Legal Shut-Down Criteria?

Decision making process regarding the management of ageing of nuclear reactors

Yves Marignac

Director of **WISE**-***Paris***

Exploratory Workshop

"Ageing of nuclear power plants: a threat to nuclear safety?"

European Parliament
Brussels

19th March 2014

Summary

"We all desire to reach
an old age,
but we all refuse that we've
actually succeeded"

Francisco de Quevedo,
Politica de Dios y Gobierno de Cristo, **1619**

Age of reactors

Starting point

Lifespan and delays

Problems arising from ageing

Safety margins and conformity

Design limitations

Safety requirements

Open questions

Industrial consequences

Decision making process

Open and opposable decisions

Shut-down criteria

Conclusion and recommendations

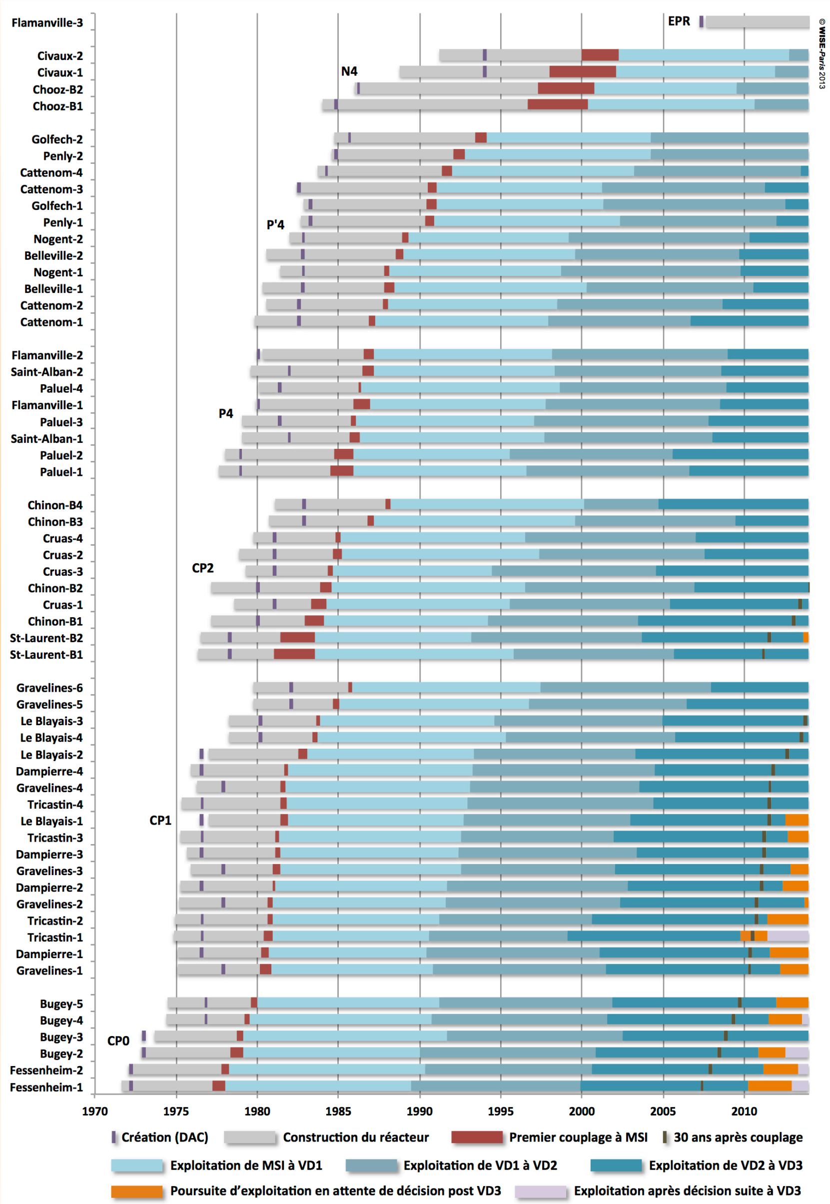
Which starting point to define the age of reactors?

