
Decommissioning concept as part of the planning for new nuclear facilities in Switzerland, with reference to general licence applications for the replacement nuclear power plants Beznau and Mühleberg

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Based on a representation of the requirements applicable for the party required to carry out decommissioning under Swiss law, this paper outlines the content of the decommissioning concept to be submitted with an application for a general licence for a new nuclear power plant. It also distinguishes between the decommissioning plan to be maintained as current throughout the entire operation of the facilities and which is to be submitted with the application for construction licence, and the decommissioning project required for the dismantling work. In addition it distinguishes between the decommissioning concept and the feasibility of radioactive waste disposal. It explains that, although alternatives cannot be specifically ruled out, an immediate dismantling or a later dismantling with secure containment are the likely decommissioning options in Switzerland for legal reasons. Concerning the decommissioning process, the basic work to be carried out in the decommissioning phase following directly on from a post-operational phase are described and the possibility of a phased approach to decommissioning is examined, the aim of which can be the continued operation of disposal installations beyond the decommissioning of the facilities. As a conclusion to decommissioning, the paper demonstrates that the facilities will no longer present a radiological hazard and that the site can accordingly be used further without being subject to the restrictive conditions of the nuclear energy legislation. The paper also lists principles which apply in the event of decommissioning. These concern organisation and human resources on the one hand, and the optimisation of work on the other, with regard to quality, to radiation protection legislation, and to the provision of finance. Finally, criteria are given for the choice of the decommissioning option to be made later in the decommissioning plan, and mention is made of the fact that international standards which have regard to the protection of man and the environment are taken into account when deciding in favour of immediate dismantling as the preferred decommissioning option.

1 Introduction

Since the late 1960s and early 1970s Axpo AG and BKW FMB Energie AG have been successfully operating Beznau and Mühleberg nuclear power plants. Viewed in the long term these nuclear power plants at the Beznau (KKB1 and KKB2) and Mühleberg (KKM) sites will have to be replaced. An alternative to the current solution of purchasing electricity from other countries will also have to be found. In order to meet these capacity requirements, the intention is to construct new nuclear power plants, one at Beznau and one at Mühleberg. To this end, in December 2008 the planning company Resun AG submitted the relevant general licence applications to the Federal Office for Energy on behalf of the construction and operation companies Ersatz Kernkraftwerk Beznau AG and Ersatz Kernkraftwerk Mühleberg AG. These new plants, referred to as EKKB and EKKM, are advanced light water reactors of identical design.

According to the Swiss nuclear energy law (KEG) [1] a general licence¹ must first be obtained from the Swiss Federal Council before construction and operation may begin. In order to obtain these licences, an appropriate application for a general licence must be submitted accompanied by the relevant documents². The nuclear energy ordinance (KEV) [2] states³ that together with the application for a general licence – including reports dealing with safety, security and environmental impact, conformity with urban planning and the feasibility of radioactive waste disposal – a concept for decommissioning must also be submitted.

The decommissioning concept describes the basic features of the decommissioning process implemented after the final shutdown, whenever that may occur. This concept will later serve as the basis for drawing up the decommissioning plan which will be needed to obtain the construction licence⁴ and which must be updated throughout the duration of the plant's operation⁵. Following the final shutdown the plant must be decommissioned⁶, and to this end a decommissioning project conforming to the statutory provisions⁷ must be submitted to the supervisory authorities.

2 Legal principles

Swiss law makes the following requirements for the decommissioning of a nuclear power plant:

- As a prerequisite for the issue of the general licence for a nuclear power plant, the Swiss nuclear energy law [1] requires that a concept for decommissioning must be submitted⁸.
- The decommissioning obligations are enshrined in the Swiss nuclear energy law [1] in such a way⁹ that the proprietor is required to decommission his plant in the event of final shutdown, if the operating licence has not been issued or has been withdrawn or has expired¹⁰ and the government department responsible demands the plant be decommissioned. In such cases, the party required to decommission the facilities must in particular fulfil the provisions for nuclear safety and security, transport the nuclear material to another nuclear facility, decontaminate the radioactive parts or treat as radioactive waste, dispose of the radioactive waste and monitor the plant until all sources of nuclear hazard have been removed.
- The nuclear energy ordinance [2] requires of the applicant for a general licence for a nuclear power plant that he submit the concept for decommissioning as a part of the application documentation¹¹. It also requires of the applicant for a construction licence that he demonstrate that the principles of nuclear safety and security are adhered to¹² and that he submits to this end the plan for decommissioning as part of the application documentation¹³. The nuclear energy ordinance [2] also defines the project documents which the party required to carry out decommissioning has to submit together with the decommissioning project¹⁴, and governs the manner in which the plan or project for decommissioning is to be updated¹⁵.

