Current Status and Development of CO_2 Geological Utilization and Storage (CGUS) in China

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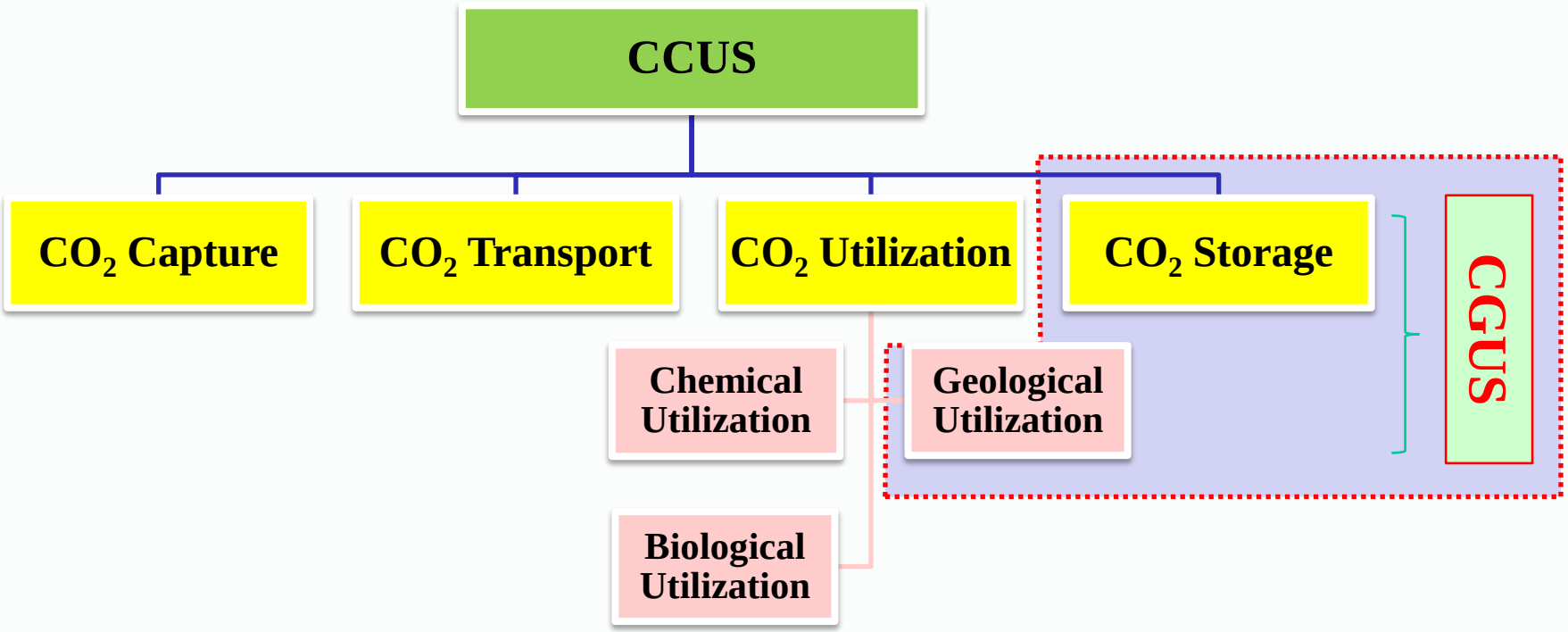
- Storage Capacity
- Demonstration Projects
- Expected Progress and Contribution
- Challenges

CCUS and CGUS



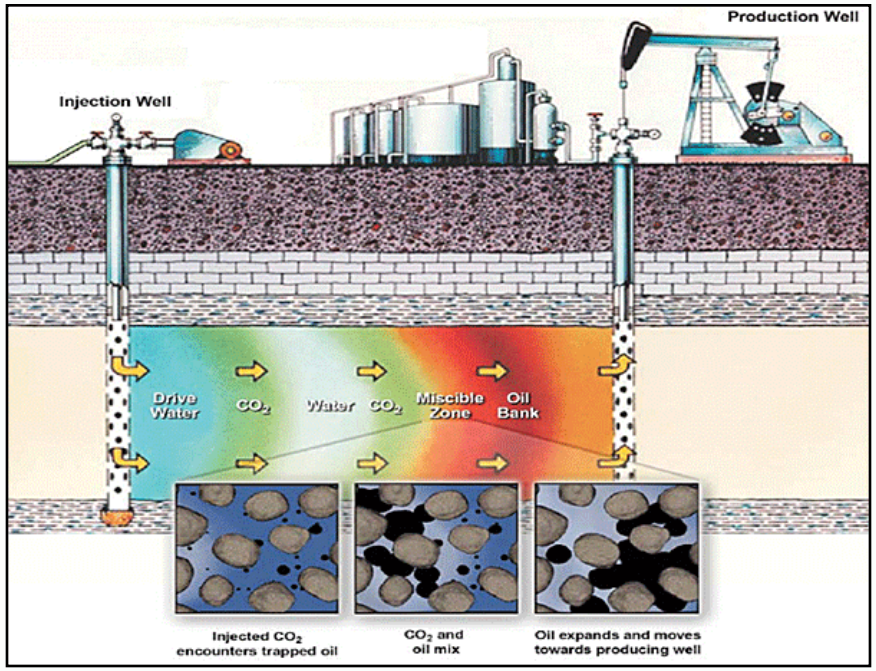
Introduction of CGUS

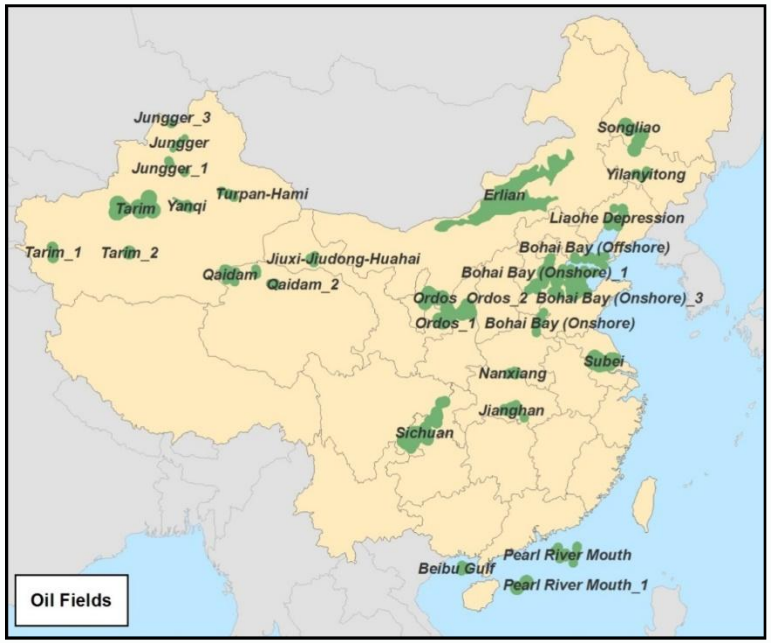
Application Fields	Technology Categories
Energy Resources	• Enhanced Oil Recovery, CO_2-EOR
	• Enhanced Coalbed Methane, CO_2-ECBM
	• Enhanced Gas Recovery, CO_2-EGR
	• Enhanced Shale Gas Recovery, CO_2-ESGR
	• Enhanced Geothermal Systems, CO_2-EGS
Mineral Resources	• Enhanced uranium leaching，CO_2-EUL
	• Enhanced water recovery，CO_2-EWR
Geological Storage	• Saline Aquifer; Depleted Hydrocarbon Fields

Introduction of CGUS

CO_2-EOR and storage capacity

(Li et al., 2009; Shen etal., 2010; Peng, 2013)





