Environmental Impact Assessment Report

for the Decommissioning of Units 1 to 4

at Kozloduy Nuclear Power Plan

CHAPTER 2

STUDIED ALTERNATIVES FOR TECHNOLOGIES AND REASONS FOR THE CHOICE MADE FOR THE EXAMINATION, CONSIDERING THE IMPACT ON THE ENVIRONMENT, INCLUDING THE "ZERO ALTERNATIVE"

CONTENTS

2. Studied alternatives for technologies and reasons for the choice made for the examination, considering the impact on the environment, including the "Zero alternative"

The purpose of this chapter is to consider and evaluate the different alternatives on the basis of the available information, and the comparative analysis of the Alternatives:

- Alternative "0" (without dismantling)
- Alternative "1" (deferred dismantling)
- Alternative "2" (continuous dismantling).

The basis for evaluation and assessment are:

- The applicability and recommendations of BREF for BAT
- IAEA standards and documents related to decommissioning, and
- Experience from othe WWER 440 decommissioning projects.
- Comparison of alternatives based on social and economic concequences and environment factots impact.

The result of the evaluation and assessment are the basis for the justification of the selected Alternative 2

2.1 Zero Alternative

Zero Alternative is characterized as the situation and its consequences that would arise, if the proposed activity did not take place. In case of Kozloduy NPP decommissioning, zero alternative is the status that would arise the Units are shut down without commencement of decommissioning activities and they remain in that state indefinitely. This means that zero alternative does not represent further operation of the Units.

This Alternative is not stipulated by the IAEA recommendations [57] during decommissioning of nuclear facilities.

In accordance with the Law on Safe Use of Nuclear Energy [4], Nuclear Power Plants will be operated in such an extent, so that their radiation safety would be ensured and continuously monitored after the reactor final shutdown. Therefore, in case of Zero Alternative the following systems will have to be permanently operated:

- HVAC systems creating suitable hygienic and radiological conditions for personnel during inspections of active rooms and technological equipment, enabling at the same time moderate heating of rooms to minimize corrosion conditions for technological equipment;
- Special drain water system (collection and control of potential leakages) with waste water let down system;
- Radiation monitoring of equipment and rooms using a stationary radiation monitoring system and portable devices;
- Automated technological information system – (equipment monitoring system, civil barrier tightness monitoring system, signaling of leaks in the controlled area, etc.);
- Electronic fire protection system;

- Electrical distribution systems for lighting of rooms and power supply to operating systems (permanent operation of power supply systems);
- Piping distribution systems for media (fire water, drinking water for changing rooms and contamination checkpoints, etc.);
- Groundwater monitoring system in the vicinity of individual buildings;

Simultaneously, the maintenance and reconstruction of the aforementioned systems will be ensured. In addition, buildings maintenance with emphasis on the check-ups and maintenance of barriers will be necessary.

The mode of operation under Zero Alternative is similar to the activities performed during Safe Enclosure Operation, the only difference is that it lasts much longer. Basically, duration of Zero Alternative is determined by a spontaneous decay of radioisotopes in the shutdown power plant. Zero Alternative thus means preservation of Kozloduy NPP shutdown status without time limitation. This alternative does not require availability of decommissioning investments, even if it is not time limited.

Site release for further use would be postponed to far future.

In addition, risk of possible leakage of radioactive substances into environment will be increased. It is not an advantageous alternative with regard to costs for maintenance, reconstruction of buildings and equipment and institutional control needed for an indefinite period of time.

From the ethical point of view, it means transfer of responsibilities to the next generations and non-conformance with the principle of sustainable development.

Hence, Zero Alternative is unacceptable for KNPP Units decommissioning, due to increased radiological risks and related costs.

Its continuation would be the infringement of the sustainable development principle and the principle of safe handling and storage of radioactive waste.

It is very probable that implementation of zero alternative would lead to re-consideration of the decision not to perform decommissioning, but in more difficult conditions (loss of continuity of operation, possible loss of information, necessity to train new inexperienced personnel, abundance of financial means could be a problem, etc.).

According to IAEA recommendations during the nuclear facilities decommissioning [57] the Zero Alternative is not acceptable.

2.2 Alternatives for realization of the Investment Proposal

Specific decommissioning alternatives will, among other things, define the timing and sequencing of the decommissioning activities according to [57]. Decommissioning alternatives can range from immediate dismantling and removal of all radioactive materials from site, allowing unrestricted release to an option of in situ disposal involving encapsulation of the reactor and subsequent restriction of access.

IAEA requirements

According to the IAEA documents [57] the two basic decommissioning alternatives should be considered as follows:

- Immediate dismantling
- Deferred dismantling following one or more periods of Safe Enclosure (defined as Stage 1 and Stage 2).

An intermediate alternative consists of a minimum degree of early dismantling and conversion of the plant to Safe Enclosure, before potential dismantling. Similarly, options can include the dismantling of some parts of the plant, usually externally accessible areas, while placing others, particularity the reactor core, into a Safe Enclosure mode. Most alternatives consider the safe removal of the fuel and operational waste early in the decommissioning phase in order to obtain a significant reduction in the hazards associated with the installation.

The selection of a Safe Enclosure alternative for a defined period of time is known as a deferred dismantling. If the chosen option is deferred dismantling, the appropriate methods and approach should be also conducted in preparation for the potential dismantling.

The most important factors related to the selection of the decommissioning option are:

- Legislative and regulatory requirements
- Decommissioning cost and funding;
- Spent nuclear fuel management strategy;
- Radioactive waste management infrastructure;
- Criteria for removal of material from regulatory control;
- Social and socially acceptable aspects;
- Conditions of the plant and ageing processes;
- Plant owner interests, including planned use of the site;
- Resources availability;
- Radiological aspects.

Each factor affecting the selection of the decommissioning options cannot be examined without proper consideration of conditions specific to the facility.

In the IAEA document [57] the above mentioned factors for WWER type reactors are described in more details, which should be considered when choosing the decommissioning option.

An evaluation of the various decommissioning options should be performed by considering a wide range of issues, with special emphasis on the balance between safety requirements and the resources available at the time of implementing

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decommissioning. Cost-benefit or other types of analysis provide systematic means for such an evaluation. These analyses should utilize realistic estimates of both cost and radiation doses. It should be ensured that the selected option meets all applicable safety requirements. According to the IAEA standard [56] the selection of the decommissioning option should be made by analyzing components such as:

- Compliance with laws, regulations and standards that should be applied during the decommissioning;
- Characterization of the facility including the design and operational history as well as radiological inventory after the final shutdown and how this changes with time;
- Safety assessment of the radiological and non-radiological hazards;
- The physical status of the plant and its evolution with time, including if applicable, an assessment of the integrity of buildings, structures and systems for the anticipated duration of deferred dismantling;
- Adequate arrangement for waste management such as temporary storage and disposal;
- Adequacy and availability of the financial resources required for the safe implementation of the decommissioning option;
- Availability of the experienced personnel, especially staff of the former operating organization, and proven techniques including decontamination, cutting and dismantling as well as remote operating capabilities;
- Lessons learned from previous similar decommissioning projects;
- The environmental and socioeconomic impact, including public concerns about the proposed decommissioning activities;
- The anticipated use of the plant and the site for other purposes.

This list contains other aspects as well depending on the specific circumstances of decommissioning in each country.

The radiological and non-radiological hazards should be identified in a formal safety assessment, leading to the provision of appropriate protective measures to ensure the safety of the personnel, the population and the protection of the environment and to ensure that the relevant criteria are met. The safety assessment will allow the identification of engineering and administrative arrangements needed to ensure the safety of the decommissioning process and will enhance the choice of the particular decommissioning option.

The implementation of a waste management procedure should be considered as an option during decommissioning. The amounts and types of waste generated will depend on the chosen methods. Appropriate and safe waste management infrastructure should be available including disposal and storage routes.

When considering decommissioning options, all activities described in the decommissioning plan should be included in the estimation of the cost for decommissioning. These activities include planning and engineering during post-operational phases, development of specific technologies for decontamination, dismantling, conducting of site final survey and RAW management. The cost of maintenance, surveillance and physical protection of the plant should also be taken into account.

When making the choice between different decommissioning strategies, consideration should also be given to: local factors, including the anticipated development and use of land; local population employment and degree of impact on the population.

