CAGS II Mini Workshop, Wuhan, China, 19 November，2014

Status of CCUS in China

The Administrative Centre for China's Agenda 21

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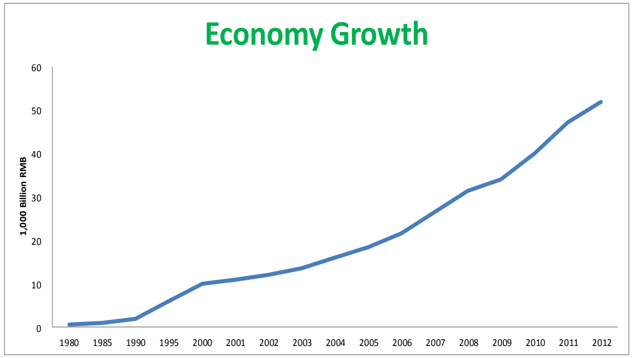
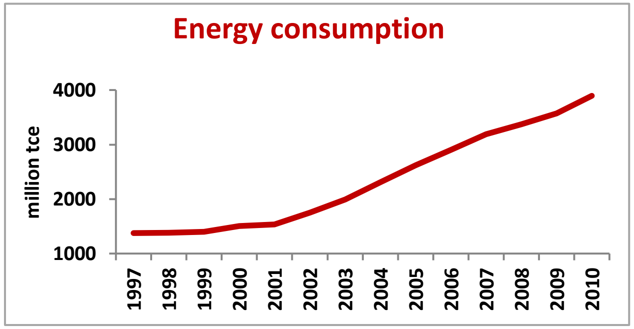
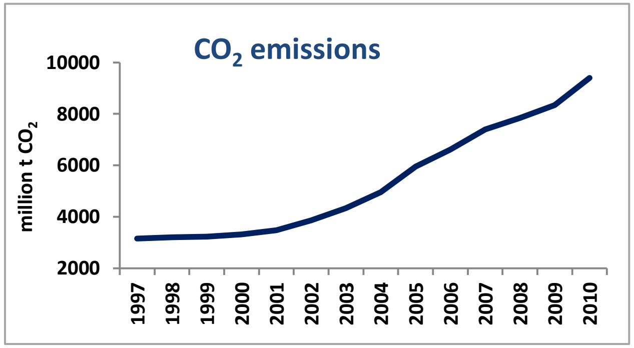
OVERVIEW OF ECONOMY, ENERGY AND EMISSIONS

Economy, Energy and Emissions in China

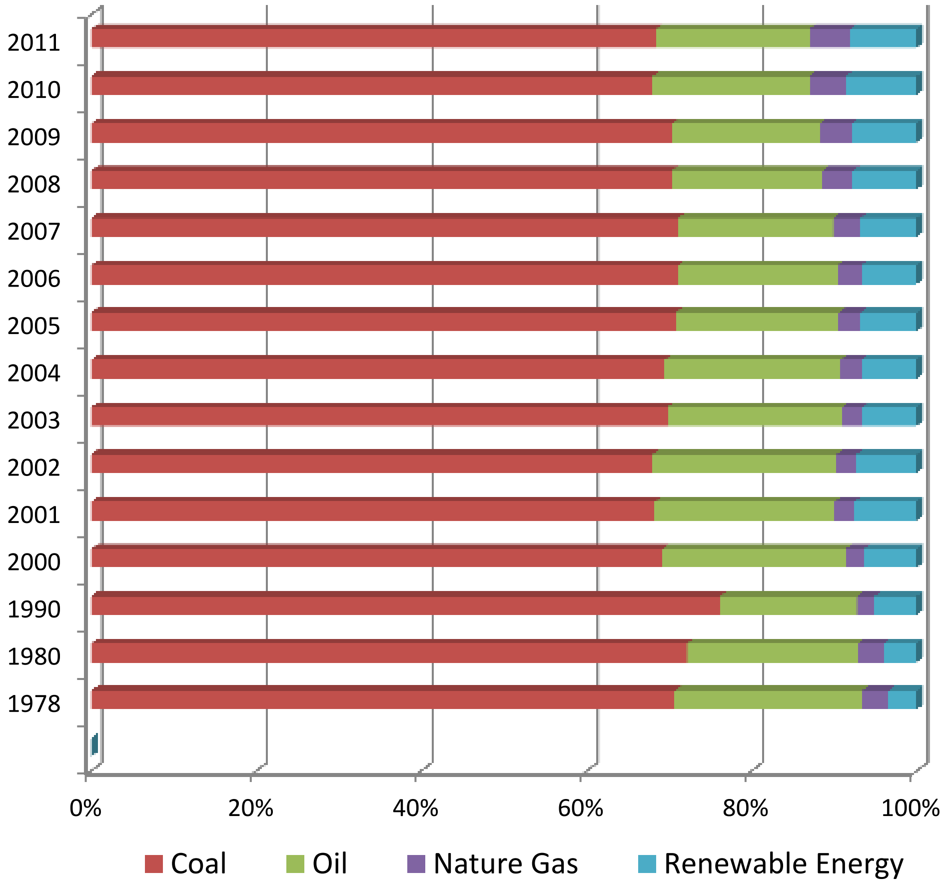
- During the period of rapid industrialization and urbanization, the GDP from high energy-intensive industries accounted for a big proportion in China.
- The energy demand increases by 200 million tce annually in the recent years.
- From 1990 to 2010, CO2 intensity declined by 57%, that is rare all over the world.
- From 1990 to 2010, the GDP grew by 7.3 times, while energy consumption and CO2 emission increased by 3.3 and 3.0 times.
- CO2 emission intensity to drop 40-45% by 2020 according to the 2005 level.

