EDF EPR PROJECT LESSONS LEARNED

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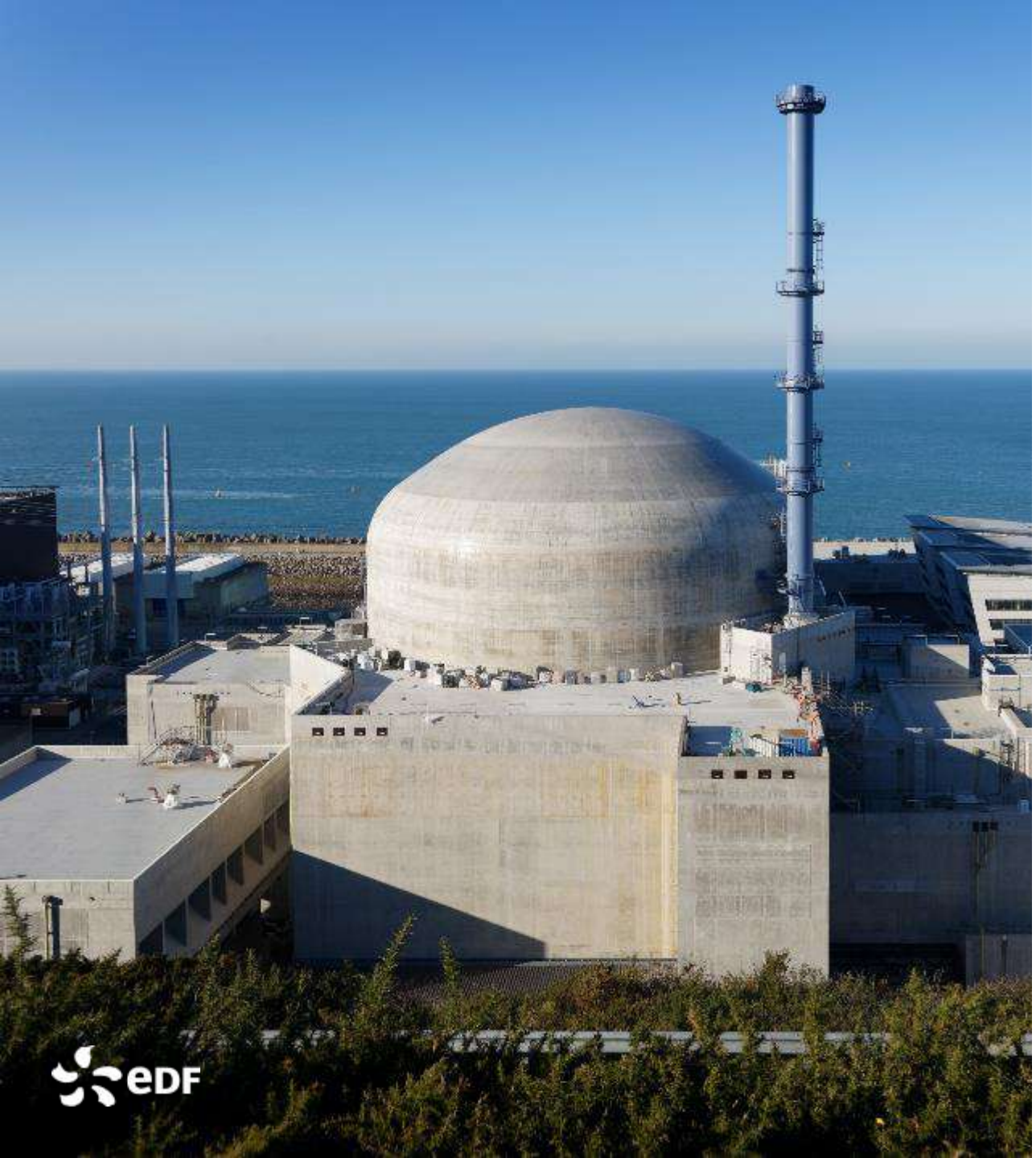

