China's nuclear power industry evolution and implications on uranium

Macquarie Global Nuclear Conference 2010

Presentation document

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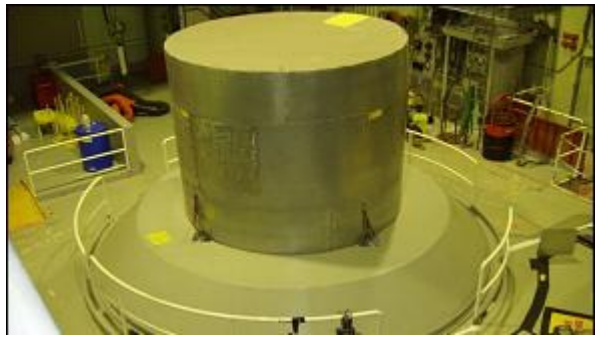
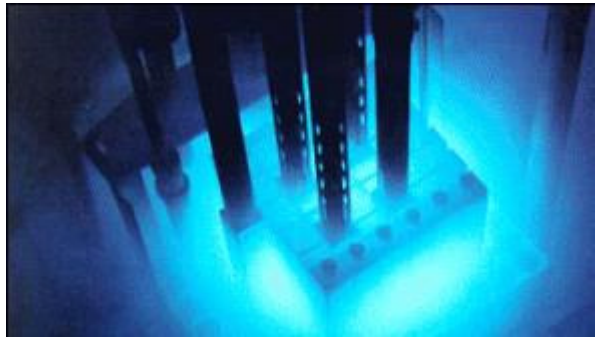
McKinsey&Company

Key messages

Official targets state China's nuclear power plant (NPP) capacity will increase from 9 GWe in 2009 to 75 GWe by 2020; potential for NPP capacity to reach 120 GWe

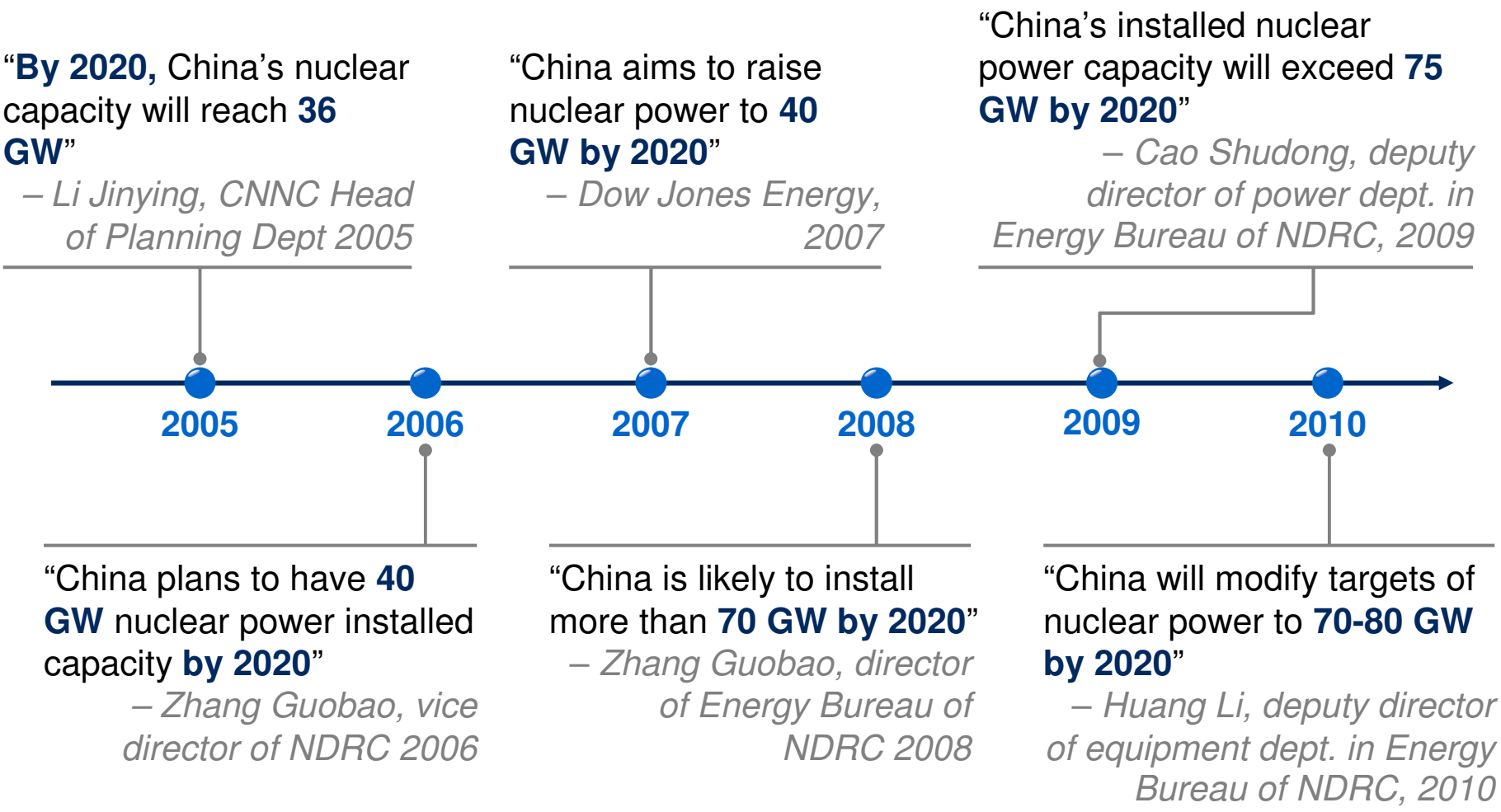


Risks to nuclear development limited: manufacturing capacity secure with no bottlenecks in reactors, critical components or human capital; environmental concerns / NIMBY activism expected to be limited



