‘Grand Carénage’ Presentation of major renovation programme

ENSREG

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THE EDF NUCLEAR FLEET

- 58 reactors in operation, one reactor undergoing construction
- Homogeneous fleet of PWR reactors
  - 34 x 900 MWe reactors
  - 20 x 1300 MWe reactors
  - 4 x 1450 MWe reactors
  - 1 x EPR reactor undergoing construction
- Average reactor age in EDF fleet: 31 years
  - Reactors commissioned between 1978 and 1998
- Power generated ≈ 400 TWh/year
  - 70% of electricity production in France
- Extending the service life of the EDF fleet is driven by the 'Grand Carénage' or Major Renovation programme

TEN-YEARLY OUTAGE

1

Full plant inspection

- **Full post-maintenance testing** of main reactor coolant system
  - RCS hydrotest
  - Non destructive examination of equipment (in-service inspection machine in reactor vessel)
- **Re-testing** of containment vessel

Plant compliant

2

Periodic safety review

Compliance review

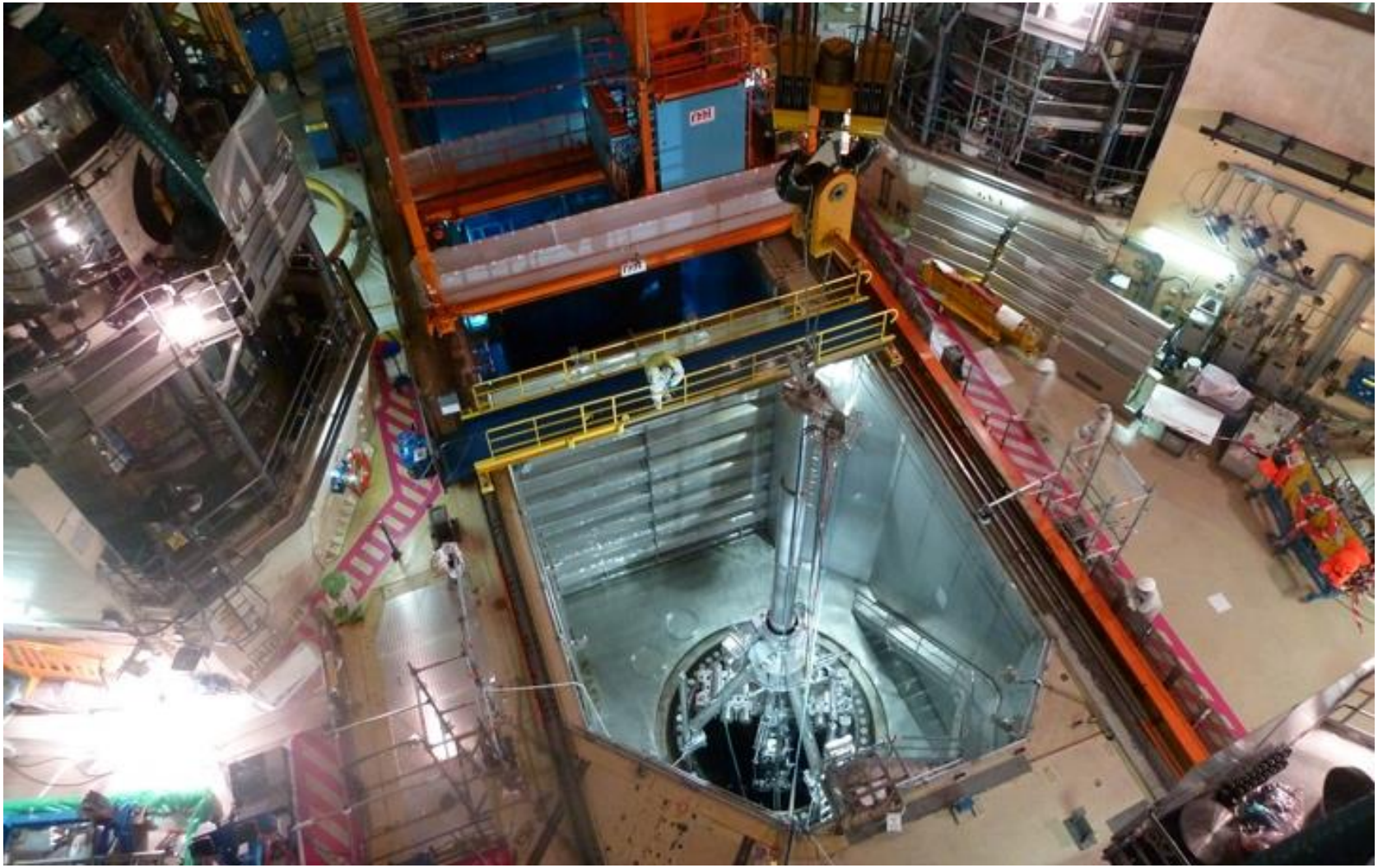
- **Compliance Review (ECOT)**
- **Additional Investigation Programme (PIC)**
- **Aging control (>30 years)**
- **Continued post-maintenance testing (>40 years)**

