Lessons Learned from KHNP's Nuclear New Build Projects

March 16, 2022

KOREA HYDRO & NUCLEAR POWER CO., LTD

CONTENTS

1 KHNP

2 Safety, Quality vs. Cost, Schedule

3 Project Management & Advanced Technologies

4 Conclusion

1 KHNP

Top 3

Nuclear Power Utility in the World

KHNP

The Largest
Power Generator
in Korea

'27%'

Domestic Electricity
Generation

'28,622MW'

34 Units Completed Construction

25 Units in Operation (24 in Korea and 1 in the UAE)

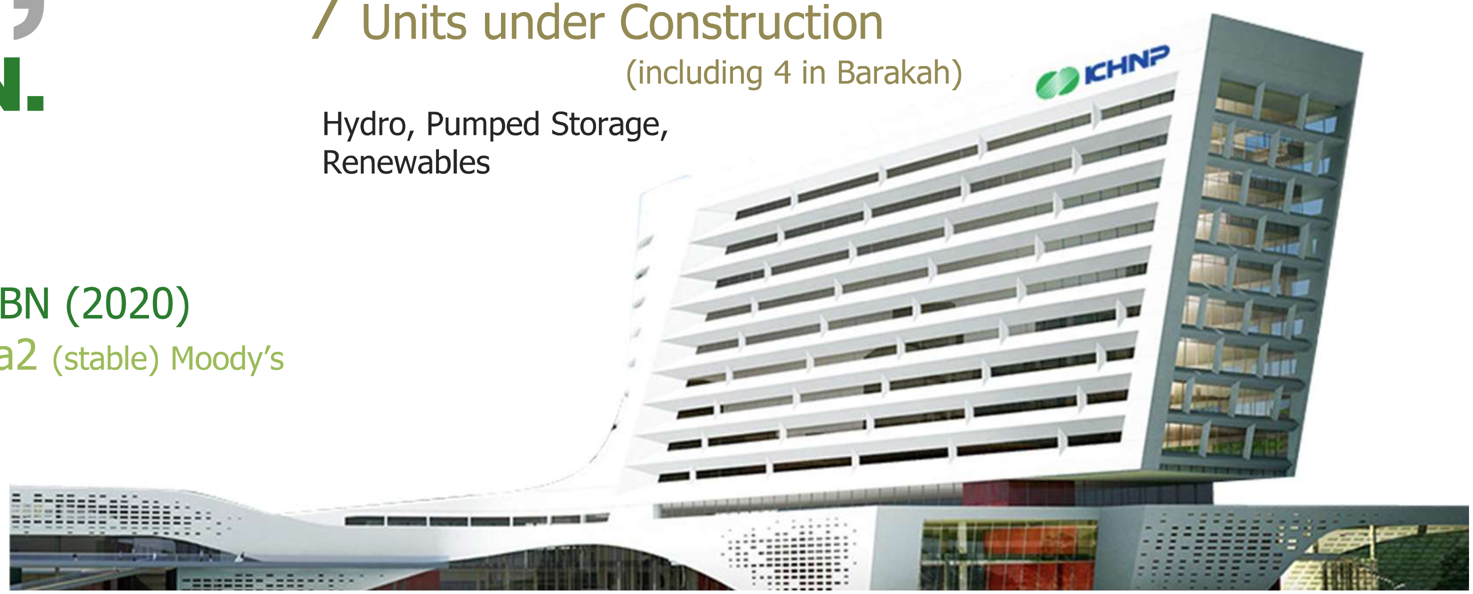
7 Units under Construction
(including 4 in Barakah)

Hydro, Pumped Storage,
Renewables

'$54BN.'

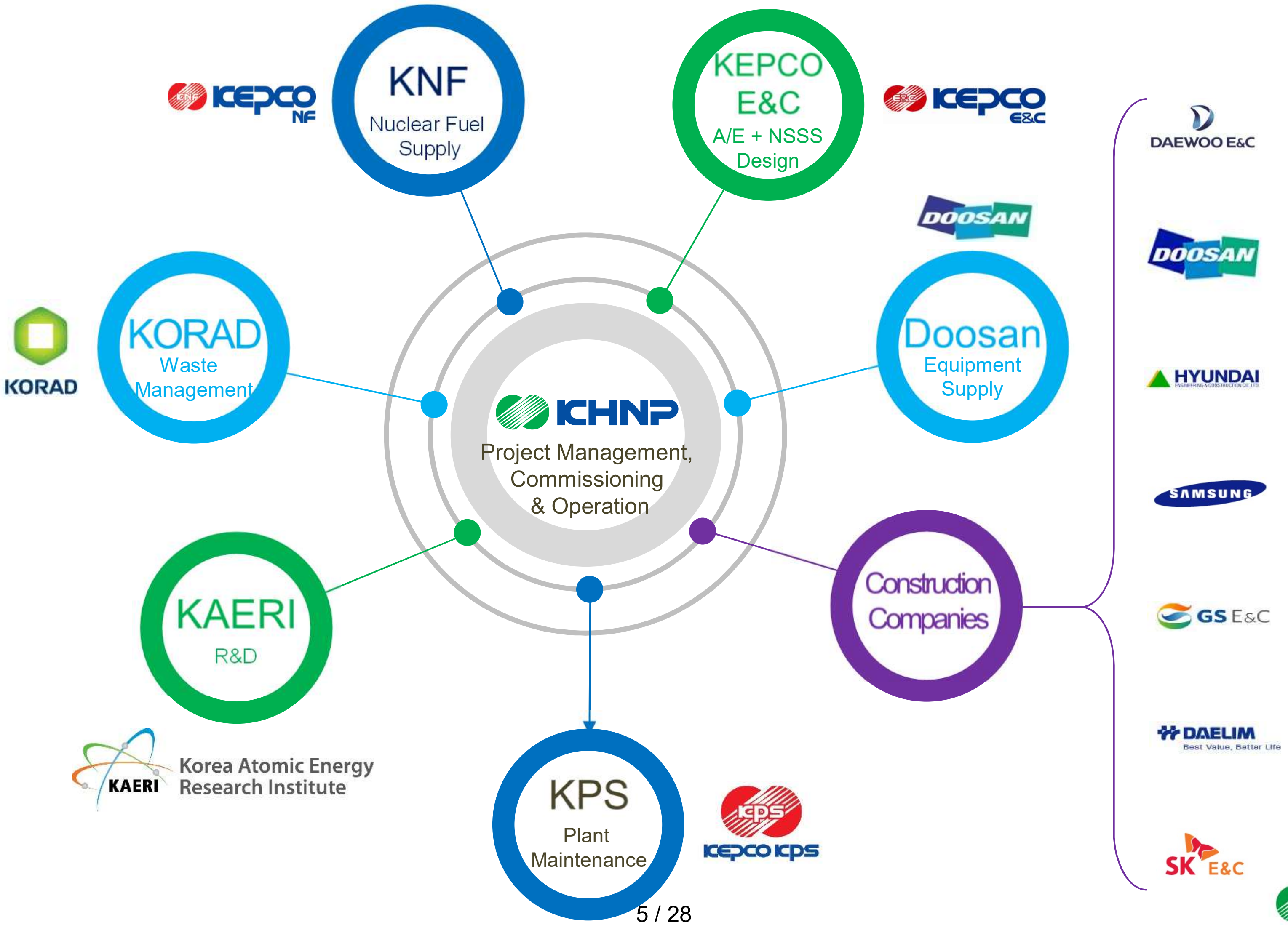
Total Assets

Sales : USD 8.5 BN (2020)
Credit rating : Aa2 (stable) Moody's



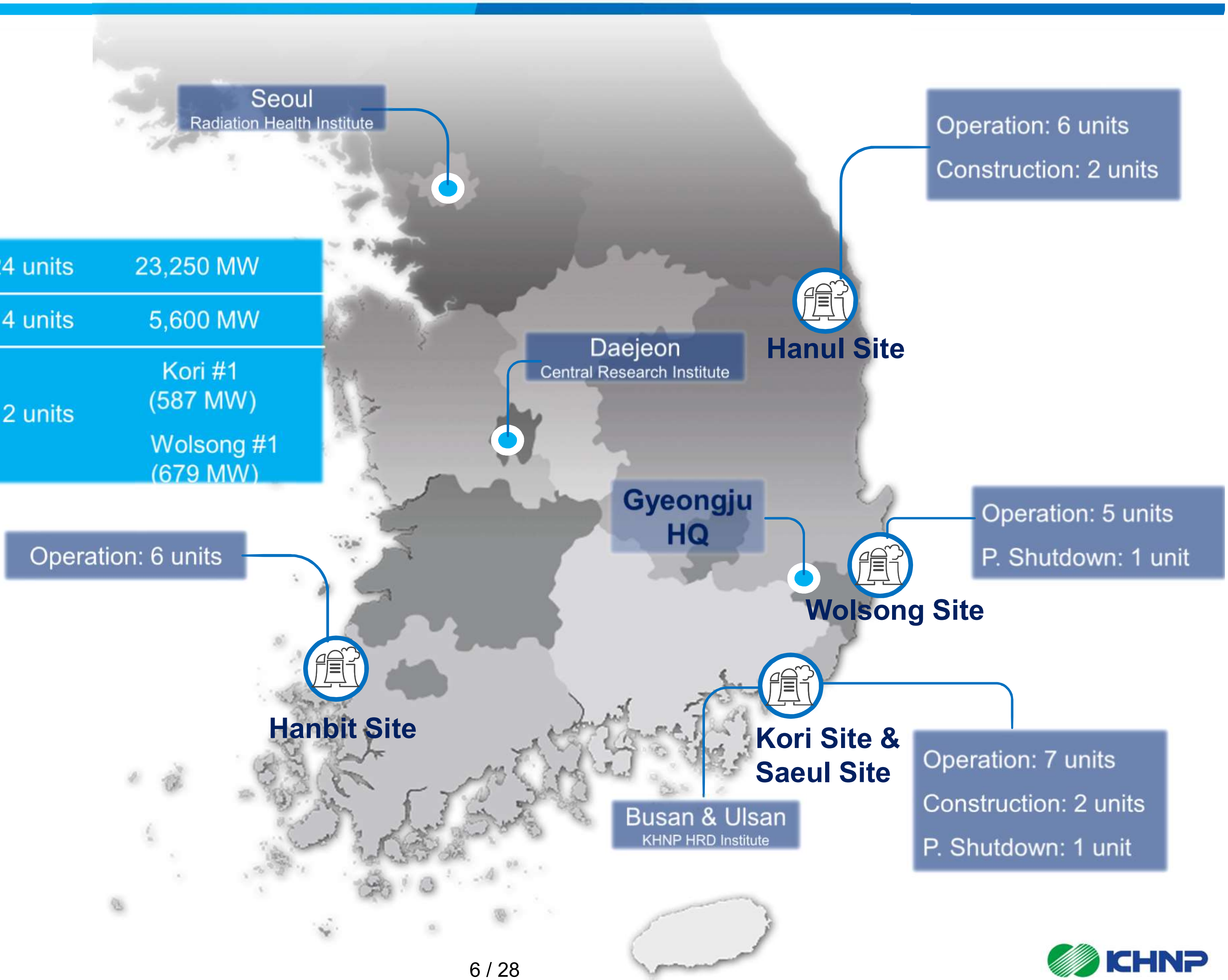
KHNP's Role in Korean Nuclear Industry

The Sole NPP Owner/Operator in Korea & Leader of Team Korea



Nuclear Power Plants in Korea

Operation	24 units	23,250 MW
Construction	4 units	5,600 MW
Permanent Shutdown	2 units	Kori #1 (587 MW) Wolsong #1 (679 MW)