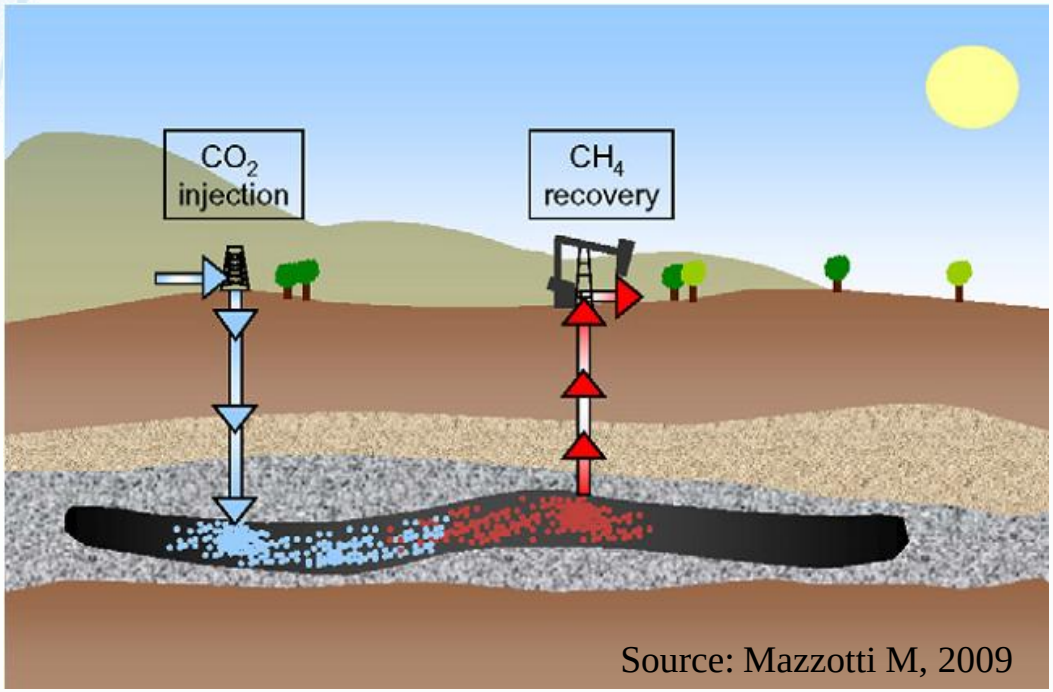
Source: http://caccscoalition.org/files/2010/06/CSSwtihEORdiagram.gif

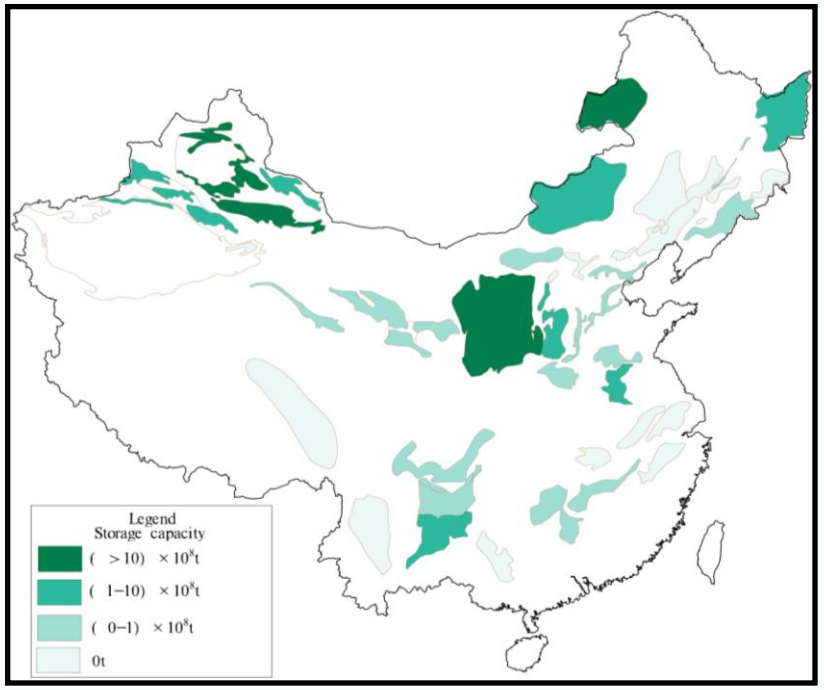
- **Storage capacity: 2.0-19.2 $GtCO_2$**
- **Additional oil: more than 0.89Gt**

Introduction of CGUS

CO_2-ECBM and storage capacity

(Fang & Li, 2013)





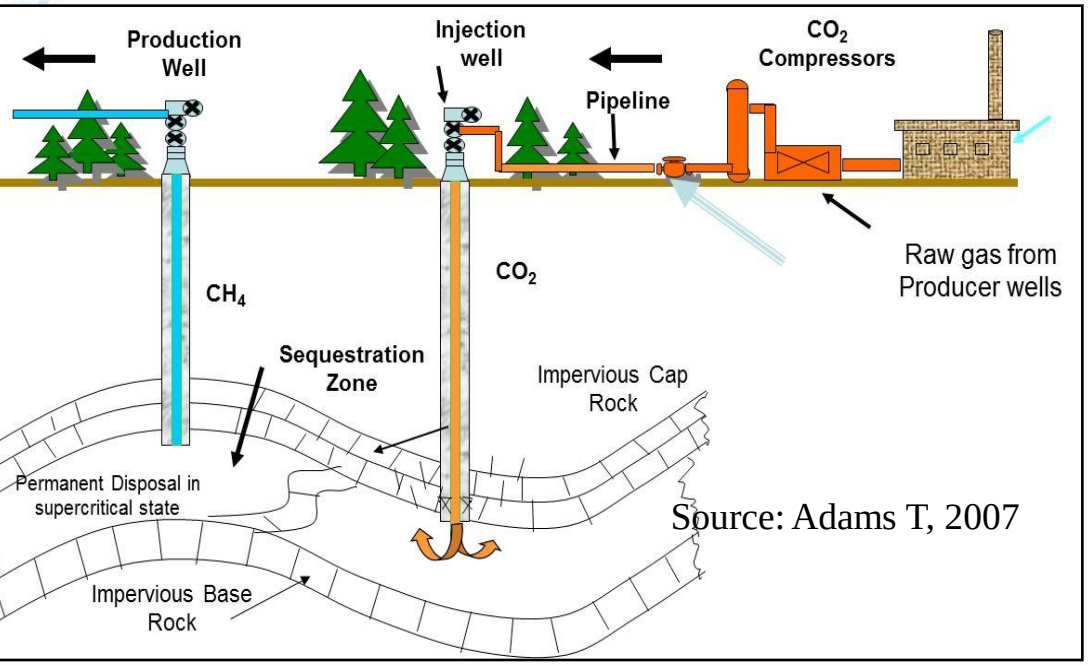
- **CO_2-ECBM:** CO_2 is injected and stored in a deep, unmineable coalbed to reduce its emission, meanwhile displace CBM (Mazzotti, 2009).

- **CSLF method**
- **28 basins**
- **Depth:1000-2000 m**
- **Assuming 10% of CBM reserve suitable for ECBM**
- **Capacity: 9.9 Gt CO_2**
- **CBM production: 13.5 trillion m^3**

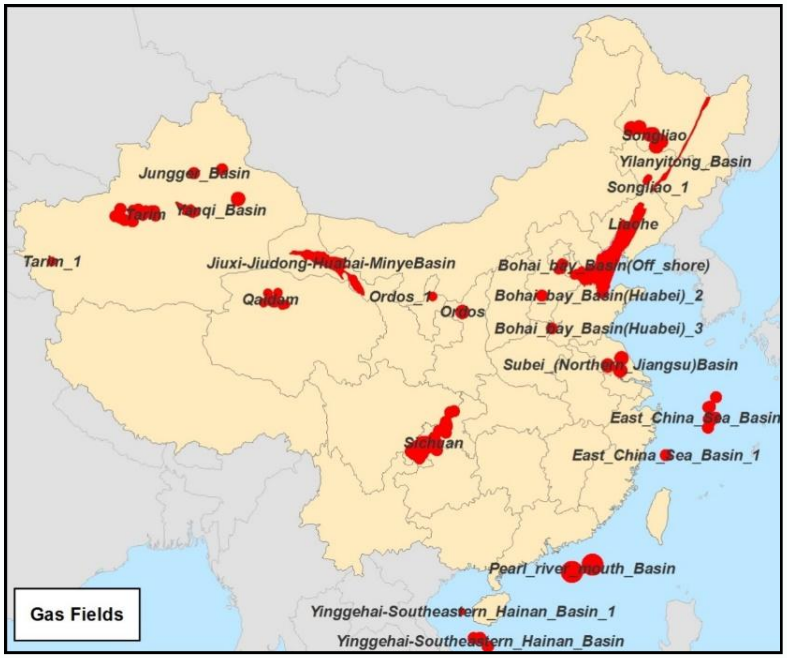
Introduction of CGUS

CO_2-EGR and storage capacity

(Li et al., 2009; Song et al., 2013)



