Clean Coal-based Power Generation Technology Option in China

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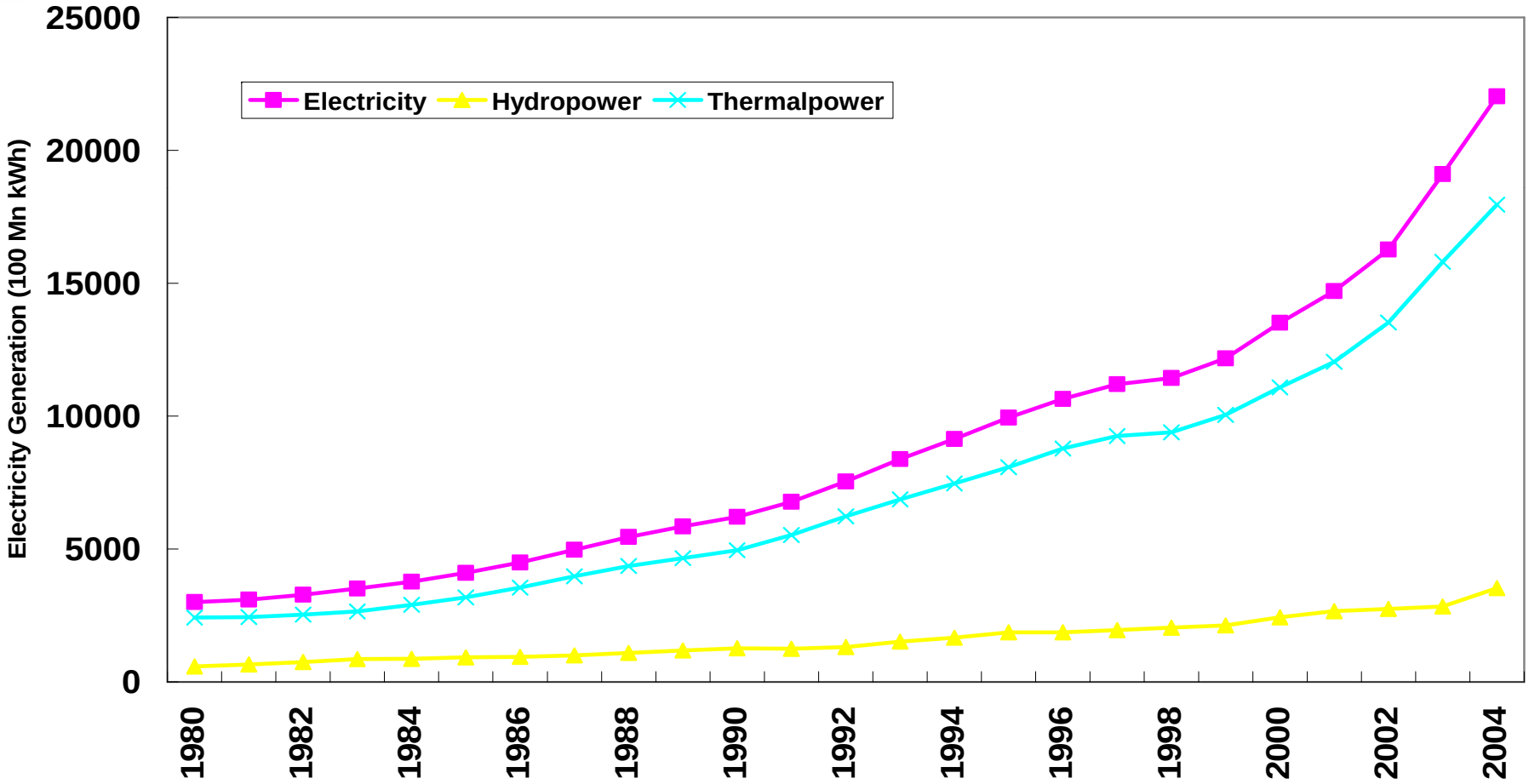
- China's Energy Demand and Clean Coal Tech
- Advanced Clean Coal Tech: IGCC and Polygeneration
- Promoting Clean Coal Technology Strategy in China

