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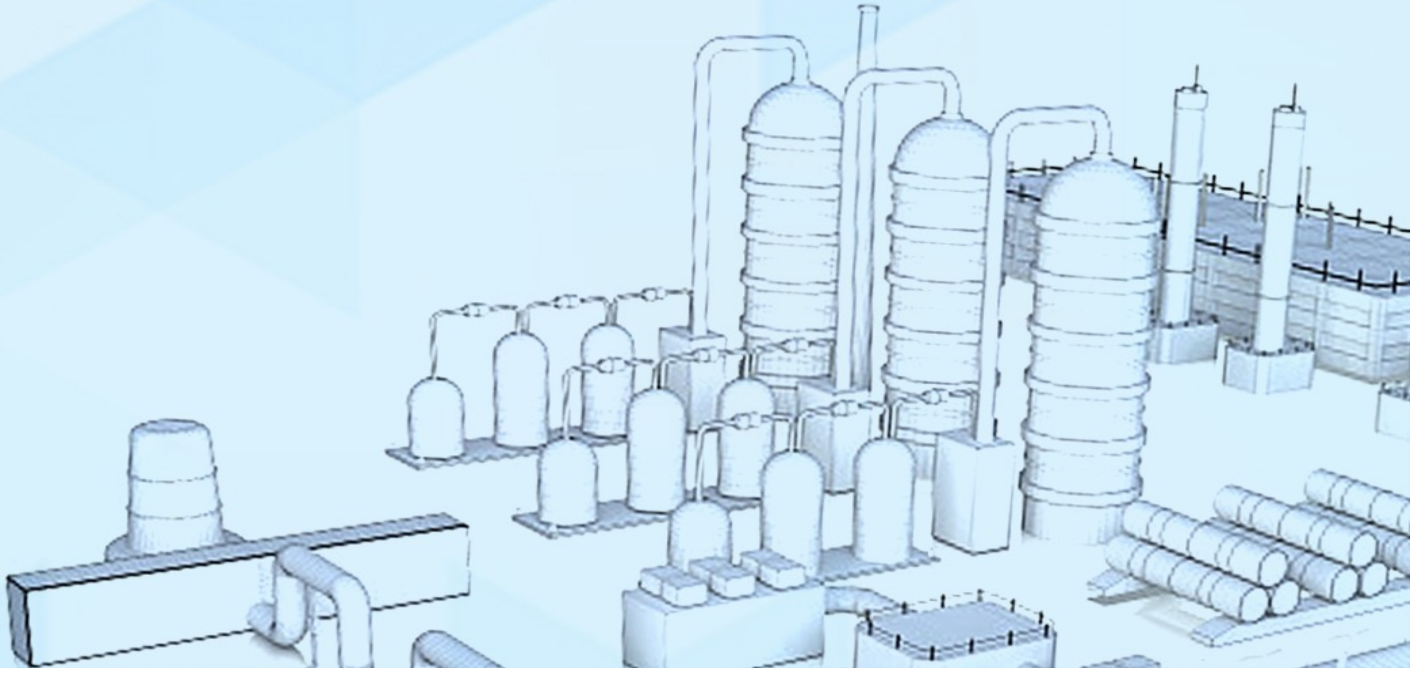
Guangdong CCUS Centre

Shaanxi Longmen Iron and Steel Plant Carbon Capture and Utilization Project Preliminary Feasibility Study Report



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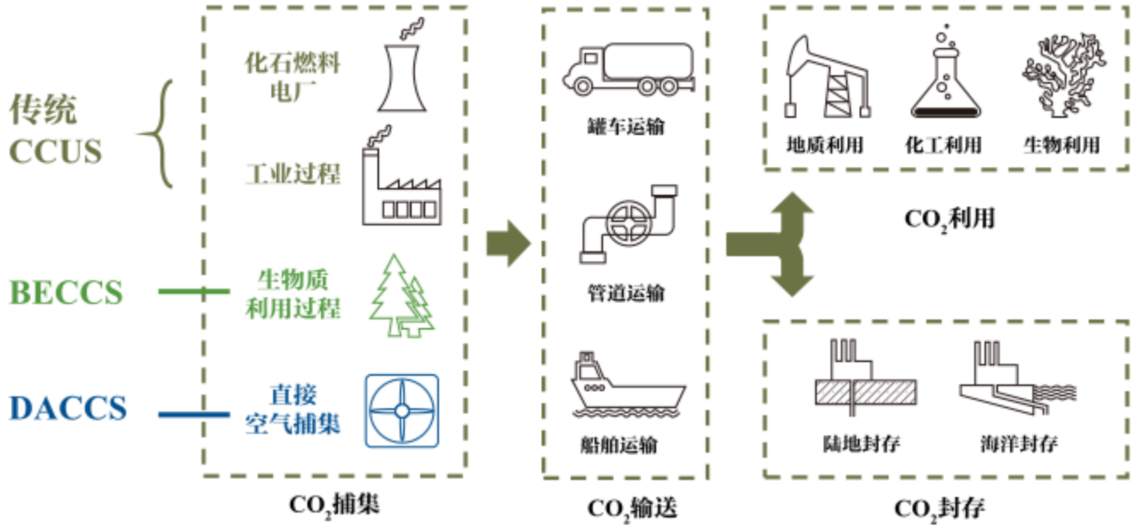
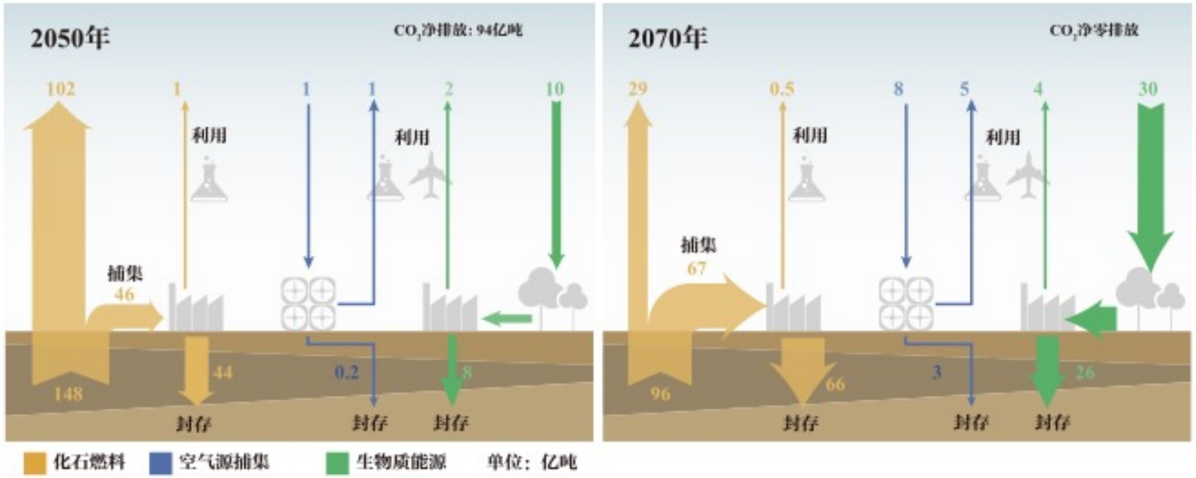
Carbon Storage

