1. Nuclear Energy Worldwide
2. History of Nuclear Energy in China
3. Goals of Nuclear Energy in China
4. Outlook of Development
Part I

Nuclear Energy Worldwide
Four Phases of Nuclear Energy

1. **Start**
   - Fast development
   - Obnisk NPP
   - Three Mile Accident
   - 1979

2. **Fast development**
   - Chernobyl Accident
   - 1986

3. **Stagnation**
   - 2011
   - Fukushima Accident

4. **Recovery**

Timeline:
- 1954
- 1960s
- 1970s
- 1980s
- 1990s
- 2000s
- 2010s
- 2020s
Technology Evolution

Gen I
Early Prototype
- Shippingport
- Dresden, Fermi I
- Magnox

Gen II
Commercial Power Reactors
- PWR, BWR
- CANDU
- VVER, RBMK
- AGR (Advanced Gas-cooled Reactor)

Example:

Gen III
Advanced LWR
- ABWR
- EPR
- AP1000
- ESBWR, APWR

Example:

Gen IV
Innovative Design
- Fast Reactor
- VHTR
- SCWR
- MSR

Example:

Three Steps:

Fast Reactor

- 2040: Joint Development
- 2060: Accumulating Pu; FBR deployment; FBR breeding Pu; Closed fuel cycle

Fusion

PWR

Technology Evolution

Security

Economy

Safety
Part II

History of Nuclear Energy in China
Premier Zhou Enlai decided to develop nuclear power

Daya Bay Unit 1 was introduced (900MWe)

Qinshan Phase II was built by our own (600MWe)

Tianwan Unit 2 was introduced from Russia (1060MWe)

Self-designed Hualong One Construction Started (1000MWe)

Mar 1985

Aug 1987

Jun 1996

Oct 1999

May 2015

Self-designed Qinshan Phase I (300MWe)

Export of Chassima NPP to Iran (300MWe)

HWR imported from Canada at Qinshan Phase III (700MWe)

AP1000 imported from US at Sanmen NPP (1050MWe)

Karachi Unit 2 (Hualong One) Started construction At Pakistan (1100MWe)

At present, in mainland China 36 units are in commercial operation and another 20 units under construction.
Guidelines

- Insist the principle of “Focus on own-technology Supplemented by Foreign Cooperation”
- “Import, digest, absorb, and innovate”
- To achieve the autonomization and localization at nuclear power

Three phases of nuclear power in China

- Phase I: starting (1986~1995)
- Phase II: Moderate development (1995—2005)
- Phase III: Large-scale development (2005 till now)

After 30 years’ endeavor

Achievements

- Established a complete system of nuclear fuel cycle, for better utilization of nuclear resource;
- Established a complete system of nuclear power industry, and cultivated a group of enterprise in key equipment production;
- Built a number of high-quality NPP, which have achieved excellent operation performance;
- Cultivated a large number of talents in R&D, construction, operation, and management in nuclear power;
Established a complete system of nuclear fuel cycle

- Natural Uranium
- Hydrometallurgy
- Enrichment
- Fuel production
- Recycle (MOX)
- Processing
- Operation
- Waste management
- Complete nuclear fuel cycle
Established a complete system of nuclear power industry

The production capability of heavy casting and forging of the top three companies

<table>
<thead>
<tr>
<th></th>
<th>水压机</th>
<th>钢水能力 （吨）</th>
<th>双真钢锭 （吨）</th>
<th>最大铸件 （吨）</th>
<th>最大锻件 （吨）</th>
<th>年提供核岛、常规岛大型铸锻件能力</th>
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<tr>
<td>一重</td>
<td>1.5 万吨</td>
<td>700</td>
<td>600</td>
<td>500</td>
<td>400</td>
<td>目前具备生产百万千瓦核岛、常规岛5套铸锻件能力，已承接压力容器锻件175件，已承接蒸汽发生器锻件139件</td>
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<tr>
<td>二重</td>
<td>1.6 万吨</td>
<td>700</td>
<td>600</td>
<td>500</td>
<td>400</td>
<td>形成核岛、常规岛5套铸锻件能力</td>
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<tr>
<td>上重</td>
<td>1.65 万吨液压机</td>
<td>720</td>
<td>600</td>
<td>500</td>
<td>400</td>
<td>目前具备核岛、常规岛2.5套铸锻件能力</td>
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一重：China First Heavy Industries (known as CFHI)
二重：China National Erzhong Group Co.
上重：Shanghai Electric Heavy Industry Group
cultivated a group of companies in key equipment production

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<tr>
<th>哈电、东电、上电三大核电设备制造基地</th>
<th>核岛主设备：蒸汽发生器、压力容器、稳压器、主泵</th>
<th>常规岛：汽轮机、发电机</th>
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<td>重一重、二重、上重三大大型铸锻件及压力容器制造基地</td>
<td>核岛：压力容器、蒸汽发生器、稳压器、主泵及堆内构件铸锻件，压力容器（一重）</td>
<td>常规岛：汽轮机、发电机转子锻件、汽缸铸件</td>
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<tr>
<td>沈鼓、大连深蓝、重庆水泵、上海阿波罗</td>
<td>核岛主泵（沈鼓）</td>
<td>常规岛：主给水泵（沈鼓、上海电修）、凝结水泵、BOP 系统海水循环泵</td>
</tr>
<tr>
<td>上电、东电</td>
<td>堆内构件、控制棒驱动机构、装卸料系统</td>
<td></td>
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<tr>
<td>大重、上重、太重</td>
<td>环吊</td>
<td></td>
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<tr>
<td>中核苏阀、大连大高、江苏神通、江苏东吴等</td>
<td>核级阀门</td>
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<tr>
<td>广利核</td>
<td>全数字化控制系统</td>
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Built a number of high-quality NPP units under operation and units under construction.
Reserved NPP sites in China

Sites passed preliminary review: ~43 sites with 200GWe.
Part III

Goals of Nuclear Energy in China
Goals of Nuclear Energy in China

Safety is the basis.