Licensing act
Industrial order
First concrete (starting point of materials ageing)
First criticality (starting point of neutronic ageing)
First generation
Industrial qualification
…

- **Different reference points from the technical and regulatory perspective**
- **No clear and shared reference of "starting point"**

Which basis to count the age of reactors?

- **A calendar basis starting with one of the previous reference points**
- **A "full power equivalent" time which better reflects the actual fatigue**



The case of the French nuclear fleet

- **29 years of operation on average**
  (as of 31/12/2013, since first generation)

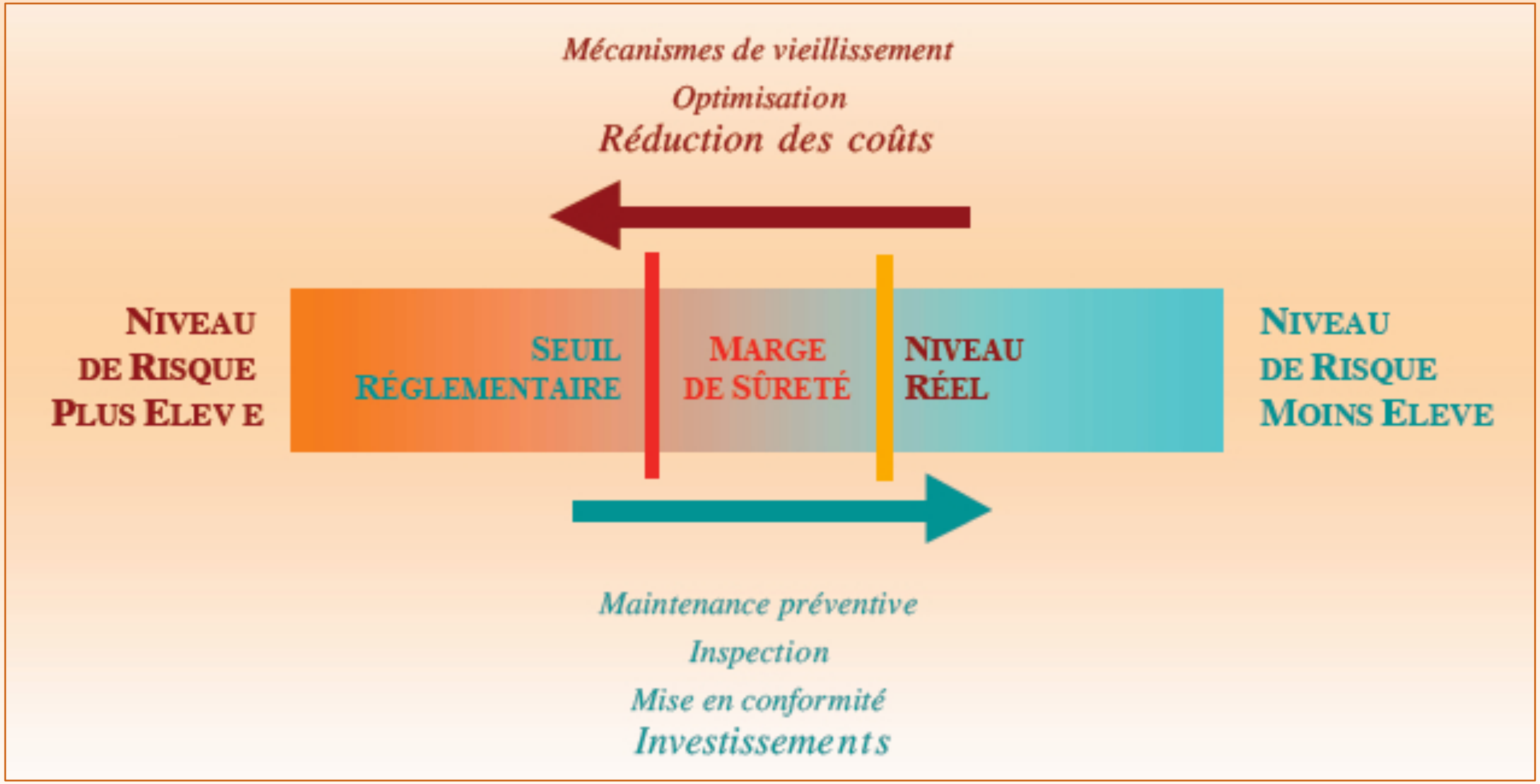
- **A decenial reactor per reactor safety reassessement**
  - significant gap in the actual period through time and between reactors

