

# *China's Energy*

## — Challenges and Strategy

**Prof. Ni Weidou**

Tsinghua University

Chairman of Steering Committee of

Tsinghua-BP Clean Energy Research and Education Centre

Member of Chinese Academy of Engineering

Chairman of Science and Technology Commission of Ministry of Education

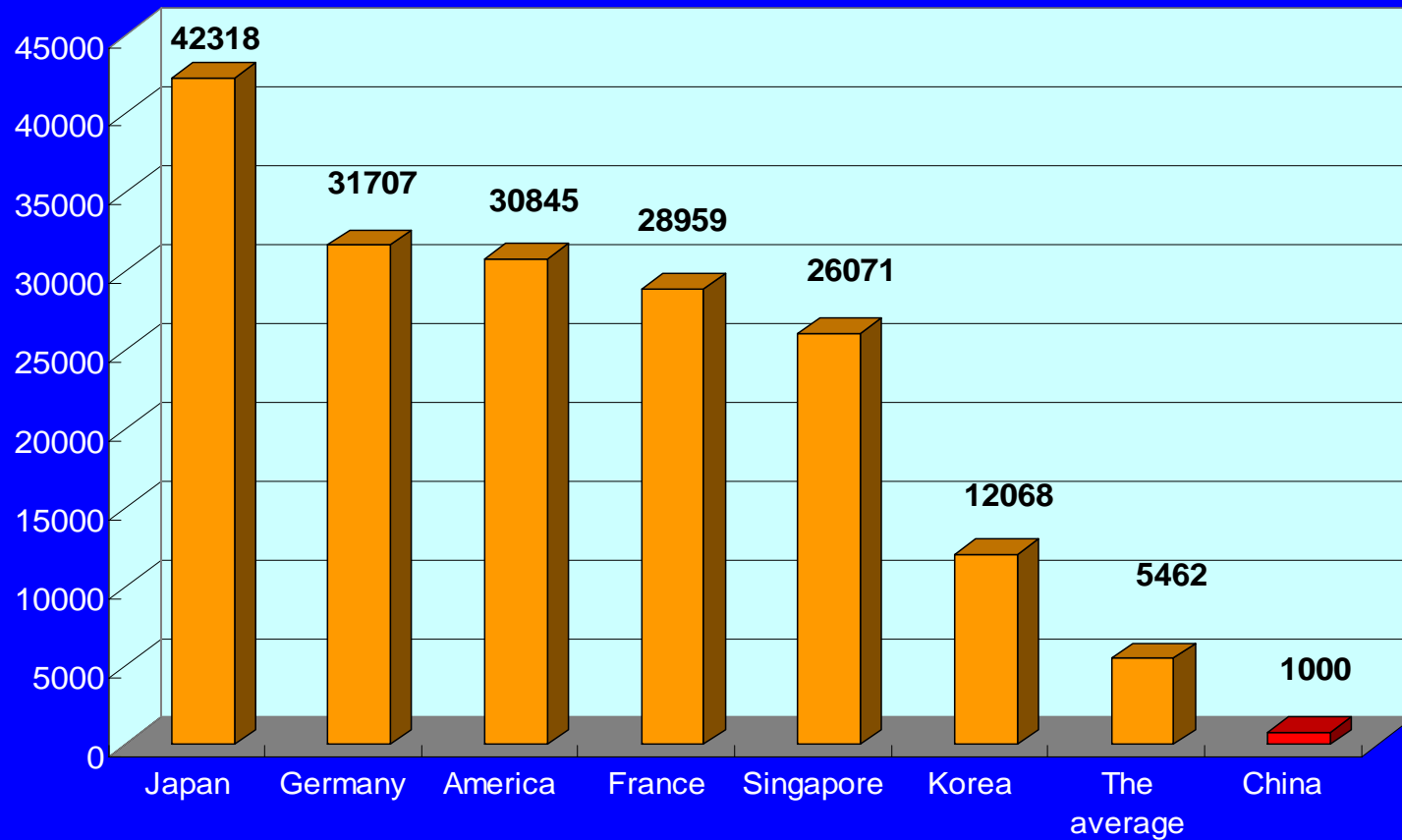
- If today's trend of utilization of fossil fuel will continue (BAU technology), we are running out of atmosphere faster than we're running out of fossil fuels.
- Terrorism doesn't threaten the viability of the heart of our high technology life-style, but energy really does.

## *Five challenges China is facing*

- **Enormous energy demand**
- **Shortage of liquid fuels**
- **Severe environmental pollution**
- **Greenhouse gas emissions**
- **Rural energy supply**

# GDP per capita comparison of countries

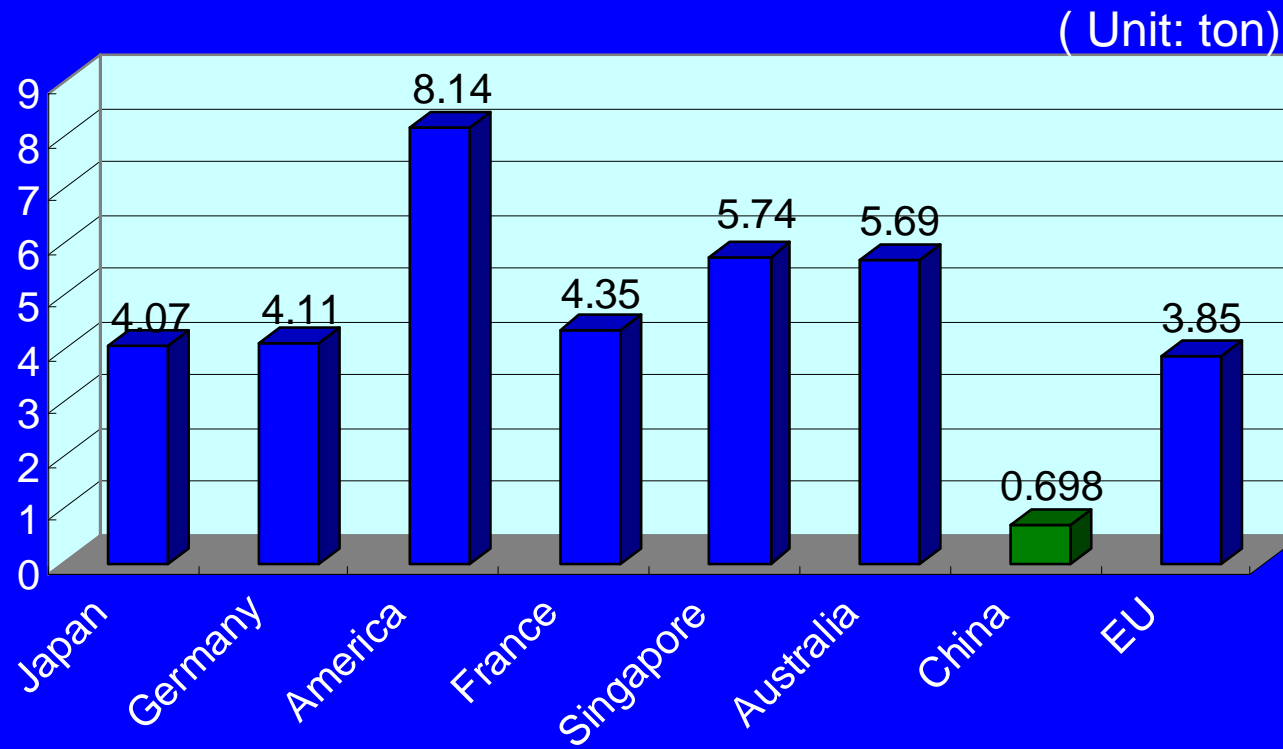
( Unit: US dollars)



Notes: Prices of 1995

Sources: 《日本能源经济统计手册》 (2002)

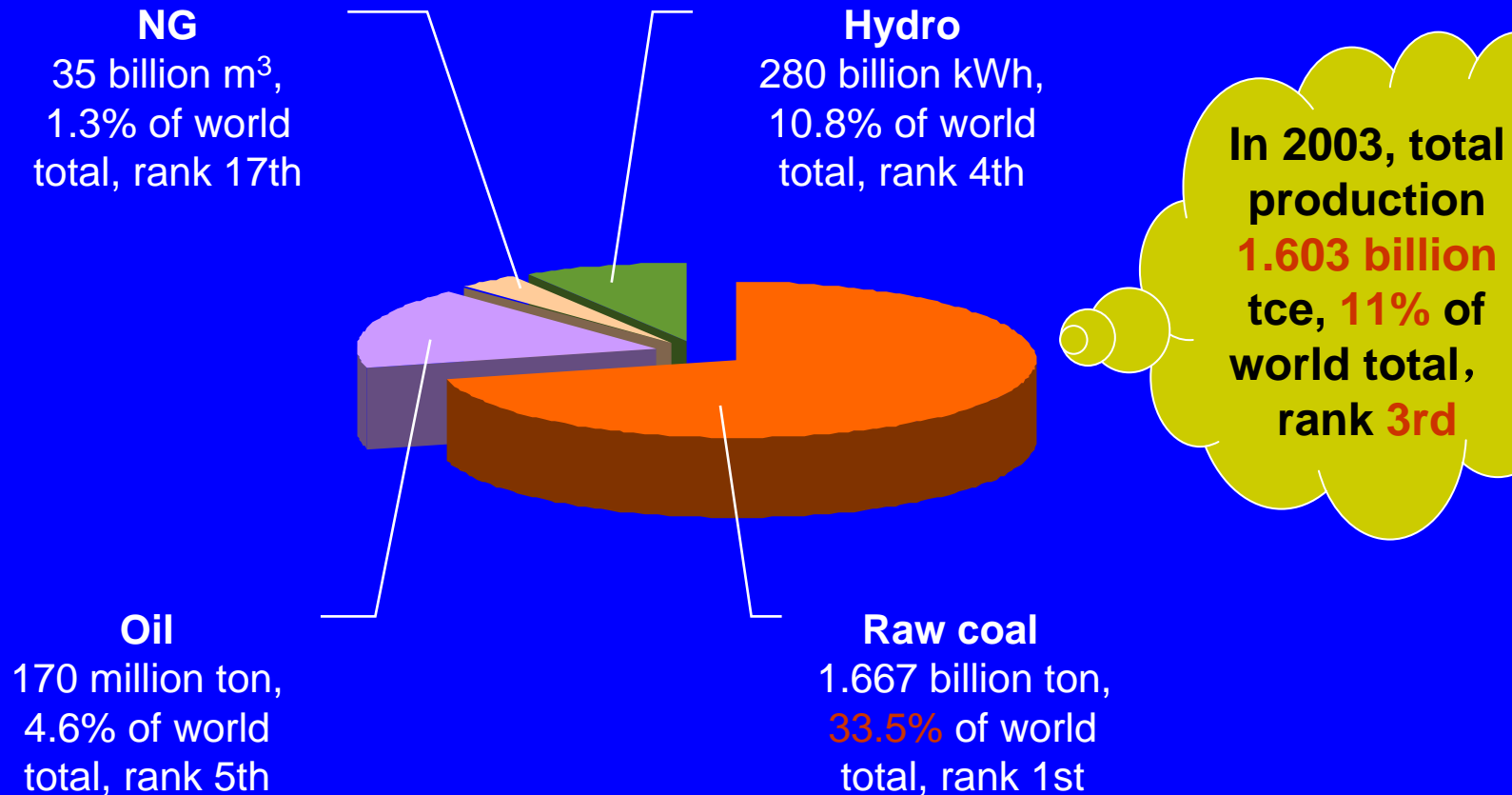
## Per capita energy consumption



Notes: Data in 1999.