Project Overview

(1) Project background

- Climate change is one of the most significant challenges facing mankind in the 21st century；
- According to the *Transforming Industry through CCUS Report* released by the IEA in 2020, over 28 Gt of CO_2 will be captured from the cement, steel and chemical sectors with CCUS technologies by 2060;
- On September 22, 2020, China’s President Xi committed at the general debate of the 75th UN General Assembly that China will peak its CO_2 emissions by 2030 and achieve carbon neutrality by 2060.





Project Overview

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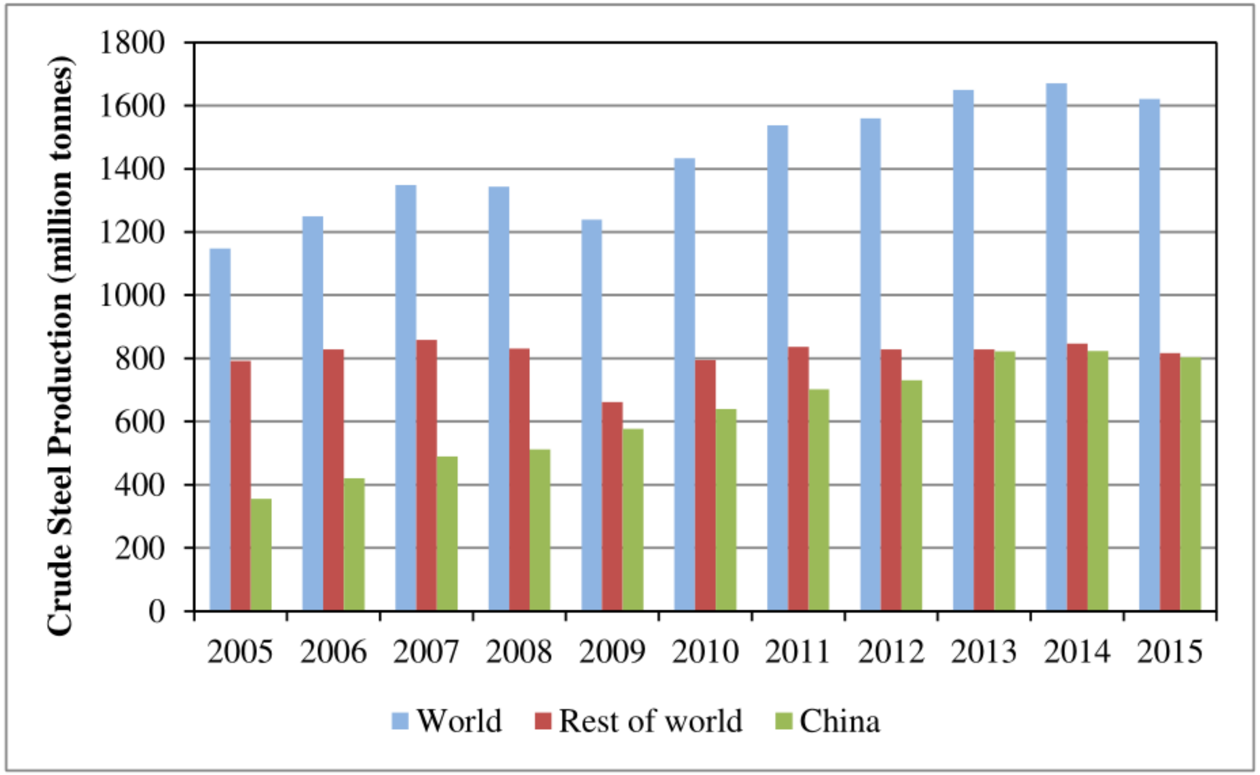
(1) Project background

- Providing a fundamental structural component to society, the steel sector remains one of the most energy- and carbon-intensive industrial.
- According to the *Fifth Assessment Report* (AR5 of the IPCC), the production of steel sector generates more than 2.5 billion tonne carbon dioxide per year, equivalent to approximately 5% of anthropogenic carbon dioxide emissions in the world.
- The world's crude steel production reached 1.6 billion tonne for the year 2015. China alone produces 0.8 billion tonne crude steel in 2015, achieving a remarkable increase of 126% over the 0.36 billion tonne in 2005.



World and ChinaCrude Steel Production (World Steel Association, 2016)

