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GreenGen

--- Near Zero Emission Coal Based Power Generation Project in China

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- Why does China need GreenGen ?
- Roadmap of GreenGen Program
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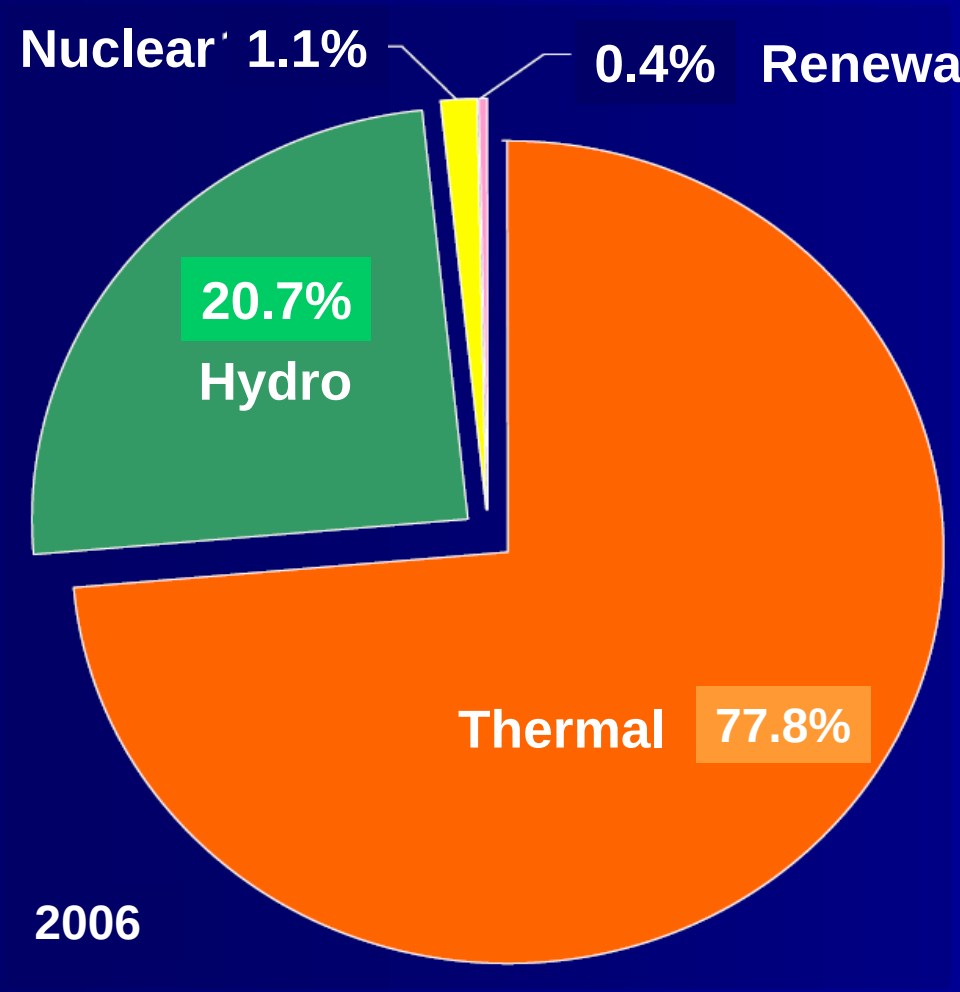
Why coal ?

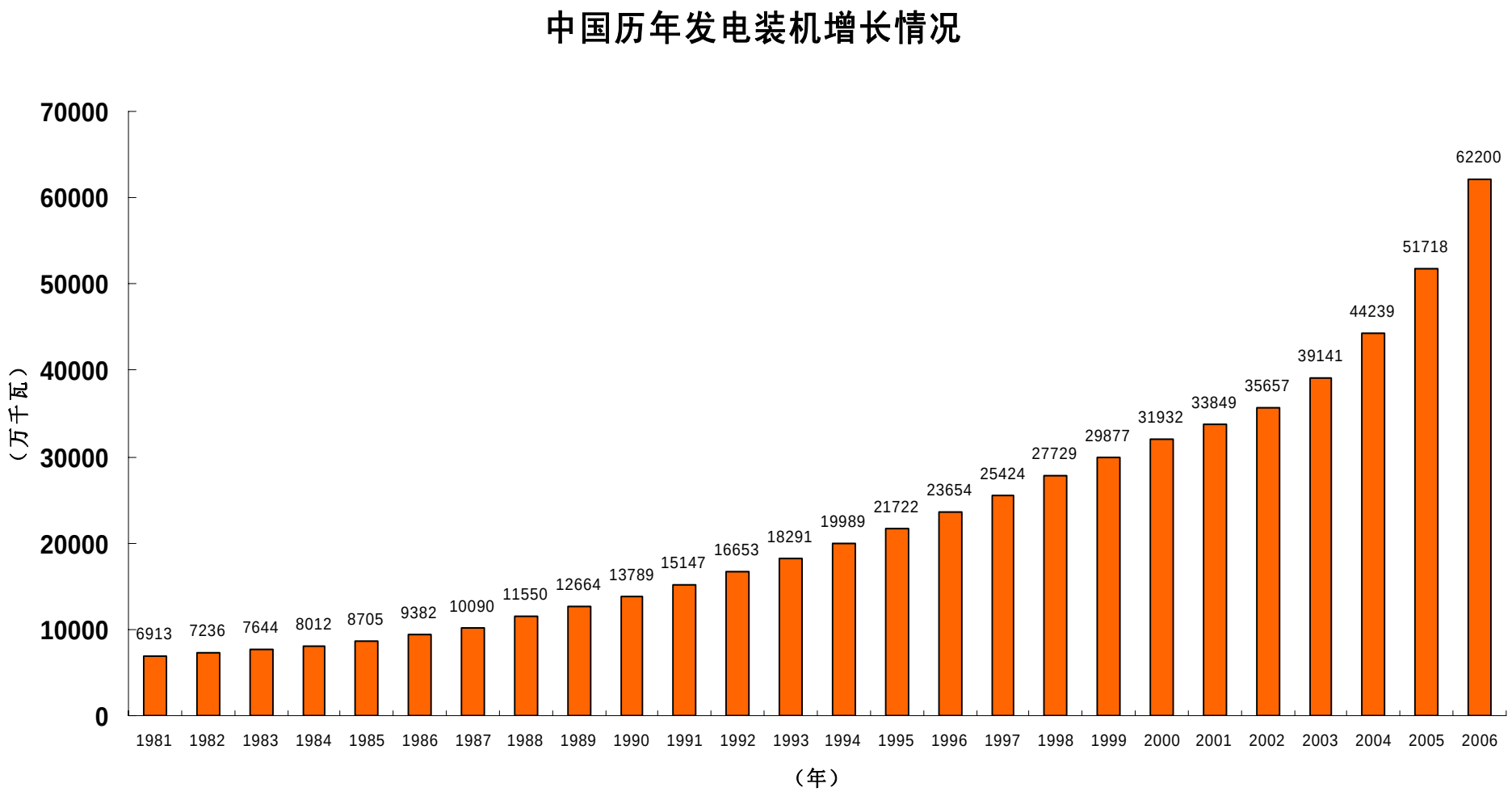
	Oil	NG	Coal
300 200 100 0			
Year	40	60	230
C : H (wt.%)	85:15	75:25	95:5
CO_2 emission	80	60	100

Why Coal?

