*CAGS Workshop II, Shanghai, China, 12 May，2014*

# Status of CCUS in China

The Administrative Centre for China's Agenda 21

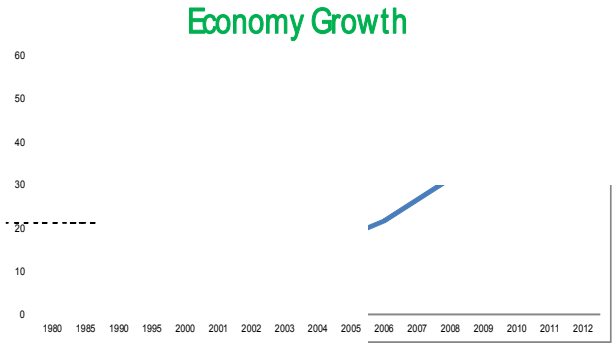
# Contents

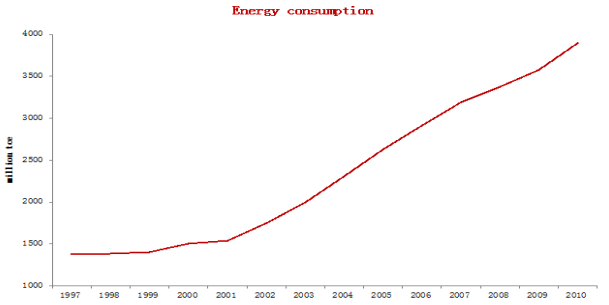
# 1

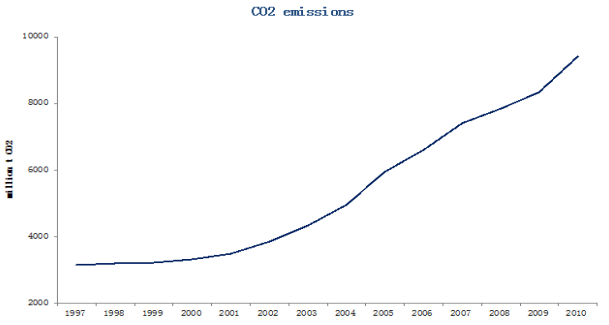
# Overview of Economy, Energy

# Economy, Energy and Emissions in China

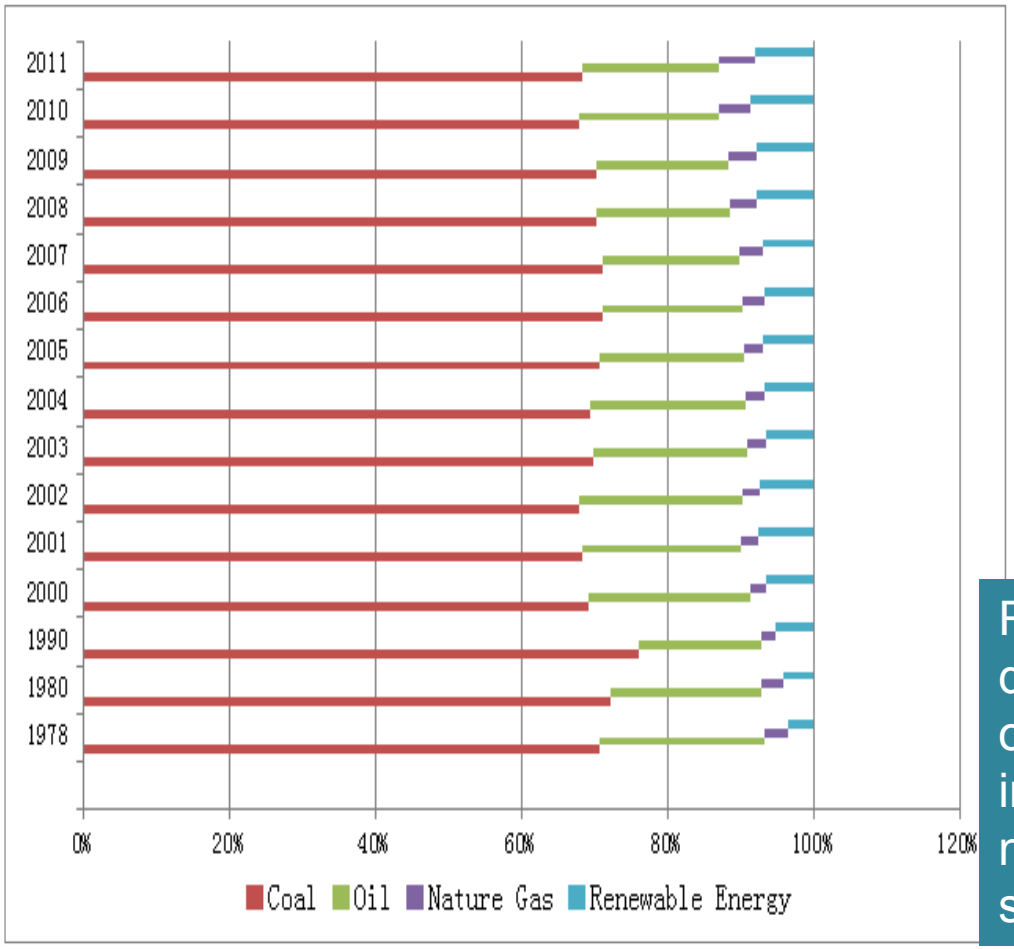
- **During the period of rapid industrialization and urbanization, the GDP from high energy-intensive industries accounted for a big proportion in China.**
- **The energy demand increases by 200 million tce annually in the recent years.**
- **From 1990 to 2010, CO2 intensity declined by 57%, that is 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-**

