



# NPP Periodic Safety Reviews (PSR) in France

**ENSREG workshop**

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# NPP Periodic Safety Reviews in France Outline

- **Regulatory framework for PSRs in France**
  
- **NPP PSRs in France**
  - ❑ Process in practice
  - ❑ Examples :
    - ❖ PSR “VD3-900”
    - ❖ PSR “VD3-1300”
  
- **Conclusions**



## Standardized fleet:

- 58 operating PWRs (+1 under construction)
- 1 vendor
- 1 licensee (EDF)

## 1979 → 1990: 3/4 of the fleet built

## Fleet age :

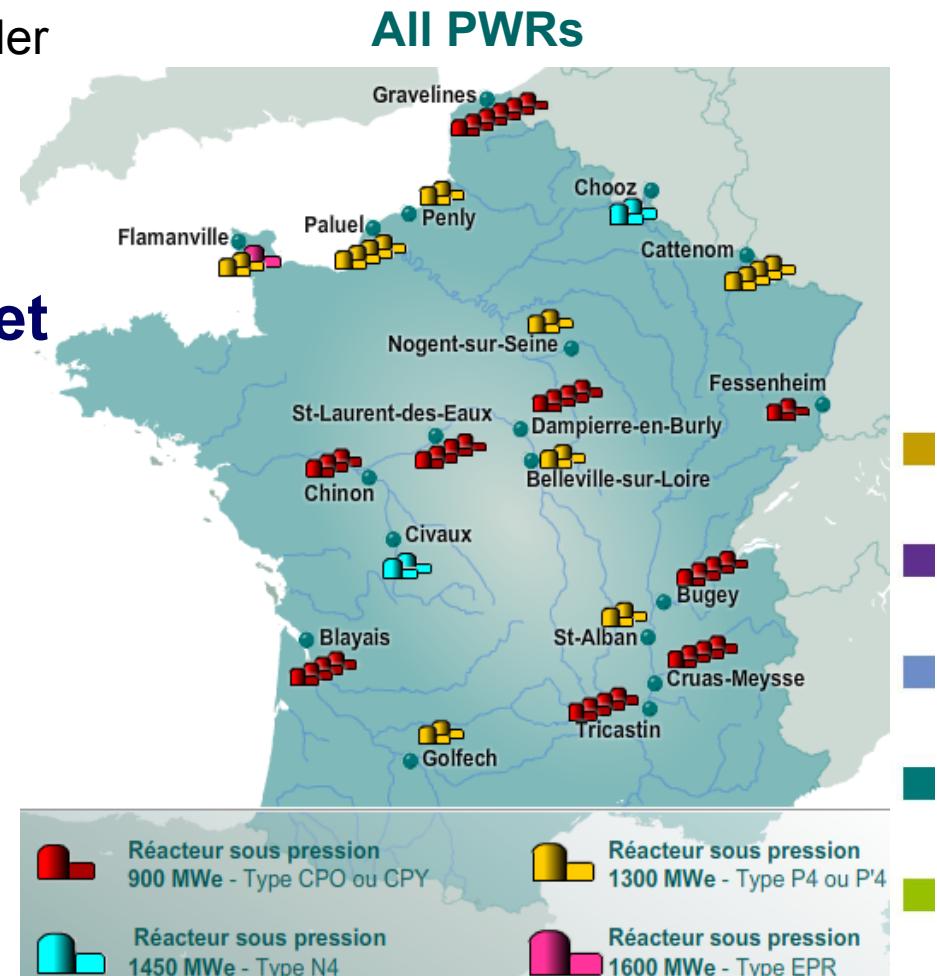
### French fleet average age

- 30 years (1<sup>st</sup> criticality)
- 28 years (connection to the grid)

### NPP average age (1<sup>st</sup> criticality)

- 900 MWe: 34 reactors ⇒ 33 years
- 1300 MWe: 20 reactors ⇒ 27 years
- 1450 MWe: 4 reactors ⇒ 17 years

### Oldest reactor: 38 year old





## Regulatory framework (1/6)

### ➤ Regulatory framework in France:

- The operator is the first responsible for the safety of its installation (L. 593-6)
- No legal pre-established time limit for service operation of a nuclear installation
- Every 10 years: periodic safety review (PSR) required for each basic nuclear installation (BNI)
- Continuous supervision performed by the regulator (ASN)

***If serious and immediate hazard: ASN has legal power to stop, immediately, the installation (L. 593-22)***





## Regulatory framework (2/6)

### Regulatory framework: art. L. 593-18 and L. 593.19 of Environment Code (law)

**“L. 593-18 The licensee of a basic nuclear installation carries out *periodic safety reviews* of his installation by taking account of the best international practices. This periodic review must allow the situation of the installation to be appreciated with regards to the rules applying to it and must make it possible to update the assessment of risks or drawbacks the installation presents for the interests mentioned in L. 593-1 [i.e. safety, security, environment, radiation protection, emergency preparedness], by taking account in particular of the state of the installation, the experience learned from operation, and the evolution of knowledge and of the rules applying to similar installations.**

***Safety reviews take place every ten years.* However, the authorisation decree can set a different periodicity if this is justified by the specificities of the installations.**

**L. 593.19 The licensee sends the Nuclear Safety Authority and the ministers in charge with nuclear safety a *report including the conclusions of this review and, where applicable, the provisions it envisages taking to remedy the observed anomalies or to improve the safety of his installation.***

***After analysing the report, the Nuclear Safety Authority can impose new technical prescriptions. It sends the ministers in charge with nuclear safety its analysis of the report.”***



## Regulatory framework (3/6)

### ➤ **PSR objectives:**

- ❑ Perform a **conformity check** with current safety requirements (i.e. currently applicable to the installation)
- ❑ Look for and determine the need for **improvements**
- ❑ Improve the safety of the installation considering:
  - ❖ The experience learned from operation;
  - ❖ The evolution of knowledge and of the rules applying to similar installations.

