Prospect of Nuclear Power, New and Renewable Energy Development in China and Issues Facing Regional Cooperation in Asia

ZHANG Aling

Institute of Nuclear and New Energy Technology
Tsinghua University, China

Asia Energy Forum, Tokyo, Japan 2005-11-25

Contents

1. China's current situation and challenges on Energy Utilization

- Current situation and future prospect on energy utilization
- Challenges and future growth tendency of CO_2 emission
- The roles of nuclear and new energy

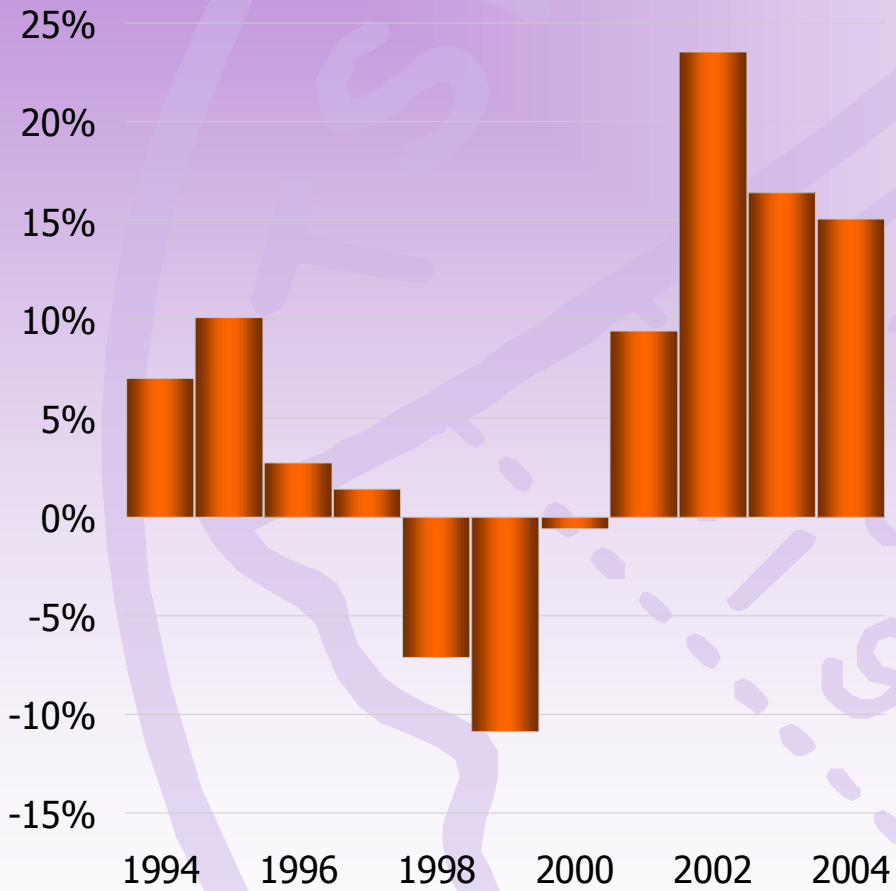
2. China's issues facing Asia regional cooperation

1. China's current situation and challenges on Energy Utilization

- Current situation and future prospect on energy utilization
- Challenges and future growth tendency of CO_2 emission
- The roles of nuclear and new energy

China: Energy Growth

Growth of total primary energy consumption



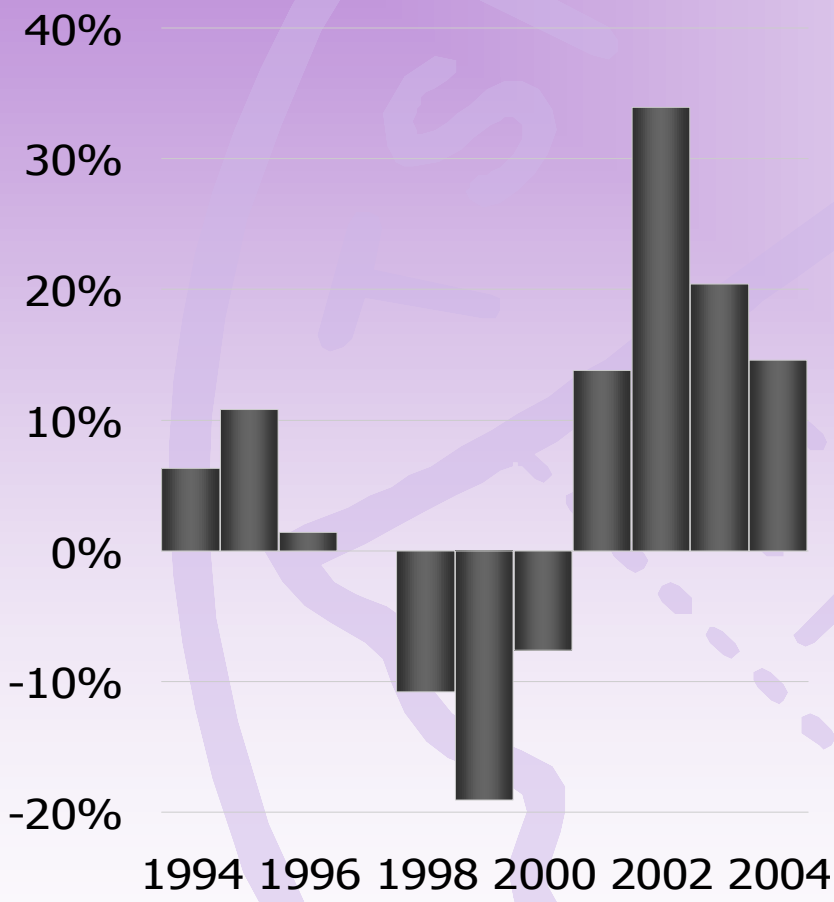
Source: BP Statistical Reviews of World Energy 2005