Source: Adams T, 2007

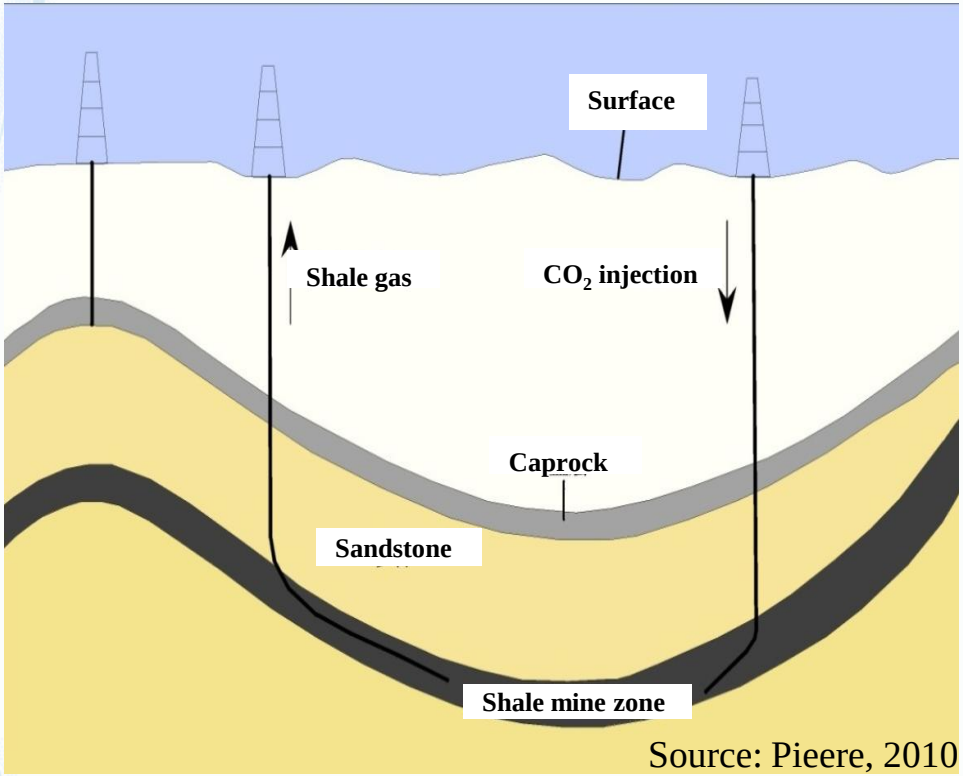


- **23 onshore basins, 6 offshore basins**
- **Capacity: 0.9-4.6GtCO_2**
- **Additional NG: 60-190Gm^3**

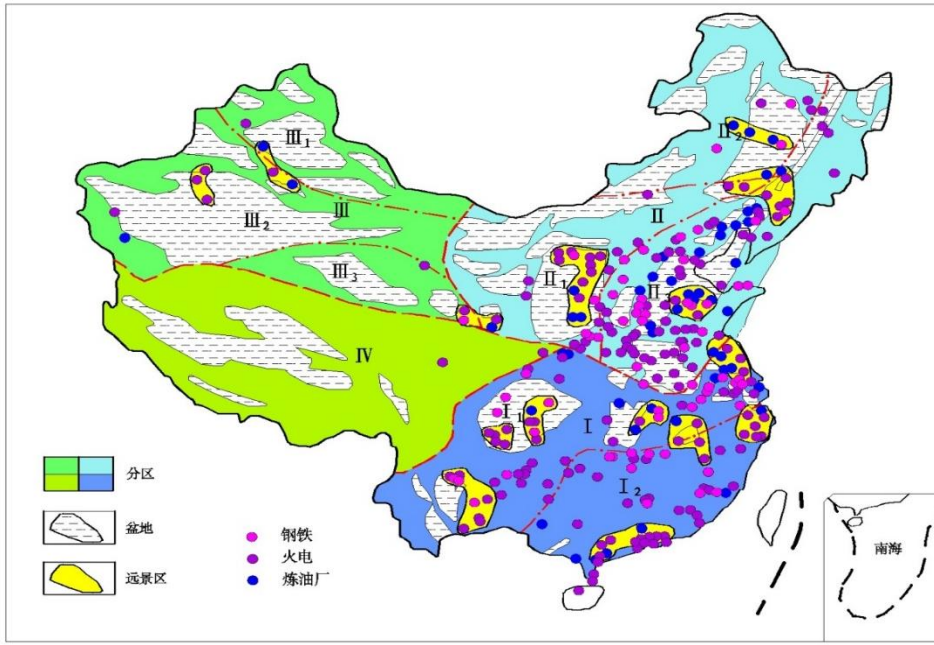
Introduction of CGUS

CO_2-ESGR and storage capacity

(Li et al., 2013)



Source: Pieere, 2010



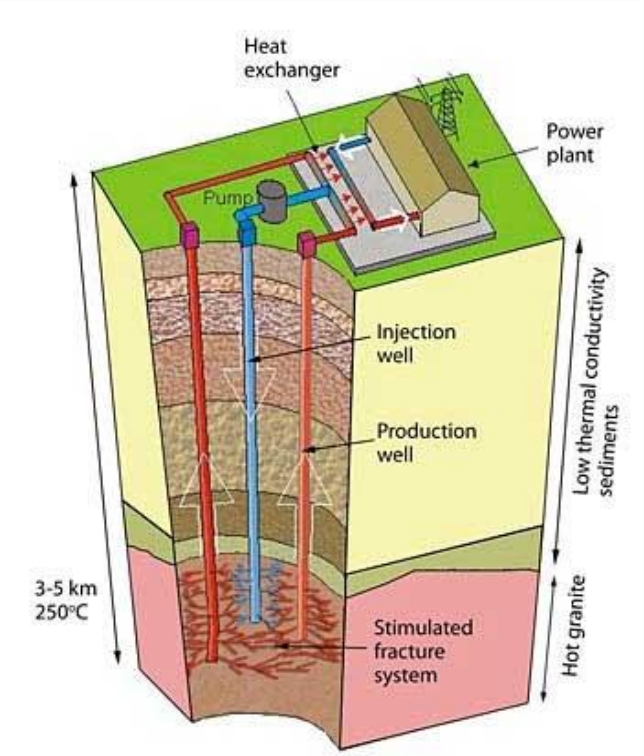
- **Storage capacity: 1.82Gt**

- **CO_2-ESG** is a technique that drives out and displaces shale gas by injecting CO_2 into a shale stratum to increase the recovery efficiency of shale gas, meanwhile sequestering the CO_2 in the reservoir (Xie et al., 2013).

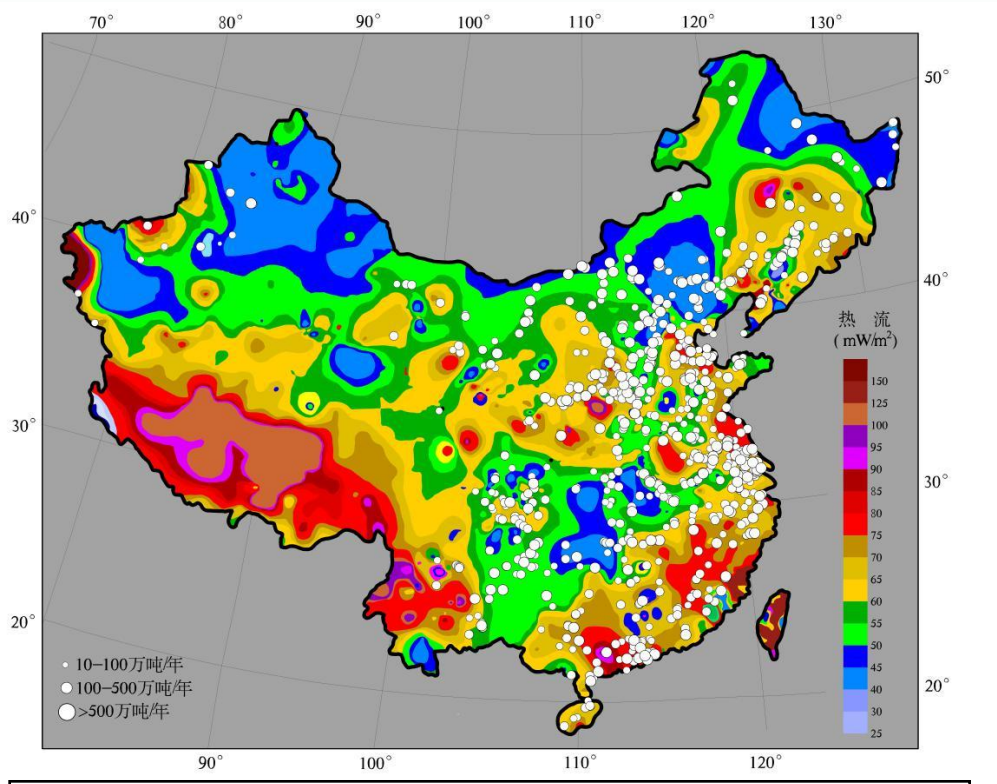
Introduction of CGUS

CO_2-EGS and storage capacity

(Xie et al., 2013)