China focused on developing the full fuel cycle and increasing its participation in uranium via direct investment into mines, long term uranium contracts, and development of re-enrichment

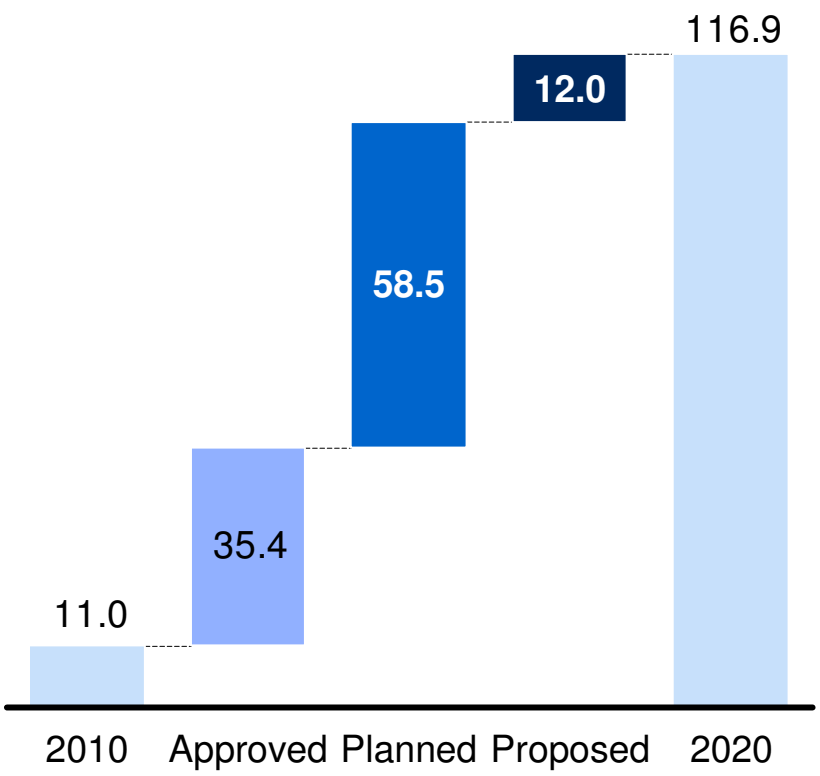
China's official nuclear targets continue to rise; current announcements suggest at least 75 GWe of installed nuclear capacity by 2020

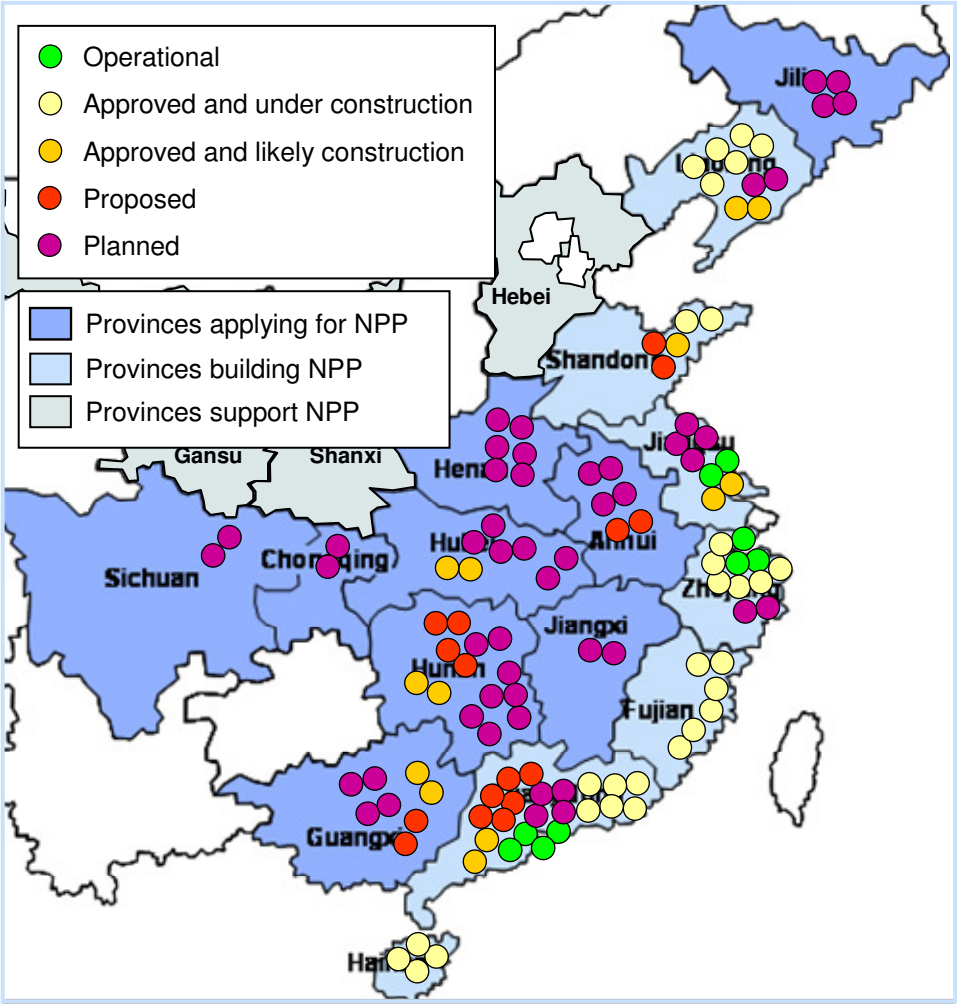


SOURCE: Literature search

However, if all planned nuclear plants are developed, China's capacity could increase to ~120 GWe by 2020