### ➤ **Scope of the PSR : risks (related to potential accidents) and drawbacks (related to normal operation)**

**At the end, the ASN takes up a position on maintaining or not each reactor in operation and gives its position to the French government**



# Regulatory framework (4/6)

## Art. L. 593-19 of Environment Code



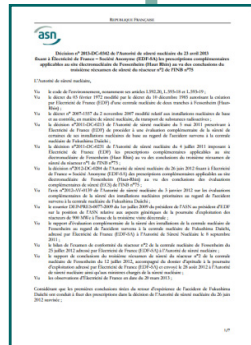
Licensee

- *PSR conclusions*
- *Proposed provisions to:*
  - *address deviations*
  - *enhance safety*

Licence conditions  
(Prescriptions)



**PSR date =  
Date of submission  
of the licensee's report  
(Article 24 - decree 2007-1557)**




Review





# Regulatory framework (5/6)

- Drawbacks
- Risks:
  - Radiological
  - Non radiological
  - Malevolent origin

 PSR:  
Specific to each BNI!

**PSR**  
Every 10 years

**Safety Reassessment**



**Conformity check + Ageing management**

- Best international practices
- Knowledge evolution
- Rules applicable to similar facilities
- Operating experience



Licence conditions  
(Prescriptions)







# Regulatory framework (6/6)



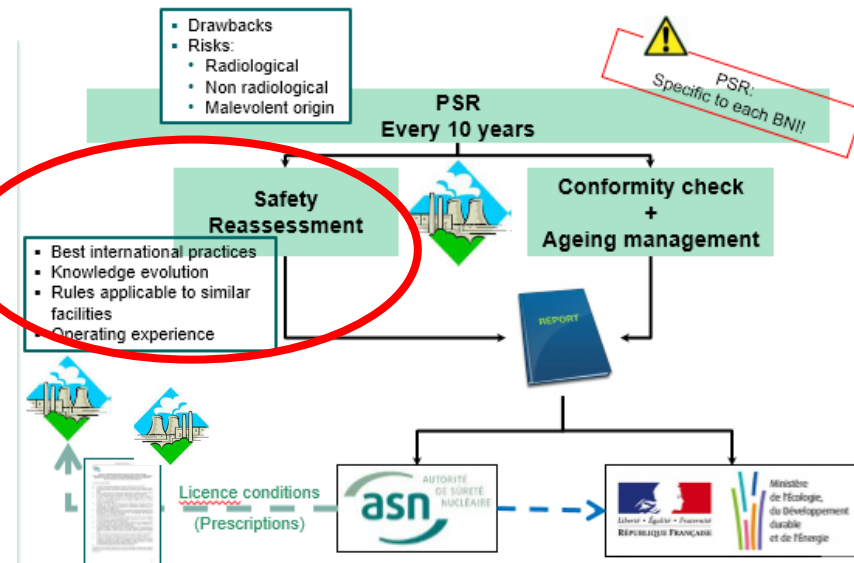
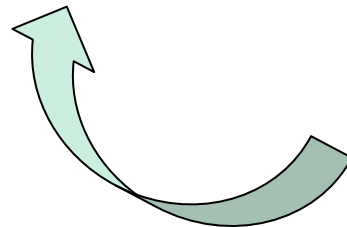
Commission européenne

Art 8 bis  
Directive n°2014/87/Euratom  
issued 08/07/2014

*Defines safety objectives for new nuclear installations*



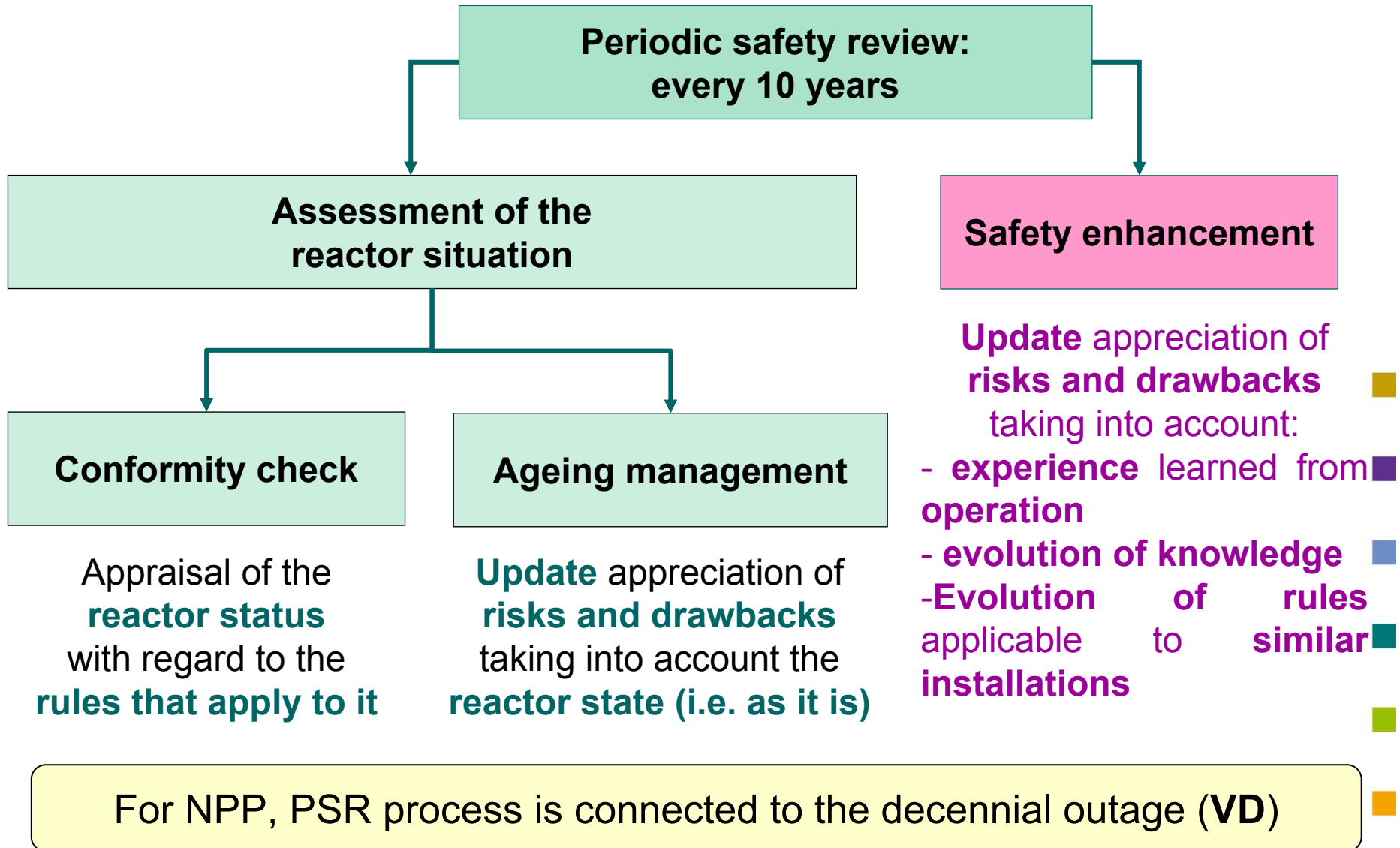
*Reference for implementation of reasonably practicable improvements as part of PSR for existing nuclear installations*



