Nuclear Power in China

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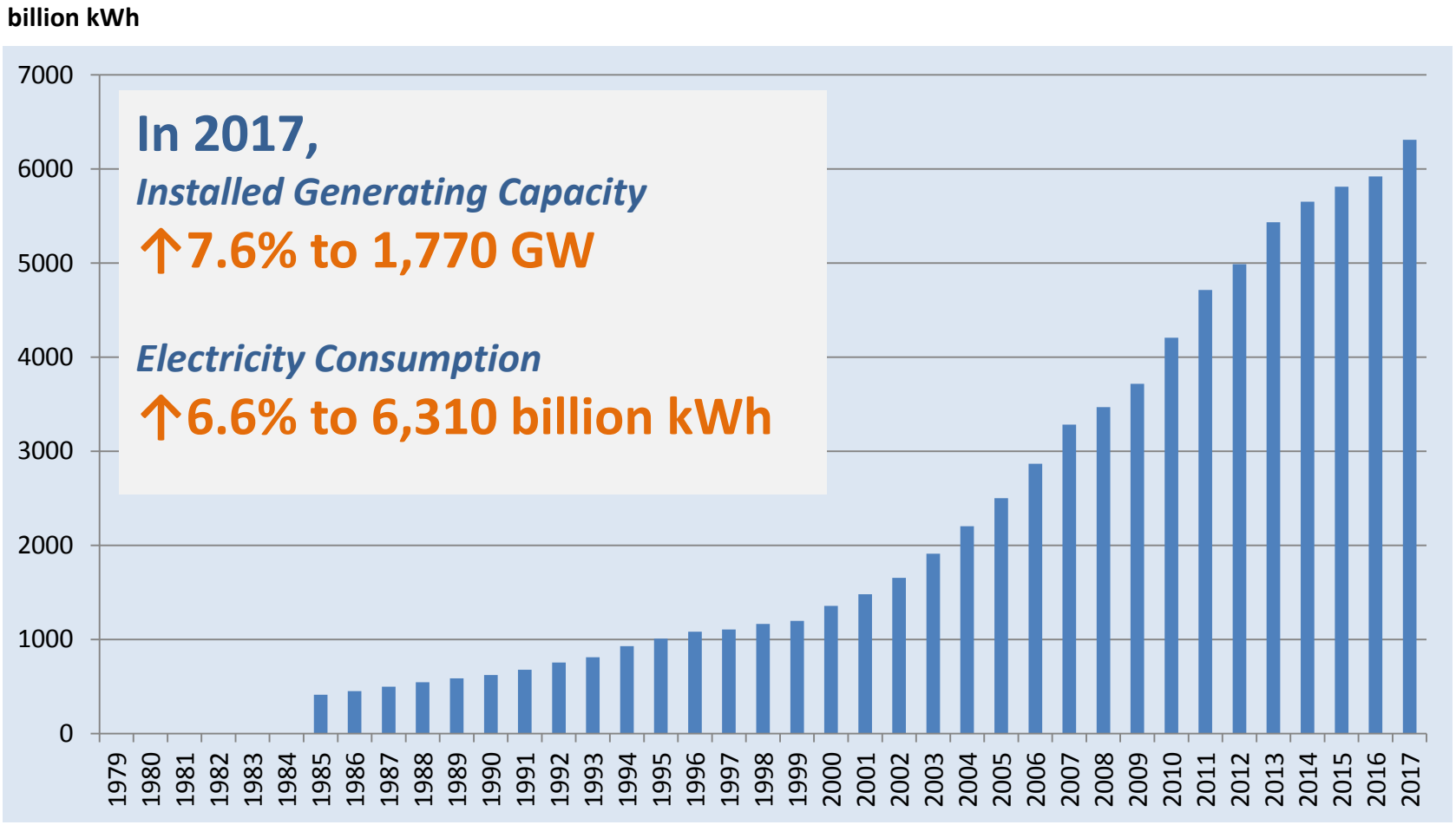
15 June 2018

Nuclear Power in China | Agenda

- Background
- Energy Policy of China
- The Nuclear Roadmap
  - From Import to Export
  - Nuclear Fuel Cycle
  - Public Acceptance – Post Fukushima
  - Future Outlook
- Nuclear Import of Hong Kong
- Q&A