Sources: 《日本能源经济年鉴》(2000)

## Huge Pressure on Demand and Supply



## Production of Raw Coal

(Units: 10<sup>8</sup> ton)

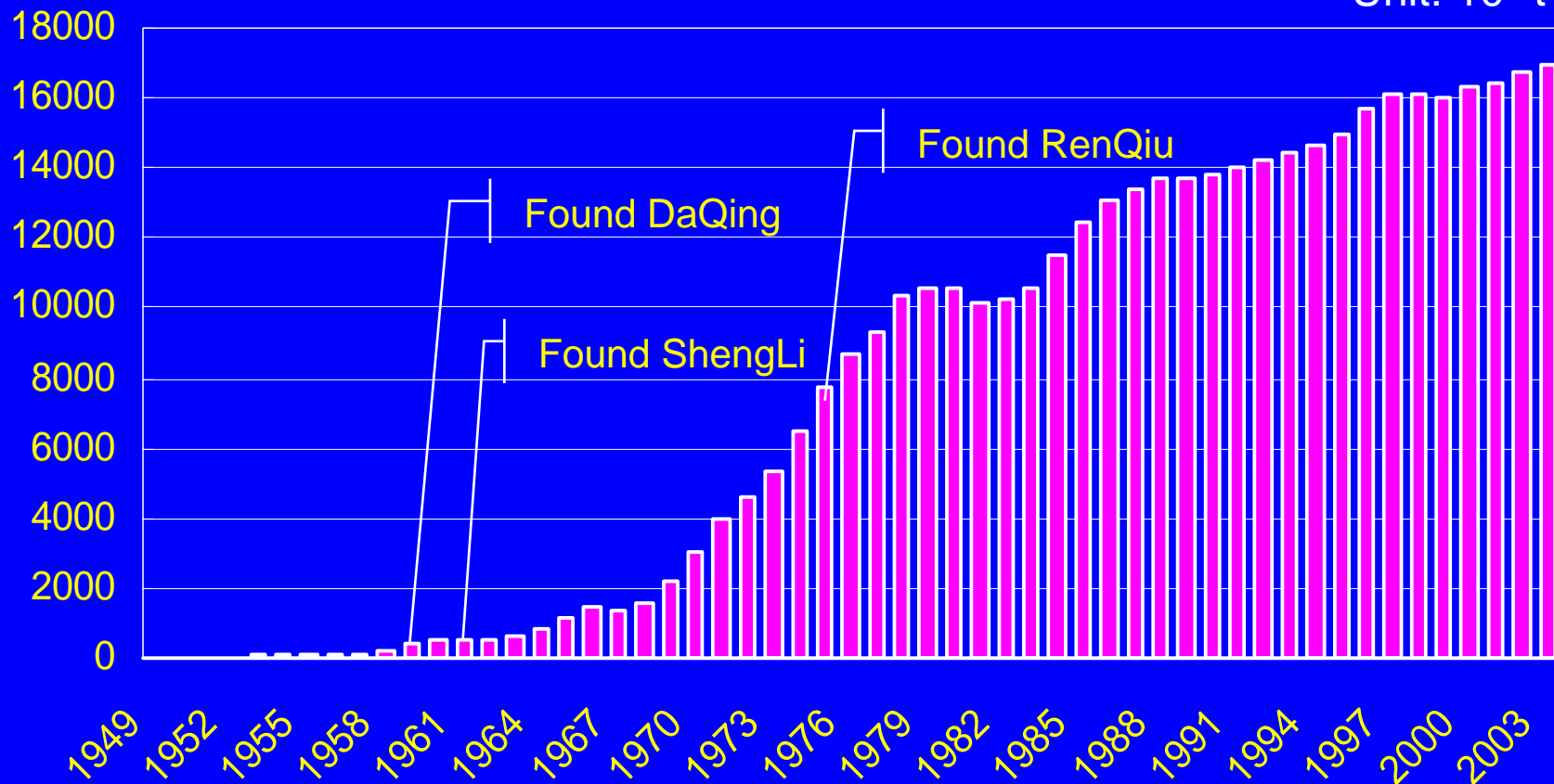
Year	1980	1990	2003
<b>Total</b>	6.2	10.8	16.67
<b>State-owned Key Mines</b>	3.5	4.8	8.3
<b>State-owned Local Mines</b>	1.6	2.0	2.9
<b>Small Mines</b>	1.1	4.0	5.47

