Research, Development, Demonstration and Deployment (R&D3) of Clean Coal Technology in China

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1. Review of Policies Related to Clean Coal Technologies (CCT)

1.1 National Attention to CCT

- National Leading Group for CCT Deployment Plan was set up in 1995
- The State Planning Commission issued “China's 9th Five-year Plan and Development Program to the Year 2010 for CCT” in 1997
- The Ministry of Science and Technology (MOST) has included CCT in its High Technology Research and Development Program since 2001

1.2 Science and Technology Development Strategy for Sustainable Energy

- **Principles**
  1. **Prioritize energy efficiency, reduce energy intensity**
  2. **Increase energy supply, while diversifying the country's energy mix**
  3. **Promote clean, safe, and efficient utilization of coal resource, reduce pollution**
  4. **Strengthen digestion, assimilation and re-innovation of imported energy technologies**
  5. **Research and develop advanced power transmission and distribution technologies**

National Medium- and Long-Term Strategy for Science and Technology Development, 2006

1.3 Priorities in CCT Development

1. **High efficiency mining technology and facilities**
2. **Heavy gas turbines**
3. **IGCC systems**
4. **USC pulverized coal power generation technology and facility**
5. **Supercritical CFB power generation technology and facility**
6. **Coal conversion technology involved coal liquefaction, coal gasification and coal chemical engineering**
7. **Coal gasification based co-production technology**
8. **Comprehensive pollution control technology and facility**

National Medium- and Long-Term Strategy for Science and Technology Development, 2006

1.4 Industrial Policies

- **Power Sector**
  - To develop cleaner power generation; Combined heat and Power
  - To phase out obsolete technologies and close down small size plants
  - Based on the close of small-size coal-fired unit, permit newly build coal-fired large size power plant
  - New coal-fired units must be synchronously equipped with FGD
  - Existing plants must have begun to be retrofit with FGD technology before 2010, and all plants should meet SO_2 requirements before 2015
  - To call for the new plants to set aside space for future flue gas denitrification equipment installations
- **Coal Sector**
  - To employ briquette, Coal water mixture (CWM)
  - To develop gasification, liquefaction and clean coal combustion technology
- **Manufacture Sector**
  - To develop desulfurization, dust removal, denitrification technology and equipment

1.5 Environmental Policies

- **Emission standard**
  - **Prescribe emission concentrations of SO_2 and NOx**
- **NOx and SO_2 emission charge system**
  - **Fee based on the type of pollutants and total amount**
  - **630 RMB/ton ($ 80/ton) for SO_2 and NOx**
- **SO_2 emission trading system**
  - **Still under experiment (March 2002)**
    - Four Provinces (Jiangsu, Shandong, Henan, Shanxi)
    - Three cities (Shanghai, Tianjin, Liuzhou)
    - One enterprise (China Huaneng Power Corporation)

1.6 Fiscal Policies

- A preferential electricity price to power plants with FGD
- Financial subsidy
- Low interest loans
- Reduction & exemption of taxes

2. R&D2 and Early Deployment of CCT during the Tenth Five-Year Plan (2001-2005)

2.1 R&D Organization

- MOST (Ministry of Science and Technology)
  - National Basic Research Program of China (973 Program, “the day after tomorrow”)
  - High Technology Research and Development Program of China (863 Program, “tomorrow”)
  - Key Technologies Research & Development Program (*Gongguan,* “today”)
- NSFC (National Natural Science Foundation of China)
  - Fundamental Research
- CAS (Chinese Academy of Sciences)
  - Knowledge Innovation Engineering

2.2 Coal Technologies Supported by MOST

- CFB Power Generation Technology
- USC Pulverized Coal Power Generation Technology
- FGD Technology
- NOx Control Technology
- Coal Gasification
- CTL Technology
- IGCC and Coal Gasification Based Co-production

2.3 CFB Power Generation Technology

- Funded by MOST
  - Conceptual design for large 600 MW supercritical CFB boiler
  - Demonstration plants of 135 MW and 200 MW with reheat
- Industry progress to date
  - First 300 MW CFB plant using imported technology and equipment, April of 2005
  - First 300MW CFB plant made in china, June of 2006
  - Over ten 300MW CFB boilers under construction