- **A growing shift between the technical and regulatory ages**
  - 27 reactors over 30 years of operation
  - only 5 have completed 3rd reassessment and obtained the authorization up to 40 years
  - these 5 had 34 years operation on average

- **No clear definition of a "40 years" limit**
  - neither calendary
  - nor technical

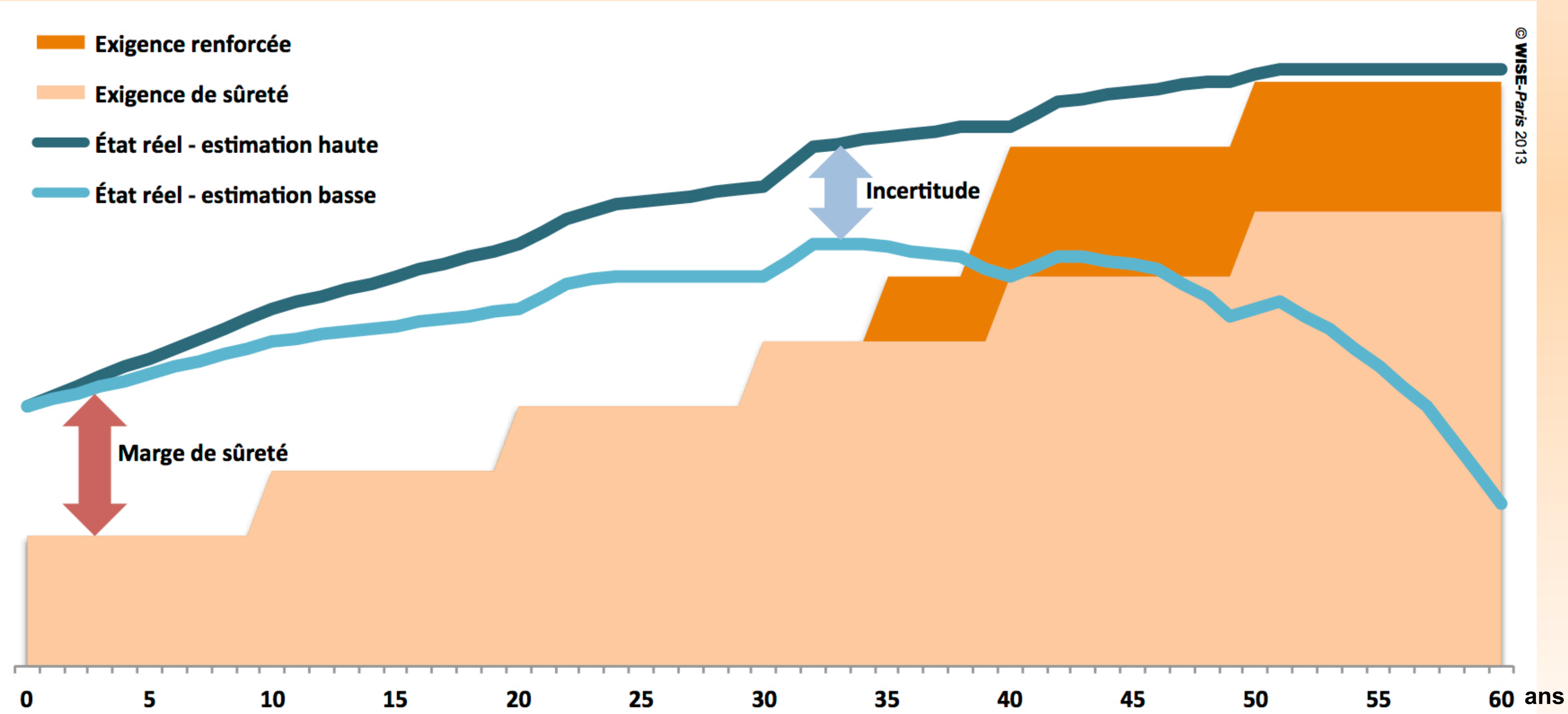
Maintaining safety margins

- **Margins were integrated during desing and construction**
- **Permanent need to compensate for ageing effects**
- **A balance between safety requirements and economic pressure**



