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US-CHINA ROUNDTABLE ON CARBON CAPTURE, UTILIZATION AND STORAGE

BY DAVID SANDALOW, SALLY QIU AND ZHIYUAN FAN
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Introduction

On November 17, 2021, New York time/November 18, 2021, Beijing time, the Center on Global Energy Policy at Columbia University and Energy Foundation-China convened an online roundtable on carbon capture, utilization and storage (CCUS) in the United States and China. Scholars, industry officials and policy makers exchanged information and ideas concerning CCUS development in each country. Participants discussed the role of CCUS in achieving net zero emissions, focusing on three topics in particular: CCUS costs, strategies for utilization of carbon dioxide (CO_2) and CCUS policies. This report summarizes key points made by participants at the roundtable, which was held under the Chatham House Rule.[1]

This event summary reflects the authors' understanding of key points made in the course of the roundtable. It does not necessarily represent the views of CGEP.

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Key Themes

In the view of most roundtable participants, CCUS technologies are important for meeting the challenge of climate change and the goals of the Paris Agreement. Participants discussed topics including the potential role for CCUS in deep decarbonization of hard-to-abate industries, production of low-carbon hydrogen at scale and removing carbon dioxide from the atmosphere.

Several participants noted the gap between CCUS deployment today and the deployment that could be required to meet climate goals. By some estimates, CCUS deployment must increase at least 100-fold[2] in the decades ahead to limit warming to 2°C/3.6°F above pre-industrial levels (and even more to limit warming to 1.5°C/2.7°F above those levels).

At least 27 CCUS projects are in operation globally. At least 135 are in the pipeline, at different stages of development. Most projects are in North America or Europe. Among the 70 new CCUS facilities added to the project pipeline in 2021, 41 are in North America and 25 are in Europe.[3]

CCUS technologies are being applied in increasingly diverse sectors, and are now being explored in hard-to-abate industrial sectors including steel and cement as well as in the power sector. Blue hydrogen (steam methane reforming or coal gasification with CCUS) is an especially important application of CCUS, according to some participants. Low-carbon hydrogen may be essential to decarbonizing some sectors such as heavy-duty transportation, and it was noted that blue hydrogen offers a potentially cheap pathway for producing low-carbon hydrogen for at least the next decade and perhaps beyond.[4]

The adoption of more ambitious climate targets is a key driver of the growing momentum behind CCUS. More than 100 countries and several thousand companies have set net-zero targets in the past several years. This ambition can create a virtuous cycle in which governments have strengthened policies to drive private sector investment while the private sector has responded by advancing new projects and developing new business models to reduce costs and risks. This has given rise to CCUS networks and hubs, as well as new strategic business partnerships. There are currently more than 30 CCUS networks in development globally.[5]

The United States has greater experience with CCUS than China. The US first deployed CCUS technologies in 1972 (for enhanced oil recovery). Government grant programs have supported work on CCUS in the United States for almost 15 years. Today, roughly 20 million tons of CO_2 are used and/or stored annually in the US. The Chinese government has supported small CCUS pilot projects for many years. Roughly 2 million tons of CO_2 are used and/or stored annually in China.[6]

Scaling up CCUS may involve many challenges, including energy penalties (additional energy required to capture, separate, and compress CO_2), water consumption and costs, infrastructure issues, financing gaps and policy uncertainty. Continued dialogue between US and Chinese experts can help in meeting these challenges, participants noted.

Carbon Capture Costs

Carbon capture costs vary chiefly as a function of the concentration of CO_2 in emissions streams. When CO_2 is highly concentrated, such as in many fertilizer and coal-to-chemical plants, carbon capture costs are currently roughly $10/ton CO_2. With more dilute streams such as in the steel industry, carbon capture costs can be roughly $50/ton CO_2. With even more dilute streams such as from natural gas power plants, costs are currently roughly $100/ton CO_2 or more.[7]

These costs are not static. Carbon capture costs have fallen roughly 50 percent in the past 10 years and are expected to fall another 50 percent in the next 10 years, as carbon capture technologies scale.[8]

Technical innovations have the potential to reduce costs by roughly a third, and economies of scale have the potential to reduce costs by another third.[9] New business models and lower costs of capital have the potential to reduce costs as well, according to some participants.

