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Economic comparison of long-term nuclear fuel cycle management scenarios: The influence of the discount rate

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Abstract

This article presents some main economic results obtained by the CEA in the DERECO project, which aimed to evaluate the global cost of contrasted and long-term nuclear fuel cycle scenarios. The scenarios have been studied for the period 2000–2150 in the French context. They all assume a sustainable nuclear development. These scenarios must not be considered as forecasts and do not reflect any industrial strategy. The article focuses on the comparison of five scenarios including the Generation IV fast reactors and their associated fuel cycles. Common trends as well as specific features can be identified. The article describes the scenarios with the replacement of the nuclear power and the associated fuel cycle. It details the main technical and economic assumptions common to all the scenarios, and exposes some main key results, concerning the flows and inventories as well as concerning economic evaluation. Economic results are given in a comparative manner due to the level of uncertainties at this time horizon. The key economic elements described in the article deal with the sensitivity of the results to the choice of the discount rate.

Keywords: Nuclear; Prospective scenarios; Economic evaluation; Discounting

0. Introduction

Four years of research in the working group gathered around the DERECO project have permitted to obtain interesting results concerning the technico-economic evaluation of nuclear fuel cycle management options. The DERECO project was led by the CEA in the frame of its activities linked to the 1991 French law, which was about R&D on high and intermediate level and long-lived (H&IL-LL) radioactive waste management. In this framework, the CEA had to be able to propose waste management options to enlighten the public decisions in the 2006 term, especially in perspective of the Parliament debate and the vote of a new law (which took place in spring 2006).

The fuel cycles scenarios have been analysed on the long term, for the period 2000–2150, and have been built in a contrasted manner and in the French context. All the scenarios studied assume sustainable nuclear development but each one proposes a different representation of the nuclear fuel cycle for the next century.

Uncertainties being taken into account on this time horizon, economic estimations must rather be considered as an illustration of what can produce the calculation tool with the methodological assumptions associated. The robustness of the results comes from the economic comparison in relative values rather than on absolute monetary values, for which nobody could infer realism in a long term.

The costs of these fuel cycle scenarios, estimated globally or on the level of the investment costs, are very dependent on the choice of the discount rate. It is useful to remember that the discount rate is a key parameter in the economic evaluation, which is based on a mean value between the individual preferences for the present time, the average capital cost, and the growth rate of the economy. The discount rate, inherited from financial mathematics and interest theory, is used to evaluate future expenses at their

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current value. Therefore discounting procedure permits taking into account the value of time in the economic analysis.

This article presents the comparative costs of various prospective nuclear fuel cycle scenarios, and shows how the influence of the discount rate is crucial in the interpretation of results.

1. Description of the scenarios for the replacement of the nuclear power and the nuclear fuel cycle

It is useful to precise here that a scenario study is not a forecast study. As they are all together a speculative exercise using prospective tools, scenarios are built without looking for a realistic representation of the future; their probability of occurrence is not considered in their construction, in contrast to the forecasts. Moreover, the scenarios studied in the DERECO project have been built to test the methodology of evaluation, they do not reflect any industrial strategy.

The nuclear fuel cycle scenarios assume the progressive replacement of the current nuclear park by a more modern one (see Figs. 1–3). In the period 2000–2150, nuclear electricity production is constant at 400 TWh with a nuclear capacity installed constant at 60 GW. Two periods are considered for the replacement of the nuclear reactors currently in operation and installed between year 1997 and year 2002:

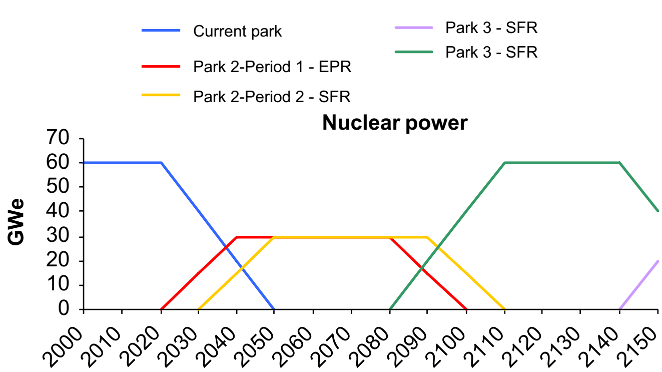

Fig. 1. The nuclear power in the Scenarios 1 and 5.