*Statement on safety objectives for new NPP (November 2010)*



# NPP Periodic Safety Review





# PSR: Conformity check and ageing management

- **Checking the conformity of the plant to its referential (Safety Analysis Report...):**
  - Search for potential anomalies resulting from the design, construction, operation or modification phases
- **Checking the ageing management programmes (>VD3)**
- **Examples of topics under scrutiny for the 900 MWe 3<sup>rd</sup> PSR:**
  - Stability of the components after a seismic event
  - State of the components used for beyond design accidents
  - External flooding (Blayais)
  - Prevention of criticality accidents
  - Ventilation systems
  - ...



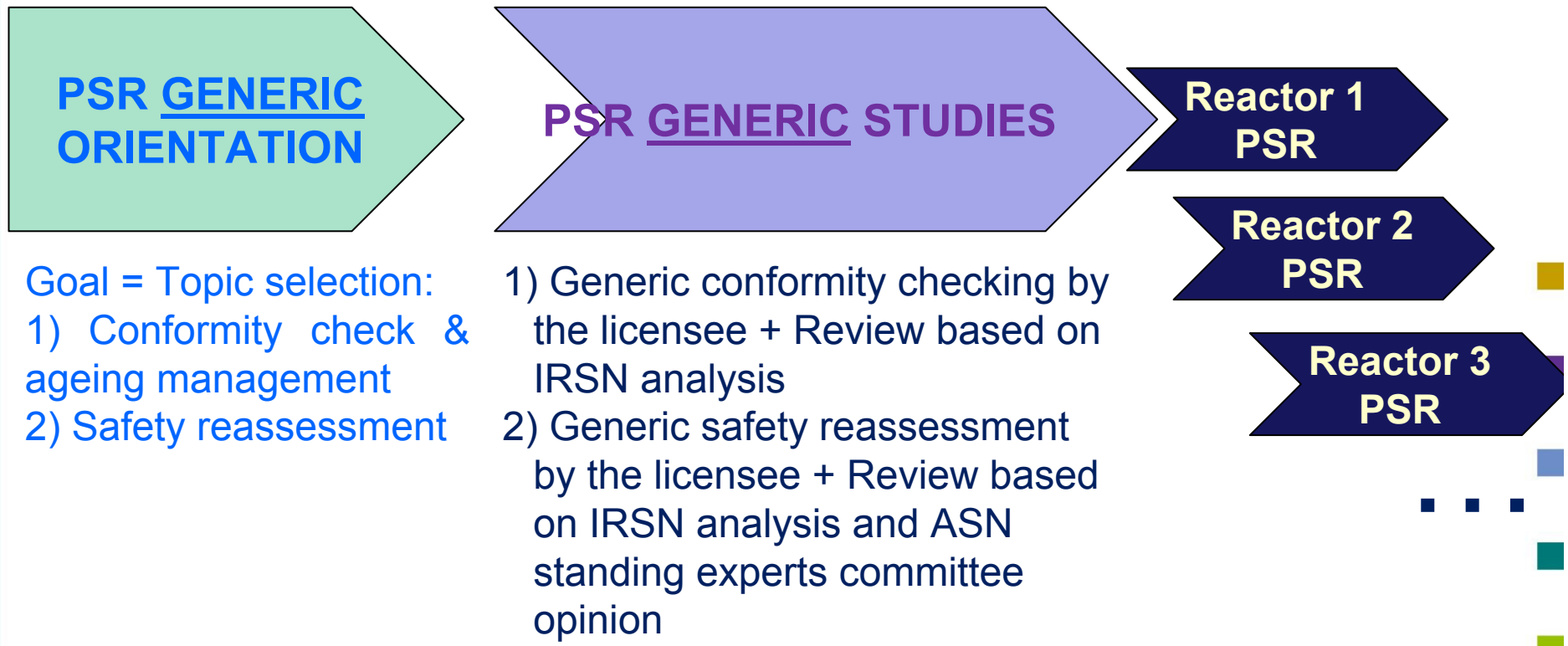


# PSR: Safety reassessment

- **Basis:**
  - National operating experience (fleet and generic approach)
  - International operation experience feedback (IRS database, international cooperation, ...)
  - New regulations and safety rules (for example, new basic safety fundamental rules on seismic hazard assessment,...)
  - New reactors standards (“Technical guidelines for design and construction of the next generation of nuclear power plants with pressurized water reactors”)
  