The Coal Context in China

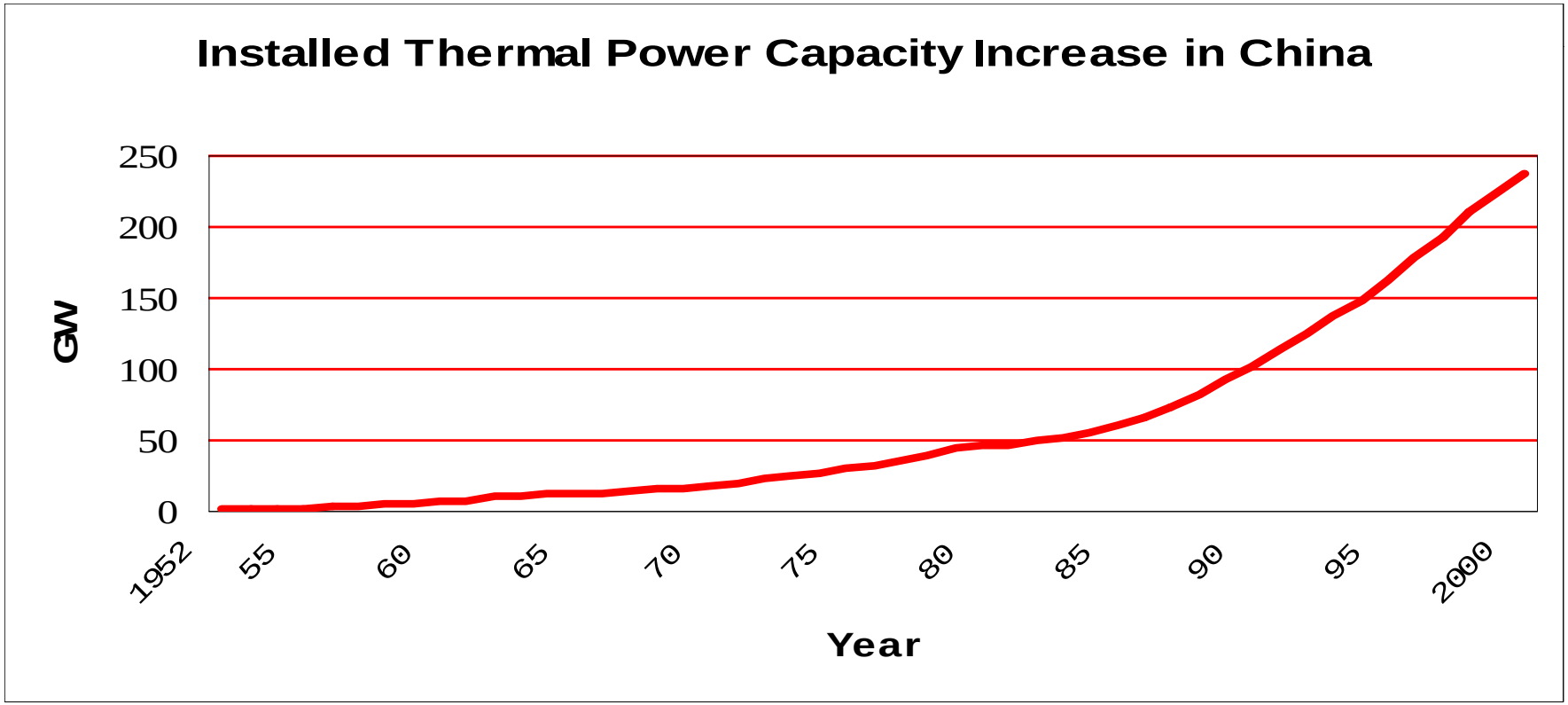
- **Energy consumption: 2.65 bn tce in 2007, coal 69.5%**
- **Electricity Generation:**
  - ✓ **3256 TWh in 2007, thermal 83%**
  - ✓ **annual rate 19% from 2002 to 2007**
  - ✓ **1474 kWh per capita**
- **Installed capacity of power generation:**
  - ✓ **713.3 GW in 2007, coal-based 78%**
  - ✓ **annual rate 25% from 2002 to 2007**
  - ✓ **0.54 kW per capita in 2007**

Electricity Generation in China



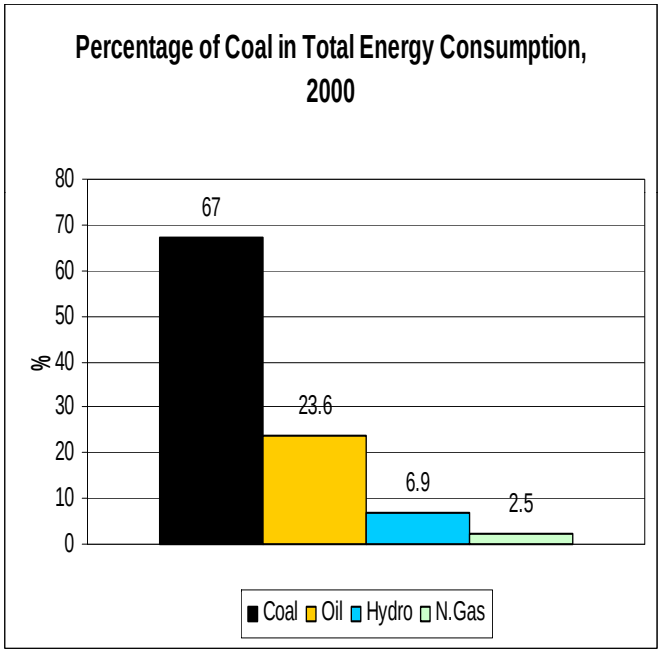
Installed Thermal Power Capacity

- **95% of China's power plants are coal-fired and total installed capacity has been increasing rapidly**



Issues of Coal Utilization

- **China is one of the biggest coal consumers and producers in the world, in 2006:**
  - ✓ **38.5% of the total**
  - ✓ **China, US and India, about 65% of the total**
- **Issues caused:**
  - ✓ **Local air quality: SO2/Acid rain, PM2.5**
  - ✓ **Ecological issues like ground subsidence**
  - ✓ **CO2 emission, about 75% from coal**
  - ✓ **Transportation stress**
- **Low efficiency utilization**