Background I Ever Growing Electricity Demand in China



Source: BP 2016/National Energy Administration

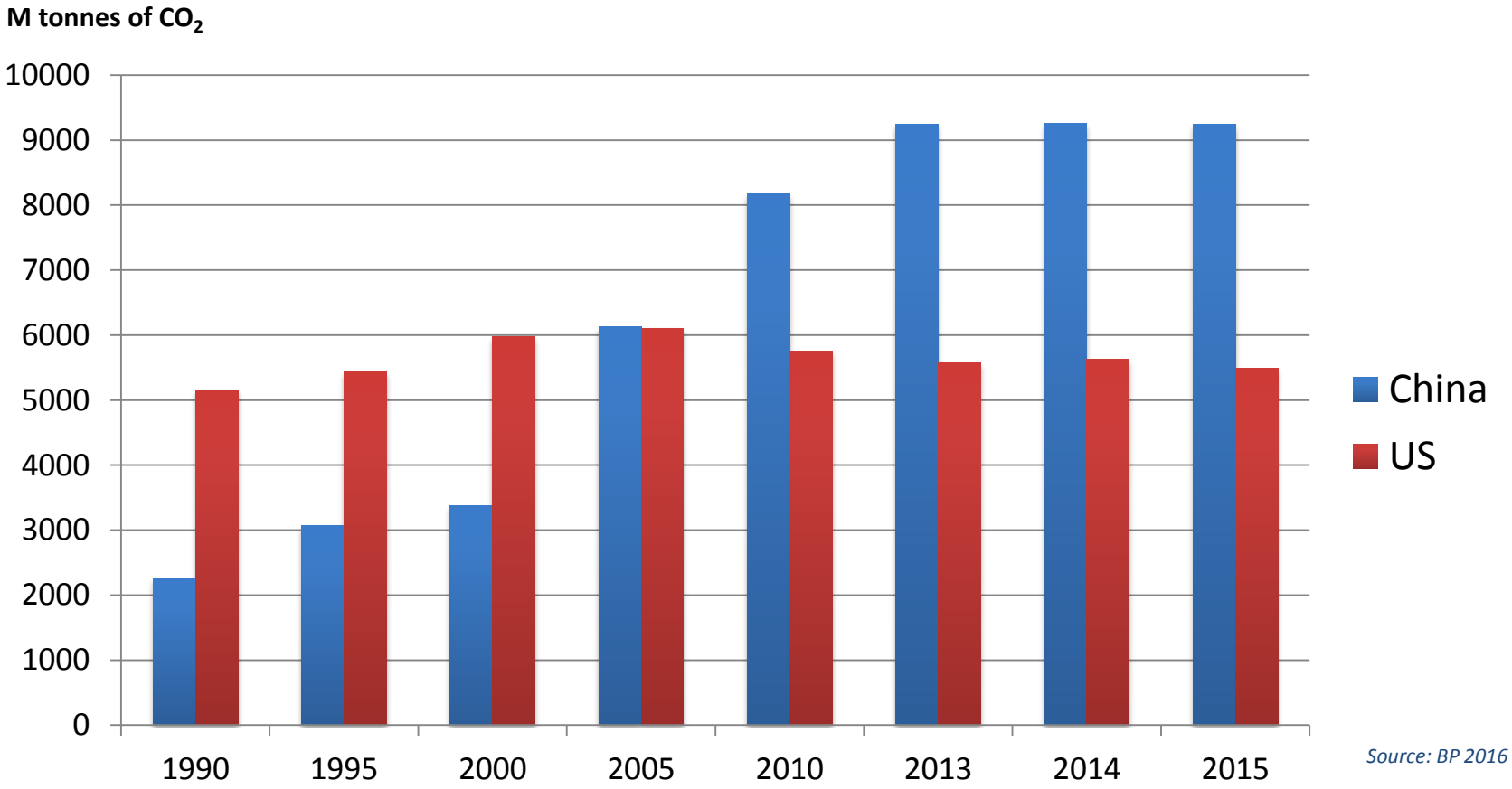
Background I Greenhouse Gas Emissions

China, the world's no. 2 economy, is also the largest CO_2 emitter in the world despite of a levelling-off in recent years