Annual increase **45 mil. ton**, average increase rate **4.4%**

# Production of Oil

Average increase rate **14.4%**

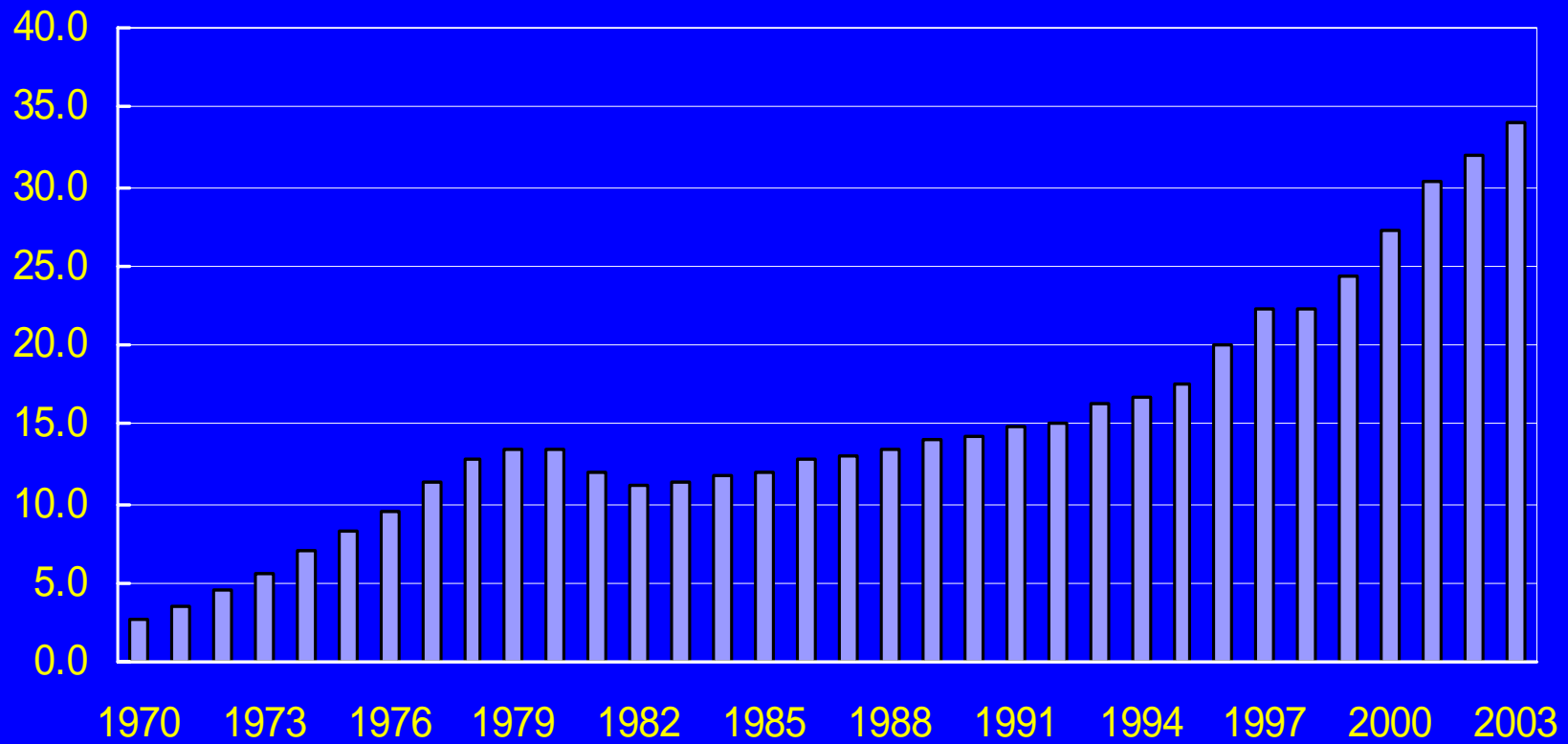
Unit: 10<sup>4</sup> t



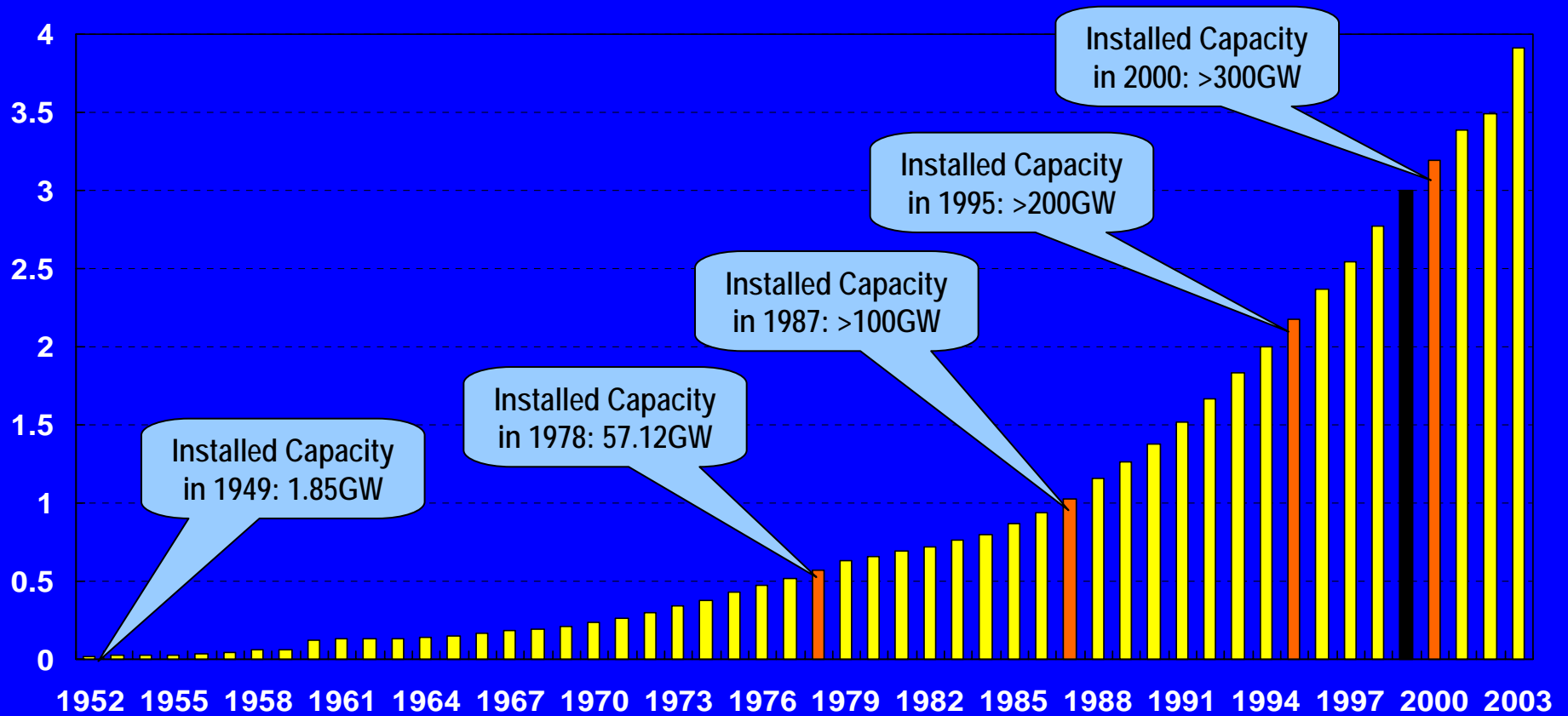
# Production of NG

Average increase rate **16.3%**

Unit: billion m<sup>3</sup>



# Power Sector

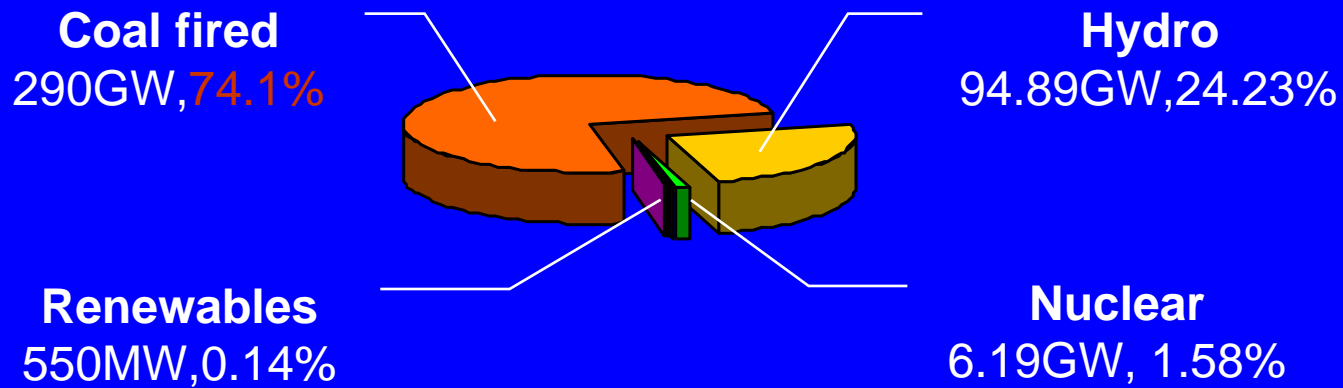


From 1996, total installed capacity ranked 2nd in the world. 2005, about

**430 GW**

## Power Mix of China in 2003

By the end of 2003, Installed capacity **391GW**

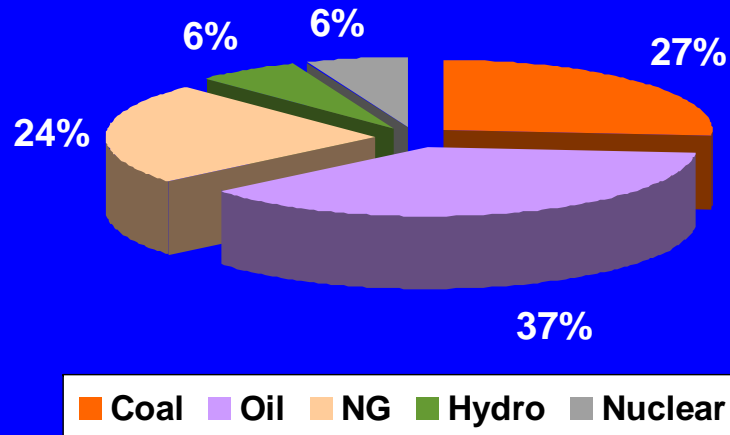


Coal fired Hydro Nuclear Renewalbes

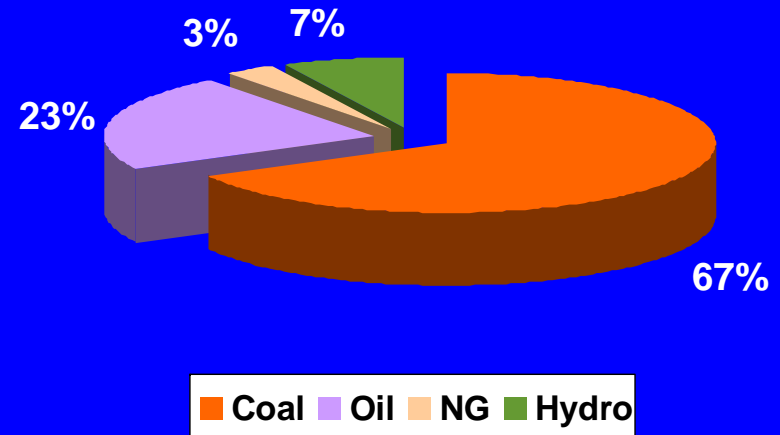
## The supply of energy is the big problem

From 2000, shortage of energy supply becomes more and more severe. Though the domestic average energy production increase rate – 14.35%, and oil import increase rate – 11.7%, the supply of energy is still the big problem

# Energy Consumption Structure



World Energy Mix



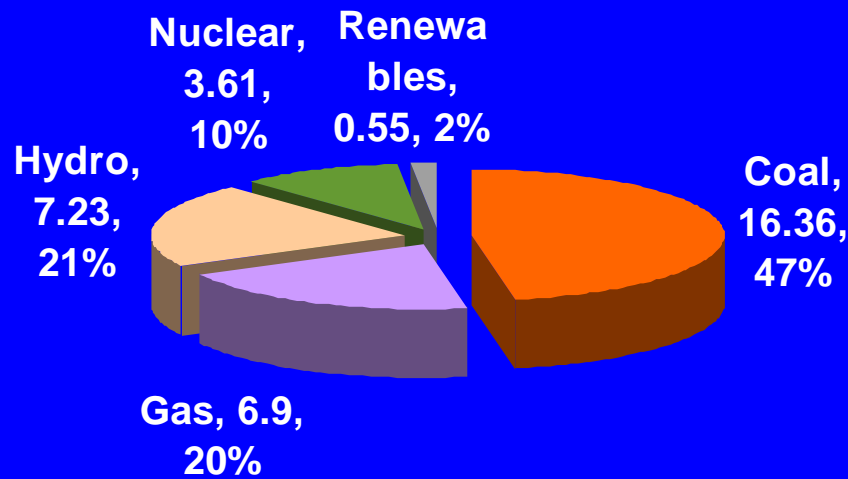
Energy Mix in China

Coal (China) = Oil + NG (World)

Oil + NG (China) = Coal (World)

Consequently, serious pollution and low efficiency

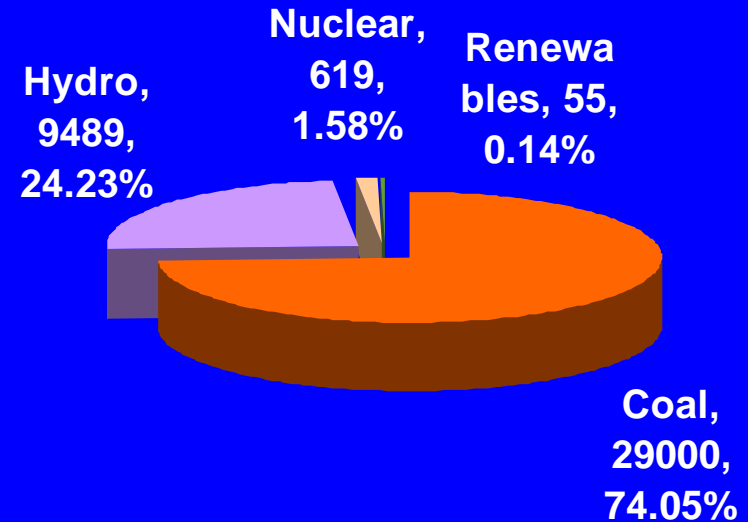
# The constituent of Power Sector



(Unit: 100GW)

2001 World Power Mix

Coal – 1636 GW, 47%  
 Gas – 690 GW, 20%  
 Nuclear – 361 GW, 10%

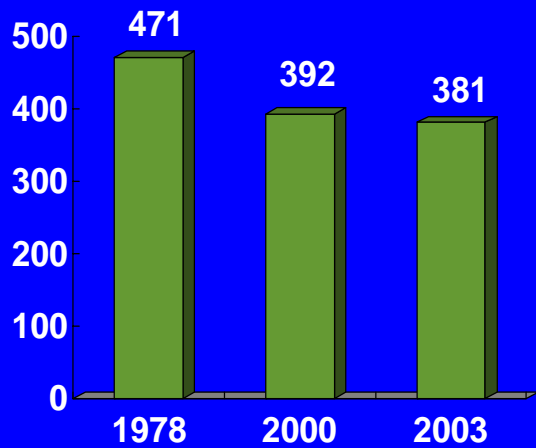


(Unit: 10MW)

2003 China Power Mix

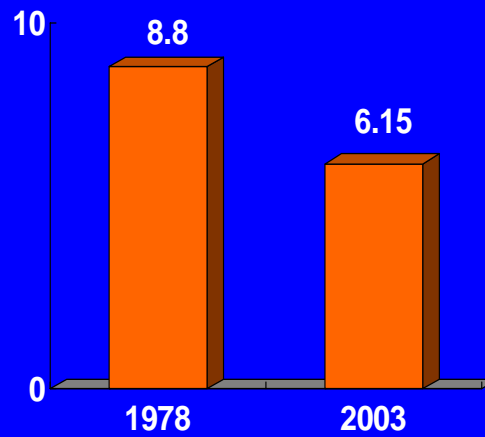
Coal – 290 GW, 74%  
 Hydro – 95 GW, 24%