China NPP build out by 2020
GWe

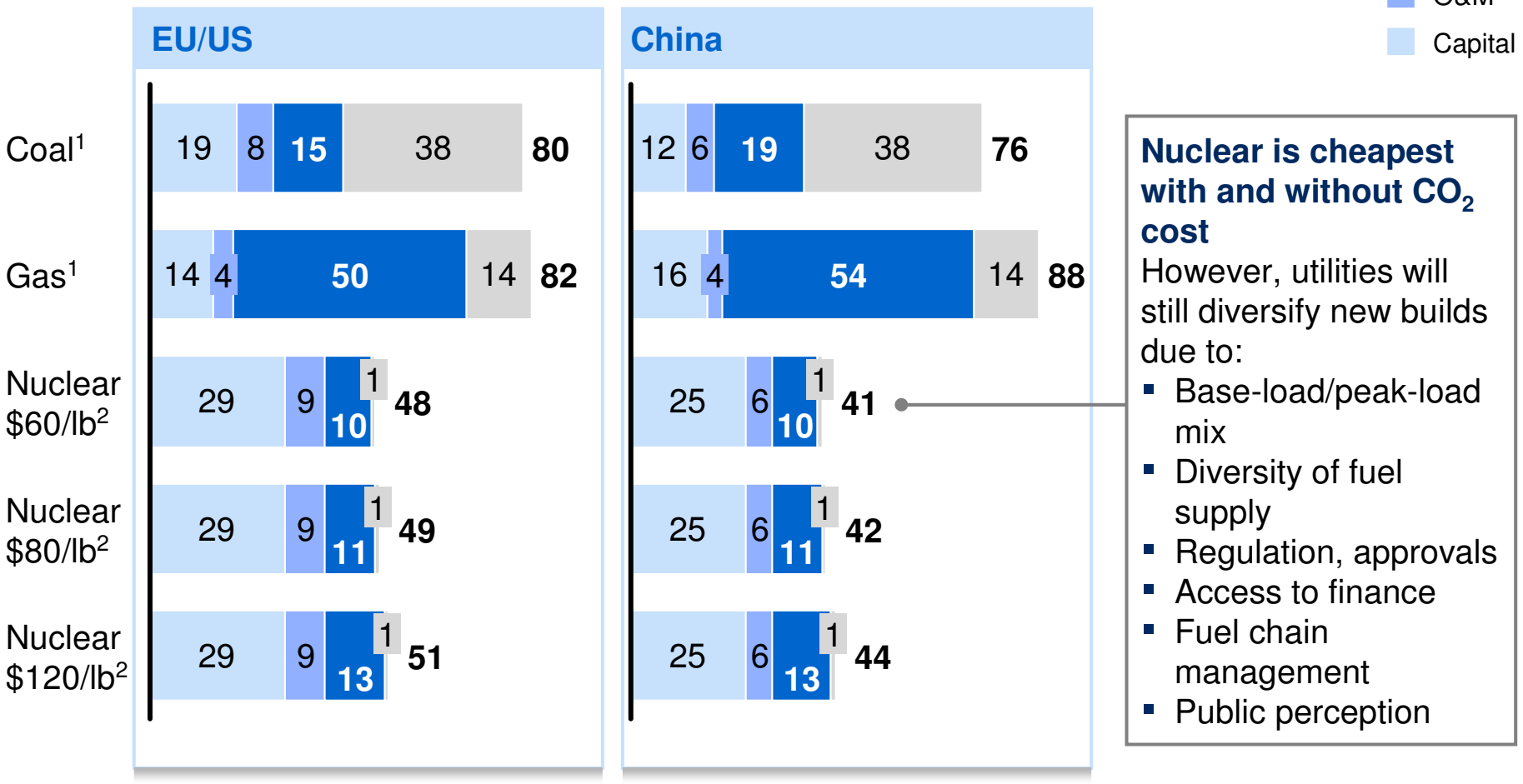




SOURCE: BHI; McKinsey analysis

Competitive power generation economics and GHG abatement opportunity support extensive nuclear power plant development