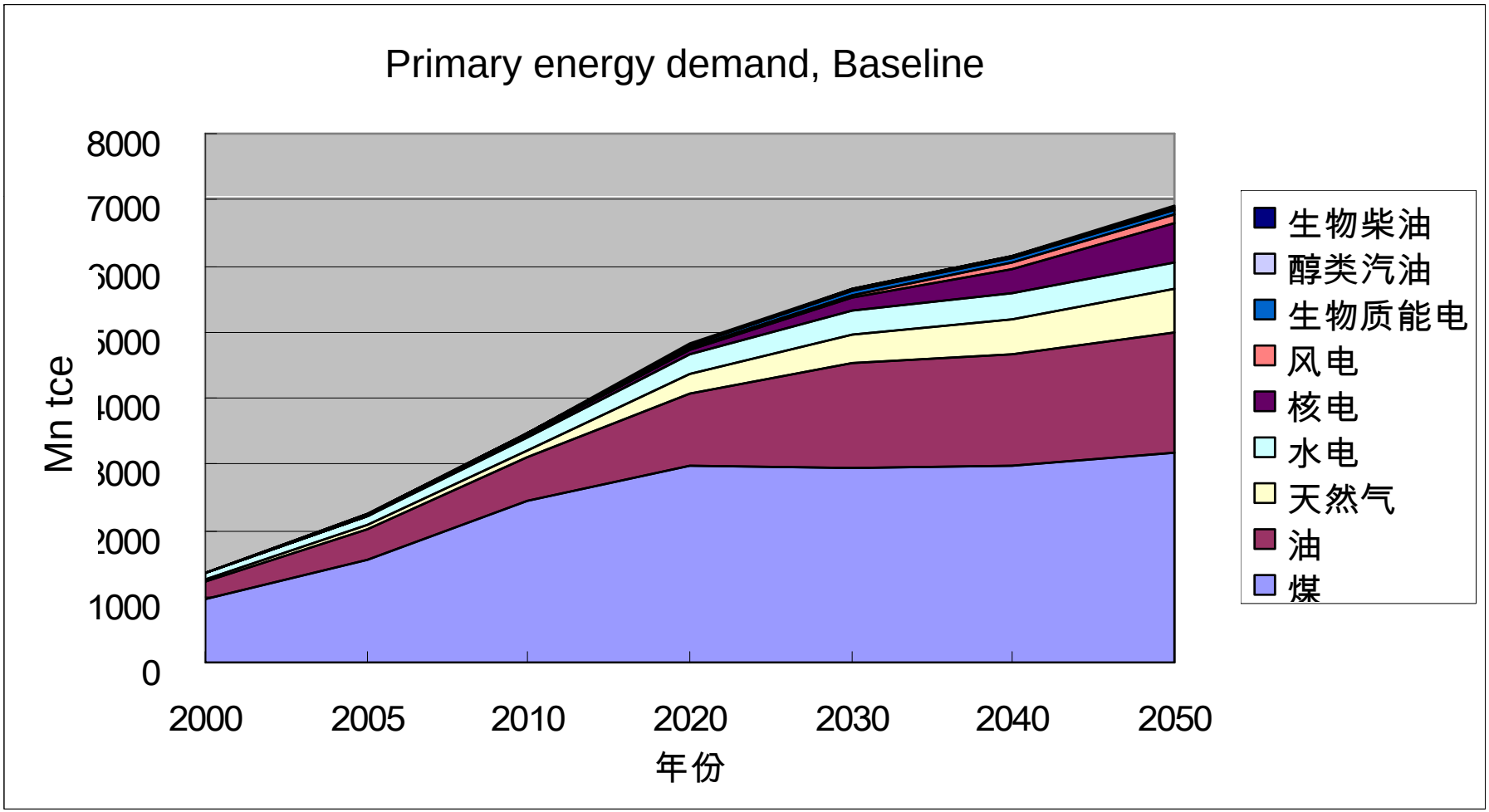
Coal Reserves in China

- **China has 12% of world proven coal reserves, 80% of which in 4 Provinces/Regions:**
  - ***Shanxi, Shaanxi, Inner Mongolia, Xinjiang***
  - **Transportation and ecological issues**

