GLOBAL CCS INSTITUTE

Dr Alan Finkel
AO Commonwealth Chief Scientist
NEM Security Review Expert Panel
via email: NEMSecurityReview@environment.gov.au

21 February 2017

Re: Independent Review into the Future Security of the NEM – Preliminary Report

Key points

- CCS is essential to achieve the Paris climate targets at least cost and can play a significant role in a future Australian low emissions power system.
- CCS is proven, safe, reliable and operating at commercial scale in the power sector today.
- CCS is being blocked from competing with renewable sources because of "in-principle" and ill-founded perceptions of its cost and association with fossil fuels.
- CCS on coal and gas-fired generation is cost competitive with other low emission technologies, and like these other technologies, will decrease in cost with higher rates of deployment.
- Fossil fuel generators equipped with CCS complement other intermittent sources of low carbon generation by providing controllable output and other benefits to system stability and operation.

Background

The Global Carbon Capture and Storage Institute (the Institute) is the world's preeminent authority on carbon capture and storage (CCS) and appreciates the opportunity to provide a submission to the Review Panel on these matters.

The Institute's mission is to accelerate the deployment of CCS globally in order to achieve the deep cuts in carbon dioxide (CO_2) emissions necessary to meet climate targets.

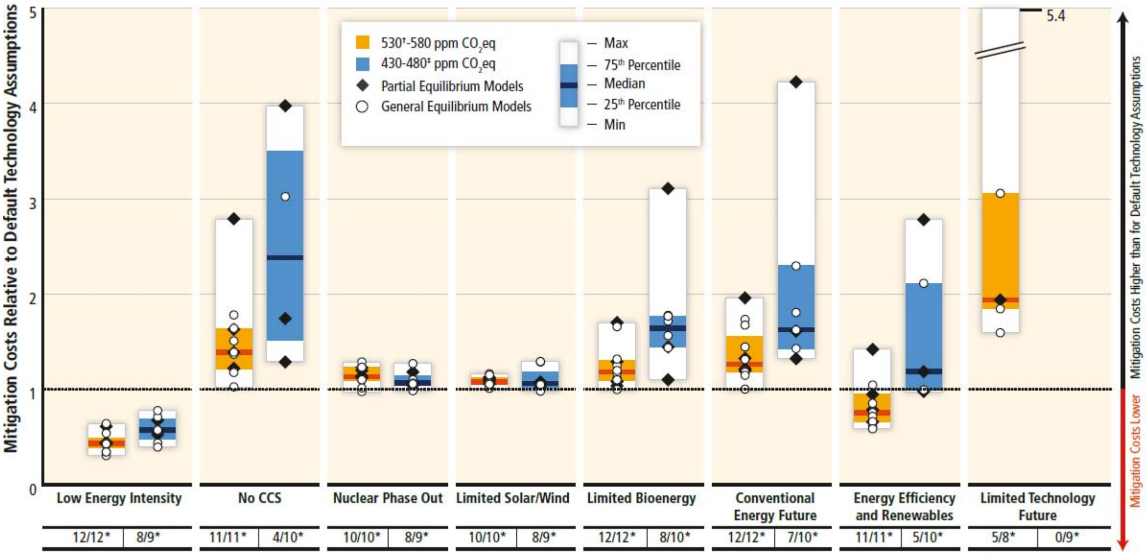
CCS represents a range of technologies that directly reduce emissions from a variety of industries involving the combustion of fossil fuel (e.g. power generation and steel manufacture) and others where CO_2 is a by-product (e.g. chemical and cement production).

CCS is essential to meet Paris commitments at least cost

Modelling of least cost emission pathways consistently identifies that CCS would be deployed in large volumes if emission targets arising from the Paris Agreement are to be achieved. The importance of CCS in these results is in direct contrast to claims that CCS is 'too costly' or 'cannot compete with renewables' (see further discussion on costs below).

