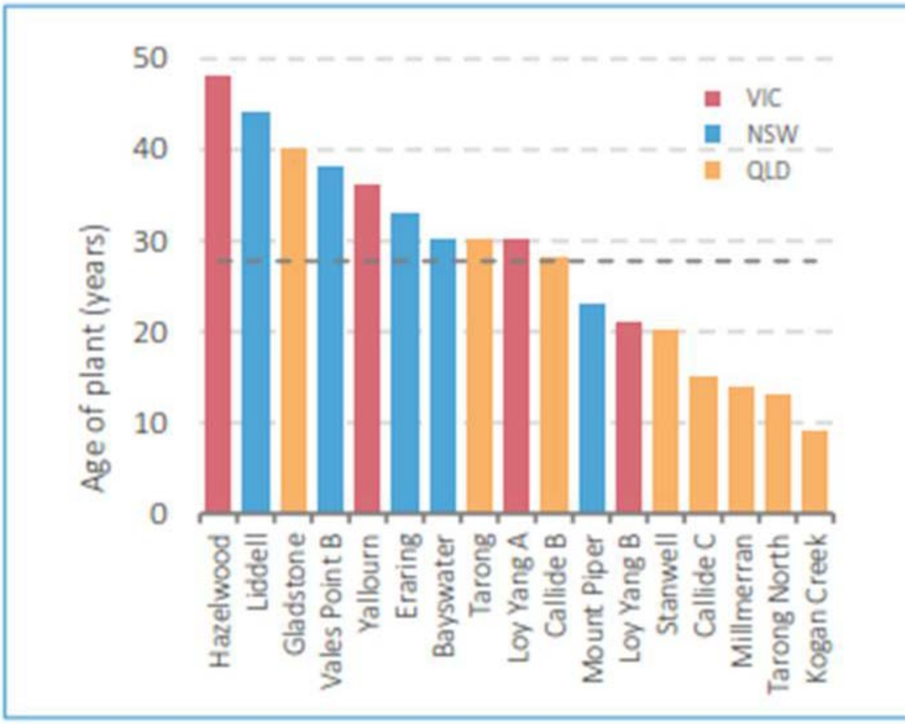
1. **<u>Impacts on the "side-lining" and "premature retirement" of some of the NEM's best five Coal Fired Power Stations all located in Queensland , attributable to the SA-Qld Interconnection Option or its absence</u>**

- It is a commonly held view that it is unlikely that a commitment will be made to a new major coal-fired power station in Australia.
- Australia's coal fired fleet has a wide range of actual asset ages, efficiencies, fuel costs, remaining technical lives, Co2 emissions : ages are illustrated below



- The NEM's five newest (less than 20 years old), most efficient, lowest coal cost, lowest CO2 emissions, longest remaining potential technical lives(20 to 30 years) are ALL located in Queensland, mostly being supercritical technology and fuelled by very low cost, mine-mouth dedicated coal mines with many decades of proven reserves.
- NSW, on the other hand has a much older coal fired power station fleet, with Liddell, Vales Point B, Eraring and Bayswater already 30 to 45 years old and with only 5 to 20 years of technical life remaining - at best, due to their advanced age, lower efficiency, much higher coal costs, and higher CO2 emissions.

- Victoria’s Hazelwood station has just closed and Yallourn is already nearly 40 years old with only around 10 years of remaining technical life. Even Loy Yang A is 10 to 20 years older than the five newest Queensland coal fired power stations.
- SA’s Northern Power Station was recently closed and demolished, significantly ahead of its technical end-of-life because of economic pressures largely due to the record installation of wind farms in South Australia, the low existing interconnector capacity between SA and the rest of the NEM, which together drove low (and sometimes negative) SA pool prices, making the ongoing economic operation of the Northern Power Station unviable.
- The Queensland Gladstone Power Station is unlikely to be retired until such time as the Boyne Island Aluminium Smelter is closed due to their co-ownership, the contractual agreements and the Gladstone Power Station Act, and the terms of Gladstone’s capacity purchase (CPA) contract and Interconnection and Power Pooling Agreement (IPPA) which is effectively a long term power purchase agreement that largely isolates the owners of Gladstone power station from NEM electricity market prices, as well as strongly incentivises ongoing refurbishment of Gladstone Power Station to achieve high availability and full capacity for another 15 to 35 years.
- Queensland is now experiencing an explosion in new, committed large scale solar PV farms together on top of Queensland already having the highest penetration of rooftop PV in Australia and the world. Further development of Queensland renewables are forecast and indeed there are already more than 20,000 MW of mostly large scale PV projects being planned and expedited in Queensland.
- The Qld total demand is significantly less than the total NSW demand.
- The capacity of the existing interconnector between Qld and the NEM, is via a long, thin, single tower 330Kv line and then via a low capacity, aged 330kV NSW grid whose transfer transmission capacity is expected to reduce even further when Liddell power station retires and as new windfarms connect along the route. The existing Qld to NSW interconnection is unlikely to be an effective means of enabling the five newest NEM coal fired power stations, all located in Queensland , to play their rightful national role providing increasing support to NSW, Victoria and South Australia as their much older coal fired stations inevitably shut down.
- Clearly, it is strategically important nationally that a new, high capacity, low loss, unconstrained interconnection be established between southern Queensland, home of the three very newest Queensland coal-fired power stations, directly into the far end of the NEM, and bypassing the frequent constraints and very high marginal transmission losses of the existing 3,000km long, series of transmission lines through NSW, Victoria and South Australia.
- Even though the current avalanche of new Qld committed renewables is only partly commissioned, the wholesale pool price in the Qld region is rapidly declining, compared with just a year ago, and is already sometimes zero during daytimes on weekends when the rooftop PV and new large scale PV is generating and overall Qld load is lower than during the week.
- This is already creating significant economic pressures on Queensland’s existing fossil fuelled power stations. Much greater economic pressure are definite within even the short term outlook, with a “blood-bath” certain to occur in the medium to long term in Queensland.
- It is inevitable that this will result in the premature, sidelining, closure and possible demolition of some of Queensland’s modern coal fired fleet. Even Queensland government sources are now saying that it is not a question of whether premature retirement of modern

Queensland coal-fired generation will occur, but which stations will be first sidelined and how soon.