A triple problematic

- Need to compensate ageing by reinforcements
- Introduction of new safety requirements after Fukushima-Daiichi
- Managing a growing uncertainty between theoretical and real status



Safety issues

• **Intractable limits of the initial design**
  - for 30 to 40 years of operation at most (big / not replacable components)
  - severe accidents discarded (before Three Mile Island and Tchernobyl)

• **Unavoidable problems of ageing**
  - concerning big and especially not replacable components (vessel…)
  - concerning diffuse equipement (e.g. pipings, electric wires…)

• **Major failures of "in-depth defense" approach as demonstrated by the return of experience after Fukushima**
  - design against external events
  - reassessement of the risk of major accident on reactors
  - evidence of the risk of severe accident arising from spent fuel storage

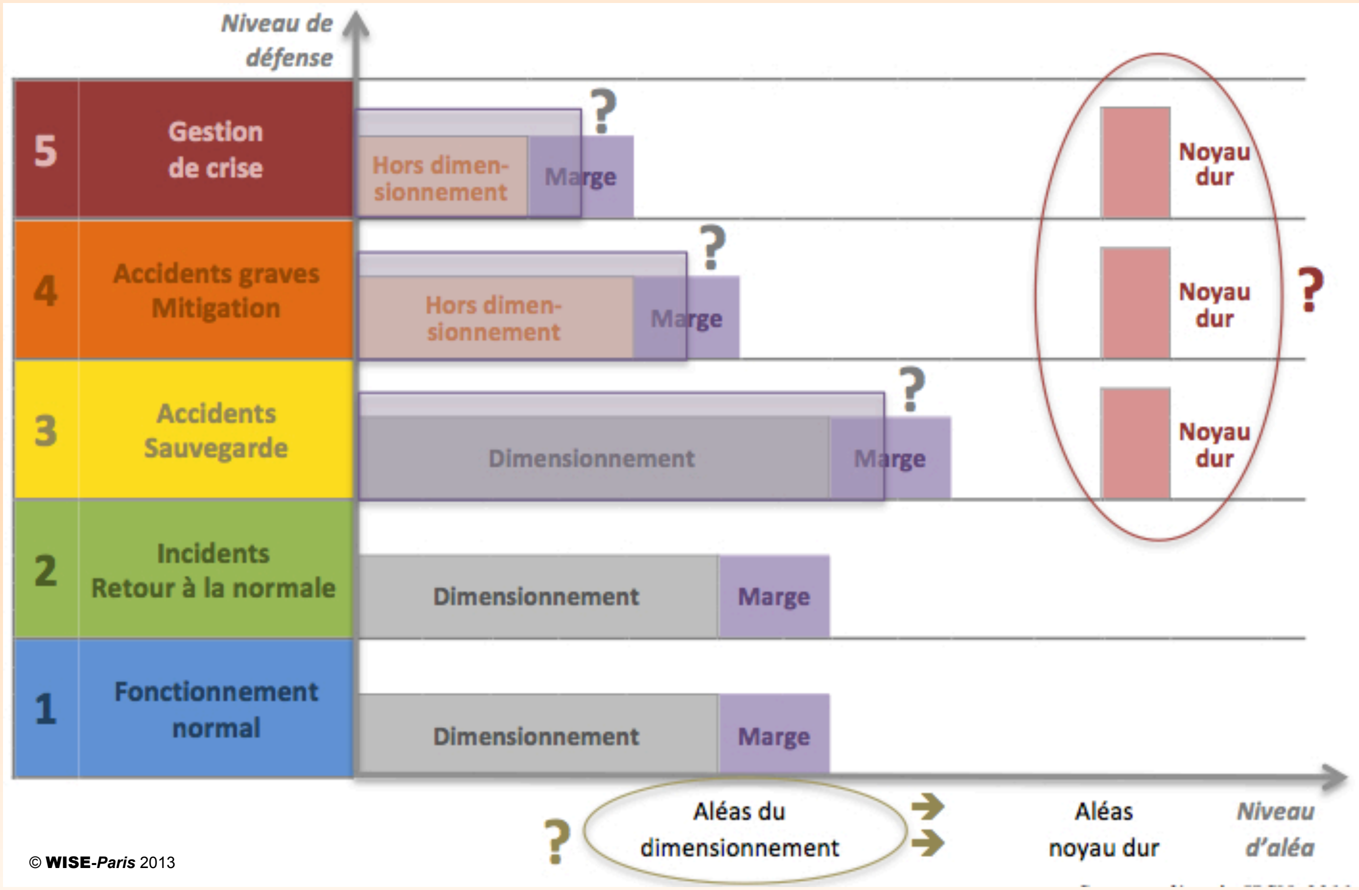
• **Reinforcements introduced following the "stress tests" but still a long process with a lot of major question marks still open**
  In France, over 55 detailed instructions after Fukushima, only 8 are directly implementable