2.4 USC PC Power Generation Technology

- Funded by MOST
  - 1000MW
  - Huaneng Yu-Huan Power Plant
  - Online on Nov. 13, 2006
- Industry-updated progress
  - 22×1000MW and 12×600MW USC units, under construction
  - 600MW supercritical and 1000MW USC units will become the standard in the coming years

2.5 FGD Technology

- MOST financed 4 FGD Demonstration Projects
- Industry
  - 2000: 5GW
  - 2005: 53GW, 14% of total installed thermal power capacity
  - Over 100GW under construction
  - Over ten FGD technologies in use, wet limestone gypsum accounts for 90% of FGD technologies

2.6 NOx Control -- Reburning for NOx Emissions Reduction Technology

- MOST financed 3 Reburning technology Demonstration Projects
  - 600MW, 200MW, 350MW boilers
  - Below permitted NOx emission level
- Industry
  - New power generation units are equipped with low NOx burners
  - Existing units were retrofitted with low NOx burners
  - Reburning technology was applied to several power plants

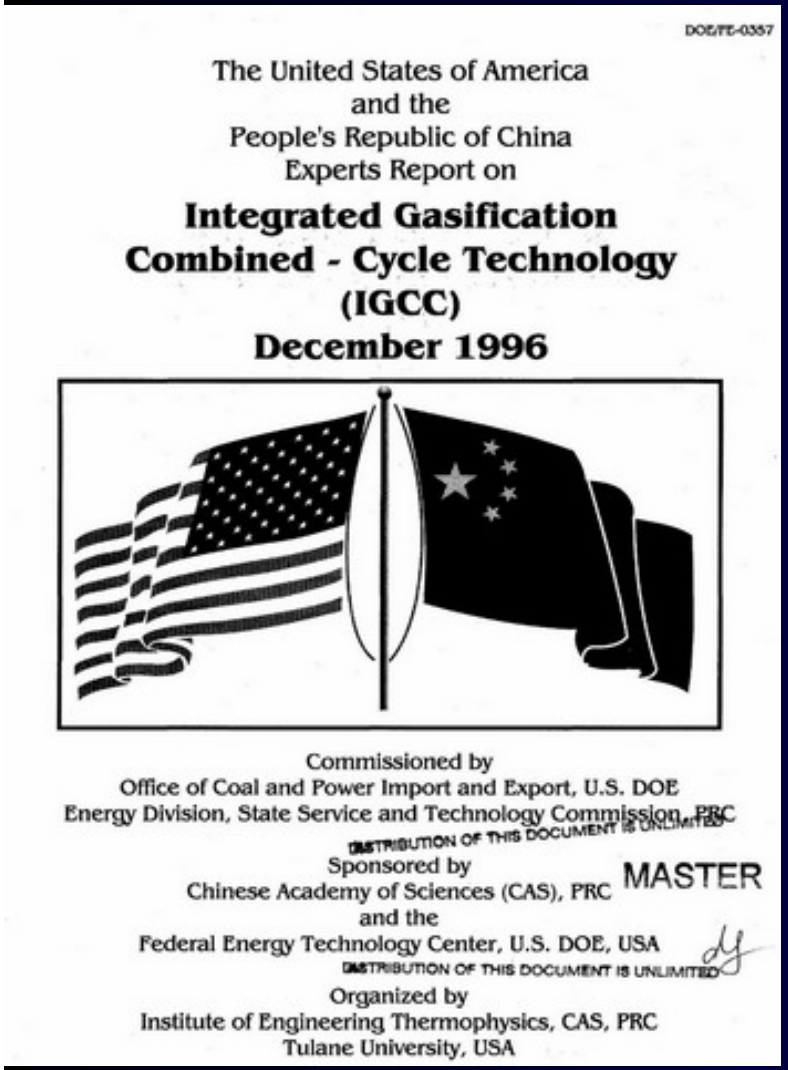
2.7 Coal Gasification

- New-style Coal-water Slurry Gasification Technology
  - Scale : 1150 tons/day
- Dry pulverized coal pressurized gasification
  - Scale : 36 tons/day and 45 tons/day

