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CO2 mitigation opportunities in China

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NICE

CO_2 Mitigation Opportunities in China

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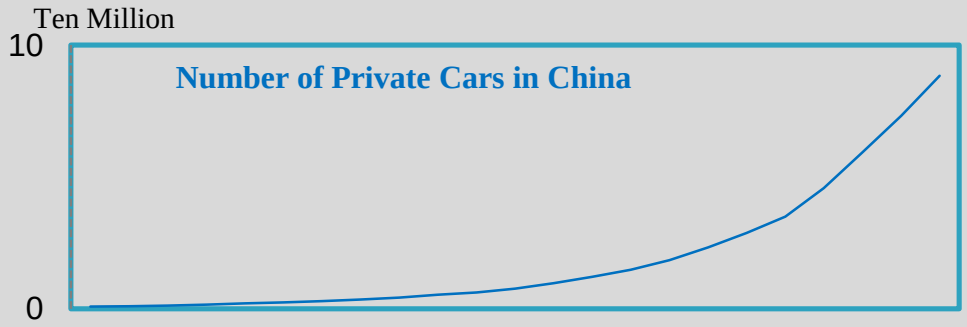
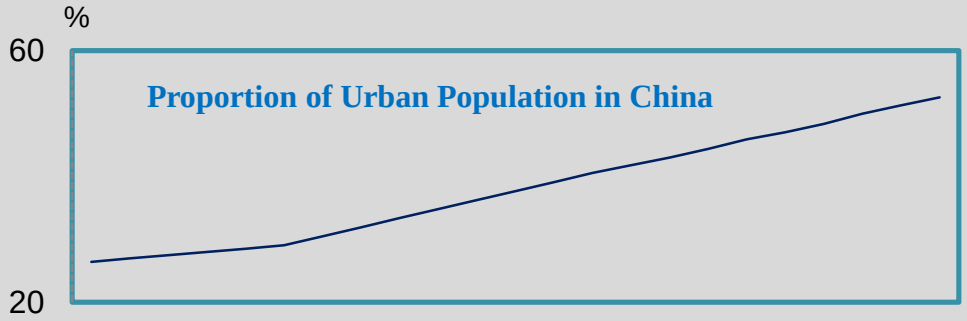
Outline: the Picture in China

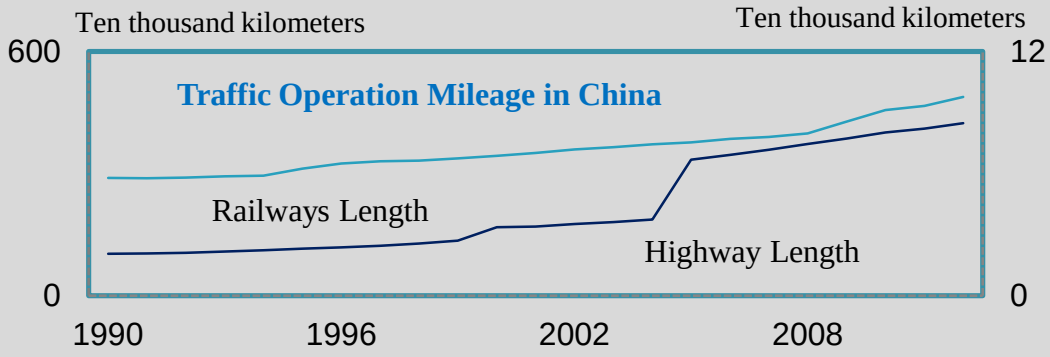
- Overview of Carbon Emission
- Challenges in Carbon Mitigation
- Opportunities in Carbon Mitigation
- Actions in Carbon Mitigation for China, Shenhua, and NICE

Overview of Carbon Emission in China

Rapid Economic Development in China

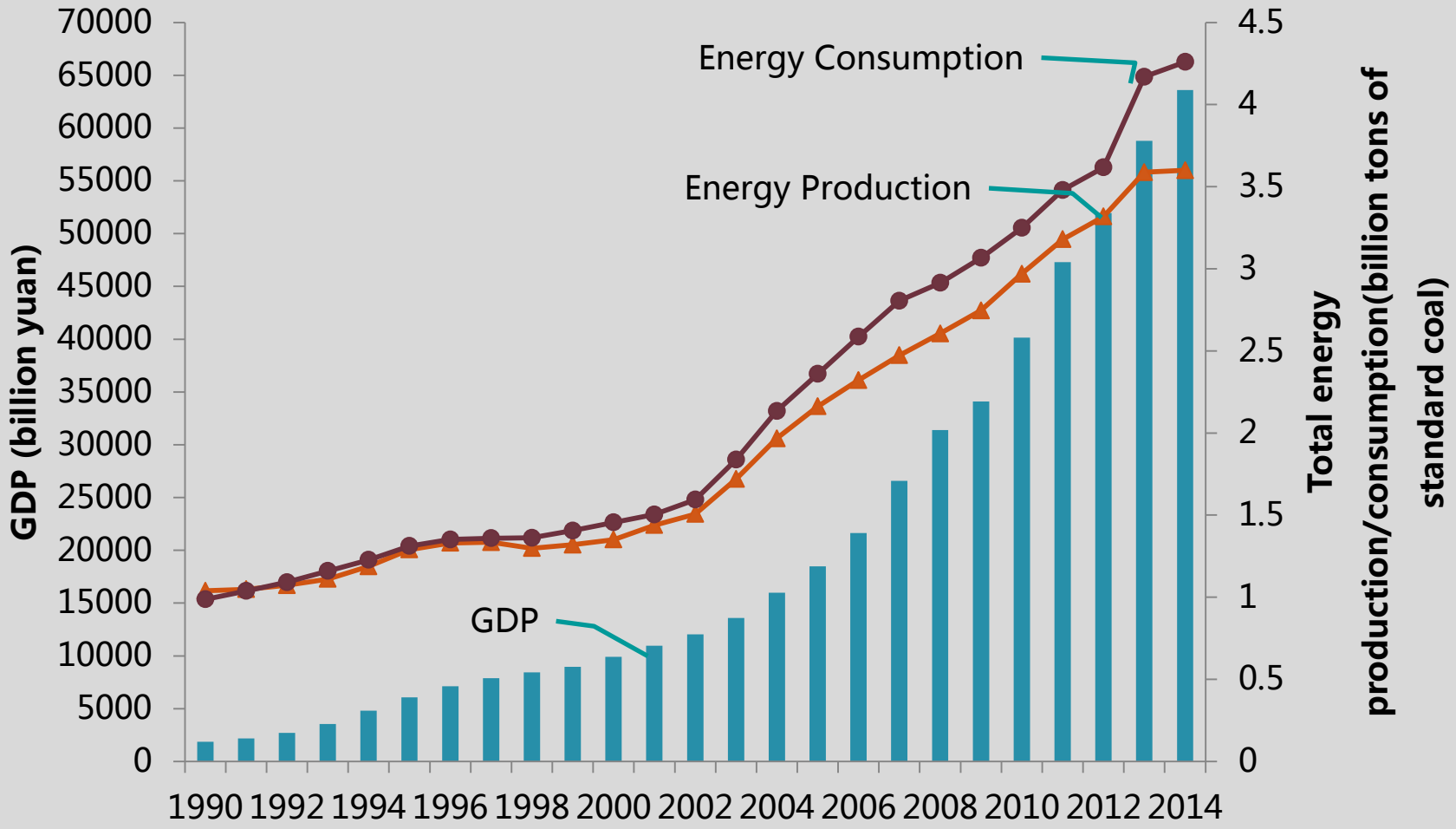






Rapid Economic Growth in China

Economy, energy production and consumption in China (1990-2014）

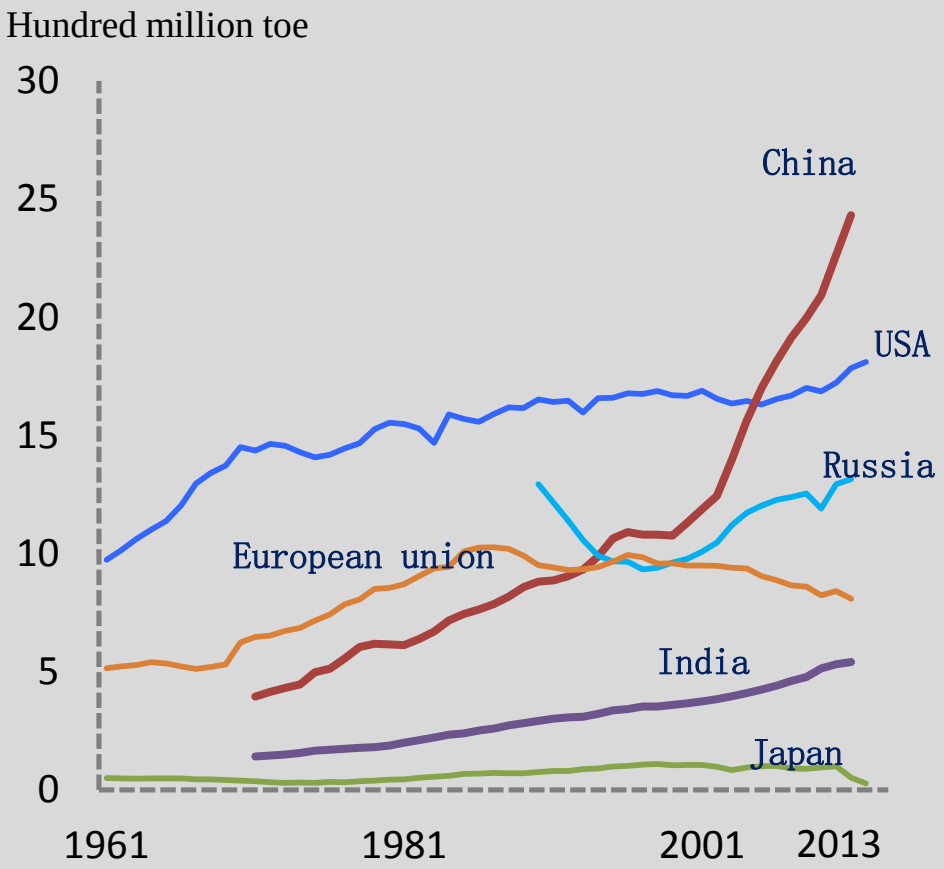


In 2014

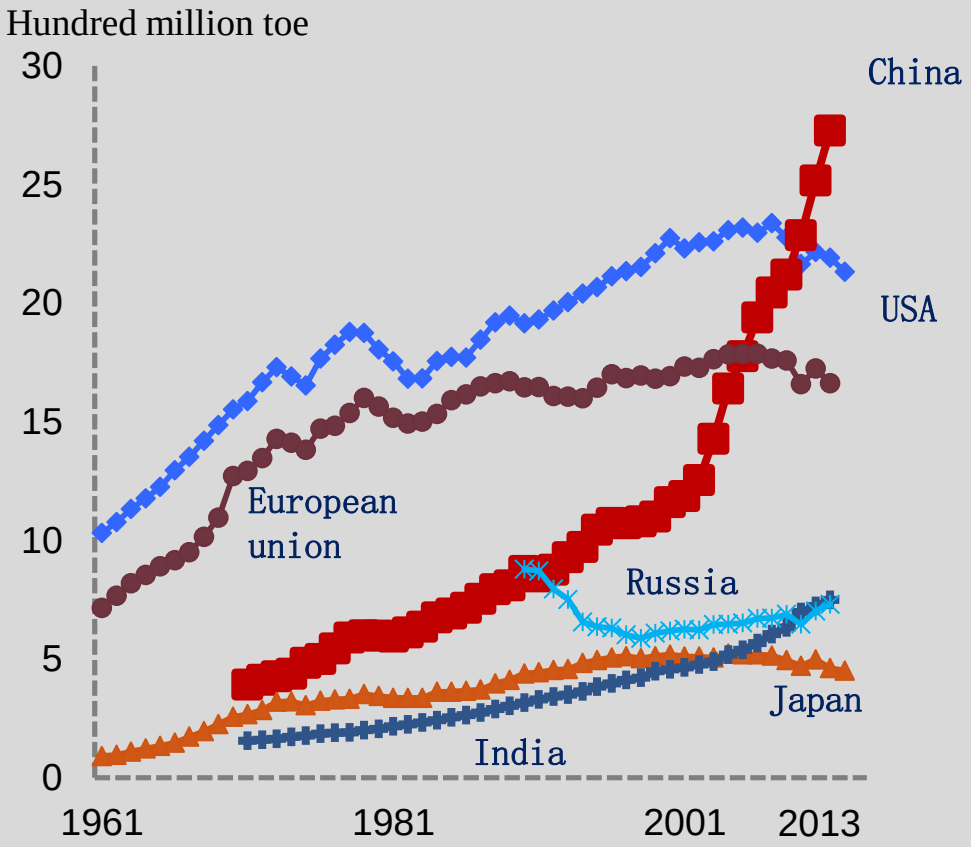
- Energy Production 3.6 Billion tce
- Energy Consumption 4.26 Billion tce

Rapid Growth in Energy Production and Consumption

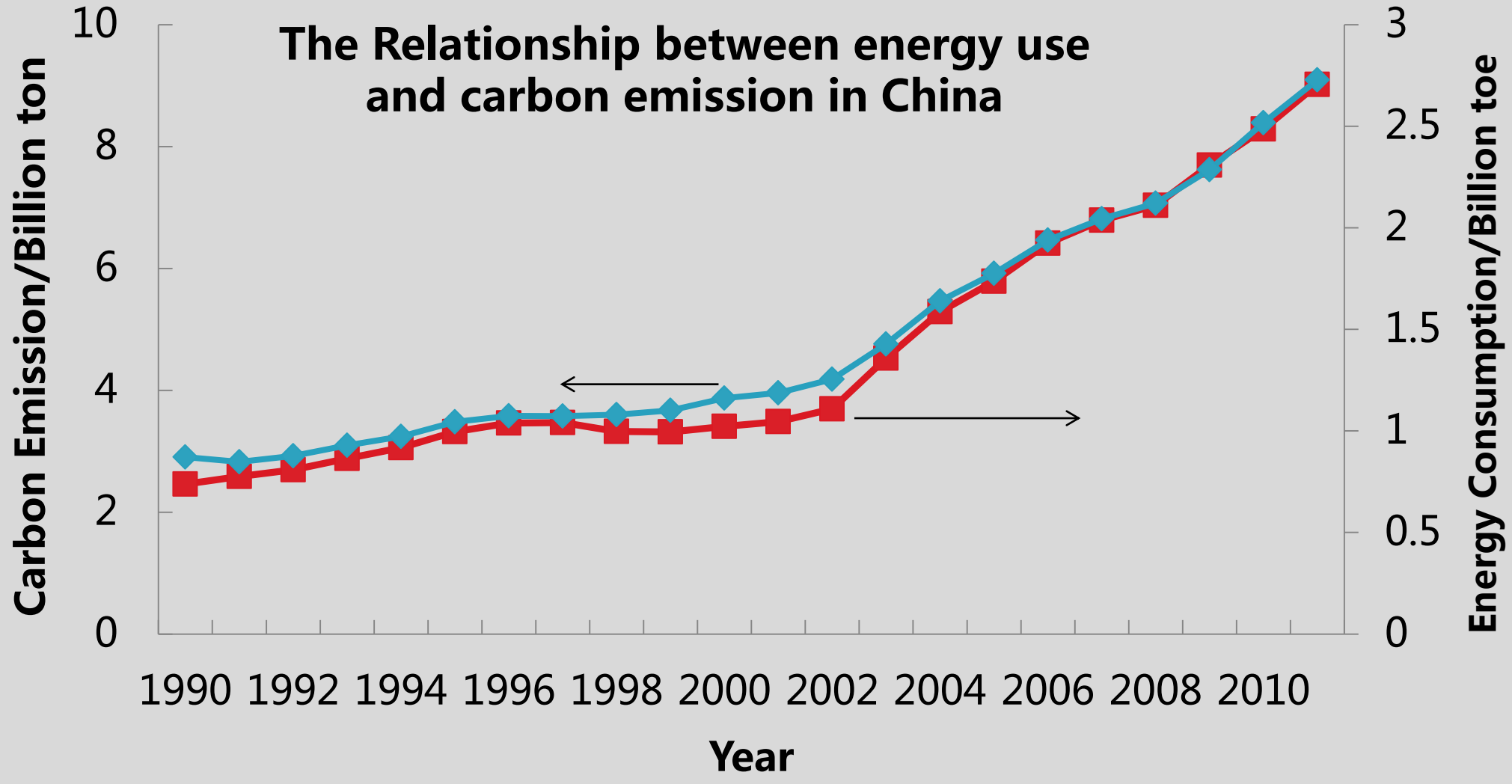
Energy Production Trends in Major Countries



