CCUS in Cement and Steel Industry: policy challenges and options

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Recognized as one of the priority in energy technologies

- In the 82 energy production and utilization relating technologies, 2 CCUS-related are among the Top 10. (CAS, 2012)

No.	Technology
1	Large-scale gasification technology
2	Solar thermal power technology
3	Highly efficient ultra-supercritical power generation technology
4	CCS-ECBM technology
5	Circulating fluidized bed combustion technology
6	Renewable energy grid technology
7	Hydrogen cell technology
8	Nuclear fusion technology
9	Renewable resources recycling technology
10	Carbon sequestration technologies

CCUS application – mainly in EOR

- CO2for EOR has been widely applied in the United States, Canada, Angola, Trinidad, Turkey and other countries and regions
- By 2012, oil production through CO2-EOR in the U.S. was about 16.872 million tons/year, accounting for 90.62% of the world ’s total, the number of projects is 121, or 89.63% of the world’s total.
- Oil and gas reservoirs could store about 923 billion tons of CO2, equivalent to 45% of the global cumulative emissions of 2050.
- In China, the CO2 injection enhances the oil recovery above 30%. In the Market maturity stage

Current CCS-EOR Demo Projects

- Ji-Lin

The single well production in the demonstration zone is 60% higher than that by water-flooding, oil production rate is maintained at more than 2%, and the recovery rate of more than 10%. During the 12th Five-Year plan period, CO2 flooding will be industrialized in Daqingzijing oilfield, which will create an annual output of 500,000 tons, with an expected EOR of 13.4%, and 4.589 million tons of CO2 be stored.

- Sinopec

O&G field	Scale	CO2 resource and content	Technic	Capture commissioning time	CO2 use	EOR start time	Recovery rate improved %	Injected CO2 Tons	Oil production increased Tons
Zhong-Yuan	60t/d	FCC plant tail gas, 14%	MEA	2002	99%，Commercial sales+EOR	2008.5	7.6	4.34	0.64
Sheng-Li	100t/d	Coal-fired power plant flue gas, 14%	MEA	2010	99.5%，EOR	2008.1	17.2(Expected)	7.66	1.8
Song-Nan	1500t/d	High CO2 content natural gas, 23%	MDEA	2009	99.8%，EOR	2011.4	15.4(Expected)	8.3	0.14

Current CCS-EOR Demo Projects(2)

- CUCM
  - Recovery rate of Coalbed Methane is expected to be improved by 10%
  - CO2 storage: 300,000 m^3/km^2
- Shenhua Group
  - Get CO2 from the world's first direct coal liquefaction equipment。
  - Designed CO2 capture and storage capacity at 100 ,000 tons /a.
  - High purity CO2 is captured from coal to liquid plants

CO2 Capture Project

- Huaneng Group
  - 120,000t/a Post-Combustion Capture CO2 and Refining Utilization
  - 660 USC in Huaneng Shanghai Shidongkou No.2 power plant
  - Scale： capture from 70,000Nm3/h flue gas, recovery CO2 16.7t/h and 100,000t/a
  - CO2: main food-grade, remain industrial-grade
  - Cost: Less than 30$/t CO2

CCUS Related National Projects

Since 2006, the Chinese government launched national projects of CO2 resource utilization, the consequently formed carbon industry is significant for the national policies on CO2 emission reduction.

- The National Science and Technology Support Project: Technology demonstration of CCUS in coal chemical industry at northern Shaanxi
  - To build a CO2 capture unit of 50,000 tons/year, together with a field test and demonstration base of 10-15 well groups for CO2 -EOR, with an annual producing geological reserves of 5 million tons, and an annual storage of CO2 over 40,000 tons, to lay the foundation for the future CCUS for northern Shaanxi coal chemical.
- 12th five-year-plan national 863 projects: Key technologies for CCUS of flue gas from coal-fired power plants
- National major science and technology special project : Development of large scale fields of oil, gas and coal-bed methane.
  - Research the CCS-EOR theories and build demonstration projects. Set up the integrating mode of CCS-EOR and emission reduction.
- National major science and technology special project : Research of CCS-ECBM technology and equipment in Deep coal seam

Chinese CCUS related Policies

- China's Scientific and Technological Actions on Climate Change (2007-2020)
  - One of the key tasks in the development of GHG control technologies.
- National 12th Five-year Plan on S&T Development
  - Technology to mitigate Climate Change
  - Clean Coal Technology for Power generation
- National 12th Five year work plan on GHG emission Control
  - *Capture pilot in power, coal chemical, cement, steel sectors*
  - Establish integrated CO2 CCS-EOR demonstration

Steel Sectors in China

- Steel sector accounts for 14.71% in the total energy use; 50-100 kgce/t higher than the international advanced technique.
- The ironmaking system(coking, sintering and ironmaking) accounts for 67.2% of energy use in the steel producing.
- The emission factors of steel sector are between 1.7t/t and 2.5t/t.