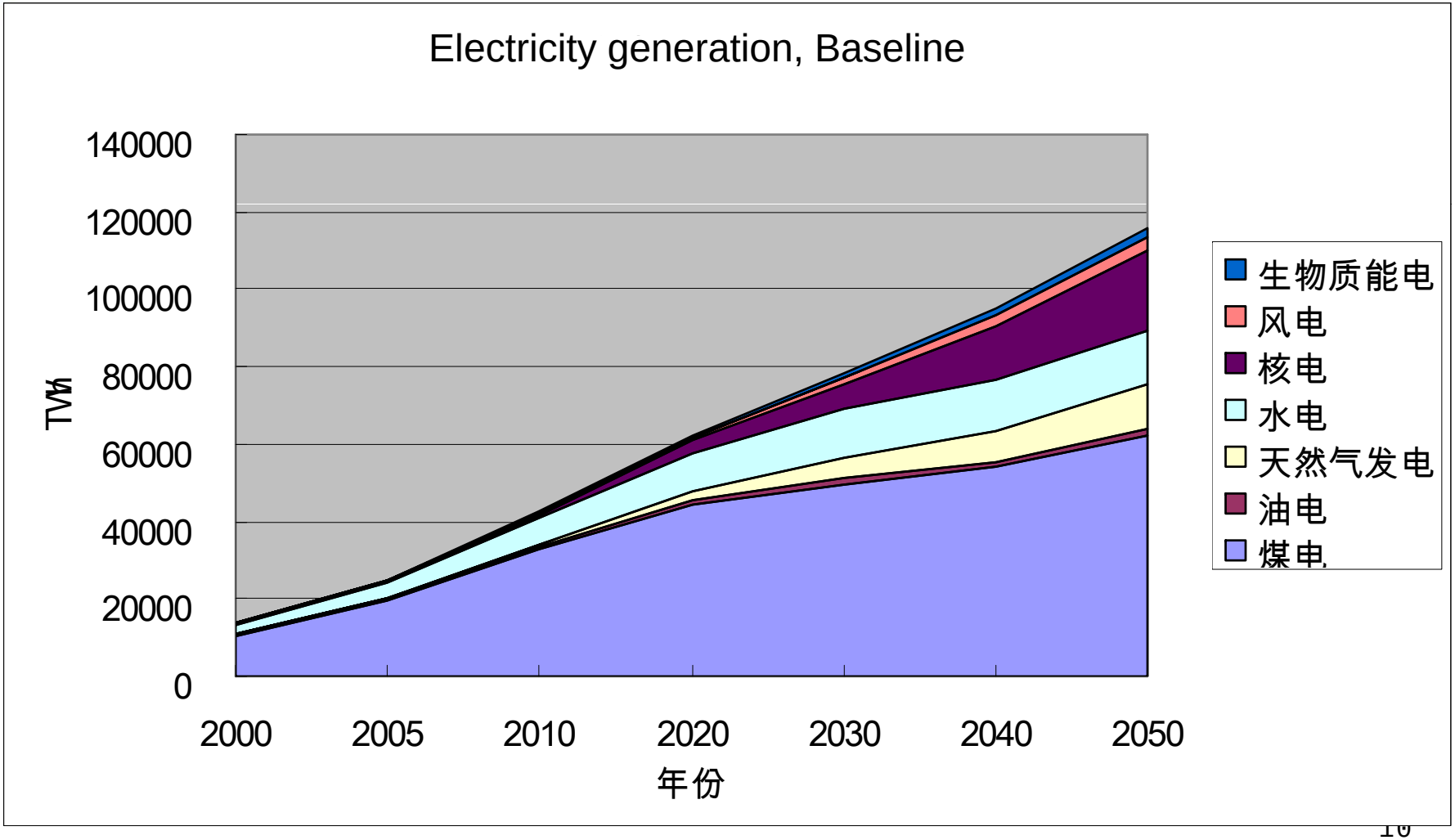
Energy Demand in China

- China's energy demand (Baseline):
  - 2010: 3 bn tce
  - 2020: 4-4.5 bn tce
  - 2030: 5-5.4 bn tce
  - 2050: 6.5 bn tce
- China's energy consumption will hopefully become No. 1 in 2025

