CCUS Plays Key Role in Transition to Carbon Neutrality Future for China

碳捕集利用与封存在中國向碳中和未來過渡中扮演關鍵角色

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China's President Xi recently announced, at the UN General Assembly, that China aims "to have carbon dioxide (CO_2) emissions peak before 2030 and achieve carbon neutrality before 2060".[1]

中國國家主席習近平最近在聯合國大會上宣布，中國的目標是"在 2030 年前使二氧化碳（CO_2）排放達到峰值，并在 2060 年前實現碳中和"。[1]

CCUS A PART OF CHINA'S DECARBONIZATION

碳捕集利用与封存是中國低碳化的一部分

Without China's commitment, the goals of the Paris Agreement, which would otherwise appear too remote to reach, become closer to being achievable. With the largest production capacity in major heavy industry sectors to meet the international and domestic market demand as the world's largest energy consumer and producer, China released the equivalent of about 10 billion tonnes of CO_2 into the atmosphere in 2018, according to the Global Carbon Project that tracks emissions worldwide.2

憑藉中國的承諾，本來遙不可及的《巴黎協定》目標，距离實現近了一步。根據跟踪全球排放量的"全球碳规劃"组织的数据，中國主要重工業行业领域均具有最大规模的生產能力，以滿足國際和國內市場的需求，是世界上最大的能源消費國和生產國，2018 年中國向大氣中釋放了約 100 億噸二氧化碳。[2]

China's pledge of carbon peaking and neutrality is ambitious and inspiring. In order to meet such a large commitment, all low-carbon solutions will be required. China has an opportunity to deploy carbon capture, utilization and storage (CCUS) as a priority for its energy sustainability, while it boosts other strategic sectors, such as hydrogen, transportation electrification, smart grid corridors, and carbon sinks of forestation. Across all low-carbon energy solutions, CCUS will play a critical and evolving role for China's energy transition as a competitive companion to renewable energy.

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Zewei Yu has built on strong business connections in CCUS with China and other Asia Pacific economies over a decade, has facilitated successful communications and continued collaboration, and helped inform CCUS shareholders of the evolving trends, issues, and the complex challenges associated with large-scaled CCUS deployment, drawing on his public service experiences in climate change planning, and Canadian CCUS success stories and expertise.

于泽伟，在过去十多年中，与中国及其它亚太经济体在 CCUS 领域建立了牢固的业务联系，在此基础上，充分发挥了他担任公务员从事气候变化规划的经验并深刻领会加拿大开展 CCUS 的成功案例和专业知识，促进了富有成果的沟通和持续的合作，并帮助 CCUS 利益攸关方深入了解与 CCUS 的大规模部署相关的不断发展变化的趋势与问题以及复杂的挑战。

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中國承諾實現碳峰值和碳中和的目標可谓雄心勃勃。為了履行如此重大的承諾，將需要所有低碳解決方案。中國有機會部署碳捕集，利用与封存（CCUS）作為其能源可持續性的優先选項，同時促進其他戰略性布局的發展，例如運輸電氣化，氫能利用，智能電網走廊以及来自植树造林的碳匯。在所有低碳能源解決方案中，碳捕集利用与封存作為可再生能源的既競爭又相互依存，將在中國的能源轉型中發揮越来越关键的作用。

Large-scale CCUS is currently the only solution available to significantly, and directly, reduce or avoid some of the most hard-to-abate emissions from existing key heavy industrial facilities in the next decade and into the foreseeable future. As China continues to grow, greater number of manufacturing processes will need to be decarbonized. Business models and experiences of full-chain, large-scale CCUS deployment and commercial operations from proven iterations can aid in decarbonizing the flue-gas emissions from the production processes of cement, iron & steel production, chemicals, refineries, and power generation. China may have to rely on an energy mix including decarbonized fossil fuel-based clean energy with low- to no-carbon emissions during its energy transition.