Overview of Global CCUS Development

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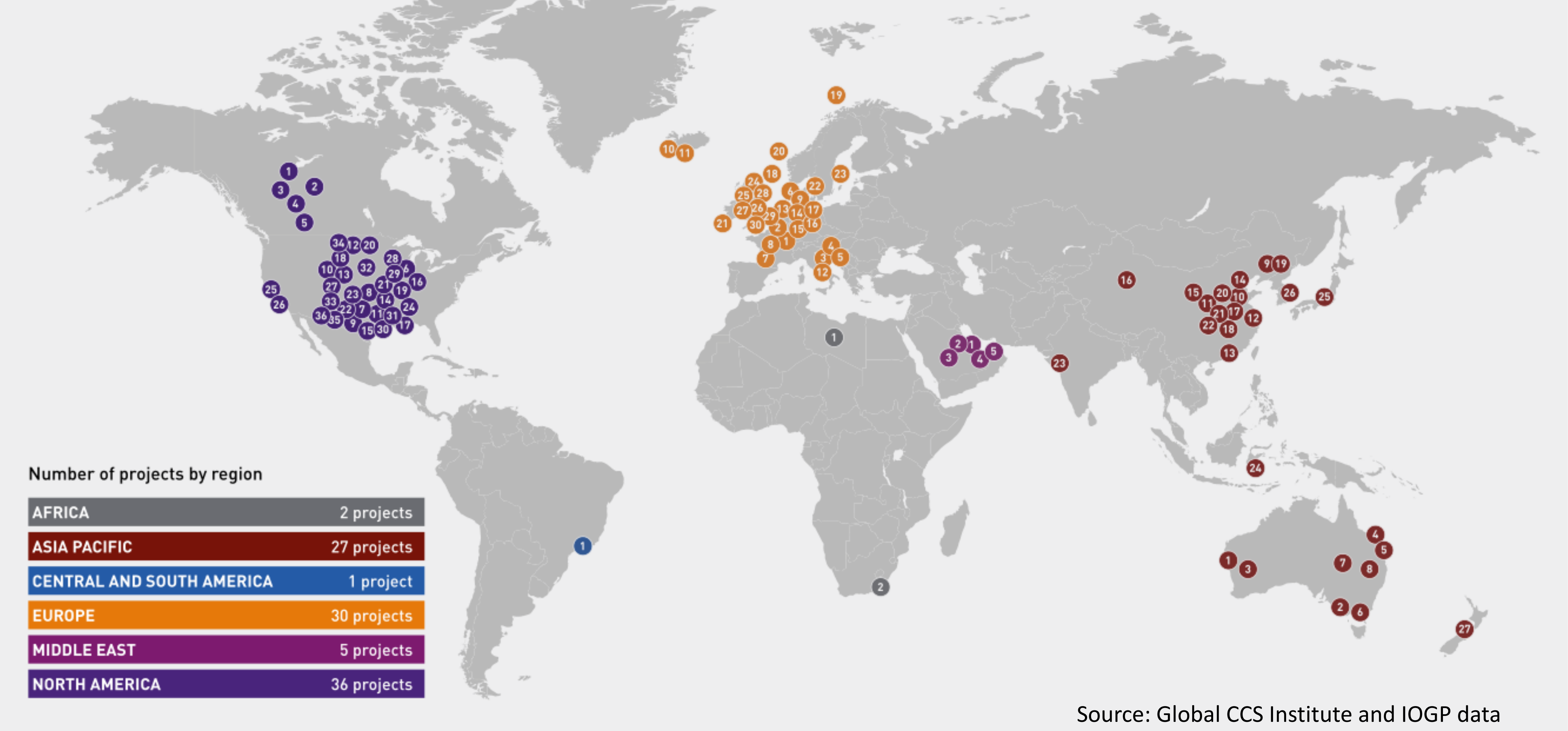
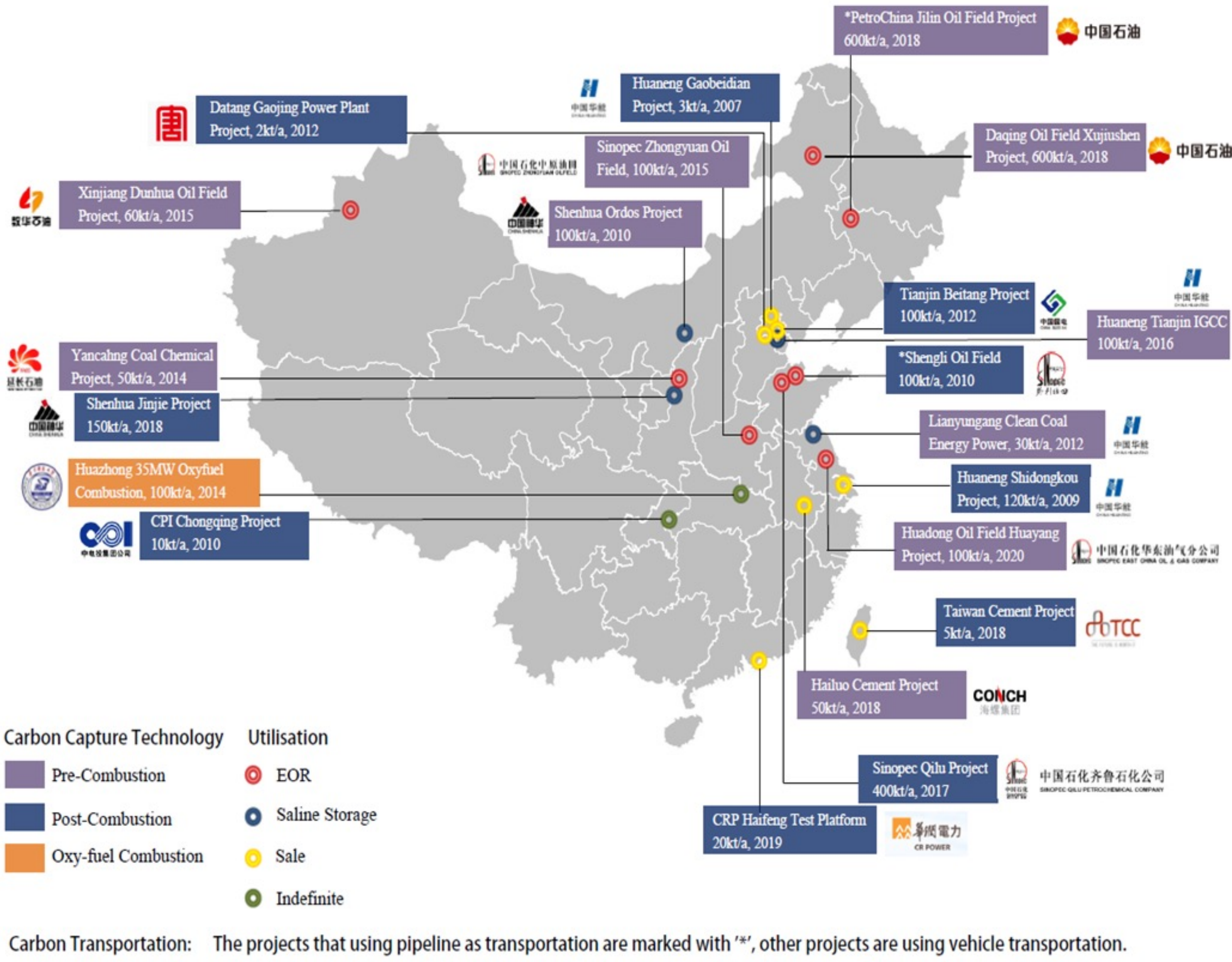
Overview of existing and planned CCUS facilities



Source: Global CCS Institute and IOGP data

Overview of CCUS development in China

As of 2021, China has implemented 19 CCUS demonstration projects in the power, oil and gas, cement, chemical and other industries, with an annual CO_2 capture capacity of about 1.7 million tons and geological storage capacity of about 1 million tons.

