Past, present and future trends of French nuclear

François Lévêque,
Professor of economics at Mines ParisTech
and Romain Bizet,
PhD Candidate at Mines ParisTech

Disclaimer

• A research programme on nuclear power economics at Mines ParisTech
  – details and publications: http://www.cerna.mines-paristech.fr/fr/recherche/economics-nuclear
  – financially supported by EDF

• The views and analyses expressed in this communication are our own and do not represent EDF’s positions, strategies or visions
1. The current state of the French nuclear fleet

• A mature fleet...
  – built during the late 1970s and early 1980s
  – 32 years old on average

• ... built at a reasonable cost...
  – Standardization (PWR, Westinghouse licence)
  – A single supplier (Franco Américaine de l’Atome) and a single buyer and architect engineer (Electricité de France)
  – Smooth and steady safety regulation

• ... and without subsidies
  – paid by French consumers, not by French taxpayers (unlike fundamental nuclear R&D)
Construction of the existing fleet

Over two thirds of the French fleet was connected to the grid between 1977 and 1987

(Source: IRSN)
Evolution of construction costs

(Source: Report from the French Court of auditors on the costs of the nuclear industry, 2012)
2. The economics of the existing fleet

- In France, **existing NPPs** are cost competitive and will likely remain so, even if costs continue to increase
  - construction costs have been amortized
  - life extension investment is a cheap investment
- The safety regulatory framework is satisfying
  - Independency, transparency and competency of the ASN
- However, the context has changed and EDF needs a new business model
  - Less political emphasis on nuclear power, more on renewables
  - Erosion of regulated tariffs and depression of wholesale market price
  - Financial constraints and huge needs in investment
# The costs of the existing nuclear fleet

<table>
<thead>
<tr>
<th></th>
<th>€/MWh</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel (including WM)</td>
<td>5,7</td>
<td>Cour des comptes (2014)</td>
</tr>
<tr>
<td>Opex</td>
<td>24,4</td>
<td>Cour des comptes (2014)</td>
</tr>
<tr>
<td>Cash cost</td>
<td>32</td>
<td>E. Macron (2016)</td>
</tr>
<tr>
<td>Considered costs to set the regulated access tariff to EDF nuclear MWhs</td>
<td>39</td>
<td>Champsaur Commission (2011)</td>
</tr>
<tr>
<td>Average cost 2010</td>
<td>49,6</td>
<td>Cour des comptes (2012)</td>
</tr>
<tr>
<td>Average cost 2013</td>
<td>59,8</td>
<td>Cour des comptes (2014)</td>
</tr>
</tbody>
</table>
The increase in investment and maintenance costs in M€

Source: Rapport annuel de la Cour des Comptes, 2016)
Estimated costs of life extension

• Multiple, but coherent, sources
  – EDF (2014) : €55 billion (1 be\textsubscript{2013}/reactor)
    • Capex (2014-2025)
  – Court of Auditors (2016) : €100 billion (1,7 be\textsubscript{2013}/reactor)
    • Capex + Opex (2014-2030)

• Remarks
  – Figures include post-Fukushima safety upgrades
  – Equivalent LCOE for 15-year operation (900 MW, 80% load) 1,7 be\textsubscript{2013}/reactor = 18 be\textsubscript{2013}/MWh
The evolution of safety

- Numerous and increasing significant safety events are declared by EDF to the NSA
  - Bad proxy because of an increased transparency and broadened scope of survey

- Automatic shutdowns
  - A better proxy
  - But still a proxy
The French energy transition law

• Focus on renewables, energy efficiency, long-term planning
• Nuclear aspects and their consequences
  – A capacity cap at 63,2 MW:
    • FL3 completion will require to phase-out two existing reactors
  – A 50% share in the electricity mix “at the 2025 horizon”:
    • Vague objective with highly uncertain consequences
      – from no changes in case of new political majority in 2017
      – to the shutdown of up to 20 reactors (Cour des Comptes, 2016)
• Early closures under constant safety
  – Incentives for early phase-outs are mostly political
  – They are economically inefficient as the MWh from existing NPPs is cheaper than any other technology and than investments in energy efficiency
Why is a new business model needed?

• Most of EDF output is no longer sold at regulated tariffs but influenced with the wholesale market price

• Financial constraints
  – Broke but greedy main shareholder
  – Small free cash-flow
  – Risk of derating

• How to finance the huge needed investments?
3. Future issues

• EDF faces multiple short-term issues
  – Areva NP acquisition and integration
    • EDF is becoming a manufacturer
  – Engineering a new version of EPR NM
    • Shorter lead times and lower costs
  – Ending FL3
    • Uncertainties on safety tests regarding the steel reactor vessel
  – Signing HPC’s FID
    • HPC now versus a new EPR version or nothing?
    • Opportunities of learning-by-doing before new French projects?
Future issues

• EDF also has to address global stakes...
  – life extension
  – new business model
  – cost tightening for new builds

• ... that will depend on multiple factors
  – internal factors
    • human resources management,
    • engineering capabilities...
  – external factors
    • future power prices
    • \( \text{CO}_2 \) prices
    • stability of French nuclear and energy public policy
Concluding remarks

• The French Nuclear is at a cross road
  – Past success-story vs. « Change or die » future

• Stakes for existing NPPs
  – Ensure safety to benefit from cheap extensions
  – Counteract political forces in favor of early phase outs

• Stakes for new builds
  – Context of present European overcapacity
  – Convince financial markets
  – Overcome the increasing costs curse
Some publications


Website: [http://www.cerna.mines-paristech.fr/fr/recherche/economics-nuclear](http://www.cerna.mines-paristech.fr/fr/recherche/economics-nuclear)