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**Cost Study 2011 (CS11)
Overview Report**

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Summary

Article 77 of the Nuclear Energy Act (NEA) requires the operators of the nuclear power plants to establish a decommissioning fund and a waste disposal fund; following the shut-down of the reactors, these funds will have to contain sufficient financial provisions to cover the costs of decommissioning of the plants and waste disposal activities.

The calculation of the contributions to the two funds and the provisions to be set aside by the operators for ongoing waste disposal costs is based on a comprehensive assessment of the decommissioning and waste disposal costs that is carried out every five years (Article 4 of the Ordinance on the Decommissioning and Waste Disposal Funds (Funds Ordinance)). In parallel with the regular updating of the decommissioning and waste disposal cost studies, the costs of the so-called post-operational phase are also re-assessed; these are paid directly by the power plant operators and appropriate provisions also have to be set aside for this.

The last estimate of the decommissioning and waste disposal costs was based on data from the year 2006. It was reviewed by the nuclear safety authority HSK (now ENSI, the Federal Nuclear Safety Inspectorate) and approved by the Commission of the Decommissioning and Waste Disposal Funds (Funds Commission) and formed the basis for calculating the provisions and funds contributions to be made by the waste producers for the period 2007 – 2011. As part of the legally prescribed periodic updating of costs, at the beginning of 2010 the Funds Commission requested swissnuclear to re-assess the costs together with other organisations responsible for radioactive waste management in Switzerland and to submit the results by the end of 2011. Two reports /1/ and /3/ were prepared and submitted in response to this request and have been reviewed by ENSI on behalf of the Funds Commission.

A comparison of the results for the 2011 estimate of the costs of waste disposal, the post-operational phase and the decommissioning of the Swiss NPPs with the estimates for 2006 is shown in the table below. The cost studies are always carried out at the monetary value of the year of the estimate. For the purpose of making a direct comparison, the costs estimated in 2006 are projected from the 2006 price basis (PB) to the 2011 price basis using an inflation rate of 3% per year; this rate is anchored in the Funds Ordinance and is taken into account in the financial provisions model. After adjustment for inflation, the total costs showed an increase of 10%.

CS11 PB11	KKB	KKM	KKG	KKL	Zwilag	NPP total
Waste disposal	4,124	1,834	5,071	4,940		15,970
Post-operational phase	475	319	455	460		1,709
Decommissioning	809	487	663	920	95	2,974
Total	5,409	2,640	6,190	6,320	95	20,654

Diff. CS11 - CS06 (%)	KKB	KKM	KKG	KKL	Zwilag	NPP total
Waste disposal	8%	9%	11%	10%		10%
Post-operational phase	3%	28%	-5%	-5%		2%
Decommissioning	28%	11%	10%	10%	204%	17%
Total	10%	11%	10%	8%	204%	10%

KKB = Beznau NPP, KKM = Mühleberg NPP, KKG = Gösgen NPP, KKL = Leibstadt NPP

Differences in the sums are due to rounding.

Estimate of total costs for CS11 and comparison with CS06, price basis (PB) 2011 (MCHF)

As a result of new information and experience from ongoing nuclear construction projects being integrated into the planning of the geological repositories, new assessments of operational activities that continue to be required during dismantling (so-called operations during dismantling) and decommissioning based on actual foreign decommissioning projects and assuming higher operating costs for the post-operational phase, the cost estimate for 2011 shows a significant increase. A number of changes in the regulatory, societal and technical boundary conditions have also been implemented or are anticipated in the 2011 study.

The next cost estimate is planned for 2016.

Contents

1	INTRODUCTION	1
2	BOUNDARY CONDITIONS AND ASSUMPTIONS	1
3	RESULTS OF THE COST ESTIMATES	4
3.1	BACKGROUND	4
3.2	ESTIMATE OF WASTE DISPOSAL COSTS	4
3.3	ESTIMATE OF DECOMMISSIONING COSTS	5
3.4	ESTIMATE OF THE COSTS OF THE POST-OPERATIONAL PHASE	6
A. Appendix		7
A.1 Reference Reports		7

1 Introduction

The 2011 cost study (CS11) comprises three sub-studies:

- Estimation of the waste disposal costs for the Swiss nuclear power plants /1/
- Estimation of the costs of the post-operational phase for the Swiss nuclear power plants /2/
- Estimation of the decommissioning costs for the Swiss nuclear installations /3/

This report outlines the boundary conditions for the study and summarises the key results.