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Status of NPPs in Korea (Units in Operation)

Kori 2,3 & 4 / Shin-Kori 1,2,3 & 4

Hanbit 1,2,3,4,5 & 6

Wolsong 2,3 & 4 / Shin-Wolsong 1 & 2

Hanul 1,2,3,4,5 & 6

Status of NPPs in Korea (Units under Construction)

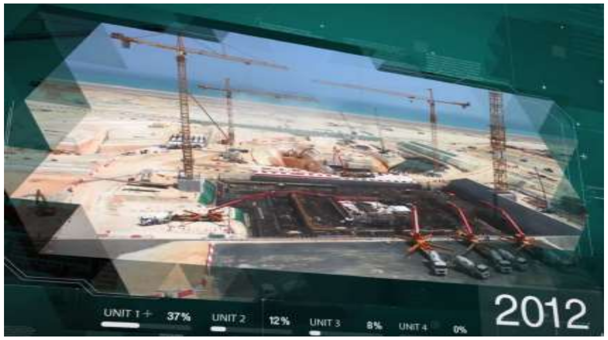
Shin-Hanul Units 1&2

- Capacity: 1,400 MW x 2
- Reactor type: PWR (APR1400)
- Operating License
  - **Unit 1: Jul. 2021**
  - Unit 2: 2Q 2022 (expected)
- Progress rate
  - Unit 1: 99.2%, Unit 2: 98.9%

Shin-Kori Units 5&6

- Capacity: 1,400 MW x 2
- Reactor type: PWR (APR1400)
- Operating License
  - Unit 5: 3Q 2023 (expected)
  - Unit 6: 3Q 2024 (expected)
- Progress rate
  - Unit 5: 84.3%, Unit 6: 63.8%

Status of NPPs in the UAE



BNPP Units 1 to 4

- Capacity : 1,400 MW x 4
- Reactor type: PWR (APR1400)
- Status
  - Unit 1: COD (Apr. 2021)
  - Unit 2: Connected to the Grid
  - Unit 3: Construction Completed
  - Unit 4: 91%

APR1400

- **NRC Design Certification (Aug. 2019)**

UNITED STATES NUCLEAR REGULATORY COMMISSION

The United States Nuclear Regulatory Commission
certifies the

Advanced Power Reactor 1400
Standard Design

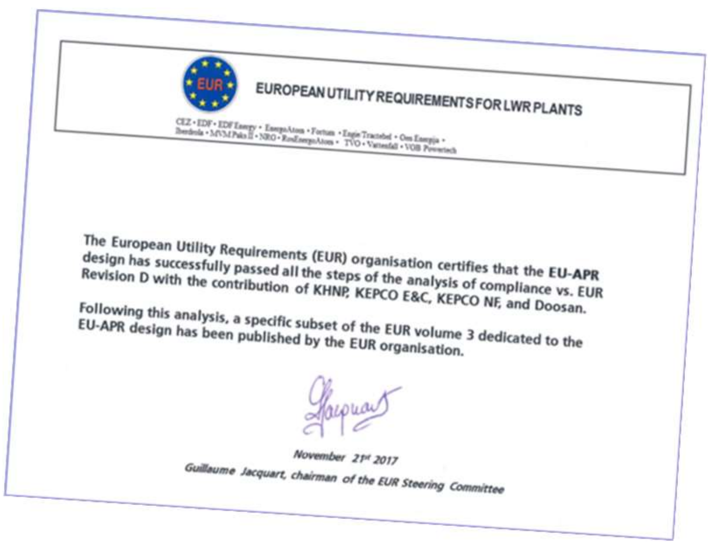
as set forth in Appendix F of 10 CFR Part 52

Frederick D. Brown
Director, Office of New Reactors

Annie Caputo
Commissioner, U.S. Nuclear Regulatory Commission

Dated the 26th day of August, 2019

- **EUR Certification (Nov. 2017)**



EUR

EUROPEAN UTILITY REQUIREMENTS FOR LWR PLANTS

CEZ • EDF • EDF Energy • EnergoAtom • Fortum • Engie Tractebel • Gen Energija • Iberdrola • MVM Paks II • NRG • RosEnergoAtom • TVO • Vattenfall • VGB Powertech

The European Utility Requirements (EUR) organisation certifies that the EU-APR design has successfully passed all the steps of the analysis of compliance vs. EUR Revision D with the contribution of KHNP, KEPCO E&C, KEPCO NF, and Doosan.

Following this analysis, a specific subset of the EUR volume 3 dedicated to the EU-APR design has been published by the EUR organisation.

November 21st 2017

Guillaume Jacquart, chairman of the EUR Steering Committee

KHNP

2

Safety, Quality vs Cost, Schedule

Safety Intelligent CCTV Operating System

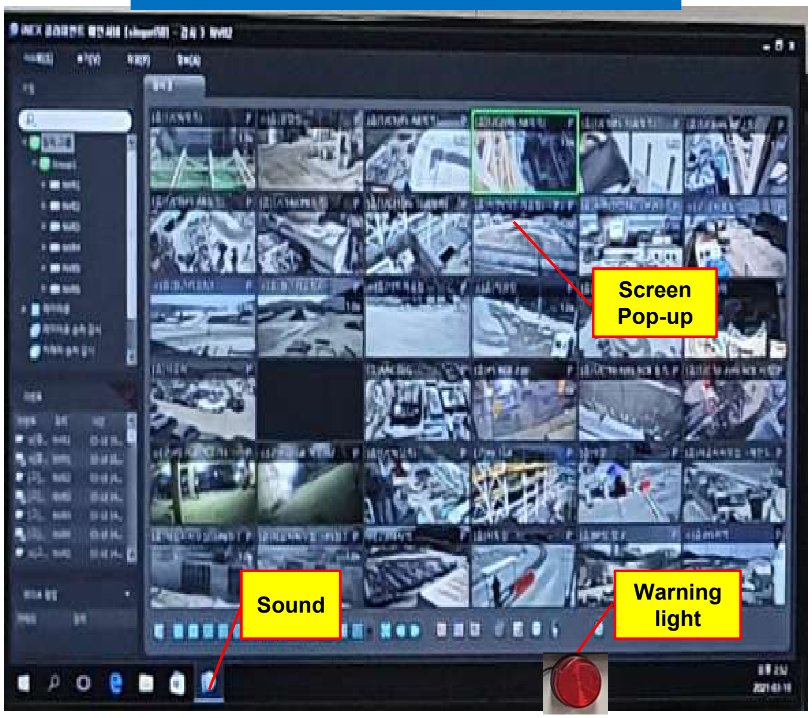
Restricted Area Break-in

Falling Down

SOS

Smoke, Flames

Monitoring Room



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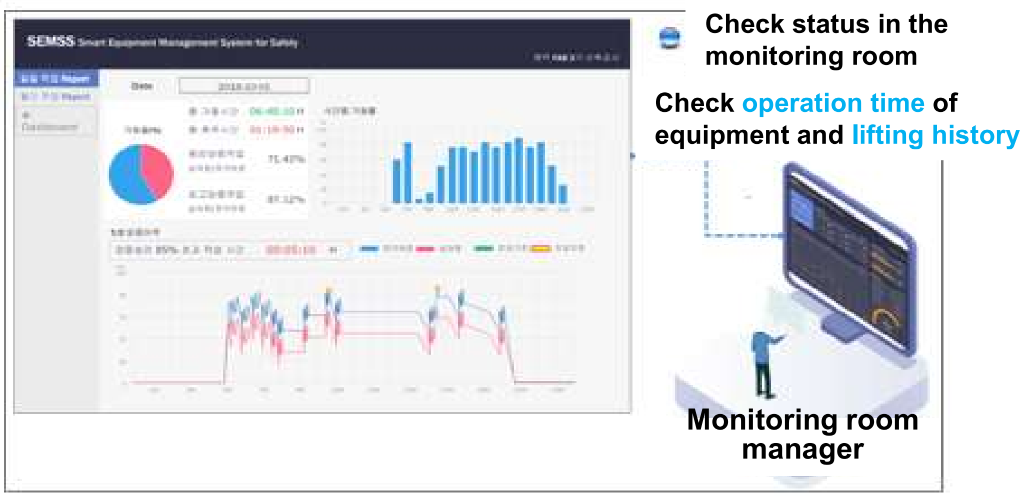
Safety Smart Lifting Work Monitoring System



