



中国石油大学(北京)

CO₂ Storage in Oil Reservoir and Enhanced Oil Recovery

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July.11-15, 2011
Changchun,China

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China Australia Geological Storage of CO₂

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- 1. Background
- 2. Basic Research
- 3. Pilot Test
- 4. Opportunity
- 5. Challenge
- 6. Cooperation
- 7. Conclusion

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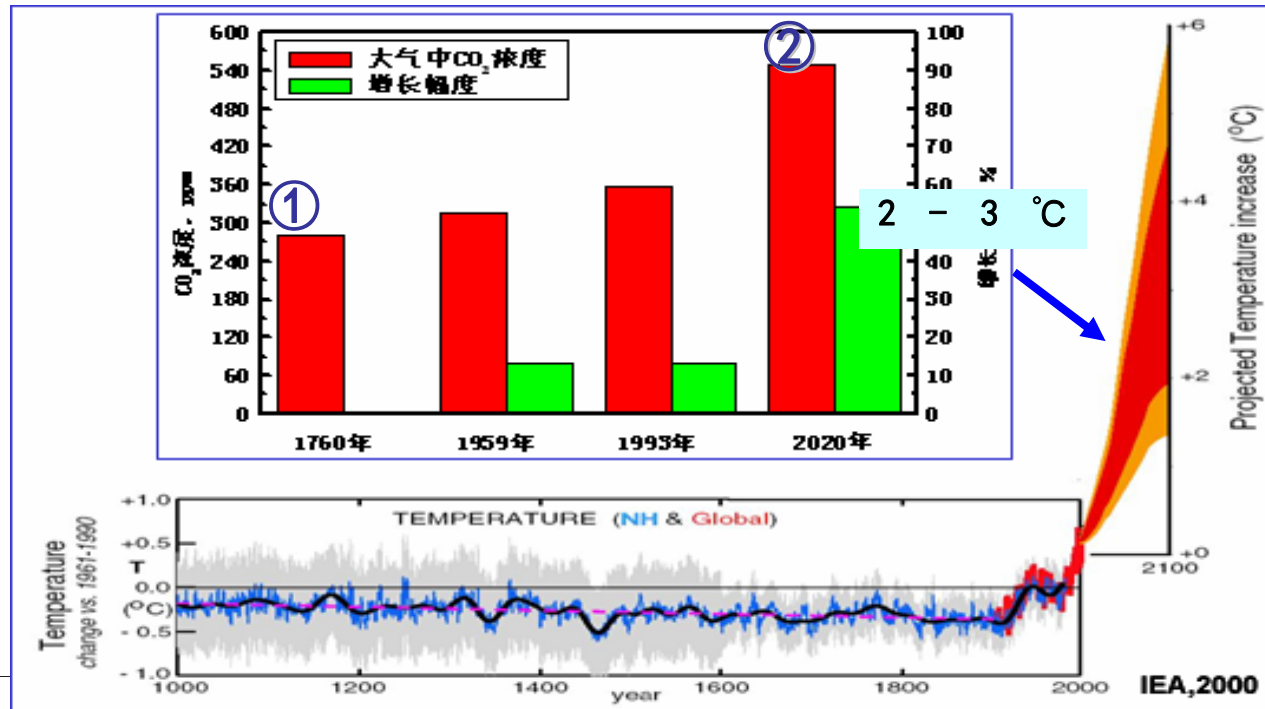
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1. Background

1). Reduction of Green House Gas Emission---A topic which concerned around the world nowadays. Carbon Capture and Storage(CCS) is one of the most important technology.



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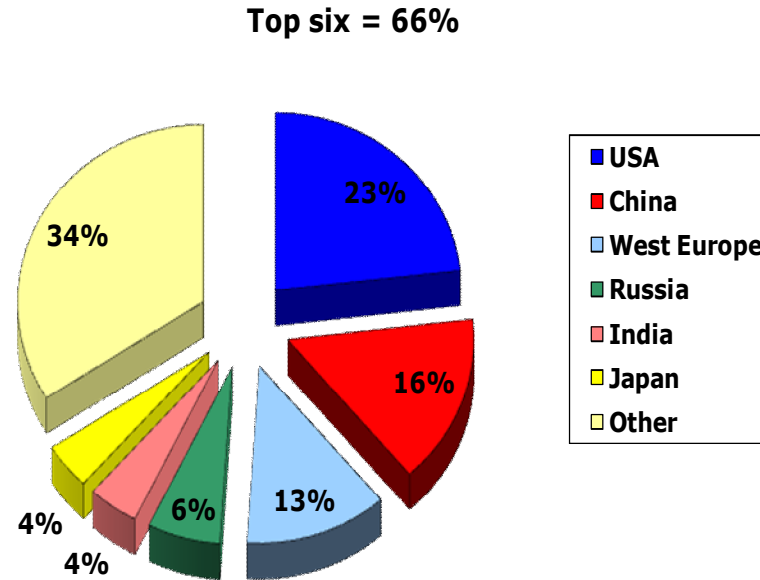


1. Background

2). Chinese Government Concerns Greatly about Reduction of CO2 Emission and Utilization of It as Resources

Biggest Emitters 2000-2025

- Chairman Hu Jintao
- Primer Wen Jiabao
- “973”, “863” Reseach Projects....
- Petrochina, HuanengP ilot Test....

