Perspectives on China CCUS Developments and Plans

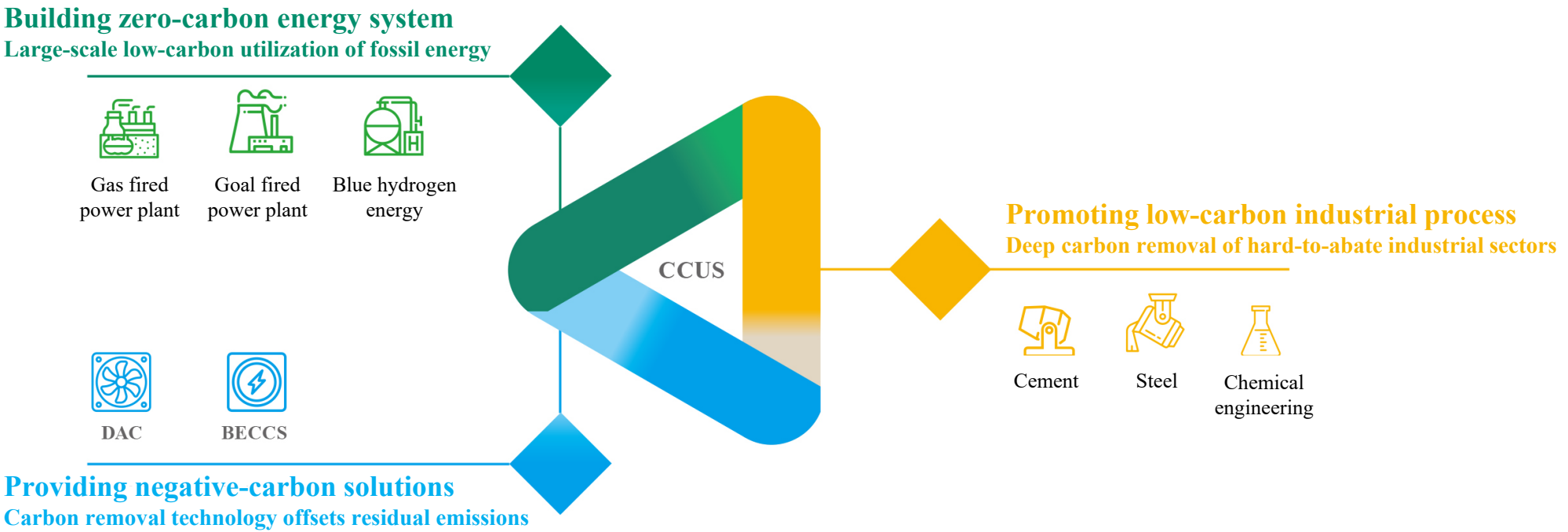
Tao Wang, Professor
Email: oatgnaw@zju.edu.cn

State Key Laboratory of Clean Energy Utilization
Zhejiang University, China

Aug. 30th, 2023

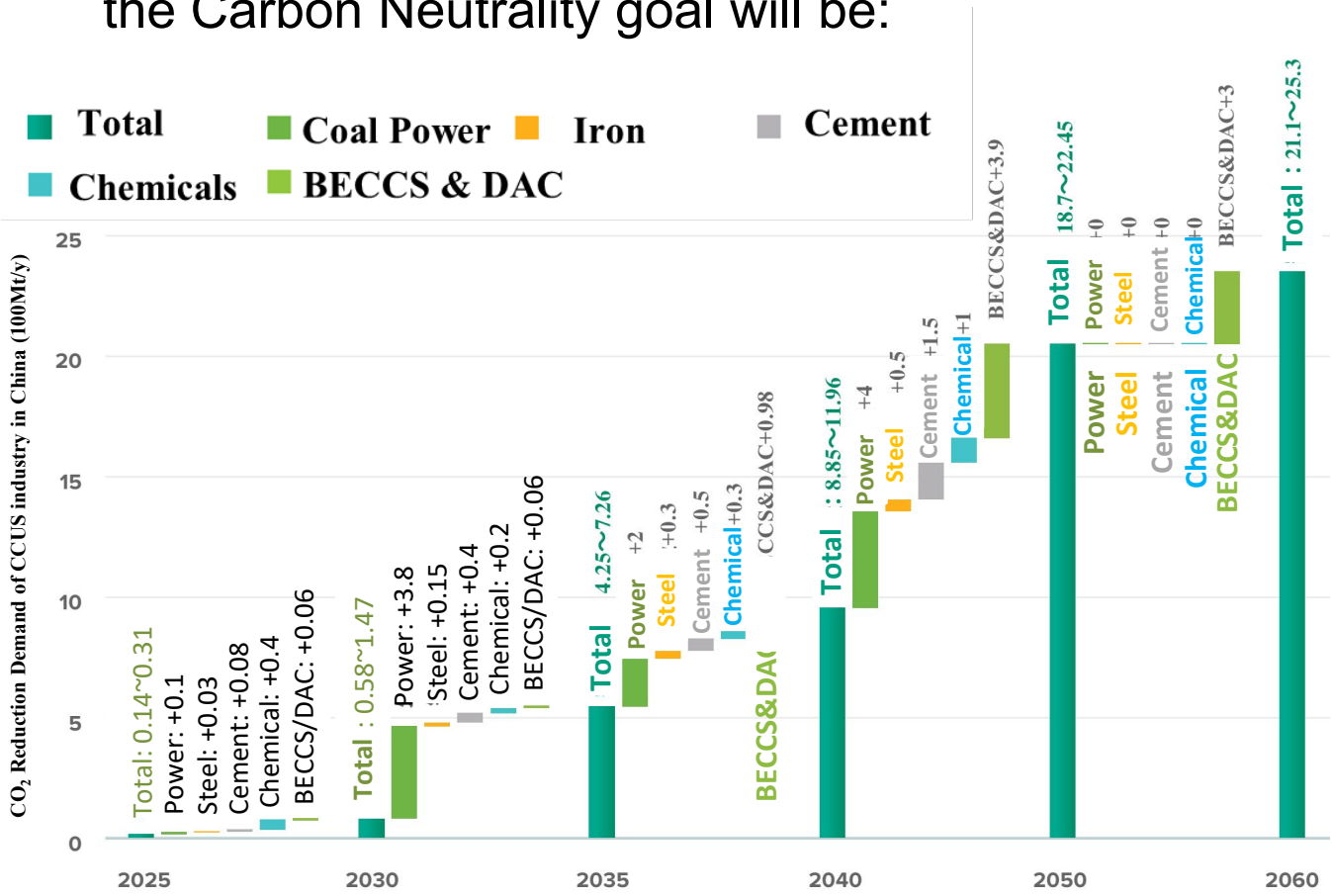
Reposition of CCUS Technology under the carbon neutrality goal of China

- CCUS has gradually transitioned from being a "strategic reserve technology for large-scale low-carbon utilization of fossil energy **(Can be replaced)** “ to becoming an "integral component of the technology portfolio for achieving carbon neutrality goals **(Cannot be replaced)**"



Requirement and potential of CCUS under the carbon neutrality goal of China

- By analyzing the application of CCUS technology in the whole industry and its future demand for emission reduction, it is predicted that China's demand for CCUS emission reduction under the Carbon Neutrality goal will be:

