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Despite over a billion dollars of Australian government spending on CCS initiatives since 2003, there are still no large-scale coal with CCS operations in Australia. Directing CEFC funds into coal with CCS is a uniquely poor policy proposal.

Discussion paper

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Summary

In 2007, then-Environment Minister Malcolm Turnbull announced a \$100 million grant for a proposed coal plant at Loy Yang “suitable for” CCS. Turnbull said “Projects like this one ... will play an integral role in helping to reduce emissions in Australia”.¹ Five years later, the grant was withdrawn. The operator has been liquidated.

In February 2017, Prime Minister Malcolm Turnbull put CCS back on the agenda. He argued as the world’s largest coal exporter, Australia has a “vested interest” in promoting clean coal, and lamented that despite substantial public investment over the years “we do not have one modern high-efficiency low-emissions coal-fired power station, let alone one with carbon capture and storage”.²

In 2009, the head of the Australian Coal Association promised that that we will “have commercial scale demonstration plants with carbon capture and storage in operation in Australia by 2015”.³ In 2017 the chief national coal lobbyist said it is “pretty early days” with regards to CCS, which is “an evolving technology”.⁴

Despite the poor track record of coal with CCS, the Turnbull government is now proposing to fund it through the Clean Energy Finance Corporation, which has previously focused on commercial or near-commercial projects, mostly renewables.

In light of Turnbull’s proposal, this report outlines previous funding to CCS and how little Australia has to show for it.

Since 2003, successive Australian governments have backed their promises that CCS will preserve the coal industry with promises of public money. Over \$3.5 billion has been committed towards a wide range of CCS-related projects, initiatives and programs. Over \$1.3 billion was identified as actually distributed.

The government found it difficult to find projects to fund, and funded projects often failed. While funding was sometimes ‘clawed back’, other times this was not possible. ZeroGen, a proposed coal plant with CCS, went into administration despite at least

¹ Macfarlane and Turnbull (2007) *Additional \$100 million boost to clean coal*, <https://www.environment.gov.au/minister/archive/env/2007/pubs/mr12mar07.pdf>

² Turnbull (2017) *Address at the National Press Club and Q&A*, <http://malcolmturnbull.com.au/media/address-at-the-national-press-club-and-qa-canberra>

³ Jones (2009) *Ralph Hillman and Richard Denniss join Lateline*, <http://www.abc.net.au/lateline/content/2008/s2575402.htm>

⁴ Sky News (2017) *PM Agenda*, <https://twitter.com/SkyNewsAust/status/833553271503466496>

\$187 million in subsidies. The 99% Australia-funded Global CCS Institute backed more overseas projects than Australian ones and had extravagant operational spending.

The coal industry also announced a \$1 billion CCS industry fund, which they said would match federal government spending. The fund has collected and committed only \$300 million (mostly for CCS projects), and some of this fund has been spent on election campaign promotion of “clean coal”. Contributions to the fund were deducted against royalties in some states, meaning the fund was subsidised by the taxpayer.

Controversies and poor progress led to government funding for CCS being repeatedly cut. Conservative politicians showed scepticism. In 2009, then-Resources Minister Ian MacFarlane said:

The reality is, you are not going to see another coal fired power station built in Australia. ... You can talk about all the stuff you like about carbon capture storage, that concept will not materialise for 20 years, and probably never.⁵

Despite the promises and spending, there has never been an operational large-scale deployment of coal with CCS in Australia. Attempts to develop coal with CCS, such as the ZeroGen project, have been expensive failures.

Australia’s only close-to-operational CCS project is connected to gas extraction. Apart from three carbon storage projects, not expected to be operational until the 2020s, there are no other large-scale CCS projects at any stage of development.⁶

Australia has only ever had two small ‘operational’ carbon capture projects at coal-fired power plants. Callide-A, a demonstration operated by CS Energy and heavily subsidised by government and industry, successfully captured small volumes of CO₂ but there was no place to store the carbon once it was captured. A pilot plant at the Hazelwood brown coal plant captured an even smaller amount.

Asked about the Callide-A project in 2017, CS Energy CEO Martin Moore said:

We proved that technologically it’s possible to retrofit [CCS] to existing coal-fired plants, but commercially, the numbers don’t stack up ... It’s unlikely there

⁵ Ferguson (2009) *Malcolm and the malcontents*,
<http://www.abc.net.au/4corners/content/2009/s2737676.htm>

⁶ Global CCS Institute (n.d.) *Large scale CCS projects*, <https://www.globalccsinstitute.com/projects/large-scale-ccs-projects>

will be [a commercial operation for CCS in Australia], I think that technology may well be bypassed ... simply because of the economics.⁷

This track record is all the more remarkable given Australia's disproportionately large focus on CCS compared with other countries. From 2009 to 2015, Australia spent more of its energy RD&D budget on CCS than nearly every other country in the OECD.

CCS has also struggled internationally. There are only 16 large-scale CCS facilities operating globally and only two involve coal. Both sell their captured CO₂ for enhanced oil recovery. Neither can be considered 'near-zero emissions'.

In 2016 the International Energy Agency emphasised that *if* CCS is commercialised, it will then need a stable and substantial carbon price, or regulatory mandates, in order to be successful. Advocates for CCS have consistently identified a price on carbon as necessary. The first chief executive of Australia's Global CCS Institute, Nick Otter, said:

In order to get the CCS deployed, ultimately you're going to need a carbon price. In the end, the big driver will be a good, strong carbon price.⁸

There are other barriers. According to CO₂CRC, a CCS research group, by 2030 coal with CCS will be far more expensive than most renewables, and more expensive than gas with CCS. Investors are unlikely to choose the most expensive way to use CCS.

Moreover, coal with CCS is less flexible than solar thermal with storage and hydro-electric, further reducing its competitiveness in an increasingly variable grid.

Despite successive government's CCS expenditure, there are few large-scale, currently-operating CCS projects worldwide, none in Australia, and no plans for large-scale coal with CCS. The company that ran Australia's biggest carbon capture demonstration says it is unlikely it will ever be commercial. It is less flexible than other energy sources, is likely to be more expensive than about every other energy source – including gas with CCS – and it needs a carbon price, which is not being proposed.

In short, the Turnbull government's idea to direct the CEFC to fund coal with CCS is a uniquely poor one. It would redirect funds from commercial or near-commercial clean energy towards a technology that remains virtually non-existent in Australia, despite

⁷ Cooper (2017) *No more coal-fired power stations will be built in Australia, Queensland provider CS Energy says*, <http://www.abc.net.au/news/2017-02-16/coal-power-generator-says-new-plants-not-viable/8277210>

⁸ Kirkland (2010) *Can Australia afford carbon capture and storage for coal?*, <https://www.scientificamerican.com/article/can-australia-afford-carbon/>

substantial government support. Australians should ask: is it time to stop throwing good money after bad?

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Introduction

Over the past two decades, successive federal and state Australian governments from both major parties have held up carbon capture and storage (CCS) as the future for the coal industry in a world that is tackling climate change. In CCS, carbon dioxide (CO₂) emissions from an industrial source, such as a power plant, are captured and stored indefinitely, typically underground.

Government promises about CCS have been backed with substantial government funding. The coal industry has been similarly enthusiastic, although it has provided a much smaller share of the funding. Despite the promises and the large amount of money spent, CCS is still far from commercial viability and uptake. There are very few large-scale CCS projects in operation worldwide (capturing hundreds of thousands or millions of tonnes of CO₂ per annum),⁹ fewer still are capturing emissions from coal-fired power plants, and none of these are in Australia.¹⁰

The Turnbull government is now proposing support for CCS and other coal technologies via the Clean Energy Finance Corporation (CEFC). This government-owned corporation invests in renewables and other clean energy projects.