Issues

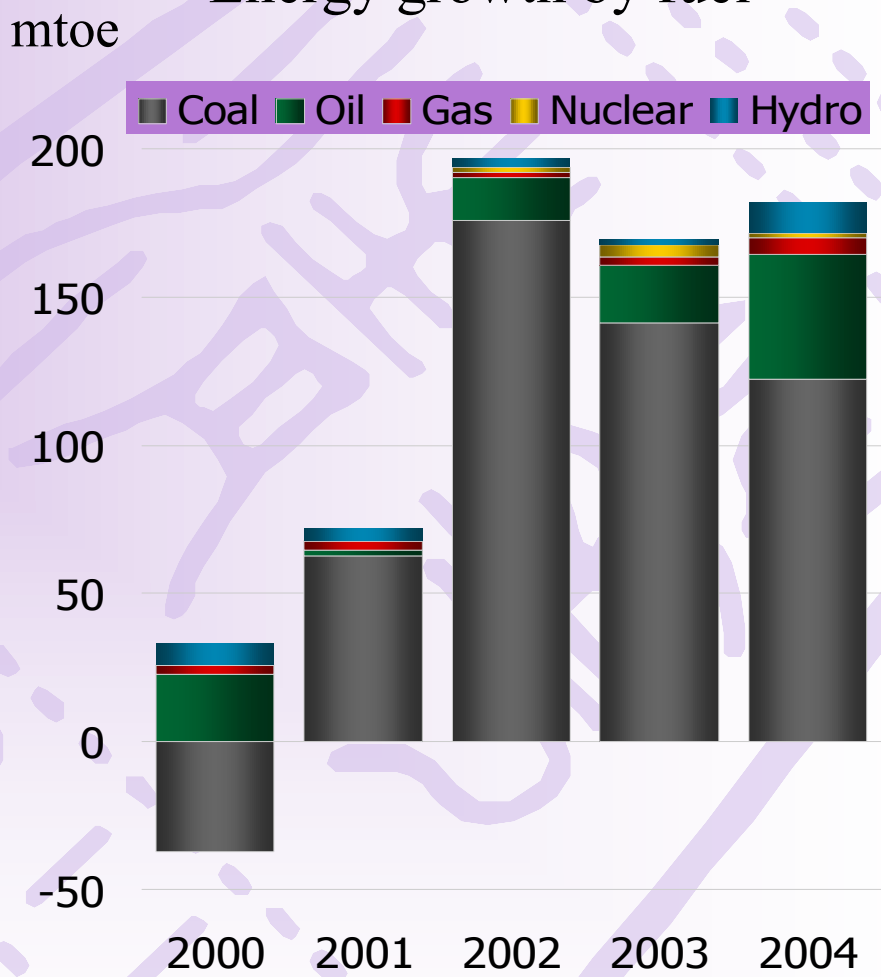
- Strength of energy consumption growth since 2002
- Slowing of energy growth in 2004
- Impact upon world energy markets