Source: http://geothermalworldwide.com/egs.html



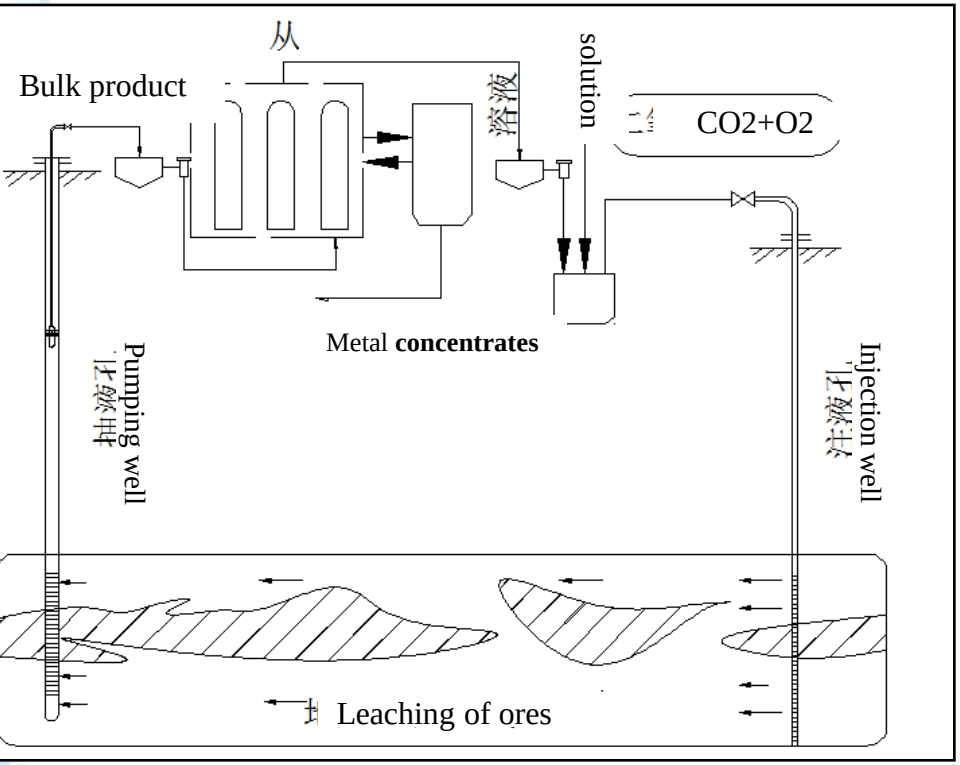
- **Storage Capacity: 7862 Gt CO_2**

- **CO_2-EGS:** Use CO_2 instead of water as work medium, and would achieve geologic sequestration of CO_2 as an ancillary benefit (Karsten, 2006)

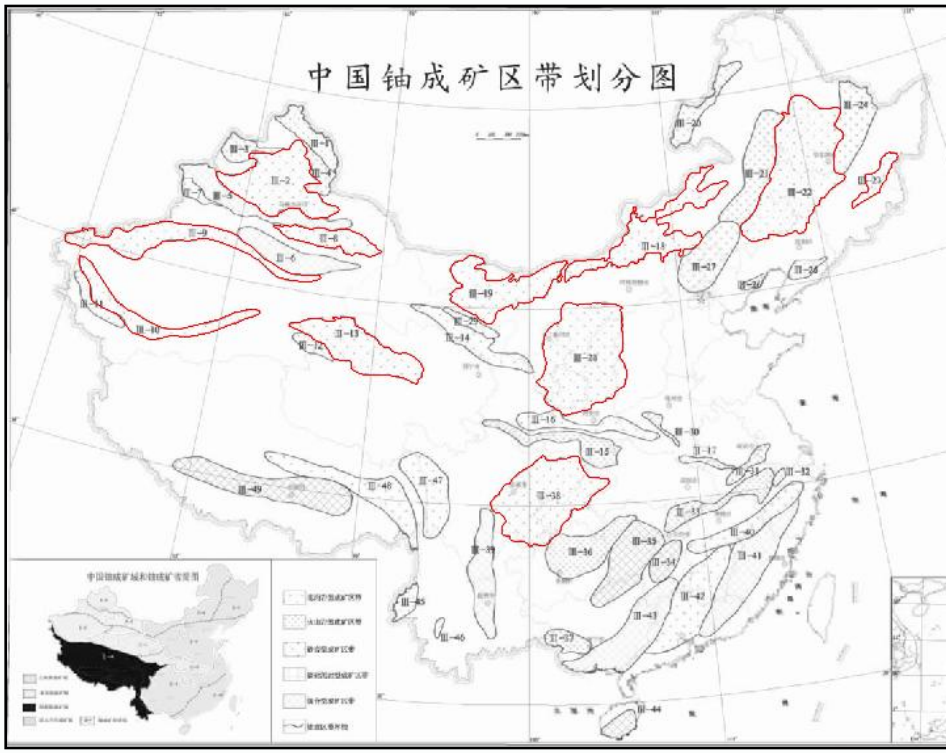
Introduction of CGUS

CO_2-EUL and storage capacity

(Zhang, 2012; Liu et al., 2013)



Source: Su, et al.， 2005

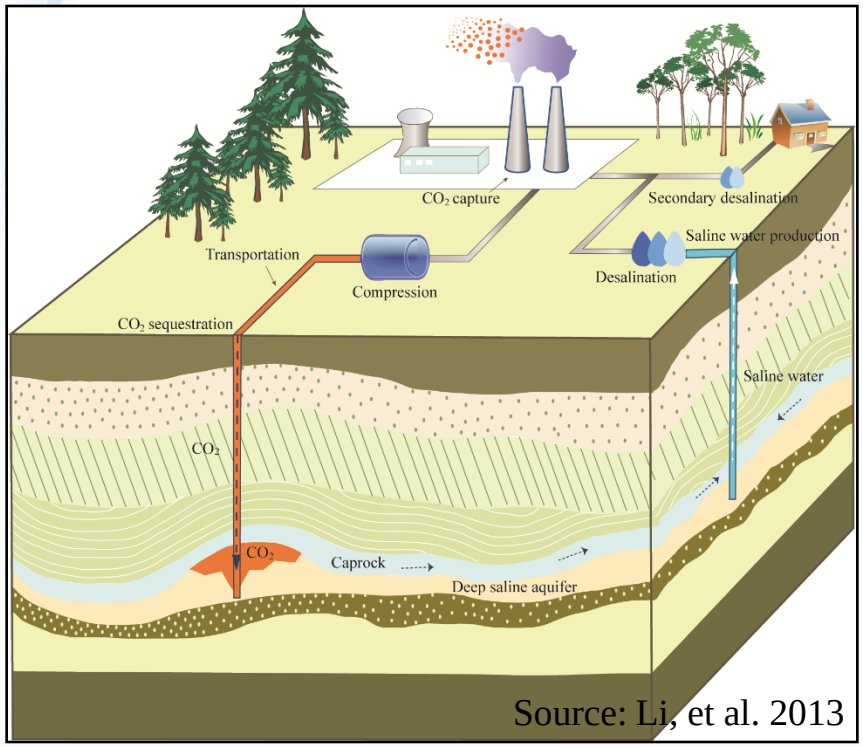


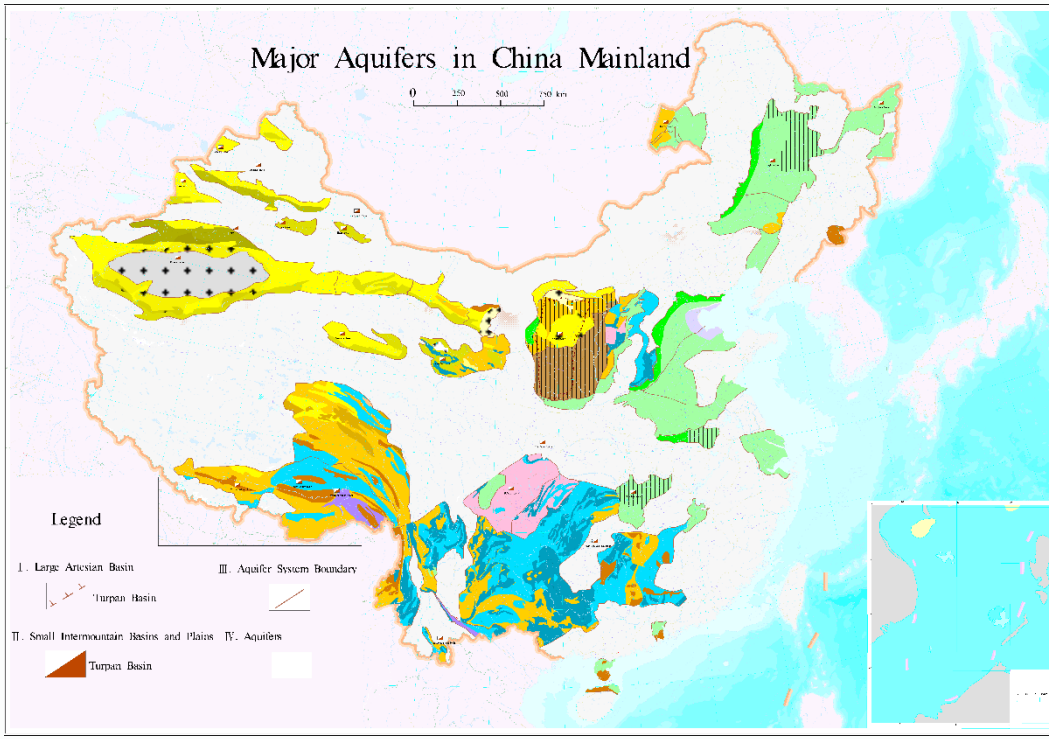
- **Storage capacity： 1-40 Mt**

Introduction of CGUS

CO_2-EWR and storage capacity

(Li, et al. 2013)