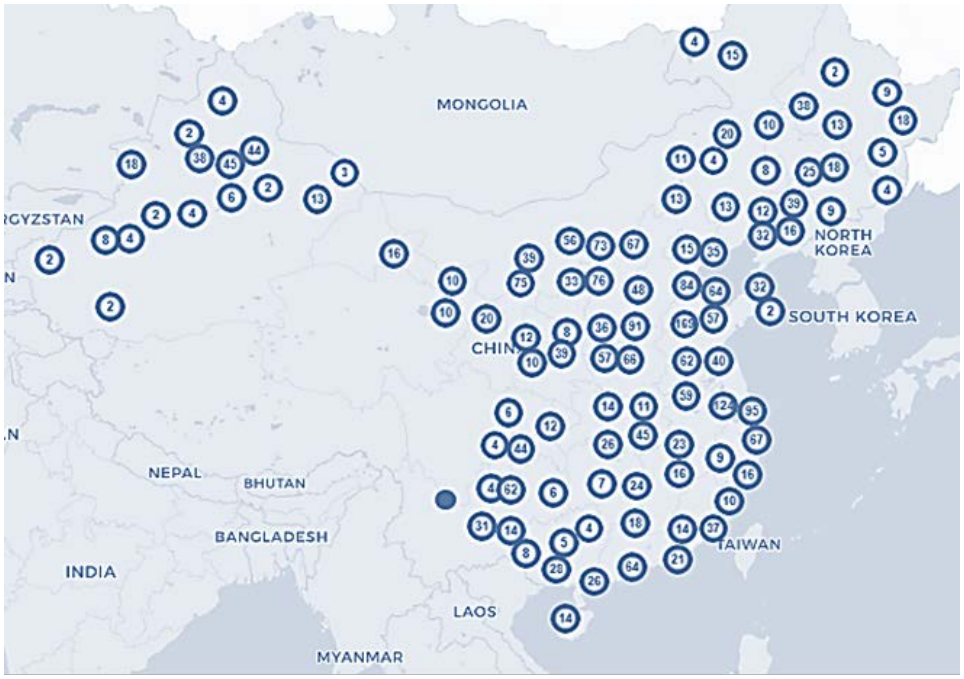
大规模碳捕集利用与封存, 是目前唯一可在未來十年乃至可預見的將來，应用於現有最難減排的主要重工業設施, 实现顯著并直接減排或避免排放的解決方案。隨著中國的持續发展，更多的加工製造過程需要脫碳。經過工业化示范驗證的全鍊条大規模碳捕集利用与封存部署应用以及商業化運營的模式和經驗， 有助于減少水泥，鋼鐵，化工，煉油和發電等生產過程中煙氣的排放。在能源轉型期，中國不得不依靠的能源組合，可能包括低碳乃至無碳排放的以脫碳的化石燃料為基礎的清洁能源。

PROGRESS IN CHINA ON CCUS

碳捕集利用与封存在中國的進展

For over a decade, China has had the highest number of CCUS piloting projects in the world. Initial attention was given towards retrofitting existing fossil fuel-based power and industrial plants to understand how the capture technology system operated at small scale. These pilot-scale applications span a variety of available capture technologies such as post-/pre-combustion and oxyfuel combustion capture, as well as capture from hydrogen production with coal chemical processes, EOR and saline formation storage.[3]

十多年來，中國擁有全球數量最多的碳捕集利用与封存試點項目。最初的注意力放在了改造現有的基於化石燃料的电力与工業裝置，以了解碳捕集技術系統如何在小規模範圍內運行。這些达中試規模的應用涵蓋了多種可用的碳捕集技術，例如燃燒後，燃燒前以及富氧燃燒碳捕集，通過煤化工從氫氣生產工艺過程捕碳，以及利用二氧化碳驱油（EOR）和咸水层构造封存等。[3]



There are 2,906 coal plants currently operating in China (another 368 are in construction, permitted, or announced). Each circle encases the number of coal plants in that area. See: *Global Coal Plant Tracker* published by *Global Energy Monitor*.

中國目前有 2906 个燃煤電廠（另外 368 个在建，获准建设或宣佈建設）。每個圓圈内为該地區的燃煤電廠數量。請參閱：《全球能源監測》發布的《全球燃煤電廠追踪》

In the power sector, 60% of China's coal-fired power fleet is considered young (approximately 10 years old).[4] As such, their useful life spans decades, beyond 2030, and are suitable candidates for CCUS retrofits. Among them, over 100 gigawatts of installed capacity are 660-1000 megawatt ultra-supercritical units - meaning they are exceptionally efficient.[5] By 2030, coal-fired power generation efficiency is expected to increase even more, up to 50%, and 20-100% will have the flexibility for peaking load requirement to be integrated with variable energy sources.[6]

