CHINA'S NUCLEAR POWER DEVELOPMENT AND HUALONG ONE (HPR1000) PWR TECHNOLOGY

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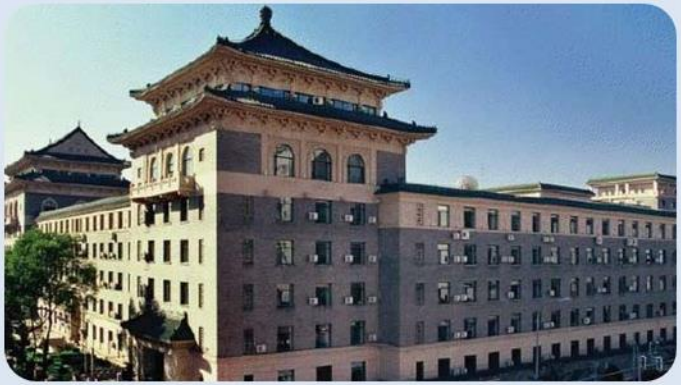
- China's Nuclear Power Development
- Hualong One Technology
  - Overview
  - Design Characteristics
  - Engineering Progress
- Lessons Learned

中核集团 CNNC



中国核工业集团公司 China National Nuclear Corporation

- Founded in 1955
- Complete system of nuclear industry
- Over 100 subsidiaries and 100,000 employees
- R & D, construction, and operation in nuclear power, nuclear fuel cycle, nuclear technology application, etc.

中国核能电力股份有限公司 China National Nuclear Power Co., Ltd.

- Qingshan Nuclear Power
- Jiangsu Nuclear Power
- Sanmen Nuclear Power
- Fujian Fuqing Nuclear Power
- Hunan Taohuajiang Nuclear Power
- Hainan Nuclear Power
- Liaoning Nuclear Power
- Sanming Nuclear Power
- Zhangzhou Energy
- .....

中国核电工程有限公司 China Nuclear Power Engineering Co., Ltd.

NPIC 中国核动力研究设计院 NUCLEAR POWER INSTITUTE OF CHINA

CHINA'S NUCLEAR POWER DEVELOPMENT

中国核工业集团公司
China National Nuclear Corporation

CNNC
China National Nuclear Corporation

1994

2007

中广核 CGN

国家核电 SNPTC

CGN
China General Nuclear Power Corporation

SNPTC
State Nuclear Power Technology Corporation

CHINA'S NUCLEAR POWER DEVELOPMENT

中国核工业集团公司
China National Nuclear Corporation

CNNC

China National Nuclear Corporation

中广核 CGN

CGN

China General Nuclear Power Corporation

国家电力投资集团公司
STATE POWER INVESTMENT CORPORATION

SPIC

State Power Investment Corporation

Newly established through the merger of China Power Investment Corporation and State Nuclear Power Technology Corporation. Approved by the State Council in May, 2015.

Roadmap of PWR Domestically-development & Oversea-introduction

1980s 1990s 2010s

Construction of the 1st NPP (300MW PWR)