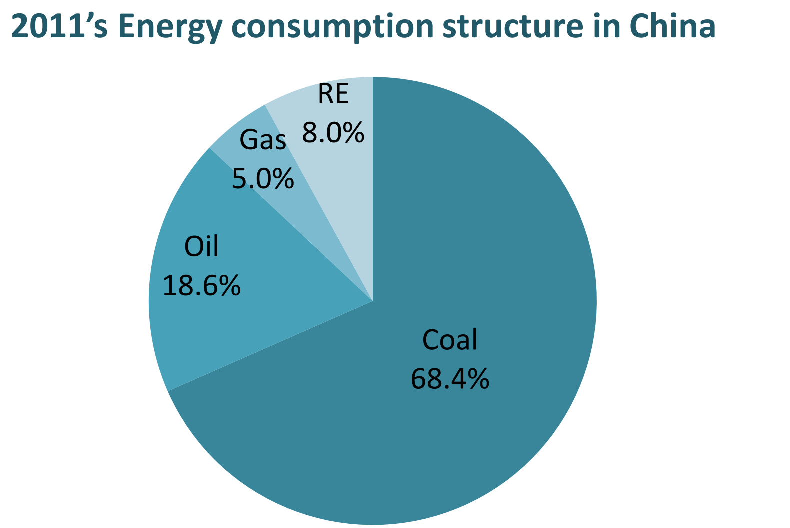






Coal accounts for around 69% of Primary Energy Consumption in the past 30 years.

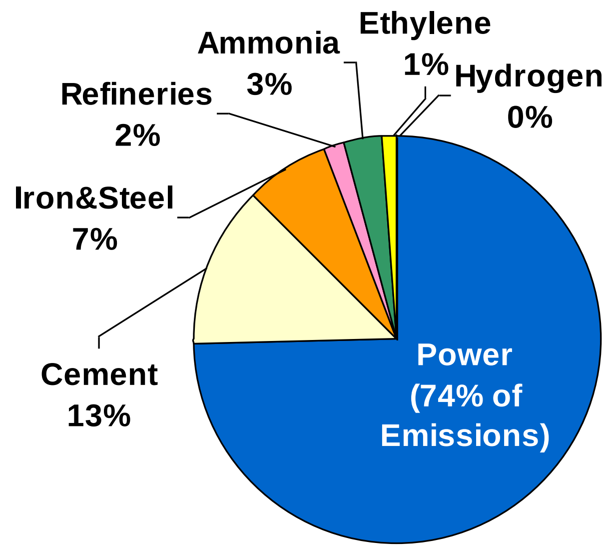


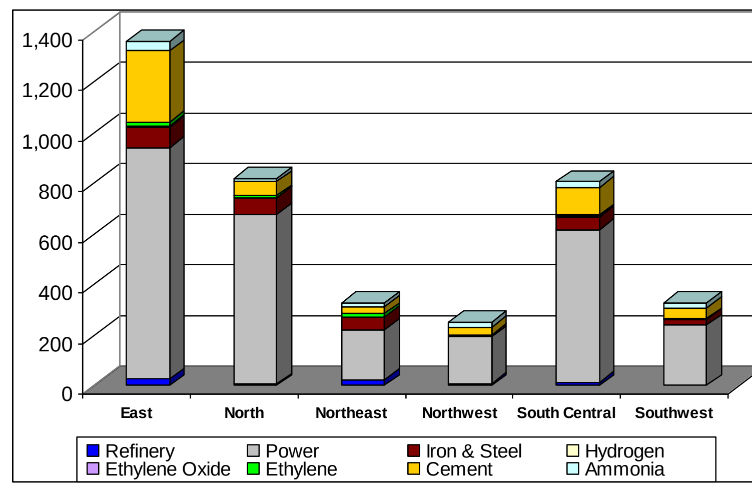


Renewable and nuclear energy development is remarkable, the share of which in primary energy mix keeps increasing, but still could not meet the new incremental demand for energy services in quite a long time.

Large Industrial CO_2 Point Sources & Distribution

- Power, Cement and Iron & Steel
- The East, North and South Central





Source: RT Dahowskia, X Li et al., A Preliminary Cost Curve Assessment of Carbon Dioxide Capture and Storage Potential in China , Energy Procedia 00 (2008) 2849-2856.

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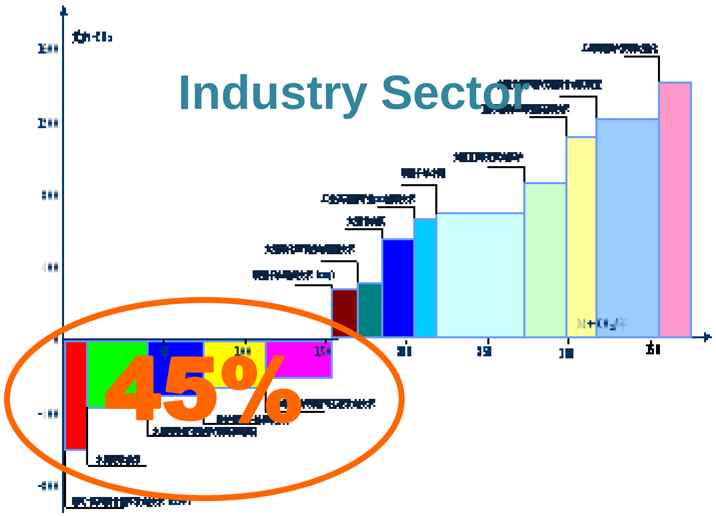
ROLE AND POTENTIAL OF CCUS IN CHINA

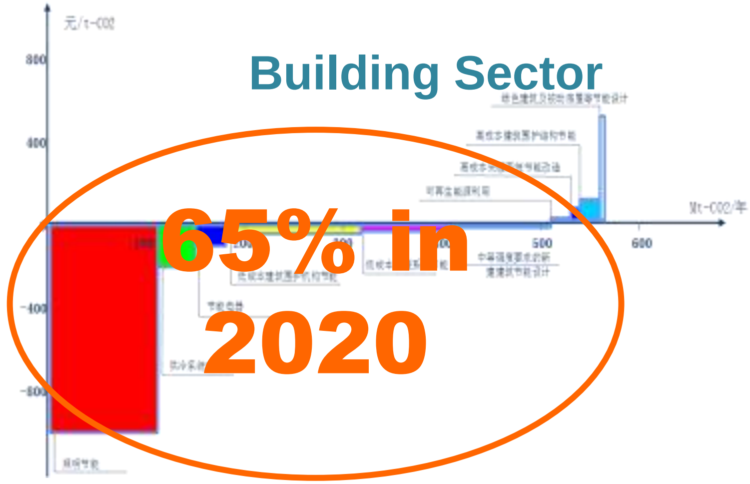
Normal mitigation technologies have great potential for CO2 reduction in China currently, and are cost effective.