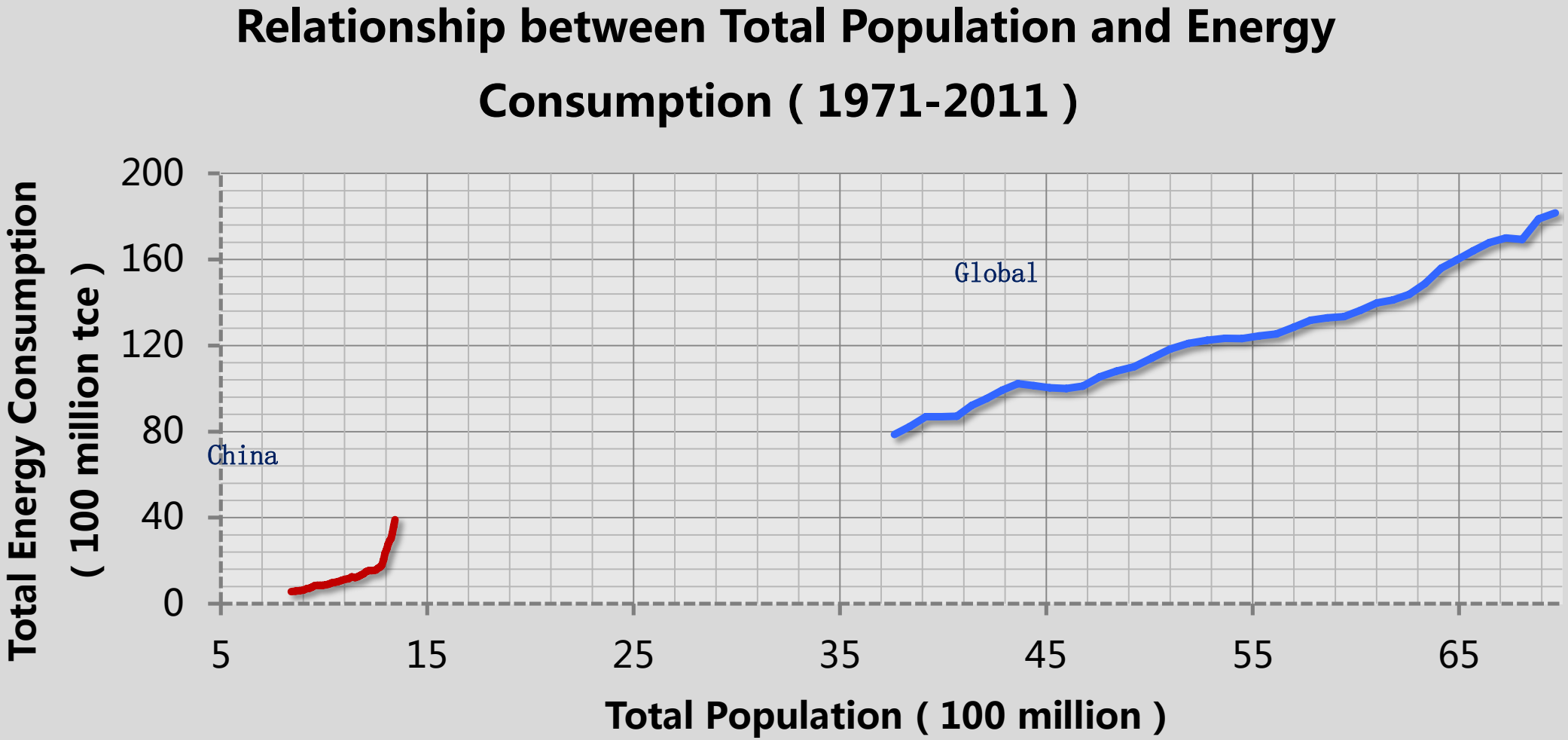
Energy Consumption Trends in Major Countries



Relationship between Energy Use and Carbon Emission in China

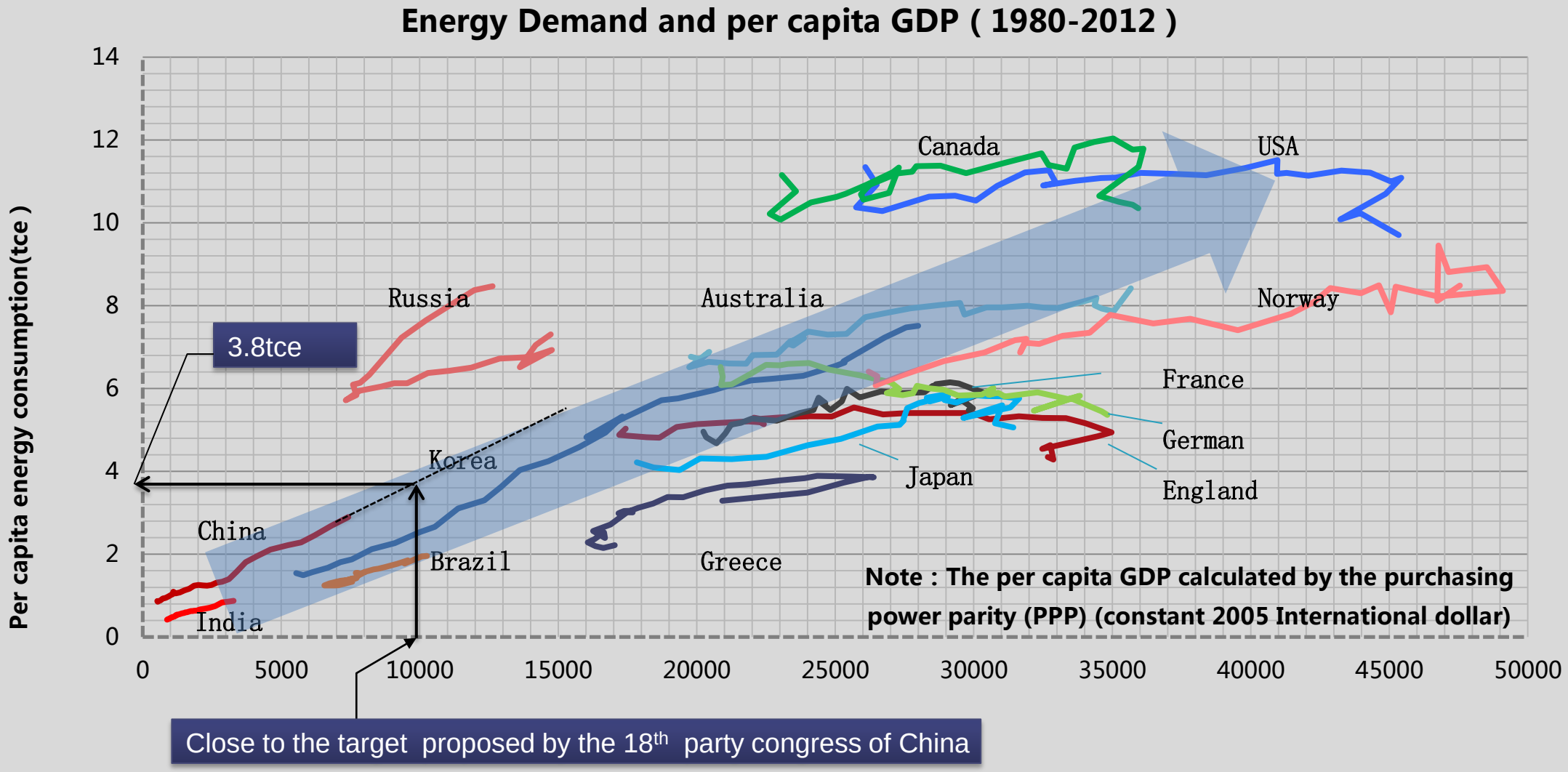


China's Energy Outlook –
Population Growth Driven up More Energy Demand



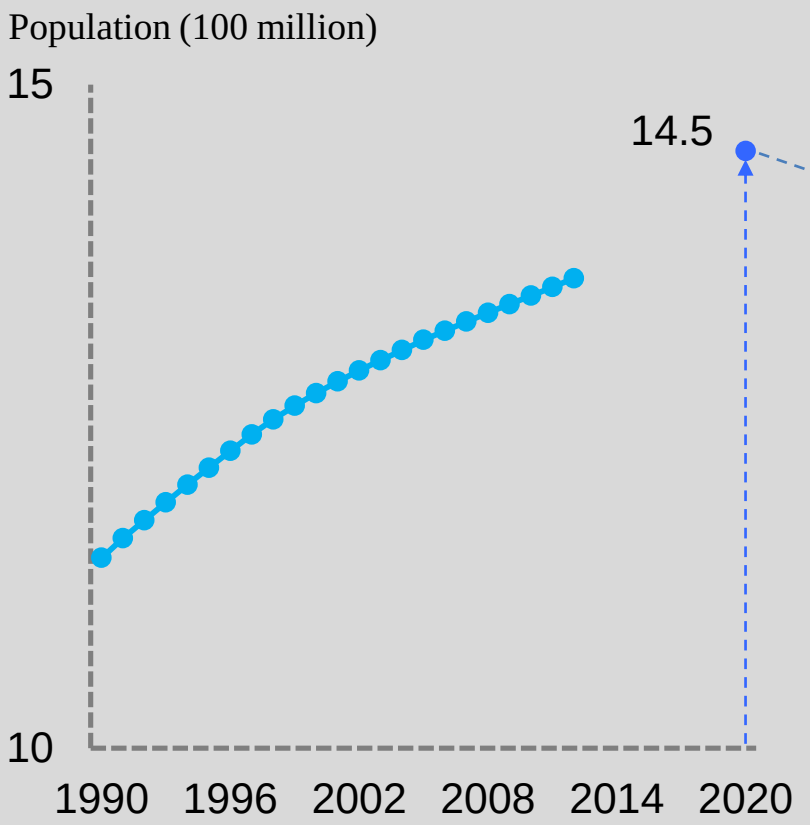
Population data : The World Bank, http://data.worldbank.org/indicator/NY.GDP.PCAP.PP.KD?display=default
Energy consumption data : The World Bank, http://data.worldbank.org/indicator/EG.USE.PCAP.KG.OE?display=default