CCUS costs in China are typically lower than world average CCUS costs. Among all costs associated with CCUS in China, roughly 60 percent–80 percent (120–480 RMB/ton-CO_2 or $20–$80/ton-CO_2) are for carbon capture. The remaining costs are for transportation and storage of CO_2.[10]

There are two major cost components of CCUS: capex (equipment, land-use) and opex (energy). In a typical CCUS project at a coal-fired power plant, for example, 16 percent of costs are for capex, with the balance going to opex expenditures such as for steam (27 percent), electricity (32 percent), ammonia reuse (12 percent) and finance (6 percent).[11]

CO_2 Utilization

Many products contain carbon atoms, including cement and concrete, aviation fuels and a wide range of chemicals. CO_2 captured from emissions streams can be used in making these products, offering significant potential benefits for climate mitigation. Markets for captured CO_2 could exceed billions of tons and tens of billions of dollars globally.[12]

Participants noted captured CO_2 can be used in a number of ways:

- The most beneficial from a climate standpoint is when captured CO_2 is stored in long-lived products such as cement, concrete or polymers. This can remove CO_2 from the biosphere for centuries, similar to the storage of CO_2 in subsurface saline aquifers or ultramafic rock bodies.
- Captured CO_2 can also be used in fuels. Although this CO_2 returns to the atmosphere when the fuel is combusted, it typically displaces CO_2 that would have come from hydrocarbons beneath the Earth's surface and therefore delivers a net climate benefit.
- Captured CO_2 can also be used for enhanced oil recovery, helping produce oil more cheaply or in greater amounts. CO_2 used for this purpose will often stay underground for decades or centuries, helping lower atmospheric CO_2 concentrations, although the cheaper or additional oil produced will increase atmospheric CO_2 concentrations

when combusted. Different studies have produced different results concerning the full lifecycle impacts of using CO_2 for enhanced oil recovery.[13]

Lifecyle analyses are essential for any CO_2 utilization strategy. To the extent that the objective is to contribute to climate mitigation, analyzing the extent to which the CO_2 benefits from a utilization strategy outweigh any incremental CO_2 emissions is essential.

Lack of infrastructure is a major barrier to greater CO_2 utilization in both the US and China. CO_2 pipelines will be especially important to growth of a robust market for CO_2-based products. Additional zero-carbon electricity generation, along with transmission capacity, is also essential.

The high cost of some CO_2 utilization strategies is another major barrier to their deployment. Technical innovations and scale-up are required to bring down costs.

Policy Support

CCUS receives policy support in both China and the US. Participants noted that additional policy support will be important in helping CCUS scale and play an important role in climate mitigation in the decades ahead.

In November 2021, the US and Chinese governments issued their Joint Glasgow Declaration, which says "The two sides intend to cooperate on … deployment and application of technology such as CCUS …"[14]

China

CCUS has been included in China's carbon mitigation strategies since the 12th Five-Year Plan (2011–2015). In May 2019, the Ministry of Science and Technology and the Administrative Center for China's Agenda 21 jointly issued an updated Roadmap for Development of CCUS Technology in China. The roadmap set goals for reducing the cost and energy consumption of CO_2 capture by 10 percent to 15 percent in 2030 and by 40 percent to 50 percent by 2040. The roadmap foresees multiple CCUS hubs across the country.[15]

The 14th Five-Year Plan, released in March 2021, highlighted the role of CCUS in low-carbon development and called for implementing near-zero-emissions CCUS demonstration projects.[16] Several CCUS hub pilot projects are in the pipeline, mostly in northwestern provinces.

The close integration between Chinese ministries and state-owned enterprises may facilitate development of large-scale CCUS projects and the rapid scale-up of CCUS in China.

Roundtable participants suggested policy options for enhancing CCUS development in China, including:

- Providing strong policy signals concerning the importance of CCUS development;
- Creating a comprehensive CCUS development strategy;
- Conducting additional, detailed geological surveys;
- Establishing additional CCUS hubs throughout the country;

- Investing in CCUS infrastructure, including, in particular, CO_2 pipelines;
- Integrating CCUS projects into carbon markets; and
- Enhancing international collaboration on CCUS.

United States

The US government has supported CCUS projects with grant programs for many years. In addition, the 45Q tax credit as amended in 2018 provides important incentives for CCUS projects in the US.

In November 2021, President Joe Biden signed the Infrastructure Investment and Jobs Act (sometimes known as the "Bipartisan Infrastructure Bill"). The act provides the largest federal investment in CCUS ever, including:

- $3.5 billion for carbon capture demonstration projects and large-scale pilots;
- $2.1 billion for low-interest loans to large CO_2 pipeline projects, to be administered by a new Carbon Dioxide Transportation Infrastructure Finance and Innovation program;
- $2.5 billion for large-scale carbon sequestration projects; and
- $3.5 billion for four regional direct air capture hubs.

In addition, pending legislation in the US Congress would, if enacted, amend the 45Q tax credit to provide greater incentives for CCUS development in the US.

Conclusion

Participants agreed that the exchange of views and perspectives had been valuable for all. They welcomed additional opportunities to share information and perspectives on these topics in the months ahead.

