China CCUS Developments and Perspective

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In 2010, China consumed more than 3 billion tons of standard coal, and the CO$_2$ emissions from coal-combustion is over 75% of the total emissions.

Source: China statistical yearbook 2010
Installed Power Capacity in China

Source: China's State Electricity Regulatory Commission
Thermal Power Capacity and Electric Energy Production

Thermal power capacity

Electric energy production

Growth of thermal power capacity and electric energy production

Source: China's State Electricity Regulatory Commission
Structure of New Power Generation Equipments

Source: China electricity regulatory annual report 2010
Energy Structure Preview of China

Source: IEA world energy outlook 2010
China and USA's emission add up to about 40% of world's total output. China’s CO₂ emission become the biggest over USA.

Based on the CO₂ emission per capita, China falls far from USA, which is the biggest in the world.
China pledged to reduce the amount of CO₂ produced per unit of GDP by 40-45% in 2020 from 2005.

Compared with 2005, in 2010 the energy consumption per unit GDP drops 19.06%, equivalent to saving 570 million tons standard coal and reducing about 1.425 billion tons CO₂ emissions and 13.68 million tons SO₂.

Ten energy-saving projects have been started to form an energy-saving capacity of 240 million tce in 2010.

The government invested RMB28 billion for energy saving in 2007.
In 2006 there were small thermal power units (≤ 100MW) of 114,000 MWe nationwide, accounting for 23.6%.

Up to now, the proportion of thermal power units higher than 300MW in total installed power stations increased from 44.37% to 67.11%.

- The country will shut down small thermal power units accumulated over 70 GW
- Electricity of this amount generated by large units will reduce
- coal consumption annually ............ 81 million tons
- sulfur dioxide emissions .............. 1.4 million tons
- carbon dioxide emissions ..............0.164 billion tons
The efficiency increase of 5% in the coal industry chain will result in a reduction of the CO₂ emission of 40.3%.

Source: NICE, 2011
CCS Demonstration projects in China

- Beijing Thermal
- Shanghai S.D.K.
- Chongqing S.H.
- Wuhan Oxyfuel
- Yingcheng Oxyfuel
- Shenhua Group
- Yingcheng Oxyfuel
- Jilin Oil filed

CCS Capacity (10^3t/a)

- CO2 Capture/Operation
- CO2 Capture/under construction
- CO2 Capture+Storage/under construction
- CO2-EOR/operation
CCS Demonstration Projects in China

- **Huaneng Beijing Thermal Power Station**
  - 3000 t/a (Operation)

- **Huaneng Shidongkou Power Station**
  - 10 × 10^4 t/a (Operation)

- **Wuhan 3MW oxyfuel**
  - 10 × 10^4 t/a (under construction)

- **Hubei Yingcheng Oxyfuel**
  - 10 × 10^4 t/a (Approved)

- **Shenhua Group CCS**
  - 10 × 10^4 t/a (Operation)

- **Chongqing Shuanghuai power station**
  - 1 × 10^4 t/a (Operation)

- **Jilin Oil field CO₂-EOR**
  - 300-400 t/d (operation)

- **Wuhan 3MW oxyfuel**
  - 1 × 10^4 t/a (under construction)
Pre-combustion carbon capture
Carbon Capture Technologies

**Pre-Combustion**

- Air
- \( N_2 \)
- \( O_2 \)
- Gasifier
- \( H_2 + CO_2 \)
- \( CO_2 \) separation & compression
- \( H_2 \)
- Gas Turbine

**Oxy-Coal Combustion**

- Air
- \( N_2 \)
- \( O_2 \)
- Boiler
- \( CO_2 \) compression
- \( CO_2 \)

**Post-Combustion**

- Air
- \( N_2 + CO_2 \)
- Boiler
- \( CO_2 \) separation & compression
- \( CO_2 \) separation & compression
- Flue Gas

Source: 2nd Asia Pacific Partnership Oxy-fuel Capacity Building Course
GreenGen started from 2005

The first 250MWe-scale IGCC plant will be accomplished in 2011 at Tianjin

To develop gasification based H₂ production, combined cycle with hydrogen gas turbine and high temperature fuel cell
IGCC in Tianjin, Huangneng Group

- Syngas: 6000Nm³/h, 14.9MWt
- CO₂ captured: 60000ton/a.
Further R&D Tasks

- Integration, optimization and modular design of IGCC system
- Pre-combustion CO₂ capture technology based on IGCC technology
- Low energy consumption Water Gas Shift (WGS) reaction-CO₂ separation technology
- Study on the absorption characteristics of absorbent
- Research on pre-combustion carbon capture technology based on solid absorbent
- Two-staged-oxygen-feeding entrained flow gasification with dry-ash-extraction
Post-combustion carbon capture
Post Combustion Capture Plant Configuration

Postcombustion capture (absorption process)

Source: http://www.captureready.com
CO₂ Capture Demonstration Project in Beijing Thermal

Investment: China Huaneng

Operation Date: 2008-7-16

CO₂ capture capacity 3000 t/a

Capture Method: MEA

CO₂ concentration: 99.99%
CO₂ Capture Demonstration Project in Shanghai

- **Investment:** China Huaneng
- **Operation Date:** 2009-12
- **CO₂ capture capacity:** $12 \times 10^4$ t/a
- **Capture Method:** MEA
CO$_2$ Capture Demonstration Project in Chongqing S.H.