China's Energy Outlook–
GDP Growth Driven up More Energy Demand

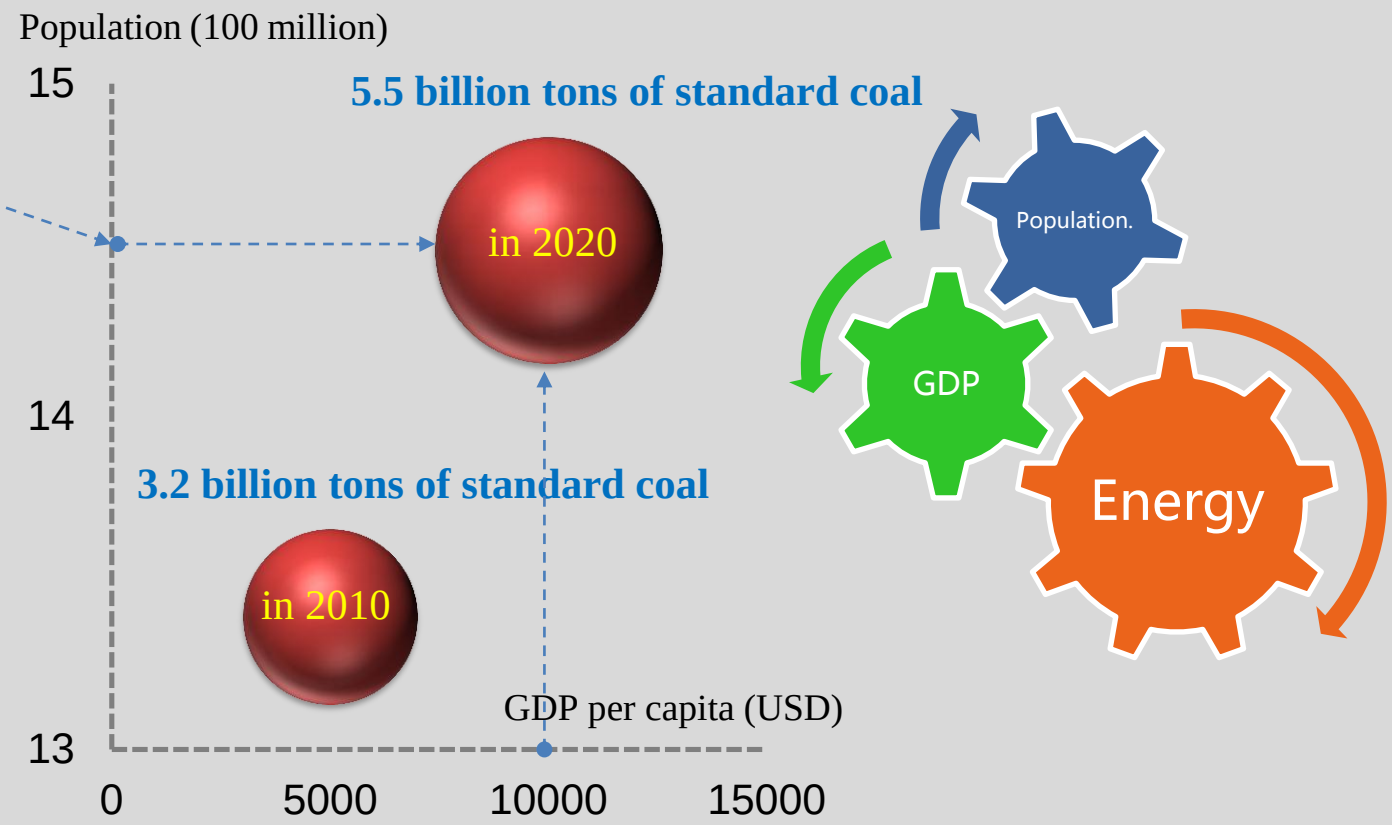


China's Energy Outlook—Rapid Expansion of Total Energy Demand

China's Population and Development

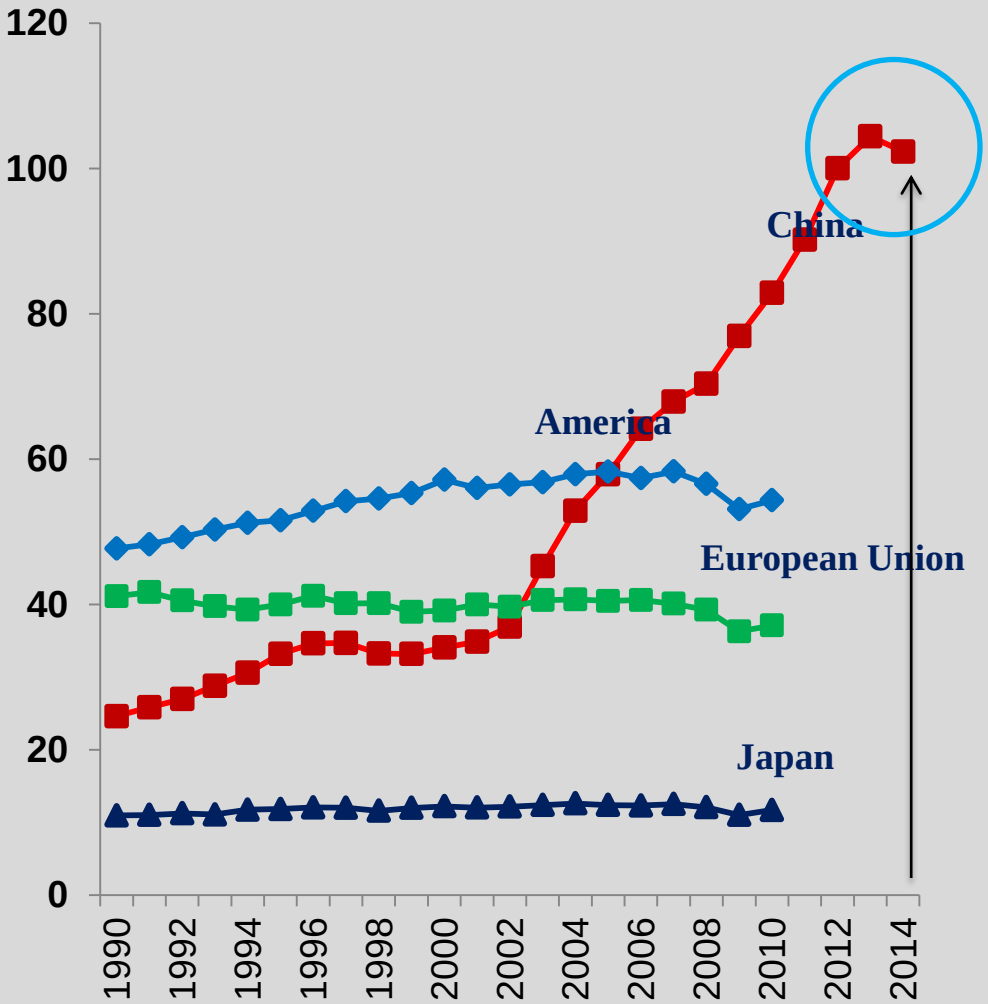


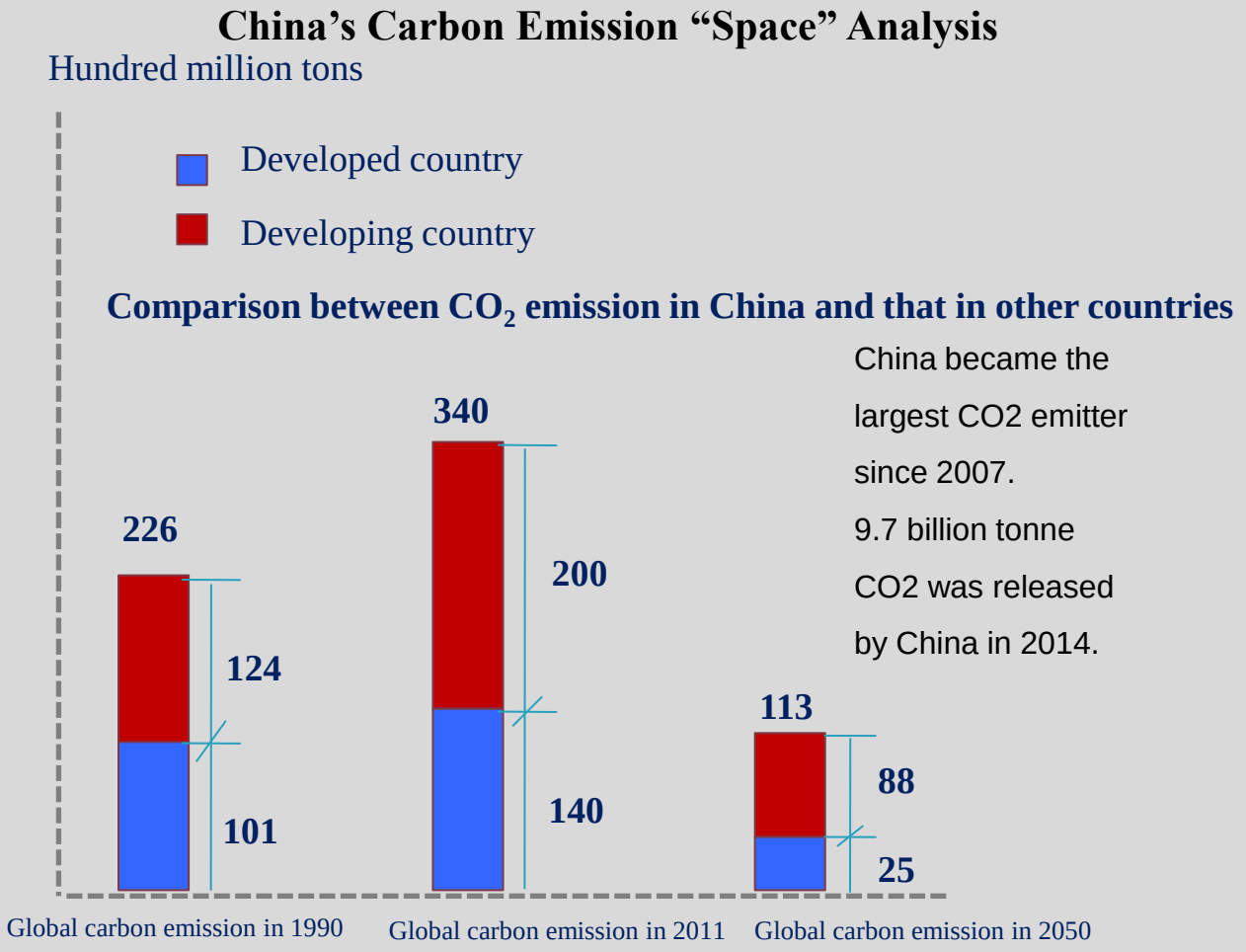
China Energy Demand Forecast



Population data source: National Bureau of Statistics
Development goals of the population: Research Report on National Population Development Strategy, 2007

China's Energy Challenges — Heavy Pressure on Carbon Emission Reduction

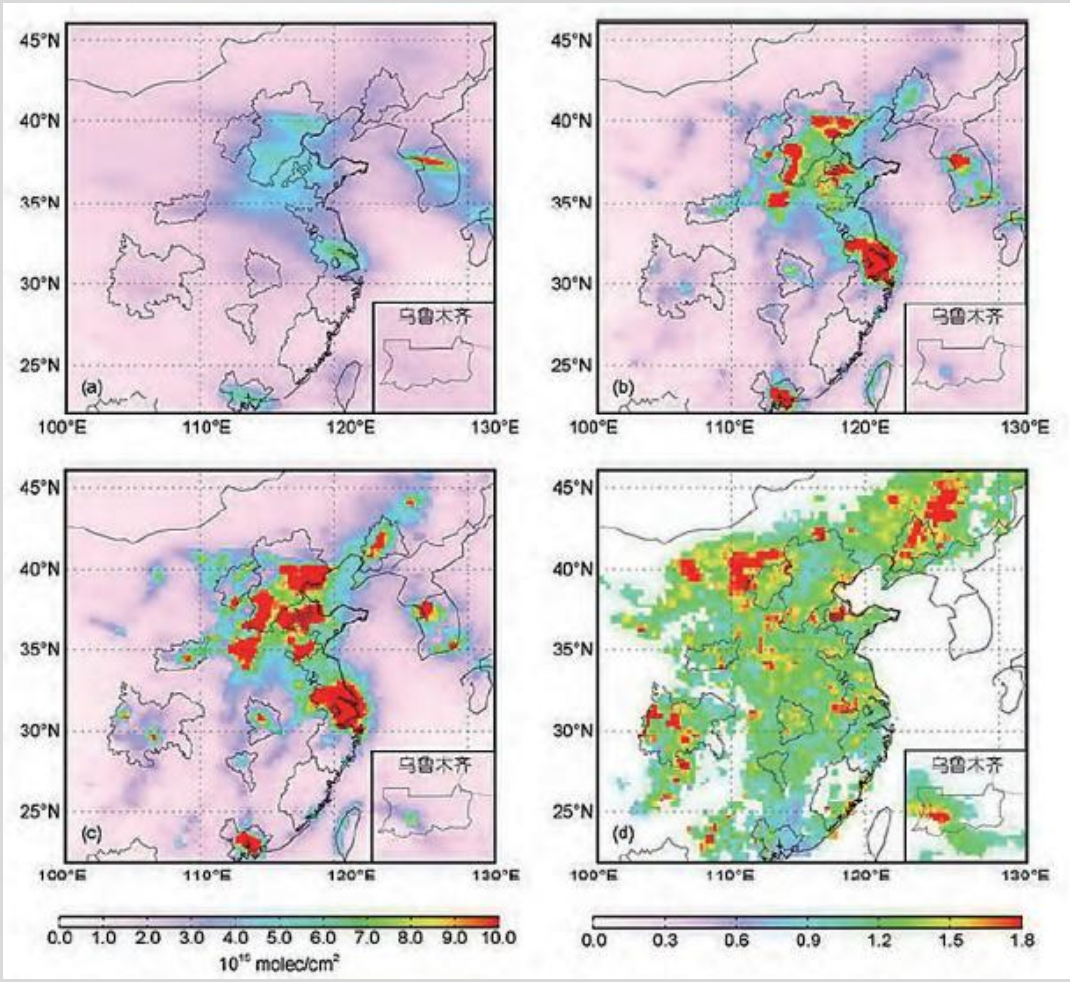




Carbon emission data source: The World bank, http://data.worldbank.org.cn/indicator/EN.ATM.CO2E.KT

The Damages Caused by Climate Change

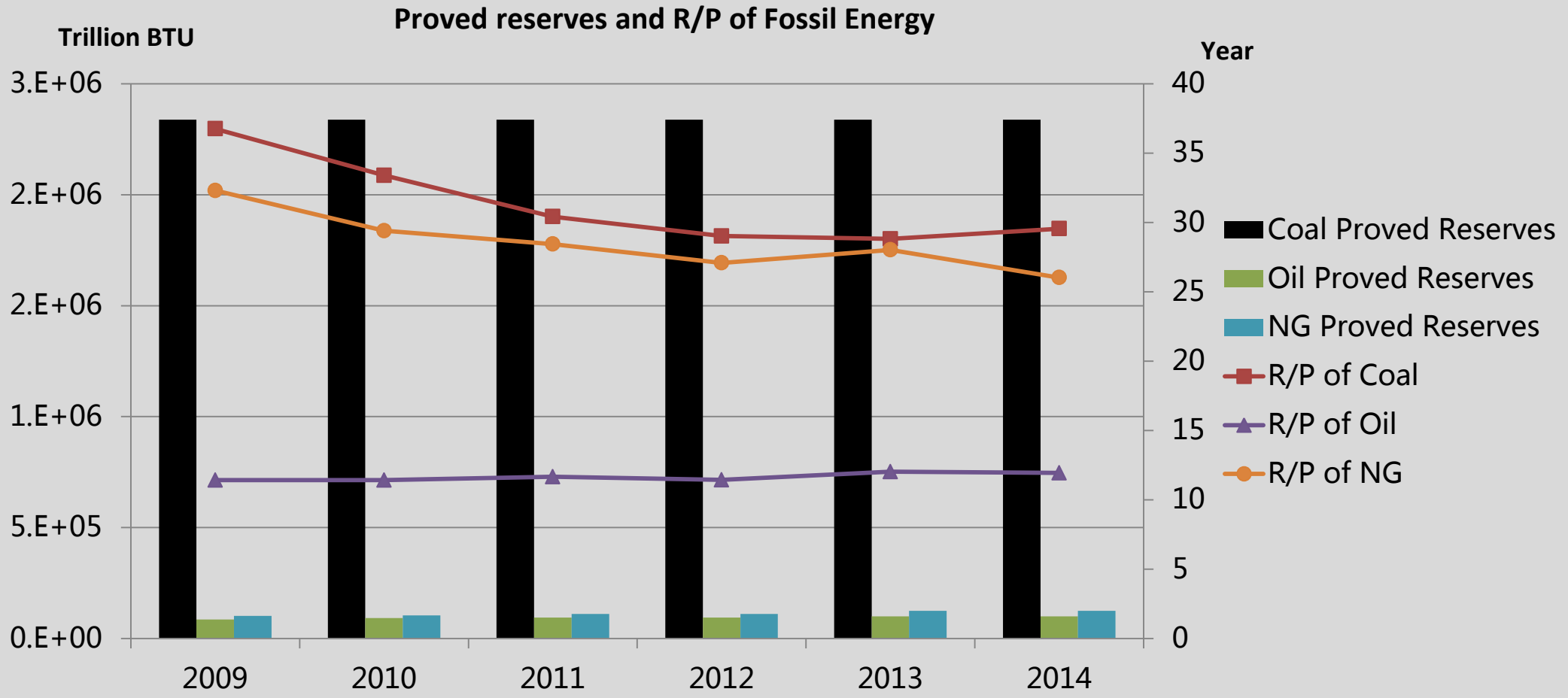
Himalaya glacier ablation



Average temperature change in China（a）1996~1998 summer average; (b)2003~2005 summer average ; (c) 2008~2010 summer average ;(d) ratio of c/b

CHALLENGES IN CARBON MITIGATION IN CHINA

Coal is the dominant energy source.

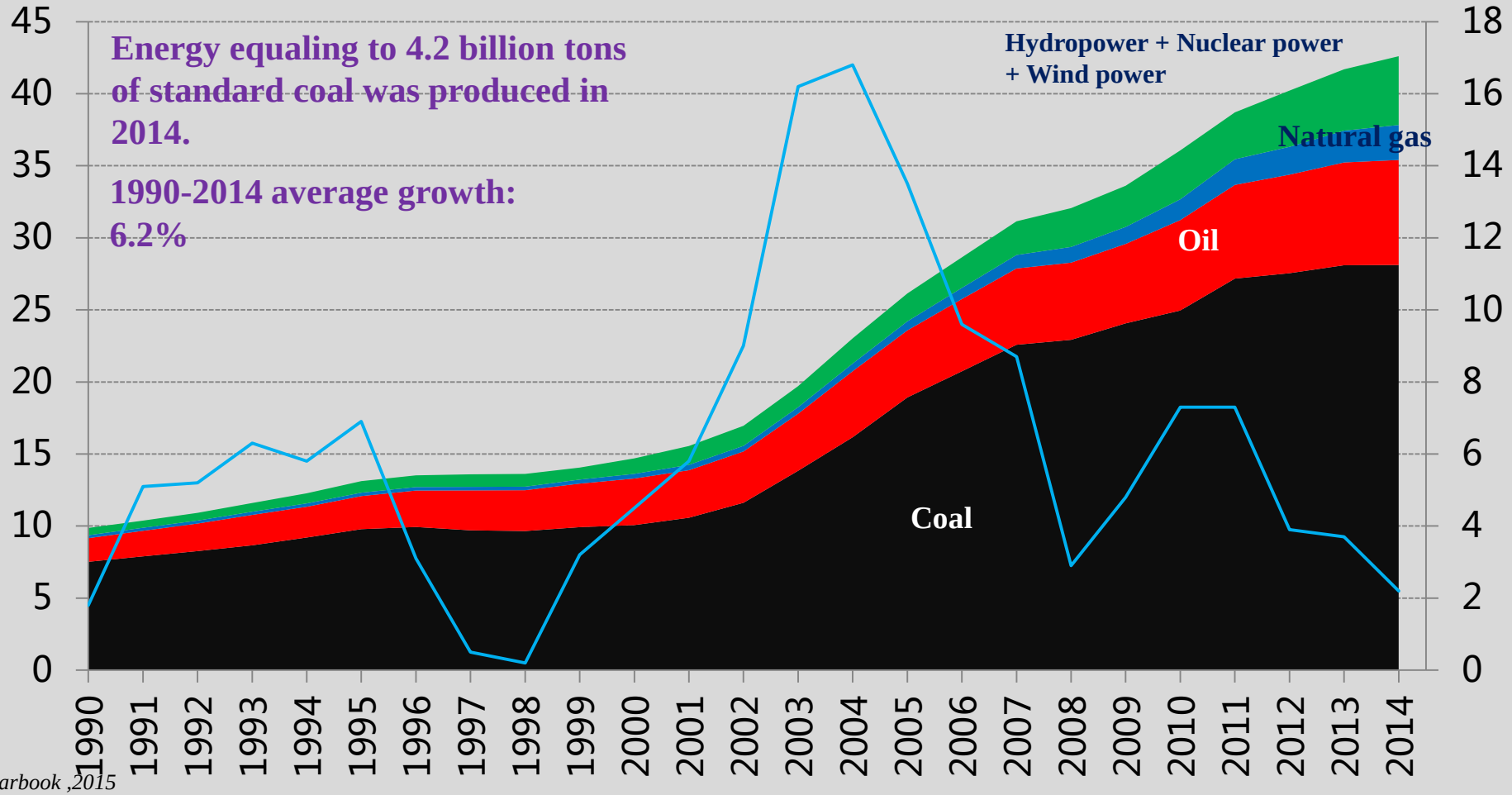


BP Statistical Review 2015

Coal is dominant in energy consumption.