- **CO_2-EWR:**

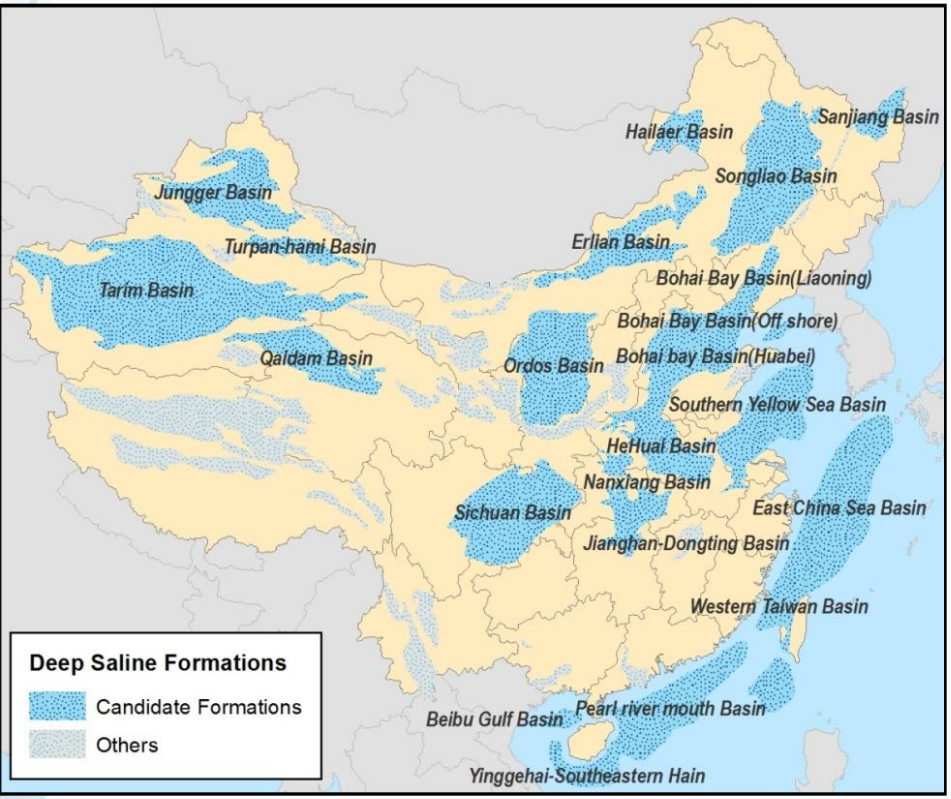
Injecting CO_2 into deep saline aquifers for CO_2 sequestration with enhanced saline water or water-soluble mineral recovery

- **Capacity: 119.2Gt CO_2**
- **Central and western region: 66.2 GtCO_2**

Introduction of CGUS

Aquifer Storage Capacity

(Li et al., 2007)



- **17 onshore basins, 10 offshore basin**
- **Capacity:0.23~3.07Tt**

Storage Capacity of CGUS

Types	Storage Cap.(Gt)	Evaluation	Practical Cap.(Gt)
CO_2-EOR	2-19	Well defined	2
CO_2-ECBM	9.9	Economy?	1
CO_2-EGR	0.9-4.6	Unproven principle	?
CO_2-ESGR	1.8	Unproven principle	?
CO_2-EGS	7862	Uncertain storage mechanisms	?
CO_2-EUL	0.001-0.04		little
CO_2-EWR	119	Dry regions	66
Aquifer	230~3067		164

- Huge theoretical storage capacity but highly uncertain.
- Practical capacity: 200Gt+, with the majority from EWR and Aquifer , considerable part from EOR and ECBM.
- EGS: huge capacity but need further research.

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- Storage Capacity
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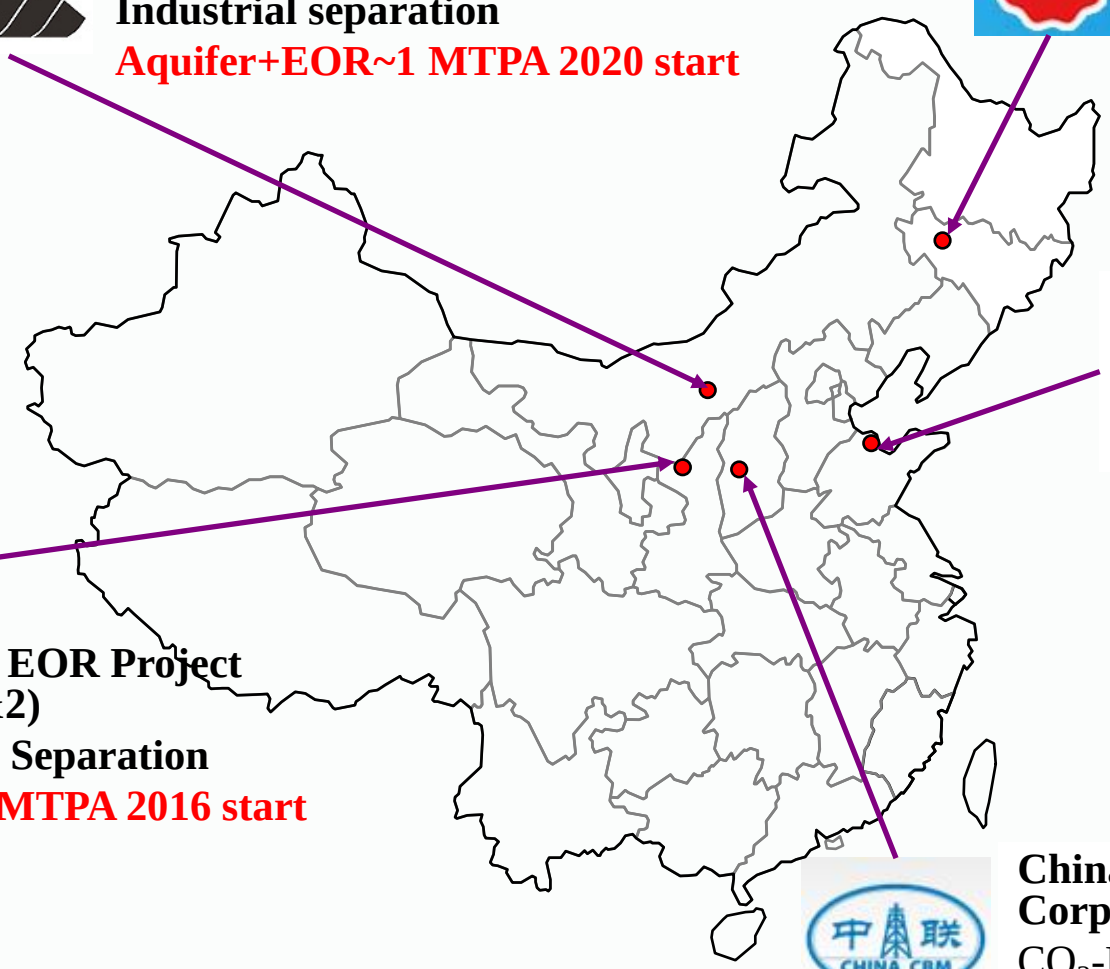
Integrated CCUS RD&D Projects in China



Shenhua Ordos CCS Project (Phase 1&2)
Industrial separation
Aquifer+EOR~1 MTPA 2020 start