The Intergovernmental Panel on Climate Change (IPCC) 5th assessment report commented on a range of modelling that examined the impact of particular mitigation technologies on the cost and likelihood of limiting global temperature increases. The results of this are shown in Figure 1, where the median cost of achieving 450 parts per million CO_2 concentration was 138% higher in scenarios that blocked CCS compared to default scenarios where CCS was included.[1]

Figure 1: Mitigation costs 2015 to 2100, with varied technology availability



† Scenarios from one model reach concentration levels in 2100 that are slightly below the 530-580 ppm CO_2eq category
‡ Scenarios from two models reach concentration levels in 2100 that are slightly above the 430-480 ppm CO_2eq category.
* Number of models successfully vs. number of models attempting running the respective technology variation scenario

Source: IPCC, 5th Assessment Report, Figure 6.24.

[1] http://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_chapter6.pdf

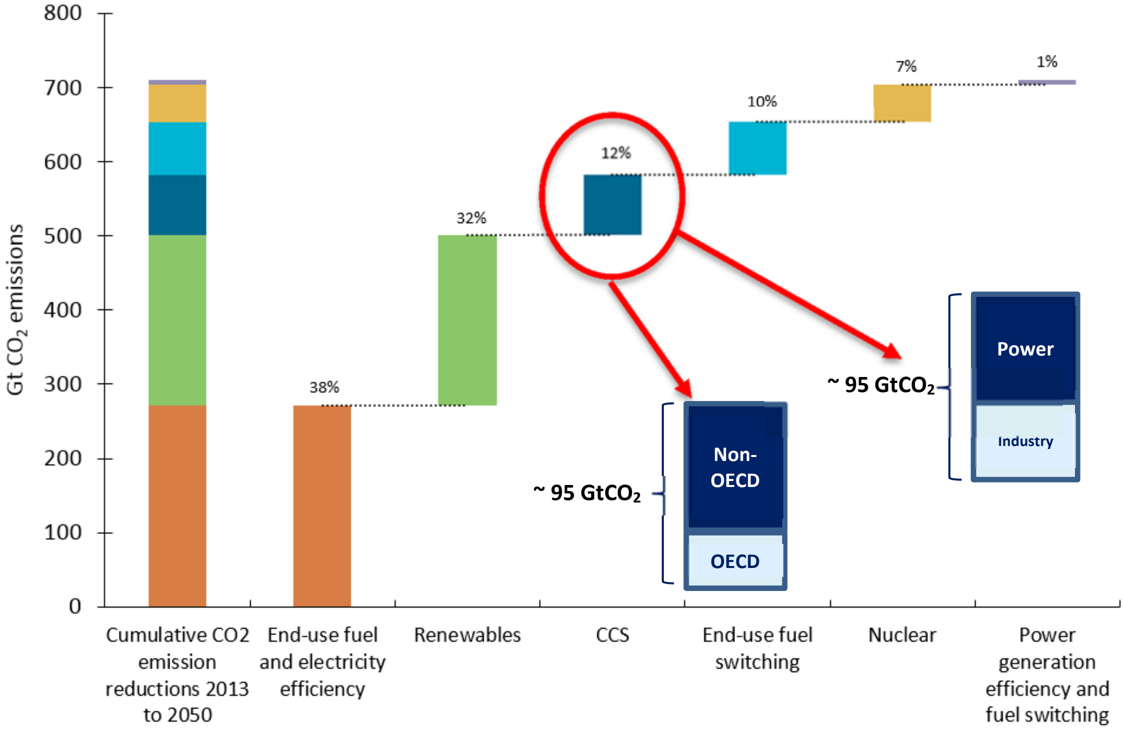
On these results, the IPCC noted:

> …the lack of availability of CCS is most frequently associated with the most significant cost increase… One fundamental reason for this is that the combination of biomass with CCS can serve as a CDR [carbon dioxide removal] technology in the form of BECCS… In addition to the ability to produce negative emissions when coupled with bioenergy, CCS is a versatile technology that can be combined with electricity, synthetic fuel, and hydrogen production from several feedstocks and in energy-intensive industries such as cement and steel.[2]

This finding is consistent with other modelling that shows that the least cost pathway to climate stabilisation requires the broadest possible range of low emission technologies including CCS. The IEA periodically reports on the potential role of CCS alongside other technologies in its World Energy Outlook and Energy Technology Perspectives reports. Its latest publication suggests CCS would contribute to 12% of cumulative emission reductions out to 2050, relative to business as usual scenario.[3] CCS complements rather than substitutes other climate mitigation measures such as renewables, and vice versa.