- It is crucial, from a national perspective that the modern, efficient and low emission Queensland coal fired fleet be kept available and utilised to perform a critical role nationally to help counter the severe market impacts of the much earlier closure of the NSW and Victorian coal fired fleet, to ensure that Australia benefits from the huge sunk investment in this modern, efficient base load generation. The premature closure of the modern coal fired generation is arguable the most important, strategic consideration to achieve the national goals of electricity affordability, security and sustainability.
- AEMO has recently estimated the economic benefit of extending the technical life of some NSW and Victorian coal fired power stations is in the range $8billion to $27billion.
- The economic benefits of enabling the modern Queensland coal fired fleet to just reach its current technical life, rather than having some stations prematurely sidelined, mothballed or closed would be expected to be well in excess of the AEMO figure due to its higher capital and operating efficiency and as it would not be necessary to invest huge sums to refurbish the modern Queensland generation as would be required to extend the technical lives of the aged NSW and Victorian stations.
- An extremely conservative estimate of the economic benefit deferring the premature closure of just 1,000MW of modern Queensland coal fired capacity by just 10 years is $5billion to $10billion comprising deferred capex investment in new renewable generation, pumped storage and transmission capacity and associated fuel savings .
- Increasing the interconnection capacity between Queensland and the rest of the NEM, via a new and efficient route is an obvious strategic and economic initiative that would considerably alleviate the Queensland market and economic pressures and reduce the amount of modern Queensland coal plant retired ahead of reaching its technical life.
- The HVDC VSC SA-Qld interconnector would have a peak export capacity of 1,000MW via the new interconnector PLUS an additional >350MW, (minimum) of increased QNI export capacity. This is due to an increase in the existing QNI stability limits from the use of the HVDC VSC interconnection to damp power system oscillations and improve the stability of QNI as conservatively estimated by Powerlink Queensland. It is likely that more rigorous studies using less conservative and improved models and data for the HVDC VSC interconnector and the existing HVAC power system and associated data and simulation tools will increase this conservative estimate of the boost the existing interconnector limits at virtually zero cost.
- Such a significant increase in the export capacity from Queensland combined with the corresponding increase in the economic life of low cost Queensland's modern power stations that would otherwise be prematurely sidelined, together with the inevitable closure of Liddell, Vales Point B, Yallourn and other older NSW and Victorian coal fired Power stations and the expected spiralling pool prices and associated huge investments in renewables, energy storage and transmission augmentations will deliver economic benefits, recognisable under the AER's regulatory investment test, expected to be at least in the range $5billion to $10 billion.
- ElectraNet has confirmed at its consultation meetings in Adelaide that it has made no allowance whatsoever for these legitimate economic benefits in its evaluation of the economic benefits of the SA-Qld HVDC interconnection option.
- Likewise AEMO has confirmed that AEMO has also made no allowance whatsoever in its recent 2018 Integrated System Plan.

- Electranet and AEMO's response at the consultation was that, whilst they admitted in principle to this serious omission, it would not be a benefit that could be attributed to the SA-Qld interconnection option but could only be attributed to an augmentation of QNI.
- This is clearly an erroneous statement as both interconnections would alleviate the pressure on the Queensland market and its modern coal fired fleet, and the SA-Qld interconnection would better enable low cost Queensland generation to supply power directly into the far end of the NEM directly into South Australia and then into Victoria to a much greater extent than a QNI augmentation The HVDC-VSC SA-Qld interconnection will also increase the QNI interconnection capability to almost the same extent as the proposed QNI interconnection being proposed by AEMO but with virtually no capital investment.

CONCLUSION: The failure of Electranet to include an appropriate allowance in their PADR assessments for the SA-Qld HVDC Interconnection Option to enable more of the modern Efficient Queensland coal fired fleet to better achieve its technical life rather that facing premature sidelining, mothballing or early closure has underestimated the economic benefits of option B alone, as allowable under the AER Regulatory Investment Test, by at least $5billion to $10billion. None of the other options have these potential additional economic benefits.

2. <u>**Cost of SA-Qld HVDC Interconnection Option**</u>

- The ElectraNet PADR has estimated the capital cost of Option B, HVDC VSC from South Australia to Queensland to be $1,790m and its NPV capital costs to be around $1,090m.
- ARCMesh has undertaken extensive assessments of the optimal scope and design of an HVDC VSC interconnection from South Australia to Queensland using at least the following three alternative independent and expert process:
- **Method A** – Line design and capital costs estimated by expert HVDC line consultant's South Africa projects; with technical review by Eskom and CIGRE's most senior and experienced technical experts on HVDC and HVAC transmission lines and HV insulation. Inverter costs estimated by three globally leading HVDC VSC manufacturers, local construction labour costs estimated by two leading Australian transmission line construction companies, EIS, easement, access costs and AC connection costs based on extensive Australian experience, engineering costs estimated by experienced HVDC and HVDC engineering firms, and allowances made for miscellaneous expenditure items.
- **Total estimated capital expenditure $A1,401 million, August 2018 price levels, 15% accuracy**
- **Method B** – Total project costs estimated by a leading HVDC consultant based on published costs for recent projects, tested over a range of new HVDC projects globally, with easements, engineering, HVSC connections, access, separately estimated as per method A. These estimates were provided for the range of scenarios and key assumptions used by Electranet in their PADR. The cost estimates are in 2017 prices and the estimating accuracy is +- 25%.

	1,600kms 100% self-supporting structures	1,600kms 90% guyed structures	1,420km 100% self-supporting structures	1,420km 90% guyed structures
HVDC VSC 700MW link 2x350MW bipole +- 400 kV	$1,559m + $140m	$1,045m + $140m	$1,416m $140m	$960m +$140m

metallic earth return	**$1,799m total**	**$1,186m total**	**$1,556m total**	**$1,100m total**
HVDC VCC 1,000MW link 2x500MW bipole +- 500 kV metallic earth return		$1262m +$140m **$1402m total**		

- **Method C:** An experienced Australian Transmission line designer/constructor was engaged to review, investigate and compare the ARCMesh and ElectraNet capital cost estimates and to identify the potential reasons for the material differences in assumptions and capital cost estimates. This expert worked with representatives from two experienced Australian transmission line construction companies and a representative from a leading Australian transmission line designer. Use was also made of 2017 EPRI HVDC handbook, Eskom insulation experts, and recent CIGRE HVDC publications. The expert report is attached and reaches the following conclusions:

- The PADR option estimates need to be broken down into major components (lines, converters, AC substations etc.) in order to provide a reasonable level of transparency to the process.

- Transparency on assumptions about relative usage of monopole, self-supporting lattice tower and guyed tower is crucial to understanding line estimates which are the major component of most options.

- HVDC guyed tower line costs should cost approximately $520,000 / km

- HVDC self-supported tower line costs should cost approximately $720,000 / km

- These line costs have been conservatively estimated, and could be considerably less

- In any case, a HVDC self-supporting tower carrying 4 or 6 conductors has to be a lot cheaper than a 275kV AC self-supporting tower carrying 12 conductors.

- Electranet's use of similar line costs for HVDC and 275kV AC doesn't add up.

- It appears that Option B (SA to QLD HVDC) has been costed in the PADR using predominately self-supporting towers.

- The route proposed for the SA to QLD HVDC interconnector by Bartlett are ideally suited to the use of guyed towers – in particular, the highly efficient and technically superior guyed cross-rope type.