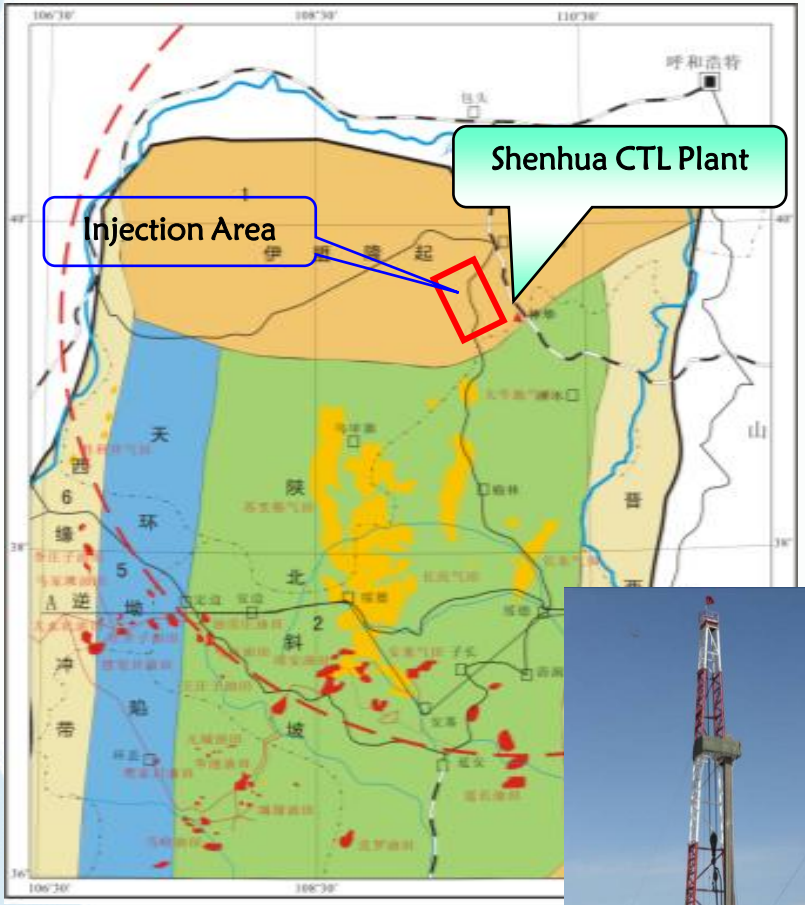
PetroChina Jilin Oilfield EOR Project (Phase 1&2)
Post-combustion capture
EOR~0.8 MTPA 2015 start

Sinopec Shengli Oilfield EOR Project (Phase 1&2)
Post-combustion capture
EOR~1 MTPA 2015 start

Yanchang EOR Project (Phase 1&2)
Industrial Separation
EOR~0.4 MTPA 2016 start

China United Coalbed Methane Corporation CO_2-ECBM Project
CO_2-ECBM Pilot Tests

Shenhua CCS Project (Phase 1)



- **Status: In operation (2011-2015)**
- **Source: Captured from CTL**
- **Transport: Trucks**
- **Storage: Aquifer,22 thin formations,**

1 injector, 2 monitoring wells

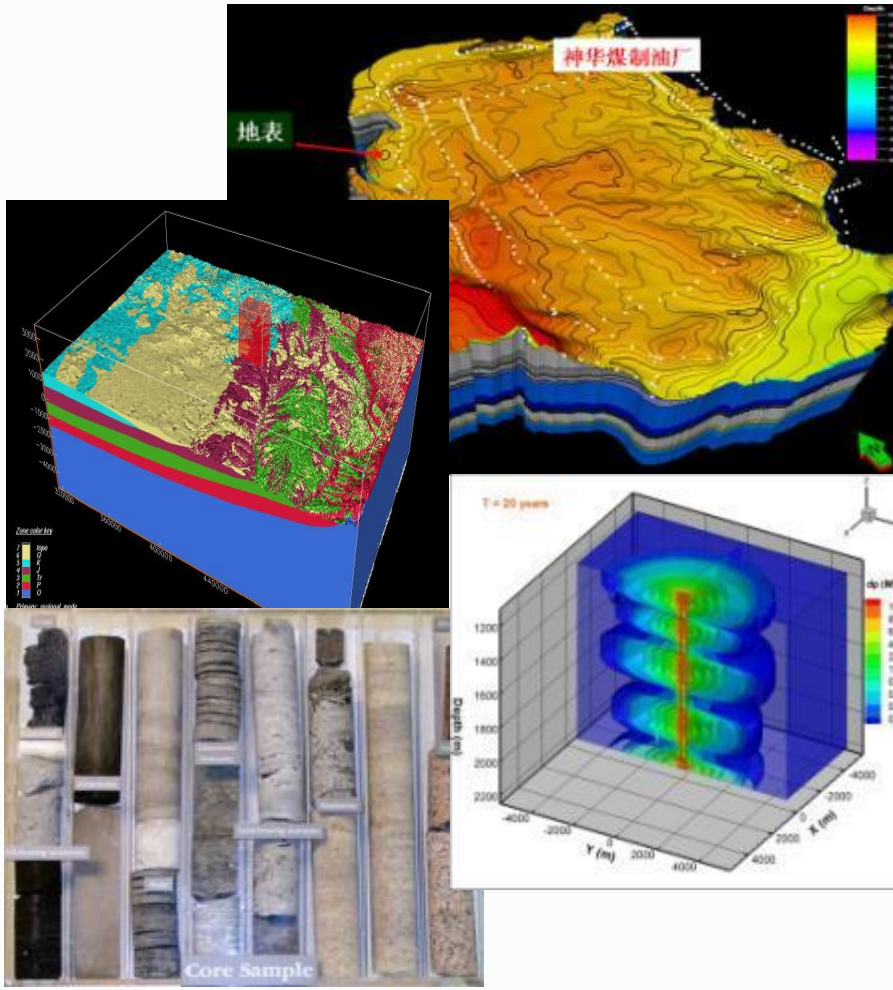
- **Injection volume: 0.3 Mt in 3 years,**

0.2Mt injected now

Shenhua CCS Project (Phase 1)

R&D Goals: Proving China's capacity of building and operating an integrated CTL-DSF CCS system

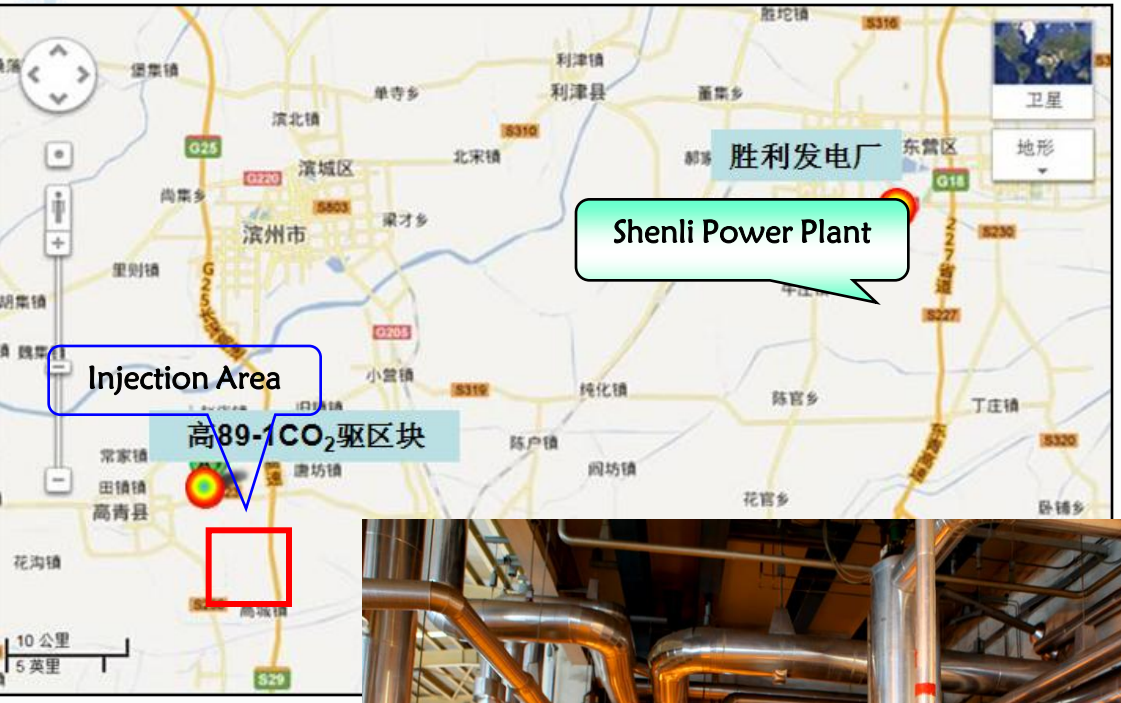
✓ Develop capacity assessment, site selection and design methods
✓ Validate the modeling and monitoring techniques for multiple-layer injections
✓ Obtain engineering experiences and economic data as a input for phase 2

