

# French nuclear issues

## A focus on some recent developments

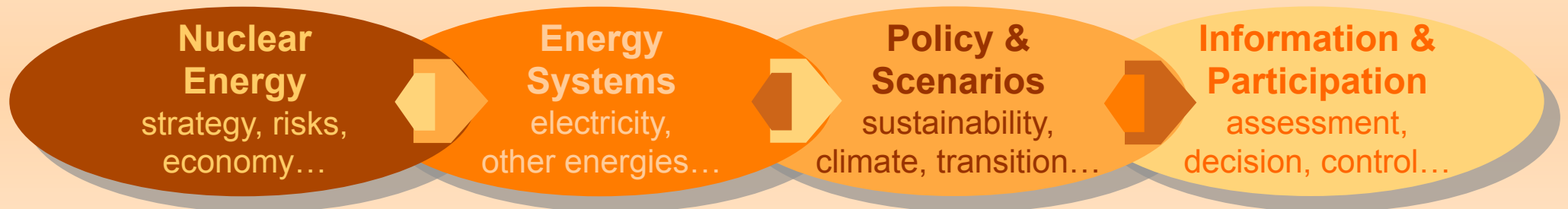
Yves Marignac

Director of **WISE-Paris**

NIRS Meeting – Washington DC – 11 May 2015

### **WISE-Paris: committed to independent expertise**.....

- Information and consultancy **independent agency** created in 1983
- Non profit status and **general interest** goal
- A **service** to institutional players, academics, NGOs, medias...
- A large but intrinsically consistent **range of issues** covered



- **Systemic** analysis of issues, international approach
- Non institutional but **professionnal** expertise
- **Critical thinking** but no activist activities
- Strong commitment to developing **pluralist expertise**

Note than since the early 1990s WISE-Paris has no tie with any other WISE organisation

# Overview

## Energy Debate

**Energy debate and political process**  
**Energy pathways comparison**  
**Energy transition bill**  
**Decision making on nuclear power**

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## Nuclear Industry

**EDF's economic situation**  
**Areva's economic situation**  
**Industrial perspectives**

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## EPR Project

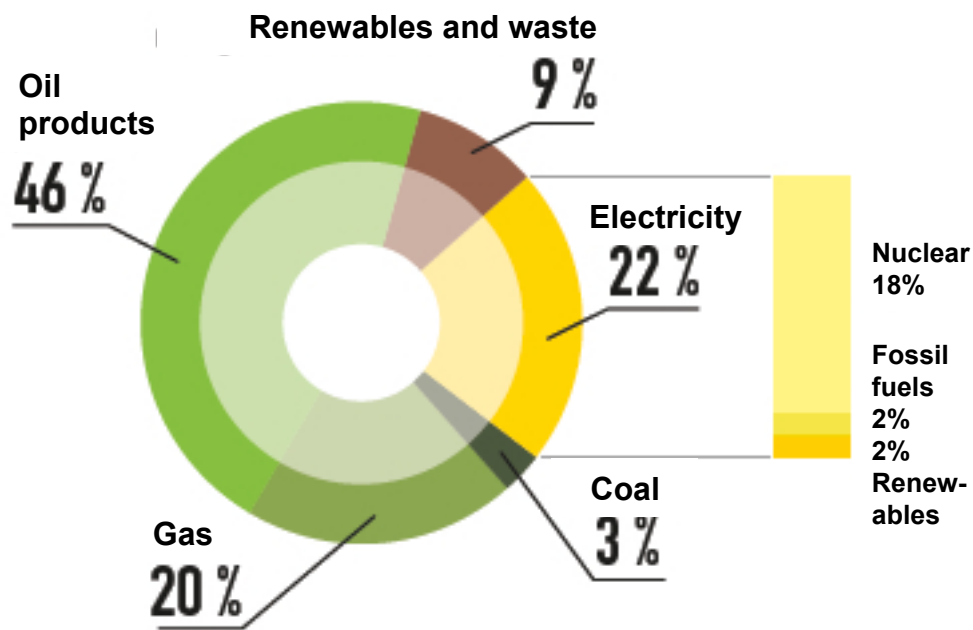
**History of the project and construction problems**  
**Costs and delays**  
**New reactor pressure vessel issue**

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### Energy Transition Debate

Shifting from the old policy  
but still unclear about the new one

### French final energy consumption by energy source (2011)



Source: bilan de l'énergie, 2011, SOeS

### French energy balance

- **Around 70% dependency on (imported) fossil fuels**  
National energy bill close to €60-70bn/a
- **GHG emissions roughly 4 times the world sustainable level**  
**=> objective of 4-fold cut by 2050**
- **Electricity up to 80% dependent on nuclear power, with an ageing reactors fleet**  
(average >30 years)

plus a broader need to renovate and replace ageing energy infrastructures

## A multi-years political process:

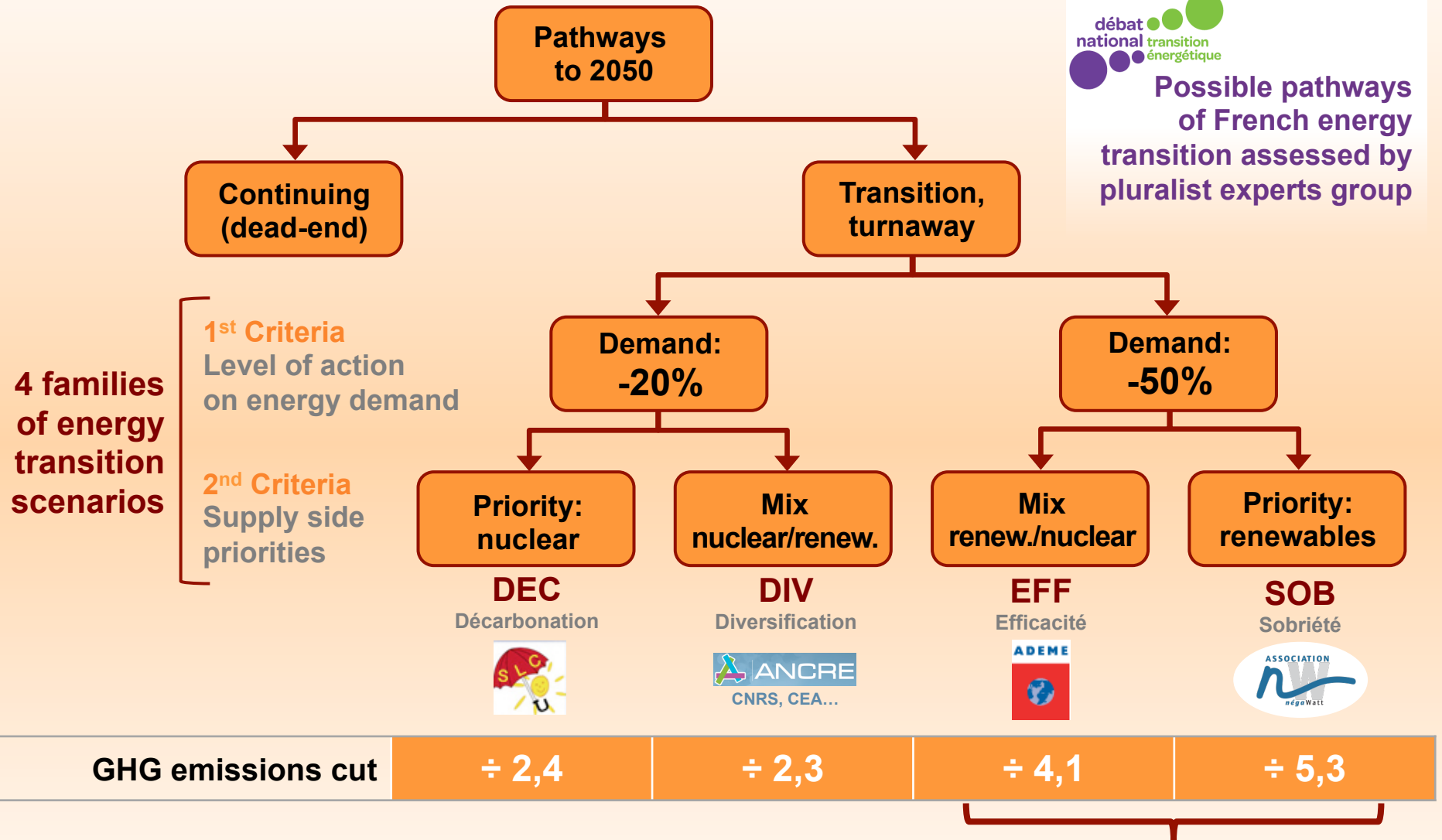
- **From Fukushima to May 2012 Presidential elections**

