Brief

Is CCS expensive?

Decarbonisation costs in the net-zero context

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1. Introduction

Transforming our energy, industrial, and transportation systems in line with climate targets and to reach net-zero emissions by mid-century is achievable. What matters is that we reduce emissions to net-zero through investment today that not only increases our chance of reaching climate goals but also aims to minimise the total cost it takes to get there. Carbon capture and storage (CCS) is needed as part of the toolkit of technologies to achieve net-zero by mid-century. Yet, texts and commentary about CCS often include qualifiers that are related to the expenditures necessary to deploy it; '*costly', 'exorbitantly expensive', 'unaffordable', 'uneconomical'*. As such, the argument most often brought forward against deployment of CCS is that it is an expensive way of reducing emissions.

Dismissing solutions that science demonstrates are needed as *expensive* to justify preferred emissions reductions pathways delays emissions reductions at best, and prevents us from reaching our goals at worst. In fact, analysis from the Intergovernmental Panel on Climate Change (IPCC) and the International Energy Agency (IEA) has consistently shown that CCS is urgently necessary to limit the overall cost of the net-zero energy transition.

This paper demonstrates that:

- To reach net-zero emissions by mid-century and achieve global climate change targets all decarbonisation options are needed.
- Carbon capture and storage (CCS) plays an important role reducing emissions to net-zero and limiting the overall system cost of decarbonisation.
- With versatile applications, CCS cost differs across its variety of industrial and power-related applications – there is no singular cost of CCS.
- Considering the urgency of the climate crisis, cost should not be a deterrent to investing in CCS nor dictate sequencing of the deployment of decarbonisation options. Instead, deployment will lead to cost reductions.
- A value on carbon is needed to support the business case for large-scale CCS deployment and overcome the technology 'valley of death'.

2. The versatility of CCS

To understand the cost of CCS, it is important to consider that CCS is a versatile suite of technologies that can reduce emissions from a range of sources and draw CO_2 from the atmosphere to deliver negative emissions. As such, not all CCS applications are created equal and different applications have different costs. The varied industries where CCS can reduce emissions include fertiliser, ethanol, and hydrogen production, as well as natural gas processing, among others.

CCS is also regarded as the only solution that can deeply decarbonise steel and cement production today, as it is able to capture emissions from both fossil fuel combustion required to generate the necessary high heat, as well as process-related emissions that cannot be eliminated through fuel switching.

Peaking and mid-merit power plants equipped with CCS are dispatchable and flexible, complementing a high penetration of renewables and supporting their critical build-out. CCS is therefore not only an important part in our toolkit to mitigate climate change, but also supports other decarbonisation options.

3. Understanding the cost profile of CCS

The capital cost of CCS often involves investments in the order of hundreds of millions of dollars, sometimes exceeding $1 billion, which in comparison to the capital investments of other sources of clean energy, such as wind and solar – both of which are at a smaller scale and require smaller absolute investments – can seem expensive. However, capital costs are not a helpful benchmark to assess whether an emissions reduction technology is expensive because they do not reflect the true cost of reducing emissions[i]. In fact, there are different ways to operationalise the cost of CCS, including for example $/t of CO_2 avoided.

Despite CCS' versatility, power generation equipped with CCS, which can be around $60/t$CO_2$ when in vicinity to quality geologic storage resources, is frequently used as a singular cost reference for CCS. Furthermore, the levelised cost of electricity (LCOE) is also often cited. However, LCOE fails to account for essential network support and balancing services many of which cannot be provided by intermittent renewables but which traditional generation equipped with CCS is ideally suited to. Bringing flexibility, dispatchability, reliability, energy security, and low emissions[ii] – all important attributes in a net-zero grid penetrated by high-levels of renewables is a strength of CCS often overlooked as these attributes are not covered by LCOE which fails to reflect overall system cost.

Most importantly, as outlined above, there are various industries which CCS can help to decarbonise, with some of these applications such as natural gas processing, ethanol and fertiliser production starting at $20/t$CO_2$. As a general rule, not all carbon capture applications are created equal in terms of cost, and the higher the purity of the CO_2 in the flue gas waste stream, the lower the cost to capture.

