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KEY SUCCESS FACTORS FOR NPP CONSTRUCTION MANAGEMENT

KINGS KEPCO INTERNATIONAL NUCLEAR GRADUATE SCHOOL

01

General Information

PART One

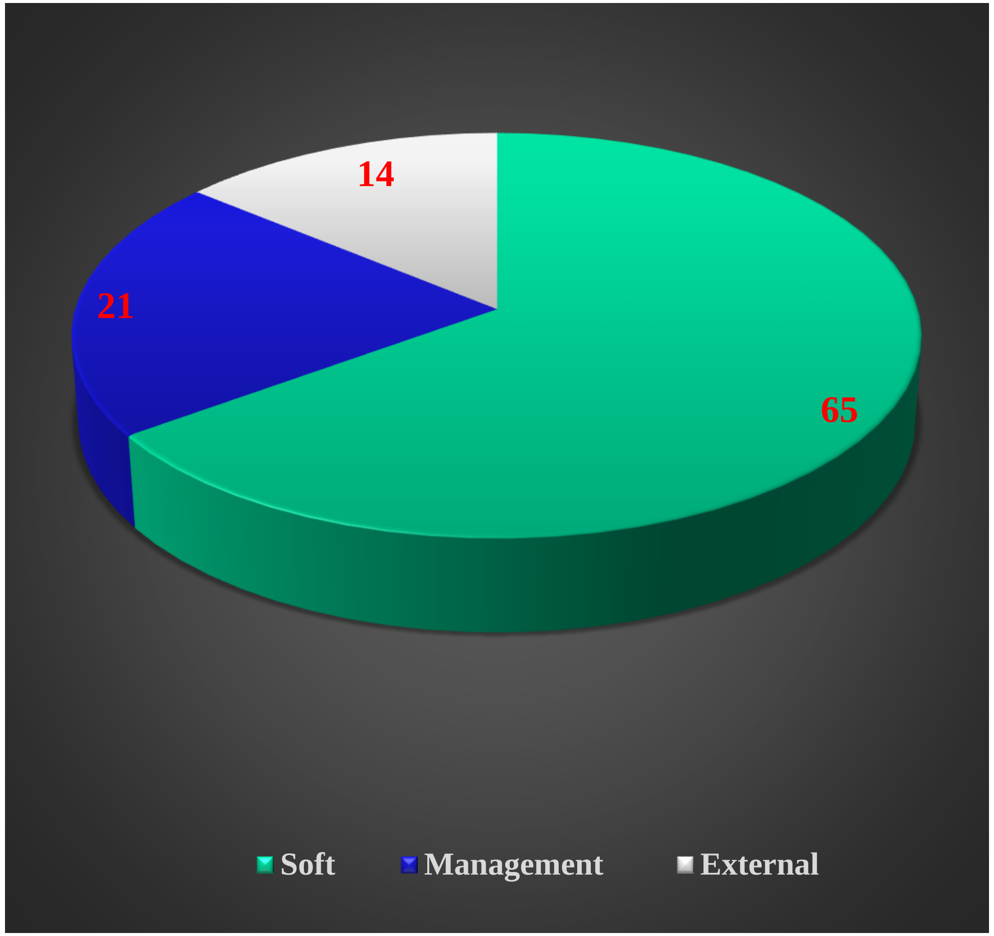
Large scale projects have a calamitous history of cost overrun

Project	Cost Overrun (%)	Project	Cost Overrun (%)
Suez Canal, Egypt	1900	Sydney Opera House, Australia	1400
Scottish Parliament Building, Scotland	1600	Montreal Summer Olympic, Canada	1300
Concorde Supersonic Aeroplane, UK, France	1100	Troy and Greenfield Railroad, USA	900
		Canadian Firearms registry, Canada,	590

3

Failure History

- 65% of project failures were due to softer aspects such as people, organization, governance.
- A further 21% were caused by management process and contracting and governance.
- 14% of the failure due to external factors such as government intervention and environment – related mandates



Three guiding questions

- **Are cost overruns and construction delays inevitable features of Nuclear New Build (NNB) ? ?**
- **Is there single model for Project management or Business model in NNB ?**
- **What are the conditions for more efficient global nuclear supply chain for NNB ?**

Focused on nuclear new build

What's Demanded

- Planned Construction Time
- Higher Quality
- Within Budget
- Localization and National Involvement

Need to Achieve

- Front-loaded Detailed Construction Engineering
- Perfect Construction Management
- Data Sharing & Technical Transfer Environment

Full Application of Construction IT

Construction Period

Categories	1970-1995 [month]	1996-Now [month]
Median	80	83 ~ more than 200
Minimum	41	47

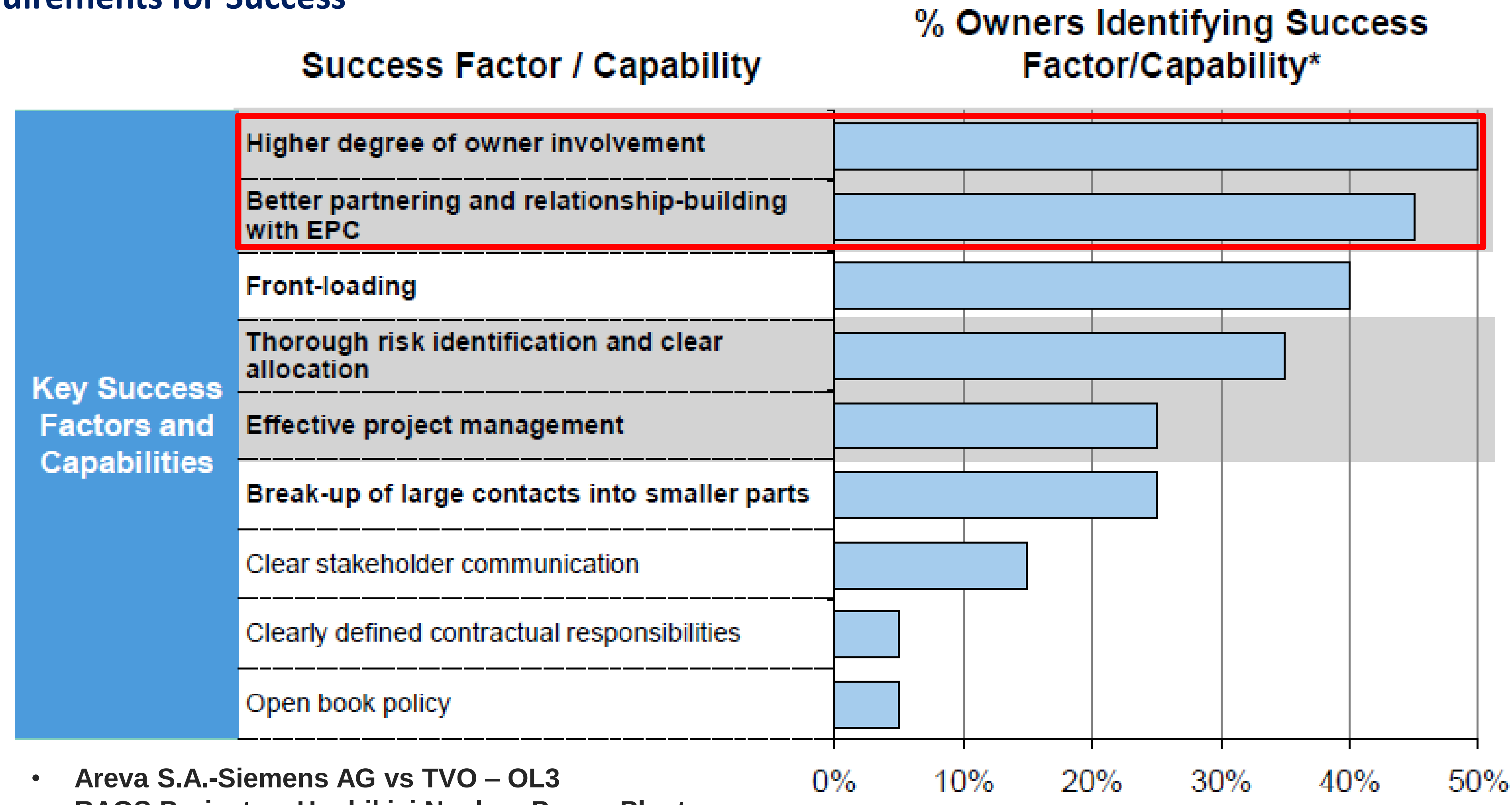
- Construction Schedule for 1350 MWe unit
  - From F/C to C/O : 62 → 49 Months
- Construction Schedule at 1000 MWe unit
  - From F/C to C/O : 64 → 47 Months