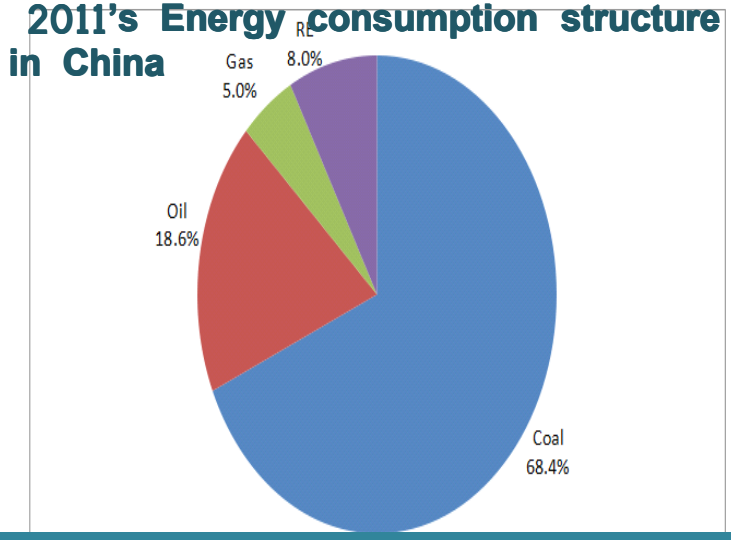


# Coal accounts for around 69% of Primary Energy Consumption in the past 30 years.

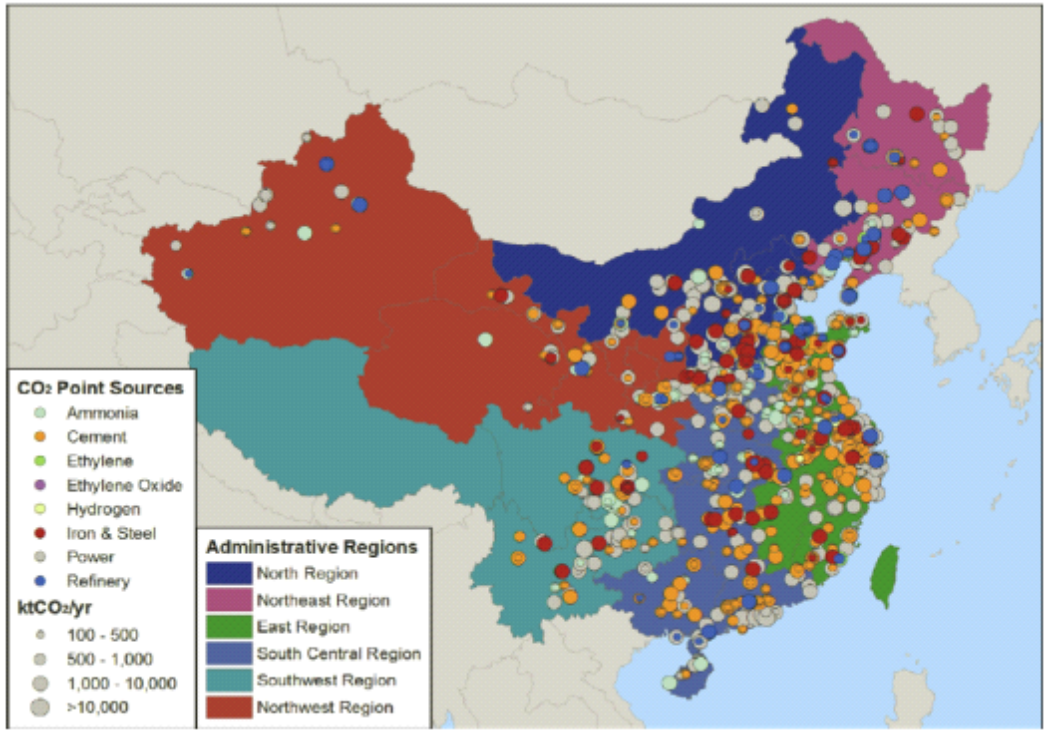


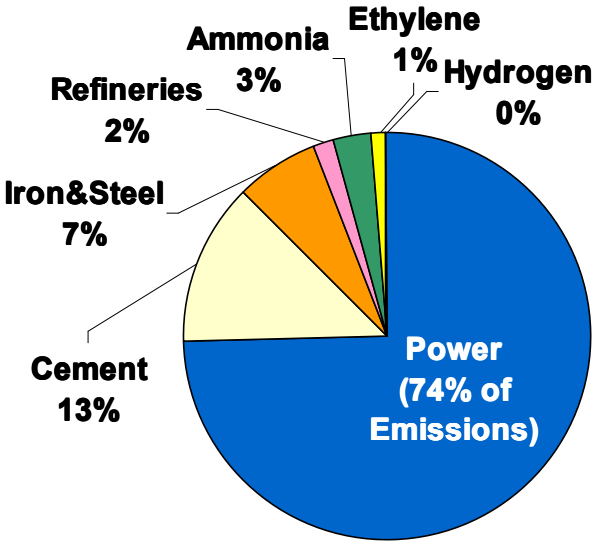



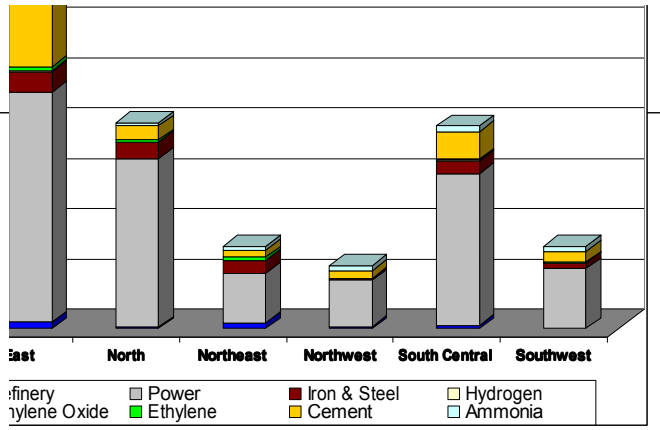

Renewable and nuclear energy development is remarkable, the share of which in primary energy mix keeps increasing, but still could not meet the new incremental demand for energy services in quite a long time.

