*Understanding the Carbon Journey*
*AAAS Annual Meeting ："Science and Technology from a Global Perspective*
*Feb. 14-18 in Boston*

# Meet Energy Needs and Reduce $CO_2$ Emission
## —— A Chinese Perspective

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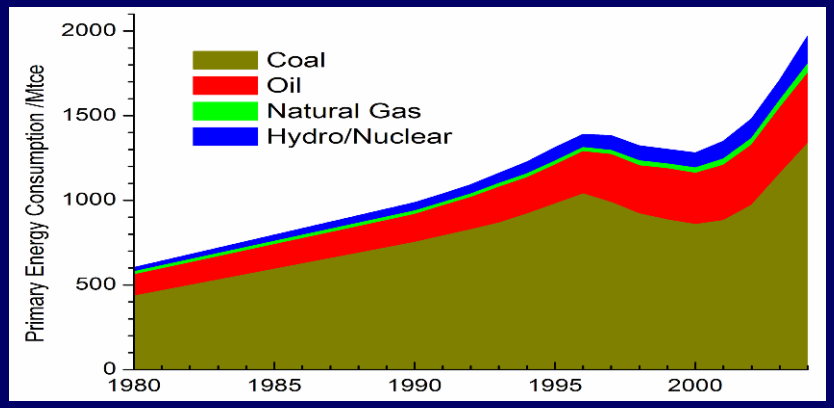
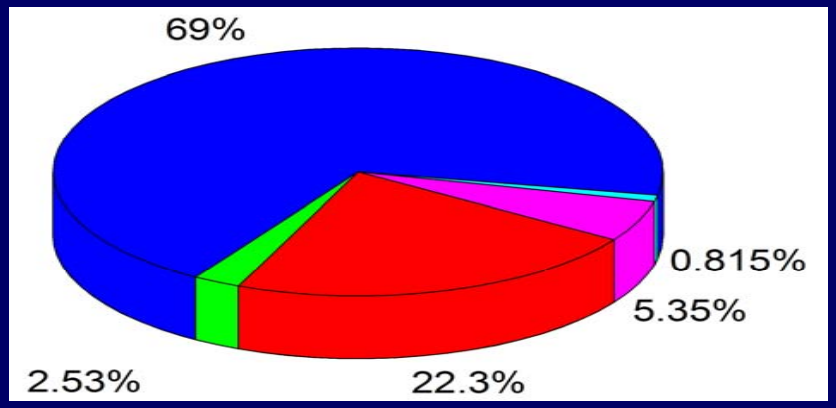
# Great Challenges for Sustainable Development of China Energy

- Huge and uncertain future energy demand .vs. Limited energy producing and supplying capability
- Environment protection .vs. Severe pollution caused by energy using
- Energy security .vs. increasing oil demand & oil importing
- Fast urbanization .vs. shortage of clean fuel supplying
- Global warming .vs. Increasing & huge CO2 emission

# Primary Energy Development (2004)




- **production – 1.846 btce**
  - **Coal: 1.956 Billion tons**
  - **Oil: 175 Million tons**
  - **Power: 2187 Billion kWh**
- **consumption – 1.97 btce**
  - **Coal: 69%**
  - **Oil: 22.3%**
  - **Natural Gas: 2.5%**
  - **Hydro: 5.35%**
  - **Nuclear: 1%**

**Oil remains the largest single source of energy in most parts of the world. Coal is the dominant fuel in China**

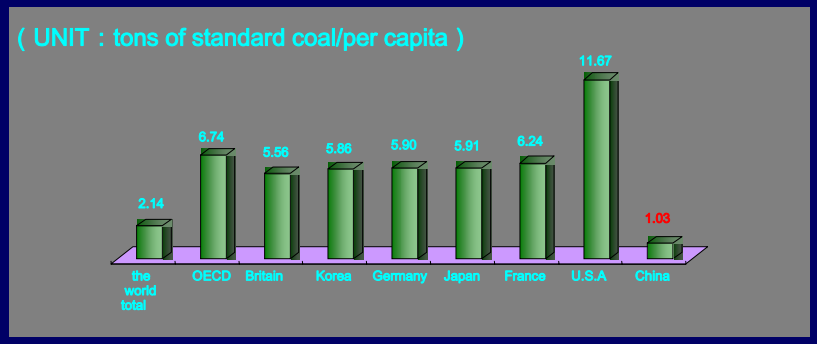
*China National Statistics Bureau*

# Status of China's Energy

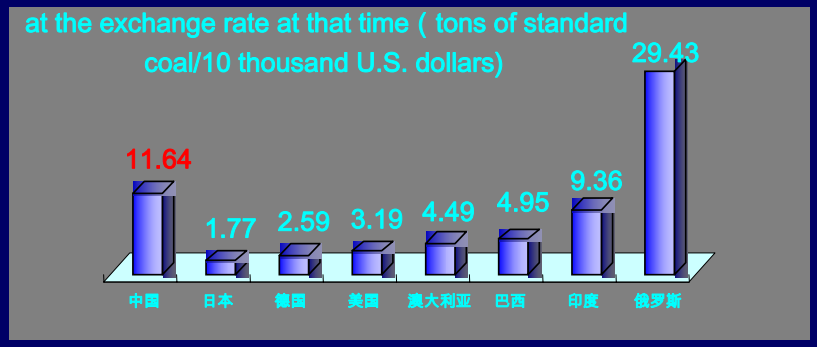
- **Ranked 1st in the world**
  - Coal production & consumption
  - $SO_2$ emission
  - Population
- **Ranked 2nd in the world**
  - Energy production & consumption
  - Oil consumption & import
  - Power market
  - $CO_2$ emission