This paper enumerates federal government and industry spending on CCS since 2003, especially coal with CCS, and puts it in the context of spending from comparable countries. It compares this spending against the record of CCS projects in Australia and worldwide. The poor track record for CCS projects provides little support for the government's proposal to divert money from commercially-viable renewables towards coal with CCS. Despite two decades of promises, there are few CCS projects in operation and the technology remains very expensive. By contrast, renewables are booming and costs are falling rapidly.

⁹ The Global CCS Institute's current threshold for "large-scale" is 400,000 tonnes per annum, or 800,000 tonnes per annum for a coal plant, although at one point it used a one million tonnes per annum threshold. Global CCS Institute (n.d.) *Large-scale CCS projects – definitions*, <http://www.globalccsinstitute.com/projects/large-scale-ccs-projects-definitions>; Global CCS Institute (n.d.) *G8 objective*, <https://hub.globalccsinstitute.com/publications/strategic-analysis-global-status-carbon-capture-storage-report-5/12-g8-objective>

¹⁰ Global CCS Institute (n.d.) *Large scale CCS projects*

A long history of broken promises

The term ‘clean coal’ was first used to market the relatively low impurities of some of Australia’s coal, in the context of concerns about local health impacts from burning coal. The term was soon used to refer to CCS, in the context of climate change.

In a 1998 speech to the Australian Coal Association, Resources and Energy Minister Warwick Parer highlighted “new advanced clean coal technologies” other than increasing efficiency, and warned that failure to deploy these technologies “could effectively exclude coal as a viable energy source post 2010” as the world started to tackle climate change.¹¹ Ministers subsequently turned this warning around, arguing that unless CCS could be made to work, the world would not successfully tackle climate change.

In 2003, the Howard government founded the CO₂ Cooperative Research Centre (CO₂CRC), a university-based initiative working on CCS. The next year, it set up the \$500 million Low Emission Technology Demonstration Fund (LETDF) to encourage industry to reduce greenhouse gas emissions.

In 2007, then-Environment Minister Malcolm Turnbull announced the LETDF’s final grant: \$100 million to HRL Ltd’s coal gasification plant at Loy Yang, which would be “suitable for” CCS. Turnbull said “Projects like this one ... will play an integral role in helping to reduce emissions in Australia”.¹² Five years later, the grant was withdrawn. HRL Ltd and its associated entities have since been liquidated.¹³

Kevin Rudd’s victory in the 2007 election resulted in a boom for CCS spending, with billions of dollars committed through various bodies. These included the CCS Flagships program and the National Low Emission Coal Initiative, both intended to support industry and research projects. The Global CCS Institute was to attract international funding and find global solutions for CCS, but has achieved neither.

¹¹ Cited in Pierce, McKnight, Burton (2013) *Big Coal*, p158

¹² Macfarlane and Turnbull (2007) *Additional \$100 million boost to clean coal*, <https://www.environment.gov.au/minister/archive/env/2007/pubs/mr12mar07.pdf>

¹³ Environment Victoria (n.d.) *How the community stopped a coal-fired power station*, <http://environmentvictoria.org.au/how-the-community-stopped-a-coal-fired-power-station-a-timeline/>; ASIC (2016) Notice of deemed special resolution to wind up a company, <https://insolvencynotices.asic.gov.au/browsesearch-notices/notice-details/Dual-Gas-Pty-Ltd-117102244/5cfbb2fa-db25-4f99-af4d-5706356c3502>

Rudd's enthusiasm for CCS was echoed by the coal industry. Ralph Hillman, head of the Australian Coal Association, announced that we will "have commercial scale demonstration plants with carbon capture and storage in operation in Australia by 2015", a commitment that has "the whole G8 behind it".¹⁴

Treasury Research into the carbon price in 2011 argued there could be a role for CCS, but found it would be modest. The modelling predicting that without CCS domestic emissions would be higher by about 25 million tonnes per annum in 2050.¹⁵ Australia's emissions are currently about 550 million tonnes per annum, so CCS was projected to reduce emissions by less than 5%. Moreover, the modelling predicted that it would mostly be gas, not coal, that would have CCS deployed.

At the time, the Coalition was highly sceptical. Then-Coalition climate change spokesperson Ian Macfarlane (now head of the Queensland Resources Council), said:

The reality is, you are not going to see another coal fired power station built in Australia. That's, that's a simple fact. You can talk about all the stuff you like about carbon capture storage, that concept will not materialise for 20 years, and probably never.¹⁶

As problems mounted in the CCS programs, successive Labor budgets pared back CCS funding. The Abbott government also substantially cut CCS funding, although it introduced its own CCS initiative in 2015.¹⁷

Now the Turnbull government is showing enthusiasm for CCS not seen since the Rudd government. In February 2017, Malcolm Turnbull said that as the world's largest coal exporter, Australia has a 'vested interest' in promoting clean coal. He lamented that:

We've invested \$590 million since 2009 in clean coal technology research and demonstration and yet we do not have one modern high-efficiency low-emissions coal-fired power station, let alone one with carbon capture and storage.¹⁸

¹⁴ Jones (2009) *Ralph Hillman and Richard Denniss join Lateline*,
<http://www.abc.net.au/lateline/content/2008/s2575402.htm>

¹⁵ Commonwealth of Australia (2011) *Strong growth, low pollution*, pp 113, 120

¹⁶ Ferguson (2009) *Malcolm and the malcontents*,
<http://www.abc.net.au/4corners/content/2009/s2737676.htm>

¹⁷ Macfarlane (2015) *New support for carbon capture and storage R&D*,
<http://www.minister.industry.gov.au/ministers/macfarlane/media-releases/new-support-carbon-capture-and-storage-rd>

¹⁸ Turnbull (2017) *Address at the National Press Club and Q&A*,
<http://malcolmturnbull.com.au/media/address-at-the-national-press-club-and-qa-canberra>

Unlike the Rudd government's programs, which were drawn from general revenue, the Turnbull government would apparently fund CCS with money intended for renewables and energy efficiency.

Greg Evans of the Minerals Council of Australia, said in early 2017 that we are in "pretty early days" with regards to CCS, which is "an evolving technology". Evans stressed that any proposals to build a CCS coal plant in Australia "are currently being costed" and there are "no precise figures at this stage" on how much it would cost to implement in Australia.¹⁹ Evans' reserved comments about CCS stand in stark contrast to Hillman's enthusiastic predictions in 2009, when he said the technology would be commercially operational by 2015.

The last eight years have been extremely unrewarding for CCS. That is despite hundreds of millions of dollars of support, big promises it, and warnings of the need to make CCS work – whether for the climate or for the coal industry.

¹⁹ Sky News (2017) *PM Agenda*, <https://twitter.com/SkyNewsAust/status/833553271503466496>

Federal spending on CCS

The Australia government has spent substantial volumes of public funds on CCS over the last fifteen years, but has little to show for it.

The government has committed over \$3.5 billion since 2003. Much of this has been either clawed back in later budgets, or returned by cancelled and failed projects. Nonetheless, since 2003 taxpayers have contributed over \$1.3 billion towards CCS initiatives. These initiatives are identified in Table 1, which outlines commitments and identified expenditure for CCS projects.