- Some political leaders moving after Fukushima catastrophe
- Primary elections of the Socialist Party: nuclear becomes an issue
- Hollande introduces the objective of 50% nuclear by 2025
- Electoral agreement with the Green Party includes that commitment
- Strong symbolic move: Hollande during the campaign calls for phasing out French “double dependency” on oil and nuclear

- **From the elections to an Energy Transition Bill**

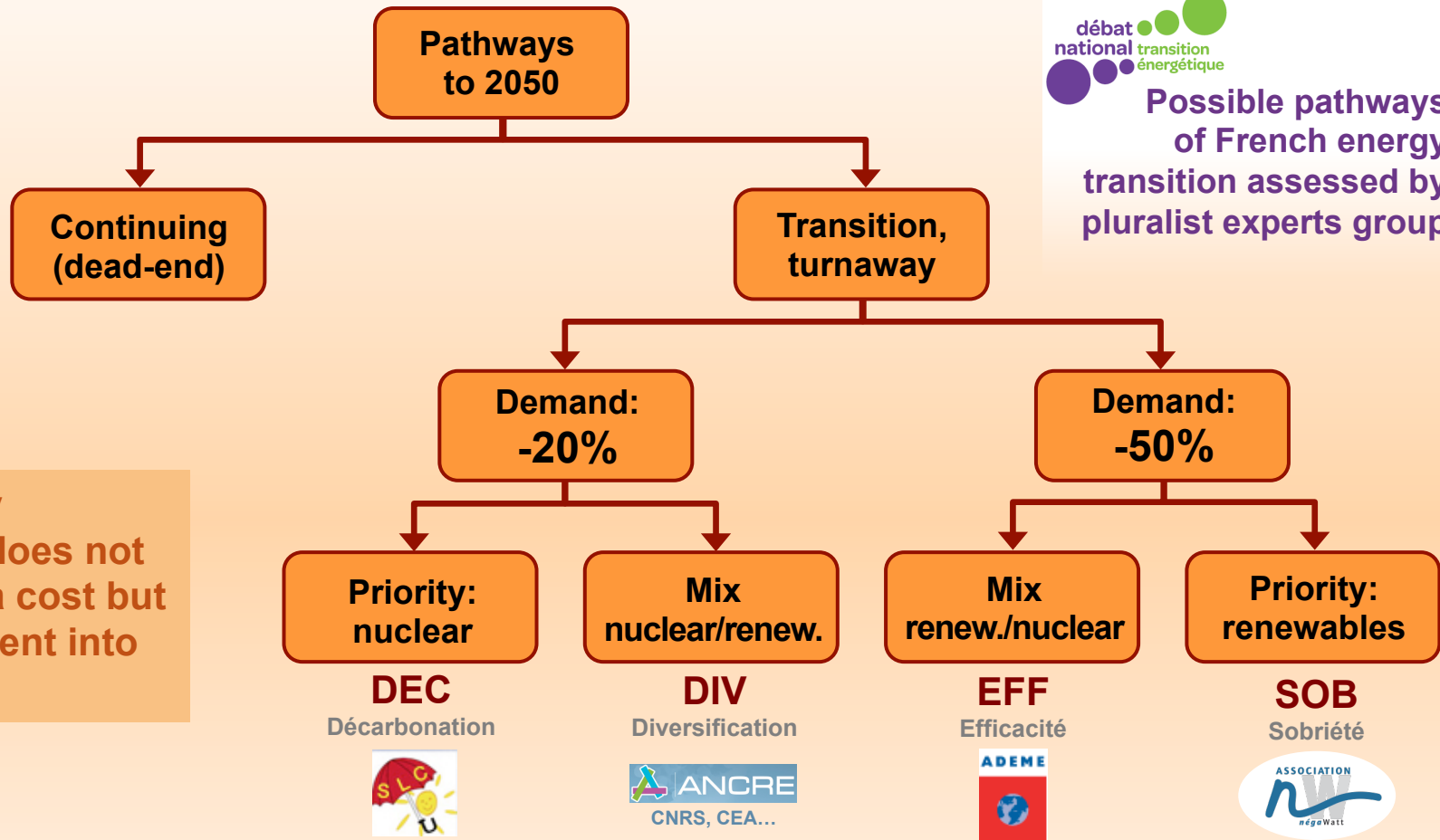
- Electoral promise held of a “national debate on energy transition”
- Large national and decentralized debate from Dec. 2012 to July 2013
- Draft Energy Transition bill presented to Parliament July 2014
- Final end of parliamentary process, bill to be passed in June 2015

débat national transition énergétique  
Possible pathways of French energy transition assessed by pluralist experts group



Needs 2-fold reduction of energy demand to meet 4-fold reduction of GHG emissions

débat national transition énergétique  
Possible pathways of French energy transition assessed by pluralist experts group

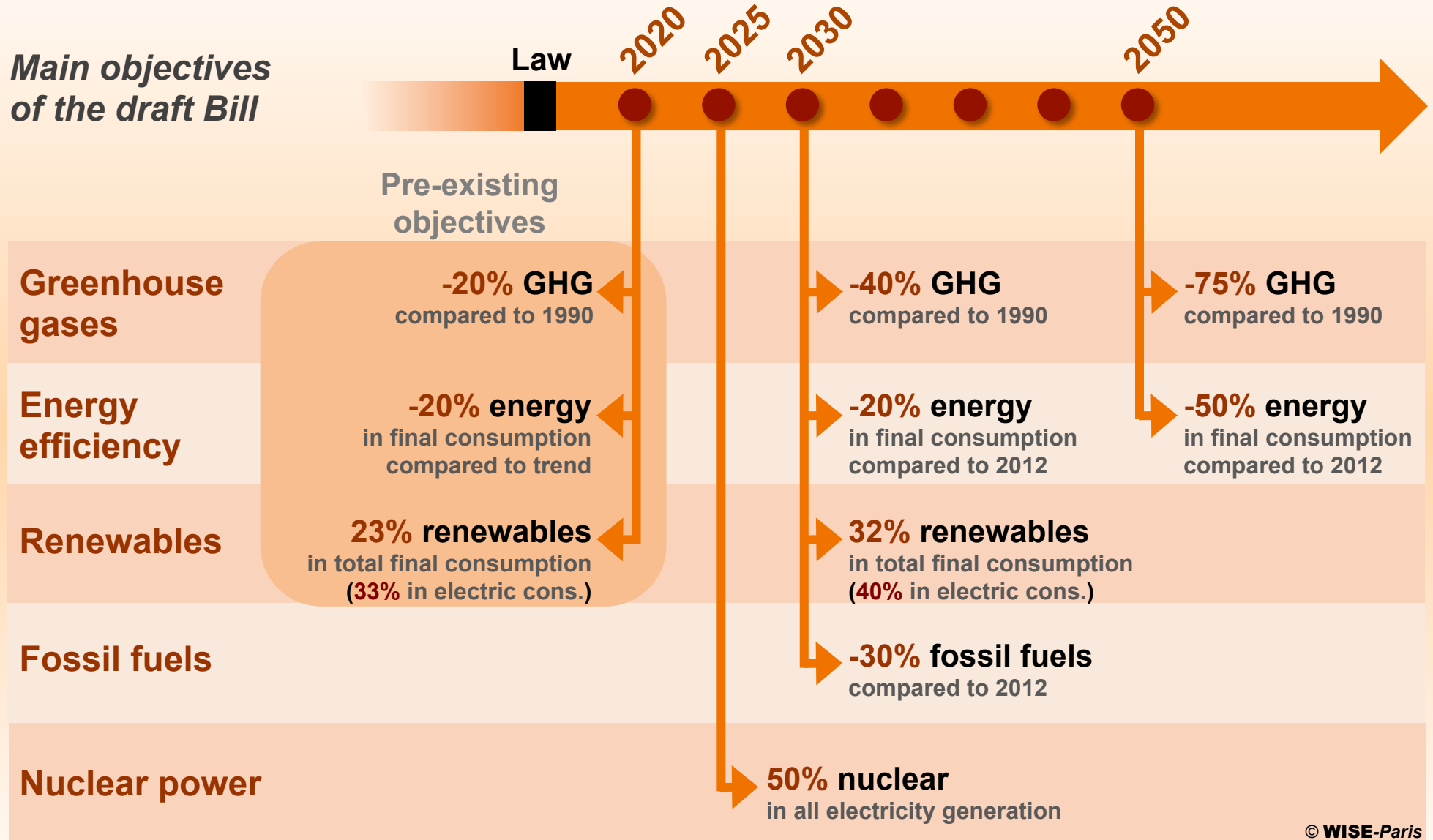


The energy transition does not represent a cost but an investment into the future

