中广核 CGN

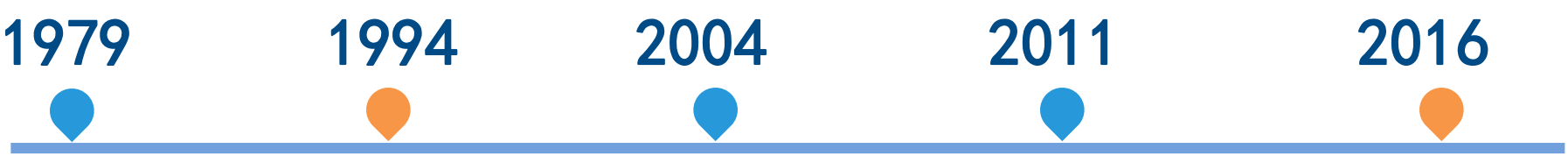
善用自然的能量
Natural Energy Powering Nature

# CGN’s Practice in Managing NPP Capital Expenditure Facing PF Environment in China

June 2017

# CONTENT

# CGN ' s History in NPP Business




## Starting

A breakthrough for business model in the planning economy via the Daya Bay NPP:

a. importing NPP from French counterparties
b. setting up a modern enterprise by joint venture, and
c. repaying the debts by selling the electricity through market driven mechanism

## Developing

- Daya Bay NPP put into operation
- LNPS I construction completed
- The localization realized