[2] http://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_chapter6.pdf, pp. 451-453.
[3] http://www.iea.org/etp/

Figure 2: Contribution to cumulative CO_2 emission reductions, 2013 to 2050



Source: data from IEA, Energy Technology Perspectives, 2016.

The large amounts of emission reductions highlighted in these studies illustrates that our energy systems must be transformed dramatically, and to do this requires very aggressive policy settings.

We note the Review has had regard to Australia's stated 2030 emission targets. These targets do not identify a clear path to the low emissions power system required by the middle of this century (and beyond) for Australia to play its part in meeting Paris commitments. Recognising the capital intensity and longevity of power system infrastructure, the Review Panel should consider the costs, risks and opportunities for Australia's power system well beyond 2030, and preferably to 2050.

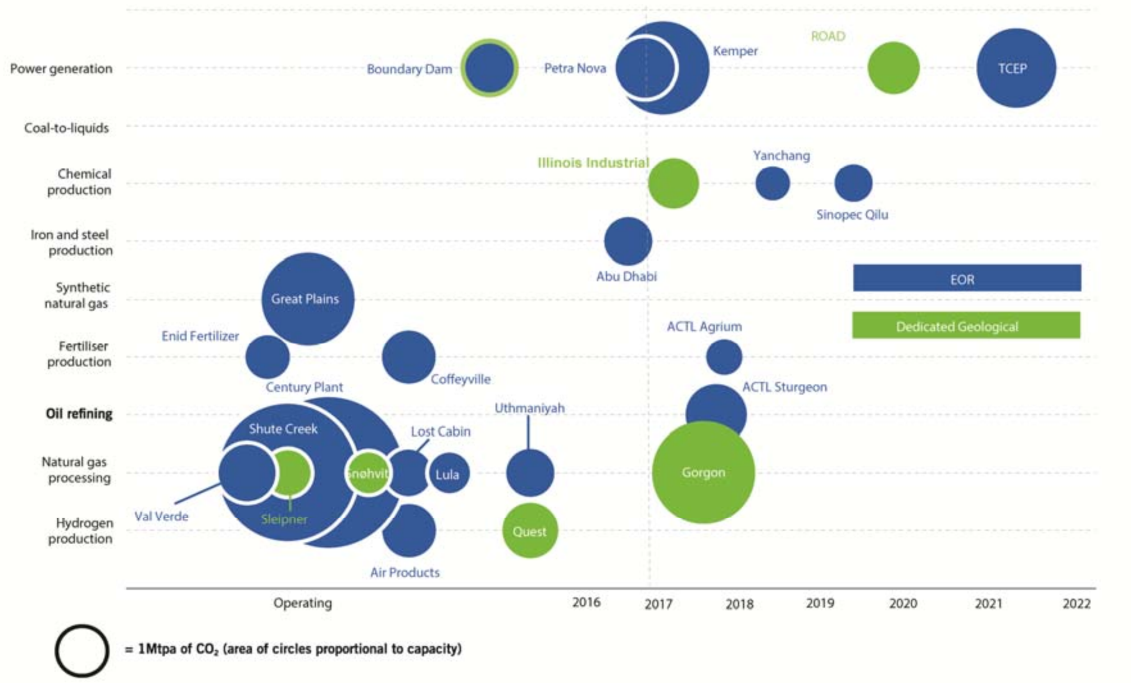
More broadly, policies must be consistent with the Paris Agreement if they are to be regarded as credible and sustainable. This includes the ability of governments to ratchet down targets in their periodic submissions to the UNFCCC. Such a solid policy framework is vital for making investments in the energy sector. As should be obvious from the current debate, highly politicised and ideological positions held by elected officials create high levels of investment risk, and will ultimately result in a suboptimal generation portfolio at higher cost and lower levels of reliability for consumers.