在電力行业，中國 60％的燃煤電力资产被認為服役时间较短（大約 10 年）。[4] 因此，它們的剩余使用壽命長達 20 年，直至 2030 年以后，成为碳捕集利用与封存改造的合適選择对象。其中，超過 100 吉瓦的裝機容量為 660-1000 兆瓦的超超臨界機組，這意味著它們的效率相当优越。[5] 到 2030 年，燃煤發電效率还有望進一步提高，最高可達 50％，而 20- 100％將具有靈活性，可以與间歇性能源整合来满足峰值负荷的要求 [6]。

For heavy industry, post-combustion capture from a steel plant has been piloted in an intensive steel production region surrounding Beijing.[7] The emerging trends include CCUS for industrial use with the first pilot of post-combustion capture on a clinker kiln, while mineralized storage and cement carbon cure is under development.[8] Recently methanol conversion using hydrogen and CO_2 from coking process emission has broken ground by an automobile company, representing captured CO_2 use for production of portable fuel with reforming potential for fuel cell engines.[9]

就重工業而言，已經在北京附近的一個鋼鐵生產密集地區對鋼鐵廠進行了燃燒後碳捕集試驗。[7] 新興的趨勢还包括，首次在水泥熟料窑中進行了 CO_2 燃燒後捕集的中試，碳捕集与 CO_2 作为工業原料利用相结合， 同時 CO_2 礦化封存与混凝土养护也在开发中。[8] 最近，一家汽車制造企业利用了來自焦化過程排放的氫氣和二氧化碳轉化制甲醇，這反应了将捕集的二氧化碳用於生產便攜式燃料的潛力，而這種燃料经过重整有可能会驱动燃料電池發動機。[9]

RENEWABLES POLICY APPROACH APPROPRIATE FOR CCUS DEPLOYMENT

適用於碳捕集利用与封存部署的可再生能源政策模式

The most remarkable success in energy technology in China has been the domestic deployment of wind and solar power, and their global spillover effects. Chinese government policy incentives include subsidized rates for renewable power while the baseload systems provide backup services. This encourages the market to drive growth in the renewable energy sector at an accelerated rate, which has significantly increased competitiveness in the last two decades.[10]

在能源技術方面，中國最突出的成就是風能和太陽能在國內的大規模部署及其對全球的溢出效應。中國政府的政策激勵措施包括對可再生能源的補貼性电价，而电力基本负荷系統則提供備份电力服務。這鼓勵了市場加快可再生能源行業的增長速度，在過去的二十年中，其競爭力大大增強了。[10]

China is well positioned to be able to accomplish its newly announced goals by prioritizing large-scale CCUS deployment as a tool towards meeting its emissions peaking challenge in this decade. To do so it may consider repeating, in CCUS development, its successful experiences in renewable energy development. China is currently applying the same approach to incentivize market and infrastructure to drive the growth in electric vehicles as part of transport electrification and hydrogen public transit demonstration.[11]

通過優先考慮大規模碳捕集利用与封存的部署，以此作為應對十年后达到碳排放峰值挑戰的有利工具，中國定將有能力實現其新近宣布的目標。為此，可以考慮在碳捕集利用与封存開發中重複其在可再生能源開發方面的成功經驗。中國目前正在採用相同的方式來激勵市場和基礎設施建设，来推動電動汽車的發展，使其成為交通運輸電氣化和氫能公共交通示範努力的一部分。[11]

High-level priorities for governments and industry to fast-track CCUS demonstration project development within this next decade, across industry sectors, requires incentive policy parity with renewable energy. This is required so that CCUS sees the same momentum gained by renewable power, to break the pilot scale bottle neck, and to usher in large-scale CCUS in China. China must prioritize developing the market for captured CO_2 and infrastructure for its transportation, use and storage, including pipeline and oilfield infrastructure for enhanced oil recovery and geological storage, as a driver for upscaled CCUS demonstration and optimization. It is imperative to develop a full chain CCUS cluster in key regions near both sinks and sources on the fringes of the basins, and infrastructure that will allow multiple sources of captured CO_2 to share at low cost. Prioritized CO_2-EOR /storage is like a consumer market rewarding early mover deployment projects of both strategic energy security and climate benefits.