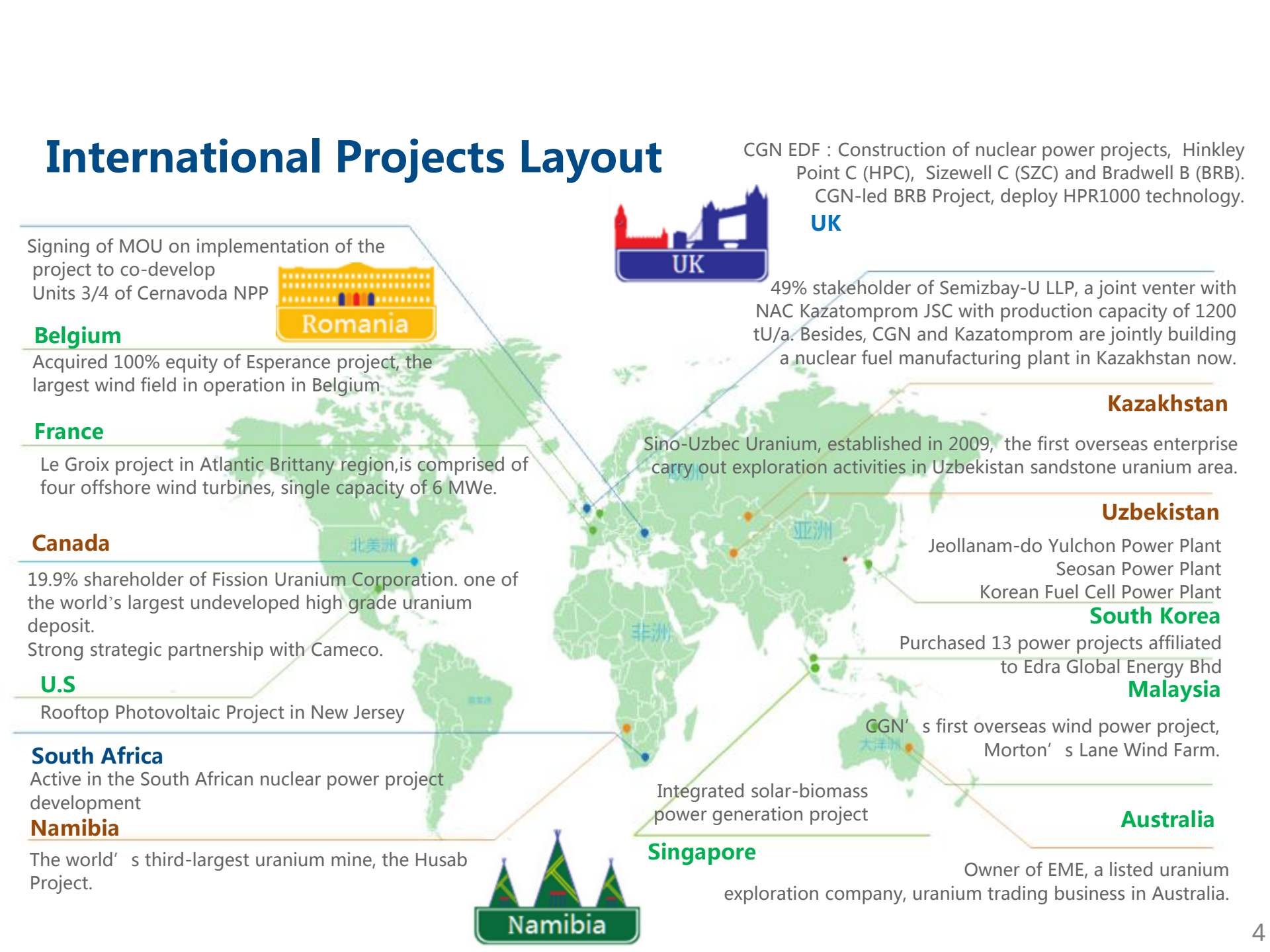
## Speeding up

Start and managing of construction of 18 units (16 CPR1000 units, and 2 EPR units)

## Innovation in Gen-III technology

- Developed HPR1000 technology
- Start of HPR1000 demonstration project construction in 2015, which is to be the reference power station of BRB project in UK

# International Projects Layout




CGN EDF : Construction of nuclear power projects, Hinkley Point C (HPC), Sizewell C (SZC) and Bradwell B (BRB). CGN-led BRB Project, deploy HPR1000 technology.

**UK**

Signing of MOU on implementation of the project to co-develop Units 3/4 of Cernavoda NPP

**Belgium**

Acquired 100% equity of Esperance project, the largest wind field in operation in Belgium

**France**

Le Groix project in Atlantic Brittany region,is comprised of four offshore wind turbines, single capacity of 6 MWe.

**Canada**

19.9% shareholder of Fission Uranium Corporation. one of the world's largest undeveloped high grade uranium deposit.
Strong strategic partnership with Cameco.

**U.S**

Rooftop Photovoltaic Project in New Jersey

**South Africa**

Active in the South African nuclear power project development

**Namibia**

The world' s third-largest uranium mine, the Husab Project.

49% stakeholder of Semizbay-U LLP, a joint venter with NAC Kazatomprom JSC with production capacity of 1200 tU/a. Besides, CGN and Kazatomprom are jointly building a nuclear fuel manufacturing plant in Kazakhstan now.

**Kazakhstan**

Sino-Uzbec Uranium, established in 2009, the first overseas enterprise carry out exploration activities in Uzbekistan sandstone uranium area.

**Uzbekistan**

Jeollanam-do Yulchon Power Plant
Seosan Power Plant
Korean Fuel Cell Power Plant

**South Korea**

Purchased 13 power projects affiliated to Edra Global Energy Bhd

**Malaysia**

CGN' s first overseas wind power project, Morton' s Lane Wind Farm.

**Australia**

Owner of EME, a listed uranium exploration company, uranium trading business in Australia.