C/O: Commercial Operation

F/C : First concrete pouring

Owner Establishment

Owner Requirements for Success



- Areva S.A.-Siemens AG vs TVO – OL3
- RAOS Project vs Hanhikivi Nuclear Power Plant

02

Previous Construction Experiences

PART Two

After first Criticality (Atuch #2) in Argentina

Net Capacit
(PHWR KV

692 Mw_e

Constructio

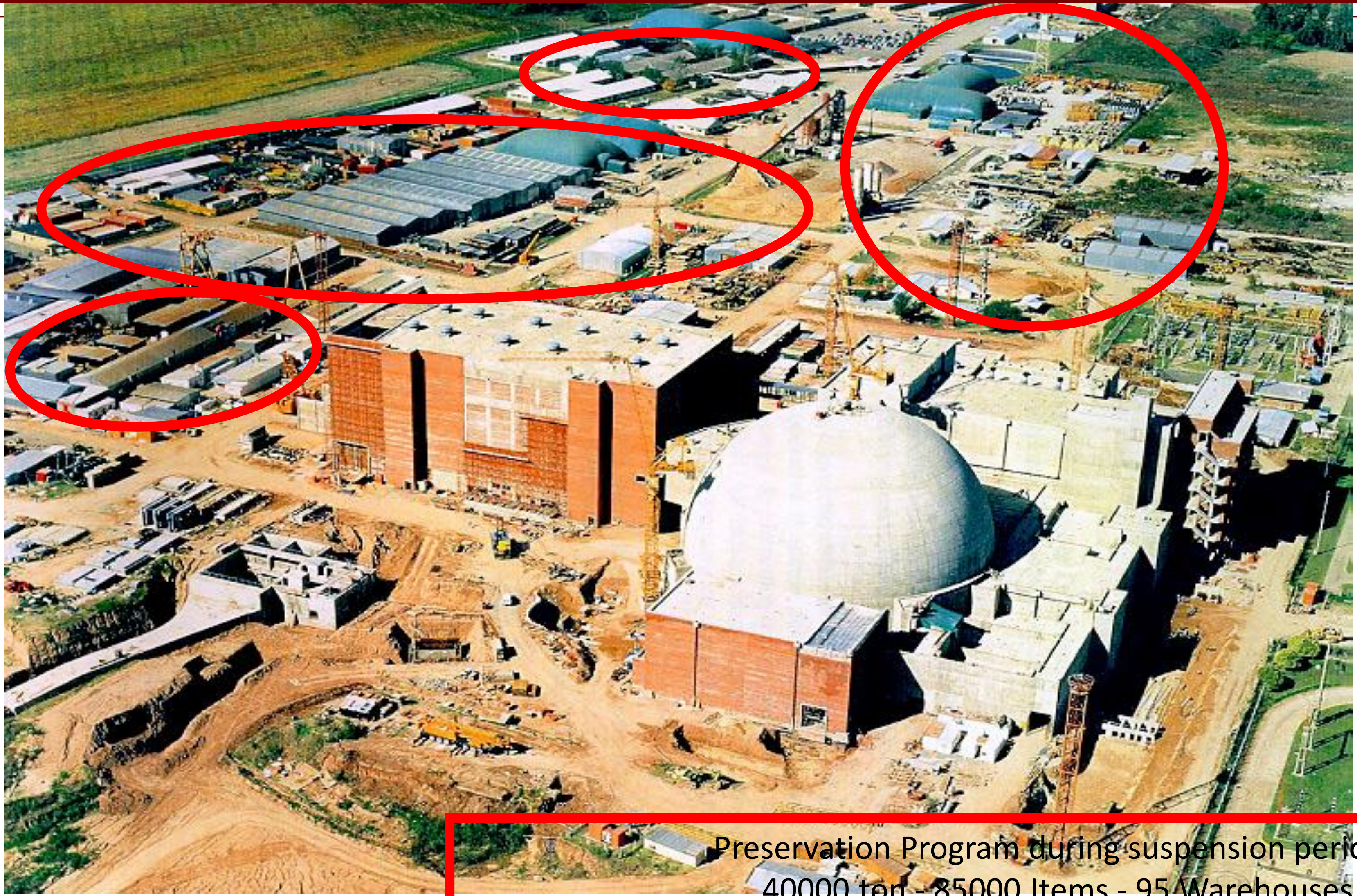
14 Jul, 198

First Grid C

27 Jun, 201

KINGS

Site Situation at the time of restarting the Project (2006) in Argentina



Preservation Program during suspension period
40000 ton - 85000 Items - 95 Warehouses

Angra 3 Npp in Brazil

- Began in 1984 but was suspended after two years.
- First concrete was poured in 2010. But stopped in 2015
- In 2022, Eletronuclear ordered construction to restart
- In April 2023 the city government ordered work to stop

Angra 3 Npp in Brazil

Preservation of Stored Components

In 2003 Photos

Bushehr 1 NPP

Unit Power VVER-446	Design Net Capacity	Gross Capacity	Thermal Capacity
915 MW_e	**915 MW_e**	**1000 MW_e**	**3000 MW_t**
Construction Start Date	First Criticality Date	Construction Suspension Date	Construction Restart Date
01 May, 1975	**08 May, 2011**	**01 Jan, 1978**	**01 Jan, 1996**
First Grid Connection	Commercial Operation Date		**17y 8m after resuming Construction**
03 Sep, 2011	**23 Sep, 2013**		

0 MW_{th}
7 MW_{el}
%

May 2008 : Start Hot Functional Tests
Aug. 2008 : First Fuel Loading
Nov. 2008 : First Criticality
April 2009 : Start Demo-Run

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December 2012, Areva estimated full cost would be about €8.5 billion, well over previous estimate of €6.4 billion , with commercial operation no earlier than 2018.

Cost overruns were considerable, rising from the original estimate of €3.9 billion, to a final cost of €11 billion, split between TVO and Areva.

April 2009 : Start Demo-Run → ***First 2022 : Start Demo-Run***

EPR construction status

EPR Taishan 1&2 (China)

- 2 × 1750 MW
- Construction began: 2009
- **Planned to go online in 2013**
- Commission date: June 2018
- Construction cost: 50.2 billion yuan (US$7.5 billion)

Taishan -1

Mid April :
Fuel arrival on site

April 10 :
Fuel Loading started <-> completed

Grid connection (June 28)

2017 → **2018**

August :
"Hot Functional Tests" completed

March :
"Hot Functional Tests" started

End March :
Regulators in charge of EPR licensing : NNSA+ASN+STUK+ONR
EPR owners : TNPJVC+EDF+TVO+NNB
EPR designer : AREVA

