Net zero commitments drive global momentum for CCUS

By Mary BURCE WARLICK

Deputy Executive Director, International Energy Agency (IEA)

A net-zero energy system requires a profound transformation in the way we produce and use energy. This can only be achieved with a broad suite of technologies. Carbon capture, utilisation and storage (CCUS) is the only group of technologies that contributes both to directly reducing emissions in key sectors and to removing CO_2 to balance emissions that are challenging to avoid – a critical part of "net" zero goals.
Over the years, CCUS deployment and investment has lagged behind other clean energy technologies. However, new investment incentives and strengthened climate goals are building a renewed momentum behind CCUS. In 2021, over 100 CCUS projects have been announced in over a dozen countries.
In order to translate ambition into action, governments and industry can build on this global momentum in four key areas: create favourable investment conditions; coordinate and underwrite industrial hubs and shared infrastructure; encourage CO_2 storage development; and boost innovation.

As a growing number of governments and companies around the world pledge net-zero emission targets, new momentum for carbon capture, utilisation and storage (CCUS) technologies is emerging. CCUS is the only group of technologies that can support direct mitigation efforts, including in so-called hard-to-abate sectors, as well as removing CO_2 to balance emissions that are challenging to avoid – a critical part of "net" zero goals.

After years of relatively slow progress, 2021 has seen plans for over 100 CCUS projects announced in over a dozen countries. Favourable policies and new funding support are contributing to this renewed interest, particularly in the United States and Europe. Governments and industry now have the opportunity to build on this momentum to support a rapid and widespread rollout of CCUS consistent with achieving net-zero goals.

We have a narrow but viable path to net zero

While recent pledges and efforts to increase commitments under the Paris Agreement are encouraging, we are still well off track to limiting global temperature rise to 1.5°C. The IEA Net Zero by 2050 Roadmap[1] found that pledges by governments to date – even if fully achieved – fall well short of what is required to bring global energy-related carbon dioxide emissions to net zero by 2050.

In other words, there is a noticeable gap between our goals and where we need to be by mid-century. To close this gap, a net zero energy system requires a radical transformation in the way we produce and consume energy. That can only be achieved with a broad suite of technologies.

In the period to 2030, most of the necessary emissions reductions can be achieved through technologies that already exist, and the policies that can drive their deployment are already proven. However, reaching net zero by 2050 requires further rapid deployment of available technologies as well as widespread use of technologies that are not yet on the market.

CCUS plays an important role in meeting net-zero goals

In the IEA Net Zero Emissions (NZE) scenario, CO_2 emissions fall to around 21 Gt in 2030 and to net-zero by 2050. In advanced economies, CO_2 emissions as a whole reach net-zero by 2045. In 2050, around 0.2 Gt is removed from the atmosphere, which helps balance out any residual emissions from emerging market and developing economies.

In order to meet these ambitions in a cost-effective manner, CCUS technologies will need to play a central role. In the NZE scenario, a total of 7.6 $GtCO_2$ is captured in 2050, roughly the equivalent of today's CO_2 emissions from India, the United States and Brazil combined. Although this rate of CO_2 capture is low compared with similar scenarios[2] assessed by the Intergovernmental Panel on Climate Change (IPCC), the need for a significant and rapid scale-up of CCUS reflects four key roles for CCUS in meeting net-zero goals.

[1] https://www.iea.org/reports/net-zero-by-2050

[2] https://www.iea.org/commentaries/a-closer-look-at-the-modelling-behind-our-global-roadmap-to-net-zero-emissions-by-2050

Tackling emissions from existing assets

If left unmitigated, today's power and industrial plants could generate more than 600 $GtCO_2$ until the end of their technical lives. This is almost 17 years' worth of current global energy sector emissions. The global coal-fired generation fleet, of which 60% could still be operating in 2050, presents a unique challenge as emerging economies seek to meet rapidly growing energy demand.

CCUS can help avoid emissions that may be "locked-in" from existing fossil fuel-fired power plants. Retrofitting power plants with CO_2 capture equipment can allow for the continued operation of these plants, while significantly reducing emissions and preserving employment. CCUS can also help meet the growing need for system flexibility as the share of variable renewable energy increases in electricity generation. As dispatchable resources, coal- and gas-fired power plants with CCUS could provide important system balancing services.

A solution for sectors with hard-to-abate emissions

CCUS is also one of the few cost-competitive options to reduce emissions in some sectors, such as heavy industry (cement, steel and chemicals production) and long-distance transport. In the NZE scenario, approximately 40% of the CO_2 captured in 2050 is from energy-related and process emissions in industry.