<b>GHG emissions cut</b>	÷ 2,4	÷ 2,3	÷ 4,1	÷ 5,3
<b>Net Investments / Energy imports (2012-2050)</b>	-€1,145bn	-€1,151bn	-€1,389bn	-€1,470bn



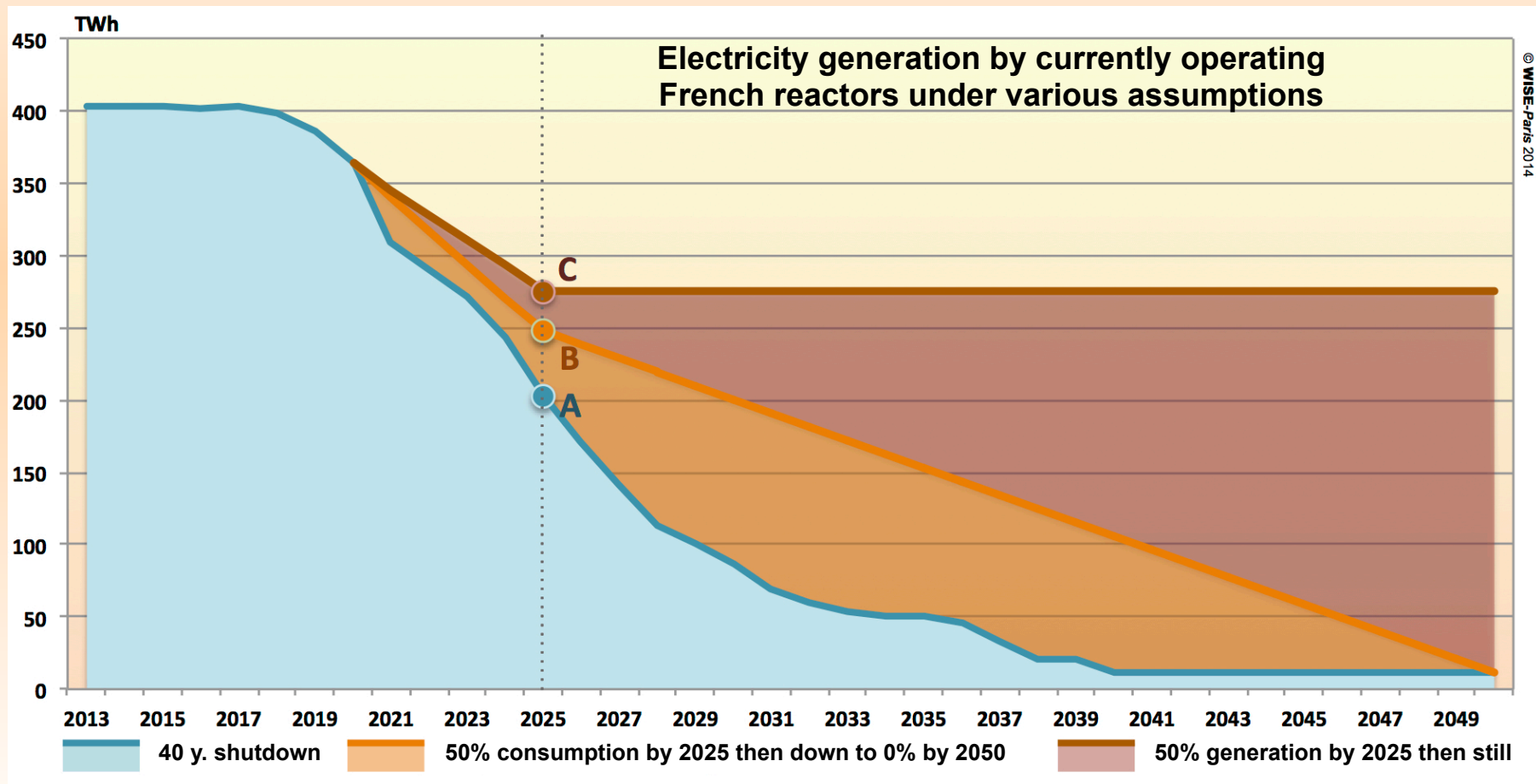
Main objectives of the draft Bill



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## 50% by 2025 is a very constrained trajectory

- Assuming flat electricity consumption, objective means some 20 reactors shut-down
- Yet this is less than the number that should shut down if no extension after 40 years



## From 75% to 50% nuclear in 2025?

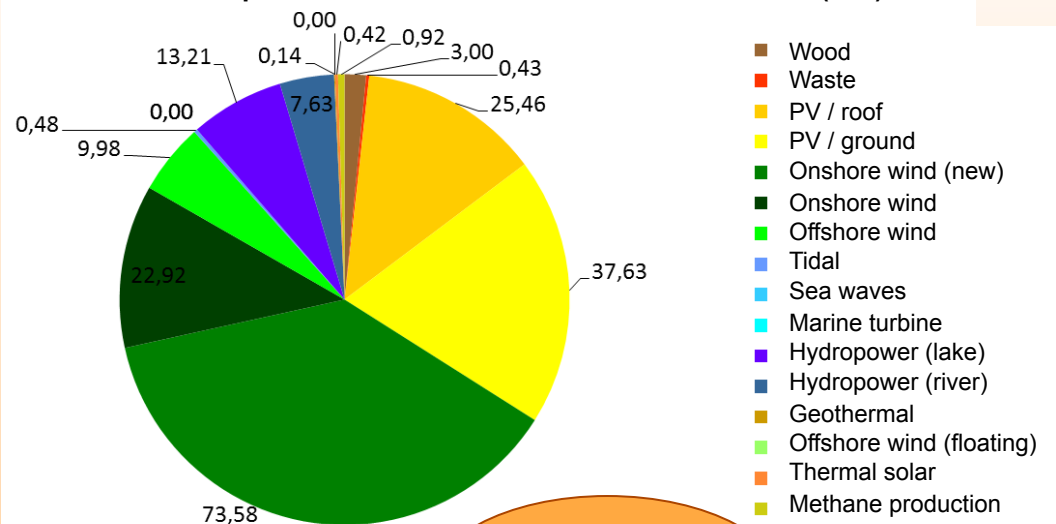
- **No clear framework for the shutdown of nuclear reactors:**
  - Commitment to shut down 2 reactors at Fessenheim by 2016
  - No real action taken yet for this to happen
  - No mechanism for the Government to impose shutdowns to EDF
  - Only a 63.2 GW cap (current existing capacity)
  - A “pluriannual energy planning” where EDF should decide
  - Also, a public inquiry will be needed for a reactor to get license extension beyond 40 years
- **No clear vision of the direction after 2025:**
  - Nothing said about what happens to nuclear power after 2025
  - Clearly the Government neither is aiming for phase-out...
  - ...nor is ready to speak about projects of new reactors

## New official study:

(by French Energy management agency)

