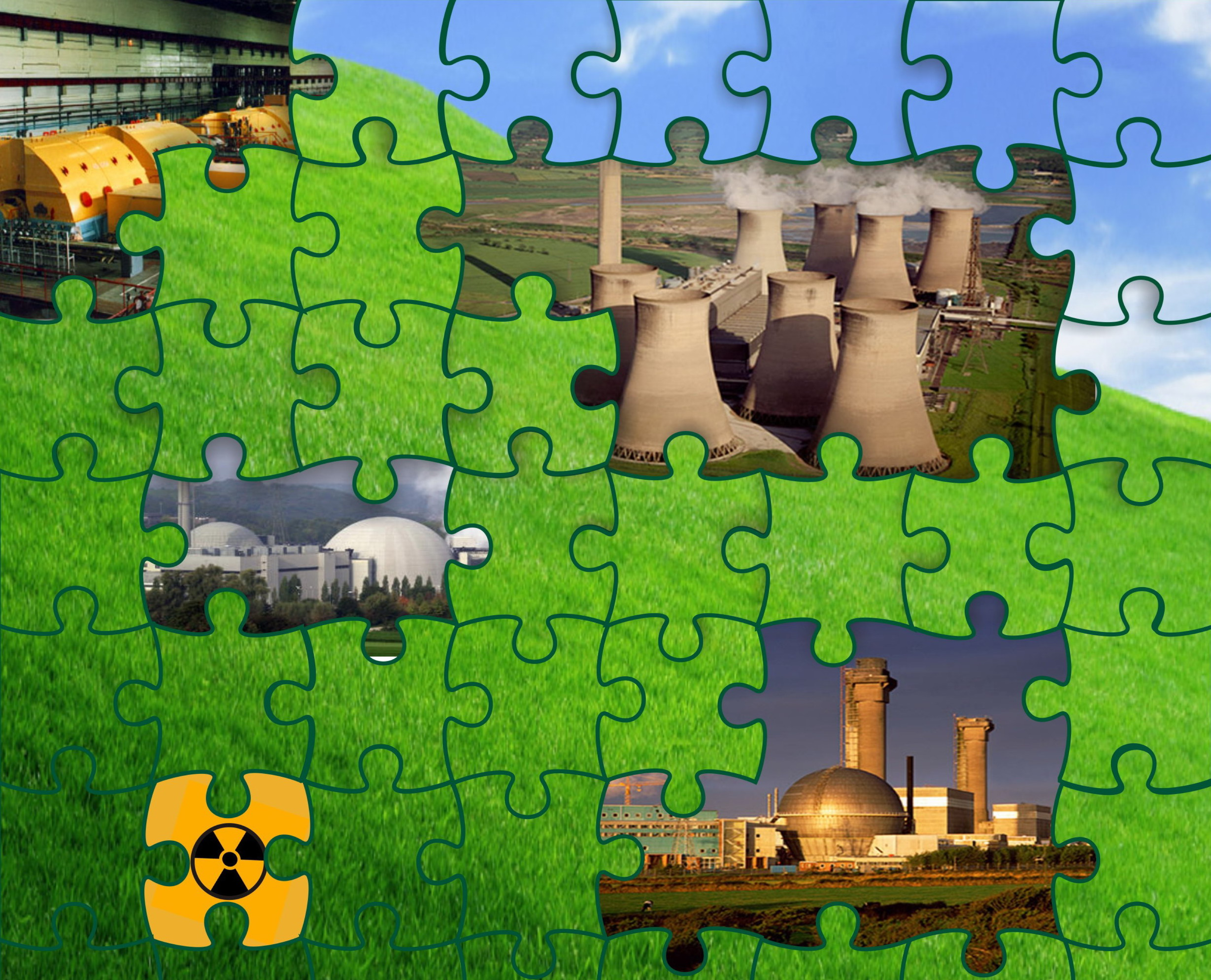

Concept of a Decommission Plan for Old Nuclear Power Reactors

Guiding Principles from Environmental NGOs

DECOMMISSION

WITHDRAWAL OF OLD NUCLEAR POWER PLANTS

CONCEPT OF A DECOMMISSION PLAN FOR OLD NUCLEAR POWER REACTORS

Guiding Principles from Environmental NGOs

GAIA
Apatiti
Murmansk
Oblast

GREENWORLD
Sosnovy Bor
Leningrad oblast

CENTER OF
NUCLEAR ECOLOGY
AND ENERGY POLICY
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ATGAJA
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NATURVERNFOR-
BUND FRIENDS OF
THE EARTH NORWAY
Oslo, Norway

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List of terms and acronyms:

BN-600	fast breeder reactor of 600 MW capacity
BWR	boiling light-water-cooled reactor
CHP	combined heat & power
Ci	Curie
CW	Council of Workers
EBRD	European Bank of Reconstruction and Development
EGP-6	water-graphite channel-type heterogeneous reactor
EURATOM	European Community of Atomic Energy
EU	European Union
GCR	(gas-cooled, graphite-moderated reactor)
HRW	high-level (activity) radioactive waste
HTGR	high-temperature gas-cooled, graphite-moderated reactor
HWGCR	heavy-water-moderated, gas-cooled reactor
IAEA	International Atomic Energy Agency
IRPC	International Radiation Protection Commission
LRW	liquid radioactive waste
mRem/h	milliRem (10-3 Rem) per hour
mSv /h	milli Sievert (10^{-3} Sievert) per hour
NPP	nuclear power plant
OSPORB-99	Basic Sanitary Rules on the Radiation Safety Provisions
OPB-88/97	General Regulations on the Safety of Atomic Stations (Russian)
PWR	pressurized light-water-moderated and – cooled reactor, European counterpart of Russian VVER
RBMK	High-capacity channel-type reactor
Rosatom	Agency for Atomic Energy of the Russian Federation
Rostekhnadzor	Federal Service for Environmental, Technological and Atomic Oversight
Rosenergoatom	Federal Company 'Russian State Concern for Production of electric and heat energy at atomic plants'
RT-1	Radiochemical facility for reprocessing spent nuclear fuel from NPPs and nuclear submarines reactors, belongs to the Mayak RW reprocessing company
RW	radioactive waste
SFA	spent fuel assembly
SNF	spent nuclear fuel
SRW	solid radioactive waste
SSI	Swedish Radiation Safety Directorate
TACIS-94	Program of the European Union for the countries of Eastern Europe, Caucasus and Central Asia aimed at promoting economic and political relations between EU and mentioned partner-states. In Russia TACIS has the following priority subjects: environment, energy, nuclear safety.
TBq	10^{12} Becquerel
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
VVER	water cooled, water moderated reactor

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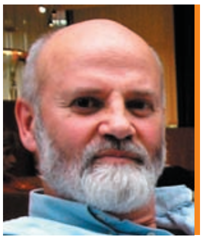

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From 2001 is the head of department of radiation technologies in JSC "Tvell". Specialization - problems of radiological safety during the decommissioning and dismantling of nuclear- and radiologically- hazardous facilities, RW management.

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Member of the International Council of the Institute for Climate and Environment, Wuppertal, Germany (1995-2005). Member of the Board of the Energy Efficiency Center (Moscow).

Contents

FOREWORD

"You should prepare your sledges in summer and your carts in winter"

Russian proverb

The Concept mission is to involve authorities, nuclear industry and general Russian public in the process of the timely planning of safe decommissioning of nuclear power units, which have reached their design lifecycle limit.

The Concept summarizes the world experience on nuclear power unit decommissioning presented at <www.decomatom.org.ru>

There are 31 nuclear reactors operated at 10 nuclear power plants (NPPs) in Russia. Some of them have already reached their design time limit, others will reach it in the nearest future, and a third group of NPPs will be in operation during the coming decades. Anyway, sooner or later all of them will have to be taken out of operation.

Decommissioning is a complex, expensive and long-term process. It requires the integrated solution of technological, environmental, social, financial and ethical problems.

For the Concept preparation the available Russian experience has been analyzed, other sources included materials and documents acquired during trips and acquaintance with the decommissioning experience of Ignalina NPP (Lithuanian town Visaginas) and NPP Nord (German town Greifswald). Both nuclear plants had units similar to those, which are operated in the North-West Russia (Leningrad and Kola NPPs).

Activities on studying the relevant experience were carried out during 2004-2007. They were financially supported by the Norwegian Ministry of Forreign Affairs. The provided funds made it possible to organize a trip to Ignalina NPP of representatives of Russian authorities, nuclear trade unions and experts, as well as public activists. The same financial source was used for arranging the trip of Kola NPP operators and representatives of environmental community to NPP Nord in Germany. Three documentaries have been produced about the decommissioning experience of German and Lithuanian NPPs.

In 2007 the Federal Agency for Atomic Energy of Russia (RosAtom) provided funding for a study trip of Sosnovy Bor and Poliarnie Zori municipal authorities, regional authorities of Murmansk Oblast and one expert to the decommissioned NPP Nord (Greifswald, Germany). RosAtom also sponsored the production of a documentary about the trip.

The Concept comprises an introduction, two parts and several attachments.