Example of the discussion in France

ASN : to get as close as possible from new reactors safety requirements (EPR)

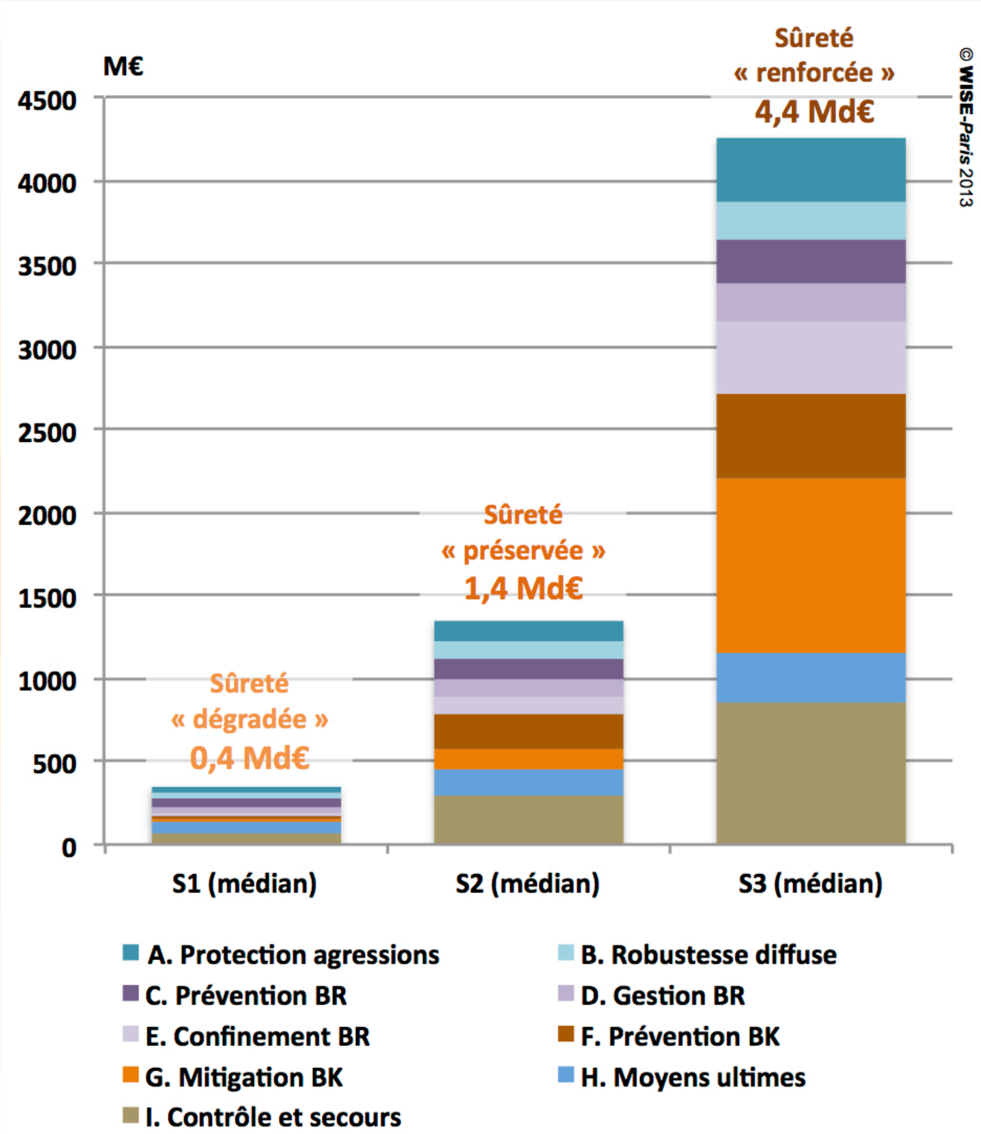
Open questions

- **External events:** level of protection against such events
- **Design limits**
- **Criteria regarding safety margins**
- **"Noyau dur" :** field of application, level of independence and robustness
- **Reinforcement of spent fuel storage compared to reactor building**



Examples of issues to discuss

- **Maintaining the integrity of the reactor vessel**
  - exclusion of vessel breach against fragilization by neutronic cumulated flux?
  - *“no crack starting”* criteria to be replaced by *“crack stopping”*?
- **Maintaining the integrity of the reactor building containment**
  - loss of tightness of concrete leading to relaxing requirement?
  - containment robustness to explosion, need of a core catcher?
- **Reinforcement of spent fuel storage**
  - obsolescence of the design in front of risk reassessment
  - need of a robust building containment where not in place?
- **Managing diffuse fatigue and obsolescence**
  - level of reactive / preventive maintenance
  - managing technological evolution (pro-active change / buying stocks…)
- **Limitations in plant operation**
  - flexibility of operation (following the load)
  - level of fuel performance (burn-up, use of MOX…)



Projections for one reactor (France)