Integrated solar-biomass power generation project

**Singapore**

# CGN Nuclear Power Business: Largest operator in China, and largest contractor in the world

As of the end of 2016

**x20** **21.46GW** 63.83% domestically

**Units in operation**

**x8** **10.26GW** 15.5% globally

**Units under construction**


## Standardized and centralized NPP operation services

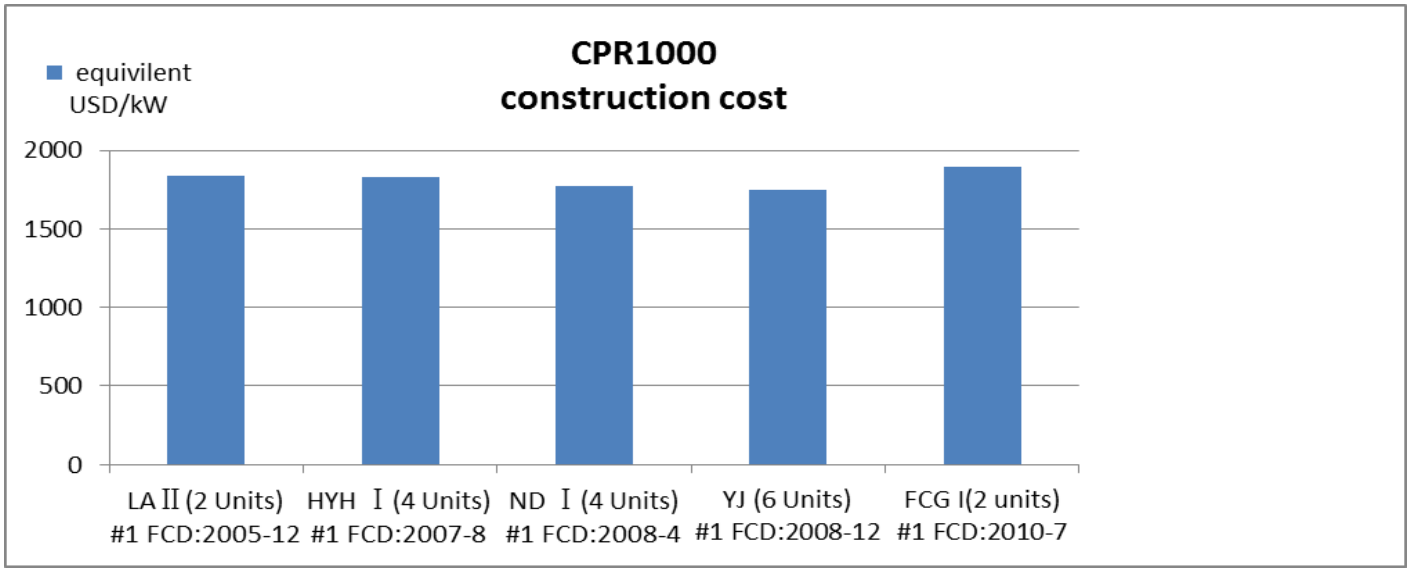
- operation & maintenance
- outage & equipment lifetime management
- spare parts
- training
- fuel management

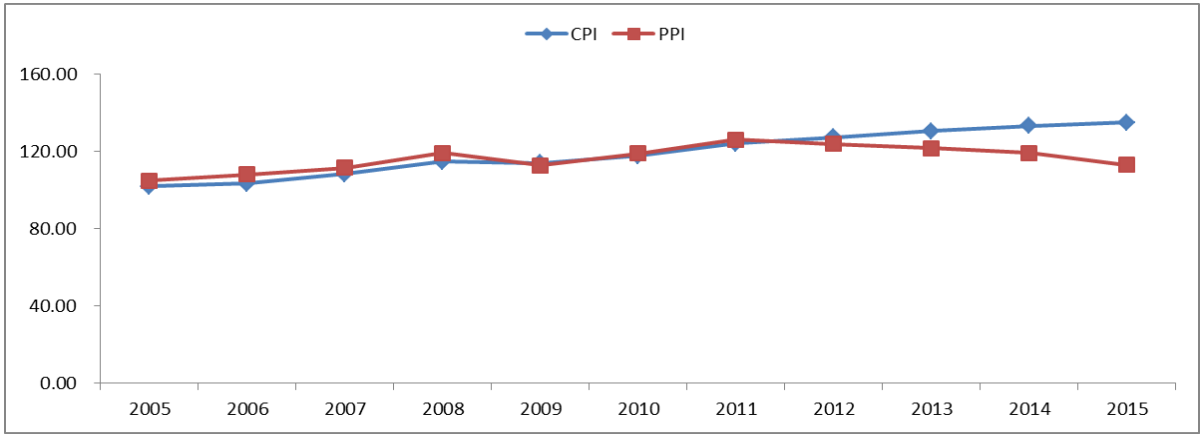
## Specialized nuclear power EPC

- design & engineering
- procurement
- Civil work and erection
- Commissioning

# A Brief of CGN's NPP Construction Cost

Despite the growing CPI&PPI, the construction costs stay flat in general.




CPI and PPI during past 10 years.

PPI increased by 13% ,
CPI increased by 35%.

# CONTENT

# SOME MAJOR CHALLENGES FACING PF IN CHINA

1. After the Fukushima accident, Chinese government issued **new policies and new regulatory safety requirements** on development of nuclear power industry (same with international standards and practices ).
2. The relevant regulators **upgraded the safety and quality regulations** on assessment, approval, and supervision of nuclear power projects and the qualification of relevant builders and manufacturers (such as issuance of public evaluation and surveillance policy, enhanced management on the quality certification or license, etc.).
3. Chinese government improved legislation and surveillance on **environmental protection.**
4. China's electric power system has been pushed into **restructuring and market-oriented reform** since 2015.

