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Presented by Prof. Li Zheng, Tsinghua BP Clean Energy Research & Education Center, at the 3rd US-China Clean Energy Workshop on October 18-19, 2004 at the National Research Center for Coal & Energy, Morgantown, WV. This meeting was sponsored by the NRCCE, the U.S. Department of Energy, and the U.S. China Energy & Environmental Technology Center.

Polygeneration Based on Coal Gasification: a strategic technology for China

Prof. Li Zheng

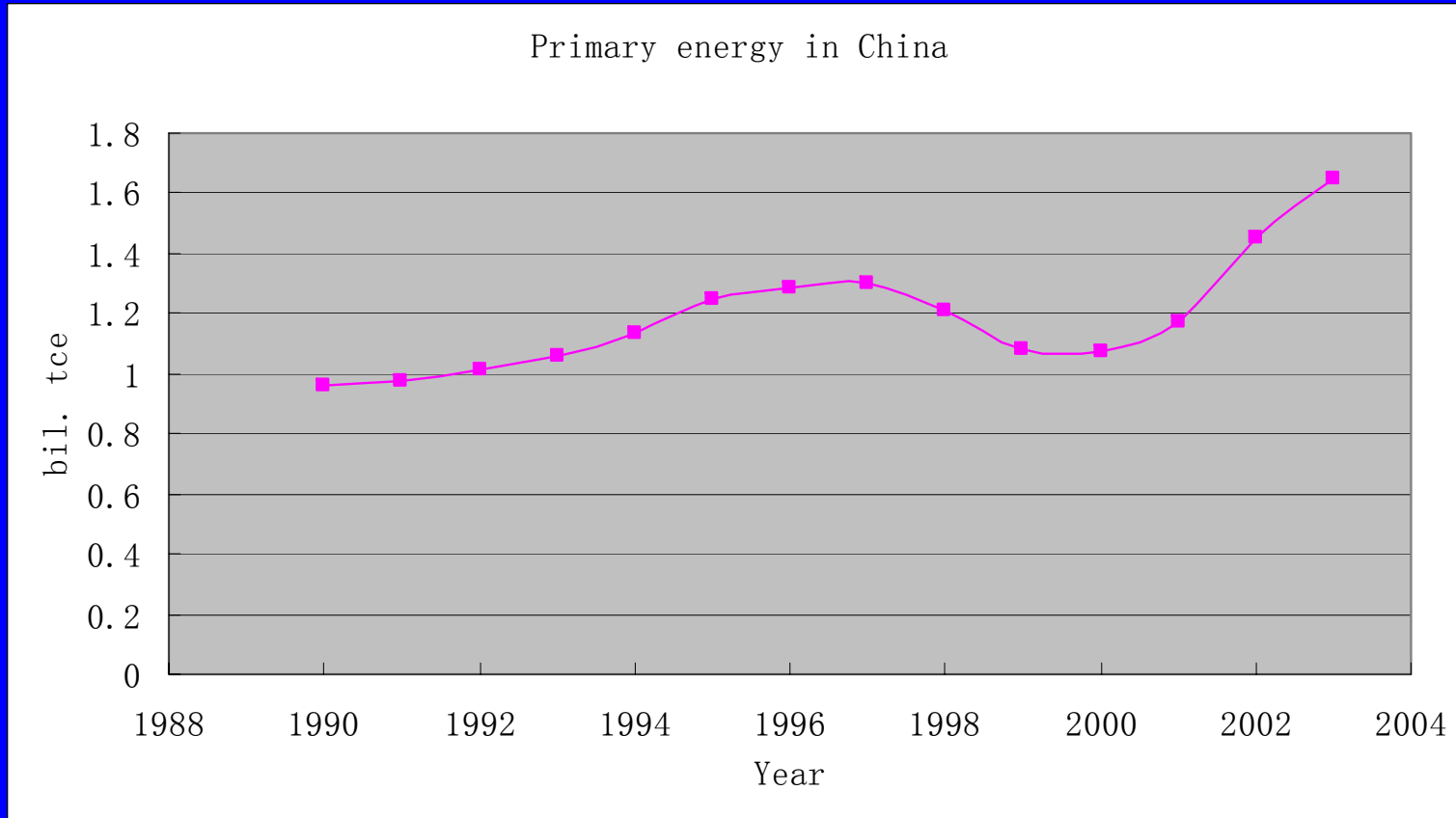
**Tsinghua BP Clean Energy Research & Education
Center**