Safety Smart Lifting Work Monitoring System

Automated messages during hazardous work

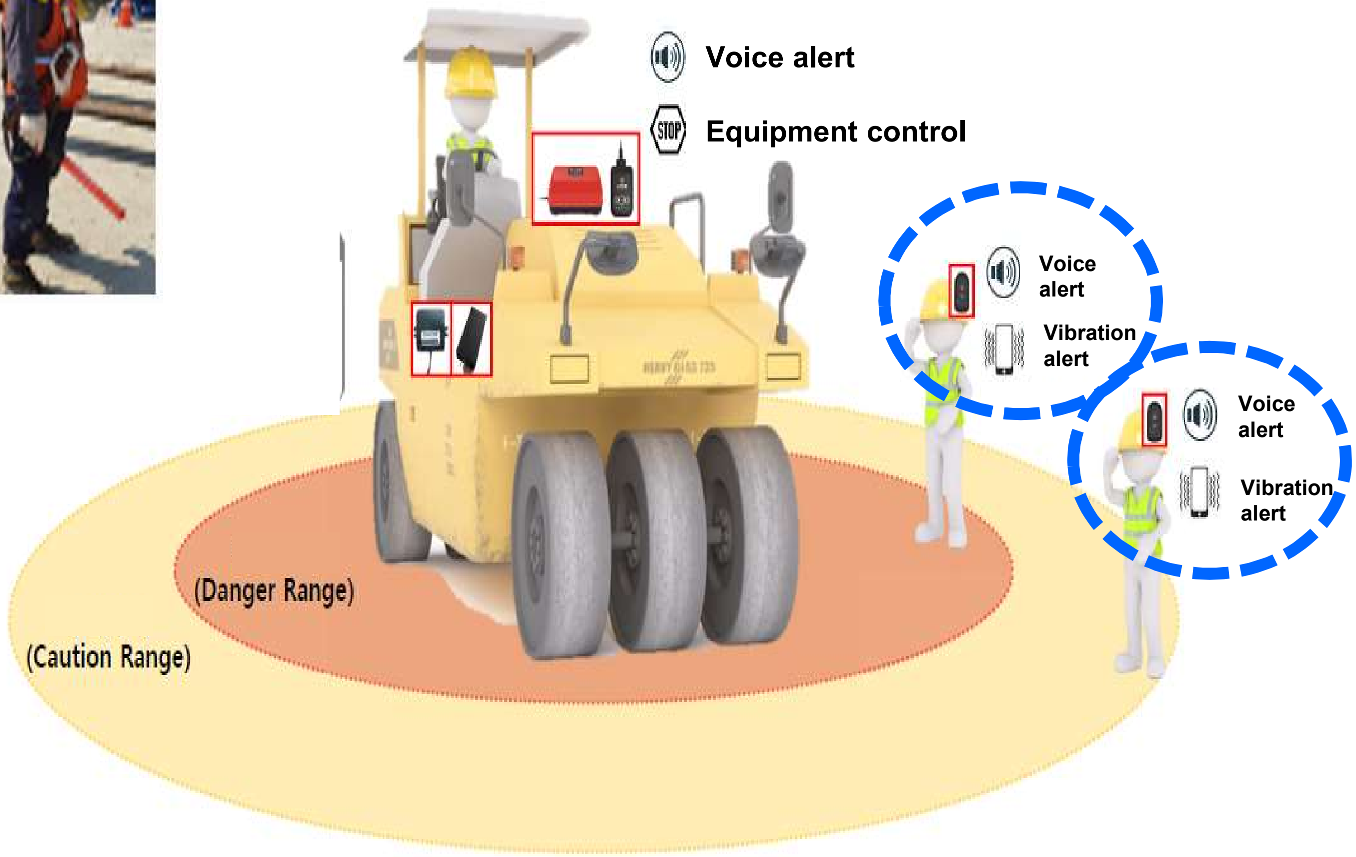
Site Manager Mobile

Multiple equipment management at once

Site manager

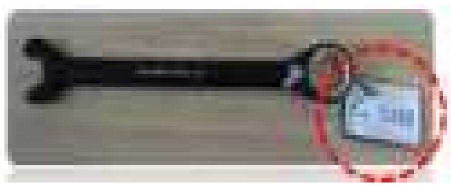
KHNP

Safety Proximity Alert System

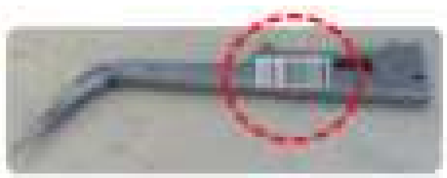


Quality Worker's Tool Management System

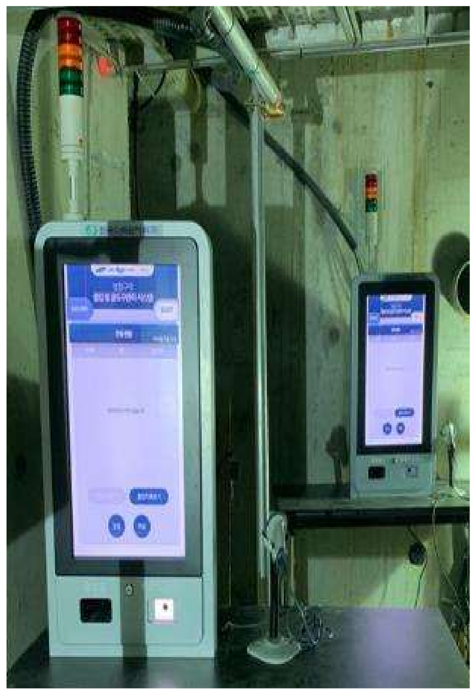
Worker's Key Card

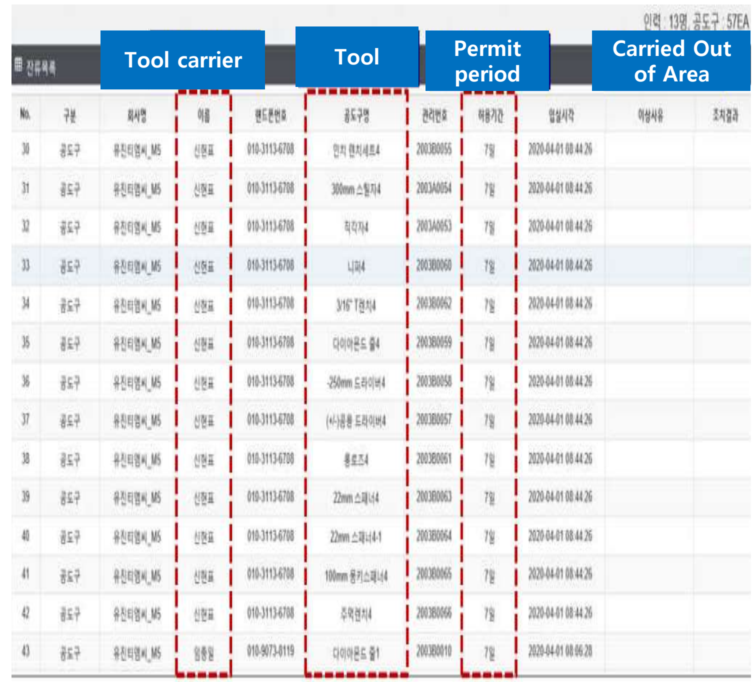


Barcode tags



Adhesive barcodes





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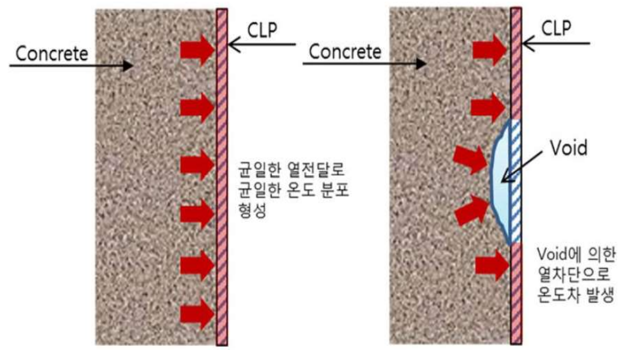
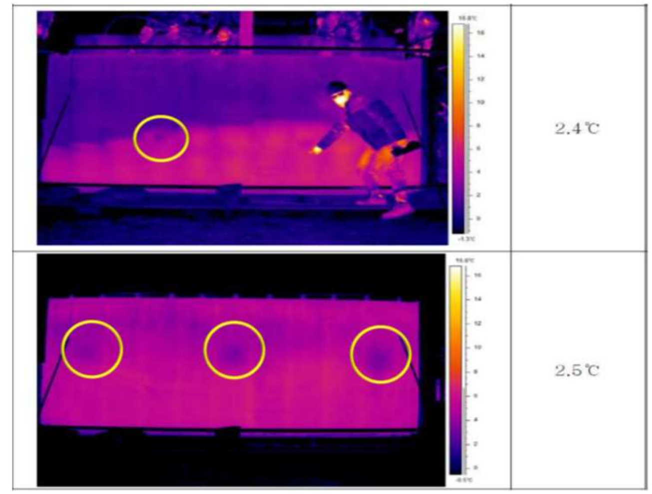
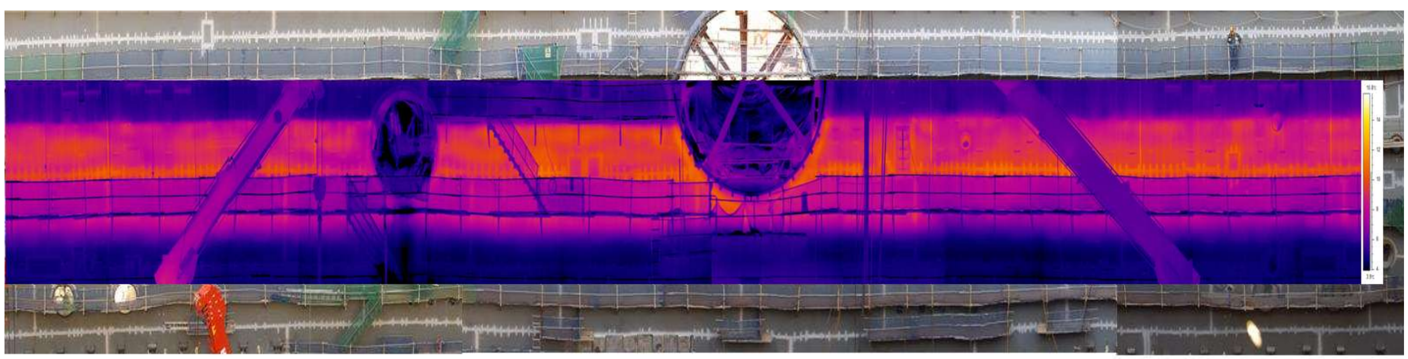
Quality Void Detection System

▶ **Principle of checking air gap and mock-up at site**





▶ **Photo of pouring concrete on the outer wall of Shin-Kori Units 5,6 reactor building**



KHNP

3 Project Management & Advanced Tech.

NPP Project Management and Information System

Project Management

Manage manpower, equipment, materials, funds, and schedules

Apply knowledge, skills, tools and techniques

The information system is a tool for efficient project management

NPP Project Management and Information System

- **iNPCMS: Integrated Nuclear Power Construction Management System**

ERP	iNPCMS	Web System
Cost Management	Schedule Management	NPP Construction Information System
Document Management	Construction Information	Knowledge Management System
Material Management	Construction Material	Engineering Information Management System
Quality Management	Construction Management (civil, arch., piping, mech., elec., cable)	
	NDE	
	Design Change	
	Start-up	
	Concrete Test	

KHNP

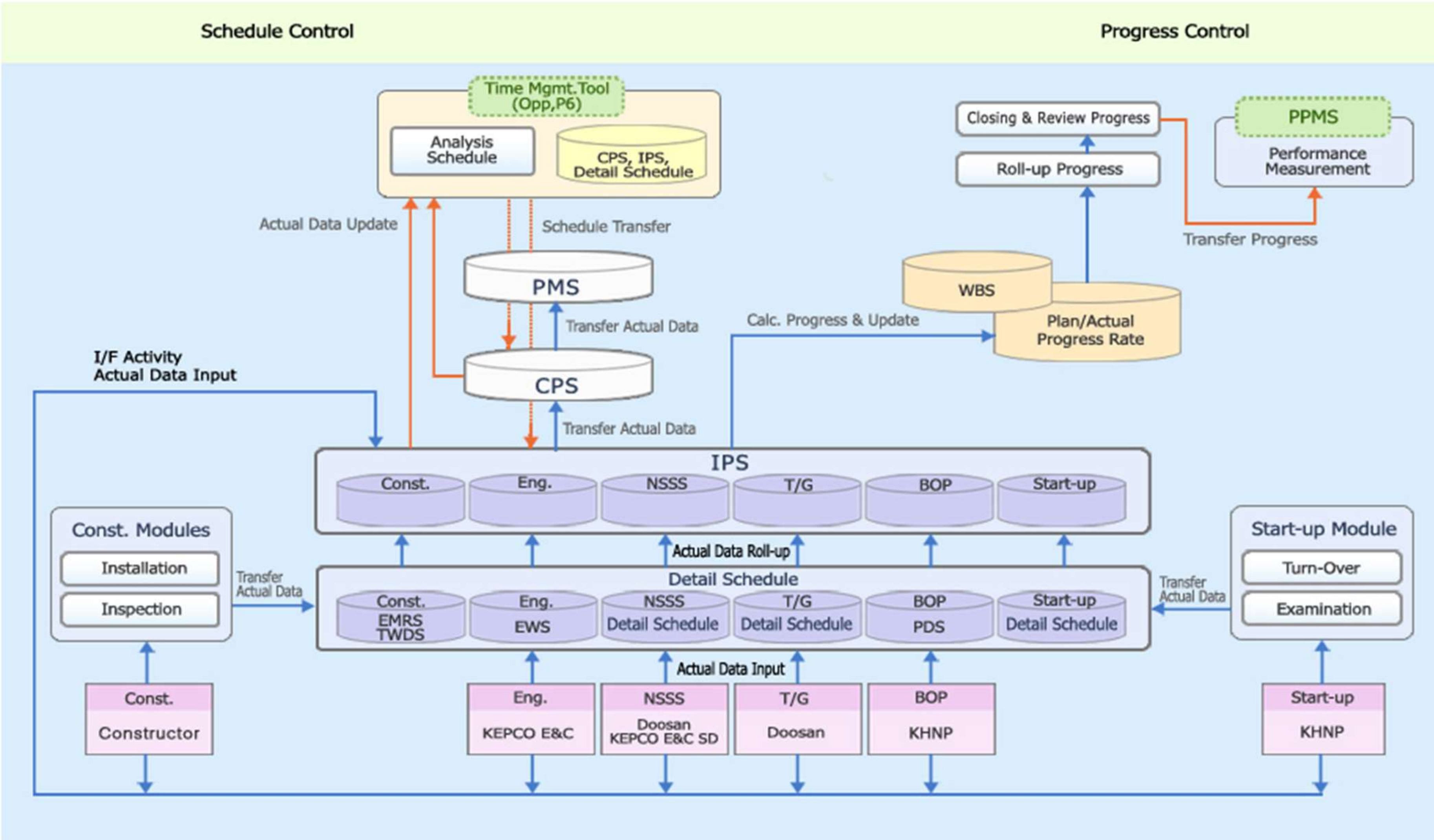
iNPCMS (Integrated Nuclear Power Construction Management System)

