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19 June 2020

Dr Alan Finkel AO
Chair
Ministerial Reference Panel – Technology Investment Roadmap
Department of Industry, Science, Energy and Resources

Dear Dr Finkel

The Technology Investment Roadmap will be an important development towards a coherent national low emissions energy strategy.

The success of this process will be measured by its outcomes to achieve Australia's low emissions ambitions at the lowest cost.

Australian electricity price competitiveness – eroded over more than a decade - will require specific attention if it is to do the heavy lifting required in relation to lowering emissions from the sector.

A roadmap that is underpinned by robust systems assessment will be effective to ensure our electricity is not over-priced. A competitive electricity price is essential to the recovery of our domestic and industrial economy.

I commend for your consideration the attached submission that I hope makes a strong case for:

- The minimising of "total system cost" for electricity generation as a metric to guide the roadmap process
- A technology neutral approach that recognises around 40GW of flexible low emissions coal and gas generation will be necessary to firm the high penetration of renewables expected to 2050
- The importance carbon capture and storage will play in a future low emissions system not just for electricity emissions but also industrial emissions including hydrogen and
- Continuing investment to ensure the current CO_2 storage reservoirs under development are progressed to injection ready deployment by 2030 with new resources developed as essential infrastructure for Australia's energy competitiveness.

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ANLEC R&D is a demonstrated Government-Coal Industry Partnership for over a decade. It has deployed a $300M effort leveraging the national research asset infrastructure of universities and CSIRO to support CCS proponents such as

- The CTSCo Project in the South Surat Basin, Queensland
- The CarbonNet Project in the Gippsland Basin in Victoria
- The South Perth Basin in WA.

I look forward to a roadmap that delivers the pathway, priorities and long-term investment strategies to achieve ambitious targets for emissions reduction and a competitive energy economy.

Yours sincerely,

Dr Noel Simento
Managing Director

Australia's Technology Investment Roadmap

Submission to the Ministerial Reference Panel

Department of Industry, Science, Energy and Resources

By Dr Noel Simento

Managing Director – ANLEC R&D

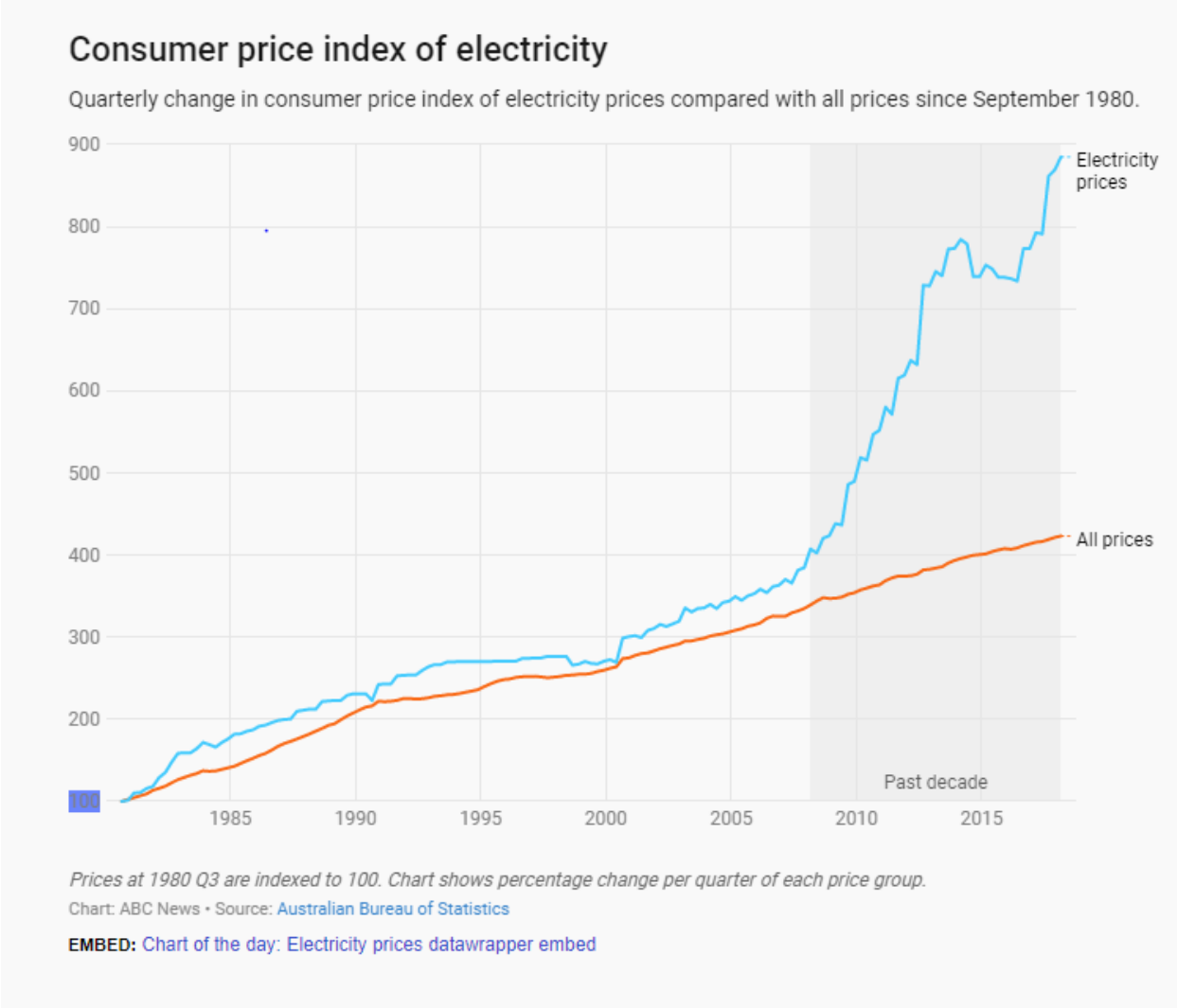
Australia's Comparative Advantage should be underpinned by the lowest priced electricity/energy.