# 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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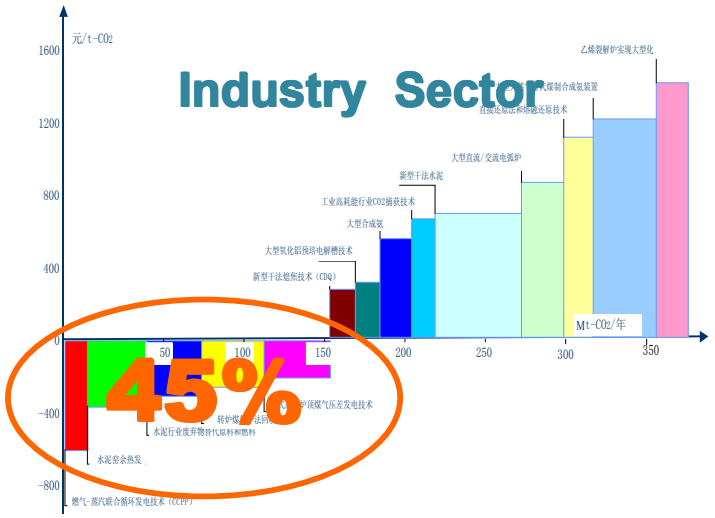
# role and Potential of ccus in china

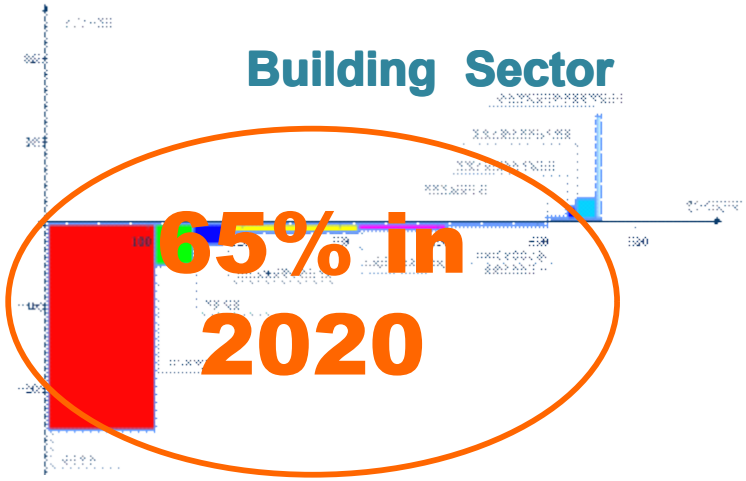
# Normal mitigation technologies have great potential for CO2 reduction in China currently, and are cost effective.

