How to reduce the construction costs of Gen-III nuclear reactors? The role of technical and organizational factors

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Overview

The constructions costs of nuclear power have experienced significant cost overruns over the last few years in some parts of the world. In the economic literature, the topic has become increasingly controversial. Some authors have even coined the term "negative learning by doing" [1], whereas recent econometric studies suggest that learning by doing can exist with the right industrial and institutional frameworks.

We argue that this controversy can, to some extent, be attributed to two factors: (i) a confusion between learning by doing and cost trends and (ii) a lack of clarity about recent projects, in particular supply chain issues, in order to understand whether costs can decline beyond FOAK reactors.

This has significant implications for the future of nuclear, as the perspective of a general reduction in construction costs is key to justify policy supports for new build.

Methods

Our methodological approach is twofold:

i. The understanding of the cost trends and learning factors that can be derived from past experience, primarily in France;
ii. The understanding of recent cost overruns based on a survey of the existing evidence. In particular, it is important to assess whether this can be prevented in the future (and if so how).

Analysis of cost trends from the French nuclear fleet data

This choice is motivated by the fact that France has experienced a highly standardized industrial structure that has often been reported to explain the success of its nuclear program [2], but whose costs have also been largely debated [1].

Given the fact that nuclear programs may change in scope and last over a long period of time, it is therefore important to develop a thorough statistical approach to distinguish as much as possible between the different factors.

Analysis of recent cost overruns for Gen-III nuclear reactors

The cost overruns of recent nuclear projects has been largely debated in policy debates [3] and academia [4]. Those reactors are under construction in several countries which limits the ability to draw definite conclusions regarding the cause and extent of costs overruns.

At the same time, one needs to be cautious when comparing projects across regions of the world where construction conditions may differ, for instance in terms of regulatory standards, or labor costs.

Nevertheless, some reactors projects have been extensively commented which allows one to gather some high level evidence regarding the main factors explaining the performance of these Gen-III nuclear projects. In particular, this is the case of the EPR reactor from Areva (under-construction in China, Finland, and France), and of the AP1000 reactor from Westinghouse (under-construction in China and the US).

Results

Technical learning vs. costs trend: the French example

In the case of the French "historical" nuclear fleet, we show that when controlling for economies of scale, series effect and FOAK factors, the cost trend of the French nuclear program would appear as higher than what is suggested by the data from the Cour des comptes. This is explained by the importance of standardization in the French nuclear program, where series effect can be expected as evidenced by econometric studies.

These costs data are usually discussed using a price index based on GDP. Conversely, when we refine this choice to prices in the industrial and construction sectors – the annual rate of increase in construction costs is reduced by about 40%, from 4.6% to 2.7%. This rate would even be lower if the reactor dataset would be restricted to those built after the first CP0 model for which competition for market entry might be driving some of the results. In this later case, the increase in French reactors cost appears negligible (about 0.2% per year).

Hence, if some construction costs increases did take place during the French nuclear program, it would appear that the description of "negative learning by doing" [2], is not supported by a more in-depth analysis of the latest costs data.

Analysis of recent costs overruns in nuclear projects

A number of reasons have been put forward to explain these recent cost overruns. Although the available information is not definite, four key factors can be highlighted:

- The existence of an optimistic bias and anticipation of a strong first mover advantage at the start of the Gen-III new build program;
- Organizational factors, with supply chains difficulties (quality insurance, coordination, lead-time, loss of human skills and know-how) due to the absence of construction for several years, issues with project management, but also vendors and suppliers taking a more cautious approach to nuclear projects ;
- Safety related factors, with issues in the implementation of new regulation, including in some case delays or new measures following post-Fukushima safety assessments;
- Changes in input prices, with for instance an increase in commodity (steel, cement) prices during this period.

These topics are discussed in detail in the full version of the paper along with short and long term policy issues for nuclear reactors construction costs reduction.

Conclusions

This paper contributes to the ongoing policy debate on the role of nuclear power in OECD countries, looking both at existing evidence based on historical costs data, and at qualitative evidence available from recent new build projects.

Although factors that have led to cost overruns represent significant challenges for the nuclear industry, it can be argued that most can be addressed through "incremental" short to medium term actions within the nuclear industry, providing that the right nuclear policies are in place to support new build.
For example, project management can follow the examples set by the French nuclear program, and good practices from successful new build programs in Asian countries, in order to deliver the right incentives regarding costs and delays. Similarly, it can be expected that uncertainties surrounding nuclear safety standards have been – to a large extent – liked to the construction of FOAK Gen-III reactors that should not apply to series programs.

In the longer run, additional opportunities can also be envisaged for construction costs reductions through further standardization of reactor designs, or with the development of new reactor concepts (i.e. optimized gen III reactors, gen IV reactors and SMRs). These long term opportunities will require a strong and consistent policy framework to support these developments.

References

[1] GRUBLER, A., "The costs of the French nuclear scale-up: A case of negative learning by doing", *Energy Policy*, **38**, 9, 5174-5188 (2010).

[2] FINON, D., AND STAROPOLI, C., "Institutional and technological co-evolution in the French electronuclear industry", *Industry and Innovation*, **8**, 2, 179-199 (2001).

[3] FRENCH PARLIAMENT, *Commission d'enquête relative aux coûts passés, présents et futurs de la filière nucléaire*, Report of the French Parliament N° 2007 (2014)

[4] RUUSKA, I., AHOLA, T., ARTTO, K., LOCATELLI, G., AND MANCINI, M., "A new governance approach for multi-firm projects: Lessons from Olkiluoto 3 and Flamanville 3 nuclear power plant projects", *International Journal of Project Management*, **29**, 6, 647-660 (2011).