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The cost of the Swedish nuclear waste program ☆

Esbjörn Segelod

Mälardalen University, P.O. Box 325, SE-631 05 Eskilstuna, Sweden

Abstract

The nuclear waste programs, which nuclear power countries are implementing today, are extremely long-term and some of the largest construction projects ever undertaken. Sweden has 12 nuclear power plants and the Swedish nuclear waste program is estimated to cost about 80 thousand million SEK or approximately nine thousand million euro. A fiscal act passed in 1981 regulated the financing system and responsibilities with respect to nuclear waste. According to this Act SKB, a company owned by the operators of nuclear power plants, must estimate the cost of the project each year and, based on this, the annual fee which must be put aside to cover any future payments. The first estimate was delivered in 1982. According to the latest of these reports about two-thirds of the work still remains undone. The purpose of this paper is to review the cost development of the Swedish nuclear waste program through the 23 annual cost estimates which SKB has produced. Based on earlier empirical studies it identifies some factors which may cause future cost escalation. The estimated cost of the program is about the same today as in 1982 although cost has escalated since 1996. Substantial uncertainties remain to be eliminated, at the same time as there are factors which should help the program not to escalate such as no shortage of funds or time to plan, and the possibility of exploiting future technical innovations to lower the handling costs.
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1. Introduction

Nuclear energy is associated with large payments for the treatment and disposal of nuclear waste from spent nuclear fuel, and the decommissioning of nuclear power plants decades after they have been taken out of production. No other energy system has such a large negative salvage value.

Swedish operators of nuclear power plants considered this problem at an early stage and allowed for these future costs in their accounts when they took their first commercial nuclear power plants into production. As these allowances deferred the taxation of future costs until they arose they soon attracted the attention of the tax authorities. Opponents of nuclear power calculated that such long-term postponement of taxation would make nuclear power self-financing. This prompted one government committee to investigate the technical aspects of nuclear waste (SOU, 1976), another to examine the organization and financing of its disposal (SOU, 1980).

The latter committee recommended that an organization jointly owned by the operators of nuclear power plants should assume responsibility for the management and disposal of all nuclear waste and the building of nuclear waste repositories, and that the state in a distant future when the deep repository was sealed should undertake the long-term

☆ This paper is based on a study made for a government committee, Finansieringsutredningen M 2003:1. The analyses and conclusions made in the paper by the author do not need to coincide with those of the committee.

E-mail address: esbjorn.segelod@chello.se

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supervision of the deep repository. The operators chose to assign this responsibility to an existing, jointly owned company, SKBF (Swedish Nuclear Fuel Supplies Co.), later SKB (Swedish Nuclear Fuel and Waste Management Co.).

One guiding principle for the committee had been that the consumers of nuclear energy should pay the full cost of its production. Thus, operators had to make advance payments to a public organization managing a nuclear waste fund from which the operators could appropriate money to cover future payments towards both decommissioning and spent fuel management. The size of these payments, their use and their management, were to be decided by the state. The role of the operators and the state was regulated in an 'Act on the financing of future expenses for spent nuclear fuel etc.' from 1981 (Act, 1981:669). This act stipulated, inter alia, that

> it is the responsibility of the reactor owners to prepare a calculation of the costs for all measures that are needed for the management and disposal of spent nuclear fuel discharged from the reactors and radioactive waste deriving from it and to decommission and dismantle the reactor plants. This cost calculation shall be submitted annually to the Government or the authority designated by the Government. SKB prepares this cost calculation on behalf of the nuclear power utilities (SKB, 2003, p. 4).

SKB, then SKBF, delivered their first report in 1982 and has since submitted another 22 reports and cost estimates of the Swedish nuclear waste program. The ability correctly to estimate the size of the pre-payment is essential to guarantee that the users of nuclear energy pay the full cost of its production and do not transfer this burden to future generations.

This is not an easy task. A survey of 35 studies of groups of major projects (Morris and Hough, 1986) showed few examples of major projects which have not exceeded their original budget, sometimes by several hundred percent. A later study of 258 major transport infrastructure projects revealed an average cost overrun of 27.6% (Flyvbjerg et al., 2002). Major engineering projects have persistently demonstrated cost escalation (Morris and Hough, 1986; Morris, 1994; Flyvbjerg et al., 2003), and the deep repositories now under construction in several countries with nuclear power plants are some of the largest engineering projects ever undertaken.

The site characterization phase of the largest of them, the US Yucca Mountain project, together with other major US nuclear waste projects has encountered large cost escalation. The cost of site characterization which was estimated in 1981 to $60–80 million per site had risen to $2.2 billion in 1984, $44.8 billion in 1987 (GAO, 1987), $4.3 billion in 1996 (GAO, 1996, 2002) and $6.3 billion in 2001 (GAO, 2003), and the deep repository project was postponed by about 20 years. The size and content of the project has changed through the years, and the site characterization phase is only a part of the larger $58 billion enterprise (GAO, 2001; Zapler, 2003) which the Yucca Mountain project constitutes, but the figures illustrate the problem of determining the correct fee to ensure that all costs are defrayed by those who use nuclear energy.

With this background it seems reasonable to scrutinize the cost development of the Swedish nuclear waste program and its parts during the last 23 years to see the extent to which past estimates have been fulfilled and thereby learn to improve future estimates when about one-third of the cost of the project is thought to have been spent.

The paper is based on a review of the cost development of the Swedish nuclear waste program made on behalf of a new government committee. The analysis will depart from the earlier mentioned annual reports (SKBF/SKB, 1982–2004) which SKB is obliged to submit, supplemented by information collected through meetings with representatives of SKB and SKI (The Swedish Nuclear Power Inspectorate), the organization appointed to control the plans and estimates made by SKB and recommend the size of the fee to the government. A few of these annual reports have been translated into English. See, e.g. SKB (2003).

In 1980, Swedish voters in a referendum voted yes to the proposals that no more than 12 reactors were to be built and that nuclear power would be phased out by 2010. Today Sweden has 12 light water reactors with a joint capacity of 1040 MW. One of these reactors has been shut down, and another will be shot down, by an agreement between the government and the power industry. As nuclear power is to be phased out all future costs have been allocated to the first 25 years of operation of these reactors, a deadline which the last two will have passed by 2010.

2. A review of 23 years of cost estimates

The first report from SKB was preceded by two earlier estimates by the industry. One from 1977 and one from 1979. As these estimates did not include the cost of decommissioning nuclear plants such an estimate was later on

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