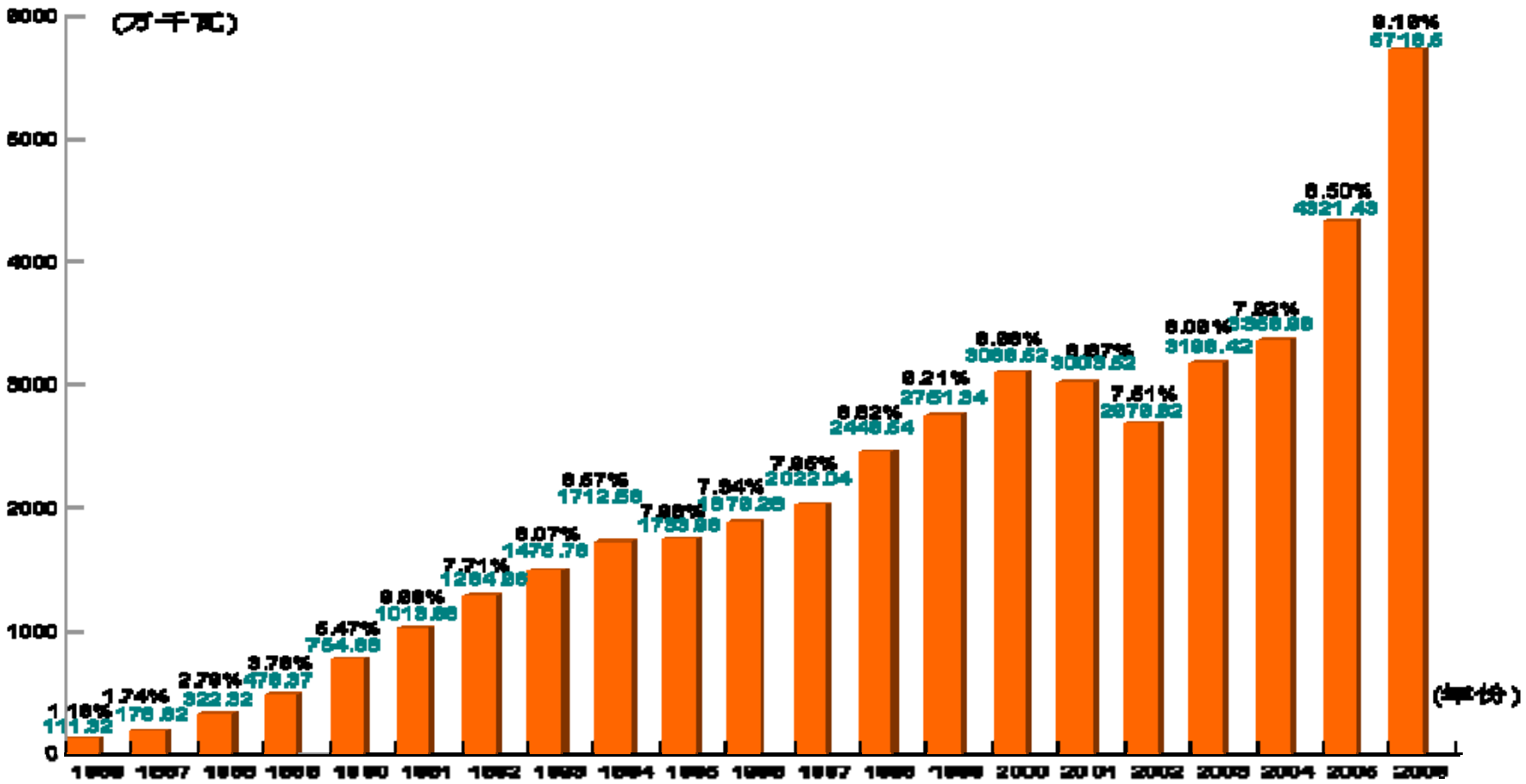
Structure of China's Electric Power



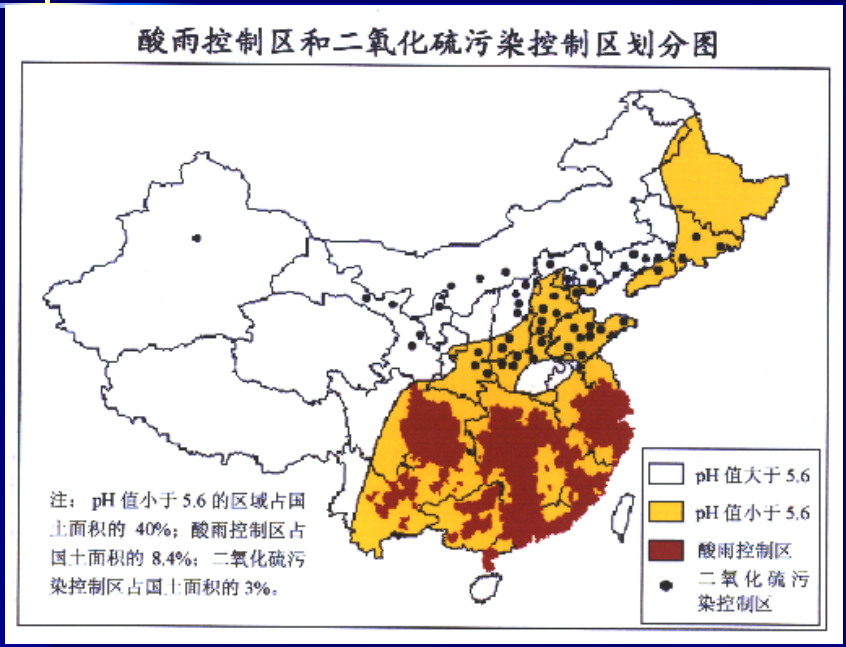
China’s electric power development

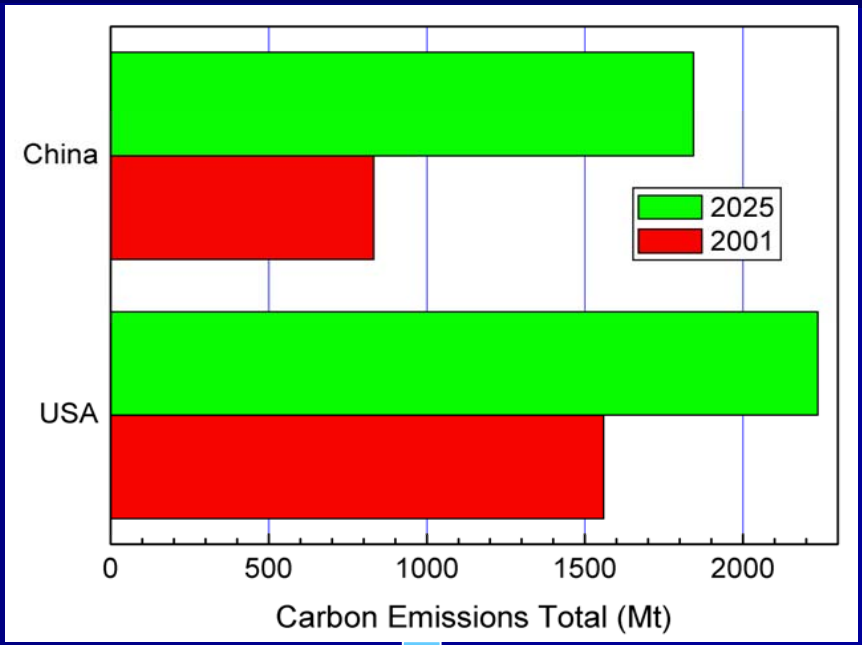


CHNG's electric power development



Coal's problem

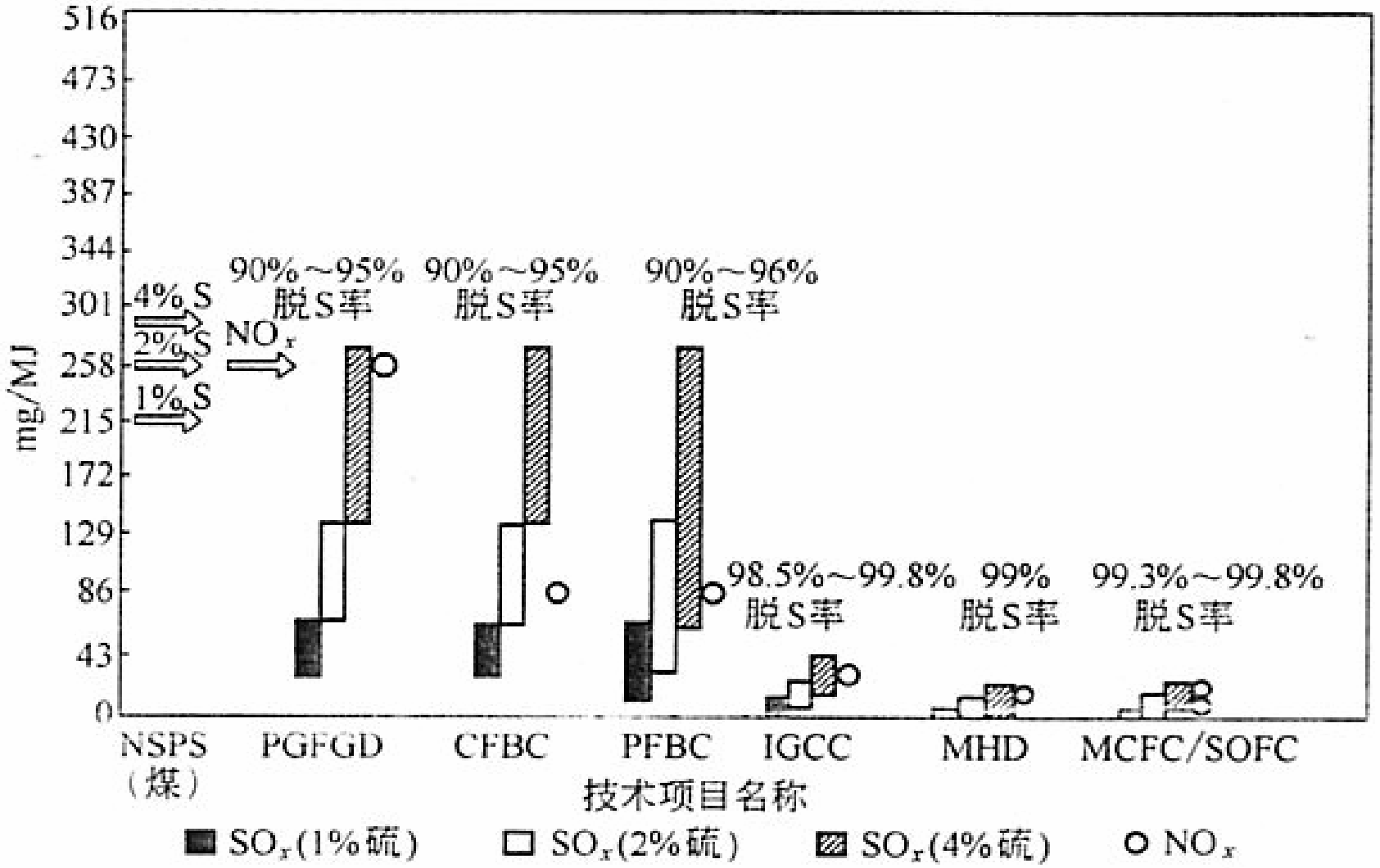




Average Coal Consumption Ratio (by end of 2006)
China:366g/kWh
World:320 g/kWh

How to increase efficiency?
How to reduce emissions?

Emission of thermal power technologies



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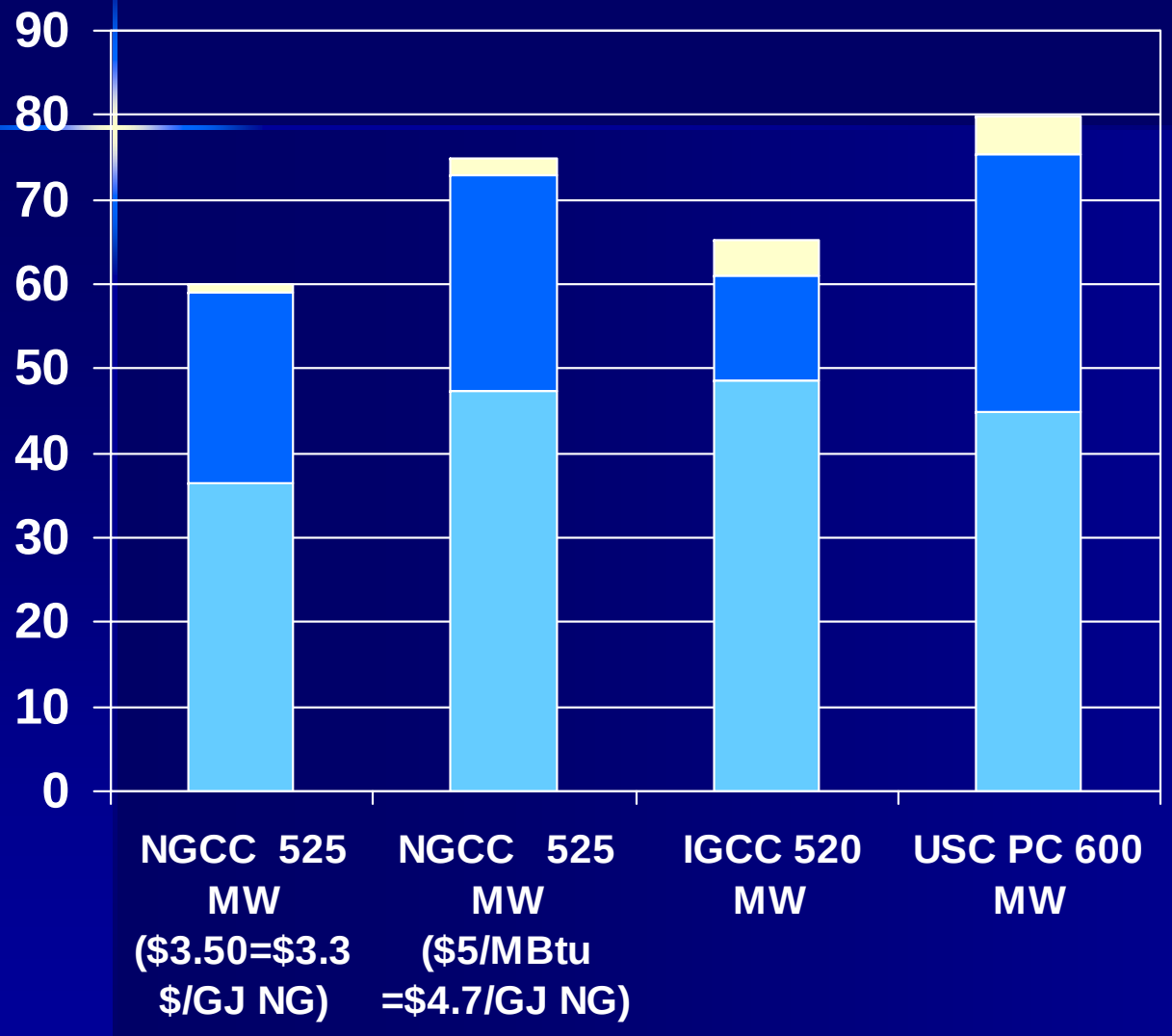
COE with CO_2 capture and sequestration



- COE $MWh with Capture & Sequestration
- COE $/MWh with CO2 Capture
- COE $/MWh w/out Capture

NGCC = Natural Gas Combined Cycle

IGCC = Integrated Gasification Combined Cycle

USC PC – Hi-efficiency Pulverized coal

CCT in the future

- SC/USC + FGD + SCR (deep clean, CO_2)

  ---- for near future

- CFBC (capacity, efficiency, deep clean, CO_2)

  ---- to complement USC

- PFBC（deep clean, technical barrier, CO_2)

- IGCC (reduce cost, CO_2)

  ---- for medium future

- GreenGen (high efficiency, near zero emission and H_2 production) ---- for long term future

The Objects of GreenGen

- R&DD on the integrated coal gasification, hydrogen production, power generation and CO_2 sequestration system
- To achieve high coal-based generation efficiency and near zero emission of all pollutant including CO_2
- To verify key technologies, sustain technologies and system integration technology and create “GreenGen” technology with full Chinese intellectual property right
- To conduct commercial demonstration at acceptable price and realize sustainable development of coal-based generation

