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Extension to 60 years lifetime

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CHANGER L'ÉNERGIE ENSEMBLE

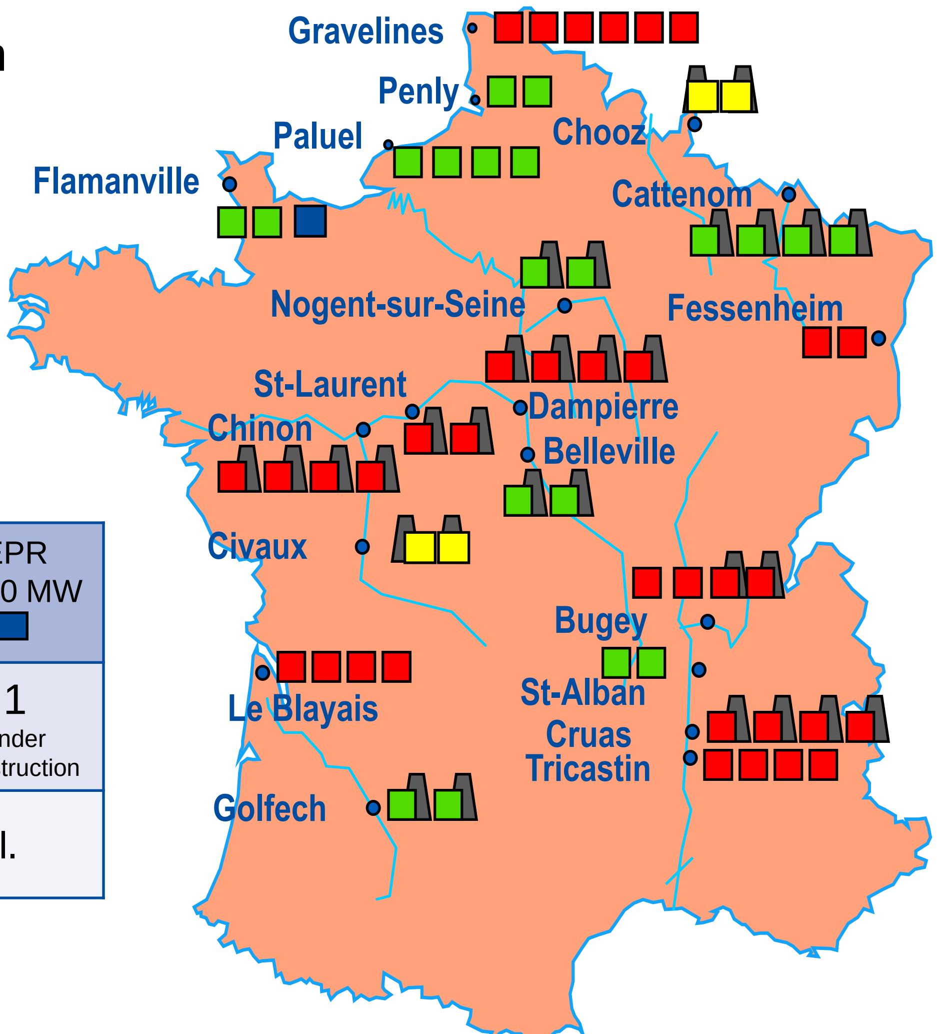
Summary

- Elements on EDF NPPs life extension program
- Asset management
- Improvement of nuclear safety
- Main challenges

EDF nuclear power plants fleet

- 58 reactors in operation
- 1 reactor (EPR) under construction
- Technology : PWR
- Spread out over 19 sites
- Nuclear generation = 80 % Total Electricity Generation