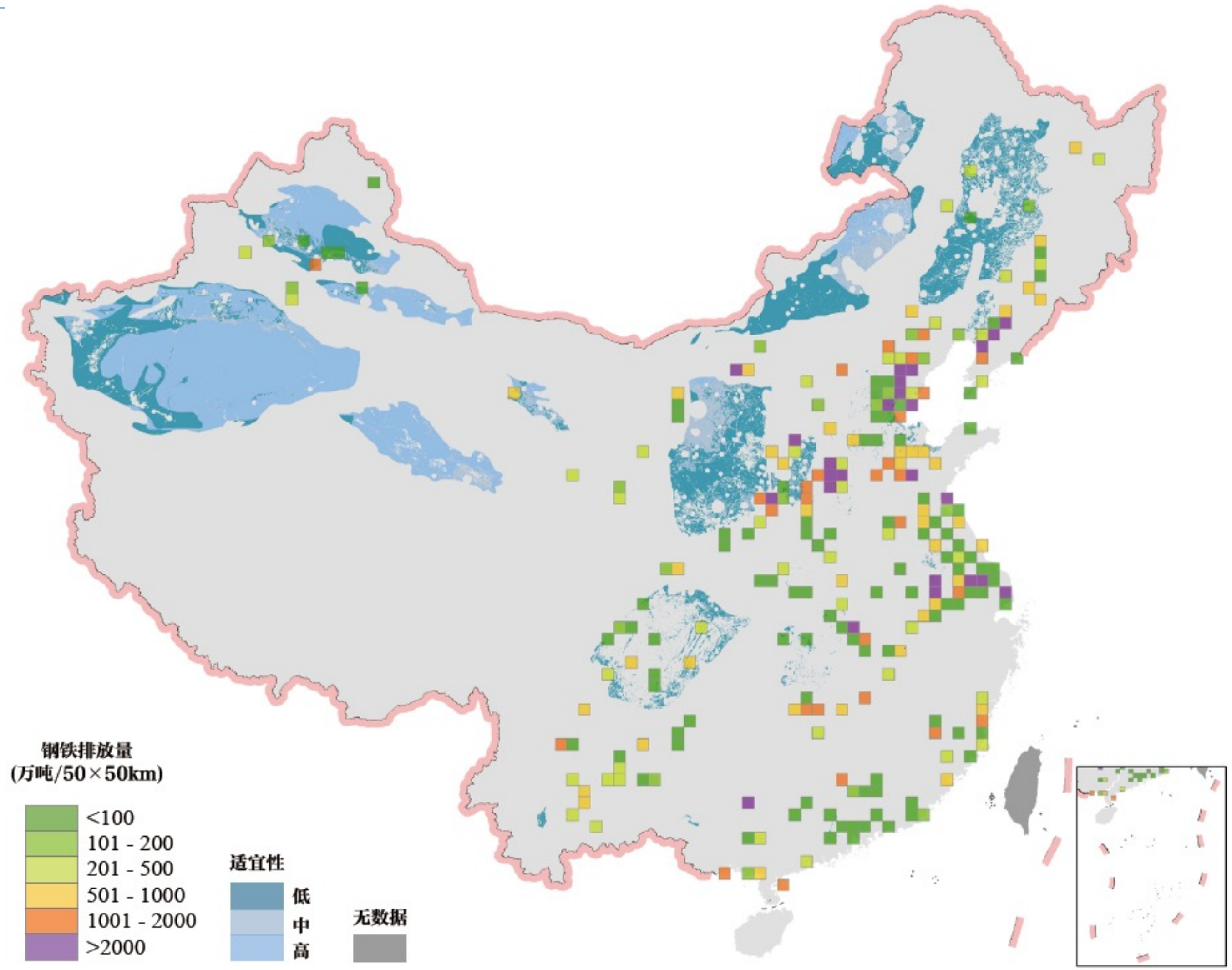


An overview of CCUS projects in China

Overview of CCUS development in China

The steel industry is the second-largest emission industry in China after the power industry. In 2020, carbon dioxide emissions from the steel industry accounted for about 16% of China's total carbon emissions.

Although China is the largest producer of crude steel, there is no steel sector CCS demonstration project located there.



Suitable regional distribution of emission and geological storage of Chinese steel enterprises in 2020