¹ Art. 12 para 1 KEG

² Art. 42 KEG

³ Art. 23 KEV

⁴ Art. 16 para 1 (e) KEG

⁵ Art. 22 para 2 (k) KEG

⁶ Art. 26 para 1 (a) KEG

⁷ Art. 27 KEG

⁸ Art. 13 para 1 (c) KEG

⁹ Art. 26 KEG

¹⁰ acc. to Art. 68 para 1 (a) or (b) KEG

¹¹ Art. 23 (d) KEV

¹² Art. 24 para 1 (a) KEV

¹³ Art. 24 para 2 (f) KEV

¹⁴ Art. 45 KEV

¹⁵ Art. 42 KEV

- The Swiss nuclear energy law [1] also governs the provision of finance for disposal and ing¹⁶, stating that the financing of the disposal of radioactive waste and spent fuel assemblies following shutdown of the nuclear facilities is guaranteed by the disposal fund¹⁷ and the financing of decommissioning and the dismantling of disused nuclear plants and the disposal of the waste thereby created is guaranteed by the decommissioning fund¹⁸. The proprietors of nuclear power plants make payments to the decommissioning and disposal fund in accordance with statutory provisions¹⁹. The contributions made to and entitlements arising from these funds are governed by the decommissioning and disposal fund ordinance (SEFV) [3]. The financing of decommissioning and the disposal of radioactive waste and spent fuel assemblies from operation and during decommissioning is thus ensured.

3 Distinctions: Decommissioning concept, plan and project

As far as the documents on the decommissioning of a plant to be submitted as part of an application for approval are concerned, the Swiss nuclear energy law [1] distinguishes the terms as follows: decommissioning concept applies to the general licence²⁰, decommissioning plan applies to the construction licence and to operation²¹ and decommissioning project applies to decommissioning²².

The *decommissioning concept* forms an integral part of the documents prescribed by the Swiss nuclear energy law [1] and which are to be included in the application for a general licence. It gives a general description of the procedure applied in the event of decommissioning, lists possible decommissioning options, gives possible criteria for deciding on a particular option, outlines the decommissioning process and discusses the various phases which might constitute this process. It does not contain a concrete timetable for decommissioning measures, nor does it make any representations regarding the resulting waste or costs.

The decommissioning concept also makes no statements regarding any decommissioning methods which might be applied.

According to the Swiss nuclear energy law [1] a *decommissioning plan* is required with the application for a construction licence²³. This will take into account the basic principles contained in the decommissioning concept. It will also contain an estimate of the quantity and type of decommissioning waste created and – in order to obtain a basis for estimating the cost of decommissioning – it will examine the decommissioning methods to be used in the form of models. Finally, it will specify the amount and cost of the work involved in decommissioning with a degree of precision which makes it possible to determine the level of contributions to be made to the decommissioning fund as prescribed by statute²⁴ so that the financing of decommissioning and the dismantling of the disused plant and the disposal of the waste thereby incurred – as required by legal statute²⁵ – is ensured. During the operation of the nuclear power plant the licence holder will, as part of his legal obligations and as part of the fulfilment of his responsibility for the safety of the plant and of its operation, in particular meet the requirement²⁶ to keep the plan for decommissioning the plant updated.

¹⁶ Art. 77-82 KEG

¹⁷ Art. 77 para 2 KEG

¹⁸ Art. 77 para 1 KEG

¹⁹ Art. 77 para 3 KEG

²⁰ Art. 13 para 1 (c) KEG

²¹ Art. 16 para 1 (e) and Art. 22 para 2 (k) KEG

²² Art. 27 KEG

²³ Art. 16 para 1 (e) KEG

²⁴ Art. 77 para 3 KEG

²⁵ Art. 77 para 1 KEG

²⁶ acc. to Art. 22 para 2 (k) KEG

The proprietor of the plant will submit a project for the proposed decommissioning to the competent supervisory authority within a timeframe set by that authority²⁷. This *decommissioning project* sets out the phases and timetable for decommissioning, the various stages of dismantling and demolition, the protective measures, the human resource requirement and its organisation, the disposal of radioactive waste, the total cost, and guarantees financing by the operator²⁸. The government department responsible will authorise the decommissioning work in a decommissioning decree and will determine which work will require clearance by the supervisory authority²⁹.