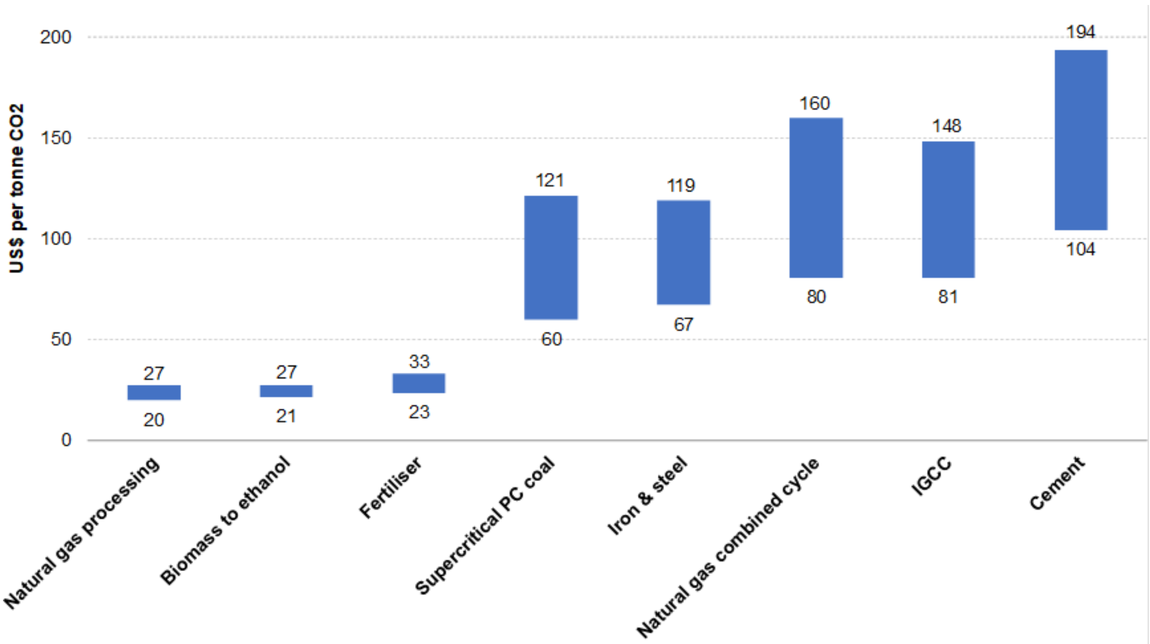

Figure 1: The cost of CO_2 avoided first of a kind from the Global Cost of CCS - 2017 Update.

4. The importance of limiting system cost

To reach global climate goals in line with limiting warming to 1.5 degrees Celsius, the IPCC estimates that an average of $3 trillion will need to be invested in the energy system each year until 2050[iii]; about twice as much as current investment. However, there are low-cost and high-cost decarbonisation pathways, and analysis has shown that the inclusion of CCS dampens the overall system cost of decarbonisation. For example, the IPCC found that it would be 138 per cent more expensive to reach global climate goals without the deployment of CCS[iv]. With regards to US power grid decarbonisation, studies have concluded that the availability of firm low-carbon resources such as natural gas with CCS consistently lowers decarbonised energy system costs, reducing cost up to 60 per cent[v] in zero-CO_2 cases. Hence, CCS deployment is vital to a globally equitable and least cost energy transition.

5. The role of technology deployment in cost reductions

Cost should not be a deterrent to investment. Rather, cost reductions are one of the prime reasons why investment in CCS today is important as the learning that results from deploying CCS will inevitably deliver cost reductions, which can also increase and improve access to the technology globally. For example, the cost of solar energy took 40 years to reduce from $100 per watt to the current $0.23 per watt[vi]. This is a stunning achievement helpful for the energy transition, but also the direct result of scaling a technology with considerable policy and incentive support said to be totalling $1 Trillion USD over the past decades.