Overview of CCUS development in China

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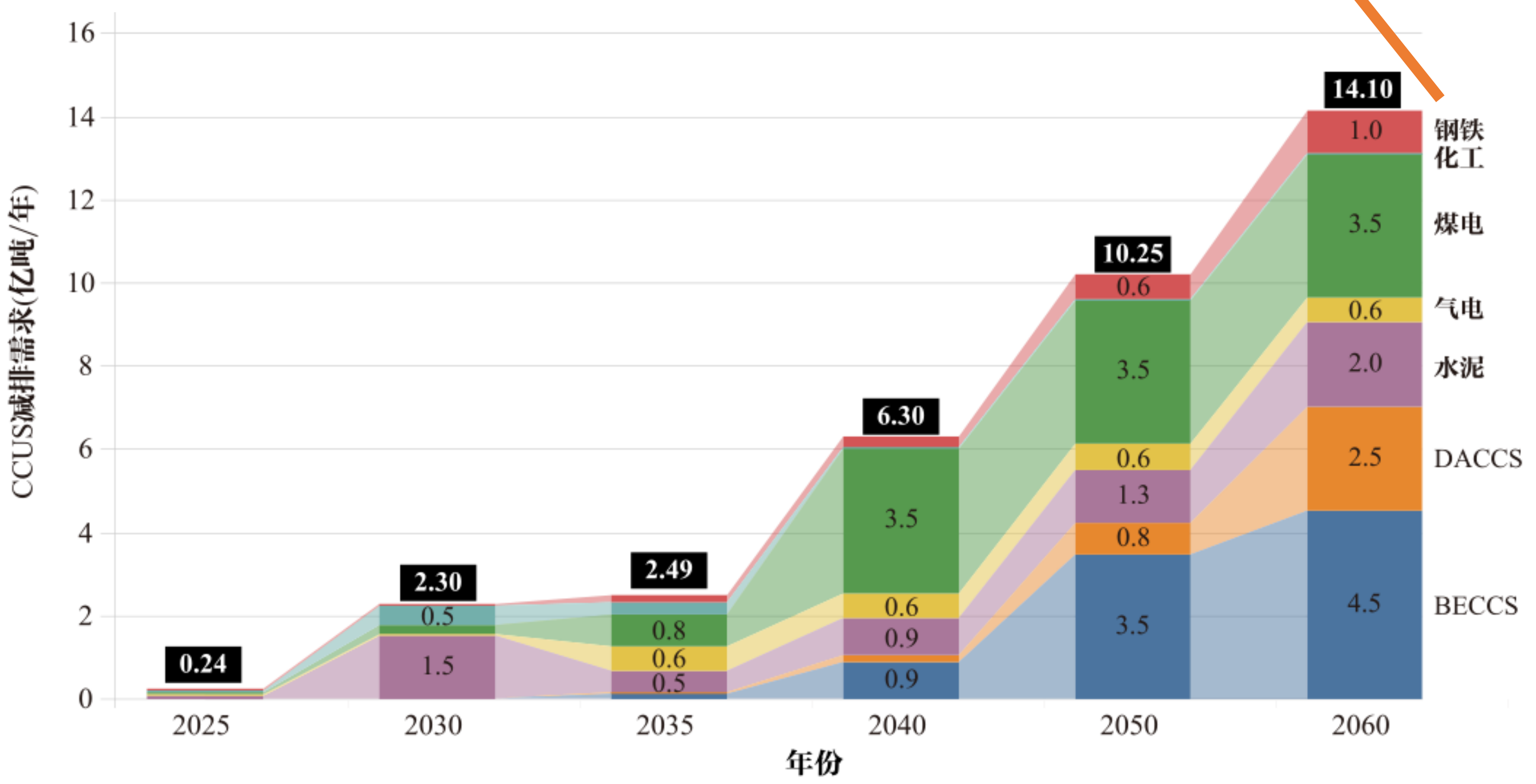
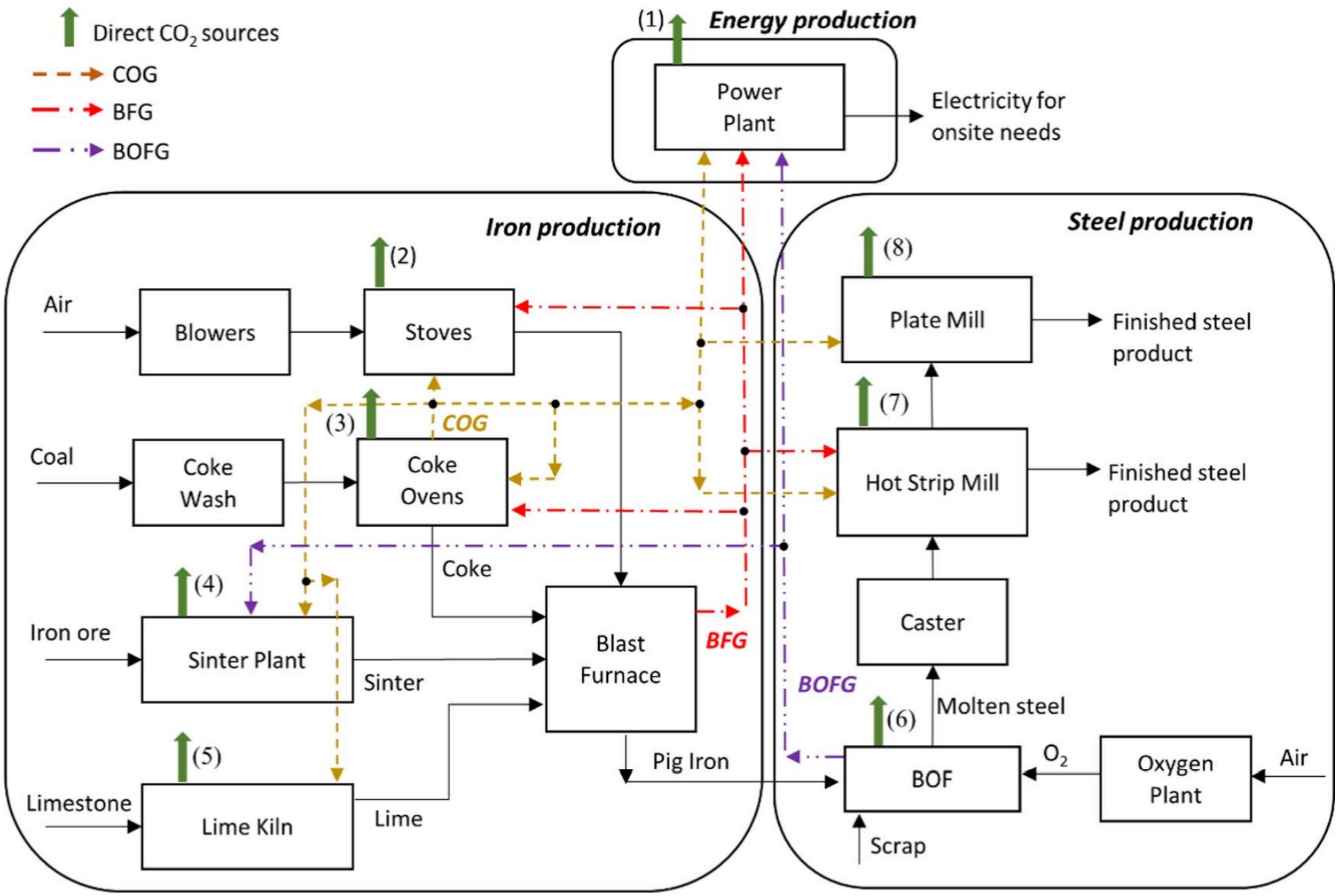
The CCUS emission reduction demand of the steel industry in 2030 is 0.02~0.05 billion t/a, and the emission reduction demand in 2060 is 9~110 million t/a.



Project overview

The carbon intensity of iron and steel production varies considerably between the production routes, ranging from around 0.4 tCO_2/t crude steel for scrap/electric arc furnaces (EAF), 1.7-1.8 tCO_2/t crude steel for the integrated blast furnace basic oxygen furnace (BOF) to 2.5 tCO_2/t crude steel for coal-based direct reduced iron (DRI) processes.



The simplified configuration of a typical steelmaking process

Project overview

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(2) Significance of the Longmen Iron & Steel CCUS project

- Shaanxi Longmen Iron and Steel Co., Ltd. is a Chinese state-owned holding enterprise officially approved by the State-owned Assets Supervision and Administration Commission of Shaanxi Province and is also one of the key emission sources in Shaanxi Province；

- Shaanxi Longmen Iron & Steel Plant is a medium-sized iron and steel enterprise, whose business involves mining, beneficiation, sintering, ironmaking, steelmaking, steel rolling and public and environmental protection auxiliaries. The company covers an area of about 5400 m^2, with a total assets of 16.5 billion yuan. It possesses five blast furnaces (4×1280 m^3, 1×1800 m^3), three sintering machines(450 m^2, 400 m^2, 265 m^2), six steelmaking converters (2×120 t, 4×60 t), five casting machines, three bar rolling mills and one wire rolling mill.