2 Boundary conditions and assumptions

Radioactive wastes arise from the commercial use of nuclear energy for electricity production and from the use of radioactive materials in medicine, industry and research (MIR). The “polluter pays” principle is anchored in Article 31 of the Nuclear Energy Act (NEA): “*Anyone who operates or decommissions a nuclear installation is obliged to safely manage all radioactive waste arising from that installation at their own cost*”. Waste that does not arise from the nuclear power plants (MIR waste) has to be delivered to the Swiss Confederation in accordance with Article 27 of the Radiological Protection Act; the Confederation charges a fee for this service.

The waste producers responsible for the construction and operation of facilities for the disposal of radioactive waste are thus the Swiss Confederation and the operators of the nuclear power plants. The duty of disposal is fulfilled according to Article 31 of the Nuclear Energy Act when “*the radioactive waste has been transferred to a deep geological repository and the funds required for the monitoring period and the eventual closure have been secured*” (see Figure 1, closure order).

Article 77 of the Nuclear Energy Act requires the operators of the nuclear power plants to set up decommissioning and waste disposal funds; following the shutdown of the plants, these have to contain sufficient capital to cover the decommissioning and waste disposal costs respectively.

The purpose of the decommissioning fund is to cover the costs of decommissioning and dismantling of nuclear installations and disposing of the waste arising from these activities; the fund has been in existence since 1984.

The purpose of the waste disposal fund is to cover the costs of disposing of operational waste and spent fuel assemblies following the definitive shutdown of a nuclear power plant. The fund was set up in 2000. Waste disposal costs arising during operation are paid on an ongoing basis from the operating accounts or from provisions set aside in accordance with Article 82 of the Nuclear Energy Act and Article 669 of the Code of Obligations (see Figure 1, which provides an overview of the link between the sub-studies). The relationship between the licensing situation and securing of the financing of the post-operational phase, decommissioning and waste disposal is also shown in the figure.

The calculation of the contributions to the decommissioning and waste disposal funds and the financial provisions set aside by the operators for waste disposal is based on a comprehensive estimate of the decommissioning and waste disposal costs that is carried out every five years (Art. 4 of the Funds Ordinance).

The expenditure associated with the post-operational phase corresponds neither to the definition of waste disposal costs in the sense of Article 3 of the Funds Ordinance nor to the definition of decommissioning costs according to Article 2 of the Ordinance. It falls under the operating licence and is thus to be considered as the final stage of the operational phase. The post-operational phase is financed directly by the plant operators, who have to set aside the necessary provisions.