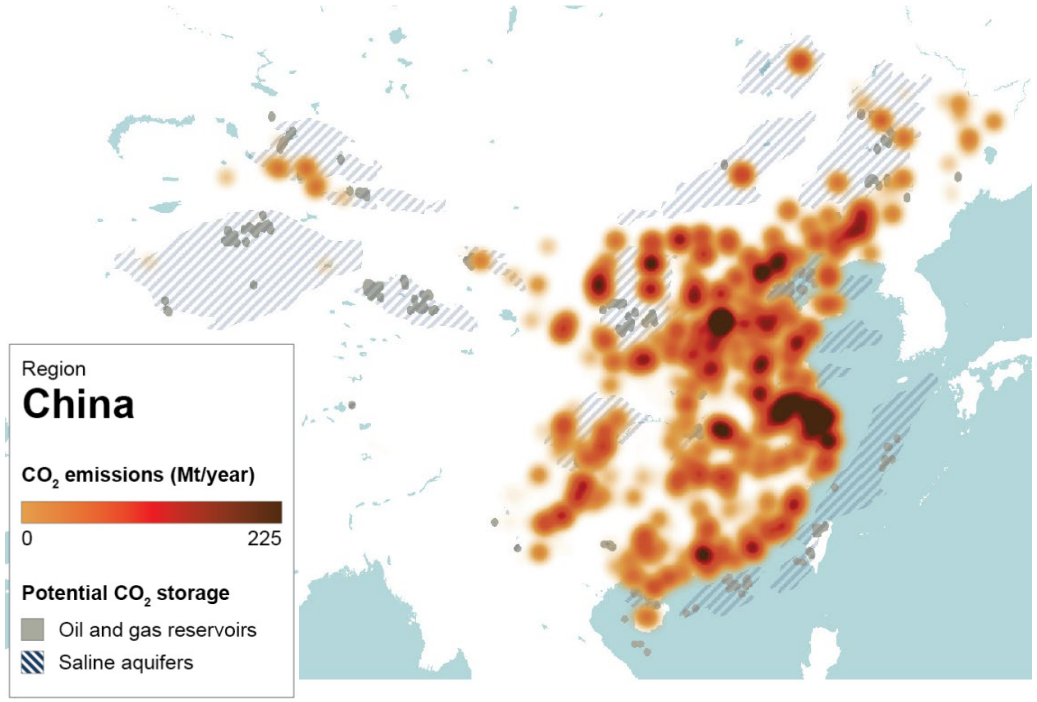


- about 24 million tons in **2025** (14 to 31 million tons)
- nearly 100 million tons in **2030** (0.58 to 147 million tons)
- more than 2 billion tons in **2050** (1.87 to 2.245 billion tons)
- about 2.35 billion tons in **2060** (2.11 to 2.53 billion tons)

China CCUS Annual Report (2023) – The administrative center for China's agenda 21

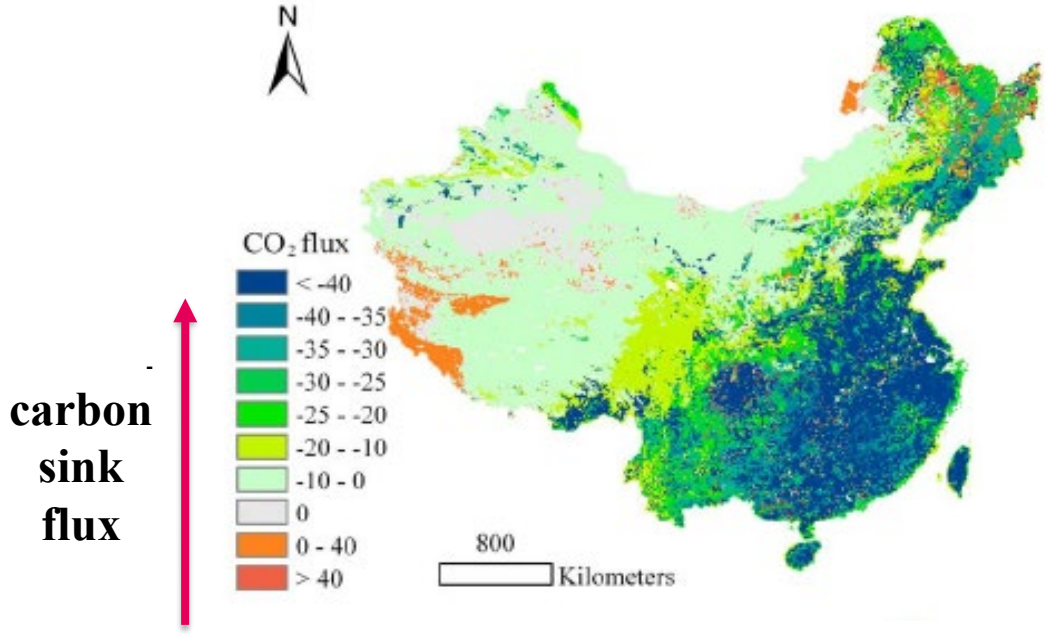
Carbon sequestration potential of CCUS in China Energy sector

- For the fixed sources of CO_2 emissions from energy and industry, about 2.8 billion tonnes/year can be geologically sequestered within 50 km and 4.1 billion tonnes/year within 100km (IEA ETP2020)
- For comparison, China's terrestrial ecosystems have a carbon sink potential of 0.7-1 billion tonnes/year



CO_2 stationary emission sources and potential geological storage distribution

IEA 2020



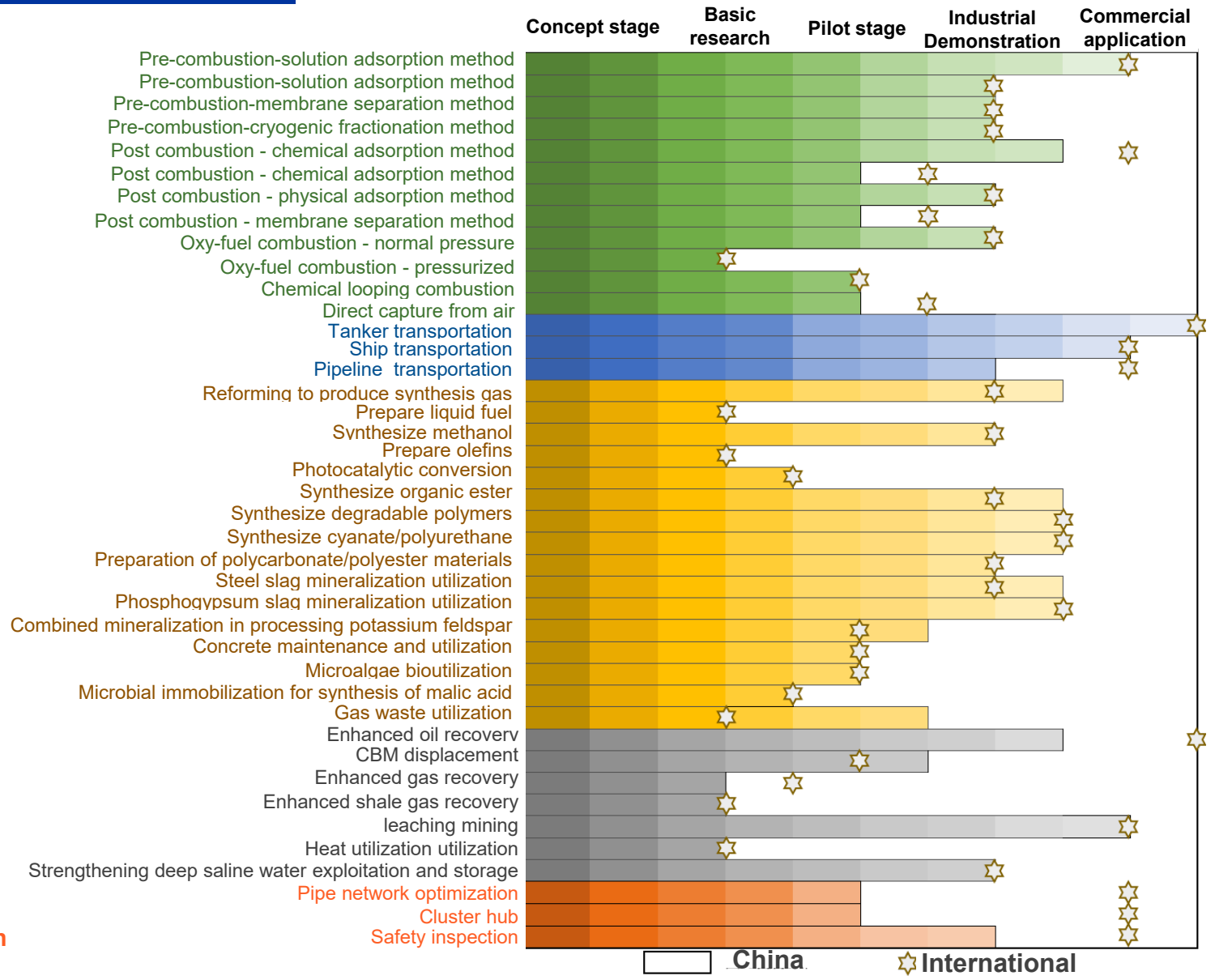
45-year average of ecosystem-atmosphere CO2 exchange