The Introduction presents main approaches, which, in the authors' opinion, can be used in working out the decommissioning strategy for Russian nuclear power units.

The first part gives an analysis of the current situation in relation to the NPPs closure in Russia and other countries. A classification of nuclear reactors in terms of their safety and design peculiarities is given; stages and possible scenarios of decommissioning are presented.

The second part discusses the problem of radioactive waste, spent nuclear fuel and legal regulation of the NPP decommissioning.

The attachments describe the international experience and give legislative documents, which regulated the decommissioning of nuclear power units in Germany and Lithuania.

The video-attachment to the Concept includes 4 documentaries. They illustrate Lithuanian and German experience on the decommissioning of power units, which had RBMK-1500 and VVER-440 reactors. The social, environmental and technological aspects of this experience are presented. Along with this, the documentaries show Russian experts, civil servants, trade-union activists of nuclear industry and the public, who give their opinion about the possibility of using this experience in Russia.

You comments to the Concept of a Decommission Plan for Old Nuclear Power Reactor, as well as proposals and criticism will be gratefully accepted at: PO Box 93/7, Sosnovy Bor 188544, Leningrad Oblast, Russia.

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AUTHORS EXPRESS THEIR GRATITUDE TO:

Artur Brunner – Deputy Consul General of Germany in St. Petersburg for support in organizing a study visit to Greifswald and NPP Nord;

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Norbert Meyer – Chairman of the Public Council on nuclear energy issues of Land Meklenburg Vorpommern (Germany) for materials on the Public Council activities on the monitoring of plant decommissioning;

Eleonora Ogienko – Deputy Chairperson of the trade union "Union of Workers", Ignalina NPP, for organizing meetings and discussion of the trade-unions' role in safeguarding social stability during NPP decommissioning;

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Dieter Rittsher –Chairman of the Board of Directors Energiewerke Nord GmbH (Germany) for provided materials and a possibility to get acquainted with the German experience of NPP Nord (Greifswald) decommissioning;

Victor Shevaldin – Director of Ignalina NPP (Lithuania) for provided materials and a possibility to get acquainted with Lithuanian experience of Ignalina NPP decommissioning;

Dalia Straupaite – Deputy Mayor of t. Visaginas (Lithuania) for a possibility to get acquainted with municipal experience of solving social problems accompanying Ignalina NPP decommissioning;

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Authors are grateful to the first readers of the Concept discussion version, who made their comments and expressed criticism after the first circulation made on 1 November 200.

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We have taken efforts to remove errors and, where possible, to take into account as wide a range of views on the issues.

INTRODUCTION

The decommissioning of NPP units after their design time limit has been reached represents a natural and indispensable stage of their lifecycle cycle.

At present in the world, there are 110 NPP units, which have been taken out of operation and have gone through different stages of decommissioning (not including experimental, research and transport reactors).

The decommissioning of old reactors is a complex and long-term process. It requires an integrated solution of technological, environmental, social and economic problems. Therefore, preparations for it should be foreseen at the design stage.

Unfortunately in Russia no integrated solutions of nuclear power unit decommissioning have been developed either at the stage of plant design or during its operation. These solutions have not materialized even after a lifecycle extension decision was taken for several reactors belonging to the first generation.

In essence, the decommissioning of a nuclear power unit includes the consecutive implementation of a package of administrative and technical measures directed at the termination of any activities related to the facility operation. The unit is brought to an environmentally safe condition, which does not require supervision from regulatory bodies. The Russian legal document ORB-88/97 governs the implementation of a complex of measures to exclude the possible use of a power unit for energy generation after the nuclear fuel has been removed from it.

World experience shows that this stage requires considerable intellectual and material expenditures and careful planning. It is necessary to prepare a special regulatory-legislative basis and develop appropriate infrastructure for solving this integrated problem, which needs innovative engineering and social solutions. Finally, the availability of effi-

Leningrad NPP. The oldest unit in the world with RBMK-1000 reactor cient and well-qualified personnel is a must.

At present 10 Russian NPPs have 31 reactors in operation. The world's oldest Obninskaya NPP, the reactors of Novovoronezhskaya and Beloyarskaya NPPs (two from each) have been shut down. Their spent nuclear fuel (SNF) has been removed; provisions for nuclear and radiological safety are taken. But the full decommissioning, which includes dismantling of equipment, cleanup of the site, etc., has been postponed until indefinite time due to the absence of appropriate guidelines and financial resources.

It goes without saying that during decommissioning most serious attention should be paid to the safety of personnel, general public and the environment. But it is not always evident to everybody that it is necessary to mitigate the negative social consequences resulting from jobs lost in the satellite towns of NPPs. These neighborhoods with 30 – 100 thousand inhabitants are socially and economically vulnerable. Their community infrastructure is rigidly tied to the operating nuclear facility. There are no alternative working places. Some of these towns are closed or semi-closed municipalities.

The challenge of old reactors' decommissioning can find a most efficient resolution , if it is taken by three sectors of the civil society – authorities, nuclear industry experts and concerned public. One of the justifications for using such approach is in the problem of site selection for the SNF storage or disposal –protests of local community often complicates the problem.

Timely and safe decommissioning of Leningrad and Kola NPP units is important not only for Russia, but also for neighboring countries of Baltic and Barents regions. It is general knowledge that the Baltic is the most radioactively contaminated sea in the world. This is the result of nuclear technologies application in the region. The risk of the large-scale radioactive contamination is present in the Barents region too.

It is also well known that the Baltic Sea belongs to one of the most vulnera-

Greifswald NPP, Germany, Baltic Sea shore.

ble marine ecosystems and it needs concerted international efforts aimed at the preservation of the habitat self-recovery capability. By now 9 power units have been closed down in the South and West of the Baltic region – at NPPs of Germany, Sweden and Lithuania.

Starting from 2004 the network of environmental non-governmental organizations from Russia, Norway and Lithuania has been implementing a project, within which the world experience of old reactors' decommissioning has been analyzed (www.decomatom.org.ru).

Available Russian documents have been studied. Project participants sent information requests to Rosenergoatom and received replies.

Trips to Lithuania and Germany have been made in order to get acquainted with the decommissioning experience at NPPs having similar reactor designs to those operated in Russia. The groups included nuclear industry experts, representatives of regional authorities and municipalities of nuclear neighborhoods, members of nuclear industry trade unions and representatives of environmental community.

A series of international seminars has been organized; the seminars were attended by highly-qualified experts, which discussed decommissioning problems, radioactive waste and spent nuclear fuel management.

The resulting document summarizes and analyzes information collected during years of project implementation. It presents (though probably not fully) the complex problems facing the Russian society at the NPP decommissioning.

Attachments to the Concept present Russian translations of documents, which formed a legal basis for decommissioning in Germany and Lithuania, as well as documentaries about NPP decommissioning in these countries. The documentaries present the viewpoints of people representing three sectors of civil society (authorities, atomic industry and general public). They comment on the adaptability of foreign decommissioning experience for Russia.

In this document, we have made an attempt to present our opinion about the key aspects of NPP decommissioning.

We have taken efforts to demonstrate most important, in the opinion of the Concept authors, lessons of NPP decommissioning of other countries. We believe that it is necessary to take this experience into account in planning the Russian power units decommissioning.

We believe that a general plan for the decommissioning of all Russian reactors must be developed. In the short-term perspective it is expedient to work out integrated plans for taking out of operation first-generation power units of Kola and Leningrad NPPs.

We hope that this material will play the role of a catalyst for preparing the strategic plan of nuclear power units decommissioning in Russia.

Meeting of the participants of the Russian Decommission Study Tour to Nord NPP (Germany) with the Major of city Greifswald.

Essentials and recommendations:

In the coming years Russian society will have to solve the complex and inevitable problem of decommissioning NPPs, which have reached the design lifecycle limit. The present generation of nuclear power consumers should not export the decommissioning problem solution to future generations.

The vast majority of Russian NPPs have sev-

Ignalina NPP (Lithuania). The dismantling of the unfinished 3-d unit..

eral power units, which have been and are put into operation in a staged way. This can mitigate social impact caused by their decommissioning.

Socio-economic infrastructure of nuclear satellite towns having a population of 30 – 100 thousand is rigidly tied to a NPP presence. Its closure will require resources for the diversification of existing infrastructure and reduction of its dependence on the nuclear facility.

The Decommissioning Plan should secure the environmental, social and economic safety of this process for Russia. It is also necessary to take care of the safety of nature and ecosystems shared by the country with its neighbor-states.

Russia has no national and regional repositories for nuclear and radioactive waste, which would be able to take them in the avalanche-like growing volumes during NPPs decommissioning. It is necessary to establish a unified radioactive waste management system and pass the Federal Act on RW Management as soon as possible.

During the decommissioning of power units, which have reached their design time limit, it is advisable to adapt the experience of other countries, Germany and Lithuania in particular, to the Russian situation.

The NPPs of the Baltic and Barents Regions.

1. DECOMMISSIONING OF NUCLEAR POWER PLANTS

1.1 Inherent lifecycle limits of nuclear reactors

The world experience shows that a power unit decommissioning requires considerable intellectual and material resources and careful planning. It is necessary to develop special legislation, establish infrastructure for solving this problem, which requires innovative political, engineering and social solutions. Last but not least: well-organized skilled personal is indispensable, as well as effective public monitoring of the process safety.