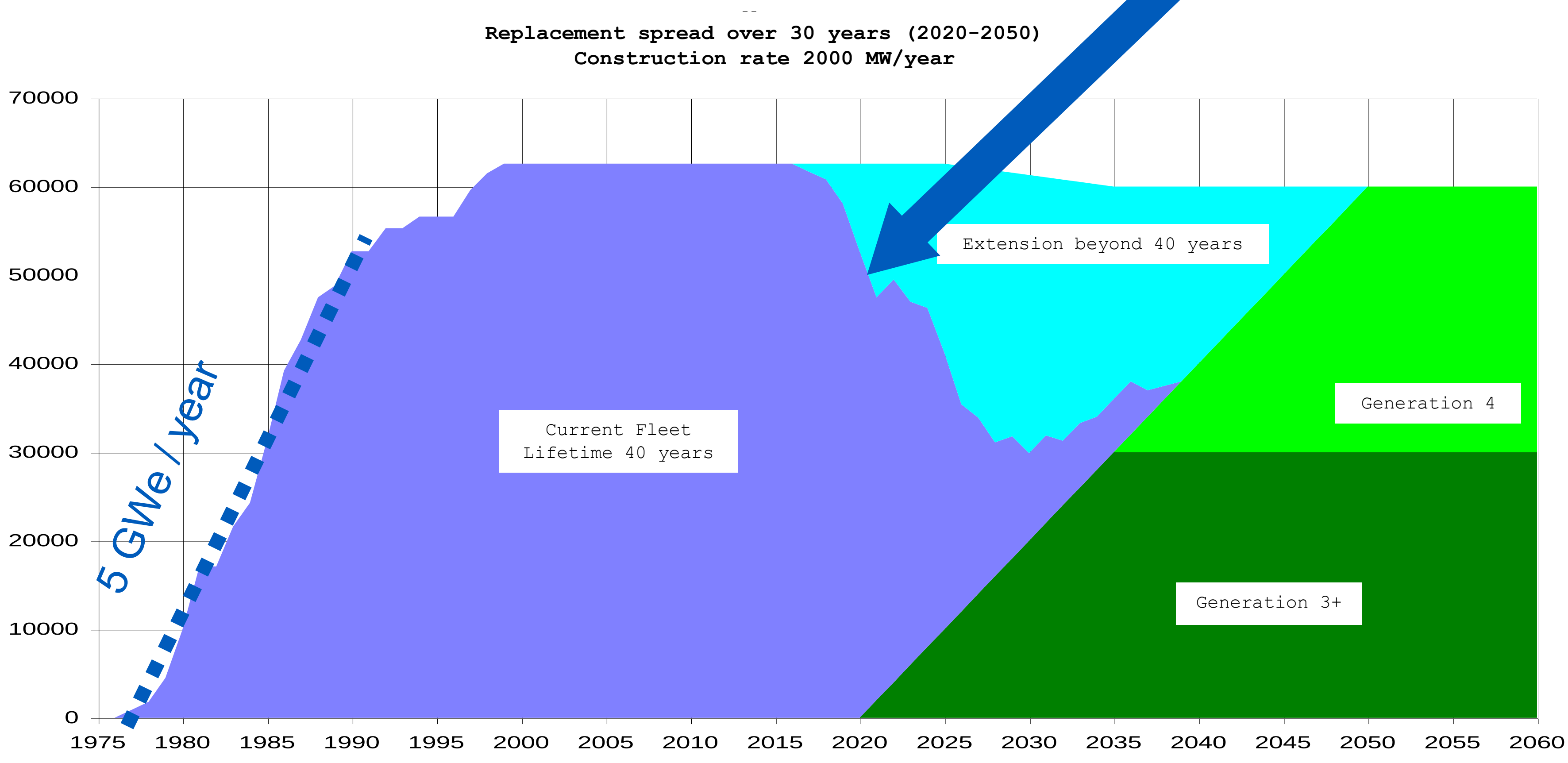
NPP	PWR 900 MW	PWR 1300 MW	PWR N4 1450 MW	EPR 1630 MW
Nb Unit	34	20	4	1 under construction
License	Westinghouse		Areva & al.	



Life extension : a strategic issue

Shutdown at 40 Y ⇒
Important investments for new units as soon as 2017

Lifetime extension (beyond 40 Y) ⇒
Smoothing the commissionning flow for new build



Life extension : made possible if

- Adequate maintenance policy
- Structured aging and obsolescence management process and asset management policy
- Efforts to significantly enhance reactor nuclear safety standards

Aging and obsolescence management

- Aging Management Process (AMP)
  - Compliant with IAEA standards (NS G 2.12 guide)
  - Approved by ASN (900 MWe series)
  - Generic AMP procedure : 3 main steps
    - Identify relevant structures, systems and components (SSCs)
    - Aging Analysis Sheets (AAS) for selected couples SSC/mechanism
    - Detailed Aging Analysis Reports (DAAR) for the most sensitive components
  - Periodic review of AAS and DAAR :
    - National and International operating feedback
    - Evolution of maintenance strategies and operating procedure
    - R&D results on aging mechanisms
  - Unit DAAR

- Obsolescence process
  - Available and mainly focused on products with short life cycle technologies (I&C, electrical components).

