The Cost of Generating Nuclear Electricity

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The cost of generating one megawatt-hour (MWh) of nuclear electricity is an essential parameter when assessing the economic value of the sector. The Court of Auditors has produced a very detailed report which has caused much debate and whose figures give a clearer idea of the current operating cost (excluding research and development) of nuclear power and how this will change in the future.

In the current climate there are growing fears surrounding nuclear safety (post-Fukushima, problems at the Flamanville site, precautionary reactor shutdowns in the autumn of 2016, etc.) as well as an increasing use of renewable energies with significant cost reductions. The cost of nuclear power has therefore become more critical than ever, particularly because of the uncertainties over investments in major refurbishments and the financing of third generation reactors. The Court of Auditors has had the opportunity to examine the issue twice, in 2012 [1] and then in 2014 [2]: its findings inform the following observations.

A production cost of around 60€/MWh, which is rising sharply

The Court of Auditors has estimated the cost of generating electricity with the existing nuclear fleet at 60€/MWh in 2013 compared to 50€/MWh in 2010[(a)]. This 20% increase in three years can be explained by three factors.

Firstly, maintenance costs, which are the largest item of expenditure and account for half of the increase in production costs. The increase in maintenance costs is due to three factors:

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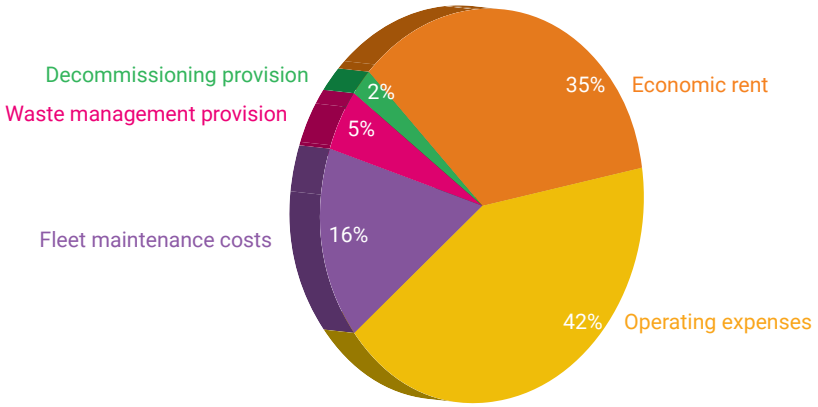

1. Share of the various contributions to the cost of production of French nuclear electricity.

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- they have needed to catch up with the level of « normal » investment (21% of the maintenance costs), following under-investment in the early 2000s which had a negative impact on operations and output;
- the need to refurbish or replace certain large components with a service life of less than 40 years (29% of the maintenance costs): these include steam generators, alternators, condensers and cooling tower components;
- the sharp increase in safety spending (50% of the maintenance costs) following Fukushima; the Nuclear Safety Authority (ASN) have made extending the operating life of reactors conditional on an improvement in safety to ensure they meet the safety requirements for third generation reactors.

Secondly, the large increase in operational spending (+31% in real terms) accounts for a quarter of the increase in production costs. This increase is partly a result of the increased maintenance costs, causing a rise in procurement and logistics expenses, and is also due to a large increase in the number of employees, and the cost of refreshing skills and speeding up the maintenance program.

Finally, changes in the calculation parameters explain the remaining increase: decline in annual production, change in the discount rate[b] for future decommissioning and waste management expenses, and change in the rate of return on capital and inflation.

This production cost is not directly comparable to the cost of renewables, which have been estimated in various studies, notably by the French Environment and Energy Management Agency (Agence de l'environnement et de la maîtrise de l'énergie, ADEME). Indeed, the latter are calculated for an investor who would enter the market today with new power plants (which would need to be paid off financially, but whose maintenance costs would be lower); the current nuclear equivalent would be the EPR, which will be discussed below. Similarly, this production cost figure cannot be used to dictate the choice between continuing to operate by extending the life of the plants or replacing them in the short term with more modern plants or even other energy sources[c].

Sensitivity to operational and capital costs

The cost of producing nuclear power, as indicated above, is known as the "economic running cost". It includes operating costs, maintenance spending and provisions to cover future expenses (decommissioning and waste and spent fuel management). It also includes an economic rent that takes into account the initial investments and their remuneration over the entire planned operating life. Three-quarters of this cost is dominated by operating expenses and the cost of using the nuclear facilities (42% and 35% respectively, see fig. 1). The economic running cost, on the other hand, excludes research and development and safety/security, which are financed from public funds. Furthermore, it does not take into account the history of the fleet and the fact that the initial investments have already been largely recouped. This production cost differs from EDF's actual current cost, which is lower and must be covered by tariffs.

The cost of production is very sensitive to changes in operational expenses and maintenance costs (16%). Even if EDF's strategic planning is based on the assumption of "controlled operating expenses", operating expenses should increase by 1.4%/year in real terms between now and 2025. Maintenance costs, meanwhile, are expected to continue to rise to an intermediate level, 16% higher than the level of investment included in the 2013 cost. However, this level of maintenance spending is only justified in view of the longer lifetime of the plants. Thus, if political decisions made this extension impossible or too uncertain, EDF would have to revise its industrial program: indeed, it would seem economically irrational to undertake major renovations of large components around 30/35 years of life, if the remaining operating life did not exceed ten years. Similarly, it wouldn't make sense to invest to raise safety standards to those of the third generation.