Context

This submission recognises that the proposed Technology Investment Roadmap is focussed on the transition to a low emissions future for the Australian energy economy.

The Australian energy economy benefits from maximising fuel export earnings and minimising the cost of internal energy consumption. The former is subject to global forces while the latter is determined by local planning and investment decisions.

When it comes to the price of electricity, Figure 1[1] below shows the long-term deterioration of Australia's competitive position. In transforming to a low emissions future, it is very important this position is improved by the proposed roadmap development process.



The east coast NEM grid is complex and sustained by various services that ensure its reliability and security. The path to decarbonisation is non-trivial due to the long-lived nature of its power generation assets. Unless well planned, the transition to any aspirational low emission asset portfolio is not

[1] https://www.abc.net.au/news/2018-07-18/electricity-price-rises-chart-of-the-day/9985300?nw=0

flexible. It can lock in a high cost electricity route that cannot be un-wound and consequently inflict long term damage to the Australian economy.

A Roadmap to Minimise the Cost of Low Emissions Electricity Generation in Australia.

Transformation to a low emissions electricity system is an opportunity to restore competitiveness to Australian industry energy costs. This submission aims to show that:

- The lowest electricity price is determined by the **lowest cost electricity generation system**
- The **lowest cost system** is a diverse range of electricity generation technologies
- Low emission coal fired power generation assets are **essential** to the **lowest cost system** for transition to net-zero emissions by 2050
- The regulation, investment and market settings going forward must be re-designed to accommodate these assets if the **lowest cost system** is to be achieved.

*The **Total System Cost** is best viewed as the payments required to service the total financial investments made to generate and supply electricity on the NEM. It consists of the payments by consumers and government grants, subsidies, off market mechanisms etc.*