The tremendous costs of NPP decommissioning make their owners wish for an operation that is as long as possible in order to maximize revenue. But there are natural reasons, which dismiss the wish to eternally prolong the reactor's lifecycle.

Uranium-graphite reactors have been and continue to be widely operated in the former USSR and Russia. This type of reactor was developed from the defense program-oriented reactors used for producing weapons-grade plutonium. The USSR built 21 reactors of this type (17 RBMK reactors and 4 - EGP-6). For safety reasons this reactor design has not been accepted elsewhere in the world. Therefore, there is no experience elsewhere in the world with their operation.

Of all RBMK power units built in the country twelve reactors are in operation still including three power units of the first generation, which were commissioned in 1973-1976. They underwent a large-scale modernization and received a license for another 5-year operation term. A political decision on the extension of their lifecycle limit for 15 years has been taken. These decisions were taken without the environmental impact assessment and the public participation required by the Russian legislation. Further prolongation is not possible, because the neutron flux causes the degradation of graphite reactor cladding, which moderates the neutrons. RBMK graphite keeps the acceptable properties of a moderator for operational neutron fluxes only for 48 – 53 years.

The VVER reactors have technological limits to their safe operation, which are related to the neutron embitterment of reactor vessel. The moment comes when it is not possible to continue safe operation of such a reactor due to the hazard of vessel failure at the emergency cooling in case of the main cooling line rupture. Some technological solutions enable the extension of the period of safe operation. E.g. in the USA the lifecycle of pressurized water reactors has been extended to 60 years.

In essence

There are inherent restrictions to the continued reactor operation, which are explained by the properties of reactor materials. For RBMK reactors this term of availability is about 50 years. For VVER reactors it can be as long as 60 years. The decision-making process did not follow the requirements Russian legislation, which prescribe the environmental impact assessment and the public participation.

1.2 Classification of Russian reactors in terms of safety level

During the late 1990s the international community initiated the development of a classification in terms of reactor safety level in Eastern Europe. In accordance with this classification the least safe are first-generation reactors VVER-440/230 and RBMK. These reactors were developed in accordance with the regulatory base of the 1960s, in absence of practical experience on the quantitative evaluation of technical solutions' adequacy.

In the opinion of the majority of international experts there are no economically justifiable technical solutions for upgrading power units of these types to meet the requirements of international safety standards.

The mentioned first-generation reactors are hazardous not only because their key components are ageing, but also because they have technically irreparable drawbacks, the most important of which is the absence of containment[1]. In accordance with the majority of experts these reactors are the first to be taken out of operation.

The second category, the less hazardous power units, includes the reactors of second generation - VVER-440/213 and VVER-1000; it is economically feasible to modernize them for safe operation lasting a prescribed period of time. This time can be used for providing a replacing source of power; the power units decommissioning can be accompanied by the social and environmental protection programs of high quality.

In case of an accident the consequences will be not only of a trans-national scale, they will have an impact on dozens future generations of people living in different countries. Therefore, reactors of first and second generation should be decommissioned as soon as possible. A strategic plan should be prepared as a first step in this direction.

The environmental NGOs urge the Government of Russia to start preparations for developing the Decommissioning Plan for the first- and second-generation NPPs immediately.

In essence:

For the decommissioning priority list it is necessary to use the criteria and analysis of NPPs' safety level;

It is not economically feasible to modernize Russian power units of the first and second generation to meet the international safety requirements.

1.3 Principles of a safe decommissioning plan

The NGOs publishing this concept propose the following principles to be observed so that decommissioning plans could ensure safety and social stability:

- **Transparency** of all decisions on technologies, environmental protection, social and economic issues;
- **Possibility** of public participation in the decision-making process;
- **Independence** of ecological and financial monitoring;
- **Nuclear, radiological and environmental safety** during the equipment dismantling; SNF and RW management;
- **Sustainable development in** the regions hosting NPPs after their decommissioning;
- **Social protection** of personnel operating the decommissioned power units.

1.4 Safety criteria of decommis sioning plan

The Decommissioning Plan for Russian NPPs should be based on the following safety criteria and the following analysis:

- **Current safety level of** a power unit and its environmental influence;
- **Advantages and drawbacks** of possible decommissioning strategies (immediate or delayed decommissioning; the power unit conservation or dismantling);
- **Nuclear, radiological safety** and environmental impact of decommissioning activities, also technological solutions for the long-term immobilization of RW and SNF;
- **Options for solving social problems** for the NPP personnel and inhabitants of nuclear satellite towns;
- **Power supply situation in the**

Greifswald NPP (Germany)

Decommissioning of Nuclear Power t Plants

Table 1.[2]
Russian Nuclear Power Plants

[2] Federal target program "Development of atomic enegy complex of Russia for 2007 - 2010 and up to 2015a" (enacted by the RF Governemnt Decree of 6 October 2006. N 605

Power unit	Type of reactor	Installed capacity MW	Genera-tor	Year of commission	Design time limit	Planned closure (with lifecycle extension)
Kola 1	VVER-440/230	440	1	1973	2003	2018
Kola 2	VVER-440/230	440	1	1974	2004	2019
Kola 3	VVER-440/213	440	2	1981	2011	2026
Kola 4	VVER-440/213	440	2	1984	2014	2029
Leningrad 1	RBMK-1000	1000	1	1973	2003	2018
Leningrad 2	RBMK-1000	1000	1	1975	2005	2020
Leningrad 3	RBMK-1000	1000	2	1980	2009	2024
Leningrad 4	RBMK-1000	1000	2	1981	2011	2025
Smolensk 1	RBMK-1000	1000	2	1982	2012	2027
Smolensk 2	RBMK-1000	1000	2	1985	2015	2030
Smolensk 3	RBMK-1000	1000	3	1990	2015	-
Kursk 1	RBMK-1000	1000	1	1976	2006	In operation
Kursk 2	RBMK-1000	1000	1	1979	2009	2023
Kursk 3	RBMK-1000	1000	2	1983	2013	2028
Kursk 4	RBMK-1000	1000	2	1985	2015	2030
Novovoronezh 1	VVER 440/210	417	1	1964	1984	Shut down. 1984
Novovoronezh 2	VVER 440/365	417	1	1969	1989	Shut down. 1989
Novovoronezh 3	VVER 440/179	417	1	1971	2001	2016
Novovoronezh 4	VVER 440-179	417	1	1972	2002	2017
Novovoronezh 5	VVER 1000/187	1000	2	1980	2010	2035
Kalinin 1	VVER-1000	1000	2	1984	2014	2029
Kalinin 2	VVER-1000	1000	2	1986	2016	--
Kalinin 3	VVER-1000	1000	2	2004	2034	--
Beloyarsk 1	AMB-100	100	1	1964	1983	Shut down. 1983
Beloyarsk 2	AMB-200	200	1	1967	1989	Shut down. 1989
Beloyarsk 3	BN-600	600	2	1980	2010	2025
Balakovo 1	VVER-1000	1000	2	1985	2015	-
Balakovo 2	VVER-1000	1000	2	1987	2017	-
Balakovo 3	VVER-1000	1000	2	1988	2018	-
Balakovo 4	VVER-1000	1000	2	1993	2023	-
Bilibino 1	EGP-6	12	1	1974	2004	2019
Bilibino 2	EGP-6	12	1	1974	2004	2019
Bilibino 3	EGP-6	12	1	1975	2005	2020
Bilibino 4	EGP-6	12	1	1976	2006	2021
Rostovя 1	VVER-1000	1000	2	2001	2031	-
Rostov 2	VVER-1000	1000	2	2005	2035	-

region during the decommissioning and options for compensating electricity instead of the source taken out of operation;

- **Schedule and financial sources** of the decommissioning program;
- **Measures ensuring transparency** and public control of the decommissioning process.

The Plan should comply with the Russian legislation and international commitments of Russia. A draft of the Plan should be subjected to a broad discussion of the concerned public living in the region, which can be affected by the decommissioning, including the region of SNF and RW disposal.

It is also necessary to involve regional and local authorities into the planning process.

It is necessary to organize public hearings of the decommission Plan for the power unit decommissioning. The Plan documentation should be available for the concerned public, so that the public environmental examination of the documents could be organized. The governmental environmental examination should be carried out.

After its approval the Plan can be updated taking into account the practical experience gained in the course of decommissioning.

Essentials and recommendations:

- *It is necessary to develop the integrated strategic plan of decommissioning, primarily and most urgently for nuclear power units, which have reached their design time limit.*
- *Such plans should be broadly discussed in the society. The possibility for their public environmental examination should be provided. The Plan implementation should be preceded by the mandatory environmental examination.*

1.5 Objectives and stages of NPP decommissioning.

The decommissioning of power units, which have reached their design lifecycle limit, consists of several stages:

Stage 1. Shutdown of the reactor and termination of power generation.

Stage 2. Conservation under surveillance.