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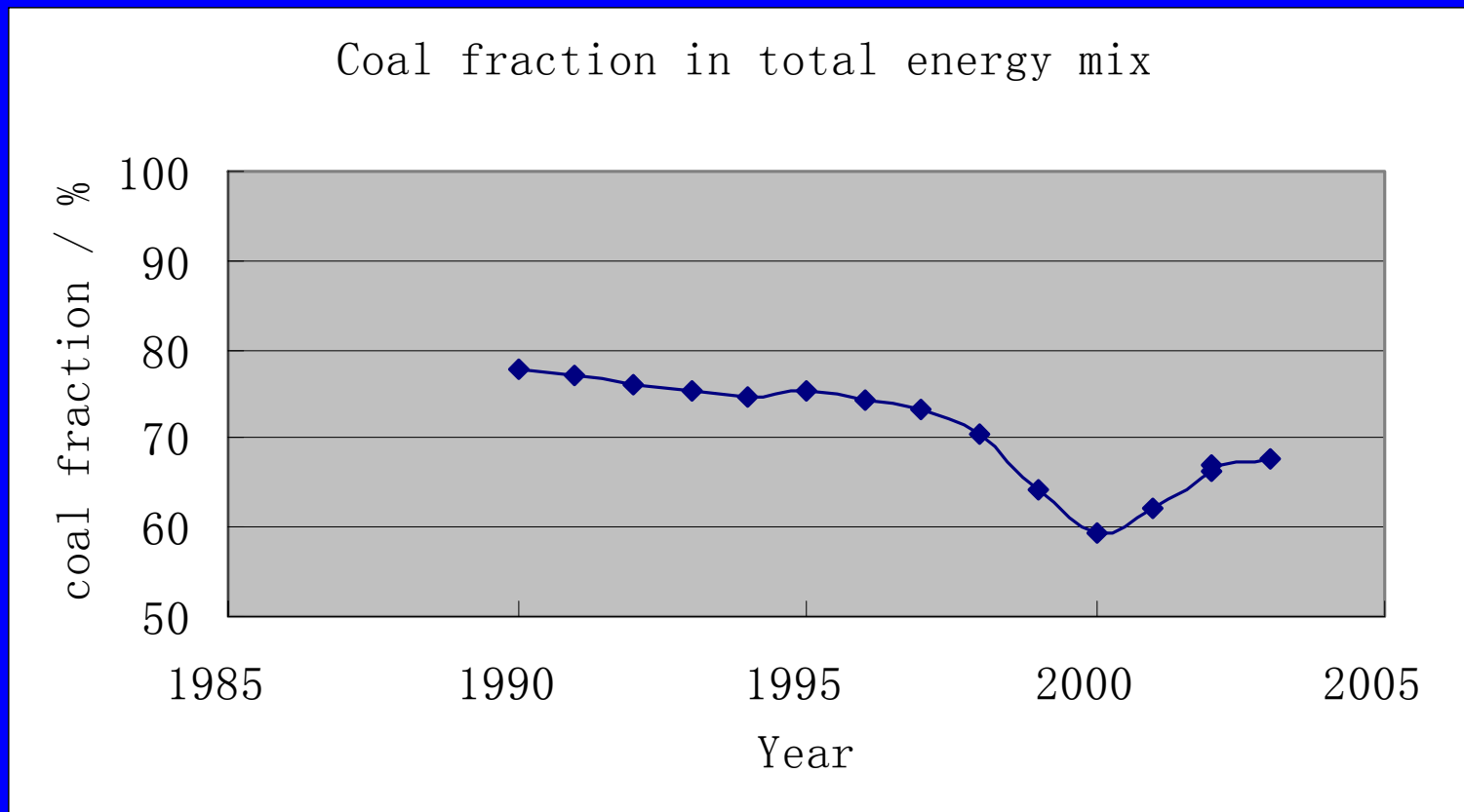
- **A short review about general energy situation in China**
- **Polygeneration could be a comprehensive way to solve China's energy problem**
- **Problems related with implementation of polygeneration**