China: Energy Growth

Growth of coal consumption

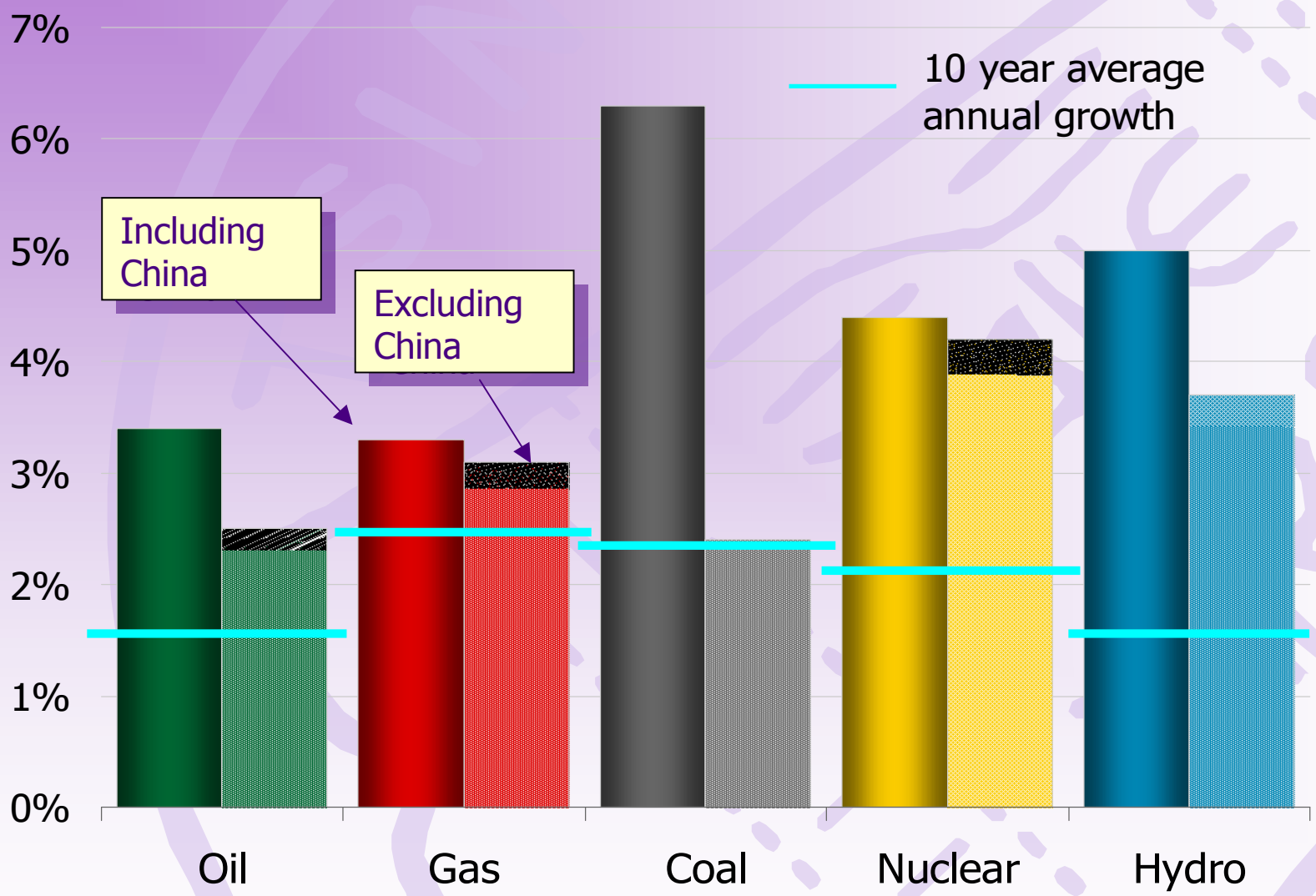


Energy growth by fuel



Source: BP Statistical Reviews of World Energy 2005

World Energy Growth by Fuel 2004



Source: BP Statistical Reviews of World Energy 2005

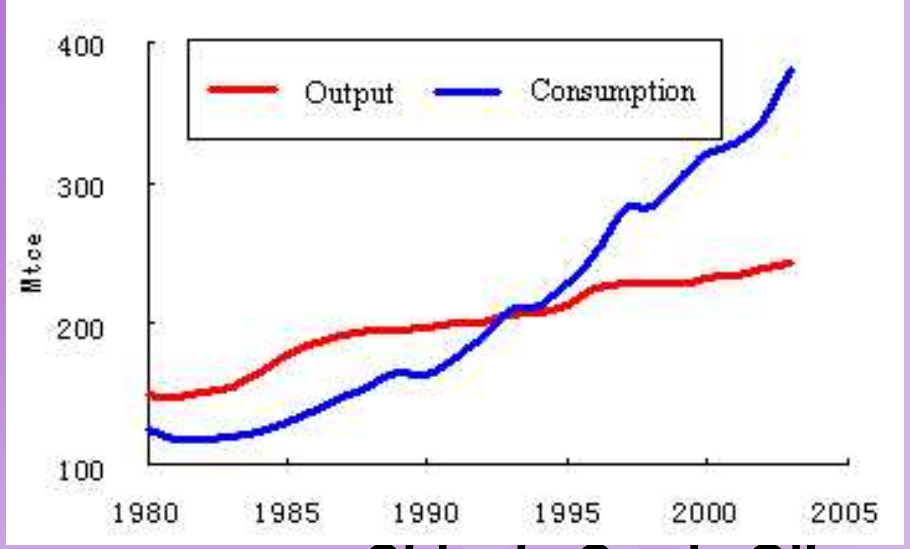
Energy Output and Consumption in 2004

Primary energy output: 1846 Mtce, the 2nd of the World

Coal: 1956 million tonnes, the first in the world
Crude oil: 174.5 million tonnes, the 5th in the world
Natural gas: 40.77 billion cubic meters, the 16th in the world
Power: installed capacity of 440GW, the 2nd in the world
Electricity generation: 2187 billion kWh
Hydropower: 328 billion kWh
Thermal power: 1807.3 billion kWh
Nuclear power: 50.1 billion kWh

Primary energy consumption: 1.97 billion tce, the 2nd in the world

Coal: 67.7%
Oil: 22.7%
Natural gas: 2.6%
Hydropower and nuclear power: 7.0%



The Comparison of Crude Oil Output and Consumption from 1980 to 2003

China's Crude Oil and Natural Gas Production in 1998 and 2003

Crude oil	*1998*		*2003*	
	Output (million tons)	Proportion (%)	Output (million tons)	Proportion (%)
China National Petroleum Corporation	107.46	67.32	109.5442	64.50
China Petroleum & Chemical Corporation	35.317	22.12	38.0478	22.40
China National Offshore Oil Corporation	16.319	10.22	21.8.89	12.87
Other	0.532	0.33	0.3802	0.02
Total	*159.628*	*100*	*16983.11*	*100*
Natural gas	Output ($\times 10^8$ m^3)	Proportion (%)	Output ($\times 10^8$ m^3)	Proportion (%)
China National Petroleum Corporation	149.83	70.77	248.82	72.91
China Petroleum & Chemical Corporation	23.24	10.98	51.69	15.15
China National Offshore Oil Corporation	38.64	18.25	32.52	9.53
Other			8.25	2.42
Total	*211.71*	*100*	*341.28*	*100*

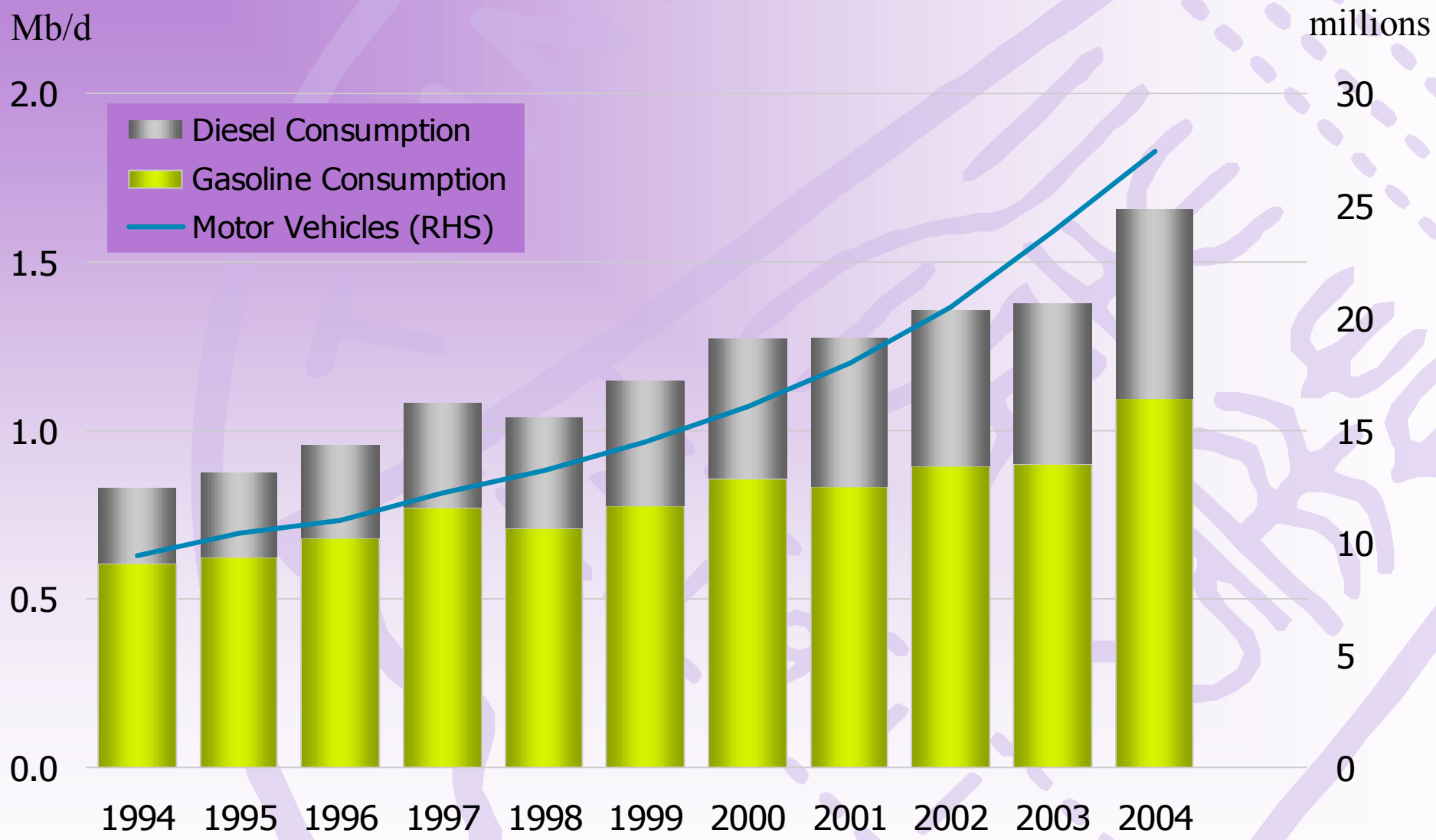
China's Power Capacity and Electricity Output during 1980-2003

