

China's Strategies and Actions on Energy Mix towards Low-Carbon Society

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Session I: Energy mix of major countries based on the '3Es'

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1. Introduction 1.1 China's Position in the World

China is the largest energy consumer, the largest emitter of CO2 and air pollutants, with largest population and second largest economy in the world, although the per capita energy consumption and CO2 emissions as well as GDP are much lower than the average in OECD countries, especially in USA.

Per Capita Index on GDP, Energy Consumption and CO2 Emissions in China and the World (2012)

	Per Capita GDP			Per Capita Primary Energy			Per Capita CO2 Emissions		
	\$/Person	OECD=100	USA=100	Toe/Person	OECD=100	USA=100	T-CO ₂ /Person	OECD=100	USA=100
World	10,377	27.8	20.1	1.79	42.7	26.2	4.63	48.2	28.3
OECD	37,356	100.0	72.2	4.19	100.0	61.4	9.60	100.0	58.7
USA	51,736	138.5	100.0	6.82	162.9	100.0	16.37	170.5	100.0
Japan	46,391	124.2	89.7	3.53	84.3	51.8	9.53	99.3	58.2
EU	32,893	88.1	63.6	3.25	77.6	47.7	6.74	70.2	41.2
Non-OECD	4,523	12.1	8.7	1.27	30.3	18.6	3.55	37.0	21.7
India	1,530	4.1	3.0	0.52	12.5	7.6	1.59	16.5	9.7
China	6,091	16.3	11.8	2.00	47.7	29.3	6.71	69.9	41.0

Sources: Compiled by Li Zhidong, based on EDMC/IEEJ, Handbook of Energy & Economic Statistics in Japan, 2015.

Cumulative Total and Per Capita Emissions in China and the World(2012)

	Cumulative Total Emissions from 1890				Cumulative Total and Per capita Emissions from 1990 to 2012					
	to 1990		to 2012		Total Emissions		Per Capita Emissions			
	Gt-CO ₂	シェア	Gt-CO ₂	share	Gt-CO ₂	share	t-CO ₂	Index		
World	778	100.0	1,295	100.0	538	100.0	80	100.0	41.0	21.6
OECD	498	64.0	737	56.9	250	46.5	195	244.0	100.0	52.8
USA	239	30.7	349	27.0	115	21.4	369	462.2	189.4	100.0
Japan	29	3.7	53	4.1	25	4.6	180	225.6	92.5	48.8
EU	211	27.1	287	22.1	80	14.8	149	186.0	76.2	40.2
Non-OECD	280	36.0	557	43.0	288	53.3	53	65.8	27.0	14.2
India	13	1.7	36	2.8	24	4.4	21	26.1	10.7	5.7
China	42	5.4	135	10.4	95	17.7	70	87.5	35.9	18.9

Notes: The cumulative total emissions are calculated based on data from IEA "World Energy Outlook 2009" and EDMC/IEEJ "Handbook of Energy & Economic Statistics in Japan 2015". The cumulative per capita emissions are estimated by [Cumulative Emissions / Cumulative population * the number of years].

Population, Energy Consumption, CO2 Emissions and GDP in China and the World (2012)

	Population		Primary Energy		CO2 Emissions		Nominal GDP	
	Million	%	Mtoe	%	Mt-CO ₂	%	Billion \$	%
World Total	7,033	100.0	12,578	100.0	32,562	100.0	72,983	100.0
OECD	1,254	17.8	5,250	41.7	12,038	37.0	46,845	64.2
USA	314	4.5	2,141	17.0	5,139	15.8	16,245	22.3
Japan	128	1.8	452	3.6	1,220	3.7	5,938	8.1
EU	506	7.2	1,644	13.1	3,408	10.5	16,644	22.8
Non-OECD	5,779	82.2	7,328	58.3	20,524	63.0	26,138	35.8
India	1,237	17.6	645	5.1	1,961	6.0	1,893	2.6
China	1,351	19.2	2,696	21.4	9,067	27.8	8,229	11.3
China's Ranking	Largest		Largest		Largest		Second Largest	

Sources: Compiled by Li Zhidong, based on EDMC/IEEJ, Handbook of Energy & Economic Statistics in Japan, 2015.

> Because of the huge impact, evaluation on China's future is important .
 ★ Without mentioning China, It would be very difficult to discuss on issues such as world energy market and global climate change prevention.

1.2 Challenges & Strategic Targets for China?

- Preventing air pollution , reducing CO2 emissions and ensuring energy security effectively are main challenges facing in China.

>>> China has already recognized the urgent need for action to meet these challenges. China has proposed mid-term mitigation action plan to the UN in 2010 and started in its 12th Five-Year Plan from 2011, to reduce energy-related CO₂ emissions per unit of GDP by 40-45% between 2005 and 2020. On the other hand, the government announced the “Action Plan for Preventing Air Pollution” (the “Plan”) in 2013.

>>> Due to its low efficiency in energy use, the highest priority is placed to energy conservation, followed by reducing the dependency on fossil fuels, especially coal. Because coal is the largest emitter of both CO₂ and air pollutants, switching away from coal is imperative for China, not only to decrease the ratio of coal in primary energy consumption, but also to control and then reduce the coal consumption in total.

>>> After the Fukushima nuclear incident in 2011 in Japan, China has strengthened its efforts to improve energy efficiency and developed renewable energy. It also reinforced its initiatives to secure the safety of nuclear power generation, such as allowing only the latest, third-generation type of nuclear power plants to be constructed.

- As the long-term strategic targets, China intends to build a low-carbon and environmental-friendly society, and realize sustainable development , through overcoming these energy related 3Es issues.