CO2 emissions of steel sector		tCO2/t		
scenarios	2000	2010	2020	2030
Reference	2.68	2.19	1.97	1.83
Current policies	2.68	1.96	1.80	1.63
Enhanced policies	2.68	1.71	1.58	1.48

Year	2005	2010	2020	2030
Domestic demands for steel and iron (hundred million tones)	3.56	5.5	6.5	7.5
CO2 emissions per ton of steel production (t/t)	2.1	1.71	1.58	1.48
CO2 emissions (hundred million tones)		9.4	10.3	11.1
Capture potential (hundred million tones)		4.4	4.7	5.1

Cement sector in China

- Cement sector accounts for above 75% of the total energy use in building materials, around 1.47 hundred million tce. Above 70% of the energy use is coal.
- The emission factors of cement sector is between 0.867t/t and 1.102mg/t

	2007	2010	2015	2020	2025	2030
Production (hundred million tons)	12.82	14.39	15.78	14.91	12.41	10.50
Population (hundred million)	13.07	13.26	13.60	13.94	14.29	14.65
Demands per capita (kg)	981	1085	1160	1069	868	716

Year	2005	2010	2020	2030
Production (hundred million tons)	10.6	12	12.5	13
Energy intensity (kgce/t)	152	138	129	125
CO2 emissions (hundred million tons of CO2)	10.6	9.6	9.4	9.1
Capture potential (hundred million tons of CO2)	0.7	2.9	3.8	4.5

In China

- CCS is seen as a strategic technology for the country;
- The investment helps to build the country's technical capability;
- Current regulations and markets might prevent pass-through of costs to customers

Challenges to the demonstration and implementation of CCUS

Overall policy strategies

- Orientation of CCS
- Matching with existing regulations
- Incentive mechanism

Key challenges to enterprise

- Costs
- Source of CO2
- Infrastructures
- Permanency of storage
- Market measures: CDM or domestic ETS

Key problems in implementations

- Responsibility sharing
- Site choosing
- Monitoring
- Risks and emergency management

- Financing
- Interaction with other energy policies
- Impacts and risks
- Regulations on demonstration and site choosing

Policies comparison between CCS and renewable energies

	CCUS	Small-Hydro	Wind Energy	Solar Energy
Energy policy legislation and planning	×	√	√	√
Direct government subsidies	×	×	√	√
Financial support to R&D	√	×	√	√
Tax incentives	×	√	√	√
Investment policy	×	√	√	√
Output subsidies	×	√	√	√
Special fund	×	√	×	×
Loan from financial institutions	×	√	√	√

- Total additional cost of deploying CCS outside OECD member countries will amount to almost USD 3 trillion by 2050.

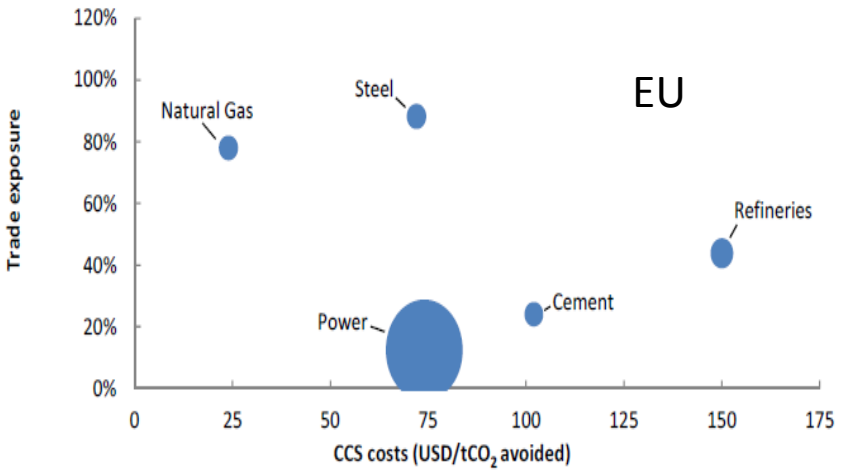
- 11th Five-Year Plan
  - 20+ CCUS related R&D projects
  - 200 million government budget
  - 1 billion from private sectors