Year	Installed Capacity/GW				Electricity Output/TWh			
	Total	Thermal	Hydro	Nuclear	Total	Thermal	Hydro	Nuclear
1980	65.9	45.6	20.3		301	243	58	
1985	87.0	60.6	26.4		411	318	92	
1990	137.9	101.8	36.0		621	495	126	
1995	217.2	162.9	52.2	2.1	1007	807	187	13
2000	319.3	237.5	79.4	2.1	1369	1108	243	17
2001	338.5	253	83	2.1	1484	1205	261	18
2002	356.6	265.6	86	4.5	1654	1352	275	27
2003	391.4	289.77	94.9	6.2	1905.2	1579	282.3	43.9

Source: China Statistics Summary 2004

Chinese Road Transport

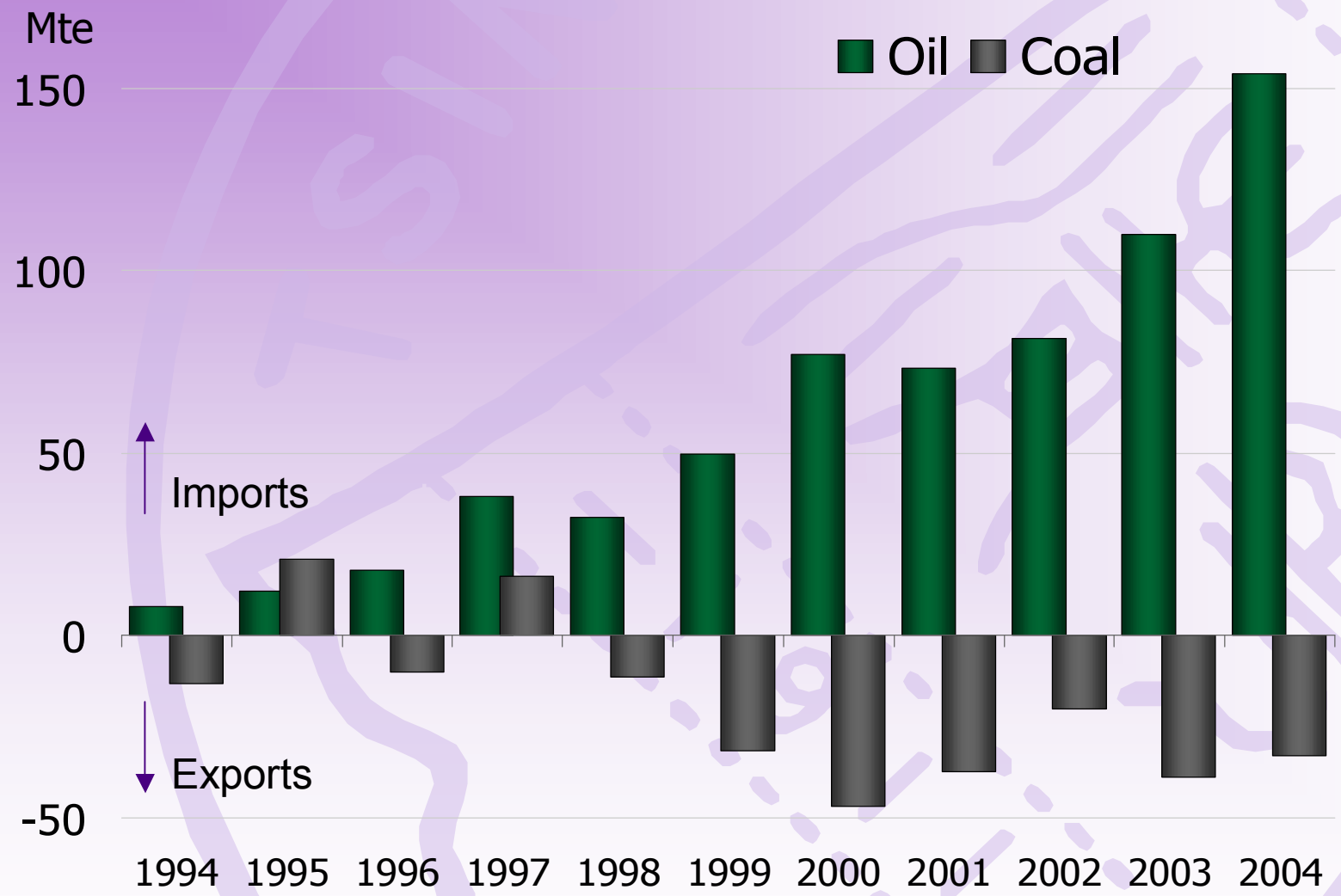
Road transport fuel demand versus vehicle stock



Source: BP Statistical Reviews of World Energy 2005

China: Energy Trade

Net imports/exports of oil and coal



Oil trade source: Customs General Administration of the People's Republic of China