Source: Geophys. Res. Atmos. 116, G02011 (2011).

Current CCUS Status in China

Technical Development Level - CCUS

- China's CCUS technologies have made progresses
- Most technologies, post-combustion capture, chemicals synthesis, mineralization, EOR etc., are in industrial demonstration stage
- Seldom technology, except tanker transportation is in commercial application

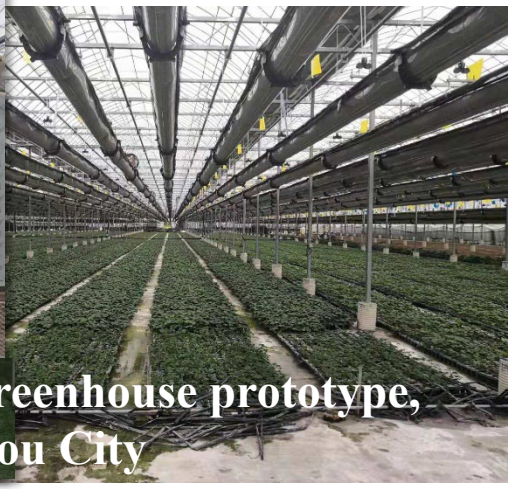


Current CCUS Status in China

Technical Development Level - DAC

- Research institute and energy companies have deployed China early DAC prototypes and demonstrations recently
- The scale of demonstration needs to be enlarged

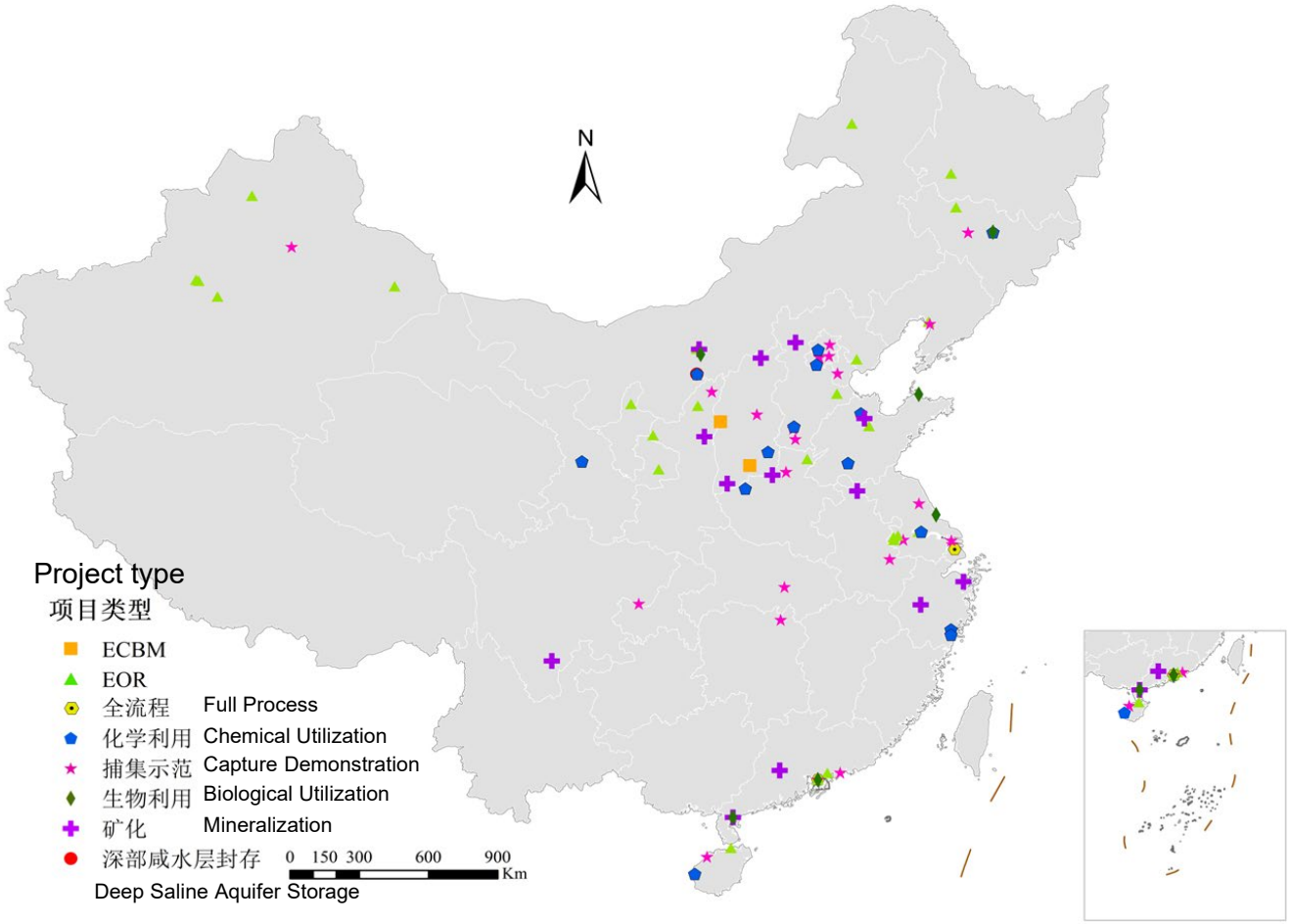
Project	Conducted by
100 tons/year DAC prototype	China National Petroleum Co.
20 tons/year DAC+ synthetic fuel prototype	China Energy Construction Co.
100 tons/year DAC prototype	Shanghai Jiaotong University
10 tons/year DAC+ greenhouse prototype	Zhejiang University
10 tons/year DAC prototype	Huaneng Group
2-ton/day DAC demonstration	Linhe Climate Technology (Beijing)