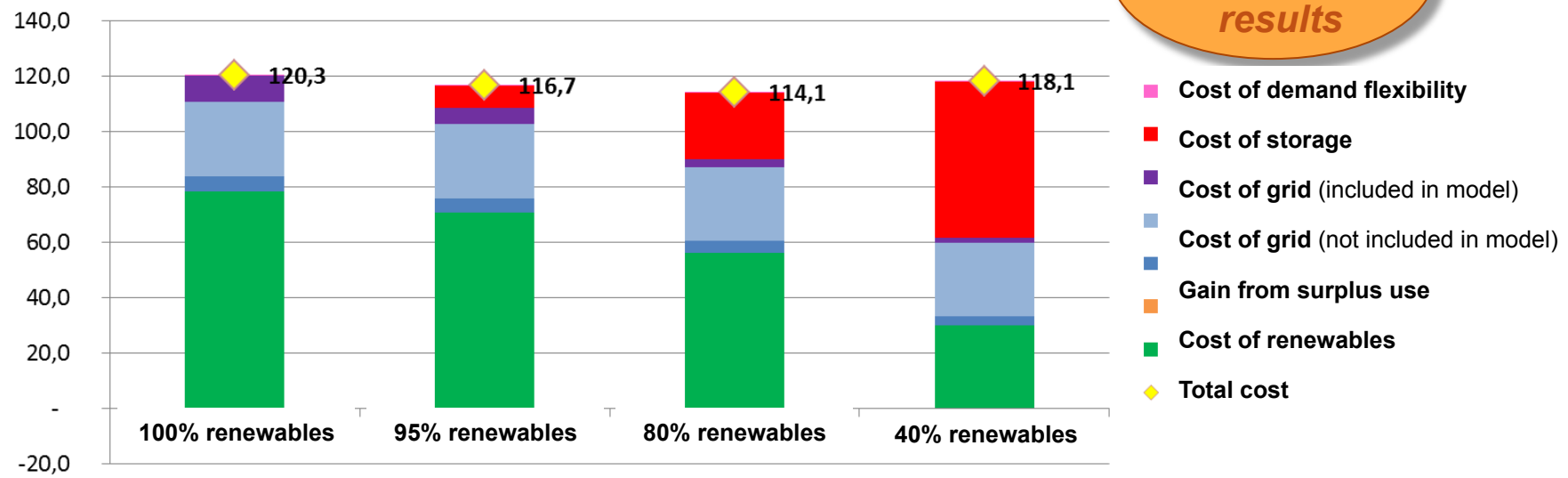
- 100% renewable electricity by 2050 is realistic and affordable (same cost as 40% plus nuclear)
- Study completed in April 2015 Government tried to push back publication but the study leaked

Installed capacities in central 100% renewables scenario (GW)



*Leaked provisional results*

Energy cost (€/MWh)

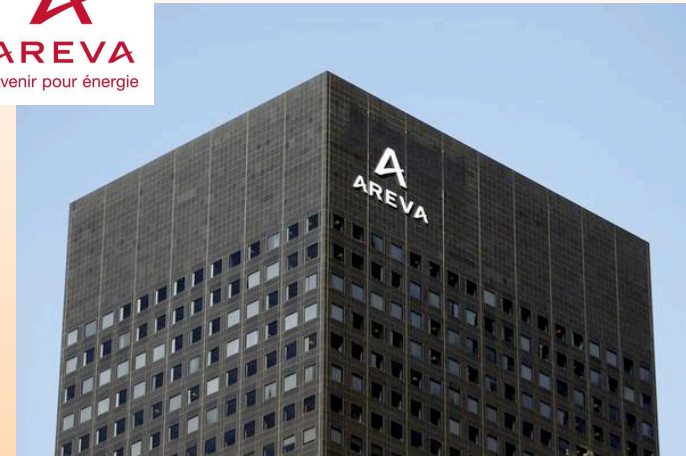
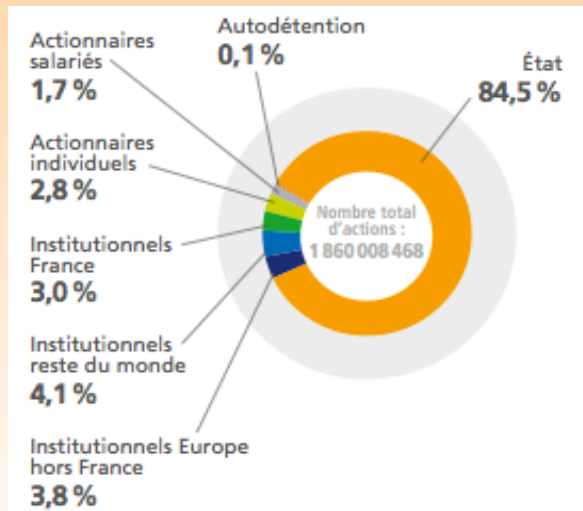


## French Nuclear Economics

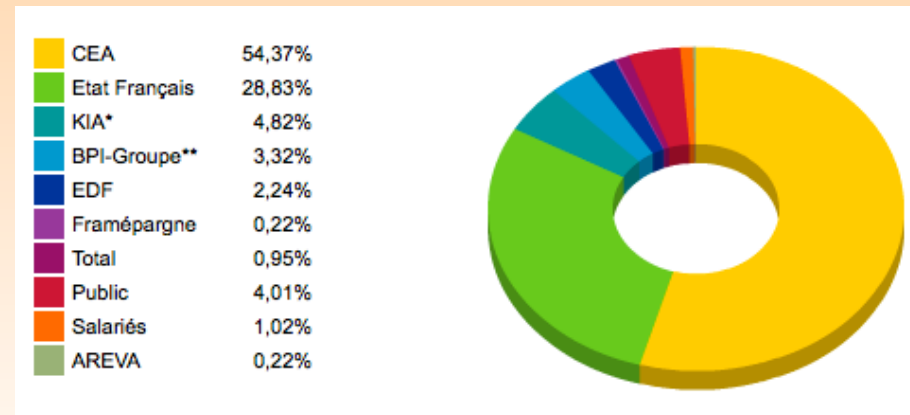
Reaching the limits  
of a subsidised system



**84.5% State owned**  
(as of 31 Dec. 2014)

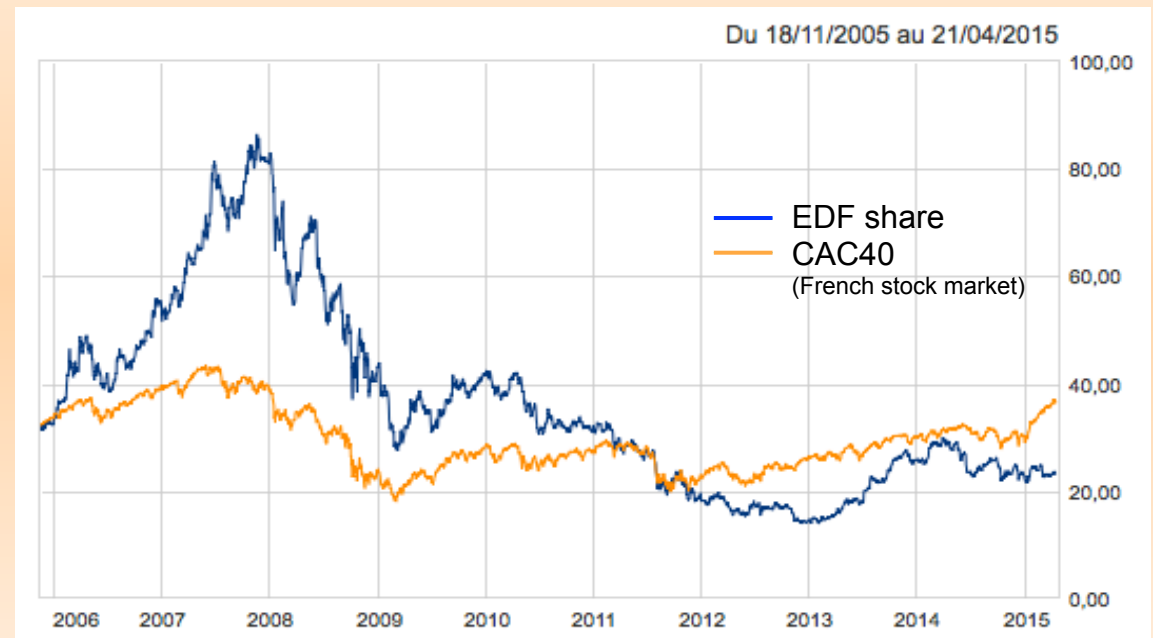
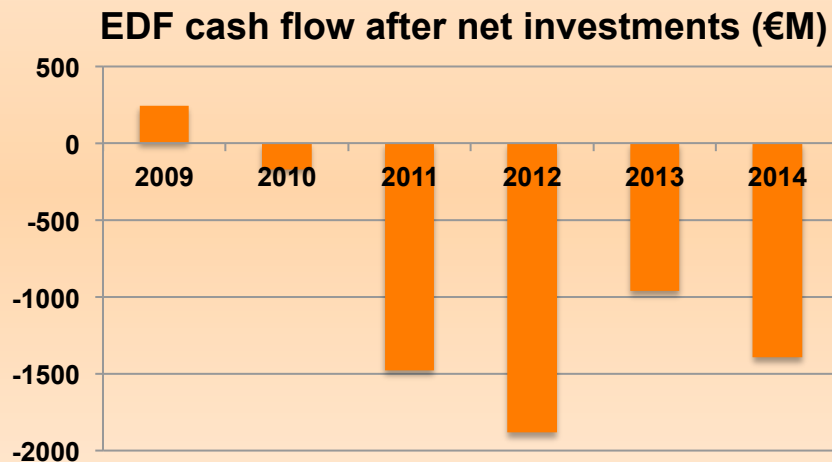