Source: BP Statistical Reviews of World Energy 2005

Scenario Analysis on China's Future Economy, Energy and Carbon Emission

	2000	2020	2050
Population (billion)	1.26743	1.427	1.561
GDP (billion Yuan), the constant price of year 2000	8946.8	35777.0	145899.0
GDP(10^9 USD), the constant price of year 2000	1081	4320	17624
Per capita GDP (Yuan /per capita), the constant price of year 2000	7086	35763	93465
Per capita GDP(USD /per capita), the constant price of year 2000	856	3027	11290
Primary energy consumption (Mtce)	1303	3000	5000
CO_2 emissions (Mt-C)	817	1640	2025
GDP energy intensity (kgce/USD)	1.21	0.69	0.28
CO_2 intensity of energy consumption (kg-C/kgce)	0.63	0.55	0.41
GDP carbon emission intensity (kg-C/ USD)	0.76	0.38	0.12
Per capita CO_2 emission (kg-C / per capita	650	1148	1297

Exchange rate: 100USD＝827.84 Chinese Yuan (China Statistics Summary 2004)

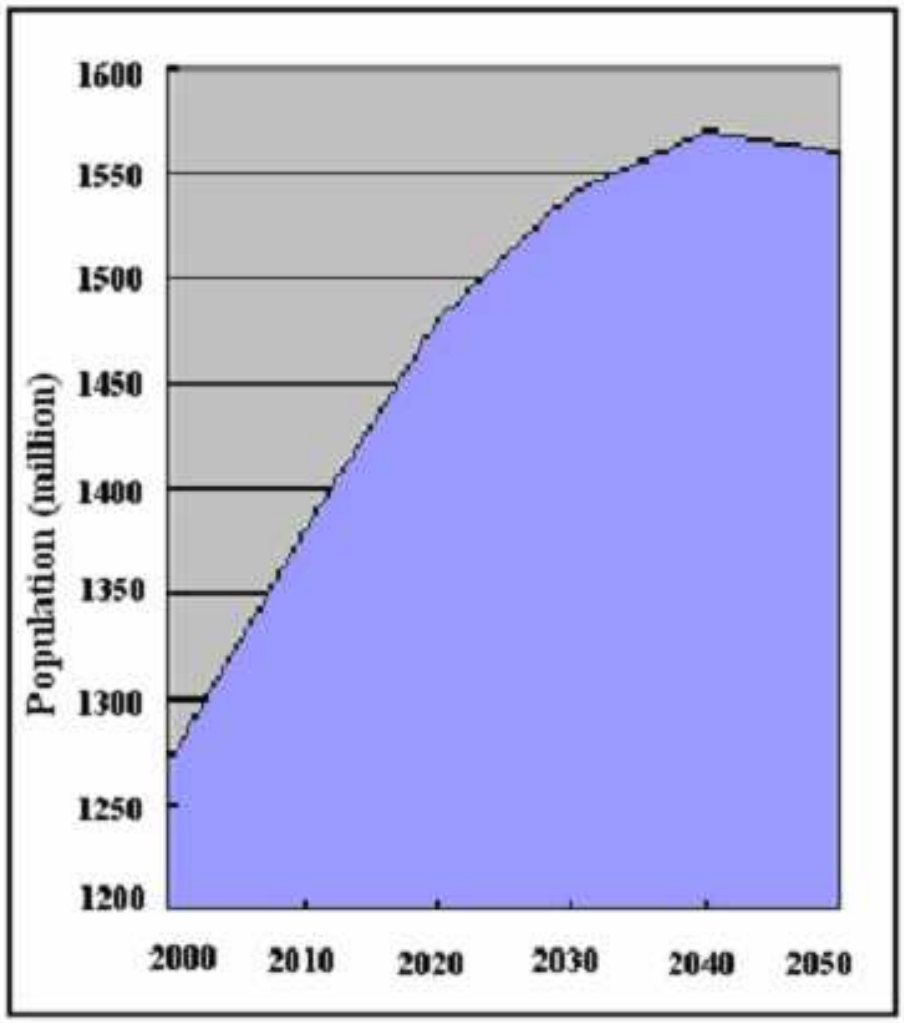
Scenario Analysis on China's Future Economy, Energy and Carbon Emission

	2000～2020	2020～2050
GDP growth rate (%/year)	7.2	4.8
Energy consumption growth rate (%/year)	4.3	1.7
Energy consumption elasticity	0.59	0.35
The decreasing rate of GDP energy intensity (%/year)	2.8	3.0
The growth rate of CO_2 emission (%/year)	3.8	0.7
The decreasing rate of GDP carbon emission (%/year)	3.3	3.8