Project overview

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(2) Significance of Longmen Iron & Steel CCUS Project

- In the context of carbon peaking and carbon neutrality, Longmen Steel Plant's implementation of low carbon transformation is both a response to the national call and an important step to deploy low carbon steel and iron products industry in advance, and a key step to improve the competitiveness of the low carbon steel and iron products industry in the future.

Table 1 Carbon footprint evaluation of main products of Longmen Iron and Steel Plant

Product	Unit	Direct load A3	Indirect load A1-A2	Total
Steel bar	$kgCO_2e/t$	1,559.22	723.84	2,283.06
Wire rod	$kgCO_2e/t$	1,559.22	723.84	2,283.06
Steel-bar-CCUS	$kgCO_2e/t$	1,442.94	724.06	2,167.00
Wire rod-CCUS	$kgCO_2e/t$	1,442.94	724.06	2,167.00

- It is estimated that by capturing 500,000 tons of carbon dioxide every year, the carbon footprint of the products can be greatly reduced. 116.05 $kgCO_2$ e/t of carbon emission reduction can be achieved for the main products, where the impacts of raw materials and energy are taken into account

Project overview

Project research content

The research task of this feasibility study is mainly to demonstrate the feasibility of the Longmen Iron & Steel 500,000 tons CCUS Project.

The main study topics include:

(1) Assess the necessity and feasibility of CCUS project design.

(2) Assess and select a suitable carbon dioxide capture technology from flue gas for the Project.

(3) Conduct the feasibility of offshore geological storage.

(4) Conduct necessary investigation and data collection, survey and sampling test.

(5) Implement various external conditions such as environmental protection, water and soil conservation, land use, water source, transportation and geology.

(6) Propose engineering scheme for the overall planning of plant site, general layout planning of plant site and each system.

(7) Project investment estimation and financial evaluation.

(8) Carry out energy saving analysis, risk analysis and economic and social impact analysis.

(9) Put forward concluding comments and suggestions on the feasibility of the project based on the above aspects.

Part 2

Project Technical Program

Carbon Capture

Overview of Longmen Iron & Steel plant

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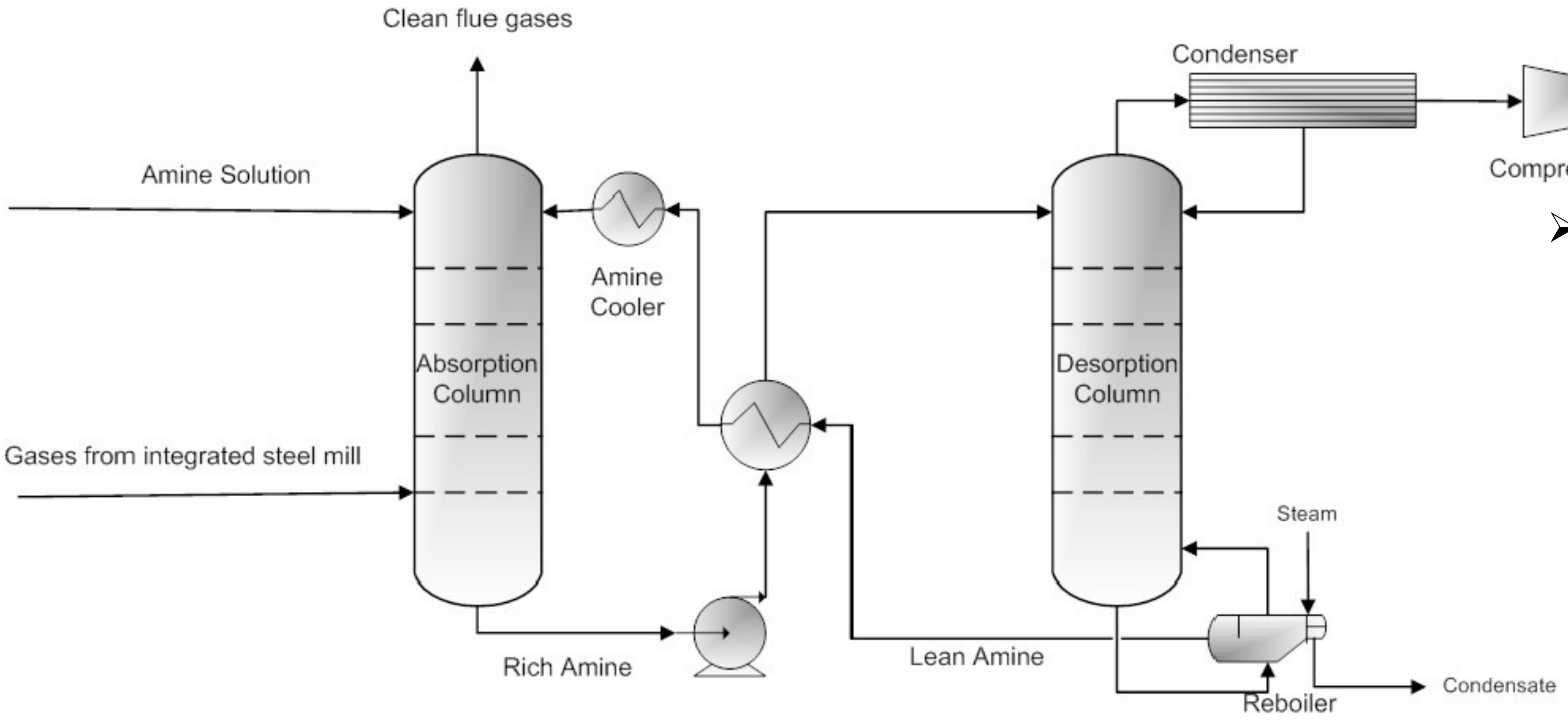
- Longmen Iron & Steel owns a total steel production capacity of 7 million tons. Based on the available data, it is estimated that the average annual CO_2 emission from the five blast furnaces of Longsteel is over 800,000 tons per year.
- Among them, the 4# blast furnace has a capacity of 1800m^3, which is the largest capacity and the most emissions among the four five furnaces；
- Over 10,000m^2 of open space is available directly south from the 4$^\#$ blast furnace, which can accommodate the establishment of capture and compression and purification equipment.
- Based on the energy consumption of the 4$^\#$ blast furnace in 2021, it is estimated that the annual emissions will be approximately 1.9 million tonnes and therefore carbon capture is proposed for the 4# blast furnace.