Given this context, the panel should consider the “end game”; that is a resilient and reliable power system, required by 2050, with a very low emissions intensity consistent with meeting Paris commitments. To be clear, a system that derives only 50% of its energy from low emission sources would not meet this requirement.

<u>CCS is proven, safe, reliable and operating at commercial scale in the power sector today</u>

CCS is a proven technology at large scale. The Institute’s projects database currently tracks 38 large scale CCS facilities around the world today in a full range of applications.[4] 21 of these facilities are in operation or in construction. Some of these facilities have been operational for over 20 years. The Institute also tracks 72 individual smaller pilot and demonstration projects.[5] Large scale projects with expected completion dates out to 2022 are illustrated by capture capacity and by industry in Figure 3.

Figure 3: Large scale facilities in operation, construction and advanced planning



Source: Global CCS Institute.

[4] http://www.globalccsinstitute.com/projects/large-scale-ccs-projects
[5] http://www.globalccsinstitute.com/projects/pilot-and-demonstration-projects

Three of these large-scale facilities are in the power sector, on coal-fired generators:

- The Kemper County Energy Facility in Mississippi is expected to be operational within the next month. It is a newly constructed plant, and has a CO_2 capture capacity of approximately 3 million tonnes per year and peak output of 582MW (net). The facility will also produce around 135,000 tonnes per year of sulphuric acid and approximately 20,000 tonnes of ammonia per year for sale. This landmark project will be the first commercial scale deployment of the TRIG™ coal gasification process developed jointly by Southern Company and KBR in partnership with the US Department of Energy.

- The Petra Nova Carbon Capture Project in Texas was launched in January 2017. It is a retrofit of an existing power station. It has a CO_2 capture capacity of approximately 1.4 million tonnes per year from a 240MW slip-steam of the 610MW (net) coal-fired generating unit. This is the world's largest post-combustion capture project at a power station.

- The Boundary Dam Unit 3 plant in Saskatchewan, Canada was launched in October 2014. It is also a retrofit to an existing power station of over 40 years of age. It has a CO_2 capture capacity of approximately 1 million tonnes per year. Unit 3 has a net generating output of 115MW.

The costs, level of government support and commercial drivers for these projects are varied, however all demonstrate that CCS in the power sector is viable and happening today. In particular, they demonstrate that coal-fired generating units can reliably operate with only 10% of the emissions of an unabated coal plant and 25% of the emission of an unabated gas plant.

<u>CCS is being blocked "in principle" from competing with renewables</u>

Debate on energy and climate policy in Australia (like many other countries) is unhelpfully framed in terms of whether positions are pro- or anti- renewables. This framing is perpetuated by interests pushing coal/ mineral resources and those pushing for more renewables investment. Against this backdrop, fossil fuels are demonised rather than their carbon emissions. CCS is simplistically viewed as a "clean coal" technology, in spite of it having applications beyond power generation, and in the power sector alone can play a role in reducing emissions from gas-fired and even biomass combustion.

The RET and state-based renewable energy policies have been effective in supporting deployment of wind and solar PV capacity, but not in creating investment in the low-emission power system we require to meet climate targets. These policies have only incentivised the cheapest forms of renewable energy generation that are closest to market i.e. wind and solar PV. These are intermittent and so create challenges for system planning, resilience and operation as penetration increases. Further, renewable energy policies reward the addition of renewable generation capacity to the grid without consideration of potential impacts on system resilience or reliability. These impacts will inevitably incur additional costs paid by the consumer as penetration increases. Other low emission technologies that do not negatively impact on system resilience or reliability at any level of penetration, are excluded. The lowest cost, low-emissions power system requires a diversity of low emission technologies (including intermittent renewables). Current policy delivers only intermittent renewables.

As the Review Panel has noted, there is a need to reconsider market incentives and regulations to encourage other renewable technologies that can supplement intermittent, cheap renewable sources. Similarly, energy storage, demand management and energy efficiency should play a much larger role than at present. The market and regulatory frameworks must also allow CCS to play its role, with investors free to determine what this role is depending on the cost and other characteristics of the range of solutions on offer. At present, CCS is being blocked because of in-principle opposition to coal, and because of well-intentioned but unsubstantiated views that CCS is expensive.