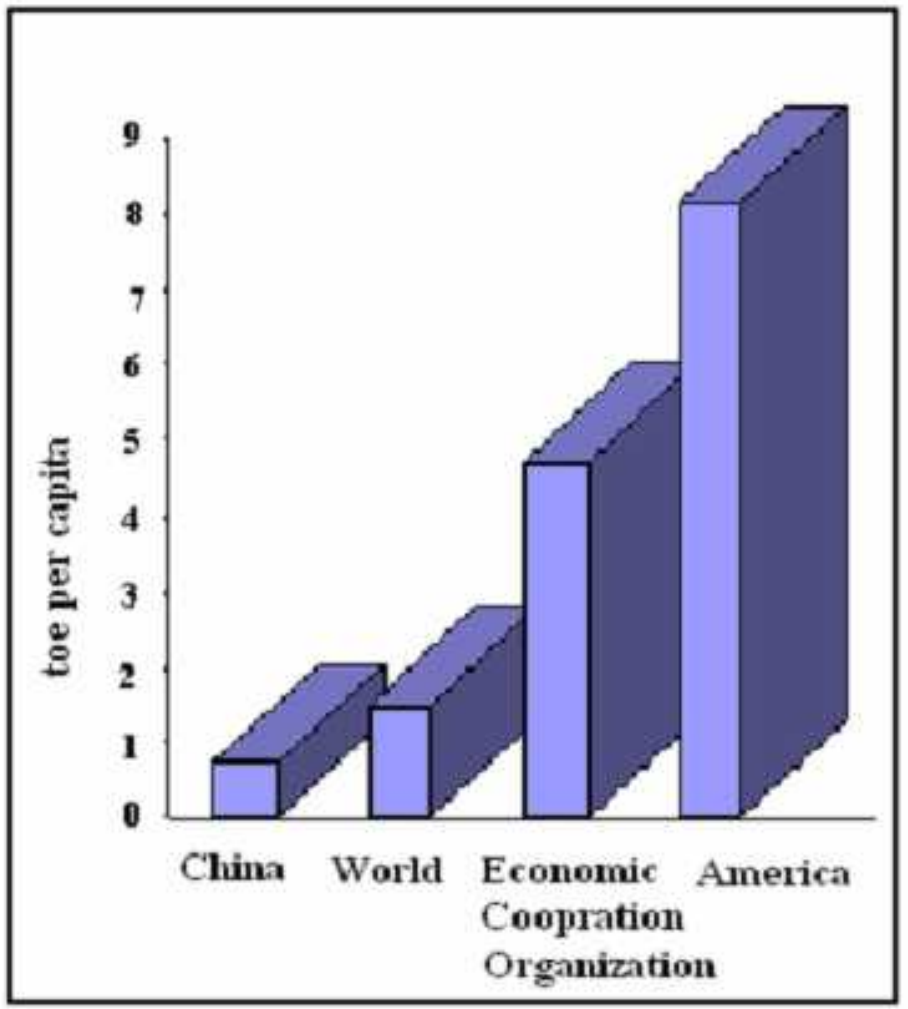
The challenges of China's Energy Development

- Making China's energy issues which has already received worldwide attentions become an extremely hot topic, which has aroused great attentions from Chinese high level officials
- Leading to more questions and worries: Can China receive enough energy to support its fast economic growth in the future?
- Raising oil price at international markets due to China's great demands in energy, especially in oil
- Resulting in climate change and global warming because of China's enormous coal consumption

China's Inevitable Increase on GHG Emission



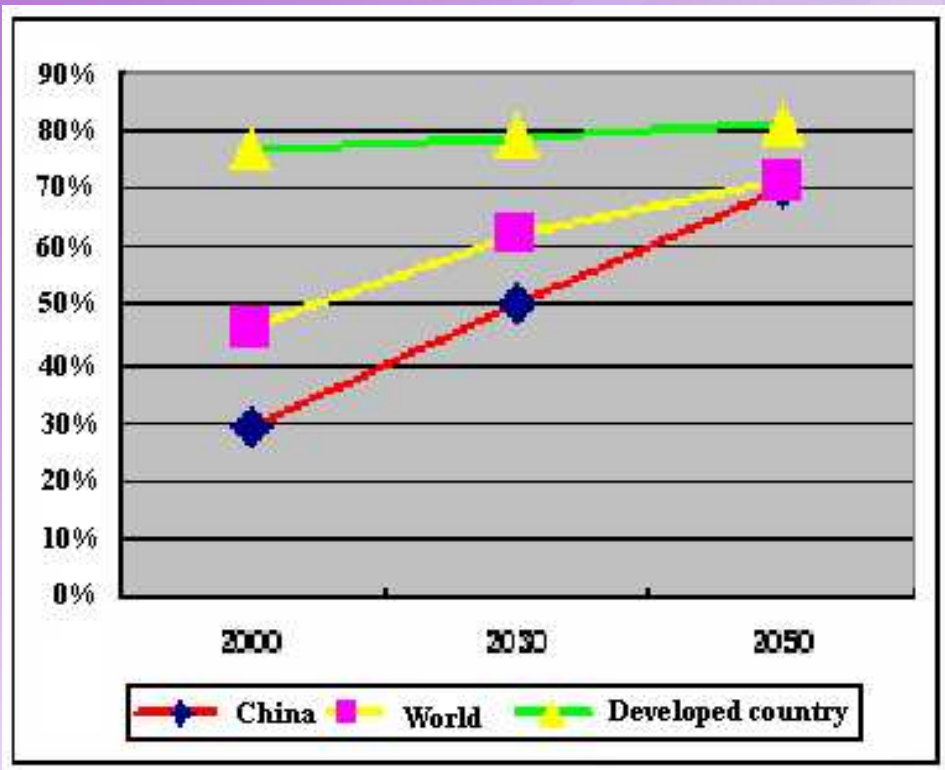
China's population growth tendency



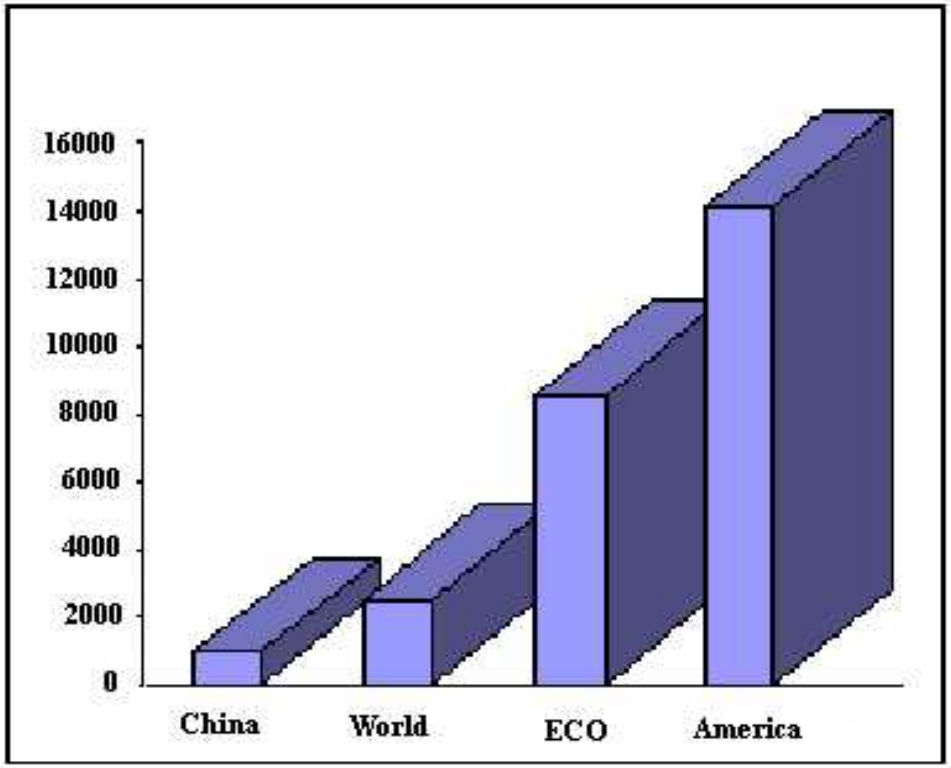
Comparison of energy consumption per capita in 2000

Compared with year 2000, if the energy consumption per capita can be maintained as the same level, by 2040, just for survival, China's 300 million newly-increased people will make the energy demands and CO_2 emissions increase 306 million tce and 625 million tonnes respectively (1tce results in 2.043t-CO_2 emissions).

