PROCEEDINGS OF THE
INTERNATIONAL CARBON NEUTRALITY TRAINEESHIP PROGRAM
Volume.01, Number.1, 2023, 63-67

A Brief Analysis and Suggestion Report Based on the Development of CCUS in EU

Yuhao GAO

China University of Petroleum, Qingdao City, Shandong Province, China, 266580
E-mail: gaoyuhao823@163.com
***Corresponding author**

Abstract

As a carbon neutralization method with large-scale carbon dioxide emission reduction, CCUS technology has attracted close attention from the EU. The European Green Agreement sets the goal of reducing greenhouse gas emissions by 50-55 per cent below 1990 levels by 2030 and achieving climate neutrality by 2050. The EU now incorporates CCUS into the technology required for the transition to climate neutrality, and gradually takes a low-carbon development path in many fields such as energy, industry, construction, transportation, agriculture, ecology and environment. This paper investigates and sorts out the strategic planning of CCUS technology development in the EU, and puts forward suggestions on the priority of CCUS project infrastructure and the distribution of multi-industry clusters in combination with the development trend of related technologies in Europe.

Keywords: CCUS; carbon neutralization; suggestions on countermeasures.

1. Introduction to CCUS/CCS

CCUS (Carbon Capture, Utilization and Storage) is the new development trend of CCS (Carbon Capture and Storage) technology, which is to purify the carbon dioxide emitted in the production process and then put it into the new production process, which can be recycled. For example, the use of chemical or physical methods (Porous carbon-based material adsorption, membrane technology capture, low temperature distillation and microalgae separation, chemical cycle combustion method, amine solution absorption method, etc.) to adsorb and capture carbon dioxide (Gunawardene, Gunathilake, Vikrant, & Amaraweera, 2022) followed by projects such as geological storage (Czernichowski-Lauriol et al., 2018). Compared with CCS, carbon dioxide can be used as a resource, which can produce economic benefits and is more practical. For example, the miscible mechanism of carbon dioxide can be used to reduce the surface tension of oil and formation rocks, thereby improving the flow environment of reservoirs underground. It is also through the use of carbon dioxide that Europe has also carried out the CO_2-EOR project for many years (Holz et al., 2021), which is a rapid development in the application of CCUS technology.

However, the key to achieving these goals lies in the construction of three CCUS chains: carbon capture, storage and utilization chains. In these systems, carbon dioxide is captured from large point sources and is usually transported by pipeline, first to storage, second to utilization, and finally to storage and/or utilization. (Hasan, First, Boukouvala, & Floudas, 2015) Each element in the supply chain must be connected to other elements in an optimal way. It is a combinatorial problem to correctly connect carbon sources through efficient capture technology. The available solutions increase with the number of locations (Leonzio, Foscolo, & Zondervan, 2019). It is important to choose a solution with the lowest total cost and / or carbon dioxide emissions.

2. Partial progress of the European CCUS projects

In June 2021, the European Commission adopted the 'Horizon Europe' major work plan for 2021-2022. Topics to be funded in the CCUS area include: integration of CCUS as an industrial hub or cluster; reducing carbon capture cost through new or improved technologies; industrial decarbonization through CCUS; direct air carbon capture and conversion. In October of the same year, the EU launched the PyroCO_2 innovation project, which aims to build and operate a facility capable of capturing 10,000 tons of industrial CO_2 per year and using it to produce chemicals. (Anning et al., 2022) The United Kingdom, Denmark and other countries have introduced enhanced oil recovery (EOR) technology and CCUS technology in the North Sea area for traditional oil and gas exploitation. There are two benefits: (1) hydrocarbon expulsion through carbon dioxide, enhanced oil recovery through miscible flooding; (2) Treatment of excess carbon dioxide and other greenhouse gases. (Suicmez, 2019). Germany plans to use CCUS technology to convert CO_2 into various energy carriers, chemicals and inorganic carbonates. And plan its CCUS industry chain (Schmid & Hahn, 2021). In addition, the European "Strategic CCUS" project uses the method of the US Department of Energy to find that the carbon dioxide storage capacity of the geological layer of the Greek trough is large, and it is planned to carry out a geological carbon dioxide geological storage project, which provides potential for implementing a promising method to reduce carbon dioxide emissions in Greece. Norway, Switzerland, France and other EU member states actively participate in the network construction of CCUS projects. Through knowledge sharing and mutual learning, member projects are promoting the delivery and deployment of carbon emission control systems, so that European member states can reduce emissions from industrial, power, transportation and heating sectors. (Koukouzas et al., 2021) .