5 years delayed

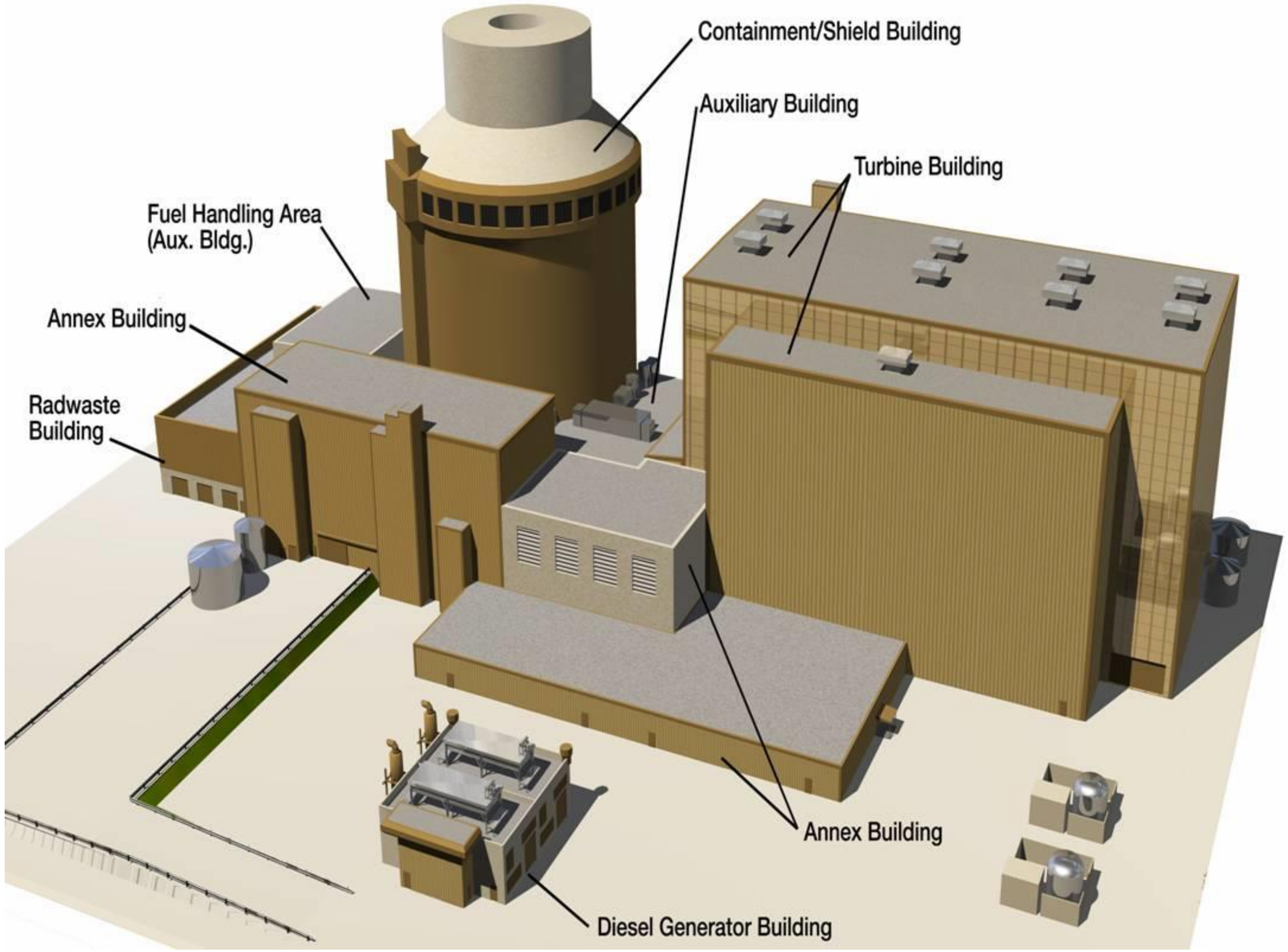
Taishan -2

1 year after Taishan-1

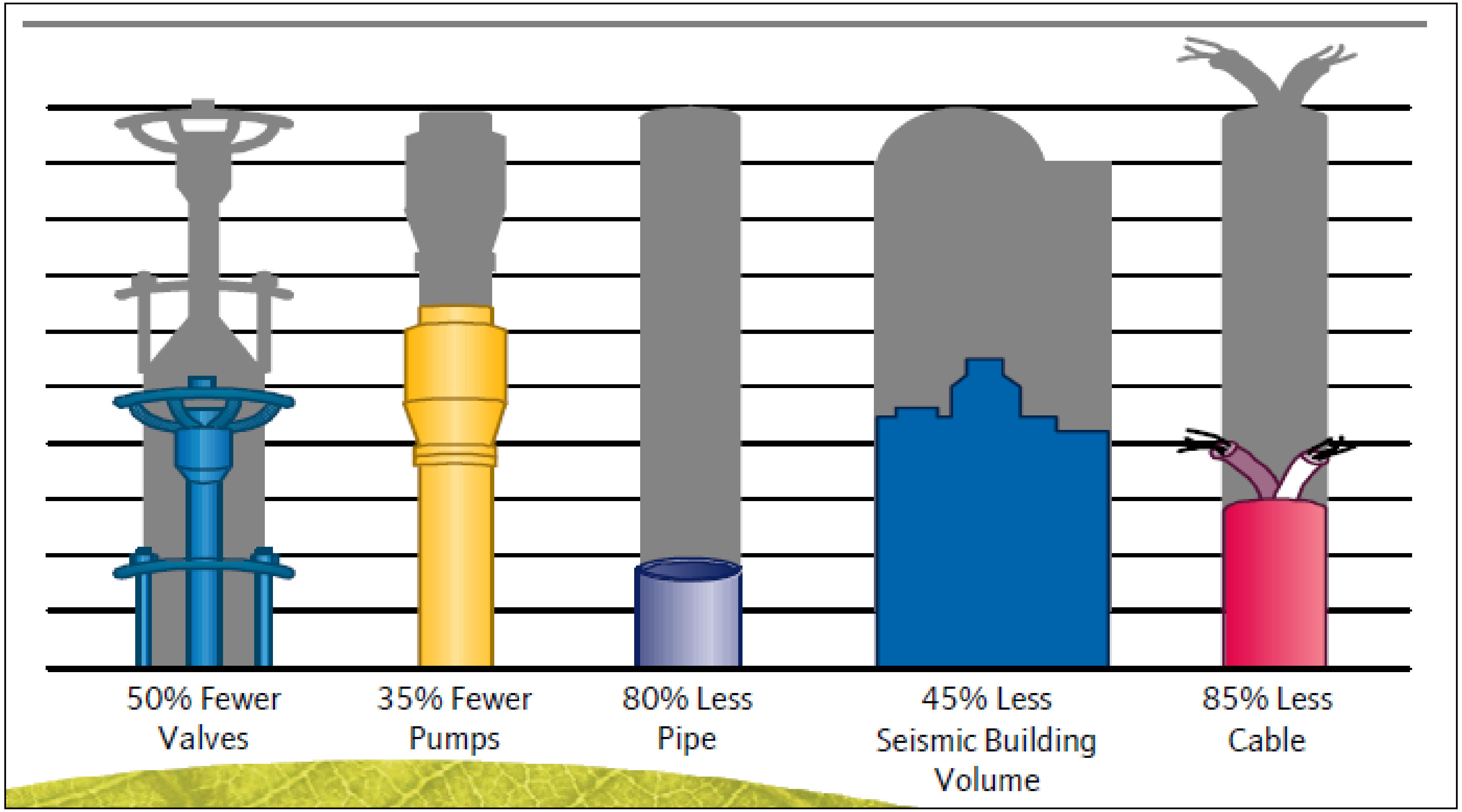
Westinghouse AP1000

A compact station

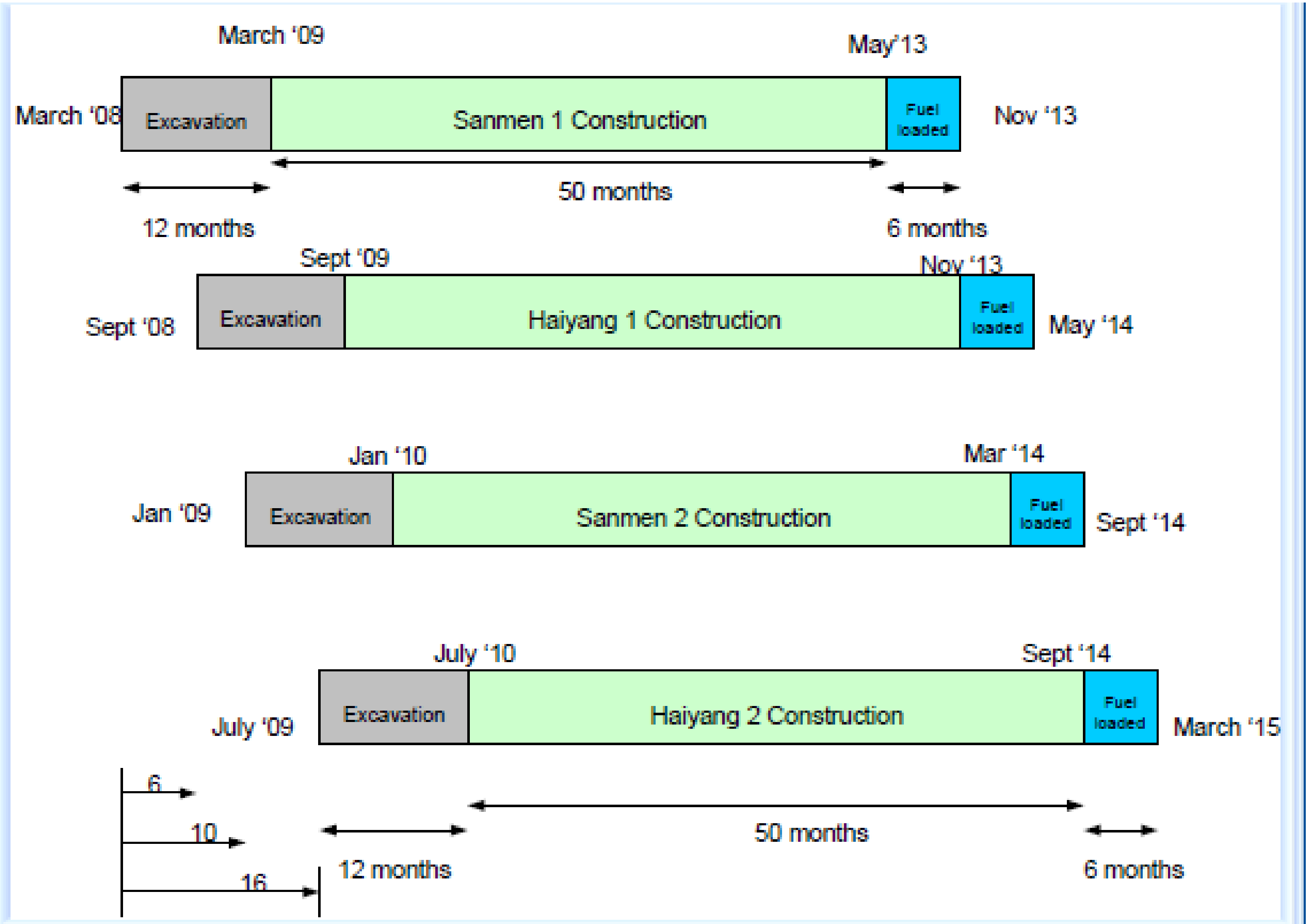
- **3415 MWt.**
- **1117 MWe**
- **2-loops, 2 SGs**