Table 1 Federal government CCS initiatives

Initiative	Scope	Lifetime	Federal funding Committed (\$m)	Distributed or to be distributed (\$m)
CO2CRC	CCS	2003–present	\$75	\$75 ²⁰
Low Emission Technology Demonstration Fund	Mostly CCS or CCS-compatible	2004–?	\$500	≤\$260–\$410 ²¹
Asia-Pacific Partnership on Clean Development and Climate	25% to renewables; CCS' share unclear	2006–2011	>\$0–\$75	\$0–\$75 ²²

²⁰ Figures include \$25 million from CCS Flagships in 2015, deducted from the overall totals to avoid double counting. Taylor (2012) *Coal hard light of day for dud scheme*; medianet (2015) *Australian Government injects \$25 million into CO2 capture & storage research*, <http://www.medianet.com.au/releases/release-details/?id=820598>

²¹ At least two projects, with federal grants worth a total of \$150 million, had their grants withdrawn. It is not clear if some or all of the grant money was recovered. Parliament of Australia (2005) *\$500m low emissions technology fund takes final shape*, <http://parlinfo.aph.gov.au/parlInfo/search/display/display.w3p;query=Id%3A%22media%2Fpressrel%2F1K8G6%22>; Macfarlane and Turnbull (2007) *Additional \$100 million boost to clean coal*; Environment Victoria (n.d.) *How the community stopped a coal-fired power station: A timeline*, <http://environmentvictoria.org.au/how-the-community-stopped-a-coal-fired-power-station-a-timeline/>; Department of Industry (2011) *Low Emission Technology Demonstration Fund (LETDF) Round 1*, http://www.industry.gov.au/Energy/Documents/energy-programs/REVISED_LETDF_Funded_projects_30_May_2011.doc

²² Australia contributed \$100 million, of which 25% was reserved for renewables. CCS' share is therefore some portion of \$75 million. Fyfe (2006) *\$445m for cleaner energy, but it won't stop climate change*, <http://www.theage.com.au/news/national/445m-for-cleaner-energy/2006/01/12/1136956302252.html>

National Low Emissions Coal Initiative	CCS or CCS-compatible	2008–?	\$500	\$343–\$370 ²³
Global CCS Institute	CCS	2009–present	\$400	\$305 ²⁴
CCS Flagships	CCS	2009–present	\$2,000	\$271–\$299 ²⁵
CCS RD&D	CCS	2015–2016	\$25	\$24 ²⁶
Geoscience Australia’s National CO2 Infrastructure Plan	CCS; note that GA also works on CCS using its regular funding	2012–2016	\$61	\$61 ²⁷
Totals			\$3,536–\$3,611	\$1,341–\$1,594

Notes: This is data as reported. These numbers are indicative only. The figures have not been adjusted for inflation.

The totals account for \$25 million paid to CO2CRC by CCS Flagships, and \$27 million taken out of CCS Flagships and NLECI without indication of what share was taken from each fund.

Note this includes all CCS – not simply coal with CCS. As discussed below, coal with CCS is a small part of the CCS story.

²³ \$27.4 million was cut from NLECI and CCS Flagships in the 2016 budget. It is not clear what share came from each fund. Alexander (2008) *\$500m to set up coal emissions bodies*, <http://www.smh.com.au/national/500m-to-set-up-coal-emissions-bodies-20080728-3lyn.html>; Australian Government (2009) *Carbon Capture and Storage Flagships*, http://www.budget.gov.au/2009-10/content/glossy/infrastructure/html/infrastructure_overview_30.htm; Department of Resources, Energy and Tourism (2012) *National Low Emissions Coal Initiative (NLECI)* [recovered from Internet Archive], https://web.archive.org/web/20120320171643/http://www.ret.gov.au/resources/resources_programs/nleci/Pages/NationalLowEmissionsCoalInitiative.aspx; Australian Government (2016) *Budget Part 2: Expense Measures*, http://budget.gov.au/2016-17/content/bp2/html/bp2_expense-17.htm

²⁴ Taylor (2012) *Coal hard light of day for dud scheme*

²⁵ \$27.4 million was cut from NLECI and CCS Flagships in the 2016 budget. It is not clear what share came from each fund. Australian Government (2009) *Budget Part 2: Expense Measures*; Australian Government (2010) *Budget Part 2: Expense Measures (continued)*; Australian Government (2011) *Budget Part 2: Expense Measures (continued)*; Australian Government (2013) *Budget Part 2: Expense Measures (continued)*; Australian Government (2013) *MYEFO Appendix A: Policy decisions taken since the 2013–14 Budget (continued)*; Australian Government (2014) *Budget Part 2: Expense measures (continued)*; Australian Government (2016) *Budget Part 2: Expense Measures (continued)*

²⁶ Department of Industry (n.d.) *Carbon Capture and Storage Research Development & Demonstration Fund*, <https://industry.gov.au/resource/LowEmissionsFossilFuelTech/Pages/Carbon-Capture-and-Storage-Research-Development-Demonstration-Fund.aspx>; Canavan (2016) *\$23.7 million for carbon capture and storage*, <http://www.minister.industry.gov.au/ministers/canavan/media-releases/237-million-carbon-capture-and-storage>

²⁷ Australian Government (2011) *Budget Part 2: Expense measures (continued)*

The Low Emission Technology Demonstration Fund, set up by the Howard government, committed \$410 million to six projects. Four of these were CCS or CCS-related. Four of the projects were cancelled or went into administration, including two of the CCS-related projects.

The trifecta of funds established by the Rudd government – the Global CCS Institute, CCS Flagships and the National Low Emission Coal Initiative – struggled to identify and fund successful CCS projects.

CCS Flagships was announced with an initial commitment of \$2.0 billion. This was cut in almost every successive budget, to under \$300 million as of the 2016 budget. CCS Flagships ended up supporting only two projects: the CarbonNet Project and the South West Hub Project. Projects supported by CCS Flagships were initially expected to be operational by 2015.²⁸ Instead, both projects now have start dates in the 2020s.

The National Low Emission Coal Initiative was allocated \$500 million, of which it committed about \$370 million to several coal with CCS and related coal projects. These included the:

- Wandoan project (cancelled),
- a NSW coal capture project (not found),
- the Hazelwood 2030 project (cancelled) and
- Callide-A (successfully captured CO₂ but could not store it).²⁹

The initiative also funded a number of research programs and plans.

The Global CCS Institute was allocated \$400 million, with the expectation that other countries would contribute. In practice, 99% of the institute's funding came from the Australian government.

The fund attracted considerable controversy over its priorities. It spent \$31 million on projects in other countries, including \$18 million on four US and Canadian projects (all cancelled). The fund spent \$54 million on “operational expenses” in its first two years

²⁸ Department of Resources, Energy and Tourism (n.d.) *CCS Flagship program: Information for applicants to support project nominations*

²⁹ The descriptions on the project's webpage are general in nature. If they do not describe the Wandoan project and the Hazelwood 2030 project, then they describe other projects that are also not operating: Department of Industry, Innovation and Science (n.d.) *National Low Emission Coal Initiative*, <https://industry.gov.au/resource/LowEmissionsFossilFuelTech/Pages/National-Low-Emission-Coal-Initiative.aspx> ; Department of Resources, Energy and Tourism (n.d.) *National Low Emissions Coal Initiative (NLECI)* [recovered from Internet Archive], https://web.archive.org/web/20120320171643/http://www.ret.gov.au/resources/resources_program/nleci/Pages/NationalLowEmissionsCoalInitiative.aspx

(2009–2010), compared with \$6 million spent on Australian projects in its first four years. The institute also gave over \$50 million to the Asian Development Bank, the IEA and the Clinton Foundation.³⁰

In 2012, the institute's second chief executive, Brad Page, said that it is "actually impossible to spend that amount of money ... responsibly".³¹

While the Abbott government cut substantial funding from CCS projects, in 2015 it announced a \$25 million CCS Research Development and Demonstration Fund, which allocated \$24 million to seven applicants in 2016.