Diagram showing the location of the blast furnace and vacant land

Design of CO_2 capture units

- Two schemes for post-combustion CO_2 capture using MEA were designed .
- Both schemes are based on an absorption-desorption cycle, the CO_2 is chemically absorbed by the solvent in an absorption column, and then the absorbed CO_2 is released by regenerating the rich solvent with low-pressure steam (3-6 bar, 130-160℃) in a desorption column.

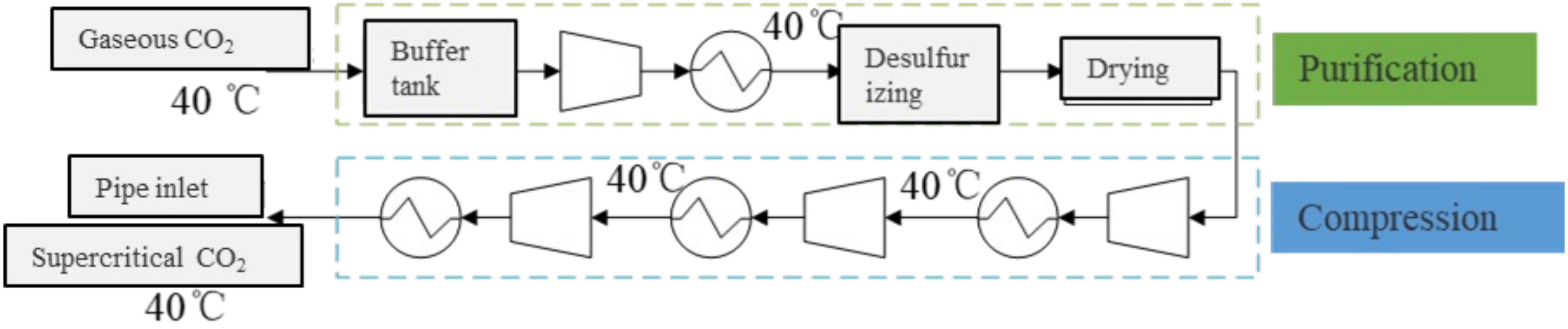


Schematic diagram of the capture unit

- The energy requirements for solvent regeneration are optimized by a split-flow configuration in which a portion of the rich amine solution from the absorber is preheated using heat from the lean amine solution from the stripper and is then carried to the flash column where the carbon dioxide rich vapor is separated from the semi-poor amine. The vapor part goes to the condenser of the stripper, while the semi-poor amine solution goes to the intercooler part of the absorber. In this way, the rich amine load that needs to be regenerated is reduced.

Design of CO_2 compression, purification and dehydration

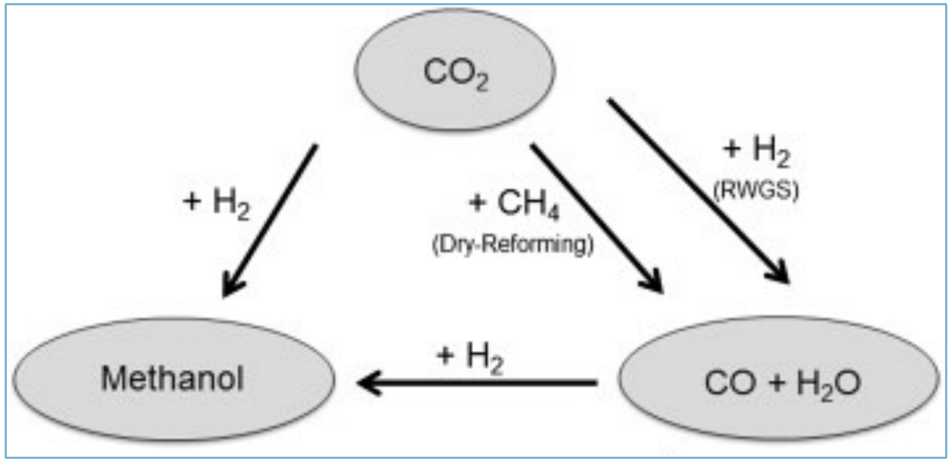
- In this project, CO_2 is separated from the flue gas after passing through the carbon capture device, and industrial grade CO_2 (liquid CO_2 purity of 99.9% and above) is obtained by compression and purification system to meet the market demand.
- The industrial grade liquid CO_2 obtained through this process is stored in storage tanks with safe storage pressure below 2.0MPa and storage temperature below -20℃.



Compression and purification process flow

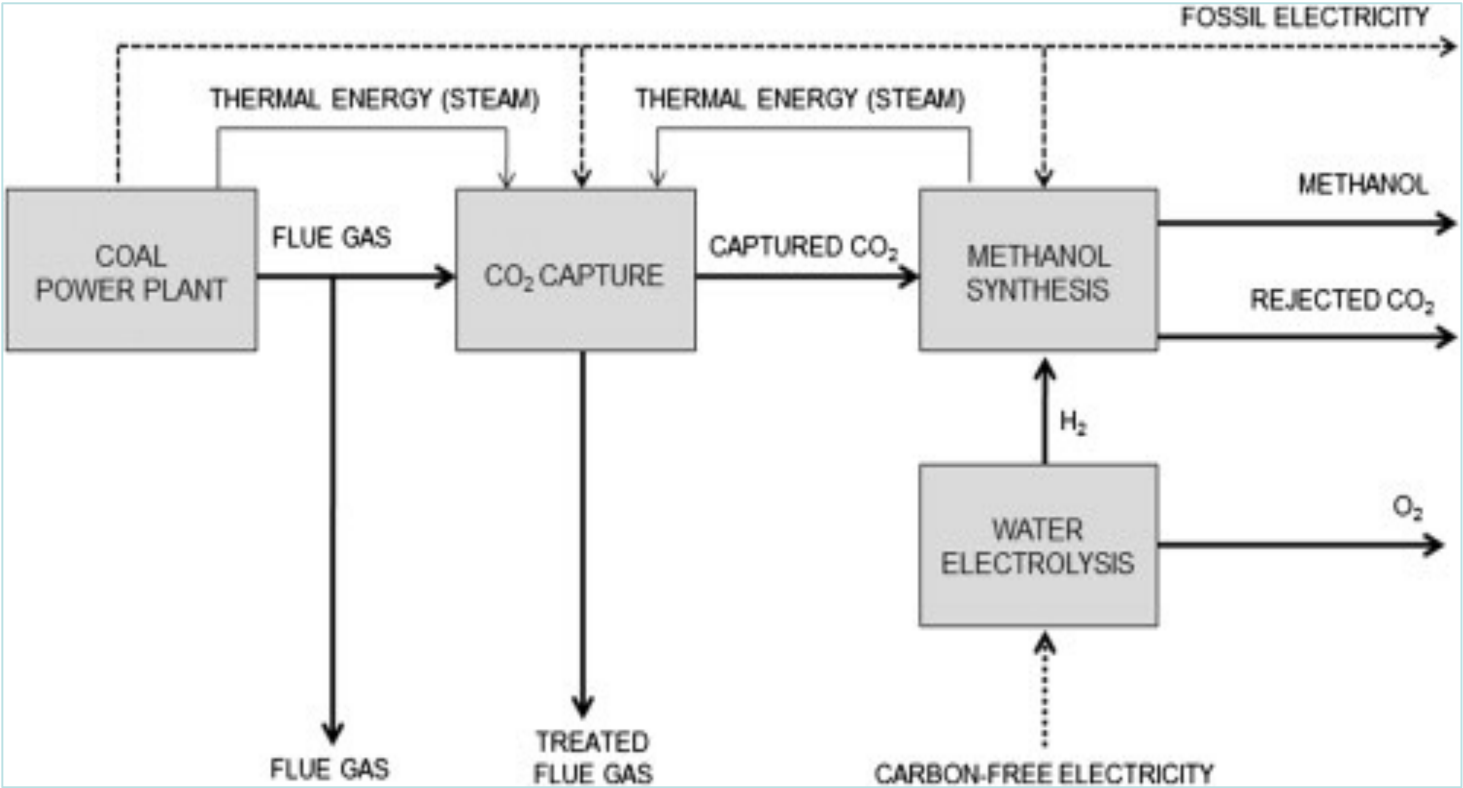
Carbon Utilization for Methanol Production

