



Global Nexus Initiative

Where Climate, Nuclear, and Security Meet

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



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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



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Chinese Development Strategy

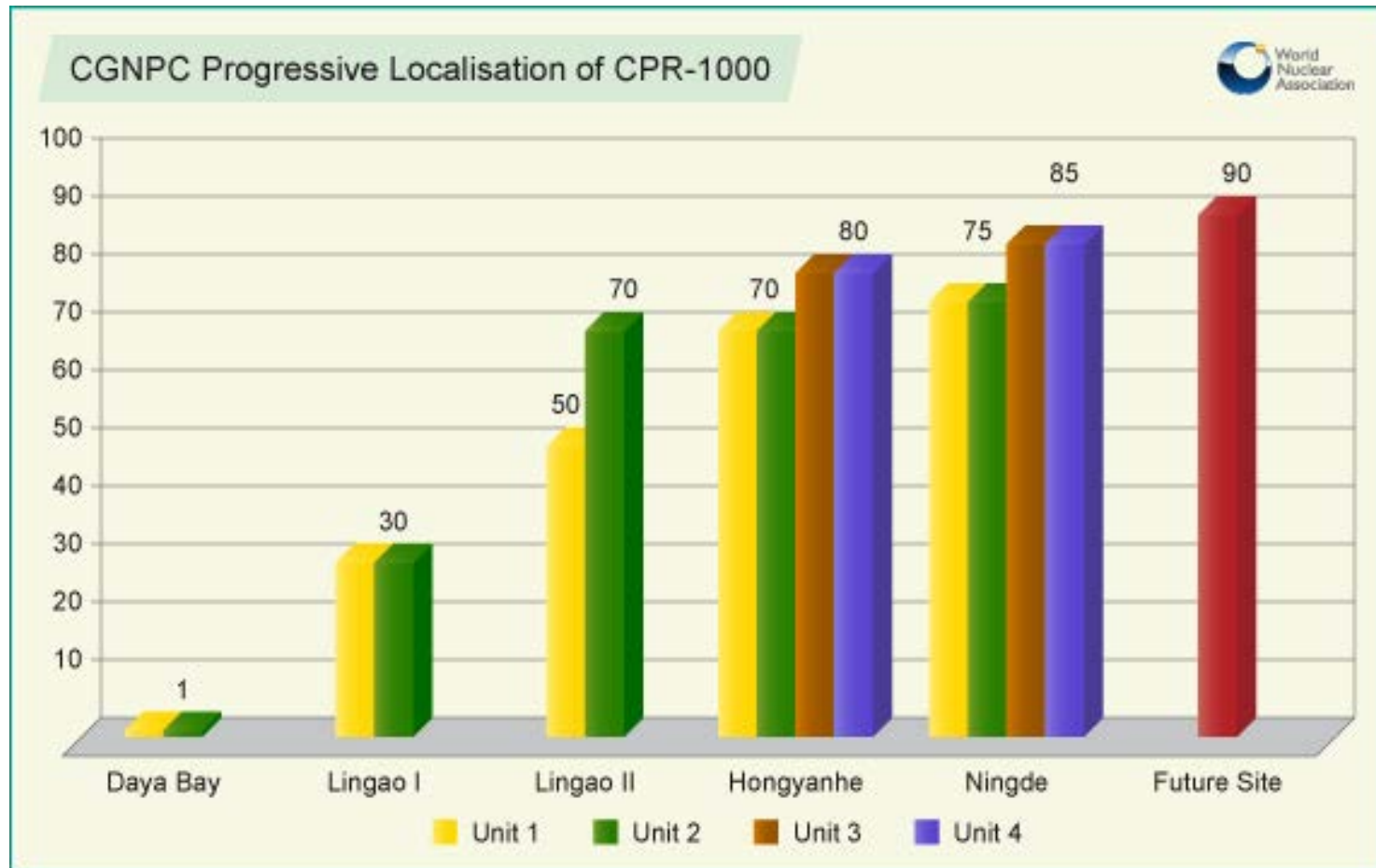
- Buy Foreign Plants
 - French, US, Russian
- Obtain technology information (licenses)
- Modify Design to make it Chinese
- Transfer fabrication to Chinese companies
 - Localization



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Localization Effort





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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



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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



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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



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China's Future Plans

- Close Fuel Cycle
 - Reprocessing
 - Mixed Oxide Fuel
- Build Fast Reactors
 - Sodium Cooled
 - Start deployment in 2020