# CGN’s COUNTERMEASURES

## 1. Innovation in Gen-III Technology—HPR1000

The HPR1000 technology satisfying the higher safety requirements of international standards with reasonable costs.

### Safety

| Items | HPR1000 | URD | EUR |
|---|---|---|---|
| Core Damage Frequency/(reactor·year) | $6.9\times10^{-7}$ | $<1\times10^{-5}$ | $<1\times10^{-5}$ |
| Large Radioactive Release Frequency/(reactor·year) | $7.3\times10^{-8}$ | $<1\times10^{-6}$ | $<1\times10^{-6}$ |
| Fuel Thermal Margin | >15% | >15% | >15% |
| Safe Shutdown Earthquake | 0.3g | 0.3g | 0.25g |
| Operator Grace Time | ≥30 min | ≥30 min | ≥30 min |

- Single unit provides better physical separation.
- Three-train physically separated and independent safety systems ensure high redundancy.
- Double-containment resists large airplane crash.
- Emergency Power system protects the unit from blackout accident.
- Safety equipment/systems are designed upon the feedback from Fukushima accident.

### Economy

Design & Engineering
- Advanced design concept
- Designed life span — 60 years
- Refueling cycle — 12-24 months
- Designed availability factor — greater than 90%

Construction
- Short construction duration — 62 months
- Optimized project management system for schedule, quality and cost

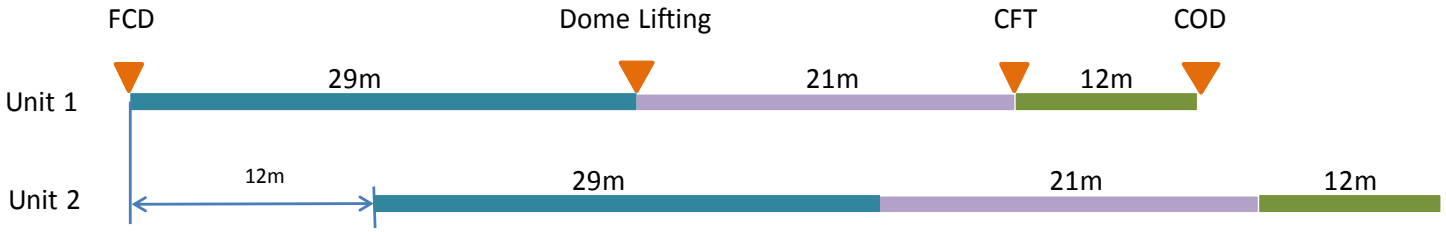
Operation & Maintenance
- Reliable and high efficient NPP operation management
- Optimal fuel cycle and outage arrangement — 12-24 months fuel cycle
- Multiple reactor management

# HPR1000 Demonstration Project-FCG II NPP

**FCG II NPP is the first HRP1000 project of CGN and to be the reference project of BRB.**

# HPR1000 Demonstration Project-FCG II NPP

**Scheduled construction duration of FCG II is expected to be within 62 months.**




#1NI CW：started in December 2015, Dome Lifting scheduled within the first half of the year 2018

#2 NI CW：Started in December 2016

# CGN’s COUNTERMEASURES

## 2. Design Optimization

The following 24 items to be optimized to increase the economical efficiency of HPR1000 based on the technical schemes and experience of FCG II NPP.