Current CCUS Status in China

Demonstration Project

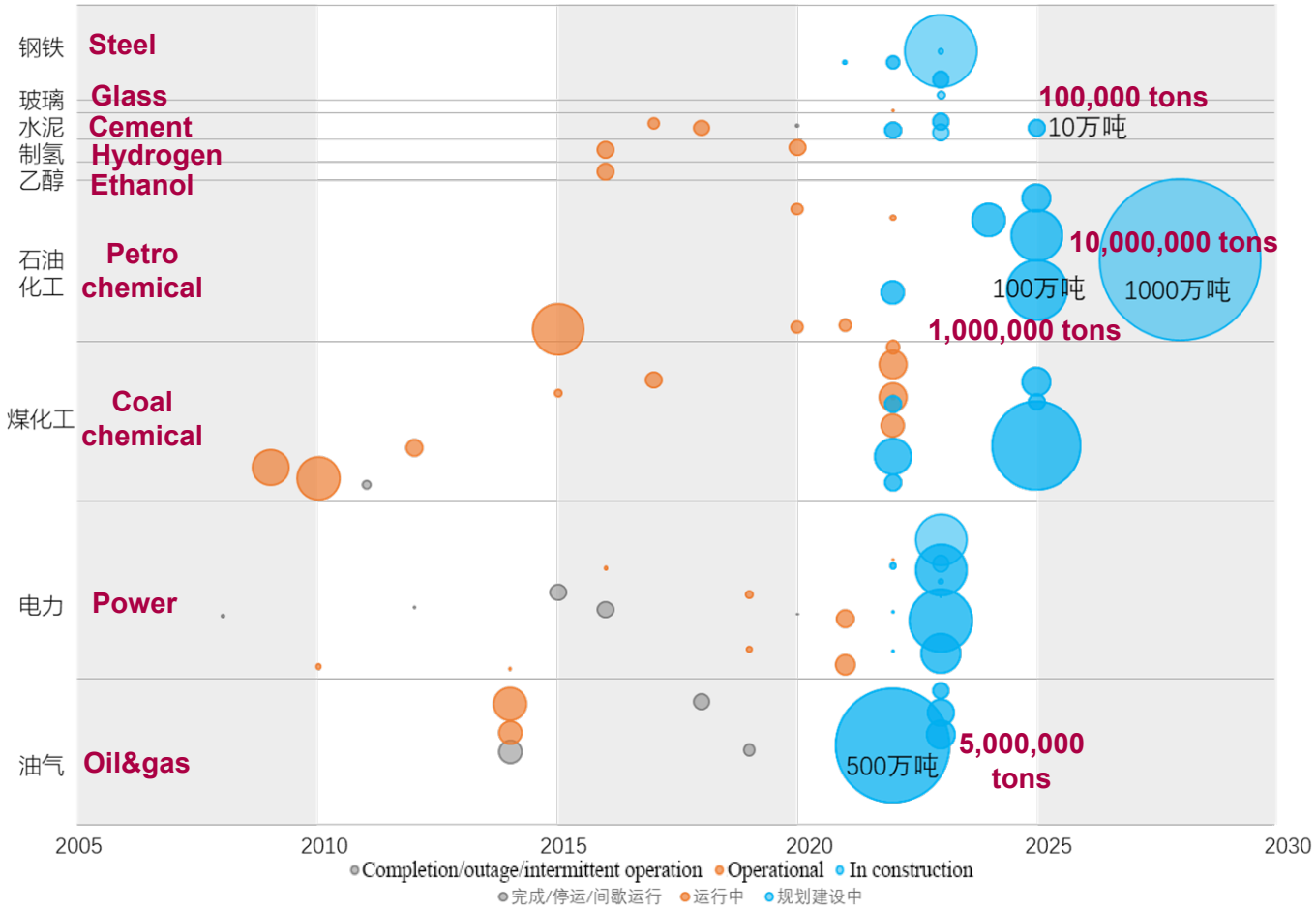
- Till 2023 Feb, China has ~100 CCUS demonstration plants in operation or planning.
- Over half of the demonstrations are in operation, with total capture capacity of 4 million t/y, total injection capacity of 2 million t/y.



Current CCUS Status in China

Demonstration Project

- Currently, China's CCUS demonstration projects for CO_2 capture includes multiple industries, such as electricity, oil and gas, chemicals, cement, and steel.
- The scale of operational and planned CCUS demonstration projects has significantly expanded. There are over 40 projects with a capacity of 100,000 tons or more, including over 10 projects with a capacity of 500,000 tons or more. Several projects with capacities exceeding one million tons are currently in the planning stage.



CCUS demonstration projects in China (industry distribution)

Industrial demonstration of flue gas carbon dioxide capture

150,000 t CO_2/y Power Plant Project
China Energy Group, Yulin City, 2021

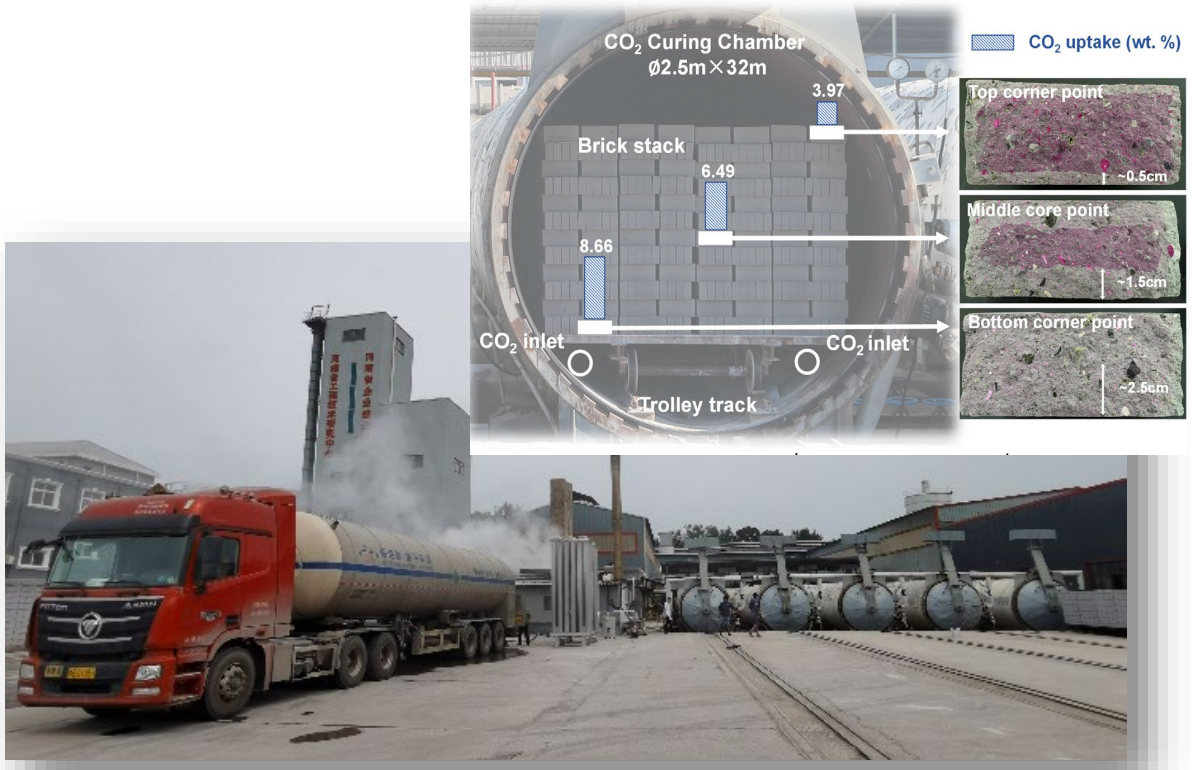
Capture rate	90%
Investment	RMB 130 Million
Reg. Energy	2.4 GJ/tCO_2
Total Cost	**~$ 41 / t CO_2**

500,000 t CO_2/y Power Plant Project
China Energy Group, Taizhou City, 2023

Capture rate	90%
Investment	RMB 385 Million
Reg. Energy	2.4 GJ/tCO_2
Total Cost	**~$ 30 / t CO_2**