政府和工业行業在未來十年內，以高度優先，跨行業快速推动 CCUS 工业化示范項目開發，需要与可再生能源发展对等的激勵政策。這是必需的，以便碳捕集利用与封存获得与可再生能源相当的勢頭，冲破碳捕集利用与封存試點規模的瓶頸，令中國走上大規模碳捕集利用与封存的道路。中國必須優先發展为捕集的二氧化碳提供市場并完善其運輸，使用与封存的基礎設施，包括油田进行提高采收率操作和地質封存所必须的 CO_2 输送管道等基礎設施，以推動碳捕集利用与封存大规模示範和優化。必須在那些盆地邊緣靠近二氧化碳彙和源的的重点區域開發全鏈条碳捕集利用与封存集群，並建立允許多個 CO_2 捕集來源以低成本共享的相关基礎設施。优先发展 CO_2 驱油并封存就如同一個消費市場，在于獎勵那些先行实施部署的具有戰略性能源安全和氣候效益的項目。

COLLABORATION TO ACCELERATE CCUS DEPLOYMENT IN CHINA

合作加快碳捕集利用与封存在中國的部署

The National-Local Joint CCUS Engineering Research Centre members, with Northwest University in Xi'an, joined the International CCS Knowledge Centre on a tour of the Boundary Dam CCS facility, the world's first large-scale carbon capture project at a coal-fired power station located in Saskatchewan, Canada, as part of capacity building programme sponsored by Asian Development Bank,[12] in the summer of 2019. (Source: The National-Local Joint CCUS Engineering Research Centre, Xi'an.)

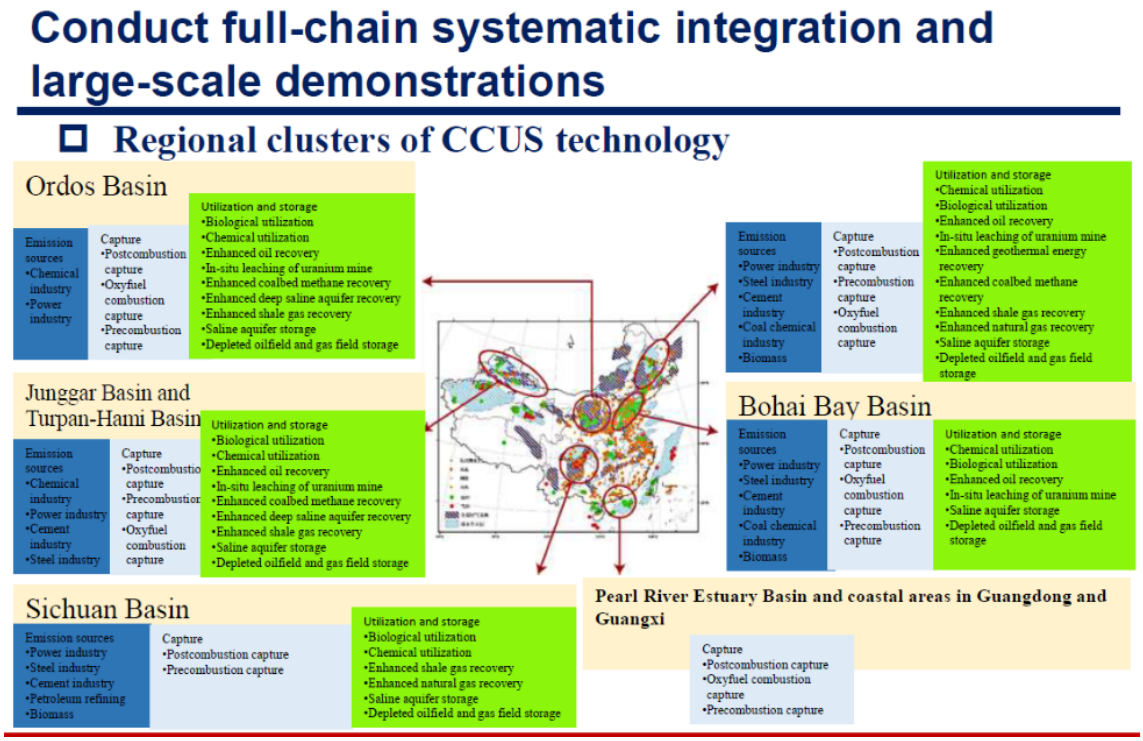
来自西北大學校园内的"国家-地方碳捕集利用与封存工程研究中心"成员，按照亞洲開發銀行贊助的能力建设計劃的活动安排,[12] 2019年夏，在碳捕集利用与封存知識國際中心人员引导參觀考察加拿大薩斯喀徹溫省境内全球首例大规模燃煤電廠碳捕集利用与封存項目---邊界壩碳捕集设施。（供稿： 西安 "国家-地方碳捕集利用与封存工程研究中心".）