- **Use of insights from Probabilistic Safety Analysis levels 1 & 2**



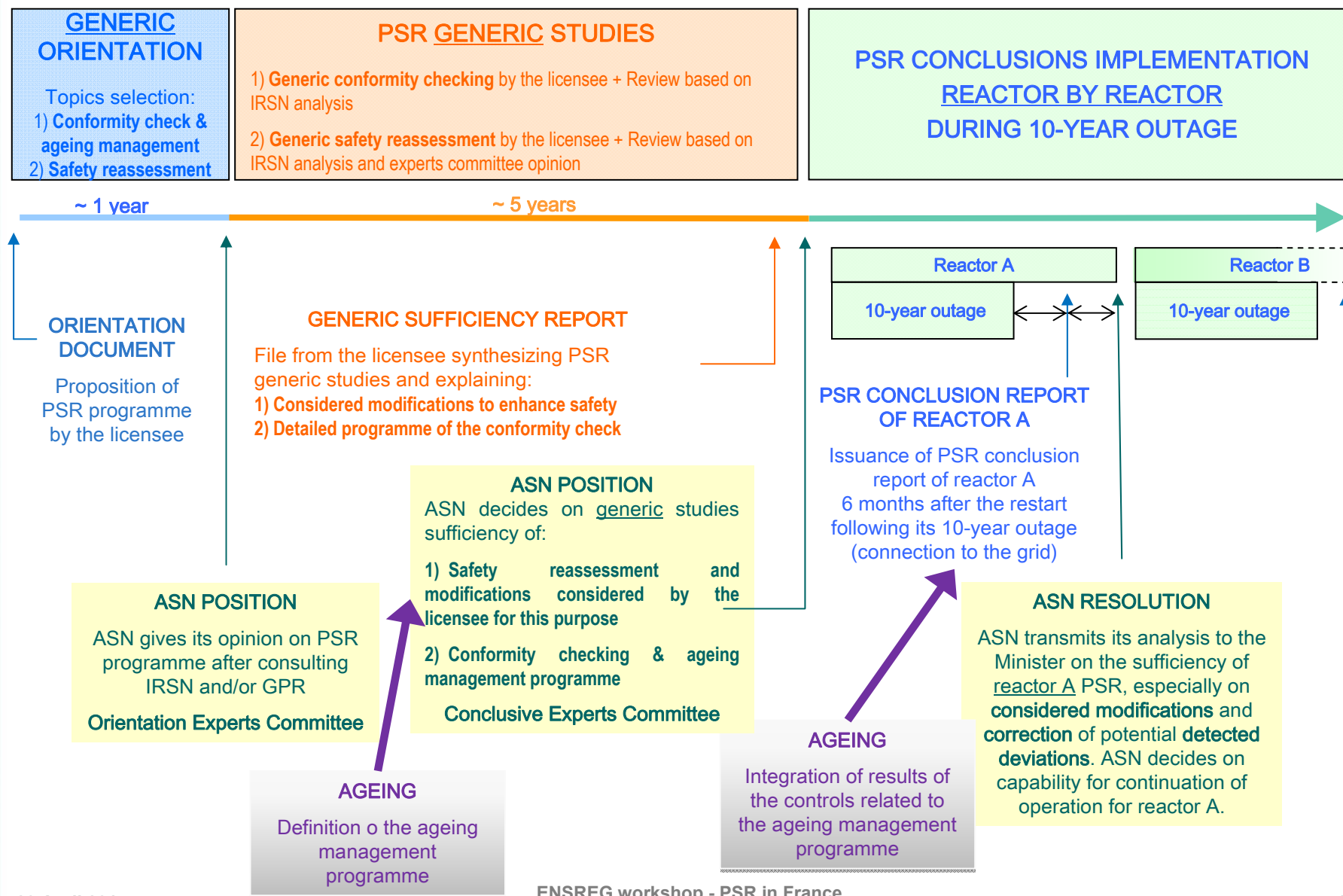
# Sequence of PSR for a fleet of reactors



