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CCUS in Europe

A New Role and Implications for France and Germany

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Key takeaways

- A second wave of projects is under development, and it is much different from the 2000 wave. While Norway, the United Kingdom and the Netherlands are at its forefront, France and Germany have major competencies, and many projects could be carried out in these countries. Italy is also becoming active.

- A turning point is in progress. Recent CCS projects rely on a "hub and cluster" approach to achieve economies of scale and cost reductions, increased cooperation between governments and industry, as well as regional cross-border partnerships.

- Regulatory barriers, which can be resolved only at the European level, still impede the industrialization of the CCUS production chain. Political support at all levels is also lacking.

- The synergies between hydrogen and CCS could be exploited in decarbonized clusters, at the level of applications, R&I, and transport infrastructure. This would help optimize the cost of decarbonization.

INTRODUCTION

2020 and 2021 have been pivotal years for carbon capture, sequestration and/or reuse (CCUS) technologies in Europe. A second wave of projects is in progress and is very different from that of the 2000s. There are now 76 projects (including demonstrators) in Europe, in 16 countries and at different stages of development. 13 of these involve the production of low-carbon hydrogen. These projects should be able to store more than 50 $MtCO_2$/year by 2030.

In the International Energy Agency's net-zero scenario, 1.6 giga tons of CO_2 per year (Gt CO_2/year) are captured per year in 2030 at global level, and 7.6 Gt CO_2/year by 2050. This compares with approximately 40 million tons (Mt) of CO_2 currently captured. Accordingly, more than 3,000 CCUS facilities will be needed by 2050 (with an average capture capacity of 2.5 Mt/year). The industrial challenge of CCUS is thus clear.

In Europe, developments are accelerating: the first large-scale projects will be operational by 2024. Norway, the Netherlands, and the United Kingdom in Northern Europe are the most advanced and have set up regulatory frameworks, while announcing more than €5 billion in CCS funding. Other projects are being established in the rest of Europe. Hundreds more will be needed.

Many European governments have recognized that achieving climate neutrality cannot be achieved without CCS, and have included it in their climate and energy policies, as a complement to natural carbon sinks. The European target of reducing greenhouse gas (GHG) emissions by at least 55% by 2030 is a key factor in accelerating the deployment of CCUS during this decade. CCUS has also been integrated into the Green Pact for Europe, and European funds are supporting initial projects. These include the Innovation Fund, which launched its first call for major projects in 2020.

A TURNING POINT IN CCS APPROACHES

Recent CCS projects rely on a "hubs and clusters" approach to achieve economies of scale and cost reductions, increased cooperation between governments and industry, and regional cross-border partnerships. This approach marks a turning point in the CCS value chain economy from previous projects, which have been based on single sources of emission, with dedicated storage facilities. It is a major trigger for new investments aimed at decarbonizing European industrial hubs.

Norway's shared transport and storage infrastructure project for CO_2 – Northern Lights – is the most advanced project in Europe, and is a "game changer." It has enabled the rebirth of CCS in Europe, by providing European industries with the ability to store safely their CO_2 emissions under the Norwegian Ocean Shelf. The investment decisions of the project promoters in May 2020 and the Norwegian government in December 2020 have prompted the United Kingdom and the Netherlands to develop more rapidly their own CCS projects and shared CO_2 transport and storage infrastructure. The United

Kingdom is now planning to capture and store 10 Mt/year CO_2 by 2030, to develop two CCS clusters by the mid-2020s and two more by 2030.

In the Netherlands, the government has put in place an innovative mechanism to finance CCS projects, and decarbonization in general, which has been hugely successful with industrial companies. It has put various decarbonization technologies in industry into competition, including CCS, and will compensate the difference between the cost of these projects and the price of CO_2 on the European market for 15 years. CCS projects are increasing across the country, which is expected to implement its first large-scale project – Porthos – in 2024. The establishment of the first storage hubs in the North Sea strengthens CCS industrial cluster projects in the coastal regions of Europe (Belgium, France, Germany, Poland and Sweden) and of emerging CO_2 shipping and buffer port terminal projects. These developments have also generated enthusiasm for CCS in the rest of Europe. Italy is developing the first CCS project in the Mediterranean region, with storage in the Adriatic, while Denmark is now aiming to store CO_2 in its depleted deposits offshore.

> The establishment of the first storage hubs in the North Sea strengthens CCS industrial cluster projects

The key applications targeted by the CCS are: i) decarbonization of the industrial sector, particularly in energy-intensive industries which are difficult to decarbonize with current technologies (steel, cement, chemicals and petrochemicals); ii) low-carbon hydrogen production, in order to mass produce hydrogen if it can be at lower cost than renewable hydrogen (which is likely if the gas feedstock costs are low), and to facilitate the establishment of the infrastructure necessary for the mass deployment of renewable hydrogen in a second stage; and iii) the creation of negative emissions, together with the Bioenergy with Carbon Capture and Storage (BECCS), and eventually the Direct Air Carbon Capture and Sequestration (DACCS), which is now at a very early stage of development. Some countries will also apply CCS to decarbonize their gas-fired electricity generation (United Kingdom and Ireland). But this will not be widespread in Europe, because the costs are prohibitive. The use and recovery of CO_2 in synthetic products and materials is also developing and CCU demonstration plants are proliferating, particularly in Germany.