Reduced Components



Construction Duration – 56 Months
(China construction- Sammen/ Haiyang)



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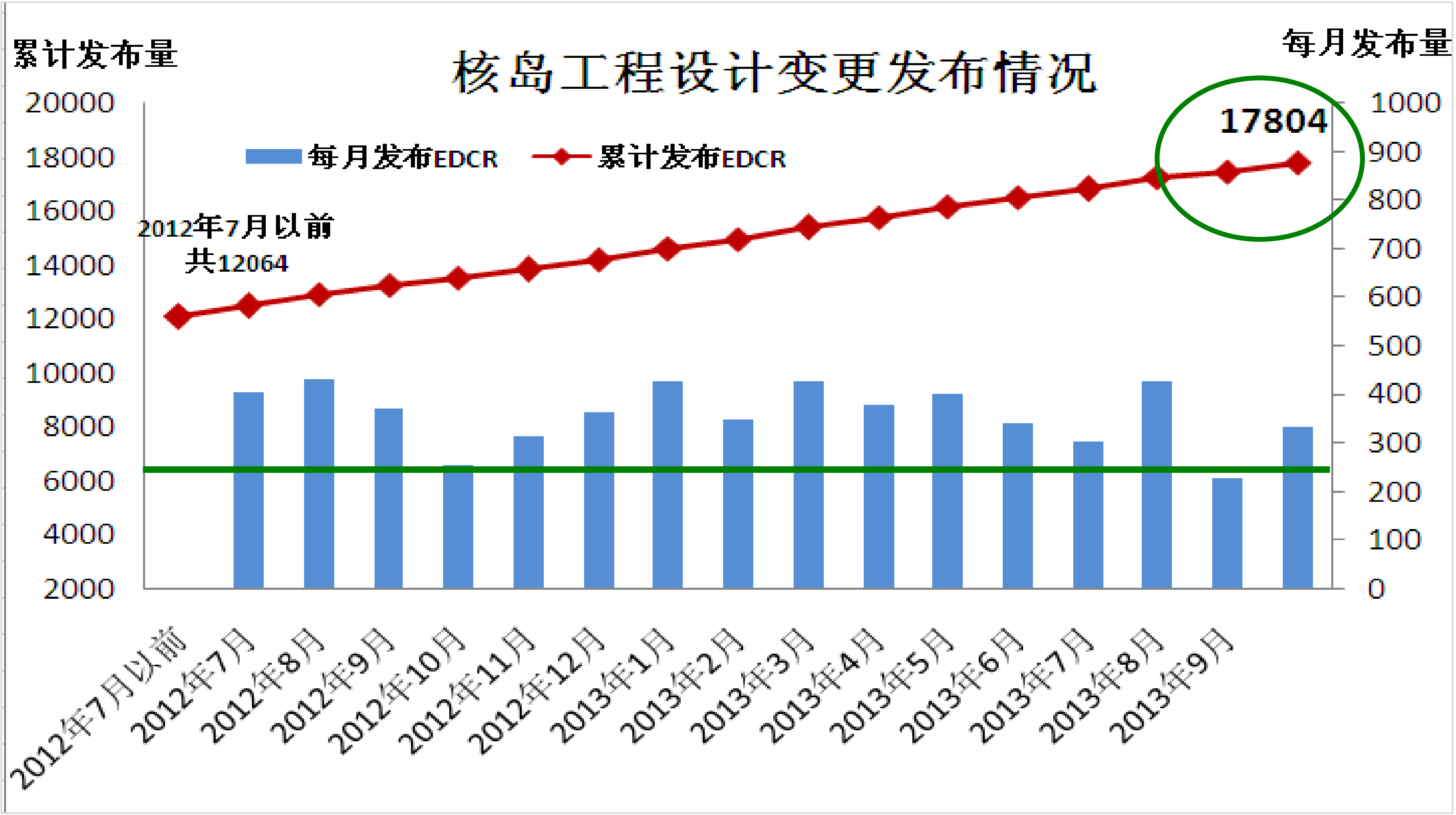
AP-1000, SANMAN CHINA

- Nov. 2013 Commercial Operation Date in Contract
- Aug.14 2018 COD

56 Months → **112 Months**

Westinghouse –EPC Contract

Challenges - Design Management



AP-1000, 4 units in USA

- **Construction began on the first of four AP1000 reactors in the USA**
  - **Summer unit 2 and Vogtle unit 3 in Georgia – March 2013,**
  - **Summer 3 unit and Vogtle 4 unit - November 2013**
- **Fixed prices**
- **Construction – 56 Months**

USA V.C Summer unit 2, 3 AP 1000

Summer unit 2, pictured on 9 June after placement of the unit's third and final containment ring (image: SCE&G)

March 2013- Unit 2
Nov. 2013 – Unit 3
Start Construction

The end of July, 2017,
Spent 9 B USD

Westinghouse – EPC Contract

USA V.C Summer unit 2, 3 AP 1000

The unfinished Unit 2 nuclear reactor pictured Sept. 12, 2024, at VC Summer NPP construction site

Nuclear reactor assemblies pictured Sept. 12, 2024

Reactor vessel pictured Sept. 12, 2024

Vogtle unit 3 and 4 in Georgia

Vogtle unit 3 in Georgia – approval of Fuel Loading : Aug. 04. 2022

Milestone	Unit 3	Unit 4
First Nuclear Concrete	March 2013	November 2013
First Sync to Grid	April 2023	October 2023 (F)

Cost of $35 billion — More than double the initial $14 billion estimate, seven years late

Ref : https://scdailygazette.com/2024/10/15/7-years-after-sc-nuclear-debacle-advisory-group-suggests-potential-restart-of-failed-project/

Temelin NPP construction in Czech Republic

PWR (VVER-320)	(3210 MWt/ 1023 Mwe)
Construction Start Date	First Criticality Date
01 Feb, 1987	11 Oct, 2000
First Grid Connection	Commercial Operation Date
21 Dec, 2000	10 Jun, 2002