China's Inevitable Increase on GHG Emission



China's urbanization trend



Comparison of power consumption per capita in 2000

Within the coming 50 years, about 720-880 million people will transfer to cities from rural areas in China, which will consequently bring on enormous changes on such respects as inhabitancy, employment, life and consumption, and all these changes will be involved not only to the social economy but also to resource and energy fields.

In 2000, China's annual electricity generation reached 1368.482 TWh, ranked the second place in the world, but compared with the developed countries, due to the lower electrified level, no matter on the power consumption per capita, or on the power consumption proportion accounting for the final energy, there is very great disparity.

China's Inevitable Increase on GHG Emission

China, which is going through the initial-middle period of industrialization at present, will continue developing its infrastructure on a large scale in the future. such sections as energy , raw materials and transportation are still the primary basic industries in China, and consequently energy consumption will continuously increase at all high energy consumption sections.

Taking steel section as an example, in 2000 steel output was 128.5 million tons, which consumed 170 mtce of energy resources. By the experts' estimation, steel output will be up to 300 million tons in 2010 and 400 million tons in 2020, so energy consumption of steel section will reach 500 mtce in 2020 if there is not any significant technology import and innovation, inevitably the corresponding GHG emissions will increase too.

Taking cement section as another example, cement output was 597 million tons in 2000 with 100 mtce of energy consumption. It is predicted that cement output will reach 800 million tons in 2010 and nearly 1,100 million tons in 2030. If the unit consumption is maintained as the level of year 2000, the energy consumption of cement section will be up to 180 mtce by 2030, and the GHG emissions will correlatively increase too.

By 2050 China's private-owned vehicles and cars per 1000 persons will respectively increase to 200 and 125, which will finally make CO_2 emissions and the demands for oil products rise sharply.

Strategies of China's Energy Development

In June 2004, Premier Wen Jiabao presided over the standing meeting of State Council, discussing the Outline of Medium and Long-term Energy Development Plan (2004-2020) (draft) which was passed in principle finally

Premier Wen pointed out, formulating and implementing the plan to solve energy problems were related directly to China's modernization process. China must insist on regarding energy as its strategic emphasis of economic development and should offer such a steady, economic, clean, reliable and secure energy guarantee for its well-off society building as to support its socio-economic sustainable development by energy sustainable development and effective utilization.

The Important Role of Renewable Energy for China's Sustainable Development

1. Renewable energy technologies are also high-efficient agricultural production and ecological environmental protection technologies which can improve China's rural economy and accelerate social development
2. Renewable energy has unique functions in solving energy and ecological environment problems in Chinese countryside especially the western regions
3. Renewable energy, as an important component of China's sustainable energy system, can ensure energy supply safety, adjust energy mix, protect the environment and reduce GHG emissions

Situations of China's New and Renewable Energy Development

Renewable energy utilization in 2004 is given in the table. Traditional biomass use still dominates in the total use, so the development of new and renewable energy still has long way to go.

	Utilization amount	Mtce
Traditional biomass use		250
Renewable energy		48.9
Small hydropower	38.7GW, 129.5TWh	37.8
Biomass		4.08
Household biogas	15.41M household, biogas 5.6 Bm^3	4.37
Large and middle biogas	3000 units, biogas 1.089 Bm^3	0.86
Straw and stalk gasification	488 units, biogas 0.15 Bm^3	0.02
Bagasse power generation	800MW, 2000GWh	0.71
Solar		
Solar heater	62 Mm^2	
Passive solar house	20 Mm^2	0.80
Solar stove	500 thousand	0.24
Solar PV	65MW, 364GWh	0.02
Geothermal		
Directly use	0.6Mtce	0.60
Power generation	28MW, 140GWh	0.05
Wind power		0.45
Grid	460MW, 1245GWh	0.44
Small and mini	33MW, 34GWh	0.01

Outlook for China's New and Renewable Energy Supply

Type		2010	2020
Small hydro	GW/TWh	50/165	75/247.5
Wind power generation	GW/TWh	5.0/11.5	30.0/69.0
PV	MW/TWh	300/0.54	2000/3.6
Biomass generation	GW/TWh	5.50/21.2	20.0/83.5
Geothermal generation	MW/TWh	50/0.25	100/0.5
Methane	Billion m^3	16	27
Automobile-used alcohol	Mt	2.00	5.00
Bio-fuel	Mt	0.20	1.00
Geothermal utilization	PJ	76	150
Solar water-heater	Million m^2	150	300
Solar cooker	Million sets	4	5
Hot water supply	Million families	0.6	1.1

Source: China Renewable Energy Development Strategy Workshop 2005/10/28

The Important Role of Nuclear Energy for China's Sustainable Development

Nuclear energy could be the important component of primary energy supply

share of nuclear in primary energy

- ***world average*** ***6.8%***
- ***U.S*** ***9.0%***
- ***Japan*** ***18.8%***

Nuclear energy could play an important role for energy security due to very low fuel cost

- ***Nuclear power*** ***6.0%***
- ***Nat.gas power*** ***75.0%***

Nuclear energy could play an important role to improve energy environment impact due to no pollutant emission of SO_2, NO_x, and CO_2