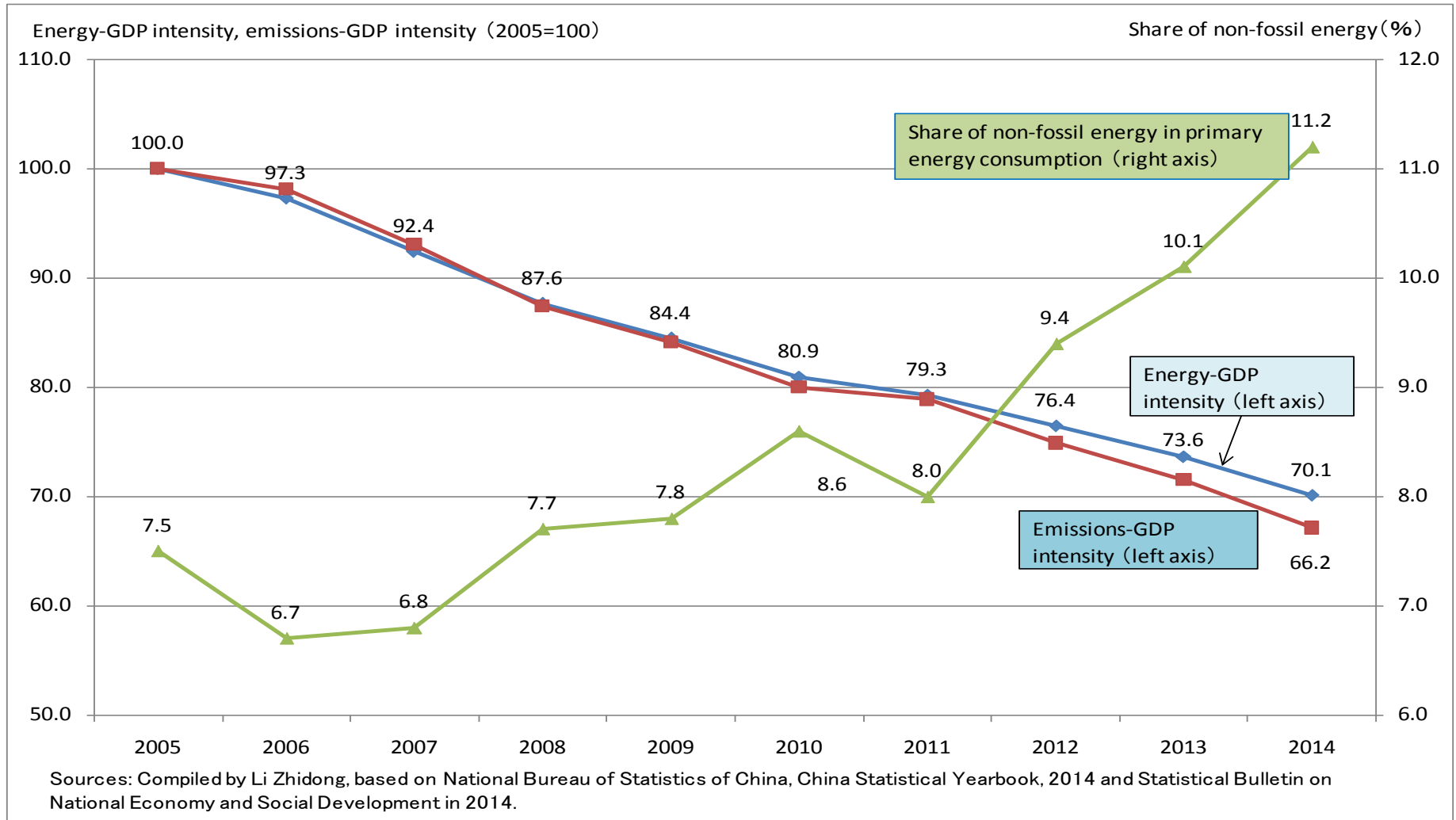
2. The Progress Status in Tackling 3Es Issues in China

2.1 Achievements (up to 2014)

★ **Energy-GDP intensity** decreased by 29.9% from 2005 level, and 13.6% from 2010 level.

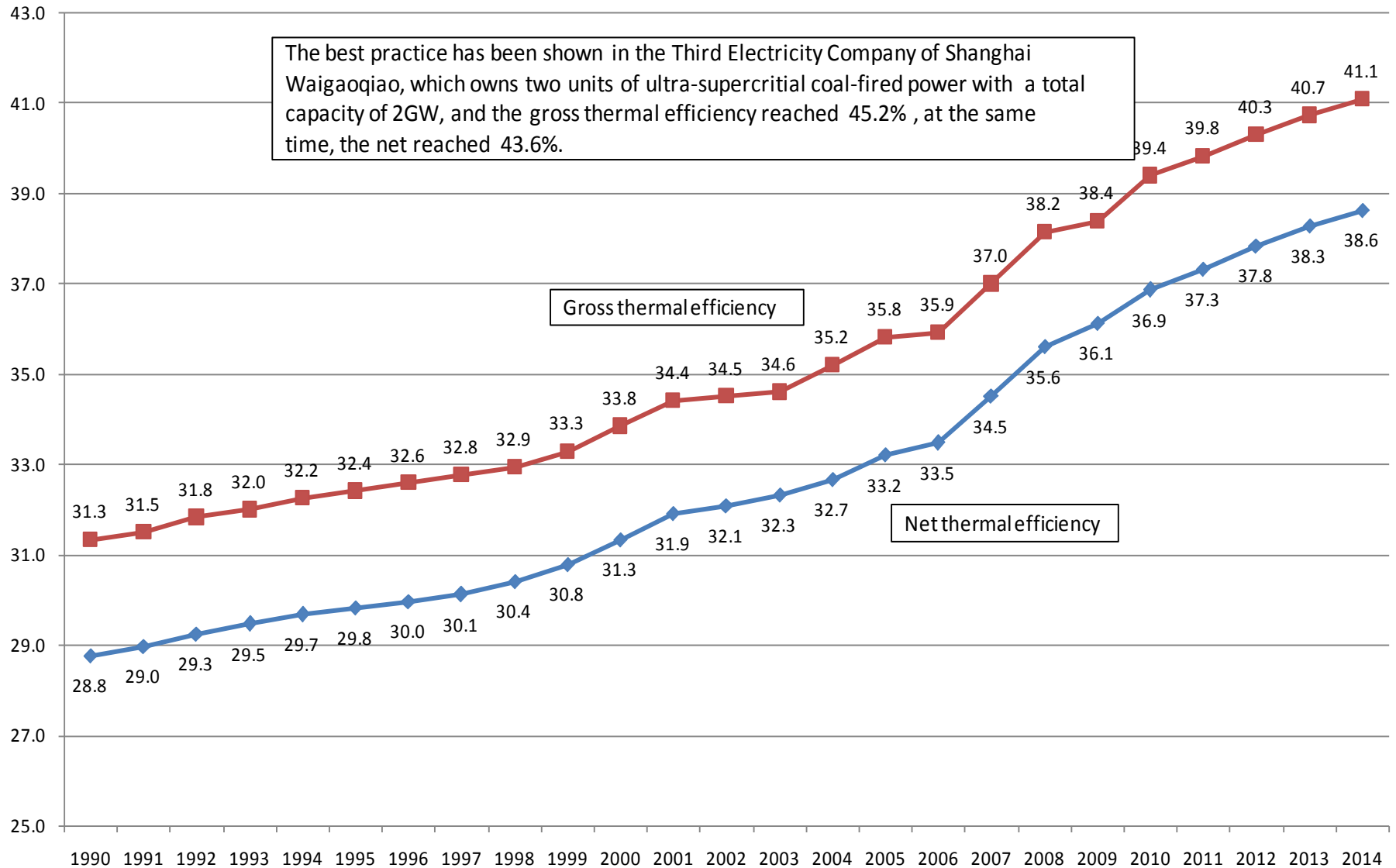
★ **Non-fossil energy share** increased by 3.7 points to 11.2% from 7.5% in 2005.

⇒ As a result, **emissions-CO₂ intensity** decreased by 32.8% from the level of 2005.



● Energy efficiency continued to improved.