Construction of 650 MWe NPP CNP600

Construction of CNP1000

R&D of CP1000

ACP1000/ACPR1000+
Hualong One
ACP1400

Introduction of Daya Bay NPP

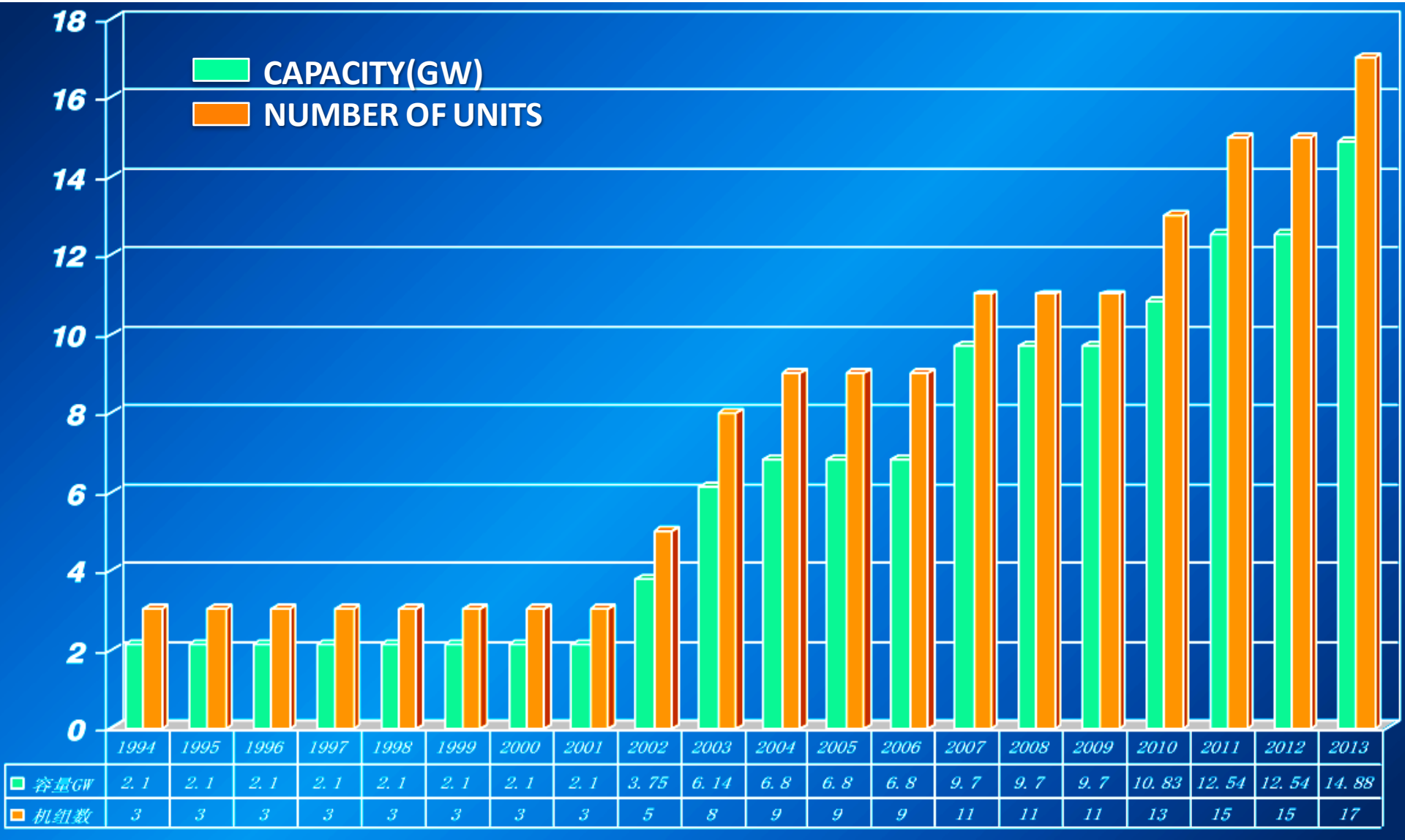
Introduction of LingAo NPP

Introduction of VVER

Introduction of EPR

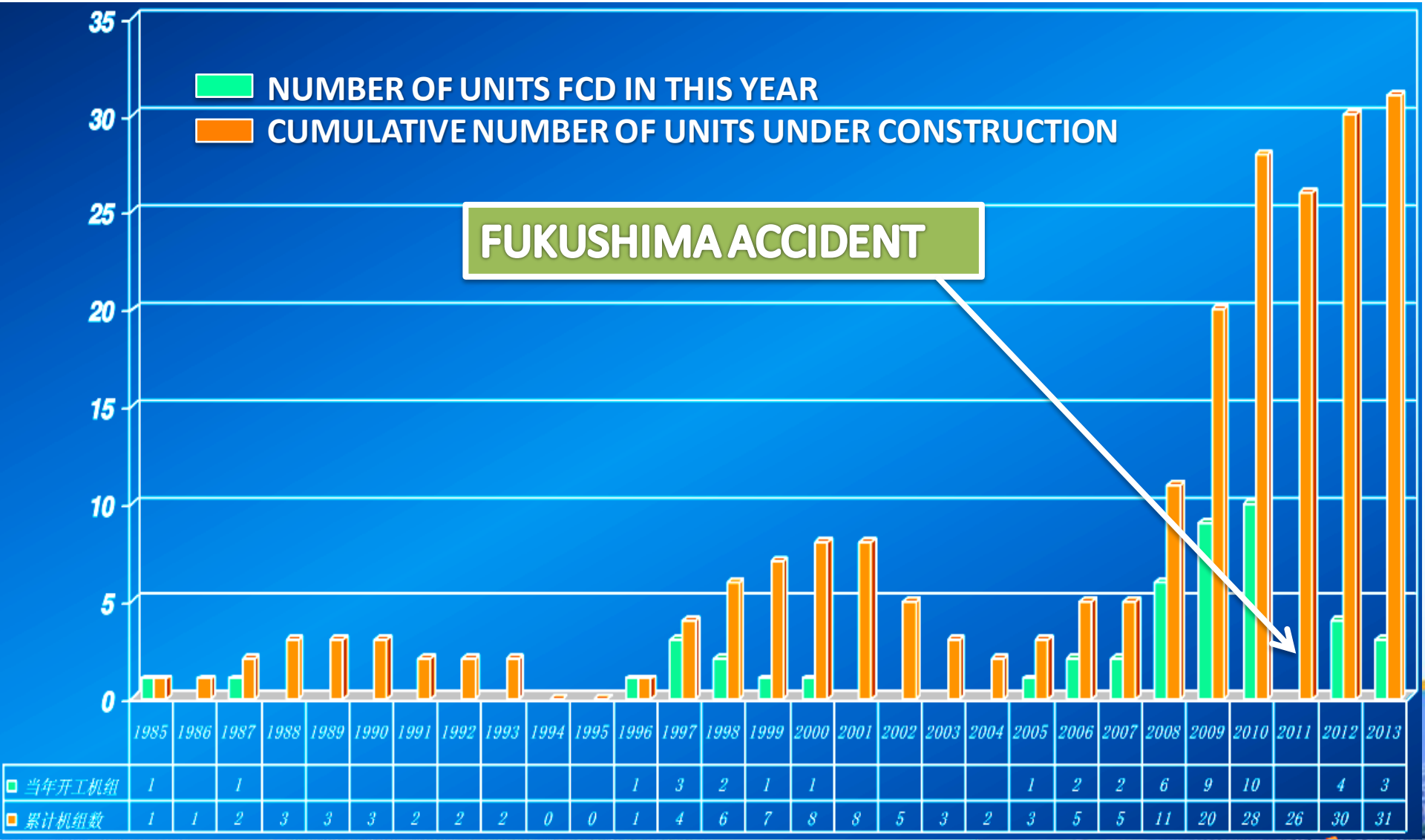
Introduction of AP1000