In heavy industry, which accounts for roughly 20% of global CO_2 emissions today, technology options that can yield significant emissions reductions are limited or not available in some cases. For example, CCUS is the only scalable solution to address CO_2 emissions from cement production, which currently accounts for around 7% of global energy-related CO_2 emissions. Notably, making cement generates a significant amount of process emissions, accounting for around two-thirds of the sector's emissions. These emissions – which are not associated with fossil fuel use – make achieving net-zero in the sector virtually impossible without CCUS. In other industries, such as iron and steel, CCUS can provide the most advanced and least-cost low-carbon production route for virgin steel.

Captured CO_2 can also help reduce emissions from long-distance transport, including aviation, through the production of synthetic hydrocarbon fuels. Captured CO_2 can be used as a feedstock with low-carbon hydrogen to produce these synthetic fuels, which alongside biofuels are the only practical alternative to fossil fuels for long-haul flights. As CO_2 emissions constraints increase over time, the feedstock CO_2 must increasingly be sourced from biomass or the air. In the NZE, around 0.5 Gt of CO_2 is used to produce synthetic fuels for aviation in 2050, with the CO_2 sourced through direct air capture as a carbon-neutral input.

A cost-effective pathway for low-carbon hydrogen production

Hydrogen is a versatile energy carrier that has the potential to decarbonise several sectors, including transport, industry, power and buildings. However, nearly all of the hydrogen produced today comes from natural gas or coal, which accounts for more than 800 $MtCO_2$ each year. This is equivalent to the combined emissions of the UK and Indonesia.

Using fossil fuels with CCUS is a cost-effective option to scale-up the supply of low-carbon hydrogen. Methane emissions in upstream fossil fuel production need to be minimised for the technology pathway to be truly low-carbon. But, today, the cost of CCUS-equipped hydrogen production can be around half that of producing hydrogen through electrolysis with renewable energy. Although the cost of electrolytic hydrogen is expected to fall significantly[3], CCUS-based productions routes will most likely remain a competitive option in regions with low-cost fossil fuels and CO_2 storage resources.

Enabling CO_2 removal

Carbon dioxide removal is key to meeting ambitious climate targets, as highlighted in the scenarios considered by the IPCC in its Special Report on 1.5°C. Removing carbon from the atmosphere can serve to offset emissions in sectors that are technically challenging or prohibitively expensive to decarbonise, and enable net negative emissions in the long-term.

Technology-based carbon removal solutions can remove CO_2 from the atmosphere by combining CCUS with bioenergy (BECCS) or via direct air capture (DAC) with CO_2 storage. In the NZE scenario, approximately 2.4 $GtCO_2$ are captured from BECCS and DAC in 2050, with 1.9 Gt of this CO_2 permanently stored for carbon removal. In particular, DAC is rapidly scaled up from just a few projects today to nearly 1 Gt of CO_2 captured per year, accounting for 10 % of total captured CO_2 in 2050.

These technology-based approaches for carbon removal can complement and enhance nature-based solutions, such as afforestation (the repurposing of land use by growing forests where there were none before) and reforestation (re-establishing a forest where there was one in the past). Other carbon removal solutions include enhanced natural processes, such as the addition of biochar (charcoal produced from biomass) to soils, enhanced weathering of minerals, and ocean fertilisation.

New momentum for CCUS is emerging

The potential for CCUS to mitigate climate change has been known for decades, but investment has lagged well behind that of other clean energy technologies. In fact, CCUS investment has consistently accounted for less than 0.5% of global investment in clean energy and efficiency technologies. Coupled with a lack of policy support and incentives to reduce emissions, CCUS deployment has been slow as a result.