**83.2% State owned**  
of which 54.4% through CEA  
(as of 8 Jan. 2015)



## EDF:

- Stock value plunged >70% (up to 85%) since 2007
- High debt €34.2bn for turnover of €73bn (2014)
- Negative cashflow after net investments

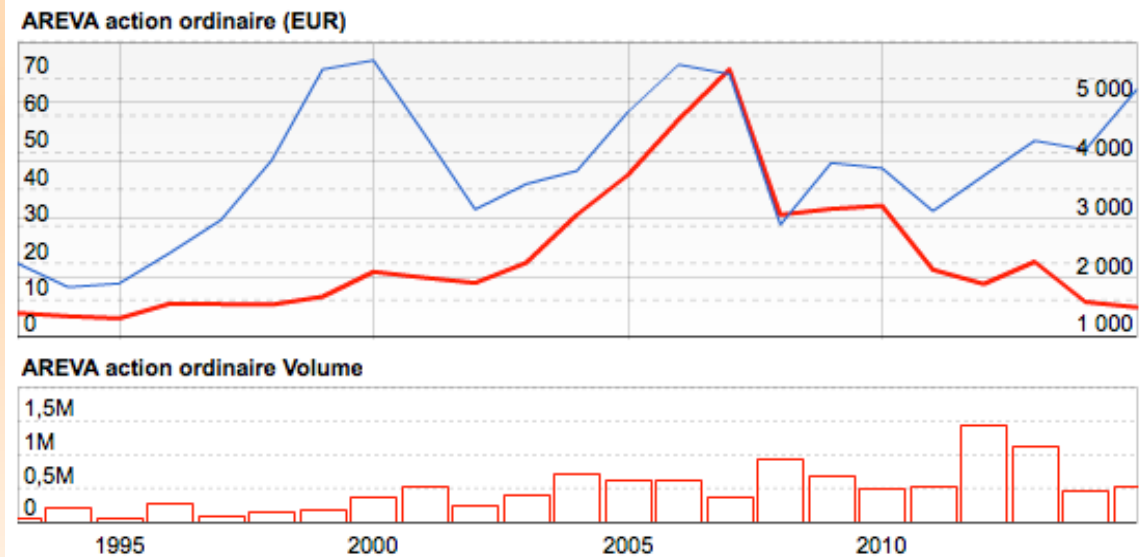
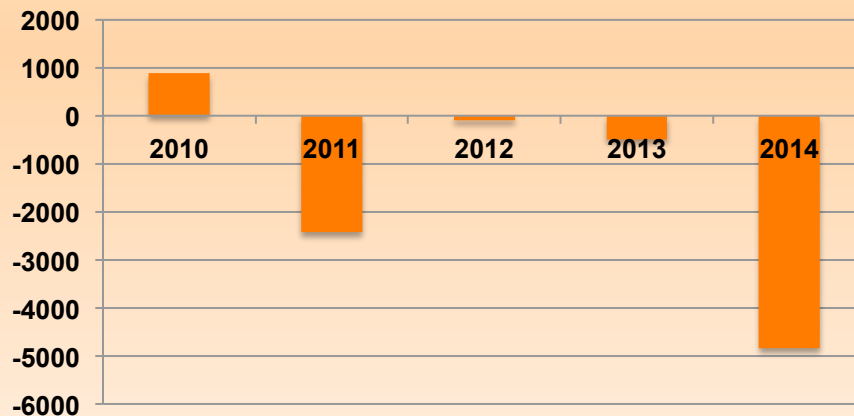


- 4.5%/a operating cost increase 2007-2012
- Need for significant tariff increases to cover the costs (legally binding, politically rude)
- Stuck between rising costs and investment needs and decreasing customers basis

## Areva:

- Loss of €4.8bn (almost €8bn in 4 years = annual turnover)
- High debt €5.8bn for turnover of €8.3bn
- Stock value plunged by > 85% since 2007 (current capital value just above €3bn)
- Standard & Poor's downgraded AREVA shares to BB+ ("junk") in November 2014 and again to BB- in March 2015

Areva net operating result (€M)

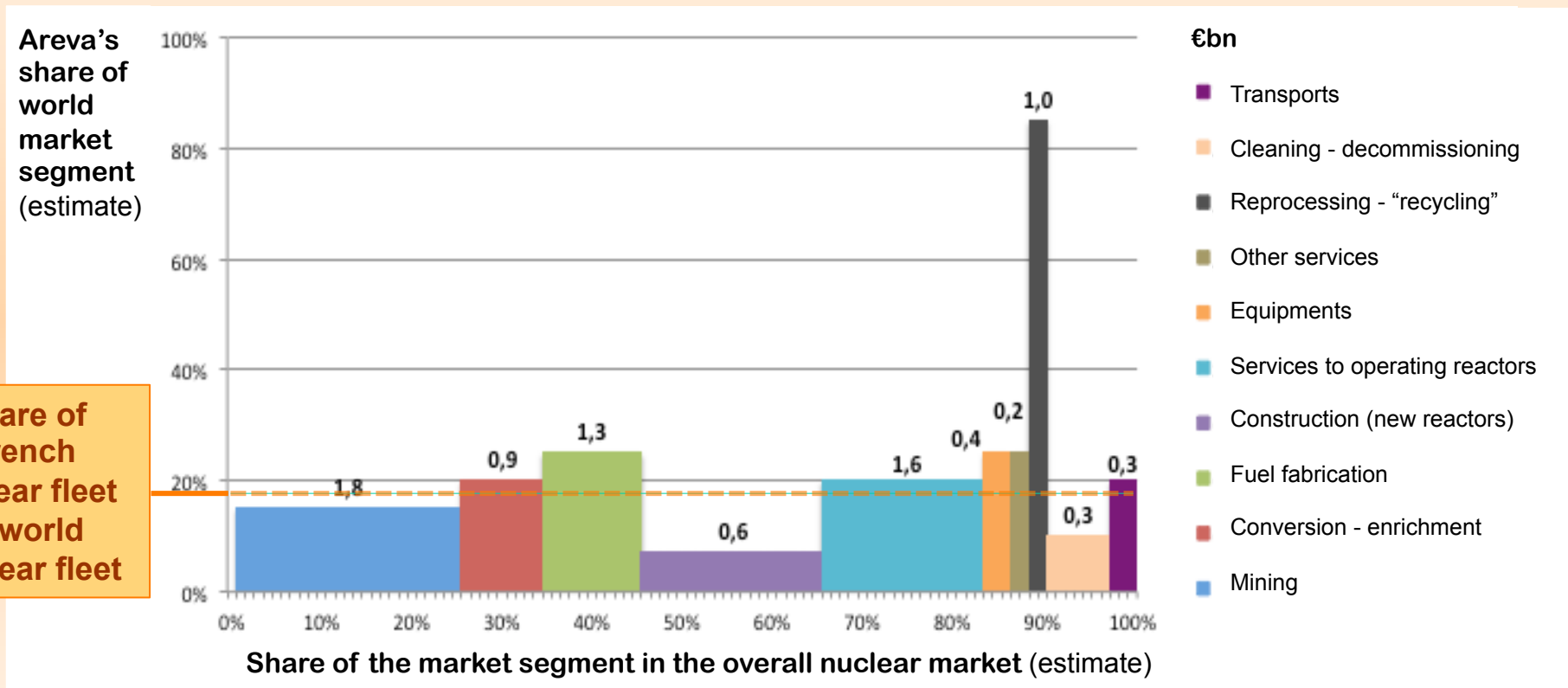


— Areva share  
— CAC40 (French stock market)