Asset management for long term operation

- Two different issues

  - Non-replaceable components (RPV & Containment)

    New methodologies and/or modifications

    to get complementary margins vs criteria

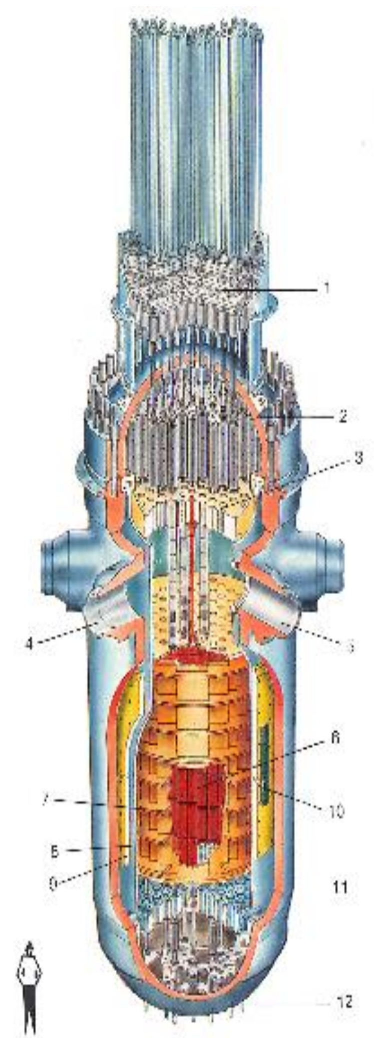
  - Replaceable components :

    Decision-making process based on

    End-Of-Life (EOL) prognosis

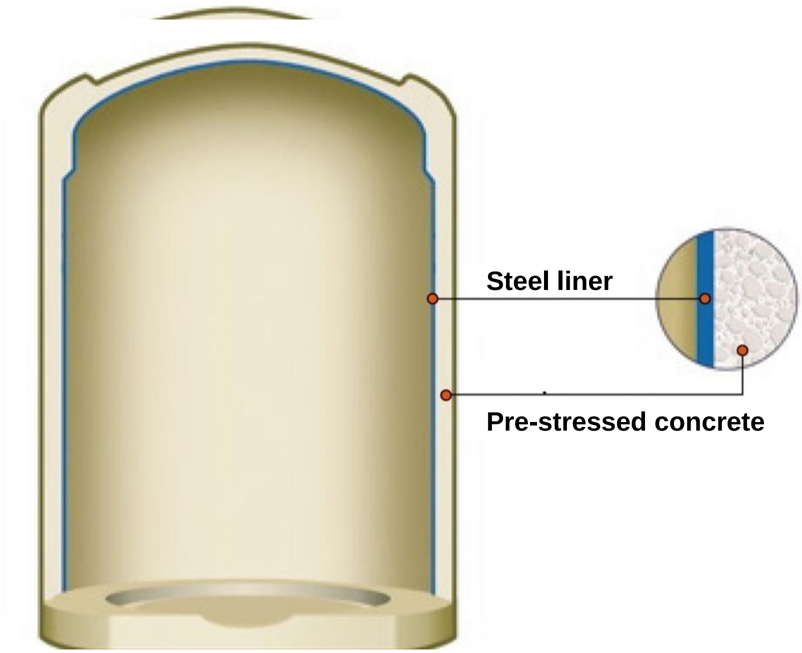
A non-replaceable mechanical component : reactor vessel

- **Prognosis : Expected EOL > 60 years**
  - Good quality (design and manufacturing), good experience feedback.
  - Two major aging mechanisms
    - Irradiation embrittlement of the core shells
    - Thermal aging of the nozzles
- **Long term operation strategy**
  - No Exceptional maintenance program planned
  - EOL prognosis based on a deterministic conservative approach
  - New methodologies required to better evaluate margins
    - Mechanical and thermo-hydraulic analyses
    - Probabilistic approach as an in–depth justification
  - Mitigation and surveillance actions
    - Low leak core management
    - Irradiation surveillance program on-site capsules)
  - Optional : if necessary beyond 40 years , increase of safety injection temperature