Implementation of a NPP decommissioning project begins from its final shutdown. The preparatory stage lasting 3 – 5 years starts. During this period the reactor is brought into the nuclear-safe condition. Nuclear fuel is taken out of the core and removed from the power unit. RW produced in the course of operation is also removed; the equipment undergoes scheduled decontamination; a number of other relevant activities is carried out.

In accordance with the requirements of regulatory bodies this period is not included into the decommissioning stage. The NPP power unit is still listed as being in service, its maintenance is performed in accordance with appropriate procedures.

The preparatory period can take several years (or indefinite time) depending on the availability of the regional or federal SNF and RW storage/repository for the certain reactor type.

A decision can be taken to keep the spent fuel on the NPP site and transfer it from the cooling pools to the dry storage in special containers.

Reactors can be dismantled after several years of idleness. Large equipment can be dismantled and transported without cutting. Big components can serve as containers (barriers for contained radionuclides).

It is expedient to employ the NPP operators in the decommissioning activities. Storage facilities for the decommissioning waste are built on the plant site on a certain level, which depends on the NPP geographic position.

The importance of decision about the decommissioning timing should be mentioned separately. After a certain period following the reactor shutdown short-lived radionuclides decay, only long-lived ones staying in the contaminated equipment continue to be noxious. This way the amount of radioactive waste decreases. After 10-30 years this process of "activity self-liquidation" slows down. The self-liquidation of some environmentally hazardous radioniclides, e.g. ^{60}Co, can last 70 years and more.

Stage3.Decommissioning:

This stage can follow several alternative scenarios. For the political choice of an option not only the current social, ecological and economic situation is analyzed. Possible long-term geodynamical, climatic and other changes in the regions of decommissioned facility and SNF/RW storage (repository) region are to be taken into account.

- Option "Storage under surveillance" means that the reactor unit, all systems and equipment are conserved and isolated from the environment. Following this they are kept in a safe condition. The uncontaminated equipment is dismantled in order to be used or recycled. Slightly contaminated equipment undergoes a staged decontamination until it has the level, which permits its unrestricted use or recycling (e.g. metal can be molten). Rooms, buildings and facilities freed from such equipment can be pulled down or used for alternative business.

- Option "Burial" of radiologically hazardous blocks and structures. Reactor, first-circuit equipment and other high-level equipment and structures are isolated. E.g. they are enclosed into a concrete matrix and kept in it until most active short-lived radionuclides decay. The "Burial" option uses the advantage of activity self-liquidation.

- Option "Liquidation" is aimed at reaching one of the following two post-decommissioning conditions of the reactor site:
  - "BROWN FIELD" means the dismantling of equipment, evacuation of buildings and facilities not planned for future use, reprocessing and removal of all RW from the territory and its conditioning so that it could be used for the needs of atomic industry, e.g. for the construction of the RW repository or for other economic activities, e.g. for the techno-park development.
  - "GREEN FIELD" means complete dismantling of reactor unit structures and buildings, as well as the conditioning, packing and removal of radioactive waste; a complete removal of all consequences of the radiologically-hazardous facility operation. Land remediation is made to allow the unrestricted use of the freed territory.

Control room of the Greifswald NPP

1.6 International experience of decommissioning scenario choice

Swedish experience shows that society can obtain the most optimal results of decommissioning procedure and conditions if it delegates this task to an independent body. In Sweden it is the Swedish Environmental Court.

In such cases an independent organization takes decisions, which are completely in tune with main societal values and norms. If the decisions are taken by organizations closely tied to the technological complex, they, in most cases, will be based on values and norms of the technocratic community. In our case it is the nuclear industry.

The money deposited on a bank account

of the decommissioning fund keeps growing, i.e. it brings revenues before the decommissioning activities are started. In the Swedish case this interest on deposit is the revenue of power plant owners. For them (account owners) it is not profitable to start decommissioning until expenditures on servicing the shutdown reactor (fuel removal, dismantling, etc.) exceed the margin of revenues from keeping the fund money on the bank account.

At this point we should not forget how costly for the society such a delay can be. A delayed start of decommissioning can result in much higher costs for society. The prospect arises of necessary expenditures for which the NPP owners are not responsible.

The two units of the Barsebäck NPP are stopped

In the case of Swedish Studsvik reactors the Swedish Environmental Court prescribed that the owners should start the decommissioning immediately after the reactors are taken out of operation, because in case of a delay the society would be forced to take much larger expenditures.

The unavailability of the final RW repository necessary for the decommissioning of Studsvik and Barsebek reactors was the main reason for the dismantling delay, for which the reactor owners appealed in the court of justice.

The court ruled that the stated reason did not justify the delay of actual decommissioning of Studsvik reactor.

The court also stated that the decommissioning of research reactor in Studsvik immediately after its shutdown should enable to use the experience and expertise of Studsvik operating personnel. The Swedish experience is presented in more detail in Appendix 6.

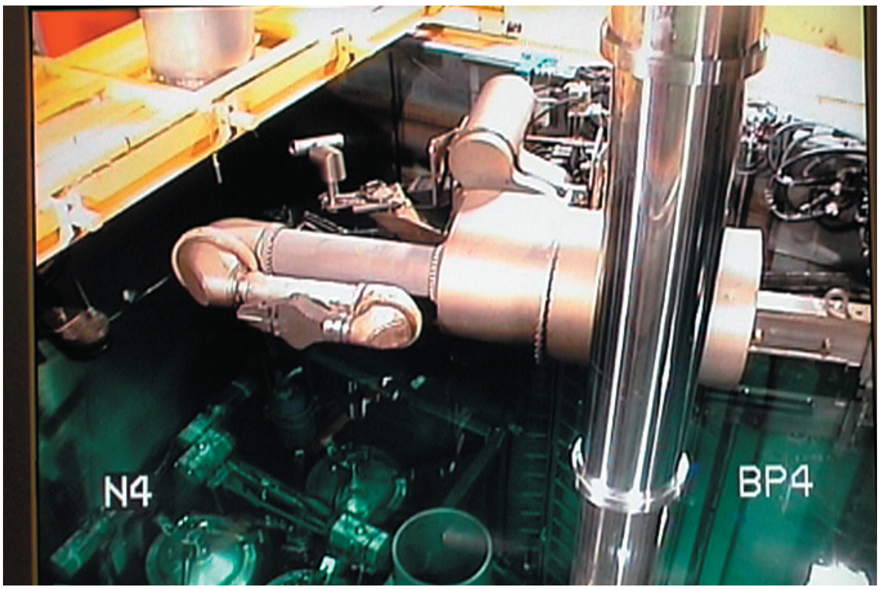
In essence:

In order to choose the most optimal (for the whole society) NPP decommissioning scenario it is advisable to appoint an organization not depending on the nuclear industry. This will enable to take a decision, which reflects the key public values and norms in the best way.

1.7 International experience of decision-making on decommissioning strategy

Germany has the most extensive and successful experience of NPP decommissioning planning and implementation in the world. That experience is the closure of 5 VVER-440 power units at NPP Nord near the town of Greifswald on the Baltic Sea coast. There the decision on the reactor decommissioning, which followed the «BROWN FIELD» scenario, was taken due to the socio-political situation of the day and technical state of the nuclear plant.

Following a strategy since the early 1990s, the social infrastructure of the nuclear neighborhood was transformed without serious social disruption. Problems related to the loss of thousands jobs were resolved. It became possible due to the social partnership of authorities, business and public. This



Manipulators working in a radioactive-dangerous zone of the Greifswald NPP experience is presented in detail in appendixes 1, 2 and in the video attachment to this document.

A large techno park has been established on the former NPP site using its buildings and structures. The techno park provides conditions for entrepreneurship and different kinds of economic activities. It hosts hi-tech companies oriented toward the dismantling and recycling of contaminated equipment, operation of long-term RW and SNF storage facilities and radiation safety provisions. New facilities and companies include biofuel production, pontoon manufacturing, a sea terminal in the NPP discharge channel, etc.

The German experience has shown that:

- contaminated equipment can be dismantled without waiting for 50-70 years necessary for the short-lived radionuclides decay; at this the dose rate for the personnel employed in dismantling was lower than during the plant operation;
- in the decommissioning of power units, which reached the design time limit, it is expedient to use the existing NPP infrastructure – this helps to cut the cost of dismantling, create new work places, reduce the unemployment problem.

The German experience is presented in more detail in sections 1.11.2, 1.12, 1.13, Appendixes 1, 2, and also in the video attachment 9 to this document.

In essence:

If the «BROWN FIELD» option is chosen for NPP decommissioning, the use of available social and technological infrastructure can reduce the cost of decommissioning activities and give an impetus for the new industrial development not necessarily related to the nuclear technologies.