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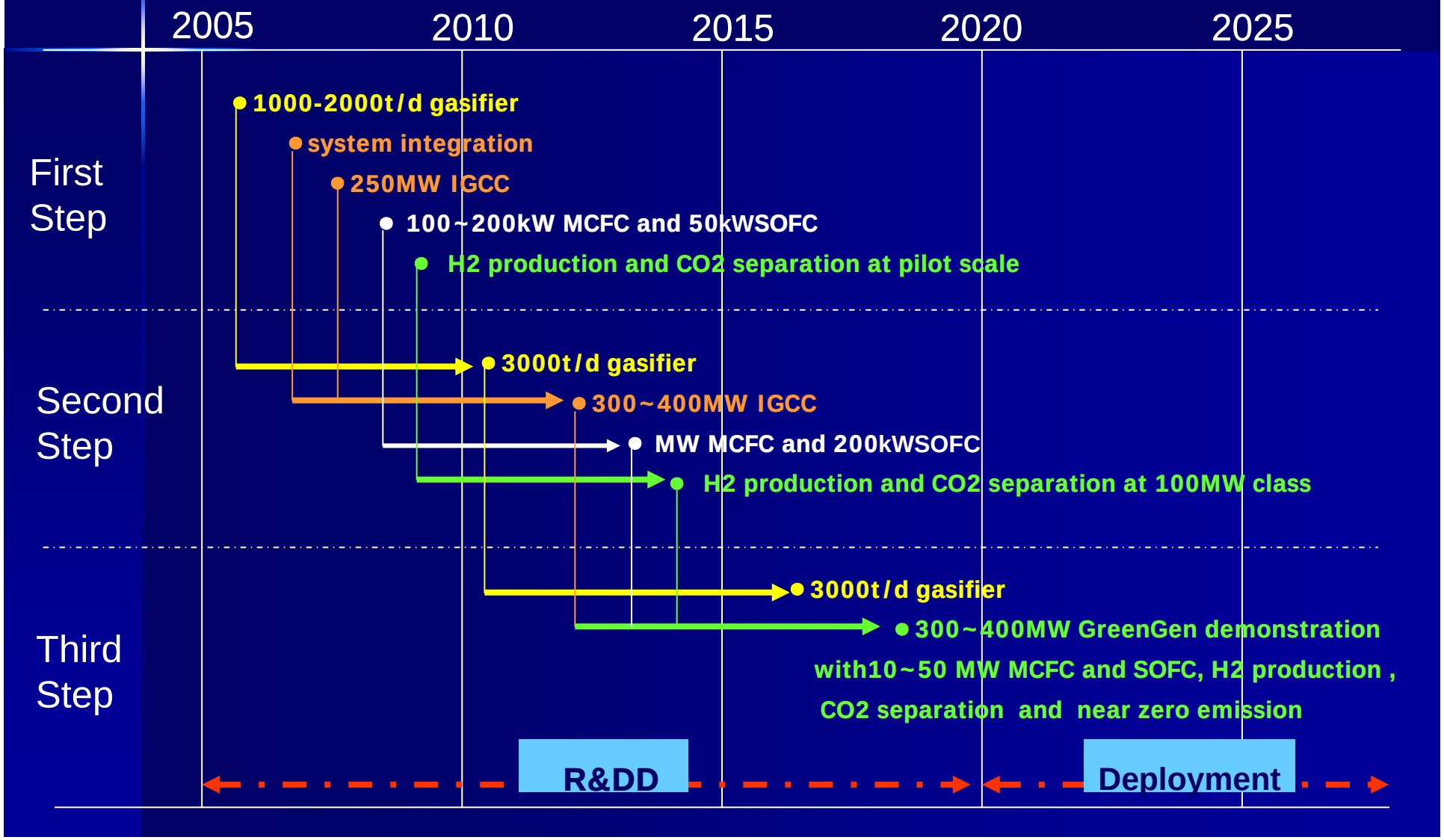
Roadmap of GreenGen Program



The final flow sheet of GreenGen

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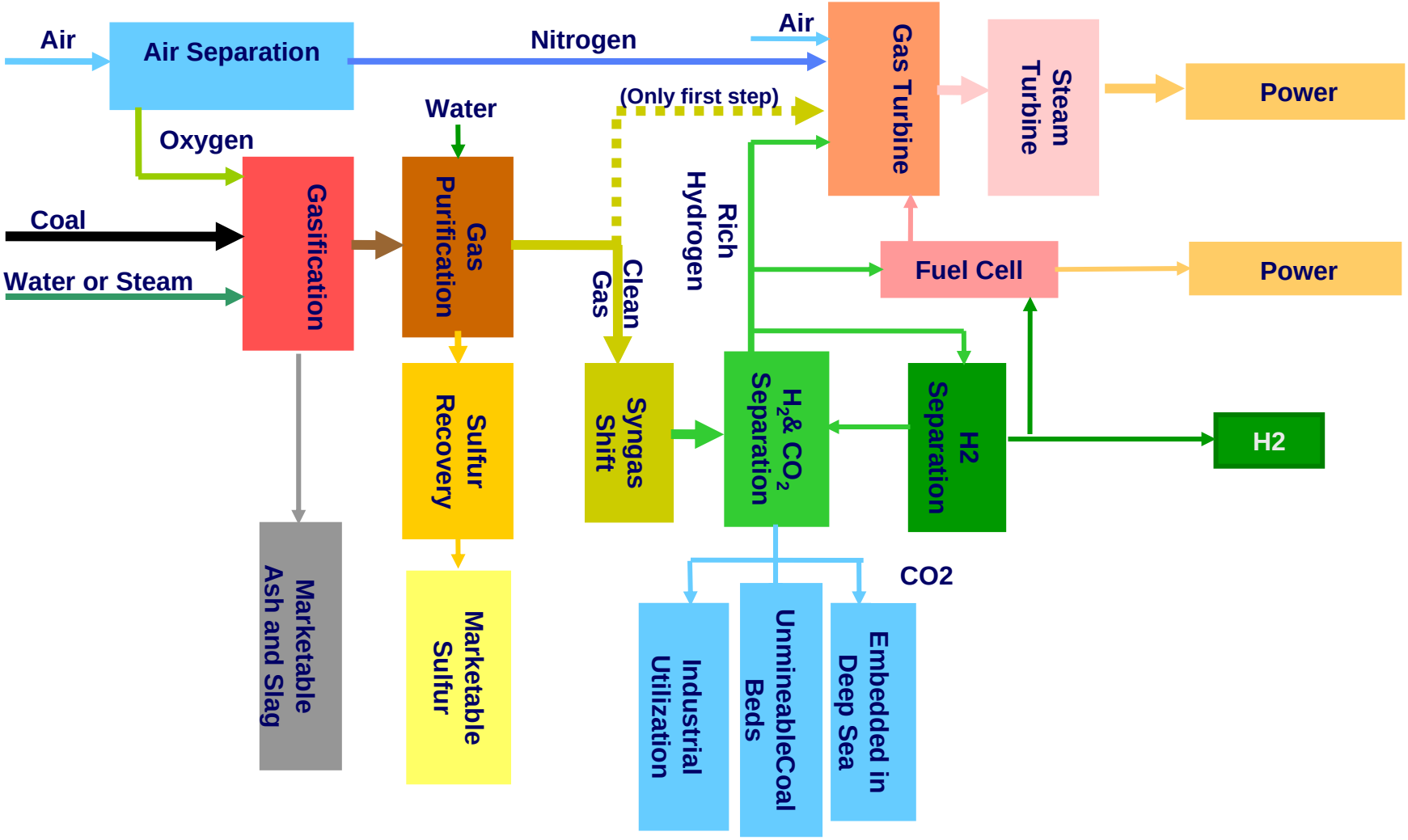

Technological goals of GreenGen

- To complete industrial demonstration project of 400MW before 2020
- Generation efficiency up to 55%-60%
- SO_2 and NOx emission less than 20mg/Nm^3
- PM2.5, Hg and VOC near zero discharge
- Over 80% of CO_2 separated and treated
- Byproducts effectively utilized
- Acceptable cost