³⁰ Atkin (2014) *Cloud hangs over Rudd's clean coal vision*; Taylor (2012) *Coal hard light of day for dud scheme*

³¹ Taylor (2012) *Coal hard light of day for dud scheme*

Industry spending on CCS

In 2004, the coal industry established Coal21. This was intended to grow to a \$1 billion fund for clean coal R&D, paid for by a voluntary levy on the black coal industry. The levy was deductible against royalties in some states. Individual companies have also paid for part of the CCS projects that they own and operate, but industry does not appear to collect and collate this information.

The fund was expected to match federal and state contributions. Ralph Hillman, head of the Australian Coal Association, said in 2009:

the [Commonwealth] Government's actually picking up about a third of the cost. It does it on the basis of a Commonwealth a third, the state a third and industry a third.³²

This does not appear to have occurred. The federal government's contribution to CCS exceeds a billion dollars, while Coal21 has stalled at about \$300 million committed after industry's four-year freeze on the levy.³³ In addition, since the Coal21 voluntary levy is deductible against mining royalties in some states,³⁴ it has ultimately been funded by the taxpayer in those states.

By 2014, the fund had spent \$250 million and a further \$46 million of grants were under assessment.³⁵ In October 2015, when the Coal21 site was last updated, there were 13 projects with \$301 million committed. Ten of these, with about \$270 million of commitments, involved CCS.³⁶

³² Jones (2009) *Ralph Hillman and Richard Denniss join Lateline*

³³ Taylor (2014) *Carbon capture and storage research budget slashed despite PM's coal focus*; Long (2017) *Pre-election coal advertising funded by money meant for clean coal research*, <http://www.abc.net.au/news/2017-02-20/coal-advertising-funded-by-money-meant-for-clean-coal-research/8287326>

³⁴ See for example: Queensland Treasury (2015) *Determination of coal royalty*, <https://www.treasury.qld.gov.au/taxes-royalties-grants/royalties/mra001.php>

³⁵ Taylor (2014) *Carbon capture and storage research budget slashed despite PM's coal focus*

³⁶ Minerals Council of Australia (n.d.) *Coal21*, http://www.minerals.org.au/resources/coal21/about_coal21

In 2013, Coal21's mandate was quietly changed to allow the fund to also "promote the use of coal".³⁷ Recently it was revealed that the publicly subsidised fund was used during the 2016 election campaign to fund \$2.5 million of 'clean coal' advertising.³⁸

Coal21 has not delivered working commercial-scale CCS nor has it matched federal government spending, as promised by Hillman in 2009. The fund, which is at least partly funded by deductions from royalty payments, has not expanded its commitment since 2014 – but has funded advertising to promote clean coal.

³⁷ Taylor (2014) *Carbon capture and storage research budget slashed despite PM's coal focus*; Brewster (2013) *'Clean coal' money used to promote coal use*, <http://www.abc.net.au/lateline/content/2013/s3787338.htm>

³⁸ Long (2017) *Pre-election coal advertising funded by money meant for clean coal research*

Australia has spent disproportionately on CCS

Australia's government is not the only government to spend public money on CCS, but it has spent more than most.

Since 2007, total global CCS investment has been less than US\$20 billion.³⁹ Australia's federal spending of over \$1.3 billion represents about 5% of the world's total expenditure on this technology. That is much higher than Australia's share of global population (0.3%) or of GDP (1%).

The IEA reports data on government spending on energy research, development and deployment, as reported by OECD members. Australia has spent more of its energy RD&D budget on CCS than nearly every other country, putting it first or second in the OECD every year between 2009 and 2015, peaking at 44% in 2012, with an annual average of 28%. In 2015, the last reported year, this fell to 19%.

The Australian federal government was responsible for an annual average of 13% of all OECD spending over this period.

By comparison, the US is responsible for between 16% and 48% of world CCS RD&D spend in various years, but this is just 3 to 5% of the total US energy RD&D spend; they also spent substantial amounts on other technologies.⁴⁰

In February 2017, IEA head Fatih Birol said that for CCS to succeed, "there is a need for a greater initiative from countries, maybe such as Australia and others".⁴¹ In fact, Australia has already punched well above its weight – with little to show for it.

³⁹ Macdonald-Smith (2015) *Carbon capture and storage needs government support: industry*, <http://www.smh.com.au/business/energy/carbon-capture-and-storage-needs-government-support-industry-20151105-gkrfxa.html>

⁴⁰ Calculations by The Australia Institute, based on: IEA (2015) *Energy Technology RD&D Statistics*, http://www.oecd-ilibrary.org/energy/data/iea-energy-technology-r-d-statistics/rd-d-budget_data-00488-en

⁴¹ Ferguson (2017) *IEA calls on Australia to lead world in carbon capture and storage technology*, <http://www.abc.net.au/news/2017-02-22/international-body-says-australia-should-be-clean-coal-leader/8294312>

Projects in Australia

There are no large-scale CCS operations anywhere in Australia, despite the Australian government having spent over a billion dollars on a plethora of projects, partnerships and institutes.

Identified CCS projects in Australia, their cost and their status are outlined in Table 2.

Table 2 CCS projects in Australia

Name	Proponent	Cost (\$m)	Funding (\$m)	Scope	Outcome
Large-scale CCS projects					
Gorgon CO₂ Injection Project	Chevron	\$2,000	\$60 (federal)	Gas extraction CCS	Ready, not operational ⁴²
ZeroGen	Qld government	\$4,300 (planned)	\$103–116 (Qld) \$39–48 (fed) \$41–50 (Coal21)	Coal with CCS	Cancelled
Wandoan IGCC Plant	Xstrata/Glencore	?	\$8–50 (federal) \$7 (Coal21)	Coal with CCS	Cancelled
Hazelwood 2030	International Power/Engie	\$369	\$30m, withdrawn (Vic) \$50, withdrawn (federal)	Coal with CCS	Cancelled
IGCC Clean Coal Demonstration	HRL Ltd	\$750	\$50 (Vic) \$100 (federal)	Coal “suitable for” CCS	Cancelled
Large-scale storage projects					
Surat Basin	CTSCo (Glencore)	?	\$9 (federal) \$24 (Coal21)	Carbon storage	Ongoing
CarbonNet	Vic government	?	\$30 (Vic) \$72 (federal)	Carbon storage	Ongoing
South West Hub	WA government	?	\$55 (federal)	Carbon storage	Ongoing
Demonstration projects					
Callide-A	CS Energy	\$245	\$10m (Qld) ? (Japan) \$63–65 (fed) \$83 (Coal21)	Coal with capture (no storage)	Completed, not operational
Otway Research Facility	CO ₂ CRC	\$60	\$5 (Vic) \$25 (federal) \$10 (Coal21)	CCS	Operational
Hazelwood Carbon Capture Pilot Plant	Engie	\$10	?	CCS	Completed, not operational

⁴² Commissioned and started-up, with CO₂ compressors expected to be operated in early 2017 when they are needed. Global CCS Institute (n.d.) *Gorgon Carbon Dioxide Injection Project*, <https://www.globalccsinstitute.com/projects/gorgon-carbon-dioxide-injection-project>

Australia has only ever had one ‘operational’ carbon capture project at a black coal power plant: Callide-A, a small demonstration plant. While this plant successfully captured carbon, the volumes were small and required a very large subsidy, and the operator could not find a place to store it. A brown coal demonstration, the Hazelwood Carbon Capture and Mineral Sequestration Pilot Plant, also operated but was even smaller.

As shown in Table 2, there is one large-scale CCS project operational or ready to operate: the Gorgon CO₂ Injection Project. This project will store CO₂ separated from gas during the extraction and purification process.

There are three carbon storage projects underway:

- CarbonNet,
- the South West Hub project, and
- a nascent Surat Basin feasibility study.

These projects are looking for sites that could take and safely store millions of tonnes of CO₂ per year. If the two most advanced projects are successful, they would allow for the storing of 1.8–11 tonnes of CO₂ per annum. This represents 0.3–2% of Australia’s annual emissions. They are not expected to be operational until the 2020s.