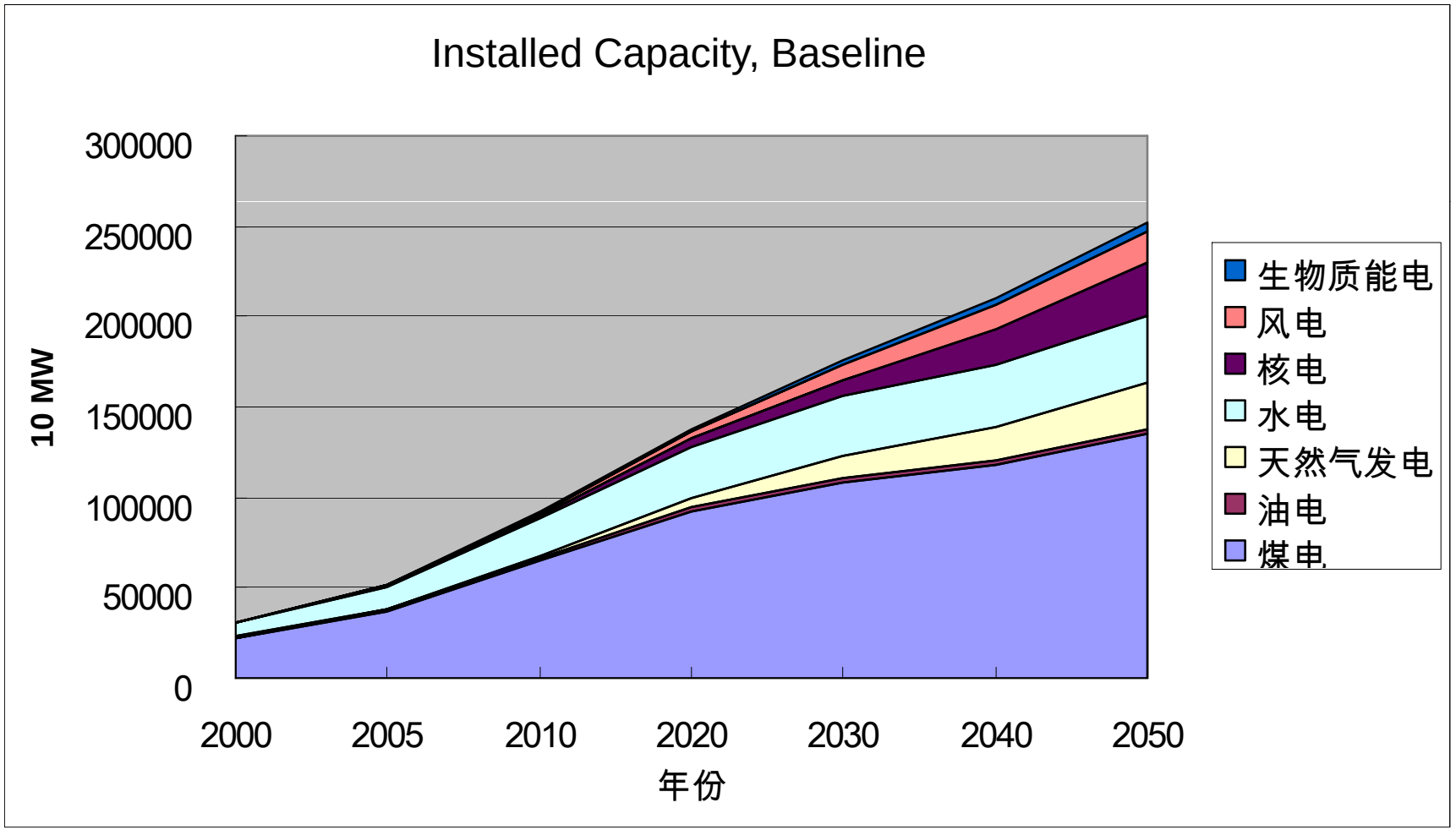
Energy Demand in 2050



Electricity Generation in 2050

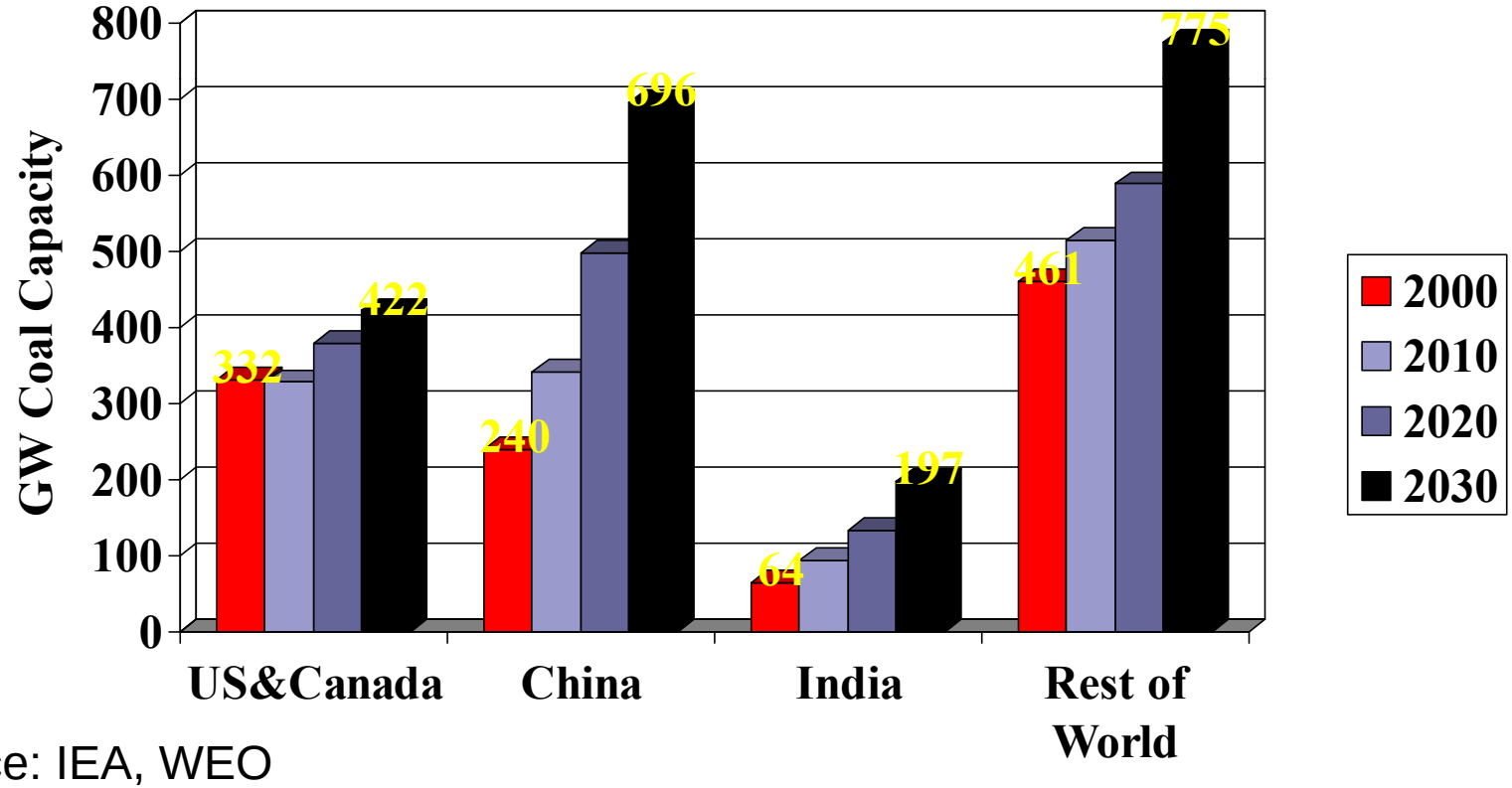


Installed Power Capacity in 2050



Installed capacity increase

- **More capacity to be added in the next 30 yrs by projection**



Source: IEA, WEO

Coal Use Indispensable

- **China will rely on Coal mainly for a long time (30-50 yrs?)**
  - ✓ **Coal abundance and large population, high energy density resources needed**
  - ✓ **Low per capita energy consumption (2 tce/yr; US: 11 tce/yr)**
  - ✓ **Rapid economic growth / industrialization (8-10% annually) and urbanization (1 percentage annually)**
  - ✓ **Rural commercial energy supply**
  - ✓ **Conventional technology inexpensive ($750/kW investment for coal power plant, while IGCC costs $1350/kW)**

Clean Coal Tech Needed

- **Clean coal technology development crucial**
  - ✓ **Govt commitment:**
    - ➢ **mandatory targets of energy efficiency (20% ↑) and pollution reduction (10% ↓)**
    - ➢ **dealing with climate change**
- **China's energy consumption demand could be controlled under 5 bn tce based on policy scenario including *clean coal tech utilization***

Advanced Coal Power Tech in China

- **In recent years, China's coal-based power generation tech develop very rapidly under energy efficiency and environmental targets**
  - ✓ **Supercritical unit: almost 100% localization**
  - ✓ **Ultra-supercritical unit: 80-90% localization**
  - ✓ **Investment cost: ￥3800-3900 yuan ($560-70)/kW, less than that of same unit in the world, strong competitiveness**
- **Since 2007, newly added units must be SC and USC in principle. 60% of newly added SC and USC units are in China**
- **In 2010, SC (600MW) , USC units and upwards estimated will account for 30% of total installed capacity, over 40% in 2020**