- **Mitigation Potential**

	2020	2030	2050
Mitigation tech. in Industry, Transport and Building	2.2Gt	3.8Gt	5.0Gt
Non-Fossil Energy Tech.	1.5Gt	3.0Gt	5.3Gt

- **Mitigation Cost (big portion of negative cost)**

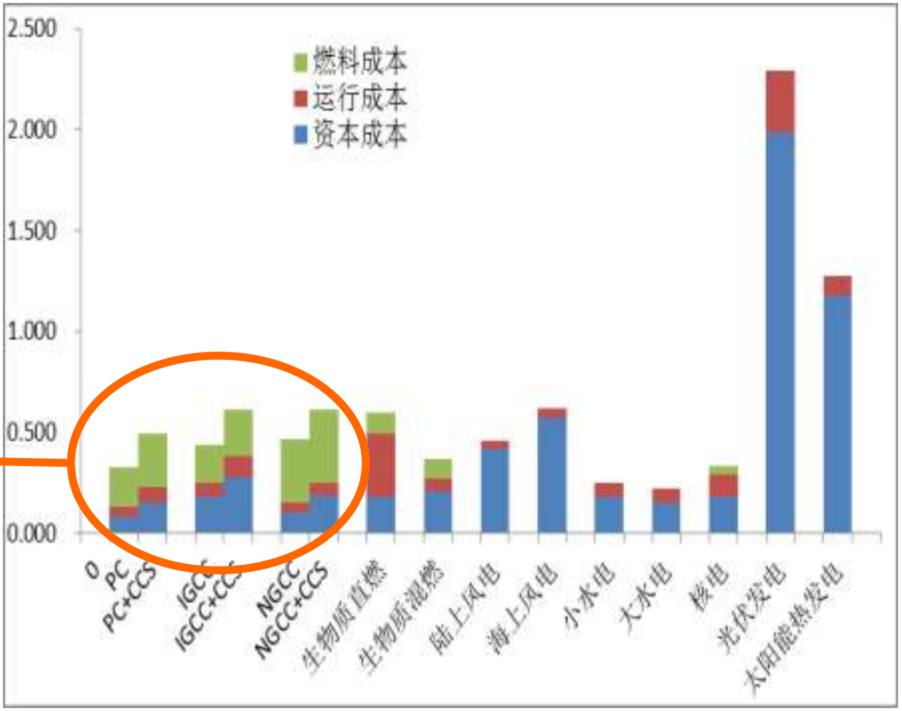




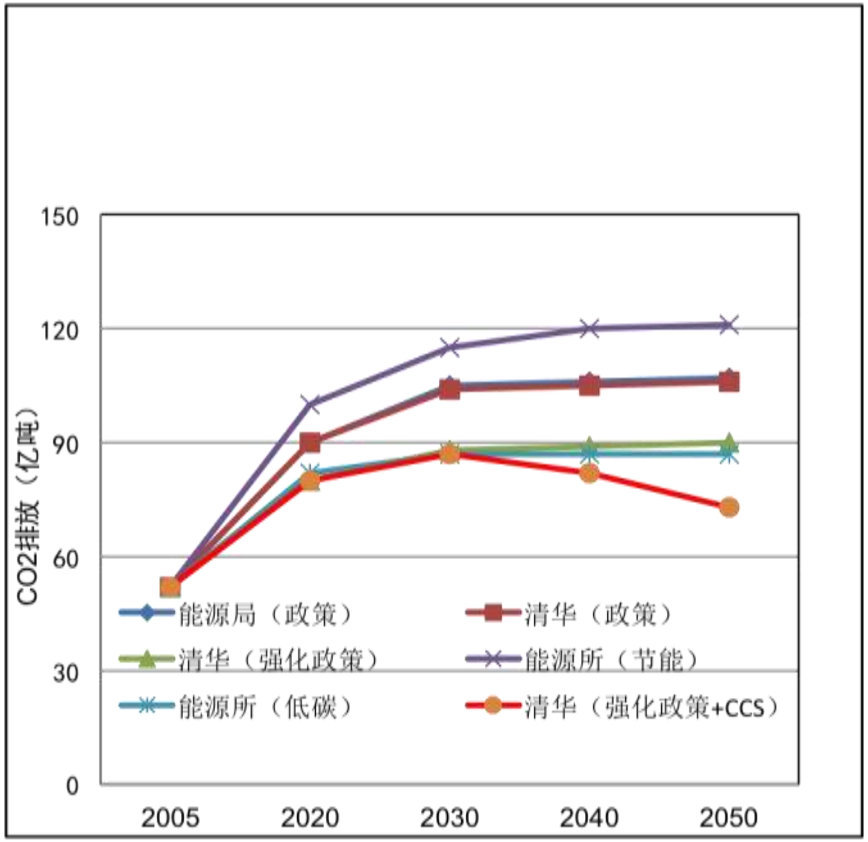
CCUS is not mature and is expensive

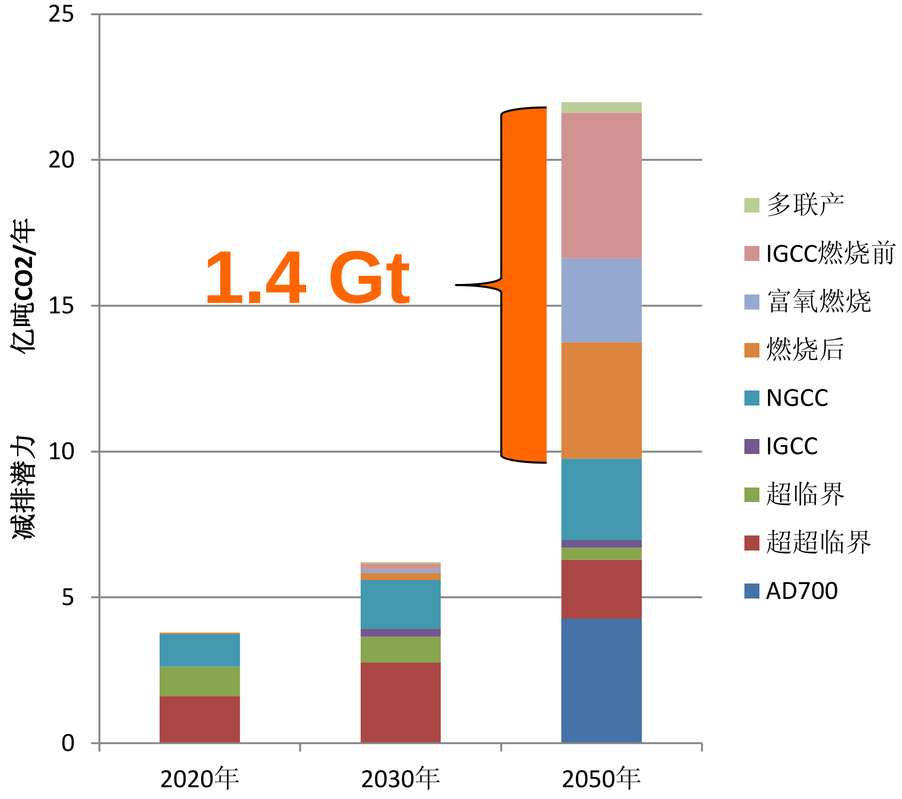
- **High costs**
- **High energy penalty**
- **High risk**

A big portion of fuel costs in total cost.



Scenario analysis suggests CCUS will play important role in mid- and long-term.





Theoretical Storage Capacity

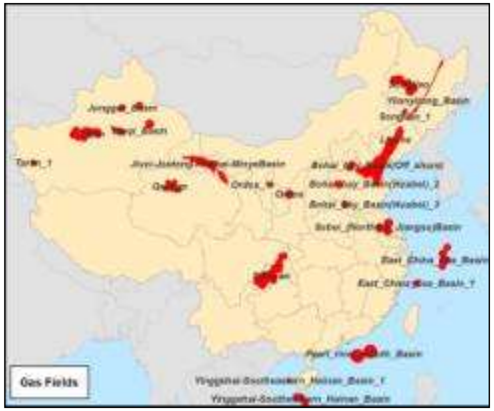
Saline Aquifer

- Examined 17 onshore basins and 10 offshore