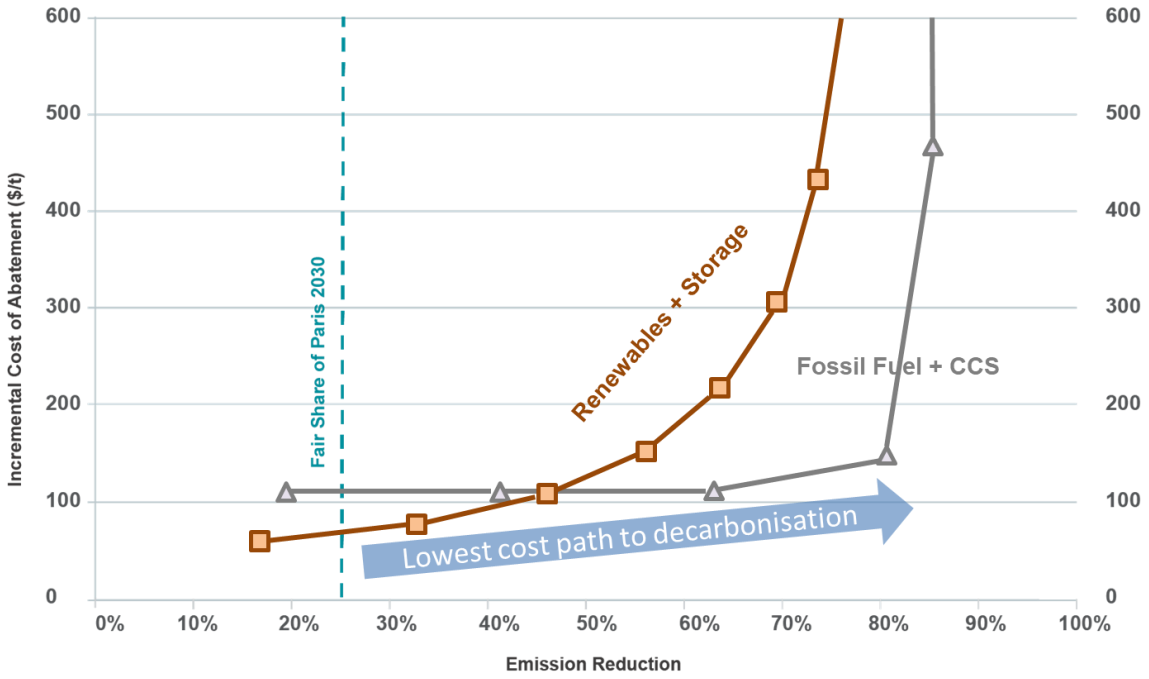


Figure 1: Lowest Cost Targets for Decarbonising the NEM.

Figure 1 shows the modelled cost of two different abatement options at different stages on the journey to a decarbonised NEM [2,3]. It shows that there is a lowest cost optimum that requires several power generation technologies to be available as decarbonisation proceeds. This means both renewable and low emissions fossil fuel generation with CCS.

Stretch Targets for the Cost of Low Emissions Electricity

Departmental consultation on the roadmap discussion paper referred to stretch targets for wholesale electricity price in the range of $20-30/MWhr. The current whole-sale price for electricity averages at about $70/MWhr.

[2] Boston, A., Bongers, G., Byrom, S. and Staffell, I. (2017), Managing Flexibility Whilst Decarbonising Electricity
[3] Boston, A., Bongers, G., Byrom, S. (2018), The Effect of Meeting Renewable Energy and Climate Targets

The whole-sale price of electricity does not lend itself to technology based targets. This is because it reflects many variables that are not technology dependent such as market forces and structures. **Total Systems Cost is a more robust metric** than whole-sale electricity price as a technology roadmap target.

Transforming the electricity generation grid will require the replacement of older assets (with written down capital financing costs) with new capital assets. This inherently increases total system cost. *Independent modelling[4] does not find a single future scenario for low emissions electricity generation that reduces **the total systems cost**.* When viewed as a payment by the Australian economy, i.e.: the price paid by consumer and governments, the most effective objective would be to **minimise the total system cost**. Latest modelling (Figure 2) suggests that 100% decarbonisation of the NEM can be achieved at a total system cost of less than $120/MWhr.

Recommendation:

a) The total system cost is adopted as a metric for the cost of decarbonising the NEM.
b) The relevant stretch target should be to maintain **total system cost** below $120/MWhr). (**Important Note:** Total system cost is NOT the wholesale price of electricity which is determined by market regulation and structure).
c) Any technology included for investment by the proposed Technology Investment Roadmap should be selected on the basis of its potential to reduce the total system cost for net zero emissions from the electricity sector.

Minimising the Cost of Low Emissions Electricity – Prioritising Return on Investment

*The roadmap should **prioritise technology demonstration and deployment at commercial scale** to build the necessary low emissions infrastructure of the future.*

Acknowledging that a low emissions grid will have substantive renewable energy assets, recent analysis[5] has shown the comparative return on investment for four different grid-based technology infrastructure options:

- Upgraded Interconnection to GW scale between the States
- Proximate CCS Hubs available for CO_2 storage
- Large pumped Hydro Storage
- Synchronous Condensers.