- **High discrepancy of costs depending on the level of safety**

  Scenario S1 : ~ 350 M€ ± 150 M€

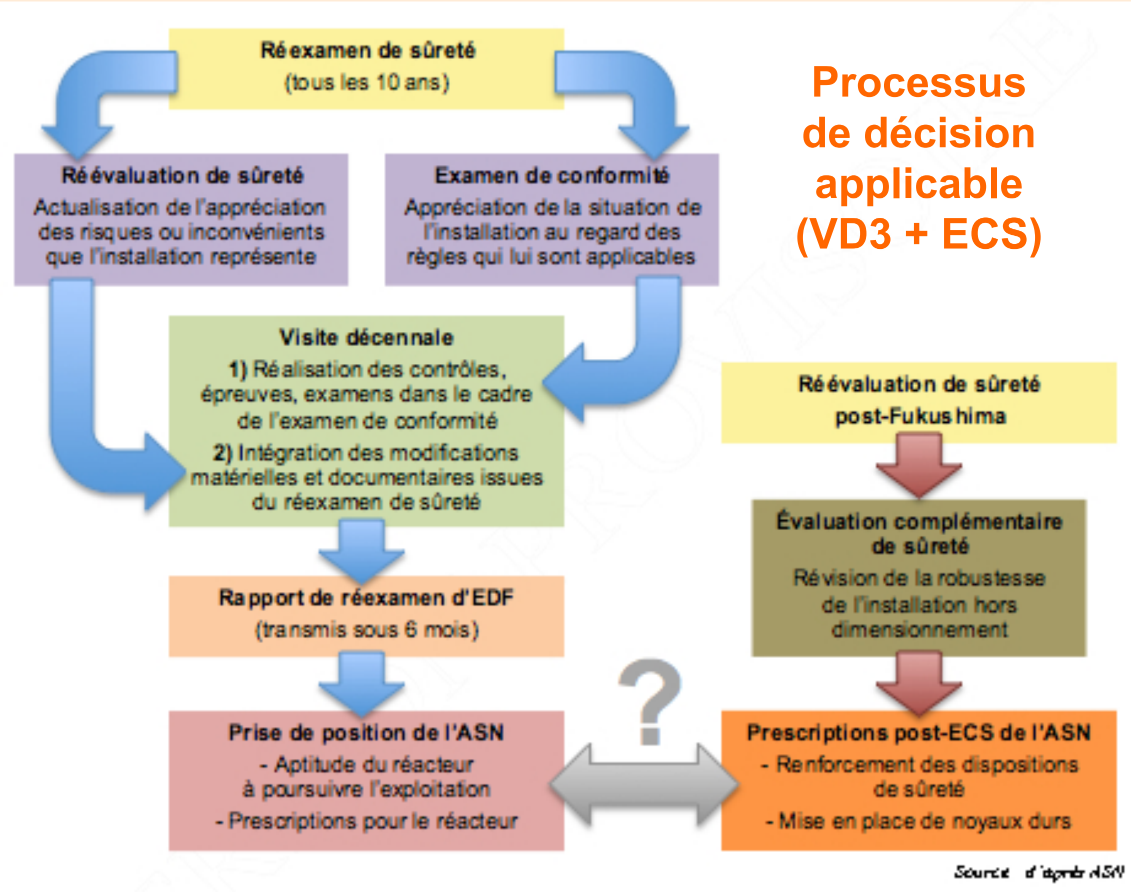
  Scenario S2 : ~ 1350 M€ ± 600 M€

  Scenario S3 : ~ 4350 M€ ± 1850 M€

- **A high profitability stake for the operator**
  (and a stake on prices for consumers)

- **A high stake of industrial capacity to manage heavy work on such a large scale**

Essential principes of access to information and participation
insuffisciently met in existing processes



Ongoing process in France

- **A technical process leading to a technical decision (between operator, TSO and regulator)**
- **No formal process of public participation on requirements or individual decisions by reactor** (although dialogue exists)
- **No or few formalisation of opposable requirements**

New requirements for decision making process

- **Safety stakes attached to the lifetime extension of reactors justify that new and specific requirements are defined**
- **Changes in safety requirements are likely to justify that life extension is comparable to the licensing of a new facility**
- **This would link to a decision making process including a formal public participation process (public inquiry, public debate…)**
- **Given safety stakes, shut-down at the end of design lifetime should be the "normal" decision, and extension could only be granted after such a formal process**
- **The outcome of this process must be a clear and opposable decision in terms of time and requirements**
- **This implies that criteria are defined that allow to check that these requirements are fulfilled, which therefore also define shut-down criteria**

Possible approach to define criteria

- **Deterministic criteria based on ageing mechanisms:**

  Principle: thresholds corresponding to the ageing of key components

  Example: vessel fragilization (ductile-fragile temperature)

  Application: key components and known and measurable mechanisms