- Applied specific storage volume method based on
- Capacity: **3.1Tt**CO_2
  - 2.3 GtCO_2 onshore
  - 0.8 GtCO_2 offshore

EOR

- Examined 29 onshore basins and 21 offshore
- Capacity **4.8Gt**CO_2
  - 4.6 GtCO_2 onshore
  - 0.2 GtCO_2 offshore
- Up to 7.0 BBO additional oil recovery

Depleted Gas Reservoirs



- Examined 23 onshore basins and 6 offshore
- Capacity **5.2 Gt**CO_2 storage potential
  - 4.3 GtCO_2 onshore
  - 0.9 GtCO_2 offshore

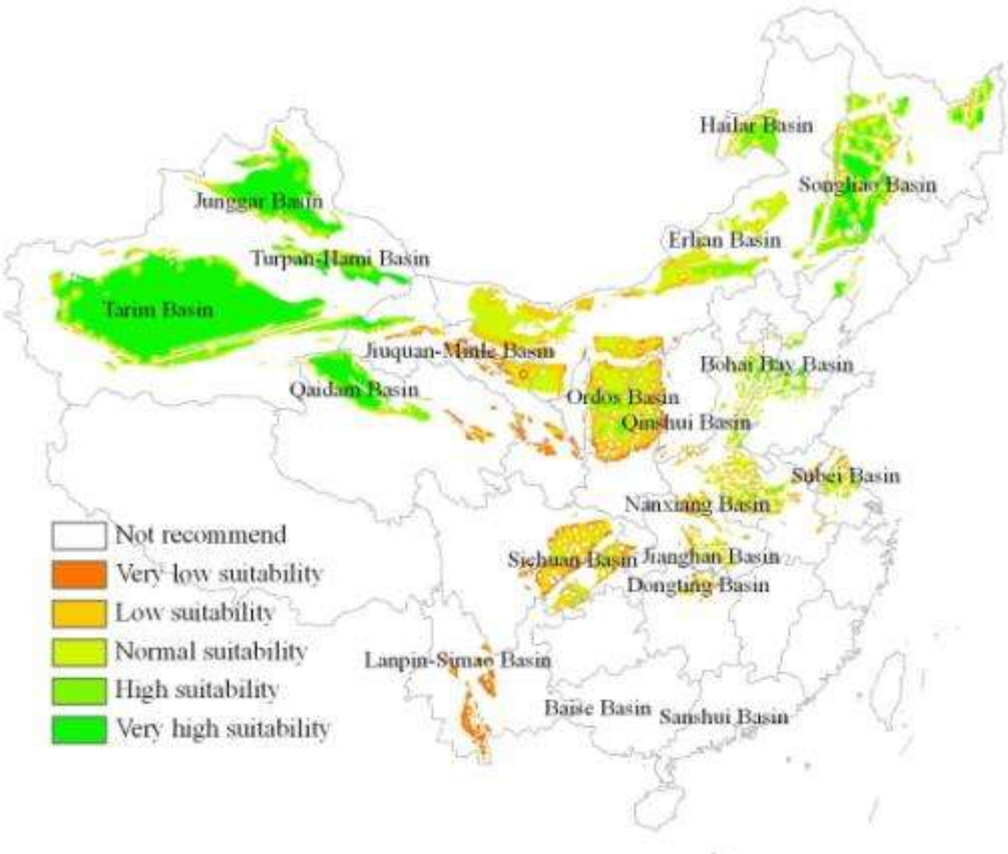
ECBM (600-1500m)

- 10% of OCIP for storage
- Examined 69 onshore coal-bearing regions
- **12.1Gt**CO_2 capacity
- 1.6 Tm^3 additional coal bed methane recovery

(Source: Li et al, 2007)