| Item | NO. | Optimization | Item | NO. | Optimization |
|---|---|---|---|---|---|
| Main Parameters & Main Equipment | 1 | Main parameters optimization | Radiation shield & waste disposal ( standard design optimization ) | 13 | TEG exhaust gas disposal system optimization |
| | 2 | Optimization and self-design of SG | | 14 | Source item design optimization |
| | 3 | CRDM optimization | | 15 | Radiation shield design optimization |
| Process System ( standard design optimization ) | 4 | SBO diesel configuration optimization | Civil works & layout ( site optimization ) | 16 | Water intake system and pump station optimization |
| | 5 | IVR core injection improvement | | 17 | Reactor building optimization |
| | 6 | Extra Cooling System ( ECS ) configuration optimization | | 18 | Safety building optimization |
| | 7 | Cold chain configuration optimization | | 19 | Fuel building optimization |
| | 8 | Safety cooling system ( DEL ) optimization | | 20 | nuclear auxiliary building optimization |
| | 9 | Emergency boronation system ( RBS ) configuration optimization | | 21 | BWX building layout optimization |
| | 10 | Safety injection ( RIS/RHR ) temperature optimization | Electrics & I&C ( standard design optimization ) | 22 | DCS inter-cabinet cable optimization |
| | 11 | Post-accident exhaust system optimization | | 23 | Remote I/O field bus technology application |
| | 12 | High density storage of spent fuel | | 24 | DCS level 2 digital platform optimization |

# CGN’s COUNTERMEASURES

## 3. Design Standardization

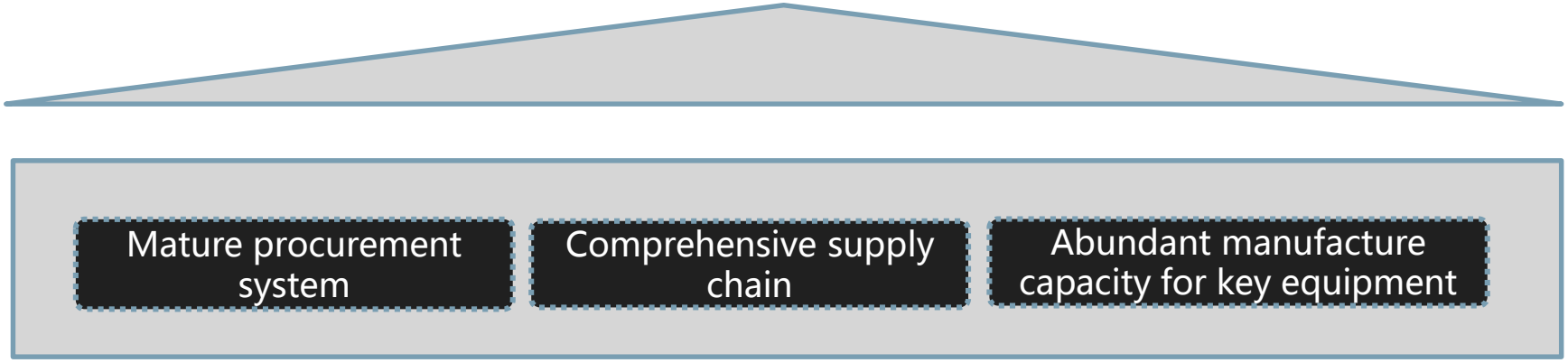
- Standard technical scheme for NI/CI/BOP
- Standard design platform
- Standard design organizational system
- Standard design output
- 3D design management system

1. **Efficient design process**
2. **Less site variation**
3. **Lower design cost**
4. **Effectiveness in batch construction**

# CGN’s COUNTERMEASURES

## 4. Centralized Procurement and Manufacture Management

- By promoting the competitiveness of procurement packages through upgrading the supply chain, over **93%** of all the procurement packages are competitive in HRP1000 Demonstration Project.
- CGN is currently cooperating with relevant equipment manufacturers in order to promote the competitiveness of the rest **7%** of procurement packages.