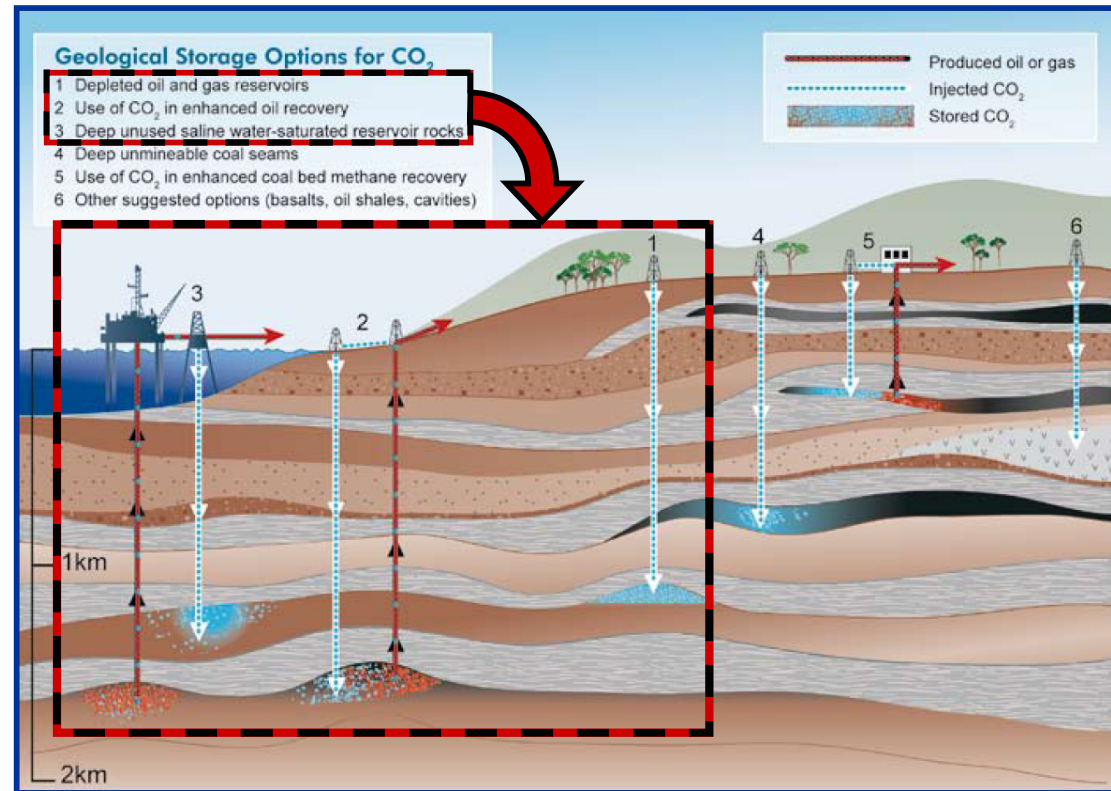




1. Background

3). CO₂ Storage and EOR in China

- Oil & Gas Reservoir, Subsurface Saliaquifer, coal bed, ideal Place for CO₂ Storage
- 923 billion tons of CO₂ can be stored in reservoir, which is 45% of global cumulative emission



in 2050.
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2. Basic Research

“ Utilizing Greenhouse Gas as Resource in EOR and Storing It Underground” (973)

- In 2006, a 973 project (The National Basic Research Program) named ‘Research for Utilizing Greenhouse Gas as Resource in EOR and Storing It Underground ’ was authorized by China Ministry of Science and Technology.
- Chief Scientist: Prof. Shen Pinpin
- 8 sub-projects is included.
- Basic Research
- In 2010, a new 973 project (The National Basic Research Program) has started



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2. Basic Research

- Project 1 Standard stipulation and potential evaluation for CO₂ storage that meets China geologic characteristic, PetroChina
- Project 2 Geologic theory of CO₂ subsurface storage, Chinese Academic of Sciences
- Project 3 Theory and technology of monitoring and front predicting during CO₂ storage process, Beijing University
- Project 4 Research on phase theory of multiphase and multicomponent during CO₂ flooding process, PetroChina
- Project 5 Nonlinearity flow mechanism and law of multiphase and multicomponent during CO₂ flooding process, China University of Petroleum
- Project 6 Principle of O₂/CO₂ circulating combustion for coal and mechanism of synergetic removal pollutant, Huazhong University of Science and technology
- Project 7 Theory and technology of CO₂ separation and concentration from industrial gas, Qinghua University
- Project 8 Theory and method of engineering for CO₂ corrosion prevention and antiscale, Jilin Oil field

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3. Pilot Test

- **“CO₂ Storage and Enhanced Oil Recovery in Jilin Oil Field” Major Science & Technology Research Project and Key Pilot Test were conducted by PetroChina**
- **In 2007, a key science& technology research project named ‘Utilizing Greenhouse Gas as Resource and Storing it Underground’ was established by PetroChina.**
- **In 2007, a key pilot test named ‘Pilot Test of CO₂ EOR and Storage in Jilin Oil Field’ was established by PetroChina**



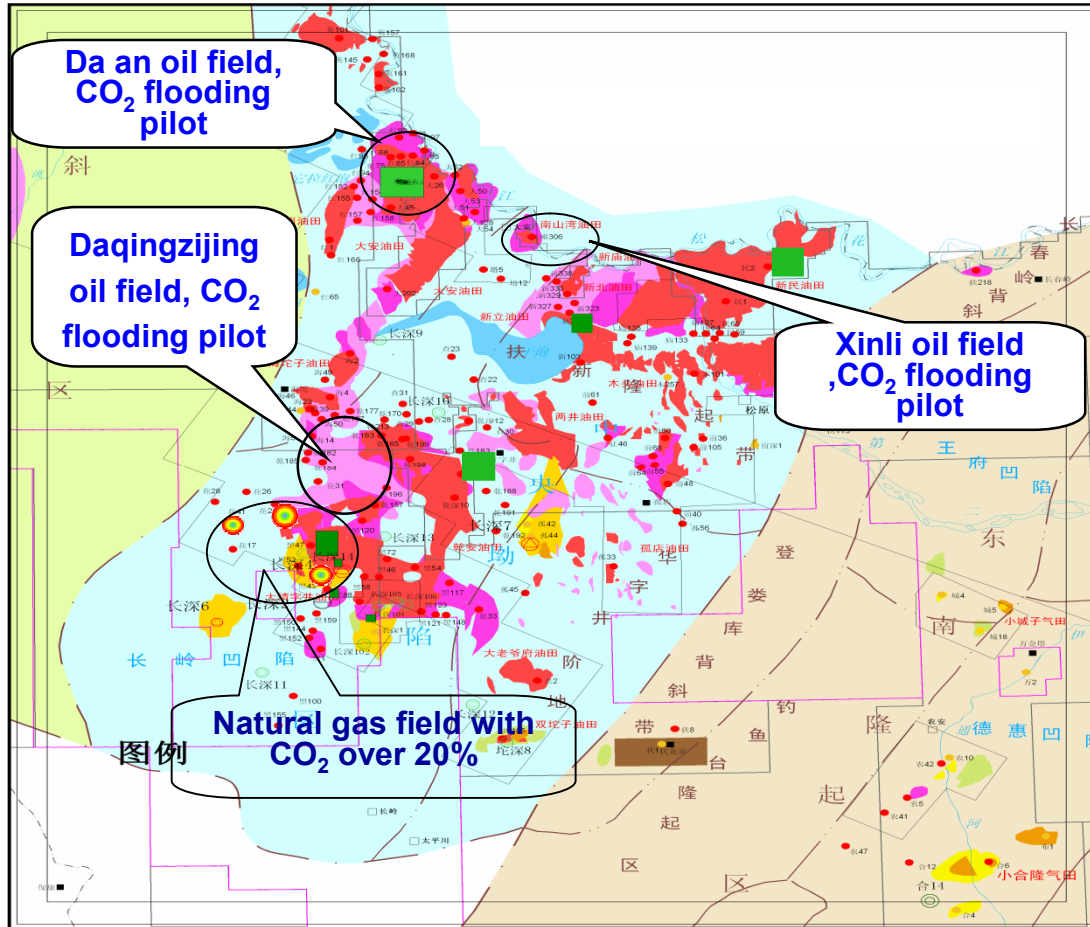
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3. Pilot Test



