A REVIEW OF COST ESTIMATES FOR CARBON CAPTURE AND STORAGE IN THE POWER SECTOR

THE ROLE OF COST ANALYSIS IN GRID DECARBONISATION

Carbon capture and storage (CCS) frequently features in lowest-cost decarbonisation pathways and has therefore received growing attention as net zero carbon emissions become a widespread policy goal. At the same time, wider deployment of this technology has been hindered by the perception of high costs at the plant level, particularly for applications in the power sector, where wind and solar power are more competitive on a levelised cost of electricity (LCOE) basis. Cost analysis is an important tool for project developers, investors, and grid planners in identifying the most economically viable sources of low-carbon power generation, as well as for enabling researchers to assess newly developed technologies. However, there is growing recognition that costing the generation of electricity alone may have limited value for determining the optimum portfolio of technologies in a decarbonised grid. A deeper analysis of technology cost – and value – at net zero can help elucidate why several countries continue to pursue the use of CCS in the power sector.

THE COST OF ELECTRICITY FROM CCS POWER PLANTS

Owing to inconsistent methodologies and variation in input assumptions, estimates of LCOE can show considerable variation for the same technology – particularly for those which have not reached widespread deployment, such as CCS. Based on a review of some 'bottom up' techno-economic studies, the LCOE of new supercritical coal plant with post-combustion CCS is typically found in the range of 90–130 $/MWh for locations in the USA and Western Europe, while combined cycle gas turbines (CCGT) with CCS are in the range 70-100 $/MWh. Lower LCOEs for coal-based CCS (in the range 80-100 $/MWh) have been estimated for China, which is one of the few regions examined where CCGT-CCS appears more costly on this basis. In the absence of carbon pricing, building a new coal or gas plant with CCS tends to incur a 70-100% increase in LCOE relative to a new 'unabated' plant of the same type. Retrofitting CCS to an existing power plant is a lower-cost option, but there is considerable variation in how LCOE is calculated for these cases.

Based on the few studies which have consistently examined different low-carbon generation, LCOEs of coal-CCS and CCGT-CCS are generally 1.5–3 times higher than those of solar power and onshore wind in OECD countries. Offshore wind shows more regional variation, with costs similar to those of onshore wind in Northern Europe but higher than CCS power plant in the USA.

In recent years, there has been a trend towards developing 'adjusted' LCOE variants which better account for other characteristics valuable to the grid, such as flexibility and dependable capacity. Such methods include value-adjusted LCOE (VALCOE), levelised avoided cost of electricity (LACE), and enhanced LCOE. Using these metrics, the cost differential between intermittent sources and CCS-equipped power plants reduces, but not significantly for the levels of renewable deployment generally considered (<50%).

THE COST OF CO_2 AVOIDED

Carbon abatement technologies such as CCS are also frequently assessed on the cost of capturing or 'avoiding' a tonne of CO_2. Studies of operating and planned full-scale coal-CCS plants indicate that the cost of capturing CO_2 is falling and is expected to be around 45 $/t for the next generation of retrofit projects in North America. This decline is associated with learning-by-doing, economies of scale and modular construction, improved financing, and technology optimisation. However, the cost of CO_2 avoided – which accounts for the energy consumed by the capture process – generally falls in the range of 60–80 $/t for new coal-CCS plant in high-income countries. CCGT-CCS appears slightly more costly on this basis due to the lower CO_2 intensity of the unabated plant. Analysis of existing coal plants in China has identified particularly low-cost opportunities for CCS retrofit, with CO_2 avoided costs as low as $30/t. Accurate comparison of CO_2 abatement costs with other low-carbon generation is highly dependent on the choice of displaced generation.

FROM COST TO VALUE: TOTAL SYSTEM COST ANALYSIS

Total system cost analysis aims to express the total cost of delivering a reliable electricity grid across a range of representative weather and demand scenarios, including all investment and operational costs over the course of the transition to lower carbon intensities. This method is increasingly useful for elucidating the value of potentially low-output, dependable capacity such as CCS, nuclear, or electricity storage in grids with very high levels of intermittent sources. In this context, the 'value' of a given technology can be identified as the cost increase which would be incurred if the grid were decarbonised without that technology being available. This approach more closely represents the overall cost of grid decarbonisation to be met by consumers or taxpayers.

Analysis of several regional and national grids show that wind and solar power consistently offer the lowest-cost option for the initial stages of decarbonisation, but low-carbon dispatchable generation becomes extremely valuable as higher levels are approached (>80–90% reduction in gCO_2/kWh). Forms of CCS frequently offer the most economic option for this dispatchable generation, with the proportions of coal, gas, or biomass-fired plant depending on various local factors. For emerging economies with rapidly growing demand, constraints on the achievable rates of renewables deployment suggest a significant role for CCS-based power plants in reaching net zero emissions at lowest cost and on the shortest timescale.

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Each executive summary is based on a detailed study which is available separately from: www.sustainable-carbon.org. This is a summary of the report: A review of cost estimates for carbon capture and storage in the power sector by Toby Lockwood, ICSC/317, ISBN 978-92-9029-640-9, 72 pp, December 2021.