# Improvement of technology



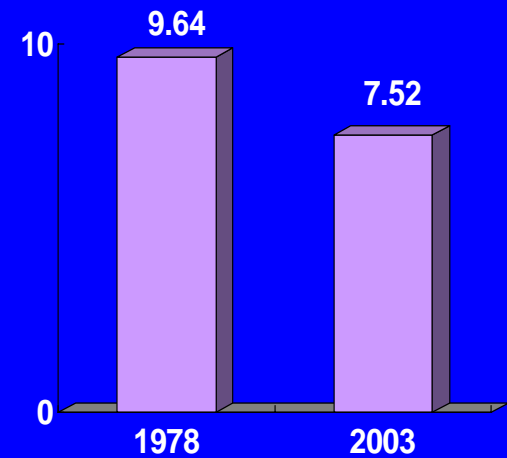
■ Specific Consumption

471 → 381 gce / kWh



■ Internal utility needs

8.8% → 6.15%



■ Transmission loss

9.64% → 7.5%

## *The main problems China is facing*

- **Constraints of domestic resources (reserves)**
- **Huge investment (up to 2020, about 1000 billion \$)**
- **Energy security**
- **Low efficiency**
- **Severe environment impact**

## Constraints of Domestic Resources (Reserves)

### *Coal*

Though the resource is abundant, but at present resource suitable for exploitation only about **100 billion ton**

## Constraints of Domestic Resources (Reserves)

### *Oil*

#### **In 2004**

- Domestic production – 170 mil. t (3.4 mil. bbls/d)
- Consumption – 290 mil. t
- Reserve / exploitation ratio 12~15, very critical (World average ~40 )
- Import 120 mil. t (2.4 mil. bbls/d), import dependence – 40%

#### **By the year 2020**

- Domestic production – 200 mil. t
- Consumption – 400~500 mil. t
- Import dependence – more than 60%

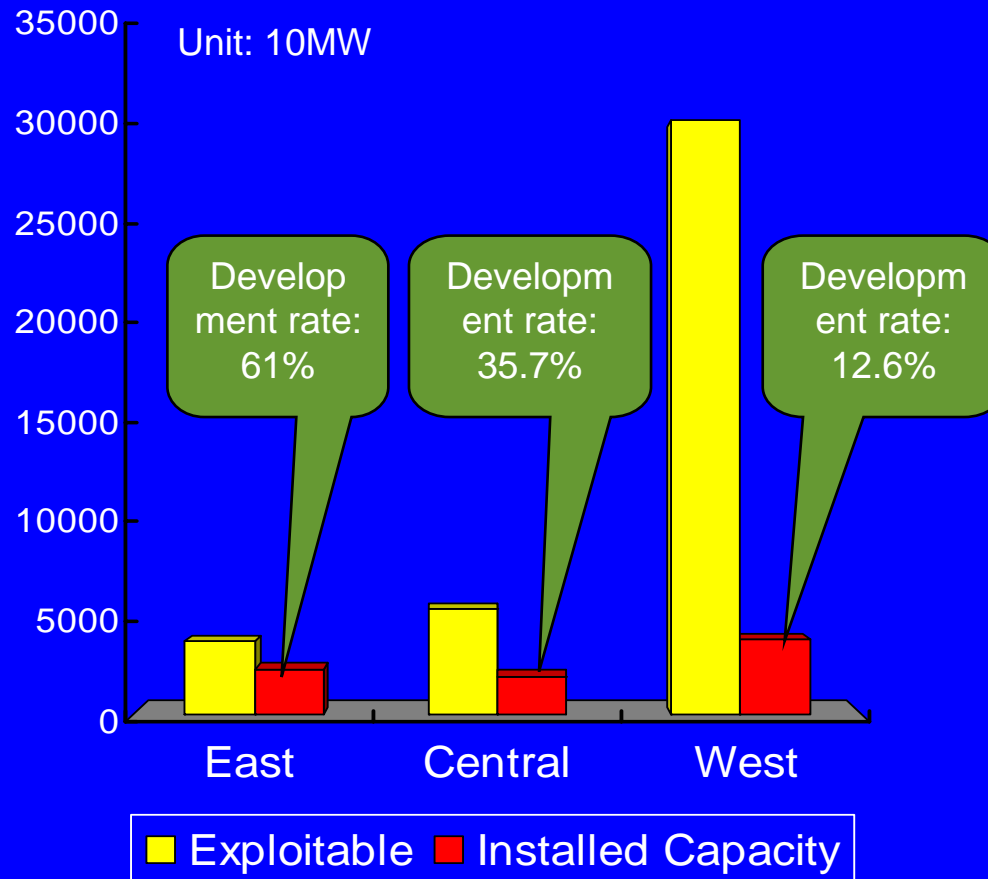
## Constraints of Domestic Resources (Reserves)

### *Hydro Power*

- Resource – rank 1st in the world, ~500GW
- Location – mainly in remote west-south areas, far from load centers
- Ecological uncertainty

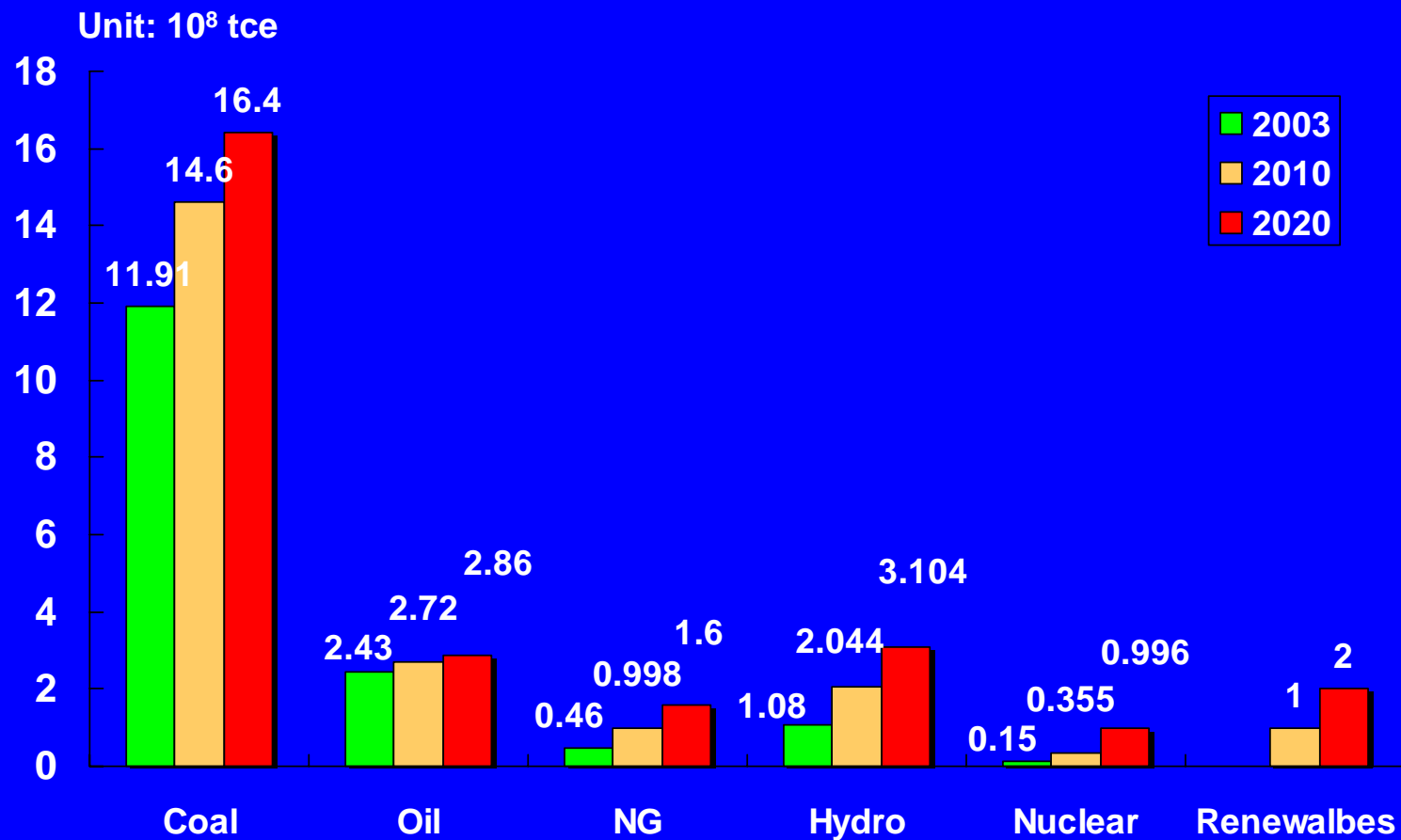
# Constraints of Domestic Resources (Reserves)

## The exploitation of hydraulic resources by areas



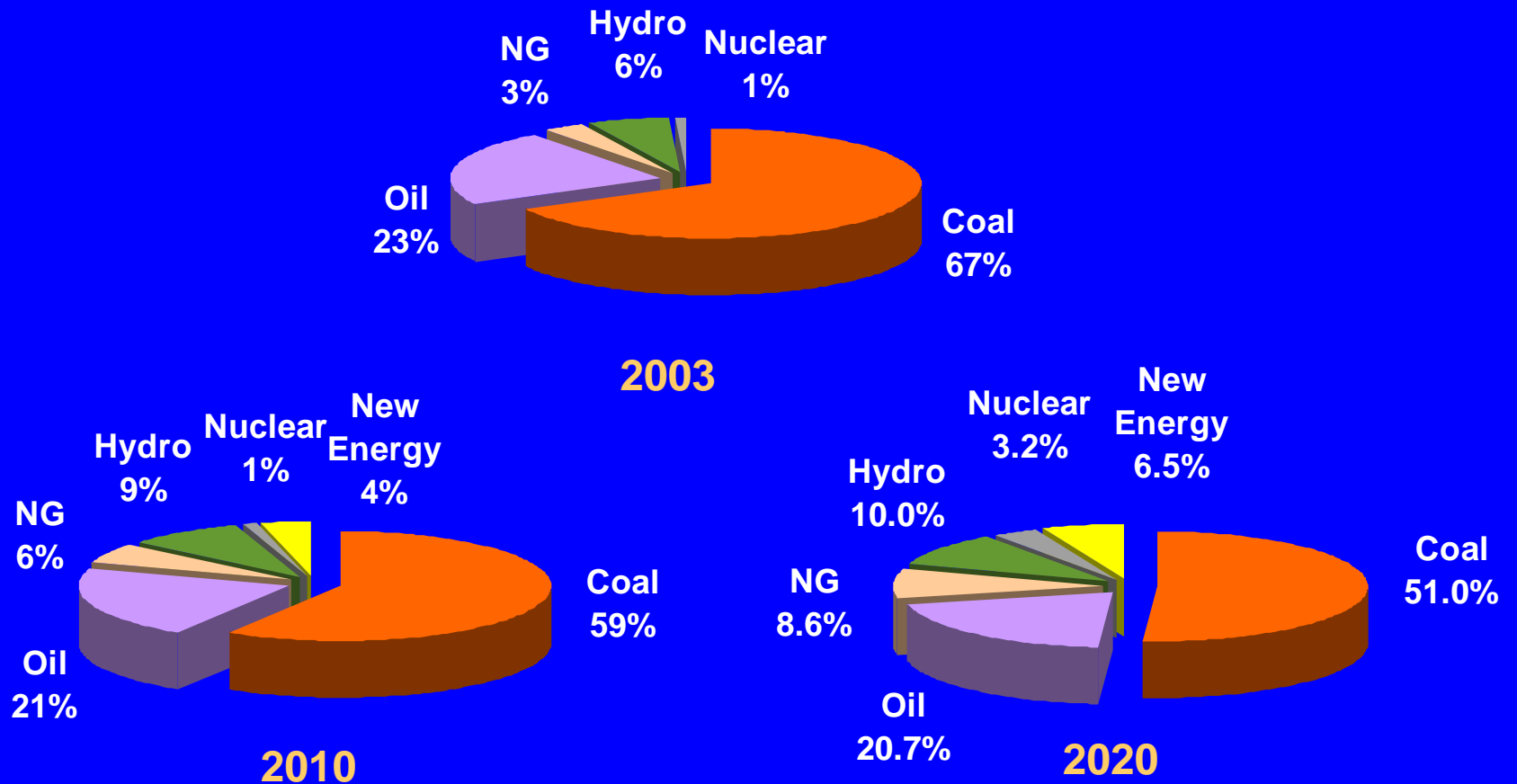
# Constraints of Domestic Resources (Reserves)