1993
Development of the first system

2003
Upgraded to manage all sectors of construction

2010~
Improved as an internet-based platform

iNPCMS Schedule Management



KHNP

Main Equipment Installation Simulation

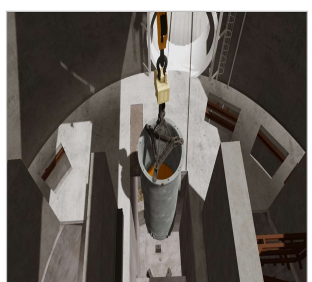
- **Improves installation workability of main equipment and prevents accidents by using Installation Simulation**

Reactor

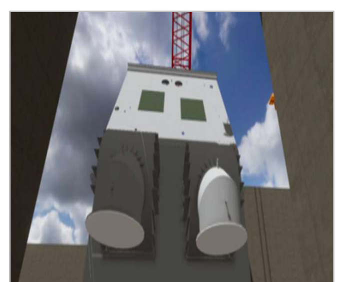
S/G

RCP

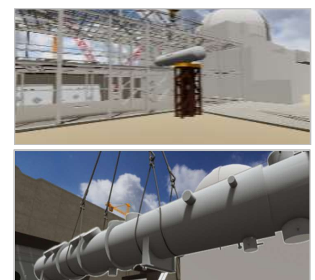
T/G



Reactor Internal



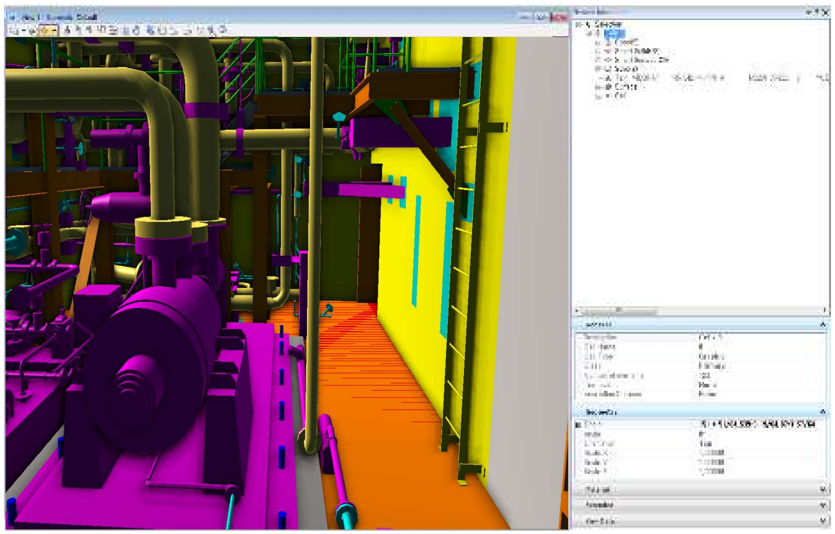
Condenser

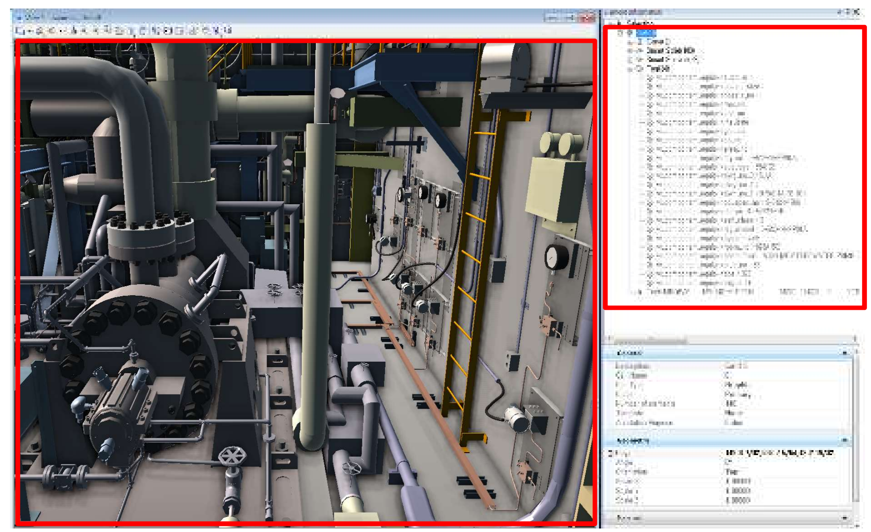


HP/LP Heater

Advanced 3D Models

- Link design, purchase, and construction information with equipment
- Include 3D models of all equipment, piping, tubing, etc.



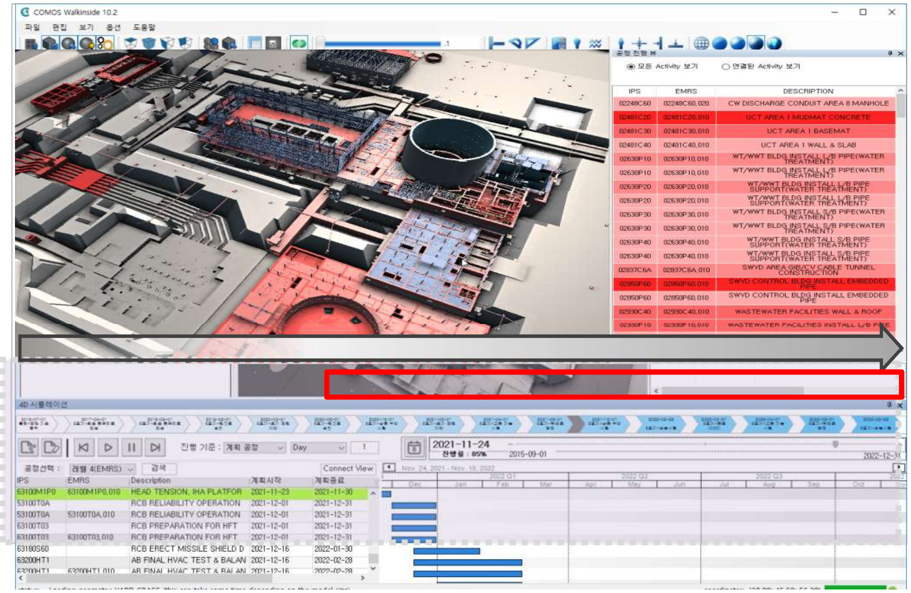


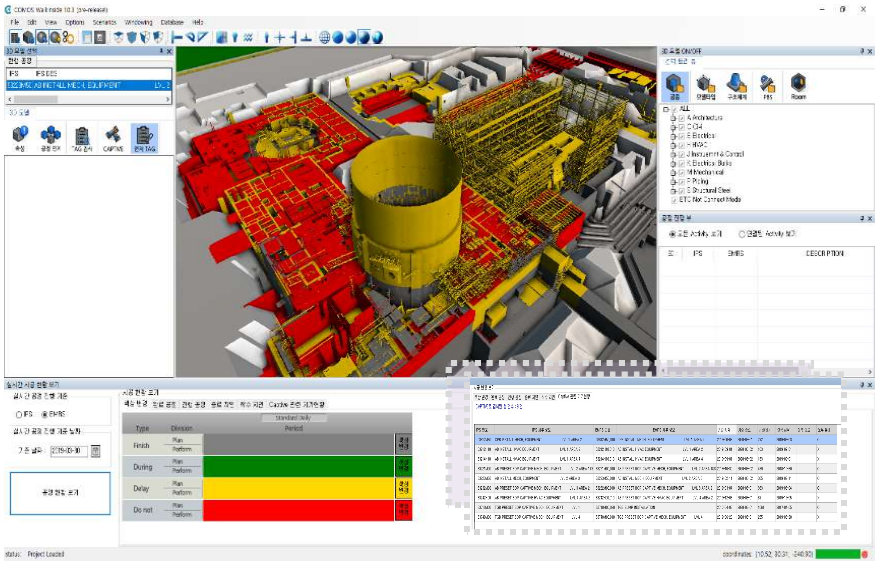
Before Existing 3D model

After Advanced model at Cyber Power Plant

4D Construction System

- **Develop 4D simulation linking the construction schedule with the 3D model**





4 Conclusion

Conclusion

- "Safety and quality before cost and schedule" to avoid cost overrun and schedule delays
- "Efficient project management through advanced technologies" to mitigate or reduce construction risks
- "Continuous construction experience and a solid project management team with well defined accountability and mutual trust" are essential for the success of the new build project


THINK SAFETY
Thank You
KHNP

Attributes for Successful New Build

a. Completion of needed portions of the design prior to the start of construction

b. Development of a proven supply chain for NSSS components and a skilled labor workforce

c. Inclusion of fabricators and constructors in the design team

d. Appointment of a single primary contract manager with proven expertise in managing multiple independent subcontractors

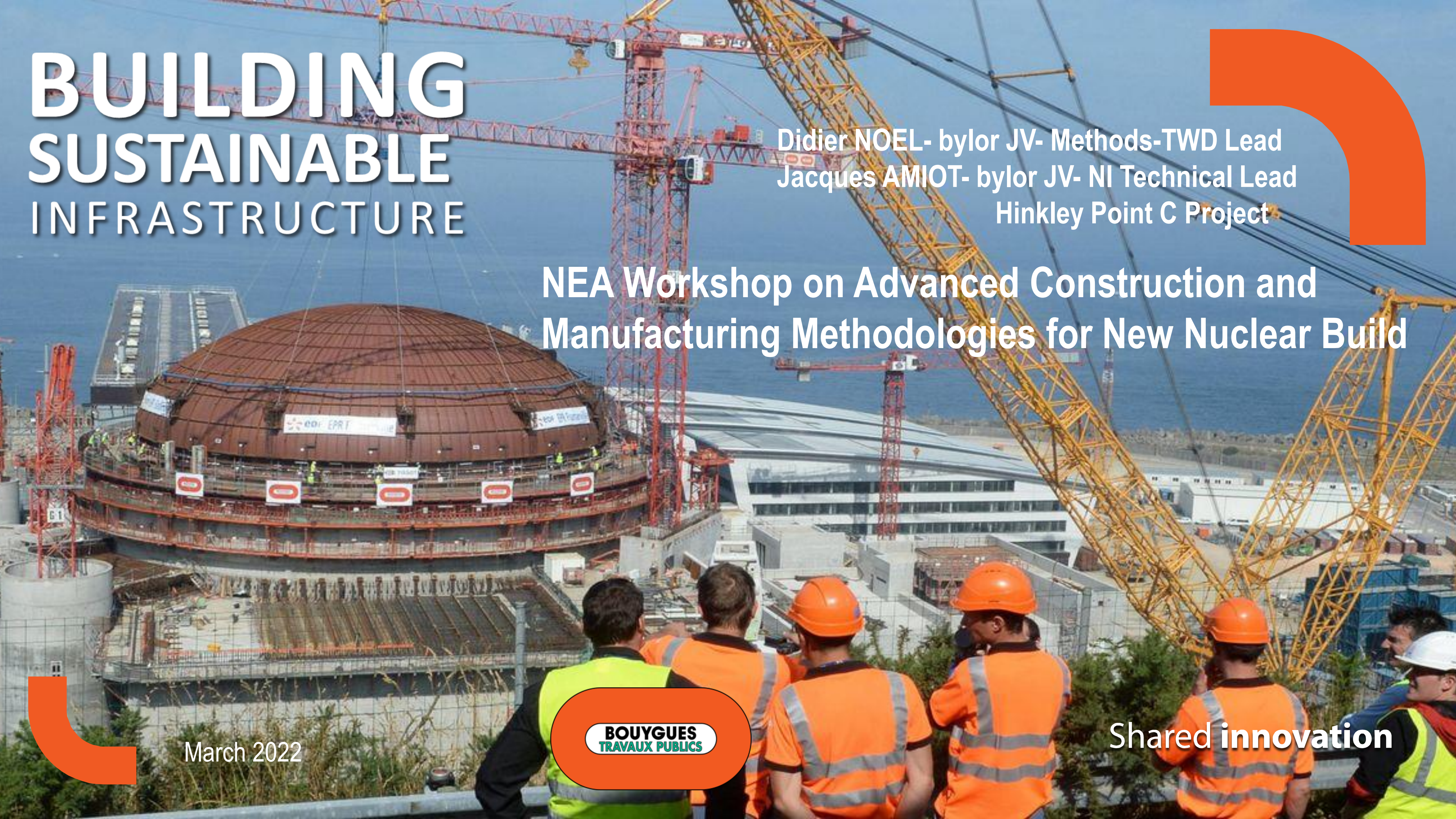
e. Establishment of a contracting structure in which all contractors have a vested interest in the success of the project