Units 1 and 2 were commissioned in September 1974 and November 1975, respectively, and were disconnected from the energy system of Bulgaria in December 2002. Units 3 and 4 were commissioned in 1979 and in November 1982, respectively, and were disconnected from the energy system of Bulgaria in December 2006.

The document describing the original decommissioning strategy – "Technical design for decommissioning of KNPP Units 1 and 2" [6] was completed in 2001, and was updated in 2005 in items 5.1 "Planning and schedules for execution of the activities" and 5.2 "Cost estimate for the decommissioning of KNPP Units 1 and 2" [22].

On 25 April 2005 Bulgaria signed the Treaty of Accession to the European Union and joined EC on 01 January 2007. As a part of this agreement, the Bulgarian government committed to shut down KNPP Units 3 and 4 before the end of 2006. In this regard, the updated decommissioning strategy for KNPP Units 1-4 was prepared in June 2006 [7]. Different alternatives were considered as a part of that strategy.

The alternatives were analyzed, considering the criteria in table 2.2-1.

Table 2.2-1 Criteria for analysis of the alternatives

Criteria for Analysis	**Weight Factors**
Least Costs	7
Maximal Safety	9
Minimal Dose Uptake	8
Least Total Effort	4
Highest and Most Even Employment Rate	6
Minimal Environmental Impact	6
Generation of Least RAW Quantities	6
Optimal Usage of the RAW Treatment Facilities	5
Maximal Recovery of Resources	4
Maximal Potential for Financial Support Assurance	6
Minimal Demands on Subsidies from National Budget	3
Public acceptance	6
Fast Reconstruction of the Site	1
Minimal Impact on the Operating Units	4
Maximal Benefit from the Site Utilities	4

The results from the analysis, presented in [7], led to the preference of the Continuous Dismantling with Shortened Safe Enclosure alternative.

A more detailed description of the original and the updated decommissioning strategy for KNPP Units 1-4 is presented in Chapter 1 and also in [7 and 36].

2.2.1 Alternative 1 Deferred dismantling

This alternative is based on the proposal presented in the latest update of the decommissioning project of February 2005 [6]. The Safe Enclosure duration is shortened to the commissioning of the National Repository for RAW.

The advantages of this option are:

- Relatively small financial needs in the beginning of the Safe Enclosure period;
- The RAW from the dismantling and the decontamination of contaminated equipment may be immediately treated, conditioned and transported to the new National Repository, without the need to be stored in an interim storage facility;
- Creation of a reasonable number of new jobs during the dismantling in the Turbine Hall in the beginning of the Safe Enclosure Period;
- The operational and expert experience of the personnel managing the plant can be used during the dismantling of the Turbine Hall equipment.

The disadvantages of this option are:

- There is an inactivity period between the completion of the dismantling activities in the Turbine Hall and the end of the Safe Enclosure;
- The experience gained during the Turbine Hall dismantling will be reduced due to the above mentioned gap (but will be not completely lost);
- The longer the Safe Enclosure period is, the more expensive the Safe Enclosure operation and maintenance is.

2.2.2 Alternative 2 Continuous Dismantling

The main characteristic of this alternative is continuous dismantling of equipment and facilities and the continuous process of waste management and control of Safe Enclosure, meeting all requirements for environmental and radiation protection. The continuous dismantling is a selected combination of the following two options:

- Immediate dismantling of certain facilities and equipment;
- Deferred dismantling of other facilities and equipment.

The continuous dismantling alternative for decommissioning of Units 1 to 4 of Kozloduy NPP includes the following two stages, according to the updated strategy [7]:

- **Stage 1:** Preparation and control for Safe Enclosure of reactor building 1 and 2 and dismantling of equipment outside of the Safe Enclosure area;
- **Stage 2:** Deferred dismantling of equipment inside the Safe Enclosure area and release of the building from regulatory control

The stages of preparing for and controlling of Safe Enclosure from the previous strategy have been merged into a single Stage 1. In Stage 1 the phases of preparation for Safe Enclosure and control of Safe Enclosure are included as well as dismantling of equipment outside the Safe Enclosure area. Under this alternative the preparatory

work starts in advance and followed by the continuous dismantling. The facilities associated with the processing of waste are loaded more evenly.

Preparatory activities such as removal of flammable and combustible materials, asbestos removal and others could be reduced by two years. Potentially, the scope of these activities could be further extended before the start of decommissioning.

Simultaneously, there are plans to dismantle the equipment outside the area of Safe Enclosure, starting with non-contaminated equipment in buildings and in the turbine hall of Units 1 to 4, namely:

- Dismantling of non-contaminated equipment;
- Dismantling of turbines;
- Dismantling of secondary circuit.

Under the Continuous Dismantling of KNPP Units 1-4 Alternative, the Auxiliary Buildings and stacks are excluded from the SE area which allows their use as radioactive waste management facilities before the SE is reopened. Therefore, the scope of SE is limited to the reactor buildings of the units, parts of the sanitary buildings and the connecting elevators. The Auxiliary Buildings remain with special statute, in order to be used in different phases of the decommissioning activities. The scope of SE will be limited to the Reactor Building 1 and Reactor Building 2 and the interconnecting passageways as illustrated on figure 2.2.2-1.

End of Stage 1 will be determined by the completion of dismantling outside the Safe Enclosure area. The duration of Stage 1 is seven years.

During Stage 2 dismantling of the equipment in the Safe Enclosure area will begin, i.e. the radioactively contaminated equipment of the primary circuit. Dismantling of the equipment of AB should take place at the end of Stage 2, according to the Alternative of Continuous Dismantling.

Then dismantling of the reactors and the activated components around them will be performed. At the end of this stage, the site and buildings will be released from regulatory control to be used for other industrial uses.

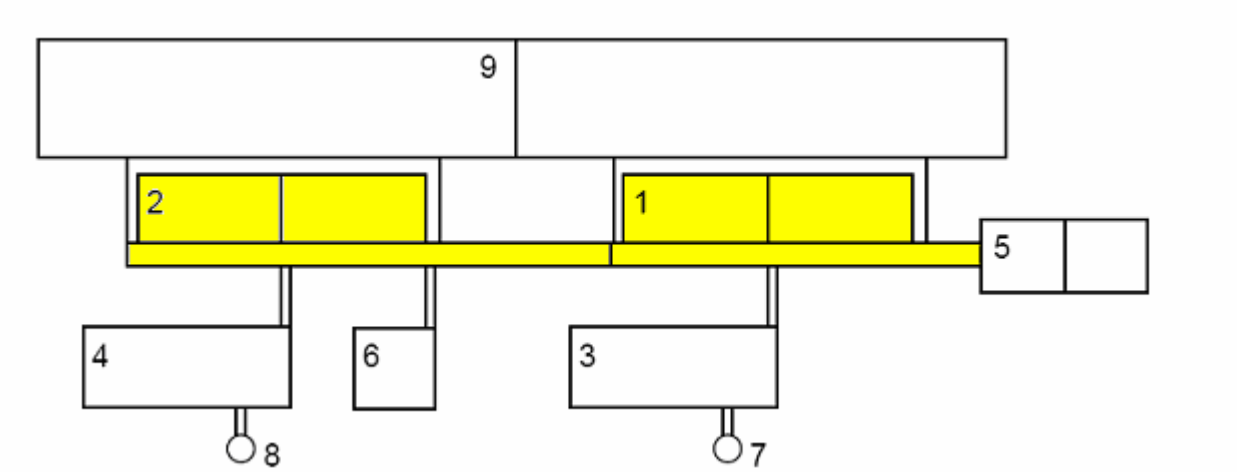
An important task of dismantling is to achieve maximum opportunity for reuse and recycling of dismantled materials, especially metals. This requires the supply and installation of appropriate infrastructure for disassembly, shredding, sorting, volume reduction, and decontamination as well as equipment for free release measurements before beginning of decommissioning activities.

For implementation of these steps necessary projects are planned, the most important ones are:

- Size Reduction and Decontamination Workshop;
- Sites for management of materials from decommissioning of Units 1-4 KNPP (Decay Storage Sites for Transitional RAW and Site for Conventional Waste from Decommissioning).

During the continuous dismantling remediation of contaminated soils is possible.

After commissioning of the national repository, the flow of conditioned radioactive waste will be directed to the site of national repository and thus the site of the Units will be free of RAW.