US EIA 2030 Projection

China 11,700 million tonnes

US 7,700 million tonnes



Source: BP 2016

Background I Pressing Problem of Air Pollution

Pollution shrouds the Forbidden City, Beijing

Tiananmen Square on a smoggy and a clearer day

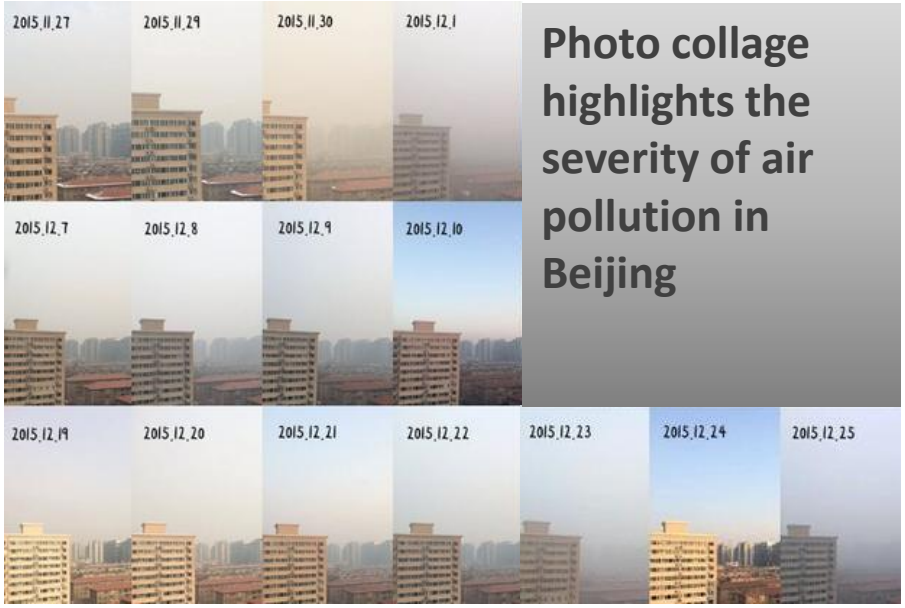


Photo collage highlights the severity of air pollution in Beijing

A smoggy day in Zhengzhou, Henan province

Photos: SCMP , GEONEWS

Background I China's Commitments in Combating Climate Change

COP22

Following the COP21 conference in Paris, COP22 agreed to take further actions and investment towards a low carbon, resilient and sustainable future

Consensus Achieved…

Target to keep global temperature rise this century to well below 2°C relative to pre-industrial levels and to drive efforts to limit it to **1.5°C**

MARRAKECH 2016
COP22 | CMP12 | CMA1
UN CLIMATE CHANGE CONFERENCE

Photo: Washington Post

China's Commitments:

- Early ratification of the Paris Agreement to cut CO_2 emissions per unit GDP by 60%-65% from the 2005 level by 2030
- Pledged that its CO_2 emissions would peak "around 2030"

1 ENERGY POLICY OF CHINA

Energy Policy of China I Towards a Decarbonised Future

The 13th Five-year Plan (2016-2020) laid out the core objectives for China energy policy:

- Reduce CO_2 emissions per unit of GDP by 18% from 2015 levels by 2020
- Increase share of non-fossil energy in total primary energy consumption to 15% by 2020 and to 20% by 2030 (from 9.8% in 2013)

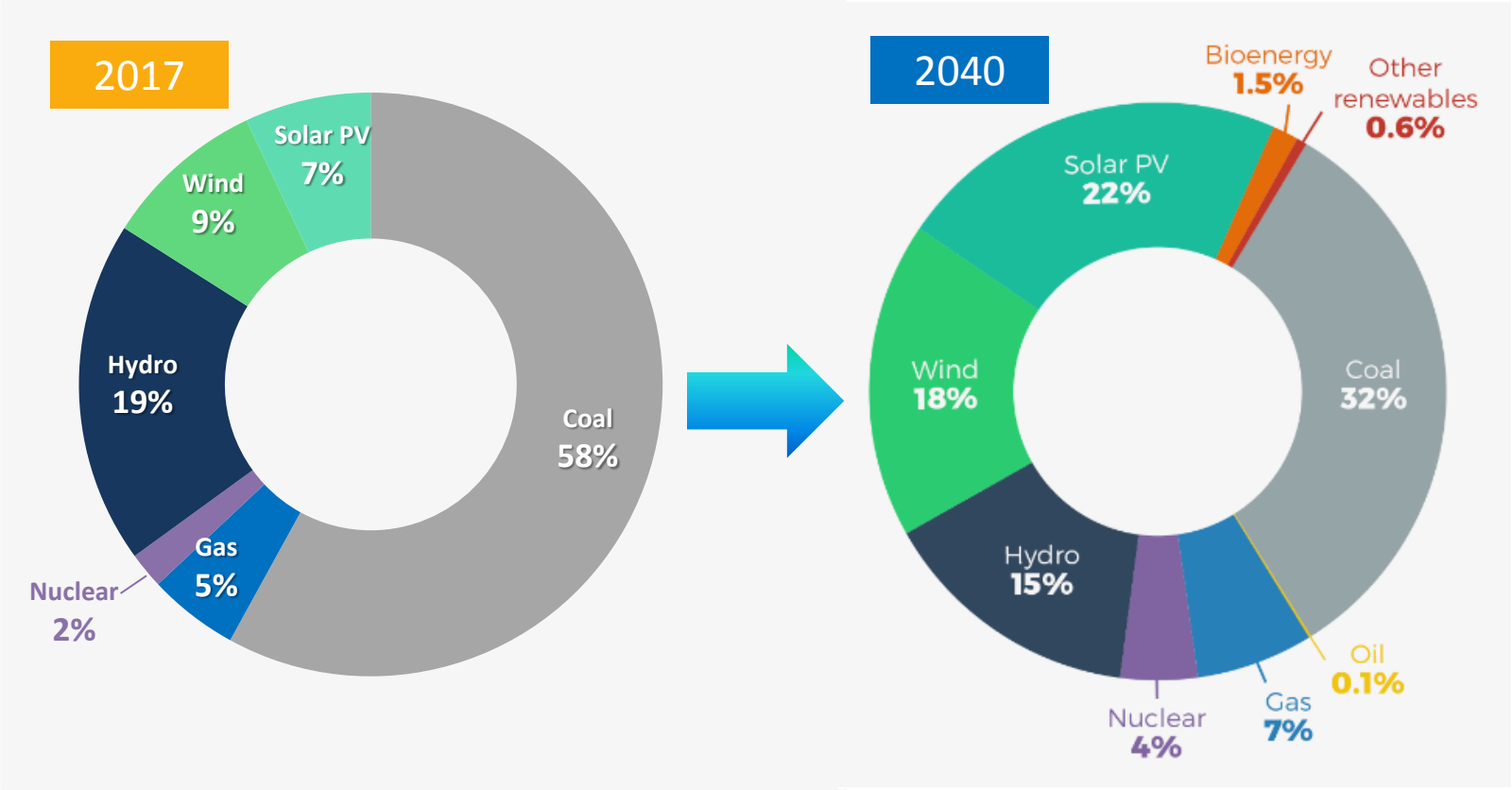
Major focuses on Nuclear Power Development