ANNUAL GROWTH OF OPERATIONAL UNITS

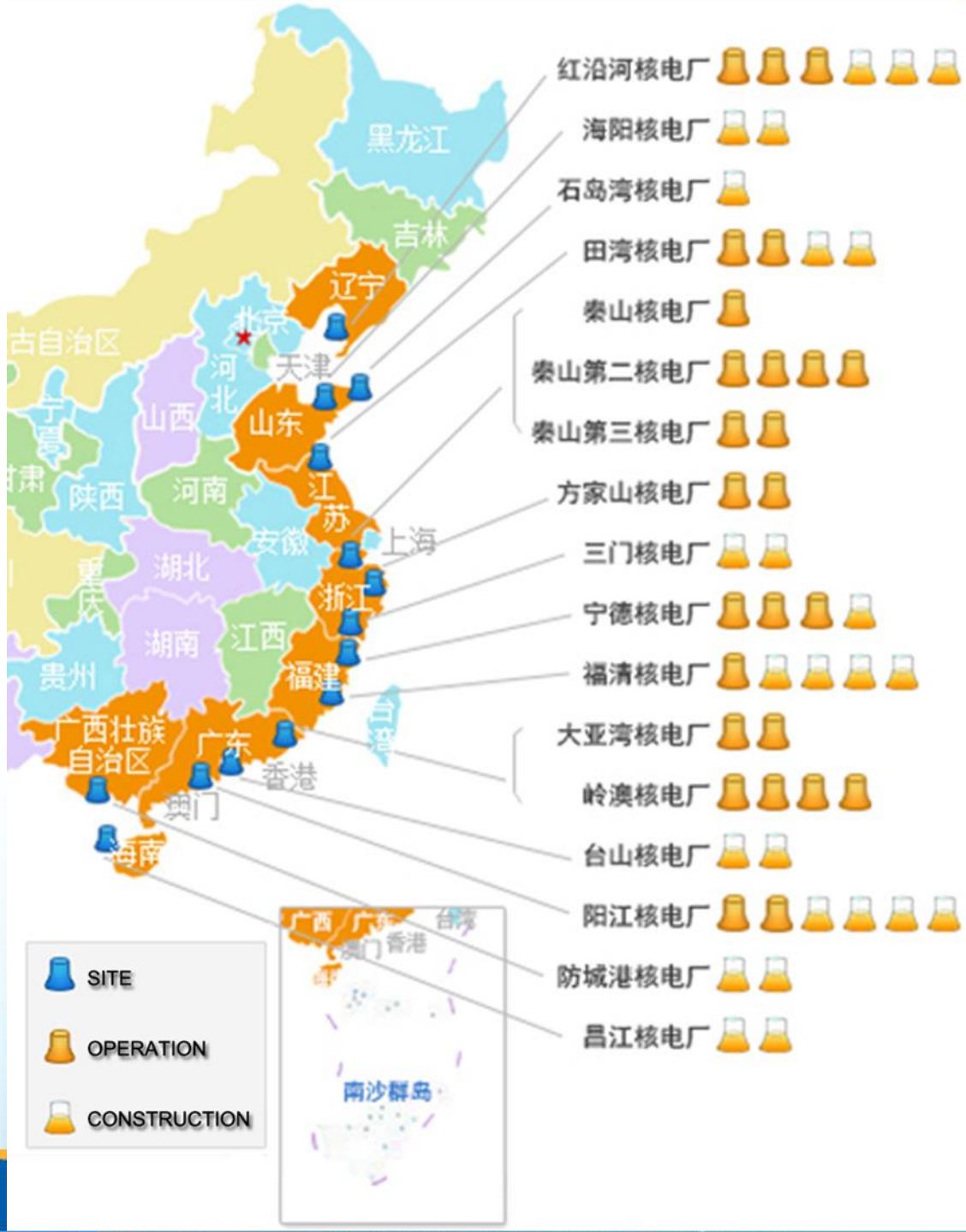


	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
容量GW	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	3.75	6.14	6.8	6.8	6.8	9.7	9.7	9.7	10.83	12.54	12.54	14.88
机组数	3	3	3	3	3	3	3	3	5	8	9	9	9	11	11	11	13	15	15	17