Ranking of potential storage sites

Criterion	Classes							weight
1st order	2nd order	Killer criterion	1	2	3	4	5	
storage capacity and injectivity (major economic factors)	Size of structure element (divided by faults)	<500 km²	<1000 km²	Small <5,000 km²	Medium <10,000 km²	Large <50,000 km²	Giant >50,000 km²	0.01
	Maximum depth	<1000m	Shallow (<1,500 m)		Intermediate (1,500 –3,000 m)		Deep (>3,000 m)	0.03
	Average permeability of storage formation	<1mD	1- 10mD	10-50mD	50-100mD	100-500mD	>1000mD	0.1
	(total, effective) porosity	<5%	5-10%	10~15%	15~20%	20~25%	>25%	0.02
	Fluid pressure		pressure ratio (> 1.2)		pressure ratio (1.0-1.2)		pressure ratio (<1.0)	0.01
	Injection thickness	<10m	10-20m	20-50m	50-100m	100-300m	>300m	0.08
	Reservoir failure (pressure build-up)		Pluvial and Alluvial facies		Fluvial facies		Lacustrine and paludal facies	0.02
	Primary seal formation		–		–		–	0.01
	Geothermal		Warm basin (>40? /km)		Moderate (20-40? /km)		Cold basin (<20? /km)	0.05
	Geology		Extensively faulted and		Moderately faulted and		Limited faulting	0.02



Methodology for site screening

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CCUS ACTIVITIES:
POLICY, R&D AND DEMO

Policies are getting into details gradually

- National Medium- and Long-Term Program for Science and Technology Development (2006-2020)
  by State Council, 2006
- China's scientific actions on climate change,
  by MOST, 2007
- 12th National Scientific and Technological Plan on Climate Change
  by MOST, May 2012
- Work plan for 12th 5-year National GHG Control
  by State Council, 2012
- S&T roadmap of China's CCUS development
  by MOST/ACCA21, 2011
- Special Plan for CCUS technology development
  by MOST, 2013

General statement

"to develop CO2 near zero emission technology"

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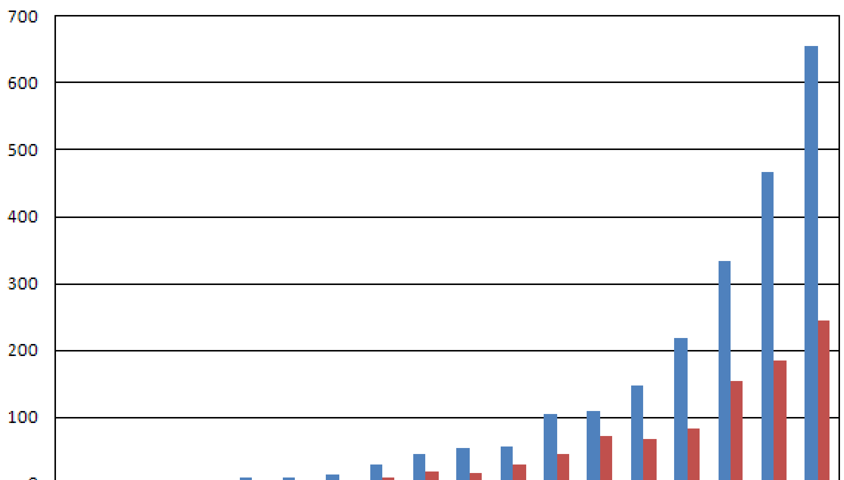
Detailed development measure

Targets, actions in capture, storage, utilization and storage, full-chain demo, etc

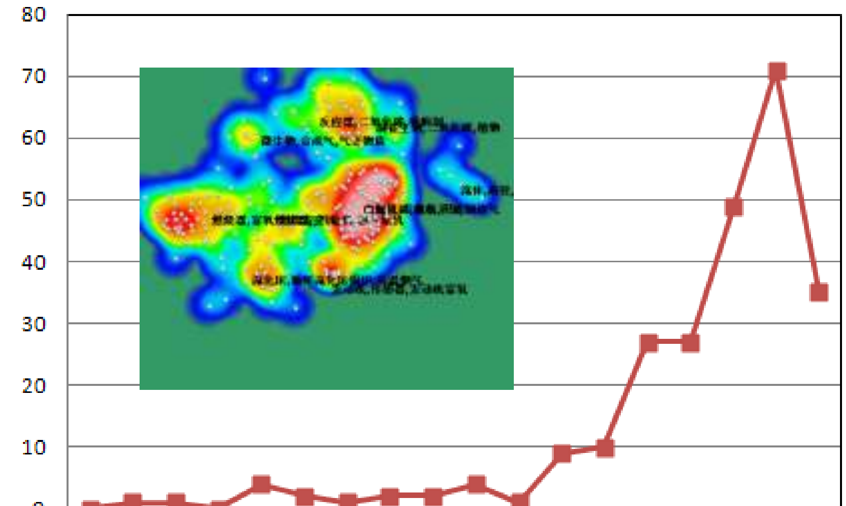
Trends of Paper & Patent on CCUS (1995-2012)

SCI & EI Papers



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
SCI	3	4	5	5	10	9	14	29	44	54	55	104	110	148	218	334	466	656
EI	1	0	3	4	0	4	0	9	18	16	29	46	72	67	83	153	185	245

Domestic Patents



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
申请量	0	1	1	0	4	2	1	2	2	4	1	9	10	27	27	49	71	35

CCUS Progress Summary: R&D

- **R&D Activities in the 11th FYP**

Project Title	Funding by	Duration	Type of projects
The Project of CCS–EOR, Utilization and Storage	National Key Basic Research 国家重点基础研究发展计划	2006-2010	Basic Research
Program of CO_2 Capture and Storage technology	National High- Tech R&D Program国家高技术研究计划	2008-2010	Technology R&D
The Key Tech Research Program on CCS-EOR and Storage	National High- Tech R&D Program国家高技术研究计划	2009-2011	
The Key Tech Research Program on CO_2-Algae-Biodiesel	National High- Tech R&D Program国家高技术研究计划	2009-2011	
CO_2- Safety Mining with CO_2 Gas Reservoirs and CO_2 Utilization Tech	National Major Special Project国家重大专项	2008-2010	R& D
Demonstration Project of Mining and Utilization Tech of Volcanic gas containing CO_2 in Songliao Basin	National Major Special Project国家重大专项	2008-2010	