1. FEEDBACK EXPERIENCE OF THE FRENCH NUCLEAR INDUSTRY AS A WHOLE
2. EPR DESIGN AND KEY FIGURES
3. EPR PROJECT LESSONS LEARNED
4. TAKEAWAYS

FEEDBACK EXPERIENCE OF THE FRENCH NUCLEAR INDUSTRY AS A WHOLE

Solid experience in decommissioning

9 units taken from operation to decommissioning

Unique experience across the entire fuel life cycle

with French industry orano

A unique experience of nuclear services

provided to more than **360 reactors all over the world** (80% of capacity installed)

framatome

40 years of inhouse architect engineer experience

European and world scale feedback in operation

2,000 reactor-year of operation feedback

73 reactors operated by the Group

A strong and qualified nuclear workforce

more than **75,000 employees** capable to manage all the steps of NPP construction

More than 100 NPPs built

Recent experience of construction

2 EPR in operation

2 EPR under final commissioning

2 EPR under construction

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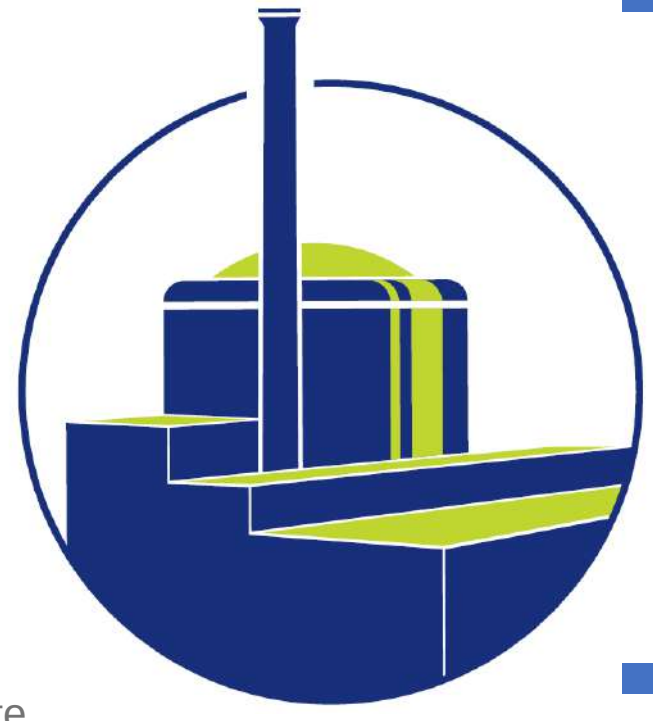
EPR : A POWERFUL & ROBUST DESIGN

The highest safety standard

- **Safe by design**
- Compliant with IAEA, WENRA, EUR standards
- Licensing experience
- Operational experience



A proven technology

- **Evolutionary design** derived from the best proven features from French and German PWR fleets
- **106 reactors** built or under construction across the world
- More than **2,000 reactor-years of cumulated operating experience feedback**

Performance improvements and efficiencies

- **37% overall efficiency** depending on site conditions
- **~ 15% savings on uranium consumption** per produced MWh
- **> 91% availability**

Benefits from high power output (1,650 – 1,770 MWe)

- **Compact Design:** Size effect & Limited footprint
- with **low carbon generation** performance

DESIGNED FOR SUSTAINABLY REDUCING O&M COSTS

EPR REACTOR MAIN DESIGN CHARACTERISTICS

Thermal Power	4,300 MWth – 4,590 MWth
Electrical power output	1,650 MWe – 1770 MWe
Thermal efficiency	37 %
Plant design availability	91 %
Primary system	4-loops configuration
Operation cycle lenght	Up to 24 months
Design service life	60 years
I&C	Full digital
Fuel assemblies in core	241 with 17x17 arrangement
Radiation Protection	collective dose < 0.5 man.Sv/y

DESIGNED FOR SUSTAINABLY REDUCING O&M COSTS

EPR DESIGN : A WIDE LICENSING EXPERIENCE

Construction license granted

Design license initiated

EUR Certification


EUROPEAN UTILITY REQUIREMENTS FOR LWR PLANTS

Certificate

The European Utility Requirement (EUR) organisation certifies that the standard EPR design has successfully passed all the steps of the analysis of compliance vs. EUR REV C with Areva's contribution.