4 Distinction between the decommissioning concept and the feasibility of radioactive waste disposal

The decommissioning of the nuclear power plant will generate conventional and radioactive waste.

The disposal of conventional waste does not form the object of the application for a general licence for a nuclear power plant. It is governed by the decommissioning decree³⁰. To obtain this decree, the party required to carry out decommissioning shall submit the environmental impact report as part of the documentation for the decommissioning project³¹.

The report on the feasibility of radioactive waste disposal (cf. Chap. 1) is required to discuss in detail the disposal of radioactive waste. In particular, it must demonstrate that the feasibility of radioactive waste disposal is given³² and that the legally³³ required precondition for issuing the general licence for this waste is fulfilled in its entirety.

5 Decommissioning options

In conformity with usual international procedures [4] various decommissioning options exist for the decommissioning of a nuclear power plant. In Switzerland, however, only two options are applicable for legal reasons³⁴: "Immediate dismantling" and "Later dismantling following secure containment".

5.1 Immediate dismantling

Under immediate dismantling, contaminated and activated equipment, components, structures and parts of the nuclear power plant are disposed of or decontaminated to such an extent that the plant can be discharged from nuclear supervision as soon as possible following the final shutdown. The implementation of this decommissioning option begins after the final shutdown, usually within five years. In the post-operational phase, as it is referred to, i.e. between the final shutdown and the beginning of dismantling measures, the fuel assemblies are disposed of, the operational waste which is still present is conditioned and also disposed of, and systems are drained and dried out. The decommissioning project is drawn up and, once approval has been obtained, the project is implemented. With immediate dismantling, all the radioactive material is removed from the plant and conditioned so that it can either be placed in intermediate storage or placed immediately in deep geological repositories. Structures which are not contaminated and do not contain activated components are demolished or can remain at the site without being subject to the restrictive conditions of nuclear energy legislation.

²⁷ Art. 27 para 1 KEG

²⁸ Art. 27 para 2 KEG

²⁹ Art. 28 KEG

³⁰ Art. 28 KEG

³¹ Art. 45 (i) KEV

³² in acc. with Art. 23 (e) KEV

³³ Art. 13 para 1 (d) KEG

³⁴ Art. 26 para 2 (d) in conjunction with Art. 31 para 2 (a) KEG

5.2 Later dismantling following secure containment

In the option with secure containment, the final dismantling of the plant occurs at a later date. The plant is made secure and is maintained in a long-term secure state. Decontamination and dismantling do not take place until a later date. Until dismantling occurs, a monitoring and maintenance programme is implemented in order to ensure the required safety is guaranteed. The measures for the so-called post-operational phase (cf. Chap. 5.1 and 6.1) are also implemented under this option. Initial decontamination and dismantling work may be necessary before secure containment. However, the majority of the plant remains under close monitoring which can last from just a few years up to more than 50 years. Only then is the remaining part of the plant dismantled and decommissioning concluded. The plant can then be discharged from the control of the authorities, as provided for by law³⁵.

5.3 Other options

Options other than the two aforementioned or modifications to these options are not specifically precluded. A decision regarding the option chosen (including any modifications) is made, with justifications, in the decommissioning project. The final decision is made in the decommissioning decree.

6 The decommissioning procedure

6.1 Post-operational phase

The final shutdown of the plant is followed by the so-called post-operational phase which is still implemented subject to the conditions of the operating licence. Key tasks performed in the post-operational phase are: unloading the reactor core, disposal of the fuel assemblies, disposal of all operative waste, draining and decontaminating the circuits, and shutting down the various systems. Under the current status of planning and knowledge, a period of five years is the typical length of time the post-operational phase lasts. Optimisation (reduction) of this length of time can be expected.