## Production target by the year 2010 and 2020



# Constraints of Domestic Resources (Reserves)

## Energy Mix by the year 2010 and 2020



## Constraints of Domestic Resources (Reserves)

### *Speed up the Nuclear power*

#### Nuclear Power

- 2003 – 6.2 GW
- 2020 – 40 GW
- More than 2 GW increase annually
- Development of domestic 1000 MW unit (advanced PWR)

## Constraints of Domestic Resources (Reserves)

### *Speed up the NG exploitation and import of LNG*

- West to east pipeline – 12 billion Nm<sup>3</sup>
- 2003, total production 35 billion Nm<sup>3</sup>
- 2020, domestic production 120 billion Nm<sup>3</sup>, consumption 200 billion Nm<sup>3</sup>
- Already signed contract with GE, MHI and Siemens for purchasing 45 units of F-class gas steam combined cycles (380 MW each). Total consumption of NG – 16 billion Nm<sup>3</sup>. Is it the right way for NG utilization?

## Constraints of Domestic Resources (Reserves)

### *Renewable energy*

- China is abundant in renewable energy – wind, solar and biomass...
- Wind energy, in shore – 254 GW, off-shore – 700 GW
- Biomass – 500~600 mil. tce (but highly scattered)

## Constraints of Domestic Resources (Reserves)

### *Renewable energy (Wind)*

- Installed capacity of wind power – 700 MW
- 170 thousand small wind mills, total capacity about 20 MW
- By the year 2020 – 20 GW, about 30 times increase
- Domestic production: 600, 750 kW units have been installed in large scale; 1.2 MW units are being tested now.



## Constraints of Domestic Resources (Reserves)

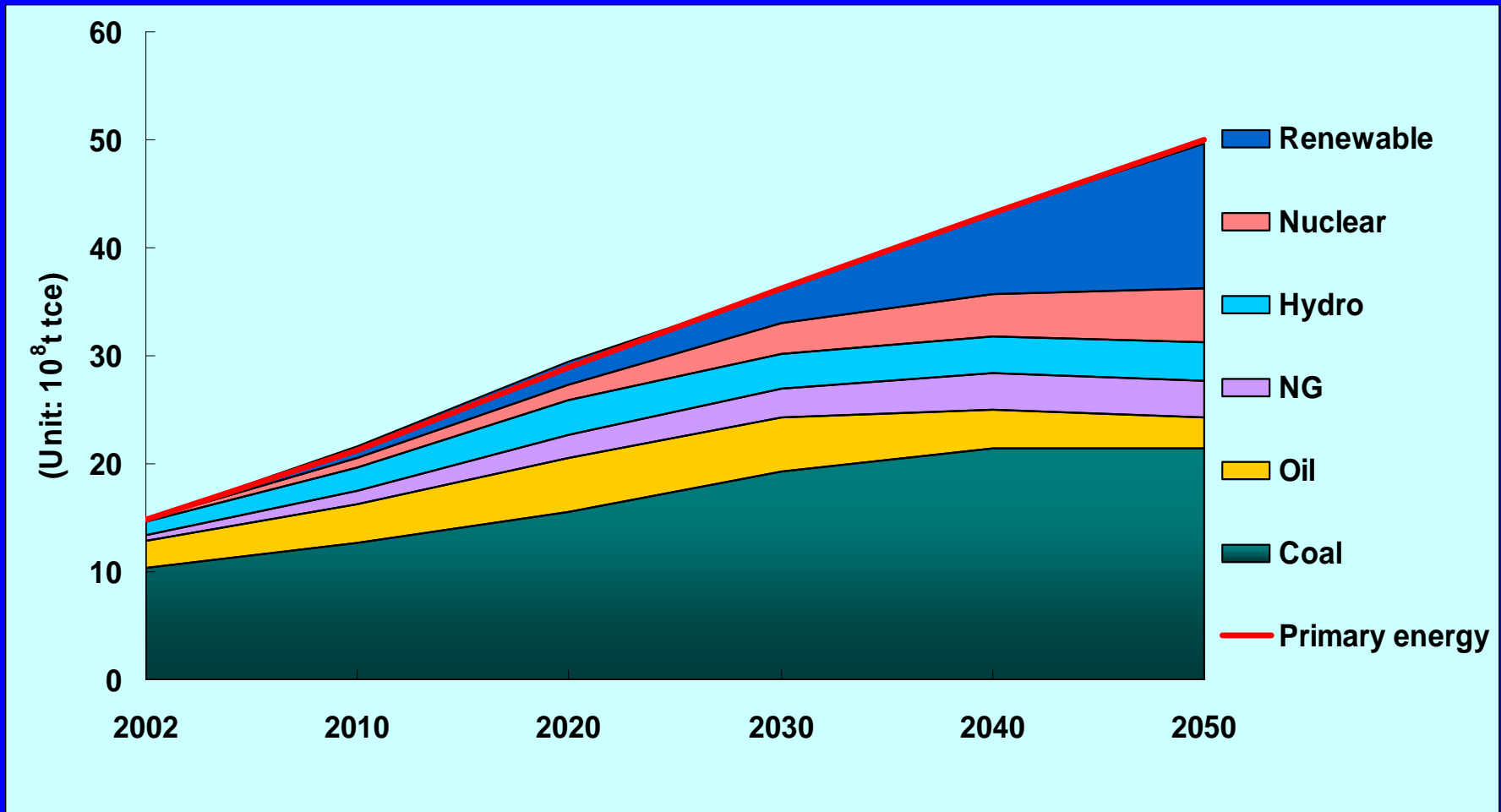
### *Renewable energy (Solar)*

- Solar heat collectors – high technology, 92~95% absorption rate
- 52 mil. m<sup>2</sup>, 40% of world's total
- Dominant in the world market
- Huge potential of energy conservation (In combination with heat pump technology)



# Constraints of Domestic Resources (Reserves)

## The Energy Production Scenarios

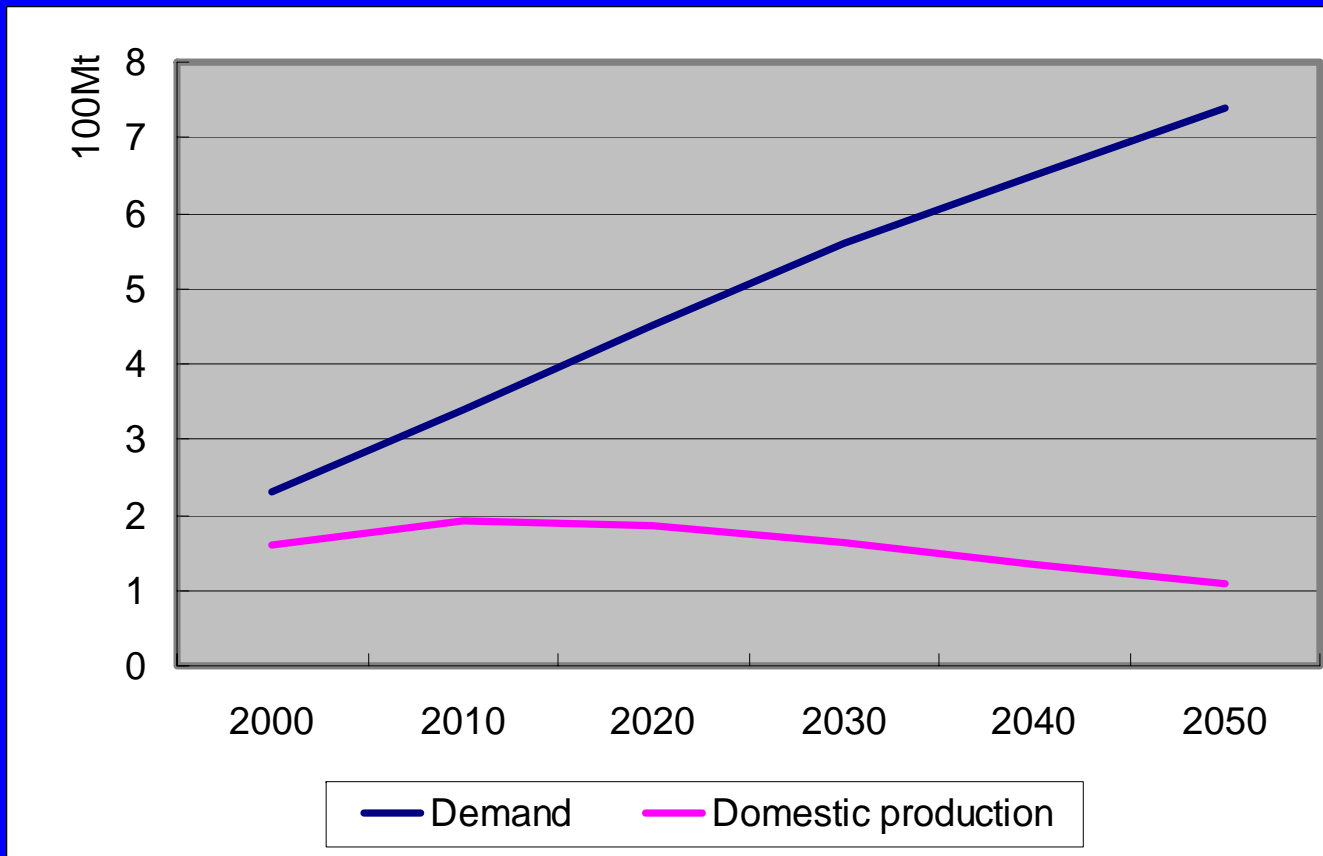


## Energy security

- The per capita energy reserves of China are much lower, especially for the oil and natural gas
- Oil will reach the peak production around 200Mt in 2020, after then the production will decrease
- 60% oil and natural gas in 2020 will depend on import
- 1000Mt coal production new capacity will be set-up before 2020, it is a very tough task (reserves, capital investment, ecology...)

