ARTICLE IN PRESS

Energy Policy ∎ (∎∎∎∎) ∎∎∎–∎∎∎

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Correspondence

Cost overruns and financial risk in the construction of nuclear power reactors: A critical appraisal

ARTICLE INFO

Keywords:
Construction cost overrun
Nuclear power
Nuclear energy
Atomic energy

ABSTRACT

Lovering and colleagues attempt to advance understanding of construction cost escalation risks inherent in building nuclear reactors and power plants, a laudable goal. Although we appreciate their focus on capital cost increases and overruns, we maintain in this critical appraisal that their study conceptualizes cost issues in a limiting way. Methodological choices in treating different cost categories by the authors mean that their conclusions are more narrowly applicable than they describe. We also argue that their study is factually incorrect in its criticism of the previous peer-reviewed literature. Earlier work, for instance, has compared historical construction costs for nuclear reactors with other energy sources, in many countries, and extending over several decades. Lastly, in failing to be transparent about the limitations of their own work, Lovering et al. have recourse to a selective choice of data, unbalanced analysis, and biased interpretation.

> It is a capital mistake to theorize before one has data. Insensibly one begins to twist facts to suite theories, instead of theories to suite facts.
>
> Sherlock Holmes, in Arthur Conan Doyle's *A Scandal in Bohemia*, 1891, p. 78.

1. Introduction

Despite sounding a bit dry, there can be little doubt that the topic of construction cost overruns is of central importance to energy and electricity planning, investment, policy, and regulation. As Bacon and Besant-Jones (1998, p. 317) wrote in the present journal almost two decades ago:

> The economic impact of a construction cost overrun is the possible loss of the economic justification for the project. A cost overrun can also be critical to policies for pricing electricity on the basis of economic costs, because such overruns would lead to underpricing. The financial impact of a cost overrun is the strain on the power utility and on national financing capacity in terms of foreign borrowings and domestic credit.

In other words, evaluations of construction cost escalation and overruns have much to tell regarding inefficiencies in the allocation of resources, and can assist with estimating likelihoods of future infrastructure risks.

It is in this regard that we appreciate and understand the interest in this topic shown by Lovering et al. (2016a), in their effort at analyzing new global data on overnight nuclear construction costs. However, we disagree with their conclusion that there is "no inherent cost escalation trend associated nuclear technology."

In this response, we critique Lovering et al. on three grounds. First, we argue that a series of methodological choices undermine their conclusions and limit the applicability of their results in respect of both historical and future nuclear construction costs. Second, we question the reliability of the data underlying Lovering et al. by discussing three recent studies that are global in scope and focus on trends including the past few decades of nuclear construction. Third, we express concerns that recent public declarations made by the authors when discussing their article are not based on their actual data or on reliable results. The first criticism refutes the piece's methodology; the second questions its comparative novelty; the third challenges the objectivity of the overall framing and interpretation.

2. Worrying methodological assumptions

Our first criticism is that the narrow definition of construction costs used by Lovering et al. (2016a), overnight capital costs (OCC), is not an appropriate metric to judge nuclear construction costs. This cost is notionally what it would take to build a reactor "overnight" , with financing and other time-related costs omitted. We raise three issues with this methodology:

- OCC are an inappropriate measure of power plant construction costs
- OCC and the author's definition of cost escalation do not include the full impacts of cost overruns

DOI of original article: http://dx.doi.org/10.1016/j.enpol.2016.03.052

http://dx.doi.org/10.1016/j.enpol.2016.04.001
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- Even if OCC was an appropriate metric, Lovering et al. do not normalize them in a way that supports the study's conclusions regarding intrinsic technology costs

First, Lovering et al. specifically exclude interest costs on the basis that they "are more predictable and have had far less variation over time and country" and because the authors want "to capture the cost intrinsic to the reactor technology." However, this contradicts subsequent statements in the study. The study notes that interest costs do have a significant effect on total direct costs for a nuclear plant, comprising an average of 46% of the total upfront cost of a US nuclear reactor. Moreover, the share of interest in overall construction costs varies considerably. The study notes that interest costs could comprise 12–54% of total upfront costs of a nuclear plant with reasonable cost of capital and construction time assumptions.

This contradictory stance indicates a major methodological limitation: excluding interest costs means the findings of this study are not a realistic picture of the costs of building a nuclear power plant, as the authors assert in their conclusion. Rather their data only examines part of a nuclear power plant's overall construction costs. No power plant can be built overnight. This is especially true for nuclear plants, which have some of the longest lead times of any power infrastructure (Sovacool et al., 2014c). Long construction times and high financing costs are not just incidental, but inherent features of the nuclear option. Nuclear developers therefore almost always include the cost of financing in the calculation of overall construction costs. The academic literature has long recognized that narrowing the scope to only overnight costs paints a misleading picture of the full costs of a nuclear power plant (Marshall and Navarro, 1991; Koomey and Hultman, 2007).