In addition to the skewed nature of the RET and the motives behind its "renewables only" design, the Review Panel should consider the role of supportive institutions like ARENA and the Clean Energy Finance Corporation. Together, these bodies and the RET provide quite substantial subsidies and supportive instruments to renewable technologies. Work undertaken by BAEconomics suggests that subsidies to renewables in Australia in 2015-16 were in the order of $3 billion.[6] Implicit in this support is that renewable technologies drive emission reductions, however if achieving emission reductions at least cost were an explicit policy goal, CCS would be given far more support. Analysis undertaken by the Institute has identified that CCS in the power sector has comparable or better outcomes than a range of renewable technologies in terms of cost per tonne of CO_2 avoided.[7] CCS can directly reduce emissions from coal and gas fired generators. In contrast, forcing more renewable generation into the market only displaces emissions in the event dispatch patterns are affected, or with the eventual exit of fossil fuel generators from the market.

CCS is cost competitive with other low emission technologies

The Institute recognises that wind and solar PV, brought into the market and down in cost via substantial government subsidies, are now a critical part of the electricity mix. In accordance with modelling of least cost technology pathways, meeting Paris climate targets will require far greater amounts of wind and solar PV than seen today. In addition to policy imperatives, the business case for their investment is strong. These

---

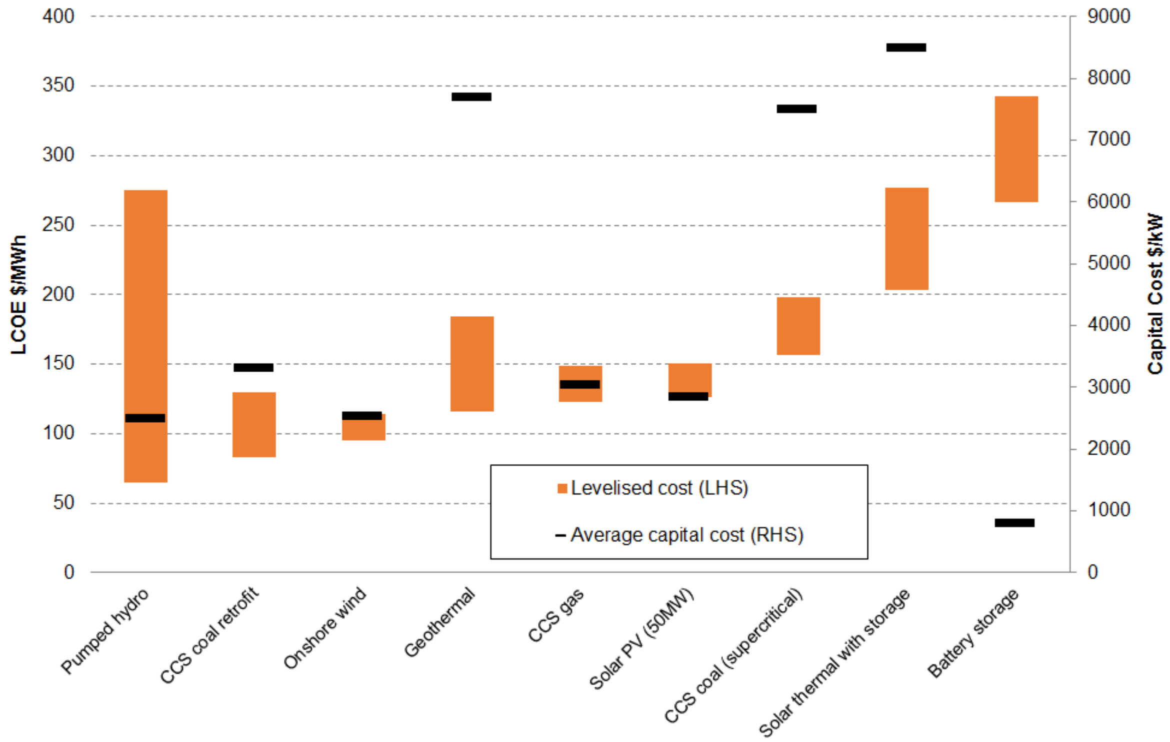
6 http://www.baeconomics.com.au/wp-content/uploads/2017/02/MCA-renewables-subsidies-8Jan2017.pdf
7 http://www.globalccsinstitute.com/publications/costs-ccs-and-other-low-carbon-technologies-2015-update