- At least 75% of the ElectraNet Option B route is ideal for guyed construction.

- Guyed structures have been used successfully in Australia and around the world, and at voltages up to 765 kV.

- Other comments made by various experts on the assumptions made by ElectraNet that would be expected to unnecessarily and substantially increase ElectraNet's Option B estimated capital cost in the PADR include

- Overall contractor costs to supply and erect transmission lines in remote parts of Australia typically comprise 50% for the materials and erection costs with the remaining 50% for site establishment, access, construction camps and other indirect costs. Using guyed cross-rope structures would be expected to reduce the first component by around 15%. The corresponding reduction in the second component would be much greater, especially if the staging of construction and site access is optimised – which the inland Queensland route facilitates by use of existing access for gas and oil pipelines. Staging camps could be located hundreds of kilometres apart along the route for tower preassembly and aerial transport to each tower site. Minimal amounts of concrete and steel and site erection are required. Towers can be erected in ~45 minutes instead of days. The cost of the second component can be more than halved by optimising the staging of construction and access, provided that guyed cross-rope structures are adopted, particularly in remote areas.

- Electric field limits for HVDC lines are completely different to HVAC electric field limits and can safely be allowed to be ~25KV/m at ground level as compared with ElectraNet's assumed 5 KV/m. This un-necessary assumption has added 2 metres to the height of every tower substantially increasing capital costs with no offsetting benefit

- There is yet to be proof that synthetic insulators have a higher failure rate than ceramic insulators, especially for HVDC transmission lines. Yet the use of synthetic long rods could deliver benefits to line erection times, costs and pollution performance

- Guyed Cross-rope tower constructions have much lower potential cultural and Heritage impacts and socio-visual impacts than conventional free standing lattice steel towers.

- The construction time for a guyed cross-rope line could be half that of a conventional free-standing lattice steel tower line. And by working on several work fronts, could be accomplished in under 18 months if required for a 1,600km long line, with good access and optimised staging.

- The lightning performance of a guyed cross-rope line is excellent due to its much better shielding and multiple earthing points

- It also has almost zero risk of bird excrement flashovers, and can have improved pollution performance and bush fire performance at lower incremental costs.

- There are minimal transverse stresses in the steel support, as they are always in compression, simplifying the design of the steel structures and their foundations and their performance in high winds.

Comparison of Consultants' Overall Line Cost Estimates with ElectraNet's PADR Line Costs

- The Consultant's report concluded that the estimated cost of the HVDC line would be $520,000/km for guyed-cross-rope structures and $720,000/km for free standing lattice structures.

- For a 1,600km long route, and assuming 80% guyed cross rope and 20% free-standing lattice structures, the total estimated cost of the line would be $864million.

- In addition, allowance must be made for the $640million estimated total capital costs of
  (a) HVDC VSC Inverter cost based on the estimated costs provided by each of the three globally leading HVDC VSC manufacturers, assuming each of the two terminals comprise two 500MW bipoles
  (b) EIS, easement, access costs based on Australian experience and costs for the route
  (c) AC connection costs based on extensive Australian experience
  (d) Engineering costs estimated by experienced HVDC and HVDC engineering firms, and
  (e) Allowances made for miscellaneous expenditure items.

- This gives a total estimated project cost of $1,504million at August 2018 price levels and an accuracy of 15%.

- Averaging the estimated total capital cost from methods A, B and C gives a figure of $1435, with a variance of around $50million or around 3%. The ElectraNet estimate of $1790m is some $350m higher or 24%, which is well beyond a plausible statistical variation due to the implausible assumptions made by ElectraNet in scoping, designing and estimating the cost of their Option B.

3 <u>Cost of SA-NSW HVAC Interconnection Option and subsequent Wagga-Yass 500kV augmentation</u>

- ElectraNet's Eyre Peninsula upgrade Regulatory Test estimated that a 272km 275 kV double circuit line between Cultana and Port Lincoln would cost $390million which is equivalent to $1,430 k per kilometres. The same line, initially operated at 132kV, but with the future ability to be operated at 275kV was estimated to cost $310million being $1,140k/km, with a future cost of $90million when upgraded to 275kV.

- It appears that ElectraNet's estimated cost of the 275kv line, without 275kv substations, was around $1,140k/km in 2017 prices. Allowing for escalation that would be equivalent to around $1,160k/km. It is noted that the Eyre Peninsula scope and cost estimate excluded transmission line easement as ElectraNet had already acquired the required easements.

- Queensland's extensive experience is that 330kv HVAC lines typically cost 5% to 10% more than 275kv HVAC double circuit lines which would indicate a comparative cost of around $1,250/km for 330kv double circuit HVAC lines.

- Based on extensive experience in Queensland, where around 80% of Australia's double circuit 275kv and 330kv HVAC lines have been constructed in the last 25 years, an estimated cost of around $1,250k/km for 330 kV double circuit lines would be reasonable.

- In ElectraNet's Network Transformation Roadmap PADR, the estimated cost of 275kV and 330kV double circuit transmission lines are estimated to be:
  (a) 275kv double circuit HVAC line: $891,000 (being only 77% of ElectraNet's Eyre Peninsula estimate of $k1,160/km)
  (b) 330kv double circuit HVAC line : $1,013k/km (being only 81 % of the above $1,250k/km

- ElectraNet advise that their $1,013k/km figure is calculated from the P 50% average of the following four estimates:

TransGrid estimate:	$1,081k/km
Vendor 1:	$700k / km
Vendor 2:	$1,051k/km
Vendor 3:	$1,113k km

- However Vendor 1 is clearly a spurious outlier and should have been excluded, and arguably replaced with the ElectraNet estimate of $1,250k/km. This would have increased the p50% average to around $1,124k/km. Over the 698 line length, this would add $30million to the project capital cost estimate.

- There is also the issue that the 330kV SA to NSW Option only goes as far as Wagga, yet it is widely known that a double circuit 500kV line from Wagga to Yass would also be ultimately required at an estimated cost of around $500million.

- Given that would be an associated advancement of a longer term network augmentation, that would be triggered by the proposed ElectraNet augmentation and consequential installations of new renewables and energy storage facilities, the effect of the advancement in capital expenditure should be included (by including the NPV of the advancement of the future expenditure on this 500kV augmentation.

To account for both factors a total capex of $530million with an NPV of $200m is proposed as an indicative adjustment to the PDR

4. <u>Choice of Technology – HVDC VSC VS HVAC</u>

- HVDC VSC is now the technology of choice in across Europe due to its power system stabilising characteristics that are increasingly important due to the weakening effect of intermittent variable renewables including wind power and solar PV driving the displacement of conventional synchronous generation and the consequential reduction in system strength, inertia and fast frequency response.

- VSC HVDC interconnector technology is far superior to LCC HVDC interconnector technology due to its ability to connect to weak power systems at one end, to strengthen that weak system and even black start a dead system.