1 – Reactor Building I (Units 1 & 2)
2 – Reactor Building II (Units 3 & 4)
3 – Auxiliary Building 1
4 – Auxiliary Building 2
5 – Laboratory/sanitary building 1
6 – Laboratory/sanitary building 2
7 – Ventilation Stack 1
8 – Ventilation Stack 2
9 – Turbine Hall

***The yellow area is the SE area, including LSB 1*

Fig. 2.2.2-1 Planned Safe Enclosure Area under this alternative

Description of the decommissioning of Units 1-4 for the chosen alternative for decommissioning are described in detail in the Plan for decommissioning of these Units 1 [36].

The justification of chosen alternative is given in section 2.3 of this chapter.

2.3 Justification of the selected Alternative 2 - Continuous Dismantling

Detailed description of the alternatives and the selected alternative according the IAEA requirements [57], as well as all related steps and activities are given in Chapter 1 as well as in [7] and [36].

The present section gives the justification of the selected Alternative 2 "Continues Dismantling" under consideration of the recommendations of the BAT according to the IPPC Directive, of the analysis of the IAEA standards and documents related to Nuclear Power Plants decommissioning, the analysis of the experience from other WWER decommissioning projects, especially the Greifswald decommissioning experience (illustrated in attachment 11.2 of Chapter 11), as well as on the basis of the decommissioning alternatives following the economical and social consequences with summarized quantitatives and estimatives indicators for the choosen alternative and based on the environmental experts assessment of the different alternatives. In the last section are also summarized all assessments in the respective matrix.

2.3.1 Recommendations of BAT according to the IPPC Directive

The execution of NPP decommissioning is a very complex system of activities with the use of different technologies and techniques. This technologies and techniques are almost the same for Alternative 1 and Alternative 2. The criteria and procedure of the selection is described below. Bellows are described the criteria and procedures on selection of alternative.

In this part are assessed the existing requirements of BAT documents for the different used techniques and technologies for decommissioning.

The purpose of the Directive 96/61/EC concerning integrated pollution prevention and control [208] is to achieve the integrated prevention and control of pollution arising from the industrial activities listed in Annex I. It describes measures for preventing or, when this is not possible, for mitigating the emissions in the air, waters and soil resulting from the above activities, including measures related to the waste, aimed at high level of environment preservation as a whole. The main principle of the Directive is the use of the Best Available Techniques (BAT), taking into account the likely cost and benefits of measures as well as aiming to protect the environment taken as a whole to avoid creating a new and more serious environmental problem when solving another.

The BAT are stated in BAT reference documents (BREF), determined by stakeholder groups (technical working groups). The decommissioning and dismantling of NPP is not listed in Annex 1 of the IPPC Directive representing a list of industrial activities according to article 1 of the Directive, and therefore, a relevant BREF does not exist. At following are assessed BREFS, related to decommissioning activities, to their applicability.

Reference Document on Economics and Cross-Media Effects [209]

This document describes the methodology for the assessment of BAT applicable to all techniques for which specific BREFs do not exist. This methodology is based on 4 Cross Media Guidelines, 5 Costing methodology guidelines and the evaluation of the alternatives under consideration of the results from the use of the guidelines, Cross

Media and cost, described in chapter 4 and last but not least the assessment of the economic viability in the sector.

The number 3 of the Cross Media Guidelines sets out the steps for estimating the environmental effects for 7 environmental themes:

- Human toxicity
- Global warming
- Aquatic toxicity
- Acidification
- Eutrophication
- Ozone depletion
- Near surface photochemical ozone creation potential.

This methodology is important for the assessment of new created techniques. The decommissioning of NPP is a very complex net of activities, but it must be taken into account, that almost all used techniques in this network, such as:

- Segmenting/cutting techniques,
- Decontamination techniques,
- Radiological characterization techniques,
- RAW treatment and conditioning techniques,
- Management of non-radioactive waste

are proven techniques and applicable for the most types of nuclear power plants and used for maintenance and operational waste treatment in operating nuclear power plants.

Taking into account, that the decommissioning experience is worldwide assessed and evaluated by the IAEA Decommission network activities including the experience from WWER 440 decommissioning (see Annex to Chapter 2), the BREF on Economics and Cross-Media Effects is not needed for the assessment of BAT for this decommissioning project.

Reference Document on the General Principles of Monitoring [210]

According to the IPPC Directive, especially Article 16, the monitoring requirements are an inseparable part of permissions for installations, listed in Annex 1 of the Directive. The reasons are:

- Compliance assessment: monitoring is needed to identify the plant performance, thereby allowing the authorities to check compliance with the conditions in the permit
- The environmental reporting of industrial emissions: monitoring is needed to generate information for reports on the environmental performance of industry (national reporting obligations).

There are three main types of industrial monitoring:

- Emission monitoring (monitoring of releases from the plant to the environment) Process monitoring
- Process monitoring
- Impact monitoring

This BREF covers only the emission monitoring. The permission writer (competent authority) is responsible for the monitoring requirements, but usually a detailed proposal from the applicant is submitted with the application documents.

The responsibility for carrying out of the monitoring is divided between the competent authorities, usually realized by third party contractors, and the operator in form of "self-monitoring". A good practice for the monitoring execution includes:

- Standard methods of measurements
- Certified and calibrated instruments
- Certification of personnel
- Accredited laboratories.

The last practice (accreditation) is related mainly to third party contractors, while in case of "self-monitoring" by the operator a periodic check by an external accredited laboratory can be appropriate.

Other main parts of this BREF are:

- "What" and "How" to monitor. This part of the monitoring program includes parameters, sampling places, and frequencies of sampling, measurement methods (standards), reporting requirements and how to deal with uncertainties.

Monitoring requirements should be tied to ELV (Emission Limited Values) from the permit. This part includes description of the aspects that have to be taken into account for the development of the monitoring program. These aspects are:

- Legal and enforceable status of the monitoring requirement
- Parameter (pollutant) being limited
- Timing requirements of sampling and measurements
- Feasibility of limits with regard to available measurement methods
- General approach to the monitoring available for relevant needs
- Technical details of particular measurement methods
- Self-monitoring arrangements
- Operational conditions under which the monitoring is to be performed
- Compliance assessment procedures
- Reporting requirements
- Quality assurance and control requirements
- Arrangements for the assessment and reporting of exceptional (in the case of incidents or emergencies) emissions.

The monitoring programs for radiological monitoring and monitoring of non-radiological parameters (chapter 1.16) fulfil formally (the IPPC Directive does not include operation and decommissioning of nuclear power plants) all requirements of this BREF. It is important to mention, that these monitoring programs were developed for the operating NPP units. After the final shut down the emissions were significantly reduced (EWN experience [50], KNPP experience after final shut down of Units 1 -4) and these levels are decreasing in the decommissioning and dismantling period [50].

Thus it can be stated that for the decommissioning and dismantling phase of KNPP additional monitoring requirements (except the operation of new ancillary installations and facilities after realization) are not necessary.

On the contrary, the scope of the radiological monitoring should be reduced with the progress of the decommissioning activities (see [50], reduction of the radiological monitoring in the EWN).

BREF on Best Available Techniques for the Waste Treatments Industries [211]

The management and treatment of RAW is excluded from the IPPC Directive and excluded from this BREF, but the applicability to conventional waste, generated from decommissioning (phase 1 and phase 2) of the KNPP Units 1 -4 has to be checked.

Conventional waste from decommissioning consist of Category I material (not contaminated and restriction free), Category II material (suspect material) and Category III (contaminated material) after decontamination and free release.

The basic reasons for treatment of waste, stated in this BREF are:

- To reduce the hazardous nature of waste
- To separate the waste into its individual components, some or all of which can be put to further use/treatment
- To reduce the amount of waste which has to be finally sent for disposal
- To transform the waste into useful material
- In this BREF 940 techniques are actually included and considered in the determination of BAT. These techniques can be assigned to the following types of installations:
- Waste transfer
- Biological treatment
- Physic-chemical treatment of waste
- Physic-chemical treatment of waste water
- Treatment of ashes and flue gas cleaning residues
- Treatment of waste catalyst
- Treatment of activated carbon and resin
- Treatment of waste contaminated with PCB
- Treatment of waste oil
- Treatment of waste solvent
- Treatment of waste acids and base
- Treatment of contaminated woo
- Treatment of contaminated refractory ceramics
- Preparation of waste to be used as fuel

This BREF is addressed to the waste treatment industry. According to the EU law for waste management the treatment of waste is strictly prohibited for companies without permission for the required waste treatment technology.