[3] https://www.iea.org/reports/global-hydrogen-review-2021

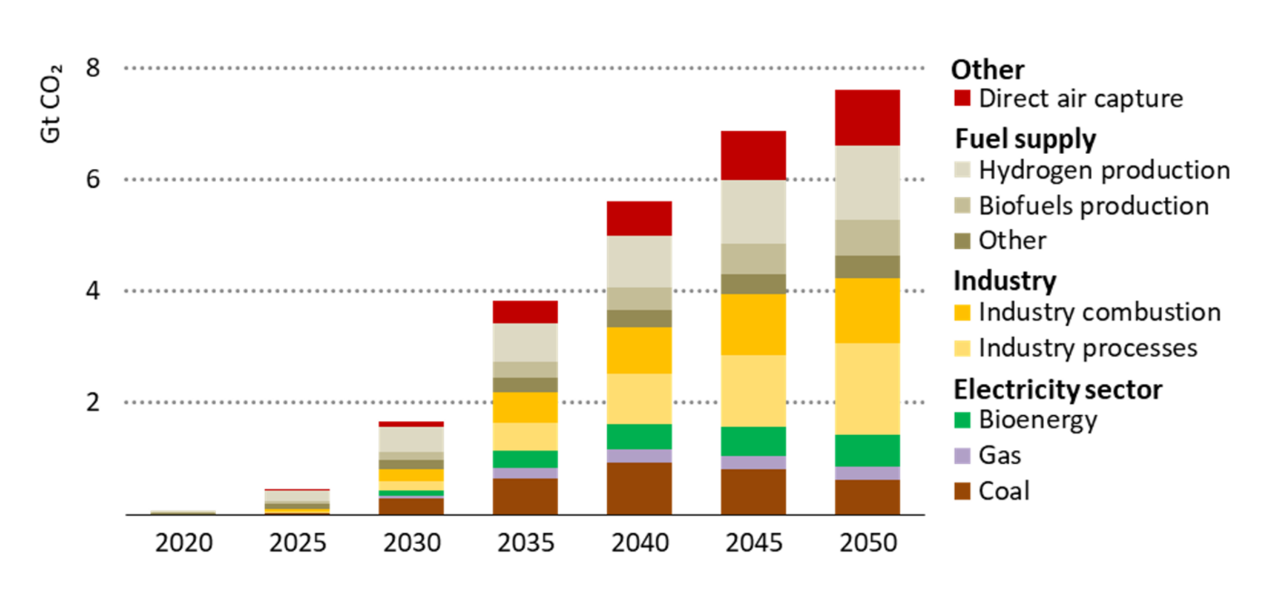

Figure 1: Global CO_2 capture by source in the NZE – Source: IEA. All rights reserved.

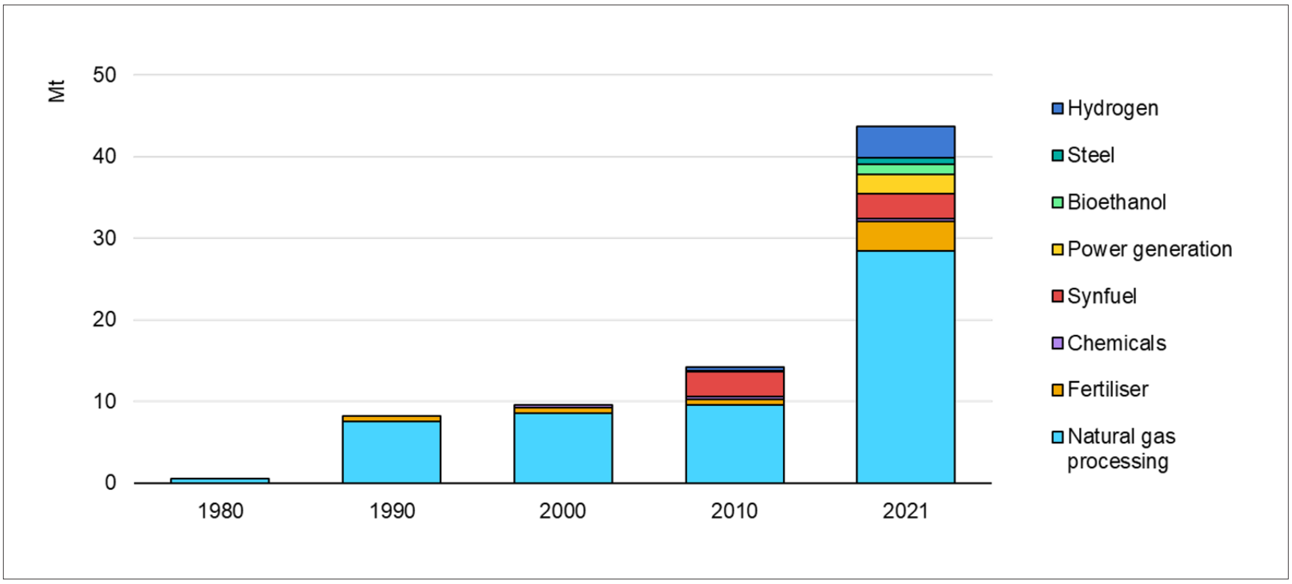

Figure 2: Global CO_2 capture capacity at large-scale facilities by source – Source: IEA. All rights reserved.

Early CCUS projects focused on capturing CO_2 from industrial applications for use in enhanced oil recovery (EOR). In the United States, natural gas processing plants in Texas began to capture CO_2 in the 1970s and 1980s and supply it to local oil producers for EOR operations. The first large-scale CCUS project with dedicated storage and monitoring was commissioned in 1996 at the Sleipner offshore gas field in Norway, which stores around 1 $MtCO_2$ per year in a deep saline aquifer.

