Nuclear generation and flexibility in renewables-driven electric systems

Arthur LYNCH*, Gilles MATHONNIERE*, Sophie GABRIEL*, Yannick PEREZ**

* Institute for Techno-Economics of Energy Systems (I-TESE), CEA, DES, Université Paris-Saclay, F-91191 Gif-sur-Yvette, France

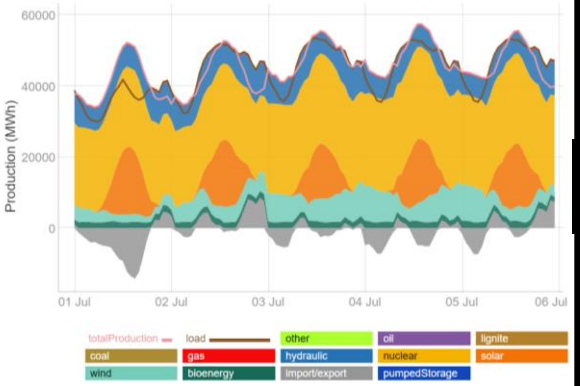
** Laboratoire Génie Industriel, CentraleSupélec, Université Paris-Saclay, 3 rue Joliot-Curie, 91190 Gif-sur-Yvette, France

arthur.lynch@cea.fr

Background and objectives

Context :
Variable Renewables Energies (VRE) are expected to ensure most of the future electric demand, thus increasing flexibility needs to ensure the demand-supply equilibrium

How much of this additional flexibility can nuclear ensure ?



Output example of Antares Simulator (RTE) : Weekly economic dispatch between technologies

Method : Economic simulation models that dispatch generation across technologies, i.e. GenX (MIT)…

Necessary to constrain the behavior of nuclear reactors in dispatch models

What are the main flexibility limits of Pressurized Water Reactors ?

1 Ramping rate

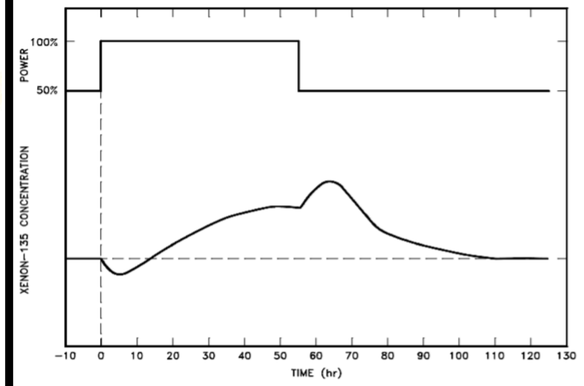
Sub-hourly constraint

$\%P_n$/minutes	
Nuclear	**5**
OCGT	20
CCGT	7
Hard coal	5

Maximal ramping comparison, Bruynooghe et al. (2010) and Savolainen (2015)

2 Xenon 135 transient

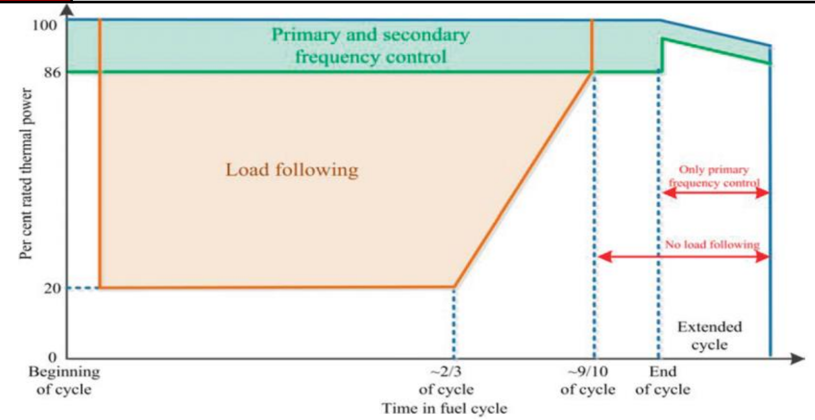
Inter-hourly constraint



Xenon 135 variations during power changes, U.S. Departement of Energy (1993)

3 Minimal power

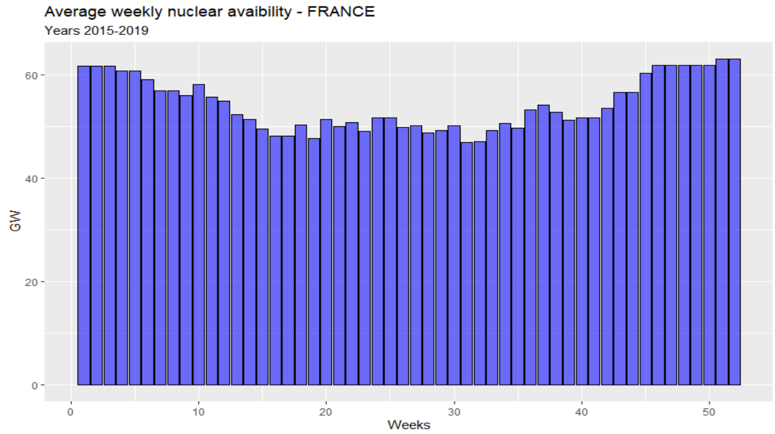
Inter-monthly constraint



Minimal power limits during a fuel cycle in a French PWR, IAEA (2018)

4 Maintenance and refueling planning

Yearly constraint



French nuclear fleet's average availability – 63 GWe (2015-2019)

Modeling practices

Current economic dispatch models only include a portion of the primary limits of PWR flexibility.
Three aspects could be improved to reflect actual flexibility:

- Xenon transients (2)
- Minimal power evolution related to fuel burn-up (3)
- The fleet's operational planning (4)

Our future works

➔ Implementing new nuclear flexibility constraints into electric systems simulation models would improve the dispatch's accuracy.

➔ The accuracy benefits are highly dependent on the flexibility required to the nuclear fleet; thus, on the installed capacity mix

1) Build an economic dispatch model that encompasses most of the flexibility limits of PWRs

2) Compare the newly-created model's results to pre-existing ones to assess the impact of those new limits