# Other Features of China's Energy

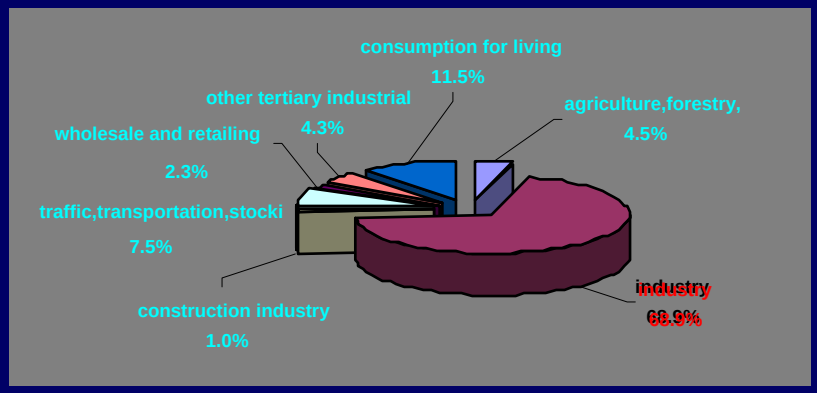
- **Low per capita energy consumption**




- **High energy intensity, low energy efficiency**

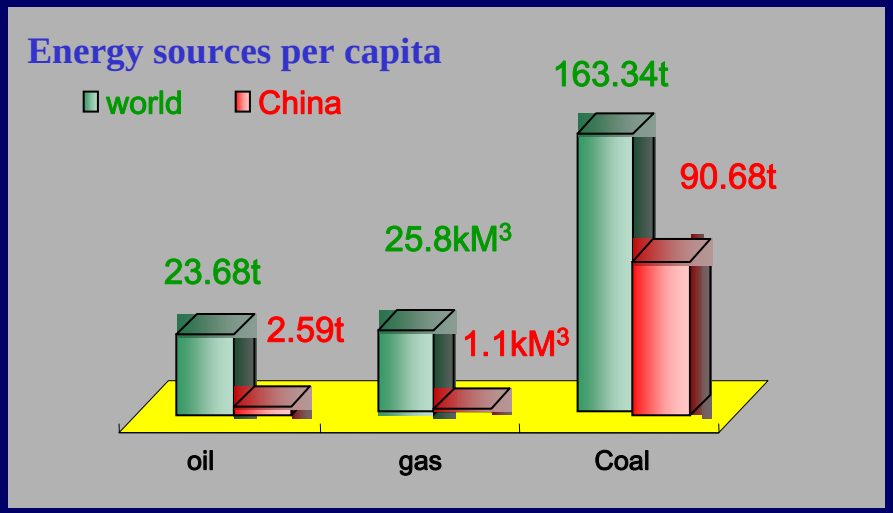


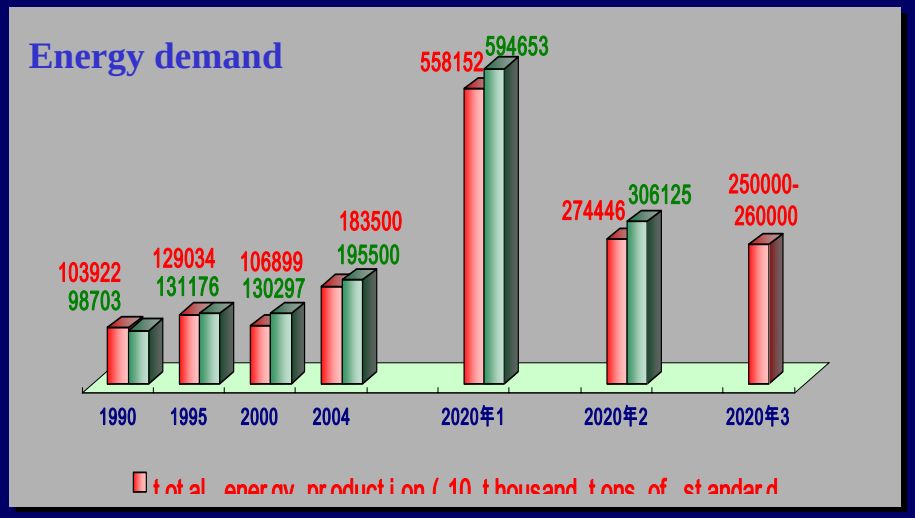

- **Industry is the dominant energy consumer**



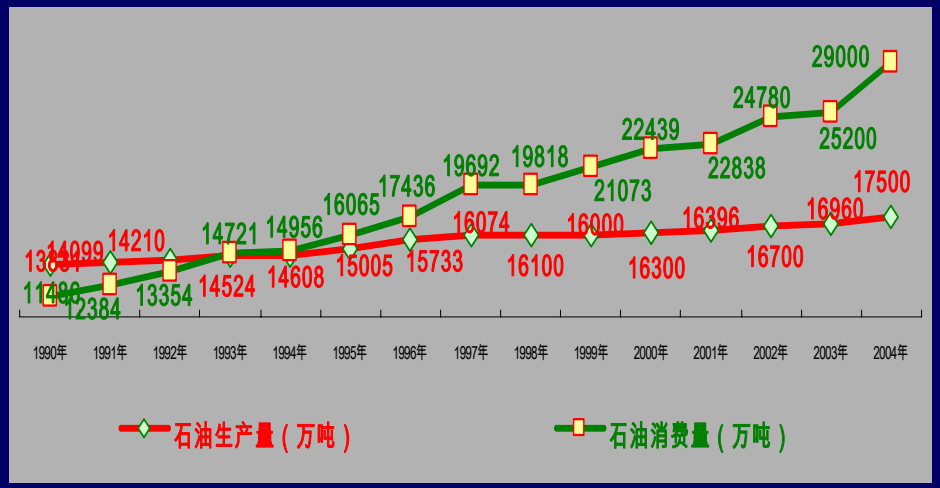
# Challenges – Supply & Demand, Resources