1.8 Specific features of Russian nuclear industry in terms of decommissioning planning

In terms of NPP decommissioning the Russian nuclear power industry has a number of specific features:

- **Multi-unit power plants**. The majority of Russian NPPs have several power units, which were put into operation in a staged way. This factor can make the problem of a simultaneous loss of many jobs less dramatic.
- **Syndrome of a big country.** It is a generally-accepted attitude that Russia has no deficit of living space and territories for industrial development, which would require a complete removal of the facilities after the plant is taken out of operation.
- **Socio-economic vulnerability of NPP satellite towns** (30 – 100 thousand inhabitants) vitally dependent from this core industry. Such towns are very often closed or semi-closed municipalities. It means that that all vital functions of such a city are provided by the nuclear technologies and there are no alternative jobs. Due to their limited accessibility it is difficult to develop alternative business and create new working places, which would correspond to the qualifications and educational level of people working at the decommissioned NPP.
- **Absence of national and regional storage sites** of nuclear and radioactive waste, which could take them in volumes arising at the power unit decommissioning. The radioactive waste arising will grow by one order in comparison with the power unit operation during life cycle.
- **Centralized SNF reprocessing** is different from the majority of nuclear countries. In Russia SNF reprocessing is concentrated in the Urals region (t. Ozersk of Cheliabinsk Oblast, plant RT-1). A national long-term storage of SNF is under construction in Siberia (Zheleznogorsk of Krasnoayarsk Territory). Metallic RW is processed in North-West Russia (Sosnovy Bor of Leningrad Oblast, Ecomet-S plant).This causes the necessity to consider the risks of negative socio-economic consequences of decommission-

ing not only for the region of the closed NPP units, but also for the region of centralized SNF and RW reprocessing (storage).

If a NPP taken out of operation is located in the catchments area of a water body of international value, both Russian safety standards and international agreements and regulations should be taken into account.

Therefore, in the decommissioning plans for the Leningrad NPP power units, which is located on the Baltic Sea coast and which will have to dispatch its SNF to the national storage in Zheleznogorsk of Krasnoyarsk Territory, it is necessary to take into account a possible impact on the Baltic Sea and on the Yenissei Rive catchment area. Taking into account the international stratus of the Baltic Sea, it will be necessary to comply with international commitments (Espoo Convention, etc.).

The ideal target condition of the decommissioning project for a power unit taken out of operation would be a "green field", which can be safely used as a public park or kindergarten. But such scenario is hardly realistic for Russia due to the above-mentioned peculiarities of the country.

The target condition to be reached by the decommissioning project in Russia is likely to be the "brown field" site. It means that former NPP territory is brought into compliance with such a level of safety that makes it possible to use it for any other industrial or economic activity without taking special measures of health protection for the future personnel.

The "brown field" strategy is justifiable not only for engineering-economical, but also for social reasons. It enables to use the developed infrastructure, provide jobs for unemployed personnel; it stimulates the socio-economic development of the territory, etc. Expediency of such strategy is confirmed not only by the above-given experience of a techno park establishment on the site of Greifswald NPP in Germany, but also by the example of a gas-turbine power plant built on the site of Fort St. Vrain NPP in the USA, etc.

In essence:

- *«BROWN FIELD» as the final condition of reactor site after the power unit decommissioning to the highest extent corresponds to the national peculiarities and mentality of the contemporary Russian society; international experience shows that it is also economically justifiable.*
- *The resolution of infrastructural problems in the NPP satellite towns and of the social adaptation problems for the plant personnel during the power unit decommissioning are the key factors of social stability in the nuclear neighborhoods;*
- *In the decommissioning scenario planning it is necessary to take into account the risks of negative socio-ecological consequences not only for the region, where the power unit is located, but also for the regions of centralized SNF and RW reprocessing (storage).*

1.9 Specific features of RBMK reactors important for the decommissioning planning

There are specific structural and technological properties of reactors, which are to be taken into account in developing the decommissioning scenario. The RBMK reactors have a problem, which is difficult to solve at the current technological level. It is the disposal of radioactive graphite used as the moderator of neutrons in the reactors of this

Greifswald NPP, top view

type.

The mass of RBMK-1000 graphite cladding is 1700 t. The main contributor to the graphite cladding activity is the long-lived isotope ^{14}C, which has the half-life period of 5400 years. This is 95 % of total graphite activity. For this reason the irradiated graphite as the solid radioactive waste will stay radiologically noxious for several tens of thousands of years. Due to graphite inflammability its storage requires special safety measures. Along with that, carbon is one of the most widely found components of living systems. This means that, when the radioactive isotope ^{14}C gets into the ambient environment, it is included into the natural circulation and can become a part of living

Greifswald NPP, dismantling of equipment

systems. It means that organism accepting it as a "brick" of its body will get the internal exposure, which can cause serious negative consequences for the health of this organism.

[3]Radioactive waste handling in Russia and in the countries with developed atomic power industry /Editor V.A. Vasilenko. – SPb., Morintekh, 2005. – 303 p.

In accordance with UNSCEAR the ^{14}C input into the technogenic exposure of the population reaches 90% of the collective dose, therefore the challenge of radioactive graphite management is of international importance[3]. Graphite burning as a method of its pre-disposal processing requires the purification of flue gases and the isolation of resultant ashes. Along with that, at burning graphite transforms into a different physical form, which needs special handling. Existing ways of gaseous ^{14}C immobilization are based on CO_2 catching and its conversion into solid insoluble carbonates. This results in the production of 1,5 – 2 times larger volume of SRW than before the burning of radioactive graphite.

It is evident that graphite processing by burning is expensive and results in the increase of SRW volume.

Beside Russia the commercial and research reactors with graphite moderators are operated in Great Britain, France and Japan. The total amount of reactor graphite in the world is ~ 105 t. Not a single country operating uranium-graphite reactors has developed technologies for reactor graphite conditioning for disposal. In France such reactors have been shut down until better times, when technological solutions are found. For details see Appendix 7.

The possibility for irradiated graphite conditioning can be provided by the monolithic technologies. However, at present they are at the research & development stage. The essence of the technology is in the graphite crushing and utilization of the resulting chips in the production of mineral or slagstone matrix.

Efficiency and safety of decommissioning depends on the availability of SNF and RW storage (processing) technologies, which should take into account the half-life period and biological mobility of radioactive elements contained in them. The chapters below will discuss this topic in more detail.

In essence:

- *The technology of safe reprocessing or long-term isolation from the living matter has not been developed for RBMK graphite cladding. Such technology should take into account the half-life period of radioactive graphite ^{14}C and possible negative consequences for the ecosystems from a possible inclusion of the radioactive substitute of one of the most common elements of living systems.*

- *Safe handling (storage) of RW and SNF at the power unit decommissioning is the key factor ensuring safety of the process.*

1.10 Difference of VVER and RBMK decommissioning approaches

Comparing the VVER and RBMK decommissioning scenario options in other countries we should note that in Lithuania the period from the decommissioning start to the "brown field" condition following the immediate dismantling scenario was evaluated as 75 years. These are the problems of RBMK radioactive graphite utilization, which present additional obstacles, uncertainties and make this process longer than in case of the VVER reactors in Germany. Lithuanian experience of Iganalina NPP decommissioning is presented in more detail in Appendixes 3, 4, 5 and in the video attachment 9.

RBMK decommissioning

In Russia the basic option accepted by Rosatom for the RBMK-1000 decommissioning is the long-term (after SNF removal) conservation. This scenario foresees the use of existing barriers preventing the radioactivity transport in the environment. These barriers can be strengthened by additional sealing. The power unit will be dismantled in stages. In our opinion this will enable to take optimal decisions in terms of safety and optimize them further as new technologies develop and international experience grows.

The duration of decommissioning period has not been determined for this option of storage under surveillance.

At this the following is not assessed for Leningrad NPP decommissioning:

- **Risks for the Baltic Sea living systems** from the indefinitely long storage of four shutdown RBMK-1000 units at a 100-m distance from the waterfront. The materials stored in the conserved power units will include 7800 t of ecologically mobile and biologically consumable carbon containing radioactive isotope ^{14}C. This element will keep its noxiousness for biological systems for tens of thousands years. This substantially exceeds the duration of relatively quiet periods in the geodynamics and climatic history of the Baltic region, which were established during the last 10 thousand years.
- **Risks of technogenic influence** from a new Leningrad NPP-2 sited next to the existing LNPP. The closed power units of which will be subjected to the influence of e.g. daily discharges of hundred thousands cubic meters of steam from the cooling towers of a new NPP.

VVER reactor decommissioning

For VVER reactors the decommissioning period can be shorter than for RBMK power units. The Greifswald experience (Germany) shows that decommissioning of 6 power units with VVER-440 reactors built with the support of the Soviet Union and conversion of a former NPP site into a technopark takes 45 years. More details about the Greifswald NPP decommissioning procedure and monitoring can be found in Appendixes 1, 2 and in the video-attachment 9.

1.11 Financial aspects of nuclear reactor decommissioning

1.11.1 History of the Russian decommissioning fund

Russian organizational and financial infrastructure for the NPP decommissioning underwent radical changes during the country's transition from the centralized and planned economy to market conditions. In more detail this subject is discussed in a report prepared by environmental NGOs in 2006[4].

[4] K. Album, O. Bodrov et al., Status of the Russian NPP Decommissioning Fund,- Report of the environmental NGO network of Northwest Russia and Norway, Apatiti, Oslo, Sosnovy Bor, May 2006 r., 18 p.

The 3-d and 4-th power units of the Leningrad NPP from above.