During the post-operational phase – and possibly during operation – the plant proprietor will draw up the project for the envisaged decommissioning³⁶ to be submitted to the supervisory authorities and will submit this project within the deadline imposed by these authorities.

6.2 Decommissioning phase

Decommissioning begins following the authorisation issued by the competent government department in the decommissioning decree³⁷ and takes into account the provisions contained therein.

In general terms, decommissioning can be divided into the following phases or milestones which partly overlap:

- planning (as early as the post-operational phase)
- submission of the decommissioning project by a deadline set by the supervisory authority³⁸
- decommissioning decree (authorisation of the work by the competent government department³⁹)
- dismantling and removal of equipment
- decontamination and clearance of the buildings

³⁵ Art. 29 para 1 KEG

³⁶ in acc. with Art. 27 KEG

³⁷ cf. Art. 28 KEG

³⁸ in acc. with Art. 27 para 1 KEG

³⁹ in acc. with Art. 28 KEG

- demolition of the buildings (or alternative use)
- re-use of recyclable residual materials
- disposal of all waste (parallel to the dismantling and demolition measures)
- clearance measurement of the site (quantitative proof that the site no longer contains any materials falling under the provisions⁴⁰ of radiation protection legislation)
- conclusion of decommissioning (determined by the competent government department⁴¹).

According to the current status of knowledge and experience obtained from the planning of decommissioning projects and from current international decommissioning projects (e.g. in Germany), the total duration of immediate dismantling is 10 – 12 years.

Where the decommissioning option "Later dismantling following secure containment" is concerned, the dismantling and removal of installations and equipment is carried out in the initial stage to the point where the facilities are in a condition in which operational activities and interventions and maintenance work are reduced to a minimum. The facilities remain in this condition under monitoring for the duration of the secure containment. Subsequently – following the reactivation and renewal of the required systems – dismantling and demolition work is continued. The procedure is more or less analogous to that for immediate dismantling. With later dismantling, the total length of time taken depends largely on the length of time chosen for secure containment and can amount to several decades.

The various decommissioning stages, in particular the duration of the secure containment of the nuclear plant, are determined in the decommissioning decree⁴². In this respect, the party required to carry out decommissioning shall, in accordance with legal requirements⁴³, submit a comparison of the various phase options, of the timetable for the decommissioning work and of the final status to be expected, together with a justification for the option chosen. This comparison shall form part of the documents accompanying the decommissioning project.

6.3 Phased decommissioning

Interim storage and conditioning facilities are expected to be built and operated at the sites of the new nuclear power plants. If, at the time decommissioning takes place, there is a need to operate a part of these facilities after the power plant has been decommissioned, these parts will be retrofitted so that they can continue to operate as an independent nuclear facility. This type of retrofitting concerns in particular the systems necessary for ensuring safety and security.

The need to continue the operation of disposal plants can result, for example, but not exclusively, from the fact that no suitable deep geological repository is available at the time the plant is due to be shut down – either because it has not yet been constructed or is not in operation at this time.

Phased decommissioning may be taken into account in the decommissioning project and can accordingly become the object of the decommissioning decree. The decommissioning project will in this case state that

- disposal facilities should continue to be operated in such a way that they are precluded from the provisions of the decommissioning decree and continue to exist as nuclear plants in their own right according to the conditions of the existing general licence and irrespective of decommissioning of the power plant

⁴⁰ Art. 1 in conjunction with Annex 2 and 3 StSV

⁴¹ in acc. with Art. 29 para 1 KEG

⁴² cf. Art. 46 (b) KEV

⁴³ Art. 45 Bst. (a) KEV

- or if the decommissioning decree should have the effect that the power plant is first dismantled, the relevant part of the area (not significantly differing from the decommissioning decree⁴⁴, and subject to the clearance of the supervisory authority⁴⁵) made available for a continued use which is non-nuclear in character, and the disposal facilities continued to be operated for a certain length of time before the completion of decommissioning.

6.4 Completion of decommissioning

Following the completion of decommissioning work in line with all relevant requirements, evidence of conformity is furnished that no activities, installations, equipment, events or states exist or can be practised coming under the area of application⁴⁶ of the radiation protection law (StSG) [5] at the site of the former nuclear power plant, which entail a hazard through ionising radiation. In particular, evidence of conformity is furnished that the plant no longer presents a radiological hazard and that no events occur which might cause increased radioactivity in the environment. The competent government department can then in conclusion determine that the plant no longer presents a radiological hazard and is thus no longer subject to nuclear energy legislation⁴⁷.