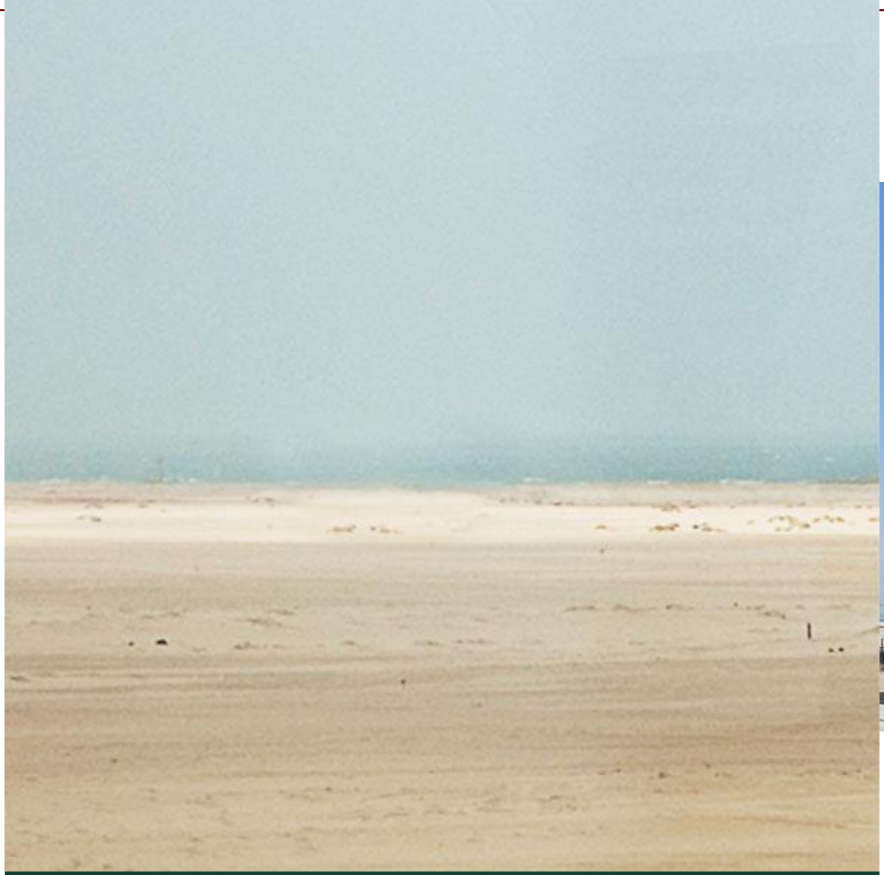
Temelin commissioning challenges

U1 individual Power Ascension Test = 525 days/ 1.43 year

Power level	From – To	Days	Interruption	Note
5%	30 Oct – 10 Nov 2000	12	-	-
12%	14 Nov – 9 Dec 2000	26	-	-
30%	15 Dec 2000 – 8 Mar 2001	84	approx. 70 days	The stage was repeatedly in terruptet with T/G
55%	19 Mar – 27 Sep 2001	193	3 Apr –16 Apr [14 days] and 26 Apr – 12 Aug [109 days]	Vibration of the turbine and the pipeline between control valves and HP cylinder of T/G
75%	19 Oct - 18 Dec 2001	61	1 Nov – 26 Nov [26 days]	RCP autonomous circuit leak
90%	21 Dec 2001 – 3 Jan 2002	14	-	-
100%	10 Jan – 24 May 2002	135	24 Feb – 22 Apr [58 days]	Non-functionality of fast acting valves Argus

The period between termination of the previous stage and the initiation of the subsequent stage is the period of waiting for the approval of State office for nuclear safety. = 1.7 years

2009, 1st Export of APR1400 to UAE



Before site preparation in 2009

4 units construction completion in 2024

Barakah Unit 1, 2, 3, 4 (UAE)

- **Design :** APR1400 x 4 units
- **Expected Cost:** 541 billion CZK
- **Construction Duration**
  - Unit 1: 2012 – 2021 (8.7 yrs)
  - Unit 2: 2013 – 2022 (8.5 yrs)
  - Unit 3: 2014 – 2023 (8.4 yrs)
  - Unit 4: 2015 – target to 2024
- **Project Schedule**

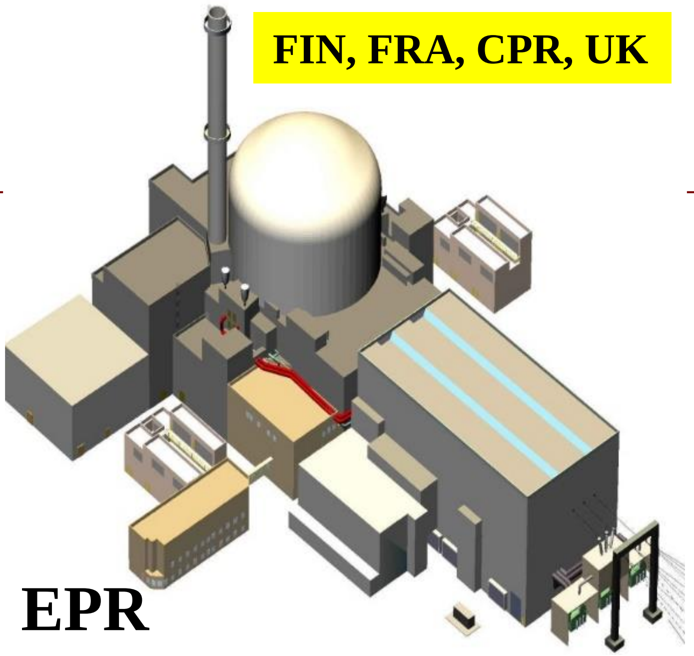
Major Milestone	Unit 1	Unit 2	Unit 3	Unit 4
Contract signed	2009			
Site Excavation	2011 – 2015			
1st Concrete (after Construction License)	2012	2013	2014	2015
Reactor Installation	2014	2015	2016	2017
Fuel Loading (after Operation License)	2020	2021	2022	(2023)
Project Completion	2021	2022	2023	(2024)

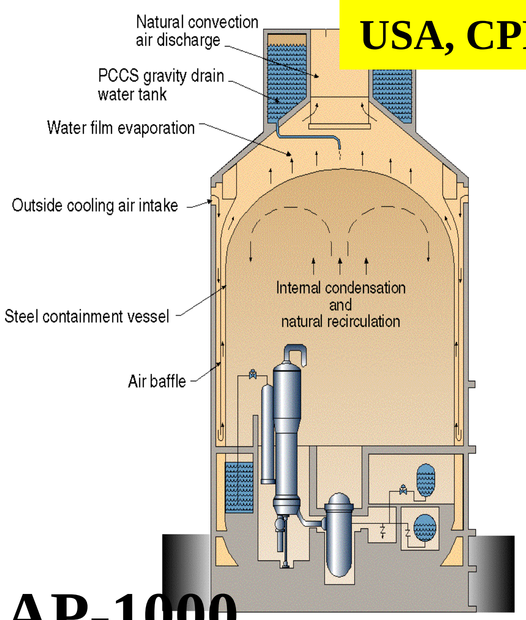
Senior Reactor Operator
- Reactor Power Plant Theory
- Plant Systems Training
- Formal Simulator Training
- Structured Reviews
- Simulator Exercises
- Final Examination

03

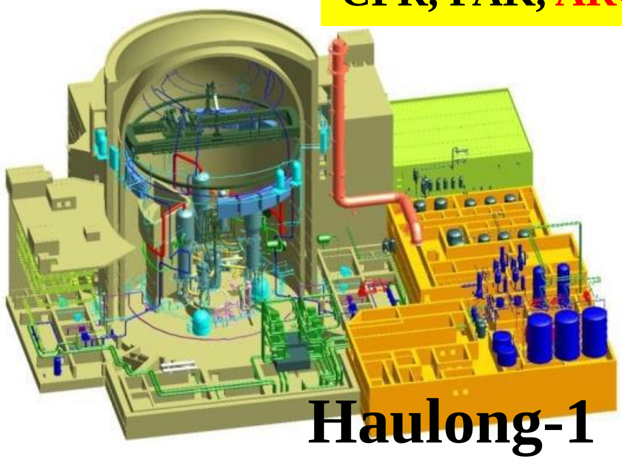
Advanced Technology

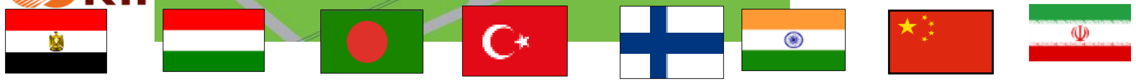
PART Three





Advanced Water Cooled Reactor Technologies





Construction Methods

Open Top Installation

Modularization

Advanced Welding Techniques

Steel Plate Reinforced Concrete Structures

All Weather Construction & Round the Clock Work

- **Concrete Composition Technologies**
- **Excavation Techniques**
- **Cable Installation**
- **Area Completion Schedule Management**
- **Application of Computer Systems for Information Management and Control**

Open-top Construction
HRP-1000, Zhangzhou Steam Generator installation

All three SGs for unit 2 of the Zhangzhou NNB in China's Fujian province have been installed over a five-day period,

The hoisting of the second **SGs took just 2 hours and 54 minutes**, "setting a new record in the history of nuclear power".

