COMPETITIVENESS OF NUCLEAR POWER IN FUTURE LOW CARBON ENERGY MIXES

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NUCLEAR ROLE FOR CLIMATE CHANGE MITIGATION

THE NUCLEAR INDUSTRY IN TRANSITION

CURRENT & PROJECTED COSTS OF NUCLEAR POWER

VALUE OF NUCLEAR IN THE MIX

CONCLUSIONS
The electricity sector will play a central role in countries’ pledge to the Paris Agreement

- World electricity production x 2.5 in 2050 from 2010:
  - 55% renewable sources of which 36% wind + solar
  - **21% nuclear power** (~1100 GWe new build)

Role for nuclear in line with the estimates from the IEA

ANCRE (2015) study: « **technical** » potential of low carbon technologies just enough for 2DC pathway

- Corollary 1: Need to integrate synergies between NUC and RES in future energy mixes
- Corollary 2: Need to **rapidly boost** low carbon R&D

ANCRE Decarbonization Wedges study based on UN-DDPP trajectories (2015)
NUCLEAR IN TRANSITION: SHORT TERM CHALLENGES AND OPPORTUNITIES

Ongoing reorganization of the nuclear industry

- Restructuring of vendors
- Some plants at risk of economic early retirement in the US
- «Nuclear promise» programme to reduce O&M costs

A number of FOAK Gen-III reactors connected to the grid (or soon will):

- EPR & AP1000 in China to start by the end of the year / beginning 2018
- Construction EPR in France and Finland completed: now ongoing tests before commissioning in 2018
- VVER-1200 completed Russia

Plans for nuclear new build

- 60 NPP under-construction worldwide (vs. 448 in operation) + 160 planned (WNA, 2017)
- Many of these projects could take place in Asia

NPP under-construction in 2017 (Σ=60 GWe)
Source: IAEA/PRIS
RECENT ESTIMATES ON THE COMPETITIVENESS OF NUCLEAR NEW BUILD (POST-FOAK)

- Rapid reduction in the costs of renewables, but **nuclear expected to remain competitive in many parts of the world** on a LCOE basis
- Role of the **cost of capital** (nuclear, solar PV and wind are all capital intensive)

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**International trend in LCOE for Nuclear, Solar PV & onshore wind, 10% discount factor**
(Source: IEA/NEA, 2010 & 2015 + projections for 2030)
LESSONS FROM RECENT GEN-III FOAK PROJECTS

Importance of indirect costs for which industrial organization and regulatory framework are key

Efficiency can rapidly improve with an effective supply chain & feedback from FOAK projects (see EPR Flamanville vs. Taishan)

Overnight construction costs estimates for generic PWR in the US (Total = 6400 $/kWe)

Source: NREL (2012)

Some “optimistic bias” for some projects launched without fully completed designs

Source: EDF
Recent studies (Berthelemy and Escobar, 2015; Escobar and Lévêque, 2016) on nuclear construction costs and learning:

- **Learning by doing conditional on standardization**
- **Trade-off between reductions in costs enabled by standardization and potential gains from adopting new technologies**
  → Optimal pace of technological change?

**Construction time** in the US and France

**Historical construction costs** in the US and France
On construction costs of nuclear new-build post-Fukushima

- Safety « stress tests » no direct impact on costs as Gen-III safety margins large enough...but indirect impact through delays?

Nuclear safety goes far beyond simply looking at the probability of an accident

- Need to distinguish between safety standards, their implementation, and the safety culture
- Economic implications of safety rules not always anticipated ex-ante... and may not be easily revised ex-post

In the short run, a number of new technologies focused on both costs reduction and safety improvements

- E.g.: new fuel designs, civil engineering techniques, project life management tools

In the longer run, advanced reactors could bring intrinsic & more passive safety

→ If safety regulations can be revised accordingly further costs reductions can be envisaged
In the future, to compensate intermittency, dispatchable power plants will have to be flexible.

- In France, load-following already operational due to the large fleet which cannot be used only for baseload + VRE capacity already induced more flexibility needs.

- Flexibility can also be achieved through modulation of output: heating, H2, desalination.

Once key issue facing nuclear is for this value to be recognized in existing and future energy market rules.

-- Annual load following profile of Blayais 2 nuclear reactor from Jan. 2014 to Feb. 2015.

- Participation in frequency regulation.

- Realised power ramps.

- Number of power variations far from design limitations.

Source: Data from RTE, 2015.
Renewed interest for SMR and « Advanced Reactors » that could provide a number of economic benefits:

- **Series effects** through **modular construction** and **standardization**

- **Integration in the mix** (e.g. replacement of coal plants in the US, distributed power, additionnal load-following)

- **Passive and intrinsic safety** (cf supra)

Beyond technological innovations, **new innovation model** supported by venture capital (> 50 nuclear startups in the US)
The nuclear industry is coming out of the FOAK period

- **On cost / on budget series reactors needed to maintain LCOE competitiveness** compared to fossil and renewable power technologies

- **Asian economies leading the way** with construction costs and duration. Would this be enough?
  - Issues with financing may remain
  - System costs that can destabilize power markets (see OECD/NEA)

Post-FOAK, energy policies supporting directly/indirectly nuclear may still be warranted to correct for market failures, but it is primarily **up to the industry to prove its competitiveness**

→ Ongoing initiatives across the industry to maintain competitiveness

→ Longer term prospects with innovative reactor designs
THANK YOU FOR YOUR ATTENTION