f. Adoption of contract administrative processes that allow for rapid and non-litigious adjustments to unanticipated changes

g. Operation in a flexible regulatory environment that can accommodate small, unanticipated changes in design and construction in a timely fashion

Source: MITEI, 'The Future of Nuclear Energy in a Carbon-Constrained World, An Interdisciplinary MIT Study', 2018

KHNP



BUILDING SUSTAINABLE INFRASTRUCTURE

Didier NOEL- bylor JV- Methods-TWD Lead
Jacques AMIOT- bylor JV- NI Technical Lead
Hinkley Point C Project

NEA Workshop on Advanced Construction and Manufacturing Methodologies for New Nuclear Build

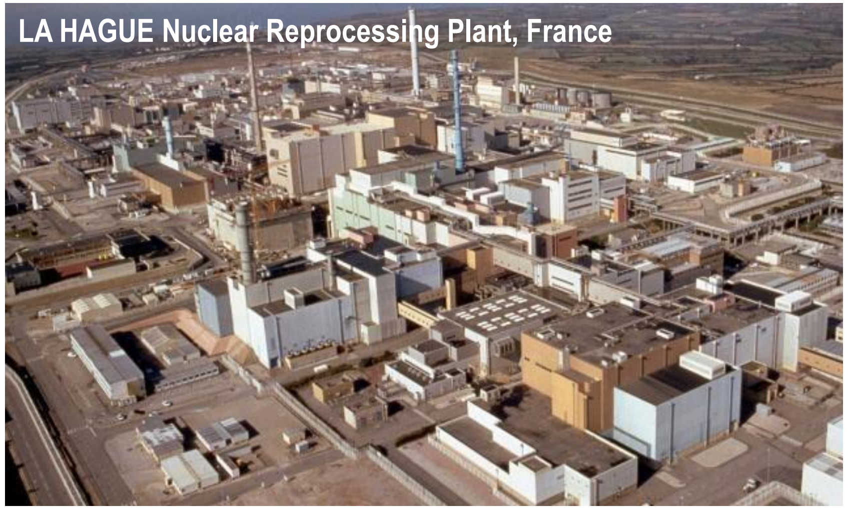
March 2022

BOUYGUES TRAVAUX PUBLICS

Shared **innovation**

BOUYGUES TP FOR NUCLEAR CIVIL WORKS WORLDWIDE


FLAMANVILLE Nuclear Plants, France


LA HAGUE Nuclear Reprocessing Plant, France

50 YEARS Expertise

Civil Works Construction

Decommissioning, Dismantling and Waste Management

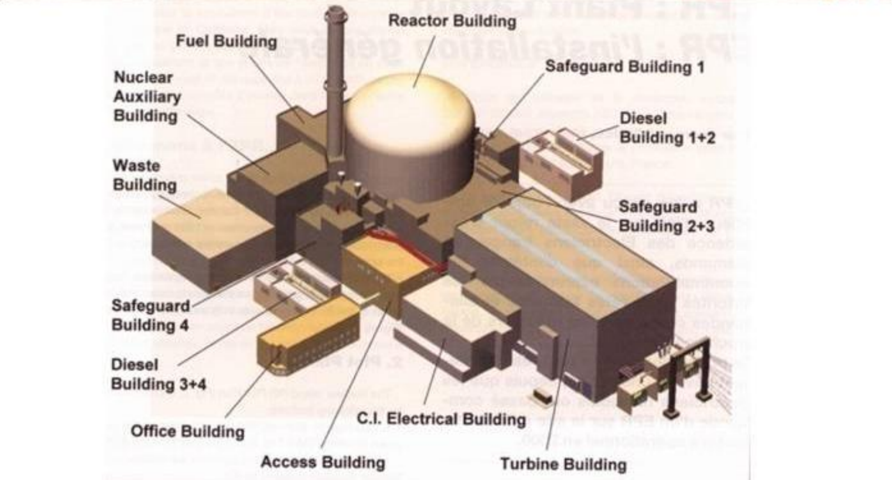

CHERNOBYL new Safe Confinement, Ukraine


OLKILUOTO 3 Nuclear Plant, Finland

Olkiluoto Nuclear Power Plant (EPR), Finland

LOCATION
OLKILUOTO - FINLAND

CLIENT
AREVA



SCOPE OF WORKS
This power plant is the first of a new generation of EPR nuclear plants (European Pressurised Reactor). .

- Nuclear Island
- 4 Safeguard Buildings
- Fuel Storage Building

MAIN QUANTITIES

• Concrete:	145,000 m3
• Steel reinforcement:	30,200 tons
• Shuttered surface:	275,000 m2
• Inserts: (110 000 units)	3,440 tons

DATE
2005 – 2011 (75 months)

Flamanville 3 Nuclear Power Plant (EPR), France

LOCATION

MANCHE (50) - FRANCE

CLIENT

EDF

SCOPE OF WORKS

- Nuclear Island
- Earth Works
- Conventional Island
  - Balance of Plant
  - Turbine Hall
  - Control Building
  - Pumping Station

MAIN QUANTITIES

• Concrete:	350,000 m^3
• Steel inserts: (96,000 units)	2,500 tons
• Steel Reinforcement:	56,000 tons
• Steel liner (inner containment):	1,200 tons
• Steel structure (turbine hall):	9,000 tons

DATE

2006 - 2016

BOUYGUES TRAVAUX PUBLICS

Hinkley POINT C (2 EPR units), United Kingdom

See NNB-HPC video on youtube with this link:

https://www.youtube.com/watch?v=Fia7Qo4ITxY

Ongoing

LOCATION

HINKLEY – SOMMERSET - UNITED KINGDOM

CLIENT

(SPV) - New Nuclear Build (NNB)

TYPE OF CONTRACT

NEC3 Contract, option D (target price & bill of quantities)

KEY DATES AND PROGRAMME

- *Signature of Heads of Terms & Early Contract Involvement (ECI): June 2012*
- *Signature of Main Contract expected in October 2015*
- ***Order: 1st January 2016***
- ***Project duration: 89 months***
- *Gap between unit 1 and unit 2: 12 months*

SCOPE OF WORKS

Main civil works for nuclear and conventional islands, Balance of Plant (BOP) and ancillary buildings on Hinkley Point on the Bristol Channel coast of Somerset:

Nuclear Island

- Carbon steel liner
- Stainless steel pools
- Paintings
- Doors
- Structural steel works
- Anchor plates and embedded parts

Conventional Island

- Turbine Hall

Balance of plant (BOP)

- Pumping stations

All along these 3 projects, Development of the modularisation / prefa / precast

The knowledge / feedback gained on OL3 and FA3 projects allowed BYTP to develop Modularisation, prefabrication and precast considering:

- the best gain by removing from the main critical path areas with the more important interfaces;

- The lifting capacity of the available Heavy Load Crane;

- The possibilities to design lifting equipment, lifting anchorages,

All along these 3 projects, Development of the modularisation / prefa / precast

For HPC project, Sarens developed a specific HLC:
SGC 250- erection of a Liner Containment Ring

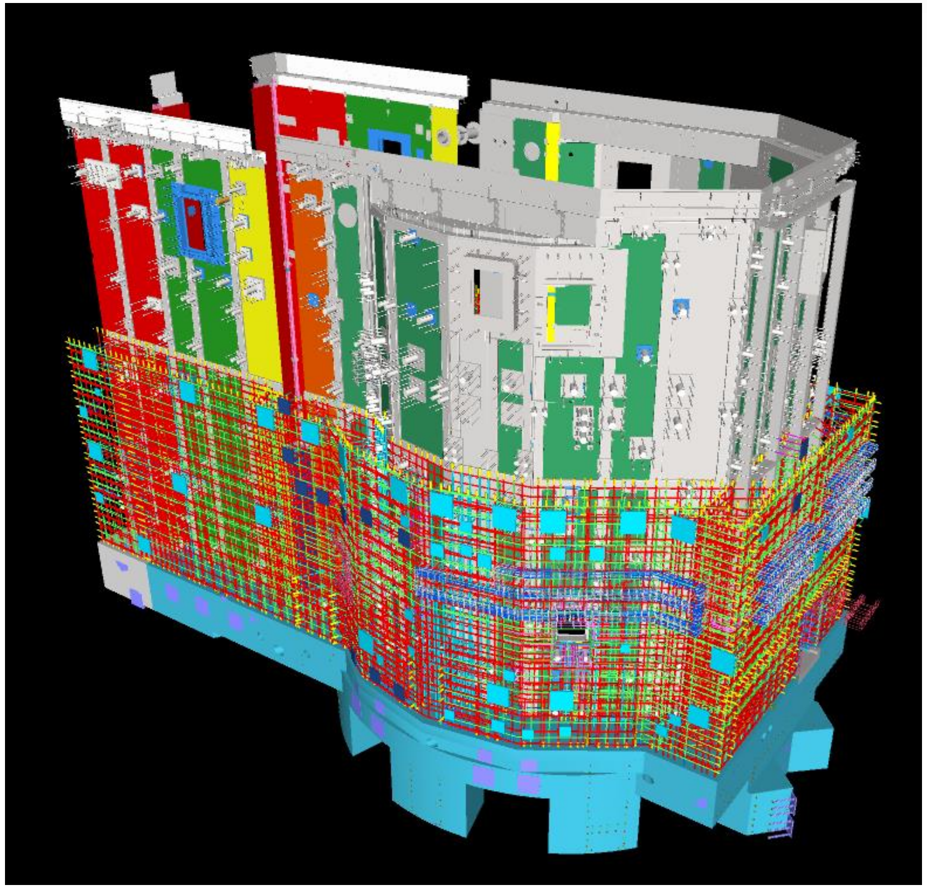
Photo: Lift Liner Ring 1 Unit 2 – 8 Dec. 2021

All along these 3 projects, Development of the modularisation / prefa / precast

Module of Pools and Tanks with or without Precast:

Photo: Lift ASG tank HL1 Unit 1 – 17 May.2021

Model: Cavity Reactor Module



All along these 3 projects, Development of the modularisation / prefa / precast

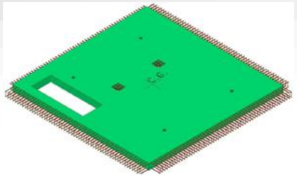
Several type of Precast elements:

Photo: Lift South Precast Slab -2.30
HR-Unit 1- 18 Dec. 2020

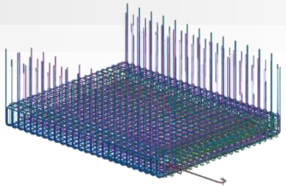
Photo: Lift Radial Wall
HR-Unit 1- 12 Nov. 2021

Photo: Lift HL1-02 Precast Slav – 18 Aug. 2020

Modules/ prefa / precast heavy lifts come in addition of the Equipment



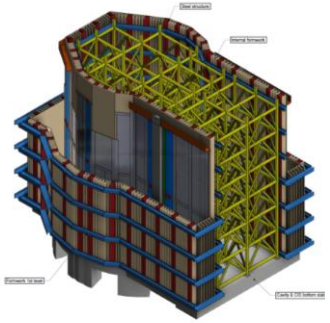
slabs



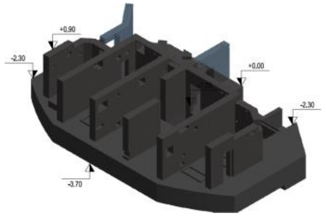
Reinforcement cages

More than 500 prefabricated elements

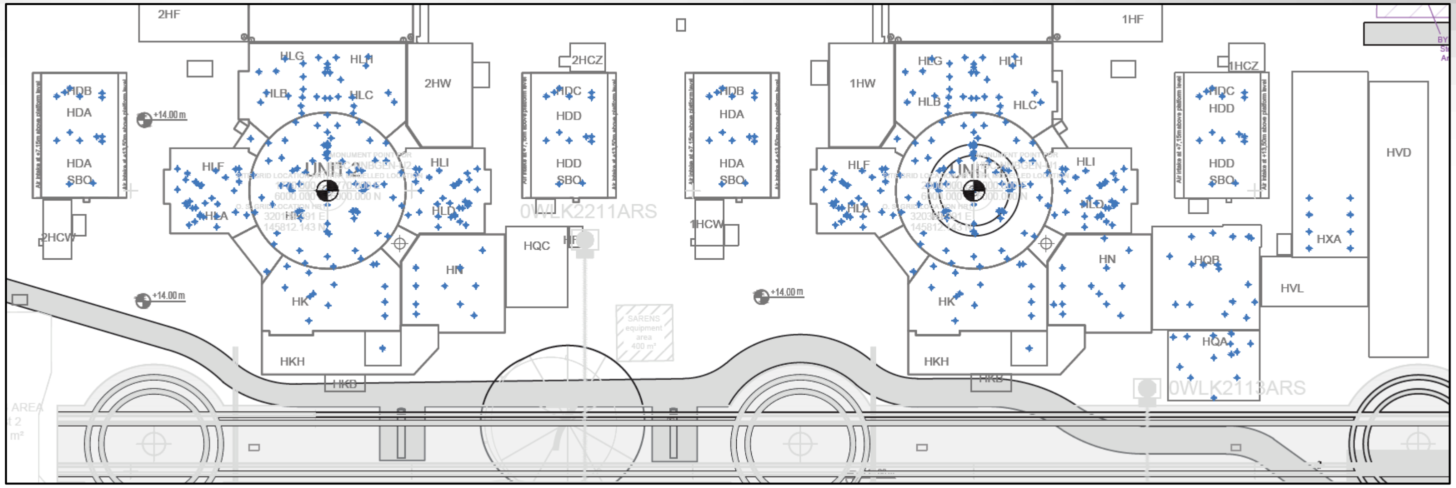
Pools, Tanks modules



Slabs with walls



Prefabricated element location



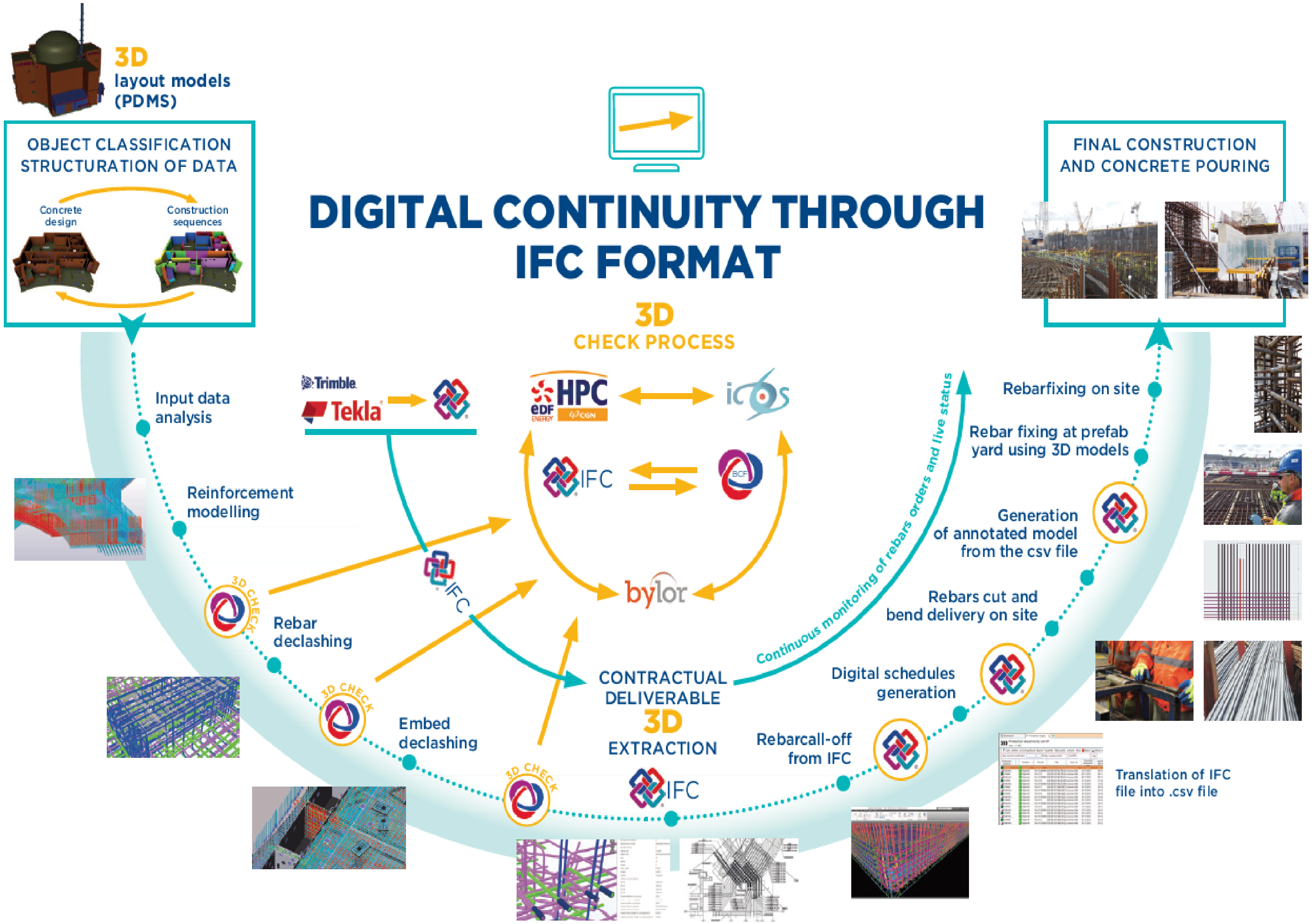
and more than 100 equipment

. . .spread over 20 buildings

Polar crane, tanks, fix points, MCR,…

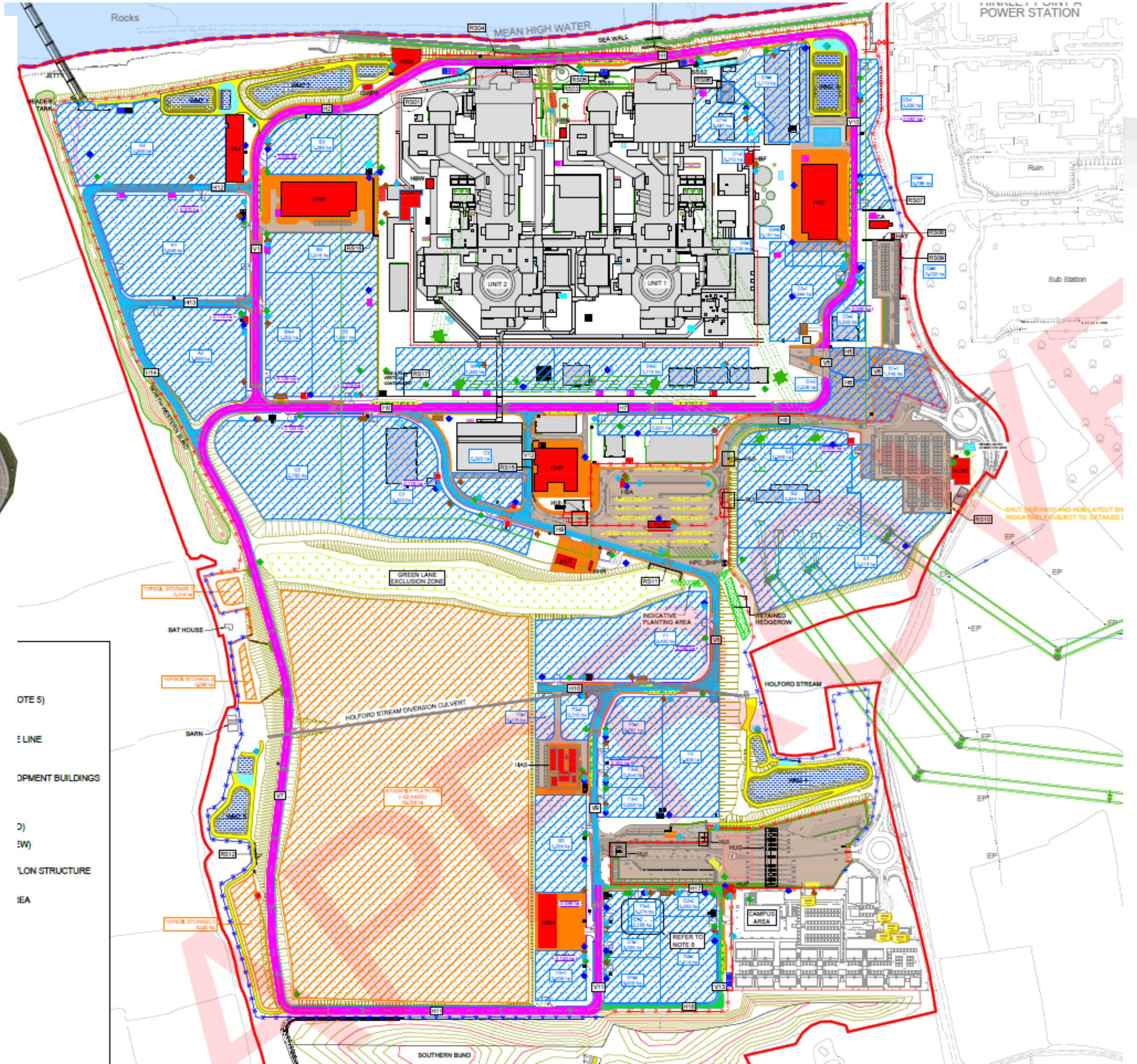
Development of the digitalisation to move toward full Paperless and then Drawingless processes

Drawingless and paperless shall mean simplification of the processes for staff and labour;
not complexification considering these processes are easiest to manage due to the digitalisation.



