Recycled Paper

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Carbon Capture, Utilization and Storage

Development in China

Editors:

The Department of Social Development, the Ministry of Science and Technology of China

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1. PRINCIPLES OF CCUS TECHNOLOGY DEVELOPMENT IN CHINA

Dr. Wan Gang, Minister of Science and Technology of China, delivers a speech at the CSLF Third Ministerial Meeting held in London in 2009

Climate change is one of the most serious challenges facing mankind in the 21st Century. Ever since the industrial revolution, human activities, especially the massive consumption of energy and resources by developed countries in the process of industrialization, have increased the atmospheric concentrations of greenhouse gases, produced significant impact on Earth's natural ecosystems and created severe challenges for the survival and development of human society. In order to avoid irreversible adverse effects on the climate, measures must be taken to reduce and control the production and emission of greenhouse gases.

"As CCS technology is still not mature, we should put our priority and emphasis on strengthening CCS technological development."

Carbon Capture and Storage (CCS) is an emerging technology with potential for large-scale emissions reduction. CCS is expected to achieve near-zero emissions of CO_2 in the use of fossil energy, and so become one of the important ways to control greenhouse gas emissions. However, CCS in general is still in its development and demonstration stage. There are still many significant problems hindering its development. For instance, the energy penalty and cost are high; the co-benefits on sustainable development are not significant; and the safety and reliability of long-term CO_2 storage cannot be guaranteed, etc.

"Developed countries should take the lead in demonstrating CCS technology, and provide the support of funding, technology transfer and capacity building to developing countries and help them to develop CCS technology."

To promote the development and application of the CCS technology, the EU, the United States, Australia and other developed countries have launched large-scale programs for the research, development and demonstration of CCS projects. They are also actively promoting its development globally under the G8 and G20- frameworks. The international community shall jointly address the Climate Change issue under the framework of the United Nations Framework Convention on Climate Change (UNFCCC), and developed countries should take the lead in demonstrating CCS technologies and strengthening technology transfers and financial support to developing countries.

"We shall pay special attention to the research and development of new and innovative methods and technologies to use captured CO_2 as a resource."

To capture and store CO_2 is economically a pure resource and energy consuming activity. If the captured CO2 can be used as resource, it will generate additional benefits. Therefore, Carbon Capture, Utilization and Storage (CCUS) technology shall be current priority and be developed systematically. China attaches great importance to the development of CCUS technology. The National Medium- and Long-Term Program for Science and Technology Development (2006-2020) noted that in key research areasof advanced energy technologies, "we shall develop efficient and clean technologies for developing and utilizing fossil energy with near-zero emissions of CO2". China's Scientific and Technological Actions on Climate Change clearly lists developing CO_2 capture, utilization and storage technologies as an important task in controlling greenhouse gas emissions and in mitigating climate change. The research, development and use of CCUS technology will provide a strategic technical option for China to control greenhouse gas emissions in the future. To this end, China's Ministry of Science and Technology (MOST) has been supporting the development of theoretical studies, key technologies, demonstration plants and strategies for CO_2 capture, transport, utilization and storage, to strengthen technological innovation, reduce energy consumption and costs, and explore the utilization of CO_2.

"With a strong sense of responsibility for future generations, we should boldly shoulder our due responsibility, draw on our common wisdom, make our utmost efforts, and take concrete actions to address climate change. In doing so, we can work together to build a sustainable and promising future for our children."

(The contents in quotation marks were cited from the speech made at the CSLF Third Ministerial Meeting held in London by Dr. Wan Gang, Minister of Science and Technology, in 2009)

2. CCUS S&T POLICIES IN CHINA

National Medium- and Long-Term Program for S&T Development (2006-2020)

"To develop efficient, clean and near-zero emissions fossil energy utilization technologies"

The National Medium- and Long-Term Program for Science and Technology Development (2006-2020) was issued by the State Council of China on 9th, Feb 2006. There are 10 parts in the Program, including the preface, guiding principles, development goals, overall deployment, main areas and priority topics, major special projects, frontier technologies, basic research, reform of the S&T system and the construction of a national innovation system, major policies and measures, S&T input and S&T infrastructure platforms, and talent development. In particular, CCUS was highlighted in the Program as an important frontier technology.

China's National Climate Change Programme

"Vigorously develop coal liquefaction, gasification, coal-chemistry and other technologies for coal conversion, coal gasification based multi-generation systems technology, and carbon dioxide capture, utilization, and storage technologies."

China's National Climate Change Programme was issued by the State Council on 4 June 2007, as the first national climate change program among developing countries. China's objectives, principles, priority areas, countermeasures, positions, and recommended areas for international cooperation for addressing climate change by 2010 are stated in the Programme. Developing CCUS is included as one of the key areas of GHG mitigation by the Programme.

China's Scientific and Technological Actions on Climate Change

"Technological development for GHG emission controls and climate change mitigations including CO_2 capture, utilization and storage technologies"

In order to coordinate climate changed-related scientific research and technological development and to enhance the comprehensive science and technology capacity in response to climate change, China's Scientific and Technological Actions on Climate Change (hereafter referred to as China's S&T Actions) was issued by the Ministry of Science and Technology (MOST), in conjunction with 13 other ministries and departments, on 14 June 2007. It defined CCUS as one of the key tasks in the development of GHG control technologies in China.

CCUS R&D AND PILOT PROJECTS IN CHINA

3. CO_2 CAPTURE

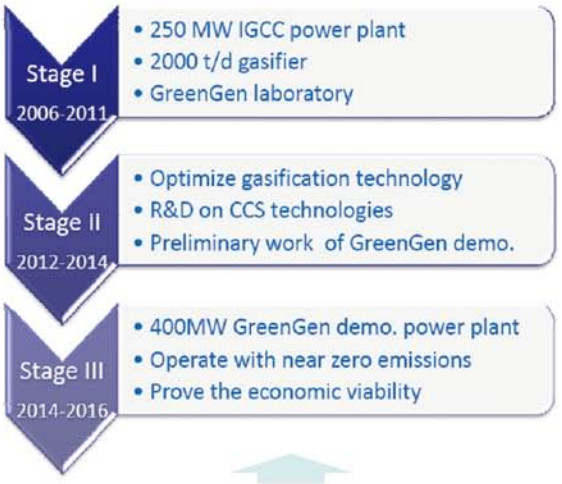
3.1 CHINA HUANENG GROUP'S TIANJIN GREENGEN 400 MW IGCC POWER STATION DEMONSTRATION

The Tianjin IGCC power station demonstration project is the basis of the "GreenGen" project of China Huaneng Group (CHNG). The station is located in the Binhai New Area in Tianjin with a three-stage construction plan.

