‘Grand Carénage’
Presentation of major renovation programme
ENSREG
Brussels 29/06/2017
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 $\approx$ 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
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
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

Ten-yearly outages Nos. 1, 2 and 3

Modifications stemming from Post Fukushima Operating Experience (phases 1&2)

4th periodic safety review
MAIN MODIFICATIONS DURING 4\textsuperscript{TH} 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
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)
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