- **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)**

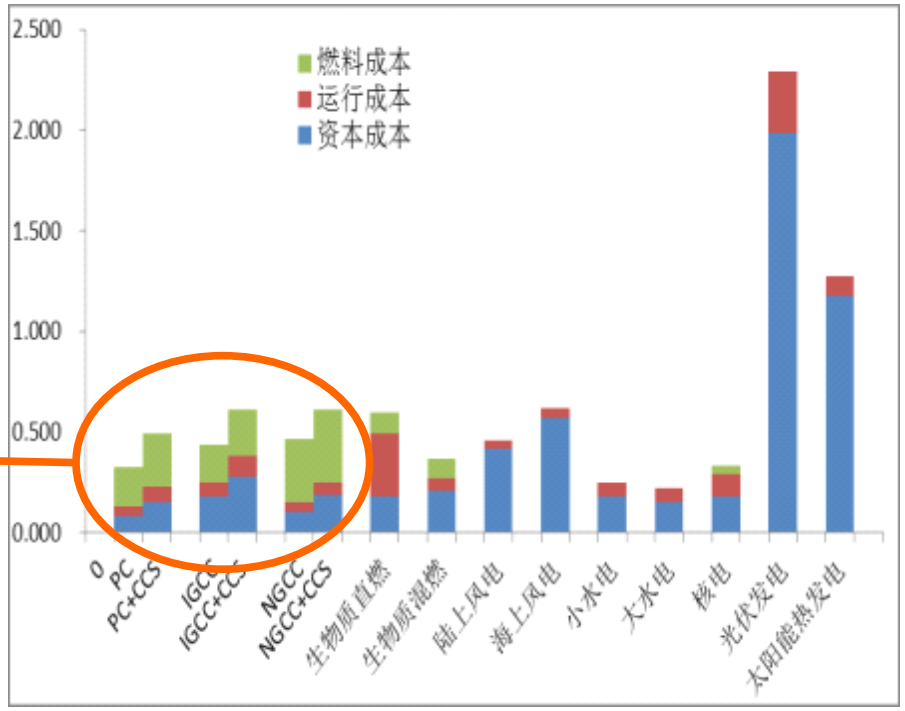


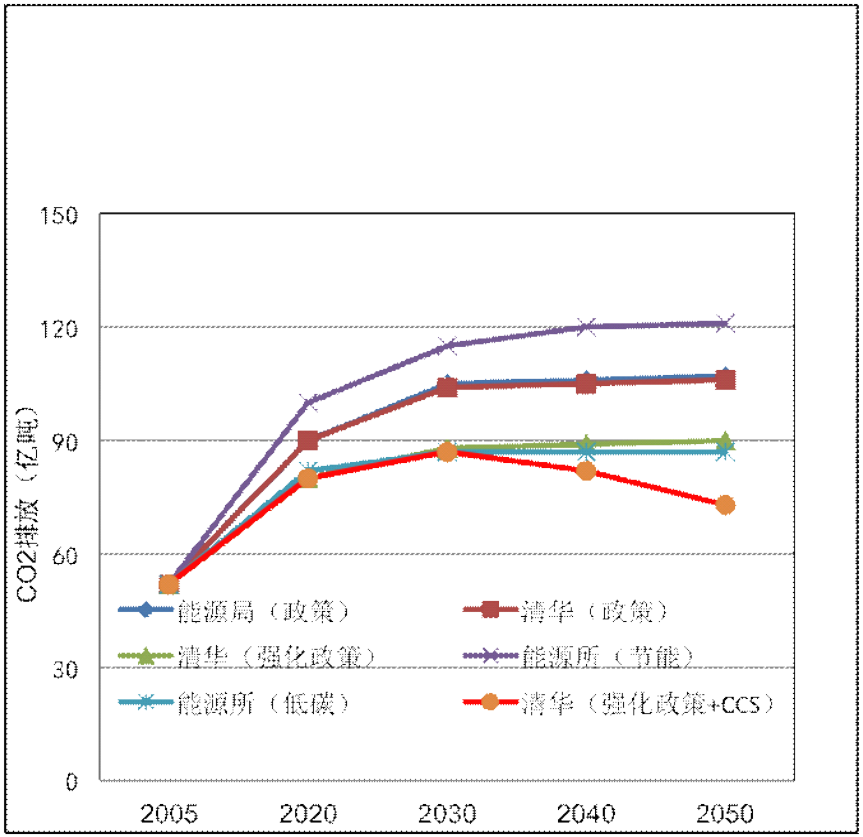
# CCUS is not mature and is expensive

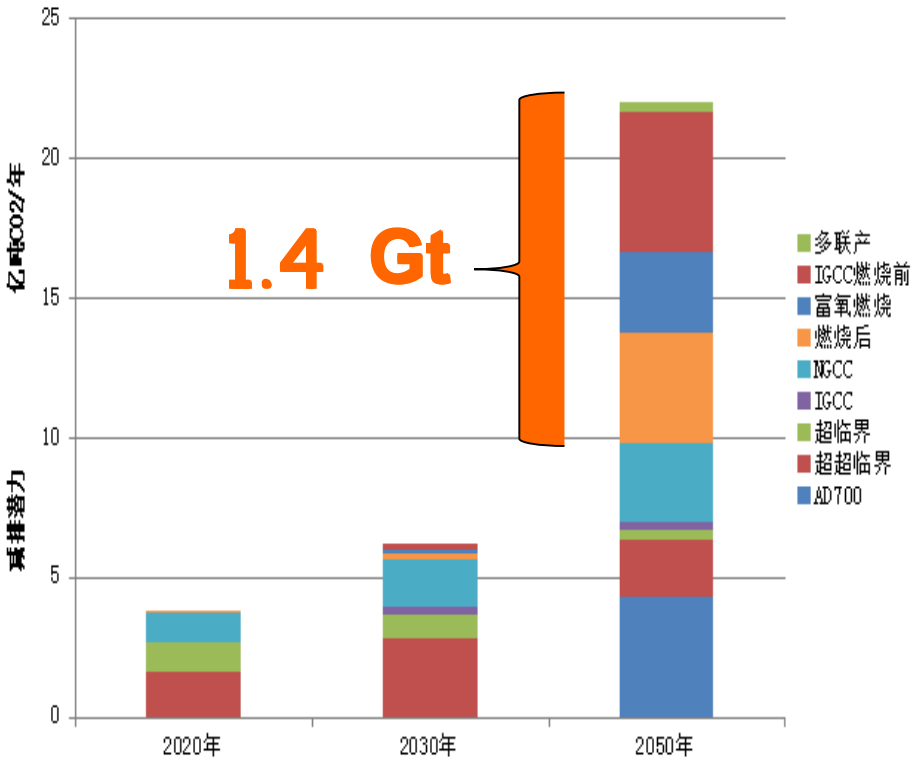
- High costs
- High energy penalty
- High risk