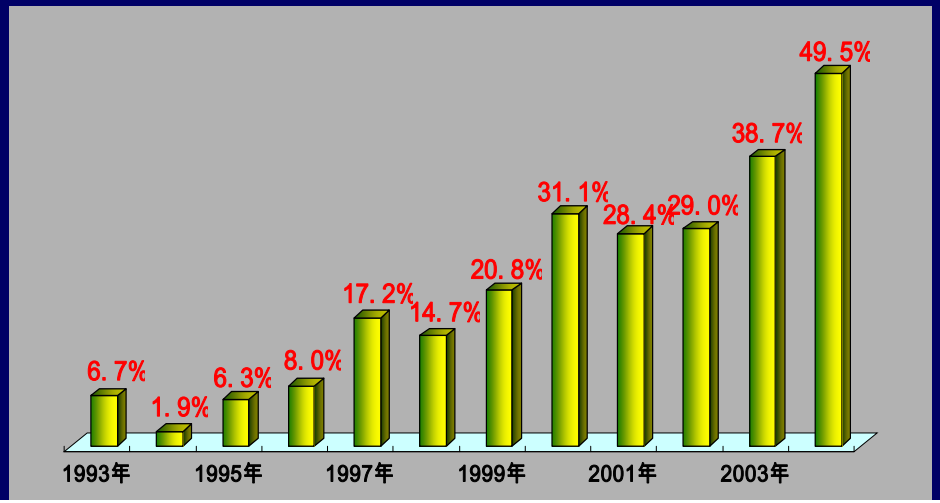
- **Recoverable reserves per capita are far below the world average levels**
  - Oil: 2.60 tons, 11.1% of the average level of the world
  - Natural Gas: 1074 $m^3$, 4.3% of the average level of the world
  - Coal: 90 tons, 55.4% of the average level of the world



# Challenges – Security, Oil Import Dependency



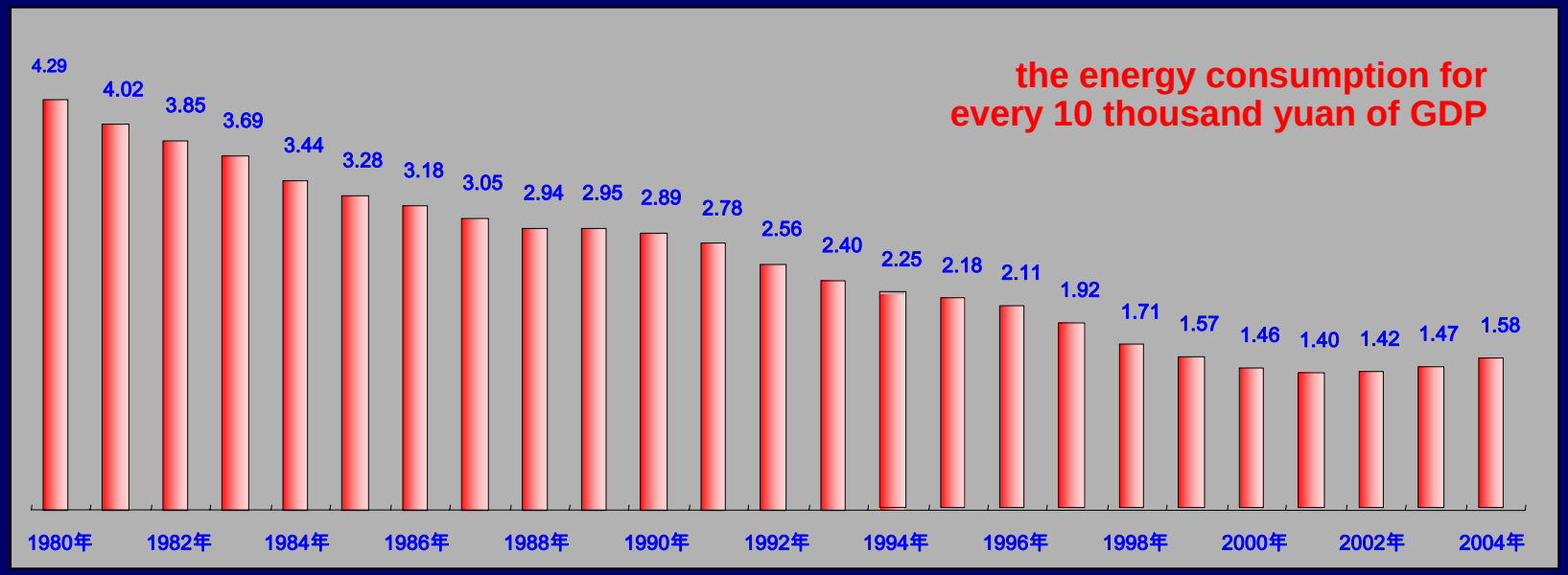




- **In 2020 (Institute of Energy, China)**
  - 450-610 million tons oil demands
  - 180-200 million tons domestic oil productions
  - Import dependency, 60% (same as the present US level)
- **Chain-reacting Anxiety**
  - Oil supply disruption & price fluctuation
  - Shaken Energy security
  - Vulnerability of Economies & Social security to oil

*World Energy Outlook, IEA, 2004*

# Challenges – Energy Efficiency, Energy-Saving

- **Energy Efficiency**
  - Low energy efficiency, 31.2%
  - Unit energy consumption of main industrial products is 30% higher than that of developed countries
- **Energy-Saving**



# Challenges – Environmental Impacts

- **Coal, the main source of gaseous contaminants**
  - 70% particles
  - 70% $CO_2$
    - ranked 2nd in the world now
    - undergo great pressure from the global appeal for Greenhouse Gas abatement
  - 90% $SO_2$
    - Totally 19.48 Mt, ranked 1st in the world now
    - acrid rain area exceeds one third of China's total area
  - 67% $NO_X$
- **Environmental capability and emissions**
  - capability
    - $SO_2$, 16.20 Mt
    - $NO_X$, 18.80 Mt
  - Emissions of 2020, business as usual
    - $SO_2$, 40.0 Mt
    - $NO_X$, 35.5 Mt

# Energy Development Strategic Goals – Sustainable Development

- **Goals**
  - 2020, quadruples Gross Domestic Product (GDP) of 2000 by only doubling energy consumption
- **Strategies**
  - Assuringly meets the increasing energy demands in the future
  - By energy efficiency improvement and energy saving, achieves high-speed society and economy development at the price of lower energy growth rate
  - Adjusts the energy and industrial structures
  - By protecting the domestic local environments and global climate, realizes the sustainable development

