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Radioactive waste disposal fees—Methodology for calculation

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HIGHLIGHTS

- Policy of radioactive waste management in the Czech Republic.
- Methodology for calculation of fees for radioactive waste disposal.
- Comparison of fee for radioactive waste disposal for selected countries.
- The most important factors influencing fee-case example of the Czech Republic.

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ABSTRACT

This paper summarizes the methodological approach used for calculation of fee for low- and intermediate-level radioactive waste disposal and for spent fuel disposal. The methodology itself is based on simulation of cash flows related to the operation of system for waste disposal. The paper includes demonstration of methodology application on the conditions of the Czech Republic.

1. Introduction

Radioactive waste and spent fuel are generated in the Czech Republic as a consequence of the peaceful use of nuclear energy, health care, research and industry. In comparison to other hazardous waste, it possesses about one-hundredths of the mass of the total hazardous waste generated. Depending on the concentration of radionuclides and intensity of emitting radiation, radioactive waste is classified as low, intermediate or high-level waste (spent fuel), depending on the period of time required for decay, such as short-term and long-term (Czech Republic, 1997).

Currently, Czech Republic has four low- and intermediate-level radioactive waste (herein below referred to as LLW and ILW) sites at disposal, namely: (a) Dukovany; (b) Richard; (c) Bratrstvi; and (d) Hostim, which was closed in 1965. The Dukovany repository was designed for management of low- and medium-level radioactive waste, which is generated by nuclear power plants. It is the biggest and most modern of all repositories in the Czech Republic and it meets construction and safety standards valid in advanced European countries. The repository is situated within the area of the Dukovany nuclear power plant. It has been in permanent operation since 1995. The Richard repository was built in the complex of the former limestone mine Richard II and has been available since 1964. Its primary purpose was to accommodate waste from institutions like hospital or research facilities. Finally, repository Bratrstvi was constructed by adapting a mining shaft, during which five disposal chambers were created and is entirely for the disposal of waste containing natural radionuclides. The facility was put into operation in 1974.

Physical flow of spent fuel is shown in the Fig. 1. Major part of this type of waste originates from nuclear power plants (State Office for Nuclear Safety, 2013). A small part of spent fuel and other high-level waste also comes from the ŘEŽ research institute.

There are two basic ways of spent fuel final disposal after its temporary storage: final disposal without or with fuel reprocessing.

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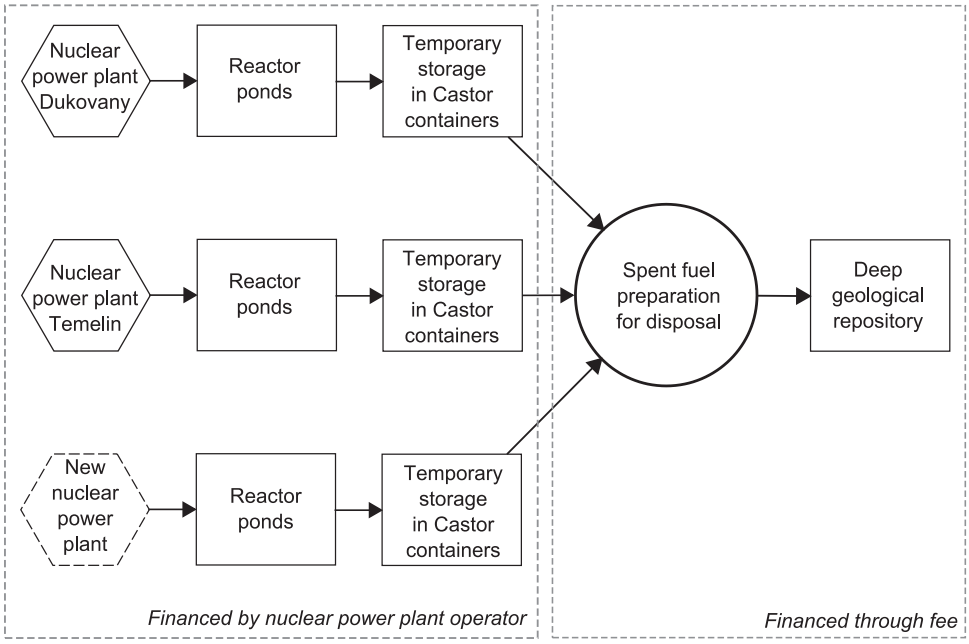

Fig. 1. Physical flow of spent fuel.