ANNUAL GROWTH OF UNITS UNDER CONSTRUCTION



	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
当年开工机组	1		1									1	3	2	1	1					1	2	2	6	9	10		4	3
累计机组数	1	1	2	3	3	3	2	2	2	0	0	1	4	6	7	8	8	5	3	2	3	5	5	11	20	28	26	30	31



Name of Nuclear Power Plants	Capacity (Gross, MWe)
Qinshan Phase I	1*310
Qinshan Phase II	2*650
Qinshan Phase II Expansion	2*660
Qinshan Phase III	2*728
Tianwan NPP Units 1&2	2*1060
Daya Bay NPP	2*900
Ling Ao Phase I	2*990
Ling Ao Phase II	2*1080
Fuqing NPP Unit 1	1*1000
Fangjiashan NPP	2*1080
Hongyanhe NPP Units1&2&3	3*1080
Ningde NPP Units 1&2&3	3*1080
Yangjiang NPP Units 1&2	2*1080
Fuqing NPP Units 2&3&4	3*1080
Fuqing NPP Units 5	1*1150
Changjiang NPP Units 1&2	2* 650
Tianwan NPP Units 3&4	2*1060
Sanmen NPP Units 1&2	2*1250
Haiyang NPP Units 1&2	2*1250
Ningde NPP Unit 4	1*1080
Hongyanhe NPP Units 4&5&6	3*1080
Yangjiang NPP Units 3&4&5&6	4*1080
Fangchenggang NPP Units 1&2	2*1080
Taishan NPP Units 1&2	2*1750
Shidaowan NPP Unit 1	1*200

CHINA'S NUCLEAR POWER DEVELOPMENT PLAN

- Now (until August)

In Operation – 26 Units, ~ 24 GWe
Under Construction – 25 Units, ~ 28 GWe

- Plan

By 2020, China's nuclear power installed capacity will reach 58 GWe, while the capacity under construction will reach 30 GWe or more.

- That means,

New Construction (FCD) of 4-6 Units per year

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HUALONG ONE TECHNOLOGY
1. OVERVIEW

March 2011
- CP1000 PSAR Review by NNSA
- ACP1000 - Technology Improvement after Fukushima Accident

March 2012
- ACP1000 General Design finished, Reviewed by NNSA

April - June 2013
- ACP1000 Basic Design finished
- CNNC and CGNPC Hualong One technology

2014 - 2015
- Three round of Review Conference for PSAR by NNSA
- Review Conference by National Committee of Experts before FCD

HUALONG ONE TECHNOLOGY
1. OVERVIEW



- Dec 12th ,2013, CNNC and IAEA signed the frame contract of Generic Reactor Safety Review (GRSR) of Hualong One (HL-1) Reactor
- May 2014, CNNC submitted《HL-1 Reactor Safety and Environmental Evaluation Report》（Approximately 5,000 pages）
- 13 Experienced experts from 7 countries formed the committee of review under the requirement of IAEA
- The review committee held two rounds of review workshop with delegation of CNNC
- Dec 2014, IAEA issued the review report of HL-1 GRSR. The evaluation conclusion is positive

HUALONG ONE TECHNOLOGY
1. OVERVIEW

3rd Generation PWR
Satisfying latest nuclear safety codes and standards with advanced technology

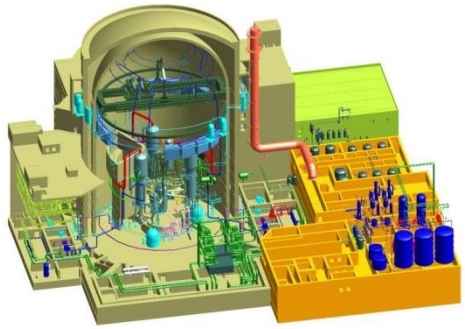
3 Design Features
- 177-fuel-assembly core
- Single unit layout
- Double shell containment

3 Active + Passive Systems
- Residual heat removal from secondary side
- Containment heat removal
- Cavity injection and cooling

3 Enhanced Protection Capabilities against
- Seismic
- Commercial aircraft crash
- Plant emergency

General Parameters

Reactor core thermal output	3050 MWt
Nominal power	⩾1150 MWe
Design life	60 years
Fuel assembly number	177
Refueling cycle	18 months
Average Availability	⩾ 90%
Nuclear island layout	Single-unit
Containment	Double-shell



General Parameters (cont.)