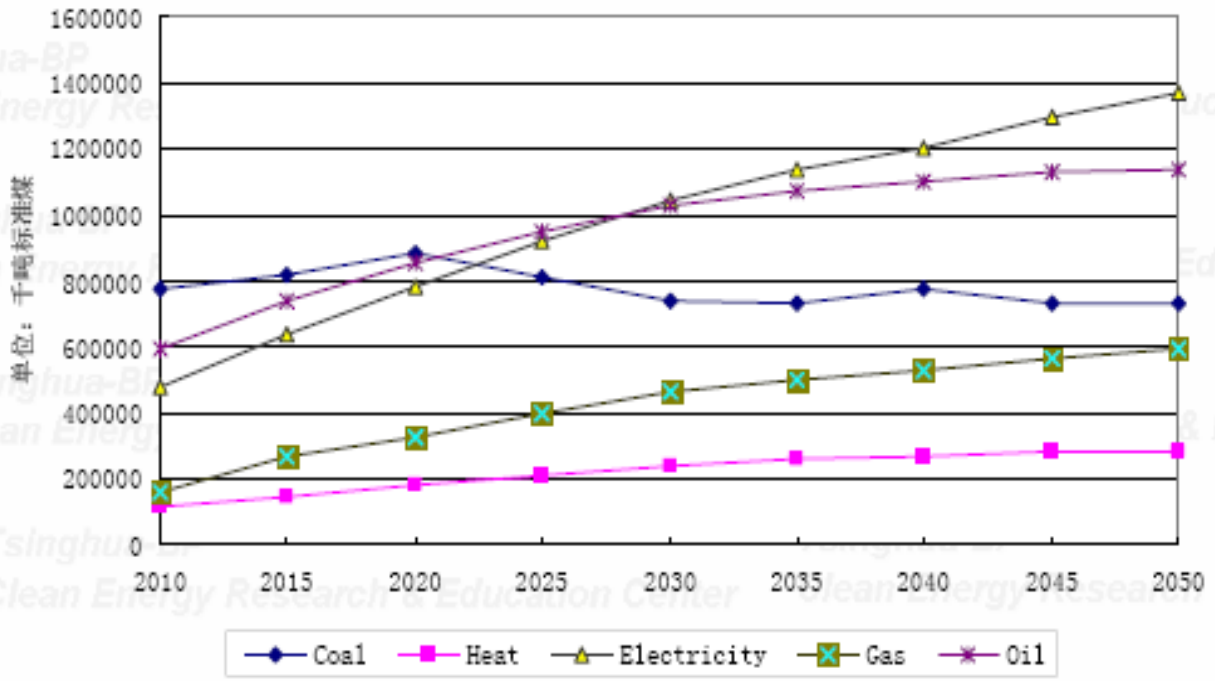
# Development of alternative energy

- **Natural gas—high price, best for household using**
  - Local resource exploring and NG importing still at the beginning, always need long distance transportation, restricted supply & high price.
  - In 2030, at most 400-500 billion cube meters, only 0.5-0.6 billion tce (total energy consumption >4 billion)
- **Nuclear—limited building speed**
  - Nuclear: 40 GW in 2020, at most 120-160 GW in 2030, only 0.11-0.15 billion tce
- **Hydro--limited total resource**
  - 400 GW at most, only 0.17 billion tce
- **Renewable--high price/ immature technology / low quality**
  - Wind power
  - Solar power/heat: at most
  - Biomass power/heat/liquid fuel
  - Geothermal power/heat
  - Ocean energy

# Coal will still be the major energy resource before 2050

- **Case of accelerating Nuclear/Hydro/Renewable energy:**
  - Accelerating the development of nuclear/hydro/renewable
  - Coal still be the major primary energy, 42% at total primary energy consumption in 2050
- **Case of stabilize CO2 emission after 2025 at 2005's level:**
  - Accelerating the development of nuclear/hydro/renewable
  - Applying CCS before 2025, which means more coal consumption
  - Fraction of coal in total primary energy consumption increase to 44% in 2050
- **Case of control oil import dependency at 60% after 2010:**
  - Develop bio-fuel and coal-derived fuel
  - Fraction of coal in total primary energy consumption increase to 52% in 2050

# Fast increasing of electricity/oil demand before 2050 (BAU Case)




Assumption: GDP increase about 10% before 2010, then decrease to 8.4%, 6%,3.5%,3.5% in the following 4 decades

**China is currently constructing the equivalent of two,500 megawatt, coal-fired power plants per week and a capacity comparable to entire UK power grid each year**

# Developing Clean Coal Technology (CCT) is essential for sustainable development of China energy

- **Power generation:**
  - Improving efficiency and reduce emission for conventional technology SC/USC/CFBC)
  - Applying new technology such as IGCC/FC
  - Considering CO2 reduction in a appropriate time
- **Alternative liquid fuel :**
  - Coal to liquid: using relative abundant energy to alternate scarce energy (MEOH/DME/DTL/CTL/H2) for energy security
- **Polygeneration system integrated energy/economy/environment:**
  - Energy system based on coal gasification, which could supply power/liquid fuel/chemicals with high efficiency/near zero pollution/ near zero CO2 emission/ low cost,

# CCT for Power generation (conventional tech.)

- **SC/USC： Deploying, efficiency around44%**
  - Barrier: high investment, lack of experience for long time running
  - Potential: the main selection of power plant built before 2020
  - Policy: improving economy and accumulating experience to be competitive before 2010
- **CFBC: competitive, small unit scale**
  - Barrier: scale limited, no compensation for lowing pollution and burning low grade coal
  - Potential: an important selection for combined with SC/USC
  - Policy: scale up, and restrict environmental standard, preferential policies for burning low grade coal, make it more competitive before 2010
- **CCS: post combustion carbon capture, more cost added and efficiency reduced**

# CCT for Power generation (new technology)

- **IGCC： building demo, efficiency expected to be 40-45%**
  - Barrier: high investment and cost, low reliability, lack of experience
  - Potential: super clean and easy for CCS, easy to be changed into polygeneration, may be the dominant technology in the future
  - Policy: increase R&D and finance supporting, international collaboration, make it completive before 2020
- **FC： in R&D, efficiency expected to be 40-60%, even 80-90%**
  - Barrier: small scale, extremely high cost, short life time and low reliability
  - Potential: a section for combined with IGCC, suit for distributed power supply in the future, still far away
  - Policy: increase R&D, make it competitive before 2030
- **CCS: pre-combustion capture, lower cost added and lower energy compensation than post combustion capture**