- Further develop advanced generation III nuclear power projects in coastal regions with the latest safety standards
- Continue to evaluate inland nuclear power projects
- Feasibility studies of commercial reprocessing plants
- Strengthen the fuel security system

Energy Policy of China I Towards a Decarbonised Future

- Announced target for nuclear by 2020: 58 GW in operation and 30 GW under construction

Installed Power Generation Capacity in China

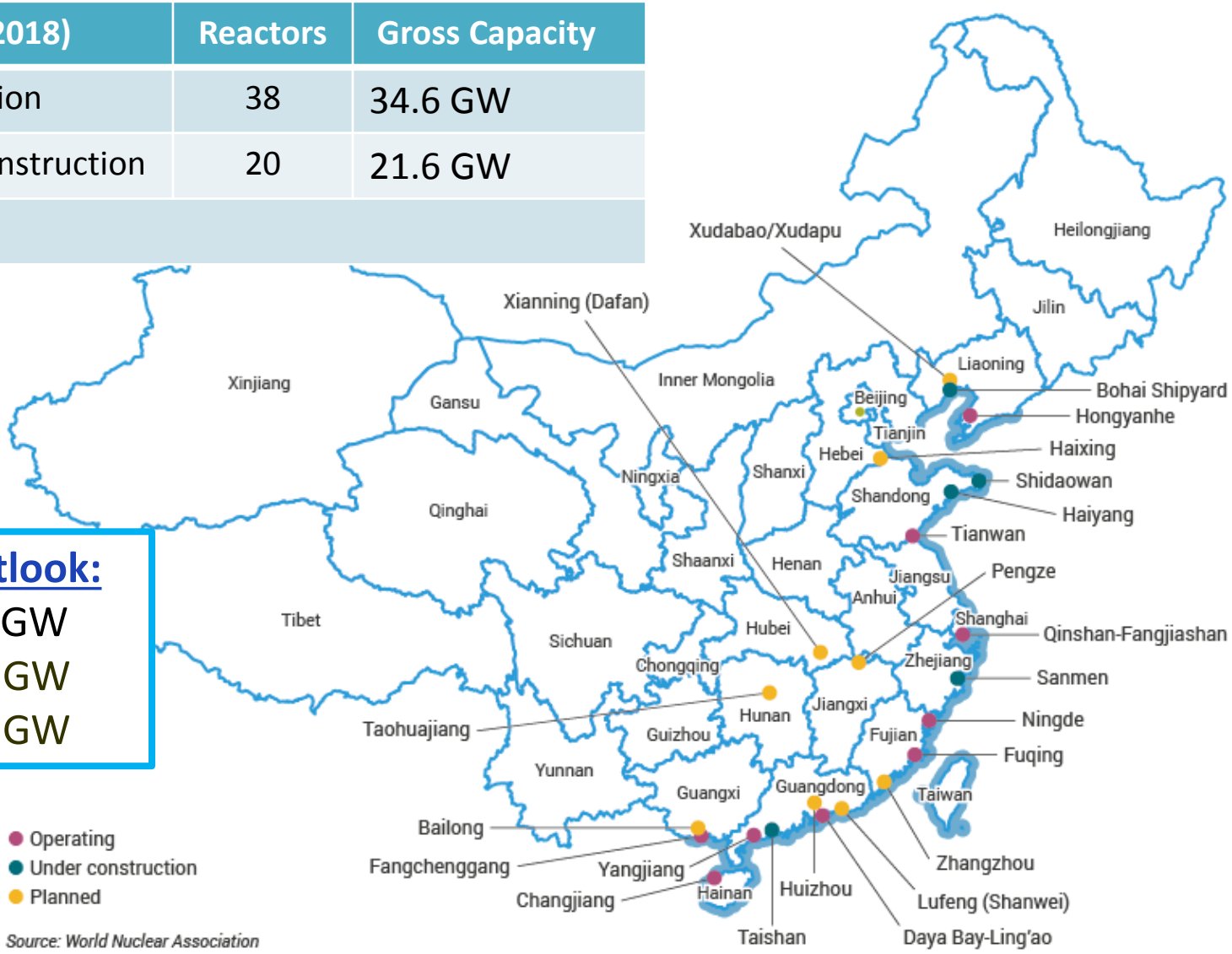


Sources: China Baogao, International Energy Agency

2 THE NUCLEAR ROADMAP
FROM IMPORT TO EXPORT

The Nuclear Roadmap | Distribution of Nuclear Power Stations

Status (May 2018)	Reactors	Gross Capacity
In Operation	38	34.6 GW
Under Construction	20	21.6 GW
Planned		



Source: World Nuclear Association

Future outlook:

2020: 58 GW

2030: 120 GW

2050: 300 GW

The Nuclear Roadmap | China's Reactors as at May 2018

Nuclear site	Province	Technology
Hongyanhe	Liaoning	4 x CPR1000 & 2 x ACPR1000 (M310)