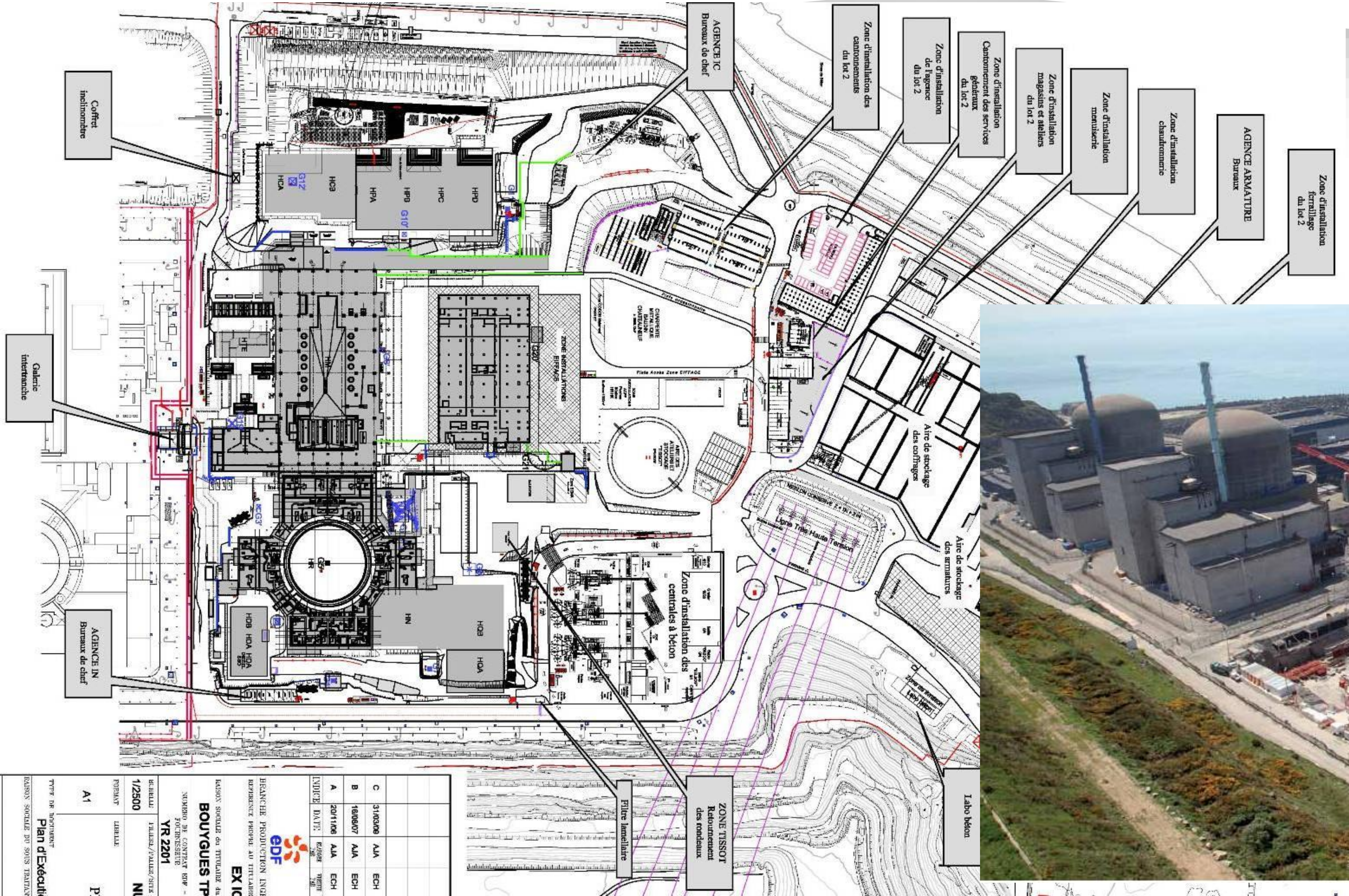
Additional points necessary for the success of a NPP

The site shall be very large with enough areas around the buildings, Hinkley is a good example



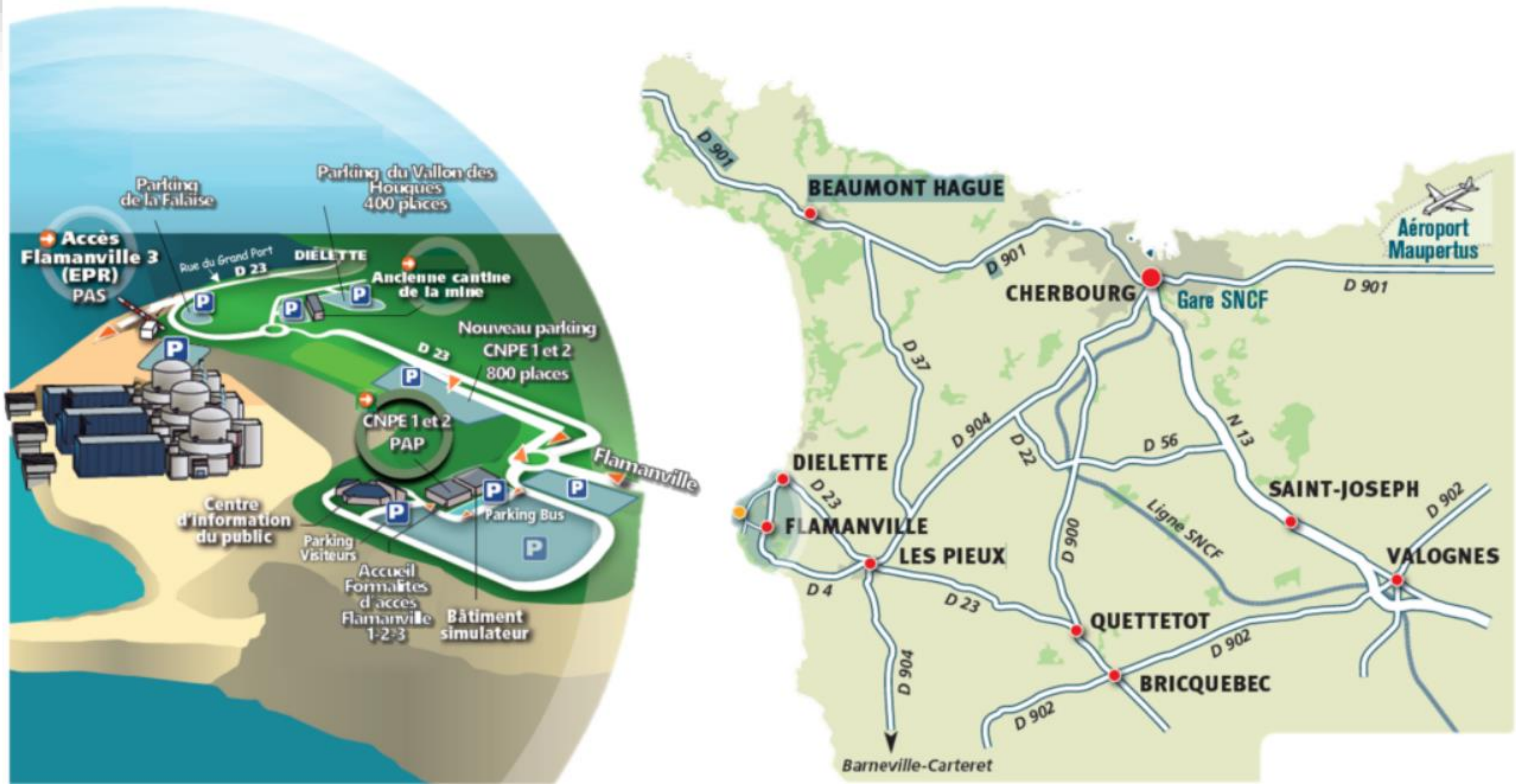
Additional points necessary for the success of a NPP

The site shall be very large with enough areas around the buildings. Flamanville was a bad example due to the small distances between Buildings and cliff on East side, previous Unit on South side, and National Grid connection on North side.



Additional points necessary for the success of a NPP

The site shall be easily accessible mainly by roads, and by sea, possibly by train as mitigation. Flamanville is a good example large roads which do not cross towns. Hinkley is more difficult with the bottleneck of Bridgwater



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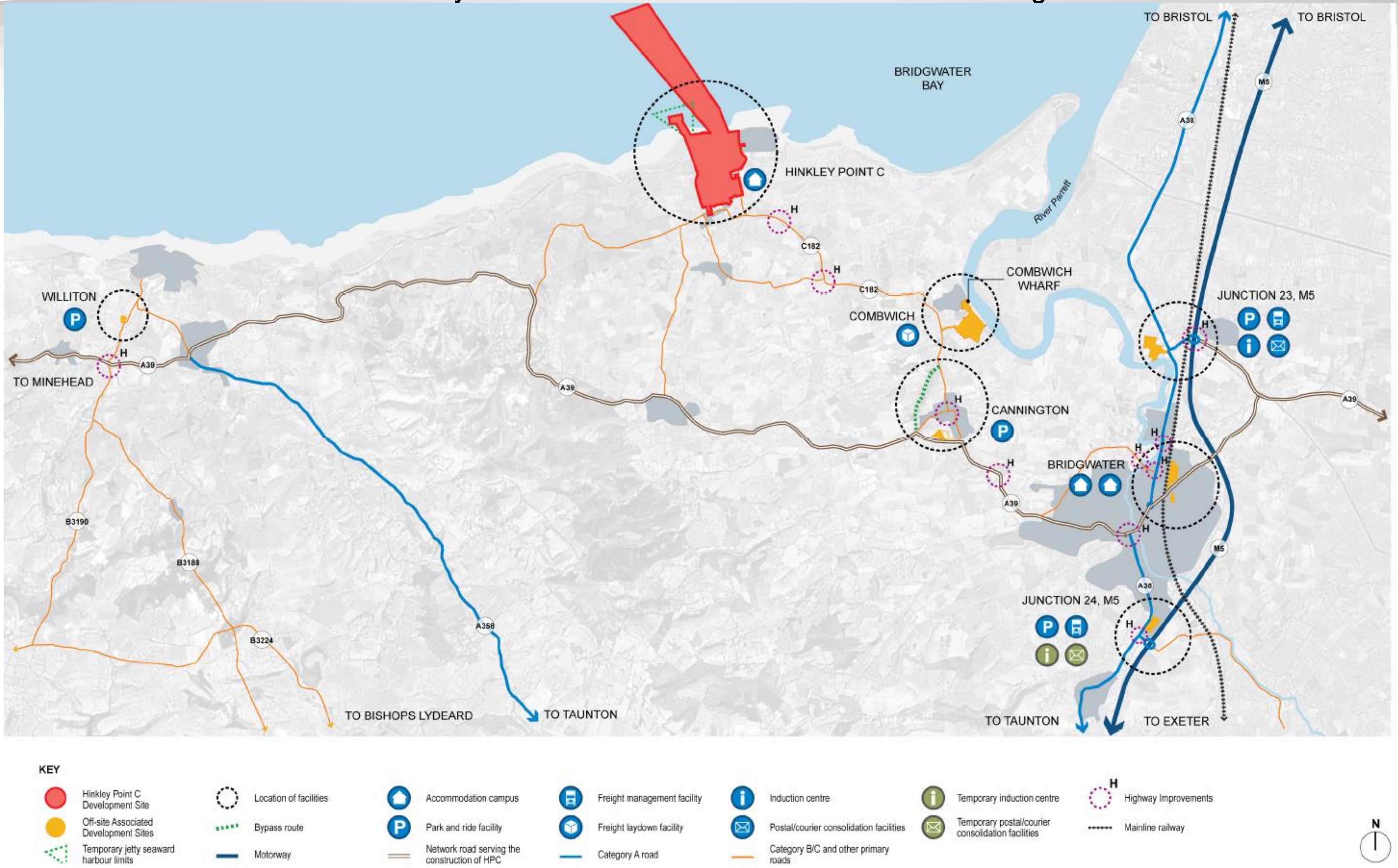


Additional points necessary for the success of a NPP

Resources:

- Mobilisation of the necessary resources; the necessary competences: S.K.A.T.E.