Historical Primary Energy Consumption of China

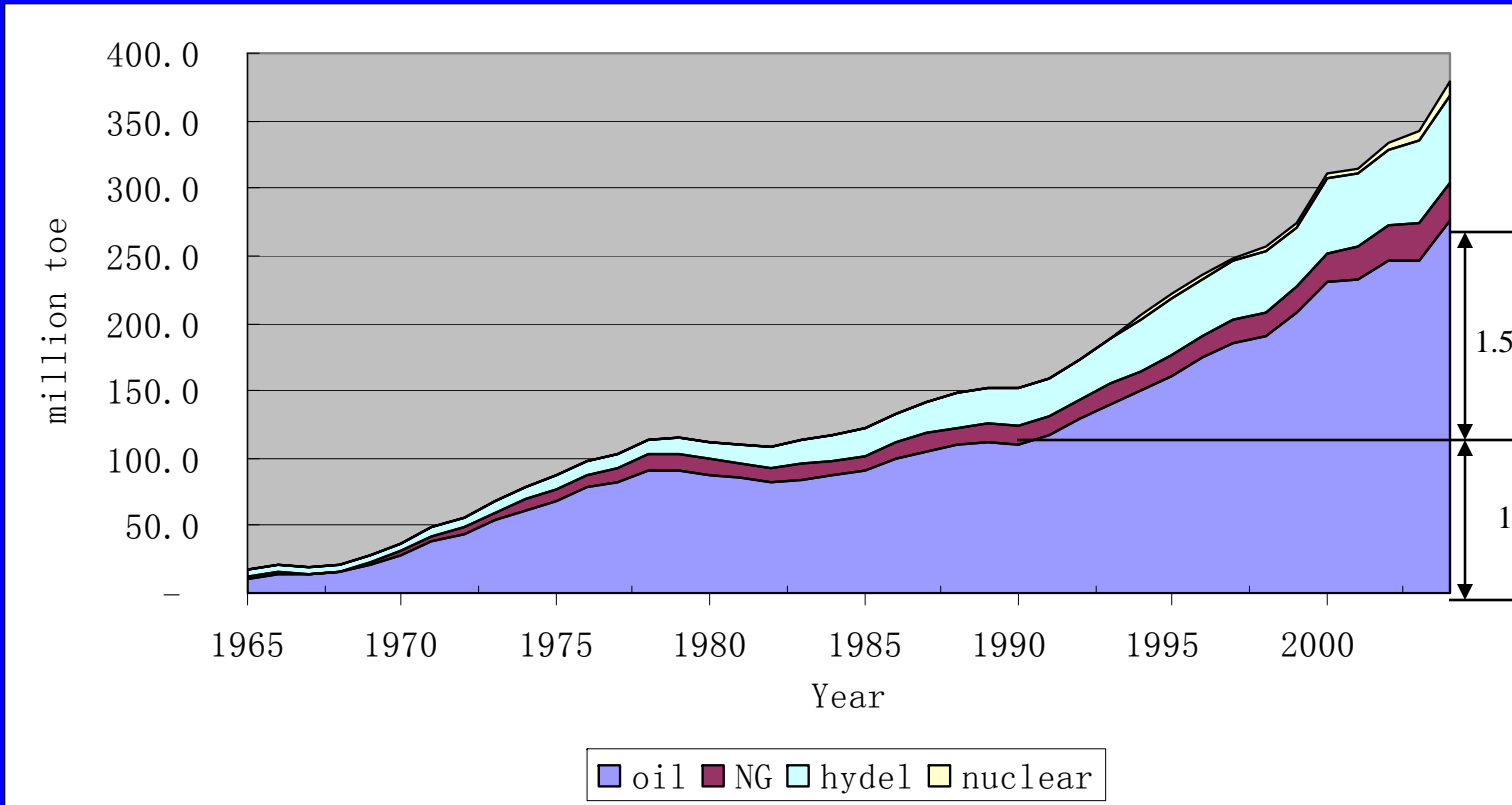


Source: BP Statistical Review of World Energy June 2004

Coal Fraction in Total Energy Mix of China



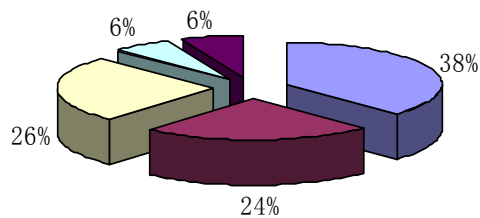
Oil consumption increasing rapidly since 1990



Source: BP Statistical Review of World Energy 2003/2004

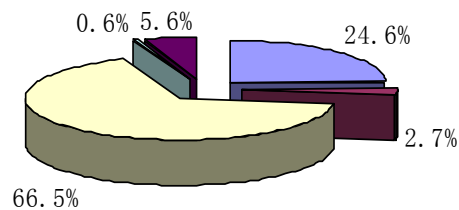
Feature of China Energy Mix—coal is the Main Primary Energy of China