## Limited role and capacity on the international scene

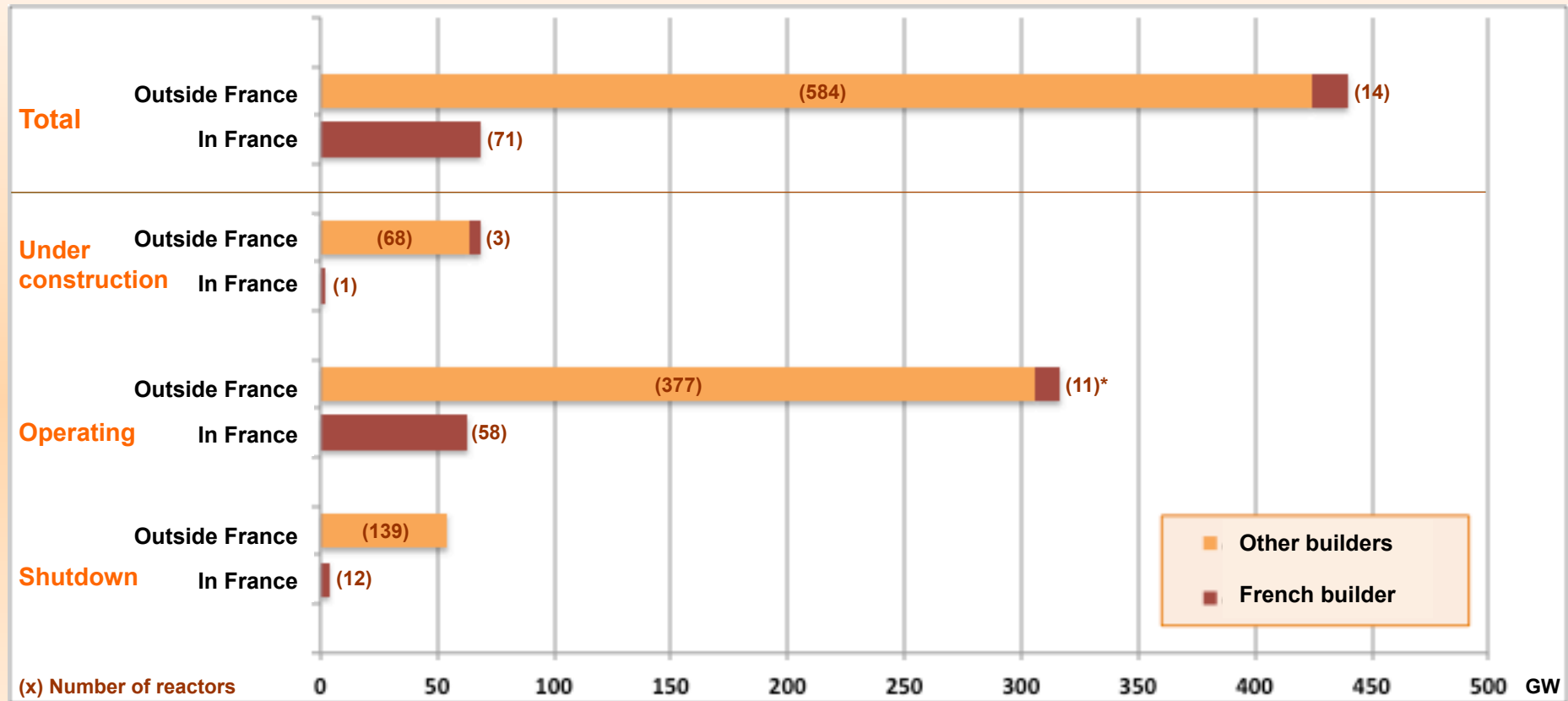
Share of Areva's turnover in 2013 (€9,2bn) by market segment



Share of French nuclear fleet in world nuclear fleet

- Average performance on international market close to the size of its domestic market
- Under-performing in new-build and over-performing in reprocessing

## Focus: reactors export

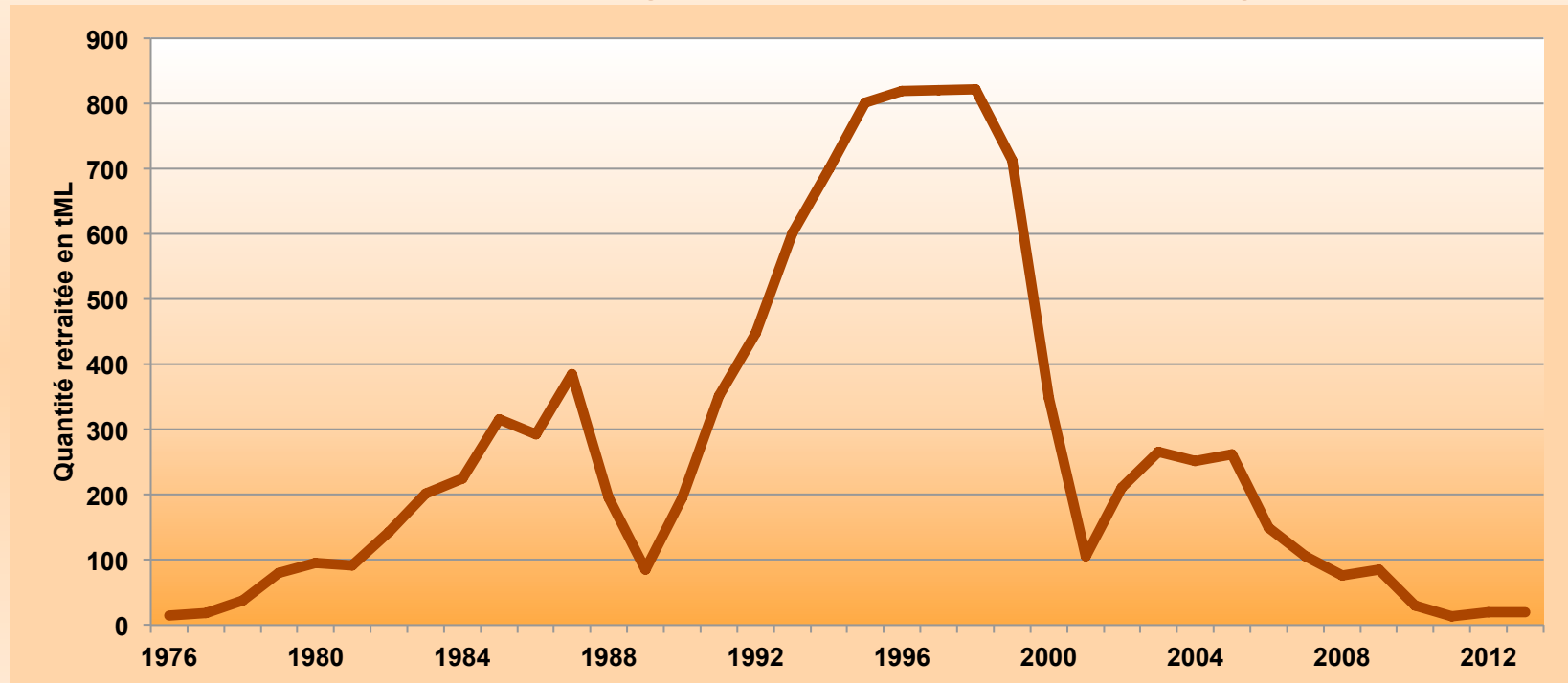


Source : WISE-Paris based on Elecnucl, PRIS, 2014

- France only exported 11 completed reactors + 3 under construction
- 2,4% of overall cumulated market outside France
- 3<sup>rd</sup> exportator on the international market, very far behind US and Russia