The Flow Sheet of GreenGen Stage 1

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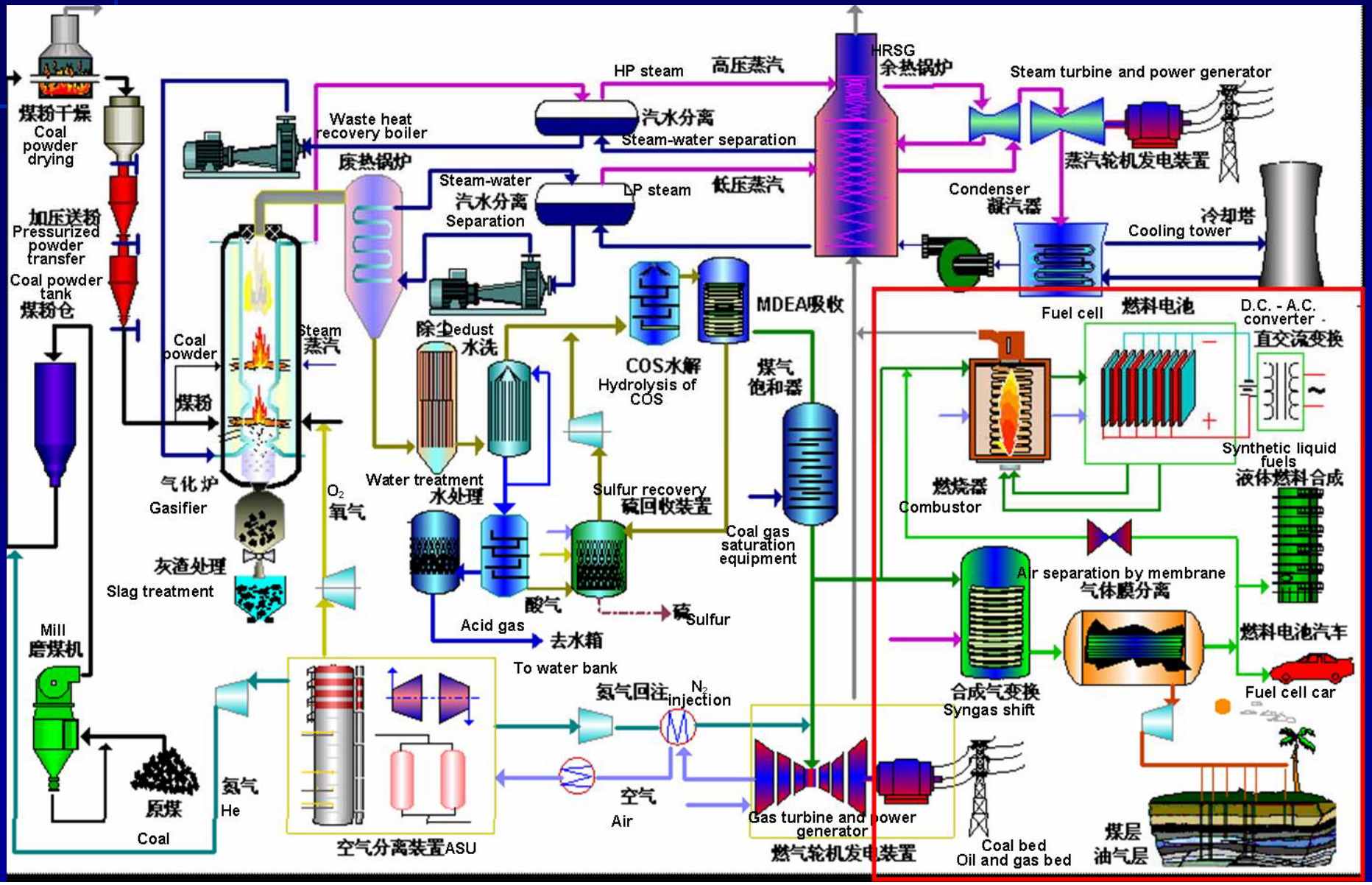

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中国华能集团绿色煤电示范工程

First stage objects

- 250MW
- Eff.(net): >42%(LHV)
- De SOx eff. : >98%
- NOx: <80mg/Nm^3(16%@ O_2)
- Operation in 2009
- <2000mRMB

Key technologies

Gasifier: TPRI-2000T/D

E - Gas turbine :

- Nanjing+ GE Turbine
- Shanghai Electric Group+ SIMENS
- Dong Fang Electric + MHI

ASU, HRSG, ST,etc.: Domestic Manufacture

Design: Domestic

GreenGen Lab.

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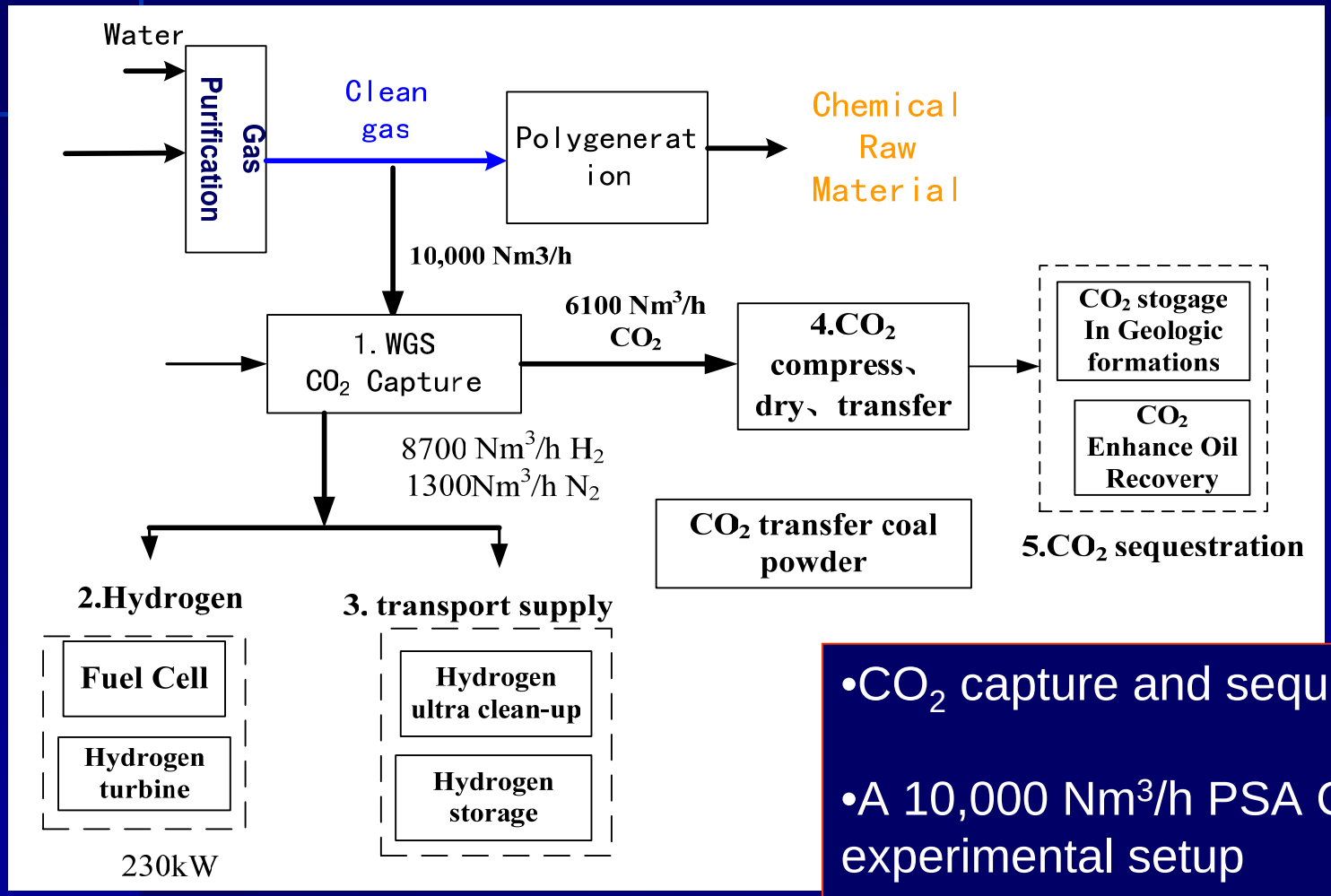

- CO_2 capture and sequestration:
- A 10,000 Nm^3/h PSA CO_2 capture experimental setup
- A 150 Nm^3/h CO_2 membrane separation capture experimental setup

