Barriers and Opportunities for Nuclear Power in China

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Outline

1. Nuclear Power Status in China
2. Debate about the Nuclear Power Development Strategy of China: Can China Solve the Energy Supply Issue Without Nuclear Power?
3. Key Issues for the Near Term Development of Nuclear Power in China
4. Key Issues for the Mid/Long Term Development of Nuclear Power in China

1. Nuclear Power Status in China

- Before Fukushima Crisis
  - Development Policy: from “Moderate” to “Active”
  - As of March 2011
    - 14 units in operation with an installed capacity ~12GW (~1% of the total electricity production capacity)
    - 27 units under construction (~30GW)
    - Most of them are Generation II+, except for 4 AP1000 units and 2 EPR units; All of them are PWR (Pressurized Water Reactor)
    - According to the development plan issued in 2006, the expected installed capacity is ~40GW and another 18GW under construction by 2020

1. Nuclear Power Status in China

- In response to Fukushima
  - Licensing process of all the new reactors are suspended
  - Extensive nuclear safety inspection over the nuclear power plants (operating and under construction) and nuclear facilities (experimental reactors, fuel facilities…)
    - 9 months, led by NNSA(National Nuclear Safety Authority), NEA(National Energy Administration) and China Earthquake Administration
    - The final report <Integrated Safety Inspection Report of the Civil Nuclear Facilities> opened to the public
  - A series of safety enhancement requirements were issued in succession in the past three years

1. Nuclear Power Status in China

- In Nov. 2012, the State Council made the decision to resume the nuclear power development with steady steps
  - New units started the construction in the end of 2012
    - Rongcheng NPP(Nov. 21st) — HTGR demonstration plant
    - Unit 4 of Fuqing NPP(Dec. 17th) — CNP1000, twin unit
    - Unit 4 of Yangjiang NPP(Dec. 17th) — CPR1000, twin unit
    - Unit 3 of Tianwan NPP(Nov. 27th) — VVER1000
  - New units started the construction in 2013
    - Unit 5 of Yangjiang NPP (Sept.18th) — CPR1000, scheduled units
    - Unit 4 of Tianwan NPP(Sept. 27th) — VVER1000
    - Unit 6 of Yangjiang NPP(Nov. 23rd) — CPR1000, scheduled units
  - 3 units started the commercial operation in 2013
    - Unit 1 of Ningde NPP(Apr. 18th) — CNP1000
    - Unit 1 of Hongyanhe NPP (Jun. 6th) — CPR1000
    - Unit 2 of Hongyanhe NPP (Nov. 23rd) — CPR1000

2. Can China Develop Without Nuclear?

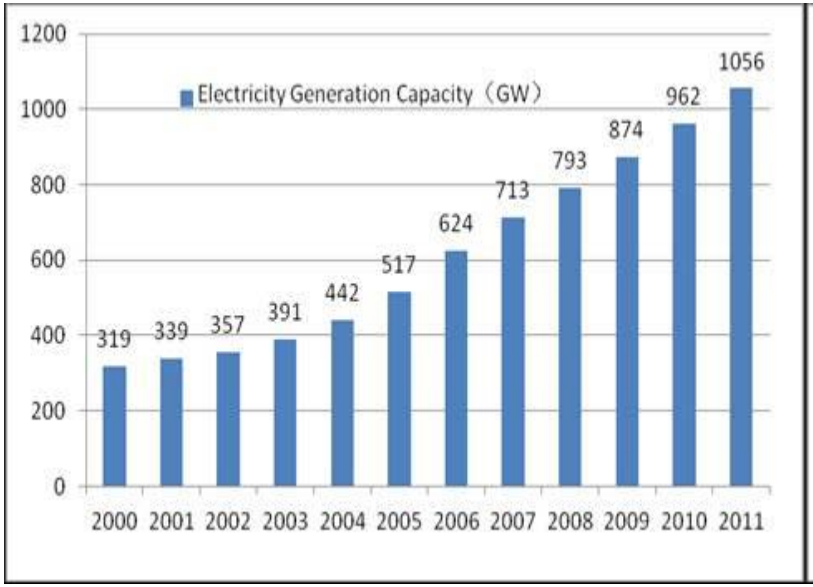
- Nuclear development recovery is ongoing, however the detailed roadmap is still not clear
  - In macro scale, there are strong debates about the possibility that whether can China solve the energy supply issue without nuclear power
  - In micro scale, there are also strong debates about the selection on the reactor technologies: which can be sufficiently advanced and mature in light of post-Fukushima requirements
  - Important policies such as Nuclear Safety Development Plan and Nuclear Power Development Plan are subject to revise recently