CNPC promise “0” CO₂ emission in developing the Gas Field

In recent years, there is a major breakthrough in natural gas exploration in the deep reservoirs of Songliao Basin. A large amount of natural gas resources has been discovered and CO₂ resources are amounted to more than 100 billion cubic meters.



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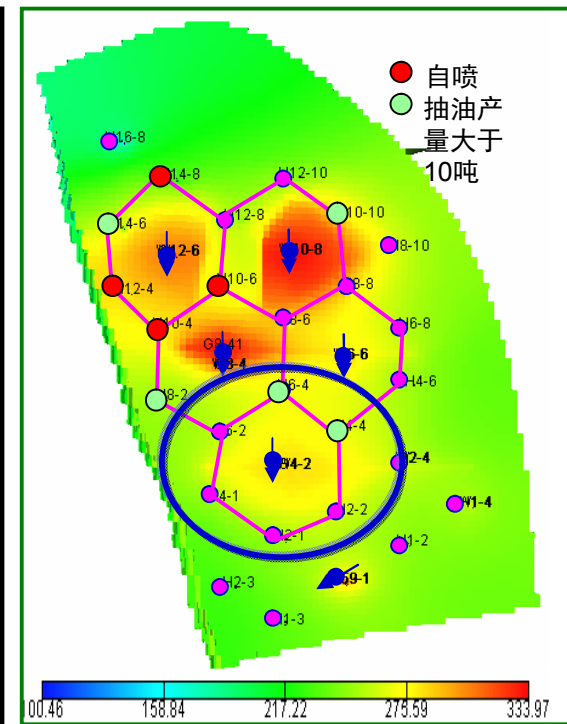
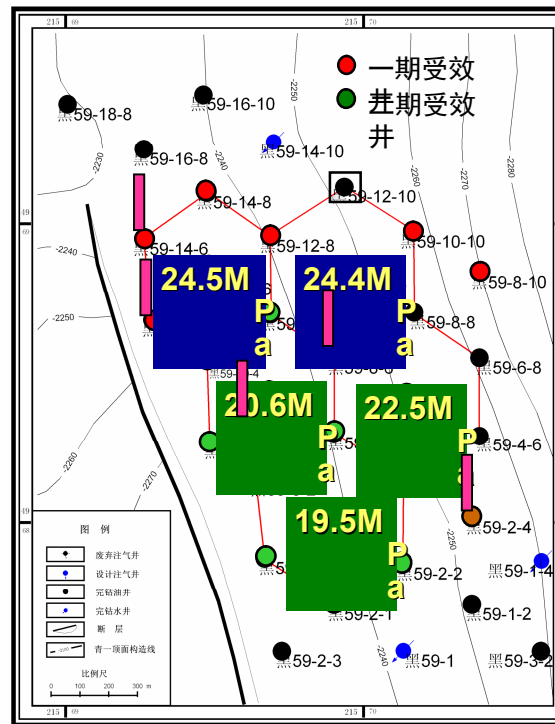




3. Pilot Test

Hei59 CO₂ Pilot test

- **EOR layer: QING1 7,12,14 layer, average depth 2400 meter**
- **Well Pressure $\leq 40\text{MPa}$;**
- **CO₂ Injection :30~40t/d**
- **Well groups: 5 well groups,(1inject well, 6 product well), Total:5In.19Pr.,**
- **Liquid CO₂ continuous injection**
- **MMP: 22.1 MPa**



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3. Pilot Test

Pilot test of CO2 injection

Pilot Test for Liquidfied CO2 Injection --- Xin 228 Block of Xinli Oilfield

- Xin 228 block is a part of Xinli structure and is located in the north of it. The angle of structure dip is 1.06 degree. The average effective thickness of reservoir is 8.93 m, average permeability of reservoir is 0.35 mD, porosity is 12.38%, temperature is 66 °C

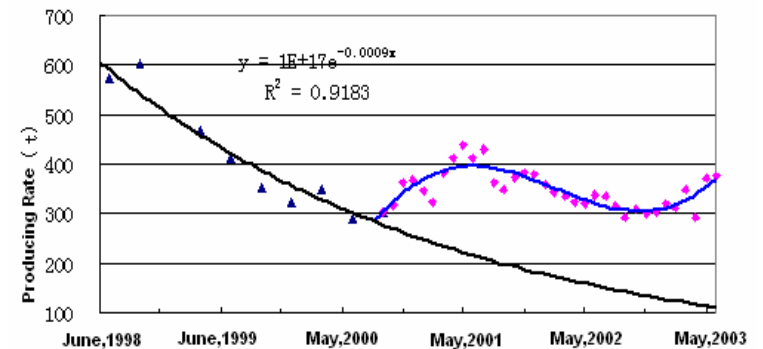
Test Result

- As of the end of June, 2003, 5121 tons of crude oil was cumulatively increased, with the injection/production ratio 1:4.28, corresponding to 3.2 tons of crude oil increased by each ton of CO2.