Hundred million tons of standard coal

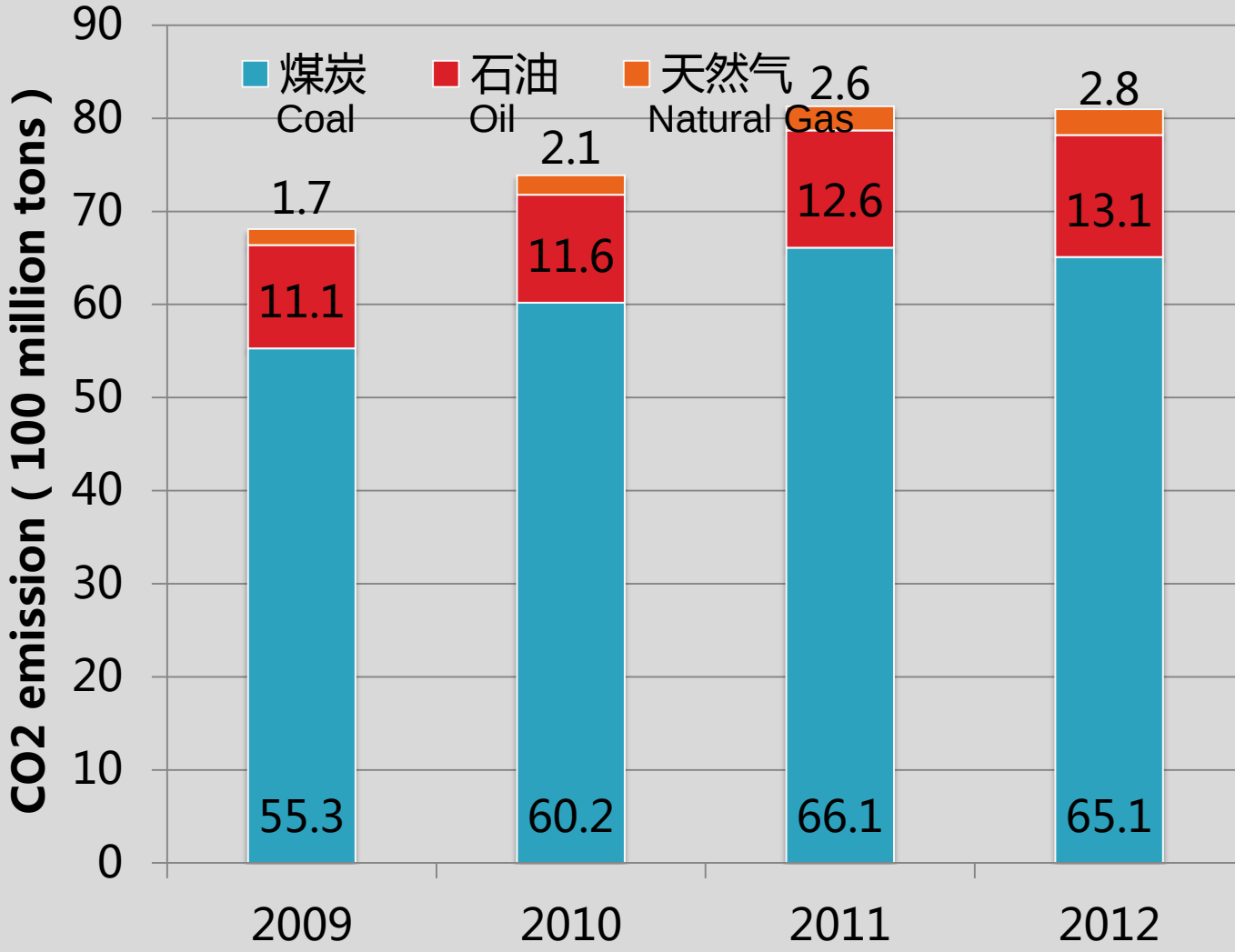
Energy Consumption and Growth in China (1990-2014)



China Statistical Yearbook ,2015

Carbon emissions are mainly from Coal.

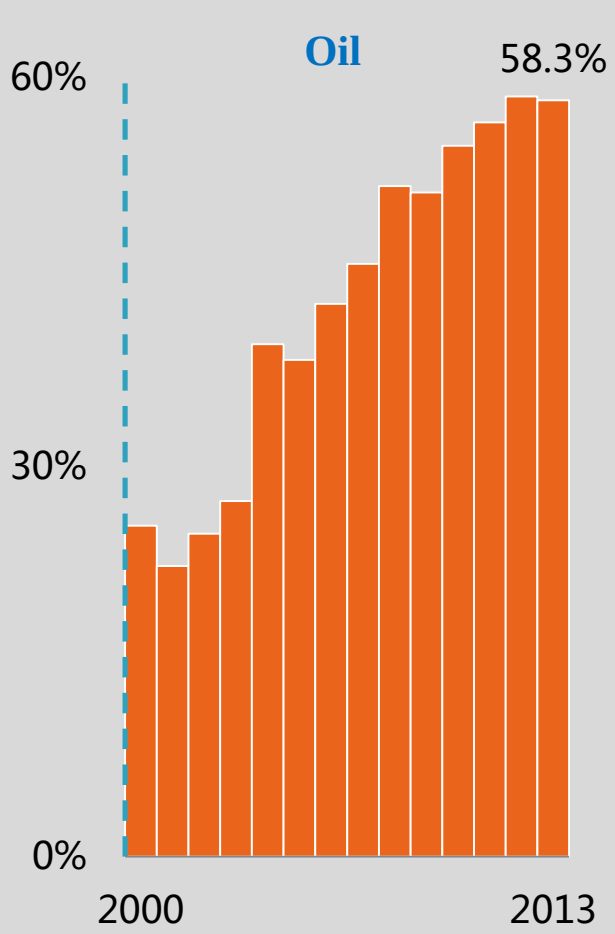
Fossil fuel	CO_2 emission factor (tCO_2/TJ)
 Coal	87.3
 Oil	71.1
 Natural gas	54.3

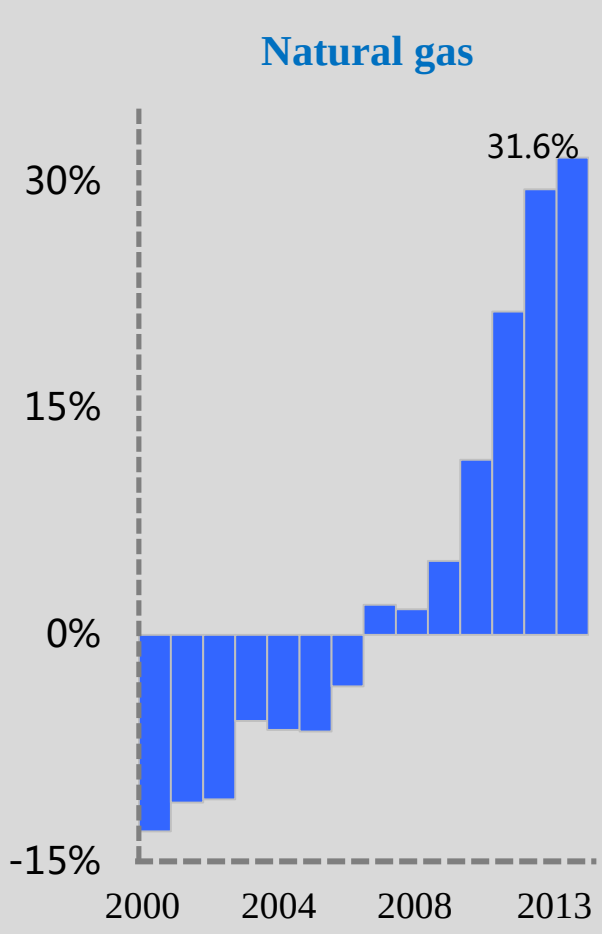


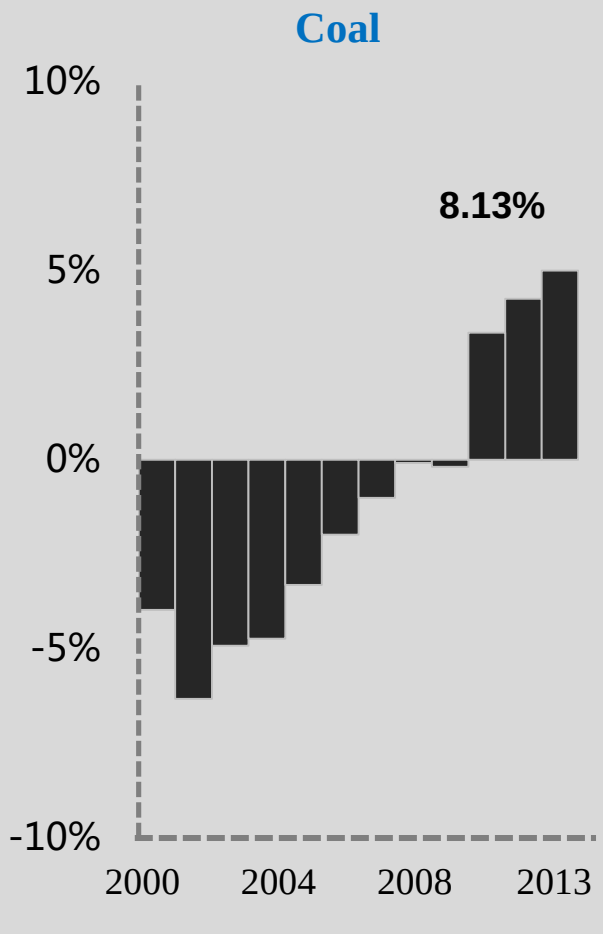
(Data source：EIA)

Heavy Dependence on Energy Import

Fossil Energy Import Dependence for China







Oil, coal and natural gas import dependence data source: National Bureau of Statistics , http://data.stats.gov.cn/

It is difficult for China to shake off its dependency on coal.

"We are reducing the proportion of coal in the energy consumption, but coal is still the main energy in a long period of time. Coal is rich in China. We not only develop new energy and renewable energy, but also focus on the coal resource" —Speech of the central economic work conference, 2014

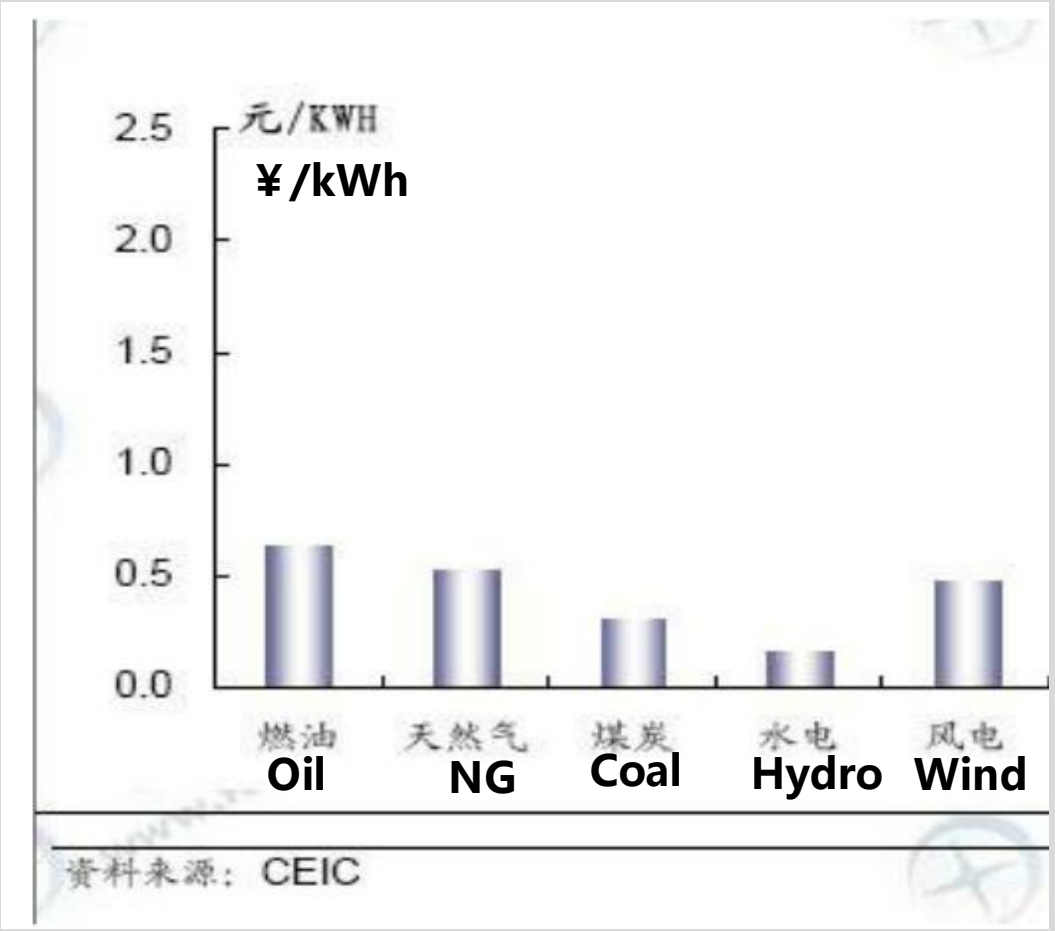
In 2030, coal consumption is less than 5 billion tons, and try to reach the peak of about 4.5 billion tons, accounting for about 55% of the total energy consumption — Chinese Academy of Engineering , 2013

High Cost of Renewable Energy

- The cost of solar and wind power is much higher than that of fossil fuels
- For example, the cost of wind power is about 1.7 times as coal power, and the cost of solar power is about 2-3 times as coal power

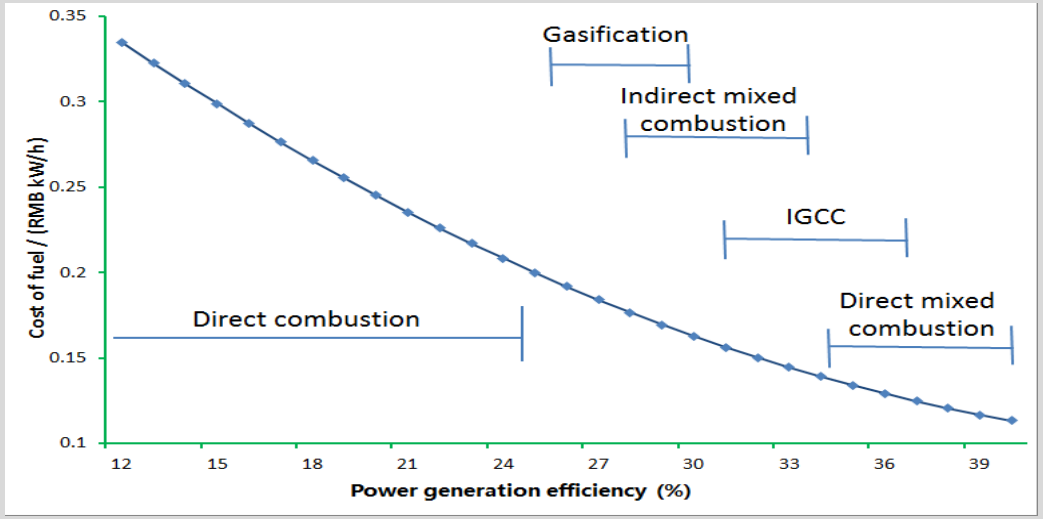
Xinjiang, Dabancheng
(达坂城，新疆)

Shangyi County, Hebe
(尚义县，河北)

