China
The Emerging Nuclear Energy Leader

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Current Status of China’s Nuclear Program

- Operating Reactors – 33 – 28.8 GWe
- Under Construction – 22 – 22.1 GWe
- Additional Planned by 2020 – 58 GWe

• Companies Allowed to Build New Plants
  - China General Nuclear Power Group
  - China National Nuclear Corporation

• Regulator
  - National Nuclear Safety Authority
  - Under Ministry of Environmental Protection
  - Reports to State Council
Reactor Technologies Being Built

- CPR 1000 (Areva based)
- AP 1000
- EPR
- VVER 1000
- CANDU 6 (Heavy Water)
- CAP 1400
- ACPR 1000

Note – All Pressurized Water Reactors
No Boiling Water Reactors
Location of Chinese Nuclear Plants
National Policy

• Decisions on nuclear energy are made at the highest level of government in 5 year plans.
  – State Council
    • State-Owned Assets Supervision & Administration Com.
    • 120 State owned enterprises
    • $ 3,700 Billion in assets
  – National Development and Reform Commission
  – National Energy Administration
  – Other state agencies are obligated to follow direction
Chinese Development Strategy

• Buy Foreign Plants
  – French, US, Russian
• Obtain technology information (licenses)
• Modify Design to make it Chinese
• Transfer fabrication to Chinese companies
  – Localization
Localization Effort

[Bar chart showing CGNPC Progressive Localisation of CPR-1000 with data for Daya Bay, Lingao I, Lingao II, Hongyanhe, Ningde, and Future Site, with units 1 to 4 indicated by different colors.]
Chinese Nuclear Industry

• 146 named state commissions, generators, major companies, suppliers
  – State owned
• 5 Major Generators
  – Datang, Gupodian, Huadian, Huaneng, China Power Investment
• China National Nuclear corporation
  – Controls most nuclear sector business
• Major Construction Company
  – China Nuclear Engineering and Construction Group
• Developer and Operator Groups
  – China General Nuclear Power
  – China National Nuclear Power
  – China Power Investment
Major Vendors and Suppliers

- Shanghai Electric Company
  - Major Components
- China Nuclear Fuel Element Company
- Baotou Nuclear Fuel/China Nuclear Fuel Co
- Beijing Institute of Nuclear Engineering (CNNC)
- China Nuclear Power Engineering
- China First Heavy Industries/Dongfang Heavy Mach
- Shanghai Electric Group
- Institute of Energy and New Energy Technology
  - Tsinghua University
Technologies Being Developed

- **Generation I**
  - CNP– 300, 600 – Indigenous Qinshan
  - Candu 6
- **Generation II**
  - CPR-900 – AREVA – Daya Bay
  - CPR-1000 - Indigenous – Ling Ao Phase II
  - VVER-1000 – Russia
- **Generation III**
  - AP-1000 – Westinghouse – 1200 Mwe
  - CAP-1000 – China
  - CAP-1400 – China
  - CAP-1700 – China
  - EPR-1660 – France
- **Generation IV**
  - High Temperature Gas Reactor – Pebble Bed – 200 Mwe
  - ACP-100 Small Modular Reactor
  - CAP-150 Small Modular Reactor
  - Fast Neutron Reactor – 1000 Mwe – 2022 operation
Regulatory System

• National Nuclear Safety Administration
  – Reports to State Council
  – Direct Report to China Nuclear Energy Agency
• International Atomic Energy Agency reviewed regulatory process and found it acceptable meeting international norms
• Standards include IAEA, NRC, ASME, etc.
• Gives approval for construction and operation
China’s Future Plans

• Close Fuel Cycle
  – Reprocessing
  – Mixed Oxide Fuel

• Build Fast Reactors
  – Sodium Cooled
  – Start deployment in 2020
The Growth Challenge

• Building so many plants at once
• Maintaining high quality construction
• Different technologies
• Staff training and qualifications
• Regulatory oversight
Numbers are rate of NPPs per year connected to the grid taken at the maximum persistent rate.

China 2.48
Build 32 NPPs in 13 years

USA 4.63
France 3.83
Japan 1.82
Russia 1.26
Korea 0.89
Canada 0.74
China 0.50
Required Manpower for CGNPC Nuclear Projects

>13,500 People Needed for Operating the Existing and Future NPPs

>4,500 People Needed for Project Construction of Planned and Future NPPs
## Cost Example

- **Cost Element**  
  - Daya Bay (2)  
  - Ling Ao (2)  
  - Ling Ao Phase II

- **Total Cash**  
  - 4,072 (93/94)  
  - 3,317 (02)  
  - 3,366 (10)

- **Nuclear Island**  
  - 998  
  - 900  
  - 714

- **BOP**  
  - 455  
  - 460  
  - 322

- **Financing**  
  - 598[2]  
  - 358[3]  
  - 368[4]

- **Fuel**  
  - 145

- **Cost/kwe**  
  - 2,050 (yr)  
  - 1,677  
  - 1,700

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[1] All dollars in a current year dollars as expended.  
[2] 10% equity – rest financed by export/import bank debt at 7%  
[3] 20% equity – foreign debt at 6%  
[4] 20% equity – local @ 4.5% and foreign banks at LIBOR 7%
China As A Competitor

- China can build plants quicker and less expensively
  - Hardware – indigenous supply
    - Fuel, reactor vessels, valves, computers, etc.
  - Labor
- China looking at export market
- Technology is western based and improved
Chinese Exports of Nuclear Plants

• United Kingdom
  – Proposing to build CPR 1000 (Bradwell)
  – Investing in Hinkley and Sizewell

• Active in selling technology worldwide
  – Including High Temperature Pebble Bed Reactor being built in Shandong Province (start up expected in 2017)
New Reactor Financing

• Research and Development is FULLY Funded by Government
• Once the R&D is complete, government provides some (30%) capital to build plants – 70 % raised by utilities (government owned) from banks and other investors.
• Companies are accountable for operating safely and economically to pay back loans.
Finland vs. China Construction

- Olkiluoto
  - Start of construction – 2005
  - Estimated Operations -- 2017

- Ling Ao Phase II
  - Start of Construction – 2006
  - Start of Operations – 2010
Summary

• China will be a world leader in nuclear energy
• The pace of construction is manageable
• Quality of construction appears to be fine
• Vendor oversight needs to be enhanced
• Regulatory oversight needs to be enhanced
• Operations are challenged by inexperienced staff – will improve with time.
• For future an independent assessment of China’s nuclear program would help China.