The Effect of Well

| Well | Date for action | Effect time (day) | Oil increased per day | Oil increased accumulative | Ratio for production enhancement | Remark |
|------|-----------------|-------------------|-----------------------|----------------------------|----------------------------------|----------------------------|
| 54-6 | Oct.,2000 | 730 | 1.02 | 743.70 | 48.5 | Work |
| 56-4 | Sep.,2000 | 560 | 0.34 | 190.00 | 24.2 | Work |
| 56-2 | Oct.,2000 | 540 | 0.32 | 170.60 | 28.7 | Work |
| 52-4 | Dec.,2000 | 323 | 0.11 | 34.00 | 11.7 | Work |
| 54-2 | Nov.,2000 | 360 | 0.26 | 93.30 | 32.4 | Water cut decline at first |
| 52-6 | | | | | | Water cut decline at first |
| 56-6 | Feb.,2001 | 400 | 0.86 | 343.60 | 24.5 | delay |
| 52-2 | Nov.,2001 | | | 77.80 | | |

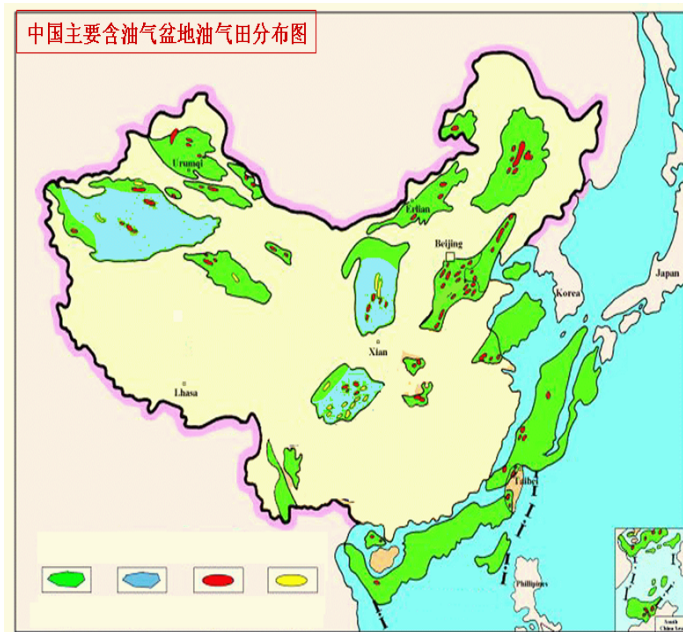
Curve for decreasing of producing rate





4. Opportunity

- Low permeability reservoir account for a large percentage



- **30% OOIP deposited in the low-permeability reservoirs in China.**
- **2/3 undeveloped oil in place deposited in low-permeability reservoirs ($K < 10\text{mD}$).**
- **95% oil in CNPC produced from waterflooding reservoirs.**

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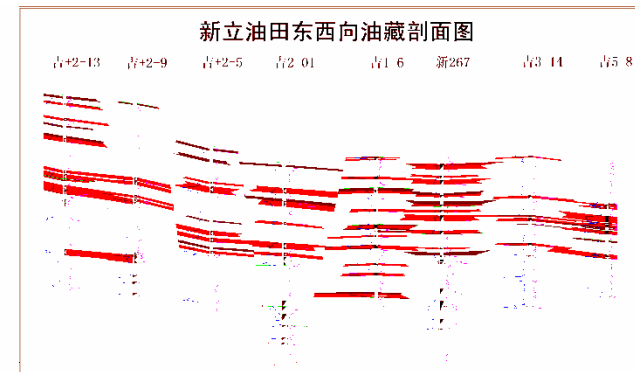
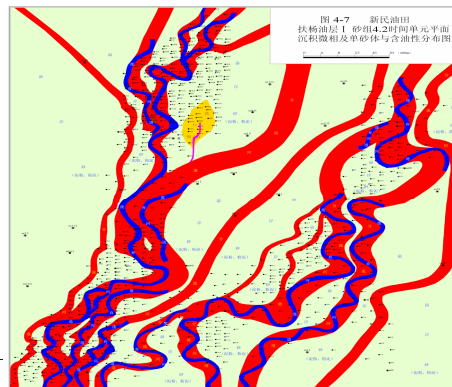
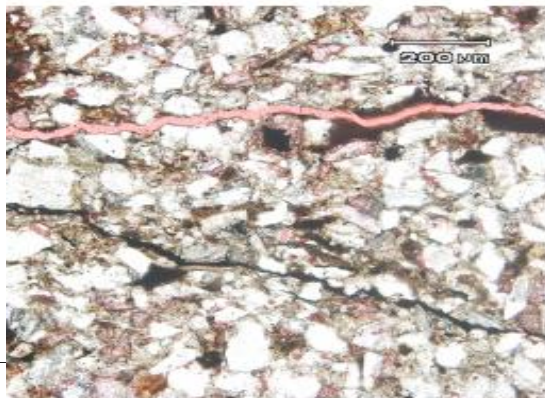




5. Challenge

Reservoir characteristics of low permeability reservoirs in China

- Small pore throat, low P&K, poor reservoir quality
- lithologic trap, poor reservoir continuity
- thin interbedded sandstone and mudstone
- variable reservoir thickness and physical properties
- well-developed micro-fracture
- strong heterogeneity
- higher water saturation



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6.Cooperation

Oil Co.:

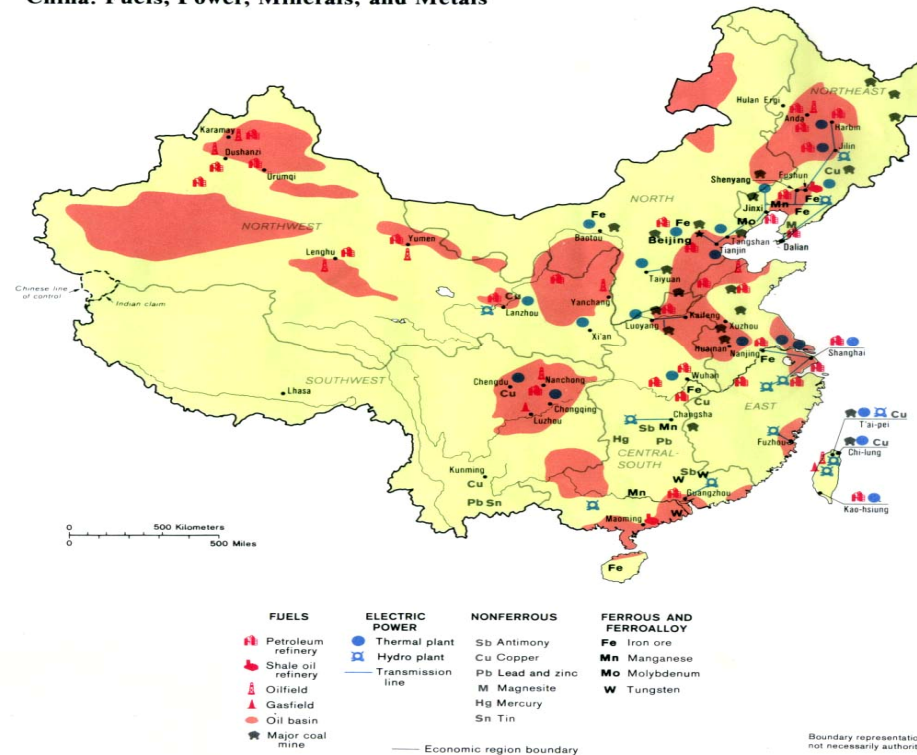
Power Co.:

New Mechanism?

CO₂ Tax?

CO₂ Price?

China: Fuels, Power, Minerals, and Metals



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6. Cooperation

International Cooperation: NEZC, COACH, STATRA, CAGS... CDM???



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7. Conclusion

- **China is a developing country. With the sense of responsibility, China has taken a series measures, such as conducting the national project of Research for Utilizing Greenhouse Gas as Resource in EOR and Storing It Underground.**
- **In 2010, a new major science & technology research project named 'CO₂ EOR and Storage Underground' and a key pilot test named 'CO₂ EOR and Storage Pilot Test in Jilin Oil Field' were established by PetroChina.**
- **Petrochina will start new 'CO₂ EOR and Storage Underground' pilot test in Daqing and Changqing Oil field.**
- **More Cooperation is needed to do in CO₂ storage and EOR.**



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Challenge and Opportunity for China Universities on CCS

Prof. Bo PENG

China University of Petroleum (Beijing)

July11-15, ChangChun, P. R. China

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1. Introduction
2. Chinese Government and Enterprises concerns on CCS
3. Challenge and Opportunity for Chinese Universities on CCS
4. Activities of China University of Petroleum on CCS
5. Conclusion



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1.Introduction

- Climate change is the serious problem for human being



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1.Introduction

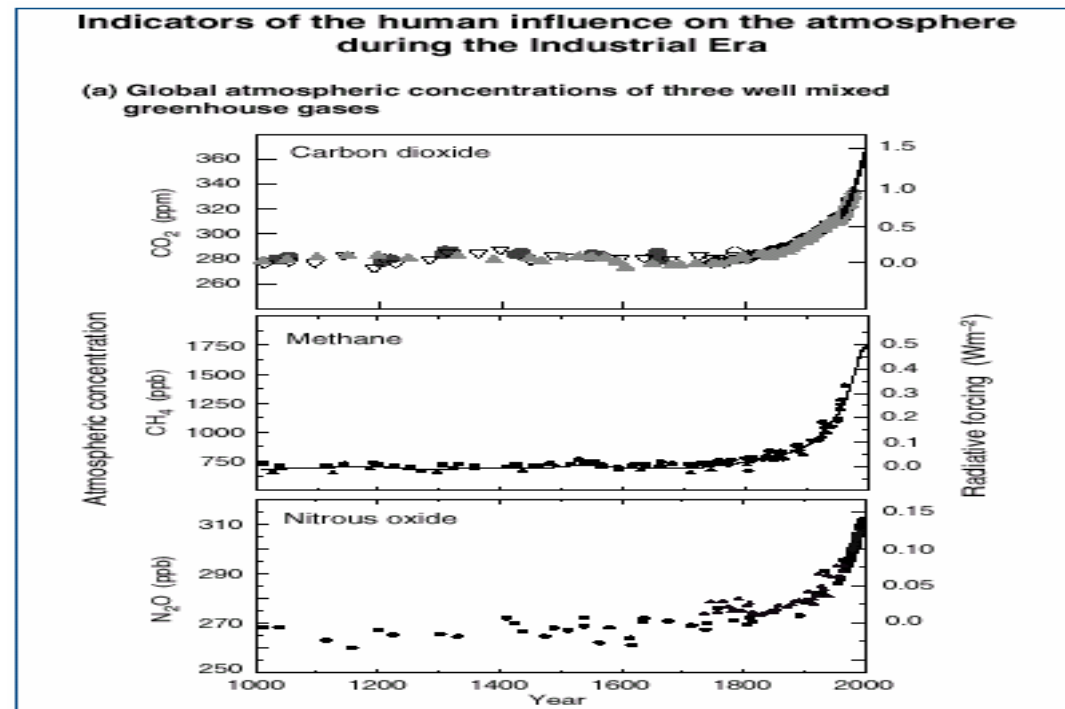
- Climate change and green house gas(GHG)