The savings in **total systems cost** was examined if each of these technologies were not available to a low emissions grid in 2050. Table 1 below shows their comparative advantage.

Table 1: System Cost Reduction and comparative benefit for a low emissions NEM grid.

Infrastructure Upgrade	System Cost Reduction ($M)	Infrastructure Capex ($M)	Cost Benefit
Four Interconnectors	10,870	5,170	2.1
CCS Hub	9,320	4,370	2.1
PHES Max	37,500	31,000	1.2
Synchronous Condensers	1,290	850	1.5

[4] ibid [2]
[5] Boston, A., Bongers, G., Byrom, S. (2020), What happens when we add big infrastructure to the NEM?

The study suggests:

- One of the best benefits to reducing total systems cost is improving interconnection between the states. It can result in **reducing the total system cost** of the NEM by some $11B from a capital investment of $5B.
- **CCS is also one of the highest value investments identified;** The deployment of CCS hubs can reduce total system cost by $9B for a capital expenditure $4B.
- While the deployment of pumped hydro energy storage delivers some of the largest improvement on total system cost, it is also significantly expensive to deploy. Therefore, the cost benefit to the system much lower. Further, the level of resources and services required is much more than that known to be available.
- Synchronous Condensers have a relatively small impact on reducing TSC.

All these technologies deliver a reduction to **total systems cost** for a low emissions electricity generation grid. Therefore, one can expect a lower wholesale price of electricity if these technologies are included in any technology investment roadmap for electricity generation.

Recommendation:

a) The roadmap should prioritise investment in low emissions infrastructure for the NEM.
b) In the period to 2030, this should include a significant investment in the deployment of CCS for power generation emissions mitigation

Dispatchable Carbon Capture and Storage (CCS) underpins a Lowest Cost Low Emissions Grid

If Australia is to meet its emissions targets and aspire to net zero emissions in the second half of the century, the **lowest cost pathway** is as important as the destination.

The Australian electricity sector will be required to contribute a fair or disproportionately larger share of the emissions reduction targets required into the future. It is especially true if the transport sector were to move rapidly to electric vehicles (EVs) that require charging from the grid.

Assuming that a 2050 grid will have major interconnector upgrades and much more pumped hydro storage beyond Snowy 2.0, the lowest cost asset portfolio for the NEM grid may be demonstrated in Figure 2.