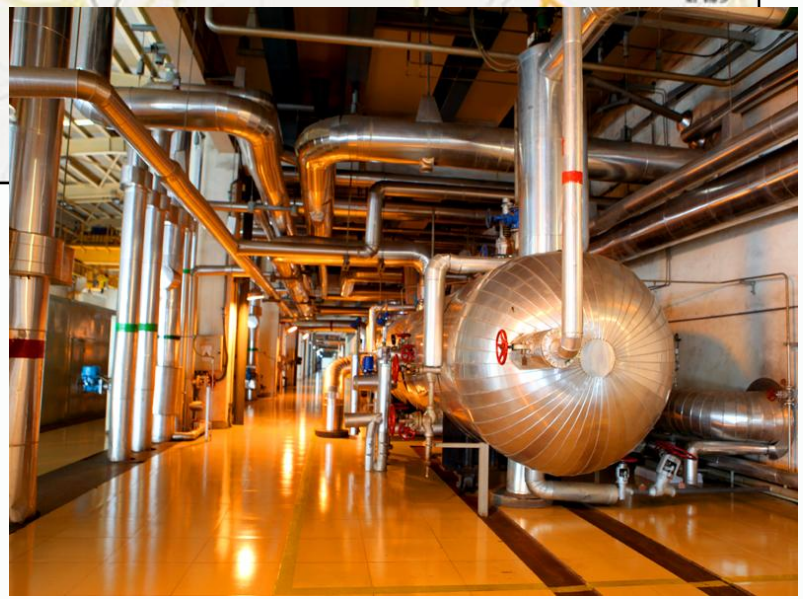


Phase 2 in definition

✓ CO_2-EOR and aquifer storage
✓ Seeking a efficient business model to facilitate joint venture between multiple companies

Shengli EOR Phase 1





To examine the company's capture and EOR techniques and achieve engineering experience

- **In operation since 2010**
- **CO_2 Source: Power Plant**
- **Capture: Post-combustion**
- **Transport: trucks**
- **Storage: EOR, 0.2Mt-CO_2 injected so far**

Shengli EOR Phase 2

Phase 2

- ✓ Expand engineering scale, 1 Mt/a EOR Project is scheduled to be completed in 2015
- ✓ Test key techniques such as absorbents, corrosion resistance, monitoring and flooding control
- ✓ Examine economic, carbon footprint and energy penalty

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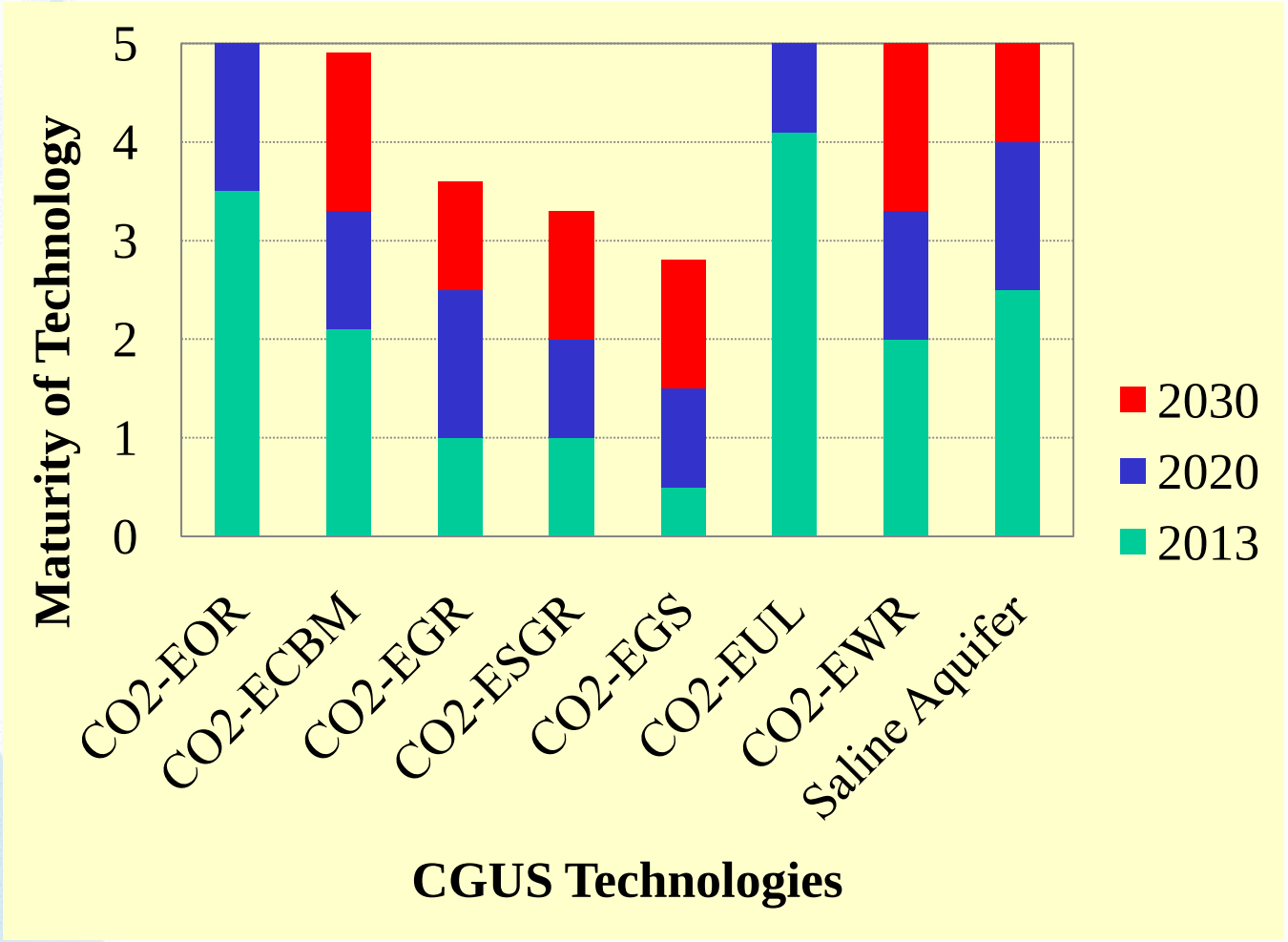
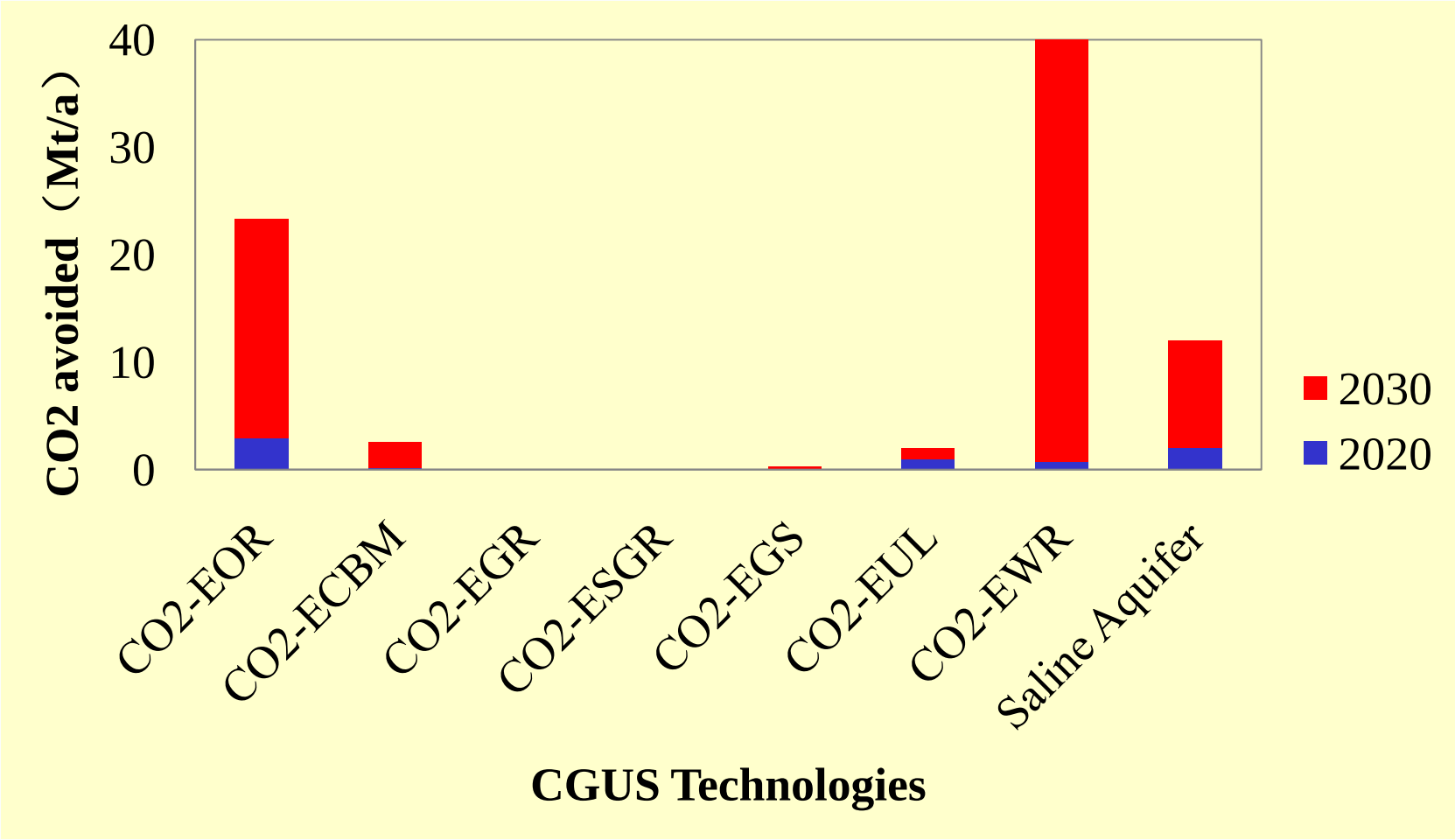
Maturity: current, 2020 and 2030