Zhangzhou NPP Reactor Pressure Vessel Installation, Nov. 2. 2021

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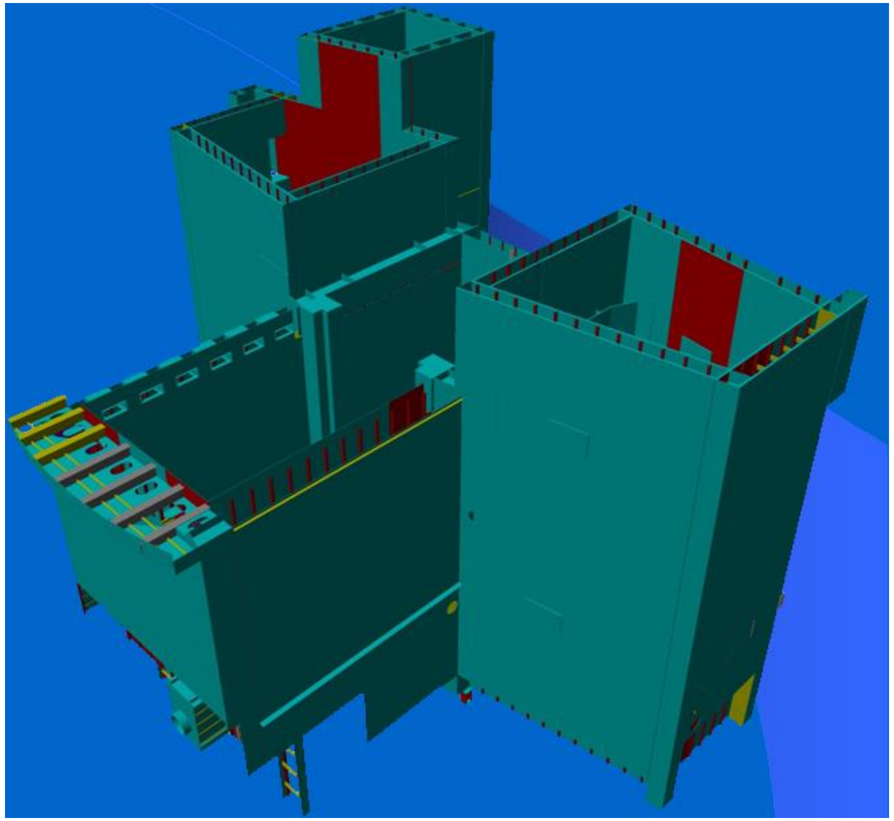
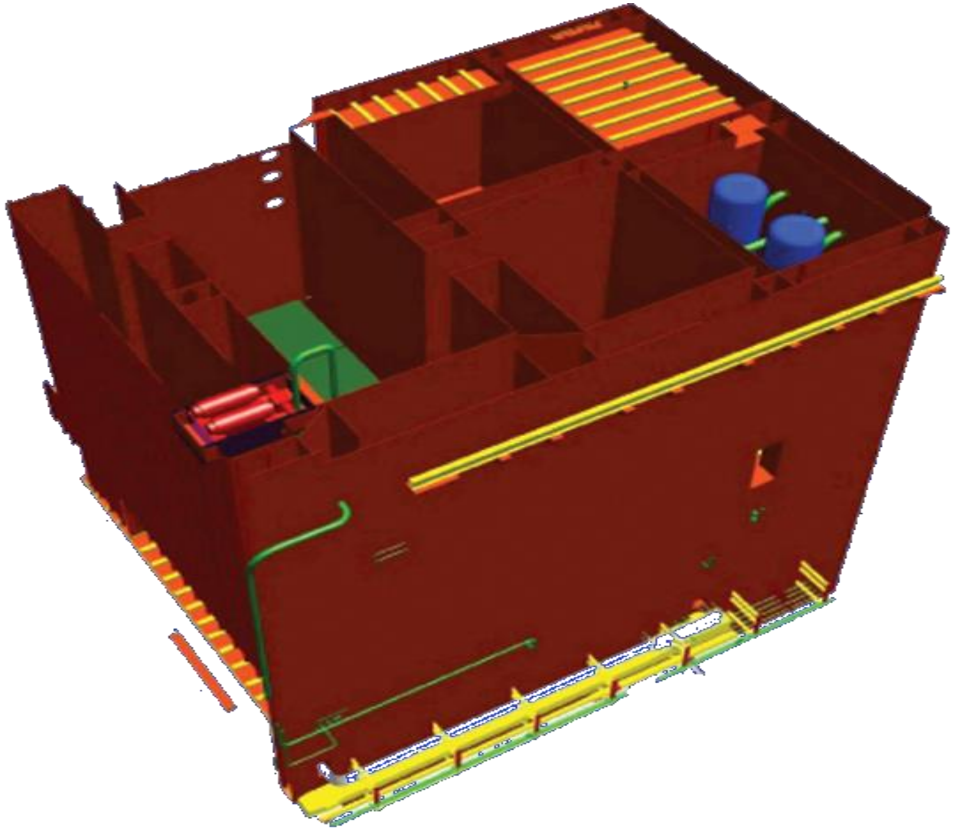
Module categories : Structural module

CA01 25mX29mX26m, 750T



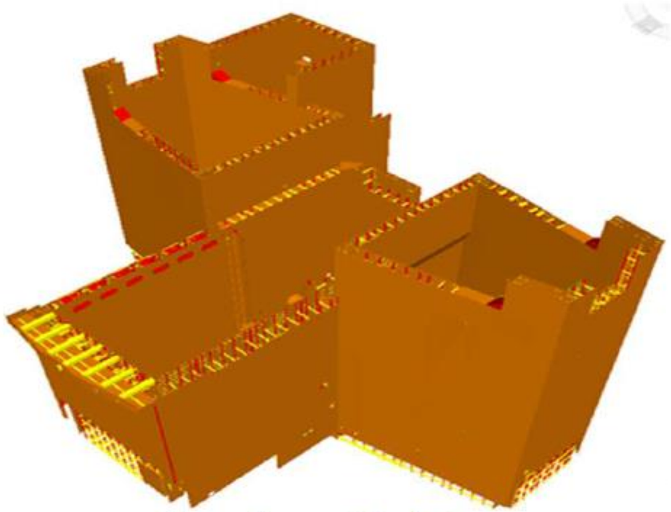
CA20 21mX14mX21m, 872T



Modularization Design and Construction

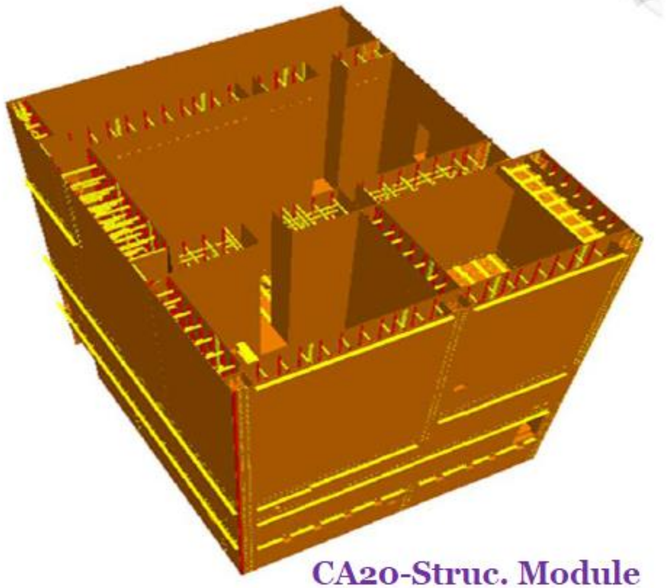
- **Parallel construction, shorten the construction period, Achieve manufactory**
- **pre-fabrication and pre-assembly, to improve the production quality**

Nuclear Island	**Struc. Module**	**Equip. Module**	**Total**
Reactor Building	65	12	77
Auxiliary Building	19	42	61
Total	84(29)	54(59)	138(88turbine)