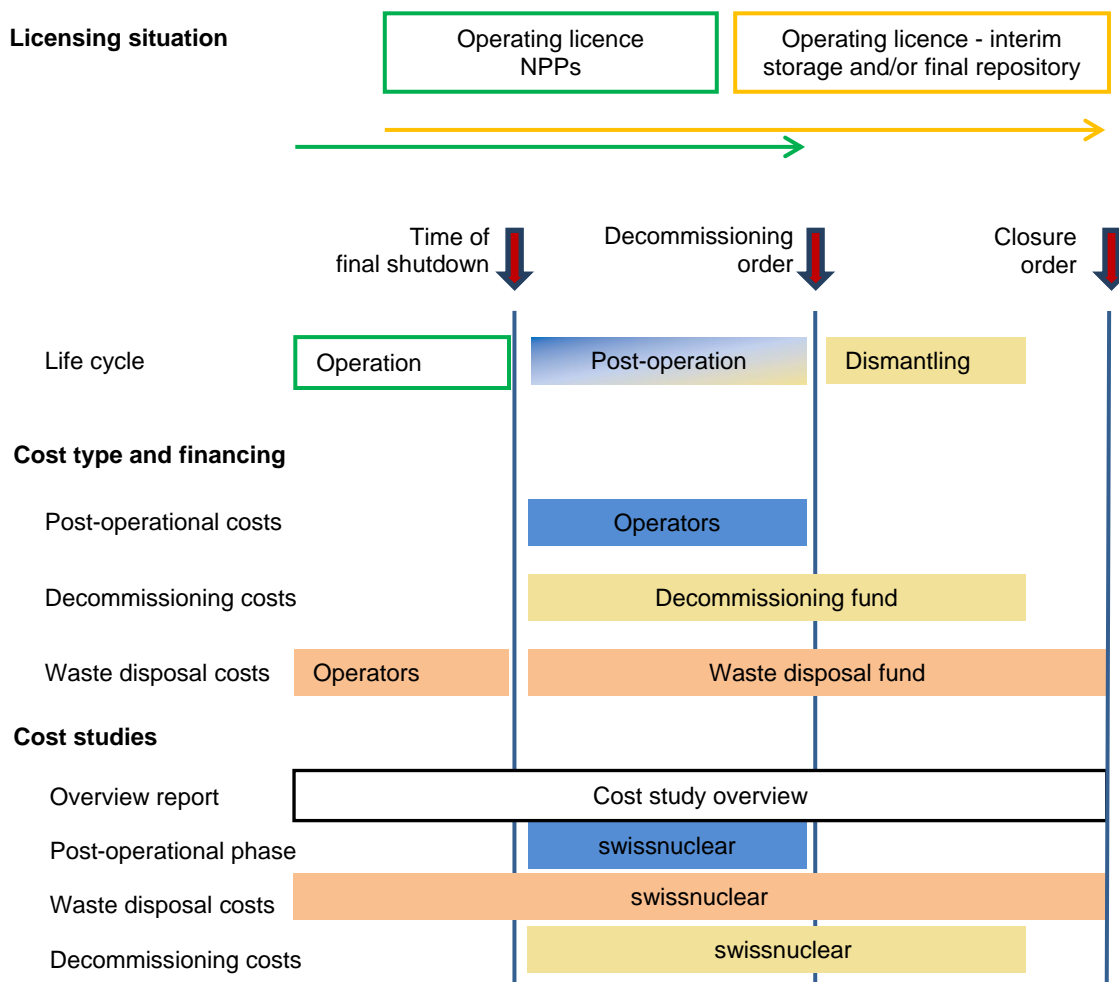


Figure 1: Overview of the links between the sub-studies. The relationship between the licensing situation and the financing of the post-operational phase, decommissioning and waste disposal, including the main documents of the CS11

The basis for the calculations assumes an operating lifetime of 50 years for the nuclear power plants (Article 8 of the Funds Ordinance). If a plant can be operated for longer, the Federal Department of the Environment, Transport, Energy and Communications (DETEC) is responsible for modifying the calculation basis.

The decommissioning model used assumes that the condition of the plant at the start of the dismantling work differs from the operational state in that there are no longer any fuel assemblies in the plant and that all operating media that are no longer required, as well as the operational waste, have been removed from the plant. The post-operational phase begins directly after final shutdown of the plant. It comprises the (operational) measures that are necessary

for the safe operation of the systems that are still required, as well as measures for preparing for decommissioning.

The activities in the post-operational phase are covered by the operating licence according to the Nuclear Energy Act (see Figure 1). During the post-operational phase, the fuel assemblies have to be further cooled, secured and packaged in transport and storage casks. The post-operational phase ends five years after the final shutdown of the plant. During this time, all the fuel assemblies have to be removed to a storage facility that is independent of the plant. The transfer of the operational waste to a centralised interim storage facility or a geological repository is also done during the post-operational phase.

The first decommissioning activities run in parallel with the post-operational phase; these include preparing the documentation for the decommissioning project and obtaining the decommissioning order, as well as making preparations for dismantling. The dismantling and demolition work begins after the post-operational phase, i.e. after the granting of the decommissioning order by the responsible department. An NPP will have been completely dismantled and returned to a greenfield site within 15 to 20 years after final shutdown. The plant is then released from the provisions of the Nuclear Energy Act.

As foreseen in the Funds Ordinance, CS11 is based on the current Waste Management Programme. The disposal concepts defined in the programme are in line with legal and regulatory requirements and, in particular, they implement the legally prescribed concept of deep geological disposal (main facility, pilot facility, test facility; monitoring phase following the operational phase). Once waste emplacement operations in the repository are complete and the disposal chambers have been closed, most of the surface facility will be dismantled and a monitoring phase begins. After 10 years, the direct accesses to the disposal chambers and the access tunnel are backfilled and sealed. After a further 40 years, the entire facility is decommissioned and dismantled and the remaining underground installations are backfilled and sealed (see Figure 1, closure order).

3 Results of the cost estimates

3.1 Background

The last estimate of the decommissioning and waste disposal costs was based on data from the year 2006. It was reviewed by the regulatory authority HSK and approved by the Funds Commission and formed the basis for setting aside provisions and making contributions to the funds by the operators for the period 2007 to 2011. As part of the legally prescribed periodic updating, swissnuclear was requested by the Funds Commission at the beginning of 2010 to carry out new cost estimates, working together with other organisations responsible for nuclear waste disposal in Switzerland, and to submit the results by the end of 2011. Two reports (/1/, /3/) were prepared and submitted and were reviewed by ENSI on behalf of the Commission. At the same time, the cost estimate for the post-operational phase, which is financed directly by the NPP operators, was also updated (see /2/).

