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ETC Report on the role of CCUS in the Energy Transition

This month, the Energy Transitions Commission[1] published the results of its analysis on the role of CCUS in a report entitled "Carbon Capture, Utilisation & Storage in the Energy Transition: Vital but Limited". In describing the complementary role CCUS has alongside clean electrification, the use of hydrogen and a limited use of sustainable low-carbon bioresources, it raises important issues:

- The roles that CCUS must play on the path to net-zero and what must happen to ensure it can do so are assessed.
- With just 40 $MtCO_2$/year currently captured, from around 30 facilities, the need to accelerate progress in the 2020s is recognised.
- The total investment in CCUS infrastructure is estimated at up to $5 trillion by 2050 which, it points out, is less than 5% of the total investment needed for the energy transition and equivalent to 0.1% of projected global GDP over the period.

While the report contains much to commend, the inclusion of the qualifier "*limited*" in the title was surprising to many. In the report, the ETC quotes that by 2050, "*the world will likely need to capture and either store, or in some cases use, 7-10 $GtCO_2$ per year of CO_2 through engineered carbon capture solutions*", a quantity that appears at odds with "*limited*" and which encompasses or exceeds the IEA's NZE Scenario projection for 2050 of 7.6 Gt.[2]

The very legitimate concern is that, even though the role of CCUS in the energy transition is described as "*vital*", following that by describing its role as "*limited*" may be sufficient to detract some policymakers and investors from timely action – and timely action is now essential – on all low-carbon technologies – if the objectives of the Paris Agreement are to be met.

Yet, and perhaps equally troubling in the report was the dubious rationale for exaggerating the cost of achieving high capture rates. ETC state quite correctly that, while capture rates above 90% were possible, costs would become progressively higher as rates approached 100%. While the peer-reviewed literature is replete with references to this effect, from both academic and industry sources, it is the magnitude of the increase quoted that appears inconsistent with the majority of evidence. Several studies published over the past two or three years have demonstrated that a capture rate of 99% or higher would incur a relatively modest increase in marginal cost relative to 90% capture. These include but are not limited to:

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[1] According to their publicity, "The Energy Transitions Commission (ETC) is a global coalition of leaders from across the energy landscape committed to achieving net-zero emissions by mid-century, in line with the Paris climate objective", with Commissioners representing "energy producers, energy-intensive industries, technology providers, finance players and environmental NGOs" that operate across both "developed and developing countries".

[2] International Energy Agency (IEA), "Net Zero by 2050: A Roadmap for the Global Energy Sector", Paris, May 2021.

- Feron, P., Cousins, A., Jiang, K.Q., Zhai, R.R., Hla, S.S., Thiruvenkatachari, R. and Burnard, K., 'Towards Zero Emissions from Fossil Fuel Power Stations', International Journal of Greenhouse Gas Control 87, 188–202, 2019.
- Jiang, K., Feron, P., Cousins, A., Zhai, R. and Li, K., 'Achieving zero/negative-emissions coal-fired power plants using amine-based post-combustion CO_2 capture technology and biomass co-combustion', Environ. Sci. Technol. 54, 2429–2438, 2020.
- Hirata, T., Tsujiuchi, T., Kamijo, T., Kishimoto, S., Inui, M., Kawasaki, S., Lin, Y.J., Nakagami, Y. and Nojo, T., 'Near-zero emission coal-fired power plant using advanced KM CDR process™', Int. J. Greenhouse Gas Control, 92, 2020.
- Du, Y., Gao, T.Y., Rochelle, G.T., Bhown, A.S., 'Zero- and Negative-Emissions Fossil-Fired Power Plants using CO_2 Capture by Conventional Aqueous Amines', Int. J. Greenhouse Gas Control, 111, 103473, 2021.
- Danaci, D., Bui, M., Petit, C. and Mac Dowell, N., 'En Route to Zero Emissions for Power and Industry with Amine-Based Post-Combustion Capture', Environ. Sci. Technol. 55, 10619−10632, 2021.