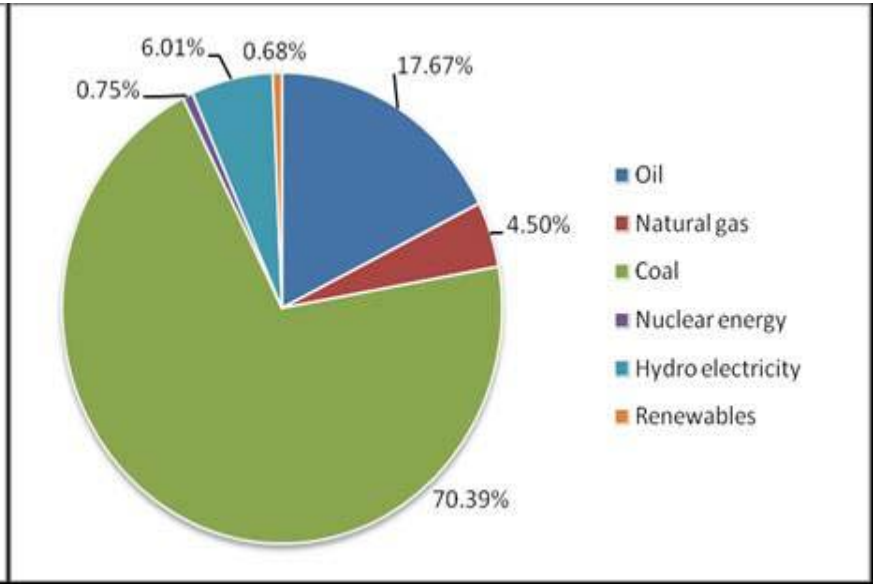
2. Can China Develop Without Nuclear?

- A consensus amongst the government, industry and scientist is almost reached: China can hardly ensure the safe and accurate economic development without nuclear
  - Reason #1: Strong demand from economic development
  - Reason #2: Environmental resources limitation and environmental protection pressure
  - Reason #3: Energy supply security

2. Can China Develop Without Nuclear?

- Reason #1: Strong demand from economic development





- The structure shall be optimized towards low-carbon
- Nuclear power has its unique risk feature
- Can we meet the energy demand by the combination of Solar + Wind + Water + Biomass + Natural Gas + other clear energy but without nuclear?

2. Can China Develop Without Nuclear?

- Reason #1: Strong demand from economic development (con'd)

Year	Electricity shortage（TWh）	Percent over the total demand	Equivalent installed capacities by nuclear（GW）	Equivalent nuclear units of 1000MW
2015	312	5.8%	~40	40
2020	540	8.0%	~70	70
2025	858	10.2%	~110	110
2030	995	13.0%	~140	140

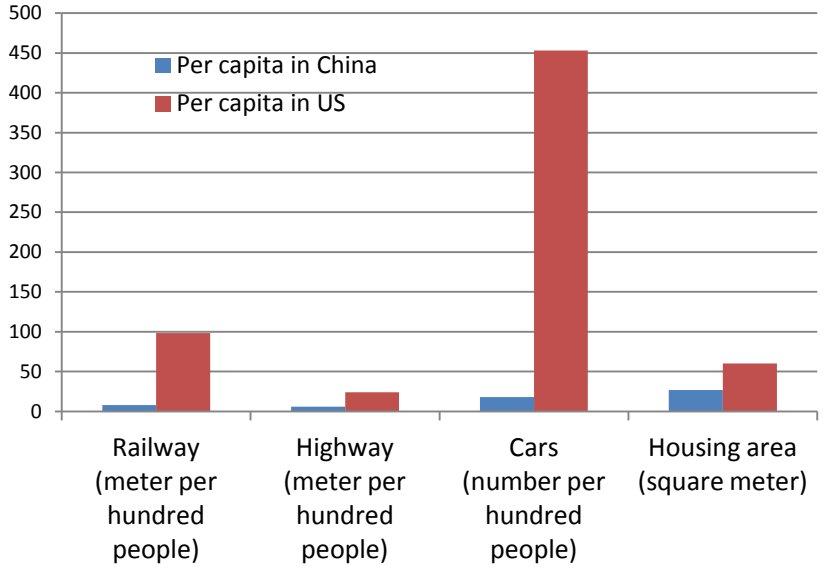
Assumption:

1. Water energy will be fully developed by 2030 with a total installed capacity of 400GW
2. Wind and Solar energy are fully encouraged to develop and will reach the total installed capacities of 300GW and 200GW by 2030, which are 10 times and 200 times of 2010's capacity
3. Coal energy contribution will be limited by the scientific production requirement of raw coal per year

2. Can China Develop Without Nuclear?

- Reason #1: Strong demand from economic development (con'd)
  - The huge GDP requirement determines the huge amount of energy supply. So, can we ask for less GDP? Unfortunately, we cannot.
  - China is still a developing country!

	Electricity consumption per capita (KWh)
Developed Country	8000
China (2011)	~3000
China (2030)	~6000



2. Can China Develop Without Nuclear?

- Reason #1: Strong demand from economic development (con'd)
  - Nuclear development does not reject the development of the other clear energies
  - All the possible clean energy resources, like nuclear, solar, natural gas and so on, shall work together, and work even harder, in order to meet the energy supply demand to support the economic development

2. Can China Develop Without Nuclear?

- Reason #2:Environment resources limitation and environment protection pressure
  - Fog and haze, water pollution, and other environment problems shrouded a large parts of China.
  - The importance of environment protection, low-carbon living are deeply recognized by most of people.