CCUS deployment does not happen overnight, and China has made headway with its pilot projects and international collaboration efforts. For instance, the Shaanxi Provincial Government is supporting a national-local cross-sector initiative involving petroleum together other multiple industries and a research centre to advance CCUS deployment and international cooperation in the northwestern region,[13] while on Shandong Peninsula along the eastern coast, an oil company has implemented a training programme for its CCUS project leaders through international cooperation, after independently piloting a full-chain CCUS.[14] But this progress has not yet led to a large-scale CCUS project being developed. Learning from large-scale CCUS demonstration projects, specifically from the Boundary Dam 3 CCS Facility across sectors in the next 5 years will provide China with the opportunity to be a CCUS leader, suppling a competitive low-carbon technology solutions applicable to its own industries and to those of the Asia Pacific region and beyond. Internationally available learnings could be transferrable to facilitate CCUS demonstration and deployment in China from the full chain cluster of large-scale CCUS projects in operation that have proven successful and viable.[12]

碳捕集利用与封存的部署不会一蹴而就，中國在試點項目和國際合作方面已经取得了长足進步。陕西省在支持着包括了一个研发中心和石油等多个工业行业的国家-地方跨行业协调合作机制，以促进在西北地区部署 CCUS 以及国际合作;[13] 而与此同时，在山东半岛的某石油公司，则在独立进行 CCUS 全链条试点的基础上，通过国际合作为其 CCUS 项目带头人实施了实地培训。[14] 然而，這些進步尚未启动大規模碳捕集利用与封存項目的開發。從大规模碳捕集利用与封存示範項目中吸取教訓，尤其是借鉴"边界壩 3 碳捕集与封存設施"等项目获得的经验教訓，在未來 5 年中國將有機會成为引领碳捕集利用与封存的先驱，同时為自己的工業行業以及亞太地區及其它地區提供有競爭力的低碳技術解決方案。國際上業經證明为成功且经济可行的大规模碳捕集利用与封存項目全鏈条产业集群已在运行， 其实用的知识成果可轉移并促進在中國工業化示範并部署碳捕集利用与封存項目。[15]

With these commitments in China, we are seeing a distant light at the end of the tunnel for carbon neutrality - we have to go through the next decade of CCUS demonstration and deployment to experience that light ahead of us.

憑藉中國的承諾，我們仿佛置身于隧道看到了盡頭那一线碳中和的曙光---我們必須經歷碳捕集利用与封存工业化示範和部署应用的下一個十年，才能亲身感受我們前方的光明。



This graph indicates the critical importance of regional CCUS clusters by illustrating the significant potential for storage and proximity to intensive emission sources. Source: 21st Agenda Administration Centre, China: Roadmap for Carbon Capture, Utilization and Storage, Technology in China (2019).

上圖显示由于具有巨大封存潛力和靠近密集排放源，區域碳捕集利用与封存集群至關重要。資料來源：中國 21 世紀議程管理中心：《中國碳捕集，利用和封存技術路線圖》（2019 年）。

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ABOUT THE INTERNATIONAL CCS KNOWLEDGE CENTRE

The International CCS Knowledge Centre (Knowledge Centre) is dedicated to advancing the understanding and use of large-scale carbon capture and storage (CCS) as a means of managing greenhouse (GHG) emissions. Through experience-based guidance, the Knowledge Centre provides the know-how to implement and optimize large-scale CCS projects through the base learnings from both the fully-integrated Boundary Dam 3 CCS Facility, and the comprehensive second-generation CCS study, known as the Shand Study. The Knowledge Centre was founded in 2016 as a non-profit organization by BHP and SaskPower. For more information: https://ccsknowledge.com/

碳捕集利用与封存知識國際中心简介

碳捕集利用与封存知識國際中心(简称知識中心)，致力於利用其作为控制溫室氣體（GHG）排放的手段，促進深入掌握并推广碳捕集利用與封存(CCS)技术的大規模部署应用。知識中心以經驗为指南，以全容量一体化的“邊界壩”CCS 設施项目以及针对第二代 CCS 设施项目进行的全面研究---尚德电站碳捕集利用與封存项目的可研过程所掌握的专业知识为基礎，为實施和優化大型碳捕集利用與封存項目提供可操作的真知。知識中心系由必和必拓和萨斯喀电力集团於 2016 年成立的非營利組織。欲了解更多信息，請访问：https://ccsknowledge.com/