Thus the normal way is that the different kinds of waste are given to specialized waste treatment companies which have the appropriate permission.

For a decommissioning project of WWER 440 reactor sites it is recommended to find a similar way like it was decided for EWN. The EWN is certified as “Waste

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Management Facility" [50] and based on this certification the responsible department is legitimated to the waste related activities sampling (only EWN site), sorting, transport on site and out of site, interim storage of not hazardous waste and interim storage of hazardous waste in a permitted storage.

The following part includes review of the requirements for activities that can be performed during the management of conventional waste from decommissioning:

- Storage and handling (see BREF 2.1.4, page 36)

This part is related to the storage of waste in the waste treatment facility before treatment.

- Decommissioning (2.1.6, page 43)

This part is related to the decommissioning at the end of life of a waste treatment facility.

- Size reduction (2.1.8, page 2.1.8)

This part is related to shredder facilities for size reduction. The cutting of scrap metals, an important activity for metallic waste from decommissioning, is not included.

- Waste Composition characterization (4.1.1.1, page 279)

This part is a methodology with steps to identify unknown waste and the determination of pollutants. This methodology is important for the internal or external laboratory responsible for waste characterization.

- Pre-acceptance procedure (4.1.1.2, page 283)

This part is a description of the methodology for the determination of acceptance criteria for the waste management facility.

- Sampling (4.1.1.4, page 289)

This part describes the sampling requirements for determination of waste composition characterization and pre-acceptance procedure in the laboratory.

- Handling of solid waste (4.1.4.7, page 328)

This part is related to storages of all kinds of solid waste, but not relevant to scrap yards or storage of building and concrete structures, used during dismantling of NPP.

BREF on industrial cooling systems [212]

Subject of this BREF are the industrial cooling systems preforming the heat exchange between the process and coolant systems via heat exchangers. The coolant transports the heat into the environment. In the KNPP the heat is transported into the Danube.

Thus the cooling of cutting/sectioning activities during dismantling of components and facilities are per definition not industrial cooling systems.

Main environmental aspects of industrial cooling systems are:

- Energy consumption,
- Emission of heat in surface waters,

– Emission of water pollutants (e.g. additives of the cooling water, corrosion products).

For the process of decommissioning and dismantling of the KNPP Units 1-4 additional industrial cooling systems are not needed. In comparison to the operation phase, the existing cooling systems have been significantly reduced in terms of need for cooling and thus the heat emissions are very low.

Taking into account that the cooling systems of KNPP Units 1-4 will be dismantled themselves, improvement of the coolant systems according BAT requirements is not necessary.

Summary

The BREFs with possible relevancy to the decommissioning project were assessed, although the IPPC Directive is not valid for decommissioning of NPPs (not listed in Annex I).

When taking into account that the decommissioning experience is worldwide assessed and evaluated by the IAEA Decommission network activities included the experience from WWER 440 decommissioning, the BREF on Economics and Cross-Media Effects is not needed for the assessment of BAT for this decommissioning project.

The KNPP monitoring programs for radiological monitoring and monitoring of non-radiological parameters of KNPP (chapter 1.16) fulfill formally (the IPPC Directive does not include operation and decommissioning of nuclear power plants) all the requirements of the general principles of this BREF.

The BAT requirements for treatment of waste are valid for the waste treatment industry. A NPP under decommissioning is not a facility for treatment of non-radioactive waste, but moreover a company for waste management activities. Interim storage, sampling and waste characterization must be executed regarding the requirements of BAT.

The best way according to EWN experience is the elaboration of a manual for conventional waste management (see chapter 6 and [50]) with detailed instructions for all waste management activities.

These instructions must be elaborated under consideration of the relevant requirements of the BREF. Another important stipulation in the manual for conventional waste management must be the control/auditing of waste treatment facilities, which receive waste from KNPP before contract signing.

Taking into account that the cooling systems of KNPP Units 1-4 will be dismantled themselves, improvement of the coolant systems according BAT requirements is not necessary.

2.3.2 IAEA standards and documents related to NPP decommissioning

According to its Statute, the IAEA is authorized to foster the exchange of scientific information and technical experience information on the uses of atomic energy, nuclear fuel cycle, radioactive waste management and decommissioning.

In comparison to the experience, information exchange and evaluation and assessment of the Best Available Techniques in form of BREFs, these processes are much more

dynamic in the IAEA, on a high level of cooperation and coordination, and the use of the worldwide experience. An International Decommissioning Network (IDN) was launched in 2007 to promote safe and efficient practices in the execution of decommissioning programmes.

At present altogether 63 IAEA publications on decommissioning and decontamination are listed on the IAEA website, 11 Safety Series documents, 27 Technical Reports, 19 Technical Documents and 6 other documents. In the following part the compliance of the KNPP decommissioning project with the in this regard important IAEA documents is assessed.

Safety Series Documents

These documents are divided in three categories:

- Safety Fundamentals: present the safety objective and principles as basis for the Safety Requirements,
- Safety Requirements: establishes the requirements that must be met to ensure the protection of people and the environment,
- Safety Guides: provide recommendations and guidance on how to comply with the Safety Requirements. They present international good practices.

The following document is a Safety Requirement, the other assessed Safety Series documents are Safety Guides.

Decommissioning of Facilities Using Radioactive Material [214]

This publication applies to all types of facilities but includes NPPs and addresses radiological hazards from decommissioning activities. These activities encompass *the preparatory phases* including decommissioning strategy and radiological characterization and *the implementation phases* included the final decommissioning plan for approval by the authority, project management, realization of the decommissioning plan and the management of waste.

In Section 2 of this document the requirements for the protection of health (workers and public) and for the protection of the environment are established. These requirements are common with them for operation of NPP in many cases. Specific for decommissioning are the requirements: protection against normal exposures and for prevention exposures from incidents or accidents during decommissioning activities; safety culture and specific training related to the decommissioning activities; environmental radiation protection during the entire decommissioning process and beyond the facility is released with restrictions.

In Section 3 the responsibilities associated with decommissioning are stated. A legal framework for all phases of decommissioning is necessary, under the responsibilities of the government and the regulatory body. The operating organization is responsible for planning and carrying out the whole decommissioning process in compliance with the legal framework and is also responsible for all aspects of safety and environmental protection for all above described phases of decommissioning.

In Section 4 basic requirements for the definition of the Decommissioning Strategy by the operating organization are stated. It is important that “the preferred strategy shall be immediate dismantling”

In Section 5 the requirements for a Decommissioning Plan are stated. The final Decommissioning Plan must be supported by a Safety Assessment Report and is a basic document for approval by the regulatory body.

In Section 7 the requirements for Decommissioning Management are stated. A main demand is a management and personal structure related to the safe decommissioning. Important requirements are: qualification and training of staff in each position; clear definition of responsibilities on all levels of the personal structure; and a comprehensive quality assurance programme, applied to all phases of decommissioning.

In Section 8 the requirements for Conduct of Decommissioning inter alia are stated: responsible organization structure for all aspects of safety and environmental protection during decommissioning activities; preparation and implementation of appropriate safety instructions; optimized decontamination and dismantling (ALARA); justification and approval before the use of new decommissioning methods; and control of all activities by the regulatory body.

In Section 9 the requirements for Completion of Decommissioning are stated.

On the basis of the actual available documents for decommissioning of KNPP Units 1-4 can be assessed that at the present phase, the start of the implementation with the final decommissioning plan the requirements of this document are fulfilled.

Radiation Protection and Radioactive Waste Management during NPP operation [215]

This Safety Guide is not listed in the above mentioned list of decommissioning documents. In the introduction is stated that this Guide does not address the decommissioning of nuclear power plants and refers to the following document:

Decommissioning of Nuclear Power Plants and Research Reactors [56]

This Safety Guide is based on the above assessed Safety Requirements for Decommissioning [214] and provides more detailed recommendations for promotion of fulfilling the basic requirements and is related to the decommissioning of nuclear power plants and research reactors. Thus the structure and contents of this document are similar to the above mentioned Safety Requirements.