- **In 2020, EOR and EUL could be in commercial application, and the others below.**
- **In 2030, plus ECBM, EWR and Aquifer**

0	1	2	3	4	5
Concept	Basic Research	Technology Development	Technology Demonstration	Industrial Operation	Commercial Application

Expected contributions



✓ **5MtCO_2 avoided in 2020, and 70MtCO_2, in 2030.**

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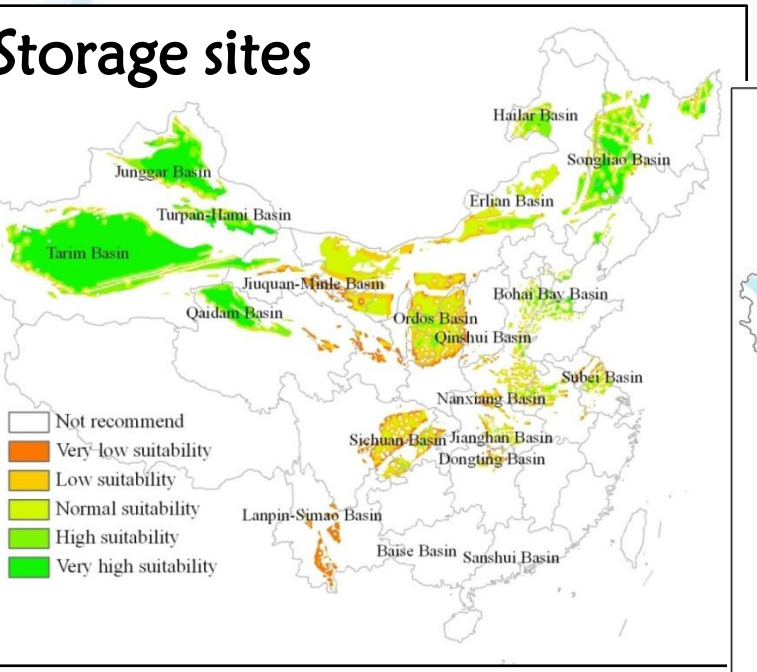
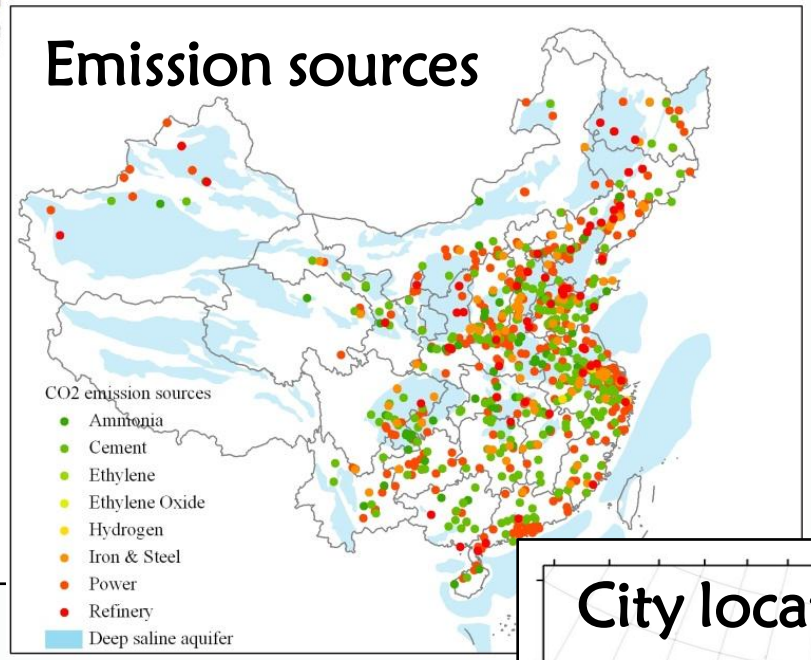
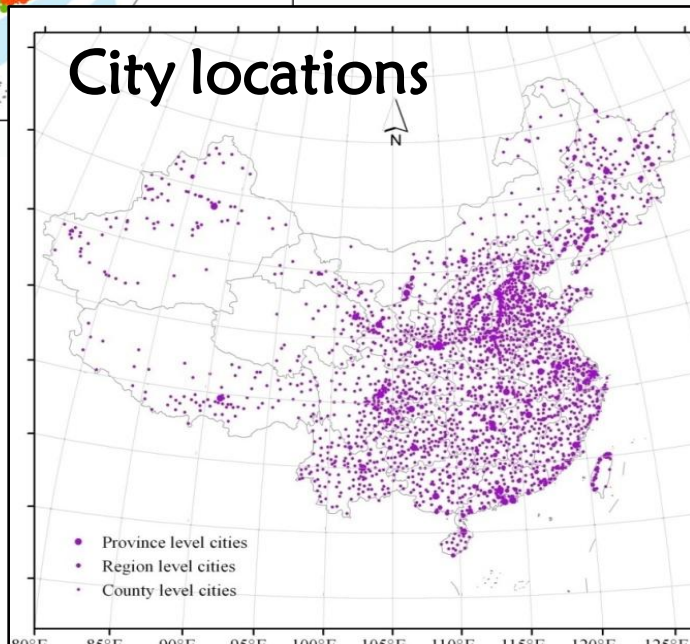
Technological Challenges







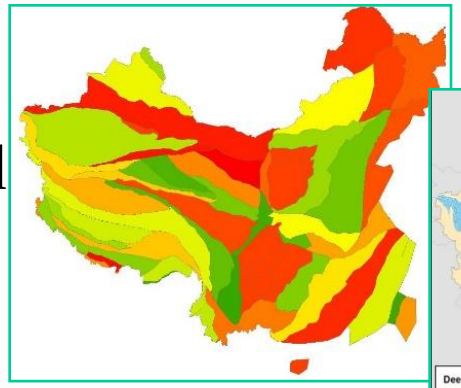
Dislocation between emission sources and storage sites, and **overlapping** between emission sources and population

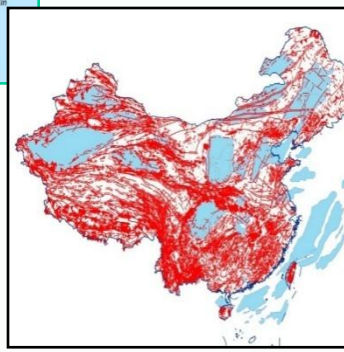
Long distance transportation and high-level safety pipelines

Technological Challenges

Complex geology

- Fragmented basins, targeted storage formation in continental deposits
- high discontinuity and heterogeneity at all scales
- Challenges in characterization, assessment and monitoring technologies.





Basin / Time	Tarim	Junggar	Turpan	Jiuquan	Qaidam	Sichuan	Ordos	Bohai Bay	Songliao	Erlian	Jianghan	Jiangsu	Sanshui	Pearl River Mouth	BeibuWan	Yinggehai
Q		Non-marine Facies														
N		Major target formation								Target formation				Target formation		
E																
K									Target formation							
J						Target formation										
T			Transformation Facies							Transformation Facies						
P																
C																
D			Marine Facies													
S																

Summary

- China has diverse CGUS options and huge capacity
- EOR provide early opportunities for CGUS, and the majority of the sizable projects will be EOR in near future.
- ECBM, EWR and aquifer storage will be also demonstrated at large scale before 2030
- Technical challenges: long and high secure pipelines, and difficult in the whole storage chain.