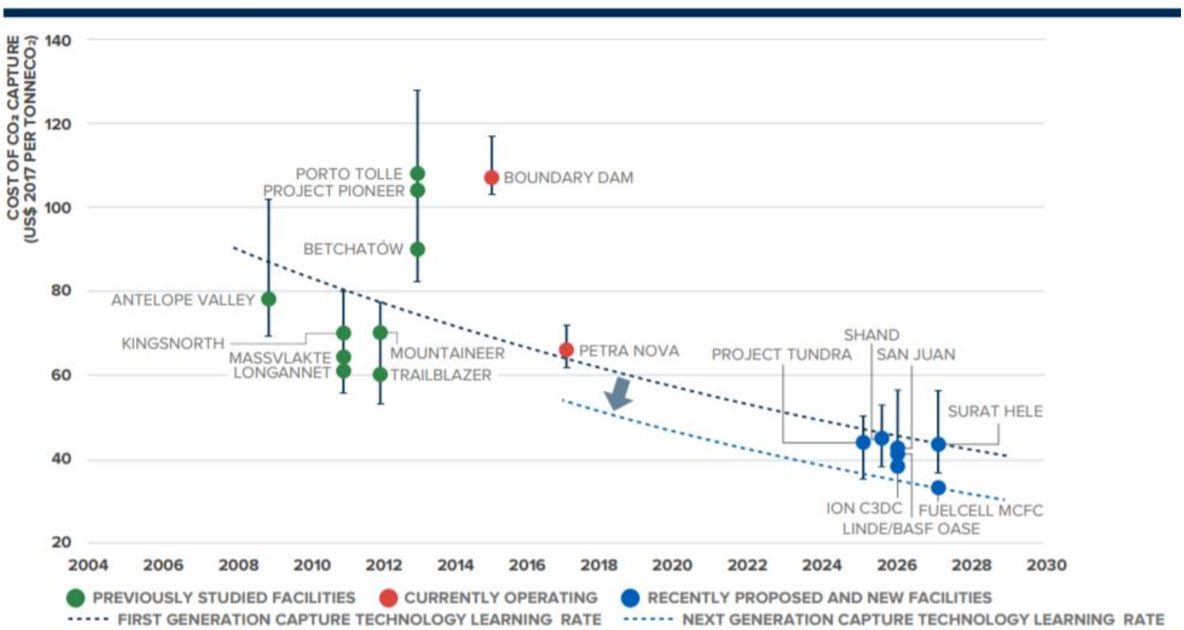

Figure 2: Levelised cost of CO_2 capture for large-scale post-combustion facilities at coal-fired power plants, including previously studied facilities from the Global Status of CCS: 2019.

Experience demonstrates that the cost of CCS will fall. In the Global Status of CCS 2019 report, the Institute analysed the cost trajectory of CCS on coal plants with the help of estimated costs from a range of feasibility and front-end engineering and design (FEED) studies for coal combustion CCS facilities. It shows that the cost of capture reduced from over $100 per tonne CO_2 at the Boundary Dam facility to below $65 per tonne CO_2 for the Petra Nova facility, just three years later. The most recent studies show capture costs (also using mature amine-based capture systems) for facilities that plan to commence operation in 2024-28, cluster around $43 per tonne of CO_2. New technologies at pilot-plant scale promise capture costs around $33 per tonne of CO_2[vii].

As with many technologies that are not widely deployed, the cost of capital for CCS facilities is currently high. Considering the potentially large amounts of capital investment, high costs of capital are a significant factor driving up overall project cost. However, with increasing deployment the cost of capital is expected to fall (Figure 3).