3. Noteworthy aspects of European CCUS development

3.1. Priority to develop CCUS technology in specific industries

At present, CCUS projects are mostly demonstration projects. The common ones are carbon dioxide geological storage, carbon dioxide enhanced oil recovery, thermal power carbon dioxide capture, carbon dioxide water gas or synthetic methanol and so on. Europe is currently calling for energy conservation, the development of CCUS technology, plans to phase out thermal power, the development of new energy and so on. However, the cost of new technology and new energy is generally higher than the price of traditional energy, and the energy density is smaller than that of traditional energy such as oil, natural gas and thermal power generation. People tend to be more willing to consume traditional energy. Europe is currently a large energy demand, such as thermal power and can not completely give up, but this way of producing electricity and a large amount of carbon emissions, so the development of CCUS direction still have to pay attention to the main and secondary, according to the actual needs of the design CCUS development direction, more conducive to commercialization.

3.2. The development level and speed of CCUS in EU member states are not synchronized

Although the EU promulgated the CCUS technology development roadmap and strategic planning, but in the short term to achieve the goal still needs time, but also to strengthen the national level of technical guidance and macro-control. The R & D strength is relatively scattered, which may lack sufficient information and resource sharing to a certain extent, making it difficult for CCUS to form a complete and stable industrial chain. As mentioned above CCUS projects need to give priority to the construction of infrastructure in order to strengthen the integration of CCUS network projects. For example, carbon dioxide capture and transportation links, or involved in carbon dioxide geological storage projects are required pipeline transportation, the EU countries in the CCUS co-sharing, co-ordination, in order to ensure the steady progress of the project.

3.3. Long construction period and high cost problems

The cost of CCUS is affected by technology and project size. For example, in carbon capture, chemical and physical methods sometimes consume a large amount of chemicals or materials depending on the capture mechanism, and the capture integration is also closely related to the concentration of the emission source. The distribution of carbon sources and the construction of their capture infrastructure cost more, such as the construction of CCUS project network, and the completion of the commercialization of the project may take a long time.

4. Suggestions for the development of CCUS

4.1. Strengthen cluster planning and establish CCUS development path for carbon neutrality

Clarify the strategic positioning of CCUS technology and incorporate it into the European carbon neutrality action plan. Clarify the development focus and key links of CCUS technology, and systematically arrange a number of CCUS projects with industrial chains. For example, traditional carbon emission industries such as thermal power generation, steelmaking, and cement manufacturing (Perez-Fortes, Moya, Vatopoulos, & Tzimas, 2014) are interconnected with a series of carbon sequestration and carbon utilization industries. Specifically, by connecting carbon dioxide production sources to geological storage sites through pipelines, or by merging with carbon dioxide enhanced oil well networks to improve the comprehensive application of CCUS technology, such as exploring recycling paths for the hydrogenation of carbon dioxide to fuels such as methane and methanol, industrial clusters, and the development of CCUS development roadmaps and medium- and long-term development plans.

4.2. Strengthen the CCUS investment and financing policy to solve the high cost problem of the project

Improve the green financial system, promote the innovation of green financial products, and effectively guide the investment of social capital in CCUS through green bonds, green assets and other products and combinations; incorporating CCUS into the carbon trading market, formulating a CCUS emission reduction pricing mechanism, and promoting a virtuous cycle of increasing investment and financing and continuous cost reduction; for investors of low-cost, low-energy technologies and negative emission technologies coupled with new energy, increase financial support and form a clear incentive environment.

4.3. Accelerate CCUS industry innovation and establish an intelligent monitoring mechanism

Building a bridge between laboratory research and large-scale industrial demonstration; integrate the upstream and downstream industrial chains, promote the joint research of related enterprises on key common technologies and the construction of large-scale CCUS technology demonstration projects, establish a large-scale carbon dioxide emission source database and monitoring system, intelligent control system, and quantify CCUS technology application information.

4.4. Carry out industrial co-construction and sharing mechanism, strengthen infrastructure construction, and break through the technical difficulties related to large-scale CCUS projects

Holz et al. (2021) argued that the deployment of CCUS (CCS) in Europe depends on two factors: 1) the development of low-cost carbon capture power generation technologies (coal and / or gas), and 2) a sufficiently high CO_2 price to compensate for the cost of deploying CO_2 transport infrastructure. Once the carbon dioxide transport infrastructure is built, CCUS (CCS) will become the preferred choice for carbon reduction in the industrial sector.

Carry out CCUS co-construction and sharing mechanism to promote cooperation in the field and facilitate the coupling and integration of technology and industry; increase the scale of infrastructure investment and construction such as carbon dioxide transportation and storage, optimize and integrate resources, improve and upgrade equipment, and gradually improve infrastructure; co-build carbon dioxide collection, transportation network, hubs and other facilities to reduce costs and enhance economies of scale.