Following this analysis, a specific subset of the EUR volume 3 dedicated to the standard EPR project has been published by the EUR organisation.

A ROBUST DESIGN ALREADY LICENSED IN 4 DIFFERENT COUNTRIES

EDF EPR PROJECTS WORLDWIDE

UNDER OPERATION

EPR TAISHAN
The 2 first EPR units in operation worldwide

UNDER COMMISSIONING OR CONSTRUCTION

EPR FLAMANVILLE 3
The first EPR unit built in France

EPR HINKLEY POINT C
First nuclear construction project in the UK since 30 years

UNDER DEVELOPMENT

EPR JAITAPUR
The world largest nuclear power plant
6 units, 9.9 GWe

EPR SIZEWELL C
A replication of EPR Hinkley Point C

EPR KSA PROJECT
2 EPR Units

EPR FLAMANVILLE 3 REFERENCE PLANT

GENERAL INFORMATION

- First EPR reactor built in France
- Power output: 1,650 MW
- EDF combining its skills and responsibilities of Owner & Operator and Architect Engineer
- 100% EDF ownership

MAIN LESSONS LEARNED

- Management of regulatory changes
- Quality and safety culture as an overriding priority
- Building trust through dialog with stakeholders
- FOAK effects

August 2017
Nuclear circuit cleaning

August 2018
Functional tests
vessel open
successfully completed

September 2019
Start of hot functional tests

CURRENT STATUS | **NEXT**

January 2018
Cold tests carried out

Fuel loading and start-up operation

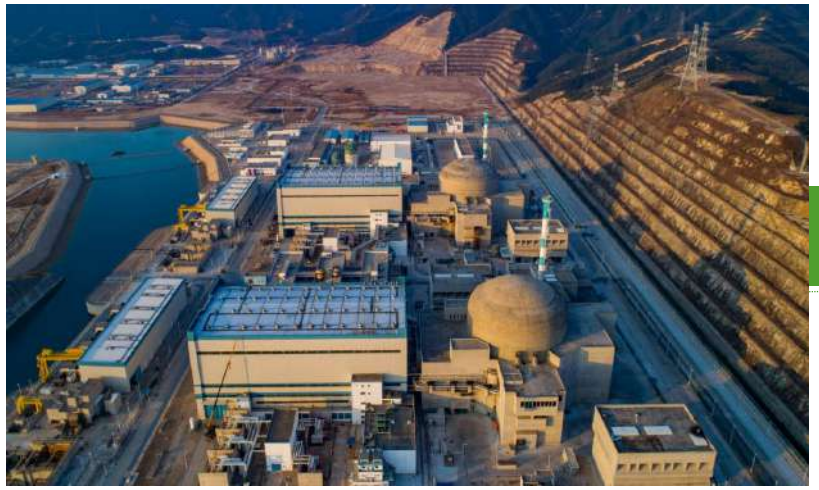
EPR TAISHAN 1 & 2: FIRST EPR UNIT IN COMMERCIAL OPERATION

GENERAL INFORMATION

- The first two EPR reactors in China
- Power Output: 1,750 MW each
- EDF as co-owner and co-operator – 30% EDF onwership

MAIN LESSONS LEARNED

- EPR design adaptability to tropical conditions
- Twin effects and benefits of lessons learned on EPC performance
- Deep localization based on robust qualification processes and partnership
- Early training and setting of a pre-operation team for smooth commissioning and operation readiness