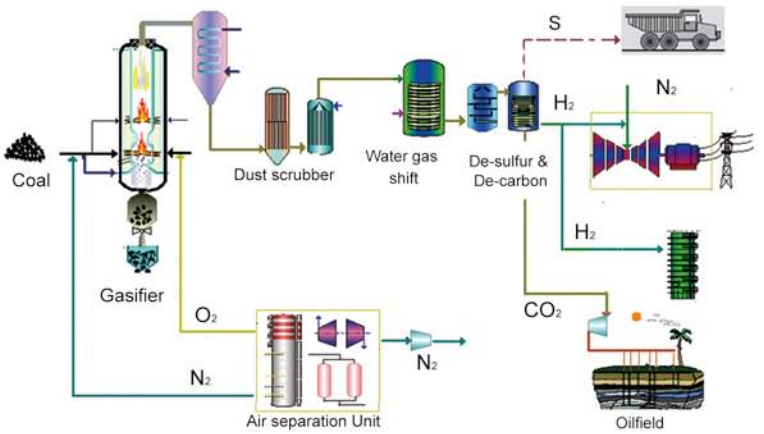
Greengen aims at the development, demonstration and promotion of a near-zero emissions power plant which will improve coal power generation efficiency and realize near zero emissions of pollutants and CO_2. The focus of the demonstration project is to design and produce equipment for coal gasification of 2000 tons of pulverized coal per day as well as to master the knowledge of designing, constructing and operating a large-scale coal gasification plant. The station generating efficiency is expected to be 48.4%. The first stage design of the station was reviewed and approved by the China National Development and Reform Commission in May 2009 and has been under construction since July of that same year. The 1st stage is expected to be finished and begin operation in 2011.

Title:	Tianjin GreenGen 400 MW IGCC power station demonstration
Entity:	China Huaneng Group
Goal:	To construct a demonstration project of 400 MW IGCC and to capture CO_2 for EOR in the Dagang Oil Field
Scale:	250 MW IGCC (1st stage), 400 MW IGCC + Capture + EOR (3rd stage)
Location:	Binhai New Area, Tianjin
Technologies:	IGCC + EOR
Timeline:	The 250 MW IGCC demonstration power station is to be operational in 2011; with the 400 MW (with CO_2 capture) demonstration project to be finished in 2016.
Status:	Under construction

Groundbreaking of the IGCC power station (July 2009)



three stages of the GreenGen Project



Flow diagram of the GreenGen demonstration

3.2 CLEAN ENERGY TECHNOLOGY DEMONSTRATION PROJECT IN LIANYUNGANG

The clean energy technology demonstration project in Lianyungang implemented by the Energy Power Research Center of the Chinese Academy of Sciences aims to complete the infrastructure of a new generation clean coal energy power system.

The construction of the clean energy technology demonstration project will include designing an advanced 1200 MW IGCC ultra-clean power generation plant, two 1300 MW ultra-supercritical power generation plants, a 10 MW solar thermal power generation plant integrated with the IGCC and ultra-supercritical generation systems, co-production of chemical raw materials and fuel such as polyethylene and glycol, and development and demonstration of a system to capture 1 million tons of CO_2 per year and store in the saline layer. In the current plan, the research and development of the technology demonstration project as well as project approval will be completed in 2011 and construction will begin in 2012 for completion within 3 years.

Effect drawing of clean coal energy power system

Title: Clean Energy Technology Demonstration Project in Lianyungang

Entity: Chinese Academy of Science, Jiangsu Province and the Municipality of Lianyungang

Goal: To develop and construct a new generation clean coal energy power system.

Scale: Construct a capture demonstration system of 1 million tons of CO_2 per year

Location: Lianyungang, Jiangsu province

Technologies: IGCC + Aquifer storage

Timeline: Planned for 2012-2015

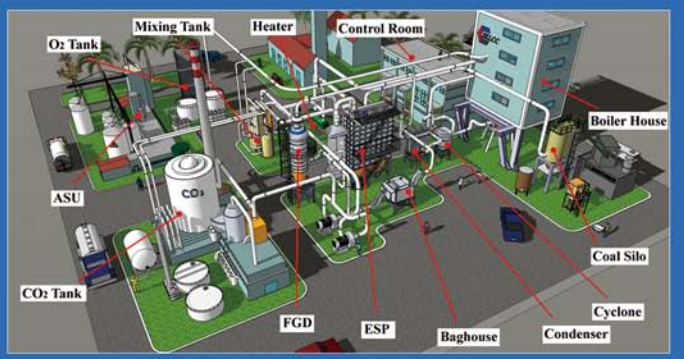
Status: Early preparation stage

3.3 HUAZHONG UNIVERSITY OF SCIENCE AND TECHNOLOGY (HUST) 35 MWt OXY-FUEL INDUSTRIAL PILOT PROJECT

400 kW Oxy-fuel Combustion Pilot System: After extensive fundamental research and development, HUST has built a 400 kWt oxy-fuel pilot facility. This facility uses staged combustion and fires pulverized coal and/or oil under air with O_2/CO_2 flue gas recycling and a calcium-based sorbent inside the furnace for desulphurization.