Power generation cost comparison – 2009, USD/MWh



Nuclear is cheapest with and without CO_2 cost

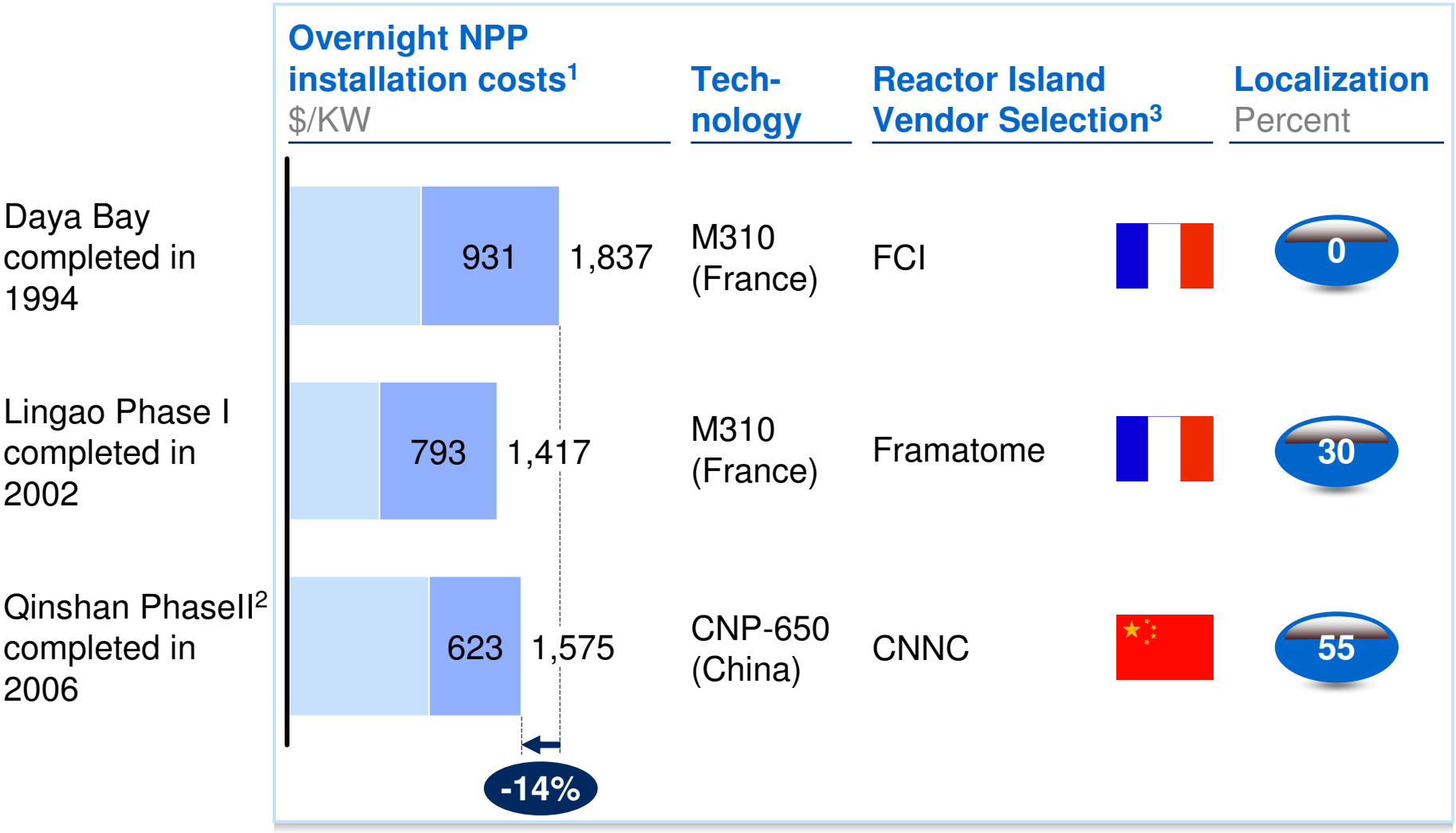
However, utilities will still diversify new builds due to:

- Base-load/peak-load mix
- Diversity of fuel supply
- Regulation, approvals
- Access to finance
- Fuel chain management
- Public perception

1 Sub-critical coal plants at $60 / ton of coal; CCGT Gas plant at $7.5 / mmBTU
2 Includes waste management & decommissioning costs for NPP. Based on overnight costs, annualized as fixed-payment annuity

SOURCE: McKinsey energy models

Localized component manufacturing has contributed to an ~15% reduction in nuclear installation costs over the past 10 years

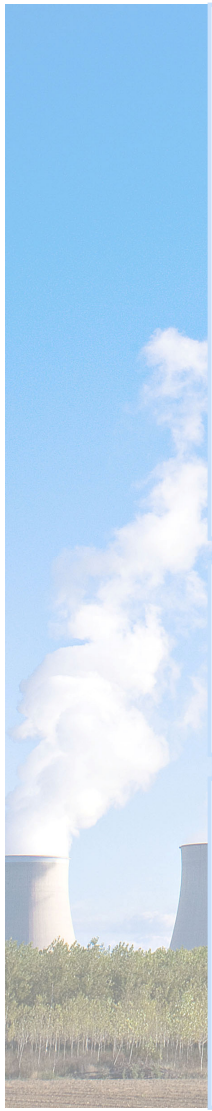


1 Excluding financing costs during construction, typically valued at 15%-20% of total capex. Others include designing fee, testing fee, etc.
3 Qinshan phase II is of GII, with capacity of 2* 650 MW
4 Not exhaustive

SOURCE: China Bureau of Statistics; company reports; literature search; China Atomic Information Network; IEA

GOVERNMENT SUPPORT

China's government is taking the necessary initiatives to support the development of its nuclear industry