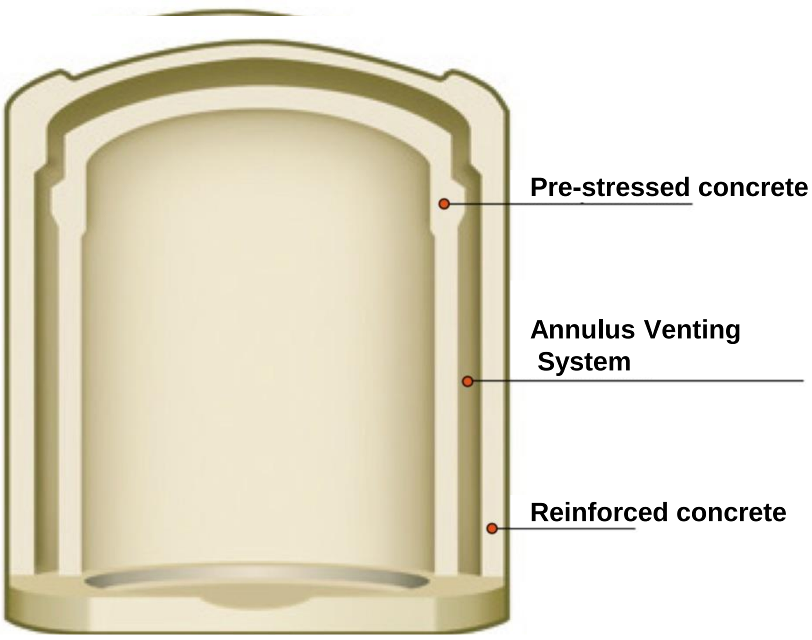


A non – replaceable civil work component : containment (1/2)

900 MWe series
Simple wall + liner



1300 MWe and N4 series
Double wall



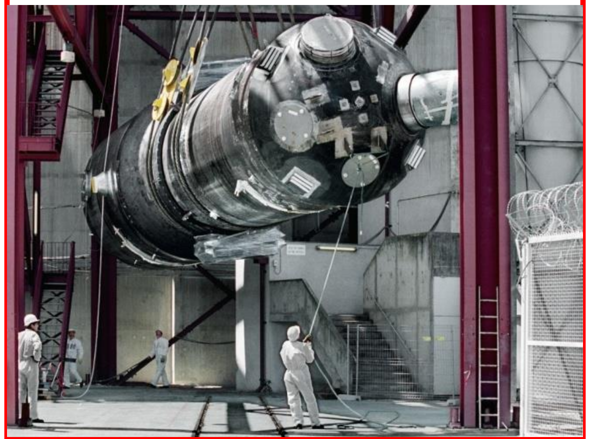
A non – replaceable civil work component : Containment (2/2)

- Simple wall containment (900 MWe series)
  - Current routine maintenance towards 60 years without any major change (periodic air leak test and in service inspection program).
  - Corrosion of inner liner : periodic in service inspection

- Double wall containment (1300 and 1450 MWe series)
  - Repair and reinforcing works for preserving inner wall tightness
  - Improvement of leak treatment system and assessment of resistance to severe accident conditions based on an experimental program (1/3 scale mock –up) and R&D support
  - Updating of monitoring system
  - Reassessment of air leak test conditions (under discussion with ASN)