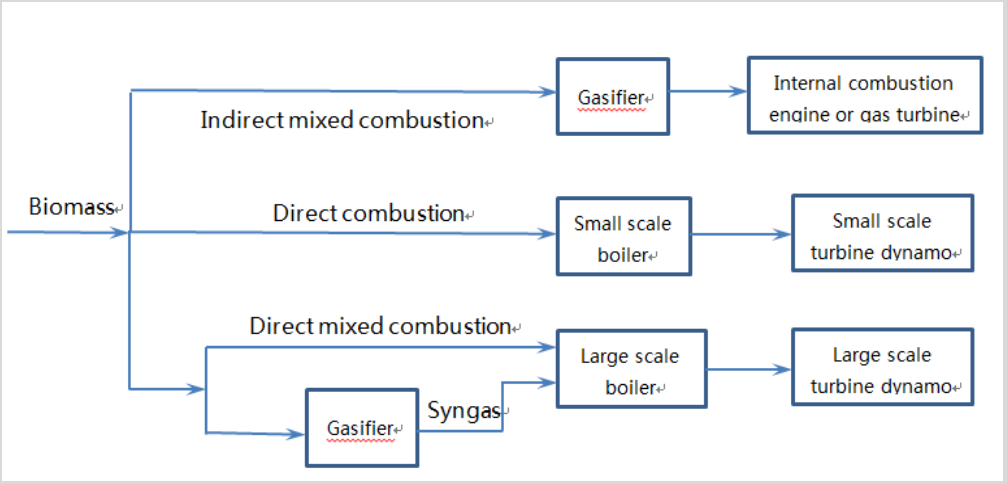


Costs of different power sources

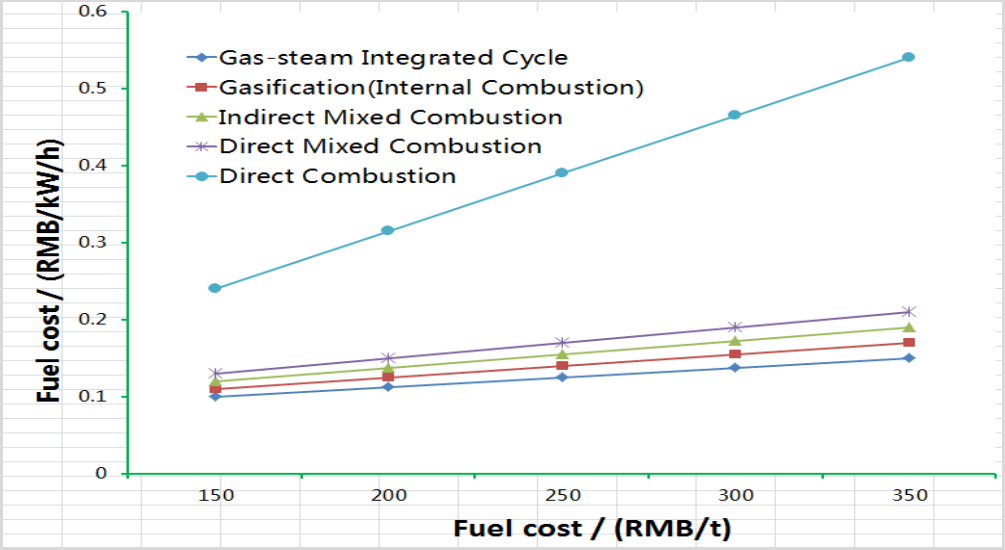
High Cost of Biomass Energy



Cost of Biomass Power Generation



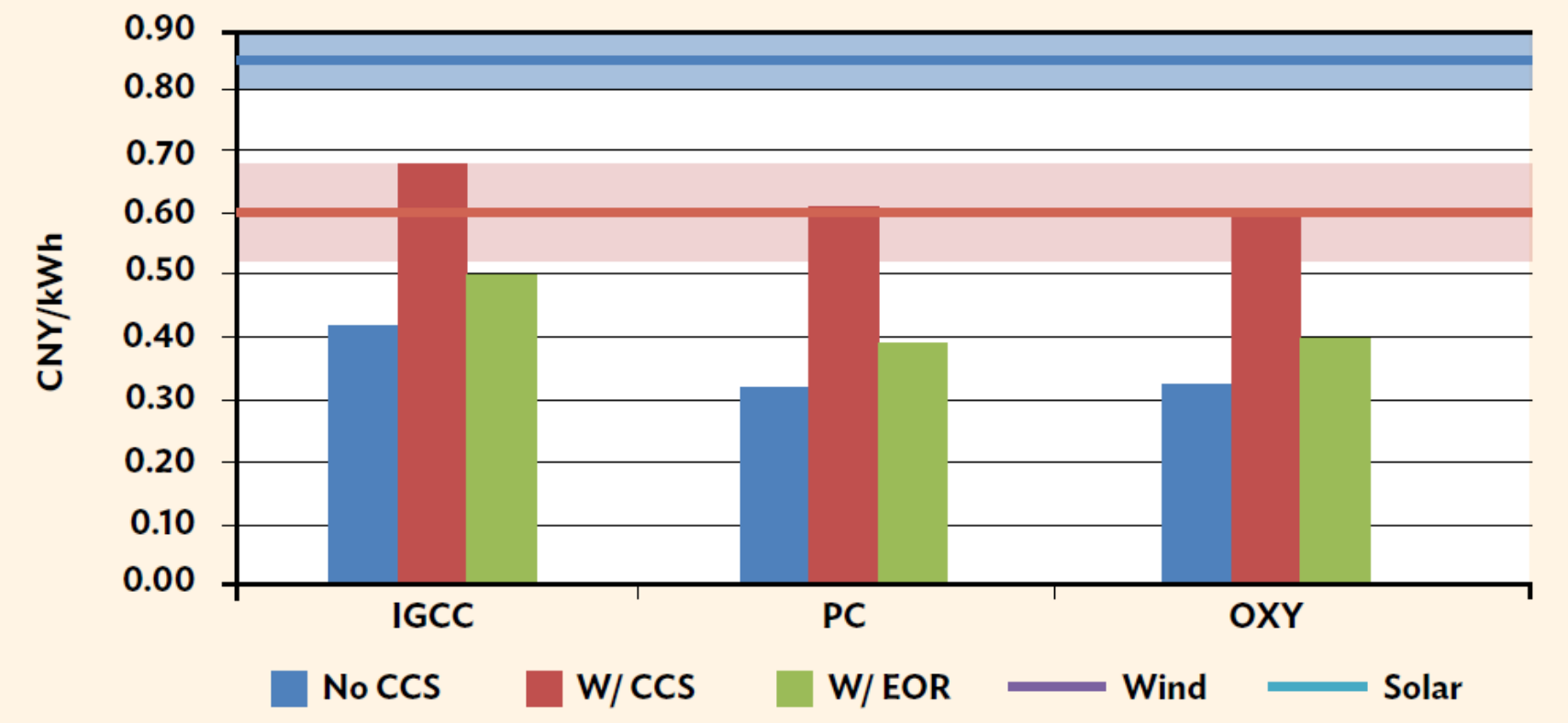
Main Routes of Biomass Power Generation



Fuel Cost of Biomass Power Generation

High Cost of Carbon Capture in the Thermal Power Plant

Benchmarking CCS against Alternative Power Generation Technologies

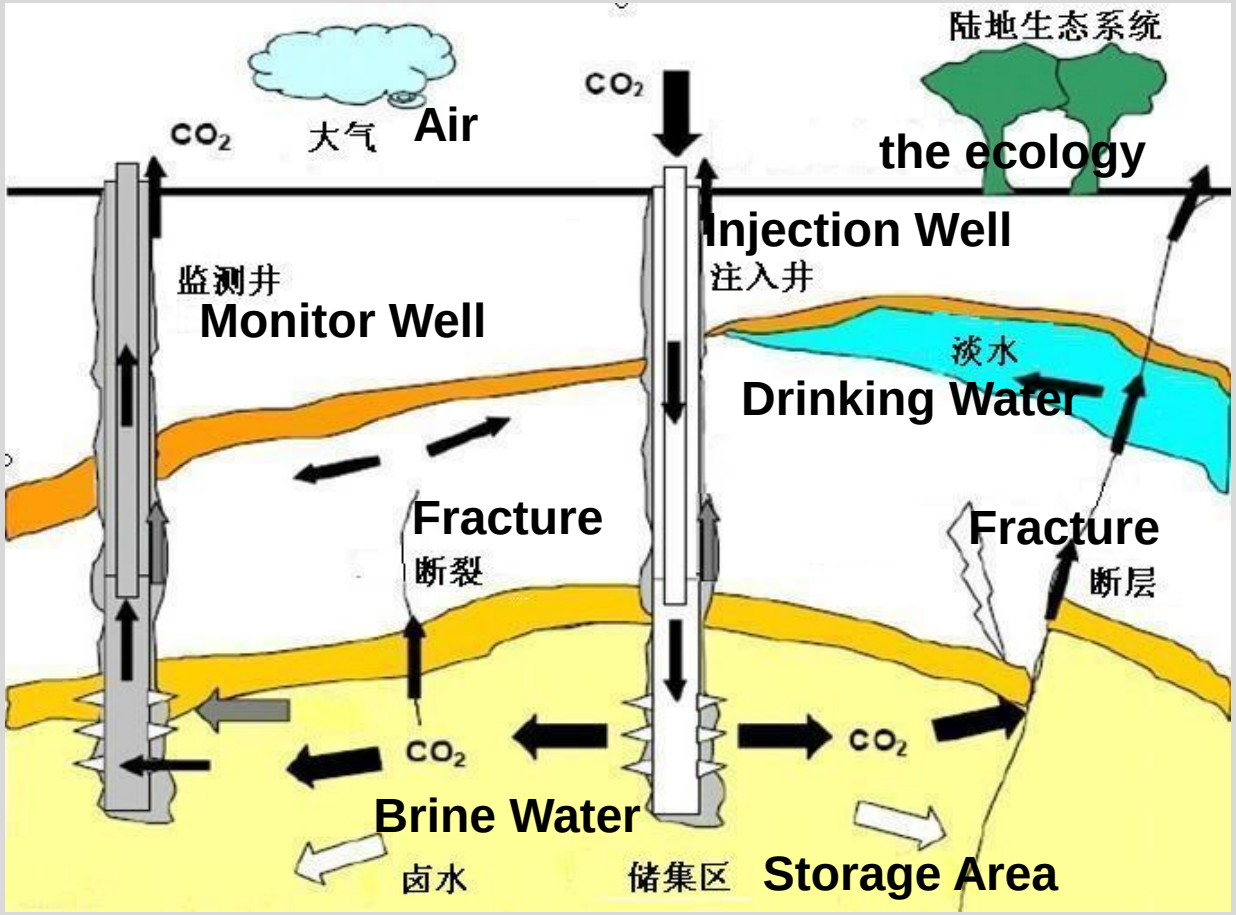


Total cost for a power plant increases by 25% ~90%

CNY/kWh = yuan per kilowatt-hour, IGCC= integrated gasification combined cycle, oxy = oxy-fuel combustion, PC=pulverized coal, Note: CO2–EOR assumes a CO2 sales price of CNY 120 per ton of CO2

Asian Development Bank, Roadmap for carbon capture and storage demonstration and deployment in the People's Republic of China, 2015

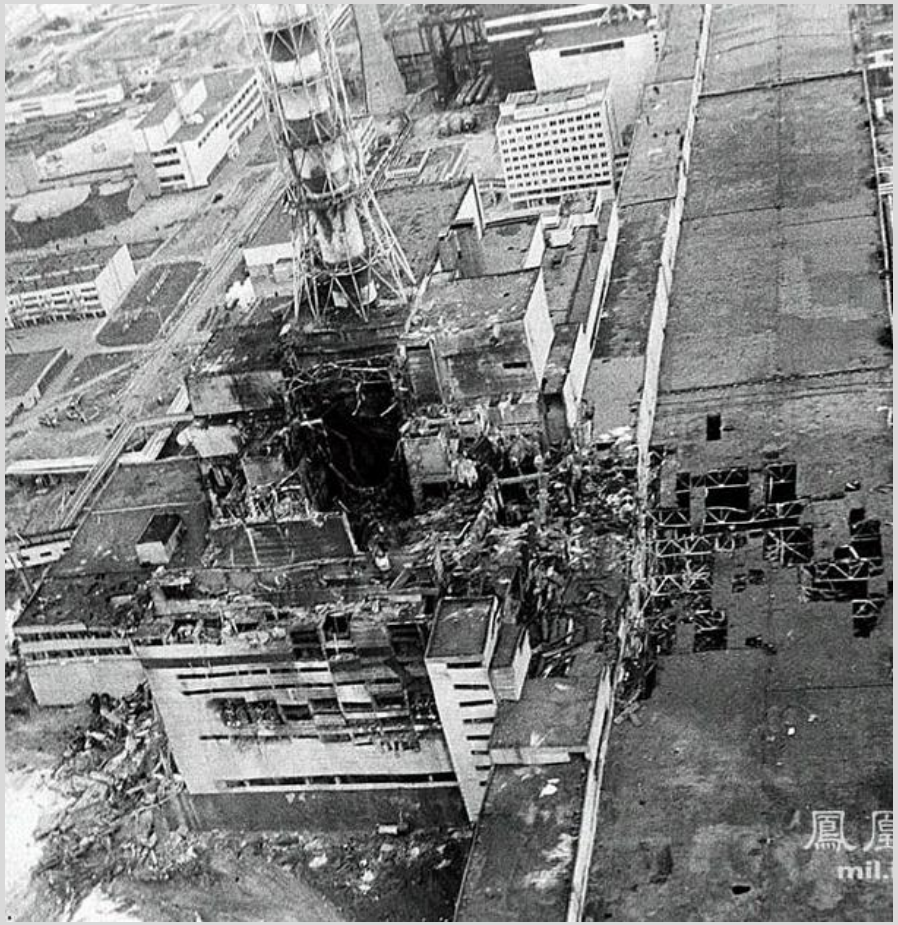
CCS risk is not clear.



Risks:

- Fracture
- Earthquakes
- Others

Nuclear risk is worrisome.

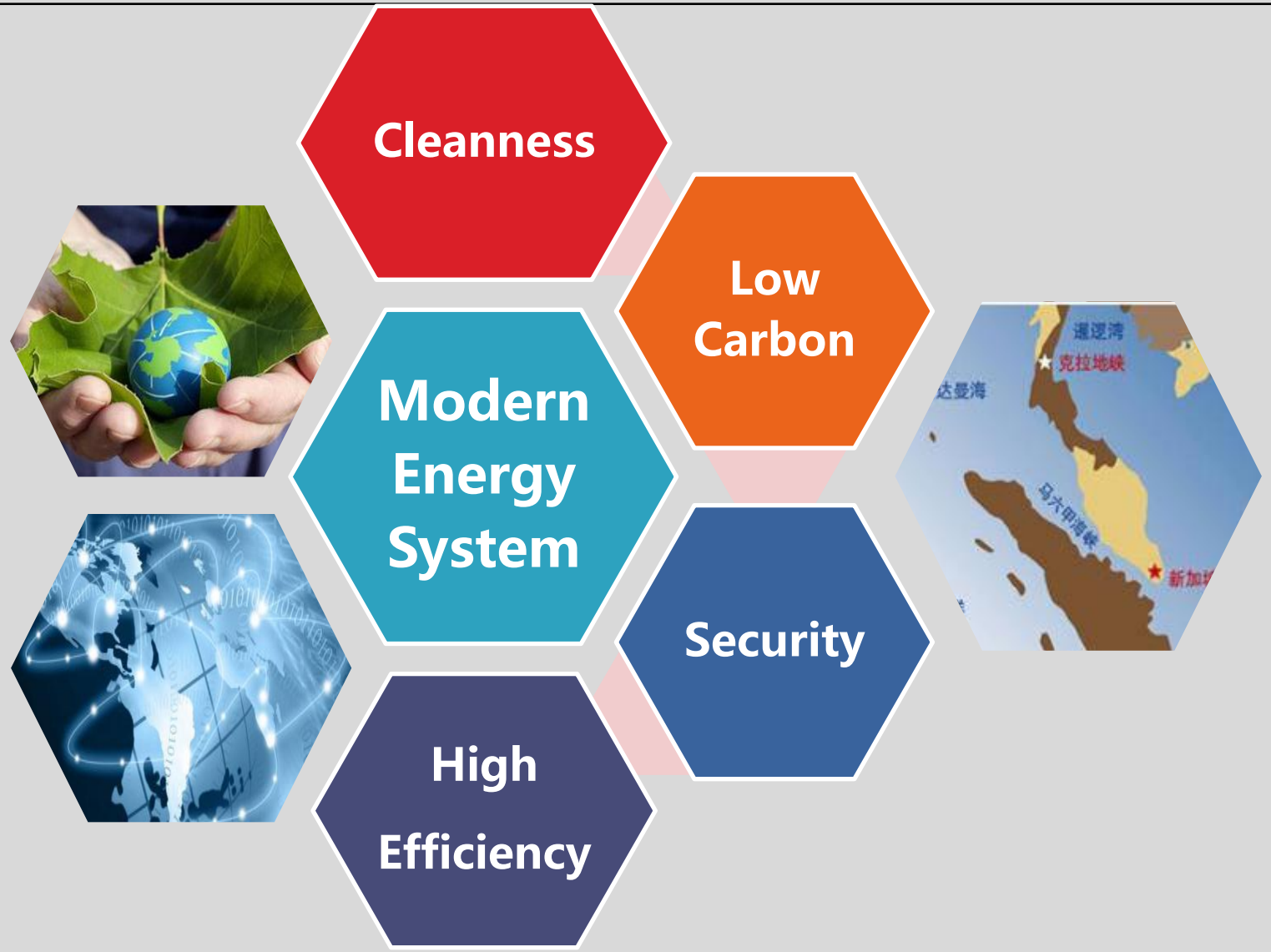


1986 Chernobyl Accident
(切尔诺贝利核事故)

2011 Fukushima nuclear accident (福岛核电站事故)

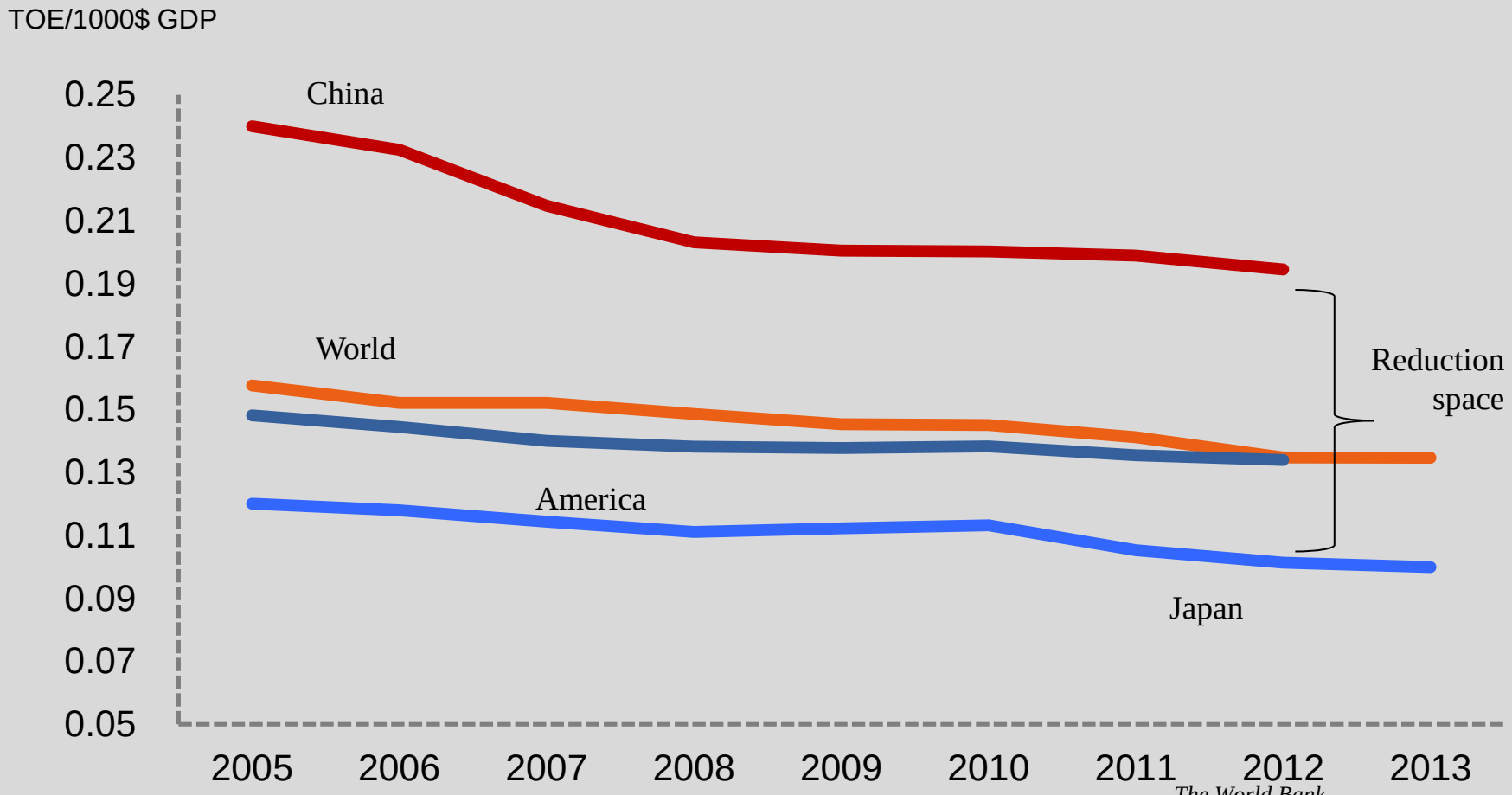
OPPORTUNITY IN CARBON MITIGATION IN CHINA

Modern Energy System



Great Potential in Emission Reduction for China

Comparison between the Energy Intensity of China and that of the World and the Developed Country