2.8 CTL Technology

- Indirect Liquefaction
  - 750 tons per year pilot plant
  - 5000 tons per year pilot plant
- Direct Liquefaction
  - 6t/d pilot plant
  - Building the world's first direct coal liquefaction demonstration plant
    - Planned scale of direct coal liquefaction is 5 million tons per year
    - The first production line is 1 million tons of liquid per year

2.9 IGCC and Coal Based Co-production (cont.)



DOE/FE-0357

The United States of America
and the
People's Republic of China
Experts Report on

Integrated Gasification Combined - Cycle Technology (IGCC)

December 1996

Commissioned by
Office of Coal and Power Import and Export, U.S. DOE
Energy Division, State Service and Technology Commission, PRC

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- Pursuing IGCC since the 1970s
  - Plan to build an experimental 10MW IGCC power plant in 1979
  - Stop without start
- IGCC key technologies and system analysis & optimization
  - Three five-year plans
- USA and PRC Experts Report on IGCC in 1996
- The IGCC demonstration project in Yantai, Shandong, initiated in 1999, not start construction yet

- IET pursuing co-production since 1998
- The First Demonstration Plant in Yankuang, Shandong in Commercial Operation since Apr. 2006

2.9 IGCC and Coal Based Co-production (cont.)

Demonstration Plant

- Coal gasifier : New-style Coal-water Slurry Gasifier : 1150TPD X 2
- Power: 60MWe，Methanol: 240 thousand tons/Y
- Investment: 1.6 billion RMB ($0.2 billion)
- Capital payback period: 8.1 years（including construction period）

2.10 Other Innovative Technologies

- Direct Hydrogen Production from coal
- Simultaneous CO_2 control and gaseous pollutants removal during coal combustion

3. Prospect of CCT during the Eleventh Five-Year Plan (2006-2010)

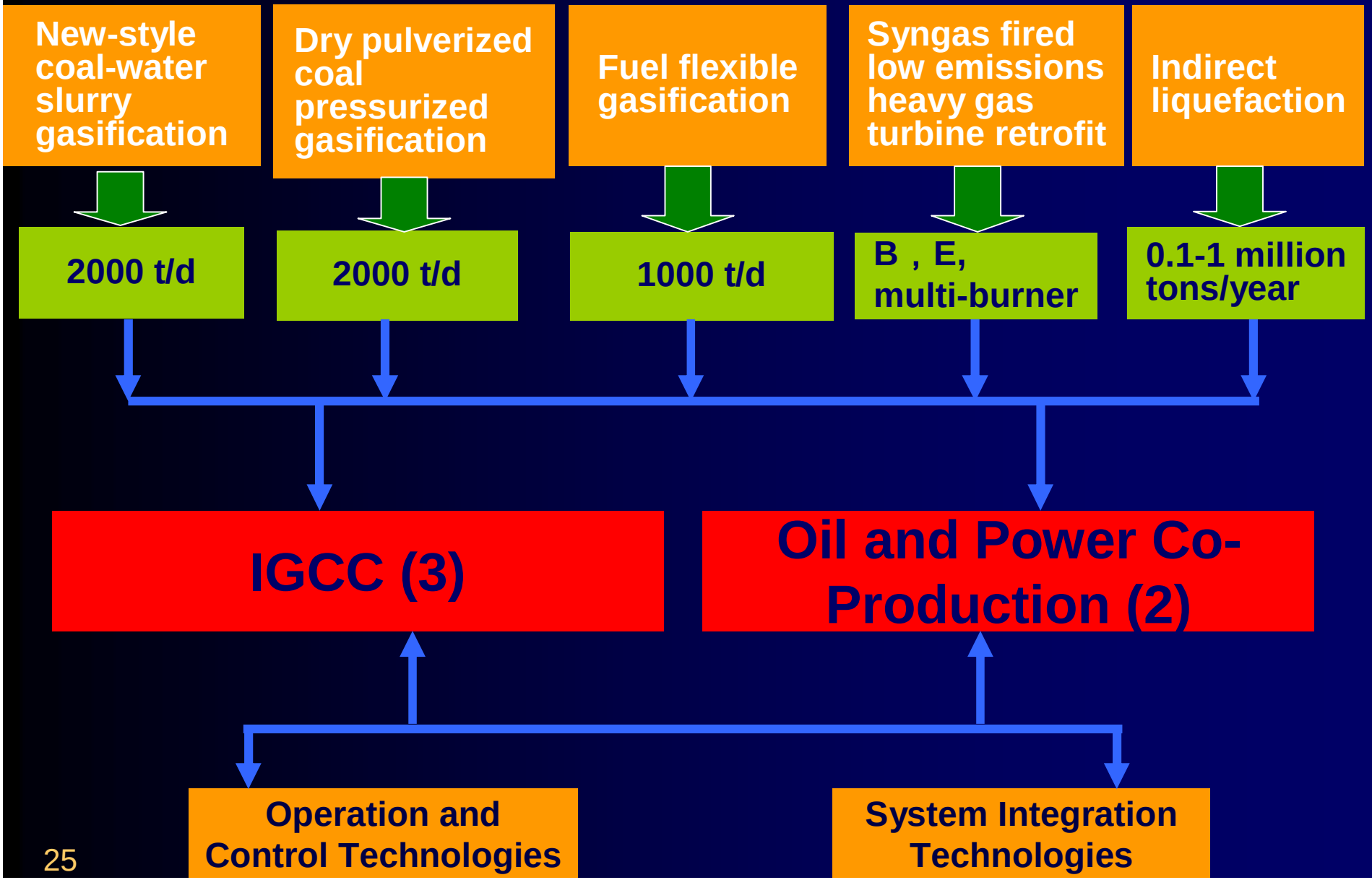
3.1 Three Project Levels in the 863 Program