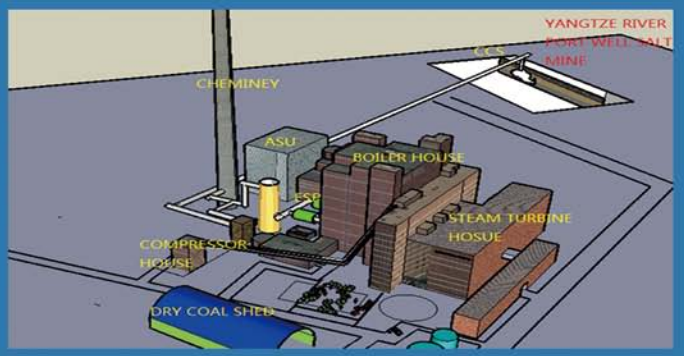
3 MWt Oxy-fuel Pilot Plant: An oxy-fuel pilot will be built in HUST by the end of 2010 with a firing rate of 3 MWt with the ability to capture 1 ton per hour of CO_2.

400 kWt Oxy-fuel recycle combustion facility



3 MWt Oxy-fuel Pilot Platform

35 MWt oxy-fuel small industrial Pilot : The objective of this project is to set up a full demonstration plant combining carbon capture, storage and utilization in China based on a 35 MWt traditional thermal power plant at the Changjiang Chemical Salt Co., Ltd. When the project is complete, the CO_2 concentration in the flue gas will be over 80% and the rate of CO_2 capture will be over 90%. 100,000 t/a of CO_2 will be captured and stored in salt mines.



35 MWt Oxy-fuel Combustion Boiler Industrial Demonstration Project

Title: 35 MWt oxy-fuel industrial Pilot

Entity: HUST and others.

Goal: To set up a full demonstration plant combining carbon capture, storage and utilization

Scale: 35 MWt oxy-fuel combustion boiler with 100,000 t/a CO_2 storage

Location: Yingcheng, Hubei Province

Technologies: Oxy-fuel combustion + storage in salt mines

Status: Under preparation

Capture rate: > 90%

3.4 CHINA HUANENG GROUP'S 3,000 T/A PILOT AND 100,000 T/A FLUE GAS CO_2 CAPTURE DEMONSTRATION

3,000 t/a flue gas CO_2 capture pilot: In 2008, the Huaneng Group built an experimental flue gas capture demonstration system at its Huaneng Beijing Thermal Power Plant with a capture capacity of 3000 tons of CO_2 per year. The system has already operated reliably for one, successfully meeting all the design technical and economic standards. The CO_2 capture rate has topped 85%, while the CO_2 purity has reached 99.997%. A total of more than 4,000 tons of CO_2 has been captured and fully utilized.

100,000 t/a flue gas CO_2 capture demonstration: In 2009, Huaneng launched a CO_2 capture project at the Huaneng Shanghai coal-fired Shidongkou No.2 Power Plant with a capture capacity of 100,000 tons of CO_2 per year using post-combustion capture with independent intellectual property rights. The flue gas is drafted from the funnels of two 660 MW ultra-supercritical boilers and will capture 100,000 tons of CO_2 per year. The construction and commissioning was finished at the end of 2009 and has been in demonstration operation since then. CO_2 with a purity of more than 99.5% has been captured that meets the food-grade CO_2 product regulations for beverage usage after a refining system processes the captured CO_2. This demonstration project is the largest coal-fired power plant post-combustion capture unit in the world.

3000 t/a CO_2 capture pilot in Huaneng Beijing Thermal Power Plant

100 kt/a CO_2 capture demonstration in Huaneng Shanghai Shidongkou Power Plant

Title: Huaneng 100,000 t/a Flue Gas CO_2 Capture Demonstration System
Entity: Huaneng Shanghai Shidongkou No.2 Power Plant
Goal: Construct and demonstrate a 100 kt/a CO_2 capture plant
Scale: Capture 100,000 tons of CO_2 per year
Location: Baoshan district, Shanghai
Technologies: Post-combustion capture + reuse in the beverage industry
Status: Demonstrate running
CO_2 purity: >99.5%

3.5. CHINA POWER INVESTMENT CO.'S CHONGQING HECHUAN 10,000 T/A CO_2 CAPTURE INDUSTRIAL PILOT

The Chongqing Hechuan Shuanghuai Power Plant Carbon Capture Industrial Pilot Project funded by the China Power Investment Corporation was officially put into operation in January, 2010. The project plant can annually treat 50 million Nm3 of fuel gases, from which 10,000 tons of CO_2 with the concentration of over 99.5% can be captured. The CO_2 capture rate exceeds 95%.

10,000 t/a carbon capture device

Panoramic View of Chongqing Hechan Shuanghuai Power Plant

Title: Chongqing Hechuan Shuanghuai Power Plant Carbon Capture Industrial Pilot

Entity: Chongqing Hechuan Shuanghuai Power Plant, China Power Investment Corporation

Goal: To set up an industrial pilot to capture 10,000 t/a CO_2

Scale: Capture 10,000 t/a of CO_2

Location: Hechuan, Chongqing

Technology: Post-combustion capture

Status: Demonstration operation was started in January, 2010

Capture Rate: >95%

CO_2 Purity: >99.5%

3.6. CHINA GUODIAN CO.'S 20,000 T/A CO_2 CAPTURE AND USE PILOT

China Guodian Corporation will put a CO_2 capture pilot into operation at the end of 2010 after laboratory studies; They plan to establish a 20,000 ton per year CO_2 capture and utilization pilot plant by the end of 2011. The project will be located in the Tianjin Beitang Power Plant, China Guodian Corporation using chemical absorption to capture the CO_2. The liquid CO_2 product will be treated to obtain food grade CO_2 for sale in Tianjin.

Title: China Guodian CO_2 Capture and Utilization Pilot Project
Entity: Tianjin Beitang Power Plant, China Guodian Co.
Goal: To build a pilot project capturing 20,000 tons of CO_2 per year
Scale: 10,000 t/a CO_2 Capture
Location: Beitang, Tianjin
Technologies: Post-combustion + utilization in the food industry
Status: Under preparation
Timeline: The pilot plant will be operational at the end of 2011
Capture Rate: >95%
CO_2 Purity: >99.5%

Experimental validation of CO_2 absorption process

3.7 R&D ON CO_2 CHEMICAL ABSORBENTS

The chemical absorption of CO_2 for removal based on the absorbent amine is an effective mature CO_2 separation and capture technology to control CO_2 emissions. However, the process still has some shortcomings such as the high investment cost, high energy consumption and the impact on the power station. Therefore, further research is needed to develop the chemical absorption technology, especially to reduce the energy consumption.