Key Issues specific to decommissioning are outlined in Section 2. Issues to be taken into account for KNPP decommissioning are inter alia definition of the term decommissioning: that some activities may be carried out after shut down under the operating license (e.g. decontamination, treatment of operational waste and assessment of the radioactive inventory); radiological criteria for removal of regulatory control from materials (after free release); optimal (minimal) generation of radioactive waste by dismantling and decontamination.

In *Section 3* the selection process for the decommissioning option (strategy) is discussed. It should be underlined, that the experience from previous, similar decommissioning projects should be used. This selection process for the KNPP Units 1-4 is described above in this chapter.

Section 4 describes the considerations at the design, construction and operation which facilitates the decommissioning. This section is not relevant for KNPP decommissioning.

In *Section 5* the decommissioning planning, the safety assessment and financial assurance is addressed. For the final planning is stated: "The experience from previous decommissioning should be appropriately taken into account as a matter of principle" For the "phased" decommissioning, as planned for KNPP with a short phase of SE, are listed the requirements for the preparation and control.

Section 6 describes critical tasks of decommissioning. Tasks of importance for KNPP are:

- A survey of radiological and non radiological hazards during operation,
- A radiation – and contamination register,
- An inventory register of all hazardous chemicals in the installation,
- Fuel removal

These tasks are fulfilled for this decommissioning project. The task

- Decontamination

is at the state of technical preparation and planning of the procedure. The task

- Dismantling methods and techniques

is at the state of technical preparation. According to EWN experience the best way to select the dismantling method/technique is during the elaboration of the documentation for part projects and work packages when all influencing factors (e.g. material, radiological situation) are assessed in detail. Last but not least the comprehensive EWN experience should be used.

The task

- Final radiological survey at the completion of all decontamination and dismantling activities and documentation in a final survey report

is a main prerequisite for the release of the site from the atomic law and will be realized after completion of the decommissioning process.

In *Section 7* requirements for the management during decommissioning are listed. The requirements for staffing and training: competent staff, familiar with technical details of the site and radiation and health protection; additional training for decontamination, dismantling and demolition, qualification for special tasks (e.g. robotics and remote dismantling); can be fulfilled in the best way by the employment of experienced personal from operation and maintenance of KNPP Units 1-4.

A main requirement for organization and control is an organizational structure appropriate to the decommissioning process with clear declination of authorities and responsibilities on all levels. It is proposed to form a project structure for managing the decommissioning project. This is corresponding with the EWN experience.

The requirements for radiation protection and on site and off site radiological monitoring can be fulfilled during the decommissioning process without problems, as the KNPP has a high level of safety culture.

The requirements for waste management, RAW management and management of conventional waste, during decommissioning can be fulfilled by the application of the updated RAW Program of KNPP [162] and systematic application of the SNF and RAW strategy until 2030, which includes the decommissioning and ensure integrated approach by SE RAW infrastructure.

The requirements for emergency planning and physical protection and safeguards during the decommissioning period can be fulfilled on the basis of the existing SAR

The requirements for quality assurance and documentation can be most suitable realized with the implementation of the above mentioned project management for decommissioning.

Technical Reports

The Technical Reports and other publications (without Safety Standard Series) are instruments for information, knowledge and experience transfer and practical guidance.

Managing low radioactivity material from decommissioning of nuclear facilities [217]

This report focuses on materials from decommissioning with low or very low level of radioactive concentrations. High or intermediate level waste for disposal in repositories and operational waste are not focused on in this report.

Very important is the availability of radiological clearance criteria and technical solutions to achieve them. These clearance criteria are given by the law of the EU [218]. In this EURATOM Directive nuclide specific limited values for the clearance of materials are given. Thus for KNPP decommissioning legal clearance criteria are existing. According to EWN experience [50] the predominant technical solutions to achieve this criteria are cutting and decontamination. In this respect this document is of lower importance for the KNPP decommissioning project.

The Decommissioning of WWER Type Nuclear Power Plants[57]

This report is the result of a Technical Co-operation Project and describes the state of knowledge in the preparatory phase of decommissioning of WWER NPPs. The first WWER decommissioning project (EWN) started during the project period. Thus only few practical experiences from decommissioning execution are described.

Planning, managing and organizing the decommissioning of nuclear facilities: lessons learned [219]

This report should be a source of information and experience for the preparation of decommissioning projects. The experience from the EWN decommissioning at a more advanced state is included in this document, as EWN staff were contributors.

Innovative and Adaptive Technologies in Decommissioning of Nuclear Facilities [220]

This document is a final report of a research project. The state-of-the-art, similar to the Best Available Techniques, and pending issues are described for:

- Segmentation/cutting

- Decontamination
- Radiological characterization
- Restricted vs. unrestricted release
- Tools to support planning and decision making.

This document should be used by KNPP for detailed planning.

2.3.3 Comparison of Alternative 1 and Alternative 2

2.3.3.1 Comparison of Alternatives based on the consequences of the implementation of the different alternatives

The comparison of Alternative 1 and Alternative 2 is made on the basis of the results as can be seen in the analyses given in [7] (Updated Decommissioning Strategy) within the assessment of the potential consequences from a respective postponement of the decommissioning process. The consequences of postponement due to Alternative 1 – Deferred Dismantling may cause economic, social and potentially possible radiological impacts, as described below.

Economic consequences

The most obvious economical result from a delay of each project is the increase of costs according to the respective inflation rate. In the Updated strategy for decommissioning of Units 1 to 4 of KNPP [7] it was assumed that the average inflation rate in Bulgaria within the next decade will be 6 %.

The EBRD support funds availability has a much bigger economic impact. The financial support on behalf of the European Union to assist the decommissioning efforts is specified in a special program for assistance of the decommissioning activities over the period 2000-2011. The Kozloduy International Decommissioning Support Fund (KIDSF), administered by the European Bank for Reconstruction and Development (EBRD) is the main source for actions related to the grants under this Program. Therefore any delay in the decision making or in the financial assurance of the investments may eventually result in an unavailability of the KIDSF for pre-decommissioning and decommissioning projects.

The final shut-down of Kozloduy NPP units has to be executed under the conditions of a valid operational license during the so called post-operational E-mode phase till the issuance of a decommissioning permit. On the other hand, the decommissioning permit can only be issued upon completion of definite conditions (removed spent fuel, submitted documentation and ready decommissioning infrastructure). Maintaining of a unit under the conditions of the operating license also means that a bigger number of personnel related to the nuclear safety assurance are needed. This means that delays of the pre-decommissioning projects unconditionally lead to considerably higher expenses for the operational personnel of the units. The current number of the employees at Units 1-4 at 01.05.2012 is less than 970 and this number will be gradually decreased. It is supposed that one year delay in Units 1-4 decommissioning license issuance will have an impact on the cost of the personnel.

Radiological consequences

One of the strongest arguments for the Deferred Dismantling Alternative – Updated Decommissioning Strategy [7] is the reduction of the radiological impact during the

dismantling. But it is clear, that the overall radiological impact resulting from the delay will be a balance between the positive and the negative factors. The most significant factors are:

- The reduction of the occupational exposure dose will be significant only in case of the main share of the doses due to the short-lived isotopes (mostly ^{60}Co);
- The dose rate in the buildings predominantly depends on the ^{137}Cs containing contamination;

Upon elaboration of a detailed prognosis for the dose budget by activities (see chapter 7 of document [36], satisfactory information will be available concerning the gross dose intake value for the personnel due to postponement of the decommissioning. There is a considerable chance that the delay might result into an increase of the total exposure dose, because most of the operations may take more time and will be performed at areas with higher dose rate.

Social consequences

The assessment of the social consequences from the delay in the decommissioning projects is not synonymous to the assessment of the other impacts.

- Any delay means a prolongation of the post-operational stage and due to this - leads to a higher employment rate. A higher staffing rate shall be maintained for the units that are under the operational licenses conditions due to nuclear safety reasons.
- The long term maintenance of shutdown reactors is not motivational for people, the loss of involvement in the work leads to a loss of experience, which on its side results in loss of operational knowledge, which is needed for the successful decommissioning. Alternative 2 provides opportunity to prevent these consequences. It was planned for instance and is under way of application to transfer part of the personnel of the Electricity Production 1 (EP-1) of KNPP to SE ”RAW” with conservation of their working status and social services already used from them.