29 June 2018
Unit #1: grid connection

13 December 2018
Unit #1 in Commercial Operation

29 May 2019
Unit #2: 1st criticality

STATUS

24 TWh nominal power

6 June 2018
Unit #1: 1st criticality

10 December 2018
Unit #2: Start of hot functional tests

7 September 2019
Unit #2: in Commercial Operation

EPR HINKLEY POINT C: A NEW BUSINESS MODEL FOR NEW NUCLEAR THAT INSPIRES OTHER COUNTRIES

GENERAL INFORMATION

- First nuclear construction project in the UK since 30 years
- 2 EPR units,1,638 MW each
- A successful certification process: Generic Design Assessment (GDA)
- Contract For Difference (CFD) guarantying a fixed price of electricity for 35 years
- 66.5% EDF ownership

MAIN LESSONS LEARNED

- Early contractors involvement
- Increased level of design maturity at FCD
- Use of digital tools (design, schedule)
- Industrial and contractual schemes aligned to focus on delivery and project performance

CURRENT STATUS

October 2013
UK Governments agrees Contract For Difference for HPC

September 2016
Final Investment decision

March 2017
Reactor common raft first concrete successfully poured for power station galleries

June-2019
Unit #1 « J0 » achieved
Completion of Nuclear Island common raft

NEXT

2025
COD Unit #1

2026
COD Unit #2

EPR SIZEWELL C: THE NEXT NEW BUILD IN THE UK

GENERAL INFORMATION

- 2 EPR units on the site of Sizewell totalizing 3,200 MW of capacity installed
- Project developed by EDF Energy together with CGN
- Replication of Hinkley Point C design

LESSONS LEARNED TO BE IMPLEMENTED

- Maximizing replication benefits (design, project management, industrial scheme)
- Adapting financing solutions to replication

Stage 2 Public consultation

Stage 3 Public consultation

Nuclear Site Licence Application

CURRENT STATUS

SCHEDULE

Generic Design Assessment

JAITAPUR PROJECT – THE MOST POWERFUL NUCLEAR SITE

GENERAL INFORMATION

- 6 EPR units on the site of Jaitapur totalizing 9,900 MWe of installed capacity
- First EPR reactors in India
- Works shared with NPCIL, Nuclear Power Corporation of India Limited and other international partners

LESSONS LEARNED TO BE IMPLEMENTED

- Deep localization through strong partnerships
- Anticipation of qualification and training processes
- A robust industrial scheme as a pillar of contractual arrangements