**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)

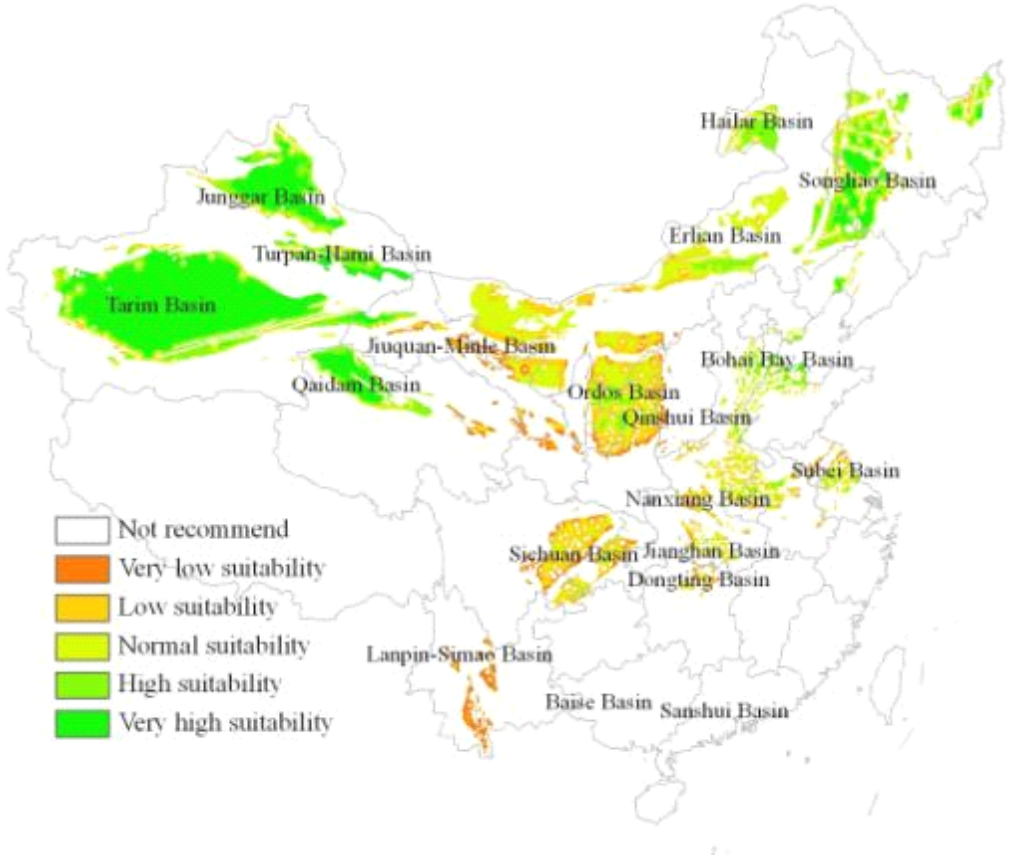

- 10% of OCIP for storage
- Examined 69 onshore coal-bearing regions
- **12.1Gt**$CO_2$ capacity
- 1.6 $Tm^3$ additional coal bed methane recovery

(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) | <200 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 fractured | | Moderately faulted and fractured | | Limited faulting | 0.02 |
| | Active faults | <10km | 10-20km | | 20-40km | | >40km | 0.06 |
| | maturity | | | | | | | |
| | Sedimentary facies | | Pluvial and Alluvial | | Fluvial | | Lacustrine and paludal | 0.03 |
| | Primary seal formation | | seal by different lithology | | regional seal formation | | Basin scale seal formatin | 0.03 |
| | Buffer formations | | Pluvial and Alluvial | | Fluvial | | Lacustrine | 0.01 |

## 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**

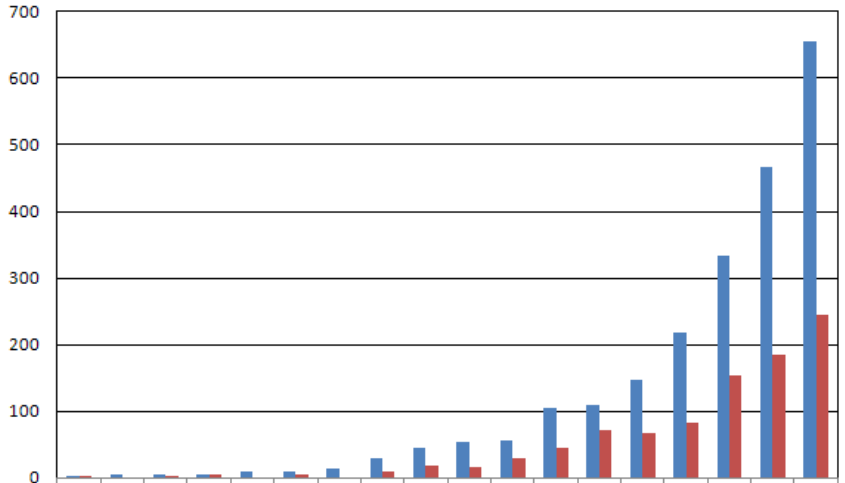
*"to develop CO2 near zero emission technology"*