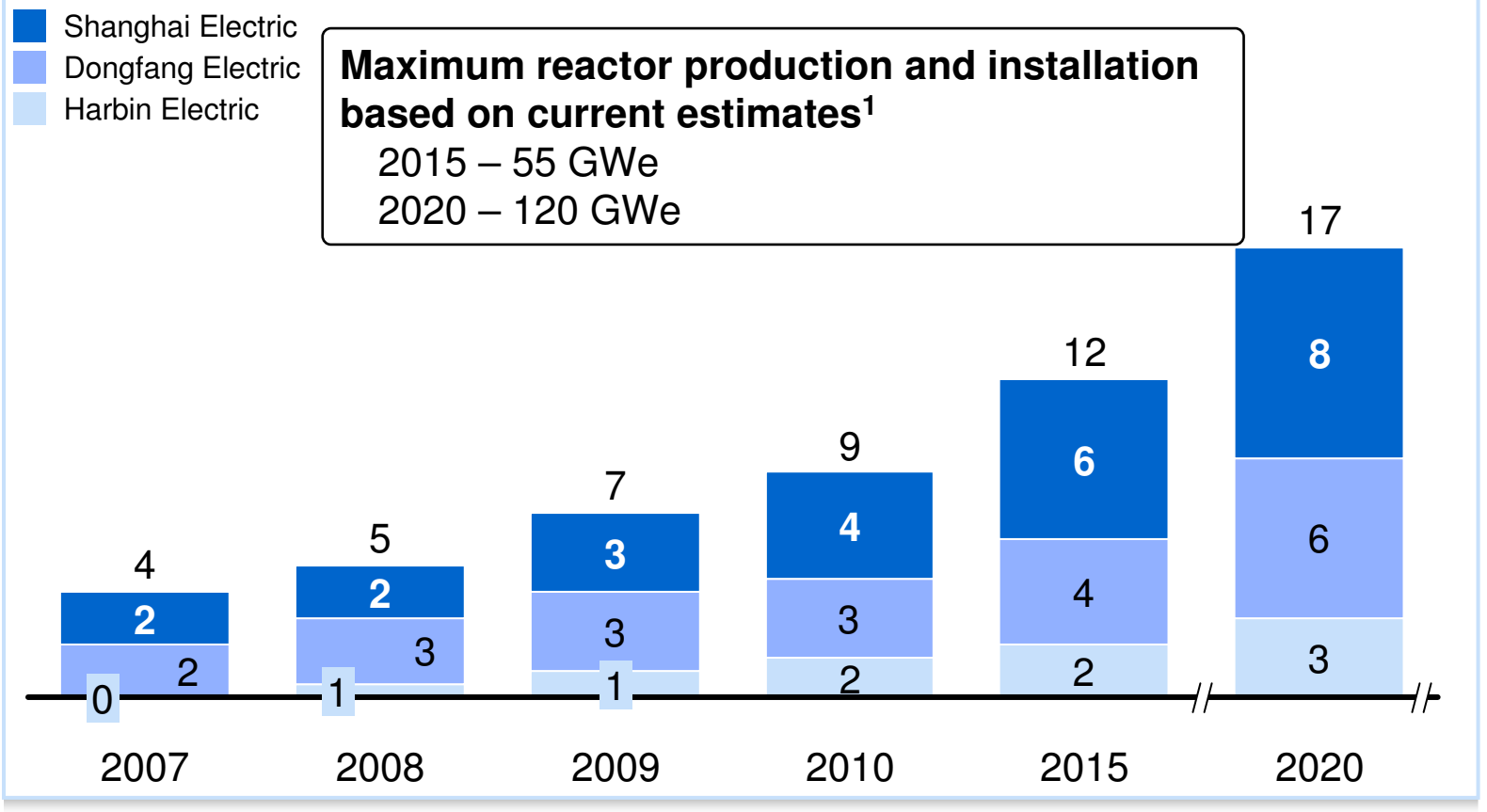
High safety and technical standards	▪ A recent **IAEA** safety review declared "**confidence** in the effectiveness of the **Chinese safety regulatory system** and the **future safety** of the vast expanding nuclear industry" ▪ **Active involvement** of government bodies in **oversight**: – State Energy Bureau is responsible for fuel regulation – **NNSA** is involved in **safety regulations**; **SNPTC** established for **technology transfers** ▪ New AP 1000 model passed **US Nuclear Regulatory Commission certification** ▪ Clear guidelines for the treatment of civil spent fuel have been drafted by CNNC
Control and oversight	▪ **High barriers to entry** allows for better oversight over nuclear development: – Only **3 companies** are permitted to **invest** in and **operate nuclear plants** – Only **2 companies** have nuclear **fuel purchasing rights**
Unified political support	▪ Strong, **unified support for nuclear power** at national and local levels: – National government champions nuclear power as "safe, economical and clean" – Local governments support nuclear power given need for local economic growth – **Limited local opposition has surfaced**, but there have been no large-scale protests

SOURCE: Literature search; interviews; McKinsey analysis

Forecast reactor production capacity will be able to reach cumulative production volume equivalent to 120 GWe of nuclear reactors by 2020