The mixed amines method developed by the Research Institute of the Sinopec Nanjing Chemical Company is currently being evaluated at relevant CCUS pilot plants in China. Many universities and research institutes such as Tsinghua University and Zhejiang University are also developing this process. Laboratory results suggest that the energy consumption for CO_2 capture can be reduced by as much as 20% compared to existing industrial MEA technology. The goal of the experimental program is to reduce the energy consumption for CO_2 capturing by 40-50% .

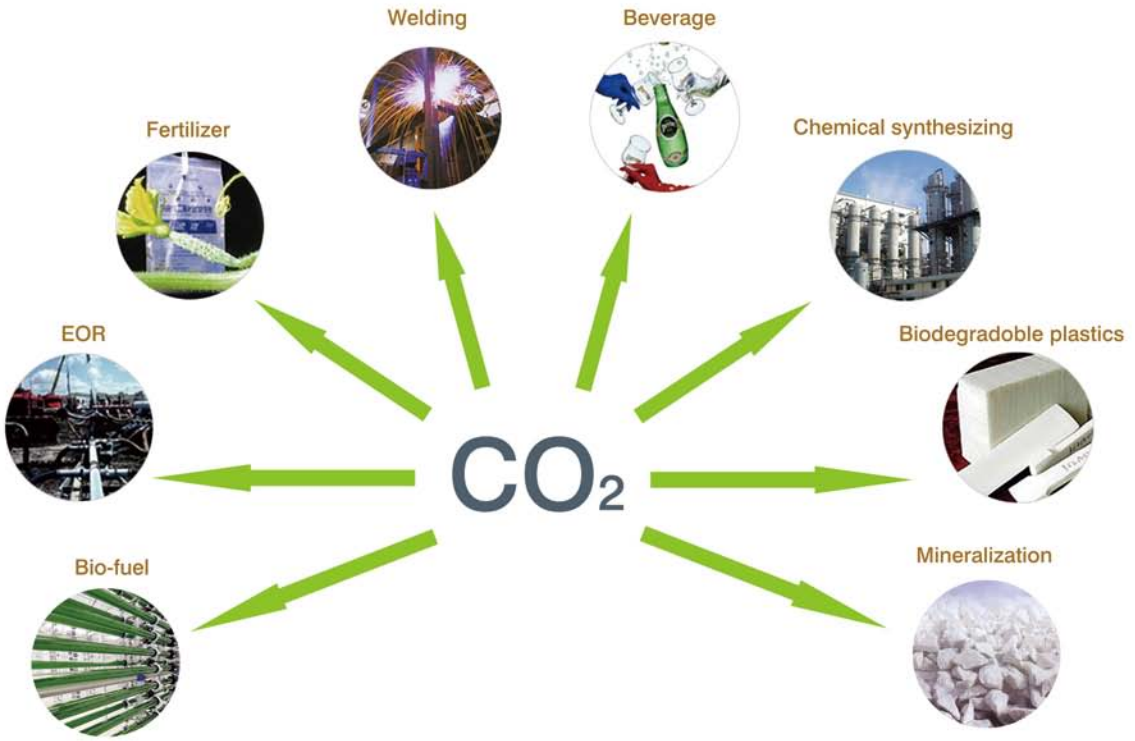
Chemical absorption test facility

Vacuum regeneration test rig

4. CO_2 UTILIZATION

The separation and capture of CO_2 from coal-fired power plants and industrial processes and CO_2 storage consume much energy. Therefore, for China, the first priority is utilization rather than storage. CO_2 is an important industrial gas that can be used to make carbonated beverages, to distend tobacco, for welding as an inert gas, to synthesize organic compounds, fire fighting, refrigeration and can be used to enhance oil recovery (EOR) and to enhance coal bed methane (ECBM). Consider EOR as an example, the geologic reserves controlled by CNPC (China National Petroleum Corporation) in low permeability and ultra-low permeability reservoirs that are to develop contain about 7 billion tons of oil. Initial studies show that the 0.6-1 billion tons of recoverable oil reserves can be increased using CO_2 flooding and sequestration while providing storage for 1-1.5 billion tons of CO_2. Thus, CO_2 flooding and sequestration is a promising application in China.

At present, Chinese enterprises have already completed many initial R&D and demonstration projects related to EOR, ECBM, microalgae bio-energy, and preparation of chemical products and raw materials.



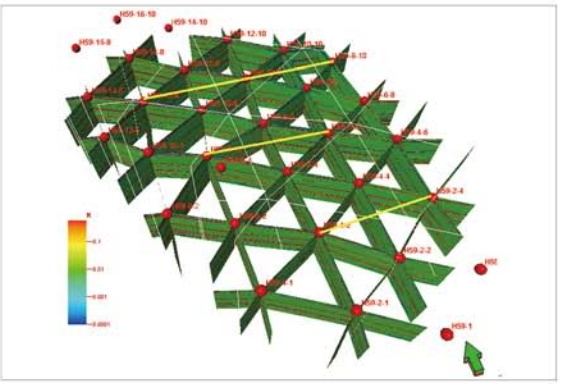
4.1 PETROCHINA'S CO_2 EOR RESEARCH AND PILOT PROJECT IN THE JILIN OIL FIELD

With the support of the Ministry of Science and Technology, China National Petroleum Corporation (CNPC) has launched a major science and technology project, entitled "Research on the Development, Resource Comprehensive Utilization and Storage of CO_2 from a Carbonated Natural Gas Reservoir in the Jilin Oil Field" The goal of the project is to research and develop EOR and storage technologies, enhance the oil recovery from low-permeability oil reservoirs and improve the use rate of super-low-permeability reservoirs to address the CO_2 emissions in the development of highly-carbonated natural gas.