All Russian power units to be decommissioned in the near future were designed and built in the period of centralized and planned economy. Then the issues of NPP decommissioning and RW handling did not get proper attention. It was assumed that in future these problems would be solved by centralized planning and with financing from the national budget. For this reason special funds, which would accumulate money necessary for the decommissioning, were not established (unlike in the countries with the market economy).

The concept of decommissioning for reactors approaching their design lifecycle limit was not formulated. Costs of decommissioning preparation and implementation for reactors of different types were not estimated.

As a mater of a fact, the whole concept was reduced to the long (several decades) period of shutdown reactors conservation and waiting until most active radionuclides decay.

In 1996 in Russia, which at that time was developing amarket economy, a fund was established which later was transformed into the Reserve for the decommissioning of power units reaching the design time limit. It receives 1,3%[5] of revenues from the sold power generated by NPPs. All Russian NPPs channel their money to this reserve, and available means are spent in accordance with the decisions of Rosenergoatom, the utility operating all nuclear power plants. It actually is spent on the safety provisions of previously closed power units and on other purposes.

The money is not accumulated for the decommissioning of reactors, which have reached the design lifecycle limit, but continue to operate. The existing rate of allocations is insufficient. It is based on the theoretical recommendations of IAEA, which do not take into account the current situation and decommissioning experience.

In accordance with IAEA expert estimates made in the early 1990s, the cost of NPP decommissioning is about 12 % from the cost of its construction[6] . The latest experience of NPP decommissioning projects have shown that this percentage is sufficiently higher. Actual expenditures amount to not less than 37%. The next section presents this information in more detail.

In February 2007 the joint meeting of the research & development councils of the Federal Atomic Energy Agency (Rosatom) and "Rosenergoatom" acknowledged the urgency of completing a new "Methodology for calculating the costs of NPP power unit decommissioning preparation and implementation". It was proposed to prepare a draft of the RF Government Decree on increasing allocations to the Reserve of NPP decommissioning up to 2,2 % of the revenues from the sold power.

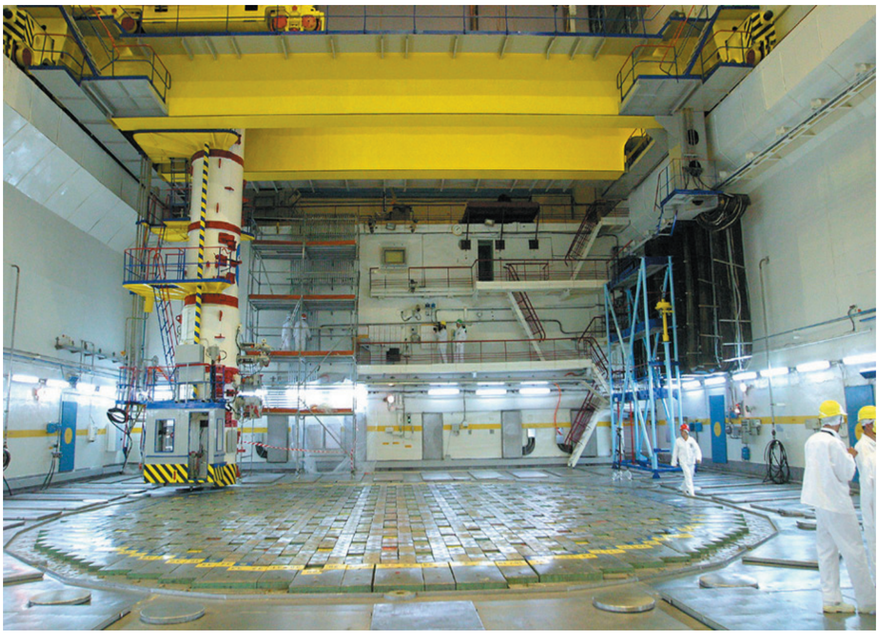
It was proposed to consider the prolongation of service life for NPPs, which have reached the design time limit, as an additional source of the Reserve replenishment. The meeting participants also noted the necessity to develop "Concept for decommissioning nuclear power units, radiation sources and storage places", and to revise regulatory documents on the NPP power unit decommissioning.

1.11.2 Foreign experience of the decommissioning fund establishment and management

In countries with market economies a

[6]Decommissioning of Nuclear Power Plants and Research Reactors. - IAEA, Vienna, 1996.- 41 p.

[5]Rules for the allocation of means by companies and organizations operating extremely radiologically-hazardous and nuclear facilities (atomic plants), which make reserves necessary for providing the safety of nuclear power plants at all stages of their lifecycle and development. Approved by the RF Government Decree of 30 January 2002. N 68, with updates of 5 December 2003., 21 January, 2005)



Hall of the first power unit with RBMK-1500 reactor of the Ignalina NPP (Lithuania) natural source of fund or reserve replenishment is the money from the nuclear power sold. These resources are managed either by the plant operating utility or by specially established organizations, which do not directly depend on the operating utility. The approach to the fund (reserve) management influences the effectiveness of its use and compliance with the set objectives.

In France, Germany and Russia the funds are managed by the operating utilities. It gives more flexibility to the organizations, which control it, but does not secure transparency. It happens that the money assigned for decommissioning is spent on other purposes. In France, for example, the fund money was spent on the liquidation of debts and investment into new projects, in Russia – on reactor lifecycle extension.

In the Czech Republic, Finland, Hungary, Italy, Lithuania, the Netherlands, Slovakia, Slovenia, Spain and Sweden the funds are not managed by the NPP operating utilities. It provides better transparency and guarantees the appropriate fund money spending.

In the USA an additional source of decommissioning fund replenishment is the lifecycle extension too. At the modernization cost of 8 - 10% from the cost of new power units the reactor's lifecycle is extended for a rather long period of time. As mentioned before, RBMK reactors present a special case – their lifecycle extension is restricted by the properties of graphite (more about it in the chapters below).

International experience of decommissioning cost evaluation

The analysis of modern decommissioning experience shows that the average decommissioning cost of a VVER-440 power unit can be $350 mln. at immediate dismantling and $300 mln. at a dismantling delayed for 40 years[7]. These data include a large number of uncertainties explained by the national policy on RW management, technological level, etc.

[7] Nuclear Power Reactors in the World // IAEA issue 2, Vienna, 2002, p. 26.

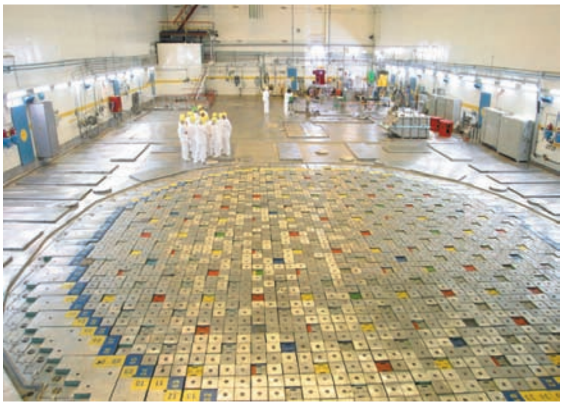
Therefore, the cost per unit of installed power amounting to 750 $/kW can be considered as a first approximation and serve as a reference for calculating decommissioning projects with different reactor types.

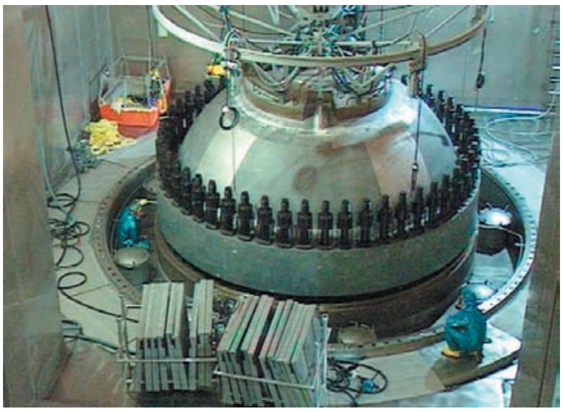
Greifswald decommissioning experience shows that six power units (5 of them were in operation) needed the budget of €3.2 bln. ($4.8 bln.) for 35 years of decommissioning process (Appendix 1). This cost is much higher than the budget planned for Russian reactors.

If we take the German scenario and experience as a reference and exclude expenses during the first 5 years of waiting and planning, then the closure of four VVER-440 power units of Kola NPP can be roughly estimated as €1.3 bln. ($1,95 bln.).

As for the power units of RBMK type, using the experience of Lithuania, which followed the scenario of dismantling without waiting, the decommissioning cost of four Leningrad NPP units can be roughly estimated as € 2.3 bln. ($3.45 bln.) during 25 years of the decommissioning project.

Further costs after this period can be related to the continued isolation of SNF, which contains Pu^{239} having the half-life period of 24000 years and the graphite cladding of





Ignalina NPP (Lithuania). The cover of the RBMK-1500 reactor. Underneath the lead blocks are the channels for loading the nuclear fuel.

Barsebäck NPP (Sweden). A reactor after loading with nuclear fuel is closed with a cover.

Table 2
NPP decommissioning costs [6,8]

[6] Nuclear Power Reactors in the World // IAEA issue 2, Vienna, 2002, p. 26.