- It can also effectively transport inertia, system strength, spinning reserve, frequency regulation capability and fast frequency response from a much stronger power system at the far end to a weak power system at the other end.

- VSC HVDC interconnector technology is rapidly being further develop and can already perform “grid forming” rather than “grid following” functions for isolated power systems and wind-farm islands, connected by HVDC VSC to the mainland grid.

- Recent HVDC VSC developments in Germany have seen even greater advances where the new HVDC VSC interconnector are designed to perform in the parallel grid-forming mode, with even greater grid stabilisation effects.

- There are already examples of HVDC VSC interconnectors running in parallel with an HVAC power system and damping power system oscillations and thereby increasing existing voltage stability and oscillatory stability limits.

- Even more is being demanded by recent changes to the European Grid Code and some European Transmission System Operators, where new HVDC VSC interconnector may be required to be designed to operate in the Parallel – grid forming mode with some level of virtual synchronous machine capability. CIGRE Task Force TF B4.77 is expediting its task to investigate what this will mean to the design, specification, performance and cost of new HVDC VSC interconnectors.

- All of the above enhanced performance capabilities of HVDC VSC interconnectors are extremely relevant to the South Australia to Queensland HVDC VSC interconnection option B, as
    (a) The South Australian power system is extremely weak and is in urgent need of cost effective inertial, system strength, frequency regulation and fast frequency response services
    (b) The Southern Queensland power system is extremely strong and is likely to continue that way for many years due to its modern, low cost base-load coal fired power stations and its excellent large scale hydro-electric pumped storage schemes already operational at Wivenhoe and ready for development at Mount Byron (up to 2,000MW), Borumba (up to 2,000MW), Burdekin Falls (up to 1,500MW) and Tully River (up to 1,000MW)
    (c) The NEM HVAC grid, stretching 3,000km from Queensland to South Australia, takes the “long way round” and has many limitations due to oscillatory stability and voltage stability constraints that could be significantly increased by having a properly designed and tuned HVDC VSC interconnector, taking the “short cut” across central Australia to span the HVAC from Queensland to South Australia and stabilise the entire National Grid from Queensland to South Australia.
    - However the ElectraNet PADR and the AEMO Integrated grid plan have made almost zero recognition or financial benefits of the very significant grid stabilisation benefits of using HVDC VSC interconnection technology to mesh the NEM grid. These benefits could be delivered at almost no additional cost over and above the capital costs already included for Option B in the ElectraNet PADR.

- The additional benefits are likely to be very significant given the high costs of continuing to operate existing gas fired generating units as well as the high capital costs of the less effective, old-world technologies currently being proposed by ElectraNet and AEMO such as rotating synchronous condensors, phase shifting transformers, weak HVAC interconnectors that cannot perform many of these grid stabilising functions, SVC's, large chemical batteries, and inefficient pumped storage schemes in many states.

It is estimated that the financial benefits would be in the order of at least $500million, based on the costs in the ElectraNet PADR and AEMO Integrated Grid Plan

5. <u>Route of SA-Qld HVDC Interconnection Option</u>

- The interconnector route proposed by ElectraNet and AEMO for an HVDC VSC interconnector between South Australia and Queensland is virtually a straight line crossing north-west NSW, which:
  - (a) Passes through intensive cultivated land in the Goondiwindi and north-east NSW area, which would rule out using guyed cross-rope structures in that area and increase line costs
  - (b) Crosses north-west NSW in a direction that has very poor existing access tracks and quite difficult channel country to navigate.
  - (c) Has lower solar intensity than further to the north –west.

- A superior and lower cost route, with significant potential generation benefits, would be to head due west, parallel to the Qld-NSW border along the extensive series of good access tracks and existing gas and oil pipeline easements.

- This route has minimal heavily cultivated land to traverse and is mostly ideally suited to the use of guyed cross-rope structures.

- There is also a considerable higher level of solar intensity along this route compared with the NSW route, together with other existing infrastructure, towns and industry that supports the existing gas supply industry and pipelines in that area.

- Once the SA-Qld border is crossed, the ideal route would be to skirt around the Innamincka reserve and then head south-west, again along the existing gas pipelines and associated good access tracks.

- A potential long term intangible advantage of this route may be the future development of the extensive gas reserves and even potential development of geothermal deep hot-rocks, should the technology ever be proven for its economic exploitation.

The ElectraNet PADR and AEMO Integrated System Plan have both omitted the financial benefits of the Queensland-SA route, which comparisons undertaken by ARCMesh have valued at least $200million.

6. Evaluation of cost/benefits of new generation developments along each interconnection

- The ElectraNet PADR appears to have only included an allowance for the financial benefits of future generation being developed along the SA-NSW interconnector route. No allowance appears to have been included for each of the SA-Qld HVDC VSC route or the SA-Victoria route.

- AEMO has a similar deficiency in its Integrated Grid Plan and its New Renewable Energy Generation Zones. In respect to the latter AEMO has ruled out a future Renewable Energy Zone in Central Australia and South-Western Queensland, as AEMO only considered the economics of that zone for the case where new renewable generators would be saddled with the full cost of the associated long transmission line to such a remote area. However AEMO's conclusion is flawed in the case where the interconnector to Central Qld and South-West Queensland funded by a separately justified NEM interconnection project such as the SA-Qld interconnection.

- This is what occurred in the Surat Basin some 300kms west of Brisbane during the late 1990s when QNI was constructed through the area, enabling new power stations to connect to QNI and exploit the low cost and plentiful undeveloped coal and gas resources in the Surat Basin. Within only 5 years, six major new power stations were built in the area, including Millmerran, Braemar 1, Breamar 2, Darling Downs, Kogan Creek and Condamine power stations, of which five are private investors.

- A similar development of Australia's best solar PV resources and undeveloped gas and even geo-thermal resources could be an economic outcome stimulated by the development of Option B, without the large additional cost of a long new transmission line allocated to the new generation in the area, as assumed in AEMO's recent studies.

- HVDC VSC is ideally suited to multi-terminal HVDS interconnectors and two such HVDC interconnectors are already operating in China and more are planned.

- ElectraNet has not included any economic benefit from such an outcome, notwithstanding the QNI demonstrated proof that it has already happened along QNI. ElectraNet defend their omission by the additional cost of the additional inverter station, however the following preliminary assessment indicates that the net benefit could be some $250million:

- Assumed installation of 1,500 MW of PV, taking place in central Qld rather than further south in central NSW or northern Qld. Nil additional PV farm investment as it's just a relocation

- Estimated amount of additional PV energy generation – based on 1,500MW and an additional 2% annual capacity factor = 250,000 Mwh pa annual value of this energy, priced at $100/Mwh = $25million

- NPV over lifetime of interconnector ~$400million

- Cost of an additional 1,000MW inverter = $250million

- Savings in transmission augmentations in NSW due to absence of 1,500MW of PV in remote areas of NSW = $100million

Based on the above, the net additional benefit = $400m + $100m - $250m = $250 million

7. Efficiency Considerations – transmission losses, dispatch efficiency, pumped storage etc.

- There would be considerable savings in transmission losses throughout the life of a new controllable HVDC Interconnection spanning the NEM power system from Queensland to NSW.