World's Primary Energy Composition



Oil Natural Gas Coal
Nuclear Energy Hydro electric

China's Primary Energy Composition



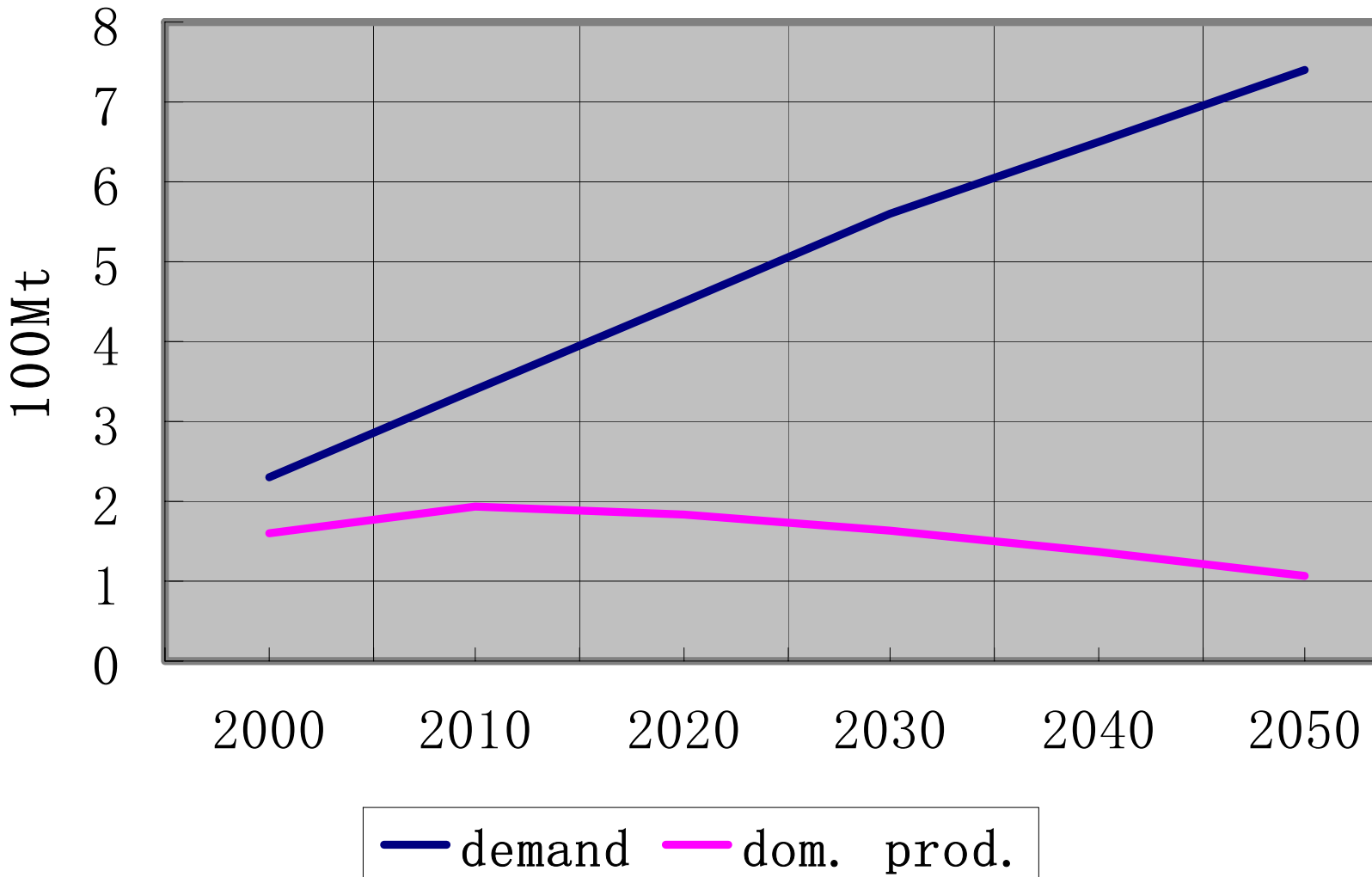
Oil Natural Gas Coal
Nuclear Energy Hydro electric

	China	World	US
Oil	24.6	38	39.8
NG	2.7	24	25.7
Coal	66.5	26	24.3
Nuclr	0.6	6	8.1
Hydro	5.6	6	2.1