Generic = applicable to all reactors of the fleet



# Sequence of a NPP PSR





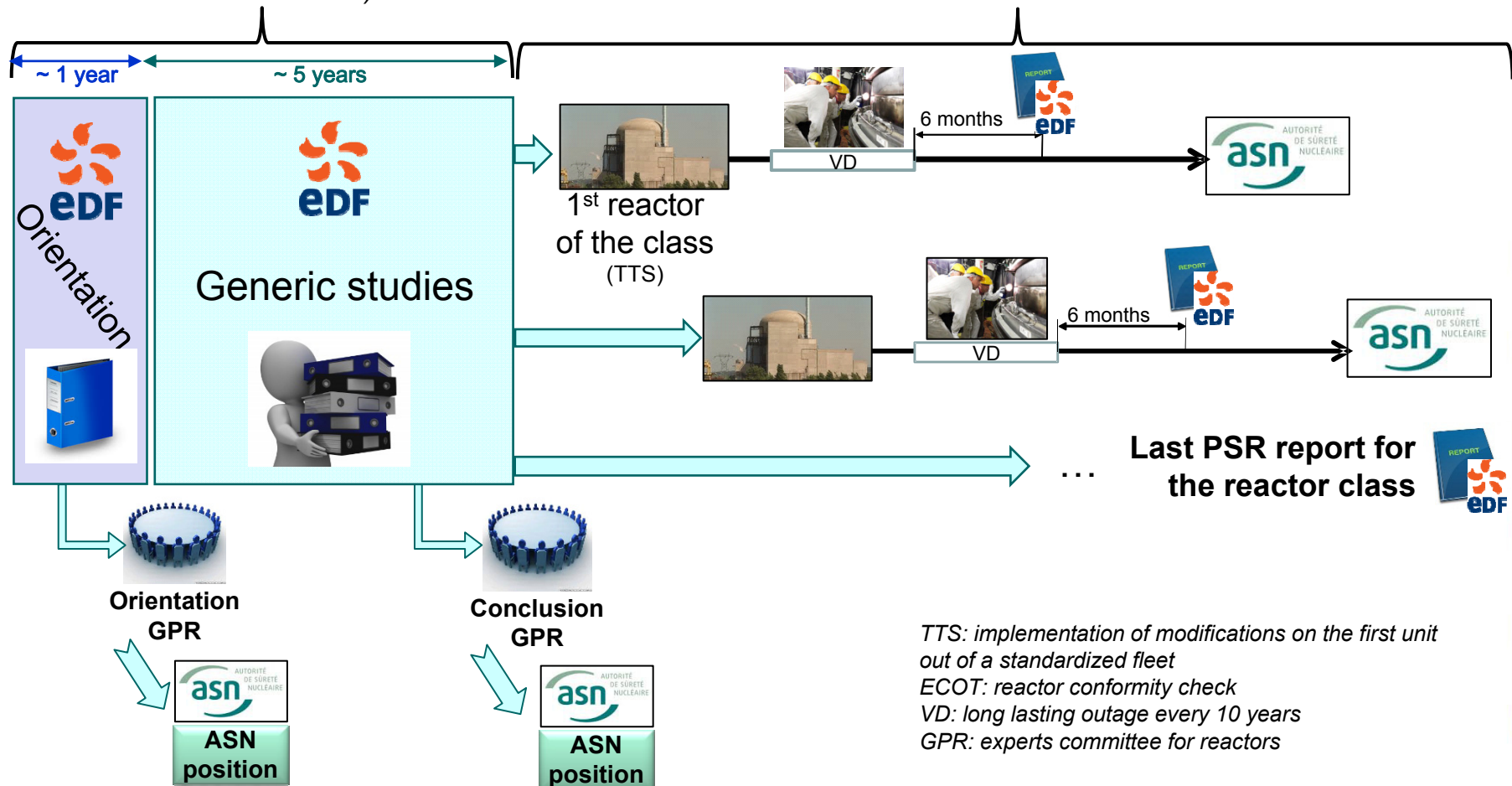
# Sequence of a NPP PSR Connection with decennial outage

## Implementation during each reactor PSR

- ✓ Implementation of modifications
- ✓ Conformity check (ECOT)
- ✓ Decennial tests (containment, RCPB, ...)

## Generic phase of PSR

(common studies for all the  
reactors of a class)





# 900 MWe reactors 3<sup>rd</sup> PSR (VD3-900) Timeline

2002

**GENERIC ORIENTATION**  
Topics selection:  
1) **Conformity check**  
2) **Safety reassessment**

2003

**PSR GENERIC STUDIES**  
1) **Generic conformity checking** by the licensee + Review based on IRSN analysis  
2) **Generic safety reassessment** by the licensee + Review based on IRSN analysis and GPR opinion

2008-2009

2009

**PSR CONCLUSIONS IMPLEMENTATION REACTOR BY REACTOR DURING 10-YEAR OUTAGE**

2020



Orientation GPR



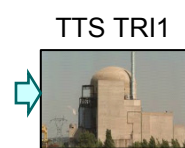
ASN position on the PSR program



Conclusion GPR



ASN position on the generic studies and the proposed modifications to improve the safety

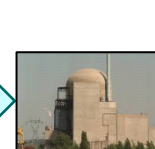


TTS TRI1



VD

6 months



VD

6 months



Last PSR report in 2020







# Main modifications batch for the 900 MWe 3<sup>rd</sup> PSR (1/2)

## ➤ **Postulated Initiating Events**

- Automatic closure of the emergency feedwater system control valve on high SG level signal (to prevent overfilling after SGTR)
- Automatic trip of the primary pumps on high level signal (for intermediate LOCA)
- Modification of the pressurizer safety valves for overpressure protection of the reactor vessel in shutdown states
- Improvement of the containment hatch behaviour for severe accident
- Improvements to the reactor vessel level measurement system
- Improved prevention and mitigation of the risk of loss of cooling and of inadvertent draining of reactor and spent fuel pool



# Main modifications batch for the 900 MWe 3<sup>rd</sup> PSR (2/2)

## ➤ Severe Accidents

- Detection of reactor vessel melt through
- Measurement of H<sub>2</sub> release into building

## ➤ Internal and external hazards

- Fire protection of some rooms with 6,6KV and 380V busbars in the electrical building
- Prevention of H<sub>2</sub> release in the auxiliary building (*BAN*)
- Protection of diesel generators for long LOOP (15 days after seismic event)
- Seismic reinforcement of safety related systems, structures and components

## ➤ Radioprotection and other

- Reduction of dose thanks to exchangers (biological protections added / modified layout)
- High-flow purification of the primary circuit
- Improvement of fuel handling system