The steel industry, accounting for around 5% of European GHG emissions, has embarked on a fundamental transformation of its processes to produce CO_2-free steel by 2050. This transformation involves the use of renewable hydrogen in the production of direct reduced iron (DRI). Most European steel makers plan to transform the sector in stages, to include CCS, the CCU, and the use of low-carbon hydrogen in a transition phase, before renewable hydrogen and renewable electricity generation are available in sufficient quantities at competitive prices.

Regulatory and political challenges

CCUS technologies, however, still face several economic, regulatory and societal challenges. Although CCS is the least expensive option or the only option in some industrial applications, the cost of CCS technologies remains high, especially for the CO_2 capture segment which is very energy intensive, and requires increased R&I efforts to lower costs, as well as financial incentives to develop initial projects. Social and political acceptance of onshore storage remains a constraint, but the perception is changing in the face of the challenges of industrial decarbonization. Regulatory barriers, which can only be dealt with at the European level, still impede the industrialization of the CCUS chain.

The current developments already provide some lessons:

- CCUS projects do not develop without strong commitment from national policymakers, through roadmaps defining the CCUS's expected contribution to decarbonization and the regulatory framework needed to fund initial projects. Territories that may host projects need these national roadmaps to support their projects with local stakeholders. The policies of northern European countries provide crucial lessons in defining such national plans. The European Innovation Fund will facilitate initial European projects, but it will not be enough to allow for their full development. Support for the CCUS needs to be strengthened in order to decarbonize industries at lower cost, to preserve and develop industrial clusters, and to generate new value chains.
- CCS is rarely put forward by national policymakers outside the three leading countries, which for their part present it as a new industrial horizon. While these three countries have advantages in terms of oil & gas infrastructures and expertise, other European countries, including France and Germany, also have key strengths. These lie in their strategic position in the transport of CO_2, their storage experience (Germany is the Europe's largest natural gas storer, and France is the first country to have stored natural gas in deep saline aquifers), their dense gas networks, and the excellence of their academic and industrial research in CO_2 capture and storage technologies. Such expertise will be required to build European and global markets for CCS.
- CCS is one of the options among a set of solutions to decarbonize energy systems. The costs of CO_2 abatement using CCS technologies depend on a number of factors. In order to realistically assess CCS's decarbonization potential, particularly in the industrial sector, a sufficiently detailed assessment of CCS (and/or CCU) sectors' potential is needed, as well as their comparison with realistic decarbonization alternatives, such as renewable hydrogen. These models should help optimize public spending and the costs of the energy transition that society will bear.

- European and national policies supporting hydrogen and CCS must be viewed as complementarity and not as being in competition. Ambitious policies to develop renewable hydrogen are not inconsistent with a strong commitment to CCS technologies, as the ambitions to develop renewable hydrogen projects in the three lead countries clearly demonstrates. On the contrary, the synergies between the two technologies in applications, R&I, and transport infrastructure levels can be exploited in decarbonized clusters, thus optimizing the costs of decarbonization.
- The cross-border transport of the initial CCS projects is being organized and CO_2 emitting sites in Europe's northern coastal regions will have evacuation routes for their GHGs. But without CO2 pipelines, sites situated far inland will have difficulties. Further efforts will be required to create regional CO_2 transport networks which do not exist in Europe today. A holistic approach encompassing CO_2, hydrogen, existing gas networks, storage sites and/or CO_2 user sites is needed, given the synergies being developed between the CCUS and hydrogen.
- An increased R&I effort is needed to reduce the cost of CCS/CCU technologies and enable the industrialization of CCS and the promising developments offered by CCU.
- The availability of CO_2 storage capacity is critical in the implementation of CCS activity chains. While offshore storage is now helping to accelerate the deployment of CCS technologies, it is worth remembering the onshore potential and the experience of gas storage in other countries. An effort must be made, both to characterize better storage potential and to raise public awareness of the challenges of industrial decarbonization. The development of pilot schemes would be a first step in this direction.
- Finally, the role of CCS in the energy transition must be explained: It is a tool to decarbonize massively, quickly, and potentially at lower costs, with the end goal being to use fossil-free energy, which renewable electricity and hydrogen generation ultimately promise.

CCUS policies and projects in Germany and France are essential

Since 2019 and the imperative of accelerated decarbonization, CCS has been on the agenda in both countries, and interest in the contribution of CCS/CCU technologies to industrial decarbonization has lately been strengthened. New measures for CCS are being implemented, and CCS projects are being initiated by industrialists who want to reduce their emissions quickly, with requests being made for financial support from the European Commission.