CCUS Progress Summary: R&D

- ## R&D Activities in the 12th FYP

Name of Projects	Funding by	Duration	Type of projects
Demonstration Project of CO2 capture and geological storage in Coal Liquification Plant, China Shenhua Group	National Key Technology R&D Programme国家重点基础研究发展计划	2011-2014	Technology R&D
The Key Tech Research Project of CO2 Emission Reducing on Iron-Steel Sector	National Key Technology R&D Programme国家重点基础研究发展计划	2011-2014	Technology R&D
Research and Demostration Program of IGCC +CO2 Caputure, Utilization and Storage	National Key Technology R&D Programme国家重点基础研究发展计划	2011-2013	
CO2 Storage Capacity Assessment and Demonstration in China	China Geological Survey	2011-2014	
The Program of CCS –EOR, Utilization and Storage	National Key Basic Research 国家重点基础研究发展计划	2011-2015	Basic Research

CCUS Progress Summary: Enterprise Action

Project Title	Scale	Capture Tech	Storage/ Utilization	Status
The pilot project of CO2 Capture, Huaneng Beijing Gaobeidian Thermal Power Plant	Capture Capacity:3,000 T/Y	Post-Combustion	Food Use	Operated in 2008
Demonstration Project of CO2 capture and storage in Coal Liquification Plant, China Shenhua Group	Capture Capacity:100,000 T/Y Storage Capacity: 100,000 T/Y	Coal liquefaction	Saline Aquifer	operated in 2011
Demonstration Project of CO2 capture, Storage and Utilization in IGCC Plant Greengen of Huaneng	Capture Capacity:60,000--100,000 T/Year	Pre-Combustion	EOR	Launched in 2011
Small Scale Demonstration Project on CO2 Capture and EOR in Shengli Oil Field, Sinopec	Capture/Utilization:40,000T/Y	Post-Combustion	EOR	Operated in 2010
Demonstration Project of CO2 capture, Shanghai Shidongkou Power Plant, Huaneng	Capture Capacity:120,000 T/Y	Post-Combustion	Food/ Industrial	Operated since 2010
Demonstration project of Carbon Capture, Shuanghuai Power Plant, China Power Investment	Capture Capacity:10,000 T/Y	Post-Combustion	Food/ Manufacture	Operated in 2010
Pilot Plant of CO2 capture in Lianyungang City, CAS	Capture Capacity:30,000 T/Y	Pre-Combustio	N/A	Operated in 2011

Demonstration

China Power Investment,
中国电力投资集团
10,000t/a capture pilot

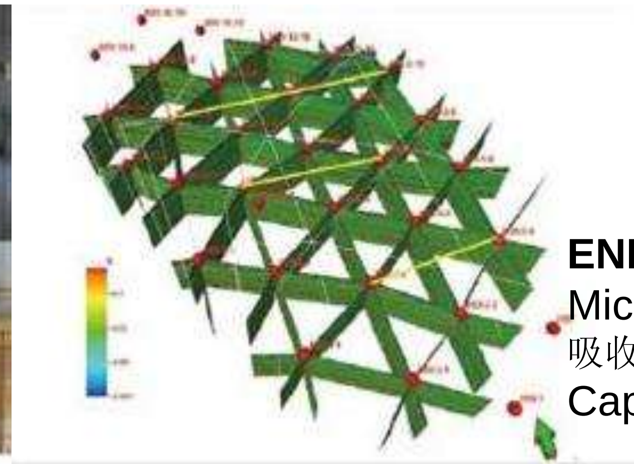
Huazhong University of S&T (HUST)
35MWt Oxy-fuel pilot,