The average thermal efficiency (%)

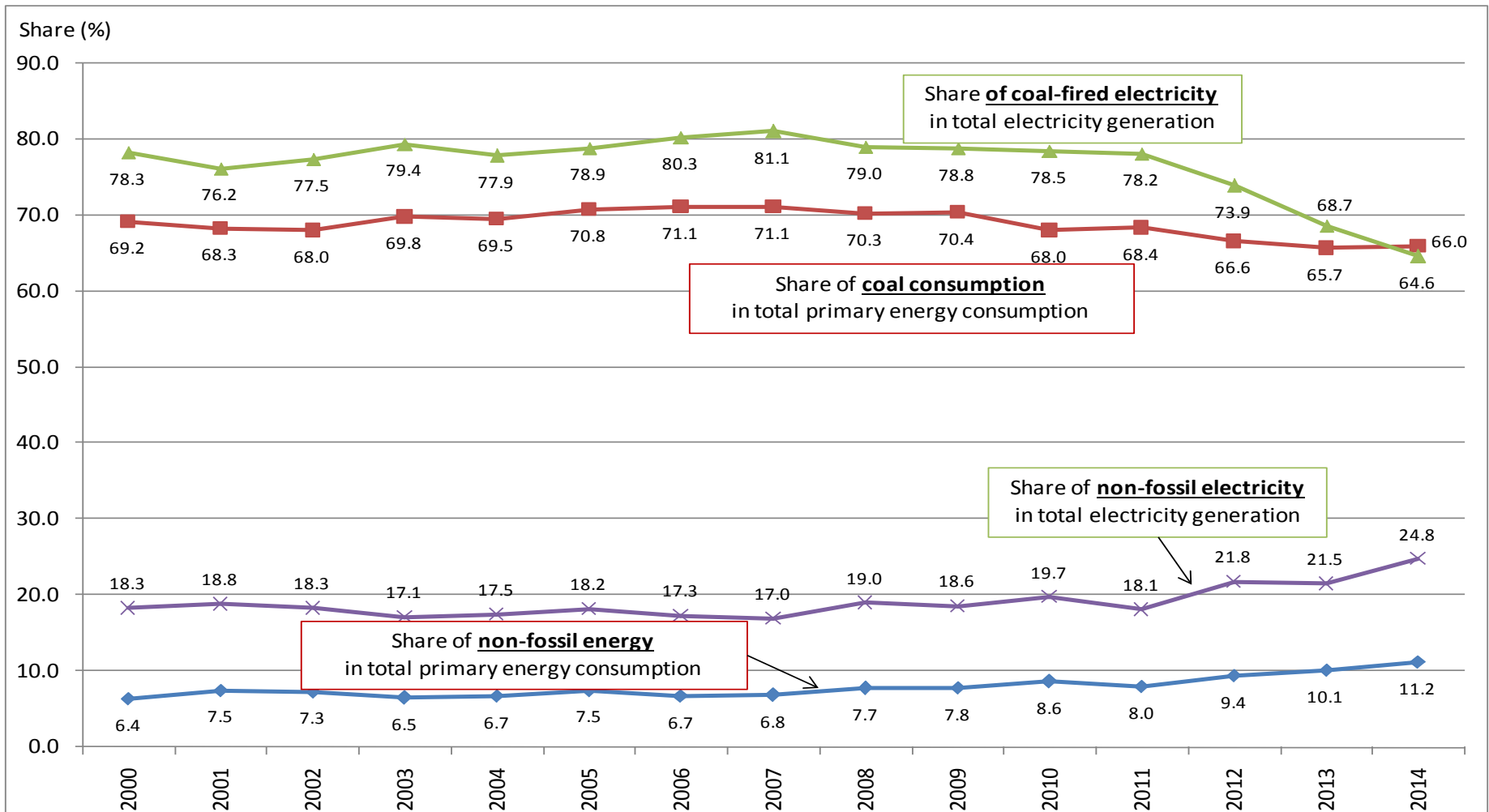


Sources: The National Energy Administration, China; China Electricity Council.

Notes: The gross thermal efficiency in 2014 is estimated by assuming the own use ratio in plant didn't change from 6.01% of 2013.

● Energy mix improved a lot in both primary energy and electricity

★ In primary energy consumption, share of coal decreased to 66%, and non-fossil energy increased to 11.2%. ★ In electricity generation, share of coal-fired electricity decreased to 65%, and non-fossil electricity increased to 25% (of which, **19.2% for hydropower, 2.8% for wind, 2.3% for nuclear, 0.4% for PV**)

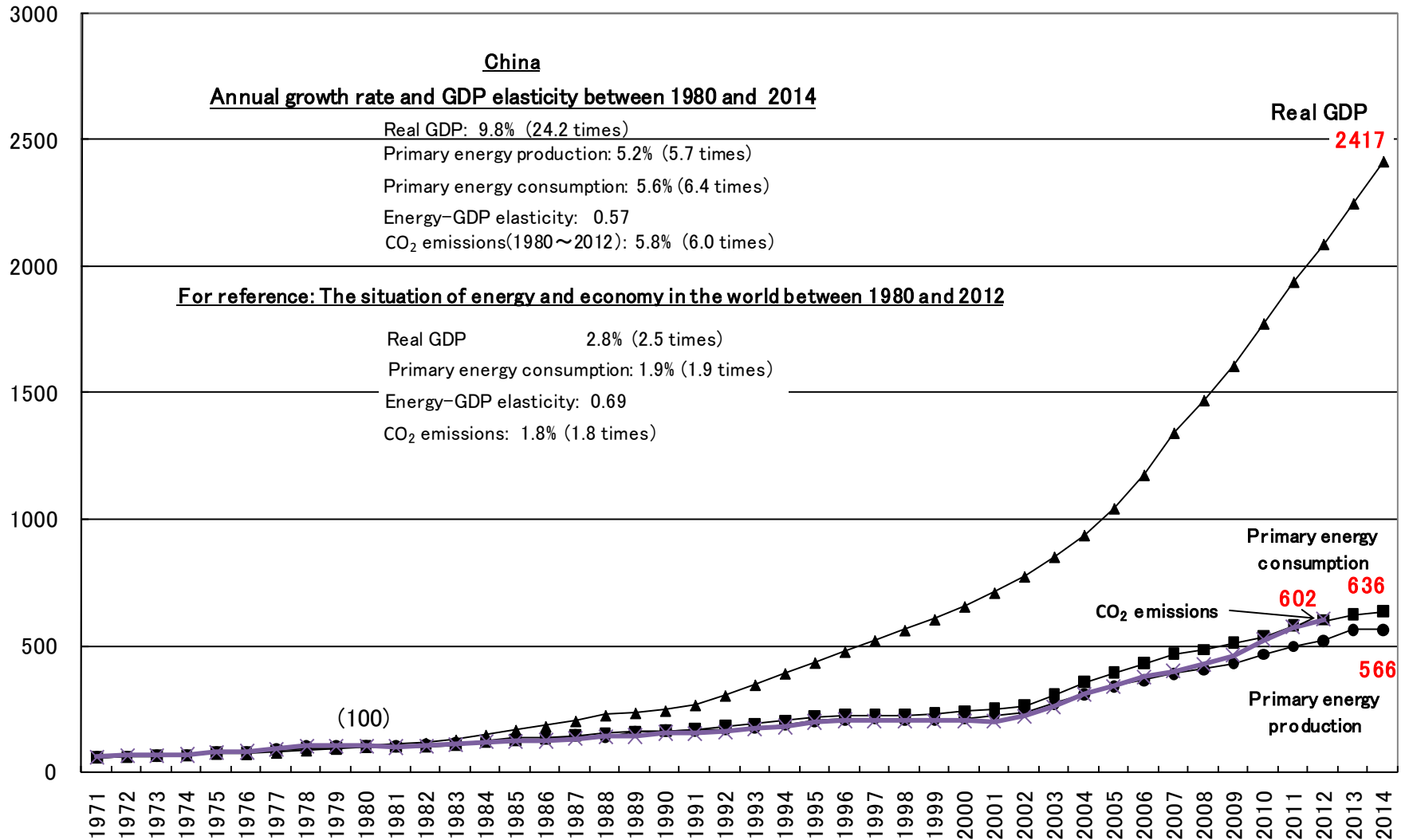


Sources: Compiled by Li Zhidong, based on official statistics issued by National Bureau of Statistics of China and China Electricity Council, except coal related shares in 2014.

