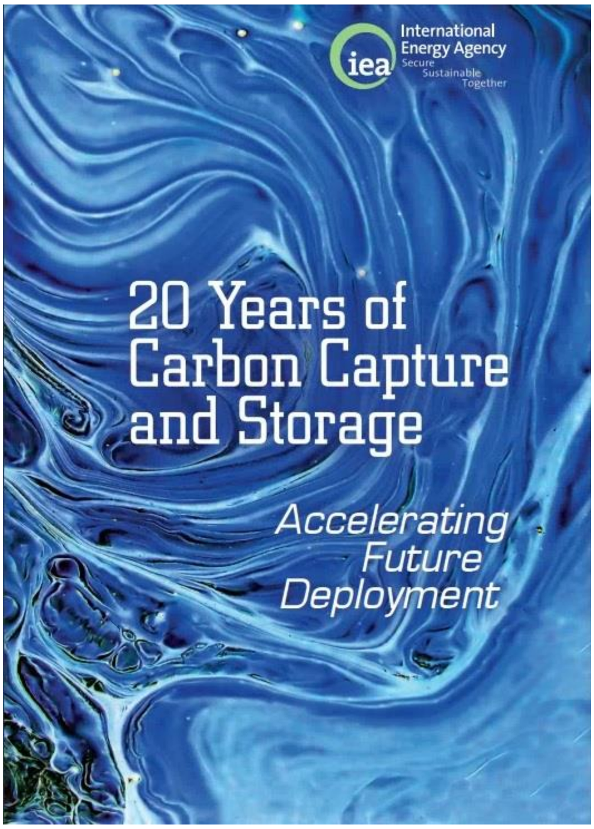
IEAGHG Information Paper 2016-IP51; 20 Years of Carbon Capture and Storage: A new IEA report highlights progress but stresses the need to redouble efforts.



Year 2016 marked a significant milestone with two decades of successful CCS operations at the Sleipner project in Norway since 1996, resulting in permanent storage of some 17 million tonnes of CO_2. Sleipner is significant not because it was the first large-scale CO_2 capture and injection project – three projects had already been capturing CO_2 for enhanced oil recovery (EOR) in the United States – but because Sleipner was the first project to have permanent, dedicated CO_2 storage with associated CO_2 monitoring as its main objective. The start of Sleipner very much signified the birth of large-scale CCS.

To take stock of these first 20 years of CCS, IEA has published a report looking at experience gained in CCS across the globe. The report, targeted at policy-makers and non-expert readers, highlights the fact that despite slow progress, we do have more CCS now than we did back in 1996. The number of large-scale CCS projects in operation has expanded to 15, with six more expected to come online within the next two years in various sectors. The size of capture and dedicated CO_2 storage projects is also growing, soon reaching the 3 $MtCO_2$ per year milestone. Very importantly, the experience with CCS projects to date underscores the reality that CCS is not just a "clean coal technology", but a family of technologies offering CO_2 reduction solutions to a wide range of industries and feedstocks. In addition to the first industrial-scale projects, more than 20 years of dedicated CCS research and development have delivered significant technical advances across capture, transport and storage of CO_2.

Despite technical advances, wide CCS deployment has been hampered by fluctuating policy and financial support. Following the release of the 2005 IPCC Special Report on CCS and in the lead-up to the 2009 Copenhagen climate negotiations (COP15) there was a period of considerable momentum in CCS. More than USD 30 billion in public funding announcements were made and G8 leaders pledged to build 20 new large-scale CCS demonstration projects. However, this momentum was not maintained as early CCS deployment proved to be more complex, expensive and politically challenging than anticipated. Of the USD 30 billion in public funding announcements, less than 10% was actually invested in large-scale CCS projects between 2007 and 2014.

CCS is not optional in a climate-friendly energy future

After a review of progress, the report discusses the role that CCS can play in the accelerating energy transition. The global community agreed in Paris last year to a more ambitious temperature target of "well below 2°C", to pursue efforts towards 1.5°C, and to balance emissions during the second half of this century. This commitment provided a step-change in the level of shared ambition and will require rapid and extensive deployment of all low-emissions technologies, including CCS.

In the IEA 2°C scenario (2DS), CCS delivers 94 gigatonnes (Gt) of CO_2 emissions reductions in the period through 2050. This amounts to 12% of the cumulative emissions reduction task in the energy sector. Around 56%, or 52 Gt, of total CO_2 captured is from the power sector, predominantly from coal-fired power generation (80%); 31% or 29 Gt is captured from industrial processes; and 14% or 13 Gt is captured from fuel transformation. The 29 $GtCO_2$ captured in industry in the 2DS represents around 20% of the cumulative emissions reductions from these sectors. This may sound like a relatively small contribution, however it is a critical one. If CCS were not available, much of the 29 $GtCO_2$ reductions achieved by CCS would need to be offset by efforts in other sectors.