Second, the authors do not address time and cost overruns in calculating capital costs or cost escalation for nuclear technology, despite their central role. This is elided by the unfortunate way in which established literatures tend to use the term "cost escalation" in two ways when it comes to nuclear construction economics:

- First, to describe how aggregate nuclear capital costs have increased over time (Grubler, 2010; Koomey and Hultman, 2007);
- Second, to describe how the costs for an individual nuclear reactor climb during construction due to cost overruns (Sovacool et al., 2014a, 2014a, 2014b).

When Lovering et al. suggest "there is no inherent cost escalation trend associated with nuclear technology", they focus on the first definition of cost escalation. However, when calculating general historical costs for nuclear reactors, the second definition relating to cost overruns is just as important from a policy perspective and much more important from a financing perspective.

Our own work on the role of cost overruns in nuclear economics yields several points that deserve highlighting. One of them is that almost all nuclear reactors suffer from cost overruns. Another is that nuclear cost overruns occur in all countries. Yet another is that cost overruns are much greater for nuclear than for other energy sources. A final one is that nuclear cost overruns are heavily influenced by interest costs and time overruns (Sovacool et al., 2014a, 2014a, 2014b). Lovering, et al. do not challenge this picture from the existing literature. Indeed, by failing to address the roles of interest costs or construction delays, their study effectively ignores some of the most important issues in understanding historical nuclear construction cost trends.

Third, while Lovering et al. provide value from compiling comparative OCC figures, their conclusions regarding the meaning these figures are limited by a lack of normalization. Overnight capital costs in the study's sample are not normalized for input costs, such as labor, commodity costs, exchange rates, and interest rates. These factors impact both total capital costs and cost overruns for individual power projects (Sovacool et al., 2014a, 2014a, 2014b). Yet Lovering et al. only briefly acknowledge the role these factors play in nuclear reactor costs and do not examine how they influence reported overnight capital cost outcomes across their sample.

Admittedly, controlling for these factors may be difficult – they vary significantly both over time and by location. However, if the goal is to assess cost trends for a specific reactor technology (as Lovering et al. aim to do), then assessing these factors is absolutely essential in order properly to account for technological learning over time and to exclude the potential impacts of these factors on technology cost trends. Without thoroughly examining these factors, the applicability of Lovering et al.'s conclusions regarding global cost trends is narrower than they purport.

Similarly, Lovering et al. focus on overnight capital cost trends within individual countries, without a full analysis across countries with normalized currencies. Major cost trends are only assessed in comparison with other reactors in the same country. Yet when seeking to determine cost trends for a specific technology, global comparisons are more appropriate (provided material, labor, and other factors are already normalized).

The case of South Korean nuclear power provides a good illustration. Lovering et al. argue that South Korea provides a strong counter example to the picture of escalating overnight capital costs in other countries, noting that "from the first reactor in Korea in 1971, costs fell by 50%" for the most recent reactors constructed. This analysis relates to a limited sample of only 24–28 reactors,[1] yet the resulting picture of apparently declining in-country nuclear costs plays a central role in their main general conclusions. Beyond this, however, there is a more salient issue in this country-level focus.

Although the authors do not discuss or analyze the differences, they normalize overnight capital costs for currency differences across all countries in the samples shown in Figures 12 and 13. Compared to the global reactor fleet in these figures, the overnight capital costs of recent South Korean nuclear reactors (around $2000/KW) are still at the high end compared to the prevailing capital costs of reactors that began construction in the 1970s (around $1000–2000/KW). This is especially notable as the lower normalized prices from the 1970s apply to a period when nuclear was beginning commercialization, when learning might be expected to begin driving costs down.

Moreover, Lovering et al. repeatedly use terms that have the effect of depreciating capital cost escalations in some countries as 'mild' or 'milder'. Yet currency-normalized cost estimates for the U. S., France, West Germany, Canada, India, and South Korea are 1–10 times overnight capital costs during initial commercialization (Grubler, 2010; Koomey and Hultman, 2007).

3. Limited comparative novelty

Another element in our critique of Lovering et al. is that their study is not as novel as claimed, with questionable reliability compared to previous work. They posit that "drawing any strong conclusions about future power costs based… [on the U.S. experience] … would be ill advised." They also claim that "past studies have been limited in their scope, focusing primarily on cost trends in the 1970s and 1980 for the US and France." Yet a series of recent studies led by some of the present authors (Sovacool et al.,

[1] As explained in Section 3, there are an inconsistent number of South Korean nuclear reactors in the study.