Australia also has one non-commercial demonstration project, the Otway project, which is successfully capturing and storing a small volume of CO₂.

There are a number of CCS projects that failed, despite government subsidies, including:

- ZeroGen is the most prominent and expensive, but others include
- HRL Ltd’s coal gasification plant,
- International Power’s Hazelwood 2030 project and
- CTSCo’s Wandoan coal gasification plant,

There are no other Australian large-scale CCS projects at any stage of development, even the most remote “identify” stage, as classified by the Global CCS Institute.⁴³

The following sections outline some of these projects, showing the great difficulties involved in getting CCS to work.

⁴³ Global CCS Institute (n.d.) *Large scale CCS projects*

ZEROGEN (ZERO RESULTS)

The ZeroGen project was a plan to build a \$4.3 billion, 530 MW IGCC coal power plant in central Queensland, with the “longer term potential” for CCS to capture 2 million tonnes of CO₂ per annum.⁴⁴

The bulk of the project funding was spent trying to identify a storage location for captured CO₂. ZeroGen spent four years and \$90 million exploring and appraising the Denison Trough, finding it “unsuitable for large scale commercial storage”. Having failed in Denison, ZeroGen had its eye on two “undiscovered, un-risked resources” – the Galilee Basin and the Surat Basin. A \$300 million pipeline would have been required to transport the CO₂ to either basin.⁴⁵

The project went into administration in October 2011, despite having received \$183–214 million from the federal government’s NLECI fund, the industry Coal21 fund and from the Queensland government (including \$6 million transferred to the Australian Coal Association after the project’s collapse).⁴⁶ The Queensland government had earmarked a further \$200 million for the project.⁴⁷

The Minerals Council of Australia website describes ZeroGen as a “completed” “feasibility study”.⁴⁸ The Minerals Council is correct: ZeroGen’s failure shows that coal with CCS is not feasible in Australia, and suggests it will not be for some time, if ever.

CALLIDE-A

The Callide-A Oxy-firing Demonstration, built by CS Energy, has the distinction of being Australia’s only successful carbon capture from a black coal-fired generator.

⁴⁴ Bonney (2010) *ZeroGen Project: Low emissions coal fired power with carbon storage*, p 3, <https://www.engineersaustralia.org.au/sites/default/files/shado/Divisions/South%20Australia%20Division/Resources/Groups/ZeroGen%20-%20EESA%2014th%20July%202010.pdf>; ZeroCO₂ (n.d.) *ZeroGen*, <http://www.zeroco2.no/projects/zerogen>; Minerals Council of Australia (n.d.) *Coal21*; MIT Carbon Capture and Sequestration Technologies (2016) *ZeroGen fact sheet*, <https://sequestration.mit.edu/tools/projects/zerogen.html>

⁴⁵ Bonney (2010) *ZeroGen Project: Low emissions coal fired power with carbon storage*

⁴⁶ Lion (2011) *Anna Bligh’s team wastes another \$116m on controversial ZeroGen clean-coal debacle*, <http://www.couriermail.com.au/news/queensland/clean-coal-plan-goes-to-zero/news-story/1e99a6d01bdecaa62bc34ac1273da6cd?nk=2e467983dd127e480f2d57a43e72fd20-1487559359>; MIT Carbon Capture and Sequestration Technologies (2016) *ZeroGen fact sheet*; Minerals Council of Australia (n.d.) *Coal21*

⁴⁷ MIT Carbon Capture and Sequestration Technologies (2016) *ZeroGen fact sheet*

⁴⁸ Minerals Council of Australia (n.d.) *Coal21*

The project, which cost \$245 million, was never expected to be profitable. It received in-kind support from Japanese industry, and funding from the Queensland state government, the Japanese government, the Coal21 fund and two to four different federal government programs. These subsidies dwarf the project's expected revenue of \$18 million.⁴⁹

The demonstration project operated for two years and nine months and achieved a "partial capture" of 75 tonnes of CO₂ per day (27,300 tonnes per annum), but storage for the captured CO₂ could not be found. Eight potential storage sites were examined but were unsuitable because of location, availability and geological profile.⁵⁰

Chief executive of CS Energy, Martin Moore, said in 2017 on ABC 730:

We proved that technologically it's possible to retrofit [CCS] to existing coal-fired plants, but commercially, the numbers don't stack up ... It's unlikely there will be [a commercial operation for CCS in Australia], I think that technology may well be bypassed ... simply because of the economics. ... If you could decarbonise coal by capturing and sequestering the emissions, then you'd have clean coal. It sounds easy if you say it fast enough, but it's not that simple.⁵¹

⁴⁹ About \$50 or \$60 million of funding is attributed to the LETDF by MIT, but NLECI also says it distributed about that much to the project, and media reports the project received an unspecified amount of funding from CCS Flagships. It is not clear if one grant has been wrongly attributed to multiple funds, or if multiple funds contributed to the project. The Global CCS Institute also provided \$2 million. Oxyfuel Technologies (2016) *The Callide Oxyfuel Project*, p 24, http://www.callideoxyfuel.com/Portals/0/Callide_Oxyfuel_Project_Legacy_Publication.pdf; CS Energy (2015) *Callide Oxyfuel Legacy* (video), <https://www.youtube.com/watch?v=tIP4dIZ0BxQ>; Asia-Pacific Partnership on Clean Development and Climate (n.d.) *Callide-A Oxy-Fuel Demonstration Project*, <http://www.asiapacificpartnership.org/pdf/Projects/CFETF/CPD/CFE-06-05.pdf>; Greig, Bongers, Stott and Byrom (2016) *Overview of CCS roadmaps and projects*, http://www.co2crc.com.au/wp-content/uploads/2017/02/WP3_CCS-Roadmaps-and-Projects.pdf; MIT Carbon Capture and Sequestration Technologies (2016) *Callide-A Oxyfuel fact sheet*, https://sequestration.mit.edu/tools/projects/callide_a_oxyfuel.html; CS Energy (n.d.) *Callide Oxyfuel Project*, [http://www.csenergy.com.au/content-\(91\)-callideoxyfuelproject.htm](http://www.csenergy.com.au/content-(91)-callideoxyfuelproject.htm); Department of Resources, Energy and Tourism (n.d.) *National Low Emissions Coal Initiative (NLECI)* [recovered from Internet Archive]; Rollo (2014) *Budget not expected to impact carbon capture plant*, <http://www.abc.net.au/news/2014-05-16/budget-not-expected-to-impact-carbon-capture-plant/5456858>

⁵⁰ Greig, Bongers, Stott and Byrom (2016) *Overview of CCS roadmaps and projects*, p 16; MIT Carbon Capture and Sequestration Technologies (2016) *Callide-A Oxyfuel fact sheet*

⁵¹ Cooper (2017) *No more coal-fired power stations will be built in Australia, Queensland provider CS Energy says*, <http://www.abc.net.au/news/2017-02-16/coal-power-generator-says-new-plants-not-viable/8277210>

CS Energy, the only company to demonstrate carbon capture on a black coal plant in Australia, does not have faith in the commercial viability of CCS.