# Energy security

## Increasing Dependence on Oil Import



## Energy efficiency

- The energy consumption intensity of GDP of China in 2000 was 0.89kgoe/\$US, 3.34 times of world average level and 4.63 times of OECD average
- 4% of world GDP consume 10% of the world electricity
- 4% of world GDP consume 30% the world iron and steel and 40% of the world cement
- In developed countries – industry, construction and transportation each consumes roughly 1/3 of the total energy. But in China, industry consumes about 70% (Iron steel, cement, aluminum – about 60% of the industrial energy use)

**Structure Change needed !**

## Energy efficiency

- **Comprehensive energy efficiency – 33%, about 10 points percentage lower than OECD countries**
- **Power, Iron and Steel, Nonferrous metals, petroleum chemistry, Construction materials, Chemical engineering, Light industry and textile – 8 industrial sectors, their unit product consumption is about 40% higher than OECD countries**
- **Iron and Steel, Cement, Paper – specific energy consumptions – 21%, 45% and 120% in comparison with advanced level respectively**
- **Efficiency of vehicles – 25% lower than in Europe and 20% than in Japan**
- **Specific energy consumption for building heating is about 2~3 times higher than the developed countries at the same latitude**

## Energy efficiency

***Enormous potential of energy conservation and efficiency improvement***

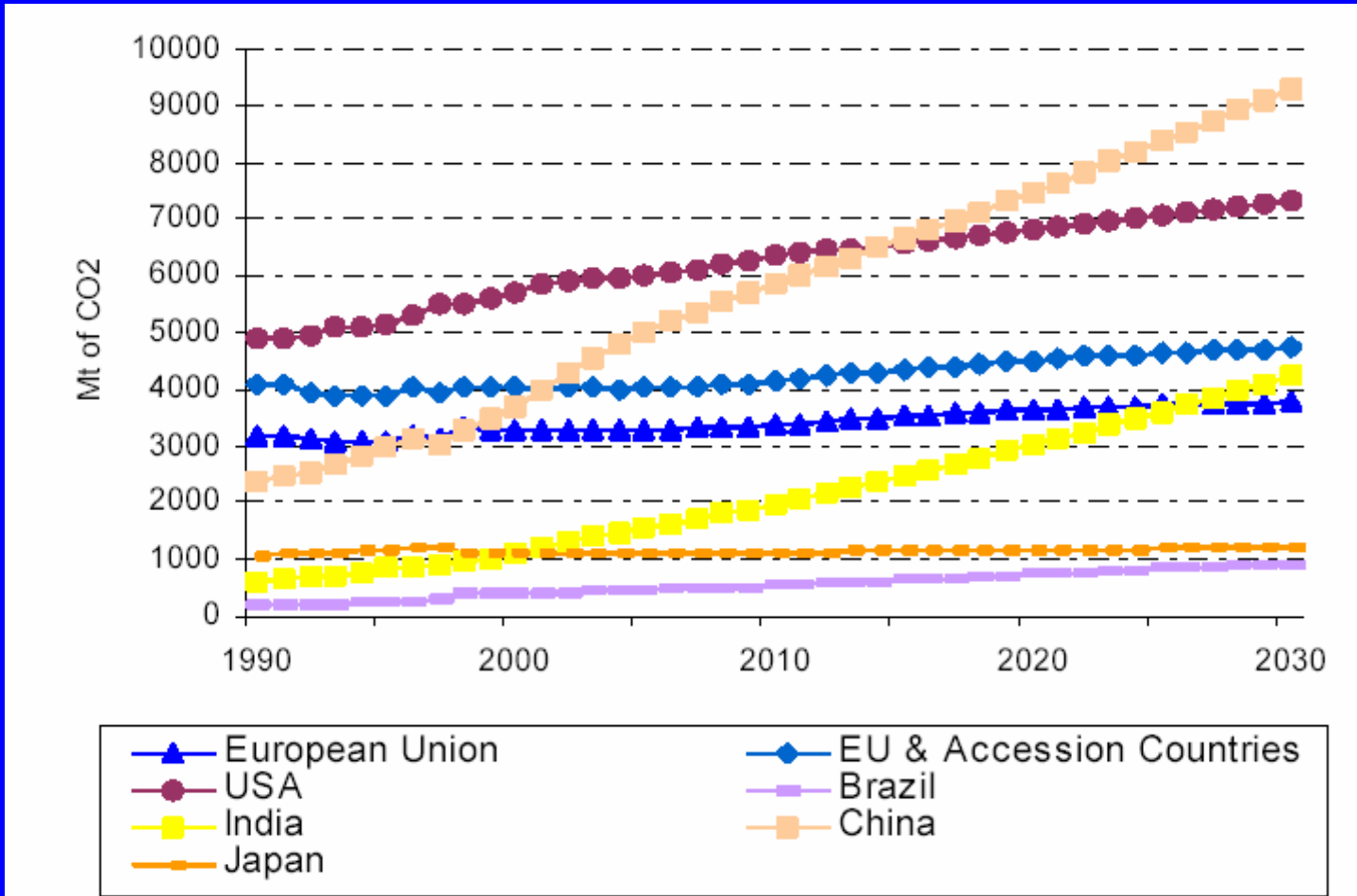
In this concern, not only technology, more important is the institutional issues – government policy and regulations, taxation, financial incentive of the parties (sectors)

## Severe Pollution

- In 2020 the SO<sub>2</sub> and NO<sub>x</sub> pollutant could be 40Mt and 35Mt and exceed 16Mt and 19Mt of the pollutant limits respectively, if no additional control measures will be taken
- About 40% of the territory of China is suffering acid rain
- China is the second largest CO<sub>2</sub> emission country, it will increase in the future

# Severe Pollution

## Forecast of CO<sub>2</sub> emission from different countries



## General Conclusions

- According to the projection of energy demand and supply, coal will still play the dominant role (50%~60% in 2050)
- Coal utilization will contribute about 70%~75% of CO<sub>2</sub> in China (at present 76.8%), and SO<sub>2</sub>, NO<sub>x</sub>, PM<sub>5</sub>, Hg as well
- Coal mainly will be used for power generation in future (up to 80%, at present about 45~50%), It means coal fired power plants will contribute 60% or more CO<sub>2</sub> of total

## General Conclusions

- Large scale mitigation of shortage of liquid fuel could be realized only by coal-derived alternatives (F-T synthetic fuel, Methanol, DME), Biodiesel and ethanol from corn and cellulose could only solve small part of the shortage problem
- Capture CO<sub>2</sub> from flue gas of power plants is investment intensive and with unaffordable large (per unit CO<sub>2</sub>) energy consumption
- “Hydrogen Economy” with renewable derived hydrogen is still a long way to go (20~30 years)

## *What is the way out ?*

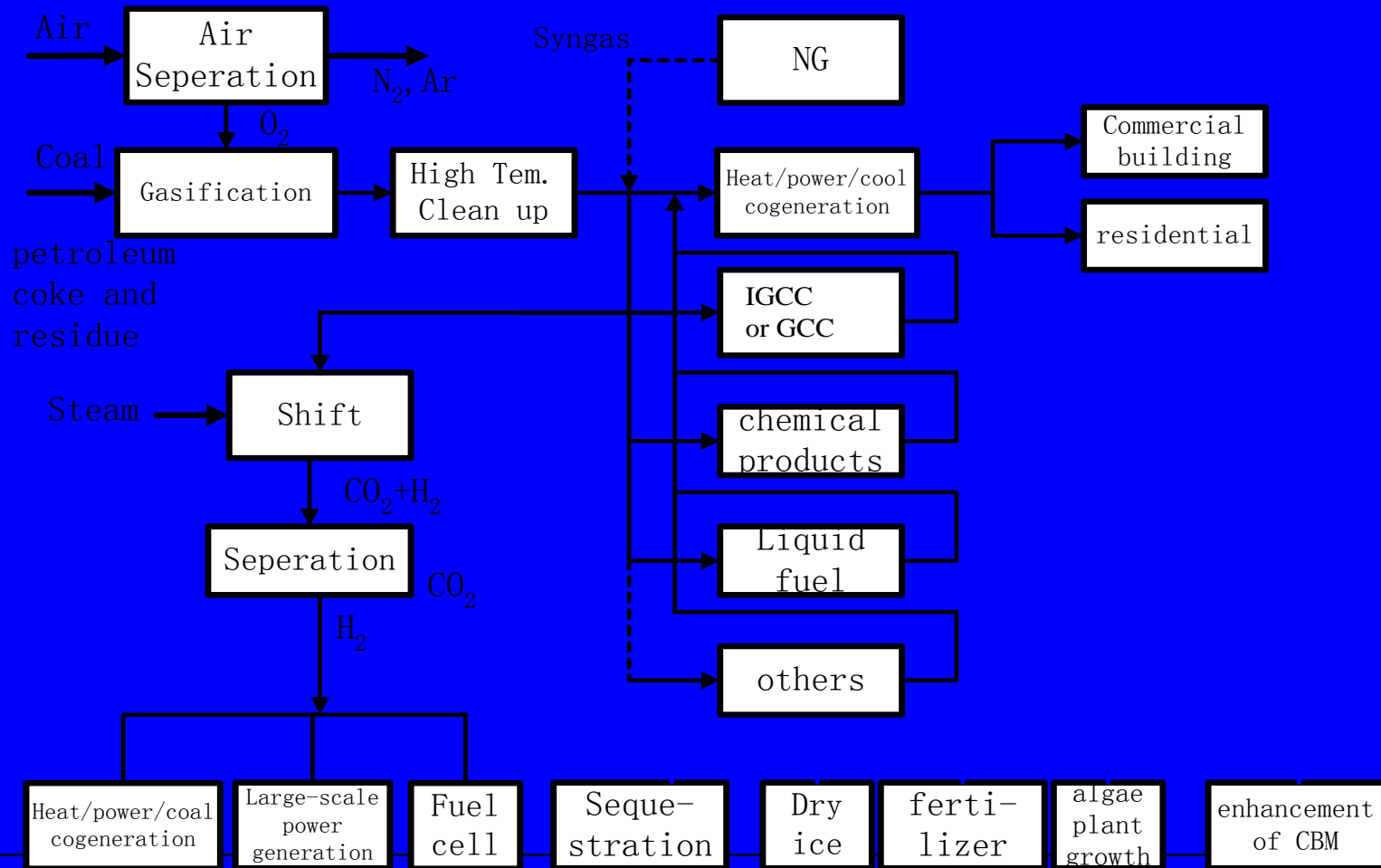
Except to speed up the development of nuclear and renewable energy

- Sustainable utilization of coal or modernized coal utilization beyond direct combustion
- Coproduction of Power, liquid fuel, chemicals, heat and gas via coal (or petrol coke) gasification and once-through chemical reactors.