Safe shutdown earthquake (SSE)	0.3g
Load Following Capability	Yes
Operator nonintervention period	30 mins
Plant autonomy	72 hours
Occupational exposure dose	<1 m·Sv/reactor year
safety systems concept	Active+Passive
CDF	$<10^{-6}$
LRF	$<10^{-7}$
Deployment site	Fuqing, Fujian

Fundamental Safety Functions Realization

Fundamental Safety Functions

2. Removal of decay Heat

- Safety Injection System
- Auxiliary Feedwater System
- Atmospheric Steam Dump System
- Passive Residual Heat Removal System of Secondary Side
- Feed & Bleed
- Reactor Cavity Injection and Cooling System
- Temporary water makeup for the primary and secondary loop

1. Control of Reactivity

- Control rod
- Reactor Protection System
- Chemical and Volume control system
- Emergency Boron Injection System

3. Confinement of radioactive materials

- Double-shell containment
- Containment Isolation System
- Containment Spray System
- Passive Containment Heat Removal System
- Containment Hydrogen Removal System
- Containment Filtration and Exhaust System

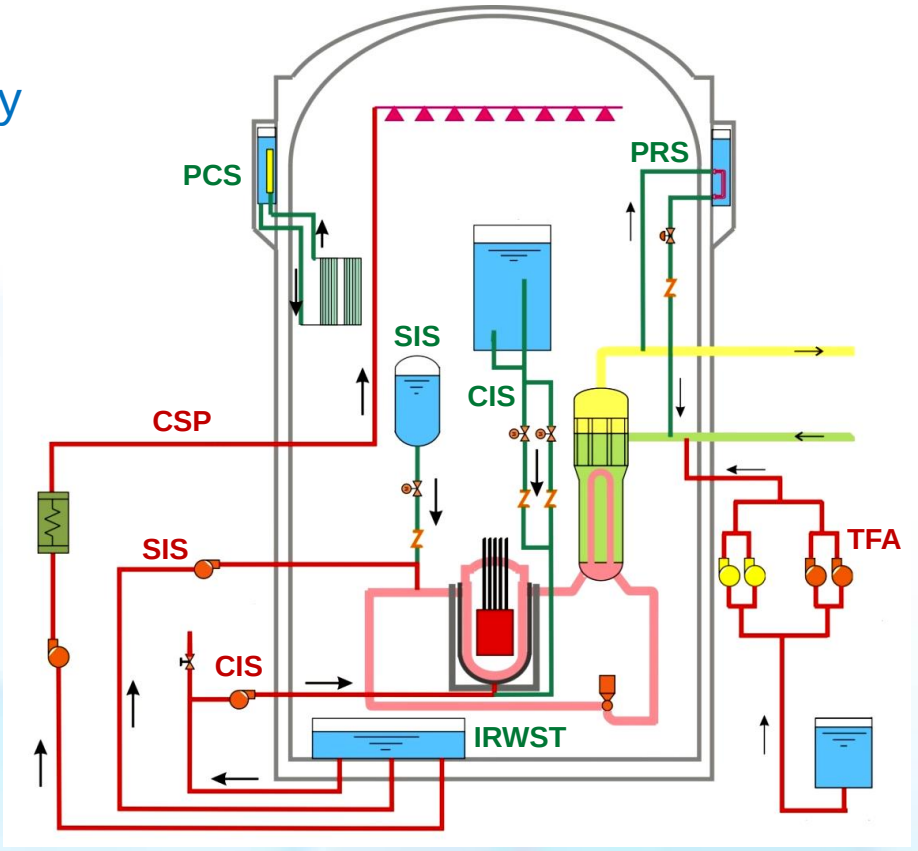
Active + Passive Safety Design

- Diverse approaches to perform safety functions

✓Core residual heat removal

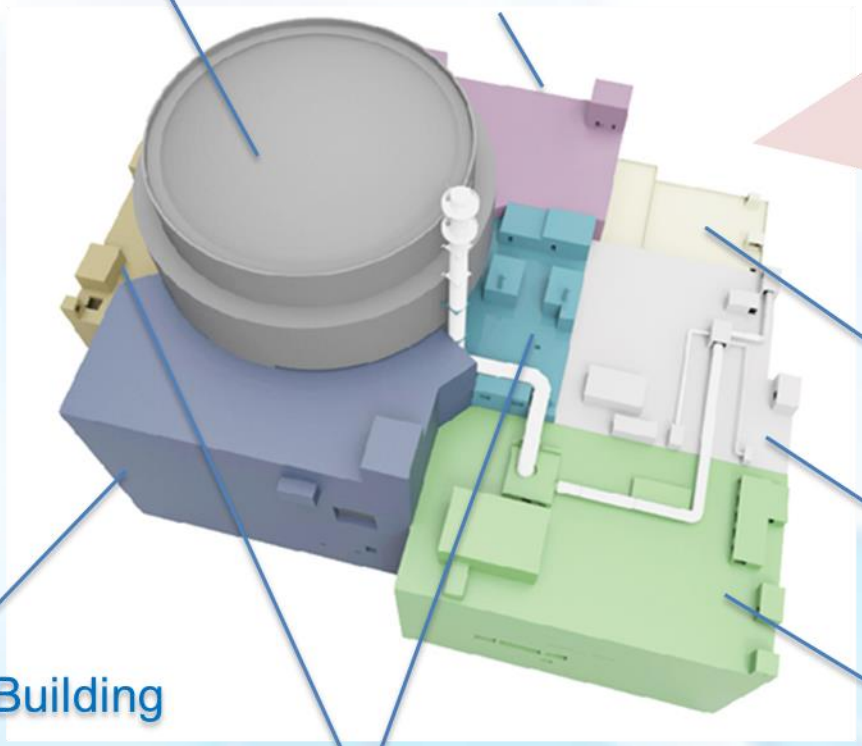
✓ Cavity flooding and cooling (IVR)