- At present, the marginal transmission losses across the NEM's interconnectors can reach some 40% if all NEM interconnectors between Queensland and South Australia are flowing in the same direction at close to full load (i.e. summation of the mlf's for QNI, NSW-Vic and Vic-SA exceed 1.40.

- A HVDC interconnection is fully controllable, unlike an HVSC interconnection, and would optimally be dispatched at the interconnection power flow where the marginal transmission losses across the new interconnector equals the marginal transmission losses around the existing HVAC NEM interconnection path.

- This should continuously reduce the overall transmission losses across the existing interconnectors by a substantial percentage, depending on the overall interconnector power flows. Based on an average flow of 500MW and a savings in losses of 10%, 50% of the time, the annual savings in transmission losses would be some 220,000MWh pa, which at $80/MWh would save $17.6m pa with an NPV of $264million over Option B's life.

- This estimated savings aligns with modelling undertaken by a UQ master of engineering scholar that predicted annual NEM wide loss savings in the vicinity of $25m pa.

- ElectraNet has used a DC power flow to estimate the sharing of power flows between NEM interconnectors that run in parallel and thereby the interconnector transmission losses for each option. Whilst a DC load flow may be an approximate method for estimating load sharing and transmission losses for HVSC interconnectors running in parallel, this is an inappropriate method for HVDC interconnectors as its load flow can be precisely controlled to minimise overall pool price differences and interconnector transmission losses. The optimal outcome coincides with the marginal losses across the parallel HVDC and HVAC being equal during every dispatch interval, unless an interconnector constraint is reached.

- ElectraNet's inaccurate modelling would have significantly under estimated the loss savings for Option B with its controllable HVDC controllable interconnector. Assuming that ElectraNet only modelled around half of the full interconnector loss savings due to ElectraNet's sub-optimal modelling, the additional economic savings from a correct assessment are estimated to be approximately $132million NPV.

- Another efficiency savings attributable to option B, is increased efficiency of generation dispatch due to the greater access to higher thermal efficiency super-critical coal-fired power stations in Queensland, compared with the less efficient NSW and Victorian coal fired power stations.

- Another significant longer term efficiency gain attributable to option B is access to the higher cycle efficiency of Queensland's pumped storage schemes (around 80% overall cycle efficiency) due to their large scale, high heads and short penstocks compared with the inefficient Snowy 2.0 scheme (~ 50% cycle efficiency due to the much higher friction losses in its 27km long tunnel) and the less efficient, smaller, low-head pumped storage schemes proposed elsewhere in NSW, SA and Victoria

Allowing for these improved dispatch efficiency improvements would increase the efficiency savings by a further $79million NPV, taking the total efficiency savings to $211m NPV.

8. <u>Construction lead times</u>

- ElectraNet's PADR has forecast around a one year longer construction lead times for Option B "HVDC VSC SA to Qld" than Option 3 (i) "HVAC SA to NSW", however ElectraNet has not provided any rational explanation for the longer duration**.**

- The critical path for both projects is expected to comprise the following activities:

    - Complete regulatory consultation and approval processes
    - Environmental investigations and consultation, Cultural Heritage assessment, town planning approvals, easement resumptions.
    - Easement clearing, access track formation
    - Line construction, testing and commissioning

- The critical path for both Options is unlikely to include substation EIS and site acquisition activities and the procurement, manufacturing, installation and testing of substation equipment including turn-key HVDC VSC converter stations.

- The time to complete the regulatory consultation and approval processes for both options would be similar and ElectraNet has forecast completion by end 2018

- The time to complete EIS, C&H, Town Planning and easement acquisition processes depends on the complexity of the individual circumstances for each route, competing land uses, the legislative framework in each state being traversed, and whether federal legislation especially the EPBC act will be triggered.

- The interconnector length in not as significant as the number of properties impacted, the conflicts with existing land use, environmental values and land tenure.

- Critical factors that could significantly extend the time to complete this phase include:

  - A procedural requirement to first consult widely on a broad range of alternative transmission line corridors, before commencing the evaluations of the preferred corridor. This is understood to be NSW requirement that can substantially add to lead times and project risks. Queensland has a more efficient process and it is understood that the SA process may provide greater flexibility depending on the sensitivities of the overall route.

  - The requirement to first negotiate easement acquisition with affected land owners and lessees, and only as a last resort, to compulsorily acquire the required easement rights. It is understood this is a firm requirement in NSW and South Australia, however the Queensland Electricity Act can empower the interconnector developer to move immediately to compulsory resumption of the required easements and land under the Acquisition of Land Act, without the need for prior negotiations failing to reach agreement. This can considerably shorten the easement acquisition process and the associated risks and uncertainties.

  - The requirement to engage with local government to seek town planning approval to use the relevant land for the purpose of the interconnection vs having State legislation that allows for State Government Ministerial Designation to deem compliance with local town planning requirements (or equivalent State Government legislation and processes). It is understood South Australia and NSW legislation and practices may be more likely to require the former town planning processes, at least initially, whereas Queensland legislation and processes tend to favour the latter process.

- The environmental, C&H, access track, town planning and easement acquisition challenges for Option C (i) are understood to be significant due to its proximity to high value conservation reserves, national parks, other areas of high environmental value as well as cultivated in in some parts of the route. Option C(i) also have greater socio-environmental impacts from its use of free-standing, lattice steel structures supporting double circuit 330kV lines which will compound the delays in the evaluation and approval processes summarised above.

- Option C (i) also has more onerous access track requirements due to its much greater need to transport large quantities of tower steel, concrete, and double the number of conductors compared with Option B. Some of these access tracks will be new and located in quite sensitive environments

- The route being investigated by ARCMesh for the SA to Queensland HVDC interconnector makes extensive use of existing gas and oil pipelines, may utilise easements no longer required and use existing access tracks that run close to the proposed route for a significant proportion of the total route. The environmental, access and other challenges are much lower for Option B along the ARCMesh route.

- The adoption of guyed cross-rope line structures for option B vastly reduces its environmental impacts and access requirements as:

  - Less tower steel is required and the towers can be pre-assembled at a small number of staging locations and air-lifted to each tower location, rather than being assembled and erected at every tower site
  - There is no requirement to bore and construct extensive foundations at every tower site as required for free-standing lattice steel towers for Option C. Guyed cross-rope towers have much simpler foundations with minimal needs for boring large holes, which must then be filled with large volumes of concrete made at local concrete batching plants and then transported to each tower site.
  - The length of conductor required per km for Option B is less than half that required for option C (i).
- The vast reduction in below ground excavations for Option C also vastly reduces the potential for adverse Cultural & Heritage impacts and thereby reduces the extent and cost of the required C&H investigations and monitoring of below ground construction activities.