Huaneng Group
Gaobeidian & Shidongkou Power Plant
Demo， 燃烧后捕集+食品利用

Demonstration

PetroChina

CO_2 EOR ,Jilin Oilfield，天然气分离CO2



ENN Group

Micro algae Bio-fuel Pilot

吸收CO2生产生物柴油

Capacity: 20,000t/y

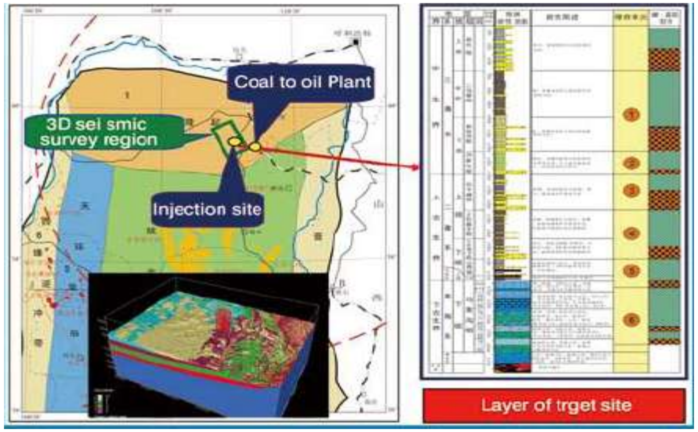
China United Coalbed Methane

ECBM Pilot Project

Qinshui, Shanxi

Demonstration

SINOPEC, Shengli Oil Field
CO_2-EOR, 1Mt CO_2/year



Shenhua Group
Erdos, 100,000t/a

CCUS Progress Summary: International Collaboration

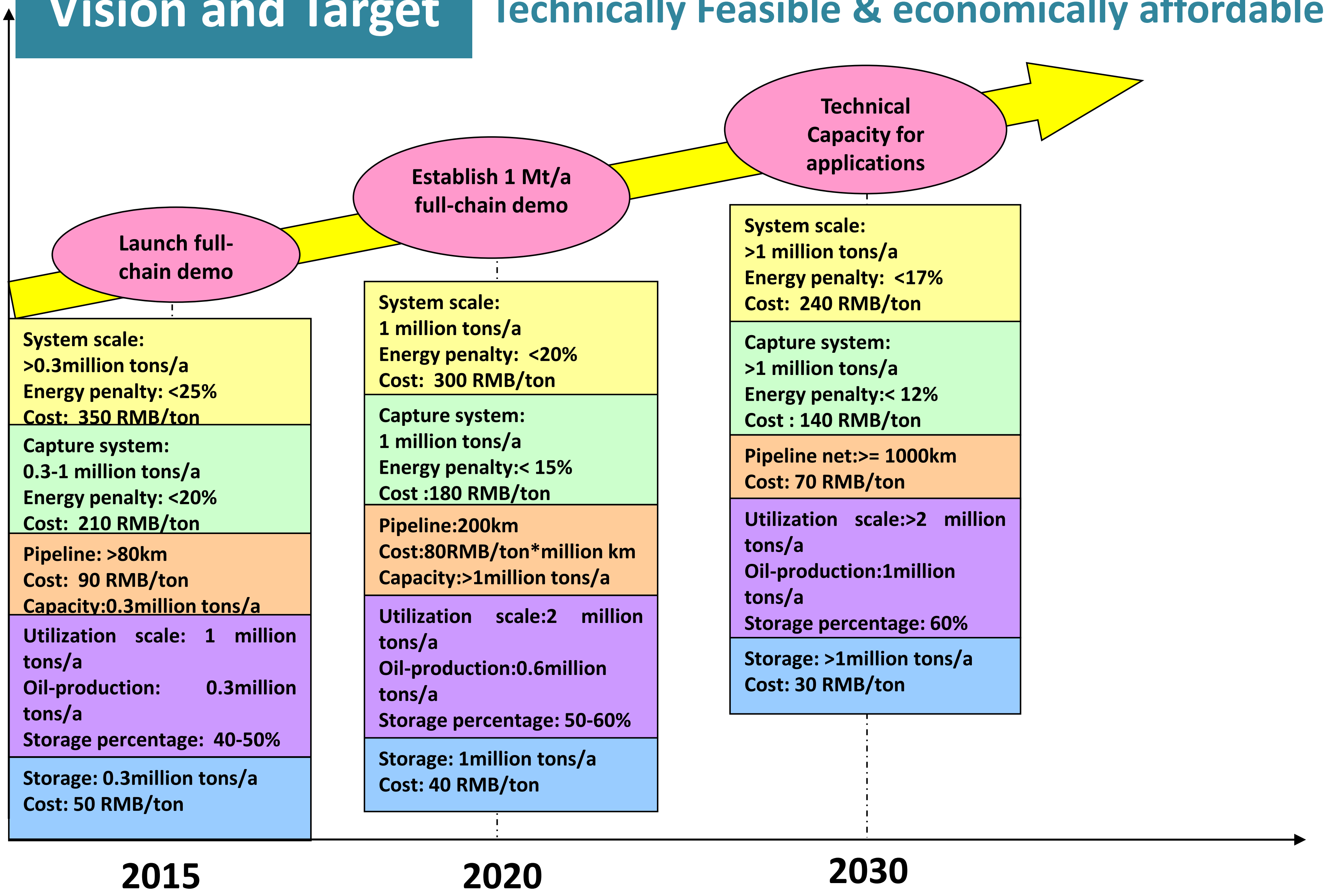
Project	Partner	Duration
China-Australia Geological Storage of CO2 (CAGS)	RET, GA	2012-2014
China-EU NZEC Cooperation	UK, EU, Norway	2007-2009
China-EU Carbon Capture and Storage Cooperation（COACH）	EU	2007-2009
Sino-Italy CCS Technology Cooperation Project(SICCS)	ENEL	2010-2012
China-US Clean energy Research Center	MOST, NEA, DOE	2010-2015
CSLF Capacity Building Projects	CSLF	2012-
MOST-IEA Cooperation on CCUS	IEA	2012-

Technology Roadmap Study on Carbon Capture, Utilization and Storage in China

- 为促进中国CCUS技术发展，组织有关单位和专家共同编写中国CO2捕集、利用与封存技术路线图报告。目的是梳理全球和中国CCUS技术发展现状，识别其未来重点发展方向和路线，探索提出CCUS技术发展的相关政策、监管制度等。
- 路线图研究提出我国CCUS技术发展的愿景，为应对气候变化提供技术可行和经济可承受在技术选择，促进我国经济、社会的可持续发展。

Vision and Target

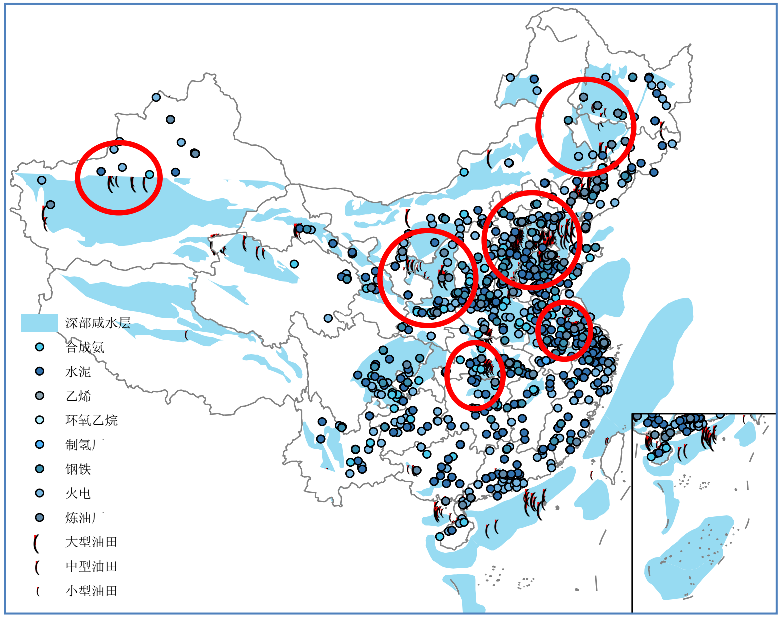
Technically Feasible & economically affordable