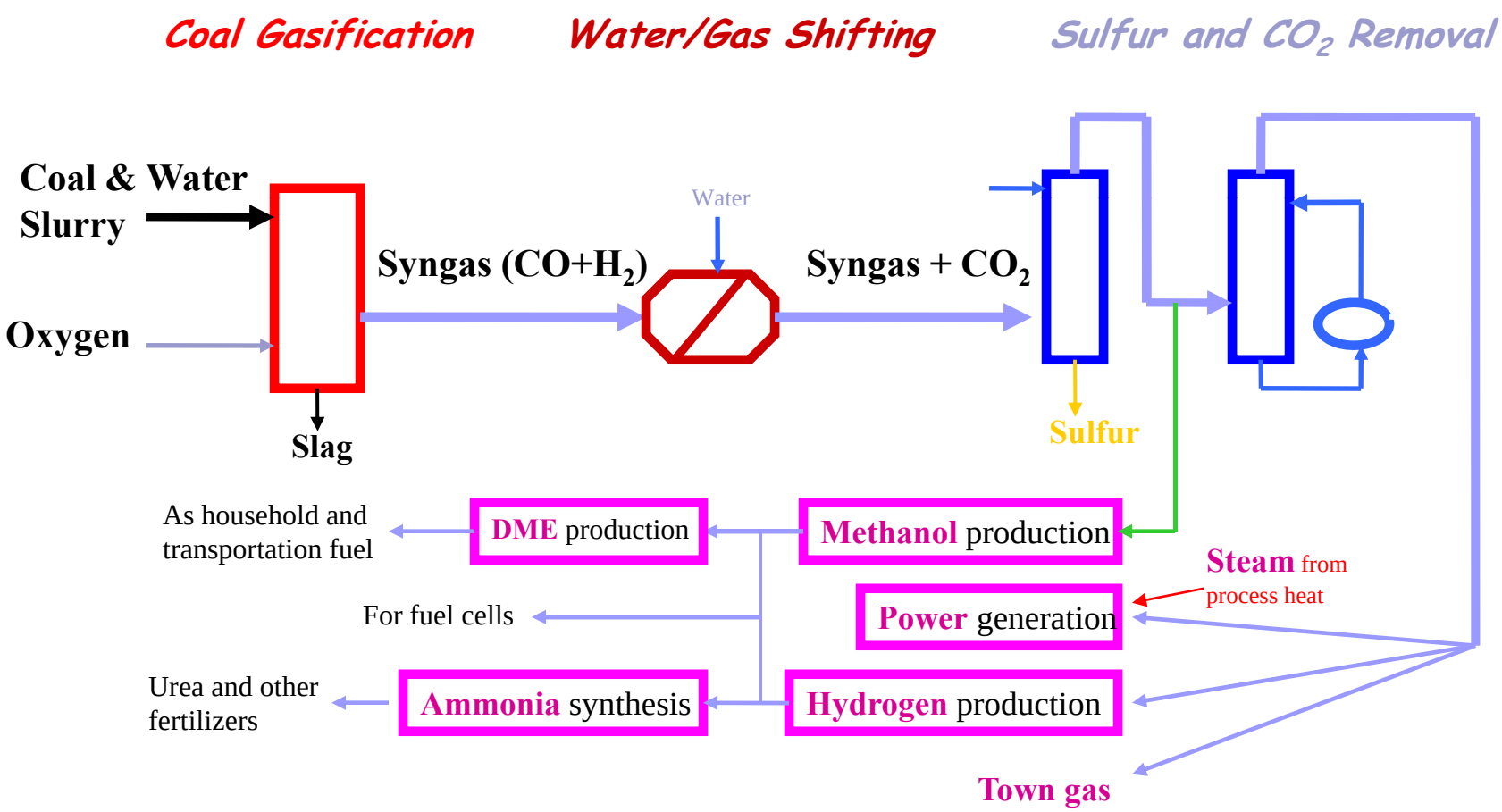
IGCC in China

- **Integrated Gasification Combined Cycle (IGCC) has better performance than SC and USC. Advantages:**
  - ✓ **High efficiency (43-45%) and save water**
  - ✓ **Environment: de-S, de-N**
  - ✓ **Fuel flexible and peek adjustment**
  - ✓ **Bridge to coal chemical engineering, power generation, CCS, hydrogen economy**
- **Disadvantages:**
  - ✓ **System complicated**
  - ✓ **High construction cost: ￥7000-8000 yuan ($1030-1170)/kW, twice of SC/USC**

IGCC in China

- IGCC has industrial scaling demo stage
- 4 demo stations are under construction (Tianjin 2, Guangdong 1, Zhejiang 1), another 15 are in the pipeline, overall design capacity available
- Supporting policies needed
- Combination with Polygeneration system development in order to reduce cost and more comprehensive approach
- Considering multiple policy goals, IGCC would be prioritized strategically than SC/USC

What is polygeneration?