In the first case the fuel is prepared just for the final disposal (e.g. fuel is put into special containers). In the second case the fuel is reprocessed, leaving only a few percent as high-level waste. During this process the waste is chemically separated into uranium, plutonium and high-level waste solutions. These solutions usually contain a rich mixture of alpha, beta and gamma emitting radionuclides with half-time ranging from days to thousands of years. For examples we can state ^{14}C (5730 y; beta−), ^{41}Ca (1.03×10^5 y; electron capture), ^{59}Ni (7.6×10^4 y; electron capture+beta+), ^{63}Ni (100.1 y; beta−), ^{90}Sr (28.79 y; beta−), ^{94}Nb (2.03×10^4 y; beta−), ^{99}Tc (2.111×10^5 y; beta−), ^{129}I (1.57×10^7 y; beta−), ^{137}Cs (30.07 y; beta−), ^{239}Pu (24110 y; alpha, spontaneous fission) or ^{241}Am (432.2 y; alpha, spontaneous fission) (The Lund/LBNL Nuclear Data Search, 2013). Liquid high-level wastes are evaporated to solids, mixed with glass-forming materials, melted and poured into robust stainless steel canisters which are then sealed by welding. Highly active wastes are disposed in a similar way as spent fuel without reprocessing.

The Czech Republic, in accordance with the document NEA (2008), defines the final disposal of spent fuel in Deep Geological Repository (DGR) as the basic scenario and also does not assume spent fuel reprocessing. All the economic models include information only about the scenario without fuel reprocessing (RAWRA, 2011).

The cost of storage in reactor ponds and the cost of further temporary storage are the responsibility of the plant operators and are therefore not included in the fee calculation. Fee imposed on radioactive waste producers in Czech Republic covers only the costs of radioactive waste disposal in repositories.

2. Methodology

The task of the fee calculation is split into two relatively independent tasks:

- calculation of fee for ILW and LLW disposal in existing repositories,
- calculation of fee for future disposal of spent fuel in deep geological repository.

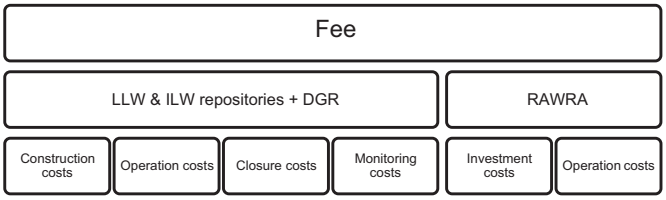

Fig. 2. Disposal fee usage.

The revenues (money inflows into a given system) consist of payments of waste producer and of appreciation (interest revenues) of the nuclear fund.[5] Expenses include all current and expected expenses related to the operation and closing of repositories.

In the case of spent fuel the fee is related to the MWh produced. Waste producers pay at the same time as they derive benefit from the use of fuel, because amount of spent fuel produced is proportional to the amount of electricity generated (gross). This scheme ensures that sufficient money is available when needed. The system for spent fuel disposal is characterized by time disproportion between creation of the “money source” and utilization (generation of financial means precedes their utilization).

The disposal fee usage is described in the Fig. 2.

In case of a system for LLW and ILW disposal the fee is related to the volume amount of radioactive waste–standard 200 l drum (barrel).

LLW and ILW and spent fuel are stored in different kinds of repositories, and the cost of waste disposal differs significantly. Repositories have different expected lifetimes of operation and different structures of costs. Waste producers out of nuclear power utilize only repositories for LLW and ILW. Two different systems for radioactive waste disposal thus exist in effect:

- system for LLW and ILW disposal,
- system for spent fuel disposal (DGR repository).

[5] Collected financial means on special, so called nuclear account in National Bank.