● As a result, both energy supply/demand and CO₂ emissions are gradually decoupling from GDP growth.

⇒ **But the 3Es issues are still serious!**

Index (1980=100)

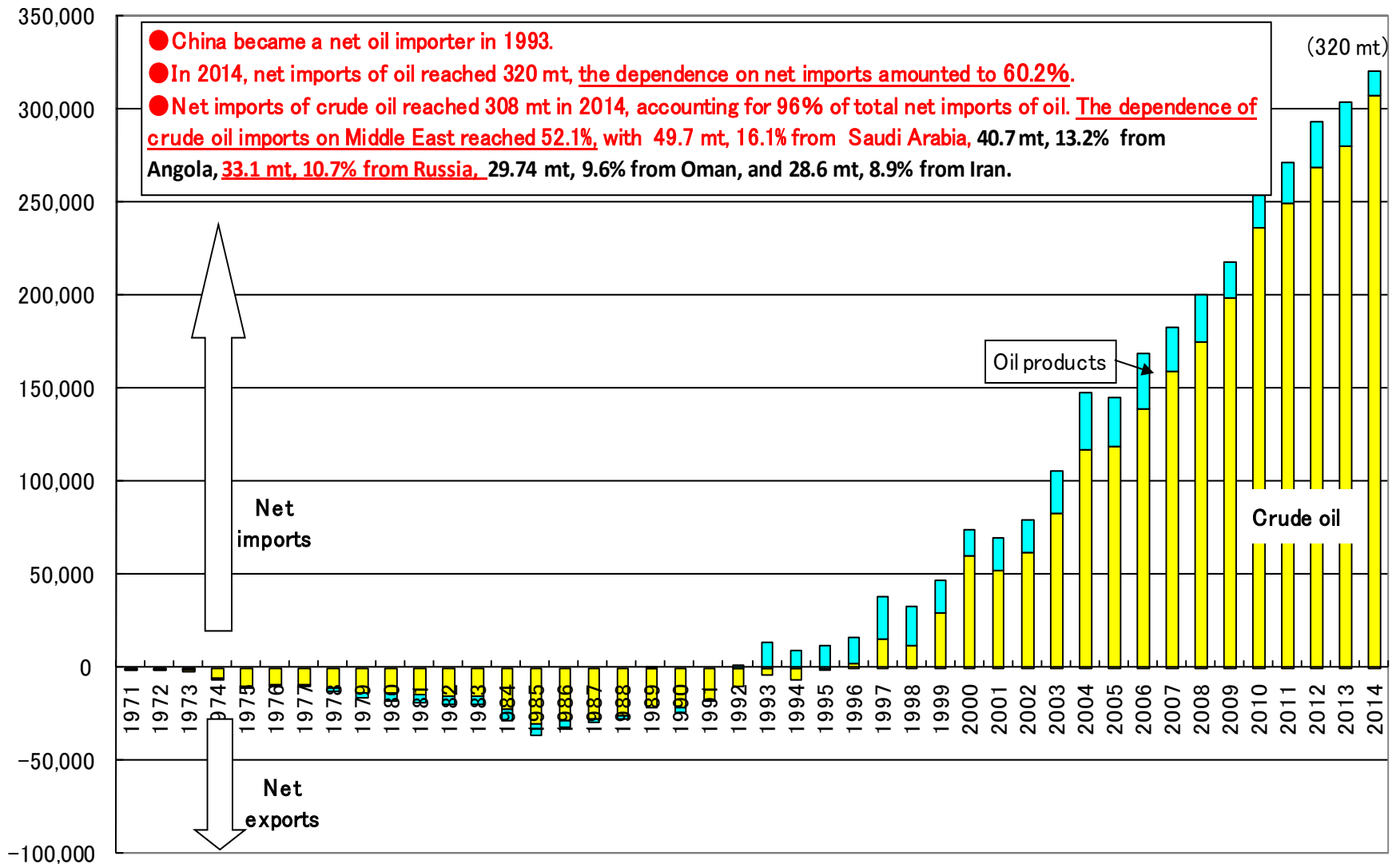


Sources: Compiled by Li Zhidong, based on National Bureau of Statistics of China, China Statistical Yearbook, 2014 and Statistical Bulletin on National Economy and Social Development in 2014, EDMC/IEEJ, Handbook of Energy & Economic Statistics in Japan, 2015.