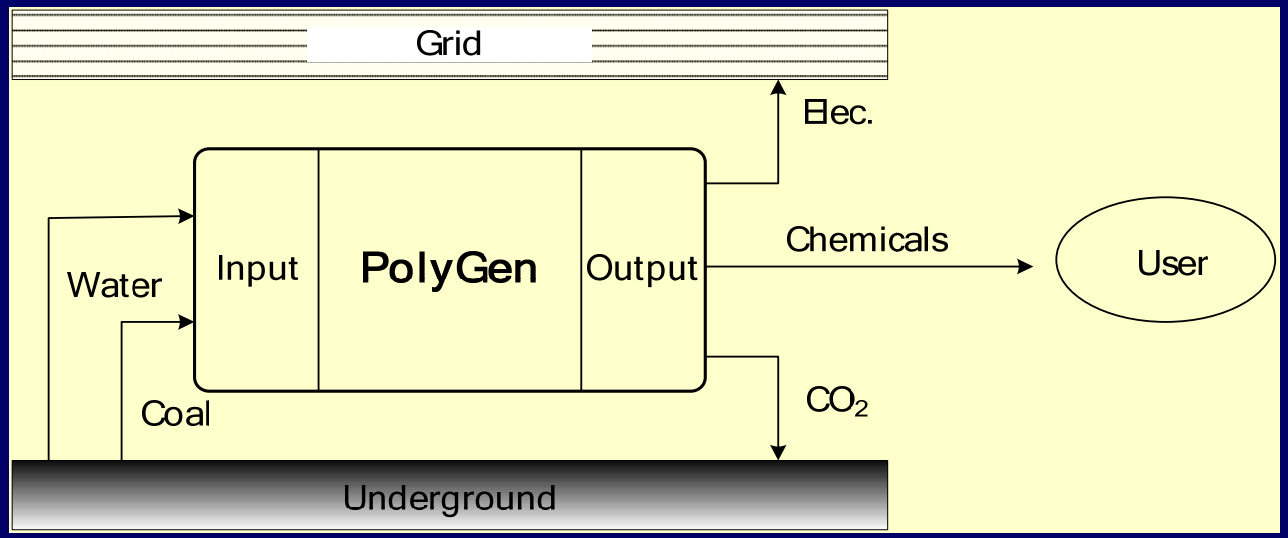
# CCT for liquid fuel production

- **Coal to methanol: regional deploying, M5-M15 gasoline**
  - Barrier: public acceptance, engine erosion, no market incentive policy from national level
  - Potential: could be thousands of tons for alternative vehicle fuel
  - Policy: engine technology, market incentive and public education, develop M100 vehicle fleets. Make it competitive before 2010
- **Coal to DME: competitive for domestic fuel, demo for transportation fuel**
  - Barrier: no market incentive, small scale/ high cost, engine technology in developing
  - Potential: large scale alternatives for LPG, important selection for alternative vehicle fuel (for diesel)
  - Policy: scale up production, market incentive in domestic using, finance support for vehicle fuel

# CCT for liquid fuel production

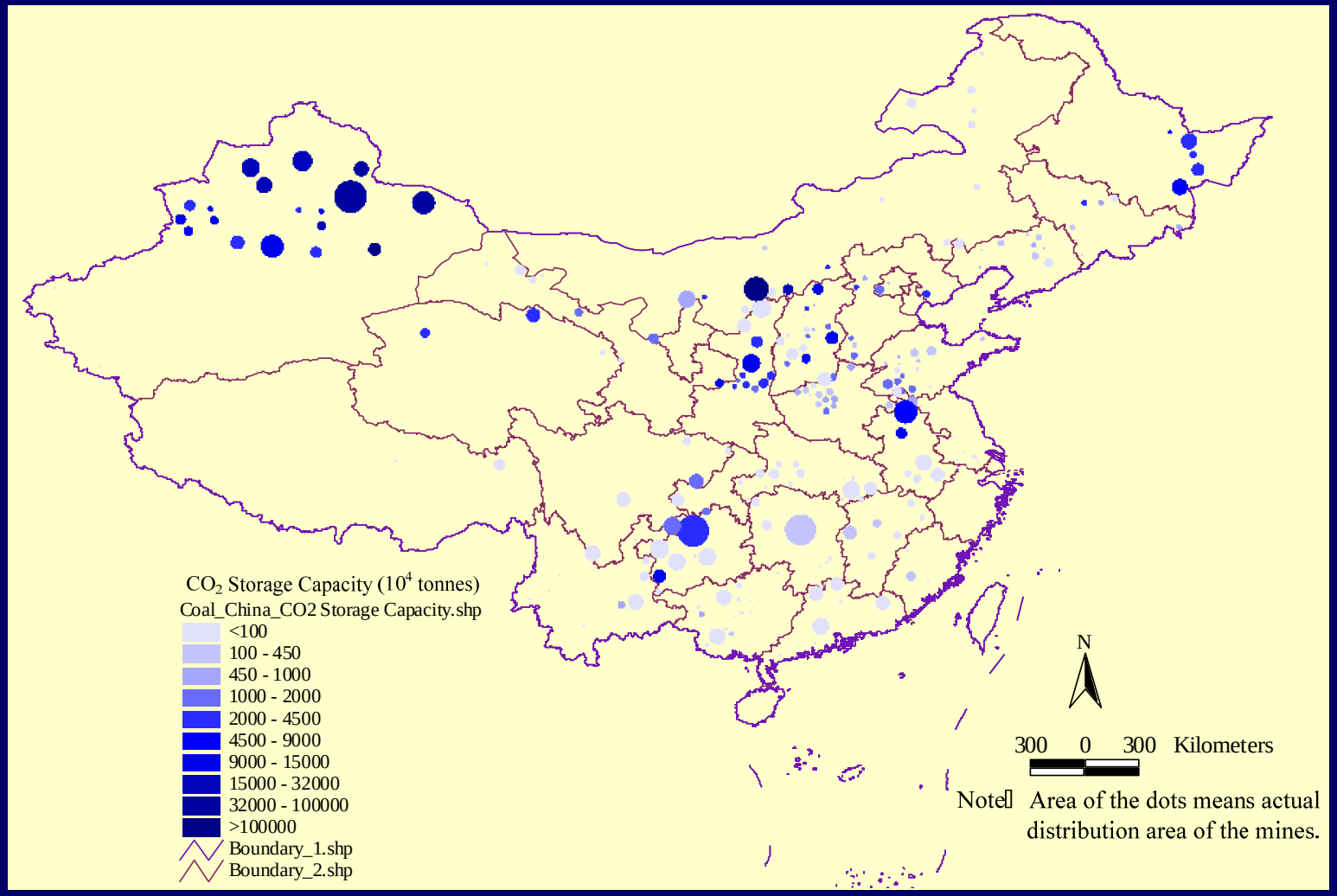
- **Coal to liquid: building demo**
  - Barrier: high investment, economic risk, no market incentive, CO2 emission
  - Potential: the major selection for secure oil supply
  - Policy: increase finance supporting and market incentive, build large scale plant before 2020, and indirectly coal to liquid should be preferred
- **Coal to H2: R&D**
  - Barrier: technology, infrastructure cost
  - Potential: competitive after 2040
  - Policy: R&D, small scale demo