Projection of future energy demand

- **The total energy demand in 2020 will range 2.5-3.3 billion tce in terms of different scenarios**
 - Coal : 2100~2900Mt
 - Oil : 400~500Mt
 - Natural gas : 160~200 bm^3
 - Power generation capacity : 860-950 GW
- **In 2050 the total energy demand will be beyond 5 billion tce**

Increasing Dependence on Oil Import



Energy challenges China is facing in the future

1. The energy security

- The per capita energy reserves of China are very low, especially for the oil and natural gas
- Oil will reach the peak production around 180Mt in 2020, after then the production will decrease
- 60% oil and 40% natural gas in 2020 will depend on import
- 100Mt coal production new capacity will be set-up before 2020

Energy challenges China is facing in the future

2. Energy efficiency improvement

- The energy consumption intensity of GDP of China in 2000 was 829toe/million \$US, 3.15 times of world average level and 4.33 times of OECD average, attributed to 42% industrial proportion in GDP and low value added for most products, and low energy efficiency.
- The specific energy consumption for most energy intensive products are as 20-50% higher than that of the industrial countries.

Energy challenges China is facing in the future

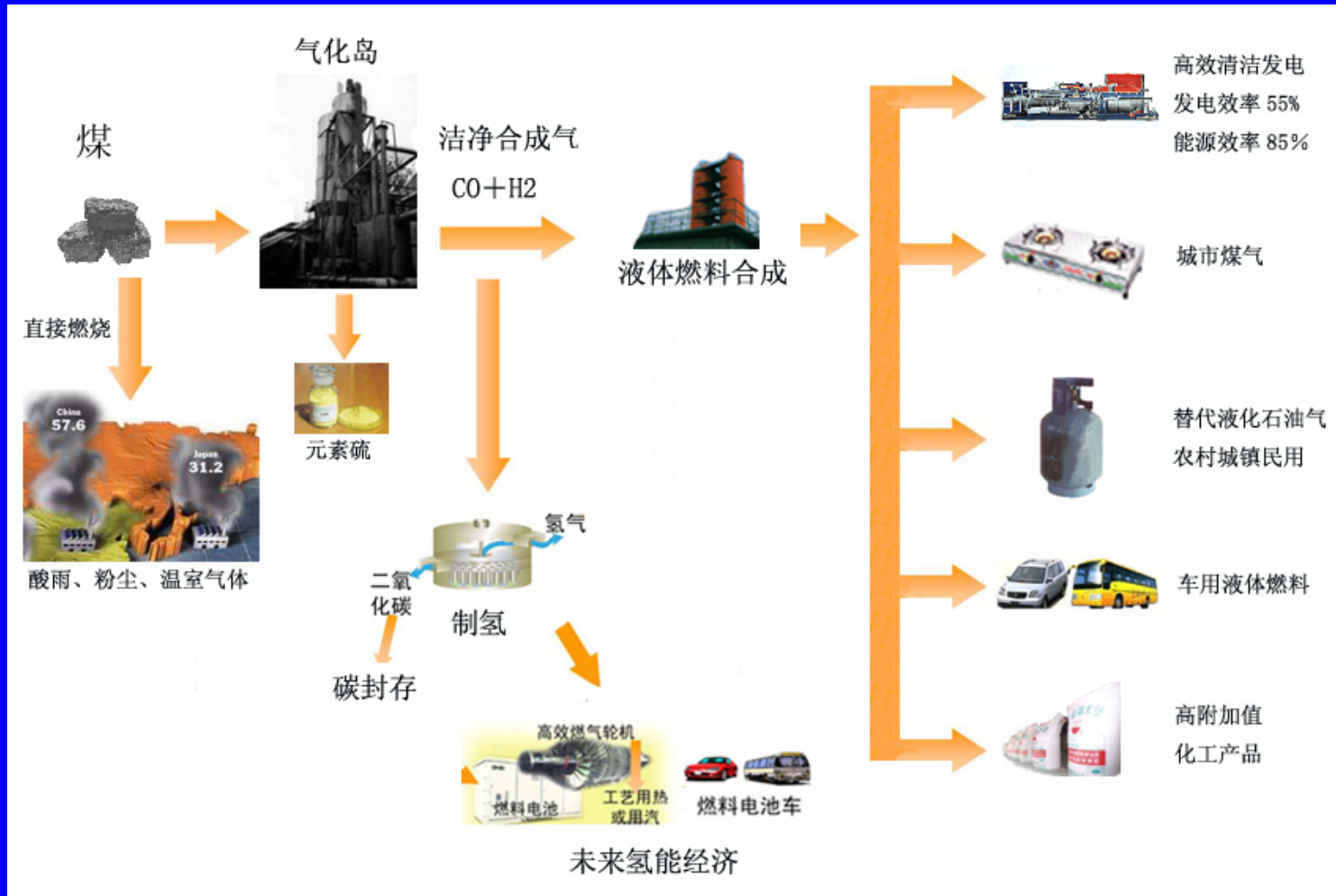
3. Environmental impact of energy pollutant