In Germany, CCS is no longer a taboo subject, and indeed has become inevitable given stronger targets of reducing emissions by 2030. The federal government recognizes that the CCS will be essential to maintaining the competitiveness of industries. Funding has been in place since May 2021 to enable the development of CCS and CCU, and to ensure the acceptability of CCS/CCU technologies as "transition technologies". Projects are being initiated to decarbonize industrial sectors (especially steel), and to transport and store CO_2 in the North Sea. Germany is lso very advanced in terms of CCU, with policy seeking to create a circular carbon economy. However, despite these favorable developments, legislation in Germany is a hindrance to the start-up of CCS projects on the national territory. Crucially, Germany needs to reopen the debate about the acceptability of CCS. Beyond updating national legislation, public support will be essential.

Germany needs to reopen the debate about the acceptability of CCS

In France, the 2020 National Low Carbon Strategy (Stratégie Nationale Bas Carbone, SNBC2) now incorporates CCS into its objectives of achieving carbon neutrality, but too carefully. The roadmaps for decarbonizing energy-intensive industries (steel, chemicals and cement) were revised in the second quarter of 2021, and now incorporate CCS as a lever for decarbonization by 2030 (steel and chemicals), or by 2035 (cement). A roadmap for the development of the CCUS is being developed with industry, in order to propose concrete avenues forward, while new funding is being considered. Several CCS projects have been initiated by companies wishing to reduce emissions from their production by 2030. As in Germany, initial projects target CO_2 storage in the North Sea, but the first CCS industrial cluster projects which include underground storage in France itself are emerging. France has sedimentary structures suitable for CO_2 storage, and established a regulatory framework for the storage of CO_2 as early as 2010. It thus now has industrial competence covering the whole CCS chain, and has all the necessary conditions to start CCS projects and develop its know-how.

These developments need to be backed up by the establishment of an appropriate regulatory framework to support the financing of initial investments and to cover the difference between the cost of projects and the price of CO_2 in the European market. There is also a need to strengthen the R&D efforts in CO_2 capture, which will significantly reduce the costs of the CCS value chain. Technological advances in France are already showing very promising results. Moreover, the contribution of CCS/CCU technologies in the decarbonization of industry has to be defined, by assessing the potential of CCS (and/or CCU) systems, and comparing them to realistic decarbonization alternatives. In France, studies of the Parisian and Aquitaine basins have shown that they offer a storage potential. However, this potential needs to be better characterized, while that of maritime areas needs to be evaluated. Local populations should to be engaged in examining the issue at stake in industrial decarbonization as well as concerning the safety aspects of CO_2 storage. In Germany, the question of storage within its national territory (on land or at sea) also requires reviewing the 2012 Geological Storage of CO_2 Act. To begin with, German CCS projects are considering cross-border storage of CO_2 in the North Sea, which should facilitate their acceptance. At the same time, a regional CO_2 transport network must be created, which will require the establishment of a European-wide regulatory framework.

While Germany and France do not have the luck of having North Sea-like hydrocarbon deposits in their seas, both countries are ideally positioned to develop CCUS technologies. They are located in the heart of Europe, with access to CO_2 storage being developed in the North Sea. They have a strategic position for the delivery of CO_2 and the creation of a European CO_2 network, and they have natural gas storage experience, as well as dense gas networks. France, in particular, has internationally renowned players throughout the CCS value chain, including Air Liquide, Total, IFPEN, Axens, BRGM, and some 30 other actors, which have also organized themselves within the Club CO_2. TotalEnergies is involved in major advanced CO_2 transport and storage projects in the North Sea, including Northern Lights, Endurance and Aramis. In terms of innovation, Germany can rely on strong partnerships between universities and the private sector, and on its industrial firms, such as Heidelberg Cement and Linde, which are already working on CO_2 capture. Industrial giants, either national or operating in France and Germany (e.g., ArcelorMittal, ThyssenKrupp, Heidelberg Cement, Vicat, LafargeHolcim, Total, ExxonMobil, Yara and Borealis) are strongly committed to decarbonizing their activities, and have included CCS in their strategies. CCS technologies will be needed to build the global market, which is set to experience exponential growth (more than 7 giga tons of CO_2 stored by 2050, according to the International Energy Agency's report on carbon neutrality by 2050). Germany is positioned in the CO_2 capture and use segments, and France along the whole CCS/CCU value chain. Both countries are well-placed to commercialize these technologies, which will also eventually be needed to produce negative emissions.

Both countries are ideally positioned to develop CCUS technologies

Conclusion

CCUS provides energy-intensive industries and territories with the flexibility to achieve carbon neutrality. It constitutes a new industrial horizon that can sustain jobs, economic development, and export earnings. Europe is positioning itself as a lead player with the United States in CCUS technologies, whose markets hold out exponential growth. This momentum is driven by industrial companies which want to decarbonize their production in the short term. It must be encouraged and strengthened.

The perception of CCS has changed a lot over the past decade, and it appears to be the only possible short-term option to decarbonize industries, until electrolysis technologies reach a critical mass. A holistic view encompassing all decarbonization options is thus needed. Moreover, it also accelerates the development of a decarbonized hydrogen economy by building the necessary infrastructure and exploiting the synergies between CCS, CCU, and hydrogen within decarbonized industrial clusters.

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