For the CW of two EPRs: Labour :~4000 and Staff: ~1200;

- Mobilisation of the specialised companies like Stainless Steel Liners; The discontinuity of the NPP new build programmes in Western Countries is not a good point to ensure a continuous workload for these specialised companies.

- Prevent a huge turn-over for these long projects; very often more than 10 years from start of Design to COD; People are efficient if they remain more than 3 years.

- Training of the future workers/staffs shall be anticipated with the support of the Department of Education.

Additional points necessary for the success of a NPP

Take care to the management of the 4D interfaces especially by letting more floats and/or more distances between stakeholders. Examples of interfaces :

- Equipment inputs / Design;
- Design / works;
- Earthworks / CW;
- Enabling works / CW;
- Adjacent buildings, Galleries / buildings;
- CW / embedded items + Pools
- CW / Finishes / MEH;
- …..

A design is never transposable from one country to another. It is always more or less impacted by:

- Cultural differences;
- Local Nuclear Specifications;
- Local CW General specifications;
- Local human resources …..

These differences shall always be well assessed.

BOUYGUES TRAVAUX PUBLICS

THANK YOU

ANY QUESTIONS?

HEALTH & SAFETY
A SHARED COMMITMENT!

OECD NEA - New Nuclear Build Workshop
Advanced Technology & Nuclear Costs Initiative

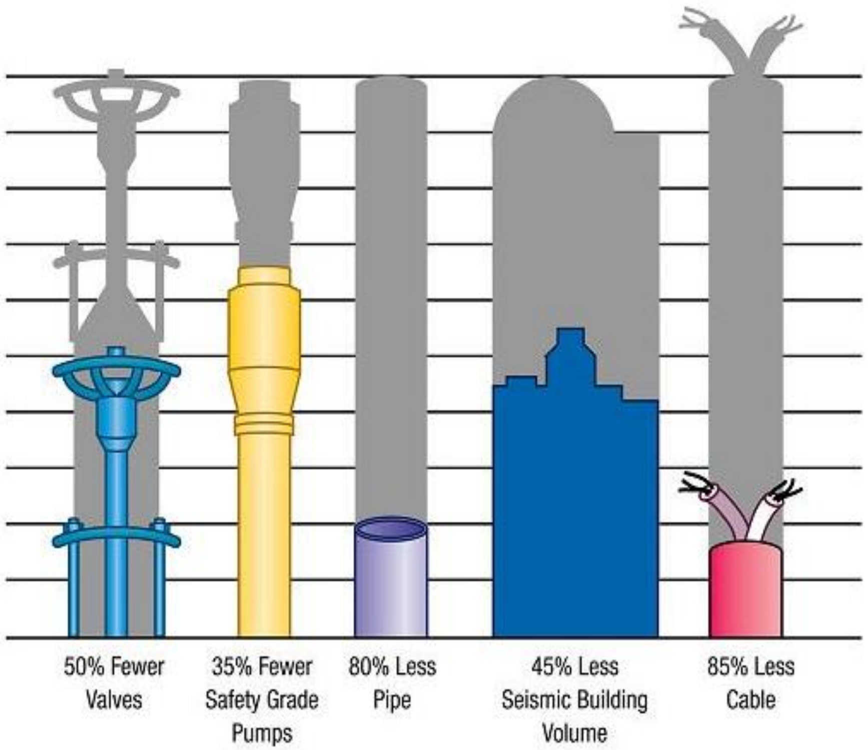
Greg Barnett MSCE, MBA
Georgia Power Co Nuclear Development
Plant Vogtle Units 3 & 4 – AP1000 Technology

16 March 2022

Georgia Power

AP1000 Differences To Legacy Plants

- Intended less plant equipment
- Modularization of structures
  - Walls and floors shop built
  - Assembled on site
- Reactor Coolant Pumps
  - Canned rotor no seal water
  - Attached to bottom of SGs
  - VFD for low speed operations
- RV Instrumentation all routed through the top of the RV
- Fully digital plant with 13,000 alarms
- Use of soft controls like mouse interface to computers



Vogtle 3&4 Modularization Overview

- Final Delivery in 2019
- 1485 Modules for Vogtle 3 and 4
- First Delivery in 2011
- All Modules manufactured offsite
- Transported via rail and truck to site
- Modules included floors and walls assembled into structures in the Modular Assembly Building (MAB)
- Lifted with 560 ft Heavy Lift Derrick

Final Module Installed May 2021
Unit 4 CB20 Tank Holding 750,000 Gallons of Cooling Water

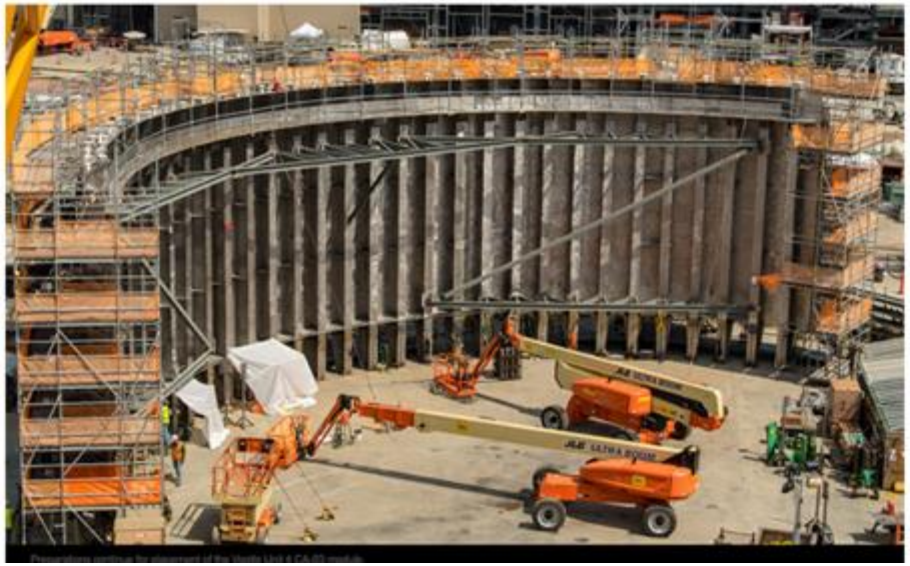
Modules Lessons Learned – CA20 Structural Module

- CA20 Module
  - Nearly 1,000 Tons
  - 72 total submodules
  - Largest AP 1000 component
  - Houses the Spent Fuel Pool and other rooms
  - Fabricated in Lake Charles/Oregon IW/IHI

- Key Lessons:
  - Nuclear Safety Culture
  - Multiple, Experienced Module Suppliers
  - Cost Dispute Resolution For Design Changes
  - Fabricator Design Finalization
  - Smallest Possible Work Packages

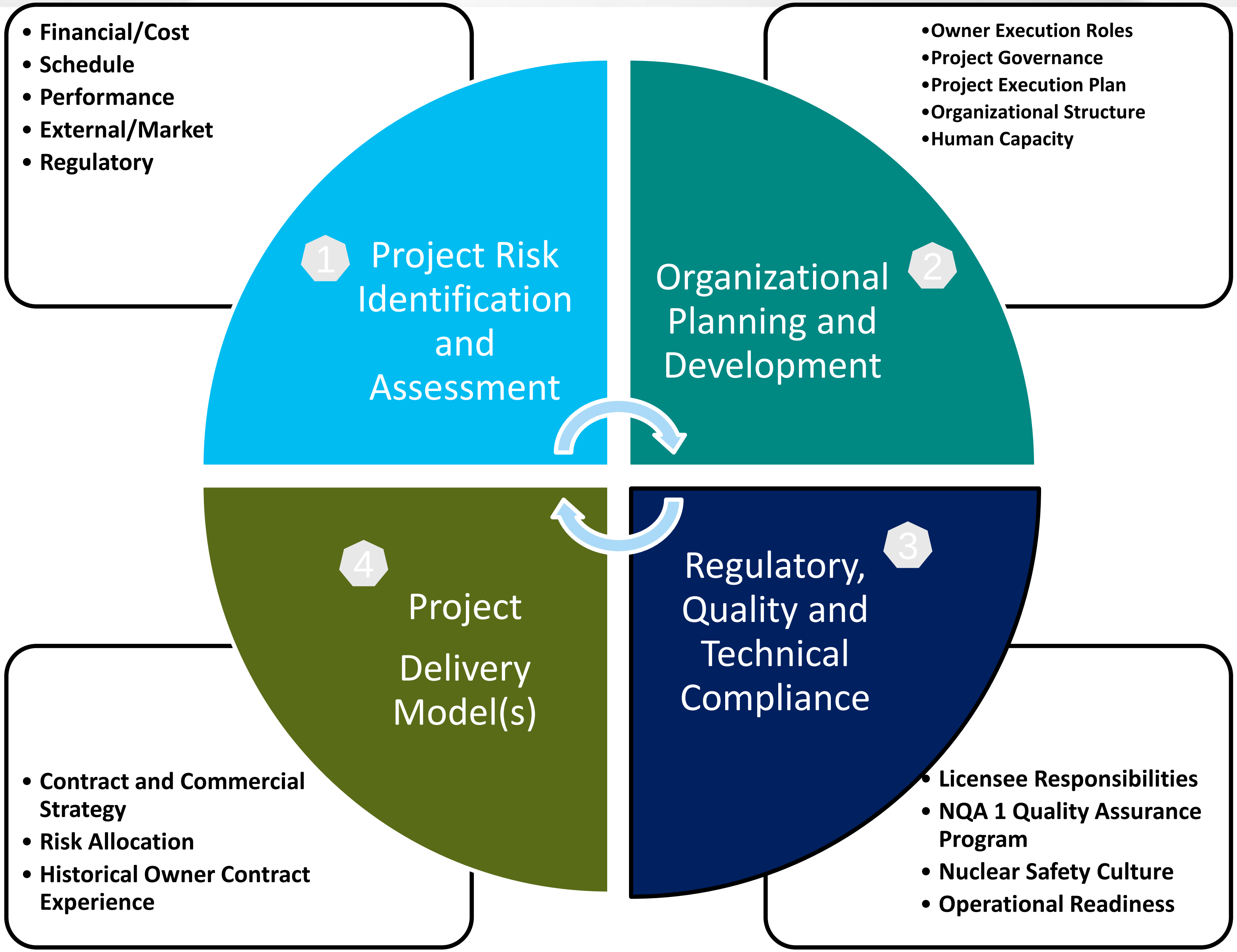
Licensing Departure for CA03 Structural Module

- CA03 or IRWST (In-Containment Refueling Water Storage Tank)
  - 237 Tons
  - Fabricated at MetalTek-SMCI /Lake Charles
  - 17 Submodules



- Key Lessons:
  - ❑ Volume of Part 52 License Amendment Requests
  - ❑ Preliminary Amendment Requests
  - ❑ Industry and Staff Collaboration

4 Key Owner/Licensee Focus Areas



Areas of applicable Southern Company experience and lessons learned.

Georgia Power