The implementation programme for the present cost studies is in line with the current Waste Management Programme of 2008. From 2016, the cost studies and the waste management programmes will be prepared synchronously.

The costs estimated in this study form the basis for recalculating the financial provisions to be made by the operators and their contributions to the funds for the period 2012-2016. The next regular cost study is planned for 2016.

The cost estimates presented here are so-called “best estimates” based on a detailed technical-scientific concept that takes into account the newest information and a clear time schedule of events. The costs are estimated realistically, but without additional safety reserves, using best expert understanding at current market prices (overnight costs).

The results of the 2006 cost estimate (CS06; /4/, /5/ and /6/) are presented in sections 3.2, 3.3 and 3.4 for comparison purposes. The cost studies are always carried out at the monetary value of the year of the estimate. To allow a direct comparison, the costs estimated in 2006 are projected from the 2006 price basis (PB06) to the 2011 price basis (PB11) using an inflation rate of 3% per year that is anchored in the Funds Ordinance and used in the provisions model. The accrued costs of waste management were not adjusted for inflation and the effective expenditure for the years 2006 to 2010 was therefore taken over for CS06. The effective outgoings up to 2010 are thus identical in the comparison between CS06 and CS11.

3.2 Estimate of waste disposal costs

The waste disposal costs include all past and future costs of planning, constructing and operating waste management facilities (centralised interim storage facility Zwiilag, waste treatment/conditioning facilities, deep geological repositories, waste encapsulation plants, Zwibez at Beznau and the Gösigen NPP wet storage facility), the acquisition costs of transport and storage casks and the costs of contracting the services of third parties (for reprocessing, transport, etc.). The costs also include the decommissioning of the waste encapsulation plants and the repository surface facilities, as well as the closure of the geological repositories. These cost elements have been estimated by Nagra, Zwiilag and the NPPs.

The results of the estimate of the waste disposal costs for the Swiss NPPs for 2011 compared with the results for 2006 are shown in *Table 1*. As mentioned at the outset, the cost estimate for 2006 was adjusted to the 2011 price basis. Up to 2010, the NPP operators had paid 4.8 billion CHF for the disposal of spent fuel and radioactive waste.

Waste disposal costs	KKB	KKM	KKG	KKL	NPPs
CS11 PB11 Total amount	4,124	1,834	5,071	4,940	15,970
Accrued costs up to 2010	1,469	638	1,685	1,008	4,799
Future costs from 2011	2,655	1,197	3,387	3,932	11,171
CS06 PB11 Total amount	3,813	1,686	4,559	4,505	14,563
Accrued costs up to 2010	1,469	638	1,685	1,008	4,799
Future costs from 2011	2,344	1,048	2,875	3,498	9,764
Difference CS11 CS06 absolute	311	149	513	435	1,408
Difference CS11 CS06 %	8%	9%	11%	10%	10%

Differences in the sums are due to rounding.

Table 1: Estimate of waste disposal costs for CS11 and CS06, price basis 2011 (MCHF)

Adjusted for inflation, the increase in costs is around 10%. As the method for estimating costs has effectively not changed, the differences for the years 2006 and 2011 can be explained by the influence of external factors. The largest component of the increase can be traced back to the deep geological repositories. Experience accumulated from various tunnel construction projects and construction of nuclear installations has resulted in higher cost estimates for the geological repositories. It should also be noted that the increase in costs between CS01 and CS06 was quite small. The large difference between CS06 and CS11 compared with previous years can also be seen partly as the result of the stricter requirements being placed in recent years on nuclear construction and not as an expression of general inaccuracy in the estimates.

3.3 Estimate of decommissioning costs

The last full revision of the decommissioning cost study was in 2001. The study was updated in 2006 but the costs were not recalculated from scratch. In order to integrate the knowledge and experience from ongoing decommissioning projects in Germany and current conditions in Switzerland into the study, swissnuclear requested the NIS Engineering Group (NIS) to carry out new decommissioning cost studies for the Swiss nuclear power plants and the Zwiilag interim storage facilities. These studies also include a decommissioning plan as required by Article 42 of the Nuclear Energy Ordinance.

The estimated decommissioning costs for the 2011 study are compared in *Table 2* with the 2001 study that was updated in 2006.