A finding of this type concerns in particular the site itself, so that no restrictive condition whatsoever according to nuclear energy legislation will exist for its further use.

7 Implementation of decommissioning

7.1 Organisation and human resources for decommissioning

The plant proprietor shall inform the supervisory authorities of the human resource requirements and of the organisation⁴⁸ as part of the decommissioning project. The organisation will be determined in the decommissioning decree⁴⁹. The operator responsible for decommissioning will, analogous to the provisions valid for the operation of the plant, construct the organisation consistent with the general obligations of the licence holder⁵⁰ and will employ a sufficient number of appropriately and technically trained personnel in order to thus fulfil the statutory⁵¹ decommissioning obligations.

7.2 Decommissioning and monitoring

The scope of the decommissioning work, the limits for the emission of radioactive material to the environment, the monitoring of the emission of radioactive material and of direct radiation are specified in the decommissioning decree⁵². To this end, the party required to carry out decommissioning shall submit the following documents required by ordinance⁵³ as part of the documents accompanying the decommissioning project.

- The description of the various work steps and the means required to perform each step, i.e. the determination of the radiological status of the plant, the dismantling, disassembly and decontamination of equipment, the decontamination and demolition of buildings.

⁴⁴ in the sense of Art. 65 para 3 KEG

⁴⁵ in acc. with Art. 47(d) KEG

⁴⁶ in acc. with Art. 2 para 1, 2 StSG

⁴⁷ Art. 29 para 1 KEG

⁴⁸ cf. Art. 27 para 2 (d) KEG

⁴⁹ cf. Art. 46 (e) KEG

⁵⁰ see Art. 22 para 2 (b) KEG

⁵¹ Art. 26 para 2 KEG

⁵² cf. Art. 46 (a), (c), (d) KEG

⁵³ Art. 45 (b-h) KEG

- The procedure for separating radioactive waste from non-radioactive waste and the disposal of radioactive waste.
- Measures for the radiological protection of employees and for preventing the release of radioactive material into the environment.
- Safeguarding measures.
- Considerations of incidents, i.e. the determination of possible incidents during decommissioning, estimating the frequency of the radiological effects of the incidents, as well as counter-measures and any emergency protection measures.
- Proof of the availability of a sufficient number of appropriate and technically trained personnel for the implementation and monitoring of decommissioning work and a suitable organisational structure with clear assignment of areas of responsibility.
- The quality management programme.

The implementation of decommissioning will in particular take into account practical experience from decommissioning projects currently taking place and national conditions prevailing in Switzerland, statutory provisions, other legal requirements, disposal strategies, working conditions, etc. This includes the selection of methods used (in particular giving consideration to the exposure to radiation of personnel), the required qualification and number of personnel, the duration and procedure of the various measures, and the disposal of the dismantled components and plant parts.

In accordance with the principles provided for in radiation protection legislation, in particular the minimisation of waste⁵⁴ provided for in the radiation protection law (StSG) [5] and with the optimisation⁵⁵ provided for under the radiation protection ordinance (StSV) [6], the methods used will be chosen according to the principles of "Preventing radioactive waste" and "Preventing unnecessary exposure of personnel to radiation". These goals can be achieved (e.g.) by means of procedures for retaining (radioactive) materials, for minimising the production of waste and preventing additional contamination of the infrastructure. Appropriate procedures have already been implemented in practice, especially with regard to remote handling of radioactive structures.

Decontamination is particularly important during dismantling work, with personnel being less exposed to radiation and the mass of radioactive material placed in deep geological repositories being reduced by clearing as much material as possible. The disposal of radioactive waste is dealt with in the report on the feasibility of radioactive waste disposal (see Chap. 4). The mechanical and chemical decontamination procedures used have proven themselves in practice.

At the end of decommissioning, the decontamination and clearance of any remaining building structures and of the site itself take place. The decommissioning work is considered completed when radioactivity levels comply with conditions⁵⁶ set in the radiation protection ordinance throughout the entire controlled zone and all other areas on plant site. The measuring procedures and their degree of detail are defined in the decommissioning project, taking into account the requirements of the authorities.