While the power sector could be decarbonised without CCS, this would have significant cost implications. Without CCS, the transformation of the power sector would be *at least* USD 3.5 trillion more expensive. In a "no CCS in power" scenario variant of the 2DS, deployment of renewable technologies would need to be expanded by an additional 1 900 GW by 2050 over and above the 2DS requirements. This is equivalent to around four times the total wind and solar PV capacity additions achieved in the last decade. In parallel, such scenario would require a virtual elimination of all coal-fired power generation, with significant stranding of assets, as well as considerable challenges for existing energy networks.

Faster deployment of CCS could support the shift from 2°C to the Paris Agreement target of well below 2°C. Greater penetration of CCS could help to reduce the remaining 7 $GtCO_2$ of industrial emissions in 2050, and bridge the gap between a 2°C target and well below 2°C. Furthermore, faster deployment of CCS on coal-fired power generation could reduce cumulative emissions by 35 $GtCO_2$ through 2050 and on gas-fired power by an additional 10 $GtCO_2$.

The higher the ambition, the more role ne
gative emissions will have to play. It is noteworthy that of the 94 $GtCO_2$ captured in the IEA 2DS, BECCS delivers around 14 Gt of "negative emissions" over the period through 2050, primarily from biofuel production. These negative emissions are able to compensate for higher emissions elsewhere in the energy sector. Going below 2 degrees, the role of negative emissions will significantly increase.

Accelerating the pace of CCS deployment: The next 20 years

Accelerating the pace of CCS during the next 20 years will require significant political commitment from governments – and from industry. The introduction of financial incentives and the identification and characterisation of CO_2 storage resources are critical in paving the way for CCS deployment. In addition, the report lists a number of areas where increased emphasis would be particularly relevant:

- **Focus on retrofitting**: CCS is needed to reconcile today's reality of more than 1 950 GW of existing coal-fired power plants and a 2°C, or below, pathway. Coal currently generates around 40% of global electricity and the ability to retrofit CCS to coal power plants can help reverse the "lock-in" of emissions while limiting the economic and social cost associated with the premature closure of these plants.
- **Revive BECCS:** negative emissions will take on increased importance as the world seeks to achieve a net balance of emissions in the second half of the century. BECCS is the most mature of the negative emission technology options. However, widespread deployment will require that associated technical, economic and social challenges are addressed, particularly the availability of sustainable biomass and access to CO_2 storage sites.
- **Encourage low-carbon "clean industrial products":** Chemicals, steel and cement all have significant carbon footprints, and CCS is a key technology to achieve deep cuts in the associated carbon emissions. A combination of market "push" and "pull" levers, such as regulations, incentive mechanisms, and stimulating consumer interest, can help create the demand for "clean industrial products", and to incentivise the investment in CO_2 capture in various industrial processes.

- **Drive transition towards "EOR+":** novel EOR practices that include monitored CO_2 storage can produce verifiable, net emissions reductions. The volume of CO_2 injected and stored can significantly outweigh the emissions from the additional oil produced. Commercial interest in EOR+ could also encourage further investment in CCS deployment.
- **Disaggregate the CCS value chain:** the development of CO_2 storage resources remains critical for widespread deployment of CCS. Separating out CO_2 storage development as a distinct business, partially insulated from the different operational and risk profiles of capture and transport, could present an attractive investment proposal for entities with subsurface expertise.

The future for CCS will ultimately depend on a significant strengthening and expansion of the global climate response. As stated by the IEA Executive Director Dr Fatih Birol in the foreword of the report, "Deployment of CCS will not be optional in implementing the Paris Agreement." The Paris Agreement marked an important and historic milestone with increased ambition, however a significant gap exists between the national pledges ("NDCs") and a well below 2-degree outcome. Bridging this gap will require high levels of political commitment on national level. The required mid-century national strategies can provide a significant opportunity to ensure the positioning of CCS in countries' low-carbon energy landscape. The pace and intensity with which governments now enact ambitious national climate and energy policy will ultimately determine the future of CCS deployment.

The IEA secretariat thanks IEAGHG for excellent contributions made to the report! The report is available at: http://www.iea.org/topics/ccs/

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05/12/2016