- Investment: CPI Corporation
- Operation Date: 2010-1-22
- CO$_2$ capture capacity: $1 \times 10^4$ t/a
- Capture Method: MEA
Further R&D Tasks

- 120,000 tons / year CO$_2$ capture system operation optimization
- Large-scale CO$_2$ capture and utilization of coal-fired power plant
- Study on the absorption characteristics of absorbent
- Engineering design of large-scale post-combustion CO$_2$ capture systems
- Research on novel CO$_2$ absorption solution
Oxy-fuel combustion carbon capture
Oxy-Fuel Plant Configuration

Source: 2nd Asia Pacific Partnership Oxy-fuel Capacity Building Course
Roadmap for Oxy-fuel R&D in China (SKLCC Draft)

1995
- Fundamental Study

2005
- 300kWt small pilot study
- Burner development
- Data collection and Optimization
- Thermal Design

2010
- 3MWt large pilot study
- 7000T/a full chain validation
- ASU-CPU coupling
- FGC and drying

2014
- 35MWt pilot plant
- 0.1 million ton capture
- ASU-CPU-power generation integration and optimization

2020
- 200-600MWe full demo.
- Millions ton CCS-EOR
Further R&D Tasks

- Combustion and pollutant emission characteristics
- Pilot scale evaluation and optimization
- Field Testing and CO₂ Utilization
- Process simulation and optimization
- Commercial scale engineering feasibility
CO$_2$ Utilization and Storage
**CO₂-Geological sequestration tech**

- Geological sequestration
- Ocean sequestration
- Vegetation sequestration

- Using the deep part saline aquifer of sedimentary basin for storing CO₂
- Using the oil-gas field for CO₂ sequestration: the discarded oil-gas field/ CO₂-EOR Tech
- Using the abundant coal bed for reserving CO₂ unminable thin seam, overembed deep coal bed
CO$_2$-EOR Demonstration Project in Jilin Oil Field

Total CO$_2$ injection amount from 2008 to 2010: $8 \times 10^4$ t  
Now: 300~400 t/d

100t/d CO$_2$ capture and EOR Demonstration project is under construction in SINOPEC Shengli oil field.
ENN’s Micro-algae Bio-fixation of CO₂

Algae Photo-reactors
Algae harvest
Algae refinery
Algae Product

Biodiesel
High Value products
Animal Feeds
ENN’S Micro-algae Bio-fixation of CO₂

Genetic Engineering 基因工程
--- Multi-objective Strain Screening Process of High-throughput 高通量藻系筛选
ENN0601A
Mutagenesis and screening 基因突变及筛选
--- Genetic Modification 基因修正

Process Development 过程开发
--- Efficient Photobioreactor 高效的光生物反应器
Tubular PBR 管状光生物反应器
ENN Crystal Wall 新奥的催化墙
--- Optimized Mass-culturing Process 优化培养过程
ENN0601A (Stained with Nile red, un-induced)
Current: 30 g/m²/day
40% oil (dry weight)
2-year goal: 80 g/m²/day
50% oil

Commercialization 产业化
--- Hectare Demo Units in Northern and Southern China 在中国的北方和南方进行公顷规模演示
--- Innovative Techniques 创新技术:
1. Micro-sized CO₂ bubbles 微尺度CO₂气泡技术
2. Low-cost harvesting 低成本收获技术
3. Low-cost automated PBRs 低成本自动化PBR
4. Low-cost greenhouse lighting and heating for high productivity 低成本高产量温室照明及加热技术
Hydrogen Production - chemical Fixation of CO₂

1. Photoelectrochemical Cell (PEC)
2. Electrolyzer

Solar Energy → PEC Module → H₂ → Electrolyzer Plant

 Integrating renewable energy with coal resources
CO$_2$ Capture & Storage Demonstration Project in Inner Mongolia

Investment: Shenhua Group

Operation Date: Dec 31$^{st}$, 2010

CO$_2$ capture capacity
$10 \times 10^4$ t/a

CO$_2$ capture & Storage Project
UCG — an integrated mining technology
**UCG in China**

Long Tunnel, Large Cross-section, Two stages UCG, China University of Mining and technology

ENN UCG technological flow sheet of commercial demonstration station

Pilot demonstration completed
Potential and adaptability evaluation of CO$_2$-ECBM in Orods Basin

Brine-rock-CO$_2$ interactions and its effect on CO$_2$ migration pattern

Potential and adaptability evaluation of CO$_2$ saline aquifer storage in Orods Basin

Grading and selection of potential storage blocks in Orods Basin

Potential and adaptability evaluation of CO$_2$-EOR in Orods Basin

Technical proposal of CO$_2$-EOR adapting to site characteristics in Orods Basin
Summary

Clean Power Generation

Clean Coal Conversion

Gasification technologies
UCG
CTL/CTO
SNG
Poly generation

USC
CFBB
IGCC

Pre-Combustion Capture
Post-Combustion Capture
Oxyfuel Combustion

CO₂ Capture Demonstration Project

Roadmap for Oxy-fuel R&D in China

EOR
Bio-fixation (Algae)
Chemical-fixation

CO₂ Storage Demonstration Project

CO₂ Utilization
CO₂ Sequestration
Thank you for your attention