- It is concluded from the above, that the total time, effort, cost and risks of the environmental, C&H, planning approvals, easement and land acquisitions for the interconnector and associated access tracks for Option B would be significantly less for Option B than Option C, regardless of its longer route length.

- Overseas experience in the construction of guyed cross-rope transmission lines is that they are constructed and erected much faster than conventional lattice steel tower transmission lines, for reasons including:

  - Far better suited to pre-fabrication at staging points, rather than requiring each tower to be assembled and erected at each tower site
  - Much quicker to establish tower foundations
  - Can air-lift the much lighter structures, from staging points, quickly to site
  - Tower standing and erection is extremely fast, for example 45 minutes per tower
  - Conductor stringing much fasters as there is half the number of conductors
  - Reduced need for heavy, specialise construction equipment, and lower requirement for skilled construction workers , enables work to be more easily undertaken at multiple construction fronts which can greatly shorten overall construction times for longer transmission lines.

- **Contrary to the view expressed in ElectraNet's PADR that Option B would take a year longer to deliver than Option C, it has been demonstrated above, that the reverse is true. It should be feasible to deliver Option B, at least one years earlier than Option C, with lower risks of delays and cost over-runs**

9. <u>Availability of design and construction skills, labour, & specialised construction equipment</u>

- An important practical consideration in assessing the cost, time and risks of delivering a major interconnection project in Australia is the availability in Australia of the required personnel to design and construct the transmission lines as well as the availability of the necessary specialised construction equipment in Australia

- There is not such an issue with substation works and HVDC converter stations as the substation work is not as extensive as line construction, and the converters will be turn-key contracts mostly designed and built overseas, with local erection being a smaller part of the works.

- The success of the very major program of transmission line construction undertaken in Queensland 10 to 20 years ago, can be attributed to the strategic initiative by Powerlink to fund and strongly support the relocation to Australia of large numbers of skilled overseas construction workers as well as funding the importation to Australia of large amounts of specialised transmission line construction equipment. There were also favourable Australian Visa arrangements at the time that are no longer available.

- The above initiatives allowed the subsequent transmission line construction programs in NSW and West Australia to "piggy back" off the ready availability of skilled labour and specialised equipment for transmission line construction already facilitate by the Queensland strategic initiatives.

- The current Australian situation ten years later is that the required skilled workforce and specialised construction equipment no longer exists in the amounts required. The skilled workforce has largely moved on, and the location of the containers of specialised construction equipment is unknown.

- These are very significant, practical issues for the cost-effective and timely construction of major new transmission lines in Australia, particularly for lattice steel, free standing towers and long transmission lines which require much greater amounts of skilled construction labour and specialised construction equipment than guyed, cross-rope transmission lines, for the reasons outlined above.

- **Unless these Australian shortages of skilled construction workers and specialised construction equipment are urgently addressed (at very considerable expense), the construction costs and construction times, for Option C (i) are unlikely to be achieved. The implications and risks for Option B are much lower.**

10. <u>Other considerations</u>

- The limited time available to respond to the ElectraNet PADR has prevented ARCMesh from undertaking further analysis and quantification of a number of other, substantial considerations that strongly support the development of Option B over Option C(i). These are briefly summaries below:

MESH THE NEM

- Option B would "Mesh the NEM" by converting the existing flawed NEM grid design into a meshed interconnector configuration – at least for the mainland states of Queensland, NSW, Victoria and South Australia.

- The current mainland NEM interconnector design has the states of Qld, NSW, Victoria and South Australia, interconnected in series, end-to-end. This is particularly onerous for Queensland and South Australia being the states at each end of the linear arrangement, with only a single material interconnector to the rest of the NEM. Even NSW and Victoria only have a single interconnector pathway to each of Queensland and South Australia over a long, skinny, high transmission loss series of interconnections

- Should the single interconnector to either South Australia or Queensland trip (as occurred to South Australia in September 2016 and to Queensland in August 2018) , there is a high risk of substantial load shedding taking place, as occurred following both of the above two incidents.

- The NEM market design is such that the frequent constraints on the single interconnections to either South Australia or Queensland can cause their spot market prices to spike to very high levels, and even the threat of this happening increases the price of electricity futures to much higher levels than otherwise likely.

- There is an obvious and easy solutions to Australia's flawed NEM interconnector design and the associated serious power system security and market aberrations that are adversely impacting Australia's economy and society.

- That is to MESH THE NEM by interconnecting South Australia directly to Queensland and thereby forming a closed and complete mesh of the four mainland states Queensland, NSW, Victoria and South Australia. Meshing networks is standard practice for electricity networks everywhere and is generally essential for security and economic optimisation, at the lowest possible costs.

- The Finkel Review report recommended that AEMO and the newly formed Energy Security Board investigate MESHING THE NEM in the first national interconnector review, however this has not happened.

- The best interconnection technology for MESHING the NEM is HVDC VSC now being used extensively in Europe to stabilise their existing HVAC power systems.

NEM wide Power System Security Incident in August 2018

- In late August 2018, it appears that a single lightning strike to a transmission tower or earth-wire on the Queensland NSW Interconnector in Northern NSW caused the NEM interconnected power system to immediately "fall apart" with:
    - both 330kV QNI interconnecting lines tripping

  - both 275kv SA-Victoria interconnecting lines tripping
  - NEM immediately separated into three islands of Queensland, South Australia and NSW-Victoria-Tasmania
  - Extensive load shedding in most states

- This severe outcome, triggered by just a single lightning strike, appears to confirm the serious flaws in the NEM interconnector design and indicates that recent changes to NEM rules and AEMO's operational practices have been unsuccessful in averting another serious power system security and market incident. The incident could have been even worse had the single interconnectors to Queensland and South Australia been more heavily loaded.

- Had the NEM been already MESHED by a new HVDC VSC interconnector between South Australia and Queensland, it is highly likely that the incident in late August would not have split the NEM and that load shedding would have been avoided.

- ElectraNet's Option C(i), a new HVAC interconnection from South Australia and NSW would not have prevented the separation of Queensland from the rest of the NEM (as Option B would have prevented), nor would it have prevented the immediate loss of 800MW of power to the rest of the NEM, and the ensuing frequency reduction and power system swings, which possibly caused the cascading separation of South Australia. It certainly would not have prevented the under frequency load shedding that occurred, which would have been avoided had Option B been in place.

- It is recommended that ElectraNet test option B against Option C(i) for the incident that occurred in late August 2018 and include the relative economic consequences in their economic comparison and recommendation.