technologies offer virtually zero short run marginal cost electricity with relatively low capital costs. Solar panels and, to a lesser extent, wind turbines, can be installed virtually anywhere and in short time. Residential solar PV is particularly attractive as it, notwithstanding changes to tariff structures, allows end users to avoid significant costs of electricity network service provision.

Recognising that wind and solar PV present issues around intermittency, there is a simple view prevailing in public debate that they can be supplemented with battery storage, with very limited consideration that this comes at additional cost, or with a downplaying of this cost in expectation that batteries will be subject to the same cost decreases as “renewables” (i.e. solar PV). Pumped hydro is another storage option being considered, alongside generation sources like solar thermal and geothermal that can provide controllable power output.

Example costs of these various technologies are reported in the table below. Capital costs are also presented given levelised costs are sensitive to assumed rates of return and of utilisation, as well as fuel cost assumptions in the case of coal and especially gas generators.

Figure 4: Comparative costs of low emission energy and storage technologies



Sources: Melbourne Energy Institute/Arup for pumped hydro; Lazard for battery storage and geothermal; CO2CRC for all others.[8] Note battery storage and pumped hydro costs exclude charging. Pumped hydro levelised costs reflect 20% utilisation rate. Battery storage capital cost is per kWh for 6 hours of storage capacity.

This comparison is not intended to suggest that cheaper or more expensive energy technologies should be more or less favoured on the basis of cost. Moreover, we recognise that cost estimates are subject to a range of assumptions and uncertainties, including fuel availability in the case of CCS on gas-fired generation and expected future cost reductions for all technologies. Rather, this information is simply presented in order to illustrate that claims of CCS being too expensive and unable to compete with renewables is not supported by available data. To be clear, CCS equipped gas and coal-fired generators are comparable in cost with “renewable” technologies, including wind and solar PV when combined with storage in the form of batteries or pumped hydro.

We also recognise that CCS in power applications suffers from a limited set of information to draw inferences about cost. Two of the large scale facilities in operation today are retrofits, while the third is a new build plant.

---

[8] http://www.co2crc.com.au/wp-content/uploads/2016/04/LCOE_Report_final_web.pdf
https://www.lazard.com/media/1777/levelized_cost_of_energy_-_version_80.pdf
http://energy.unimelb.edu.au/__data/assets/pdf_file/0007/1526587/Opps-for-pumped-hydro-in-Australia.pdf

The CCS facility most frequently quoted in terms of cost and project risk is the Kemper County facility. This has a total cost of around USD$7 billion. Issues with the high cost and delay in this plant largely stem from it being the world's first IGCC plant, rather than issues with CO_2 capture technology. The difficulties and cost over-runs encountered with the IGCC plant were typical of First-of-a-Kind (FOAK) facilities. These difficulties have been overcome and will not present again when the next IGCC plant of this type is constructed.

Boundary Dam unit 3 was a post combustion retrofit of a 50 year old lignite fuelled plant. It involved plant refurbishment so its costs are likely more reflective of a new build plant, noting that the project developers encountered unexpected issues with asbestos removal and very high project management costs. The plant's owner, Saskpower has stated that, if retrofits are undertaken on Boundary Dam units 4 and 5, these would be at 30% less cost than the unit 3 retrofit.

By comparison to Kemper County and Boundary Dam, Petra Nova's (CCS retrofit to a relatively new coal fired plant) total project cost was very low, and also involved investments in downstream CO_2 transport and oil production facilities.

These three projects are first of a kind attempts, with project developers incorporating various contingencies and conservative design parameters in a focus on ensuring the plant is operational, rather than on constructing it in the optimal or least cost manner. As the case of Boundary Dam illustrates, CCS facilities are also subject to considerable site-specific issues, so generating a "representative" cost for facilities is not possible. The experience of Petra Nova suggests that retrofits can be done with a minimal of delay and expense. In light of the comments by Saskpower, there is no reason to suspect that further retrofits cannot be completed in this way.