2. The Progress Status in Tackling 3Es Issues in China

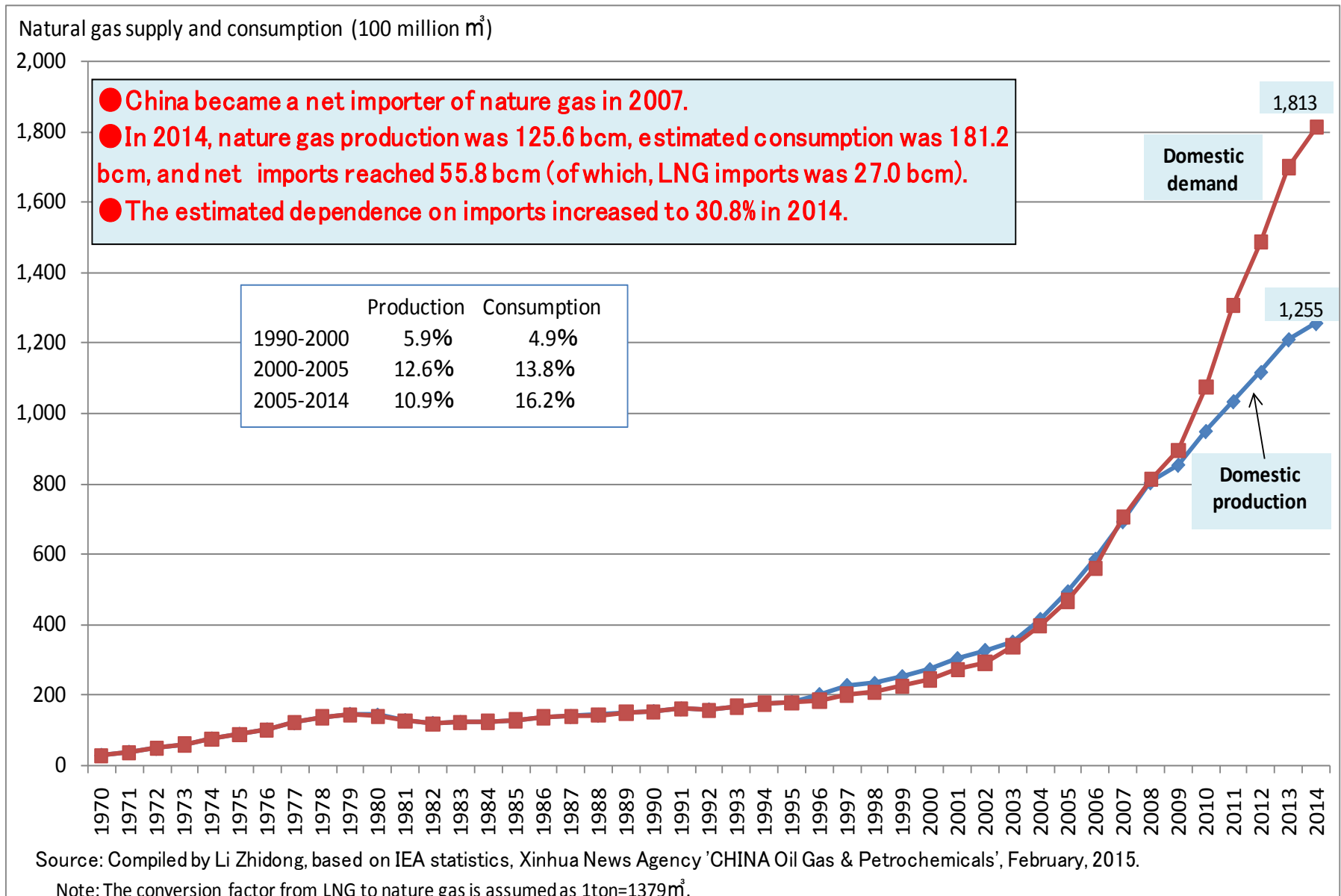
2.2 Serious 3Es Issues Remained (up to 2014) ★ Expansion of fossil energy imports makes China more difficult to ensure **energy security**. ⇒ **Trend of oil security**

Net imports of oil (kt)



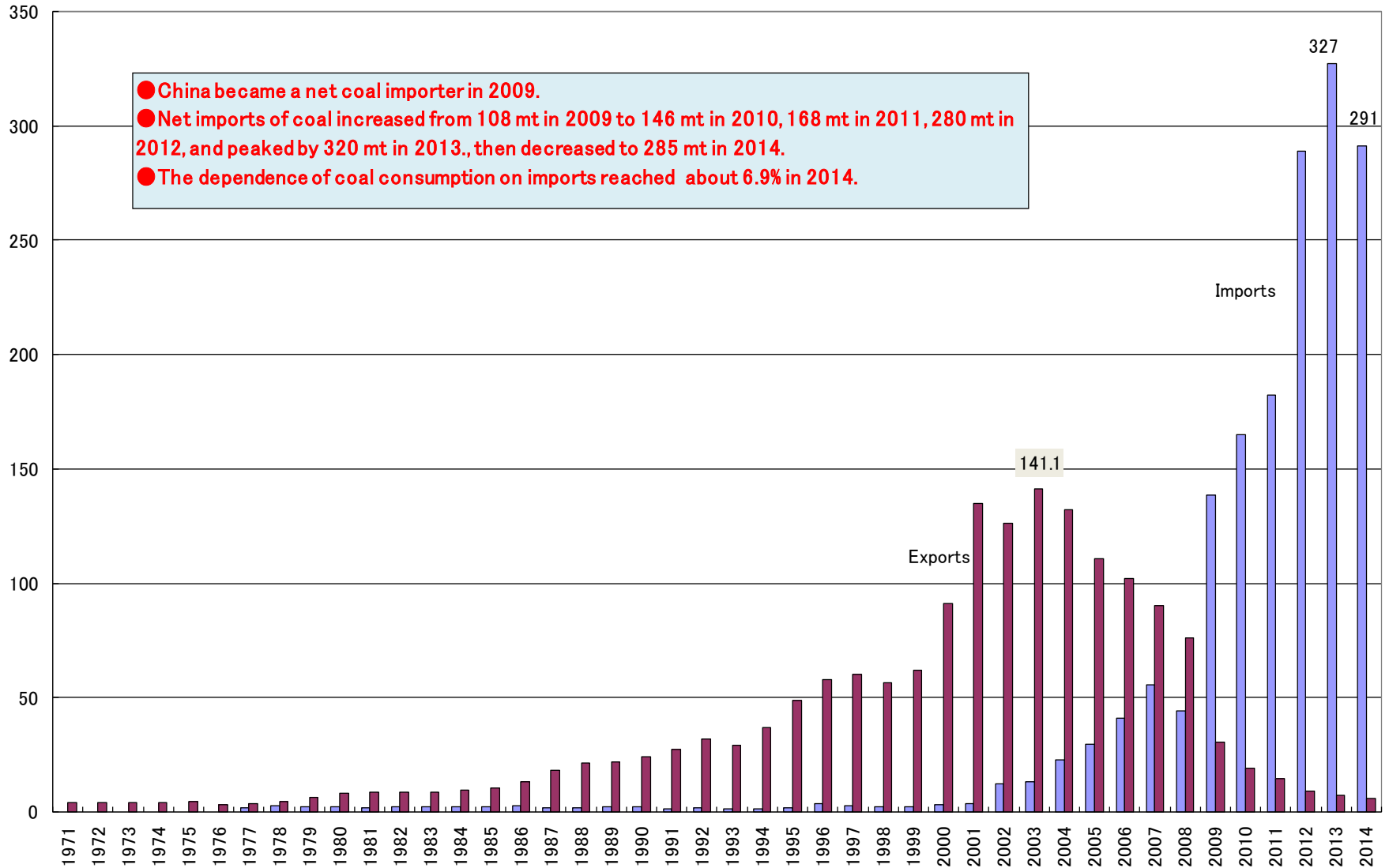
Source: Compiled by Li Zhidong, based on IEA statistics, Xinhua News Agency 'CHINA Oil Gas & Petrochemicals', February, 2015.