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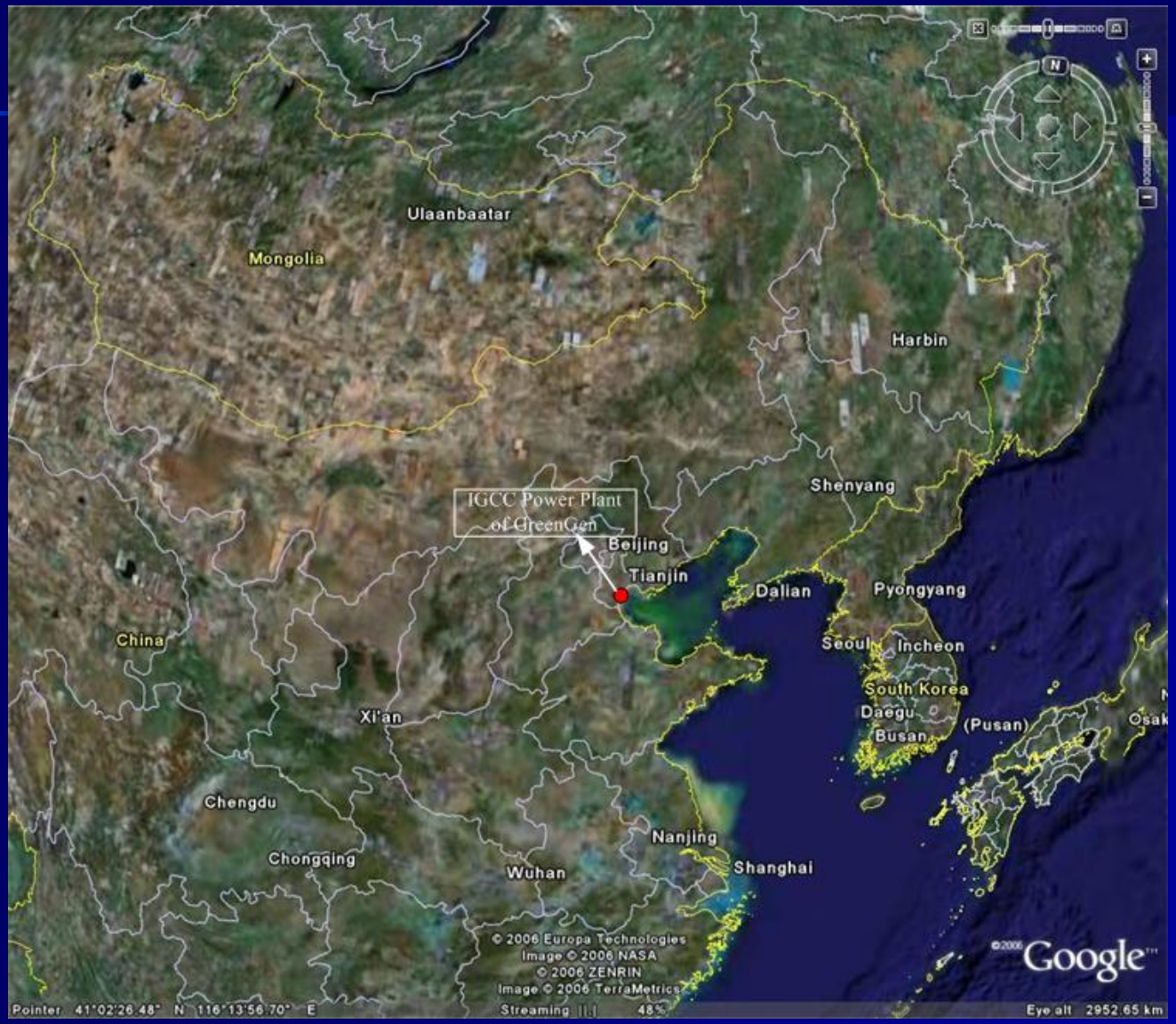
250MW IGCC Power Plant in Tianjin



Implementation of GreenGen

- CHNG approved “The Program of GreenGen ” in 2004.
- The feasibility study of the first step demonstration project has been finished in Sept. 2006, and will be started to construct in 2007 and put into operation in 2009.
- CHNG prepares to set up GreenGen Industrial Alliance, and welcome the energy companies in the world to participate in GreenGen.
- The membership agreement was singed between CHNG and the FutureGen Industrial Alliance on 27 Oct. 2005.

Vice-Premiere Zeng Peiyan meeting stakeholders

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GreenGen Ltd., Co.

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GreenGen Ltd., Co. founder agreement signing ceremony

GreenGen manifested the responsibility of state-owned energy giants in addressing energy utilization and environmental issues.

GreenGen Ltd., Co.

- China Huaneng Group, Holding Company, financial contribution 51%
- China Datang Group 7%
- China Huadian Corporation 7%
- China Guodian Corporation 7%
- China Power Investment Corporation 7%
- Shenhua Group 7%
- State Development & Investment Co. 7%
- China Coal Group 7%

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CHNG Participated in FutureGen Alliance

CHNG participated in US “FutureGen” project on Oct 27. 2005

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GreenGen stage I signing ceremony in 2006

GreenGen stage II signing ceremony on April 18th 2007

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CHNG singed the agreement about GreenGen Stage II with the government of Tianjin City ,and will build 2×400 MW GreenGen in Tianjin

Key technologies

- high efficiency and large scale gasification
- gas cleanup
- hydrogen gas turbine technology
- FC
- membrane separation
- CO_2 capture and sequestration
- system integration

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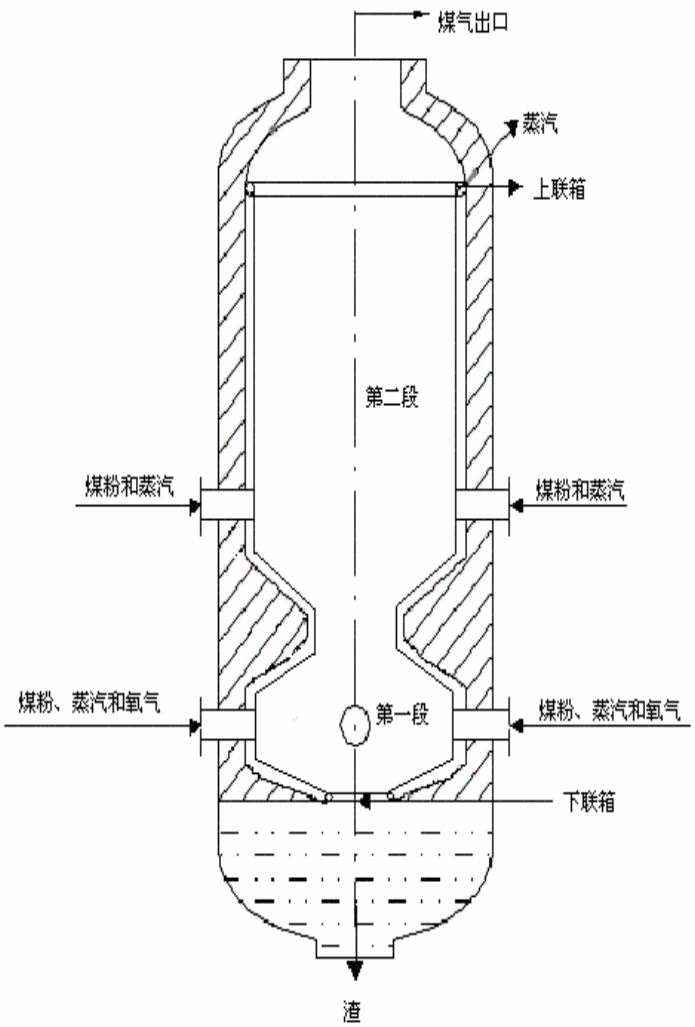
Two Stages Gasification

36t/d (10MW$_{th}$)
Funded by National "863" Program
2001-2005

700kg/d,1997-2000, funded by MOST and SPC

2000t/d， 2009

Two stages gasification



Gasifier Type:

- **oxygen Entrained flow**
- **2 Stages Reaction**
- **dry feed**
- **No syngas recycle**
- **with water cooling wall**
- **with waster heat recovery**
- **Pressure: 3.0MPa**
- **Temperature: 1300~1600℃**
- **Cold syngas efficiency: >81%**
- **$CO+H_2$>90%**
- **Carbon conversion>98%**