The very decommissioning projects will create hundreds of jobs, for which various skills and qualifications are required. This figure won't be as big as in case of the operational mode/Electricity Generation/, but will release in some way the social consequences of the shut-down of the units.

The proposed philosophy behind the updated decommissioning strategy is a smooth, even and continuous usage of human and financial resources as well as of waste treatment facilities, hence it is proposed to adopt the name ‘Continuous Dismantling’ for the updated strategy.

The key features of the updated decommissioning strategy and the Continuous Dismantling alternative [7] are:

- Shortened decommissioning period;
- Even distribution of dismantling activities;
- Even and more effective usage of financial and human resources;
- Even loading of the existing waste treatment infrastructure;

- Keeping and providing jobs over the entire decommissioning of the units;
- Optimal use of the existing personnel knowledge and experience.

In appendix 11.2.1 is given an exemple of selection of alternatives from other decommissioning projects: “Comparison and justification of decommissioning alternatives based on the EWN experience in Greifswald NPP and V1 NPP Bohunice, Units 1 and 2”.

2.3.3.2 Total cost for decommissioning according the selected alternative

According to the Updated Strategy for Decommissioning of Units 1-4 Kozloduy NPP [7] respectively the Continuous Dismantling Alternative, the cost and resourses estimate for decommissioning are presented in appendix 11.2.2 to this chapter. In this part the rough assessment of the cost for dismantling of Units 1-4 KNPP and also the cost for qualification of the personnel for site activities are included.

The methodology used for estimate of the total costs is described in more details in the EC document "Investigation for development of the methodology for calculation of the cost and planning the decommissioning activities”, prepared by EDF project ENV.C2/ETU/2000/0062.

According to this methodology the total costs are divided in the following four groups:

- Costs for engineering activities;
- Cost for surveillance and operation;
- Cost for decommissioning activities in the site;
- Cost for waste disposal

This method is used for expenses assessment of dismantling during decommissioning and treatment and conditioning of the operational waste

Expenses for engineering activities

This part covers all cost for engineering activities and investigations, concerning the strategy, preliminary design, development of the safety analysis report and environmental impact assessment, licenses management of the project and also expense for KPMU.

Cost for surveillance and operation

This part includes all expenses concerning the operation of the facilities located in the site total maintenance of the site and operation, maintenance of the decommissioning activities).

The operational cost includes maintenance and administrative expenses (medical insurance, administrative services).

Cost for decommissioning activities in the site

In this part are included all cost, connected to the decommissioning activities. This means different type of investigation, analysis, decontamination, dismantling activities and waste conditioning.

The cost for personnel is included in the decommissioning activities. The cost for dismantling includes two parts. First part is the investment allocated for the

construction of additional facilities needed for decommissioning activities. Second part is investment for remote control of the facility aiming decrease of staff number during the SE operation. These investments are includes in the dismantling costs.

Cost for waste disposal

In this cost are includes all expenses for waste transport and disposal. In this cost are taken into account the amounts of the waste transported to the disposal facility and also amounts and radioactivity of the RAW, generated during the dismantling and obtained from the conditioning of the RAW in normal operation conditions.

The costs repartition is as follows:

- - Cost for containers depending of the radioactivity,
- - Cost for transportation of RAW from KNPP to the disposal facility,
- - Cost for final disposal of container with waste.

The results analysis of the decommissioning cost are presented in Appendix 11.2.2. in reference of the provided input data.

2.3.3.3 Expert assessment of the Alternatives

Assessment of the Alternatives related to the environmental impact on Air

The analysis of the proposed alternatives for decommissioning of Units 1-4 (Alternative 0 – No Dismantling; Alternative 1 – Deferred Dismantling and Alternative 2 – Continuous Dismantling) shows that concerning the impact on the atmosphere Alternative 2 is the most appropriate one. Alternative 0 raises the risk of potential discharges into the environment (the RAW storage tanks design characteristics do not allow for long-time storage) and as a result there is higher probability of radiation background and gas aerosol emission increase. Alternative 1 sharply decreases the potential risk of adverse impact on people and environment but the risk of radioactive emission in the atmosphere rises because of the longer period of the SE and there is higher risk of damage of some of the barriers.

Under the proposed Alternative 2 for Continuous Dismantling, radioactive gas releases during the decommissioning period are expected to be considerably lower than the permissible limits and the pollution in the NPP region to be lower compared to the operational period, provided that the decommissioning is completed in accordance with the stated technological and control rules.

Assessment of the Alternatives related to the environment impact on Surface and Ground Water

On the basis of the complex analysis of the proposed alternatives for decommissioning of Units 1-4 it was realized that concerning the impact on the water component, Alternative 2 is the most appropriate one, because in case of Alternative 0 and in case of the 35 years of transitional period corresponding to Alternative 1, there is higher risk of possible leaks of radioactive substances, arising of other accidents and sources of negative impact on the water.

The preparation for SE will lead to reduction of the effluents releases into the environment, which means that the expected amount of generated liquid waste will also be reduced. As a result of the dismantling activities of part of the equipment, the

amount of liquid RAW is expected to increase. Therefore, a dedicated treatment facility is foreseen. All liquid RAW will be treated, which upon dosimetric control will be discharged directly in Danube River.

Assessment of the Alternatives related to the environment impact on Flora

As a result of the complex analysis of the proposed alternatives for the decommissioning of KNPP Units 1-4 (Alternative 0 – No Dismantling; Alternative 1 – Deferred Dismantling and Alternative 2 – Continuous Dismantling) it was found out that Alternative 2 has the lowest impact on the vegetation (flora), because it allows minimizing the adverse impact on this component. In case of Alternative 0 and in case of the 35 years of transitional period corresponding to Alternative 1, the risk of possible leaks of radioactive substances, the risk of accidents and other adverse impact on the vegetation (flora) from the adjacent territories to the NPP will be increased.

Assessment of Alternatives related to the environment impact on Landscape

In the framework of this project the following alternatives have been considered for decommissioning of the units:

– Alternative Zero – No Dismantling

In consideration of this alternative a higher risk of contamination, leaks of radioactive substances etc. has to be taken into account, which will lead to adverse impacts on the landscape components. In this respect this alternative is the most unacceptable from the point of view of the landscape protection.

– Alternative 1 - Deferred Dismantling

This alternative inheres a 35-years transitional period between the preparatory works and the beginning of the dismantling, which also causes risks of possible accidents, leaks of radioactive substances etc. that could impact the landscape components. Therefore, this alternative is unacceptable in terms of landscape protection.

– Alternative 2 - Continuous Dismantling

The main characteristics of this alternative are the immediate and continuous dismantling of the equipment and facilities.

Provided that the decommissioning is completed under the condition of correct performance of the activities on decontamination and disposal as well as under continuous control, this alternative can be seen as riskless concerning landscape components pollution and due to this reason this alternative can be considered as the most suitable one.

Assessment of the Alternatives related to the impact on the Social and Socio-Economic Environment

Shutdown of the Units 1-4 has had a negative impact not only on Kozloduy NPP but on the regional and national level in many fields- economics, production, social, professional, personal, career-related etc.

The main problem examined in this part of the project is the selection of the most suitable alternative for decommissioning of the units after their shutdown in environmental, economic, human resources and social aspects.

Comparative analysis of the alternatives offered in the project for decommissioning of the shutdown Units 1-4 of Kozloduy NPP: Zero Alternative – No Dismantling, lack of any activity in this regard; Alternative 1 – Deferred Dismantling and Alternative 2 – Continuous Dismantling shows their differences, disadvantages or advantages influencing the socio-economic development both of the NPP and of the socio-economic situation and its adjacent territory.

Detailed description of the above Alternatives is provided in Chapter 1 of the present assessment. Along with this, in section 2.4 of this Chapter, the economic and social consequences from the realization of Alternative 1 or Alternative 2 are specified.

From a socio-economic point of view, the selection of an alternative option and the associated consequences regarding the decommissioning of the shutdown units of Kozloduy NPP will have a more sensitive impact on the NPP itself than on the socio-economic condition of its adjacent territory.

The Zero Alternative examined in this regard is obviously the most inappropriate one both from the environmental and socio-economic points of view, as well as from moral point of view, as far as it solves neither the environmental, nor the economic challenges and the responsibility for solution of the problem is transferred to the future generations. In terms of the socio-economic aspects concerning this Alternative, there will be more people of the operational staff who will remain unemployed due to their redundancy from the employed positions in NPP.