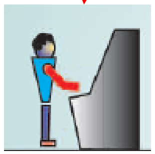
Replaceable components

SG Replacement

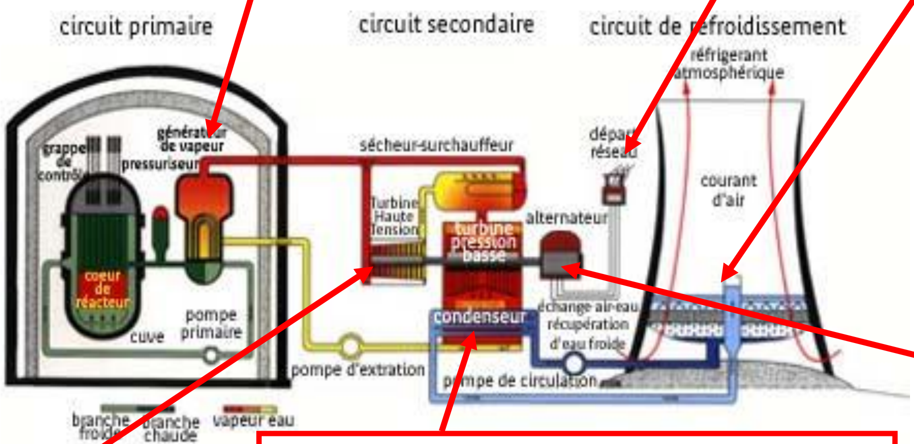


Replacement of Unit Transformers and Metal-clad Substations

I&C Modernization



Replacement of Cooling Tower Packing



Main Generator

1. Rotor Renovation
2. Stator Replacement

Renovation of Main Turbine LP Cylinders

Condenser : Renovation of

1. Tube Bundles of some units
2. Cleaning System

The french regulatory context

- General policy : continuous improvement of nuclear safety
- Periodic safety review (PSR) every ten years for each unit, based on up-to-date nuclear safety requirements
- No limited licensing life time but authorisation bg the French Nuclear Safety Authority, on a case by case analysis for each unit, to operate for another ten-years period
- Numerous modifications already implemented on the plants (after TMI, Tchernobyl, Blayais site flooding in 1999, summer heat wave in 2003, ...)

EDF safety goals for long term operation

- Obviating the need to implement countermeasures for the general public in the event of a design-basis accident
- Significantly enhancing plant resistance to hazards
- Minimizing time and space-related countermeasures in the event of a severe accident