That is: ***POLYGENERATION***

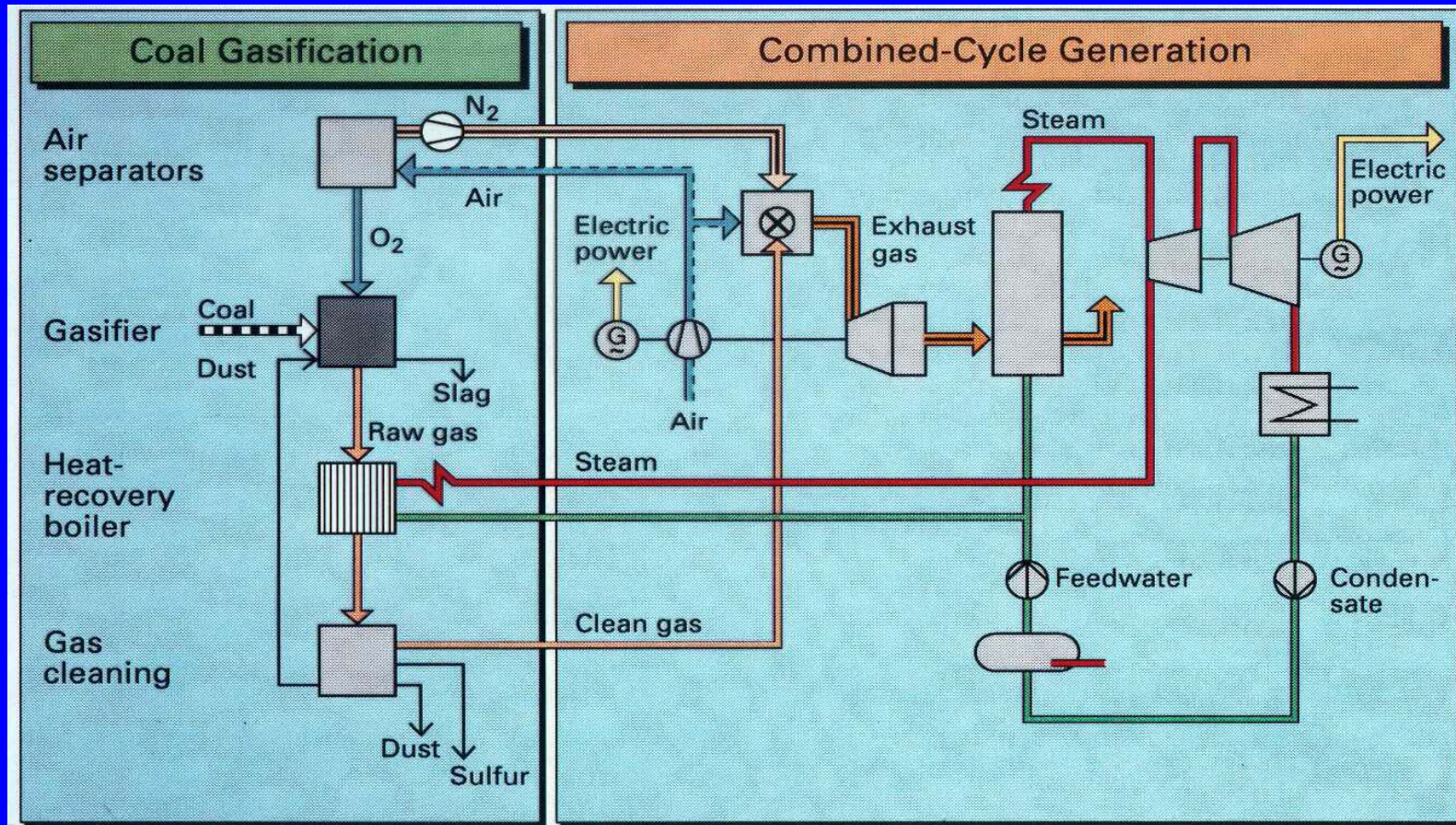
# What is the way out ?

## Integrated Resource-Energy-Environment System



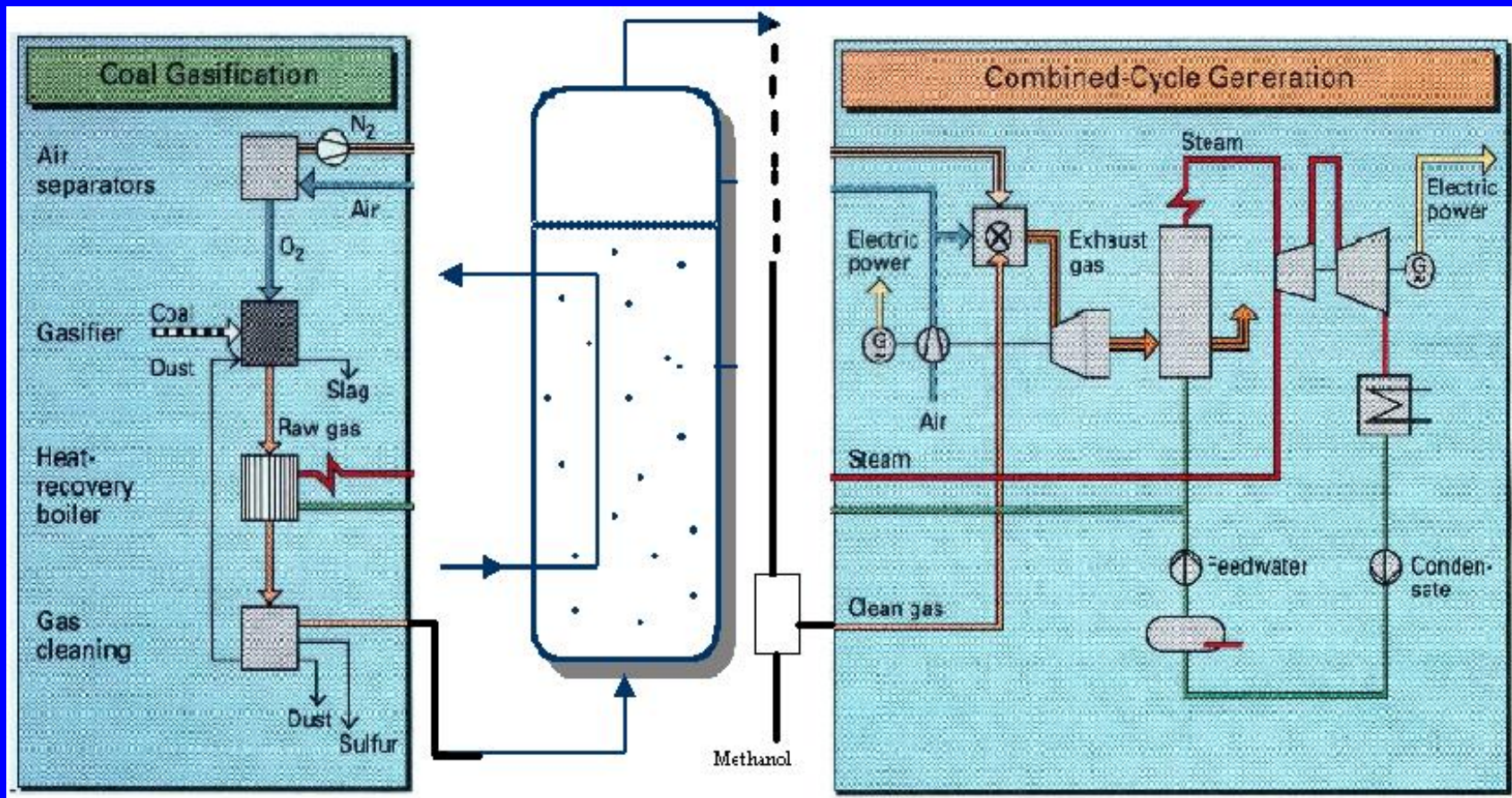
# What is the way out ?

## Integrated Gasification Combined Cycle



# What is the way out ?

## Simplified illustration of Polygeneration



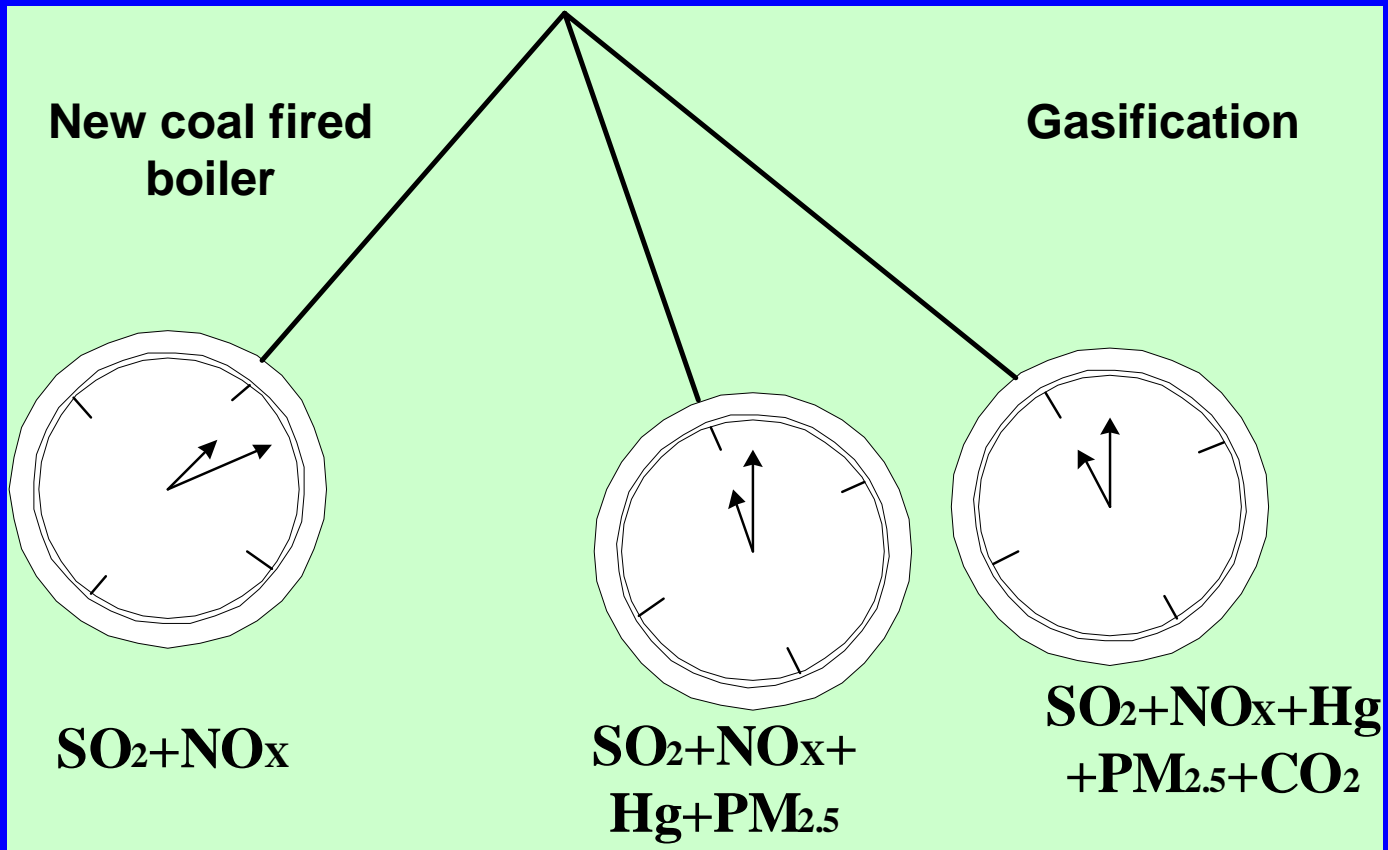
## What is the way out ?