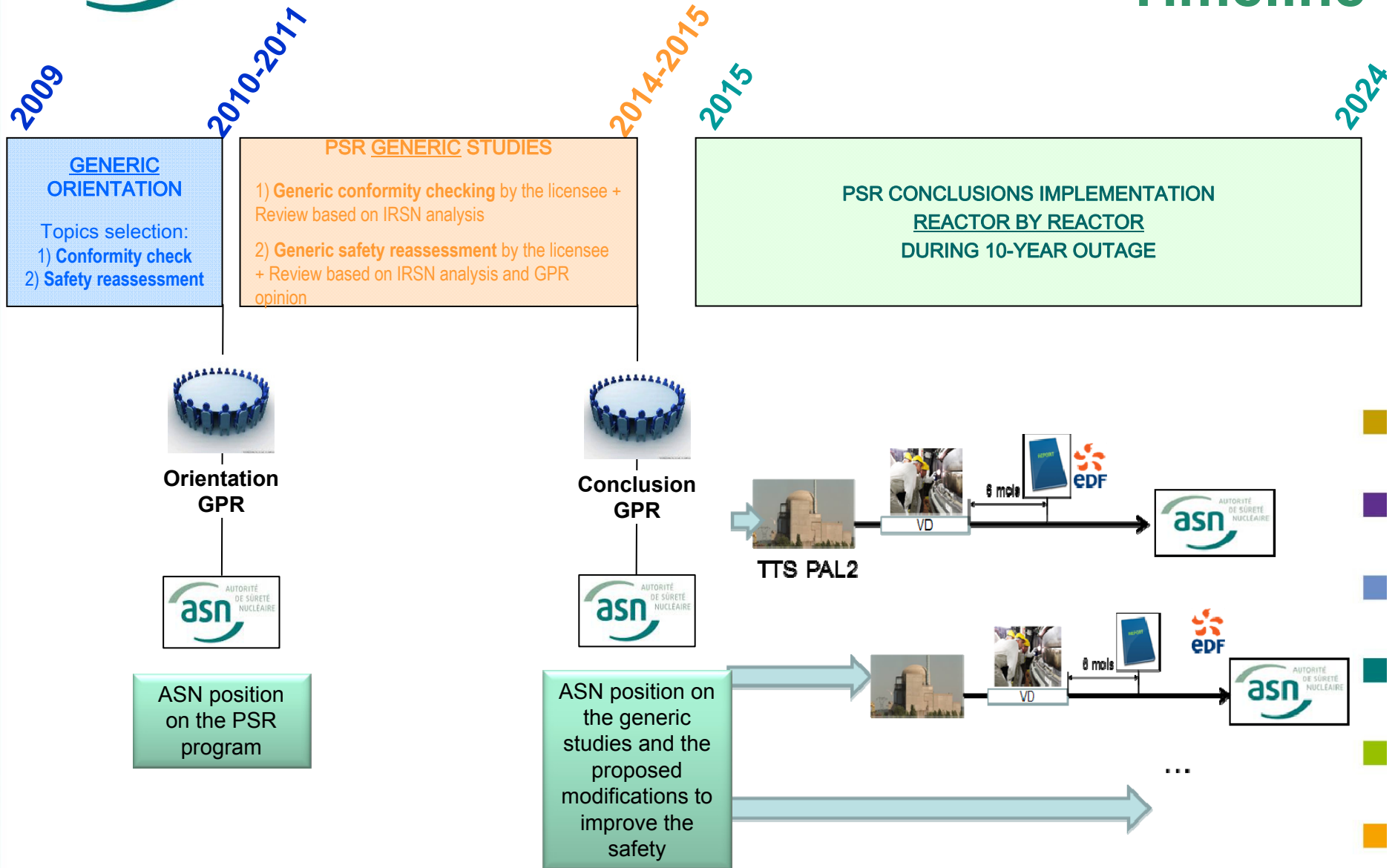


Not an  
exhaustive list  
!





# 1300 MWe reactors 3<sup>rd</sup> PSR (VD3-1300) Timeline



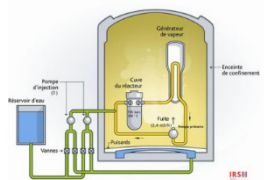
# Conclusion of the generic phase of the 1300 MWe reactors 3<sup>rd</sup> PSR (1/3)

## Topics under scrutiny

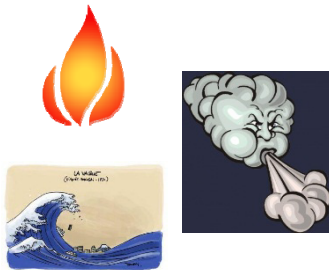
Conformity check and ageing management



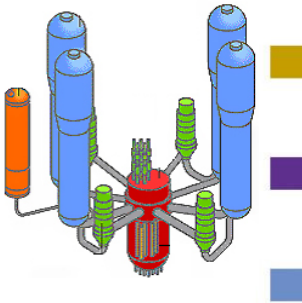
Improvement of the conception of systems and concrete structure



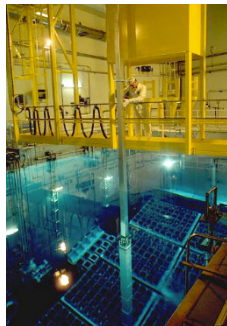
Internal and external Hazards



Accidents with or without melting core affecting the nuclear steam supply system



Risks associated with fuel assemblies in the HK building and their handling



Risks associated with peripheric buildings (effluent treatment)

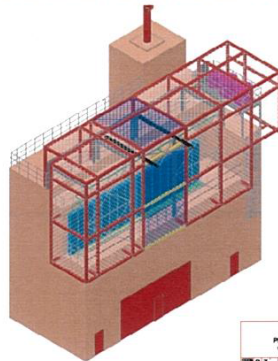


# Conclusion of the generic phase of the 1300 MWe reactors 3<sup>rd</sup> PSR (2/3)

## Some modifications resulting from the PSR

Internal and external Hazards

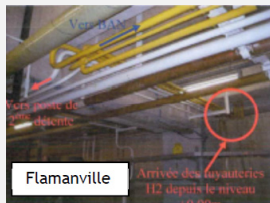
Protection diesels en toiture



AVISSE  
PALISSE PA  
PROTECTION PROJECTILES GRAND VENT  
VUE ISOMETRIQUE - BATIMENT DIESEL A  
MGP 02 13

### Extreme wind (Missiles)

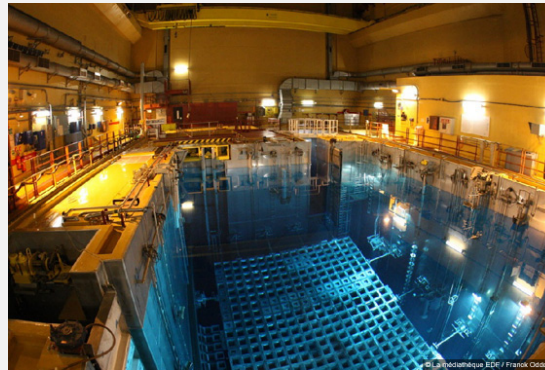
Protection of the diesel generator set against extreme wind (missiles)