# Polygeneration Energy System (PES) with CCS

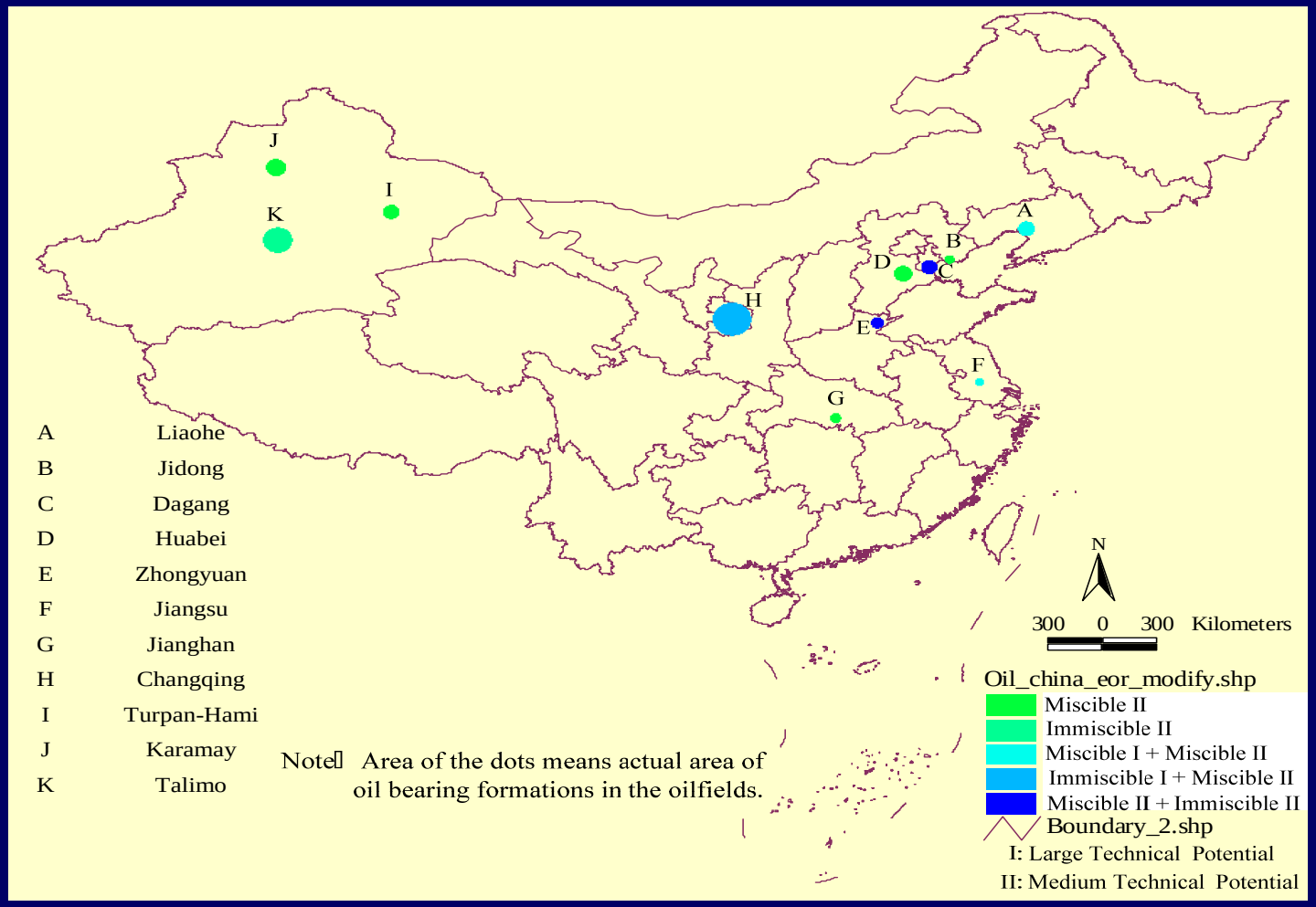



- Polygeneration Energy System (PES) provides convenient and flexible options for the implementation of CCS in China.
- The layout and location of PES in China is a pivotal issue should be considered betimes.
- The problem is affected by many factors including the suppliability of water and coal resources in upstream and the exportability of several types of products in downstream.