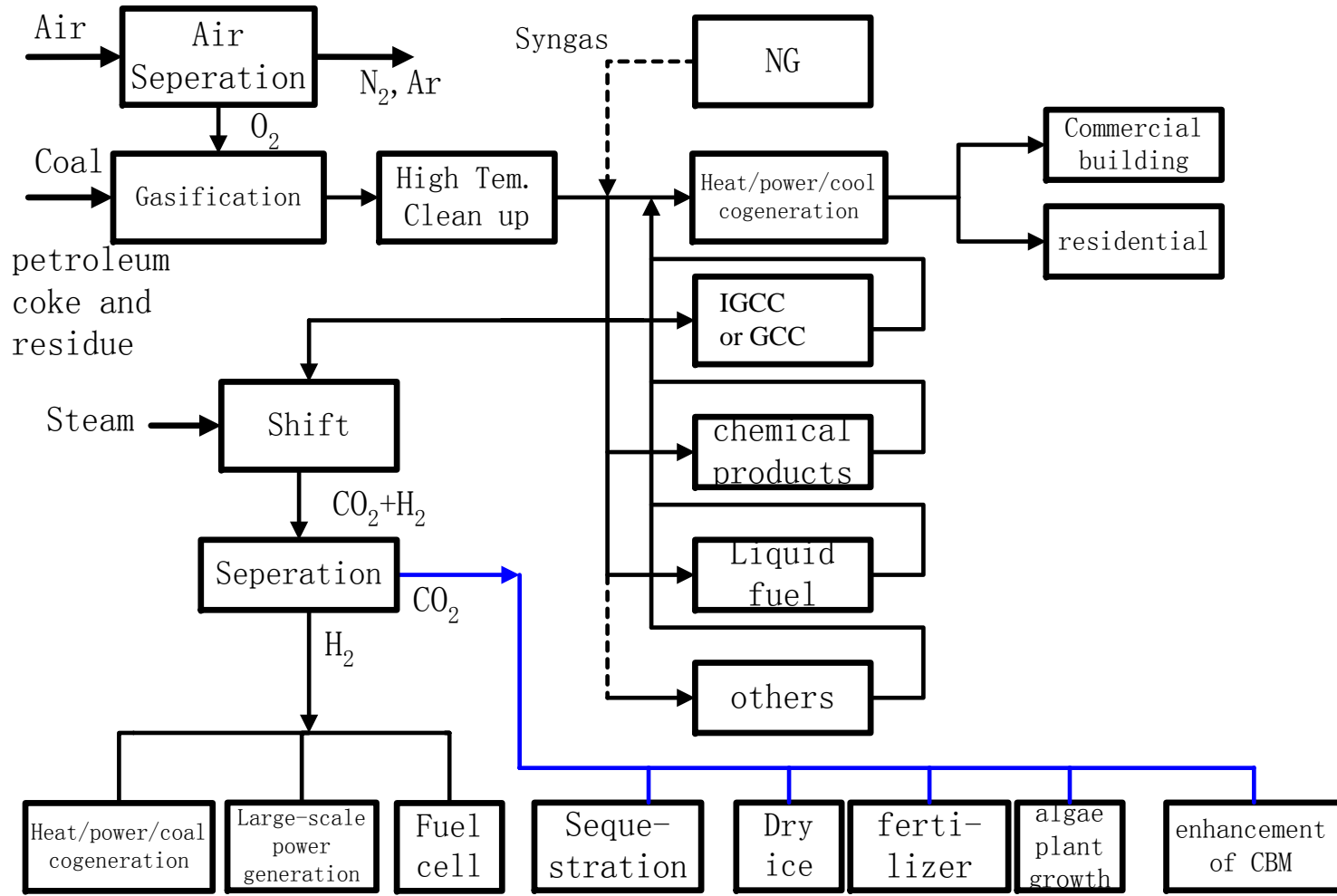
- The SO₂ and NO_x pollutant could be 40Mt and 35Mt and exceed 16Mt and 19Mt of the pollutant limits, respectively, in 2020 if no additional control measures will be taken
- China is the second largest CO₂ emission country, it would increase in the future

