THE FRENCH NUCLEAR EXPERIENCE IN THE POLISH NUCLEAR ENERGY CONTEXT

THE EPR REACTOR: SAFETY, LOCALIZATION, CONSTRUCTION, EXPERIENCE FEEDBACK

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CONTENT

1. EDF Group company profile
2. The EPR reactor and the current projects
3. Hinkley Point C NPP project
4. Feedback from current EPR projects
EDF GROUP
KEY FIGURES OVERVIEW

EDF produces around 22% of the European Union’s electricity, primarily from nuclear power.
FRENCH NUCLEAR LANDSCAPE
SOCIO ECONOMICAL BENEFITS

- 1.2% of CO₂ Emissions for 4.3% of Worldwide GDP
- 80 gCO₂/kWh compared to 300 gCO₂/kWh in Europe
- 56% Energy Independence
- 438 TWh Nuclear per year
- 220,000 Employees
- 2,500 Companies
- 3rd Industrial Sector for Export
- 3% of CO₂ Emissions
- One of lowest price of electricity in Europe
- 438 TWh nuclear per year
- 80 gCO₂/kWh compared to 300 gCO₂/kWh in Europe
- 3% of CO₂ Emissions
- 220,000 Employees
- 2,500 Companies
- 3rd Industrial Sector for Export
DESIGNING, BUILDING, OPERATING AND MAINTAINING THE LARGEST FLEET WORLDWIDE

EDF : World’s leading nuclear power plant operator

- 58 reactors in France (63 GWe)
- 15 reactors in the UK (9GWe)
- ~2000 reactor-years of experience operating the French fleet

Operating organizations ranked by number of reactors in operation (2016)

EDF International experience on project delivery

5 ongoing EPR Units

- Flamanville 3, France
- Taishan 1, China
- Taishan 2, China
- HPC 1&2, United Kingdom

An EPR Owners Operators Group: EDF, EDF Energy, TNPJVC, TVO
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THE EPR REACTOR

1,650 MWe PWR

- Generation III+ PWR
- High power output (1,650 MWe)
- Plant efficiency 36%
- Evolutionary design (Konvoi / N4)
- Low global power generation costs
  - Fuel consumption reduced by up to 15%
  - 60 years of operation
  - Availability factor 91%
  - Improved flexibility to reduce OPEX
- Load following capability
- Reduced number of welds
- Maximized benefit from size effect
- Minimal environmental impact
- MOX Fuel capability
- Reactor being designed in collaboration with utilities and safety authorities
- EUR criteria compliant
- An outstanding safety level…
STATE OF THE ART IN TERMS OF SAFETY

Reduce the probability of a severe accident with core meltdown

Protect population and environment in case of severe accident

Protect against malevolent act (e.g. airplane crash)

Physical separation, diversity, and redundancy of critical components – 4 safety trains

Confined corium and radioactive products in the reactor (“core catcher”) – Deterministic approach

High structural resistance – Double shell containment
A DESIGN ALREADY ASSESSED AND LICENSED BY VARIOUS INDEPENDANT BODIES AND SAFETY AUTHORITIES, WORLDWIDE

Construction license granted in 4 countries
Design license started
In line with the safety objectives of the Western European Nuclear Regulators’ Association (WENRA)

A smoother licensing phase supported by experienced team involved in numerous licensing contexts
### 40 YEARS OF FRENCH KNOW HOW TRANSFER AND LOCAL INDUSTRY DEVELOPMENT

<table>
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<tr>
<th>Areas of support</th>
<th>Knowledge and learning sharing</th>
<th>Examples</th>
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<td>Skills development</td>
<td>40+ years of successful human capacity building guidance and cooperation with fellow countries since 1970’s.</td>
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<td>Localization</td>
<td>45y years of local industries development, both NPP (engineering, manufacturing, and construction) and fuel cycle – through technology transfer and skills development, including R&amp;D support, to create high quality jobs locally.</td>
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<td>Education and training (all types)</td>
<td>55+ partnerships with top universities worldwide. set up of joint training centers.</td>
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<td>NPP operation</td>
<td>850+ trainees from foreign operators trained over the last 30 years.</td>
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<td>346 reactors supported, out of the 435 in operation (i.e. 80% of nuclear global fleet), with products and services.</td>
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FLAMANVILLE 3: THE EPR REFERENCE PLANT