By the end of May 2010, a total of 122,000 tons of liquid CO_2 had been injected into the EOR and storage pilot test site, with about 80,000 tons of CO_2 stored. The total oil production due to the EOR reached 51,000 tons. At the same time, a plant was built in the Jilin Oil Field to separate and capture 200,000 tons of CO_2 annually. By late 2015, the flooding capacity is expected to reach an annual output of 500,000 tons of oil with a CO_2 storage capacity of 0.8-1.0 million tons annually.

Title: CO_2 EOR Research and Pilot Project, PetroChina Jilin Oil Field Company
Entity: PetroChina
Goal: To research and develop CO_2 EOR and storage technologies
Scale: 0.8-1.0 million tons storage of CO_2 annually
Location: Jilin Oil Field
Technologies: Separation of CO_2 from natural gas + EOR
Status: Phase I has been completed and phase II is in progress
CO_2 Source: Separation from highly-carbonated natural gas

PetroChina EOR Project



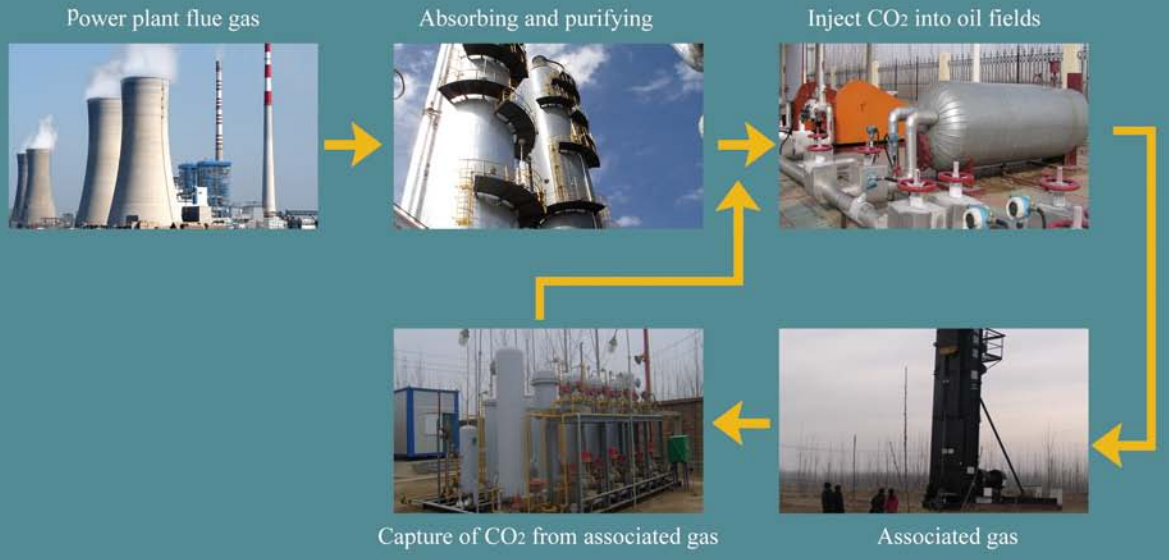
Jilin Oil Field CCS-EOR pilot test block well network design

4. 2 SINOPEC'S 1 M T/A CO_2 FLUE GAS CAPTURE AND EOR DEMONSTRATION IN SHENGLI OIL FIELD

Since 2008, the Shengli Power Plant, China Petrochemical Co. Ltd has been operating a 100 tons-per-day CO_2 capture, storage and EOR pilot. The pilot captures the CO_2 with a volume concentration of about 14% from the flue gas of the Shengli Power Plant of the Shengli Oil Field. The company is extending the project to use purified CO_2 with 99.5% purity for EOR and storage in low-permeability reservoirs with the project to be put into operation in July, 2010.

With the support of the Ministry of Science and Technology, the Sinopec Group will further undertake a 1 million tons-per-year CO_2 capture and purification, EOR and storage demonstration project. The project is scheduled to be completed in 2013-2014.

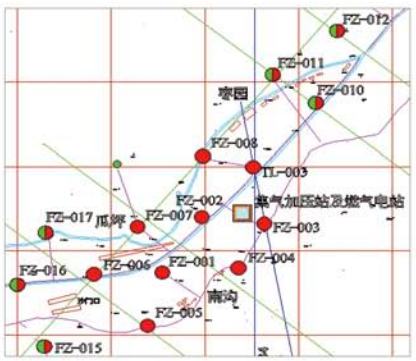
Title: CO_2 capture and EOR demonstration, China Sinopec Shengli Oil Field
Entity: SINOPEC Group
Goal: To capture CO_2 from flue gas and inject into oil reservoir for EOR
Scale: 100 t/d pilot established, with a 1,000,000 t/a demonstration in plan
Location: Shengli Oil Field
Technologies: Post-combustion + EOR
Status: The 100 t/d pilot storage plant will operate in July 2010, with the 1 Mt/a demonstration plant under preparation and to be completed in 2013-2014.
CO_2 Source: Flue gas from the Shengli Power Plant
CO_2 Purity: 99.5%



4.3 CHINA UNITED COALBED METHANE'S ECBM PROJECT

With the support of the Ministry of Science and Technology, the China United Coalbed Methane Company (CUCBM) has implemented the "CO_2 Sequestration and Enhanced Coalbed Methane Recovery (CO2-ECBM) in Unmineable Deep Coal Seams Project". The CO_2 absorption and desorption characteristics in the coal were investigated in laboratory tests with CO_2 injection tests in a CBM well. The objective of the project is to develop systems for CO_2 sequestration and to enhance CBM recovery in unmineable deep coal seams. The project is based on previous cooperative projects between the Chinese and Canadian governments (2002-2007).

The pilot tests were begun on April 21st, 2010. The wellhead pressure has stabilized at around 4.5 MPa. By May 16th, the project had met its goal of 240 tons CO_2 injection.