Summary of China's Energy Problems

- Shortage of total energy supply, especially shortage of liquid fuel supply
- Primary energy predominantly based on coal
- Environmental pollution, especially related with coal utilization
- Clean energy supply for small towns and rural areas
- CO₂ emission, especially related with coal
- Polygeneration based on coal gasification could be a comprehensive solution to the above problems

Coal based Polygeneration for now and for the future





The benefits of polygeneration

- **For shortage of total energy supply:** coal conversion efficiency can be increased by co-production of multi-products; high sulfur coal resources could be used
- **For shortage of liquid fuel:** coal derived fuel such as methanol, DME and F-T liquid can be produced in large scale
- **For environmental pollution:** conventional pollutants, as well as heavy metals, can be reduced mostly, just like IGCC but more economically
- **For the areas without NG supply:**
 - To provide clean town gas for urban areas with no NG supply
 - To provide DME as an alternative to and using the infrastructure of LPG for distributed small towns and rural areas

The benefits of polygeneration

- **For CO₂ emission:**
 - the coal gasification based systems can be easily shifted to CO₂ capture with less incremental cost
 - It is also easier and cheaper to change into H₂ production

Why a strategic technology?

- **A bridge to shift BAU coal energy systems to future systems in a natural manner, to meet**
 - stricter environmental regulations
 - shortage of oil resources, energy security
 - necessity for CO₂ mitigation and H₂ demand in the future
- **Strategic technology storage for future political choice between hydrocarbon and coal derived fuels**
- **A certain number of polygeneration plants can serve as strategic buffer to protect from oil shock and crises**

Problems related with implementation of polygeneration

- The concept of polygeneration has been widely agreed in China and regarded as one of top strategic energy technologies in China's middle and long term S & T planning.
- Next step: demonstration. The possible liquid fuel products of polygeneration are Methanol, DME and F-T liquid, etc.
- However, there are arguments about which product should be developed.
 - The first argument is about coal to oil or coal to methanol or DME
 - More arguments are about methanol
- Downstream market development is major barrier for methanol and DME.

Coal liquefaction

- **Advantage: no need about changing of infrastructure**
- **Disadvantages: Low conversion efficiency, large production capital investment**
 - **direct liquefaction: 2.8-4 t coal/t oil, no existing industrial example**
 - **Indirect liquefaction: 4-6 t coal/t oil, complicated**
- **Positive points:**
 - **to overcome railway transportation bottleneck by changing raw coal into oil products**
 - **To promote the economics of coal mining enterprises**

The arguments on methanol

- **Positive opinions**

- **Coal to methanol is mature technology and with higher energy conversion efficiency.**
- **Methanol can be used to power vehicles, by either direct mixing into gasoline with up to 15 percent without much retrofit of engines, or using specific methanol engines to burn M85 and M100**
- **By using higher compression ratio, methanol engine may have higher efficiency. It is also safer for not catching fire.**
- **The infrastructure cost is also relatively low and easy**
- **it could a big chance for China to develop its unique less-dependent-on-oil energy system and technologies. We still have chance to avoid being too dependent on oil because infrastructure has not been fully developed.**

The arguments on methanol

● Negative opinions

- Methanol is bad to add into gasoline because of erosion problem. World Fuel Charter says that explicitly.
- If it is good, why US and Europe stopped the efforts to develop methanol fuels.
- All the leading car makers are not interested in developing methanol cars. China car makers has few chances to develop this kind of technology.
- Methanol car has higher formaldehyde emission.

The arguments on methanol

- **Methanol has the problem of toxicity, especially the risk of underground water pollution. It may cause irreversible disaster.**
- **Methanol has low energy density that causes shorter running distance with the same tank volume as gasoline engine.**