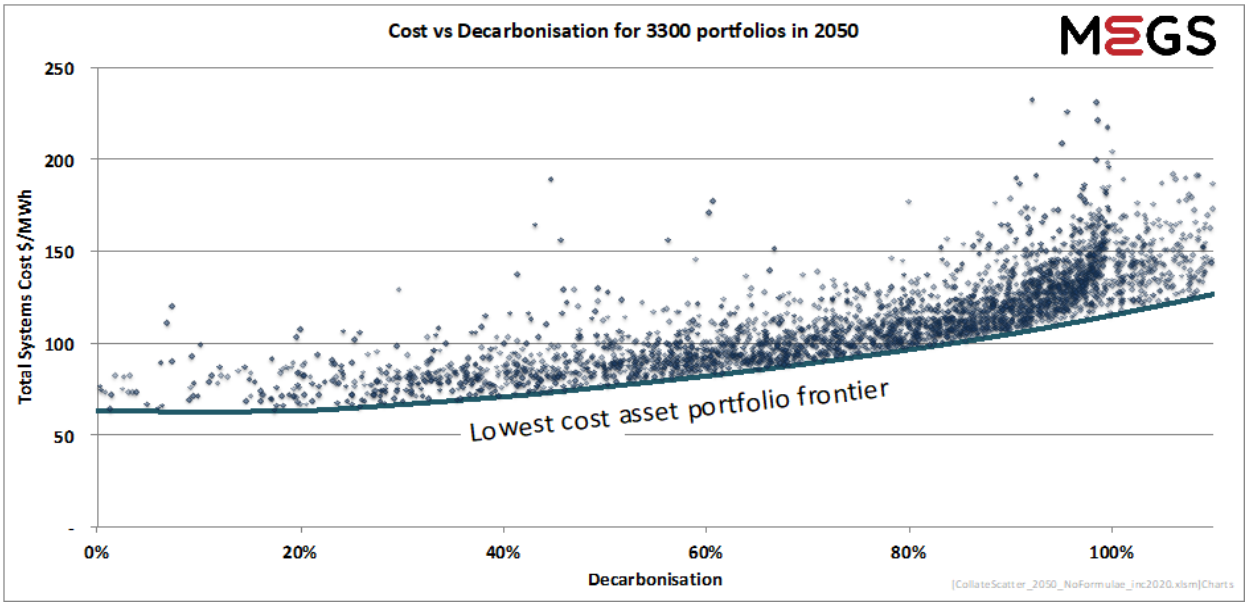


Figure 2: The system cost of possible decarbonised NEM asset portfolios in 2050

Each point in Figure 2 represents a viable low emissions asset grid portfolio. The portfolio includes different proportions of power generation technologies including renewables, gas, CCS, nuclear and bioenergy. Since it is difficult to predict how assets on the NEM grid will develop over time, over 3000 different portfolios were chosen for investigation. Conclusions from this analysis[6] suggest:

- The minimum investment required for decarbonisation of the NEM lies at the lower bound of the envelope shown.
- There are "high cost" portfolios at any given decarbonisation point that are unfavourable. These are to be avoided because they cannot be easily unwound once the assets are deployed.
- **There is no "least-cost" portfolio above 80% decarbonisation that does not include CCS for the dispatchable fossil fuel generation fleet.**

Carbon capture and storage is not a new technology. It is an essential "innovation" that Australia must deploy in the period to 2030. It is the enabling transitional technology on the pathway to net zero emissions. **It is the low emissions investment hedge that has synergy with a clean hydrogen economy and a migration to electric vehicles (EVs) that will draw from the grid.**

It is very important that the projects commenced on the Australian east coast in the South Surat Basin, Queensland and the Gippsland Basin in Victoria go to full deployment. Similar options should be taken out for on-shore Northern and Western Australia.

Why CCS?

Dispatchable power generation technologies with CCS are essential support the intermittent renewables asset fleet. The important value of CCS to the NEM grid is driven by the unique properties of the services it brings to the grid system. CCS combined with the flexibility delivered by gas turbines, modern coal fired power stations, low cost coal fuel, inertia and ready dispatch all combine to warrant its inclusion within the whole system.

Coal fired power generation with carbon capture and storage enables the best penetration and utility of renewable energy in the system. Importantly, for net-zero emissions aspirations both gas and hydrogen will also require CCS to play a role in technology deployment. In the most expensive tail end of the decarbonisation journey, CCS combined with biomass power generation – when managed well – can also deliver some negative emissions benefit to the system.

CCS Relevance to the Technology Investment Roadmap

CCS is an important investment in low emissions infrastructure. Any roadmap should also address those innovations required in the investment, regulation and market structures that will deliver nation building infrastructure over the long term. Underwriting the high upfront costs of all low emissions power generation assets is not new – Snowy 2.0 is a good example. A return on such infrastructure investment is delivered by the resulting **savings in total system cost** of new assets and a more competitive wholesale pricing for low emissions electricity. The cost benefit of CCS to the power generation system is shown in the prior section of this submission.

Recommendation:

The Technology investment Roadmap should:

a) Include investments to deploy the CCS projects in the South Surat Basin, Qld and the Gippsland Basin, Vic as required low emissions infrastructure for the east coast grid.

[6] Private Communication, A Boston, G Bongers – to be published later this year.

System Innovation: Support for deployment of innovative and flexible coal and gas generation

The **lowest system cost** asset portfolio that constitutes a viable grid system has renewable energy that is supported by low emissions fossil fuel assets with CCS to deliver the required level of system reliability, strength and stability. The nature of daily load variation that will be driven by a large variable renewable energy (VRE) asset base is highlighted in Figure 3. Using actual climate data, this figure is chosen to highlight the type of VRE availability that is encountered in an autumn week.