This means a complication of the socio-economic situation and increasing of the level of unemployment in the region, which as a result of the economic crisis shows a trend of increasing up to about 10 %. This would mean lower incomes of the local population and especially of the families having unemployed persons redundant from their jobs in the NPP, thus losing comparatively higher incomes during their employment. Besides, the energy, experience, knowledge, qualification and motivation of the staff occupied during the operation will be lost. Also, it is important to note that even on a psychological point of view when people lose their jobs and go to the labour market, this is related to a psychological traumatism.

Alternative 1 – Deferred Dismantling has also a lot of negative aspects on socio-economic point of view. Most important of them are:

- High degree of risk probability remains in view of the components of environment, health and safety of the staff employed in NPP as well as of the health and safety of the population of the territory adjacent to NPP.
- Staff redundant from the operation of the shutdown reactors will create a rise in unemployment in the region, respectively there will be a reduction of their personal incomes and of the ones of their families, thus resulting in an increase of the social tension as well. Besides, no working places will be opened for the staff with the respective qualification occupied before in the activities of the operation of the reactors, which even partially would compensate the level of the

unemployment in the region. Also, the costs of NPP for the maintenance of the conservation condition for safety disposal of the radioactive waste, economic losses from the inflation levels, losses of financial funds by EBRD amounting to hundred million euro granted to our country for the decommissioning of the shutdown reactors etc. will be increased.

Comparing the two alternatives above, Continuous Dismantling (Alternative 2) has certain advantages, such as:

- Preparation works and the decommissioning activities of the shutdown Units start at a very early stage;
- Decommissioning period is reduced;
- Jobs positions for a longer period of time will be established thus mitigating the socio-economic problems related to the unemployment;
- Continuous and even execution of the different planned decommissioning activities on the previously shutdown reactors will be achieved;
- The period for safe enclosure of the shutdown facilities is shortened;
- There are real conditions for utilizaton of funds provided as a grant by EBRD;
- Employment of the larger part of the staff redundant from the operation for longer period of time in the process of the decommissioning of the reactors;
- Smoother and trouble-free transition of the redundant staff with regard to re-training for activities related to the decommissioning will be provided;
- There are time, conditions and capacities available for provision of succession during the re-qualification of the different stages and categories of the staff by re-directing of the staff from operation positions to positions requiring knowledge and skills related to the decommissioning processes;
- Maintenance and provision of jobs for the redundant specialists from the operational staff, using their rich experience and knowledge, achieving greater efficiency in the new activities.
- The personnel (highly qualified and experienced professionals who have operated the suspended reactors) redirected to employment in the new decommissioning activities of the units, would also have another positive effect, i.e. provision of the qualified staff for eventual construction and operation of the new 7th unit of Kozloduy NPP and/or for the commissioning and operation of Belene NPP or KNPP Unit 7.

Along with the above mentioned, the implementation of Alternative 2 has some disadvantages such as: gradual reduction of the staff will partly be through natural turnover such as retirement of existing staff and resignations, another part will be redirected to appropriate and adequate functions in other structures of NPP. Obviously, due to different reasons one small part of them will be made redundant from NPP. As per NPP data (Statement of the Manager of the "Administration and Control" Division) the staff directly involved in Units 1 to 4 in 2008 was 1092 persons. According, to the elaborated by NPP "Program for management of social consequences during the decommissioning of Units 1-4 of Kozloduy NPP [157] in the middle of 2010 the number of employees in these units decreased to less than 970

persons and by the end of the forecast period 2012-2018 it will be reduced gradually to 663 persons needed for the respective activities.

Precisely these experts may require re-qualification, re-orientation or re-appointment, with their agreement, to suitable positions within the NPP structure.

Re-direction of the able-bodied staff made redundant from their previous operational positions in the previously shutdown Units 1-4 to new work places for decommissioning of the units is a delicate and hard activity, moreover considering the conditions of the continuous and ongoing crisis and increasing unemployment both in the country and KNPP region.

Based on the above, it is obvious that a more severe problematic situation will occur in the first years from the implementation of the offered Alternative 2. It will be related to the redundancies of part of the staff currently employed in the operation of the shutdown units and to the measures for their re-qualification in view of the decommissioning or some other mitigation restructuring measures for this part of them, which will join the category of retired people or will enter the unemployment system. How many people of the staff from the shutdown units, and at which positions, how many people from the staff involved in the operation of Units 1 -4 would be re-qualified, how many of them would go to other or similar free places and positions in NPP system; what would be the motivation, intentions and behavior of the people, how many of them are of retirement age and would retire or would prefer to go to the labor market until the respective age or the compliance with the other requirements to retirement could be determined and could be a subject of separate specially oriented sociological investigation.

A good basis for that would be the "Program for management of the social consequences of decommissioning of Units 1-4 of Kozloduy NPP" [157] established by the NPP Management.

The fact that there already is such a program available shows the responsible attitude of the NPP management to the people, employees of the shutdown units and to the measures and actions to be applied in order to avoid a critical situation caused by their redundancy, their eventual re-qualification or redirection to the free work places in NPP system. The program along with the clarification of the objectives, tasks and responsibilities for provision of the employment in NPP system during the decommissioning of the shutdown Units aims also to provide an alternative employment and social protection of this part of the staff that will be laid off from work in NPP. That is why, the measures, foreseen by the NPP are directed towards the extension of the basis and potential for re-qualification of the staff in the Training center of the nuclear power plant, establishment of training structure for the maintenance staff and of a welding center. This could reduce the number of redundant experts, employed in the operation of the shutdown units thus reducing the pressure on the labor market in Kozloduy municipality or in the other municipalities involved in the scope of the investigated territory.

In order to retain the highly qualified staff prior to granting of the Decommissioning Permit a scheme for target indemnifications until 2012 was elaborated for this part of the staff. It is also foreseen that Kozloduy NPP will participate with Non-governmental organizations, Association "IRIRK" and the Kozloduy Business Centre

to achieve an additional use of their capacities for motivated training and for qualification and re-qualification of work force in the region of Kozloduy NPP concerning both staff and their family members. On the basis of signed agreement between KNPP and SE ”RAW” it is planned to transfer part of the personnel of the Electricity Production 1 (EP-1) of KNPP to SE ”RAW” with conservation of their working status and social services already used by them. Also, another expression of these cares and responsibilities of the NPP management is the possibility for training and financial support by leasing schemes of that part of the unemployed people who could start their own business.

Assessment of the Alternatives related to Health Risk

The analysis of the considered alternatives for decommissioning of Units 1-4 shows that related to the occupational health risk reduction the selected project Alternative 2 – Continuous Dismantling is more appropriate. The decommissioning, which is fulfilled in accordance with the stated technological and control rules concerning the decontamination and dismantling activities, can lead to a reduction of the exposure dose of the operational staff and of the dose rate in the buildings which is mainly caused by contamination with prevailing ^{137}Cs content.

During the decommissioning, which is fulfilled in accordance with the stated technological and control rules concerning the decontamination and dismantling activities, the rate of radioactive gaseous emissions within the NPP region will be lower than during the operational stage and consequently will lead to a reduction of the health risk for the population in comparison to the operational stage.

Any delay of the decommissioning of the units will lead to an increase of the general dose consumption for the personnel, as well as for the public and next generations.

Assessment of the Alternatives related to Cultural Heritage, Protected Territories and Protected Areas

On the basis of the complex analysis of the project Alternatives for decommissioning of Units 1-4 (Alternative 0 – No Dismantling; Alternative 1 – Deferred Dismantling and Alternative 2 – Continuous Dismantling) it was found out that concerning the impact on the vegetation and habitats in the Protected Territories and Protected Areas, Alternative 2 is the most appropriate one, because it allows to minimize the adverse impact on these components. In case of Alternative 0 and Alternative 1, the risk of possible leaks of radioactive substances, the risk of accidents and other adverse impacts on the vegetation and habitats in the Protected Territories and Protected Areas is much higher.

The comparison between the decommissioning alternatives for Greifsvald NPP Units 1-5 and Bohunice NPP and the decommissioning alternatives for KNPP Units 1-4 (Appendix 11.2.1 and 11.2.2) show that the chosen Alternative 2 for decommissioning of KNPP Units 1-4 is the most suitable one, also considering the IAEA recommendations and indicators.