CA01-Struc. Module

Q601-Equip. Module



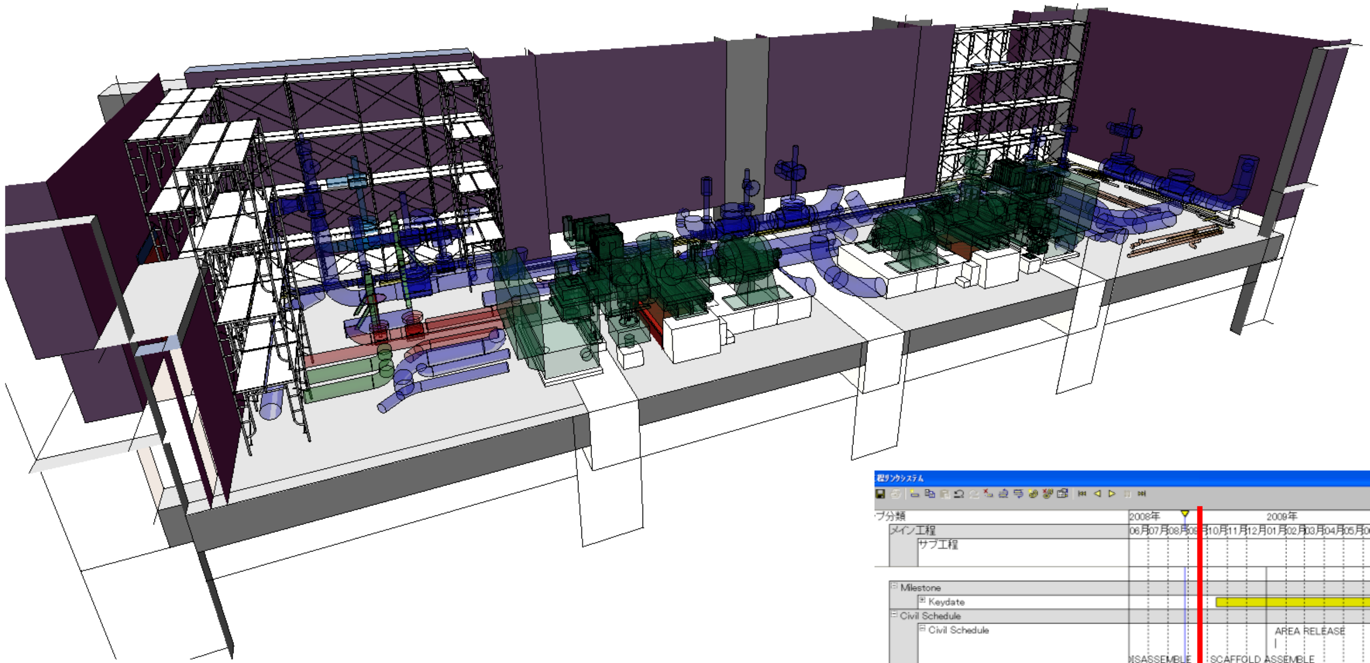
CA20-Struc. Module

Modular Construction

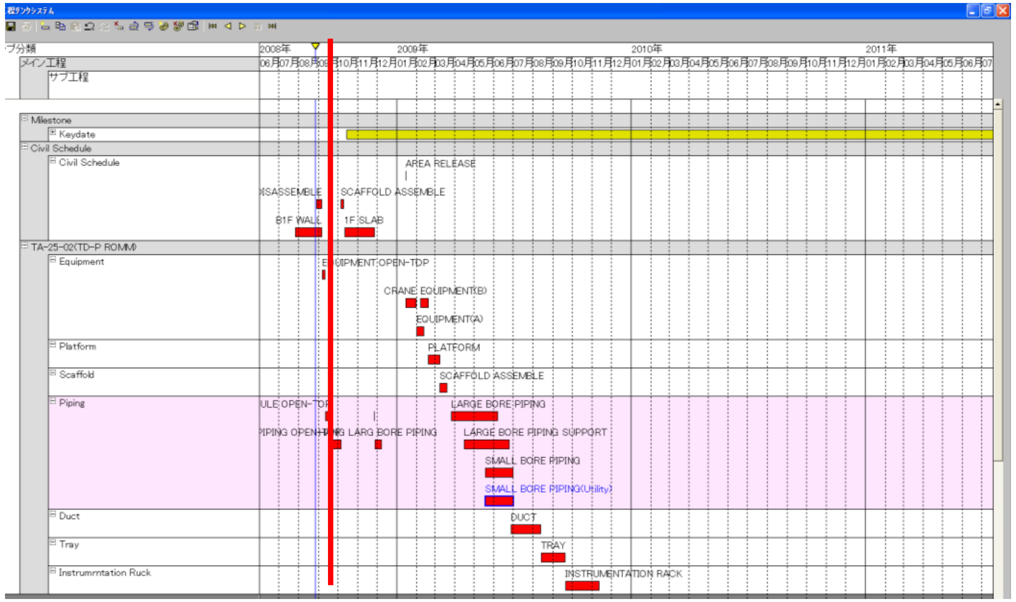
Pros and Cons need to be evaluated based on the job site conditions

Pro	Con
Reduce Schedule (If Module is applied to CP)	Increase Engineering for Module
Reduce Field Work and Leveled On-site Manpower	Increase Temporary Support Structure
Increase Productivity and Quality under Factory Environment	Early Material Requirements
More Safely and efficiently at Ground Level Work	Additional Transportation Cost (Large trailer truck, Barge)
Reusability of PPM Engineering to the Nth Plants	Increase Lifting/Rigging Requirements (Crane, Lifting Jig)
	Inspection of Modular

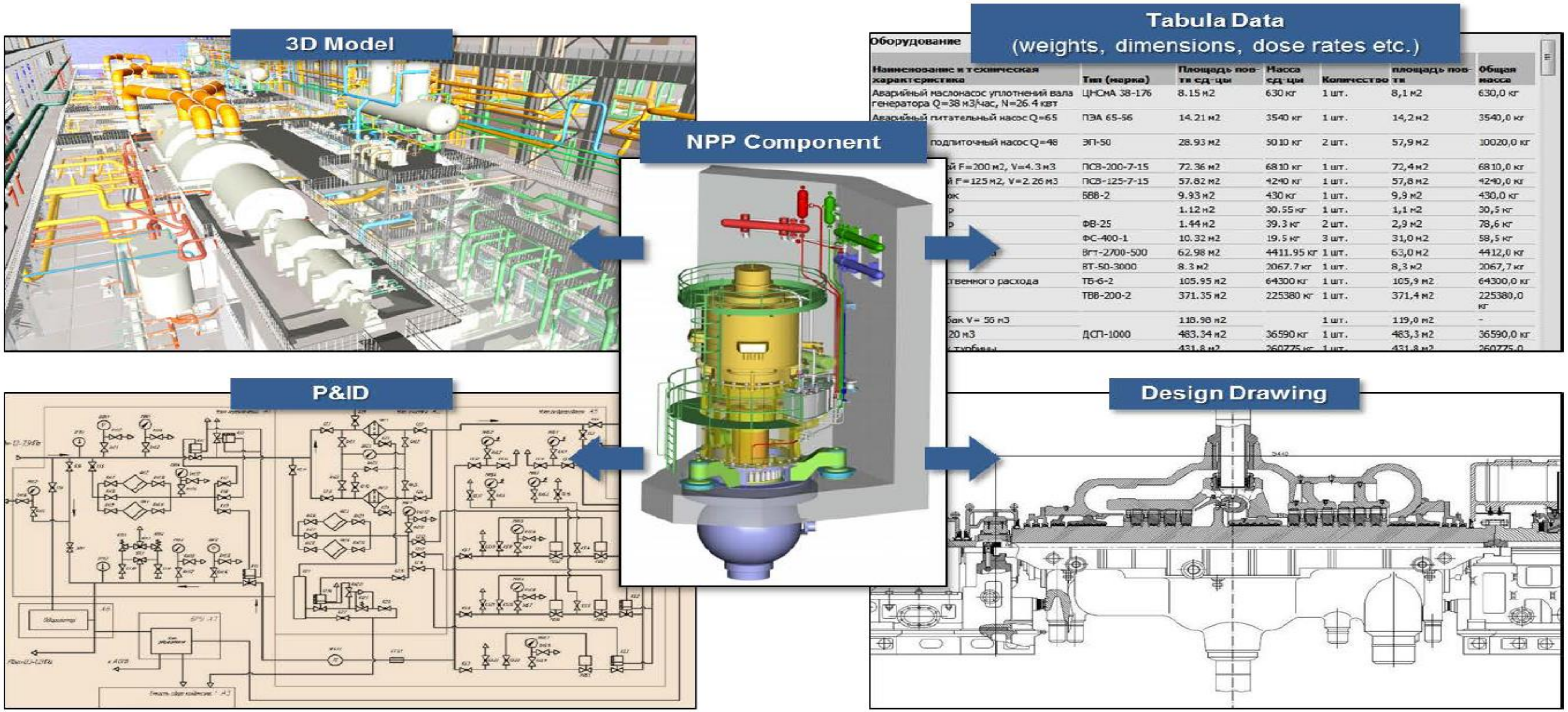
Construction Schedule with 6D



3D-model linked with Schedule



Information system for engineering data management, based on 3D models



04

Work force planning

PART Five

CENEN – CzEch Nuclear Education Network

CENEN - CzEch Nuclear Education Network

CENEN
CZECH NUCLEAR EDUCATION NETWORK

- Czech nuclear education network
- 7 universities
- Free association without legal personality
- Partners from industry, research, etc state institutions
- Currently, there is an effort to revive the activities of the association and give it legal personality

Goal

1. Analysis and prediction of human resources needs in the context of the current and planned nuclear activities of the Czech Republic.
2. Monitoring and cataloging of educational activities in the field of technical education
3. Support of technical education in the Czech Republic.
4. Preparation and implementation of educational events
5. Provision of advice and support, expert activities.
6. Implementation of educational activities.