4.5. The necessity of strengthening the publicity of CCUS to the public

A cross-country study from France and Spain on public perception of CCUS technology, (Oltra et al., 2022) argued that with the development of CCUS projects in Europe, public participation at the national and regional levels may play a crucial role in the success of CCUS projects. Once the public is aware of the benefits of CCUS and related technologies, they will support rapid deployment and implementation. Decision makers and supporters of CCUS need to invest resources to inform the public about the benefits of the technology and build trust and a sense of participation in such projects.

5. Summary

CCUS is the most important emission reduction measure to achieve carbon neutrality and is irreplaceable for high-quality economic and social development. For example, the combination of CCUS and power system helps to improve the resilience and reliability of the power grid, and also helps to create and provide new jobs in the project. It can also promote economic growth through technological innovation and realize infrastructure reuse.

This paper describes the technical development status of CCUS capture, transportation and utilization, and storage, and expounds the current development of CCUS in Europe. On this basis, the author analyzes that carbon dioxide capture technology alone is difficult to achieve the goal of carbon neutral fossil energy activities. Therefore, it is proposed to accelerate the construction of CCUS project capital cluster layout and industry coupling development, form an emerging carbon economy with commercial value, and promote the development of the project. Based on natural conditions, industrial cluster distribution and infrastructure configuration, the necessity of pipeline network construction in carbon dioxide utilization and storage projects is analyzed. In order to deepen and strengthen the promotion and development of CCUS projects, suggestions are made from six aspects: industrial cluster layout, policy incentives, technological innovation, infrastructure construction and public awareness.

References

[1] Anning, Q., Xiaoyan, W., Nana, L., Yulin, S., & Fang, C. (2022). International carbon capture, utilization and storage (CCUS) Technology development strategy and technology layout analysis. *Scientific Observation*, 17(4), 29-37.

[2] Czernichowski-Lauriol, I., Berenblyum, R., Bigi, S., Car, M., Gastine, M., Persoglia, S., ... & Wildenborg, T. (2018). CO_2 GeoNet actions in Europe for advancing CCUS through global cooperation. *Energy Procedia*, 154, 73-79.

through Physical and Chemical Adsorption Using Porous Carbon Materials: A Review. *Atmosphere*, 13(3), 397.

[4] Hasan, M. F., First, E. L., Boukouvala, F., & Floudas, C. A. (2015). A multi-scale framework for CO_2 capture, utilization, and sequestration: CCUS and CCU. *Computers & Chemical Engineering*, 81, 2-21.

[5] Holz, F., Scherwath, T., del Granado, P. C., Skar, C., Olmos, L., Ploussard, Q., ... & Herbst, A. (2021). A 2050 perspective on the role for carbon capture and storage in the European power system and industry sector. *Energy Economics*, 104, 105631.

[6] Koukouzas, N., Tyrologou, P., Karapanos, D., Carneiro, J., Pereira, P., de Mesquita Lobo Veloso, F., ... & Karametou, R. (2021). Carbon Capture, Utilisation and Storage as a Defense Tool against Climate Change: Current Developments in West Macedonia (Greece). *Energies, 14*(11), 3321.

[7] Leonzio, G., Foscolo, P. U., & Zondervan, E. (2019). An outlook towards 2030: optimization and design of a CCUS supply chain in Germany. Computers & *Chemical Engineering, 125*, 499-513.

[8] Oltra, C., Dütschke, E., Preuß, S., Gonçalves, L., & Germán, S. (2022). What influences public attitudes and acceptance of CCUS technologies on the national and regional level? Results from a survey study in France and Spain. *Results from a survey study in France and Spain (July 1, 2022).*

[9] Pérez-Fortes, M., Moya, J. A., Vatopoulos, K., & Tzimas, E. (2014). CO_2 capture and utilization in cement and iron and steel industries. *Energy Procedia, 63*, 6534-6543.

[10] Rycroft, L., Wildenborg, T., Bolscher, H., Opinska, L. G., Yearwood, J., Parmiter, P., ... & Kraemer, D. (2021, March). CCUS Projects Network: European Knowledge Sharing and Communication to Support Project Development. In *Proceedings of the 15th Greenhouse Gas Control Technologies Conference* (pp. 15-18).

[11] Schmid, C., & Hahn, A. (2021). Potential CO_2 utilisation in Germany: An analysis of theoretical CO_2 demand by 2030. *Journal of CO_2 Utilization, 50*, 101580.

[12] Suicmez, V. S. (2019). Feasibility study for carbon capture utilization and storage (CCUS) in the Danish North Sea. *Journal of Natural Gas Science and Engineering, 68*, 102924.