SURAT BASIN INTEGRATED CCS PROJECT

Storage in the Surat Basin was originally considered in conjunction with Glencore's Wandoan coal gasification plant. Although the Wandoan project has been cancelled, CTSCo continues to consider the suitability of the basin for carbon storage. To this effect, it has received \$8 million in federal and \$24 million in Coal21 funding for pre-feasibility and feasibility studies, and a University of Queensland appraisal of the Surat Basin received a further \$6 million of federal funding.⁵²

Although the feasibility study is still ongoing, CTSCo anticipates that the demonstration project will have first storage of CO₂ by 2020–2021.⁵³

CARBONNET PROJECT

The CarbonNet Project is investigating the viability of storing 1–5 million tonnes of CO₂ per annum in the Gippsland region, from carbon captured from Latrobe Valley brown coal plants.⁵⁴

The project received \$102 million in federal and state funding.⁵⁵ As a CCS Flagships project, the CarbonNet Project was expected to be operating in 2015.⁵⁶ It has been in the “feasibility” stage since 2012 and now has an expected operation date of “2020’s”.⁵⁷

⁵² Minerals Council of Australia (n.d.) *Coal21*; Department of Industry (n.d.) *Carbon Capture and Storage Research Development and Demonstration Fund: Project descriptions*

⁵³ CTSCo (n.d.) *When*, <http://ctsco.com.au/when/>

⁵⁴ Victoria State Government (n.d.) *The CarbonNet Project*, <http://earthresources.vic.gov.au/earth-resources/victorias-earth-resources/carbon-storage/about-carbon-capture-and-storage/the-carbonnet-project>

⁵⁵ CO₂CRC (n.d.) *CCS projects in Australia*; Global CCS Institute (n.d.) *The CarbonNet Project: CCS flagship status*, <https://hub.globalccsinstitute.com/publications/carbonnet-project/carbonnet-project-ccs-flagship-status>; Victoria State Government (2012) *The Carbon Net Project* (brochure), <https://hub.globalccsinstitute.com/sites/default/files/publications/50856/carbonnet-corporate-brochure.pdf>

⁵⁶ Department of Resources, Energy and Tourism (n.d.) *CCS Flagship program: Information for applicants to support project nominations*

⁵⁷ Global CCS Institute (n.d.) *Large scale CCS projects*; Victoria State Government (2012) *The Carbon Net Project* (brochure); Victoria State Government (n.d.) *The CarbonNet Project – Current Stage*,

SOUTH WEST HUB PROJECT

The South West Hub Project in Perth aims to store 2 million tonnes of CO₂ annually, captured from industry and power plants. When the project was announced in 2009, it was an integrated project with six major CO₂ emitters in the region serving as joint venture partners. These partners pulled out in 2015.⁵⁸

The project has received \$55 million in federal funding.⁵⁹ It is still in the preparation phase, which was expected to conclude in 2013.⁶⁰ As a CCS Flagships project, the South West Hub was expected to be operating in 2015.⁶¹ It is now expected to be operational in 2025.⁶²

In October 2016, the project found with confidence that the site (the Lesueur) could have 0.8 million tonnes of CO₂ injected per annum. The researchers believe that the rate could be as high as 6 million tonnes per annum.⁶³

The Collie–South West region of Western Australia is a major industry hub that generates 25 million tonnes of CO₂ per annum,⁶⁴ so even 6 million tonnes successfully captured and stored per annum would represent less than a quarter of the region's

<http://earthresources.vic.gov.au/earth-resources/victorias-earth-resources/carbon-storage/about-carbon-capture-and-storage/the-carbonnet-project/why-we-need-the-carbonnet-project>

⁵⁸ The partners were Alcoa Australia, Griffin Energy Developments, Perdaman Chemicals and Fertilisers, Verve Electrical Generation Corporation and Premier Coal Limited: Government of Western Australia (2012) *South West CO₂ Geosequestration Hub*, p 2,

http://www.ceg.uwa.edu.au/data/assets/pdf_file/0008/2186846/South-West-Hub.pdf; Western Australia Department of Mines and Petroleum (2016) *The South West Hub Project: Developing a project in unconventional geology* (webinar), 31:45–33:30,

<http://www.globalccsinstitute.com/insights/authors/WebinarOrganiser/2016/06/09/south-west-hub-project-developing-project-unconventional-geology?author=MTc1OTM%3D>

⁵⁹ CO₂CRC (n.d.) *CCS projects in Australia*; the project is not explicitly named in this DOI announcement, but it fits the description: Department of Industry (n.d.) *Carbon Capture and Storage Research Development and Demonstration Fund: Project descriptions*

⁶⁰ Government of Western Australia (2012) *South West CO₂ Geosequestration Hub*, p 2,

http://www.ceg.uwa.edu.au/data/assets/pdf_file/0008/2186846/South-West-Hub.pdf

⁶¹ Department of Resources, Energy and Tourism (n.d.) *CCS Flagship program: Information for applicants to support project nominations*

⁶² Global CCS Institute (n.d.) *South West Hub*, <https://www.globalccsinstitute.com/projects/south-west-hub>

⁶³ Western Australia Department of Mines and Petroleum (2016) *The South West Hub Project: Developing a project in unconventional geology* (webinar), 29:40 onwards, 51:40 onwards, slides 30, 37

⁶⁴ Calder (2012) *How the carbon price works*, <https://www.slideshare.net/globalccs/wayne-calder-department-of-resources-energy-and-tourism-ccs-and-carbon-price-policy-in-australia/11-The-CollieSouth-West-Hub-Major>

emissions. The next-best site for CCS in Western Australia is 400 kilometres north of Perth, but there are no CO₂-generating industries in that area.⁶⁵

HAZELWOOD CARBON CAPTURE AND MINERAL SEQUESTRATION PILOT PLANT

From 2009 until an unspecified date, the Hazelwood Carbon Capture Pilot Plant captured about 25 tonnes per day of carbon from the flue gas of one of boiler at the Hazelwood brown coal power plant. This represents 9,000 tonnes per annum, or about one third of Callide-A's captured carbon. The captured CO₂ was used for water treatment, turning it into inert calcium carbonate.⁶⁶

The project received an unspecified amount of funding from the federal government's Low Emission Technology Demonstration Fund and the Victorian government.⁶⁷

Hazelwood power plant will close in March 2017.

OTWAY RESEARCH FACILITY

The Otway research facility (run by CO₂CRC in south-western Victoria) is Australia's only successful demonstration of the complete carbon capture and storage lifecycle, from production to geological storage. It cost \$60 million, of which at least \$40 million came from government and Coal21 funding, and successfully injected 80,000 tonnes of CO₂.⁶⁸

⁶⁵ Western Australia Department of Mines and Petroleum (2016) *The South West Hug Project: Developing a project in unconventional geology* (webinar), 29:40 onwards, 51:40 onwards, slides 30, 37

⁶⁶ Global CCS Institute (2011) *A look at the Latrobe Valley's carbon capture pilot plants*, <http://www.globalccsinstitute.com/insights/authors/petercoombes/2011/10/19/look-latrobe-valleys-carbon-capture-pilot-plants> ; Global CCS Institute (n.d.) *Hazelwood Carbon Capture and Mineral Sequestration Pilot Plant*, <https://www.globalccsinstitute.com/projects/hazelwood-carbon-capture-and-mineral-sequestration-pilot-plant>

⁶⁷ International Power (2009) *Hazelwood carbon capture project under way* [retrieved from Internet Archive], <https://web.archive.org/web/20110217051851/http://www.ipplc.com.au/uploads/2010/02/InternationalPowermrCCSlaunch080709.pdf>

⁶⁸ Minerals Council of Australia (n.d.) *Coal 21*; CO₂CRC (n.d.) *CCS projects in Australia*, <http://old.co2crc.com.au/research/ausprojects.html>; Victoria State Government (n.d.) *The CO₂CRC Otway Project*, <http://earthresources.vic.gov.au/earth-resources/victorias-earth-resources/carbon-storage/about-carbon-capture-and-storage/co2crc-otway-project>

Projects internationally

Across the world, completed and operational CCS projects are extremely rare. According to the Global CCS Institute, there are only 16 large-scale CCS facilities operating globally – and only two of these projects involve coal:

- Boundary Dam
- Petra Nova

In January 2017, the Global CCS Institute also identified Kemper County as “coming on-stream in the next few weeks”. If it does so, that will make three coal plants with CCS in the world.⁶⁹

The *Financial Times* reports that there are no other coal with CCS plants “on the horizon” in the US.⁷⁰

The final report of the MIT Carbon Capture and Sequestration Technologies program identified 43 “cancelled and inactive” projects – 32 of which were coal projects.⁷¹ The MIT program itself shut down in September 2016.