Pilot Location and Well Pattern Configuration

CUCBM CO_2-ECBM Well Site

CUCBM CO_2-ECBM Well Site

Title: China CO_2 Sequestration and Enhanced Coalbed Methane Recovery Project

Entity: China United Coalbed Methane Company (CUCBM)

Goal: Studying and developing ECBM and CO_2 storage technology, testing safety and permanence of CO_2 sequestration

Location: Shizhuang, Qinshui County, Shanxi Province

Technology: CO_2 Sequestration/ECBM

Status: Ongoing

4.4 ENN GROUP'S MICROALGAE BIO-ENERGY AND CARBON SEQUESTRATION PILOT

The ENN Group in Hebei Province has developed microalgae carbon-absorbing technology and a microalgae bio-energy pilot system using microalgae to absorb CO_2 emitted from coal based chemical production. This pilot system includes all the system equipment for capturing CO_2 emitted from the coal based chemical industry and the microalgae breeding. The pilot system can absorb 110 tons of CO_2 and produce 20 tons of bio-diesel and 5 tons of proteins a year.

ENN plans to build the Daqi microalgae bio-energy and carbon sequestration pilot project based on the pilot system, in Dalate, Inner Mongolia by the end of 2011. This project will use microalgae to absorb CO_2 emitted from the flue gas of a coal-derived methanol and coal derived dimethylether production equipment and produce bio-diesel as well as feeds. The absorption capacity will be 320,000 tons of CO_2 annually. The project began in May, 2010 and will be completed in 2011.

Title: Microalgae Bio-Energy and Carbon Sequestration Pilot
Entity: ENN Group
Goal: To use microalgae to absorb CO_2 in flue gas and to produce bio-diesel
Scale: Absorption 320,000 tons of CO_2 per year
Location: Dalate, Inner Mongolia
Technology: Third-generation bio-energy technology
Timeline: To be completed in 2011
Status: Under construction
CO_2 Source: Capture from coal-derived methanol production

Microalgae bio-energy pilot system

4.5 JINLONG-CAS CO_2 UTILIZATION IN CHEMICAL PRODUCTIONS

Jiangsu Jinlong-CAS Chemical Co., Ltd. has built a production line to produce 22,000 tons of CO_2-based poly(propylene(ethylene)carbonate)annually.The poly(propylene(ethylene) carbonate) polyol is produced from CO_2 captured from ethanol plants and can be used to produce highly flame-retardant exterior wall insulation material, leather slurry, biodegradable plastics, etc. This project will use about 8,000 tons of CO_2 per year.

Jinlong-CAS is planning to build a poly(propylene(ethylene) carbonate)-based biodegradable plastics production line of 10,000 tons per year in 2010, to be expanded to 30,000 tons in 2013 and to build a poly(propylene(ethylene) carbonate) production line of 50,000 tons a year in 2011 to be expanded to 100,000 tons in 2016.

10,000 ton loop reactor

CO_2 recovery and purification unit of the alcohol plant

Title: Jinlong-CAS CO_2 Utilization in Chemical productions

Entity: Jiangsu Jinlong-CAS Chemical Co. Ltd.

Goal: To reduce the use of petroleum-based resources, to recycle CO_2, and to reduce GHGs

Scale: 8,000 tons of CO_2 per year

Location: Taixing, Jiangsu Province

Technologies: CO_2 based resin loop reactor

Status: Operation

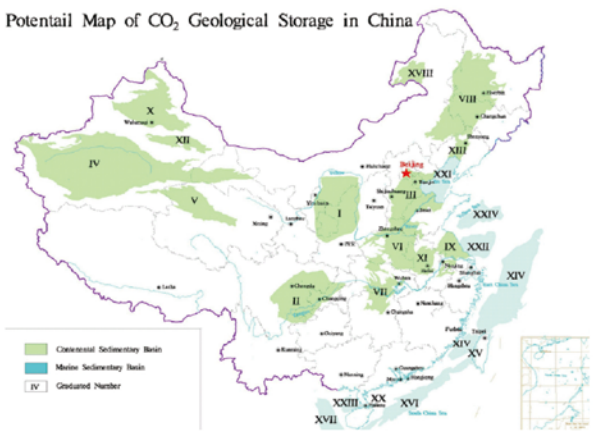
CO_2 Source: Capture from ethanol production plants

5.1 CO_2 STORAGE: PRELIMINARY ASSESSMENT OF POTENTIAL STORAGE CAPACITY IN CHINA

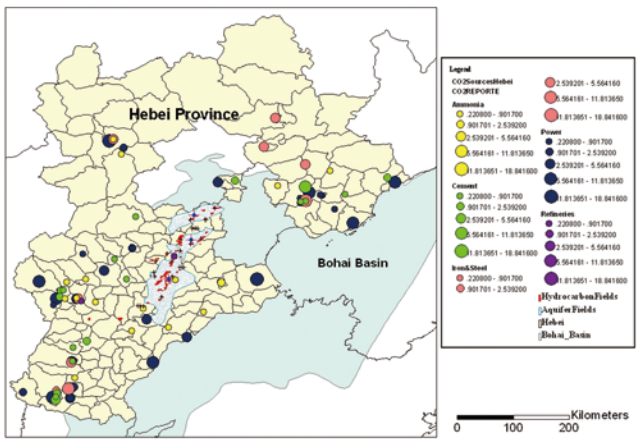
In 2009, China Geological Survey (CGS) initiated the "Potential Capacity and Evaluation of CO_2 Geological Storage in China Project". In the same year, the Ministry of Land and Resources included the investigation and evaluation of CO_2 geological storage capabilities in the monitoring and evaluation of global climate change. Investigations of underground storage resources were included in the "Geological Mineral Support Engineering Program (2010-2020)". In 2010, the "Potential Capacity Evaluation and Demonstration Project of CO_2 Geological Storage in China" was launched by the Center for Hydrogeology and Environmental Geology, CGS.

The objectives of the project are to evaluate the potential capacity for CO_2 geological storage in major sedimentary basins of China, delineate suitable targets for CO_2 geological storage, and map CO_2 geological storage sites based on their suitability. At the same time, CO_2 geological storage demonstration projects would be implemented with industry.