- EPR Reference Plant
- First EPR reactor in France
- Largest Project in Northern Europe
- Power output: 1,650 MWe
- EDF as Owner & Operator

**SCHEDULE**

- **End 2018**
  - First fuel loading and start-up operations to begin

- **August 2017**
  - Cold Test
    - Nuclear circuit cleaning

- **September 2015**
  - New schedule

**CURRENT STATUS**

- **March 2016**
  - Welding of 1st Primary Circuit

- **End 2017**
  - Cold functional test

- **July 2018**
  - Hot functional test

- **2nd Quarter 2019**
  - Connection to the grid
TAISHAN 1 & 2: ACCELERATION IN THE EPR LEARNING CURVE

- The first two EPR reactors in China
- Power Output: 1,750 MW each
- EDF as co-Owner-Operator with renewed partnership
- Tropicalized to adapt to the country’s climate

July 2017
End of Hot Functional Tests

Second half of 2018
COD Unit #1

April 2018
First fuel loading

Second half of 2019
COD Unit #2
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HINKLEY POINT C 1&2: CONFIRMING EPR AS THE REFERENCE IN EUROPE

- First nuclear construction project in the UK in 30 years
- GDA certification process
- Reference plant EPR Flamanville 3
- Contract For Difference guarantying a fixed price of electricity for 35 years
- Partnership with CGN as co-owner
- Power output: 1,638 MWe each

**CURRENT STATUS**

- **October 2013**
  - UK Government agree Contracts For Difference for HPC

**SCHEDULE**

- **September 2016**
  - Final contracts signed

- **2019**
  - FCD Unit #1

- **2025**
  - COD Unit #1

- **2026**
  - COD Unit #2

- **March 2017**
  - First nuclear safety concrete successfully poured for power station galleries
HINKLEY POINT C
Key figures

- 3.2 GW power plant with two reactors
- 25,000 new job opportunities created during construction
- 9 million tonnes (approx) of CO₂ avoided each year, equivalent to roughly 2 million cars
- 7% of the UK's electricity
- £200m annual boost to regional economy during core construction
- 64% of the construction cost will be placed with UK businesses

- 6 million homes
HINKLEY POINT C - Scale of the Construction Site

- 3 Million Tonnes of Concrete
- 5.6 Million $M^3$ of earth to be moved
- 4000 km electrical cabling
- £40M injected in local economy during operation
- Over £4 Billion benefit to local economy during construction and operation
- 30% Local workforce

4D Model illustrating part of the nuclear island
HPC INSPIRING INDUSTRIAL COLLABORATION
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LESSONS IMPLEMENTED AT HPC

Configuration

- End of construction topographical surveys with data compared with PDMS model and results made available to all parties

Mechanical, Electrical and HVAC Erection

- Development of new contractual arrangements and collaborative one-team ways of working

Civil Construction

- 3D design of rebar and solving of embedment clashes before models frozen
- Use mock-ups to trial techniques, test arrangements and competencies, test interfaces
- Modular construction of rebar cages, floors, walls and pool liners

Data-centric Approach

- Development of a central electronic depository for all project information to support commissioning and operation
MEH INTEGRATION MODEL – THE CHALLENGE

Hinkley Point C:
- Construction schedule is challenging
- Scale and complexity is unique
- Delivery needs world-class productivity, room occupancy and daily progress rates
- Delivery needs a different way of working
  - New organisational and contractual arrangements
  - New methods, tools and systems being developed, including configuration capture by one consolidated 3D topographical survey
CONCLUSION

- EDF is a strong player on the world’s nuclear market – Operates the biggest fleet in the world

- The EPR is a robust design, EPR will keep the owner-operator on the safe side

- The EPR world wide fleet is being born

- Ongoing construction projects are getting to end, no project has been stopped

- EDF long standing experience as a nuclear operator guarantees that the phasing from construction to operation will be managed smoothly and efficiently (derisk of fuel loading clearance after construction)

- Improvement slope is a fact in all fields (engineering, fabrication, construction, PMO)

- Systematic lessons learned implementation in new project is industrialized – Implementation on the biggest construction site in Europe at Hinkley Point C

- The level of confidence regarding capability to deliver future projects on time and on budget is high

- Polish EPR will be the 7th and 8th a the EPR world series
DZIĘKUJĘ
PYTANIA?