Returning to the cost data in Figure 4, it should be apparent that the new generation technologies and storage solutions to be brought into the market are higher in cost than wind and solar PV, and are also higher in cost than existing coal-fired generation which makes up the bulk of electricity supplied in the NEM. The recent analysis completed by CSIRO and the ENA suggests that various solutions can be effectively introduced to minimise the cost of transition[9], however it is still clear from this work and other studies that electricity prices will rise from their current levels. Of course, a "do nothing" approach will impose much higher costs on the community in terms of climate change impacts, as well as more immediate costs to consumers if the current issues with the electricity market are left to worsen. Having a clear idea of the cost of transition, and of inaction, is critical to the discussion and in gaining public support. It will lead to a more thoughtful consideration of the market mechanisms, policy interventions and range of technologies that will achieve net zero emissions at the lowest possible cost. As noted above, from our perspective, CCS must be part of this discussion.

[9] http://www.energynetworks.com.au/sites/default/files/key_concepts_report_2016_final.pdf

CCS-equipped generators complement intermittent sources by providing controllable low carbon output and other benefits to system stability and operation

Coal and gas-fired generators with CCS can obviously provide the same electricity and services to the NEM as unabated fossil fuel plant, but with around 90% less CO_2 emissions. This includes the same flexibility and load following capabilities i.e. the operation of capture plant can be managed so as not to interfere with power output.

Comparisons of technologies are often done on a levelised cost basis, which does not capture the value of flexible/ controllable generation to the system. Various studies have examined decarbonisation of the power sector via high rates of renewables penetration combined with storage technology.[10] These have identified declining marginal benefits of these technologies due the capacity required to accommodate variable weather and resulting curtailment. Intuitively, in these situations, much higher value is placed on controllable low emission plant such as fossil fuel generators with CCS or nuclear.

In summary, CCS has significant advantages over intermittent renewable energy sources that should be fully considered when developing policy required to drive investment in a low emissions power system:

- CCS can be applied to gas and coal plant. It is available when needed and is fully dispatchable.
- CCS does not require the generator or grid operator (or customer) to incur the costs of energy storage or additional transmission and distribution infrastructure that is required where intermittent energy sources achieve high levels of penetration in a grid.
- CCS does not require the availability of additional dispatchable back-up generation capacity (spinning reserve) that can be called upon when renewable energy sources are not producing sufficient electricity to meet demand. Where penetration of intermittent renewable energy technologies is high, this backup capacity will often not be commercially viable due to low utilisation, requiring subsidies to incentivise their operators to keep them available even when they are not producing power and generating revenue – this adds additional cost and is economically inefficient.
- CCS is applied to rotating synchronous generators and thus provides the frequency and voltage control services essential to maintain a stable grid.

[10] http://erpuk.org/project/managing-flexibility-of-the-electricity-sytem/
https://www.theccc.org.uk/publication/value-of-flexibility-in-a-decarbonised-grid-and-system-externalities-of-low-carbon-generation-technologies/
http://pubs.rsc.org/en/content/articlehtml/2016/ee/c6ee01120a

These grid services are not adequately provided by intermittent renewable energy sources without the application of additional and in some cases developmental technologies.

There are obviously alternative technologies that can provide synchronous, controllable power output as well as more rapid frequency response. We understand the Review Panel has also been asked to consider the possibility of new and emerging technologies to provide fast frequency response and synthetic inertia, as well as examining NEM operational parameters. Our expectation is that maintaining a diversity of options is more likely to allow for the system to be operated optimally.

Similarly, we expect that maintaining competitive pressure in electricity market will be improved in a situation where there is a diversity of technologies, rather than one where, as seems to be the current expectation, unabated gas-fired generation is the only technology available to provide electrical output (including for energy storage) at times where wind and solar PV cannot produce. That some market participants have high and increasing degrees of market power with the exit of coal-fired generation, and the impact this has on prices, was identified prior to the recent SA system black event.[11] The high degree of reliance on gas generation has again recently gained public attention as these generators have been forced to remain online by AEMO. Furthermore, the Review Panel and many others have identified the problems of relying on gas generation as a transitional measure in terms of the price and availability of gas feedstock.