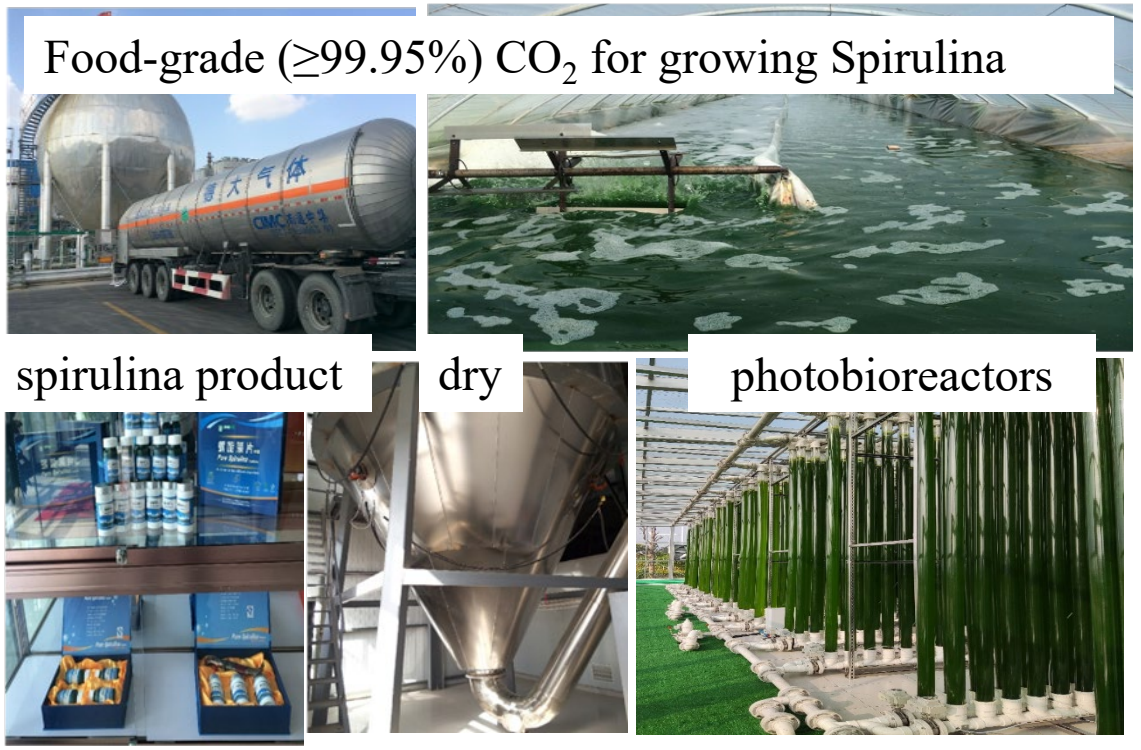
Industrial demonstration of CO_2 utilization

10,000 t CO_2/y mineralization curing, Jiaozuo City, 2020



CO_2 conversion rate	>95%
Solid waste	200,000 t/y
Product	>15 MPa concrete brick
Benefit	~$ 75 / t CO_2

10,000 t CO_2/y algae plant, Erdos City, 2021

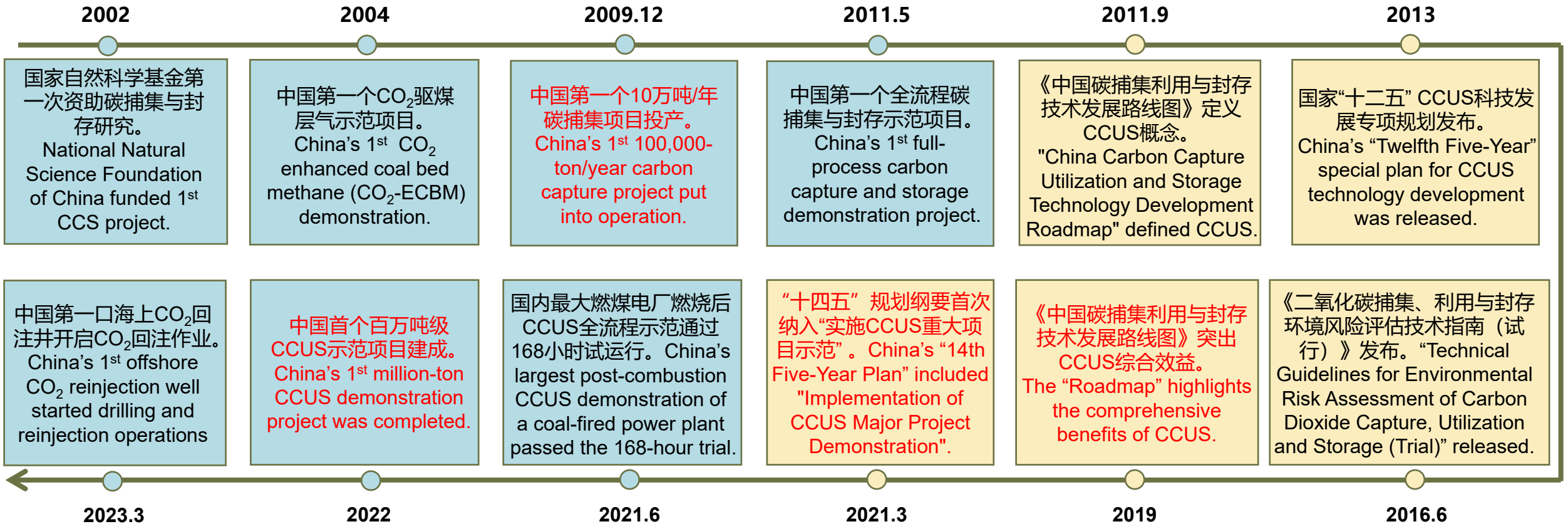


CO_2 efficiency	> 70%
CO_2 conversion rate	≥1.5 g/L/d
Product	Health care products
Benefit	~$ 2700 / t CO_2