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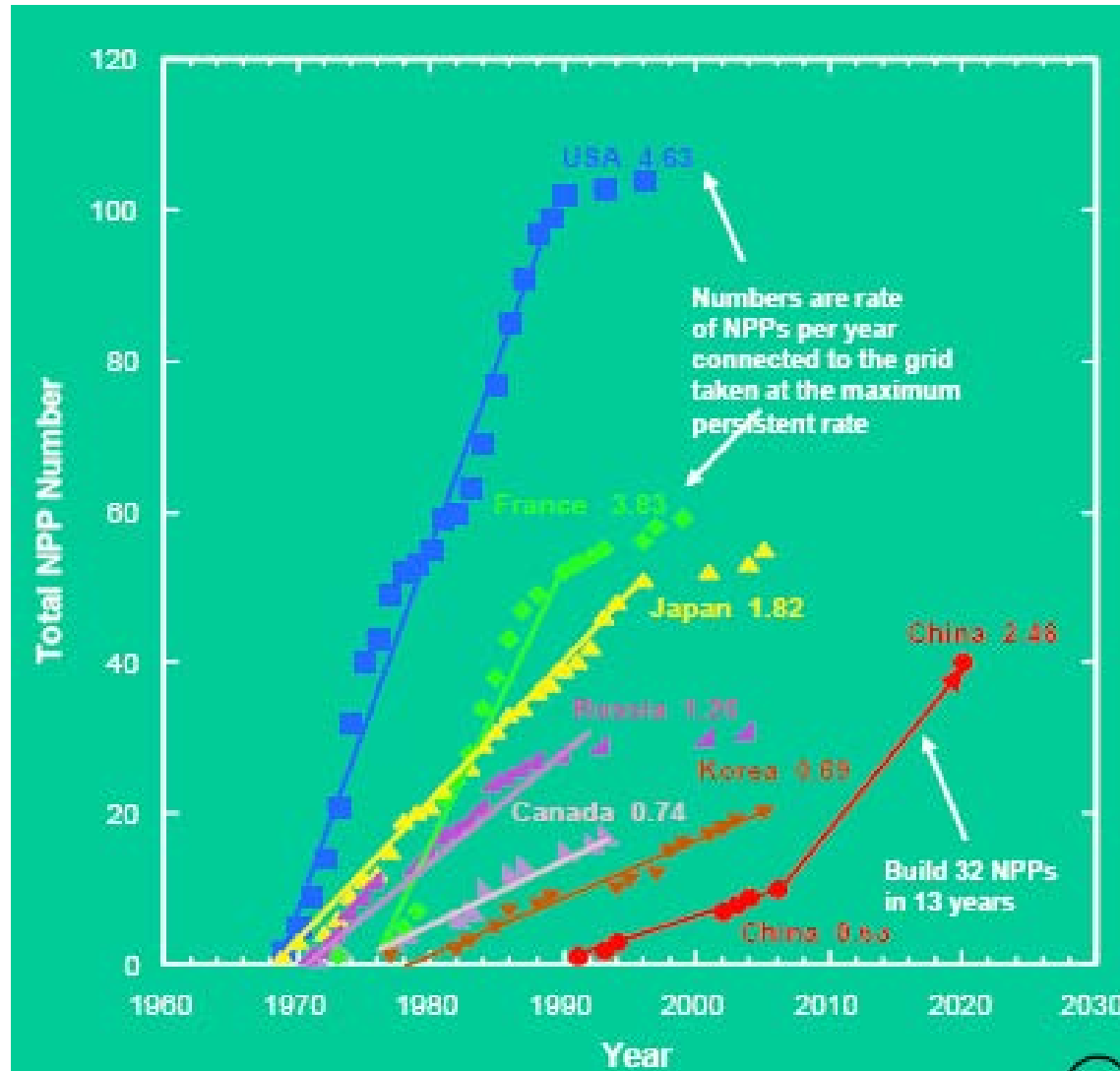
The Growth Challenge

- Building so many plants at once
- Maintaining high quality construction
- Different technologies
- Staff training and qualifications
- Regulatory oversight