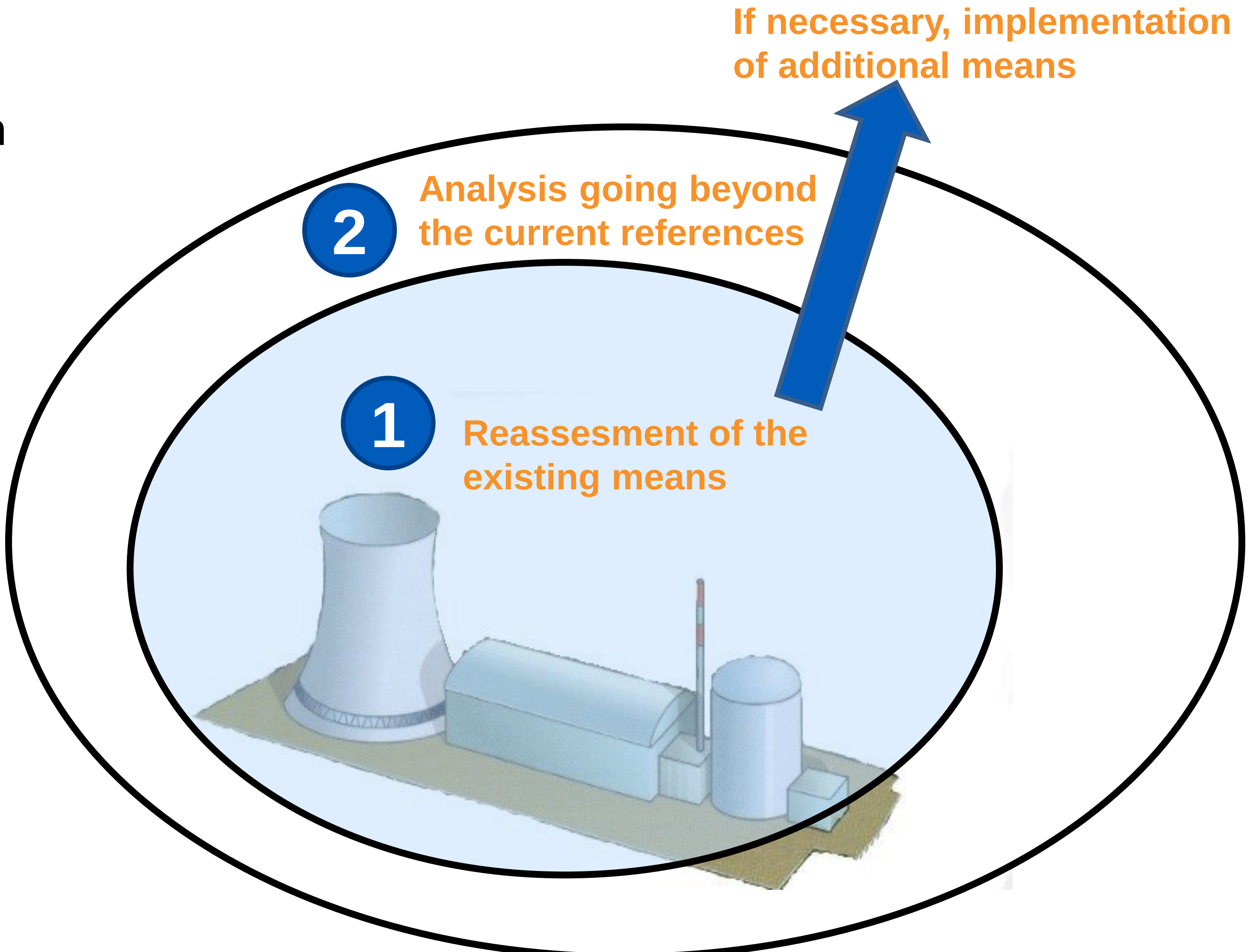
Additional modifications are needed

- Reinforcement of interconnections between safety injection system and containment spray system
- Addition of an emergency diesel generator per unit
- Modifications to prevent steam generator (SG) overflowing in case of SG tube rupture
- Improvement of containment air tightness, performances of auxiliary buildings ventilations and efficiency of containment venting and filtration system
- Seismic margins reassessment and buildings or equipment reinforcements
- ...

The EDF post-Fukushima action plan (1)

The fields which have been assessed

- Earthquake
- Flooding
- Loss of heat sink
- Station black out
- Severe accident management



The EDF post-Fukushima action plan (2)

Design bases	Hazards beyond design bases	Highly hypothetic severe hazards
Unit compliant with all criteria of the safety analysis report	No cliff edge effect	Hard core of structure systems and components to avoid large releases

The EDF post-Fukushima action plan (3)

The current nuclear safety level of each unit of the fleet is acceptable

Nevertheless immediate and mid-term improvements

- Emergency planning organization to face accidents involving more than one unit on a site:
  - Reinforcement of emergency teams : light equipment and human resources
  - Set up of a regionally-based “nuclear rapid response force” : operational on-site 24 hours after any accident ; having portable equipment and dedicated human resources (among them licensed operators)
  - Renewal of emergency control buildings as regards their protection against external hazards, their equipment and their autonomy

The EDF post-Fukushima action plan (4)

- Design modifications (hard core of SSCs)

  - Installation of one emergency back-up diesel per unit
  - Reinforcement of spent fuel pool make-up systems
  - Installation of a last resort make-up water supply (an ultimate heat sink)
  - Upgrading of the containment filtration and venting system
  - On a site-based approach, enhancement of protection against flooding and reinforcement of robustness of some equipment with regards seismic events
  - ...

Main challenges (1)

- Reasonably achievable objectives for improving nuclear safety of existing units up to 60 years ; methods used

- After Fukushima Daiichi accident a new step as been made in the general safety approach :
  - the evaluation of robustness of installations far beyond the current nuclear safety requirements and far beyond their design bases
  - associated with the definition of a “hard core” of structures, systems and components (SSC) remaining available and designed to avoid large releases in case of these extreme accidental situations

- This new approach needs to be clarified and codified to address some difficult questions such as the following :
  - For what kinds of situation ?
  - To what extent ? We agree to push reasoning to highly hypothetic situations but we don't want to go all the way up to total destruction or to totally unrealistic scenarios
  - On what bases : purely deterministic, using ALARP codified methods and/or probabilistic risk assessments ?

Main challenges (2)

- A huge financial challenge : the need for capital expenditures between 2011 and 2025 is 55 Md€$_{2010}$
  - Post – Fukushima : 10 Md€ $_{2010}$
  - Other nuclear safety improvements : 15 Md€ $_{2010}$
  - Equipement replacements : 20 Md€ $_{2010}$
  - Operation performances and other patrimonial projects : 10 Md€ $_{2010}$

- An industrial challenge
  - Equipment supply chain
  - Works on site

Main challenges (3)

- An organizational challenge for EDF

  - Engineering, procurement, supplying
  - Works on-site : how to preserve operational performance (nuclear safety during and after modifications, units availability, …) as well as people safety

  ➡ « Grand carénage» = « large refurbishment »

- A challenge in terms of human resources

  - Significant increase of needed manpower
  - Competencies renewal