It is also worth mentioning that all three coal with CCS plants offset or expect to offset some of their costs by selling captured CO₂ for enhanced oil recovery.⁷² Oil recovered using sequestered CO₂ will itself be burned, contributing to global warming.

⁶⁹ Papaspiropoulos (2017) *On clean coal*, <https://www.crikey.com.au/2017/01/11/comments-entitlements-rorts/>; Global CCS Institute (n.d.) *Large scale CCS projects*

⁷⁰ Crooks (2017) *World’s biggest carbon capture project on schedule*, <https://www.ft.com/content/eee0d5d6-d700-11e6-944b-e7eb37a6aa8e>

⁷¹ The figure of 32 includes ZeroGen, wrongly listed as having a gas feedstock, and Swan Hills, with in situ coal gasification, but not the two petcoke projects: MIT Carbon Capture and Sequestration Technologies (2016) *Cancelled and inactive projects*, https://sequestration.mit.edu/tools/projects/index_cancelled.html

⁷² Burton (2014) *Is the Boundary Dam CCS plant in Canada really a success story?*, <http://reneweconomy.com.au/is-the-boundary-dam-ccs-plant-in-canada-really-a-success-story-32486/>; Irfan (2016) *World’s largest carbon-capture plant to open soon*, <https://www.scientificamerican.com/article/world-s-largest-carbon-capture-plant-to-open-soon/>; Kemper (n.d.) *Kemper FAQ*, <http://kemperproject.org/kemper-faq/>

BOUNDARY DAM

Boundary Dam in Canada is the first CCS project to operate commercially. It is an existing plant retrofitted for CCS. The project cost C\$1.5 billion, which Toohey notes is:

about three times the capital cost of a standard coal plant. It also has higher operating costs.⁷³

Owner Saskpower “feels they can cut capital costs 20–30% on the next unit”.⁷⁴ That would still make the plant over twice as expensive as standard coal.

PETRA NOVA

Unlike Boundary Dam and Kemper County, Petra Nova appears to have been built on time and to its budget. Its commercial viability relies on US\$190 million in government subsidies, and revenue from selling the captured CO₂ for use in recovering an additional 60 million barrels of oil from a nearby oil field.⁷⁵

KEMPER COUNTY

The Kemper County coal plant, was intended to be operational by 2014. Instead, in mid-2016, the *New York Times* wrote:

The Kemper coal plant is more than two years behind schedule and more than [US]\$4 billion over its initial budget, [US]\$2.4 billion, and it is still not operational.

The plant and its owner, Southern Company, are the focus of a Securities and Exchange Commission investigation, and ratepayers, alleging fraud, are suing the company. Members of Congress have described the project as more boondoggle than boon.⁷⁶

Two years ago, when the plant had cost just US\$5.2 billion, the Sierra Club has concluded that, per energy output, the Kemper County coal plant would be the most

⁷³ Toohey (2014) *Clean coal dream little more than dust*

⁷⁴ MIT Carbon Capture and Sequestration Technologies (2016) *Boundary Dam fact sheet*, https://sequestration.mit.edu/tools/projects/boundary_dam.html

⁷⁵ Irfan (2016) *World’s largest carbon-capture plant to open soon*, <https://www.scientificamerican.com/article/world-s-largest-carbon-capture-plant-to-open-soon/>

⁷⁶ Urbina (2016) *Piles of dirty secrets behind a model ‘clean coal’ project*, <https://www.nytimes.com/2016/07/05/science/kemper-coal-mississippi.html>

expensive power plant ever built, about six times more expensive than a gas plant of equivalent power.⁷⁷ It was due (after many other delays) to come online in January 2017, as its cost exceeded US\$7 billion, but it did not do so.⁷⁸

At the time of writing in March 2017, proponent Southern Company has released an economic viability study that found that burning coal at the Kemper County plant is not economically viable unless gas prices rise substantially.⁷⁹

⁷⁷ Drajem (2014) *Coal's best hope rising with costliest US power plant*, <https://www.bloomberg.com/news/articles/2014-04-14/coal-s-best-hope-rising-with-costliest-u-s-power-plant>

⁷⁸ Perez (2017) *Costs top \$7b, deadline extended as Kemper plant reaches milestone*, <http://www.sunherald.com/news/business/article129898054.html>

⁷⁹ Balch and Bingham LLP (2017) *2017 Kemper Economic Viability Analysis*, http://psc.state.ms.us/InsiteConnect/InSiteView.aspx?model=INSITE_CONNECT&queue=CTS_ARCHIVE_Q&docid=382134

Commercialisation

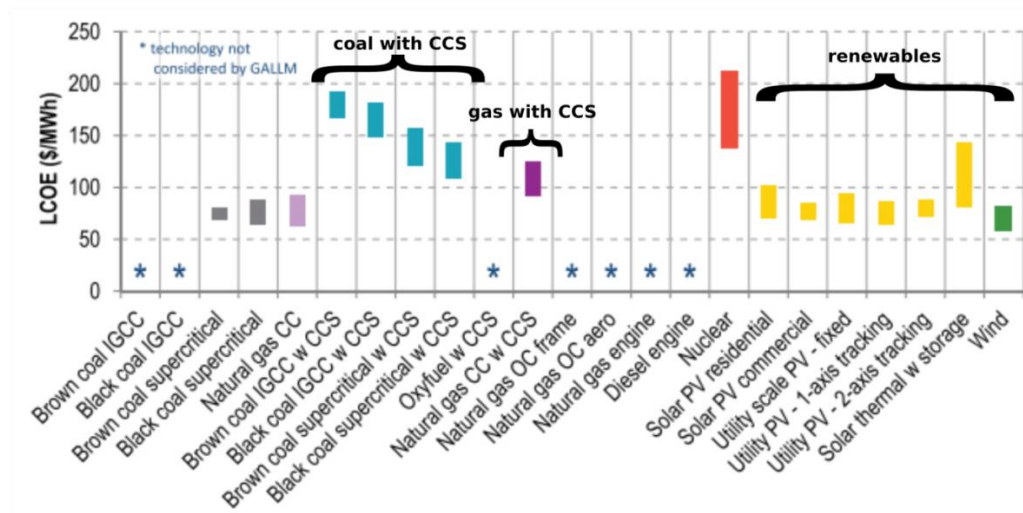
Coal with CCS faces challenges that may make it difficult to commercialise even if CCS can be implemented in Australia at scale.

PRICE AND RELIABILITY

The government has identified price and reliability as two areas where coal outperforms renewables.⁸⁰ While this may be true for coal without CCS, industry research shows that coal with CCS is as expensive or more expensive than renewables, and that solar thermal with storage and hydro-electric power are actually more flexible than coal with CCS, meaning they are better able to respond to the periods of peak demand that can cause price spikes and blackouts.