✓ Containment heat removal



Red: active Green: passive

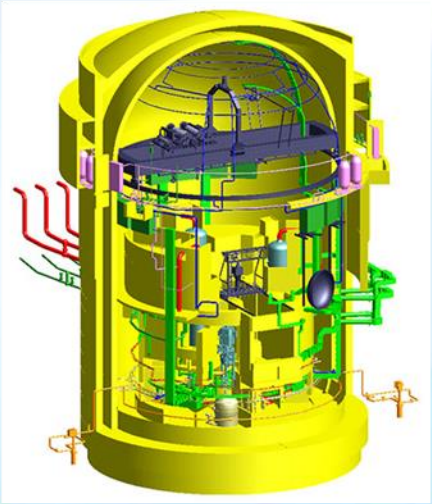
NI building: Single unit layout



- Providing physical separation, reducing interaction between units
- Convenient for plant construction, operation and maintenance
- More flexible for plant siting

NI building: Double Shell Containment

- Inner shell: prestressed reinforced concrete with a leak-tight steel liner inside
- Outer shell: reinforced concrete structure
- Annular space: keeping negative pressure, collection and filtration of the leak



- Large free volume: >80,000 m^3
- long lifetime: 60 years
- Withstand external events: large commercial aircraft crash, tornado, missile, explosion and etc.