- **Probabilistic criteria based on probabilistic safety assessment:**

  Principle: thresholds regarding the probability of severe or major accident

  Example: evolution of core damage frequency (CDF)

  Application: use of relative values (comparison) rather than absolute, problem with the acceptability and relevance of thresholds

- **Criteria based on the implementation of good practices:**

  Principle: thresholds on the gap between operator’s management and “good pratice”

  Example: failure to respect deadlines for major repairs

  Application: the field of planification, management and information where “good practices” can actually be defined and agreed upon

- **Criteria based on capacity (financial and human ressources...)**

- **Ageing of nuclear reactors is a major safety stake that must be seriously managed in terms of public decision**
- **There is an important risk that lifetime extension are decided by defect or “fait accompli” in an insufficient regulatory and political framework**
- **Investments made by investors to prepare lifetime extension with no regulatory visibility bear strong industrial and financial risks**
- **Lifetime extension of reactors goes beyond the actual design and therefore meeting new safety requirements is not granted**
- **It seems unavoidable, to maintain high safety level, to define a new and specific set of safety requirements applying to extension**
- **This implies to introduce:**
  - a shared and objective reference to define the age of reactors
  - a definition of the time when a reactor reaches the end of its design lifetime
  - criteria to assess and decide on the status of ageing reactors beyond that
  - an open and opposable decision making process based on those criteria

Thank you for your attention
and ready to answer your questions

More information :

WISE-*Paris*

Yves Marignac, Director

E-mail : yves.marignac@wise-paris.org
Tel : +33 6 07 71 02 41