CO2 in atmosphere

Before 1800 : 2800ppm

Now: 379ppm

2050: 550ppm



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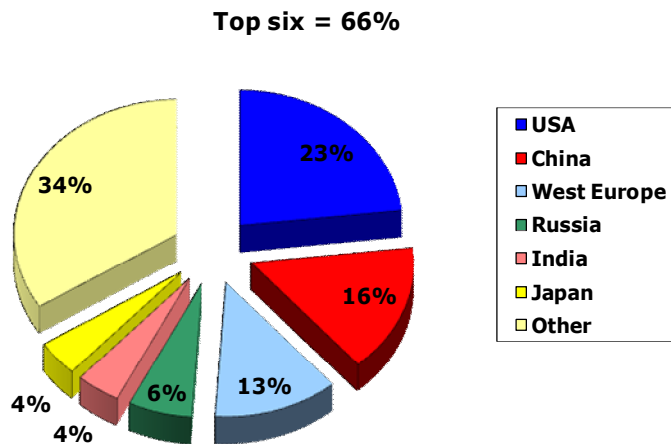




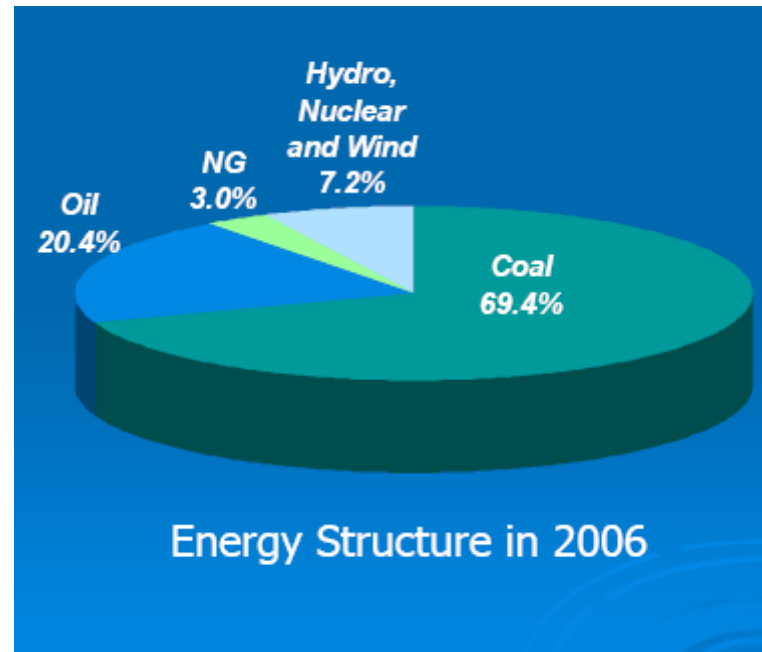
1.Introduction

- CO2 emission should be controlled facing climate change

Biggest Emitters 2000-2025



Cumulative CO2 Emissions 2000-2025, EIA, IEA 2002



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1.Introduction

New Energy Structure and Lower CO2 Emission

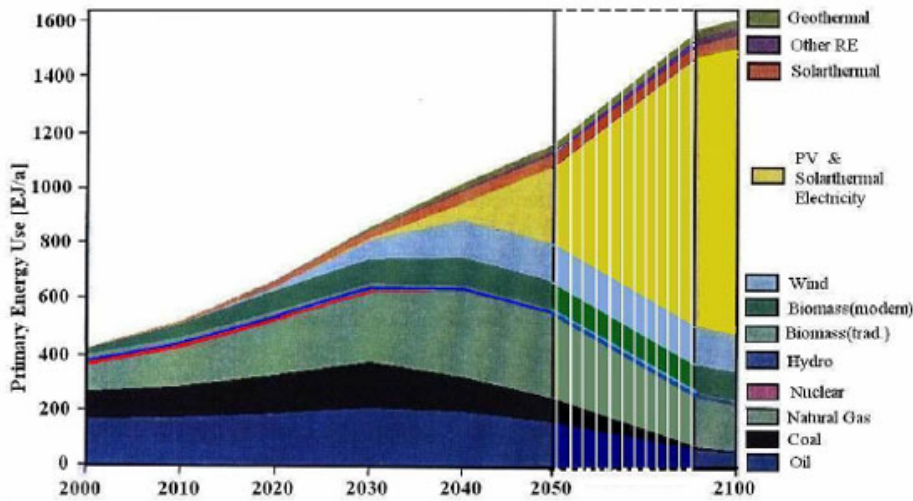
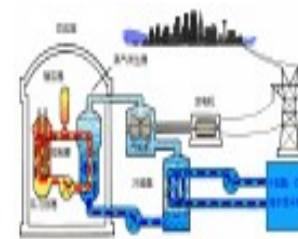


图 2、世界能源发展趋势 (PVNET2003)



Referring to the simulation results based on an energy system model, if follows today's tendency of energy technology development and energy policy, the fraction of coal in primary energy consumption will decrease after 2015, but still be high: 54.5% in 2030, and 47.2% in 2050. Coal will still be the major primary energy.



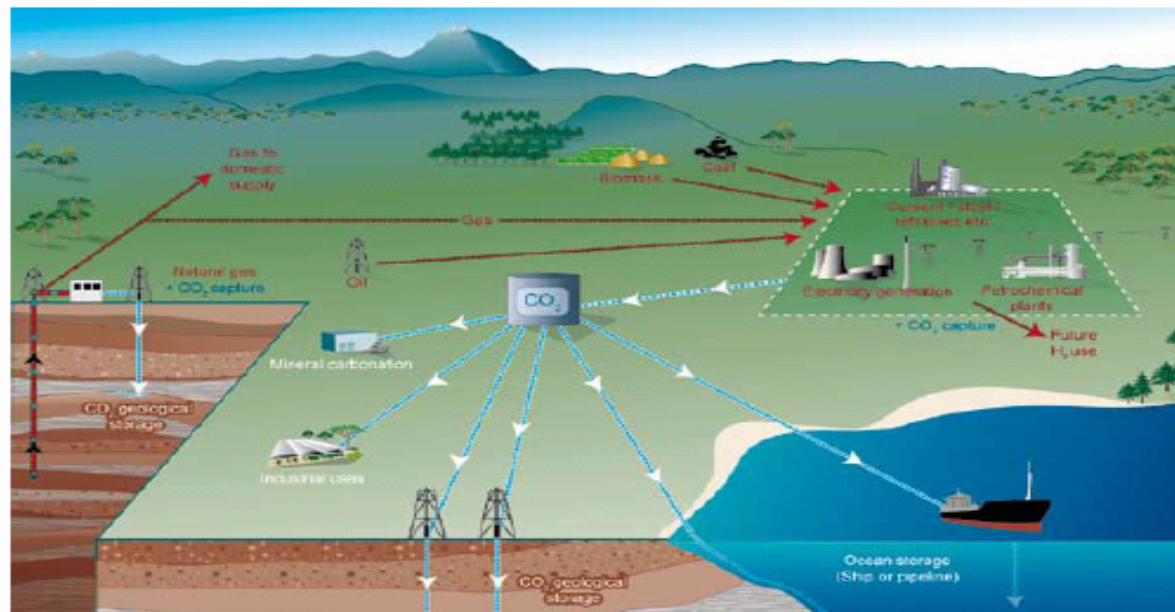
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1.Introduction