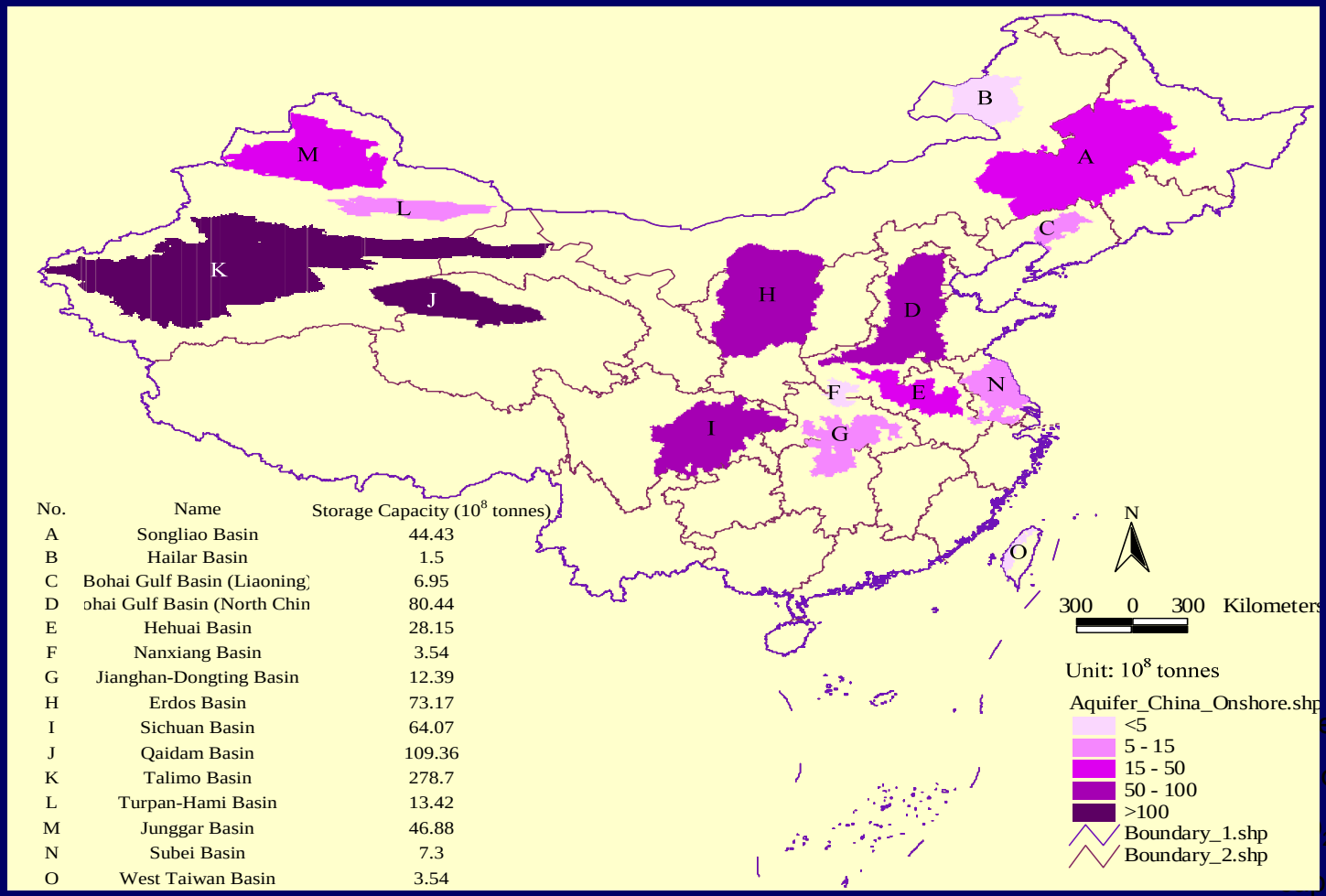
# Atlas of Unmineable Coal Seams with $CO_2$ ECBM Potential in China



# Atlas of Onshore Oil fields with $CO_2$ EOR potential in China



# Atlas of Deep Saline Aquifer for $CO_2$ Storage in China




| No. | Name | Storage Capacity ($10^8$ tonnes) |
|---|---|---|
| A | Songliao Basin | 44.43 |
| B | Hailar Basin | 1.5 |
| C | Bohai Gulf Basin (Liaoning) | 6.95 |
| D | ohai Gulf Basin (North Chin | 80.44 |
| E | Hehuai Basin | 28.15 |
| F | Nanxiang Basin | 3.54 |
| G | Jianghan-Dongting Basin | 12.39 |
| H | Erdos Basin | 73.17 |
| I | Sichuan Basin | 64.07 |
| J | Qaidam Basin | 109.36 |
| K | Talimo Basin | 278.7 |
| L | Turpan-Hami Basin | 13.42 |
| M | Junggar Basin | 46.88 |
| N | Subei Basin | 7.3 |
| O | West Taiwan Basin | 3.54 |

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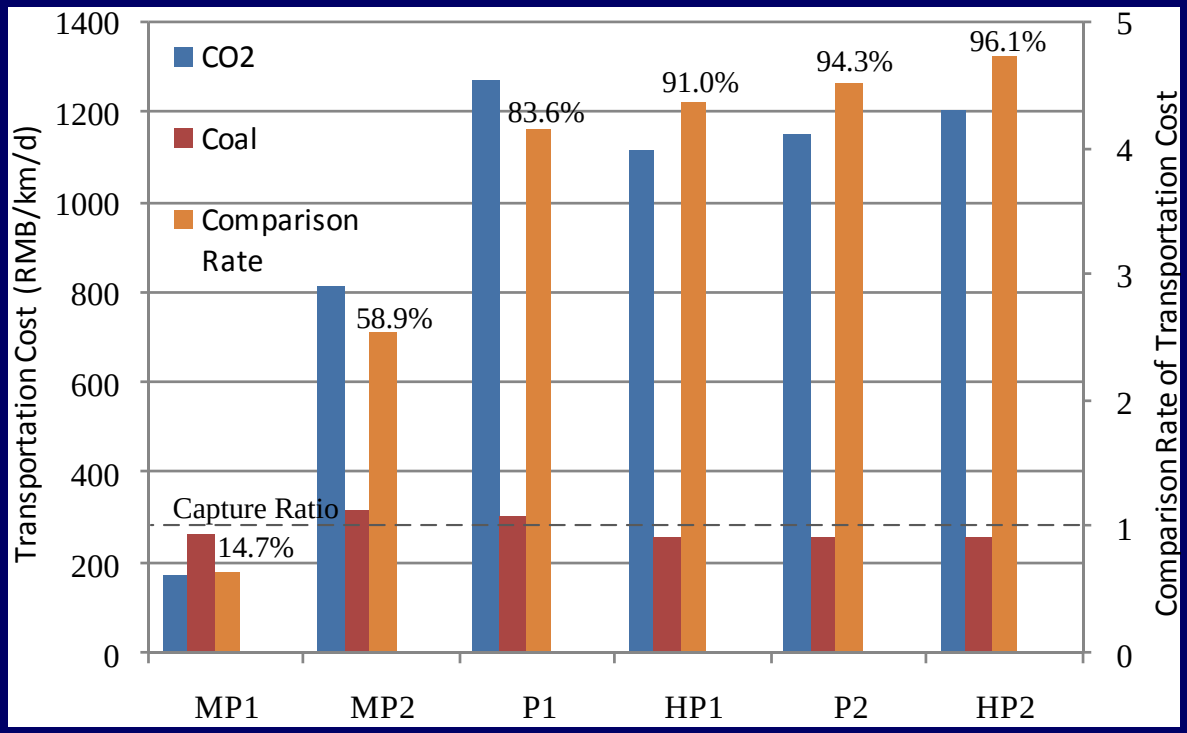
# $CO_2$ Recovery Profile of Typical PES Flowsheets