## Focus: reprocessing and plutonium recycling

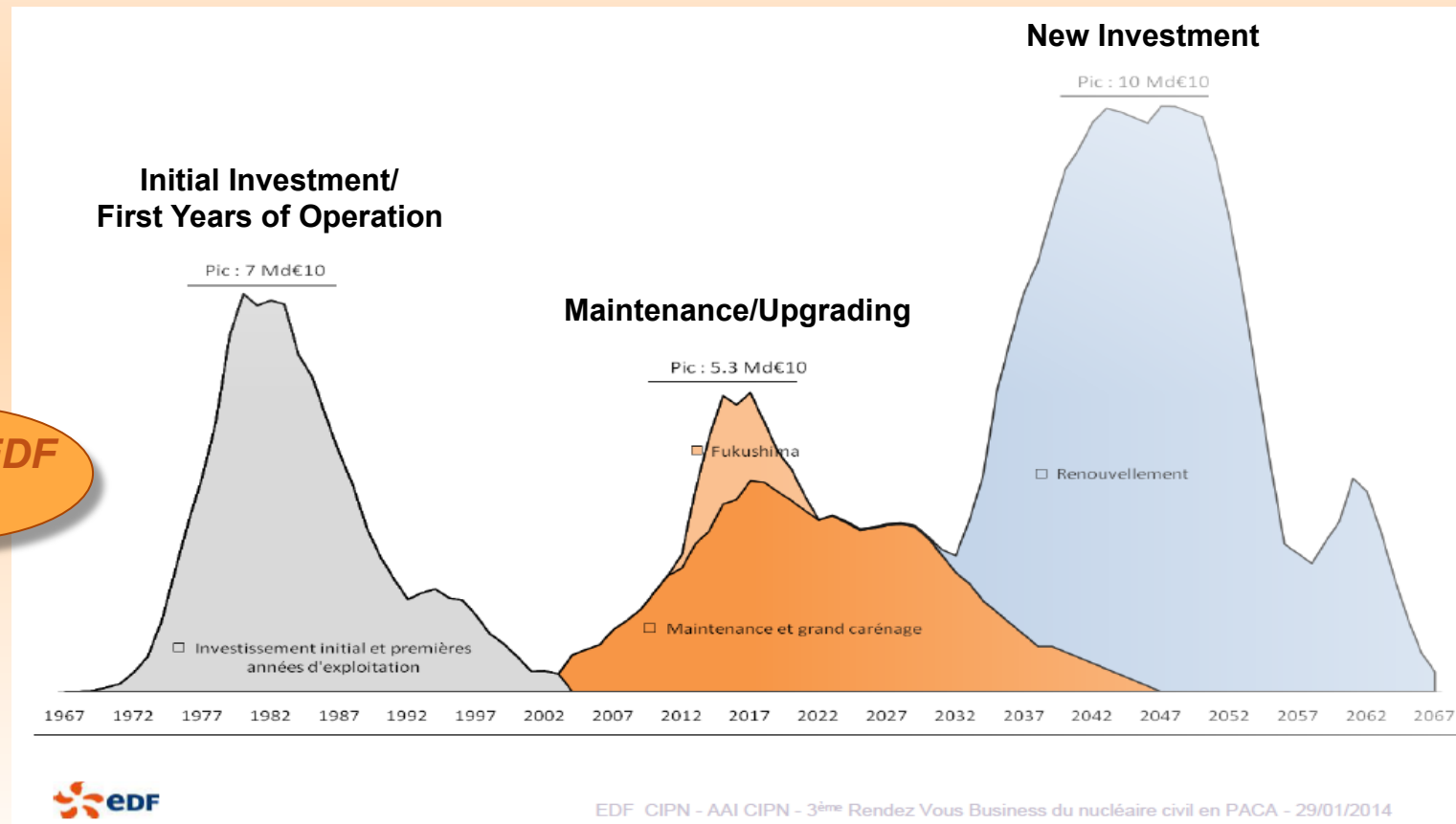
Annual quantities of foreign spent fuel reprocessed at La Hague (tHM)



- More than 80% of the world's reprocessing and MOX fabrication market
- Only one foreign customer with operating power plant left (Netherlands - 0,5 GW)
- EDF the only real customer and support

## Focus: investments needed to maintain EDF reactors

- More than €110bn ahead for reinforcing safety and extending lifetime  
Highly challenging industrial and financial programme
- Even greater costs to replace existing reactors by EPRs on the longer term



Leaked EDF graph

### EPR in Flamanville

From the industry's new wonder  
to a complete failure



## Brief EPR history:

- French/German development of a new up to 1,800 MWe design started in the 1990s
- 2003, French decision to order a French EPR to prepare for future replacement (anticipate)
- In parallel, EPR project in Finland as international showcase, key to big export expectations
- 2005, final decision to build an EPR in Flamanville
- 2007, construction license is granted, EDF plans to get it built by 2012

**Head of reactor pressure vessel:**

Oct. 2010: Numerous flaws in welding on tubes on reactor vessel head

ASN granted Areva to do repairs (instead of fabricating a new one)

During repairs, an even more important issue was found (smearing thickness)

New repairs proposed by Areva, almost completed

ASN will give its final approval once repairs completed

**Basement:**

Cracks found in the nuclear island concrete following its pouring in Dec. 2007, due to shrinkage

Non conform location of reinforcement steel found after concrete pouring in the basement of the fuel building (March 2008) and the safeguard building (May 2008)

ASN stopped the construction site from 26 May 2008 to 18 June 2008

**Containment:**

Anomaly of prestressing tendons location before pouring (November 2009)

Other non-conforming location of part of prestressing tendons in May 2011

ASN stopped the construction site during one week.

Gap in concrete poured in some cylindrical shaft (Jan. 2014) and in 2 prestressing tendons guides (July 2014) of the reactor building

**Metal liner:**

Non conform metal liner welding (June 2008) and other manufacturing deviations  
During a test of the heavy circular crane, metallic pieces are projected, one piercing the metallic liner (Oct. 2013), repair completed in 2014

**Spent fuel pool:**

Several rock pockets in pool walls due to non homogenous concrete pouring (Jul. 2011)  
Voids found behind the pool cofferdams (March 2012)