**Detailed development measure**

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

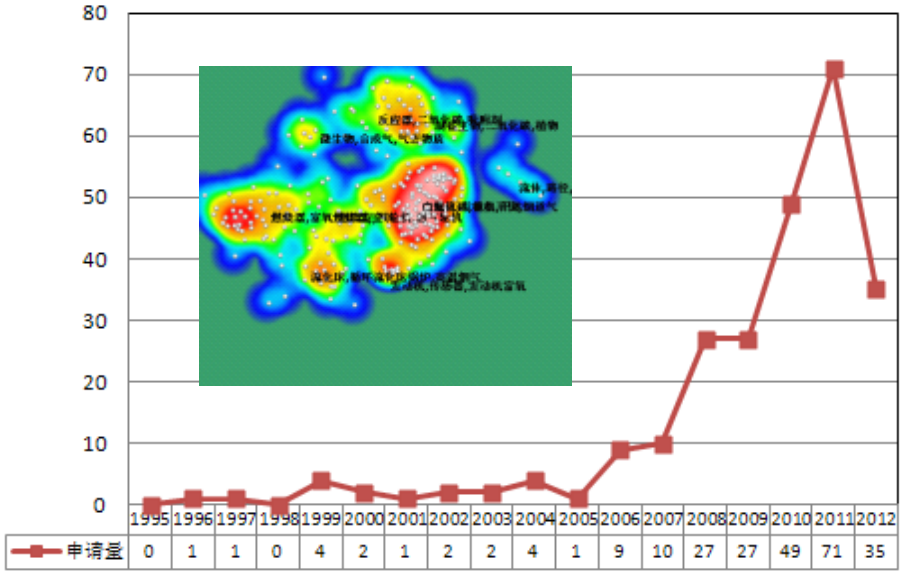
# Trends of Paper & Patent on CCUS (1995-2012)

## 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 | 973 | 2006-2010 | Basic Research |
| Program of CO2 Capture and Storage technology | 863 | 2008-2010 | Technology R&D |
| The Key Tech Research Program on CCS-EOR and Storage | 863 | 2009-2011 | |
| The Key Tech Research Program on CO2-Algae-Biodiesel | 863 | 2009-2011 | |
| CO2- Safety Mining with CO2 Gas Reservoirs and CO2 Utilization Tech | National Major Special Project | 2008-2010 | R& D |
| Demonstration Project of Mining and Utilization Tech of Volcanic gas containing CO2 in Songliao Basin | National Major Special Project | 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 | 2011-2014 | Technology R&D |
| The Key Tech Research Project of CO2 Emission Reducing on Iron-Steel Sector | National Key Technology R&D Programme | 2011-2014 | Technology R&D |
| Research and Demostration Program of IGCC +CO2 Caputure, Utilization and Storage | National Key Technology R&D Programme | 2011-2013 | |
| CO2 Storage Capacity Assessment and Demonstration in China | China Geological Survey | 2011-2014 | |
| The Program of CCS – EOR, Utilization and Storage | 973 | 2011-2015 | Basic Research |

# CCUS Progress Summary: Enterprise Action

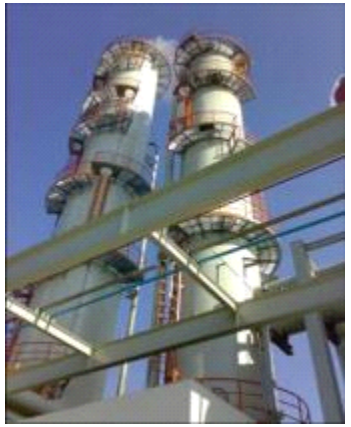
| Project Title | Scale | Capture Tech | Storage/ Utilization | Status |
|---|---|---|---|---|
| The pilot project of CO2 Capture, Huaneng Beijing Gaobeidian Thermal Power Plant | Capture Capacity:3,000 T/Y | Post-Combustion | Food Use | Operated in 2008 |
| Demonstration Project of CO2 capture and storage in Coal Liquification Plant, China Shenhua Group | Capture Capacity:100,000 T/Y<br>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**,
10,000t/a capture pilot

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

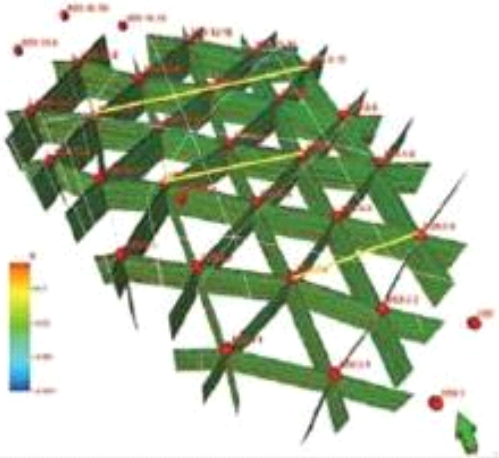
**Huaneng Group**
Gaobeidian & Shidongkou Power Plant Demo