2. Can China Develop Without Nuclear?

- Reason #2:Environment resources limitation and environment protection pressure
  - China is facing the extremely difficult situation in CO2 elimination
  - Short of environment resources has been the rigid constraint of the economic and social development

2. Can China Develop Without Nuclear?

- Reason #3: Energy supply security
  - China's degree of dependence on international oil market reached ~60% in 2012; Oil transportation risks were increasing significantly during the past years
  - Nuclear fuel is regarded internationally as the quasi-domestic resource due to its advantages in easy storage and lower contribution to the electricity production cost
    - 90 days oil reservation ~~38 billion $ ~~ 5.4 years of nuclear fuel supply to meet 150 nuclear units (1000MW per unit)

2. Can China Develop Without Nuclear?

- Nuclear is the essential part of the low-carbon energy structure of China
- Nuclear power does not reject the development of the other clear energy
- In order to meet the tremendous energy supply demand, all the clear energy, including nuclear, water, natural gas, solar and so on, shall work together and much harder

3. Key Issues for the Near Term Development of Nuclear Power in China

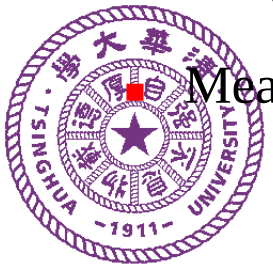
① Interpretation and implementation of the latest nuclear safety requirements

② How to promote the inland nuclear power plants

③ How to maintain the steady development of the whole nuclear industry during the reactor technology transition period

(1) Interpretation and implementation of the latest nuclear safety requirements

- Safety is the lifeline of nuclear industry
- The recent regulatory documents declares the position that new reactors must be subject to the latest nuclear safety requirements
  - Equivalent safety level with Generation III technology
  - Clear request by means of increased safety indicators (core damage frequency CDF<1E-5 per reactor year and large release frequency LRF<1E-6 per reactor); Practically elimination of large release from the design by the 13th five year period
  - Measures in response to the Fukushima experience feedback



(1) Interpretation and implementation of the latest nuclear safety requirements

- The safety requirements which have already set up by Chinese current nuclear regulations, combined with the targeted requests which are issued recently, can be the latest advanced requirements in the world
  - Chinese nuclear regulations are established based on IAEA regulation framework and used to be updated accordingly
  - The focus is how to implement the requirements by detailed technologies

(2) Inland Nuclear Power Plant

- It is hard to say that there are essential differences between inland nuclear power plant and coastal plant
  - In practice, more than a half of nuclear power plants are located in inland region, as seen in US, France, Russia
  - No international safety requirements has been setup to pose special treatment on inland plants
- However, the key point is actually the water pollution prevention and social effect in case of extremely rare accident scenario

(2) Inland Nuclear Power Plant

- Fukushima crisis revealed possibility of a large amount of radioactive waste water produced by the nuclear accidents. Current nuclear power plants don't have the measures to deal with this problem.
- It is unacceptable that radioactive waste water from the damaged plant continue to pollute the underground water and the river.
- Special engineering measures are under development . It is believed to be necessary before the inland nuclear power plant project can be put into the licensing process.

(3) Measures to maintain the steady development during the transition period

- We are facing the difficult decision of reactor technology selection
  - Generation II reactors are excluded by the latest safety requirements
  - Constructions of the first projects of AP1000 reactor are heavily delayed. We will not be able to see the first AP1000 plant even after 2016. Many experts concluded that Generation III reactor technology is not mature enough for bulk of construction
  - Nuclear equipment manufacturers are running into the situation of over-capacity productivity and supply train being broken

4. Key Issues for the mid/long term development of nuclear power in China

① Balanced development among the whole nuclear industrial train

② Public acceptance

③ Abilities of basic scientific research and technical innovation

(1) Balanced development of the whole nuclear industrial train

- It is suggested that China shall emphasize the top level design of the nuclear development strategy, because nuclear projects have longer period, higher requirements, larger investment than the other industries. Nuclear development needs the steady policy.
- Besides, the spent fuel reprocessing roadmap shall be carefully considered and scheduled. It is a worldwide dilemma.

(2) Public Acceptance of nuclear facilities

- Chinese public is awakening. They are playing more and more important roles in the decision matters. There are a number of cases in which the sensitive facilities have to be suspended or even withdrawn due to the public intervention
  - Nuclear fuel manufactory in Jiangmen
  - Inland nuclear power plant
- Special research and efforts shall be placed to this area to guide the public intervention

(3) Abilities of basic scientific research and technology innovation

- China is still short of basic scientific and innovative research, especially in the field of special material, high quality and precise manufacture, physical/thermal hydraulic experimental research to support the innovative design and so on
- The shortages are the constraints for China to own the independent intellectual property rights of advanced reactor technology
- It is foreseen that China will have quite a number of reactors. The sufficient abilities of basic research will be the necessary base to support the successful operation and management of these reactors.

Thanks for your attention!