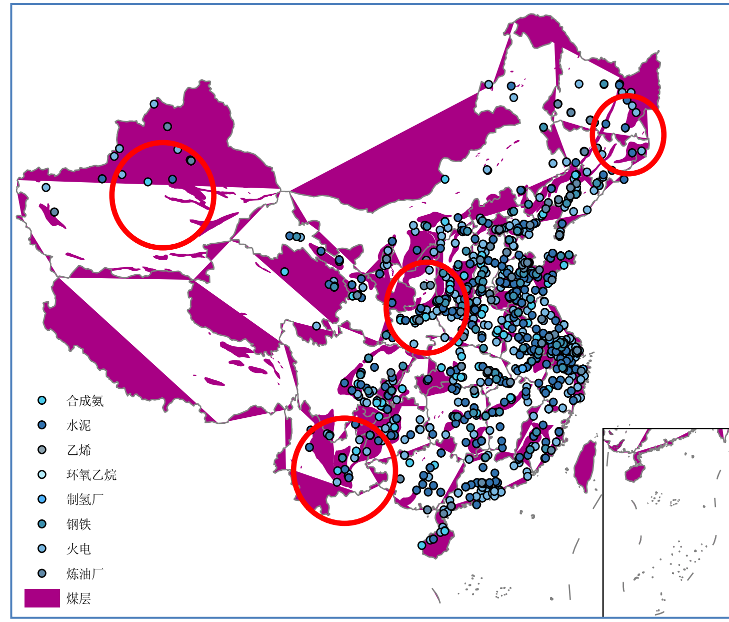
Vision and Target　Technically Feasible & economically affordable

- 到2015年：突破低能耗捕集关键技术，建立封存安全保障研发体系，开展全流程中试及示范，实现系统规模30万吨/年以上、能耗增加25%以内、成本350元/吨左右。
- 到2020年：建立封存安全保障体系，建成百万吨级全流程CCUS技术示范，实现能耗增加额0%以内、成本300元/吨左右。
- 到2030年，具备CCUS全流程项目设计、建设和运营的产业化技术能力，实现系统规模100万吨/年以上、能耗增加的17%以内、成本240元/吨以内。
- 路线图识别出CCUS各技术环节基础研究、技术研发和示范的优先技术方向，包括捕集技术、运输技术、利用技术和地质封存技术。

CCUS Technology Roadmap: Full Chain Demo



EOR and Depleted Oil reservoir Storage Opportunities



ECBM Storage Opportunities

- 鄂尔多斯盆地、松辽、苏北、渤海湾、准葛尔
- 化工、燃煤电厂、钢铁高浓度排放源

- 沁水盆地、云贵滇区域、鄂尔多斯、塔里木
- 化工、燃煤电厂

CCUS Technology Roadmap: Full Chain Demo

考虑技术组合的减排潜力、减排成本（经济性）、减排风险（安全性）和发展潜力等指标，筛选出不同的全流程技术组合示范：

- The nationwide utilization and storage capacity assessment shall be conducted as soon as possible in order to better understand the CCUS potential in China. 尽早开展全国范围的利用和封存潜力评估，掌握其应用潜力。

- The first full-chain technology demonstration shall be launched for those high-concentration emission sources (such as coal chemical) due to the low capture cost; coal-fired power plant shall also carry on full-chain technology demonstration timely because their emissions are high in volume with multi-point sources; on the aspect of technological options shall be balanced. 煤化工高浓度排放源捕集成本低，应率先开展全流程技术示范；燃煤电厂排放量大、点源多，及时开展全流程示范，技术方向选择应均衡。

- Considering the maturity of CO2-EOR technology and large potential for on-land saline aquifer storage, the full-chain technology demonstration for CO2-EOR and land saline aquifer storage shall be prioritized. EOR技术成熟度高、陆上咸水层封存潜力大，应优先部署。

CCUS Technology Roadmap: Full Chain Demo

- The demonstrations and scale-up on the integration of CO2-EOR and on-land saline aquifer with multiple capture options shall actively but steadily take forward with an aim to operate **demonstration project at 1 million tons/a and above by 2030**. 积极稳妥推进EOR、陆上咸水层与多种捕集方式的集成示范，逐步在2030年形成的1Mt/a及以上规模经营的示范工程。

- The research on **innovative and cost-effective CO2 utilization technologies shall be enhanced**, and initial demonstration can be launched jointly with other integrated systems. 加强创新型低成本高效CO2利用技术的研究，早期技术示范可考虑与其他集成系统结合开展。

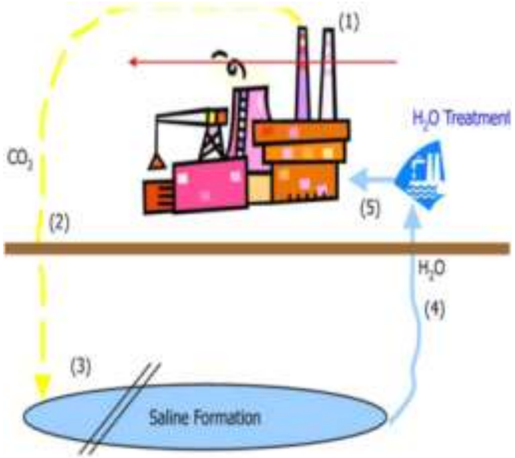
- The full-chain demonstration projects witness **more opportunities in Ordos Basin, Songliao Basin, Bohai Bay Basin and the Junggar Basin**, while the specific demonstration project shall take the cost, safety, environment and other factors into consideration. 全流程示范项目在多个盆地有较多机会，具体示范项目的确定应综合考虑成本、安全、环境等因素。

Current Work

- **An Assessment Report on CO2 Utilization Technologies in China is published this summer, led by ACCA21.**

对CO2利用技术发展定位与意义、潜力与效益、现状与挑战，以及我国早期机会和部署建议等进行系统评估

  – Enhanced Energy Recovery
  – Enhanced Resources Recovery
  – Chemicals production
  – Bio & Agriculture production
  – Products from industrial wastes



- **To update CCUS Roadmap with new recognition on Utilization technologies.**

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CONCLUSIONS

- CCUS is important to China
  - In the long term, an important technical option for CO_2 reduction.
  - In the short term, could serve as important tool to solve energy and resource issues, e.g. enhanced exploration of shale gas, geothermal, saline water and liquid mineral.
- Besides technology R&D, enabling policies are essential for the take off of CCUS.
- The nature of CCUS technology calls for enhanced International collaboration.

Thank you!

For More Information, Please Visit:

www.ccusChina.org.cn