# Demonstration

**PetroChina**

$CO_2$ EOR ,Jilin Oilfield



**ENN Group**

Micro algae Bio-fuel Pilot

Capacity: 20,000t/y

**China United Coalbed Methane**

ECBM Pilot Project

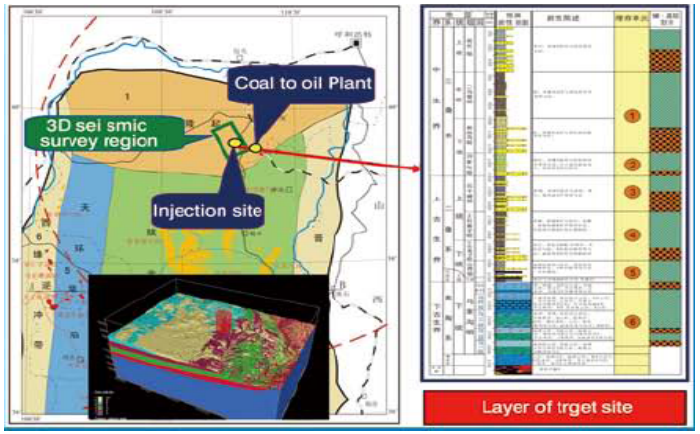
Qinshui, Shanxi

CUCBM $CO_2$-ECBM Well Site

CUCBM $CO_2$-ECBM Well Site

# Demonstration

**SINOPEC**, Shengli Oil Field
CO2-EOR, 1Mt CO2/year



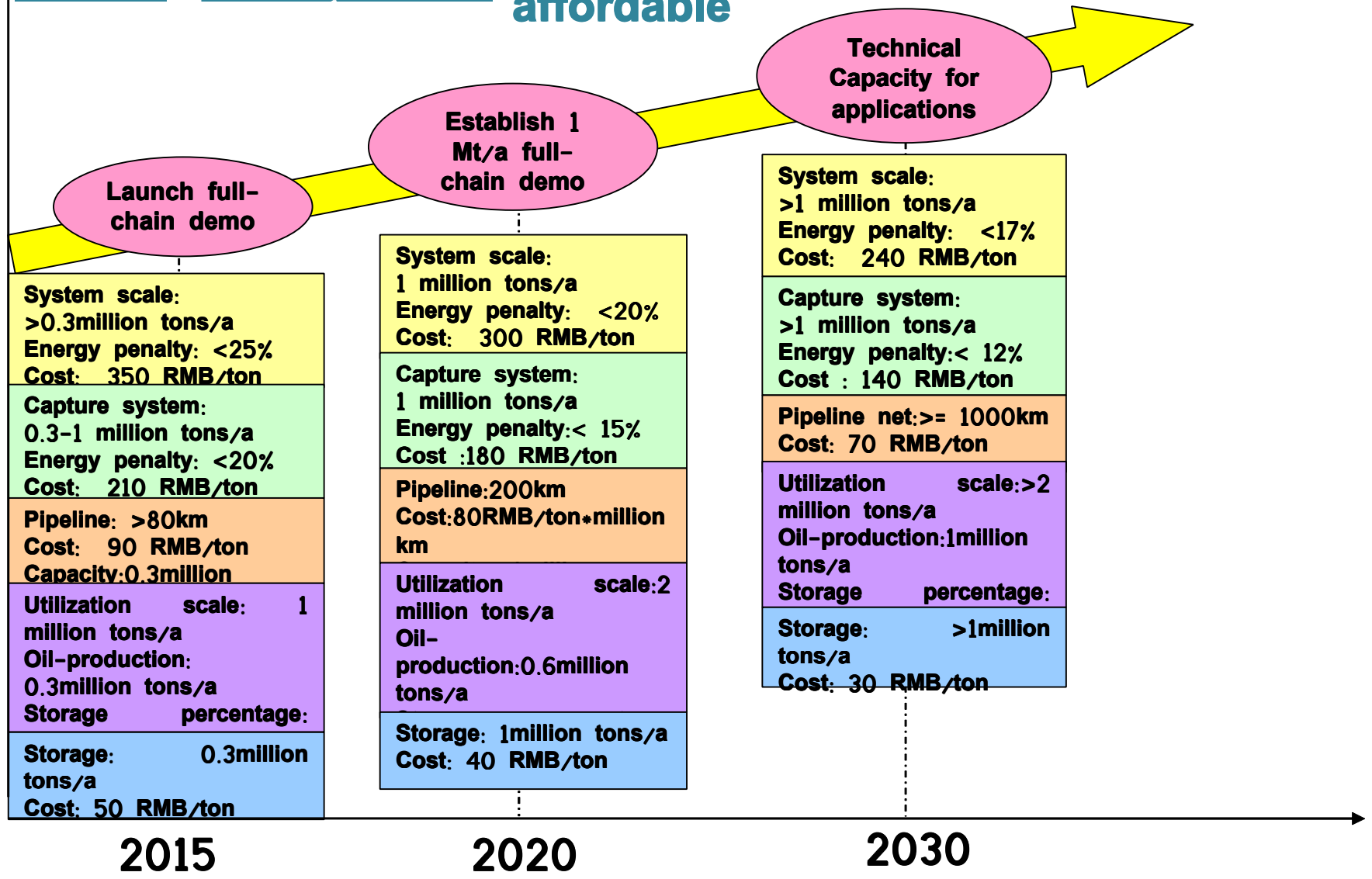

**Shenhua Group**
Erdos,
300,000t/a

# CCUS Progress Summary: International Collaboration

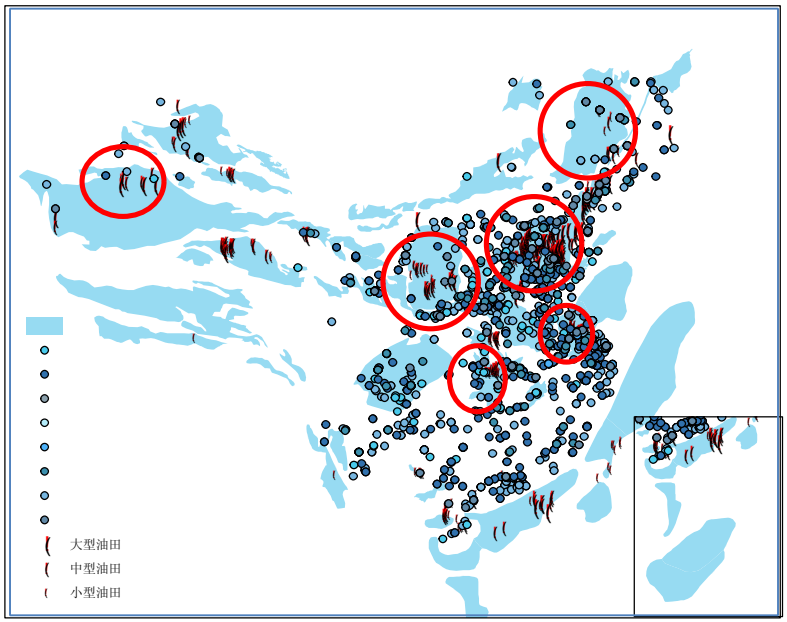
| Project | Partner | Duration |
|---|---|---|
| China-Australia Geological Storage of CO2 (CAGS) | DoI, GA | 2012-2014 |
| China-EU NZEC Cooperation | UK, EU, Norway | 2007-2009 |