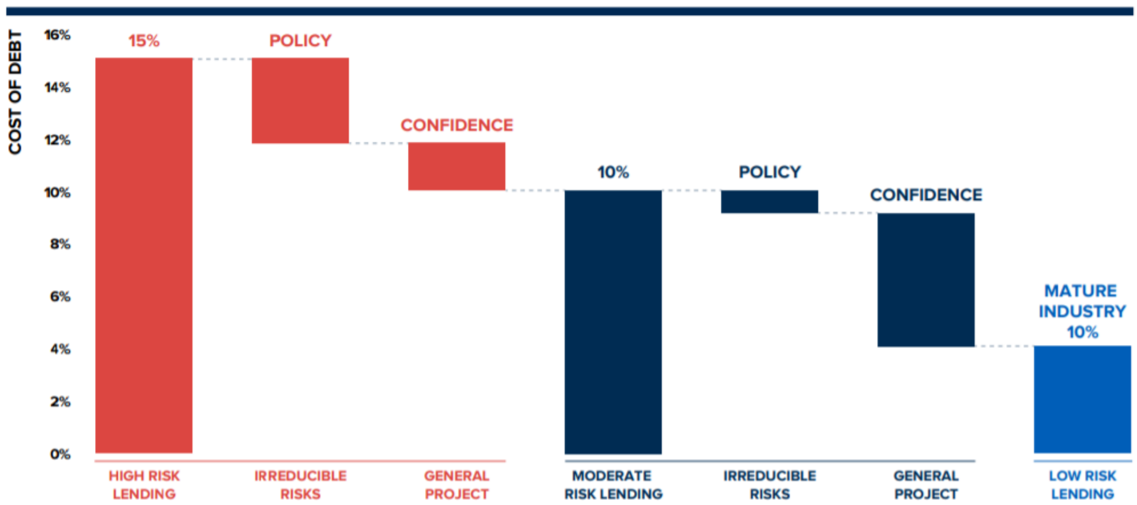

Figure 3: The Evolution of illustrative lending rates with policy de-risking and increased deployment rates for CCS facilities from the Global Status of CCS: 2019.

Larger average CCS plant sizes, as well as evolving business models such as hubs and cluster approaches where multiple sources of CO_2 share transportation and geologic storage infrastructure are expected to achieve economies of scale and further drive down unit costs. Meanwhile governments and the private sector are investing in R&D and working on developing the next generation of technologies that will cut costs even more.

6. Overcoming the technology 'valley of death': The role of a value on carbon

To contribute to emissions reductions at scale and reach climate goals, the deployment of large-scale CCS facilities needs to scale-up 100-fold between now and 2050. To spur deployment, and to overcome what some refer to as the technology 'valley of death' – the stage of successful demonstration yet high-capital cost and various factors of uncertainty undermining at-scale deployment – government policy is essential. In addition, as a climate change technology, CCS is deployed only to reduce emissions and for the pure climate benefit. In the absence of a value on carbon that reflects the externalities of emissions, companies will not deploy the technology because there is no incentive to do so

Therefore, a value on carbon is necessary for the large-scale deployment of CCS and to make the business case for deployment. In fact, IEA has estimated that as much as 450 $MtCO_2$ could be captured and stored globally with a commercial incentive as low as \$40/t of CO_2 by deploying CCS on the many low-cost opportunities available. However, according to the World Bank, 80 per cent of CO_2 emissions are not priced or priced at below \$10/t while the International Monetary Fund suggests it should be around \$75/t of CO_2[viii] to meet climate targets.

There are multiple ways of creating a value on carbon which includes tax credits, like the U.S. section 45Q awards, a carbon market like the European Union Emissions Trading System, and a credit-based system like California's Low Carbon Fuel Standard (LCFS). Mechanisms such as loan guarantees and capital grants that reduce the cost of capital can help lessen overall project cost.

TYPE OF CO_2 STORAGE/USE	MINIMUM SIZE OF ELIGIBLE CARBON CAPTURE PLANT BY SIZE ($KtCO_2$/YR)			RELEVANT LEVEL OF TAX CREDIT GIVEN IN OPERATIONAL YEAR (USD/tCO_2)									
	POWER PLANT	OTHER INDUSTRIAL FACILITY	DIRECT AIR CAPTURE	2018	2019	2020	2021	2022	2023	2024	2025	2026	LATER
DEDICATED GEOLOGICAL STORAGE	500	100	100	28	31	34	36	39	42	45	47	50	
STORAGE VIA EOR	500	100	100	17	19	22	24	26	28	31	33	35	INDEX LINKED
OTHER UTILISATION PROCESSES*	25	25	25	17	19	22	24	26	28	31	33	35	

*Each CO_2 source cannot be greater than 500 $ktCO_2$/yr. Any credit will only apply to the portion of the converted CO_2 that can be shown to reduce overall emissions.