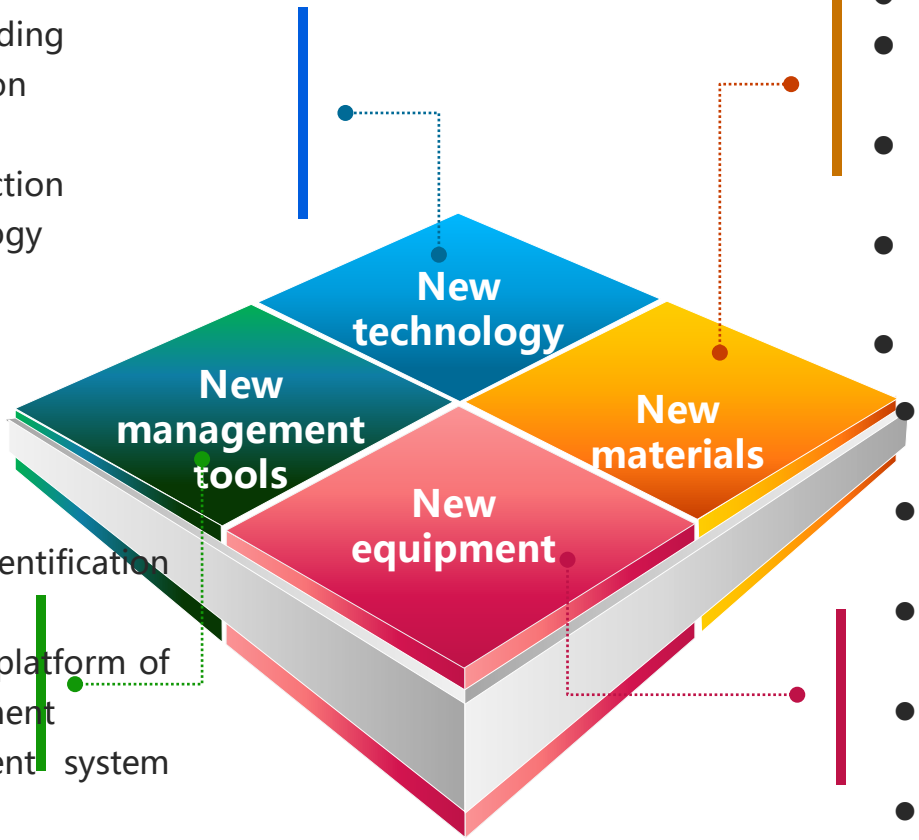


# CGN’s COUNTERMEASURES

## 5. New Technology application during Construction

Improving construction level and efficiency to shorten project duration and slash project cost through the four new measures:

- Main pipe automatic welding
- Steel lining modularization
- 3D measurement
- Digital radiograph inspection
- Hydraulic lifting technology
- ……




- Self-compacting concrete
- Stainless steel sink covering material
- Using general purpose portland cement
- New protective material for finished module
- ……

- Internet of things (IOT)
- Hidden danger identification system
- Software engineering platform of construction management
- Intelligent management system of field personnel
- ……

- Complete set of special tools for the main circuit
- Auto-reversing device for NI main equipment
- Special installments for in-service inspection
- Improved RPV insulating layer installation platform
- Auxiliary pipe installation robot
- ……

# CGN’s COUNTERMEASURES

## 6. CI Engineering and Procurement Optimization

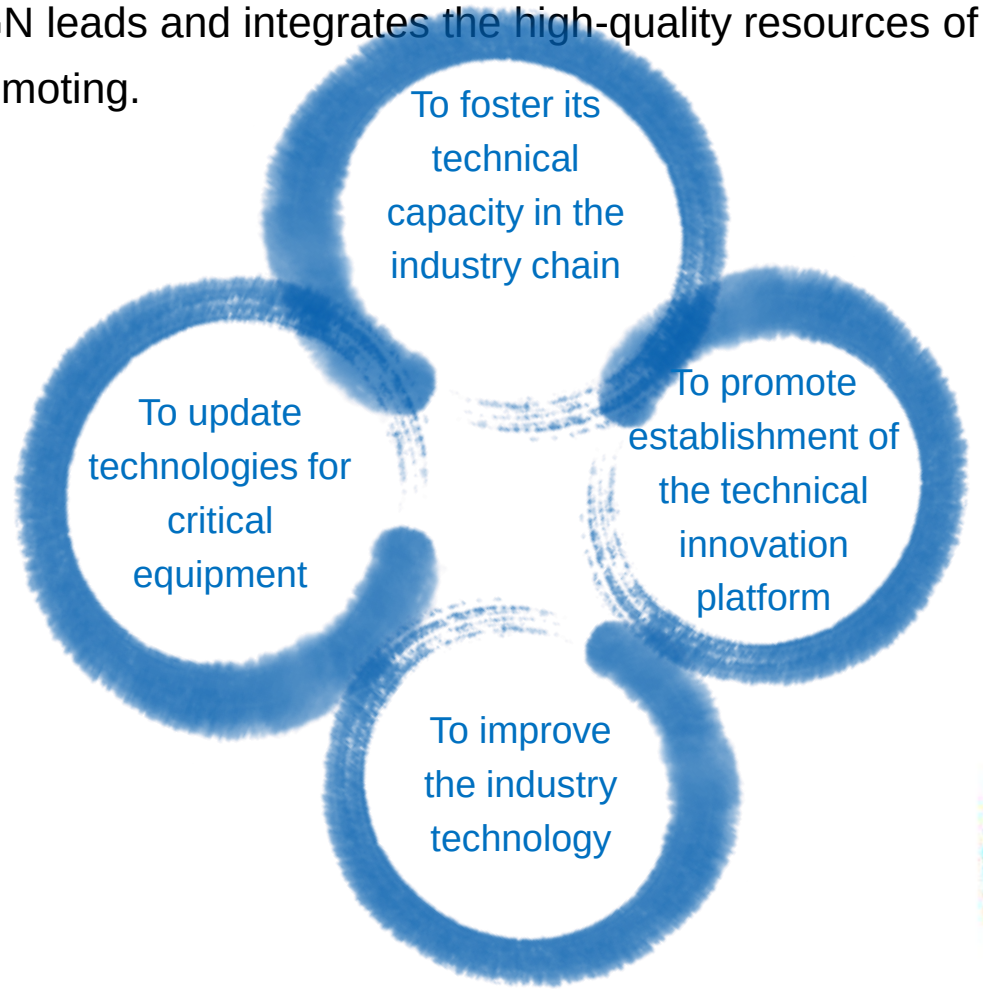
Through comparing with conventional power projects practices and taking the following optimization measures, CI construction duration and cost efficiencies are expected to be achieved substantially.