Methanol can be produced from CO_2 in two different ways: in one step or in two steps. The one step conversion is the direct hydrogenation of CO_2 to methanol. In the two steps conversions, CO_2 is first converted into CO through the Reverse Water Gas Shift (RWGS) reaction and then hydrogenated to methanol.



Methanol can be produced from CO2 in two different ways

CO_2 captured from flue gases of a coal power plant and hydrogen generated from water electrolysis are fed into a methanol plant.



Bloc diagram of the process

Project risk analysis and countermeasures

The following table lists the main risks associated with carbon capture, transport and storage for this project and the associated response strategies.

Results of Key Risk Analysis in Carbon Capture

key risk	probability level	influence degree	countermeasures
Effect of volatilization or leakage of amine collectors (MEA, AMP, MDEA) on ambient air and water environment	Low probability	Medium impact	Adding real-time air and water environment detection device ; preparation of ammonia absorption device
The presence of chemical impurities in the chemical reaction of carbon capture results in unforeseen harmful gases	Low probability	Medium impact	Clear the purity of carbon dioxide capture, grasp the impurity composition and proportion ; installation of environmental background monitoring system for continuous monitoring of leakage and discharge of environmental risk substances
Increased pollutant emission concentrations resulting from additional power consumption during carbon capture in violation of emission regulations	Low probability	Medium impact	Full simulation of carbon capture process and emission results ; optimizing process flow ; adding Waste Gas Filter

Part 3

Project Financial Analysis and Financing Proposal

Carbon Storage

Project financial analysis and financing proposals

◆ Civil construction investment for the 500,000 tons CCUS project

Serial number	Project or cost name	Construction cost (million yuan)	Equipment purchase cost (million yuan)	Installation project fee (million yuan)	Other Fees (million yuan)	Total (million yuan)
One	Carbon Capture Engineering	43.68	90.16	37.63		171.47
(I)	Thermal system		58.83	12.37		71.20
(II)	Fuel supply system					
(III)	Ash removal system					
(IV)	Water Treatment Systems		0.41	0.22		0.63
(V)	Water supply system	12.62	18.22	5.37		36.21
(VI)	Electrical system		7.07	4.85		11.92
(VII)	Thermal Control System		5.32	2.79		8.11
(VIII)	Desulfurization project	15.21	0.31	12.03		27.55
(ix)	Denitrification project					
(X)	Subsidiary production engineering	15.85				20.85
Two	Single project related to the plant site	20.02				20.02
Three	Preparation of base period spreads	12.96		0.41		13.37
Four	Other Fees				19.92	19.92
Five	Basic reserve				13.42	13.42
Six	Special Projects					
	Project static investment (one to six items in total)	76.66	90.16	38.04	33.34	238.2

Project financial analysis and financing proposals

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- the Longmen Iron & Steel intends to set up a CCUS technical service company (TSC) by organizing the project owner, key technological forces and experts to carry out secondary development of this project, financing of technological achievements and market financing, capitalizing intangible values, as well as developing new projects and transferring part of the investment obligations and various intangible benefits of the project to investors who are interested in long-term investment in the CCUS industry.
- Currently, the Longmen Iron & Steel has identified independent investors who can invest in the core equipment for the carbon capture unit for amine solutions.

Project financial analysis and financing proposals

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Project finance structure

- (Source of funds, typical capital structure in the China industry, proposed financial structure and weighted average cost of capital)

Funding Sources (assuming ADB loan covers 70% investment)

Funding sources for the whole project	USD (million)	Yuan (million)	% Total
ADB loan	34.16	218.60	70.0%
Equity funds	14.64	93.68	30.0%
TOTAL	48.79	312.28	100.0%

Funding Sources

Weighted average cost of capital		
	Foreign loan	Equity
Weight	70.0%	30.0%
Nominal cost	2.5%	12.0%
Tax rate	25.0%	25.0%
Tax-adjusted nominal cost	1.9%	9.0%
Inflation rate	3.0%	3.0%
Real cost	-1.1%	5.8%
WACC (real)	**1.0%**	

Part 4

Conclusions

Carbon Storage

Part 4 Conclusions

- The project aims at promoting CCUS technologies in the iron and steel industry of China and used the Longmen Iron & Steel plant to assess the techno-economic feasibility of developing a carbon capture and utilization system for steel plants. The MEA solvent is applied to absorb CO_2 in the capture process and then CO_2 is purified for methanol production purpose.

- The study results indicate that a CCUS plant, with 0.5Mt/yr CO_2 utilization can be implemented in Longmen Iron & Steel . As for using CO_2 to produce methanol, using hydrogen derived from coal is economically feasible. Using hydrogen derived from renewable electricity can only be economically viable if an added value of the product or a carbon credit is considered.

Shaanxi Longmen Iron and Steel Plant

Carbon Capture and Utilization Project

Preliminary Feasibility Study Report

Questions?

Thank you!