Notes

1. When a meeting is held under the Chatham House Rule, "participants are free to use the information received, but neither the identity nor the affiliation of the speaker(s), nor that of any other participant, may be revealed." https://www.chathamhouse.org/about-us/chatham-house-rule.

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14. US Department of State, "U.S.-China Joint Glasgow Declaration on Enhancing Climate Action in the 2020s," November 10, 2021, 7(e), https://www.state.gov/u-s-china-joint-glasgow-declaration-on-enhancing-climate-action-in-the-2020s/.

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About the Authors

David Sandalow is the Inaugural Fellow at the Center on Global Energy Policy and co-Director of the Energy and Environment Concentration at the School of International and Public Affairs at Columbia University. He founded and directs the Center's U.S.-China Program and is author of the Guide to Chinese Climate Policy. He teaches a one-month short course each year as a Distinguished Visiting Professor in the Schwarzman Scholars Program at Tsinghua University.

Mr. Sandalow has chaired the ICEF Innovation Roadmap Project since 2015. In that capacity, he has led development of roadmaps on biomass carbon removal and storage, industrial decarbonization, direct air capture and carbon dioxide utilization, among other topics.

In 2020, Mr. Sandalow and colleagues co-founded the Food-Climate Partnership. He is lead author of the Food and Climate Change InfoGuide (CGEP, May 2021).

Mr. Sandalow has served in senior positions at the White House, State Department and U.S. Department of Energy. He came to Columbia from the U.S. Department of Energy, where he served as Under Secretary of Energy (acting) and Assistant Secretary for Policy & International Affairs. Prior to serving at DOE, Mr. Sandalow was a Senior Fellow at the Brookings Institution. He has served as Assistant Secretary of State for Oceans, Environment & Science and a Senior Director on the National Security Council staff.

Mr. Sandalow writes and speaks widely on energy and climate policy. In addition to the publications mentioned above, recent writings include "Greenhouse Gas Emissions from the Food System: Building the Evidence Base," Environmental Research Letters (June 2021) (co-author); "Finding and Fixing Food System Emissions: The Double Helix of Science and Policy," Environmental Research Letters (June 2021) (co-author); Energizing America (CGEP September 2020) (co-author); Leveraging State Funds for Clean Energy (CGEP, September 2020) (with Richard Kauffman); Green Stimulus Proposals in China and the United States (CGEP, August 2020) (with Xu Qinhua); China's Response to Climate Change: A Study in Contrasts (Asia Society Policy Institute, July 2020); China and the Oil Price War (CGEP, March 2020) (co-author); Decarbonizing Space Heating With Air Source Heat Pumps (December 2019, co-author); Electric Vehicle Charging in China and the United States (February 2019) (with Anders Hove); A Natural Gas Giant Awakens (June 2018) (lead author); The Geopolitics of Renewable Energy (2017) (CGEP and Harvard Kennedy

School, co-lead author); Financing Solar and Wind Power: Lessons from Oil and Gas (2017, co-author); and The History and Future of the Clean Energy Ministerial (CGEP, 2016). Other works include Plug-In Electric Vehicles: What Role for Washington? (2009) (editor), Overcoming Obstacles to U.S.-China Cooperation on Climate Change (2009) (with Ken Lieberthal) and Freedom from Oil (2007).

Mr. Sandalow serves as a director of Fermata Energy and senior advisor to APL. He is a member of the Zayed Future Energy Prize Selection Committee, Global CO_2 Initiative Advisory Board, Electric Drive Transport Association's "Hall of Fame" and Council on Foreign Relations. Mr. Sandalow is a graduate of the University of Michigan Law School and Yale College.

Sally Qiu joined the Center on Global Energy Policy in October 2017 as a Research Associate. She supports the Center's Senior Research Scholar David Sandalow, Professor of Professional Practice Jason Bordoff and Dean of SIPA Merit Janow on initiatives related to U.S.–China relations on economics, energy, and climate change. Prior to joining Columbia, she worked at the ClimateWorks Foundation and the United Nations ESCAP. Her work focused on policy and trend analysis related to energy efficiency and renewable energy in the Asia-Pacific region. She holds a MS degree in Public Policy and Management with a concentration on energy policy from Carnegie Mellon University and a BA degree in History and Environmental Geoscience from DePauw University.

Zhiyuan Fan is a Research Associate at the Center on Global Energy Policy. He supports CGEP's Carbon Management Research Initiative, focusing on low-carbon industrial systems, including low-carbon fuels and processes, carbon capture and storage, and CO_2 use/recycling.

Prior to joining SIPA, he worked as a graduate student researcher at the Sustainable Engineering Lab in Columbia University's Mechanical Engineering Department, focusing on energy system modeling and optimization under deep renewable penetration, and electrification of heavy road transportation.

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