Current CCUS Status in China

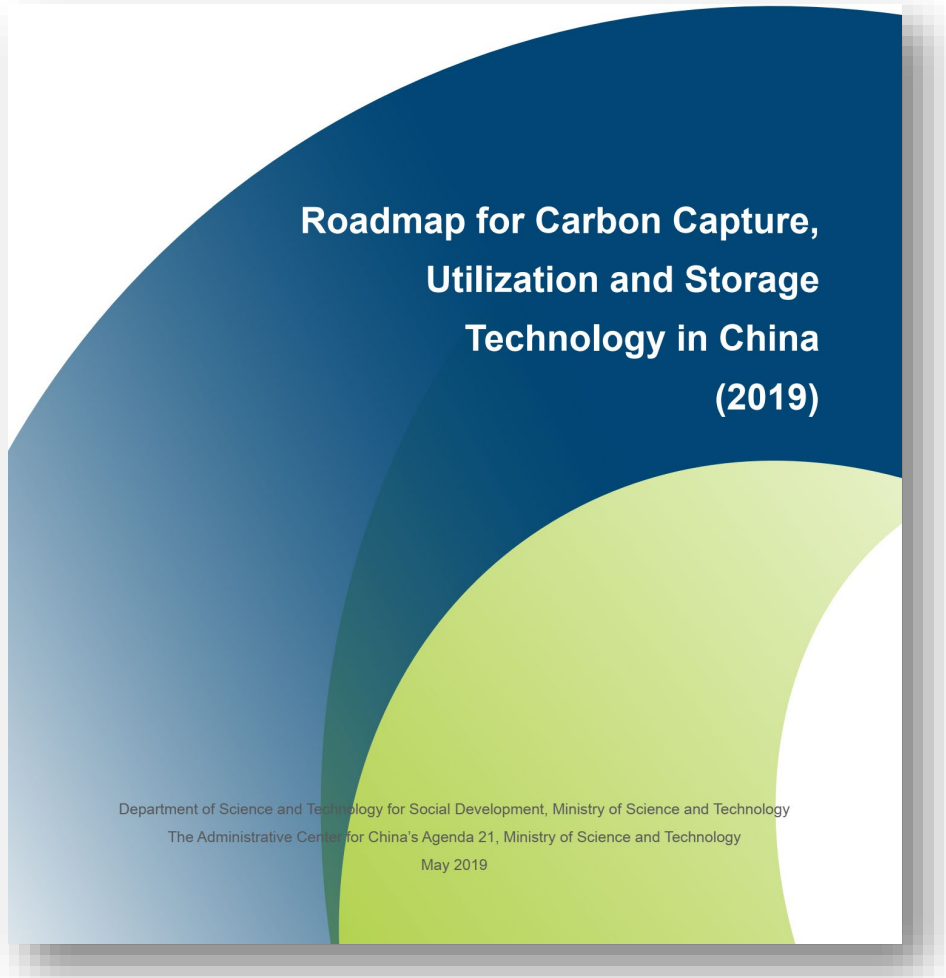
Policy and Roadmap

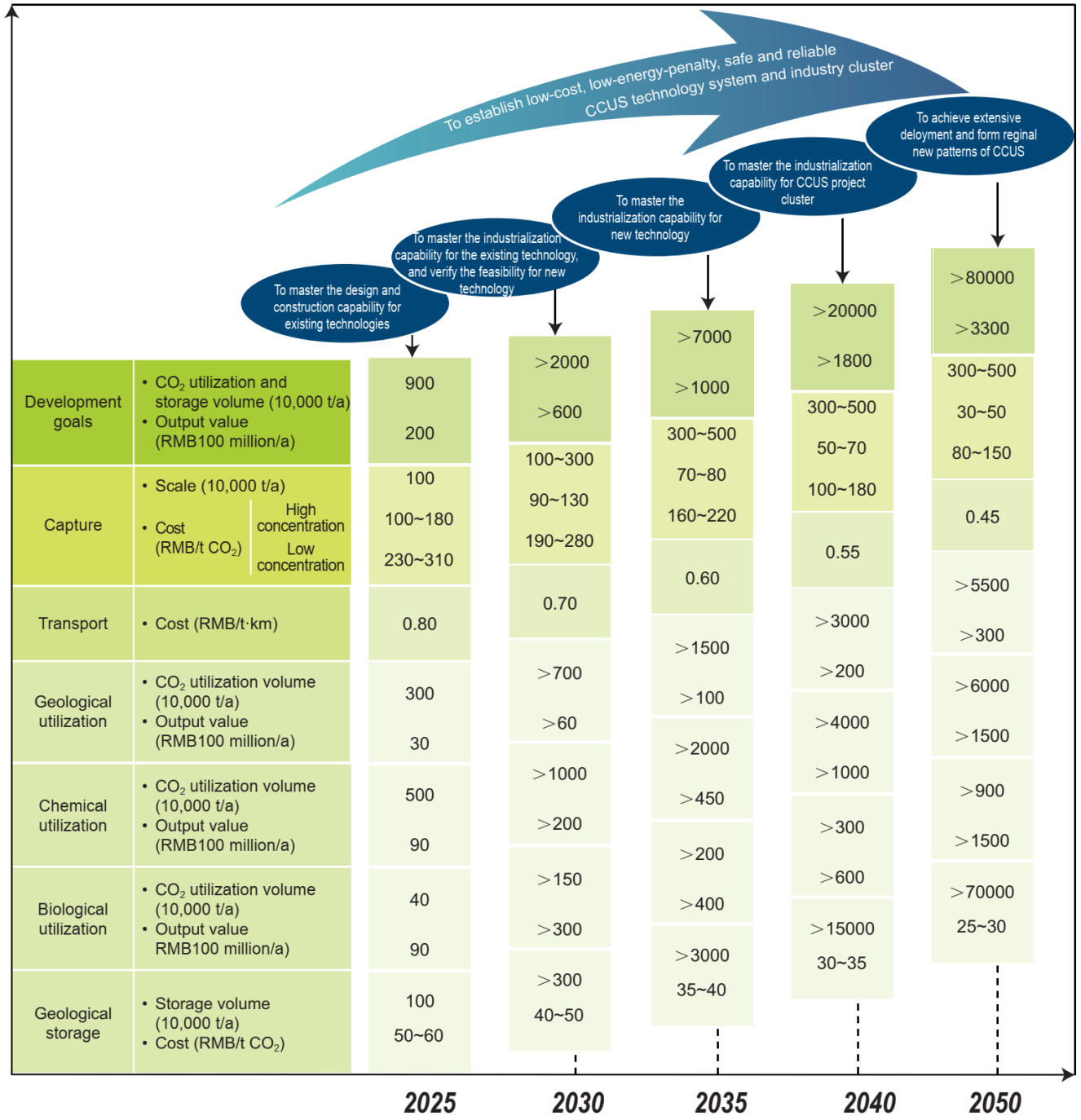
- China is committed to CCUS and maintains the funding for CCUS research, promoted technological advancement and the successful implementation of major demonstration projects
- According to incomplete statistics, as of the end of 2022, China has issued over 70 policy documents related to CCUS. These documents cover various aspects such as planning, standards, roadmaps, and technology catalogs.