China reactor manufacturing capacity

Units per year



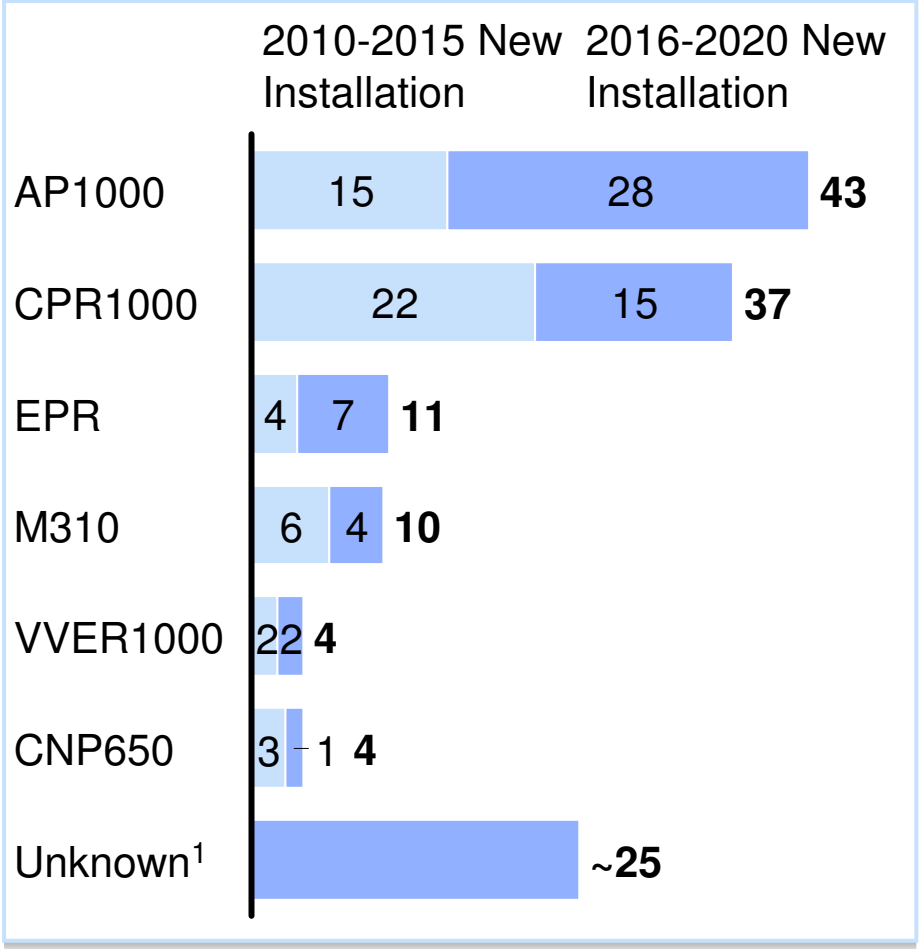
1 Assume two year lead time from reactor delivery to capacity installation; assume average capacity per unit increases from 1 GW to 1.25 GW by 2020 and to 1.5 GW by 2025

SOURCE: SEC Nuclear base; interviews; literature search; McKinsey analysis

China efforts to develop technology and manufacturing capability suggest demand for various reactors will be met

China reactor demand

GWe, by type



"China relies on domestic production for 55% of the facilities for **GIII** AP1000 nuclear projects"

– Sun hanhong, Vice manager of SNPTC 2010

"The success of the China Experimental Fast Reactor (CEFR) marked a breakthrough in China's **G IV** nuclear technology"

– Xinhua, 2010

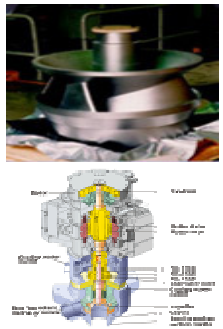
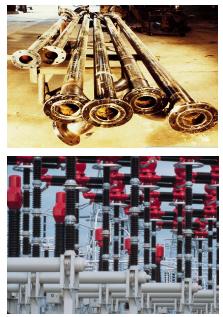
"China plans to build 2x800 MW experimental **G IV** fast reactors by 2020"

– Xu Mi, Chief Engineer of CEFR project of CNNC 2010

1 All nuclear power projects without confirmed technology map are still in the plan. About 50% of capacity could be completed before 2020

SOURCE: Citic Security report; Gaohua report ; interviews; iterature search; McKinsey analysis