| China-EU Carbon Capture and Storage Cooperation（COACH） | EU | 2007-2009 |
| Sino-Italy CCS Technology Cooperation Project(SICCS) | 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- |

# Vision and

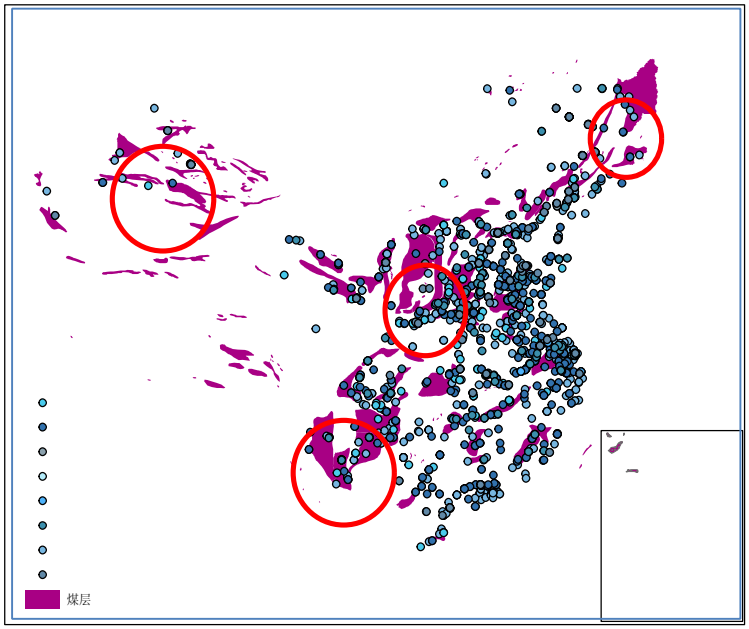
## Technically Feasible & economically affordable



# CCUS Technology Roadmap: Full Chain Demo



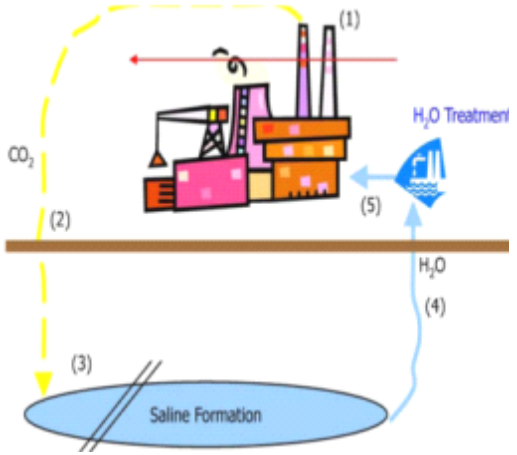

**EOR and Depleted Oil reservoir Storage Opportunities**




**ECBM Storage Opportunities**

# Current Work

- **An Assessment Report on CO2 Utilization Technologies in China will be published soon, led by ACCA21.**
  - 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.**

# 4

# 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**