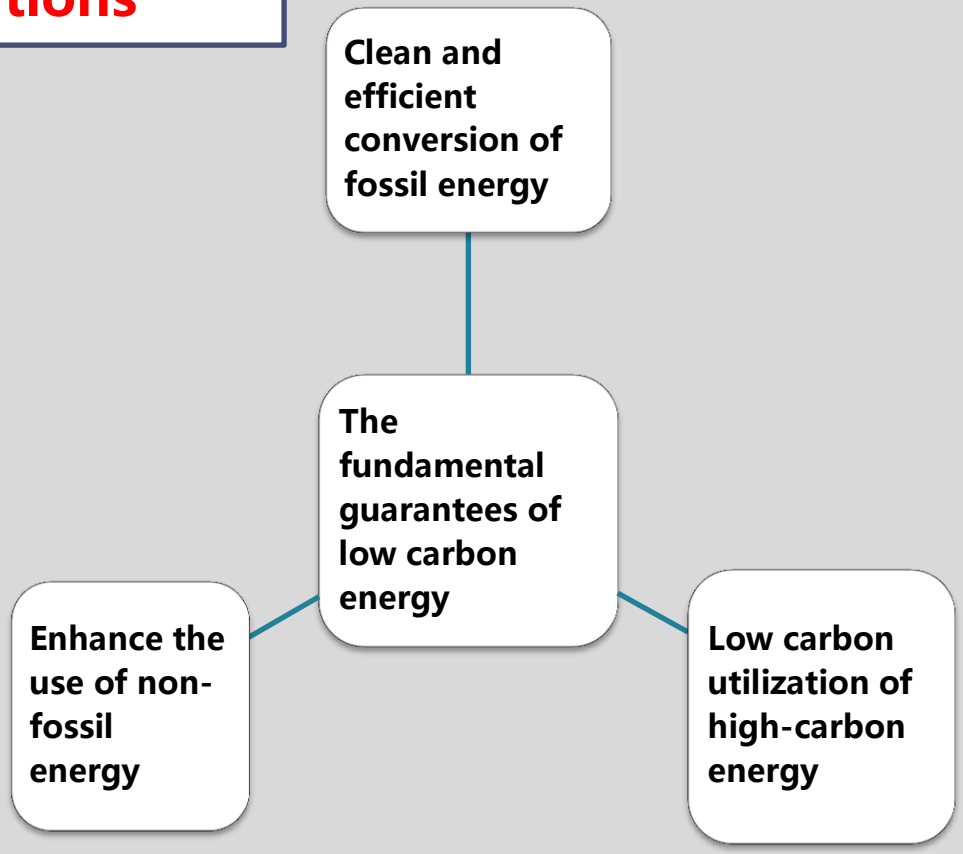


The World Bank, http://data.worldbank.org/indicator/EG.GDP.PUSE.KO.PP.KD/countries/1W?display=default

Note: The AGDP is calculated according to the purchasing power parity (PPP) (Constant international dollar in 2011)

Modern Energy System: Low-Carbon

Fundamental Solutions



Current Focus

56.9% of total carbon emissions can be reduced through energy conservation between 2010 and 2030

Energy conservation and emission reduction as well as improvement of energy efficiency are the priorities in the process of low carbon for China

Energy Savings:

To firmly establish a systematic energy conservation trend, and take every measure to improve the efficiency of energy use

To improve the transportation system, and fully tap into the energy conservation and emission reduction potential of modern transport systems

To develop strict building energy-saving standards, and vigorously implement them in building efficiency improvement projects

To enhance industrial energy efficiency standards, and limit the expansion of high energy-consuming industries and excess industries

To implement the energy conservation actions for all people, and restrict the unreasonable energy consumption

US Quadrennial Energy Technology Report

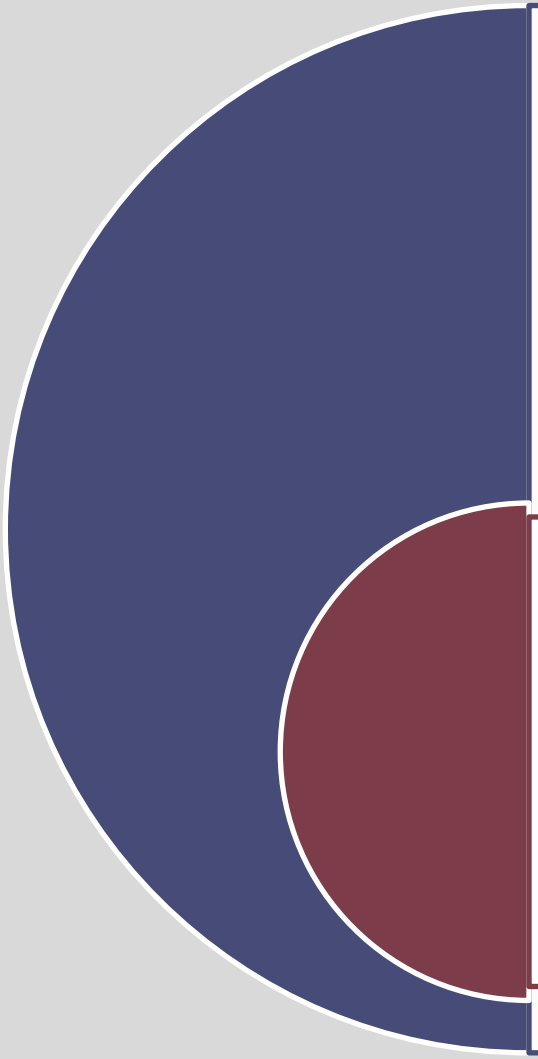
Energy Consumption Inertia

Energy-Saving Technology

Electric Power Production, Transmission and End Use

Make overall plans and accelerate developing clean, efficient, safe and diversified electric power production system	⑩ Make overall plans for clean, efficient, safe and diversified electric power production system Promote energy conservation, water conservation, desulfuration and denitration technologies in thermal power industry Adopt international highest safety standards for nuclear power Develop gas power generation in eastern prosperous regions in China ⑩ Develop wind power, solar power and focus on the development of thermonuclear fusion power generation
Integrate advanced technologies, and enhance the power absorption capacity and efficiency of energy utilization of renewable energy sources	⑩ Establish flexible and intelligent power transmission and distribution network Promote the construction of electric power telecommunication network Develop distributed power supply and management of distributed energy resources
Optimize the energy consumption structure, and significantly enhance the proportion of electric power in energy consumption of end users	⑩ Promote the electrification of domestic heat supply, hot water and cooking for urban and rural residents Accelerate the construction of power supply and power supply service facilities, and electrification of transportation sector Implement demonstration projects of electric heating replacing coal-fired boilers in cities

Coal Cap, Oil Security



Strictly control the output of coal, and effectively push the green development of coal

- Control the total volume of coal, and implement a rational distribution of coal production
- Shut-down the small scale coal mines and develop an exit mechanism for old mines
- Strengthen the large-scale coal bases and establish modern coal mines
- Promote the green mining technologies (e.g. water-preserved-mining)

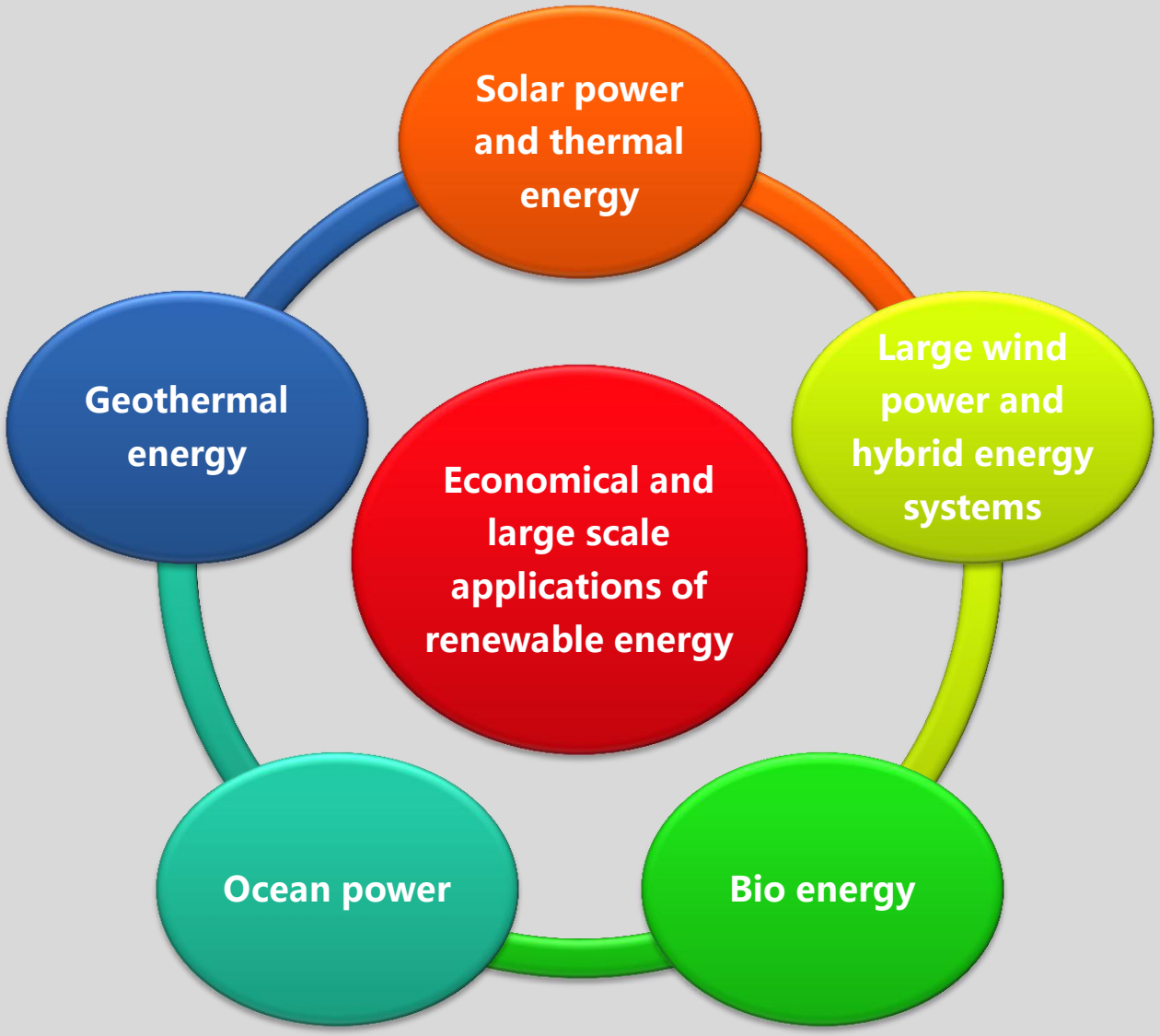
Reduce the output of low efficiency petroleum, proportionally increase oil import, and enlarge the oil reserve capacity

- Reduce domestic low efficiency petroleum output
- Cut the output of domestic petroleum and increase oil import from abroad under current low oil prices
- Increase the national strategic oil reserve, establish and improve the emergency response and safeguard the energy system.

Clean Fuel, Natural Gas:

- **Integrate conventional and unconventional developments, and strengthen the domestic gas exploration and development**
  - Establish unconventional gas R&D platform, locate and construct the unconventional gas exploration and develop the demonstration areas
  - Prolong the time limit for subsidies and preferential taxes for shale gas and coalbed methane,
  - Develop coal-to-gas and natural gas hydrate technologies
- **Formulate a comprehensive plan on the construction of consumer market and on the infrastructures, and make a rational plan on the importation of resources from other countries**
  - Diversify the importation of gas sources, and proportionally increase the import of LNG as well as the spot goods
  - Implement the transportation-out and transportation-in of gas, and establish a gas distribution center in East Asia
- **Shift the gas pricing mechanism to market based pricing**
  - Set a rational end gas price ASAP, and lower the gas prices for industrial and power generation uses
  - Impose the environmental tax or carbon tax properly to reflect the externality of energy utilization
- **Rebuild the gas management structure and regulations**
  - Improve the natural gas pipeline network
  - Strengthen legislation and supervision

Renewable Energy and Bioenergy:



Goal

- 2016-2020：**Energy structure transformation**
- Promote a shift to low carbon energy use and push to achieve a 5:3:2 composition for coal, oil/natural gas, and non-fossil energy by 2020.
- **2021-2030：Energy Revolution:** To achieving substantially optimized energy structure, push to achieve a 4:3:3 for coal, oil/natural gas, and non-fossil energy by 2030
- **2031-2050： Harvest of the Energy Revolution** To establish a new energy structure, push to achieve 3:3:4 for coal, oil/natural gas, and non-fossil energy by 2050

Key Clean Technologies

Apply and promote a batch of relatively mature technologies

- Ultra low emissions of coal-fired power generating units
- High-efficiency exploration and development technology for oil and gas fields
- The third generation of pressurized water reactors
- Renewable energy sources and building integration system
- Extra-high voltage AC and DC power transmission

Conduct demonstrations for a batch of technologies to be developed

- Coal-based polygeneration
- Enhance the recovery rate of complicated oil and gas fields
- Large-scale and advanced pressurized water reactors
- Large-scale development of offshore wind plants
- Large capacity and flexible DC electricity transmission

Cultivate the breakthrough in a batch of advanced technologies

- Ultrahigh-parameter coal-fired power generation
- Highly-efficient development technology of "deep stratum, deep water and unconventional" oil and gas
- Nuclear fuel reprocessing technology
- High-efficient power generation technology as well as large-scale grid-connection and integration technology of renewable energy sources
- Large-scale energy storage

- Promote the scientific development of coal, and accelerate its clean and efficient conversion and utilization
- Realize the high-yield and highly-efficient development of "deep stratum, deep water and unconventional" oil and gas
- Design a scientific development scheme; develop safe nuclear power; develop advance technologies for renewable energy resources such as solar energy and wind energy

International Cooperation, Interconnection, "One Belt One Road"

Strengthen international energy cooperation and focus on oil and gas

- Strengthen energy cooperation with Central Asia, Russia, Central and Eastern Europe as well as South and Southeast Asia
- Emphasize the fundamental and leading role of oil and gas cooperation in the strategy of "one belt, one road", and promote the development of oil and gas cooperations in multi-fields, at multi-levels, on multi-subjects and at multi-dimensions along the whole industrial chain
- Accelerate the construction of import oil and gas strategic channels

Steadily promote the construction of infrastructures and supporting facilities based on the important platforms of Asian Infrastructure Investment Bank and Shanghai Cooperation Organization

- Boost the construction of supporting facilities through the already-established four oil strategic channels in the northwest, southwest, northeast and offshore
- Promote the construction of cross-border electricity and power transmission channels, and further enhance the regional energy cooperation
- Strengthen the cooperation along the channels, and improve China's influence in energy area on the international community.