CO2CRC have presented their expected levelised cost of emissions for different power sources. By 2030, solar thermal will be at most about as expensive as the cheapest coal with CCS. Wind and solar PV also perform better:

Figure 2 2030 Levelised cost of electricity



Source: CO2CRC (2016) Australian power generation technology report, p v

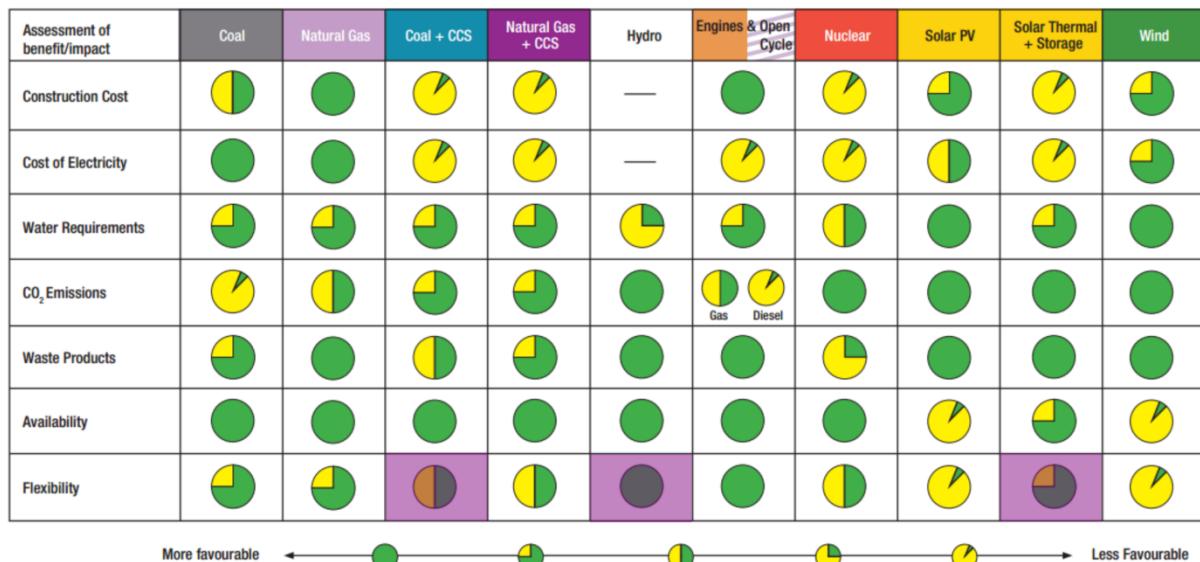
Note: Labels and braces added to make the figure easier to parse.

As well as outperforming CCS on cost, some renewables are also more reliable. A 2016 report from CO2CRC shows that two renewables – solar thermal with storage and

⁸⁰ For example, in the wake of the South Australian blackouts: Borrello (2017) *Josh Frydenberg flags changes to allow CEFC to invest in carbon capture and storage*

hydro-electric – are “more favourable” than coal with CCS in terms of flexibility in “increase[ing] or decreas[ing] output to meet changes in demand, to respond to changing output from other plants, and to respond to changing grid conditions”.⁸¹

Figure 3 Electricity technology comparisons



Source: CO2CRC (2016) *Australian power generation technology*, p 21

Note: Purple highlighting added to emphasise the flexibility ratings under consideration.

According to Australia’s premier CCS R&D organisation, coal with CCS is less capable of dealing with peaks in demand than solar thermal or hydro-electric power, and is more expensive than renewables. Given that, it is difficult to see what niche it would fill.

NEED FOR A CARBON PRICE

Advocates for CCS consistently identify a carbon price as necessary for CCS to be successful, and cited its absence as a reason that projects failed to be commercialised.

The first chief executive of the Global CCS Institute, Nick Otter, said it clearly:

[T]o get the CCS deployed, ultimately you're going to need a carbon price. In the end, the big driver will be a good, strong carbon price.⁸²

⁸¹ CO2CRC (2016) *Australian power generation technology report*, p 22, http://www.co2crc.com.au/wp-content/uploads/2016/04/LCOE_Report_final_web.pdf

⁸² Kirkland (2010) *Can Australia afford carbon capture and storage for coal?*, <https://www.scientificamerican.com/article/can-australia-afford-carbon/>

This has been repeated by numerous CCS proponents:

- The CEO of International Power, proponent of Hazelwood 2030, said €30–40/tonne was needed for CCS in Europe⁸³
- Queensland’s ZeroGen project was uncommercial on a figure of \$57/tonne⁸⁴
- TransAlta’s Pioneer Project, subsidised by the Global CCS Institute, was uncommercial at US\$30/tonne⁸⁵
- CO2CRC has said that a “carbon price alone will be too low”, and government will have to make up the gap⁸⁶
- At Callide-A, CO2CRC described the lack of GHG legislation as “a challenge”⁸⁷

The need for a carbon price was also clear in Treasury modelling that concluded that commercial uptake of CCS would “depend on the level of the carbon price in place”.⁸⁸

The same point has also been made by the IEA, which wrote in 2012 that “CCS is a high cost abatement option and will remain so in the short-term”.⁸⁹ In 2013 they added that “If CCS technology becomes fully proven at commercial scale”, widespread adoption will require “a stable economy-wide carbon price”, or other regulation.⁹⁰

Note however that the IEA does not consider CCS to be close to proven at commercial scale. This is well understood in the CCS sector in Australia. Dick Wells of the National Low Emissions Coal Initiative said that a carbon price alone would not drive CCS investment until the 2030s.⁹¹

⁸³ CO2CRC (2007) *CO2 futures* issue 5, p 4,

http://old.co2crc.com.au/dls/co2futures/CO2FUTURES_Issue_05.pdf

⁸⁴ 2010 dollars. Garnett, Greig and Oettinger (2014) *ZeroGen IGCC with CCS: A case history*, p 81,

<https://energy.uq.edu.au/files/1084/ZeroGen.pdf>

⁸⁵ TransAlta Corporation (2013) *Project Pioneer*, p 24,

<http://hub.globalccsinstitute.com/sites/default/files/publications/98046/project-pioneer-summary-report.pdf>

⁸⁶ Aldous (2011) *Carbon capture and storage – a vital part of our climate change response*

⁸⁷ Greig, Bongers, Stott and Byrom (2016) *Overview of CCS roadmaps and projects*

⁸⁸ Commonwealth of Australia (2011) *Strong growth, low pollution*, p 161

⁸⁹ International Energy Agency (2012) *A policy strategy for carbon capture and storage*, p 8,

https://www.iea.org/publications/freepublications/publication/policy_strategy_for_ccs.pdf

⁹⁰ International Energy Agency (2013) *Technology roadmap: Carbon capture and storage*, p 27,

<https://www.iea.org/publications/freepublications/publication/technologyroadmapcarboncaptureandstorage.pdf>

⁹¹ Wells (2012) *Dick Wells says clean coal will remain unviable for two decades*,

<http://www.abc.net.au/news/2012-02-15/dick-wells/3772184>

Conclusion

The Turnbull government is showing an enthusiasm for CCS not seen since the first Rudd government. Some have cynically suggested that “anything’s possible with a big enough subsidy”.

The troubled history of CCS in Australia suggests that the cynics could be wrong. CCS is so uncommercial that even the enormous subsidies of the last decade have mostly resulted in cancelled, failed and bankrupt projects.

Moreover, even if the technology could be demonstrated reliably at scale, the proponents of these projects consistently identify a high carbon price as being necessary for their commercial viability. Without such a price, any new projects will need an even greater subsidy from government. Meanwhile, the cost of renewables and storage continues to fall.

Prime Minister Turnbull put it well:

We've invested \$590 million since 2009 in clean coal technology research and demonstration and yet we do not have one modern high-efficiency low-emissions coal-fired power station, let alone one with carbon capture and storage.⁹²

\$590 million is a conservative figure. Spending more money on CCS because we have already lost so much would risk throwing good money after bad.

⁹² Turnbull (2017) *Address at the National Press Club and Q&A*,
<http://malcolmturnbull.com.au/media/address-at-the-national-press-club-and-qa-canberra>