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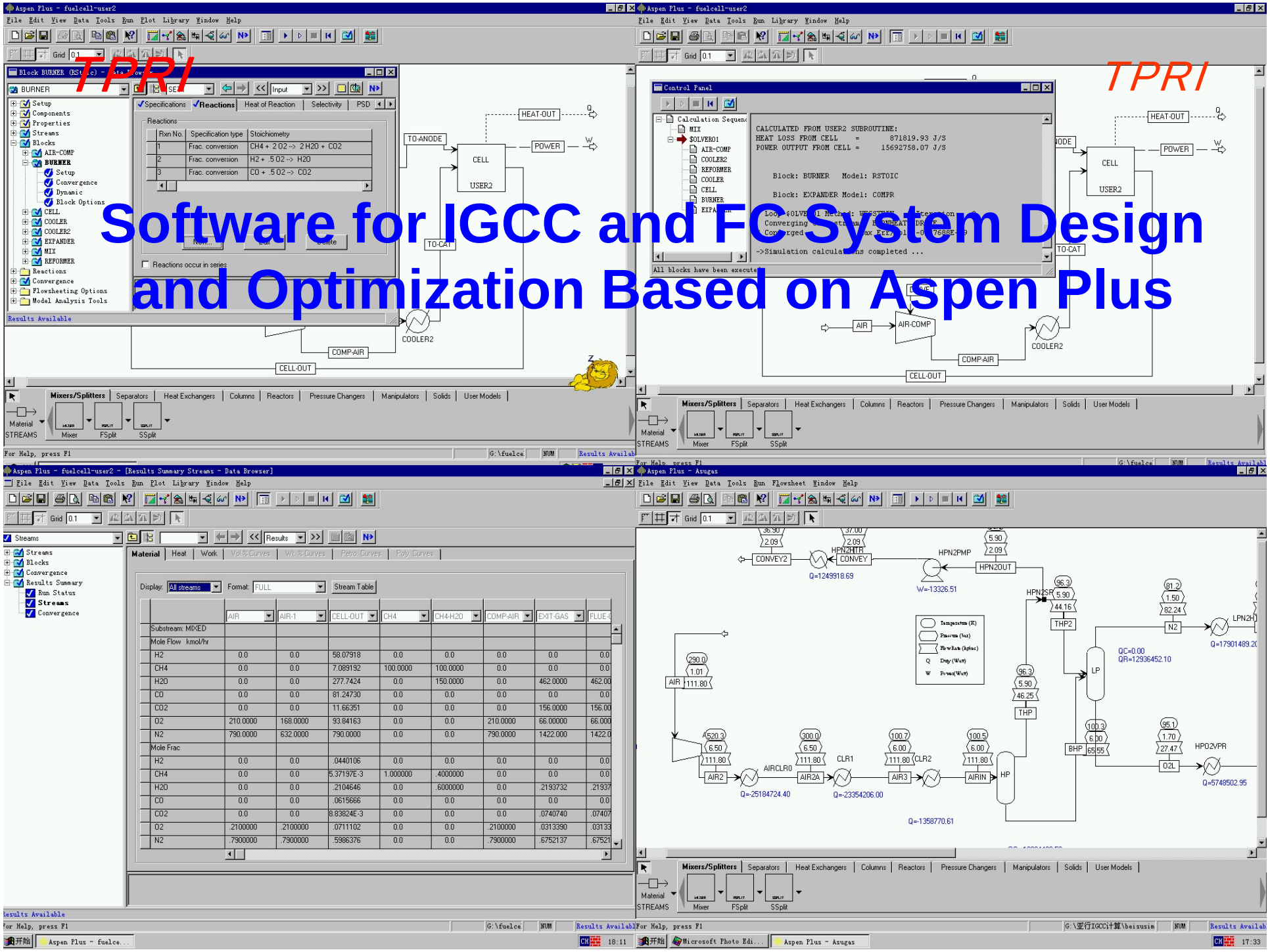
36t/d (10MW$_{th}$)
Funded by National
“863” Program
2001-2005

Syngas Cleaning Pilot Scale Facility at TPRI

Software for IGCC and FC System Design and Optimization Based on Aspen Plus



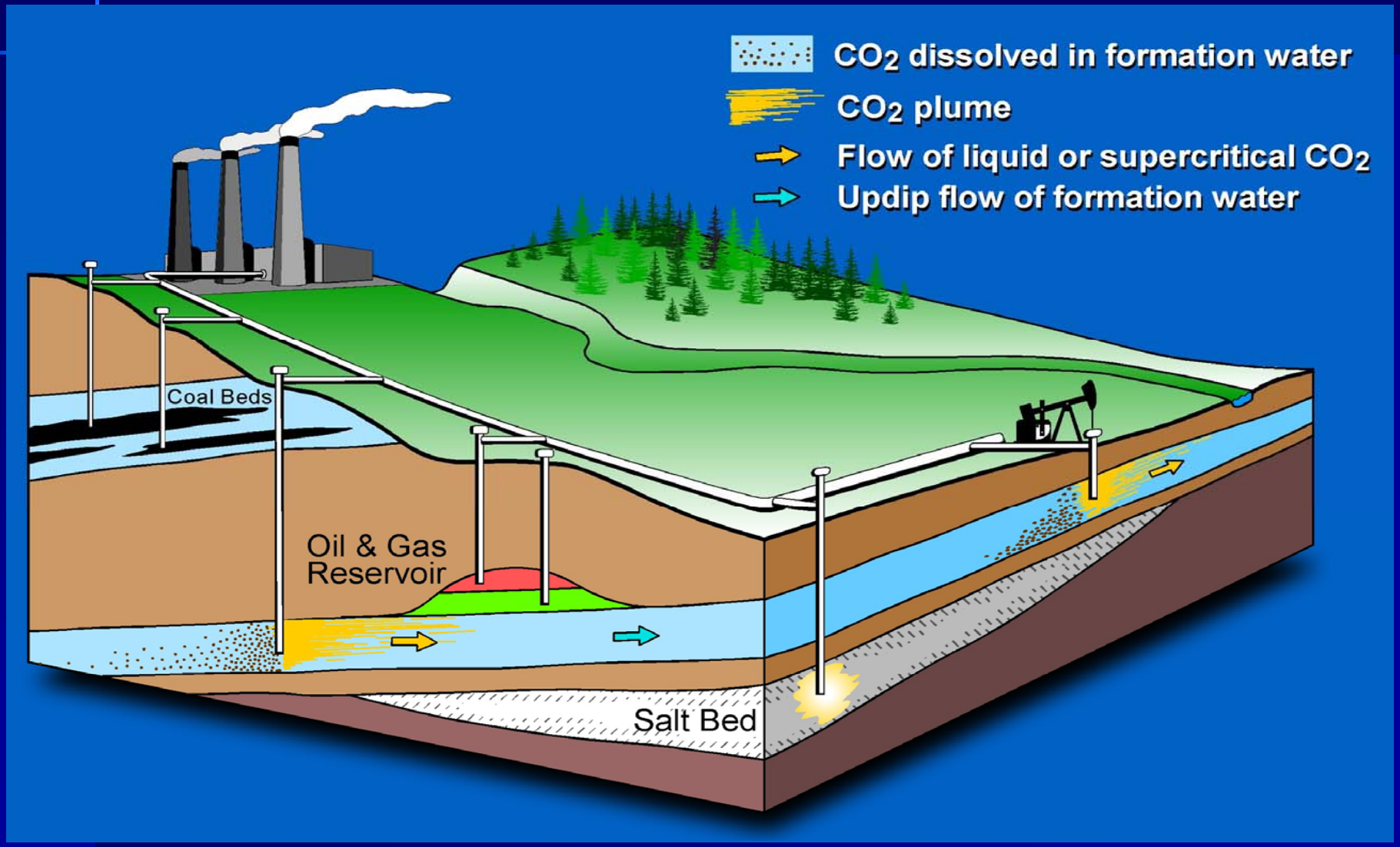
R&D on FC

- 5kW SOFC funded by MOST.
- 50kW MCFC funded by MOST.
- The software for design and optimization for FC power system funded by MOST.

H_2/CO_2 Separation

Separation methods		Shortcoming	Advantages
Absorption	Physical	Bad absorption selectivity, so good absorbent performance is the key	CO_2 can be separated only by decompressed and distilled, need little regeneration energy.
	Chemical	High energy penalty	Good absorption selectivity, CO_2 concentration can be up to 99.9%.
Adsorption	Pressure Swing Adsorption (PSA)	Limited sorbent capacity, so need more sorbent and high automatization for sorbent's frequent desorption.	Low energy penalty and simple process
Cryogenic		High energy penalty and bulky facilities	Simple principle
Membrane		Hard to get high concentration CO_2	Simple and compact facilities, so need little space. It has good efficiency and flexibility, easy to operation and low cost. No additional pollution(the cost is 25% lower than absorption)

Means of Geological Sequestration or Storage of CO_2



CO_2 storage capacity in China

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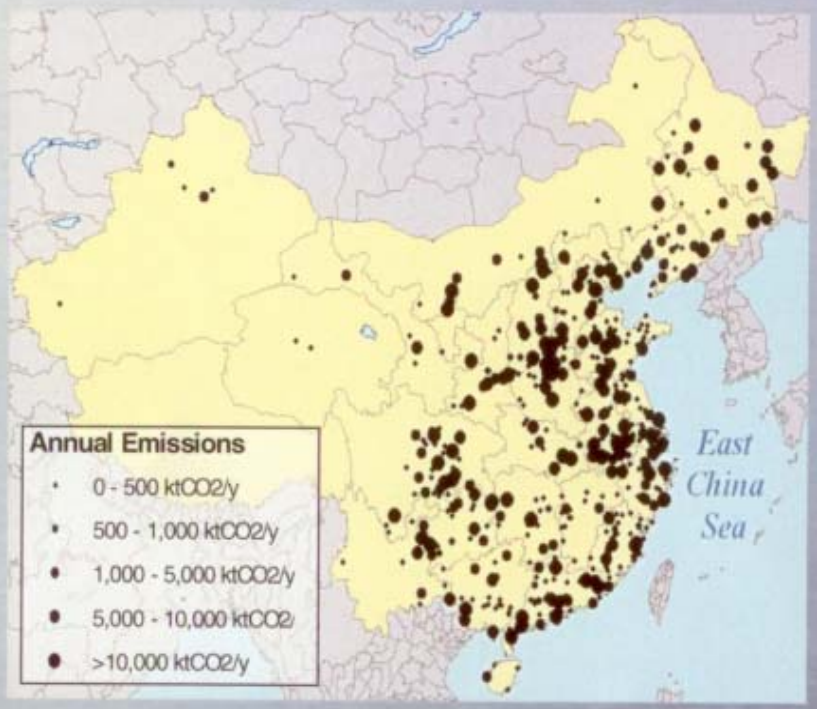
Sources by type