ACTIONS IN CARBON MITIGATION IN CHINA

--------IV--------

Government Action: Energy Revolution

Chinese government is taking actions

Energy Production and Processing

Energy Conversion and Utilization

Energy Storage and Transportation

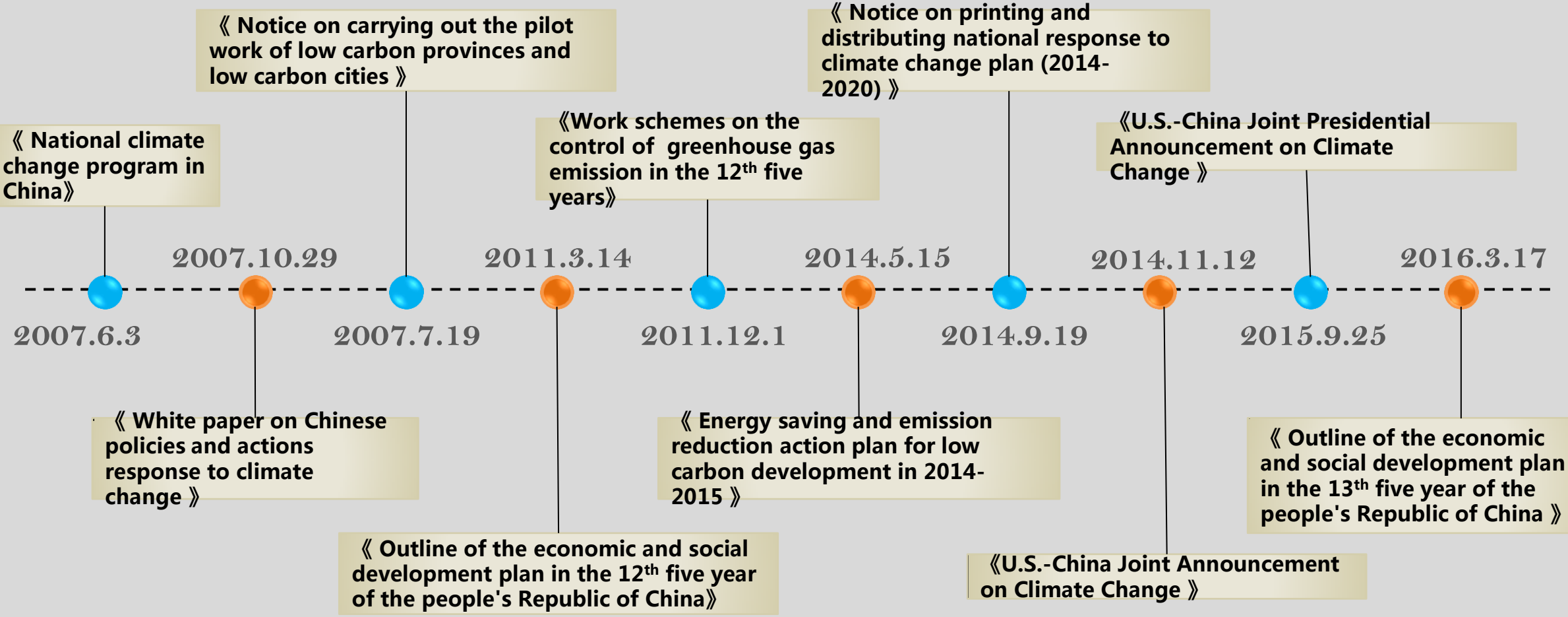
Energy consumption

Lead energy revolution: improve the energy structure, enhance energy efficiency and lower the total energy consumption

Clean, efficient and sustainable development and utilization of fossil energy, especially coal

Enable economical and scalable development of non-fossil energy. Particularly promote the safe and efficient development of nuclear power

Government Action: Strategies



Government Action: Carbon Mitigation Policies

《 Notice on carrying out the pilot work of carbon emission right trading 》

Formal approval of seven provinces (Beijing, Shanghai, Tianjin, Chongqing, Hubei, Guangdong and Shenzhen) to carry out pilot program on carbon trade

2011.10.29

《 Interim Measures for the administration of voluntary emission reduction transactions for greenhouse gases 》

The aim is to ensure the orderly development of voluntary emission reduction trading activities and mobilize the whole society to participate in carbon emission reduction activities. Accumulate experiences on the gradual establishment of the total control of carbon emission trading market

2012.6.13

《 Guide for validation and certification of greenhouse gas voluntary emission reduction projects 》

To further clarify filing requirements for the audited and certified institutions of voluntary greenhouse gas emission reduction projects, work report format, promote the audited and certified results to be objective and fair, to ensure voluntary greenhouse gas emission reduction transactions carried out smoothly

2012.10.9

《 Notice on printing and distributing the accounting methods and reporting guidelines for greenhouse gas emissions for the first batch of 10 enterprises 》

Industry include power generation, power grids, iron and steel, chemical, electrolytic aluminum, magnesium smelting, flat glass, cement, ceramics, civil aviation, etc.. The purpose of this notice is to establish and to improve the statistical accounting system of greenhouse gas, and gradually establish the carbon emission trading market.

2013.10.15

《 Notice on the work of the organization to carry out the work of greenhouse gas emission in the enterprises (matter) sector 》

The objective is to control the key units of greenhouse gas emissions, accelerate the establishment of key units of greenhouse gas emissions reporting system, improve greenhouse gas emissions statistics and accounting system at the national, local, enterprise levels.

2014.1.13

《 Interim Measures for the administration of carbon emissions trading 》

To promote the construction of ecology, accelerate transformation of the economic development and promote the system innovation and mechanism innovation. Respect the deciding role of the market in the allocation of greenhouse gas emissions, regulating the construction and operation of carbon trading market

2014.12.10

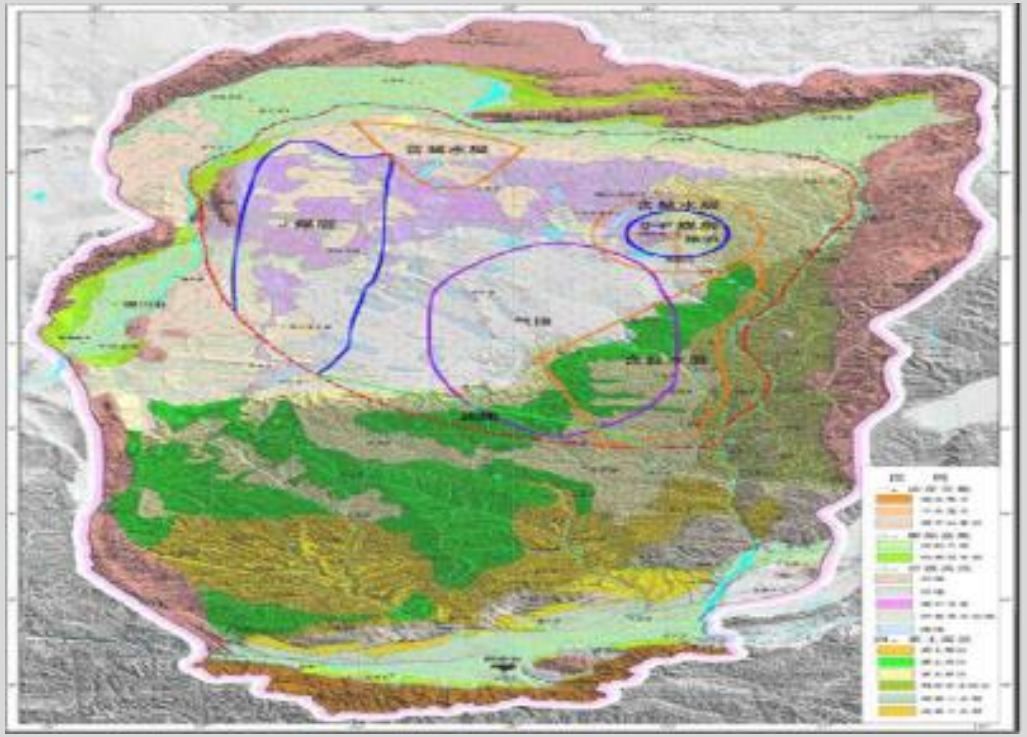
《 Notice on the effective implementation of the key work of the national carbon emissions trading market 》

This is to ensure that national carbon emission trading system is launched in 2017 , implement the carbon emission trading rules, and effectively advance the preparing work.

2016.1.11

Enterprise Action：CCS Demo Plant

中国神华
CHINA SHENHUA



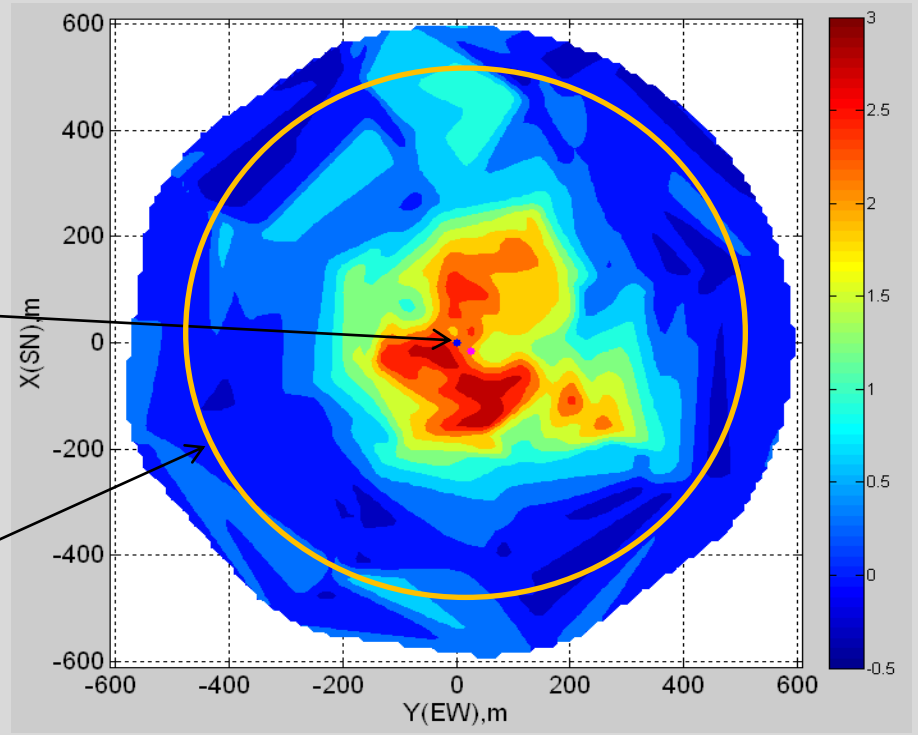
CO_2 Capture

Transportation

Storage

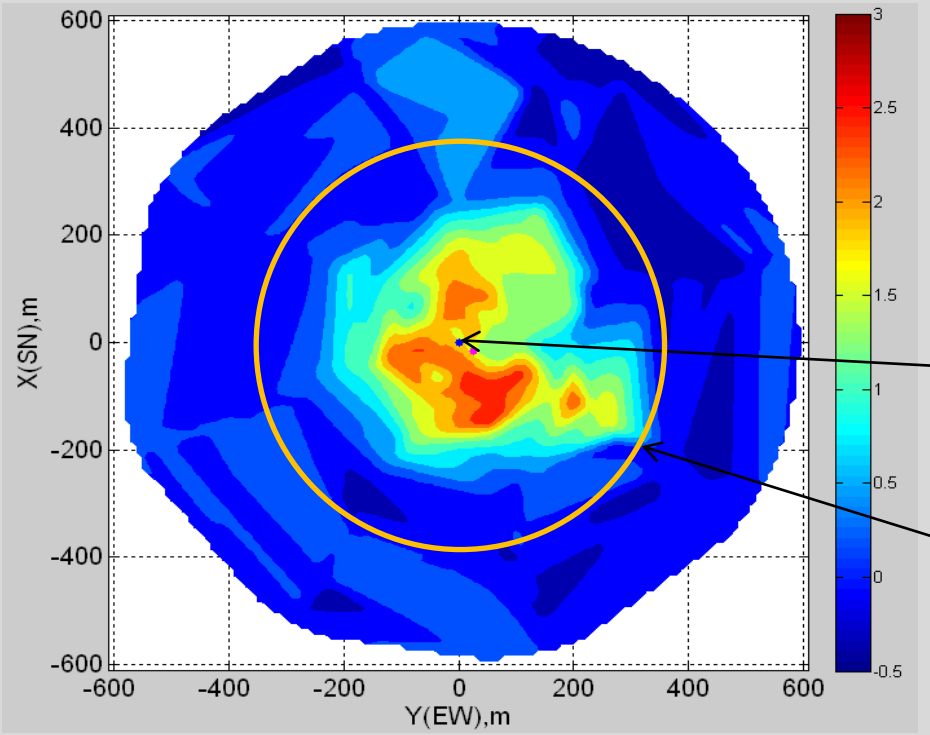
Monitoring

Enterprise Action : CCS Demo Plant



CO_2 Injection Well

R=500m



CO_2 Injection Well

R=350m

Monitoring Diagram Comparison at 2350m Depth

Enterprise Action : Wind Power

- To reduce carbon emissions, Shenhua is vigorously developing the renewable power, and the installed capacity of wind power has exceeded 6200 MW now, accounted for about 5% of the total installed capacity of wind power in China.

Shenhua wind farm in the coast of Jiangsu province

Shenhua wind farm in JInner Mongolia province

NICE Action：Business Chain for CO_2-EOR

➢ **The purpose for CO_2-EOR Supply Chain Study**

- **China's oil demand grows steadily**

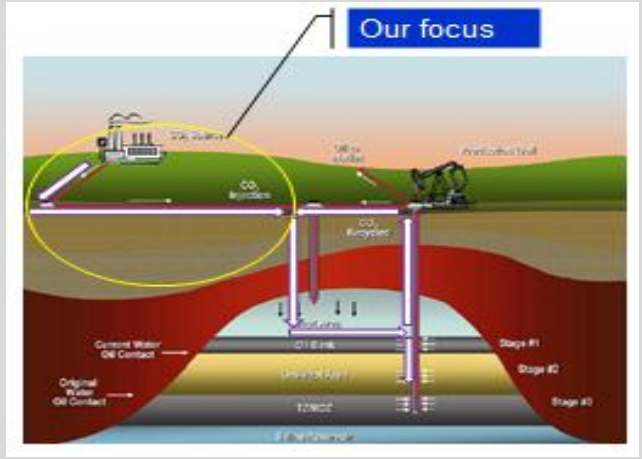
  ≥50% dependence on the import since 2011

- **CO_2-EOR utilization**

Oil output in U.S. increased by ≥10 MT/a

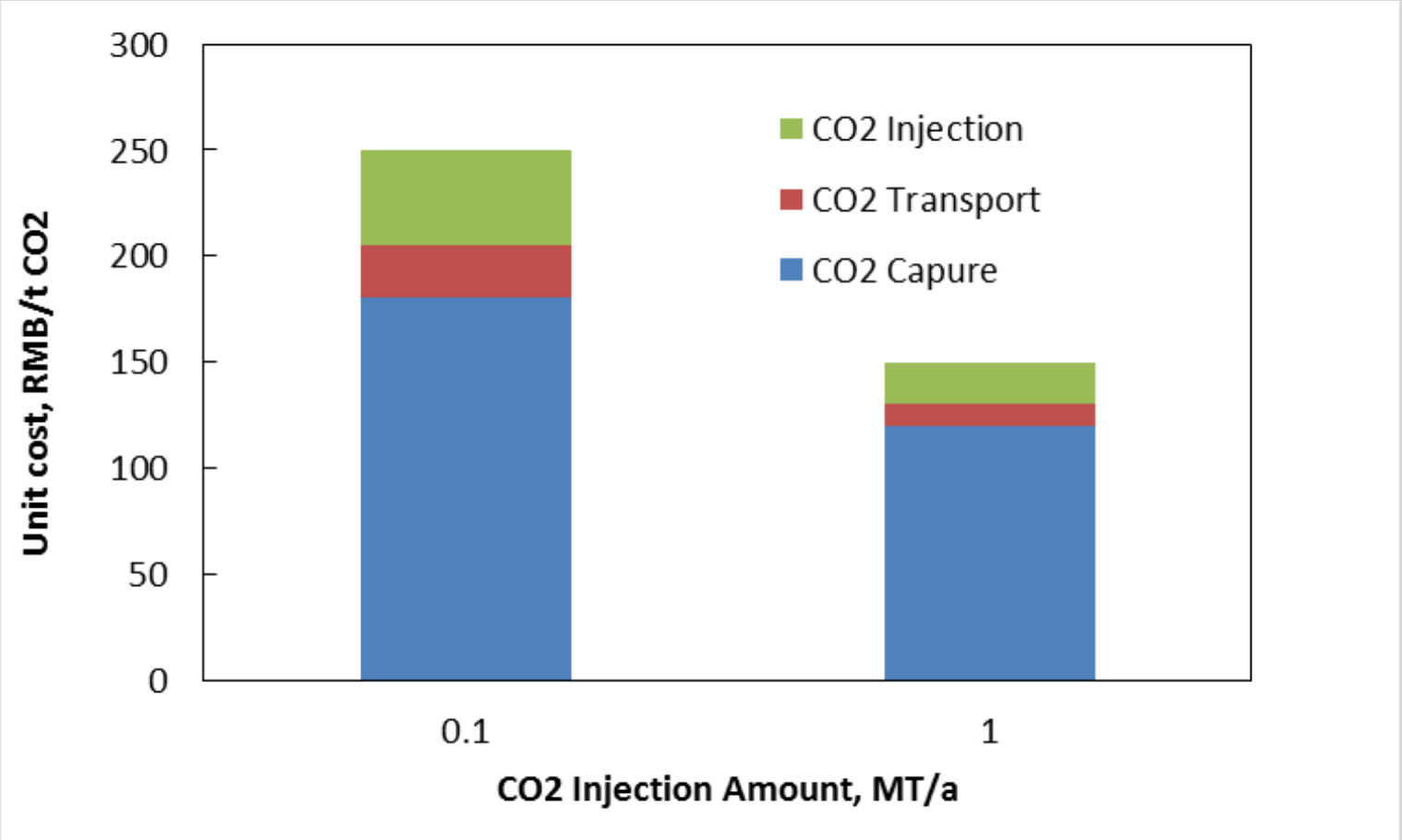
Oil output in China may increase ≥350 MT