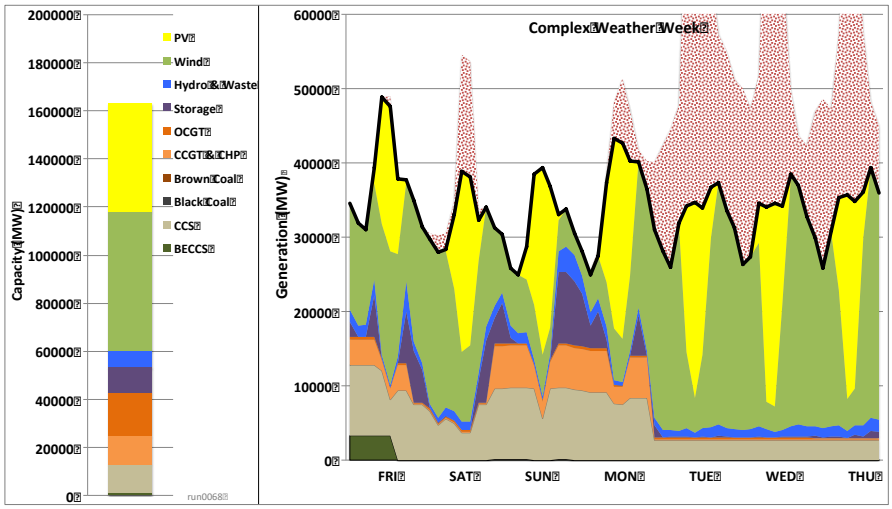


Figure 3: Load variation and simulated generation dispatch to satisfy demand for a given week for a NEM grid decarbonised to >80% by 2050.

While NG electricity generation turbines offer most of the dynamic load ramping qualities required to support VRE, it is subject to a fuel price volatility that is not observed for coal. A 2050 power generation asset portfolio that relies on VRE with energy storage and NG back-up will not be the lowest system cost. It also cannot deliver the wholesale electricity prices targeted by the proposed technology investment roadmap.

This is borne out by AEMO's recent Renewable Integration Study[7]. AEMO media statements[8],[9] acknowledge:

"… For new gas-fired plants, the cost blowout is in the order of 30-60 per cent …

The Technology Investment Roadmap in its footnote 14 observes:

"…Fully firmed wind and solar generation may require more storage than this and would further increase the costs of stored wind and solar….."

A low emissions grid targeting lowest system cost will still require 40GW of low emissions fossil generation capacity to maintain stability and meet demand in periods of low renewable production. These coal and gas generation assets will require to firstly, remain in the market and secondly operate to deliver their return on investment based on intermittent generation and lower capacity factors.

Coal with CCS enables delivery of the future low emissions **with lowest electricity pricing.**

[7] https://www.aemo.com.au/-/media/files/major-publications/ris/2020/renewable-integration-study-stage-1.pdf
[8] https://aemo.com.au/en/news/renewable-integration-study
[9] https://www.smh.com.au/national/australia-s-grid-could-handle-a-huge-leap-in-renewable-power-by-2025-20200429-p54obe.html

A viable decarbonised 2050 grid targeted at lowest electricity pricing will have a suite of electricity generation technologies as shown in the capacity bar charted (Figure 3). There will be however, significant changes to operating conditions for these assets.

The new normal is "intermittent power generation". This is as true for fossil fired generation as it is for VRE. All asset types will operate at lower capacity factors than they do today. Figure 3 shows that up to 25% of VRE generation will require to be curtailed, while coal and gas fired power generation will have to correspondingly ramp up and down daily. This is also recognised by AEMO media statements[10]:

"…AEMO will be required to curtail the contribution of these wind and solar resources to 50 or 60 per cent of their potential even though they are the lowest cost way of providing electricity…"

Coal and gas fired power generation can deliver the necessary grid stability in this new operating environment. Any technology roadmap should ensure that investment is directed to deploying these new flexible coal and gas generation technologies with carbon capture and storage. USA[11] and the UK have demonstrated their value to the system.

Recommendation:

The Technology Investment Roadmap should

a) Include mechanisms for Government to underwrite the strategic infrastructure investment that deploys carbon capture and storage from both coal and gas fired power generation.
b) Include innovative approaches to power generation infrastructure financing that will deliver the capital investment necessary through the Clean Energy Finance Corporation and the Climate Solutions Fund.
c) CCS infrastructure will require billions of dollars over the long term. Signal how these funds will be made available to leverage private investment capital over the period to 2050.

[10] ibid [7]

[11] N A Sepulveda, J D. Jenkins, F J. de Sisternes, and Richard K. Lester: The Role of Firm Low-Carbon Electricity Resources in Deep Decarbonization of Power Generation, Joule 2, 2403–2420, November 21, 2018 Elsevier Inc.