2.2 Serious 3Es Issues Remained (up to 2014) ★ Expansion of fossil energy imports makes China more difficult to ensure energy security. ⇒ Trend of nature gas security



2.2 Serious 3Es Issues Remained (up to 2014) ★ Expansion of fossil energy imports makes China more difficult to ensure energy security. ⇒ Trend of coal security

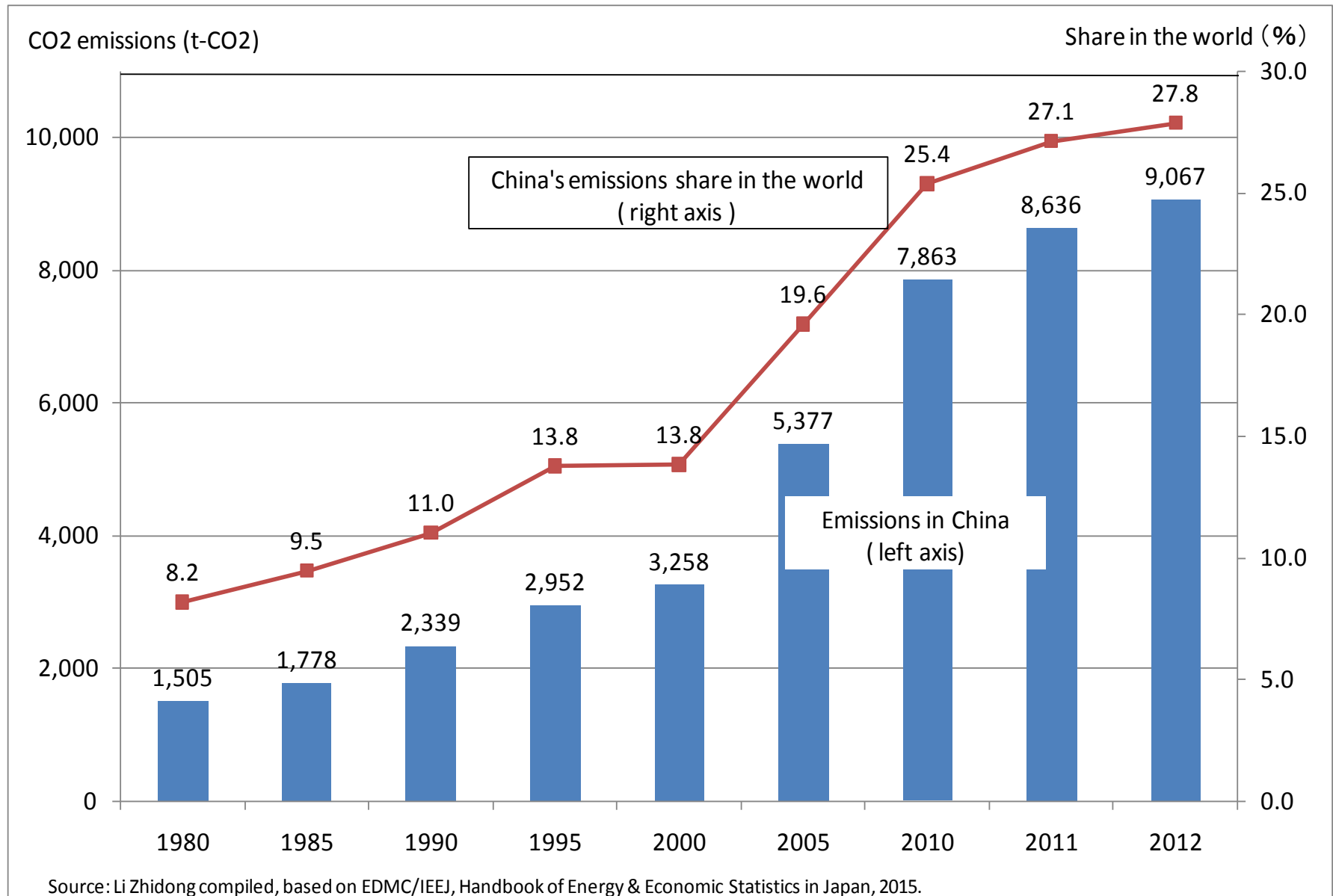
Imports and exports of coal (Mt)



Source: Compiled by Li Zhidong, based on IEA statistics, and statistics of China General Administration of Customs.

2.2 Serious 3Es Issues Remained (up to 2014)

★ CO2 emissions is increasing, and China's contribution to global GHG emissions stands unacceptably high.



2.2 Serious 3Es Issues Remained (up to 2014)

★ Preventing air pollution caused by PM2.5 is still the largest challenging task.

● In China, the daily average environmental limit for PM2.5 is 70 μg (1 millionth of a gram) per 1 m^3 , which is twice as high as in Japan.

● According to the Ministry of Environmental Protection, on January 29, 2013, PM2.5 pollution spread over 1.43 million km^2 , equal to about 4 times the total area of Japan, and the average concentration reached 354 μg , 5 times the environmental limit of China and 10 times that of Japan.

● With a diameter of less than 2.5 μm (1 millionth of a meter), the particles easily enter the lungs and are believed to have a high risk of causing respiration and circulatory diseases. According to the China Meteorological Administration, patients with respiratory diseases have risen by 10 to 40% compared to normal times.

⇒ According to the report issued by the Ministry of Environmental Protection, on April 1, 2015, for the urban regions, about 85 to 90% of PM2.5 pollutants come from automobiles and manufacturing factories, coal combustion, and soot and dust.

_Of which,

automobiles are the largest source of pollution in Beijing, Hangzhou, Guangzhou and Shenzhen.

Coal combustion serves the largest one in Nanjing and Shijiazhuang.

3. Medium- to Long-Term Perspective of Energy Mix in China

3.1 Promoting Energy Revolution and International Cooperation

On June 13, 2014, President Xi held the sixth meeting of Central Leading Group for Economic and Financial Affairs, in which he announced promoting a four-part “energy revolution” and international cooperation.

★ Without “energy revolution”, 3Es issues could be resolved effectively !!!

Energy revolution strategy promoted by Xi Jinping leadership (issued in June, 2014)

- Consumption revolution: Controlling overall energy consumption by implementing exhaustive energy saving measures in all phases of socio-economic development and all consumption areas, firmly holding the strategic priority of energy saving
- Supply revolution: Diversifying energy sources by developing energies other than coal, while strongly promoting the clean and efficient use of coal; At the same time, strengthening the development of transportation, electricity transmission and distribution infrastructure and storage facilities
- Technological revolution: Enhancing the development of green and decarbonization technologies, and reinventing the relevant industries into a new industry that can drive economic growth and elevate the level of the overall industry
- Management system revolution: Developing a competitive market by highlighting the commercial aspects of energy, focusing particularly on building the market-driven pricing mechanism and improving
- Stronger international cooperation: While domestic issues remain the highest priority, strengthening international cooperation in all possible areas related to energy production and consumption, to use international resources efficiently

Sources: Li Zhidong compiled.

3.2 Ambitious, but Achievable National Targets

In 2014, China pledged "to declare war on air pollution" to its people at the National People's Congress in March, and "to achieve early peaking of CO₂ emissions around 2030, and to increase the share of non-fossil fuels in primary energy consumption to around 20% by 2030" to the international community in November.