Efficiency brings competitiveness.

Diversity meets the new requirement.
Safety is the basis.

To guarantee that the risk is as low as possible.

The nuclear industry in China takes the highest safety criteria in the world, have plentiful high-quality sites, use the mature technologies; and guarantee that the risk is as low as possible by means of enhancing diverse supervision, strengthening safety culture, promote technology improvement, complete the emergency system.

Seismic distribution in 40 years
Efficiency brings competitiveness.

- Design optimization
- Model standardization
- Construction scale-development
- Manufacturing localization
- Operation professionalization

**Domestic Goal of Cost**
- Lower than coal power

**International Goal of Cost**
- Lower than peer companies
Diversity meets the new requirement.

Technology diversity:

- Large reactor — safe, economical, and clean basic supply of power;
- Small reactor — modularization, multiple usage, and meet the new trend of nuclear power;
- Miniature reactor — small size, low power, new field of nuclear application;
Multiple Usage:

- Community Heat Supply —— Low-carbon
- Industrial Steam Supply —— Economical
- Sea Water Desalination —— to meet the probable clean water crisis

Diversity meets the new requirement.
Part IV

Outlook of Development
Nuclear power is the strategic choice of China.

In 2015, China made the commitment in the Paris climate change conference:
We will approach the peak CO2 emission by 2030 and try our best to make it earlier; in 2030 the CO2 emission per GDP will decrease by 60-65% compared with 2005, and that the fraction of non-fossil energy will take 20% of total primary energy.

Without nuclear power, these goals will not be met!
4 basic questions of energy supply in China

1. Balance of supply and demand in the whole society
2. Environment problem caused by coal-based energy system
3. Energy transportation through carrying coal from west and north to east and south, electricity from west to east
4. Energy security due to reliance on foreign countries

China Commitment to the World

1. Non-fossil energy reach 15% in 2020
2. CO2 emission per GDP decrease by 40%-45% compared to 2005

Nuclear power is the choice of environment protection.

1. Green-house emission factor of nuclear power is 13.71g-CO₂/kWh, compared with 1300g-CO₂/kWh of coal power in China
2. The advantage of nuclear power in environment protection is significant.
Nuclear power will develop steadily in China for at least 15-20 years. Provided that the nuclear policy remain stable, 4-6 units will be added to the current fleet, bringing China to the No1. in capacity in the whole
Hualong One is independent technology, and takes the highest safety criteria. In Dec 2014, it passed the General Reactor Safety Review by IAEA, and the demonstration reactor started civil work. The project is carried on smoothly, breaking the spell that Gen III reactor projects are always behind the schedule.

The astana world expo. 2017.6

Xi Jinping: Hualong One is Completely autonomous technology

Demonstration Project of Hualong One
“Linglong One” Small Modular Reactor (ACP100)

It is based on small-size propulsion reactor and mature PWR, and completely autonomous technology. In Apr 2016, it passed the general reactor safety review of IAEA, the first of SMRs in the world to achieve such a goal. The SMR has got the project permission for Changjiang site in Hainan, and will start the civil work in 2018.
“Yanlong” Pool-type Low-temperature Heat Supply Reactor (DHR400)

It is based on mature technology, and is completely autonomous design. It is featured in no-melting, no-emission, easy to decommission, no need for off-site emergency. The preliminary design has completed, and the first reactor will be built in Xudapu, Liaoning.
MNSR——new trend of nuclear energy

Miniature Reactor is featured in small-size, easy to handle, low power, passive safety. The usage is broadened after its enrichment reduction. China is one of the few countries to own such technology. In Sep 2017, the Ghana MNSR was successfully transferred to low-enrichment core, fulfilled the ‘Ghana Model’ proposed by President Xi Jinping.
Gen IV Technology

SFR
- Increasing the utilization of U by 60%
- Passive safety
- Reduce the nuclear waste

VHTR
- Short construction period
- Passive safety
- High efficiency
- Simple system
Fusion Energy

- Infinite resource
- Zero-emission and no waste
- Permanent supply of energy
- China is among the top in research

Southwestern Institute of Physics, SWIP

Ignition Device in US

China circulator No.2
Other Nuclear Energy Technologies

Marine nuclear power platform. A combination of nuclear power and marine platform for energy supply to islands and marine applications;

Pool-shell Nuclear Heating

Developed by Tsinghua University

Nuclear Power Cute

It is based on lead-cooled reactor, and contained in a container for electricity supply to the marine platforms, remote areas.
Nuclear power is the main choice of China in energy structure optimization;
Nuclear power is an important route in ecological civilization;
Nuclear power development is affected by Fukushima accident;
Generally, the direction of future development is ‘safer, cleaner’;
CNNC will play the main role and make a great contribution to the prosperity of nuclear energy of China.