2.3.4 Matrix of the Alternatives comparison

Explanations to the matrixes

The used matrix (according to ToR [9]) was prepared on the basis of the requirements of the EC regulatory documents [44 - 46].

The origin of the Matrix is the EU Document "EC Nuclear Safety and Environment, Environmental Impact Assessment for the Decommissioning Nuclear Installation" [1].

Table 2.3.4-1: Qualitative assessment of Alternative A0 – No Dismantling

The Alternative A0 is characterized by the execution of the "E" mode activities, which are described in the section 2.1.1. No dismantling activities will be executed afterwards.

Table 2.3.4-2: Qualitative assessment of Alternative A1 – Deferred Dismantling

Table 2.3.4-3: Qualitative assessment of Alternative A2 – Continuous Dismantling

These two alternatives have approximately the same main steps. The most important difference between the Alternatives A1 and A2 is the duration of the SE operation.

For the qualitative assessment of the impacts it has to be taken into account, that the Alternative A0 is not acceptable according to the IAEA guidelines [57] and national and EC regulatory requirements.

As described above, the impacts of the Alternatives 1 and 2 are almost the same. Based on the qualitative assessment of the environmental impacts the differences between these two Alternatives consist in:

- Modification of industrial site (A1 = Negative, A2 = Positive), related to the population and economy factors
- Risk of contaminated releases (A1 = possible impact)
- Level of occupation (A1 = not acceptable, A2 = acceptable)

Justified by this qualitative assessment the Alternative 2 (Continuous Dismantling) was assessed as the preferred Alternative.

TABLE 2.3.4-1
QUALITATIVE ASSESSMENT OF ALTERNATIVE A0
MAIN ENVIRONMENTAL IMPACTS

		CHARACTERISATION OF IMPACTS																STATEMENT				EVALUATION			
		Positive	Negative	Direct	Indirect	Synergy/ Accumulation		Temporary	Permanent	Localized	Extensive	Recoverable/Modifiable	Irrecoverable/Definitive	Reversible/Unstable	Irreversible/Stable	Affects protected resources (1)		Minimization/mitigation measures required	Probabilities of occurrence (2)	Acceptable	Not acceptable	Compatible	Moderate	Severe	Critical
						yes	no									yes	no								
Env. Factor	Impact																								
Air	Demolitions																								
	Earth movements																								
	Transport of materials		X	X		X		X				X		X			X	X	A	X		X			
	Effluent releases		X	X		X			X		X	X		X			X	X	B		X		X		
Noise	Demolitions																								
	Earth movements																								
	Transport of materials		X	X		X		X		X		X		X			X	X	A	X		X			
Water	Effluent releases		X	X				X	X		X	X		X			X	X	B		X	X			
Landscape	Modification of industrial buildings																								
	Use of tips																								
Land use	Modification of industrial site																								
	Use of tips																								
	Storage of radioactive and non-radioactive waste		X	X		X			X				X		X		X		B	X		X			
Humans (health)	Transport of materials		X	X		X		X		X		X		X			X		B	X		X			
	Handling of hazardous materials		X	X			X	X		X		X		X			X	X	M	X		Y			
	Effluent releases		X	X		X			X		X	X		X			X	X	B		X		X		
	Risk of contaminated escapes		X		X						X		X		X	X		X	B		X			X	
Pop. / Econ.	Level of occupation		X	X					X	X			X		X		X	X	A		X			X	
	Modification of industrial site		X		X				X				X		X		X	X	M	X			X		

(1)Natural or cultural resource of any type (2) A=High; B=Low; M=Averag

TABLE 2.3.4-2
QUALITATIVE ASSESSMENT OF ALTERNATIVE A1
MAIN ENVIRONMENTAL IMPACTS

		CHARACTERISATION OF IMPACTS																STATEMENT				EVALUATION			
		Positive	Negative	Direct	Indirect	Synergy/ Accumulation		Temporary	Permanent	Localized	Extensive	Recoverable/Modifiable	Irrecoverable/Definitive	Reversible/Unstable	Irreversible/Stable	Affects protected resources (1)		Minimization/mitigation measures required	Probabilities of occurrence (2)	Acceptable	Not acceptable	Compatible	Moderate	Severe	Critical
						yes	no									yes	no								
Env. Factor	Impact																								
Air	Demolitions		X	X		X		X		X		X		X			X		B	X		X			
	Earth movements		X	X			X	X		X		X		X			X		B	X			X		
	Transport of materials		X	X		XX		X				X		X			X	X	A	X		X			
	Effluent releases		X	X		X		X			X	X		X			X	X	M	X			X		
Noise	Demolitions		X	X		X		X		X		X		X			X	X	B	X		X			
	Earth movements		X	X		X		X		X		X		X			X		B	X		X			
	Transport of materials		X	X		X		X		X		X		X			X	X	A	X		Y			
Water	Effluent releases		X	X		X		X			X	X		X			X		M	X		X			
Landscape	Modification of industrial buildings	X			X		X		X	X			X		X		X		B	X		X			
	Use of tips		X				X	X		X			X		X		X		A	X			X		
Land use	Modification of industrial site		X	X			X		X	X			X		X		X		M	X		X			
	Use of tips		X	X			X	X		X			X		X		X		A	X		X			
	Storage of radioactive and non-radioactive waste		X	X		X		X		X			X		X		X		A	X			X		
Humans (health)	Transport of materials		X	X		X		X		X		X		X			X		A	X		X			
	Handling of hazardous materials		X	X			X	X		X		X		X			X	X	M	X		X			
	Effluent releases		X	X		X		X		X		X		X			X		B	X		X			
	Risk of contaminated. escapes		X		X	X			X		X		X		X		X		M	X			X		
Pop. / Econ.	Level of occupation		X	X				X		X		X		X			X	X	A		X			X	
	Modification of industrial site		X	X			X	X		X		X		X			X		M	X			X		

(1)Natural or cultural resource of any type (2) A=High; B=Low; M=Average

TABLE 2.3.4-3
QUALITATIVE ASSESSMENT OF ALTERNATIVE A2
MAIN ENVIRONMENTAL IMPACTS

		CHARACTERISATION OF IMPACTS																STATEMENT				EVALUATION			
		Positive	Negative	Direct	Indirect	Synergy/ Accumulation		Temporary	Permanent	Localized	Extensive	Recoverable/Modifiable	Irrecoverable/Definitive	Reversible/Unstable	Irreversible/Stable	Affects protected resources (1)		Minimization/mitigation measures required	Probabilities of occurrence (2)	Acceptable	Not acceptable	Compatible	Moderate	Severe	Critical
						yes	no									yes	no								
Env. Factor	Impact																								
Air	Demolitions		X	X		X		X		X		X		X			X		B	X		X			
	Earth movements		X	X			X	X		X		X		X			X		B	X		X			
	Transport of materials		X	X		X		X				X		X			X	X	A	X		X			
	Effluent releases		X	X		X		X			X	X		X			X	X	M	X			X		
Noise	Demolitions		X	X		X		X		X		X		X			X	X	B	X		X			
	Earth movements		X	X		X		X		X		X		X			X		B	X		X			
	Transport of materials		X	X		X		X				X		X			X	X	A	X		X			
Water	Effluent releases		X	X		X		X			X	X		X			X		M	X		X			
Landscape	Modification of industrial buildings	X			X		X		X	X			X		X		X		B	X		X			
	Use of tips		X				X	X		X			X		X		X		A	X			X		
Land use	Modification of industrial site		X	X			X		X	X			X		X		X		M	X		X			
	Use of tips		X	X			X	X		X			X		X		X		A	X		X			
	Storage of radioactive and non radioactive waste		X	X		X		X		X			X		X		X		A	X			X		
Humans (health)	Transport of materials		X	X		X		X		X		X		X			X		A	X		X			
	Handling of hazardous materials		X	X			X	X		X		X		X			X	X	M	X		X			
	Effluent releases		X	X		X		X		X		X		X			X	X	M	X		X			
	Risk of contaminated escapes	X			X	X			X		X		X		X		X		M	X		X			
Pop. / Econ.	Level of occupation		X	X				X		X		X		X			X	X	A	X		X			
	Modification of industrial site	X		X		X			X	X		X		X			X		M	X		X			

(1)Natural or cultural resource of any type (2) A=High; B=Low; M=Average