Carbon Capture and Storage is one of necessary and important technology to control CO₂ emission



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2. Chinese Government and Enterprises concerns on CCS

- National Science and Technology Programs
 - 1. National Key Technology Program
 - 2. National Basic Research Program (973 Program)
 - 3. National High Technology Program (863 Program)
- Basic Research on enhancing oil recovery, use as resource and storage of GHG
- Basic Research of Polygeneration System with syngas co co-produced from coal gas and coke oven gas
- Basic research of high efficient catalytic conversion in reforming reaction of natural gas and syngas
- Research of thermal-to to-power conversion processes in gas turbine



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2. Chinese Government and Enterprises concerns on CCS

National Science and Technology Programs

During the 10th five-year period, the National Science and Technology Program has supported strategic, basic or technology researches on CCS by Chinese research institutions

In the following years during 11th five Year Plan period, The National Science and Technology Programs will keep support the research on the basic theory of CO₂ long term storage, high efficiency and cost effective separation, new theory and method of transportation, etc.

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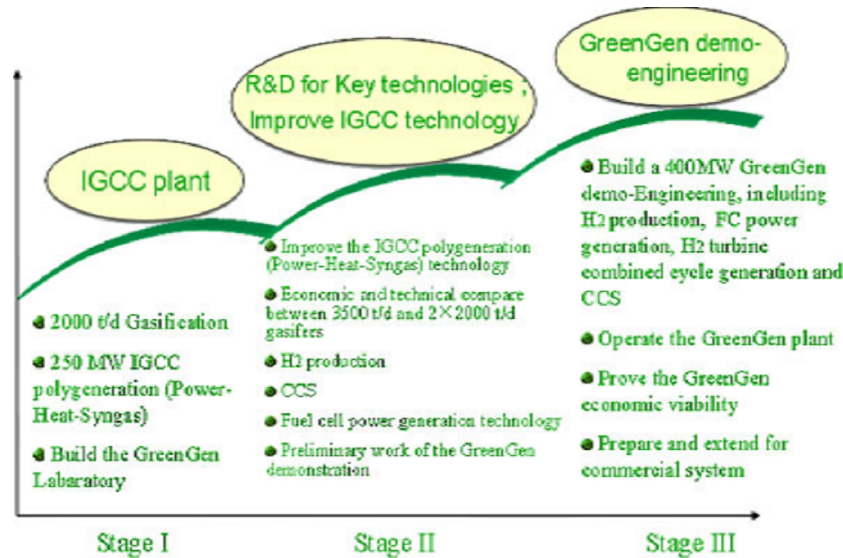
2. Chinese Government and Enterprises concerns on CCS

• CCS Pilot Test in Enterprises

Huaneng Group:

GreenGen: IGCC, 2009,6

Beijing Thermal Power Plant; 3000 CO₂t/Y capture started on 2008 before Olympic



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2. Chinese Government and Enterprises concerns on CCS

- CCS Pilot Test in Enterprises

Petrochina

CO2 storage

and EOR pilot

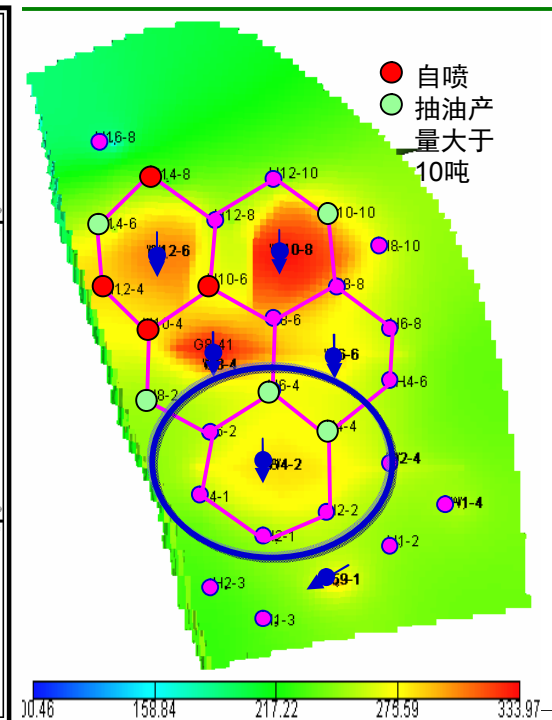
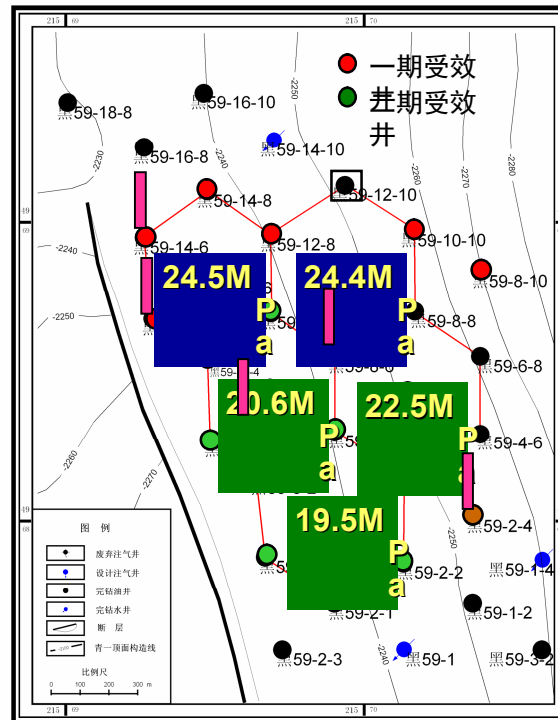
test at Jilin