On the other hand, due to discounting, the calculations are not very sensitive to changes in costs in the future. Therefore, the uncertainties that currently hang on the estimation of these costs have in reality only a very small impact on the cost of production, as calculated by the Court. A decrease (or conversely an increase) in the discount rate leads to a change in production costs of +0.8% (or -0.6%). If the decommissioning estimate were to increase by 50%, the production cost would increase by only 2.5%.

The impact of extending the life of power plants on production costs

The operating life of a nuclear power plant is a strategic issue. Although the current economic cost, and therefore the production cost, is not very dependent on the operating life of the installations, the operating life is still a determining factor in assessing the profitability of nuclear assets.

The effect on costs of extending the operating life of power plants cannot be measured by a simple sensitivity analysis. Such an extension has a number of effects on the cost of electricity generation:

- decreasing economic rent (impact however limited to 2 or 3% for a ten-year extension of the operating life);
- increasing maintenance costs required for this extension;
- decreasing provision for future expenditure due to the decommissioning schedule.

Taking into account these various elements and the above-mentioned assumptions for the increase in operating expenses, the Court of Audit estimated the average cost of production for the period 2011-2025 for a 50-year lifetime at 61.6€/MWh. If the lifetime of the installations is not extended, there is then uncertainty as to the level of maintenance investment to be retained, and calculations of the average production cost over the same period become very uncertain. EDF may also conclude that it is economically profitable to close plants before they are 40 years old in order to avoid undertaking major renovations the cost of which cannot be recouped.

It should also be noted that this estimate makes the assumption that the entire fleet will be extended beyond 40 years for a period of 10 years, whereas it is more likely that decisions will be more heterogeneous (some reactors closing at 40 years and others being extended to 60 years), given the differences in performance between the different reactors and to meet the political challenges of diversifying the energy mix.

Uncertainty about the cost of next-generation nuclear power

Regardless of their operating life, the current reactors can only be replaced, in the long term, by "third generation" reactors, whose safety standards are superior to those of the current reactors. The medium/long-term production costs of nuclear electricity will therefore be those of the EPR, which are difficult to assess in detail today. The Flamanville EPR cannot be used as a basis for calculating the average production cost of the EPR. This project, which is subject to significant delays and overruns, is suffering from the "head of series" effect and the restarting of the industry, which has lost the practice of building reactors on French soil.

However, in view of the high construction costs compared to those of the second generation reactors, and even if the EPRs are expected to have lower operating costs, it is likely that the production costs will be significantly higher than those of the current fleet. This is the conclusion that can also be drawn from the agreement signed in October 2013 between EDF and the British government, with a sale price of £92.5/MWh (approximately 106 €/MWh), even though there are many differences between the Flamanville EPR and those at Hinkley Point (site specificity, British standards, waste storage, land price, etc.) and the price calculation is sensitive to the choice made for the discount rate.

To get an idea of the order of magnitude of these future costs, we can also look at the assumptions made by the ADEME in the establishment of different scenarios of energy mix by 2050: the production cost of new nuclear power is then estimated at 80€/Mwh.

The cost of a potential accident

An international risk insurance system has been set up, obliging each reactor to be insured at up to 750 million euros and states to take over up to 1.5 billion. For its part, the Court of Auditors has cautiously attempted to extrapolate the experience of Fukushima. The order of magnitude used for the total cost of an accident in France is estimated at between 120 and 585 billion euros. This range is largely based on the work of the French Institute for Radiological Protection and Nuclear Safety (IRSN) [3]. It aims to include all costs, even those that cannot be precisely quantified and independently of what is or is not eligible for compensation, from the rehabilitation of the site and radiological monitoring, to the health and psychological effects, to changes in electricity production, as well as the consequences in terms of image on tourism, agricultural activity and exports.

In summary, if we try to establish a guiding principle from these multi-parameter calculations, major renewal investments are only viable for a sufficiently long operating life. If the existing plants are upgraded, an increase of 40-50% in the cost of electricity production is to be expected, and roughly the same for the EPR plants. While uncertainties relating to the cost of decommissioning have little impact on the overall cost of nuclear power, there are much greater uncertainties relating to the financial situation, the possible decision to not extend the lifetime of the nuclear plants, and above all the risk of accidents. Finally, the Court of Auditors points out that cost is not the only criterion for decision-making, and that many indicators relevant for making comparisons are simply not quantifiable in financial terms.

References

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2• Court of Auditors, Le coût de production de l'électricité nucléaire, Communication to the National Assembly's Committee of Inquiry, Updated 27 mai 2014, www.ccomptes.fr/fr/publications/le-cout-de-production-de-lelectricite-nucleaire-actualisation-2014

3• IRSN, Coût économique des accidents nucléaires, April 2013. Estimation des coûts d'accidents nucléaires en France : Méthodologie appliquée par l'IRSN, April 14, 2014 www.irsn.fr/FR/Actualites_presse/Actualites/Pages/20140414_Estimation-couts-accidents-nucleaires-France-Methodologie-IRSN.aspx

a. It should be remembered that 50 €/MWh is equivalent to 5 cents/kWh, compared to the public electricity sale price of around 13 to 17 cents/kWh in 2018, and a similar cost if the same amount of energy is purchased as fuel at the petrol pump.

b. The discount rate is a parameter that helps in the decision-making process when comparing current and future costs. A greater focus on future generations leads to an increase in projected costs.

c. See the article by S. Huet (p. 41).