Nuclear critical component manufacturing will not present bottlenecks

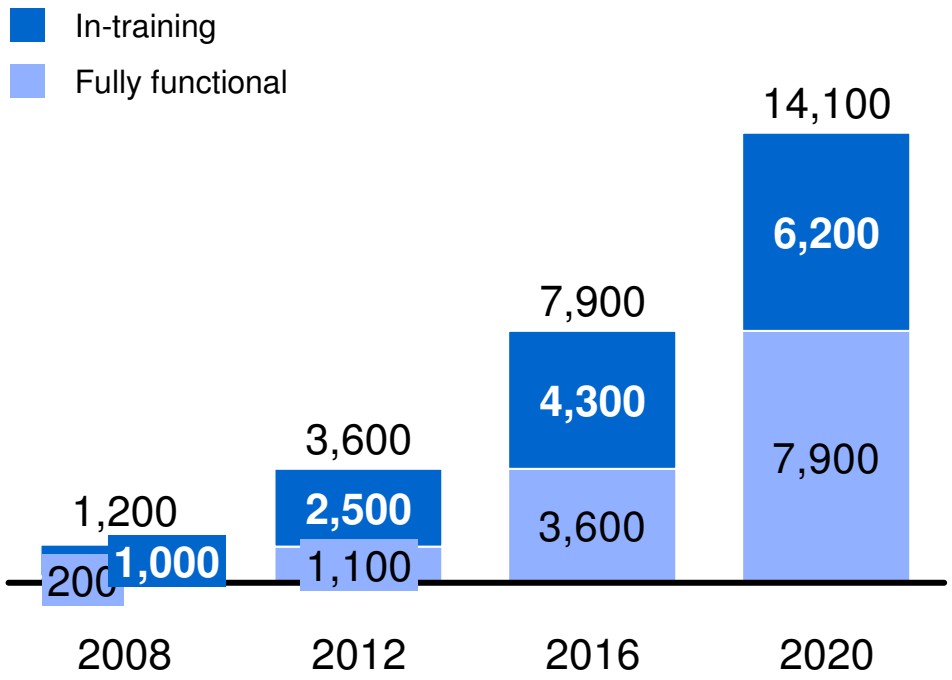
	Entry barriers limited	De-bottleneck initiatives
 **Ultra-large forging**	▪ USD 400m capex for new plant ▪ No proprietary technology/ process ▪ Non-above 4 years for installation of facility ▪ License from ASME N-stamp[1]	▪ Main players e.g., JSW, OMZ expand capacity ▪ New entrants e.g. Doosan, China 1st Heavy, SEC ▪ Sufficient components supply for the capacity expansion
 **Pumps and valves**	▪ Minimal capital required ▪ No proprietary technology/ process ▪ 6-12 months to build facilities ▪ License from ASME N-stamp[1]	▪ Leverage un-utilized capacity of MNCs, e.g., KSB, EMD ▪ China has owned technology for reactor coolant pumps ▪ Component de-bottlenecks e.g., castings, bearings
 **Critical piping**	▪ Minimal capital required ▪ No proprietary technology/ process ▪ About 1 year to build plant ▪ License from ASME N-stamp[1]	▪ Multiple specialized suppliers e.g., Sandvik, Sumitomo, SAFR, Izhora, HER, Shaw for easy sourcing ▪ Chinese players aim to develop its own technology for critical piping

1 International nuclear industry equipment quality certification (obtainable within 1yr paying a one-time “purchase” fee and pass annual compliance)

SOURCE: Literature search; interview; McKinsey analysis

Current student enrollment rates by 2020 China will have ~8,000 fully functional nuclear O&M employees

China cumulative nuclear employees
Number of people



745 people required to run pair of 1GW reactors, of which 220 need to be nuclear educated

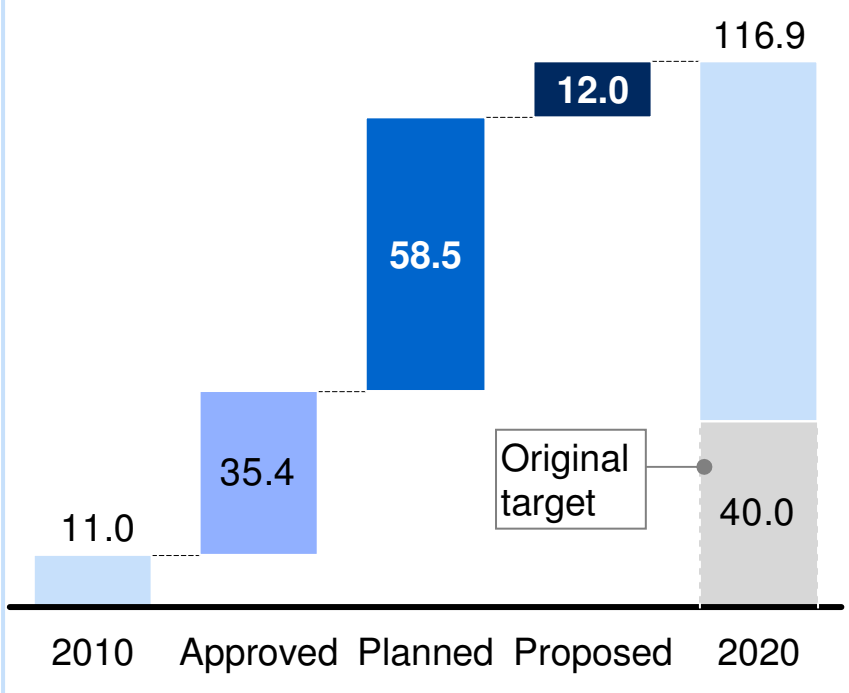
- **Human capital pipeline sufficient to meet 75 GW target**
- Gencos are innovating to address talent issue:
  - CGNPC creation of nuclear-specific programs to target undergrads
  - CNNC/CGNPC nuclear-specific 2.5-year MA to enroll general engineering college grads
  - CNNC/CGNPC 5-month training program for new hires without nuclear degrees
  - CNNC/CGNPC training centers at universities to re-train current employees

Assumptions: % graduates entering nuclear industry = 70%; % new nuclear hires enter into NPP O&M = 57%; need 8 years lead time to be "fully functional: 4 years in college, 4 years on-job training