### Explosion

Seismic reinforcement of hydrogen pipes

Risks associated with fuel assemblies in the Fuel Building and their handling



### Prevention of the fuel assemblies uncovering in the spent fuel storage pool

Automatic isolation of the aspiration of the cooling circuit of the spent fuel pool storage in case of the detection of a very low level

Accidents with or without melting core affecting the nuclear steam supply system



### Reducing releases in case of « Steam Generator Tube Failure »

Modifications of the relief valves to avoid that they remain stuck open (relief valves are not qualified to operate with water) in case of a steam generator tube failure

### Reducing releases in case of severe accidents

Alkalinization of the sumps of the reactor building with tetraborate to stimulate the retention of the radioactive iodine in water (recirculation phase)



# Conclusion of the generic phase of the 1300 MWe reactors 3<sup>rd</sup> PSR (3/3)

## Generic position of ASN (conclusions of the generic phase)

- **ASN considers that the studies and expected or already implemented modifications will significantly improve the nuclear safety of the reactors:**
  - External and internal hazards:
  - Reassessment of external and internal hazards and the protection provisions,
  - New hazards considered like tornadoes or frasil,
  
- **Accidents and associated radioactive releases (nuclear steam supply system and risks associated to the fuel storage pool):**
  - Improvement of the accidents studies to account of enhanced knowledge,
  - Modifications will permit to significantly decrease the releases to the environment in case of accidents,
  - Modifications will permit to decrease the risks of fuel uncovering in the fuel storage pool
  
- **At the end of the generic phase, ASN does not identify issues questioning the ability of the 1300 MWe reactors to continue to operate.**
  - ① As required by article L. 593-19 of the Environmental Code, ASN will take position on the ability of each reactor to continue operation after analysis of the reactor PSR report.





# PSR of NPPs in France Conclusions (1/2)

- In France, for NPPs, PSR is a 2-phase process (generic + reactor specific) lasting several years
- Due to the number of operating reactors, PSR are continuously on-going

Fleet		On-going PSR		Upcoming PSR	
Power	Units	Title	Timeline	Title	Timeline
900 MWe	34 units	3 <sup>rd</sup> 10-year outage	2009-2020	4 <sup>th</sup> 10-year outage	2019-2030
1300 MWe	20 units	2 <sup>nd</sup> 10-year outage	2005-2014	3 <sup>rd</sup> 10-year outage	2015-2024
1450 MWe	4 units	1 <sup>st</sup> 10-year outage	2009-2012	2 <sup>nd</sup> 10-year outage	2018-2020



## PSR of NPPs in France Conclusions (2/2)

- **ASN exercises a continuous oversight of the nuclear installations**
- **Periodic safety reviews (PSRs) are major steps in the process of continued operation of the reactors**
- **Safe operation of the plant requires a continuous reassessment of the safety of the plant through PSRs**
- **The PSR, while addressing technical issues, should also be an opportunity to implement transparency, especially in the perspective of continued operation of some reactors beyond 40 years.**