Current CCUS Status in China

Policy and Roadmap



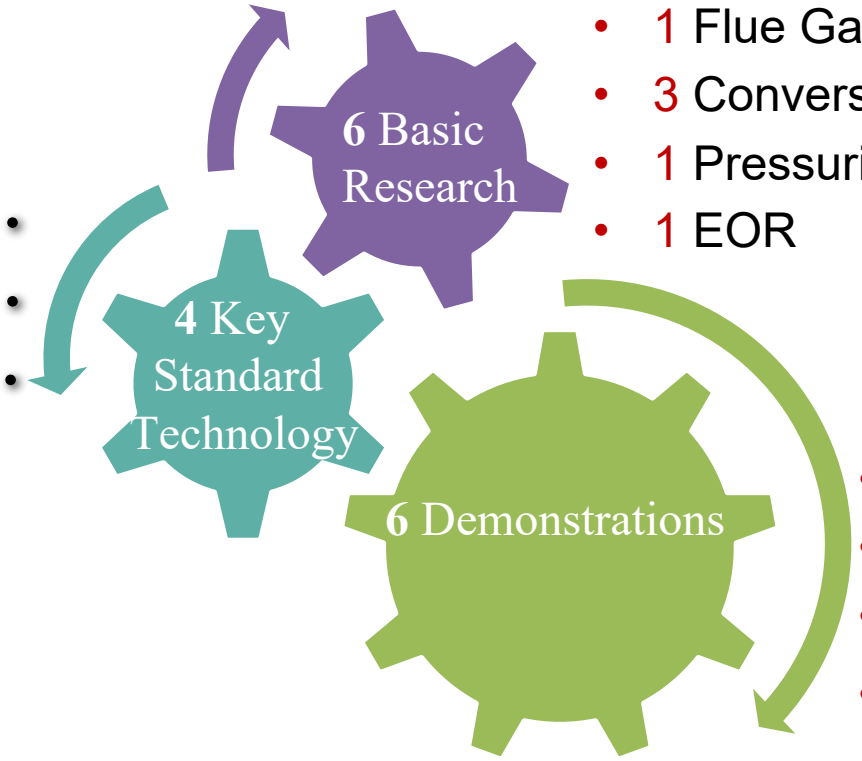


		2025	2030	2035	2040	2050
Development goals	• CO_2 utilization and storage volume (10,000 t/a) • Output value (RMB100 million/a)	900 200	>2000 >600	>7000 >1000	>20000 >1800	>80000 >3300
Capture	• Scale (10,000 t/a) • Cost ($RMB/t\ CO_2$) High concentration	100 100~180	100~300 90~130	300~500 70~80	300~500 50~70	300~500 30~50
	Low concentration	230~310	190~280	160~220	100~180	80~150
Transport	• Cost (RMB/t·km)	0.80	0.70	0.60	0.55	0.45
Geological utilization	• CO_2 utilization volume (10,000 t/a) • Output value (RMB100 million/a)	300 30	>700 >60	>1500 >100	>3000 >200	>5500 >300
Chemical utilization	• CO_2 utilization volume (10,000 t/a) • Output value (RMB100 million/a)	500 90	>1000 >200	>2000 >450	>4000 >1000	>6000 >1500
Biological utilization	• CO_2 utilization volume (10,000 t/a) • Output value RMB100 million/a)	40 90	>150 >300	>200 >400	>300 >600	>900 >1500
Geological storage	• Storage volume (10,000 t/a) • Cost ($RMB/t\ CO_2$)	100 50~60	>300 40~50	>3000 35~40	>15000 30~35	>70000 25~30

Current CCUS Status in China

Funding

- CCUS projects are deployed in the National Key R&D Program during China's "Fourteenth Five-Year"
- From 2022 to now, 10 key technologies R&D projects are planned and funded by MOST, Over 50 organization, such as university, research institutes and enterprises, participate in the special program
- Total funds of over 500 million RMB are invested into the R&D work



- 1 Flue Gas Capture
- 3 Conversion to Chemicals
- 1 Pressurized Oxyfuel Combustion
- 1 EOR

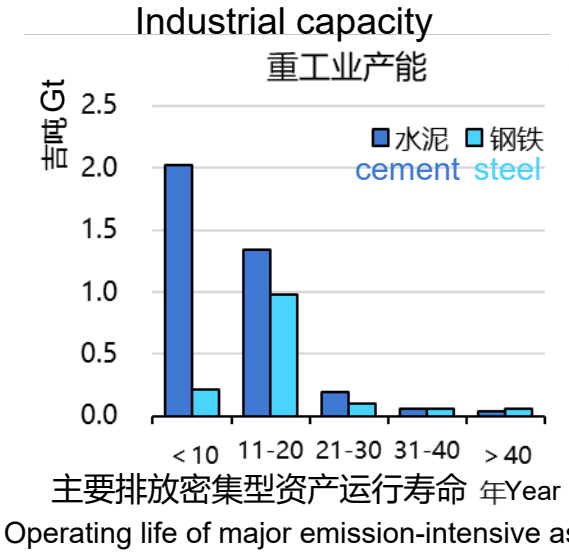
- 1 CO_2 Mineralization
- 2 Flue Gas Capture
- 1 Pressurized Oxyfuel Combustion

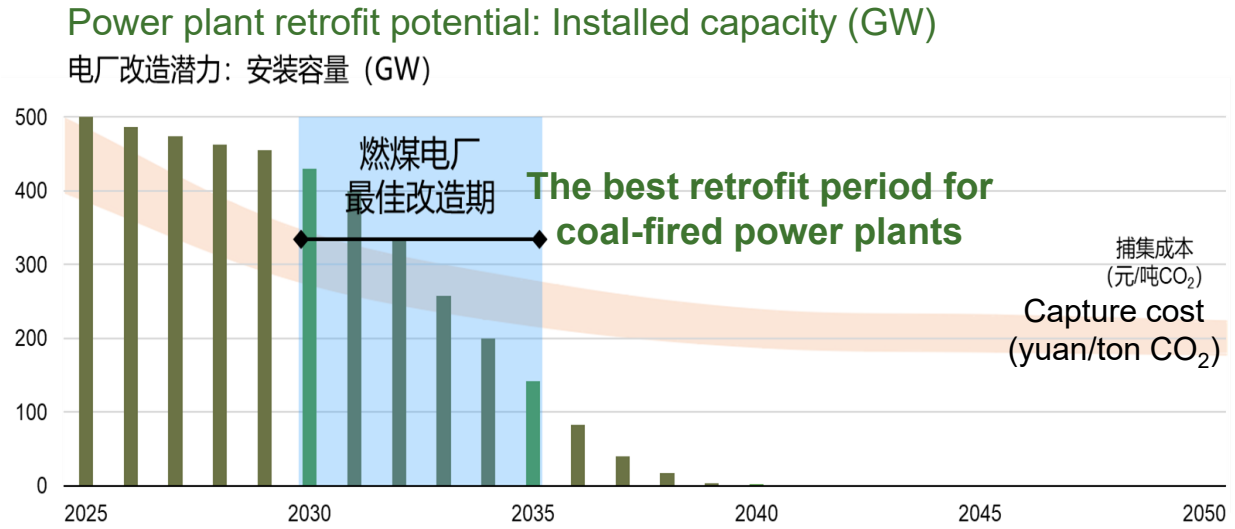
- 1 Million-ton CO_2 solvent capture
- 1 10,000-ton CO_2 sorbent capture
- 1 MW Pressurized Oxyfuel Combustion
- 3 10,000-ton CO_2 mineralization

Challenges and Suggestions

Key Issues in CCUS Development: Technology

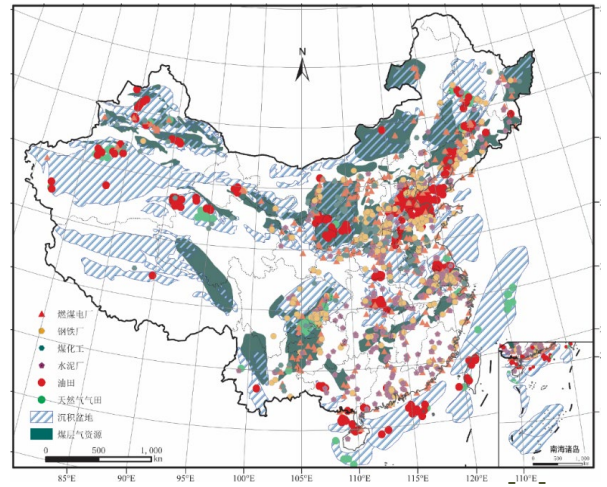
- Key technologies are not mature enough.
- Large-scale demonstration of full process is lacking.
- Blank of CCUS applications in steel or cement industries.
- Facing the risk of technology lock-in in time.
- Facing the challenge of source-sink matching dislocation in space.