Telecommunications Benefits to Western Queensland, Central Australia and North-Western SA

- The project scope of Options B and C(i) both include the installation of OPGW for both ground wires along the entire length of the interconnection, together with necessary electronics and associated amplifiers and auxiliary systems to deliver an ultra-high capacity, duplicated and extremely secure telecommunications network. In the case of Option B, the new telecommunications network connects to equivalent existing telecommunications systems at Bulli Creek substation stretching the length of the Queensland transmission grid and southwards along QNI and the NSW transmission grid.

- These telecommunications systems have a large amount of capacity well in excess of power system needs that could be made available, at minimal additional investment to Australian telecommunications providers as a commercial services, earning substantial additional income with associated profits.

- In the case of Option B, only a minor additional investment would be required to connect to the existing high capacity telecommunications systems owned by a number of telecommunication carriers in the Port Augusta area, noting that there are several ultra-high capacity commercial telecommunications system passing nearby that run from South Australia to Western Australia and the Northern Territory.

- In the case of Option B, the interconnection route passes through South Western Queensland and north-western South Australia where the existing telecommunications services are extremely limited, due to the absence of an ultra-high capacity commercial telecommunication services. It would be feasible and would only require minor expenditure to extend the Option B telecommunications system to connect it existing commercial telecommunication networks in communities in the vicinity of the route, and thereby substantially enhance existing telecommunications services in those remote parts of inland Australia. This could include industrial and mining centres in the general area.

- The business case for this ancillary use of the project infrastructure at a small incremental expenditure is likely to be strong, and the additional income could generate a substantial net benefit and revenue source that is allowable under the AER Regulatory Investment Test that has not been factored into ElectraNet's current PADR assessment

Operation and Maintenance Costs

- No details have been provided in ElectraNet's PADR of the life-cycle operation and maintenance costs for either Option B or Option C(i), other than an additional allowance appears to have been included in Option B.

- The scope of both Option B and Option C(i) include large amounts of power electronics equipment and secondary systems that may require expenditure due to obsolescence well into the study period. In the case of Option B, this is primarily some power electronics within the HVDC VSC converters. In the case of Option C(i) it includes power electronics equipment, and secondary systems in the HVAC substations, phase shifting transformers, SVC's, capacitor banks, protection and telecommunications systems.

- The operation and maintenance costs of Option B's HVDC transmission lines and primary equipment are expected to be lower than the equivalent operation and maintenance costs for Option C(i), as there are only ~ half the number of conductors and insulators and much less HVAC substation equipment.

- The route for ARCMesh's HVDC transmission line generally follows the existing gas and oil pipelines from Queensland to South Australia with good existing access tracks for ground inspections and maintenance of the transmission towers and lines. The ElectraNet PADR does not appear to have recognised the potential to share local maintenance facilities and even inspection crews, where appropriate, with the gas pipeline maintenance service providers to reduce the inspection and maintenance costs.

- The allowances made for operation and maintenance costs and equipment refurbishment later in the asset life of Option B appear to have been over-estimated in ElectraNet's PADR economical comparison of Option B vs Option C(i)

Substantial Reduction in Pool Price Volatility in the NEM, particularly in SA and Qld

- Australia's market arrangement together with the flawed NEM interconnector design results in very high volatility of wholesale pool prices, particularly in South Australia and

Queensland at the extremities of the existing mainland NEM grid. The expectation of ongoing spot price volatility also increases electricity price futures in Queensland and South Australia, resulting in higher electricity prices to industry, retailers and all electricity users in these states.

- There is a similar, but lesser, impact on wholesale electricity prices in the rest of the NEM due to the flawed NEM grid design that could be significantly reduced by MESHING the NEM

- MESHING the NEM would provide alternative interconnections to both Queensland and South Australia when their existing single main interconnect may otherwise bind and cause the local wholesale pool price to spike to up to $14.000/MWh. It would also provide an alternative interconnection route between Queensland and NSW/Victoria along the new HVDC interconnection and via South Australia, and vica-versa for South Australia to NSW and Victoria.

- By MESHING the NEM mainland states, the volatility of wholesale electricity prices, attributable to interconnector grid constraints and high marginal loss factors would be substantially alleviated.

- This has been demonstrated by market modelling undertaken by a University of Queensland Master of Engineering student using a new NEM market simulation tool developed for that purpose that simulated and optimised the half-hourly HVDC dispatch of the new interconnector over five years including the reductions in wholesale pool prices in Queensland and NSW from the increased unconstrained interconnector imports and exports across the main interconnections. The model also simulated and optimised the marginal transmission losses across the mainland NEM grid interconnectors and was used to optimise the size of the HVDC interconnector conductors to minimise life cycle costs.

- The substantial reduction in pool price volatility, especially in South Australia and Queensland will lead to increased wholesale electricity usage for efficient purposes, which is an allowable economic benefit under the AER Regulatory Investment Test. It is not a so-called "wealth transfer" as it represents a net economic gain for electricity consumers and producers.

- Recent events have demonstrated the very large magnitude of these potential economic benefits in both Queensland and South Australia where the high volatility and high costs of electricity futures (or their equivalent) have resulted in additional costs to large local industries including BHP at Olympic Dam and Pacific Aluminium at Boyne Island in Queensland. In the case of Pacific Aluminium, high wholesale electricity prices and the inability to negotiate lower medium to long term electricity hedges resulted in the closure of half of a complete aluminium potline (to reduce the aluminium smelters demand by ~150MW to avoid exposure to Queensland's pool price volatility). As a direct result, Australia's export of aluminium metal processed at the Boyne Island smelter has been reduced by some $225million pa and instead the associated alumina (that would otherwise been processed at Boyne Island is being exported to an overseas aluminium smelter for processing into aluminium metal.

- This has been a large loss of revenue and financial benefit to Pacific Aluminium, being a Queensland electricity user, that could have been avoided by lower volatility and lower priced wholesale electricity hedges.

- Only Option B will substantially reduce this pool price volatility in Queensland and the associated cost of electricity futures and electricity price hedges in the Queensland market.

- This is an allowable component of the net market benefits under the AER Regulatory Investment Test, yet ElectraNet's PADR s does not appear to have made any provision for this very large financial benefit in its assessment of Option B. The corresponding financial benefit for Option C9i) would be much smaller than for Option B.

Diversity of renewable energy resources over time of day, and east to west, and north to south

- The diversity of solar intensity and wind speeds increases very substantially between regions of Australia with large east-west and north-south distances of separation. For example there is much greater diversity in the timing of solar intensity between West Australia and the east coast of Australia, between South Australia and Northern Queensland, between Central Australia and Western Australia, South Australia and Queensland.

- This large difference in time diversity of solar and wind intensity would be directly translated into diversity of the associated renewable generation, should solar PV or wind-power be installed at these locations.