Medium- to Long-Term National Strategies and Targets in China

Action Plan for Preventing Air Pollution , issued in September 2013	<ul style="list-style-type: none"> • Reducing the concentration of PM₁₀ by 10% from 2012 levels in cities nationwide by 2017 • Reducing the concentration of PM_{2.5} by 25% in Beijing, Tianjin and Hebei (the Jing-Jin-Ji belt), by 20% in the Yangtze delta, and by 15% in the Zhujiang delta 	
Action target for 2020 to the UN , submitted in January 2010	<ul style="list-style-type: none"> • To reduce CO₂-GDP intensity by 40 to 45% from 2005 levels by 2020 • To raise the percentage of non-fossil energy (renewable energy plus nuclear energy) in primary energy consumption to 15% by 2020 from 7.5% in 2005 	
China's National Plan on Climate Change for 2014-2020 , issued in September 2014; Action Plan on Energy Strategies for 2014-2020 , issued in November 2014	Overall target	<ul style="list-style-type: none"> • To reduce CO₂-GDP intensity by 40 to 45% from 2005 levels by 2020
	Targets for energy supply/demand, and energy mix	<ul style="list-style-type: none"> • To keep energy consumption below 4.8 billion tce and coal consumption below 3.8 billion tons by 2020 • To increase domestic energy production to about 4.2 billion tce by 2020, and keep the self-sufficiency ratio around 85%
	Targets by energy sources	<ul style="list-style-type: none"> • By 2020, to raise the percentage of non-fossil energy (renewable energy plus nuclear energy) in primary energy consumption to 15%, the share of nature gas to above 10%, and reduce the share of coal to below
		<ul style="list-style-type: none"> • By 2020, expanding general <u>hydropower</u> capacity to 350 GW; expanding <u>wind</u> power generation capacity to at least 200 GW, and decreasing the electricity sales price to match that of coal-fired thermal (on average 0.41 yuan/kWh nationwide as of October 2014); Expanding <u>solar</u> power generation capacity to at least 100 GW, and decreasing the sales price (currently 0.9-1.0 yuan/kWh) to match that of the electricity tariff (consumer purchase price of electricity from electricity transmission companies)
		<ul style="list-style-type: none"> • By 2020, increasing nuclear power capacity to 58 GW, and the capacity under construction to 30 GW
		<ul style="list-style-type: none"> • By 2020, reducing the distributed use of <u>coal</u> in residential and industrial sectors, and using it centrally in the power generation sector, where the ratio of coal is increased to above 60% from 50% in 2013. At the same time, all new coal-fired thermal power plants must have a net thermal efficiency of at least 41% and fulfill an emission standard equivalent to that of gas thermal plants, while existing plants must improve the net thermal efficiency to at least 39.6% by 2020 from 38.3% in 2013.
"Made in China 2025" plan issued on May 19, 2015	<ul style="list-style-type: none"> • To reduce Energy-GDP intensity in manufacturing sector by 18% by 2020 and 34% by 2025 from 2015 levels • To reduce CO₂-GDP intensity in manufacturing sector by 22% by 2020 and 40% by 2025 from 2015 levels 	
The U.S.-China Joint Announcement on Climate Change, issued on November 11, 2014	<ul style="list-style-type: none"> • To achieve the peaking of CO₂ emissions around 2030 and to make best efforts to peak early • To increase the share of non-fossil fuels in primary energy consumption to around 20% by 2030 • To continue to work to increase ambition over time 	

Sources: Li Zhidong compiled.

3.3 About Two Typical Chinese Side Projections

China Electricity Council's 「The Status and Outlook on China's Power Generation Industry」 (March 2015) suggests that non-fossil electricity will account for 29% by 2020, 37% by 2030 and 50% by 2050 in terms of power generation, or 39%, 49% and 62% in terms of capacity.

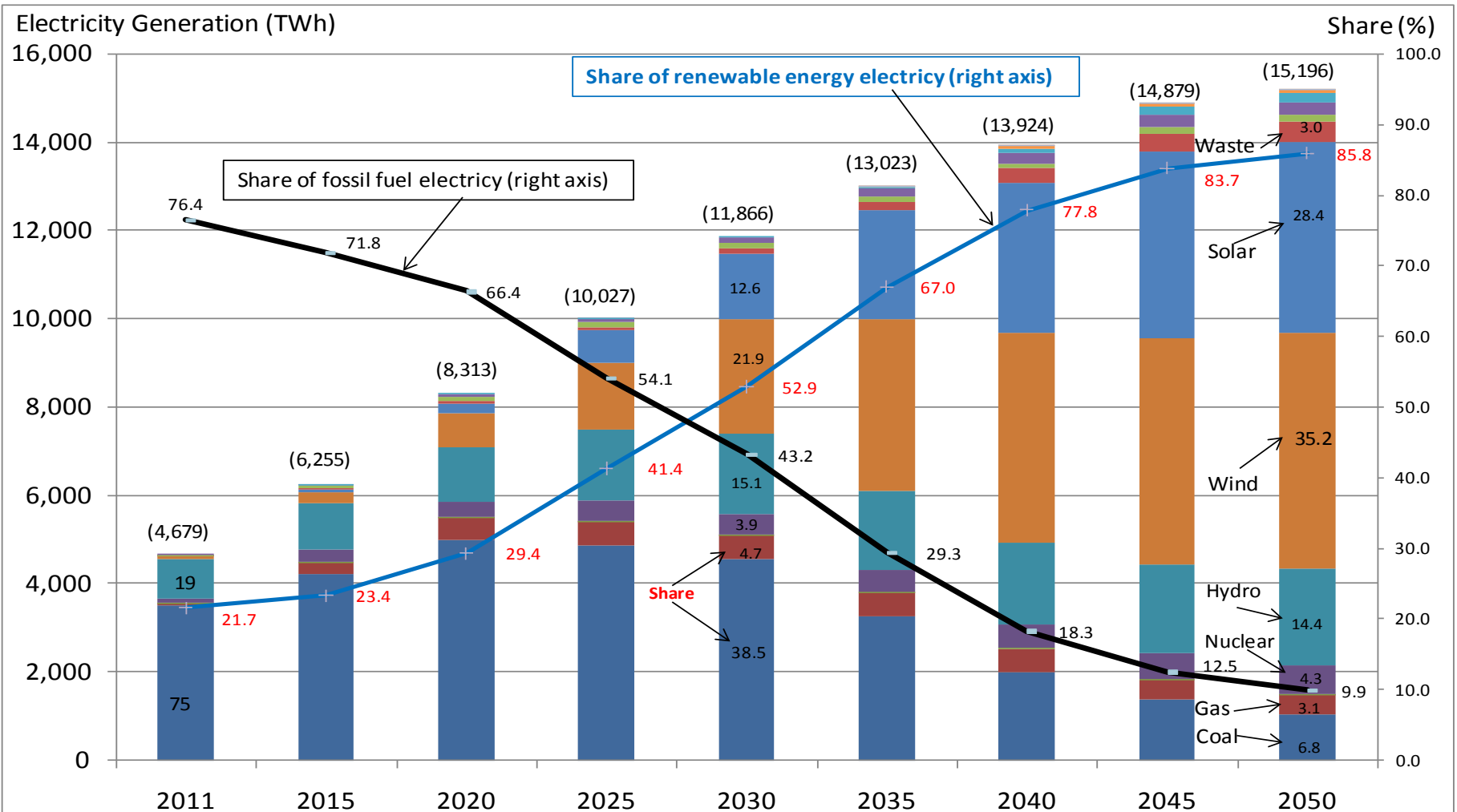
China Electricity Council's 「The Status and Outlook on China's Power Generation Industry」 (March 2015)

