Role of Nuclear Safety in Nuclear Export after Fukushima - Impact on Prospects of Chinese Nuclear Export

Nov. 21, 2014
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Fast Growing NPPs in China

20 reactors in operation
28 under construction
Growth Still in the Early Stage

2020 target: 58 GWe installed + 30 GWe in construction
Prospects of China’s Nuclear Power Export after Fukushima

• Domestic program was delayed but continues with the highest priority on safety
• More export options are emerging
• Strong domestic program combined with ample capitals has improved the export prospects relative to others
• Financing international NPPs is leading the way
Outline

• China’s Approach to Nuclear Safety
• Export prospects after Fukushima
  – AP1000/CAP1400
  – HL-1
  – ACP100
  – HTR-PM
Resumption of Nuclear Power Program

• Oct. 2012, State Council approved "12th Five-Year Plan and 2020 Target for Nuclear Safety and Prevention and Control of Radioactive Pollution"
  – The nation aims to upgrade the safety of its nuclear facilities and devices employing nuclear technologies to a new level by 2015
  – By 2020, the safety condition of the nation's nuclear power will be among the world's best
  – China will adhere to the fundamental principle of putting safety first in nationwide efforts to meet these objectives
Enhancing Nuclear Power Safety


  – New NPPs must comply with the safety standards of Generation III reactors, with more comprehensive prevention and mitigation measures for severe accidents, CDF < 10^{-5}, LRF < 10^{-6};

  – Strive to materially eliminate the possibility of large releases of radioactive materials by design
Scenarios Before Fukushima
Growth Target Adjusted Post-Fukushima

2020 target: 58 GWe installed + 30 GWe in construction
China’s Approach to Nuclear Safety

• President Xi Jinping’s speech in the Nuclear Security Summit in The Hague, 2014:
  – “To make better use of nuclear energy and achieve greater progress, mankind must be able to respond to various nuclear security challenges and ensure the safety of nuclear materials and facilities.”
  – “… we must strictly abide by the principle of making safety the top priority…”
  – “… we must … develop modern, low-risk nuclear energy technologies…”
Making Nuclear Energy Safe & Secure

Peace & Prosperity

Deterrence

Electricity

No Carbon

Bomb

Nuclear Materials

Reactors

Proliferation

Used Fuel

War & Disaster
Indigenous and Introduced Designs

- Qinshan CNP300
- Qinshan II CNP600
- CNP1000 CPR1000
- CP1000 ACPR1000
- ACP1000 ACPR1000+
- Daya Bay M310
- Ling’ao I M310
- Tianwan AES-91
- Taishan EPR
- Sanmen/Haiyang AP1000
Inside Haiyang #1
Inside Haiyang #1
AP1000 Main Supply Chain

Main Equipment

Main Materials
- Main Forging
  - China Yizhong
  - Japan Steel Works
  - Doosan Heavy Industries
  - China Erzhong
  - Shanghai Heavy Industries
- U-tube
  - China Yizhong
  - Japan Steel Works
  - Doosan Heavy Industries
  - China Erzhong
  - Shanghai Heavy Industries
- Weld Materials
  - ESAB
  - Japan Kobe Steel
  - Sandvik
  - US Special Metals

Main Production
- Fabrication Techniques
  - Doosan Heavy Industries
  - China Yizhong
  - Harbin Heavy Equipment
  - Shanghai Electric
  - Dongfang Electric
  - China Erzhong
- Welding Techniques
- Diagnosis Techniques
ACP1000 Combined with ACPR1000+ into Hualong-1 (HL-1)
HL-1 Design Features

Double-Layer Containment

Jetliner Impact Resistant
CNNC’s Hualong-1
CGN’s Hualong-1
Improving Reactor Safety

Internal Event Core Damage Frequency

- Gen II+: $1.11 \times 10^{-5}$
- EPR: $1.80 \times 10^{-6}$
- AP1000: $3.64 \times 10^{-7}$
- CAP1400: $2.41 \times 10^{-7}$
- HL-1: $1.70 \times 10^{-7}$
CNNC’s Fuqing NPP #5, 6
ACP100
Multi-Purpose Small Modular Reactor

Mature, safe and reliable technology
Short construction period and economical operation
Supply of electric power to medium/small grids, islands and remote areas
Supply of heat and power to cities
Supply of steam for industry use
Provision of seawater desalination to coastal cities lacking fresh water

ASSURED SAFETY

Meeting the highest safety standards
Inherent safety, fewer radioactive sources/items, integration of multiple defense lines
Fully passive safety facilities, independent of external power supply, nonintervention period of 14 days
Containment vessel (CV) installed in the water pool, avoiding the overpressure failure and radioactive leakage
Underground layout of reactor building, enhanced protection against external hazards

IDEAL BENEFITS

Economic and social benefits
- Small one-time investment, short construction period, low financing pressure, little expenses
- Modular, flexible, good return on investment and great prospects for future development
- Efficient and economical joint supply of electricity, heat, steam and fresh water
- Alternative for coal-fired units with reduced transportation costs, emissions
HTR-PM: Commercial Demo
HTR-PM Construction Site
China’s NPP Export Options

• **ACP1000**: already exported
• **AP1000**: with Westinghouse after demo
• **CAP1400**: demo to start in 2015
• **HL-1**: demo to start in 2015
• **HTGR**: demo started in 2012
• **ACP100**: demo to start as early as 2015
• Financing and building NPPs in UK, Romania, Argentina etc
CNNC Signed Contract with Argentine Nuclear Power Company for CANDUs
CGN Selected as the Investor in Cernavoda 3&4, Romania
CGN and EDF Ink Agreement on Nuclear Power Cooperation to Build NPPs in UK
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