Figure 4: The US 45Q tax credit from the Global Status of CCS: 2019.

For example, 45Q and the California LCFS CCS Protocol[ix] are designed to make the business case for CCS. 45Q will eventually provide \$35/t of CO_2 stored via enhanced oil recovery (EOR) and \$50/t of CO_2 for CO_2 through geologic storage[x]. The California LCFS was trading close to \$200/t of CO_2 in the first months of 2020[xi]. Already, projects that could result in at least a doubling of US CO_2 capture capacity have been announced as a result of 45Q or 45Q and the LCFS, demonstrating that a value on carbon can make an effective business case to deploy CCS.

7. Conclusion

CCS is applicable to a variety of emissions sources in industry and power, and can reduce the stock of CO_2 already in the atmosphere through delivering negative emissions. Due to its versatility, its costs vary. Hence, there is not a singular cost of CCS, and it is deficient to argue against deploying the technologies based on an overly generalised cost assumption based on high capital cost. Rather, the focus should be on pursuing a lowest-cost decarbonisation pathway, which according to numerous studies, includes CCS.

Large-scale deployment of CCS will inevitably result in cost reductions and governments and companies are already investing in achieving efficiencies. A value on carbon reflecting the externalities of emissions is essential to overcome the technology ‘valley of death’ and enable large-scale deployment, which through learning by doing is expected to reduce cost significantly.

Transforming our energy system to reach net-zero emissions is achievable and can be affordable. Deploying all available solutions, including CCS, as soon as possible is crucial to reducing technology costs, limiting the overall cost of decarbonisation and improving our chances of reaching our climate goals.

8. References

[i] Global CCS Institute. 2017. Global Cost Update. https://www.globalccsinstitute.com/archive/hub/publications/201688/global-ccs-cost-updatev4.pdf

[ii] Wanner, B. 2019. Is exponential growth of solar pv the obvious conclusion?. IEA. https://www.iea.org/commentaries/is-exponential-growth-of-solar-pv-the-obvious-conclusion

[iii] Intergovernmental Panel on Climate Change, 2018: 'Strengthening and Implementing the Global Response', *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C,* https://www.ipcc.ch/site/assets/uploads/sites/2/2019/02/SR15_Chapter4_Low_Res.pdf

[iv] Intergovernmental Panel on Climate Change, 2014: *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

[v] Nestor A. Sepulveda, Jesse D. Jenkins, Fernando J. de Sisternes, Richard K. Lester, The Role of Firm Low-Carbon Electricity Resources in Deep decarbonisation of Power Generation, Joule,Volume 2, Issue 11,2018, Pages 2403-2420, ISSN 2542-4351,https://doi.org/10.1016/j.joule.2018.08.006.

[vi] Bloomberg Green. Newsletter 4/24/2020.

[vii] Global CCS Institute. 2019 The Global Status of CCS: Targeting Climate Change. https://www.globalccsinstitute.com/resources/global-status-report/

[viii] Parry, I. 2019. Putting a Price on Pollution. International Monetary Fund. https://www.imf.org/external/pubs/ft/fandd/2019/12/the-case-for-carbon-taxation-and-putting-a-price-on-pollution-parry.htm

[ix] Townsend, A. & Havercroft, I. 2019. The LCFS and CCS Protocol. Global CCS Institute. https://www.globalccsinstitute.com/resources/publications-reports-research/the-lcfs-and-ccs-protocol-an-overview-for-policymakers-and-project-developers/

[x] Beck, L. 2020. The US Section 45Q Tax Credit for Carbon Oxide Sequestration – An Update. Global CCS Institute. https://www.globalccsinstitute.com/resources/publications-reports-research/the-us-section-45q-tax-credit-for-carbon-oxide-sequestration-an-update/

[xi] California Air Resources Board. 2020. Weekly Credit Reports. https://ww3.arb.ca.gov/fuels/lcfs/credit/lrtweeklycreditreports.htm