An outlier in this respect is a paper authored by Brandl *et al*,[3] which happens to be used as the primary reference in the ETC report. In the ETC report, it is stated that "…. *For open cycle gas-fired power plants for instance, increasing the capture rate from 90% to 96% will incur a modest additional cost penalty of about 12%, taking total cost from around \$80 to \$90/tCO_2. But increasing it to 99% could increase costs to \$160/tCO_2*". While the numbers quoted in the report are consistent with those from a figure in Brandl's paper, the paper also concludes that "*We showed that higher capture rates that are much needed for a net-zero transition are economically feasible at low marginal costs, ……. Thus, claims of capture rates higher than 90% are both technically feasible and economically reasonable in reaching GHG emissions reduction targets with negligible increase to the overall system costs*".

In the IEAGHG study[4] that underpinned the paper by Feron *et al*, it was revealed that, with dedicated process design, the additional costs of achieving essentially zero CO_2 emissions were quite modest in comparison with the costs of achieving 90% CO_2 capture. For 99.7%[5] CO_2 capture on an ultra-supercritical coal plant with CCS, the CO_2 avoided cost increased by 3% and for 99%[5] CO_2 capture on a natural gas combined cycle plant with CCS, the cost increased 8%. Findings in the other papers quoted were broadly consistent with these.

In the context of carbon capture, the capture rate is a highly important metric. For net-zero emissions to be achieved, higher residual carbon emissions result in a greater burden on the CDR technologies that will likely not only to be costlier but will also be required to mop up residual emissions from the harder-to-abate sectors and industries. It is therefore essential that the residual emissions from CCUS should, where possible, be minimised cost-effectively.

[3] Brandl, P., Bui, M., Hallett, J.P. and Mac Dowell, N., Beyond 90% capture: Possible, but at what cost? Int. J. Greenhouse Gas Control 105, 103239, 2021.

[4] IEAGHG, "Towards zero emissions CCS from power stations using higher capture rates or biomass", 2019/02, March 2019.

[5] At this capture rate the power station is CO_2 neutral, i.e., the only CO_2 emitted is that in the incoming combustion air.

Regarding the findings in the Brandl paper, Du *et al* observed that:

> *Brandl et al. (2021) explored the marginal cost of CCS for PC and NGCC power plants at CO_2 capture beyond 90% and concluded that even for the most concentrated flue gas (*30 mol*% CO_2) the marginal cost of CCS at 98% capture is higher than that of typical negative emissions technologies and thus it is uneconomical for fossil-fired power plants to achieve zero-emissions (~99.7% CO_2 capture for PC power plants and ~99% CO_2 capture for NGCC power plants) without coupling negative emissions technologies. However, in order to cover a wide range of flue gas sources for CCS (10 – 1000 kg/s flow rate and 1 – 30 vol% CO_2), their study simplified the process modelling/design (e.g. excluded solvent intercooling, and assumed absorber rich-end pinch), and used textbook costing methods (Brandl et al., 2018), which might reduce the accuracy of the results. The use of solvent intercooling can be critical to achieve high CO_2 capture economically when the CO_2 absorption driving force is low (Gao and Rochelle, 2020). Although absorber rich-end pinch often occurs in pilot scale tests with oversized absorber columns, it might not be seen in commercial-scale plants when the absorber height is optimized.*

Additionally, in a subsequent paper (Danaci *et al*) by some of the same authors (as those in the Brandl *et al* paper), they themselves noted that the use of a "*shortcut model*" and certain assumptions in the paper would have influenced the conclusions subsequently drawn.

The report concludes by recommending six critical actions by government, corporates and finance in the 2020s:

1. Overcoming the green premium to make CCUS deployment economically viable through, e.g., carbon pricing and state financial support for capture.
2. Building the enabling infrastructure such as shared transport pipelines and storage sites. Government and industry can develop CCUS hubs that enable economies of scale.
3. Targeting R&D and deployment support towards high capture, next-generation CCUS technologies, as well as developing innovative business models.
4. Regulating and managing risks to ensure responsible and secure CCUS development by assigning long-term responsibility for storage sites and meaningful penalties for leakage.
5. Setting standards and regulation to ensure high CO_2 capture rates, alongside developing transparent, best-practice monitoring of CCUS.
6. Building public support for an appropriate role for CCUS as a low-carbon technology by articulating a clear policy on the role for CCUS and transparency on performance.

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