Once it has been determined that the plant no longer presents a radiological hazard and as such is no longer subject to nuclear energy legislation, the building structures are demolished using conventional means or they are made available for an alternative use which is not subject to the restrictive conditions of nuclear energy legislation.

⁵⁴ Art. 25 para 2 StSG

⁵⁵ Art. 6 StSV

⁵⁶ in acc. with Art. 1 and 2 KEV

The experience obtained in actual decommissioning projects is available for the design of the new plants and also serves the planners of new nuclear plants as a means for assessing the extent to which decommissioning aspects are taken into account in plant design.

7.3 Decommissioning costs

The plant proprietor will provide the supervisory authorities with details of the total costs as part of the decommissioning project as well as with information on the securing of finance⁵⁷. The party required to carry out decommissioning will also, as part of the documents accompanying the decommissioning project, submit the analysis of all costs incurred through decommissioning – including the cost of disposing of radioactive and non-radioactive waste –, and will describe how financing is secured⁵⁸.

8 Choice of decommissioning option

The decommissioning option is defined in the decommissioning plan, a prerequisite for the issue of the construction licence⁵⁹ and which forms part of the respective construction licence application⁶⁰. The decommissioning plan is subject to the reservation that it may be drawn up for several options and a result applicable to the various options may be used for securing finance for decommissioning. The right to revise the decommissioning plan using another decommissioning option is also reserved.

The choice of the decommissioning option is made with reference to Swiss legislation. Legislation governing the environment is of essential importance, as well as the Swiss nuclear energy law and the radiation protection law.

The primary aim will be to select the decommissioning option so that following the correct completion of decommissioning⁶¹, the plant no longer represents a radiological hazard and is hence no longer subject to nuclear energy legislation.

As part of the decision-making process, statutory decommissioning obligations⁶² will be taken into account. These include in particular:

- nuclear safety and security
- availability of another nuclear facility to which the nuclear material present at the plant may be transferred
- means for decontaminating radioactive parts
- means for disposing of radioactive waste, in particular the temporal availability of deep geological repositories
- means for monitoring the plant until all sources of nuclear hazard have been removed.

In addition to the aspects to be considered under the Swiss nuclear energy law [1], other relevant aspects can influence the decision.

In conformity with international standards for the protection of man and the environment, as for example formulated by way of provision [7] in the rules of the International Atomic Energy Agency (IAEA), the preferred decommissioning option is that of immediate dismantling. However, it may be that this solution is not a practicable one in view of

⁵⁷ cf. Art. 27 para 2 (f) KEG

⁵⁸ cf. Art. 45 (j) KEV

⁵⁹ cf. Art. 16 para 1 (e) KEG

⁶⁰ in acc. with Art. 24 para 2 (f) KEV

⁶¹ see Art. 29 para 1 KEG

⁶² Art. 26 para 2 KEG

all the aspects to be taken into account in the decision-making process. The plant proprietor shall provide reasons in the decommissioning project for the solution selected.

9 Conclusion

This report describes the procedures applicable to the nuclear power plants intended for construction, for use in the event of decommissioning. Possible decommissioning options are indicated and the criteria on which the decision in favour of a certain option may be based are given. An outline of the decommissioning process is also given, together with a possible phased decommissioning.

The report thus illustrates that Swiss legislation ensures that the concept for decommissioning a nuclear power plant is already in place at the time at which the general licence for that new nuclear power plant is issued.

Sources

- [1] Nuclear energy law of 21 March 2003 (KEG), SR 732.1
- [2] Nuclear energy ordinance of 10 December 2004 (KEV), SR 732.11
- [3] Ordinance of 7 December 2007 on the decommissioning fund and the disposal fund for nuclear plants (decommissioning and disposal fund ordinance, SEFV), SR 732.17
- [4] Safety Reports Series No. 50, Decommissioning Strategies for Facilities Using Radioactive Material, International Atomic Energy Agency, Vienna (2007)
- [5] Radiation protection law of 22 March 1991 (StSG), SR 814.50
- [6] Radiation protection ordinance of 22 June 1994 (StSV), SR 814.501
- [7] Safety Requirements No. WS-R-5, Decommissioning of Facilities Using Radioactive Material, International Atomic Energy Agency, Vienna (2006)