Some universities and research institutions, including Tsinghua University, the Institute of Rock and Soil Mechanic of the Chinese Academy of Science (CAS) and the Institute of Geology and Geophysics of CAS have begun research on the physical characteristics of storage sources and sinks the identification of sources and sinks in some provinces.



Primary Assessment of CO_2 storage potential Capacity in China



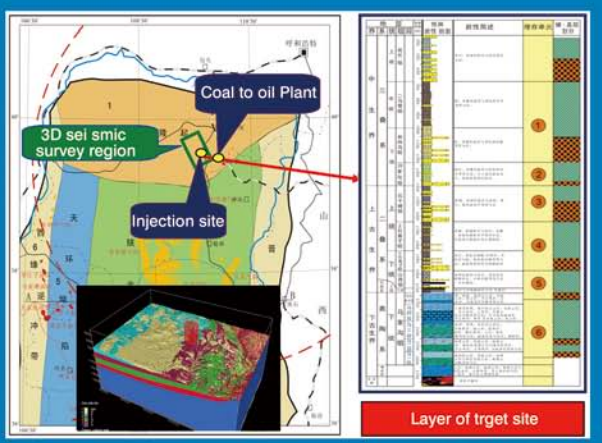
Locations of Sources and Sinks in Hebei Province

5.2 SHENHUA GROUP'S 100,000 T/A CCS DEMONSTRATION — SALINE AQUIFER STORAGE

The China Shenhua Group plans to set up a 100,000 tons-per-year CCS demonstration project and has built demonstration projects for direct coal liquefaction, indirect liquefaction, coal-burning hydrocarbons and other industrial process. They have also completed a pre-feasibility study on the CCS program for the Shenhua Direct Coal liquefaction plant, a feasibility study of the Shenhua 100,000 tons-per-year CCS demonstration project, and other projects through domestic and global cooperation.

The Shenhua Group will join Chinese and American universities, research institutions and energy companies to select a suitable deep saline aquifer for a 100,000 tons-per-year CCS demonstration project. The CO_2 emissions from the Erdos coal gasification hydrogen production center will be captured, purified, and transported to the storage sites by tankers and then injected into the target layer after pressurization. Three-dimensional seismic prospecting and preliminary numerical simulation studies have shown that the underground near the Shenhua direct coal liquefaction plant has a saline aquifer that can be used for CO_2 geological storage with a single well injecting more than 100,000 tons of CO_2 per year.

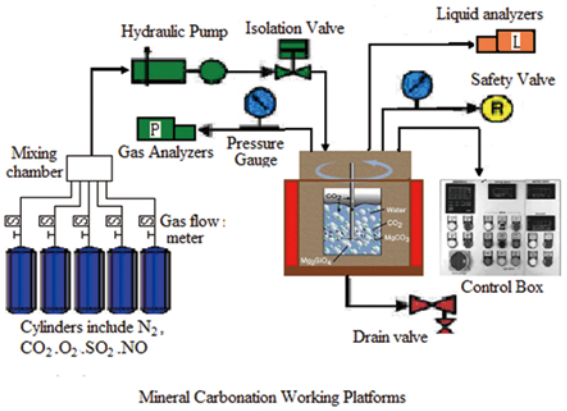
Title: Shenhua Group CCS Demonstration Project
Entity: China Shenhua Group
Location: Erdos, Inner Mongolia
Goal: To build a whole-process CCS demonstration project
Technologies: CO_2 chemical source capture + saline aquifer storage
Capture Capacity: 100,000 tons per year
Injection scale: Tens of thousand tons per year-100,000 tons per year
Injection life: Phase I, 1-2 years
Monitoring Period: 2 or 3 years
Target Layer: Deep saline aquifers
Expected Depth: 1000-2500 m
Number of wells: 1 injection well, 1 monitoring well
Timeline: On-site injection is expected to be conducted by the end of 2010
Status: Under construction
CO_2 Source: Captured from coal liquefaction plant



Shenhua CCS demonstration site

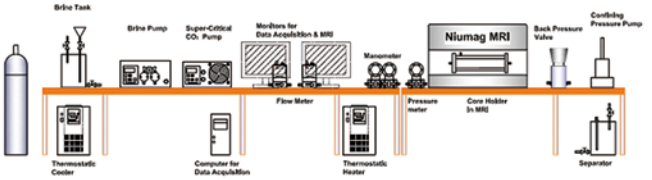
5.3 RESEARCH ON CO_2 STORAGE

Research institutions and universities such as the Institute of Geology and Geophysics, the Chinese Academy of Sciences (CAS) ,Wuhan Institute of Rock and Soil Mechanics (CAS), Tsinghua University and Huazhong University of Science and Technology have conducted preliminary studies on the migration pathways, chemical reactions, and trapping mechanism of CO_2 in saline aquifers for CO_2 aquifer storage and on the injection, control and storage technologies for aquifer storage.