Haiyang	Shandong	2 x AP1000
Shidaowan	Shandong	1 x HTGR (Rongcheng: 2 x CAP1400)
Tianwan	Jiangsu	2 x VVER + 2 x ACP1000 (M310)
Qinshan 1	Zhejiang	1 x CNP300
Qinshan 2	Zhejiang	4 x CNP600
Qinshan 3	Zhejiang	2 x CANDU
Fangjiashan	Zhejiang	2 x CNP1000 (M310)
Sanmen	Zhejiang	2 x AP1000
Ningde	Fujian	4 x CPR1000 (M310)
Fuqing	Fujian	4 x CNP1000 + 2 x HPR1000
Daya Bay	Guangdong	2 x M310
Lingao	Guangdong	2 x M310 + 2 x CPR1000
Taishan	Guangdong	2 x EPR
Yangjiang	Guangdong	4 x CPR1000 + 2 x ACPR1000
Fangchenggang	Guangxi	2 x CPR1000 + 2 x HPR1000
Changjiang	Hainan	2 x CNP600

The Nuclear Roadmap | The 3 Nuclear Power Groups in China

1. **China National Nuclear Corporation (CNNC)**

Reactor Models:
CNP, VVER, CANDU, AP, Hualong

2. **China General Nuclear Power Corporation (CGN)**

Reactor Models:
CPR, EPR, Hualong

3. **State Power Investment Corporation (SPIC)**

Reactor Models:
AP, CAP1400

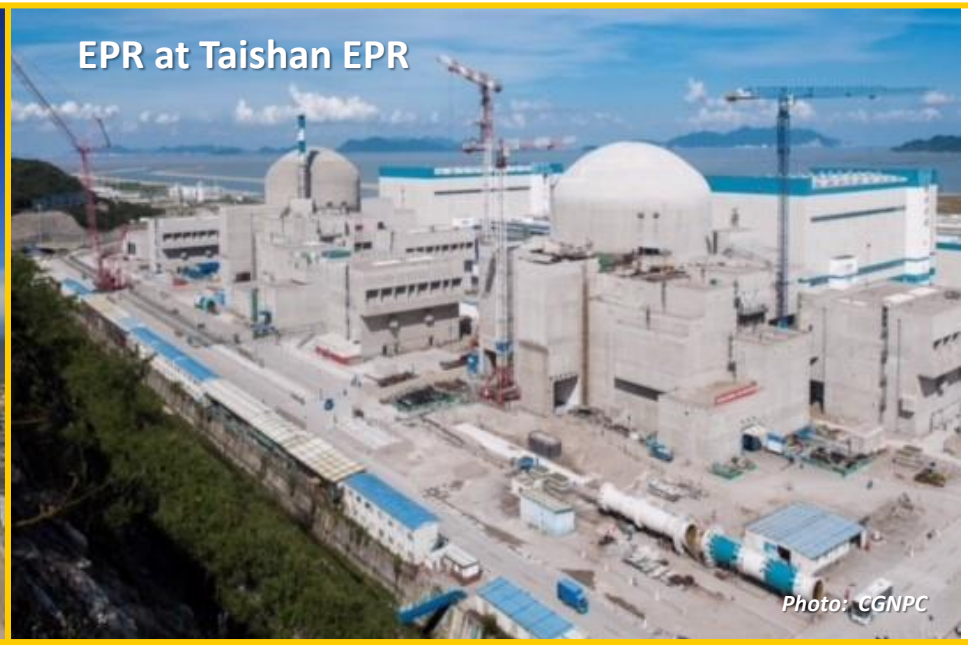
(SNPTC)