| No. | Name | Scale | $CO_2$ Capture Ratio（%） | Amount of $CO_2$ Storage（tpd） | Coal Consumption（tpd） |
|---|---|---|---|---|---|
| **MP1** | MeOH-power PolyGen by CO-rich syngas in serial mode | 200000 tpa MeOH+400MW | 14.7% | 1140.5 | 3119 |
| **MP2** | MeOH-power PolyGen by $H_2$-rich syngas in serial mode | 200000 tpa MeOH+300MW | 58.9% | 5385.6 | 3758 |
| **P1** | IGCC with $CO_2$ capture | 480MW | 83.6% | 8427.7 | 3600 |
| **HP1** | IGCC co-producing power and $H_2$ | 70000 tpa $H_2$+160MW | 91.0% | 7392.0 | 3000 |
| **P2** | SOFC hybrid cycle with $CO_2$ capture | 540MW | 94.3% | 7635.2 | 3000 |
| **HP2** | SOFC hybrid cycle co-producing power and $H_2$ | 70000 tpa $H_2$+250MW | 96.1% | 8005.0 | 3000 |

- The amount of $CO_2$ separated from typical PES systems in common scale will be more than 5000 tpd if the capture ratio over than 50%.

# Comparison between Transportation Costs of $CO_2$ and Coal




- For most typical PES systems, the transportation cost of $CO_2$ is larger than that of coal, except MP1.
- The transportation cost of $CO_2$ will be close to that of coal for a system with the capture ratio around 20~25%.

## China and USA

# A Strategic Cooperation on Clean Coal

CAS

中国科学院

CHINESE ACADEMY OF SCIENCES

It is widely known that, with the implementation of the policy of reform and opening to the outside, China's national economy has achieved rapid development. As a basic industry in the national economy, electric power is a significant criterion in evaluating the nation's progress. With its annual growth rate of 15 GW/a, China's electric power industry has now leaped to second place in the world in terms of installed capacity.

Assessing the IGCC technology by the Chinese and American specialists from different perspectives, this report points out that China is a developing country with limited economic strength but a very wide market. As a result, more attention should be paid to assimilating the imported technology, so as to reduce construction cost of the new IGCC power station by making efficient use of the existing domestic technology and construction capacity, and at the same time, providing market information for oversees enterprises who wish to extend the IGCC technology in China.

We sincerely hope that the publication of this report will provide a pragmatic analytical basis for the Chinese and American governments, related enterprises, and all those concerned with developing the IGCC technology in China.

G. Zhou

Professor Zhou Guangzhao

Member and President of the Chinese Academy of Sciences

J. BENNETT JOHNSTON
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United States Senate
WASHINGTON, DC 20510-1802

November 20, 1996

The United States and the People's Republic of China share the need for more efficient and environmentally friendly power production technologies to help meet increasing energy demands. The Integrated Gasification Combined Cycle (IGCC) technology is a promising example--it is the cleanest and most efficient means of producing power and other products from coal. China's Agenda 21 plan identified IGCC technology as a top priority for sustainable development. The U.S. has been developing IGCC technology for the past twenty years and has become the world leader in advancing and commercializing the technology. This joint effort between the United States and China to analyze the advantages and potential for IGCC should serve as a model for future cooperative efforts to find solutions to our common environmental and energy production problems.

It gives me great pleasure, therefore, to introduce the attached report. Because of the high degree of technical and financial risk associated with the use of new technologies for production of energy, the research, development and demonstration path to commercial acceptance of new power production technology is long and arduous. The demonstrated performance of IGCC in the U.S., and its potential for helping to meet the future energy needs of China, is exciting and merits the attention and resources reflected in this joint effort. This report will be critically valuable in the assessment of IGCC's potential role in mitigating climate change resulting from CO2 emissions and will also provide insight into options for the best utilization of China's vast coal reserves. Such options might include the production, using IGCC, of chemicals, automotive, residential and industrial fuels, as well as many other coal-derived products.

The joint effort that produced this report is the result of the growing recognition that the U.S. and China have common interests and purposes in the broad area of energy and environmental technology. I trust that the project will provide a useful framework for future cooperative efforts.

J. Bennett Johnston

J. Bennett Johnston
United States Senator

- Start since middle 1980's
- IGCC concept and definition in 5 years' plan
  - The 8th
  - The 9th
  - The 10th
- IET, pursues Co-production RD since 1998

# Final Remarks

- China is, and will continue to be an energy giant in the coming decades
- China faces many challenges on the road toward the harmony development in terms of energy, economy and environment
- Coal will still be the major energy resource before 2050 in China
- Developing Clean Coal Technology (CCT) is essential for sustainable development of China energy
- CO2 capture and sequestration (CCS) is the critical enabling technology that would reduce $CO_2$ emission while also allowing coal to meet the energy needs
- Cooperation are welcome for China and world's energy sustainable development

# Acknowledgement

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