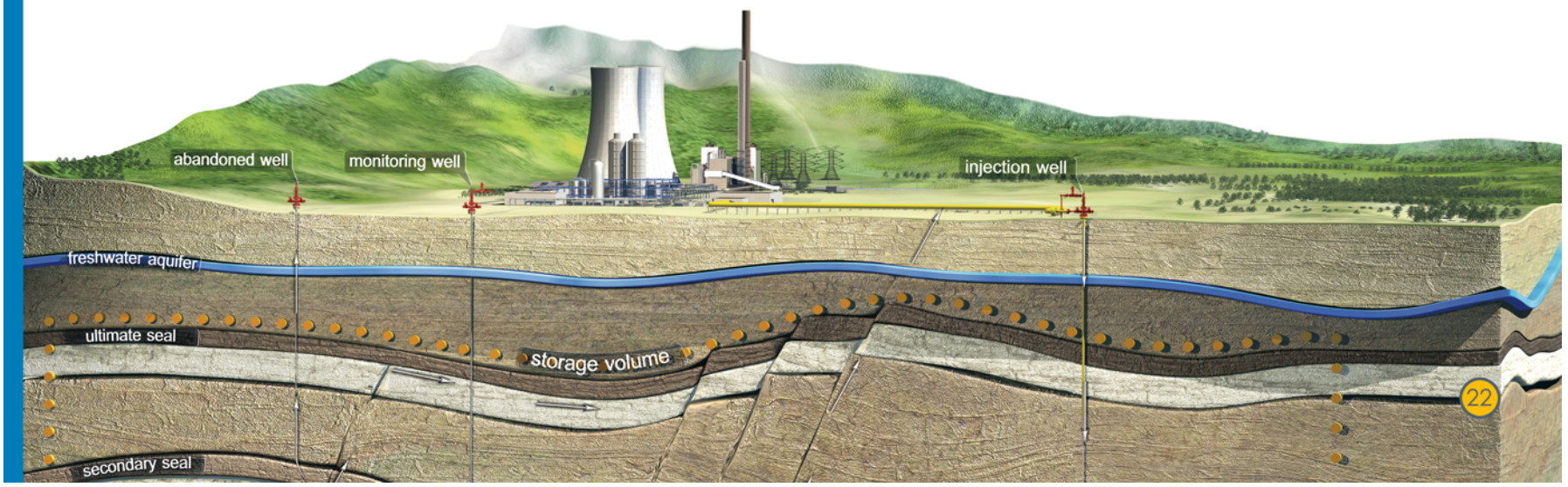


Mineral Carbonation Working Platforms

CO_2 mineral carbonation system



Schematic of the CO_2 storage visualization laboratory system



6. INTERNATIONAL S&T COLLABORATION

In recent years, Chinese universities, research institutes and companies under the leadership of the Ministry of Science and Technology have conducted extensive scientific exchanges and cooperation with related agencies in the European Union, Australia, Italy, Japan, the United States and other countries. Through these international exchanges, China has not only strengthened their research institutions and industry with the formation of core CSS research teams, but have also completed exploratory research in such areas as the selection of capture technologies, the economic evaluation of various technologies, the assessment of storage potentials, and the matching of sources and sinks.

6.1. CARBON SEQUESTRATION LEADERSHIP FORUM (CSLF)

The Carbon Sequestration Leadership Forum (CSLF) is a Ministerial-level international climate change initiative that focuses on the development of improved cost-effective technologies for the separation and capture of CO2, and for its transport and long-term safe storage. The mission of the CSLF is to facilitate the development and deployment of such technologies via collaborative efforts that address key technical, economic, and environmental obstacles. The CSLF also promotes awareness and champions legal, regulatory, financial, and institutional environments conducive to such technologies.

The CSLF currently has 22 members made up of 21 countries plus the European Commission. China is a member of CSLF and MOST represents China in the activities under the framework.

6.2 CHINA-EU/EK NEAR ZERO EMISSIONS COAL COOPERATION (NZEC)

In February 2006, MOST and EC signed a Memorandum of Understanding on EU-China Near Zero Emissions Coal Power Generation Technology through Carbon Capture and Storage, and launched the China-EU Near Zero Emissions Coal (NZEC) cooperation. The Cooperation entails a three-phase approach to achieve the NZEC demonstration objective.Phase I (2007-2009),explored options for demonstration plants and building CSS capacity in China. Phase 2 (2010-2012), will carry out feasibility studies and detailed designs of identified demonstration project(s). Phase 3 (from 2013) will see construction and operation of a full chain CCS demonstration project.

The collaboration includes the China-UK Near Zero Emissions Coal (NZEC) phase 1 project funded by the British government and two technical cooperation projects supported by the EU through the Framework Programme., ie the EU projects are the Cooperation Actions within China on CCS (COACH) and the Support of Regulatory Activities For Carbon Capture and Storage (STRACO2). The NZEC Phase 1 final event was held in Beijing on 28-29 October, 2009. There were more than 30 partners from China involved in NZEC phase 1. This collaboration has improved awareness and CCS R&D capacity in China.

During the 12th EU-China Summit held on 30th November, 2009, the Memorandum of Understanding for the 2nd phase of the Near Zero Emission Coal (NZEC) plant project was signed by Dr. Wan Gang, Minister of Science and Technology of China, and the European Commission. This officially marked the beginning of work on NZEC phase 2.

NZEC kick off meeting in Nov. 2007

NZEC phase 1 final event in Oct. 2009

6.3 CHINA-AUSTRALIA GEOLOGICAL STORAGE OF CO_2 (CAGS) PROJECT

The China Australia Geological Storage of CO_2 (CAGS) Project is a collaborative, bilateral project between Australia and China supported through the Cleaner Fossil Energy Task Force of the Asia Pacific Partnership on Clean Development and Climate and funded by the Australian Government. The project is being jointly managed by Geoscience Australia and the Administrative Centre for China's Agenda 21, Ministry of Science and Technology, China.

This project aims to help accelerate the development and deployment of geological storage of CO_2 in both China and Australia and to help develop China and Australia's technical skills in the area of geological storage of CO_2 through a number of capacity building and research programs. The project timeframe is 2009-2011 with the main activities including scientific studies, capacity building, professional and student exchanges, and study tours.

CAGS website

First technical workshop held in Canberra, Australia, Jan, 2010

6.4 CHINA-ITALY CCS TECHNOLOGY COOPEARTION PROJECT

In October 2009, China's Ministry of Science and Technology, the Italian Ministry of Environment, Land and Sea (IMELS), and the Italian ENEL signed a Cooperation Agreement on Clean Coal Technologies, including Carbon Capture and Storage Technology. They agreed to begin a pre-feasibility study on a full chain CCS demonstration project, including capturing the CO_2 from coal-fired power plants, CO_2 transport and storage. The study results will be compared with those of Italian CCS demonstration projects to promote technical exchanges and cooperation in areas related to CCS between the two countries.

The project, which is mainly funded by IMELS, is to be launched in the second half of 2010, and will be closed by the end of 2011.

Chinese and Italian sides discuss the cooperation

Chinese representatives and experts visit ENEL's ultra supercritical power plant