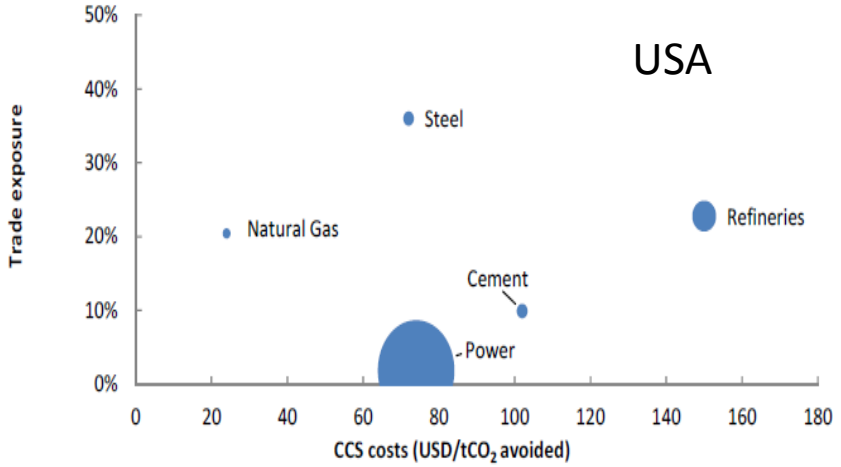
- 12th Five-Year Plan
  - already more than 400 million from government
  - 2.3 billion from the private sector

Cost and financing are still the biggest challenges

- When the oil price is 80$/t, the marginal cost of CCS is 60$/tCO2
- When the oil price is 60$/t, the profit of CCS-EOR is 8.07$/tCO2
- With no CDM-CER, the rate of return of CCS-EOR project is 47.8%
- With CDM-CER, the rate of return of CCS-EOR project is 69.2%

Kulichenko and Ereira, 2011:
Carbon price of between USD 15 and USD 50 per tonne ofCO2 could facilitate between 7 and 26 CCS projects in the developing world by 2020, delivering 26 MtCO2 to 80 MtCO2 of avoided emissions. Most of these projects will likely be in the natural gas processing sector.





Possible Policy in the near future

- Cap and trade
  - Can be applied across wide range of sectors with knowledge that cap will be met.
  - Abatement will takes place if the market reveals that it is needed to meet the cap
  - Cost will not be known in advance.
  - Free allowances can offset the total cost increase

7 domestic ETS pilots:
Beijing, Tianjin, Shanghai, Chongqing, Shenzhen, Hubei, Guangdong

Guangdong: ceramics, power generation, cement, refinery. 760 enterprises
Tianjin: steel, Chemistry industry, power and heating, refinery, oil & gas.
Shanghai: industries, transportation, building, commercial industry.

For CCUS equipment, pricing supports and beneficial tariff

Investigation on the awareness of CCUS

	Government departments	Research institutes	Universities	Enterprises	NGOs
Prospect of CCUS (to 2030)					
Technical maturity					
Economic feasibility					
scales					
Risks of CO2 storage					
Large scale leakage					
Degradation of soil and water					
Impacts on human health					
Impacts on ecosystem					
Geologic hazards					
Risks of CCS system					
Safety of pipelines					
Impacts on property right and mining lease					
Impacts on energy structure					
Renewable energy					
Nuclear energy					
Fuel energy market					
Contribution to emission reduction					

Primary conclusions and suggestions

- In long term, compared to other emission reduction measures, CCUS is not an optimistic choice.
- The total evaluation of CCUS is impacted by the costs in a big sense.
- The acknowledgement on CCUS is closely related to the positions of people.
- The lack of necessary information impacts the public acceptance.
- Long-range and stable energy policies are important to enterprises.
- Integrating in existing regulations is significant.

- Strength R&D and demo
  - funding;
  - coordination;
  - regulatory framework;
  - financing;
  - platform;
  - public acceptance
- Promote policy research for future
  - policy and Regulatory system;
  - Collaborate among sectors;
  - financing mechanism;
  - Infrastructure;
  - etc.

Thank You

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