(potentially)



NICE Action：Cost Assessment on CCS

➢ Preliminary Assessment for CCS Cost

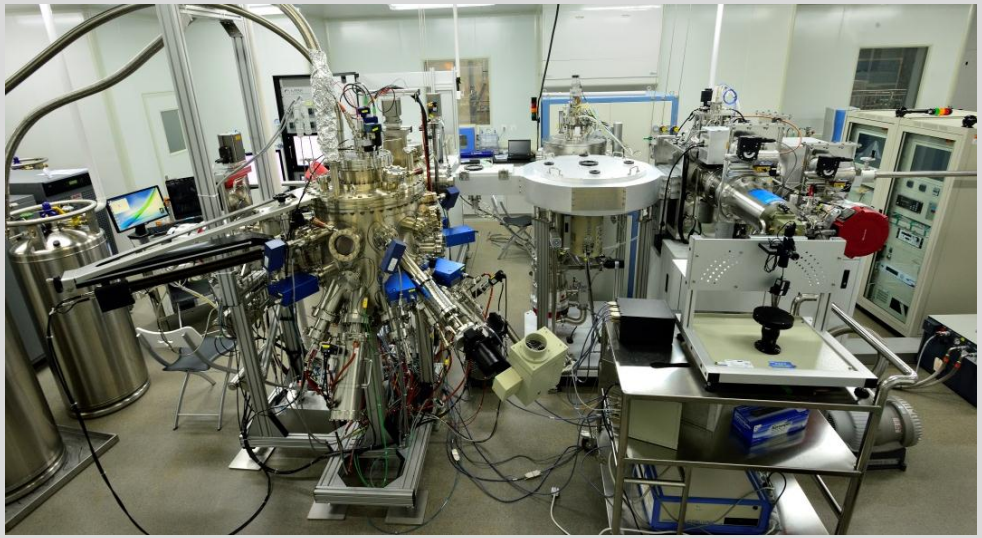


With an increase of CO_2 injection from 0.1MT/a to 1MT/a , the total CCS cost reduces from 250RMB/t to 150RMB/t.

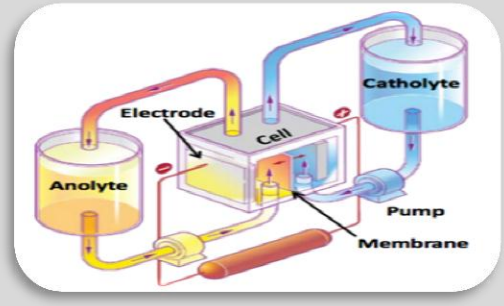
 # CO_2 transport distance: 10 km; Transportation Method: Truck (0.1 MT/a) ,Pipeline (1 MT/a); CO_2 source: highly concentrated CO_2 from a coal chemical company

NICE Action : Solar Cell

NICE Action：Solar Cell

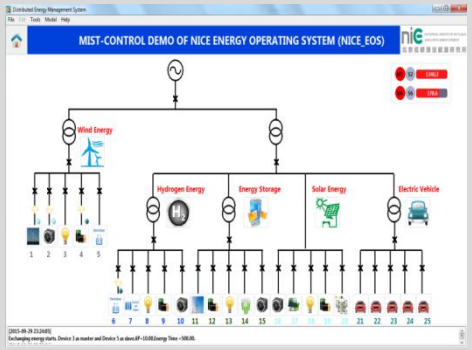


NICE Action: Distributed Energy System

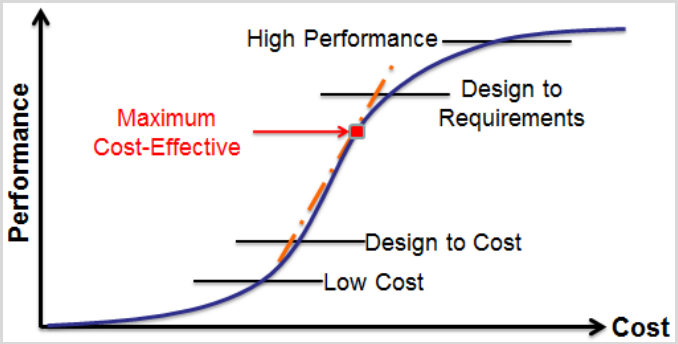


Energy Storage

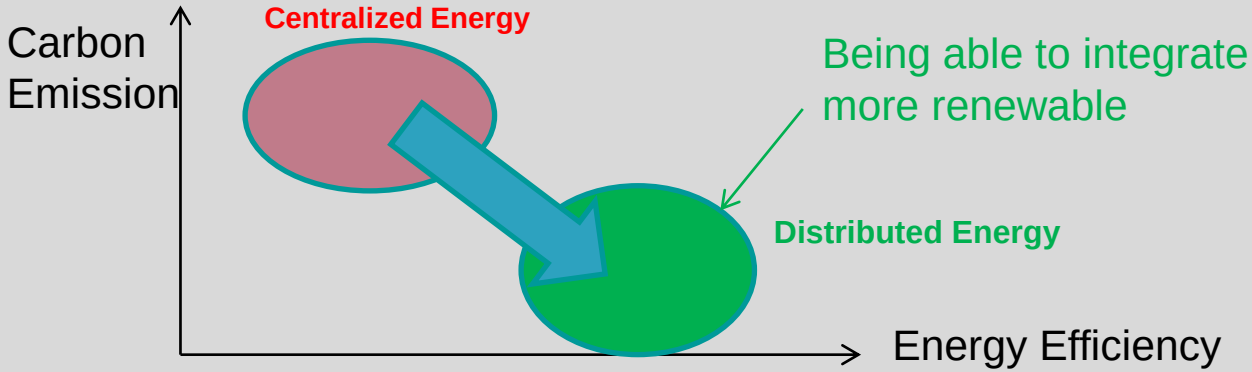
Power Electronics



Energy Management



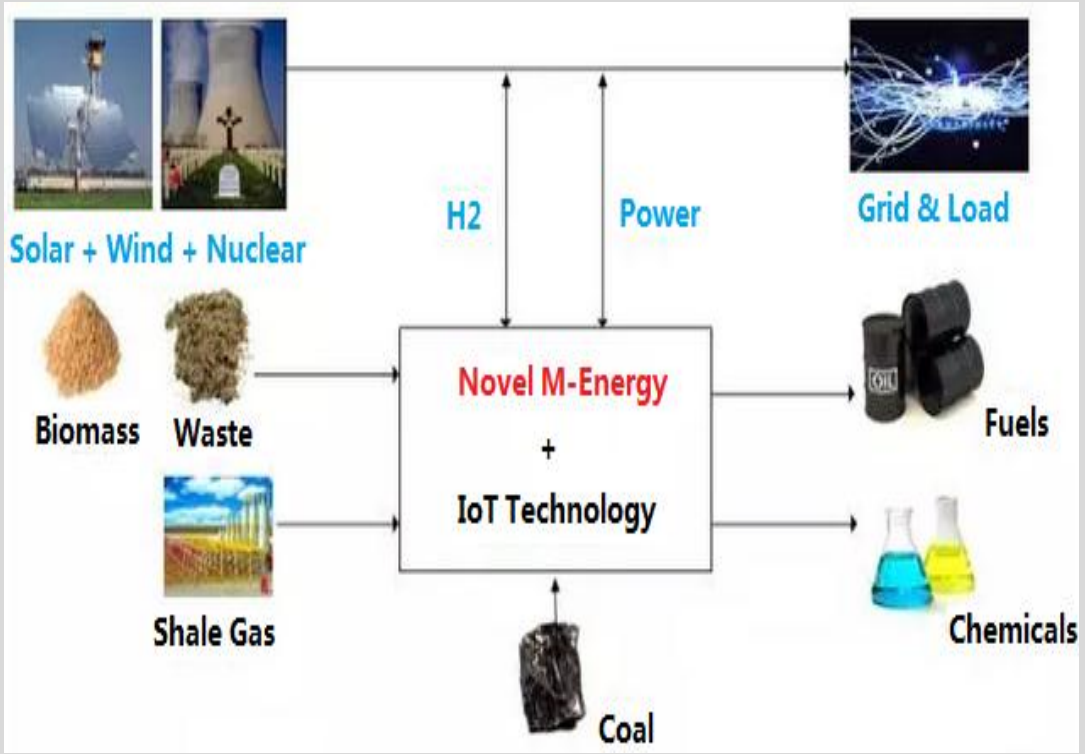
System Design

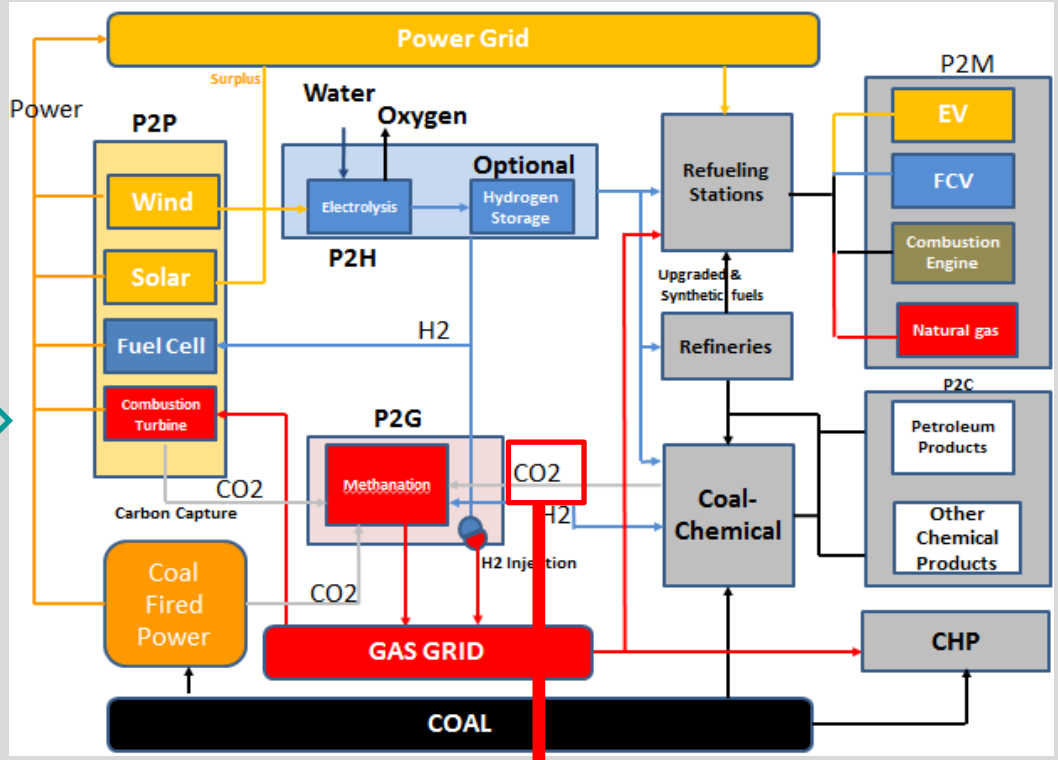


De-centralization for less Carbon

NICE Action: Industrial Energy Internet

From Vision to Design





Multi-Energy based Carbon Negative Solution

China: Abide by its commitment and strong in execution.

- At the Copenhagen climate summit in December 2009, Chinese government promised to reduce carbon emissions by 40~45% per unit of GDP in 2020, compared to those in 2005.
- In November 2014, China and the United States released "U.S.-China Joint Presidential Announcement on Climate Change ", Chinese government first proposed to reach carbon emission' s peak in 2030 or early, and plan to increase the proportion of non-fossil energy to 20% in the primary energy consumption.
- At the Paris climate summit in December 2015, China proposed to reduce carbon emissions by 60~65% per unit of GDP in 2030, compared to those in 2005.

Looking Forward:

Carbon Emission Reduction in 2014

- Reduced CO_2 and energy consumption per unit GDP by 33.8% and 29.6%, respectively (compared with 2005).
- The non-fossil energy was 11.2% of total primary energy consumption (increased by 64.7% than that in 2005)
- The CO_2 emission per unit industrial added value was expected to reduce by 21% in 2015 compared to the 2010 level

Carbon Emission Reduction in 2020

- The CO_2 emissions and energy consumption per unit GDP will decline by 44.7% and 46.1%, respectively (compared with 2005)
- The non-fossil energy will account for 15% of the total primary energy consumption (2.2 times that of 2005);
- **Chinese government's carbon reduction commitment will be achieved!**

Carbon Emission Reduction in 2030

- The CO_2 emissions and energy consumption per unit GDP will decline by at least 65.4% and 64.3%, respectively (compared with 2005)
- The non-fossil energy will account for up to 20% of total primary energy consumption (2.9 times that of 2005);
- **Chinese government's carbon reduction commitment will be achieved!**

Acknowledgements:

- Colleagues at NICE
- Chinese Academy of Engineering

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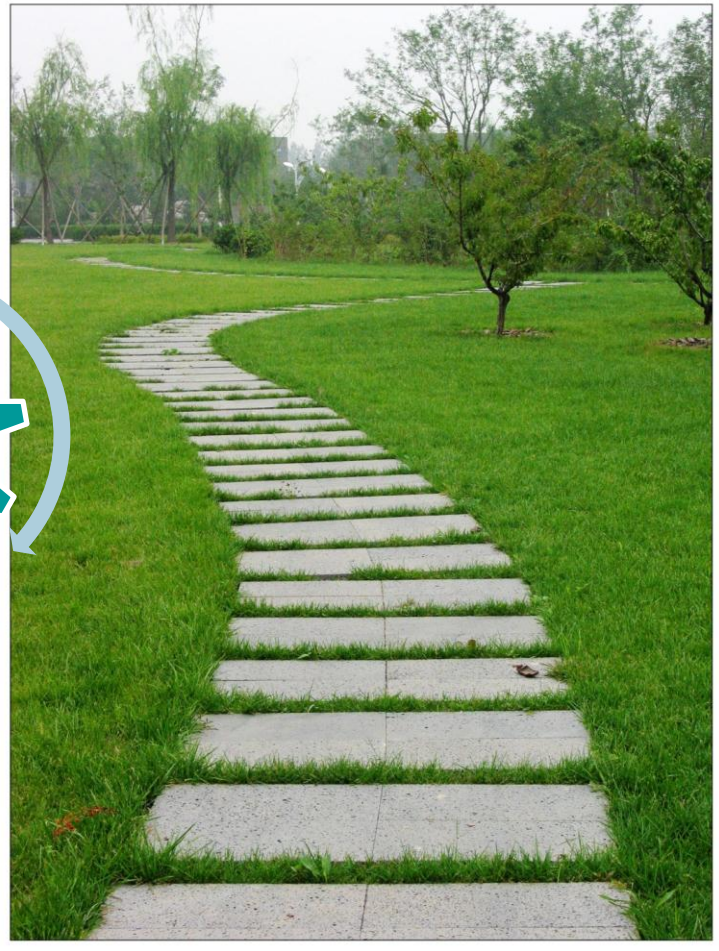
北京低碳清洁能源研究所

Thank you for Your attentions !



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