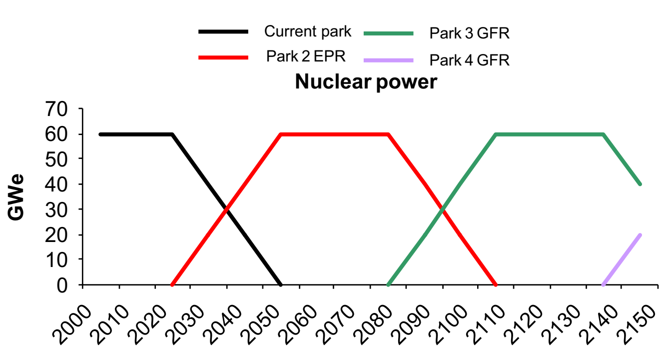

Fig. 2. The nuclear power in the Scenario 2.

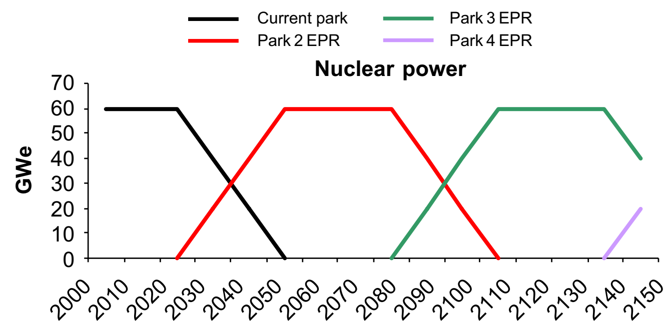

Fig. 3. The nuclear power in the Scenarios 3 and 4.

Table 1
Main characteristics of the future nuclear reactors considered in the scenarios

	EPR	SFR	GFR
Thermic power (MWth)	4400	3600	2400
Electric power (MWe)	1500	1450	1158
Output rate (%)	34	41	48
Lifetime of operation (yr)	60	60	60
Burn up (Gw_j/t)	60	140	140
Construction time (yr)	5	5	5
Dismantling time (yr)	50	50	50

- Period 2015–2050: introduction of EPR reactors from 2015, and if possible around 2035 introduction of Generation IV fast reactors (Gen. 4 FRs, either sodium fast reactors—SFR or gas fast reactors—GFR). The lifetime of current reactors is between 30 and 50 yr, and that of new reactors is supposed to be 60 yr.
- Period 2080–2110: nuclear power is completely replaced by fast reactors, with a lifetime of 60 yr.

From year 2020 in all the scenarios, the new reactors are installed at a 2000 MW/yr rate. The first of a kind EPR is installed in 2015. The reactors construction time is 5 yr and their dismantling time, immediate after the end of the operation period, is supposed to last 50 yr (see Table 1).

All scenarios are deployed according to the following general context:

- the control of the most toxic radioelements existing in nuclear spent fuels: plutonium, americium, curium.
- the spent fuels reprocessing: a spent fuel UOX irradiated to 45 GWj/t in a pressurised water reactor (PWR) is composed of around 95% uranium, 1% plutonium, and 4% minor actinides and fission products. Currently operated in France with an important return of industrial experience, spent fuel reprocessing permits to recycle energizing materials—such as uranium and plutonium—, and to package ultimate waste—such as minor actinides and fission products—, in adapted parcels (glass or concrete) able to guarantee an efficient containment of radioactivity for several decades. Recent