**Miscellaneous:**

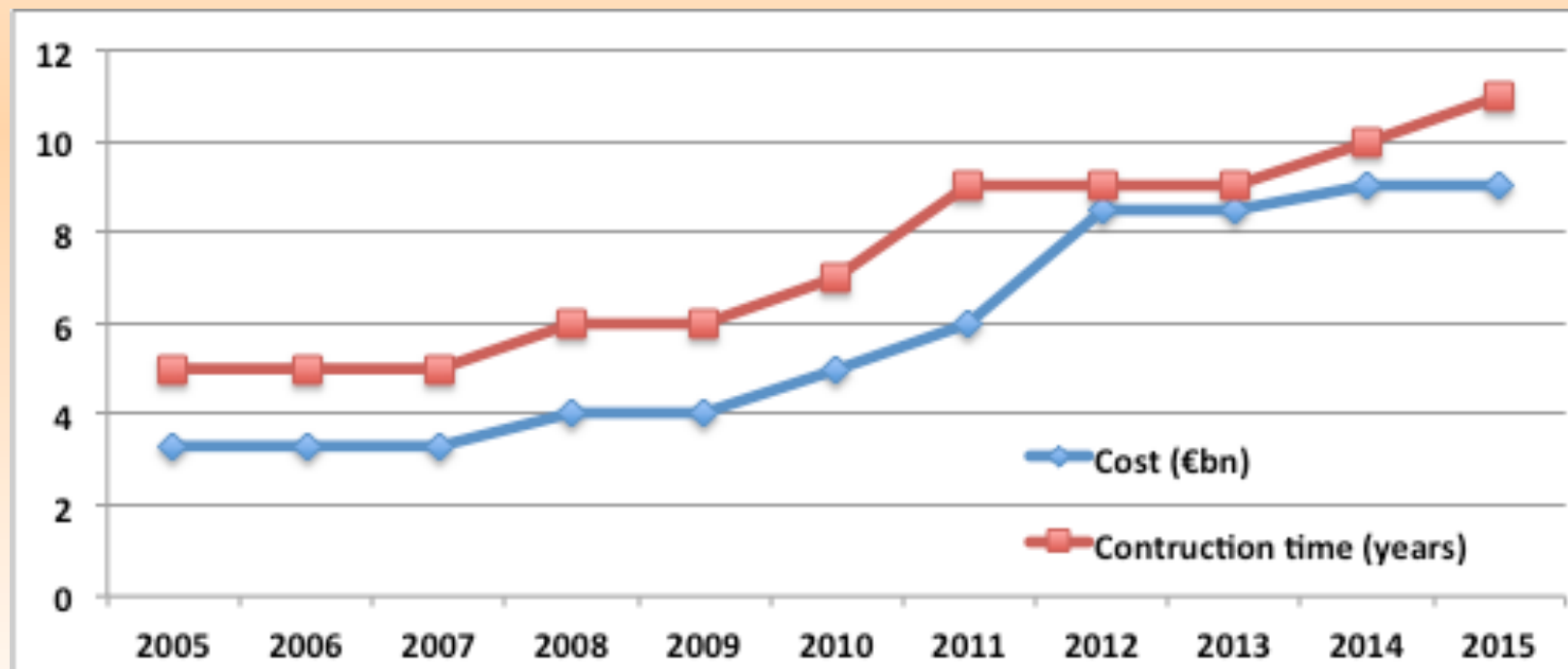
Non conform fabrication of piping for the pumping station (Jul. 2008)  
Non conform pouring of the concrete of internal structures in reactor building (May 2009)  
Anomaly detected on a steam generator component (end 2009), needed to be replaced  
Non conform welding of the heavy circular crane (Dec. 2011), had to be re-welded  
4 valves of the security injection system mounted upside down (Jul. 2013),  
ASN stopped assembly operations for some months  
An overall concern with the Instrumentation & Control system, final approval only granted by ASN around 2012-2013



## Current status of delays and overcosts

- In 2005: €3.3bn and commissioning in 2012.
- Today: at least €8.5bn and commissioning not before 2017 (cost and date provided before reactor pressure vessel flaws are known).

Official final cost estimates and time of completion through years

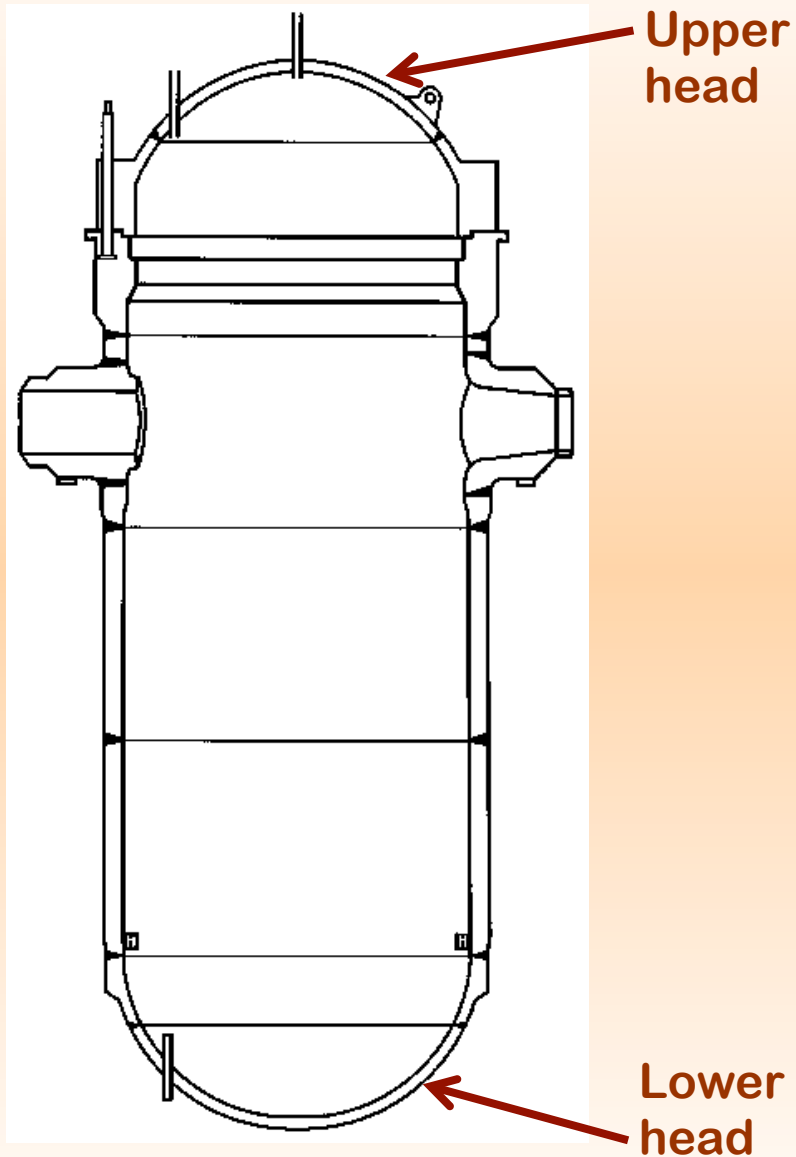


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## EPR Flamanville: official costs soaring

	Construction cost (€/kW)	Complete generating cost (€/MWh)
DGEMP 2003 (Government)	1 043	28,4
EDF 2005		43
EDF 2006	2 060	46
EDF 2008	2 500	54
EDF 2008 - 2 <sup>nd</sup> EPR		60
Today (Court of Account)	5 300	90

- EPR in Olkiluoto: fixed price €3,3bn, currently €8,5bn and 9 years late
- EPR Hinley Point project: planned 2 x €8,5bn – Needs €110/MWh guarantee
- EPRs in Taishan-1 and 2: same range of costs, also late on schedule



- 7 April 2015: ASN announced an “anomaly” with the mechanical properties of the upper and lower heads of the reactor pressure vessel of Flamanville-3
- Unlike the rest of the components which were forged in Japan, those were forged at Areva’s plant of Le Creusot, in France
- ASN later qualified the “anomaly” of “very serious” in a Parliament hearing
- Defects jeopardize the licensing of the vessel under “pressurized nuclear equipment” regulation

## Safety case: basic and seemingly serious defect

- Pieces made of 16MND5 steel
- Carbon segregation in a certain area of the upper and lower heads: insufficient elimination during the forging process of the ingot's higher part
- Destructive tests results (on a US EPR head) don't meet requirements:
  - Carbon concentration 0.30% in the central area (diameter of around 1.20m), far from domain of knowledge where required mechanical properties are well proven (0.22%)
  - Resilience is affected: between 36J and 64J in the segregated zone, with a main value of 52J. Compares to 60J in average for regulatory threshold and above 100J for expected value (margins).
- Head and bottom of Flamanville-3 fabricated under same conditions  
Non destructive chemical tests on Flamanville PRV surface confirmed the presence of similar defect
- New destructive tests will be performed using head forged for Hinkley Point  
Results announced for October 2015 (seems unrealistic)
- Challenge for Areva / EDF to build an alternative safety demonstration
- Taishan EPRs (at least) are concerned too (but not Olkiluoto)



## Trust and/or competency issue

- **Apr. 2015:** ASN announced that fabrication defects had been found
- **Dec. 2014:** Areva informed ASN about the results on the tests
- **Oct. 2014:** Areva performed the tests
- **Jan. 2014:** pressure vessel put in place in its pit, welding starts
- **Oct. 2013:** pressure vessel delivered to the Flamanville site
- **Sept. 2012:** Areva proposes ASN destructive testing program (part of the qualification)  
(...)
- **2006:** head and bottom of the Flamanville pressure vessel forged

Thank you for your attention

**More information :**



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