There also appears to be a presumption that switching from coal to gas generation would deliver emission reductions in a manner that is consistent with Australia's commitments under the Paris Agreement. Combustion from combined cycle gas generators still has an intensity of around 400kg CO_2 per MWh or over four times the emission intensity of coal generation with CCS. This emission intensity also masks upstream emissions (i.e. gas processing and venting of CO_2 as well as fugitive methane). Fitting CCS to gas generators should be considered by the Review Panel and has been foreshadowed in recent modelling of the NEM by the Climate Change Authority.[12]

More broadly, the implications of 1.5 and 2 degree emission targets are that any investment in new unabated fossil fuel generators faces risk of asset stranding over their economic life. In a market already reliant on substantial amounts of gas generation, the UK's Committee on Climate Change and a recent parliamentary committee have identified that emissions from these generators are inconsistent with legislated carbon budgets.[13] Gas-fired generation also requires CCS in a future low

[11] http://energy.unimelb.edu.au/news-and-events/news/winds-of-change-an-analysis-of-recent-changes-in-the-south-australian-electricity-market
[12] http://climatechangeauthority.gov.au/reviews/special-review/special-review-electricity-research-report
[13] https://www.publications.parliament.uk/pa/cm201516/cmselect/cmenergy/692/692.pdf , p. 6.

emissions grid. Australian policy-makers should anticipate facing the same challenges when designing policy today.

Concluding comments

This submission forms part of the Institute's broader effort to raise awareness of CCS on coal and gas-fired generators (as well as for various industrial emitters) in the public debate which will continue into the Federal Government's review of climate policy, into the next federal election and beyond.

Very little attention is being paid to the prospect of CCS-equipped fossil fuel generators playing a role in a decarbonised electricity market in Australia. This contrasts to other countries like Canada, United States and the UK where large scale CCS facilities in power generation are operational or have been actively pursued by governments.

We and our members are neither blind nor emotive advocates of CCS. The technologies making up CCS processes are varied, as are the industries and locations where CCS could be applicable. It will not be economic to apply CCS in every situation and in every market. This is particularly true for the power sector where there are alternative means of emission reduction available, notably the outright substitution of unabated coal and gas-fired generators for a wide variety of low emission technologies, in addition to storage technologies. All of the technologies being considered each have different issues in terms of cost, availability of resource, public acceptance, planning requirements etc. However CCS, while not a fossil fuel technology, is associated with fossil fuel consumption and is therefore currently blocked on ideological grounds. It is also unfairly labelled as being too expensive, which is not supported by available data. As noted previously, the cost of meeting a two degree climate target doubles in the absence of CCS. In the power sector, the proof of CCS is whether it can deliver reductions in emissions in a cost effective manner. It should be given opportunity to play a role alongside all other solutions.

Like wind and solar PV, CCS requires government support to reach the market. In particular, current policy settings are such that it is still cheaper for consumers of fossil fuels to emit CO_2 into the atmosphere. Unless governments can drive change via actual incentives or regulations, then CCS, and a whole array of mitigation technologies, will not be brought to market.

The power system does not respect ideology. It is a complex system constrained by the laws of physics and the principles of engineering. To succeed in building a reliable, affordable, low emissions power system, energy policy must abandon ideology and align with reality. The reality is that every low emission technology including CCS is required to achieve deep emission reductions and meet climate targets. Every low emissions technology, including CCS, should have access to policy support necessary to accelerate its deployment.

Any questions on this submission should be directed in the first instance to Lawrence Irlam, Senior Adviser – Policy and Economics on 03 8620 7342.

Yours sincerely

Alex Zapantis
General Manager — Asia Pacific
Global CCS Institute
P: +61 (0)3 8620 7318
E: alex.zapantis@globalccsinstitute.com
globalccsinstitute.com