[8] The USA experience of decommissioning // World power engineering, 1997, № 2, c. 16-21..

№	NPP, country	Reactor type; capacity, MW	Cost, mln. $	Notes
1	Big-Rock Point, USA	BWR, 70	25.0	After the SNF removal reactor vessel is taken away. The total mass of RW was 290 t. SNF storage of 43.3 ha was left on the site. The NPP area was 182.2 ha.
2	Fort St. Vrain, USA	HTGR, 330	173.9	The option of immediate dismantling was followed. The plant refurbished into a gas-turbine power station.
3	Tokay Mura, Japan	GCR, 166	772.5	Dismantling started in 2001 to be completed in 2017. 177 th. t of RW arises during decommissioning, including 18 th. t of high-level waste.
4	Stade, Germany	PWR, 672	668.4	First decommissioned NPP after the Law on NPP phase-out was enacted. Of 300 operators, 150 stayed for decommissioning.
5	Biblis-A, Germany	PWR, 1225	141.2	Budget for the complete liquidation of the power unit
6	Loviisa-1, Finland	ВВЭР, 440	166.5	
7	Greifswald, Germany	ВВЭР, 5×440	4000	Cost estimate for the complete liquidation of 5 power units and technopark condition achievement in the period of 1990-2035 More details in App. 1.
8	Ignalina NPP, Lithuania	RBMK, 2×1500	1500	Cost estimate for the complete liquidation of 2 power units to the technopark condition. Dismantling of the 1st power unit started. More details in App. 2.

reactors, each of which contains 1700 t of graphite mostly consisting of carbon isotope C^{14} with a half-life period of 5400 years.

Some examples of the cost of decommissioning activities for power units of different types are given in the table 2

1.11.3 Proposals for the Russian decommissioning fund model

Current situation. In accordance with Russian regulatory documents (OPB-88/97) the draft of decommissioning project should be submitted to the regulatory bodies for approval 5 years before the design lifecycle limit. This should be done irrespective of the plans for the lifecycle extension. Such projects have been developed for the power units with VVER-440 first-generation reactors of Kola NPP (units 1 and 2) and Novovoronezh NPP (units 2 and 4). These projects foresee only the solution of technological safety problems for the stopped power units. They do not provide solutions for the long-term storage (disposal) of RW, SNF, for the social protection of personnel, transformation of the municipal infrastructure in NPP satellite towns.

It can be noted that in terms of technological solutions, Russian and Finnish plans practically coincide (for NPP Loviisa, see the section above) – in terms of similar scope of work, budget for RW management, duration of dismantling and other parameters. From the time of reactor shutdown the NPP decommissioning is planned to take 12.5 years,

Activities	Costs	
	Mln. $	% of the total cost
Planning and management	2.17	1
Preparation of decommissioning	16.25	9
Conditioning of radioactive materials	8.53	5
Dismantling of contaminated equipment	66.54	39
RW packing into containers	2.04	1
RW disposal	11	6
Running costs	60	36
TOTAL	166.53	100

the number of persons employed for the preparatory work and actual decommissioning – 370; the total scope of work is evaluated as 2920 pers*years. The breakdown of VVER-440 decommissioning costs is given in the table 3.

The analysis of previous experience of the Russian fund (Reserve) for the NPP power unit decommissioning shows that Russia does not accumulate financial resources for decommissioning beyond-design-limit power units[10].

The unified Reserve for all Russian nuclear power plants, which is run and managed by the operating utility (Rosenergoatom) works inefficiently.

Even if the percentage of allocations from the revenues for sold energy is increased to 2.2%, as suggested by Rosatom, the accumulated money won't be sufficient for the plant decommissioning by the moment it reaches the design lifecycle limit.

Proposals for the Fund structure

It is advisable that the Fund structure could provide solutions to the whole complex of technological, ecological and social problems. For example, at present there are no economically and ecologically justified technologies for the RBMK SNF and graphite cladding. Therefore, the evaluation of Fund expenditures should include a budget line for the SNF and radioactive graphite conditioning and long-term storage. These means should be sufficient for the safe isolation of both waste categories during the whole period of their danger to living systems (taking the radionuclide half-life period into account).

Beside that, the decommissioning fund should foresee resources for the transformation of social structure of NPP satellite towns. It is of vital importance for municipalities where the nuclear facility is the core city-forming company.

The cost of social adaptation of the operators working at the shutdown NPPs should also be foreseen by the decommissioning fund (for more details see Lithuanian experience, appendixes 3, 4, 5).

In essence:

The structure of Decommissioning Fund should foresee budgeting for:

- power unit dismantling, RW and SNF disposal or long-term isolation for the whole period of their noxiousness for living systems;
- transformation of the municipal infrastructure in the towns, which neighbor NPPs planned for decommissioning;
- solution of the social adaptation problem for the workers of decommissioned NPP.

Proposals for the fund replenishment sources and mechanisms

It is advisable that a NPP transfers money to its own decommissioning fund; it comes from its revenues earned by supplying power to the national wholesale market or by

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Table 3
Breakdown of VVER-440 decommissioning costs [9]

[9] E. Meier. Work Plan for Loviisa NPP decommissioning // Atomic energy, 1989, v. 67, issue 2, p. 83-88.

[10] K. Album, O. Bodrov et al., Status of the Russian NPP Decommissioning Fund,- Report of the environmental NGO network of Northwest Russia and Norway, Apatiti, Oslo, Sosnovy Bor, May 2006., 18 p.

other commercial activities. The structure and periodicity of such transfers should be such that by the moment of the end of the NPP lifecycle it could be decommissioned using the accumulated money reserves.

It means that the tariffs on nuclear electricity supplied to the federal grid and on other commercial services of the NPP should be revised. The percentage of target allocations from revenues should be increased to provide enough means for solving all problems in accordance with the proposed structure of expenditures.

This also applies to the NPPs which have power units with extended lifecycles. In this case the money necessary for their decommissioning should be available by the end of this additional operation period. For NPPs with extended lifecycles it is advisable to foresee funding from the federal budget and allocations from the private and legal entities, international organizations and financial institutions (see Lithuanian experience, Appendix 2). At the same time the insufficiency of means in the decommissioning fund should not be used as a reason for a reactor lifecycle extension.

In essence:

- The Decommissioning Fund should be replenished from the NPP revenues earned by its commercial activities during the whole period of electricity selling, also by possible donations from private, legal entities and international organizations.
- Insufficiency of means accumulated in the Fund can not serve as a reason for NPP lifecycle extension.

Principles of Fund establishment and operation

Operation of the Decommissioning Fund should not be influenced by the operating utility. The Fund can be managed by the RF Ministry of regional development or the RF Ministry of economic development.

It is advisable to have a Board of Trustees controlling the Fund; and its activities should be regulated by the appropriate federal legislation. The Board should include authorities of the federal, regional and municipal level, representatives of the NPP workers, political parties represented in the regional legislative assemblies, also concerned regional NGOs.

The mission of the Board of Trustees is to ensure transparency and efficiency of the decommissioning funding.

It is advisable to develop the Act (Regulation) on Decommissioning.

In essence:

In view of the available experience of Germany and Lithuania and previous Russian experience it is recommended that the Russian decommissioning fund be formed in accordance with the principles below:

- *Individuality. Each NPP should run its own decommissioning fund sufficient for solving the whole complex of related problems.*
- *Transparency. Fund expenditures on the power unit decommissioning should be published and kept under public control.*
- *Self-repayment. Means of the fund come from the transferred percentage of the revenues from electricity sold and other financial activities of the decommissioned NPP.*
- *Independence of Fund management from the operating utility. The Fund should be managed by one of the federal ministries and controlled by the Board of Trustees, which has federal, regional and municipal representatives.*
- *Strict compliance with the Decommissioning plan should be observed.*

1.12 Social aspects of decommissioning

The solution of social problems during

NPP decommissioning in Russia is one of the most important and complex tasks. Its acuteness is explained by the fact that Russian nuclear neighborhoods grew around and depend on the NPP, which formed them. It means that all social infrastructure is run on the taxes paid by the company. As a rule, such cities do not have alternative work places corresponding to the qualification level of the workers employed at the power unit taken out of operation.

Most of the NPP operators have specialized educations in the field of nuclear physics and reactor technologies. If after the plant shutdown they are not involved in reactor dismantling and RW management activities, they will most likely experience difficulties with employment and possibly develop psychological problems.

Russian nuclear towns often keep traditions dating back to the times of the Soviet Union, i.e. they are closed to public access. Lately such admission restrictions have been justified by the protection of NPPs from possible terrorist attacks.

In this way, the NPP shutdown in such cities is not only the loss of thousands of work places for qualified specialists, but also a blow to the municipal infrastructure.

In this situation the decision-makers, social workers, trade unions and the general public of NPP satellite towns faces the two tasks on providing:

- social protection for personnel working at the closed power unit, which can include the alternative career planning, opportunity to get education for a different job, earlier pension threshold, opening of the "Third-age University";
- parallel (non-nuclear) economic development of the nuclear towns.