- The associate time diversity of generation, combined with the time diversity of the electrical load at the main Australian load centres, is arguably one of the most significant potential economic factors to be utilised in the future development of Australia's interconnected grid and renewable energy resources. This alone can lead to very large savings in capital investment in both generation and energy storage as well as large savings in operating costs of the remaining fossil fuelled generation as well as reduced risks of electricity supply shortfalls during periods of high local demand and low renewable power generation.

- Option B offers much greater opportunities for diversity than option C(i) because:

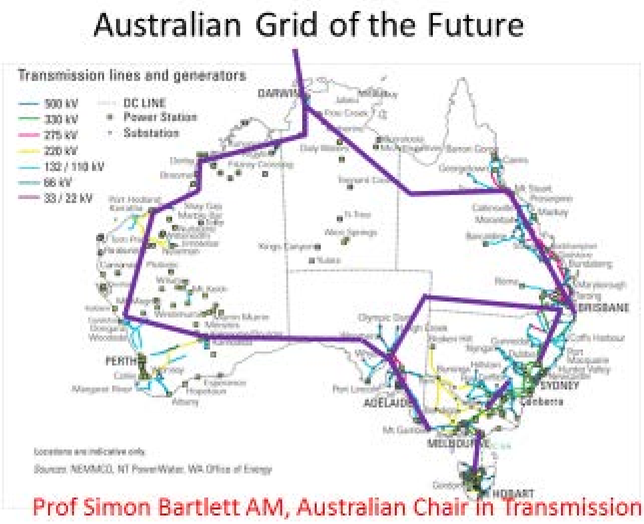
    - There is little diversity provided by Option C(i) which runs east-west over a shorter distance between areas with similar weather patterns and less solar and wind diversity
    - Option B enables much greater diversity between Queensland wind and solar resources and those renewable energy resources in South Australia.
    - Option B enables the solar diversity and higher solar intensity of Central Australia (should PV farms be developed along the inland route of Option B) compared with Queensland coastal areas and South Australia renewable energy resources.
    - Option B, terminates in South Australia at Davenport, the obvious location for a subsequent HVDC interconnector to Western Australia, which would enable the very high diversity between West Australia and Eastern Australia to be exploited via the subsequent construction of a new HVDC interconnector from Davenport to Western Australia.

- The ElectraNet PADR and AEMO Interconnected Grid Plan appear to have made no allowance for this very important strategic factor

Alignment with a Vision of an Australian Grid and Exporting Renewable Energy to Indonesia

- The concept of a global interconnector, including Australia is being proactively investigated by a CIGRE Study Committee C1 working group, ABB researchers and several visionary Australian interconnection experts.

- Below is a preliminary conceptual plan for one such system that relies on long-distance, HVDC, low-cost interconnections between renewable energy hubs across Australia and HVDC undersea interconnections between Australia and Indonesia to underpin a new export industry of Australia's plentiful renewable energy resources.



- Option B would be an essential first step in the delivery of such a vision as it would:
    - demonstrate that overhead HVDC interconnection is viable for Australia's long distance interconnections
    - demonstrate the very low costs and high performance of guyed cross-rope HVDC lines which is an essential prerequisite to the delivery of the vision
    - create the first stage of an national HVDC grid that stabilises the grid whilst enabling increased integration of Australia's best renewables
    - facilitates the second possible stage, being an HVDC interconnector from South Australia to western Australia (and thereby creating the first east-west trans-Australian interconnection

- Only Option B aligns with such a vision.

<u>Overall Impacts on capex and net market benefits</u>

The ElectraNet PADR concludes that the relative costs and net market benefits of the HVDC SA-Qld interconnection (option B) relative to the SA-NSW 330kv HVAC interconnection (Option 3(i)) are as follows

	Option B SA – Qld HVDC VSC	Option 3(i) SA-NSW HVAC	Difference
Total capital cost	$1,790m	$1,480m	$310m (+21%)
NPV capital cost	$1,090m	$890m	$200m +(22%)
Gross benefits (medium)	$1,230m	$1,580m	$350m (-22%)
Weighted net benefits	$ 490m	$960m	$470m (-49%)

Item	Description	Impact of capital cost	Impact on net benefits
1.	Qld coal fired fleet runs longer	Deferral of capex on new renewables, storage & trans	$5billion to $10 billion
2.	more correct estimate of capex for HVDC VSC link	$350 million	$213million
3.	More correct estimate of capex for 330kv HVAC option and subsequent 500KV Wagga to Yass	$30 million plus ~$500m in future	$200 million
4.	Choice of Technology – HVDC VSC vs HVAC and other old world technologies	~ $500million	$200million
5.	Alternative route through Qld and SA instead of via NSW	Included in 2 above	Included in 2 above
6.	Additional generation along the interconnector route	$250 million	$150million
7.	Improved NEM efficiency (interconnector, dispatch, pumped storage losses	Only operational costs included	$211million
8.	Construction lead times	Not costed but earlier completion would deliver significant benefits to the NEM and South Australia	Not costed but significant
9.	Availability of labour and equipment	Increases the risk of cost and time over-runs for HVAC options	Increases the risk of cost and time over-runs for HVAC options
10.	Other Considerations	Intangibles in favour of HVDC VSC interconnector from SA to Qld	Intangibles in favour of HVDC VSC interconnector from SA to Qld
	TOTAL ADJUSTMENTS	$380 million + $1.25 billion on other projects	$774million plus $5-10 billion for item 1

Including these adjustment in the ElectraNet PADR economic assessment, would change the comparative capital investments and NPV benefits of options B and Option C (i) to the following:

	Option B SA – Qld HVDC VSC	Option 3(i) SA-NSW HVAC	Difference
Total capital cost	$1,440m	$1,510m	-$70m (-5%)
NPV capital cost	$ 877m	$908m	-$31m (-3%)
Gross benefits (medium)	$1,984m	$1,560m	-$424m (-21%)
Weighted net benefits	~$1,900m	~$1,500m	-$400m (-21%)

Note: these adjusted capital investment and benefits do not include the additional $1.125 reduction in capital associated with savings in other related projects, nor the $5billion to $10billion estimated savings to the NEW from increasing the likely operating life of some of the five newest coal fired power stations in the NEM, all located in Queensland, to enable them to continue to operate up to their technical life rather than face premature sidelining, mothballing or early closure

CONCLUSION

The inclusion in the ElectraNet PADR of the above factors would overturn the ranking of Options B and C(i) by making Option B, compared to Option C9i) approximately 5% lower in project capital expenditure and approximately 21% greater in net market benefits. Much greater benefits should be attributed to Option B from its strategic benefit of enabling the NEM's five newest and efficient existing coal fired power stations to deliver their full potential value to the NEM (see note above)

RECOMMENDATION

It is recommended that ElectraNet consider this submission and where required seek any supporting material and other details from ARCMesh to enable ElectraNet to take these matters into consideration in finalising its RIT-T evaluation, including its recommended "winning" option