Sources by annual emissions



26 $GtCO_2$ storage capacity identified in the literature within Chinese coal-beds, depleted oil and gas fields

360 $GtCO_2$ storage capacity in deep saline formations in China estimated

CO_2 storage in deep geologic formation and enhance oil recovery

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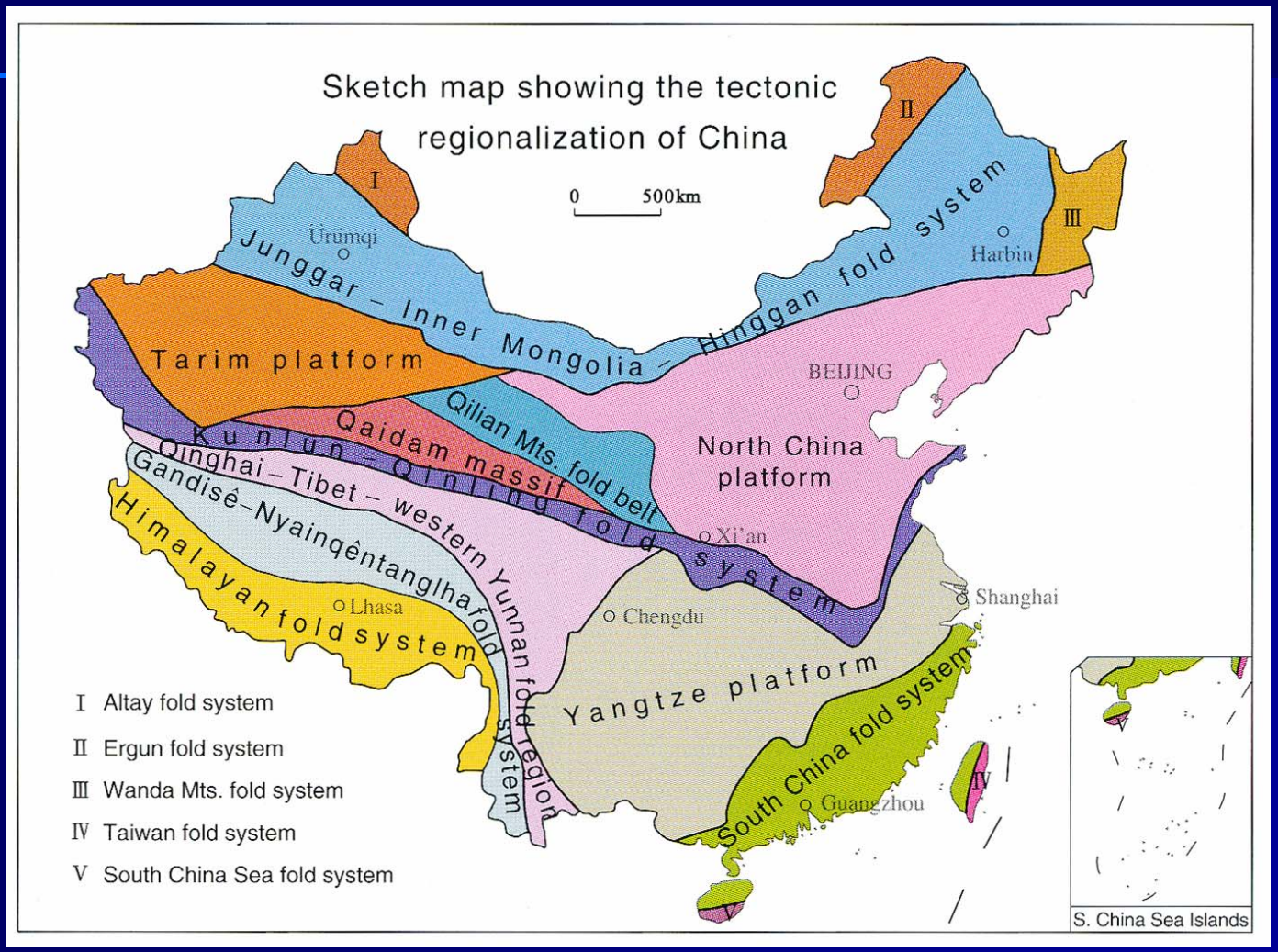
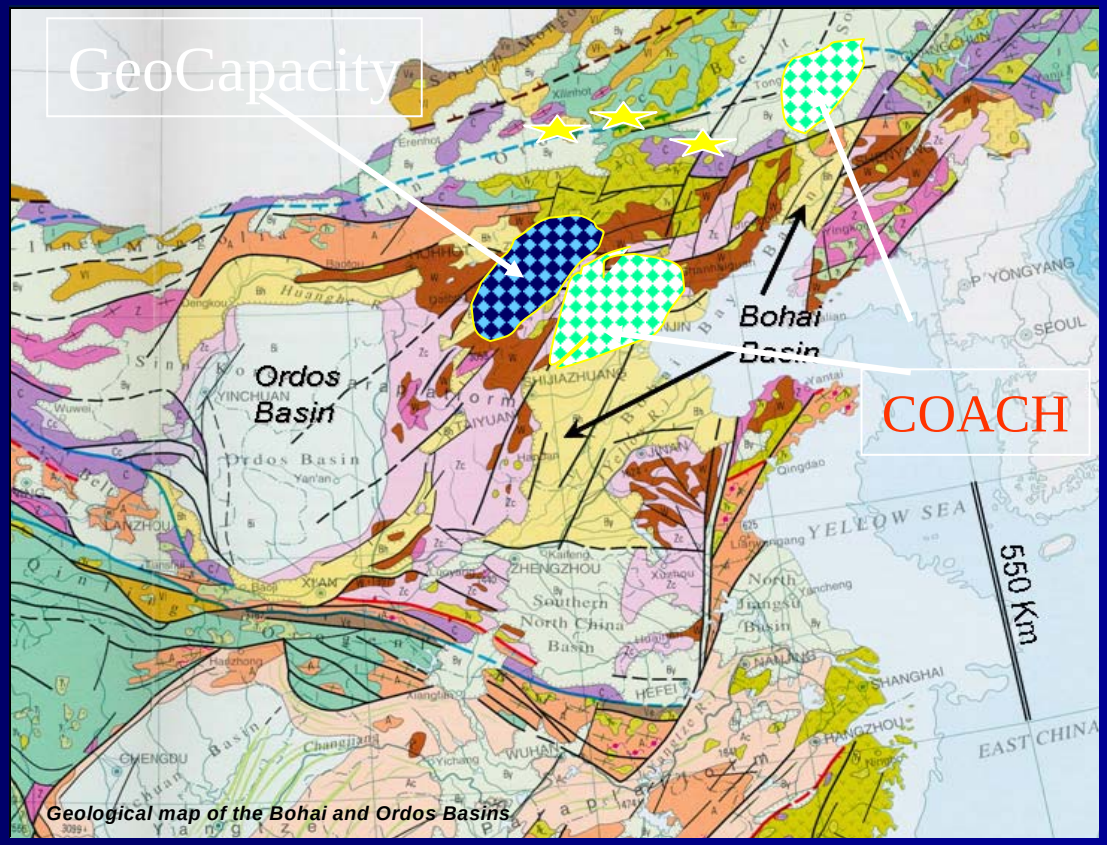


TPRI,GreenGen Co. joined the COACH and will join the cooperation with UK for CO_2 capture and sequestration



Geological map of the Bohai and Ordos Basins

Summary

- China needs GreenGen
- Roadmap of GreenGen Program was ready in 2004
- First stage demonstration project is based on the China's intellective property, and will go into operation in 2009
- Demonstration project is funded by MOST

Thank you for your attention !

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