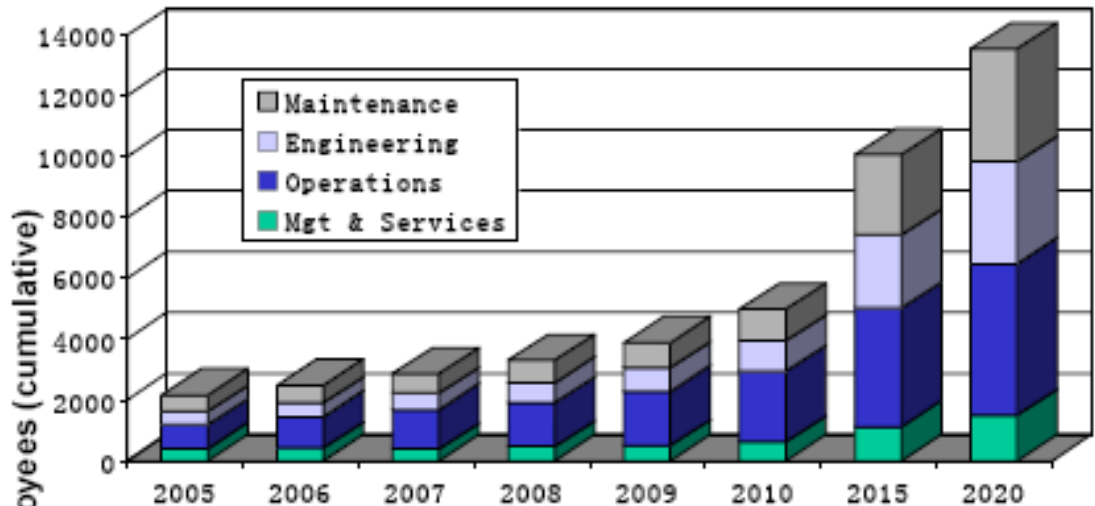
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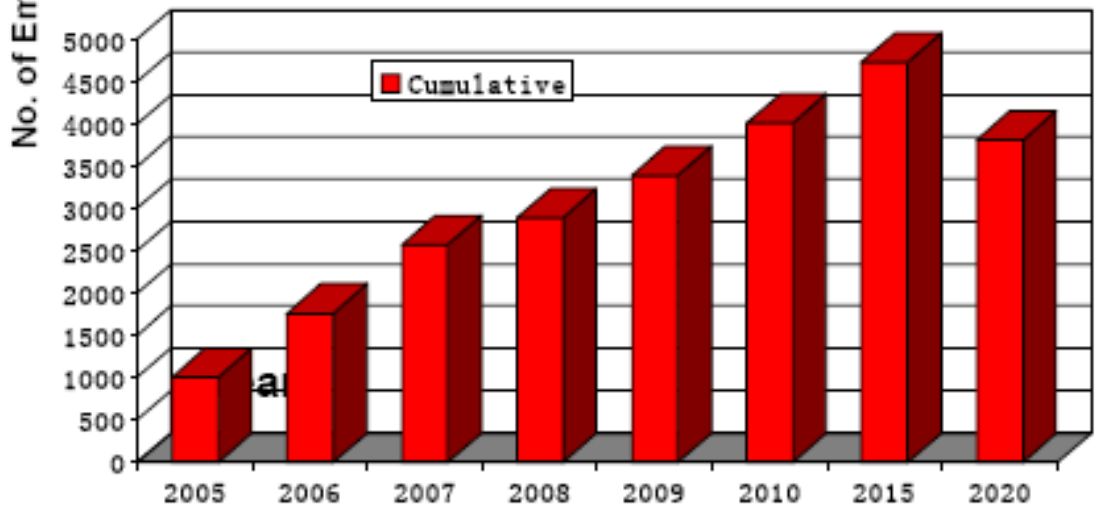


Required Manpower for CGNPC Nuclear Projects

>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

<u>Cost Element</u> [1]	<u>Daya Bay (2)</u>	<u>Ling Ao (2)</u>	<u>Ling Ao Phase II</u>
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

[\[1\]](#) 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



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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)



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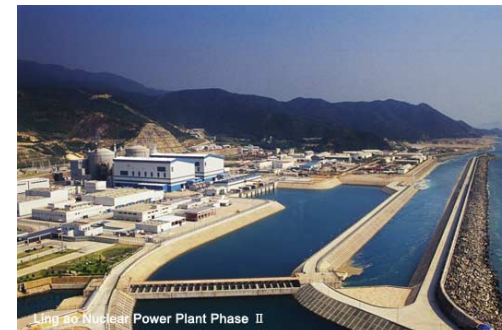
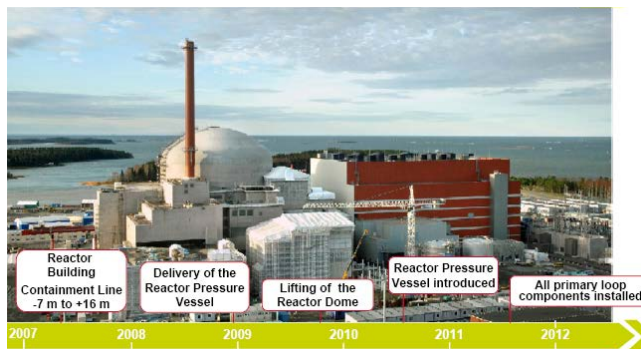
New Reactor Financing

- 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





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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.