- Adjusting construction logic in the project programming and processing
- Optimizing design scheme
- Applying hierarchical control scheme throughout the contractors
- Optimizing procurement management
- Improving procurement on pricing based on standardized cost projection

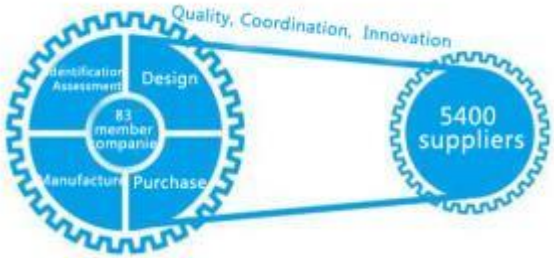
# CGN’s COUNTERMEASURES

## 7. Industrial Resources Integration

CGN leads and integrates the high-quality resources of the industry chain to guarantee project promoting.




CGN is building a nuclear power engineering "ecosphere", via cooperating with 87 core companies to jointly establish a research and development center for nuclear equipment, aiming to share resources to achieve common progress and accelerate development of 5400 suppliers.




哈尔滨电气集团公司 HARBIN ELECTRIC CORPORATION
中国一重 CFHI
NEC
DEC
上海电气 SHANGHAI ELECTRIC

# CGN’s COUNTERMEASURES

## 8. Efficient Communication with the National Regulators

CGN strictly follows the regulatory requirements of the state and actively communicates with the regulators to make the projects’ progress efficiently by actively meeting the regulatory safety and quality standards.