UZBEKISTAN PLANS TO BUILD NPP WITH 2 UNITS OF RUSSIAN VVER-1200 POWER REACTOR THE CAPACITY OF WHICH ARE 1,2 GW EACH (2,4 GW total capacity)

NUMBER OF PERSONNEL IN THE NPP (PLANNED)

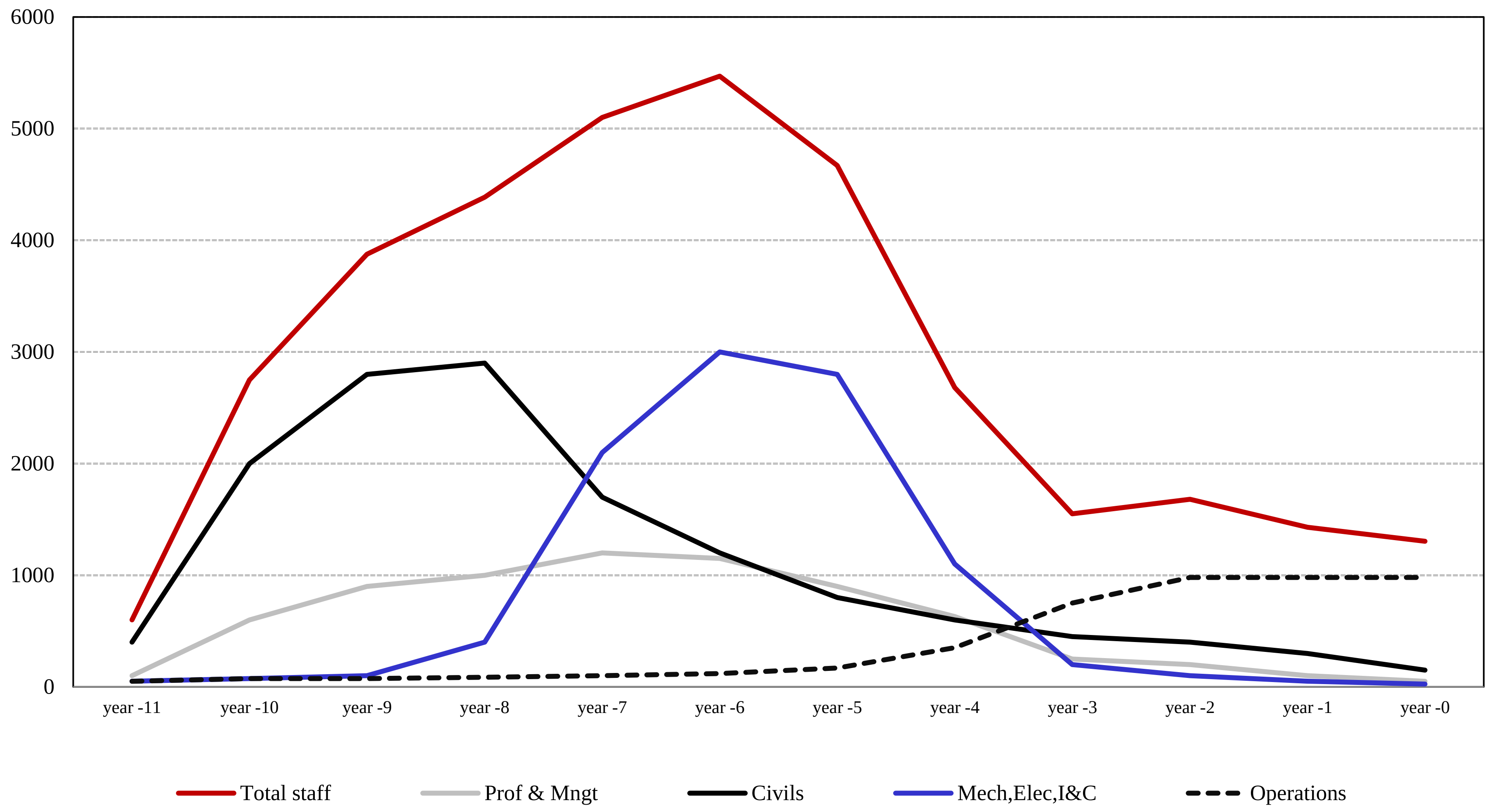
Subdivision	Number of persons
Management	235
Operation	537
Safety and reliability	234
Repairs/ Maintenance	211
Engineering support	24
Advanced Control System TP service and IT	475
Educational and training	48
Production and technical support and quality	42
Chief Inspector Division	24
Design support for the construction	17
Planning of supply and acquisition of equipment	9
Planning, economic and estimates	11
TOTAL	**1867**

NUMBER OF TRAINED PERSONNEL WITH HIGHER EDUCATION

Years of graduate	2020	2021	2022	2023	2024	2025	2026	2027	2028	Total by 2028	2029	2030	Total by 2030
Masters's degree													
Moscow Engineering Physics Institute	15	30	30	30	30	30	30	30	30	**255**	30	30	**315**
National University of Uzbekistan		15	20	20	20	20	20	20	20	**155**	20	20	**195**
Samarkand State University		12	12	12	12	12	12	12	12	**96**	12	12	**120**
TOTAL for master's degree	**15**	**57**	**62**	**62**	**62**	**62**	**62**	**62**	**62**	**506**	**62**	**62**	**630**
Bachelor's degree													
Tashkent branch of MEPhI				100	100	100	100	100	100	**600**	100	100	**800**
Tashkent State Technical University			40	40	40	40	40	40	40	**280**	40	40	**800**
TOTAL for bachelor's degree			**40**	**140**	**140**	**140**	**140**	**140**	**140**	**880**	**140**	**140**	**1160**
TOTAL	**15**	**57**	**102**	**202**	**202**	**202**	**202**	**202**	**202**	**1 386**	**202**	**202**	**1 790**

As a result of the implementation of the personnel training programme, the required number of personnel with higher education ***(1567*** *people)* will be prepared for the needs of the NPP with a reserve of **223** people.

Typical Site Skills Profile – Twin Unit Site



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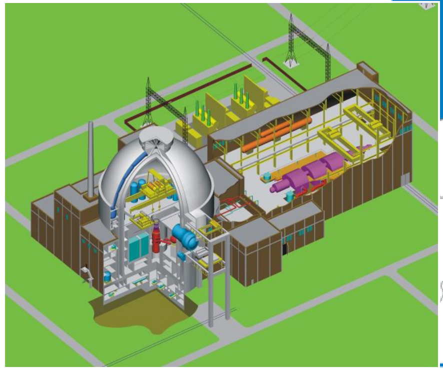
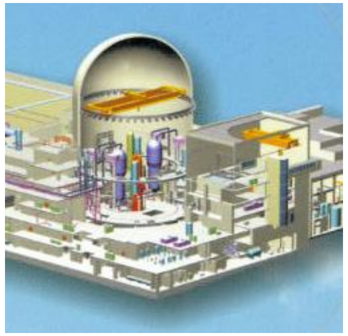
Future New Nuclear Build in Europe

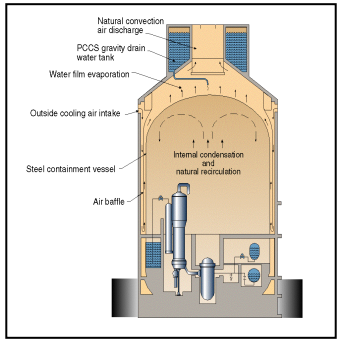
Success of NNB will depend on

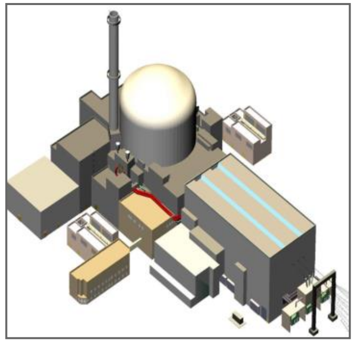
- Securing Supply Chains,
- Addressing Labor Shortages,
- Ensuring Regulatory Efficiency,
- Making the Financial Cases

All of them will begin at the end of 2020 and become operational by mid-2030.









Recommendations

- **Establish a Long-Term Plan for Human Resource Development**
  - How can we support the development of 6 to 9 GWe of new nuclear capacity?
  - After the handover from the EPC (Engineering, Procurement, and Construction) contractor, who will be responsible for operating the newly built nuclear power plants (NPPs)?
    - For the operation of an NPP, we require 6 shifts.
    - Each team should consist of 10 operators: 5 operators in the Main Control Room (including SRO, RO, TO, EO, SA) and 5 operators in the Local Control Room.

- **Consider setting up a Polish Nuclear Education Network similar to CENEN**
  - Develop a joint research policy project focused on human resource development (HRD).

CENEN : Czech Nuclear Education Network