	Capacity; Electricity				Share (%)			
	2014	2020	2030	2050	2014	2020	2030	2050
Power generation capacity (100GW)	13.60	19.6	30.2	39.8	100.0	100.0	100.0	100.0
Non-fossil energy power	4.53	7.6	14.8	24.7	33.3	39.0	49.0	62.0
Renewable power	4.33	7.1	12.8	20.7	31.8	36.0	42.4	51.9
Hydropower	3.02	4.2	6.3	8.0	22.2	21.4	20.7	20.1
of which: General hydro	2.80	3.6	4.8	5.0	20.6	18.4	15.7	12.6
Pumped hydro	0.22	0.6	1.5	3.0	1.6	3.1	5.0	7.5
Wind, solar and others	1.31	2.9	6.5	12.7	9.6	14.6	21.7	31.8
of which: Wind	0.96				7.0			
Solar power	0.27				1.9			
Waste and others	0.09				0.7			
Nuclear power	0.20	0.6	2.0	4.0	1.5	3.0	6.6	10.1
Fossil fuel thermal power	9.07	12.0	15.4	15.1	66.7	61.0	51.0	38.0
Coal-fired	8.25	11.0	13.4	12.0	60.7	55.9	44.4	30.2
Natural gas-fired	0.56	1.0	2.0	3.0	4.1	5.1	6.6	7.5
of which: General		0.6	0.8	1.0		3.1	2.6	2.5
Distributed		0.4	1.2	2.0		2.0	4.0	5.0
Oil-fired	0.26	0.0	0.0	0.1	1.9	0.0	0.0	0.3
Electricity generation (TWh)	5.55	7.7	10.3	12.5	100.0	100.0	100.0	100.0
Non-fossil energy power	1.42	2.2	3.8	6.3	25.6	29.0	37.0	50.0
Fossil fuel thermal power	4.13	5.5	6.5	6.3	74.4	71.0	63.0	50.0

Sources: Compiled by Li Zhidong, based on <http://www.cec.org.cn/yaowenkuaidi/2015-03-10/134972.html> 「The Status and Outlook on China's Power Generation Industry」 issued by China Electricity Council, and other related sources.

3.3 About Two Typical Chinese Side Projections

ERI/China's China 2050 High Renewable Energy Penetration Scenario and Roadmap Study, conducted by more than ten organizations of China, issued April 2015, estimates that non-fossil electricity could account for up to 90% by 2050.



Source: Compiled by Li Zhidong, based on Energy Research Institute, China, "China 2050 High Renewable Energy Penetration Scenario and Roadmap Study: Executive Summary", April 2015.

3.3 About Two Typical Chinese Side Projections

★Point in common: The long-term direction is towards a massive expansion of non-fossil electricity, and then decarbonization of electricity sources.

★Points of difference: ● **The share of non-fossil electricity in ERI scenario is much higher** than that of CEC. ● On the other hand, **the role of nuclear for decarbonization in CEC scenario is much higher** than that of ERI. For instance, nuclear power capacity is expected to reach to 400 GW in CEC scenario, but only 100 GW in ERI scenario.

ERI/China's China 2050 High Renewable Energy Penetration Scenario and Roadmap Study (April 2015)

	Installed capacity (GW)								
	2011	2015	2020	2025	2030	2035	2040	2045	2050
Total power generation capacity	1,084.1	1,413.8	2,093.5	2,876.3	3,930.4	5,169.6	6,157.3	6,889.0	7,090.6
Fossil fuel thermal power	782.9	917.9	1,194.9	1,206.9	1,183.3	1,195.3	1,146.2	1,121.1	1,117.3
Coal-fired power	749.1	822.5	1,083.4	1,079.9	1,052.2	1,037.6	972.3	928.5	896.7
Gas-fired power	32.6	94.3	110.4	125.9	130.1	156.8	173.1	191.8	219.8
Oil-fired power	1.2	1.2	1.1	1.1	1.0	0.9	0.8	0.8	0.8
Non-fossil energy power	301.1	495.9	898.6	1,669.4	2,747.1	3,974.3	5,011.1	5,767.9	5,973.2
Nuclear power	12.6	42.8	50.5	64.0	66.0	69.0	78.0	85.0	100.0
Renewable energy power	288.6	453.1	848.1	1,605.4	2,681.1	3,905.3	4,933.1	5,682.9	5,873.2
Hydropower	230.7	267.1	313.1	402.4	440.8	460.8	471.9	512.0	554.1
Wind power	48.4	114.9	317.1	632.2	1,103.9	1,663.3	2,092.2	2,287.6	2,396.6
Solar power	3.8	42.0	157.0	500.2	1,048.9	1,657.1	2,206.3	2,678.2	2,696.2
Municipal waste power	2.0	5.0	8.4	12.6	18.9	33.5	54.2	72.5	80.9
Biogas power	0.4	16.2	39.3	39.3	39.3	39.3	33.7	34.7	39.3
Straw and stalk power	3.4	6.7	11.3	15.6	24.4	38.3	50.1	58.1	61.0
Wood pellets power		1.1	2.0	3.2	5.0	8.2	12.3	27.5	32.9
Geothermal power						3.8	11.3	11.3	11.3
Ocean energy power						1.0	1.0	1.0	1.0
Storage power capacity	29.6	38.5	50.0	65.0	81.3	93.5	154.7	229.7	300.7
Pumped hydro storage	29.6	38.5	50.0	65.0	81.3	93.5	107.5	123.7	142.2
Chemical energy storage							47.2	106.1	158.5

Source: Energy Research Institute, National Development and Reform Commission, China, China 2050 High Renewable Energy Penetration Scenario and Roadmap Study, Executive Report; April 2015.

4. Tentative Conclusions

(1) A national consensus on urgent need for actions to address the challenges of 3Es has been formed, and the consensus will be kept and efforts will be strengthened further.

(2) A package of comprehensive energy and environment strategies has been adopted and will be strengthened in the future. These efforts will take effect progressively and assist China in realizing the targets for 2020.

(3) Regarding energy mix in the future, the direction is towards a massive expansion of non-fossil energy. For instance, ERI scenario suggests that China should aim to raise the share of renewable energy in primary energy consumption to 62%, and the share in electricity generation to 86% in 2050.

(4) Regarding 3Es issues in the future, ERI scenario suggests that ● the emissions of main pollutants such as SO₂ and NO_x will be kept with 1980 levels by 2050; ● CO₂ emissions will peak by 2025 and decrease to 3 billion tons by 2050; ● the high renewable energy penetration power system can be built at a small or non-incremental cost. The average cost per kWh of electricity will rise from RMB0.672/kWh in 2030 to RMB0.685/kWh, while in the reference scenario it will stay flat around RMB0.67/kWh between 2030-2050.

(5) In order to realize the goal of building a clean, low-carbon, secure and reliable, and economically efficient energy system, “energy revolution” should be promoted powerfully. The highlight in the near-term is whether the carbon tax will indeed be introduced recently, and whether the total volume control of CO₂ emissions will be included in the next Five-Year plan which starts in 2016.