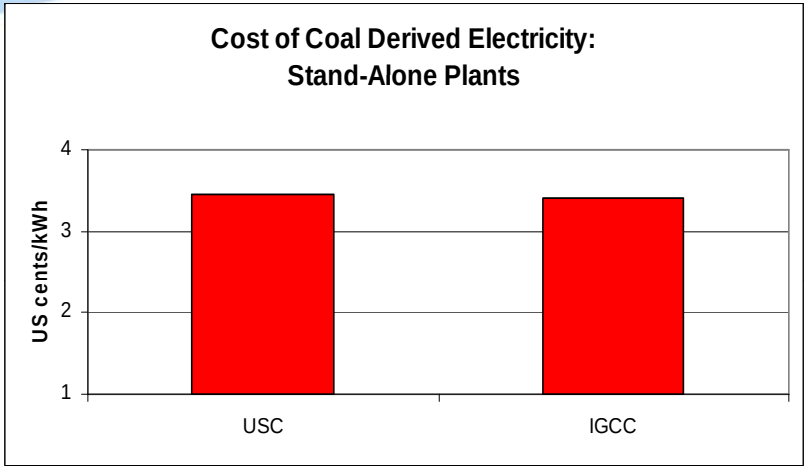


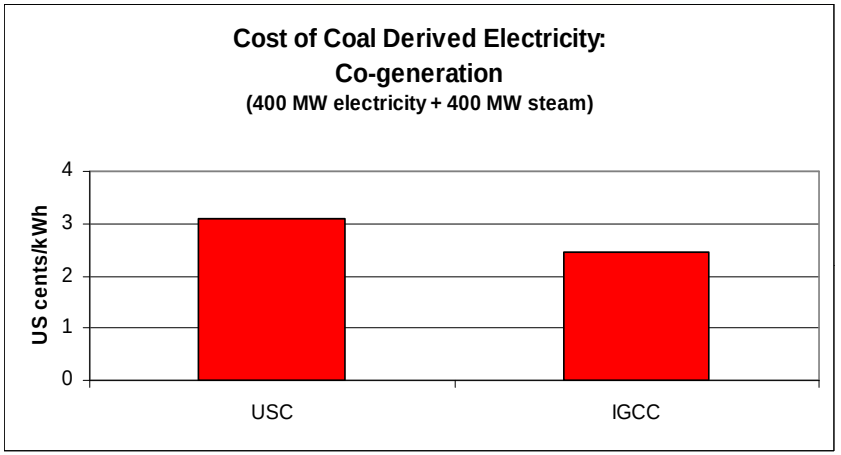
Benefits of PolyGen

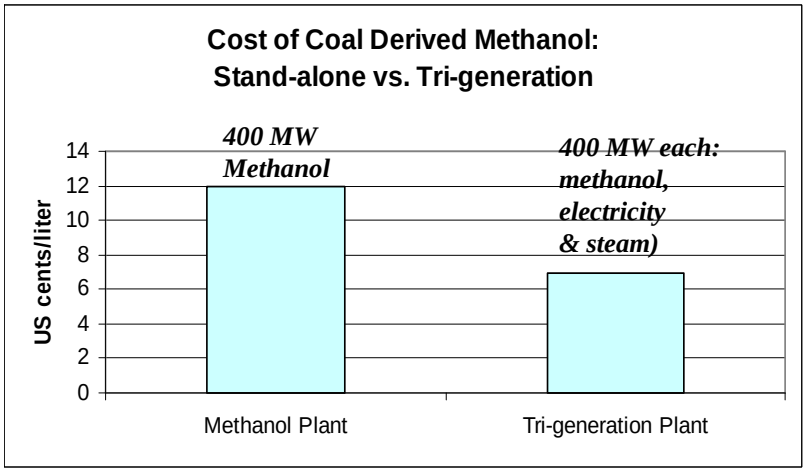
- High efficiency (coal efficiency around 60%[1])
- Easy pollution control (reduced stream volume and higher S concentration[2])
- Ready for CO_2 capture (reduced stream volume and higher C concentration[3])
- A good source of H_2 for fuel cells
- Flexible feedstock (coal, petroleum residue, solid wastes, biomass, syn gas)

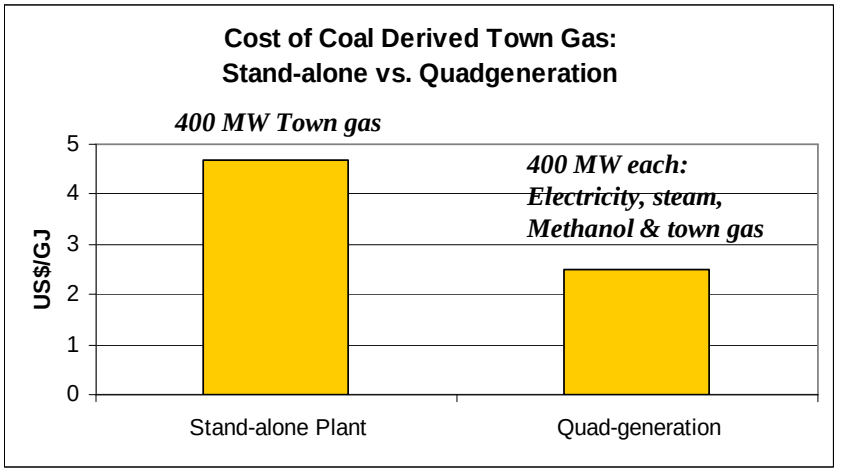
1. LHV for electricity; HHV for H_2
2. Volume of stack gas is 125 times larger
3. CO_2 concentration in stack gas is 12% while in syngas is 40%

Benefits: Low overall cost









Source: R. Williams, May 2000

Technology Components are mature

- ***Coal gasification*** **is common in ammonia production**
- ***PolyGen*** **is a concept the chemical industry has always used**
- ***What's new?***
  - ✓**Electricity as an important product**
  - ✓**Once-through configuration**
  - ✓**Carbon-capture ready**
  - ✓**Hydrogen as a fuel and other liquid fuels**
- ***A strong fertilizer industry and Good manufacturing capability*** **make PolyGen development easy**
- ***Several enterprise pilot projects like*** **Yankuang, Ningxia**

Promoting PolyGen Development

- ***A policy framework*** *conducive to polygen application* (easy access to grid connection, tax breaks for clean power, removing sectoral barriers, financial incentives, etc.)
- ***A solid action plan / roadmap*** *for reaching commercial scale applications*
- ***Speed up the IGCC and PolyGen pilot projects*** *for realizing a leapfrog from SC/USC*
- ***Encouraging collaborations*** *between power and chemical industries and govt agencies*

Conclusions

- Coal use must shift from combustion to gasification based technologies
- A Clean Coal Technologies Strategy (CCTS) offers the opportunity for meeting near-term environmental and energy security goals at lower cost than with a "business-as-usual" approach
- Clean use of coal based on gasification and PolyGen is a large and necessary component of such strategies for China's long-term development
- The percentage of IGCC units should be increased strategically comparing SC and USC units

Conclusions

- CCTS also provides a lower-cost path to low carbon economy
- This strategy is based on technologies that are mostly known and proven in China
- Gas and liquid fuels (DME, Methanol) will need to play increasingly important roles in the energy economy under high oil price context
- High end-use efficiency and renewable resources also play an important role

Thank you for your attention !

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