## Generic PSR process (1/2)

**Definition of the programme of generic studies**



**Review of generic topics  
by ASN and ASN's Standing advisory committee or IRSN**



**"Generic" ASN's position on continued operation based  
on generic studies**

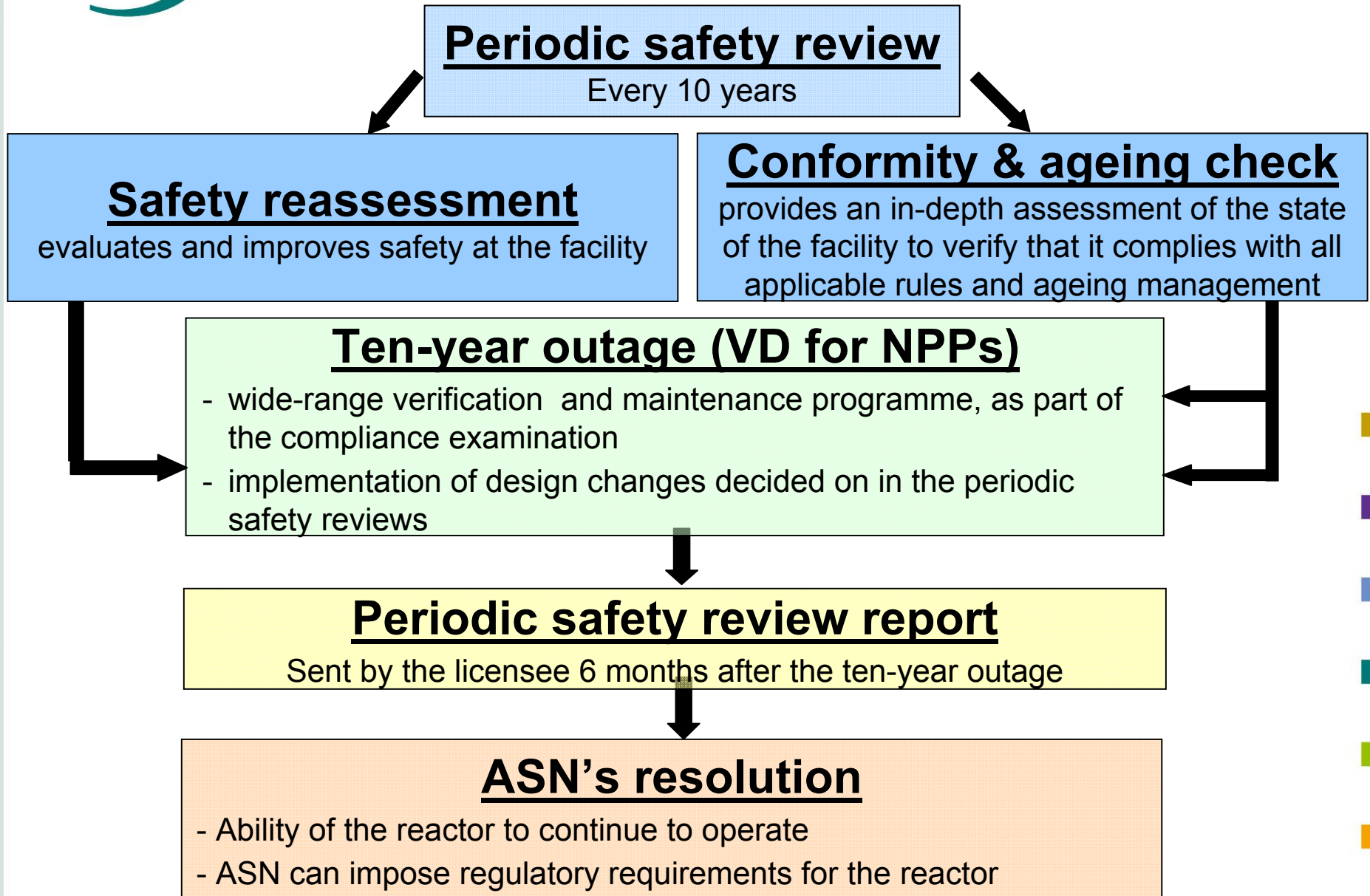


**For each reactor: implementation of design changes by  
EDF, followed by ASN's position**



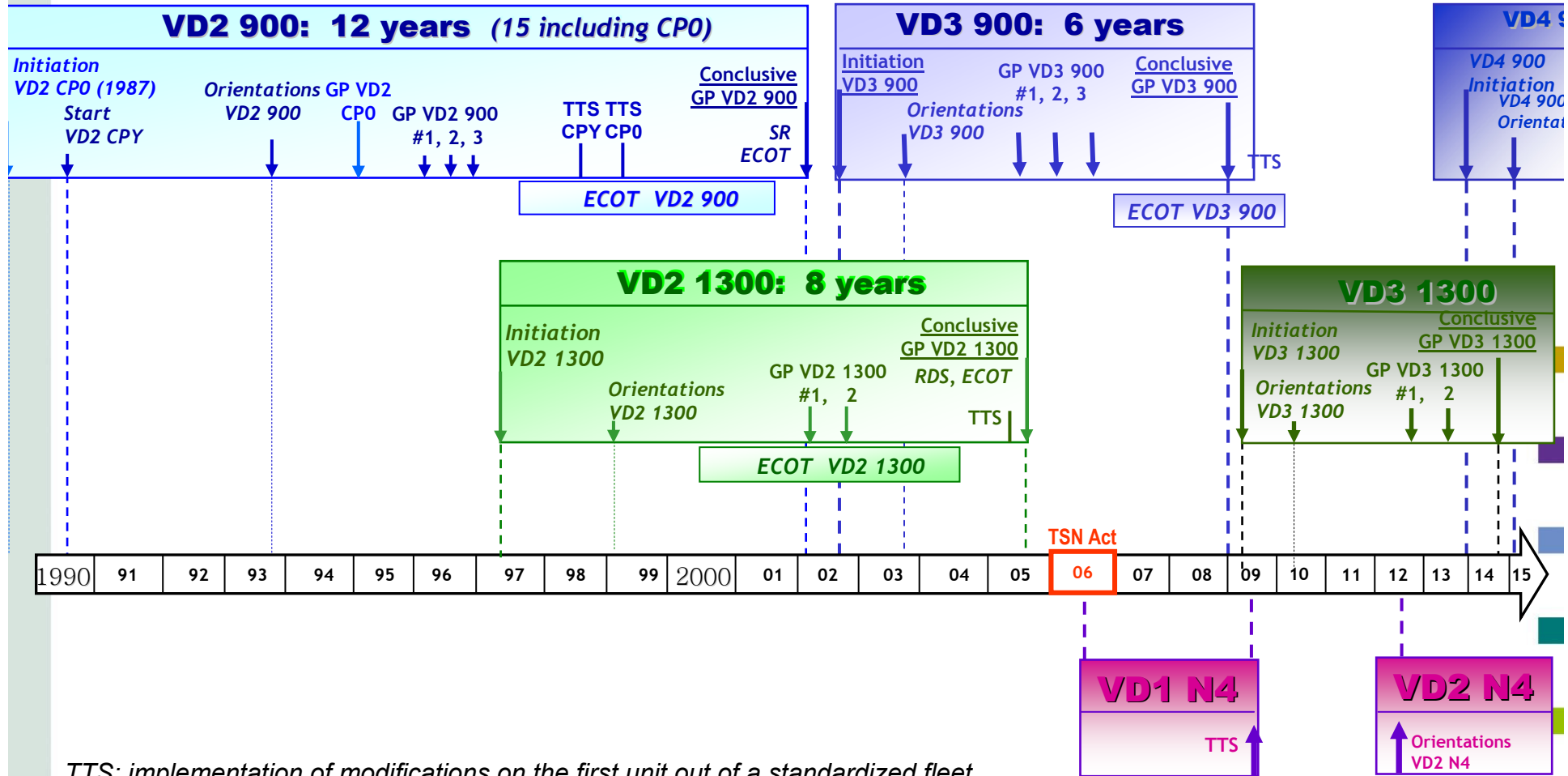
**① Process reinforced since the issuance of the Decree  
2007-1557 of 2<sup>nd</sup> November, 2007**

# Generic PSR process (2/2)





# A brief history of French NPP PSRs



TTS: implementation of modifications on the first unit out of a standardized fleet  
 ECOT: reactor conformity checking  
 VD: long lasting outage every 10 years



# EDF schedule of the PSRs for the French NPP fleet