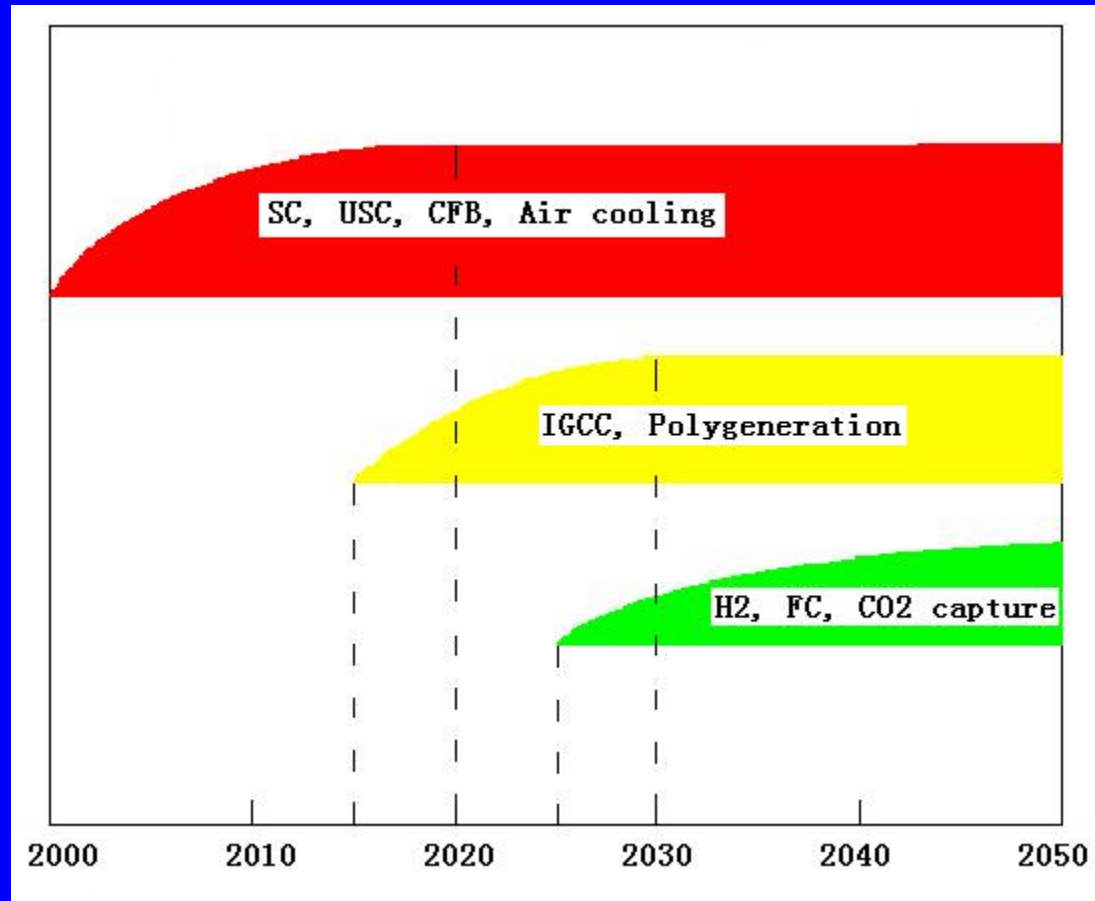
Our opinions about methanol

- **A balanced opinion about methanol should be clarified. There are a lot of inaccurate understandings in both sides, e.g.**
 - **World Fuel Chart: 3% limit of methanol addition is related gasoline engines. It is not valid for engines specially designed for methanol, such as FFV.**
 - **US stopped M85 FFV, mainly due to economic reasons rather than technical reasons.**
- **From long term strategic thinking, the methanol fuel should be considered and developed seriously as a solution to ease the pressure of oil dependency.**
- **Methanol fuel system could be firstly developed in some regions with abundant coal resources and disseminated widely.**
- **It should be very cautious with every step of development. To avoid death in cradle, mature FFV technology should be imported rather than developing in some informal way or from scratch.**

DME

- **DME is more agreed than methanol. It has great prospect for residential use. It may also have the potential for transportation use in long term.**
- **The main barrier is the cost of production.**
- **The effort for downstream market development is also crucial.**

Vision of coal utilization in China



The strategies for coal utilization

- **Develop and employ large scale, higher parameter power units with emission control facility, (SC, USC, CFB, air cooling) to meet power generation demand**
- **Compulsory policy for using low sulfur coal for distributed coal use**
- **Demonstration of coal gasification based polygeneration for power and liquid fuel production**
 - **Phase 1: combining mature technologies. Methanol and DME could be good starts.**
 - **R & D: test and verification key technologies—coal gasifier, gas turbine, advanced synthesis reactors and catalysts, air separation**
 - **Phase 2: low cost polygeneration demonstration**

The technologies needed for polygeneration

- **Large scale coal gasification, high temperature gas cleaning, low cost air separation technologies**
- **Liquid phase reactor and catalysts**
- **Large scale gas turbine for low heat value gas burning**
- **Methanol / DME engine**
- **System integration technology**

The End

Thank you!