The Nuclear Roadmap l Three Stages of Development

- **1st stage: Rolling Development (early 1980s to mid 2000s)**
  - Qinshan I (CNNC): 1xCNP300 locally developed technology
    - → Qinshan II 2xCNP600
    - → Qinshan III 2xCANDU from Canada
  - Daya Bay: 2xM310 imported from Framatome, France
    - → Lingao
- **2nd stage: Active Development (late 2000s to 2011 Fukushima)**
  - 6-8 units a year
  - CPR or CNP (improved M310)
  - AP1000 + EPR + VVER
- **3rd stage: Safe and High Efficient Development (post-Fukushima)**
  - **Legacy G2+ projects only**

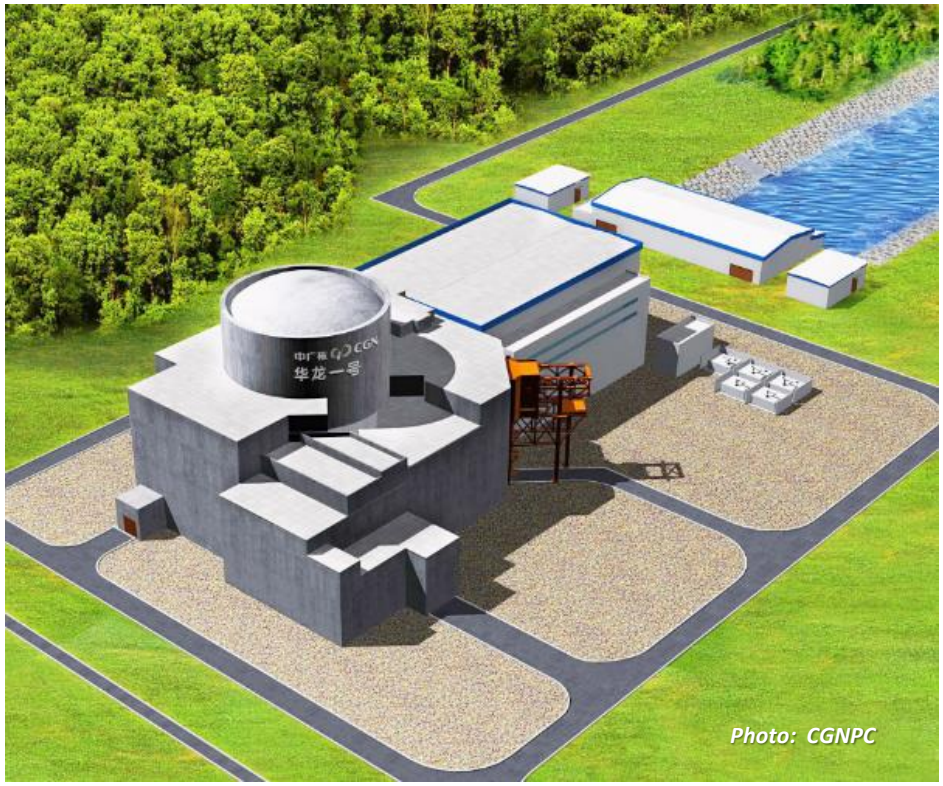
The Nuclear Roadmap l Generation 3 Technology

- Import of G3 technology from US/France in 2009 (AP1000/EPR)
  - Fuel loading at Taishan EPR and Sanmen AP1000 reactor in April 2018
- VVER from Russia at Tianwan, Jiangsu
- G3 technology at highest safety level since 2012 (post Fukushima)
- Domestic G3 design: Hualong 1(HPR1000) and CAP1400



The Nuclear Roadmap | Nuclear Export

- Over **50** operable nuclear reactors in the country by 2020
- Become largely **self-sufficient** in reactor design and construction, as well as other aspects of the fuel cycle, but is making full use of imported technology with adaptation and improvement
- **'Go Global'**
  - Export nuclear technology including heavy components in the supply chain
  - Over 40 countries along the Belt and Road have been or are planning to develop nuclear power



Hualong 1: HPR1000, China's first indigenous G3 nuclear reactor design

The Nuclear Roadmap l Advanced Reactors for the Future

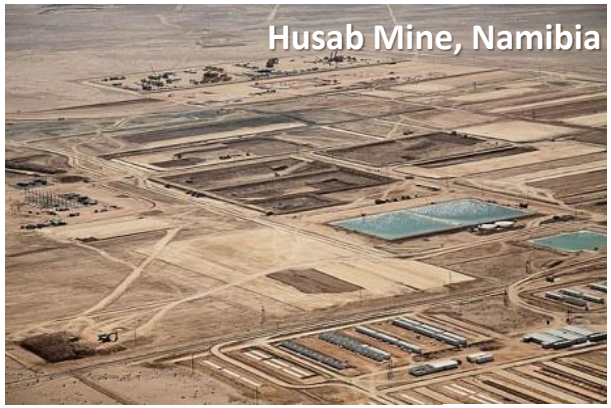
High Temperature Reactor	▪ One demonstration unit being built at Shidaowan (210 MW) – commissioning in 2019(?) ▪ Reactor composed of graphite "pebbles" containing enriched uranium ▪ Helium cooled under pressure at high temperature (>700°C) ▪ Effective reactor cooling after shutdown, even by natural circulation
Fast Neutron Reactor	▪ One experimental reactor built and tested at Beijing (25 MW) ▪ Enriched uranium (>20%) as fuel and liquid sodium for effective cooling ▪ Xiapu project (600MW) in Fujian commenced construction in end 2017 and expected COD in 2023