- Polygeneration is the sustainable, technically consistent, technologically realistic, economically beneficial, and ecologically friendly way for CO<sub>2</sub> mitigation, capture, and further sequestration. It is really the most important strategy in China, even in the world

## *What is the way out ?*

- **Polygeneration**
  - It doesn't need specific technology breakthroughs, consistent to the existing technologies
  - Concentrated CO<sub>2</sub> could be easily captured along with the natural technological processes, that is, polygeneration has the nature easy for CO<sub>2</sub> capture
  - This is the strategic way for CO<sub>2</sub> mitigation in China

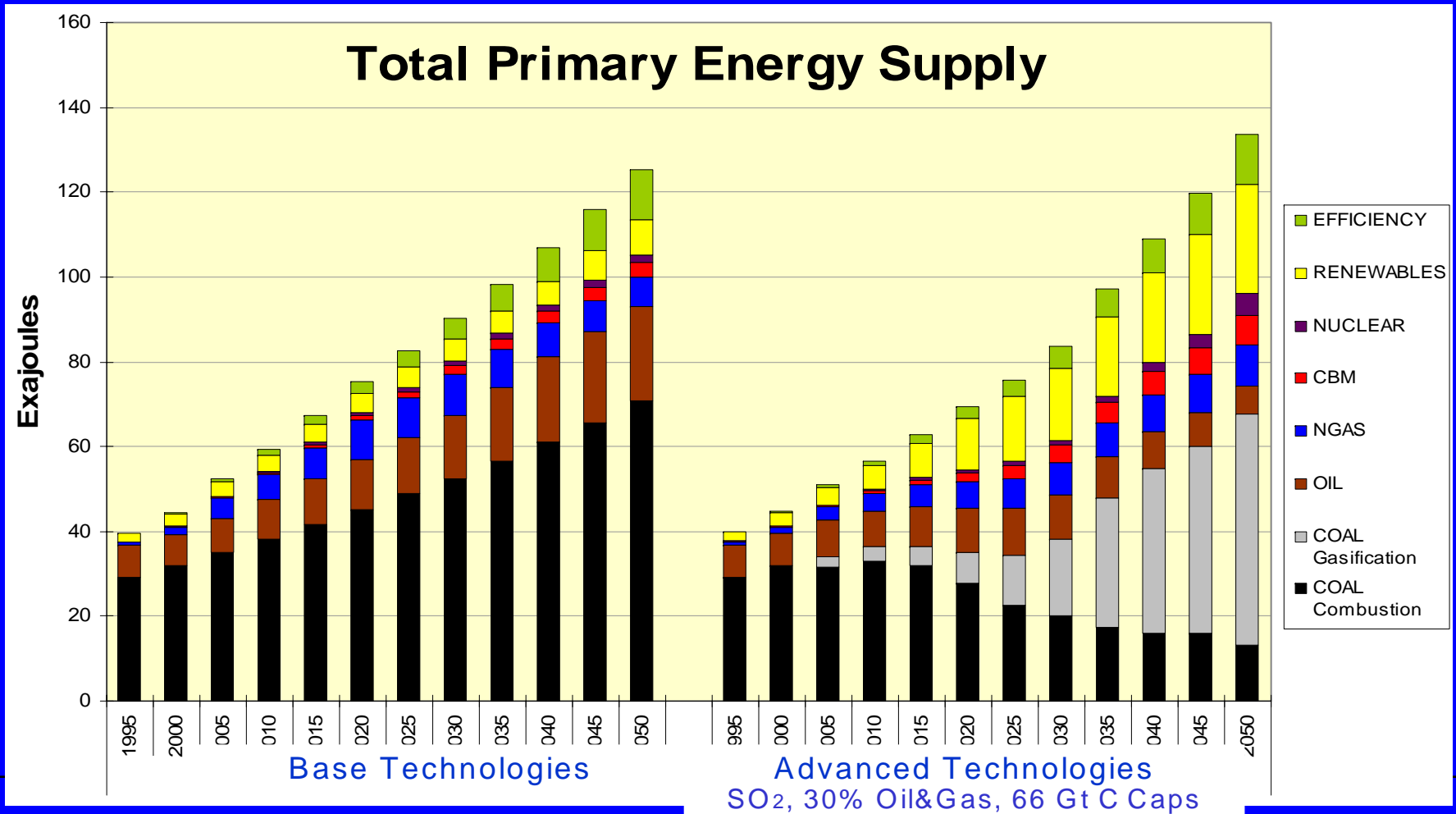
## What is the way out ?



With more and more stringent environmental regulation, the advantages of coal gasification polygeneration will be more and more economically significant

# Urgent actions should be taken (1)

## Scenario study (MARKAL model)



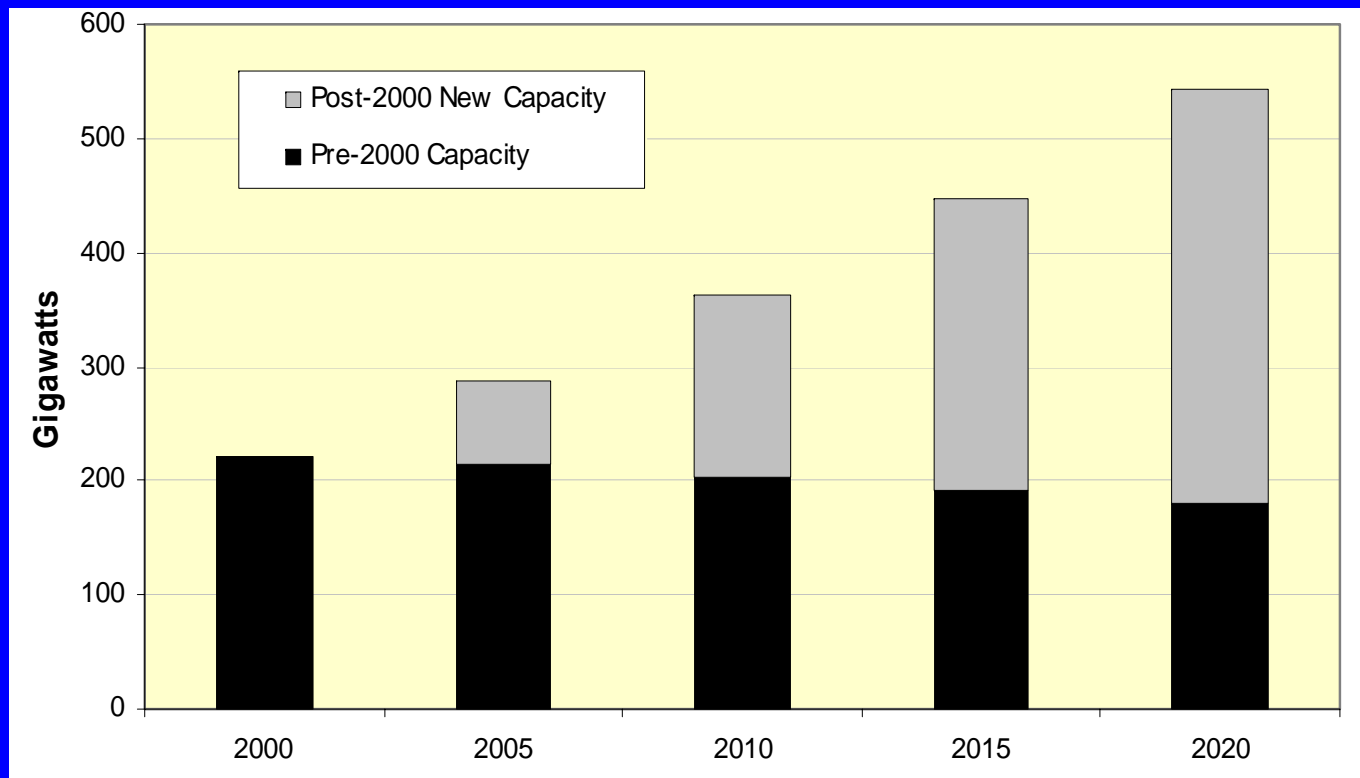
## *Urgent actions should be taken (2)*

### The effect of Advanced Technologies Scenario

- Provides the same energy services at about the same cost as the Base technologies strategy
- SO<sub>2</sub> emissions are reduced from 23.7 Mt in 1995 to 16.2 Mt in 2020 and 8.8 Mt in 2050
- Imports of oil and natural gas are limited to 30% of consumption of oil and gas over the long-term
- 66 Gt C caps

## Urgent actions should be taken (3)

### Projection for Coal Power Plant Capacity



## ***Urgent actions should be taken (4)***

*Delaying the start of the transition to coal gasification based polygeneration technology would significantly increase:*

- *the costs to China of air pollution damages*
- *the costs of oil imports*
- *the costs of reducing GHG emissions*

## Conclusions

- China needs a integrated, but divided into long term(20~50 years), intermediate term (8~15 years) and short term (3~8 years) energy strategy
- Any significant change in energy system needs long period (large inertial system with big time constant)
  - Step on the peel of watermelon (or banana), slipping anywhere without definite direction
  - When head aches – treat only headache, when leg aches – treat only leg ache

Are **not** the way for China's energy

***Thank You!***