# CONTENT

01.A BRIEF OF CGN'S NPP CONSTRUCTION COST

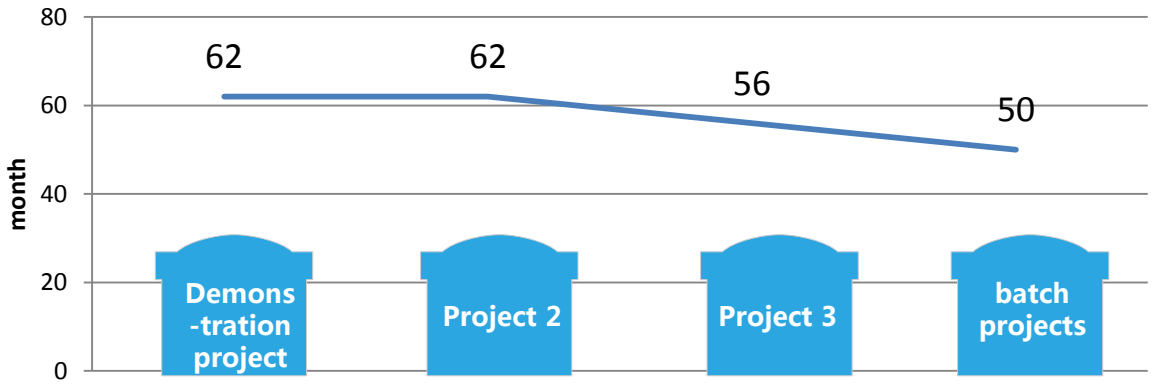
02.CHALLENGES AND COUNTERMEASURES FACING PF

03.EXPECTATION

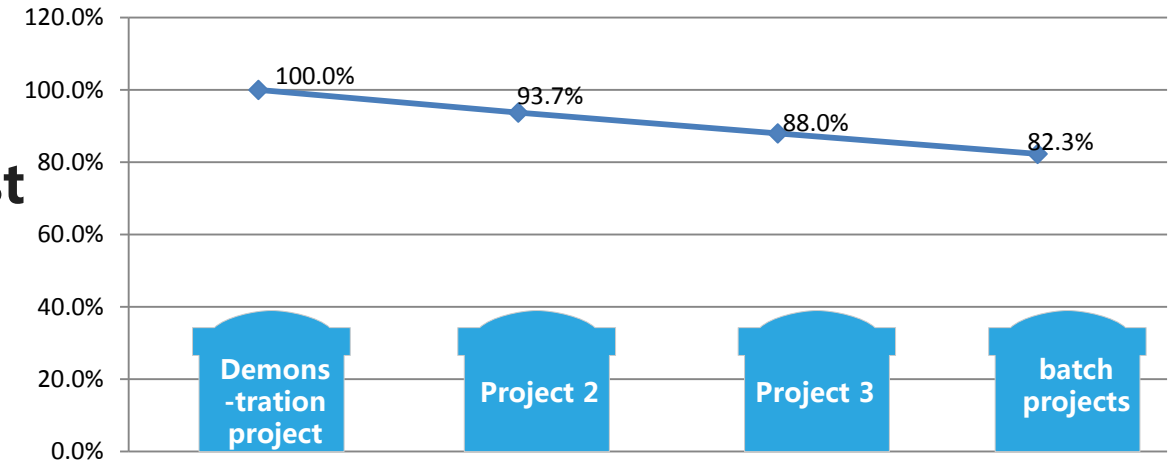
# EXPECTATION

## 1.On HPR1000 Projects

**Construction duration**



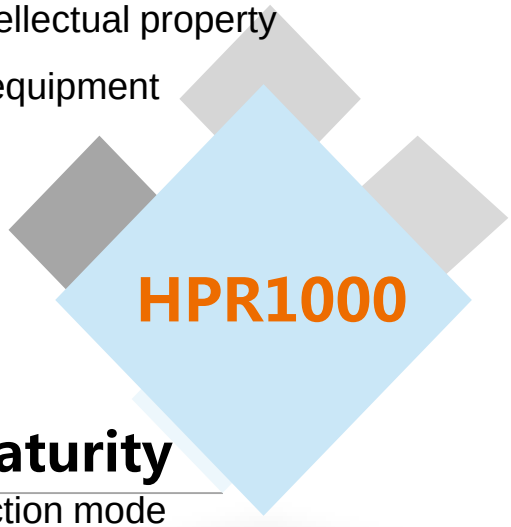

**Construction cost**



# EXPECTATION

## 2.Outlook for HRP1000

The safety , maturity and economy of HPR1000 has been preliminarily verified through the stage of R&D on its demonstration project construction, and to a comprehensive competitiveness, it is qualified for batch construction and "going abroad".




### Safety

- "3 independent trains of safety systems + passive systems"
- CDF < 1×10-6/reactor ·year 、LRF < 1×10-7/reactor ·year ,satisfy the highest safety standards

### Localization & intellectual property

- Owning complete independent intellectual property
- Realizing self-reliance for critical equipment manufacturing

### Economy

- It is expected the cost for batch-construct project shall be acceptable in terms of return on capital.

### Maturity

- High standardized batch construction mode
- 58-60 month batch construction period(expected to achieve 50-month)

# EXPECTATION
## 3.Overseas Market Potentials

**HPR1000 has started its application for EUR certification since April 2015 and for GDA (UK Generic Design Assessment) since October 2016. Potential clients who have shown interest in building HPR 1000 units are:**

中广核 CGN
Natural Energy Powering Nature

# THANK YOU