In recent years, CCUS has gained renewed global attention as countries strengthen their climate commitments and technology costs decline. There are currently 27 commercial CCUS facilities in operation and dozens more in various stages of development – a considerable increase from the handful of projects in operation just two decades ago. In fact, more than 100 facilities have already been announced in 2021. Investment appetite for CCUS is also growing. Since the start of 2020, governments and industry have committed more than USD 12 billion to CCUS programmes and projects.

Applications of CCUS have also expanded as more projects are deployed. Until the 2000s, virtually all of the CO_2 captured globally at large-scale facilities originated from gas processing plants, where CO_2 can be captured at relatively low additional cost. Now, other sources – such as fertiliser, synfuel, hydrogen and power generation – comprise roughly one-third of global CO_2 capture capacity.

Policies in the United States and Europe drive new investment plans

The deployment of CCUS to date has been largely concentrated in the United States, where public funding programs, policy incentives, CO_2 demand for EOR and a vast CO_2 pipeline network have contributed to a supportive investment environment. The Gulf Coast and Rocky Mountain regions in particular are well suited as potential hubs given the proximity of major industrial emission clusters to storage sites. The United States is home to around half of all operating facilities globally and accounts for almost 30% of projects currently under construction or in advanced stages of development. Recent policy changes are some of the primary drivers behind this momentum. The expansion of the 45Q federal tax credit, and the complementary Low Carbon Fuel Standard (LCFS) policy in California, have led to an uptick in project announcements. Over 60 projects have been announced in the US since 2018.

In Europe, there are currently only two large-scale CCUS projects operating in the region. The Sleipner and Snøhvit projects, both located in Norway, capture CO_2 from natural gas processing plants and store around 1.7 Mt annually in geological formations deep under the North Sea. There are also small pilot and demonstration projects operating elsewhere in Europe. Europe's ambitious climate goals, coupled with higher carbon prices and new funding programmes, are spurring renewed interest in projects throughout the region. At the regional-level, the EU Innovation Fund makes available up to EUR 20 billion to support the demonstration of low-carbon technologies, including CCUS, and the EU Horizon 2020 provides research and development support. At the country-level, the Dutch government has confirmed up to EUR 2.1 billion in support of the Porthos project that will be made available through the SDE++ programme. In the UK, the government has committed GBP 1 billion to establish four industrial CCUS hubs by 2030. In 2020, the Norwegian government committed USD 1.8 billion to the Longship project, which includes the Northern Lights offshore storage facility.

This improved investment environment is contributing to a growing interest in Europe to target hubs. The North Sea is at the centre of CCUS deployment, where most of Europe's potential offshore CO_2 storage capacity is located. Potential storage sites are in close proximity to several industrial clusters in Belgium, Denmark, Netherlands, Norway, UK and Sweden. The Northern Lights storage project will accept CO_2 from neighbouring European countries, with initial capacity of 1.5 Mt of CO_2 per year in 2024, when it starts operations, with plans to scale up to 5 Mt per year as demand increases.

Recent developments in France show the country's interest in using the North Sea's storage capacity. France currently has two main industrial hubs: Fos-Berre/Marseille in the South and Le Havre in the West. In July 2021, TotalEnergies signed a memorandum of understanding with Air Liquide and others to explore the feasibility of developing a northern industrial hub in Normandy. The project will aim to capture up to 3 Mt of CO_2 per year from industrial facilities in the region for storage in the North Sea.

Outside of the United States and Europe, there is also significant interest and CCUS project activity emerging in Australia, Canada, China, the Middle East and other regions. A recent IEA report CCUS: The opportunity in Southeast Asia[4] highlights the potential for CCUS to support energy and climate goals in the region.

Priorities for the next decade

CCUS is an important part of the portfolio of technologies and solutions needed to put the world on a narrow, but still achievable, path to net-zero emissions by 2050. Targeted and enhanced support for CCUS will be essential for the rapid deployment of projects, with both the public and private sectors having a critical role to play to incentivise investment and leverage financial resources. The IEA has identified the following high-level priorities for governments and industry to accelerate CCUS progress in the next decade:

- create the conditions for investment by placing a value on reducing emissions and direct support for early CCUS projects;
- coordinate and underwrite the development of industrial hubs with shared CO_2 infrastructure;
- identify and encourage the development of CO_2 storage in key regions;
- boost innovation to reduce costs and ensure that critical emerging technologies become commercial, including in sectors where emissions are hard to abate and for carbon removal.

[4] https://www.iea.org/reports/carbon-capture-utilisation-and-storage-the-opportunity-in-southeast-asia