Diversity of Power Sources

Turbine generator
During normal operation

Two trains of independent Off-site power If turbine tripped

Trains of diesel generators for each unit
As emergency power

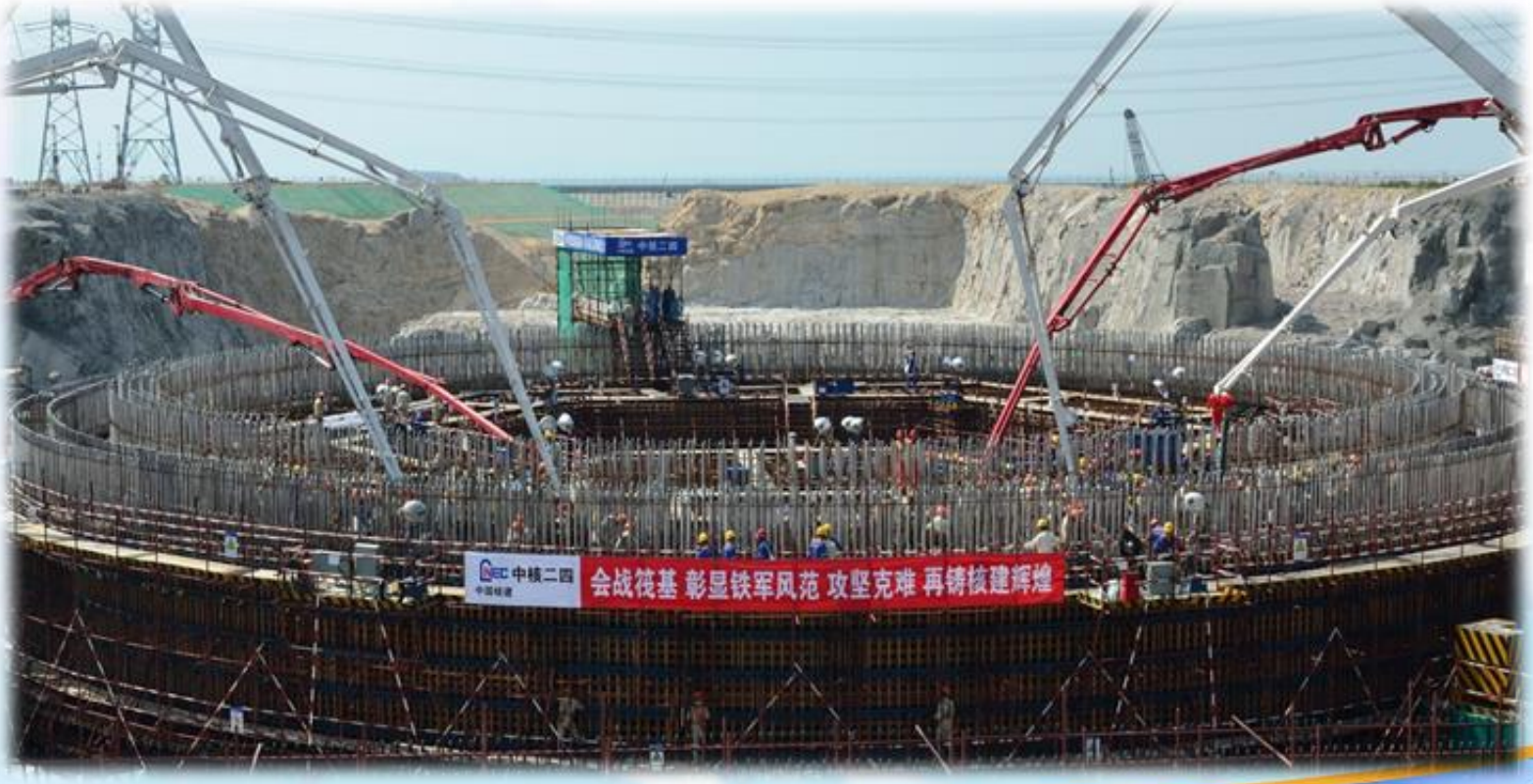
Extra diesel generator

SBO Diesel Generator
In case of SBO

DC Battery: 72 hours

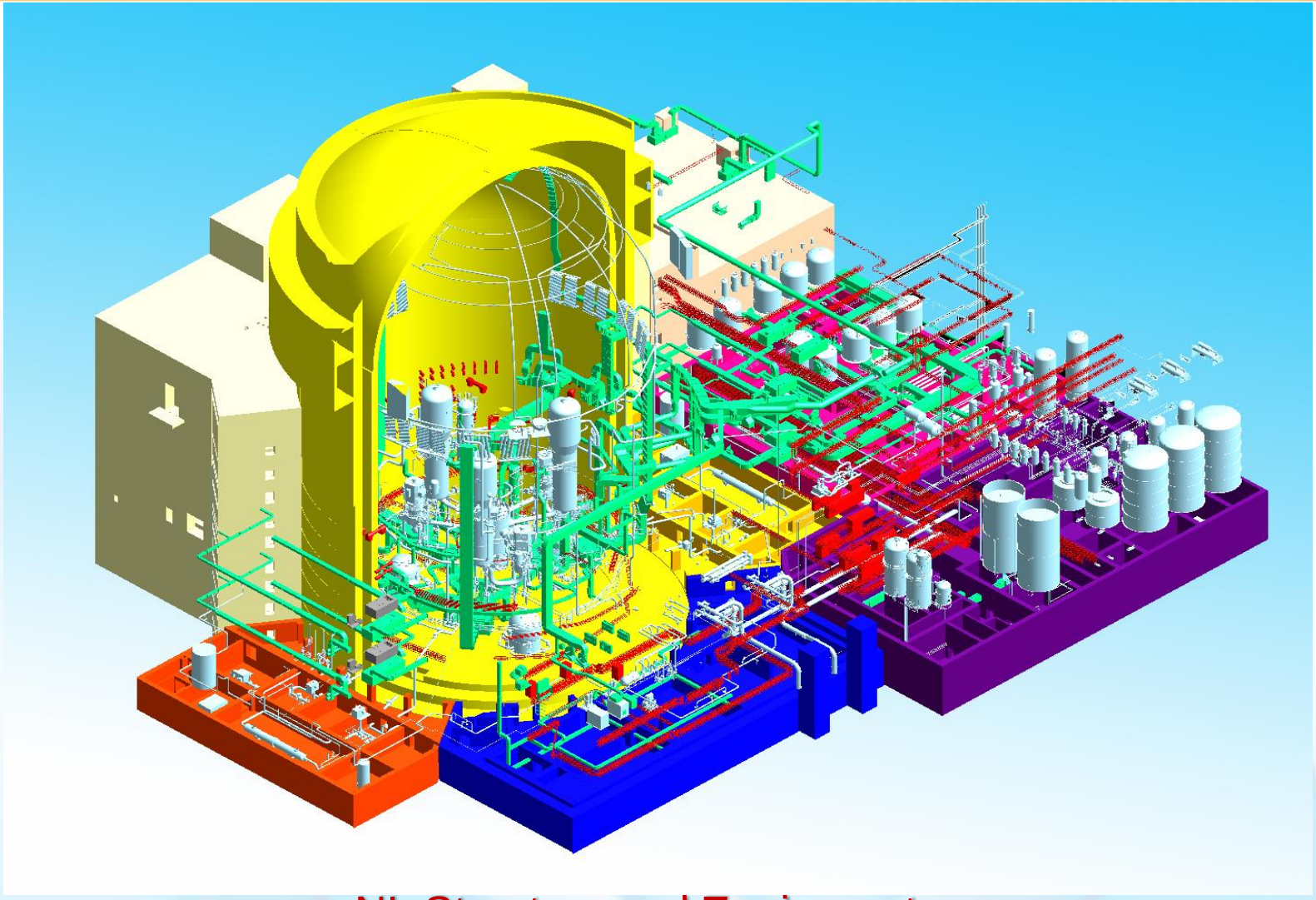
Fuqing NPP Unit 5&6

Construction: FCD in May, 2015

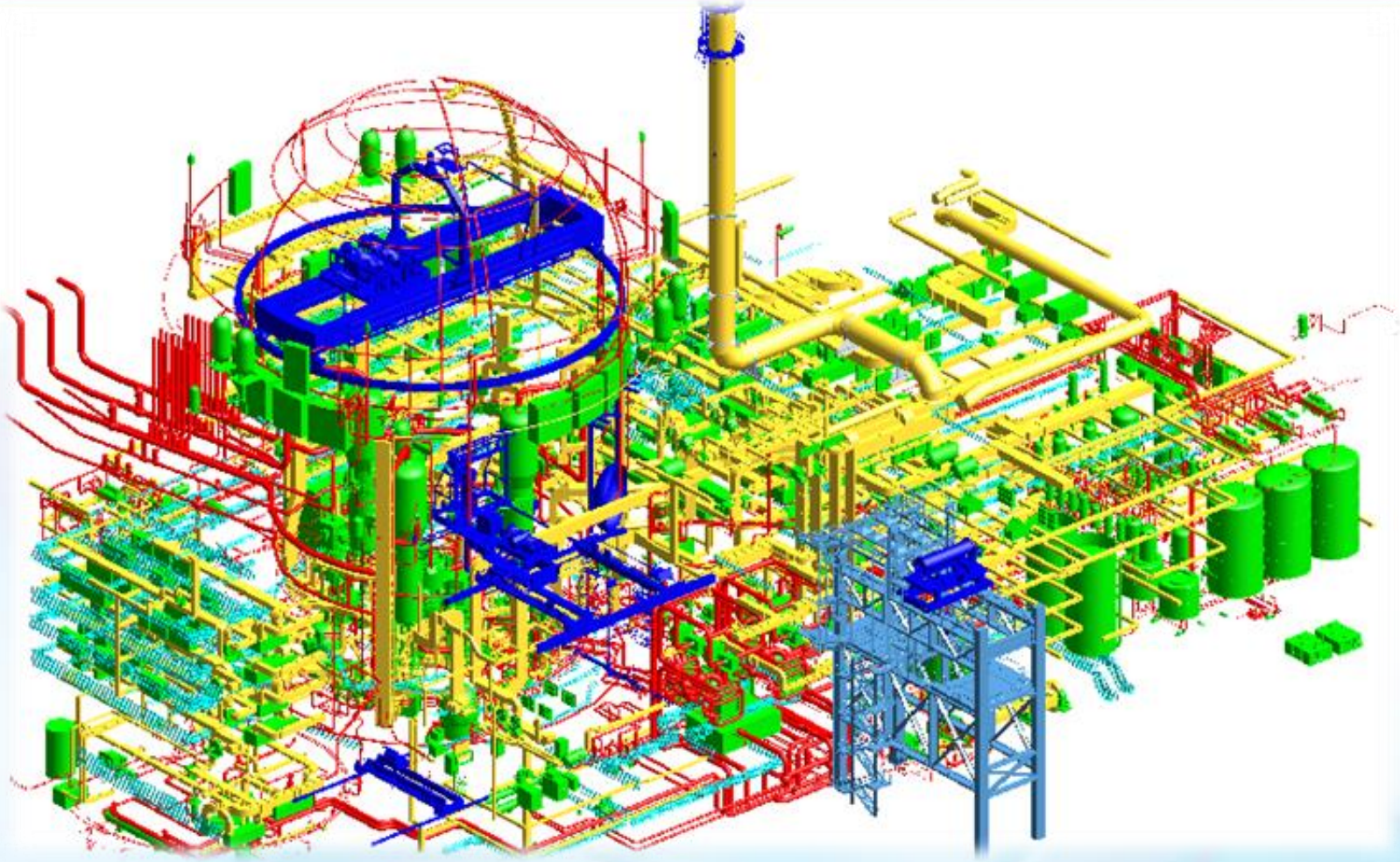


Fuqing NPP Unit 5&6

General Design	Done
Basic Design	Done
Construction Drawing before FCD	Done
Construction Drawing Reservation	+6 months ahead



NI: Structure and Equipments



NI: Piping and Equipments

Based on Proven and Verified Technology

- The configuration and operation of normal operating systems and "**active**" engineered safety features have been validated by long term engineering practice from existing PWR NPPs
- The design concept and technologies adopted for "**passive**" systems have been verified by natural science or specific experiments/tests
- The manufacture and supply capability of almost all key equipments/components is **compatible** with existing NPPs
- Benefiting from rich construction experience and outstanding feedback of operating experience, the construction period and performance of Hualong One can be ensured.

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- ☑ Maturity of key equipments and convenience of procurement
- ☑ Maturity of design tools and databases
- ☑ Experienced stuff in engineering, procurement, construction, installation, commissioning, maintenance, operation
- ☑ Economic performance accordance with existing electrovalence policy
- ☑ Steady supply of natural uranium resources (fuel)
- ☑ Public acceptability of nuclear power plants
- ☑ Mature nuclear safety review system and continuously improvement of nuclear safety culture

Thanks for your Attention!