Level	Focus	Funding size (RMB)
Momentous projects	Commercial demonstration of technology systems	>100 million (> $13 million)
Key projects	Development of core technologies	Tens of millions ($ several millions)
Research themes	R&D of Advanced technologies	1 or 5 million ($130 thousand or 650 thousand)

3.2 Momentous Projects Concerning Energy

1. Coal gasification-based co-production and IGCC demonstration plants
2. Biomass energy technology
3. Heavy duty gas turbines
4. Quick neutron reactors

3.2 IGCC and Co-Production Demonstration (cont.)



3.3 Key Projects

1. **Coal gasification & syngas cleanup**
2. **High-temperature FT synthesis**
3. **R&D on industrial energy efficiency**
4. **Micro-gas turbine and a distributed energy supply system**
5. **MW-grade photovoltaic power generation system connected to the electricity grid**
6. **Solar thermal power generation technology and demonstration**
7. **Film battery technology research**
8. **Hydrogen use and demonstration system**
9. **Nuclear security and fuel recycling technology**

3.4 Research Themes

1. **Clean coal technology**
2. **Energy efficiency and distributed energy supply systems**
3. **Renewable energy technologies**
4. **Hydrogen and fuel cells**

3.4 Research Themes- Clean Coal Technology (cont.)

- Research-Oriented Projects
  - High efficient, clean coal combustion technology
  - New coal-fired emissions control technology
  - Coal processing and conversion technology
  - CO_2 capture and storage technology
- Development-Oriented Projects
  - Advanced coal power technology
  - Low NOx combustion technology
  - SO_2 control and byproduct reuse technology
  - One-through DME synthesis
  - Key equipment technologies of coal Hydroliquefaction

4. Final Thoughts…

4.1 R&D3 on CCT

- R&D2
  - Develop IGCC and Co-production
  - Develop Large-size CFB (600MW) and supercritical CFB
  - Multi-pollution control technology
- Deployment
  - Choose USC and SC PC units as new capacity coupled with pollutant control technology
  - 300MW CFB as a supplement

4.2 Policies and Regulations on CCT

- CCT Policies and Programs in the past have been formulated in a piecemeal fashion
  - not compatible due to coming from different ministries or departments
  - lack a corresponding detailed implementation requirement
- Problems associated with local enforcement of national policies and regulations
  - Different levels of monitoring means, local protectionism
- Formulate policies and regulations more systematically
- Strengthen enforcement of policies and regulations

Thank you for your attention!