Oil-field

200million RMB

(I)

30-40t/d



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3.Challenge and Opportunity for Chinese Universities on CCS

Current maturity of CCS system components

| CCS component | CCS technology | Research phase ¹³ | Demonstration phase ⁷ | Economically feasible under specific conditions ⁵ | Mature market ⁶ |
|------------------------------------|--|------------------------------|----------------------------------|--|----------------------------|
| Capture | Post-combustion | | | X | |
| | Pre-combustion | | | X | |
| | Oxyfuel combustion | | X | | |
| | Industrial separation (natural gas processing, ammonia production) | | | | X |
| Transportation | Pipeline | | | | X |
| | Shipping | | | X | |
| Geological storage | Enhanced Oil Recovery (EOR) | | | | X* |
| | Gas or oil fields | | | X | |
| | Saline formations | | | X | |
| | Enhanced Coal Bed Methane recovery (ECBM) | | X | | |
| Ocean storage | Direct injection (dissolution type) | X | | | |
| | Direct injection (lake type) | X | | | |
| Mineral carbonation | Natural silicate minerals | X | | | |
| | Waste materials | | X | | |
| Industrial uses of CO ₂ | | | | | X |

* CO₂ injection for EOR is a mature market technology, but when this technology is used for CO₂ storage, it is only 'economically feasible under specific conditions'



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3.Challenge and Opportunity for Chinese Universities on CCS

- Technology
- Economy
- Environment
- Policy

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3.Challenge and Opportunity for Chinese Universities on CCS

- Basic theory of CO₂ long term storage, high efficiency and cost effective separation, new theory and method of transportation, etc.
- Cost evaluation, financial mechanism (investment and operation)
- Environment evaluation
- Carbon policy, carbon tax, carbon market

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3.Challenge and Opportunity for Chinese Universities on CCS



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4. Activities of China University of Petroleum on CCS

Laboratory of CO₂ Storage and Enhanced Oil Recovery
Founded on July, 17, 2008

Object: CO₂ Storage and EOR

Key Major: Petroleum Engineering, Exploration Geology, Applying
Chemistry

Including: Chemical Engineering (Capture), Transportation; Safety
and Security; Economy (Policy and CDM)

Supported by:
State Key Laboratory of Oil Resource
State Key Laboratory of Heavy Oil;
Key Lab of Petroleum Engineering of Education Ministry

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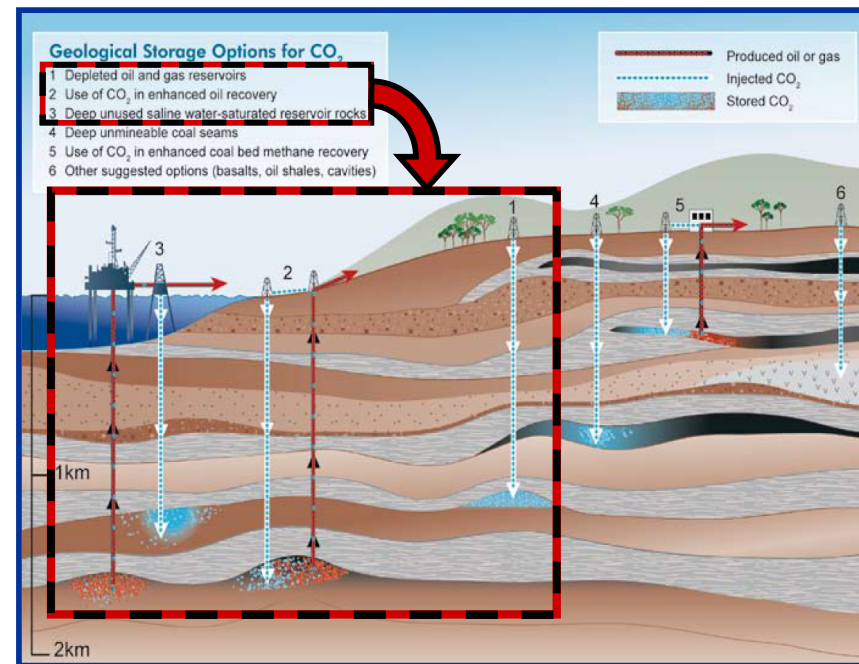




4. Activities of China University of Petroleum on CCS

- Laboratory of CO₂ Storage and Enhanced Oil Recovery

- Oil&Gas Reservoir, Subsurface Salaquifer, coal bed, ideal Place for CO₂ Storage
- 923 billion tons of CO₂ can be stored in reservoir, which is 45% of global cumulative emission in 2050.
- 30% OOIP deposited in the low-permeability reservoirs in China.
- 2/3 undeveloped oil in place deposited in low-permeability reservoirs ($K < 10\text{mD}$).



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4. Activities of China University of Petroleum on CCS

Laboratory of CO₂ Storage and Enhanced Oil Recovery



Famous scientists in EOR field, including members in CAS and CAE.

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4. Activities of China University of Petroleum on CCS

Activities in National Science and Technology Programs

- National Basic Research Program (973)
- National High Technology R&D Program (863)
- National Science and Technology Infrastructure Program
- National Nature Science Foundation
- Key Research Program of Education Ministry

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4. Activities of China University of Petroleum on CCS

Activities in International Cooperation

- China-EU COACH Project
- China-UK NZEC Project
- China-Australia GAGS Project
- China-Italia ...Project
- China-U.S.A (NETL)....in discussion

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4. Activities of China University of Petroleum on CCS Education in CCS



COACH CCS AUTUMN SCHOOL IN CHINA, OCT,12-18,2009

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5. Conclusion

1. CCS is one of the necessary and important technologies facing the climate change.
2. Chinese Government and Enterprises concern on CCS.
3. It is a great challenge and opportunity for China Universities on CCS. China Universities take activities in CCS.
4. Broad international collaboration is need for CCS



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Welcome to China University of Petroleum!



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