Adjusted for inflation, the decommissioning cost study for 2011 is 17% higher than the 2001 study (including the 2006 update). A significant contribution to the additional costs comes from the operations during dismantling; the scope and duration of these activities have been extended based on experience with ongoing decommissioning studies. The above-average increase for the Beznau NPP is largely due to the sequential dismantling of the two reactor units. For the first time, the 2011 decommissioning study for Zwiilag was carried out on the same basis as for the NPP studies. The 2006 and 2011 studies for Zwiilag are thus difficult to compare - also because a significant cost element (operations during dismantling) of the waste management costs for Zwiilag has been reassigned to decommissioning costs. For the sake of completeness, the resulting costs are however included in *Table 2*.

Decommissioning costs	KKB	KKM	KKG	KKL	ZWILAG	Total
CS11 PB11	809	487	663	920	95	2,974
CS06 PB11	631	440	605	835	31	2,541
Difference absolute	178	47	59	86	64	433
Difference (%)	28%	11%	10%	10%	204%	17%

Differences in the sums are due to rounding.

Table 2: Decommissioning cost estimate for CS11 and CS06 (update of the 2001 study), price basis 2011 (MCHF)

3.4 Estimate of the costs of the post-operational phase

The last estimate of the costs of the post-operational phase was carried out in 2006. In 2010, swissnuclear requested the NIS Engineering Group (NIS) to re-estimate the costs of the post-operational phase for the Swiss NPPs.

The key characteristic of the post-operational phase is that the fuel assemblies are still in the plant, i.e. all measures aimed at maintaining nuclear safety/security and radiological protection (including environmental monitoring) and for operating the infrastructure have to remain in place. The fuel is cooled, secured and packaged in transport and storage casks. Extensive studies for the Swiss NPPs have shown that all the fuel assemblies remaining in the power plant at the time of the final shutdown can be transported away from the plant within a period of five years. They are then stored in the central Zwiilag facility or in an independent storage facility at the NPP site. Based on these considerations, the duration of the post-operational phase for all the Swiss NPPs is assumed to be five years. As the costs of the post-operational phase depend to a large extent on fixed costs such as salaries, reducing the duration of the post-operational phase by one year would lead to savings of up to 20% of the total costs.

The estimated costs of the post-operational phase for the 2011 cost study are presented in *Table 3* together with the estimate for 2006.

Post-operational phase costs	KKB	KKM	KKG	KKL	Total
CS11 PB11	475	319	455	460	1,709
CS06 PB11	462	250	481	486	1,678
Difference absolute	13	69	-26	-26	31
Difference (%)	3%	28%	-5%	-5%	2%

Differences in the sums are due to rounding.

Table 3: Cost estimates for the post-operational phase for CS11 and CS06, price basis 2011 (MCHF)

For the first time in 2011, all the assumptions made for the estimates, such as the costs of the activities of the authorities and insurance costs, were estimated on a uniform basis for all the nuclear power plants. NPP Mühleberg assumes higher operating costs for the 2011 cost estimate than for the 2006 estimate, which results directly in higher costs for the post-operational phase. Gösigen and Leibstadt, on the other hand, corrected the estimate of operational expenditure downwards. Averaged over all the NPPs, the cost estimate for the post-operational phase for 2011 is an average of 2% higher (adjusted for inflation) compared to 2006.

A Appendix

A.1 Reference reports

/1/ Kostenstudie 2011 (KS11), Schätzung der Entsorgungskosten der Schweizer Kernkraftwerke, swissnuclear report, 13th October 2011, Olten, Switzerland.

/2/ Kostenstudie 2011 (KS11), Schätzung der Kosten der Nachbetriebsphase der Schweizer Kernkraftwerke, swissnuclear report, 13th October 2011, Olten, Switzerland.

/3/ Kostenstudie 2011 (KS11), Schätzung der Stilllegungskosten der Schweizer Kernanlagen, swissnuclear report, 13th October 2011, Olten, Switzerland.

/4/ Kostenstudie 2006 (KS06), Aktualisierung der Stilllegungskosten, swissnuclear report BET/06/001 Rev. 2, Olten, Switzerland.

/5/ Kostenstudie 2006 (KS06), Aktualisierung der Entsorgungskosten der Schweizer Kernkraftwerke, swissnuclear report BET/06/002 Rev. 2, Olten, Switzerland.

/6/ Kostenstudie 2006 (KS06), Ermittlung der Kosten für die Nachbetriebsphase der Schweizer Kernkraftwerke, swissnuclear report BET/06/003 Rev. 1, Olten, Switzerland.

Note: English translations are now available for reports /1/, /2/ and /3/.