Photo: Ministry of Science and Technology, PRC

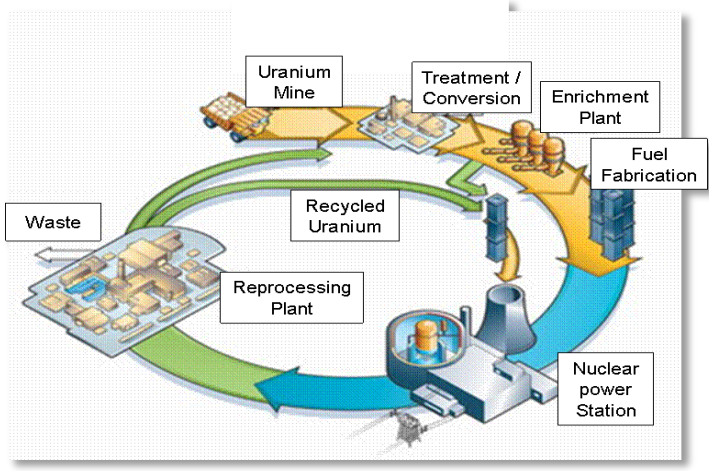
Photo: China Nuclear E&C Group

The Nuclear Roadmap I Nuclear Fuel Cycle

- **Uranium**
  - Overseas sources
    - ✓ Long-term contracts
    - ✓ Joint ventures in Kazakhstan
    - ✓ Husab mine in Namibia
  - Stockpiling



- **Conversion and enrichment facilities - localised**
- **Fuel fabrication**
  - Local facilities
  - Possible cooperation with Kazakhstan in future
- **Spent fuel reprocessing**
  - 50/60t demo plant in Gansu
  - Drawn out discussion with France on 800t commercial plant



The Nuclear Roadmap l Public Acceptance – Post Fukushima

- **Development of inland projects suspended**
  - Running out of coastal sites
  - Six units, may be more, for each existing site
    (Tianwan: 6xVVER + 2 ACP1000)

- **New fuel complex in Jiangmen Guangdong cancelled**
  - Conversion, enrichment and fabrication

- **Spent fuel plant in Lianyungang Jiangsu suspended**

- **Waste repository sites**
  - Regional

Anti-nuclear protest in Jiangmen, Guangdong in 2013

Anti-nuclear protest in Lianyungang, Jiangsu in 2016

The Nuclear Roadmap l Future Outlook

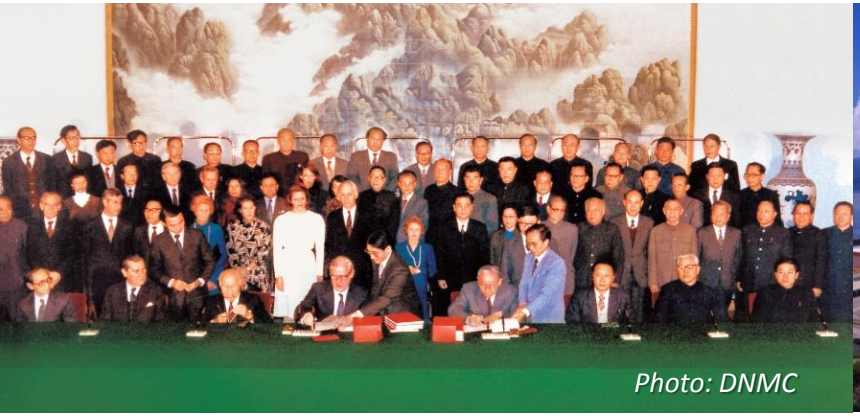
- **Official target by 2020**
  - 58 GW in operation and 30 GW under construction: UNLIKELY
- **Resume approval of new builds**
  - Commercial operation date (COD) of Sanmen 1
    - ✓ CAP1000 projects: Lufeng x 2 + Xudapu x 2 + Haiyang II x 2
    - ✓ CAP1400: Rongcheng x 2
  - Hualong One?
  - 6 to 8 units/year
- **By 2030**
  - 140 to 180 GW?
- **Hualong One for export**
  - COD of pilot units by 2021/22
  - Generic Design Assessment in UK by 2021/2022 → Bradwell B by mid-2020s
- **CAP1400 for export**
  - COD of Rongcheng units by mid 2020s