China's Operational and constructing Nuclear Power Plants

	Types of Reactors	Status	Address	Install Capacity (MW)	Technology Supplier	Connected
Daya Bay-1	PWR	Operational	Guangdong	984	France	1993/08/31
Daya Bay-2	PWR	Operational	Guangdong	984	France	1994/02/27
Linao-1	PWR	Operational	Guangdong	990	France	2002/02/26
Linao-2	PWR	Operational	Guangdong	990	France	2002/12/15
Qinshan-1	PWR	Operational	Zhejiang	300	China	1991/12/15
Qinshan 2-1	PWR	Operational	Zhejiang	642	China	2002/02/06
Qinshan 2-2	PWR	Operational	Zhejiang	642	China	2004/03/01
Qinshan 3-1	PWR	Operational	Zhejiang	728	Canada	2002/11/19
Qinshan 3-2	PWR	Operational	Zhejiang	728	Canada	2003/06/12
Tianwan-1	HWR	Constructing	Jiangsu	1060	Russia	2004/05/30
Tianwan-2	HWR	constructing	Jiangsu	1060	Russia	2005/04/30
Total				9108		

The Policies of Nuclear Energy Development in China

- ✶ Priority will be given to hydropower development and great efforts should be made to develop thermal power, and nuclear will be developed to an adequate degree
- ✶ The development of nuclear power will implement a principle of seeking Sino-foreign cooperation and " taking China's self- reliance as the dominant factor– design, manufacturing, construction and operation
- ✶ The PWR type nuclear power plant is considered as the prevailing technology option in the near future

Scenario Analysis on China's Future Power Installed Mix

	2020		2050	
	Installed Capacity (GW)	%	Installed Capacity (GW)	%
Coal Power	570	57	800	39
Natural Gas Power	60	6	180	9
Nuclear Power	40	4	200	10
Hydropower	278	27.8	320	15
Small Power	75	7.5	100	5
Wind Power	30	3	250	12
Biogas Power	20	2	200	10
PV	2	0.2	100	5
Other Renewable Energy Power			20	1
Total	1000	100	2070	100

Priority Programs for Energy S&T Development in 2020

- Energy saving enhancement and energy efficiency improvement technologies
- Clean coal exploitation and utilization technologies
- Oil security supporting system technologies
- Advanced nuclear energy technologies
- Advanced reliable power transmission and distribution systems
- Technologies of large-scale deployment of renewable energy facilities
- Hydrogen and fuel cell technologies.

Advanced Nuclear Energy Technologies

- Mastering the advanced PWR technologies and deploying that as the prevailing type
- Development of Generation IV nuclear reactor technologies aimed to improving the economy and safety performance, as well as minimizing nuclear waste generation
- Carrying out R&D on fusion

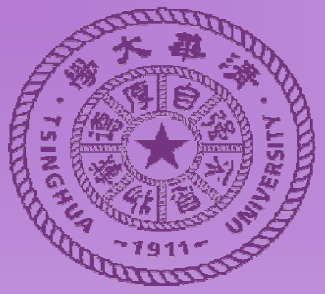
Technologies of large-scale deployment of renewable energy facilities

- Development of extra large capacity and long distance power transmission technologies
- R&D on reliability of interconnected grid in extra large capacity
- In near term, emphases on wind power, biomass use and integrated building design with solar use
- In long term, solar PV will provide a prospect largely contributing to the future energy supply

Hydrogen and Fuel Cell

Hydrogen - clear energy carrier will play important role to reducing the oil dependence in future

- **High efficiency and low cost production and storage technologies**
- **The key and integrated technologies on transport and stationary fuel cell**
- **Commercial use in city transport system**



2. China's issues facing Asia regional cooperation

China's issues facing Asia regional cooperation

Realistic contradiction: China must accelerate its economy development; while the resource and energy are relatively shortage; environmental pollution caused by fossil energy is getting more and more serious, which is common question of the world.

Necessary choice : developing and utilizing renewable and nuclear energy actively is common direction of the whole world.

Obstacle eradication: the whole world must make joint effects to guarantee the corresponding system demands, legal safeguards and finance policies for developing and utilizing renewable and nuclear energy.

Other importance: Adapting to international situation and fulfilling international obligation are the world's common responsibilities.

International cooperation and communication: cooperative study, CDM project development, capacity building and technology transfer.

Study Cooperation, Technology Transfer and Demonstration Project

1. Study cooperation and communication on advanced technologies of nuclear and new energy
2. Transferring Technologies to the developing countries
3. Helping the developing countries build demonstration projects
4. Jointly applying for scientific research projects from international organizations
5. Organizing academic communication and exchange visits

Capacity building and CDM project development

Capacity building

- Evaluation of green energy resources at provincial level
- Evaluation and feasibility study green energy on conversion technologies
- Methodology study on green energy CDM projects and their development
- Fostering and training on equipment manufactures and project developers

CDM project development

- Power development, landfill gas utilization and coal bed gas utilization

Thank you for your attention

Assumptions of macroeconomic parameters in the future

		2000	2010	2020	2030
Population / billion		1.267	1.38	1.45	1.50
GDP / billion Yuan_(2000)		8946.81	20700	37700	60000
Urbanization / %		36.22	43	55	60
GDP per capital /Yuan(2000)		7084	15000	26000	40000
Growth rate of GDP / %					
Industrial Structure / %	Primary Industry	16.4	10	9	8.5
	Secondary Industry	50.2	52	49	44
	Tertiary Industry	33.4	38	42	47.5

Situations of China's New and Renewable Energy Development

The main constraint factors of renewable energy are the un-commercialized technologies and high costs. Renewable energy technologies are in different stages in China, which are shown in the following table.

Situations of China's New and Renewable Energy Development

Technology type	Technology phase			
	R&D	Demo	Commercializing	Commercialized
Small hydro plant				◆
Solar water-heater				◆
Passive solar building				◆
Solar cooker				◆
Solar desiccator		◆		
Solar cell			◆	
Large scale wind power unit grid-connected			◆	
Small and micro scale wind power unit grid-connected			◆	
Geothermal power generation				◆
Geothermal heating				◆
Traditional biomass energy				◆
Small-scale biogas digester				◆
Large-and-middle-scale biogas digester			◆	
Generation from municipal organic waste		◆		
Biomass gasified technology		◆		
Other biomass technology	◆			
Wave generation	◆			
Tide generation			◆	
Generation from ocean temperature difference	◆			

Contact : report@tky.ieej.or.jp