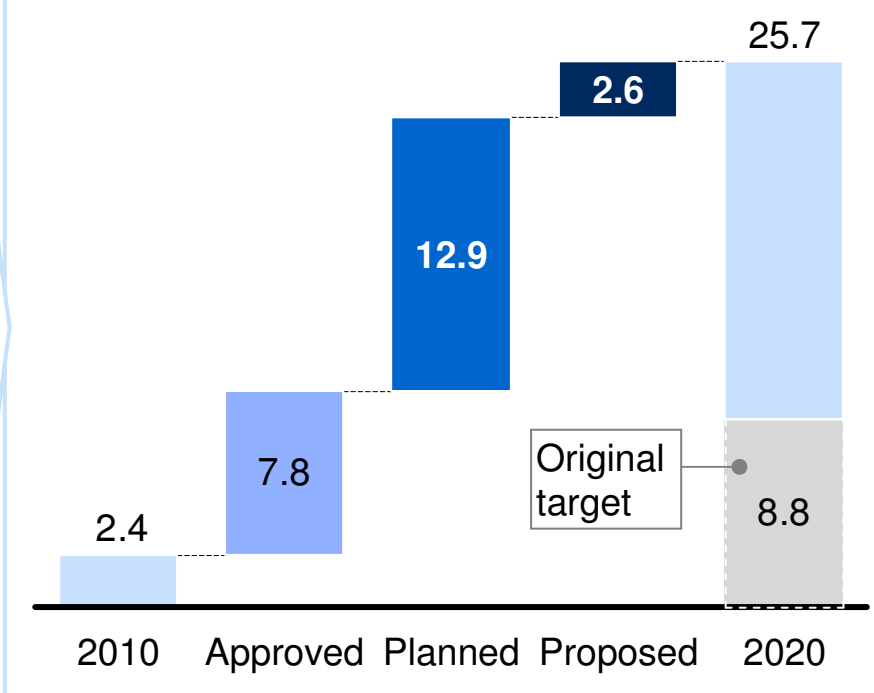
SOURCE: Literature search; industry interviews; McKinsey analysis

Growth in China's nuclear industry will create incremental annual demand[1] of ~17 kt U308 by 2020

China installed nuclear capacity
GWe



China U3O8 demand[2]
000 tons



1 Assumes incremental above and beyond original 2020 target of 40 GWe
2 Assumes 220t U3O8 per GWe capacity (estimated range ~200-250t for current and expected units in China)

SOURCE: BHI; Literature search; interviews; McKinsey analysis

China is increasing its participation in uranium to underpin the growth of its domestic nuclear industry

"**CNNC** and **CGNPC** received a combined **49% stake in a Kazakh uranium mine** company from Kazatomprom"
– Kazakhstan General Newswire, 2007

"**CGNPG** and **Chinese sovereign wealth funds** will take a **49% stake in UraMin**, Areva's subsidiary"
– Platts Commodity News, 2008

"**CNNC** offered to buy **Western Prospector**, which plans to develop resources in Mongolia of **4.3mt grade 0.189% U3O8** plus 795,000 t grade 0.126% U3O8"
– Canada Business News, 2009

"**Paladin** signed a MoU with **CGNPC** to set up a framework for **long-term uranium sales** "
– Business Spectator, 2010

"**CNNC** has signed an agreement with **China-Africa Development Fund** to jointly develop **uranium resources in Africa**"
– China Knowledge, 2010

"**Russia invites China** to join Russian projects to **mine uranium** on 3 sites **in Russia**"
– Moscow Monday; wise-uranium, 2010

Note: CNNC: China National Nuclear Corp; CGNPG: China Guangdong Nuclear Power Group

SOURCE: Literature research, McKinsey analysis

EXPORT OF NUCLEAR TECHNOLOGY

Simultaneously China has also become more active in developing NPPs abroad

NOT EXHAUSTIVE

By the end of 2010 **China** will have built **two 300 MW reactors** in Pakistan with a further two under contract and a **1 GW power plant** currently under negotiation with CNNC

"China and Pakistan are in discussions over CNNC exporting a one-gigawatt nuclear plant to Pakistan"
– Qiu Jiangang, CNNC

CNNC is in talks with South African officials and local utilities over the potential to **build a nuclear plant** and **cooperate on nuclear technology transfers**

"EDF, China Guangdong May Partner on South Africa Nuclear Plant"
– Bloomberg

CGNPG and the Vietnam Atomic Institution signed an MOU outlining their desire to **cooperate in developing nuclear power** and engaging in future **technology transfers**

"China Guangdong Nuclear signs MoU with Vietnam Atomic Energy Commission"
– International Resource News

SOURCE: Literature research, McKinsey analysis

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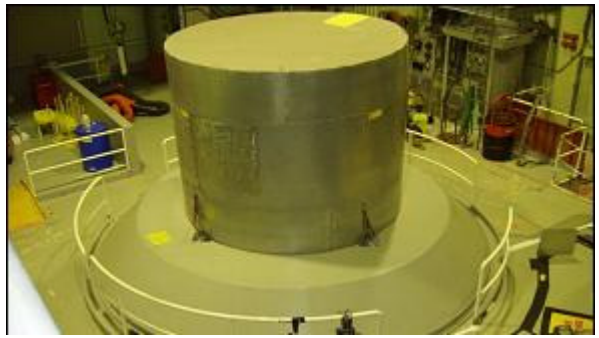

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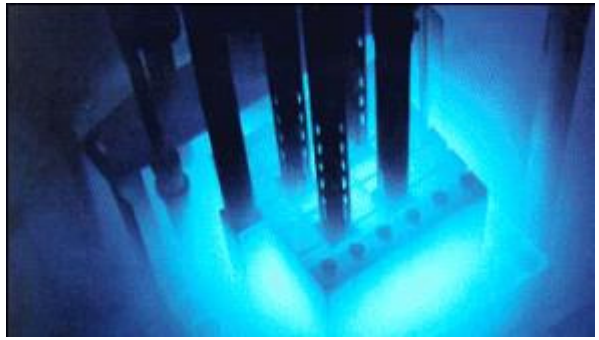

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