Photo: World Nuclear Association

BRB CGN EDF ENERGY

3 NUCLEAR IMPORT OF HONG KONG

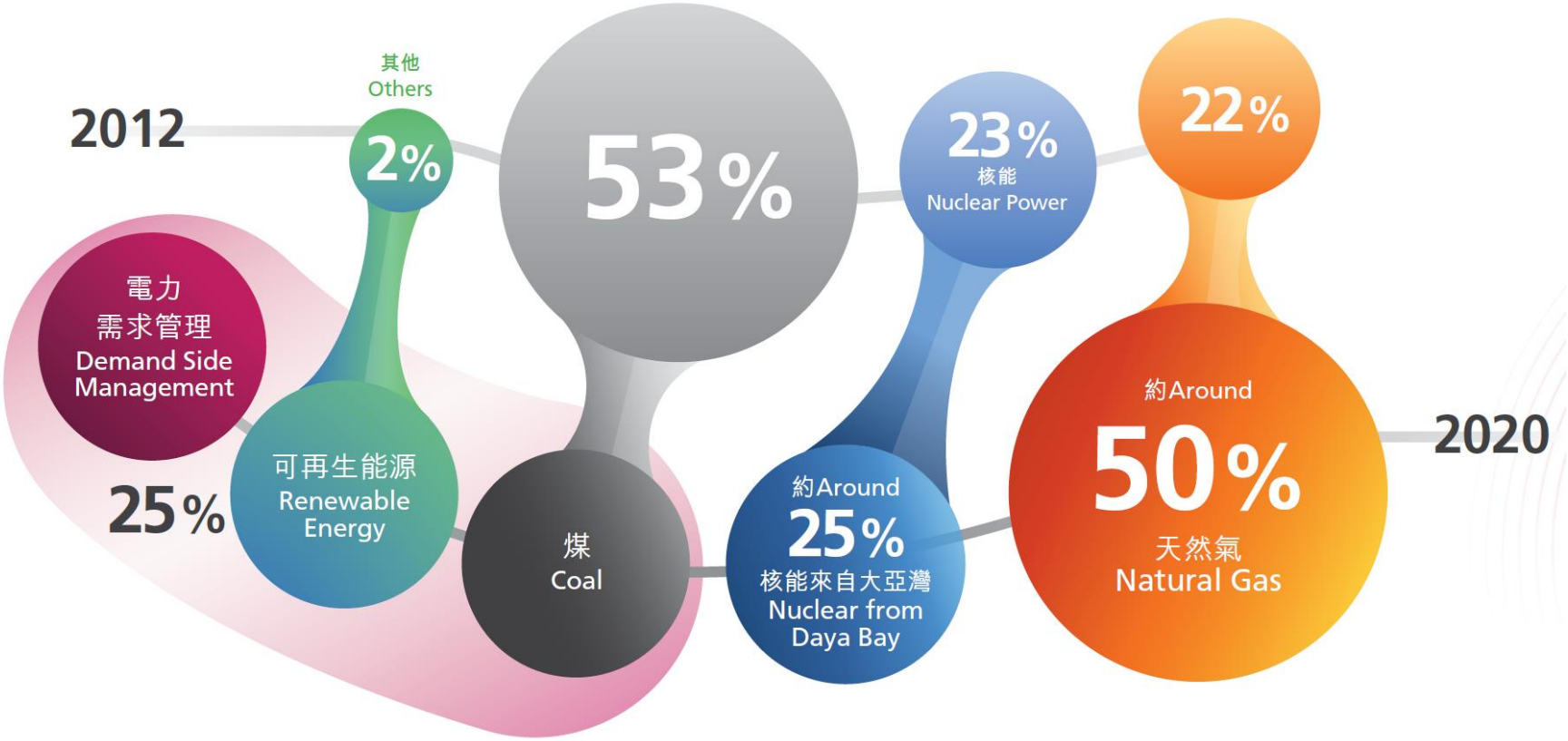
Nuclear Import of Hong Kong I Daya Bay Nuclear Power Station



- Daya Bay Nuclear Power Station is the first and the largest foreign investment since the launch of Open-door Policy in late 1970s/early 1980s
- Since 1994, nuclear power from Daya Bay has been safely supplying about **25%** of Hong Kong's electricity needs with excellent safety performance
- Daya Bay produces around **14 billion kWh** of electricity per year, of which **80%** is exported to Hong Kong
- Nuclear power forms the **base-load portion** of our electricity supply at very competitive price
- Import of nuclear power from Daya Bay **avoids 7.5 million tonnes of CO_2 emissions each year**, equivalent to planting a woodland area of 1/5 size of Hong Kong every year

Nuclear Import of Hong Kong | Future Fuel Mix

- Nuclear import will continue to account for **around 25% of the total fuel mix** for electricity generation in 2020



Questions & Answers


Thank You!