BIOENERGY WITH CARBON CAPTURE AND STORAGE

THE STATUS OF BECCS

Engineered greenhouse gas (GHG) removals have been identified by the International Panel on Climate Change (IPCC), and established by leading global research, as critical for limiting average global temperatures to 1.5°C above pre-industrial levels. Engineered GHG removals are also considered the main solution for redressing any overshoot in average global temperatures, something that looks increasingly inevitable. The most commercially ready and cheapest engineered GHG removal technology is bioenergy with carbon capture and storage (BECCS) which involves both the displacement of fossil carbon by biomass carbon, and the capture and permanent storage of that carbon. Simply put, biomass grows by taking CO_2 from the atmosphere via the short carbon cycle (photosynthesis) and when it is utilised it releases CO_2 which is then captured and stored. Thus, BECCS not only displaces CO_2 from fossil fuel use it also generates energy and ultimately removes CO_2 from the atmosphere, according to the timescale of the biomass carbon cycle. The actual CO_2 removed from the atmosphere via BECCS depends on many factors including the nature of the biomass, its cultivation, densification and transport, and the end use and CO_2 capture efficiencies. Consequently, BECCS, and particularly the supply chain development, remains an area of high research activity and, in some cases, uncertainty in actual carbon savings. Nevertheless, much key research points to a target for sustainable BECCS of 2–4 $GtCO_2$/y, and this, together with carbon reduction approaches, are currently the best and cheapest method to ameliorate climate change.

Technologies for carbon capture from bioenergy plant are similar to those used for fossil fuel plant and so many are at a high technology readiness level (TRL). This does not necessarily mean that they are ready for deployment in BECCS since experience specific to biomass flue gases as well as integration of technologies with biomass combustion processes is still limited. Next-generation technologies include those based on amine solvents and are regarded as the most suitable for deployment on the initial large-scale BECCS plant. Increased efficiencies and reduced costs are the main R&D goals.

Europe and the UK are most advanced in the development of BECCS. Two of the most notable projects are in the Skagerrak/Kattegat region of Scandinavia, including the Klemetsrud waste-to-energy plant in Norway (0.4 Mt/y), and the planned deployment at Drax Power Station (4 Mt/y) in the UK, which will be by far the largest in the world. However, while there is global experience of carbon capture and storage (CCS) from fossil fuels, the experience of BECCS is currently limited to pilot and small demonstration scale in power generation, energy from waste (EfW) and cement manufacturing. The exception is biorefineries with CCS, which is commercial for bioethanol, particularly in the USA. Here, the separated CO_2 is only a fraction of the biomass carbon and is mostly used in enhanced oil recovery; consequently, there is a net gain in CO_2 emissions to atmosphere. Other sectors which can benefit from BECCS include biomethane production from anaerobic digestion, the pulp and paper industry, and heavy manufacturing (such as iron and steel production). BECCS deployment will also benefit from the development of hubs and clusters and associated CO_2 transport infrastructure.

The next decade is key for BECCS development (*see* Figure 1). The current status of BECCS in power, combined heat and power (CHP), EfW and cement production is of the order of only 0.5 $MtCO_2$/y. There is potential for this to increase at least 10-fold by the end of the decade, but this requires clear commitment from governments to incentivise the process and invest in the CO_2 transport and storage infrastructure. Large-scale demonstration is critical for decreasing risk, lowering cost and increasing investor confidence. Further roll-out will need to be another two to three orders of magnitude greater after 2030 to begin to reach the levels of carbon removal indicated in scenario modelling for climate change mitigation.

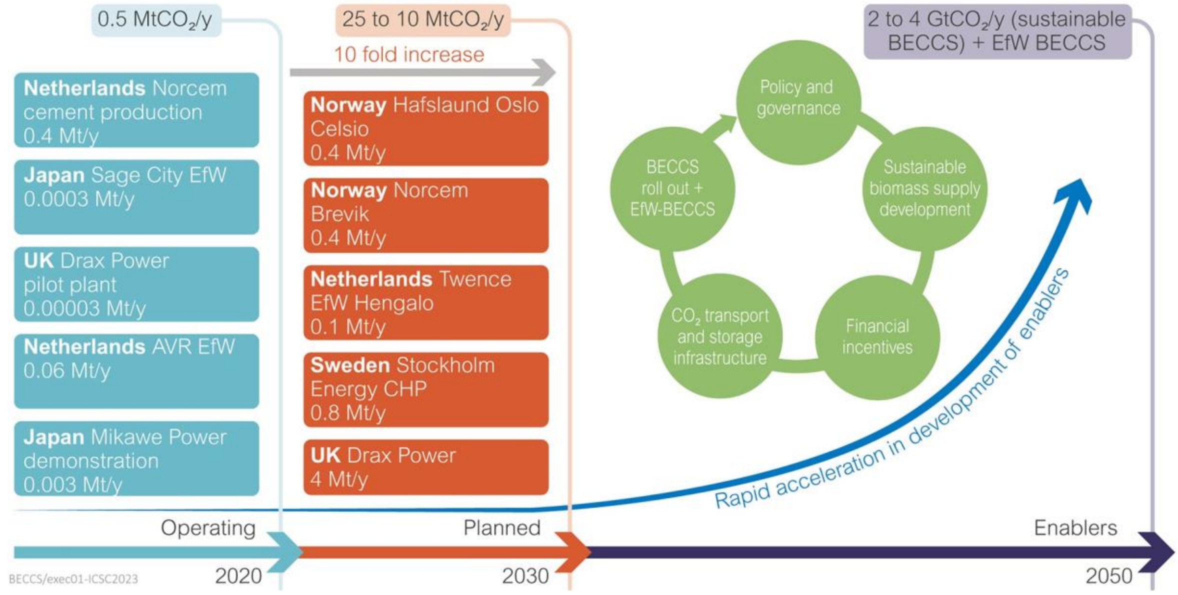

Figure 1 Roadmap for the development, deployment and roll-out of BECCS

ENABLERS FOR BECCS

BECCS is expensive and risky and will only happen, and only happen well, with the correct governance, policies and incentives that value CO_2 reduction. Emerging technologies aim to improve efficiencies of both energy production and carbon capture. Investment in R&D of next-generation technologies, together with funding to move these through the TRLs from laboratory to deployment is essential in the coming decades so that the use of sustainable biomass with carbon capture becomes increasingly transformative.

Ensuring sustainability in BECCS supply chains is a complex area which makes policy development less clear-cut. There are many factors that impact delivery of a carbon negative BECCS value chain as well as the delivery of sustainable development goals. These include, for example: land use and indirect land use changes; water availability; competition for food; utilisation of waste resources and agricultural residues; maintaining or improving biodiversity; integration to improve food security, as well as improving rural and developing economies.

Strong policies together with certification, monitoring and evaluation are required to ensure best practice of the whole BECCS value chain happens, adapts, and evolves as the research evidence directs it. In this way, sustainability, sustainable development, climate change mitigation, and technology goals can all be achieved.

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: Bioenergy with carbon capture and storage by Prof Jenny Jones, Dr Leilani Darvell and Dr Bijal Gudka, ICSC/326, ISBN 978-92-9029-649-2, 122 pp, May 2023.