CURRENT STATUS

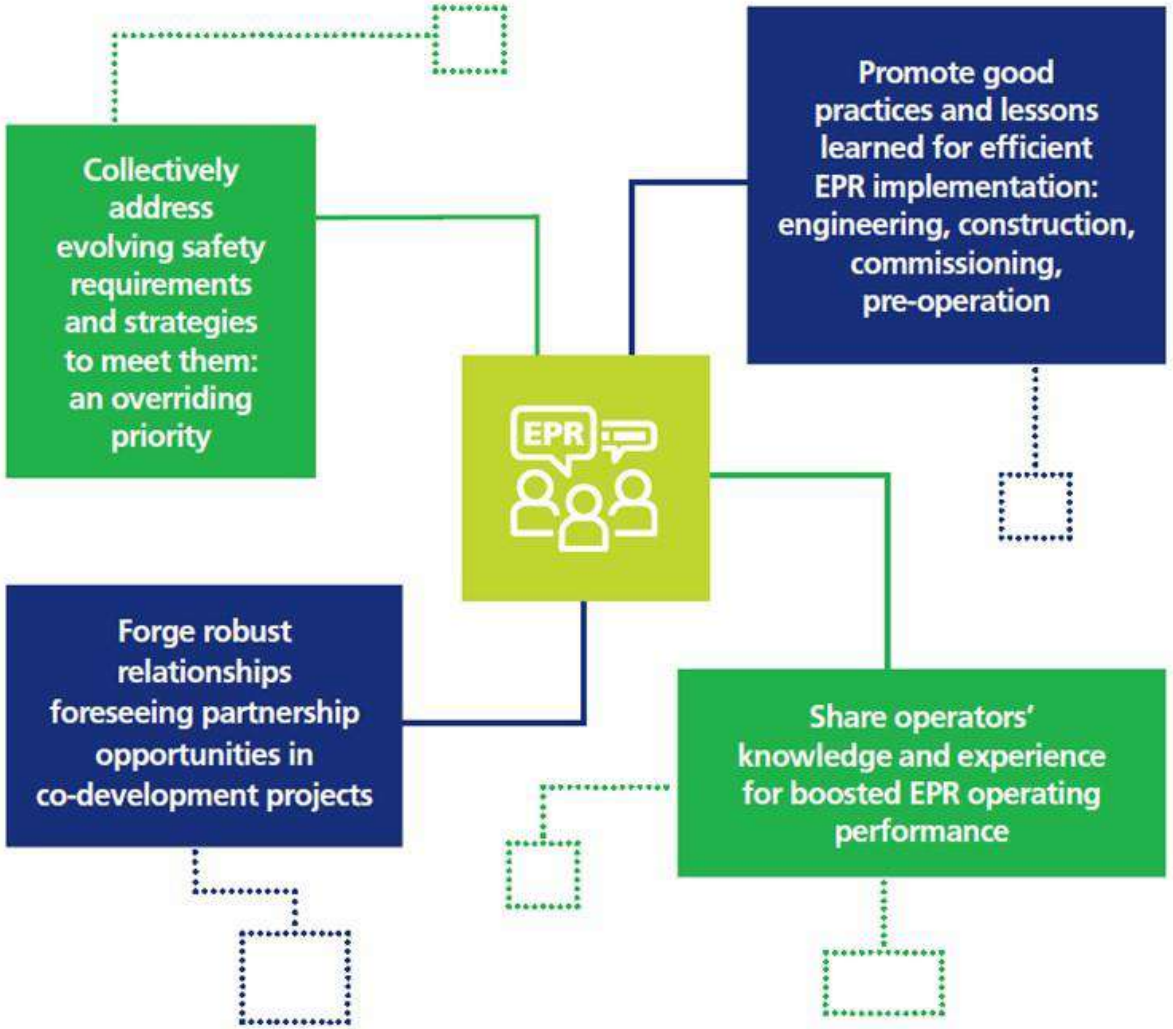
March 2018
India and France inked an agreement to expedite the JNPP project

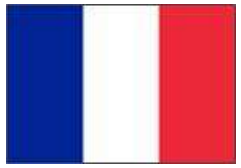
SCHEDULE

May 2018
Submission of Preliminary Commercial Proposal to NPCIL

Commercial & Technical offer by EDF to NPCIL, scheduled by end 2019

EPROOG: EPR OWNER-OPERATORS GROUP CAPITALISING ON LESSONS LEARNED





EDF

EDF ENERGY

TVO

台山核电 TNPJVC

KEY TAKEAWAYS

1. **EPR is a safe, robust an adaptable product meeting its promises with its first operational track record**
2. **Success factors for project performance and long term safe operation are:**
   - A stable and comprehensive **regulatory framework**
   - A **strong control of the design** (early design freeze, changes management, system engineering) and of the project performance
   - The early preparation and commitment of **a knowledgeable Owner-Operator**
   - The **anticipation of supply chain development** and strategic alliances (specially for deep localization ambitions)
   - **Robust industrial and contractual schemes** to align and incentivize projects participants with project objectives
   - A **clear definition and allocation of risks** among stakeholders
3. **Most of all, quality and safety culture should always be maintained and continuous improvement**

ALL LESSONS LEARNED ARE MANAGED TO BENEFIT TO CURRENT AND FUTURE EPR PROJECTS