陆海统筹源汇匹配分布情况

The matching source-sink distribution



Challenges and Suggestions

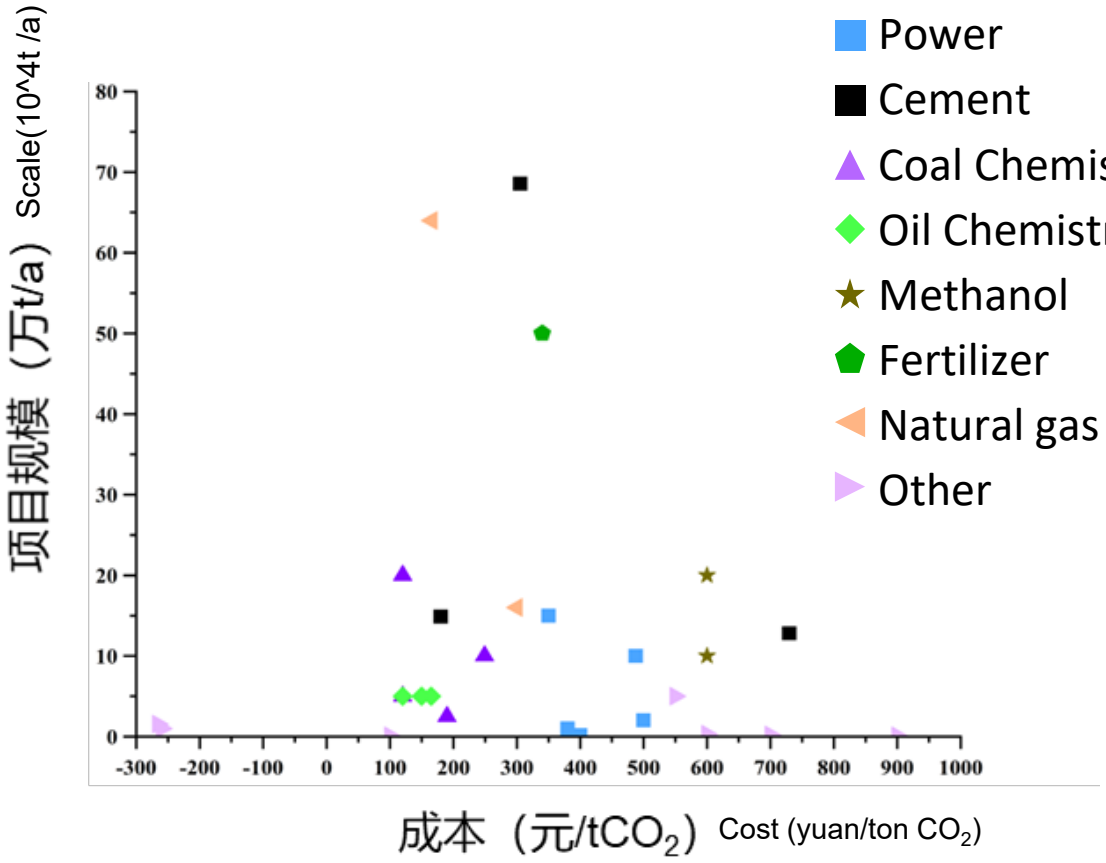
Key Issues in CCUS Development: Market

- **High cost of emission reduction restricts the popularization and application of CCUS technology**

  Abatement cost of CCUS is **RMB 100-500 /ton CO_2**, also increasing the cost of power generation if applied.

- **Lack of effective business model**

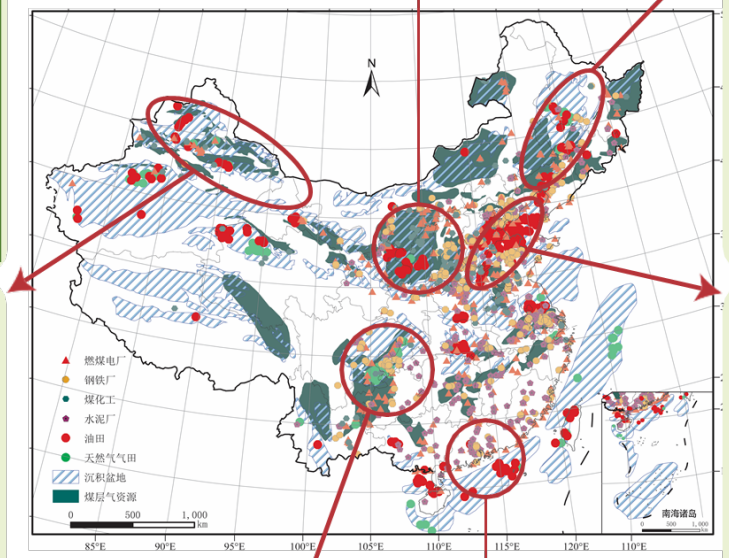
  It's difficult to collaborate across enterprises and industries for CCUS projects .



Challenges and Suggestions

Key Issues in CCUS Development: Cluster planning

- CCUS industrial clusters can effectively reduce the technology costs, the regional distribution of future industrial clusters should be planned in the future



鄂尔多斯盆地

排放源	捕集技术	利用与封存
化工 电力	燃烧后 富氧燃烧 燃烧前 工业过程	生物利用 化工利用 强化石油开采 铀矿地浸开采 强化煤层气开采 强化深部咸水开采 强化页岩气开采 咸水层封存 枯竭油气田封存

松辽盆地

排放源	捕集	利用与封存
电力(燃煤) 钢铁 水泥 煤化工 石油炼化 生物质利用	燃烧后 燃烧前 富氧燃烧	化工利用 生物利用 强化石油开采 铀矿地浸开采 强化地热开采 强化煤层气开采 强化页岩气开采 强化天然气开采 咸水层封存 枯竭油气田封存

准噶尔-吐哈盆地

排放源	捕集技术	利用与封存
化工 电力(燃煤) 水泥 钢铁	燃烧后 富氧燃烧 燃烧前 工业过程	化工利用 生物利用 强化石油开采 铀矿地浸开采 强化煤层气开采 强化深部咸水开采 强化页岩气开采 咸水层封存 枯竭油气田封存

渤海湾盆地

排放源	捕集	利用与封存
电力(燃煤) 钢铁 水泥 煤化工 石油炼化 生物质利用	燃烧后 燃烧前 富氧燃烧	化工利用 生物利用 强化石油开采 铀矿地浸开采 咸水层封存 枯竭油气田封存

四川盆地

排放源	捕集	利用与封存
电力(燃煤) 钢铁 水泥 石油炼化 生物质利用	燃烧后 燃烧前	化工利用 生物利用 强化页岩气开采 强化天然气开采 咸水层封存 枯竭油气田封存

珠江口盆地及广东广西沿海

排放源	捕集技术	利用与封存
电力(燃气) 水泥 石油炼化	燃烧后 富氧燃烧 燃烧前	化工利用 生物利用 强化石油开采（海上） 强化地热开采（陆地） 咸水层封存（海上） 枯竭油气田封存（海上）

Emission Source
- Power
- Steel
- Cement
- Coal chemistry
- Oil refining
- Biomass utilization

Capture
- Pre-combustion
- Post-combustion
- Oxygenated combustion

Utilization & Storage
- Chemical Utilization
- Biological Utilization
- Enhanced oil recovery
- Uranium ground leach recovery
- Enhanced methane recovery
- Enhanced shale gas recovery
- Enhanced natural gas recovery
- Brackish water sequestration
- Oil and gas field sequestration

Challenges and Suggestions

The development of CCUS technology requires extensive, in-depth, and pragmatic international cooperation

Bilateral cooperation

Strengthen cooperation in CCUS R&D, regulations and standards, and incentive policies

cags 中澳CAGS项目

nzeco 中欧/英NZEC项目

COACH 中欧COACH项目

中意CCS技术 Sino-Italy Cooperation 中意SICCS项目

Multilateral cooperation

UN, WB, CSLF, CEM, MI and other international multilateral mechanisms to promote knowledge sharing and technology transfer.

CLEAN ENERGY MINISTERIAL
Accelerating the Transition to Clean Energy Technologies

MI MISSION INNOVATION

carbon sequestration leadership forum

OGCI CLIMATE INVESTMENTS
OIL AND GAS CLIMATE INITIATIVE

APN

GLOBAL CCS INSTITUTE

ADB ASIAN DEVELOPMENT BANK

iea

谢 谢!

Thanks