Safety Assessment

- **Analysis of Operating Experience**
- **Update of safety assessments**
- **Inclusion of new techniques**

Modifications programme

1 : FULL PLANT INSPECTION



Non-destructive examination of reactor vessel at Saint Laurent B1, using the In-service Inspection Machine (MIS) during the plant's 3rd ten-yearly outage in 2014

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Modifications programme

2 : PERIODIC SAFETY REVIEW

COMPLIANCE REVIEW

An approach that involves EDF R&D teams

- An example of R&D: VERCORS mock-up, laboratory conducting studies into the aging of containment vessels

A 1/3 scale mock-up of reactor containments in the 1300 MW series, subjected to accelerated aging

A major challenge: in-service behaviour of reactor vessels

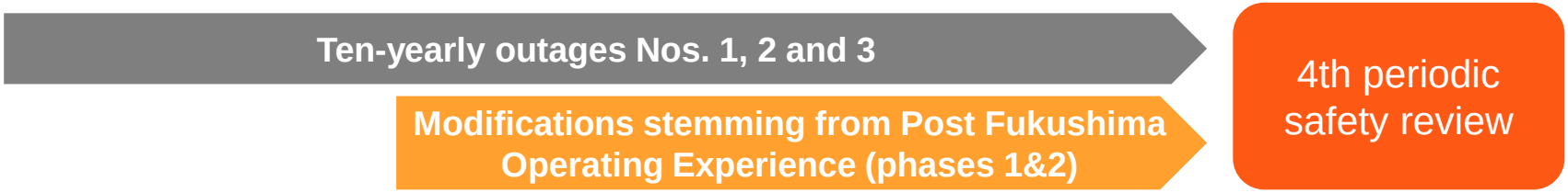
- Introduction of Hafnium rods in reactors from the 900 MWe series during the 4th ten-yearly inspection to reduce exposure of reactor vessels to neutron flux

2 : PERIODIC SAFETY REVIEW

SAFETY ASSESSMENT

- Four key areas assigned to 4th periodic safety review of 900 Mwe series (pursuant to directive 2014/87/Euratom)
  - Minimize radiological consequences of design-basis accidents, to avoid sheltering the local population
  - Prevent long-term contamination of territories in the event of core melt accidents
  - Increased focus on external hazards (earthquakes, flooding, heat waves, tornadoes, etc.)
  - Enhance safety of spent fuel storage buildings.

- A stringent requirement from French Nuclear Safety Authority: strive to reach nuclear safety objectives for generation 3 reactors
- A periodic safety review that is based on the existing improvement process



MAIN MODIFICATIONS DURING 4TH TEN-YEARLY OUTAGE ON UNITS FROM 900 MWE SERIES

- Addition of a long-term ‘hard core’ reactor cooling system, preventing opening of containment decompression filter in the event of core melt
- ‘Hard core’ steam generator feedwater system
- ‘Hard core’ system installed for emergency cooling of spent fuel pool
- Reinforcement of strength of basemat in the event of reactor vessel failure (EVS)
- Increase seismic resistance of the plants
- Upgrade of I&C

INDUSTRIAL PROGRAMME – MAJOR RENOVATION PROJECT

3 ACTIVITY CATEGORIES :

- **OVERHAUL OR REPLACEMENT OF LARGE COMPONENTS** that are reaching the end of their technical service life (exceptional maintenance)

- Perform **MODIFICATIONS REQUIRED TO IMPROVE NUCLEAR SAFETY**
(including Post-Fukushima modifications and ten-yearly outage)

- **ENSURE LONG-TERM FUTURE OF EQUIPMENT**
After 40 years

THE MAIN ACTIVITIES IN PROGRESS

- 3rd ten-yearly outage of reactors from 900 MWe series

  30/34 completed (ending 2020)

- 3rd ten-yearly outage of reactors from 1300 MWe series

  2/20 completed (ending 2024)

- Modifications stemming from Fukushima OPEX

  Construction of Ultimate Diesel Generator (SBO diesel generator)
  Construction of ultimate heat sinks

- Preparation of 4th ten-yearly outage for reactors from 900 MWe series

  1st occurrence in 2019 (Tricastin 1)

- Preparation of 2nd ten-yearly outage of reactors from 1450 MWe series

  1st occurrence in 2019 (Chooz 2)

SCHEDULED ORGANISATION WITH SET BUDGET

- The Major Renovation Programme, as it stands today, was created further to a decision of the EDF CEO. The programme has two sections:

- A technical section
- A section related to transforming operating modes

- Nuclear safety objectives for the 4th safety assessment of units from the 900 MWe series, which will reach those of the **generation 3 reactors**

- The Major Renovation Programme coordinates a portfolio of Long-Term Operation Projects

THANK YOU