For solving the social adaptation problems it is useful to evalute the experience of other countries. This section proposes certain steps in this direction; they are based on the decommissioning experience in Germany and Lithuania. This experience has an added value, because it was acquired during the decommissioning of power units similar to Russian ones. Ignalina and Leningrad NPPs have RBMK units, and NPP Nord (Greifswald) and Kola NPP– power units with VVER-440 reactors.

Beside that nuclear satellite towns in Lithuania and Germany are very similar in size to Russian ones. The plant personnel in the three countries were educated in the same higher educational institutions of the former USSR.

In this way, the social adaptation experience in Lithuania and Germany can be considered as a model, which can be adapted to Russian conditions.

Role of the Plant Workers' Council

The Council of the NPP workers can be a key player in the solution of social problems related to decommissioning. This body should have a right of voice, when socially-important decisions are taken. It also can bring its claims to the court, if the NPP administration does not agree with the worker's opinion.

In order to take optimal decisions on the employment policy it is expedient to develop a system of scores taking into account the social vulnerability of workers in case of job cuts (using the Greifswald experience). In accordance with this approach the personnel is divided into three groups:

- personnel involved into the decommissioning;
- personnel sent to retraining;
- personnel to retire.

Persons close to pension age should have an opportunity of early retirement. For the social adaptation of this category it is advised to open the Third-Age University, which is quite successful in Visaginas, a town near the decommissioned Ignalina NPP.

Up to one-third of NPP personnel can be employed directly in the power unit dismantling. The plant employees can implement up to 95 % of this work. This reduces the social tension caused by the loss of jobs.

Role of NPP restructuring and innovations in the nuclear town

It is advisable to restructure NPP departments and establish companies, which can work independently:

- transport companies;
- companies summarizing the NPP decommissioning experience to promote and use this experience on the national and international level;
- business-incubators for the regional support of the small and middle business in the nuclear town.

Norway has an interesting experience of the social transformation in a town previously dependent on one company *(Appendix 8.)*

Role of legislative support and structural changes in the region

An effective instrument for solving social problems can be provided by special legislation on the social guarantees for the workers of closed-down NPP. Such law has been enacted in Lithuania (Appendix 3).

It is also important to have open access to the NPP satellite towns. The status of "frontier zone" as well as other restrictions, which put obstacles to the investment into new "non-atomic" work places, should be abandoned. At this it is necessary to strengthen the security of nuclear facilities located near such towns.

Stade NPP (Germany) has been halted

It is necessary that not only Rosatom, but also the RF Ministry of regional development and regional/local authorities would be responsible for solving social problems of the NPP satellite towns. An effective instrument for the systematic monitoring of the whole complex of problems emerging at decommissioning can be the regional public council. Germany and Lithuania have positive experiences with such councils.

1.13 Societal monitoring (ecological, social and financial) of the decommissioning process in Russia

As shown by the Lithuanian and German experience, the informational vacuum and social stress accompanying the NPP decommissioning can destabilize life near the hazardous nuclear facility. This results in disturbing rumors, social tension, distrust to the authorities of all levels and to the nuclear industry in general.

Negative social consequences can be eliminated by establishing the Regional Public Council, a consultative body for authorities, nuclear industry and for informing the general public.

The mission of the Council is to achieve the social, ecological and technological acceptability of the decommissioning process; ensure its transparency and openness.

In Russia such a Council should include representatives of:

- Rosatom,
- Rostekhnadzor,
- Rosenergoatom (representatives of decommissioned NPP),
- regional authorities,
- municipal authorities,
- political parties represented in the regional legislative bodies,

- concerned NGOs,
- NPP trade unions,

Representatives of territories where RW and SNF are handled or stored.

The results of the Council activities should be published.

Work carried out by such a regional Council in the region of NPP Nord (Greifswald, Germany) has shown over many years its usefulness.

The budgeting for the Council activities should be provided by the regional government. The work of the council members is not paid. Only expenditures on trips and accommodation during the Council meetings should be covered.

The Council should have a right to initiate independent examinations of technological decisions and assessment of possible socio-economic consequences of these decisions.

Procedures for the Council activities in Russia can be developed on the basis of the Regulation for the Regional Public Council on the decommissioning of NPP Greifswald (see Appendix 6).

2 RADIOACTIVE WASTE (RW) AND SPENT NUCLEAR FUEL (SNF) MANAGEMENT

2.1 Importance of using the international experience of RW and SNF management

Russian activities on the RW management are governed by the international agreements signed by the Russian Federation. In particular, starting from 24 October 1996 Russia became a party to the Convention on nuclear safety signed in Vienna in September 1994.

In January 1999 in Vienna, Russia signed the Unified Convention on safe handling of SNF and RW. The Convention was enacted in Russia on 19 April 2006.

After 1994 some countries, parties to the Convention on nuclear safety, adopted new legislation or updated the previous version, other countries are in the process of its improvement.

European experience

Speaking about the trends in the nuclear legislation development on the territory of the European Union we should note that its main themes are the improvement of RW handling and legal provisions for strengthening the regulatory body independence. Much attention is also paid to the decommissioning of nuclear power units, preparedness for emergencies and radiation protection in accordance with IRPC recommendations and

Greifswald NPP (Germany). The personnel prepares for dismantling of the radioactively contaminated equipment

IAEA's main international safety norms.

Among the multiple legal documents acting in the European Community the main ones are Council Directives or framework laws. The Directives make the EU member-states committed to common objectives, and in this way, the equality of the whole community is established. But each country decides for itself how it will get to the set objectives. Another legal instrument - instructions – should be clearly formulated in the laws of all EU member-states. The third legislative instrument is a set of recommendations, Council decisions addressed to certain countries, legal and physical bodies and dealing with concrete situations.

In March 1957 after the EURATOM Treaty was concluded, the European Commission became the multi-national regulatory body in the sphere of radiation protection. After the Commission was reorganized in 2000 these responsibilities were given to the EU Directorate General for Energy and Transport, its main principles in this field are the protection of people and environment.

The total production of RW in all EU countries is about 45 th. m3 /year. Approximately one percent of that production is the high-level radioactive waste (HLW). EU countries follow different HLW disposal strategies.

Italy, Great Britain and the Netherlands decided to postpone a solution to this problem for 50 - 100 years.

Other countries (Germany, Sweden, Finland) consider it as immoral to shift the load of HLW problem to future generations and make legislative, organizational and financial measures for the problem solution. They are governed by the principle that users of benefits from "atomic electricity" should bear responsibility for such consequences of its consumption as RW.

But the attempts to find a solution for the problem of HLW final disposal "Right here, right now" face the opposition of the people living in the regions, where the RW disposal is planned. For this reason the problem of HLW disposal has both technical and social aspects.

Approximately 15% of all means assigned by the EU to the investigations in the field of RW handling is directed toward the search of new technologies of waste disposal and liquidation. In accordance with a special program for RW disposal each member-state established agencies responsible for the RW management. These agencies are subordinated to the authorities having responsibilities in the field of nuclear safety.

The whole volume of EU radioactive waste has a tendency to decrease not only because of newly-developed technologies of RW management, but as a result of consecutive policy to phase out NPPs and promote renewable energy sources (RES). In this respect Germany sets an impressive example.

2.2 Operational RW and SNF of Russian VVER and RBMK reactors

The technologies of managing RW produced by the operation of NPPs with different reactor types are practically the same. The differences are explained only by the amount of generated gaseous, liquid and solid waste. RBMK-1000 reactors produce much larger RW (especially LRW) than in the VVER-440 reactors.

The LRW depends largely on which water (sea or fresh) is used for the turbine condensers cooling.

Generation of liquid radioactive waste (LRW)

During the NPP operation, LRW arises from the purification of the first circuit

Greifswald NPP (Germany). After the turbine shop equipment has been dismantled it is ready for other equipment installation coolant, decontamination operations and repairs, washing of protective clothes, etc. LRW from processing filter materials and first circuit decontamination amounts to 10 % of the total volume of operational LRW. The activity of this type of waste is from 1×10-5 Ci/l to 1 Ci/l and, in accordance with OSPORB-99 norms, belongs to middle-level waste.

LRW arising from the decontamination and maintenance (repairs), trap water, etc., which accounts for 90 % of the total waste volume, has an activity of up to 10-5 Ci/l and belong to low-level waste.

The four power units of Leningrad NPP produce about 16,000 m^3 of LRW every year.

All LRW produced during operation is transferred to special storages to undergo volume reduction and conditioning. The annual accumulation of conditioned (concentrated) LRW (per one RBMK-1000 power unit) is 202 m^3.

At present Leningrad NPP stores 18,500 m^3 of conditioned LRW.

The volume of LRW arising after VVER-440 reactor flushing is ~150 m^3, which is lower by one order than volumes produced during RBMK-1000 reactor operation (~1200 m^3). This is explained by the difference of technologies applied, reagents used for flushing to remove deposited corrosion products, also by a much smaller volume of the VVER-440 reactor circuit.

In 2008 a low-waste facility for processing homogeneous LRW will be put into operation, its capacity of 1000 m3/year will enable to process not only newly-produced, but also accumulated LRW.

The total amount of LRW, which is yearly produced by the four power unit NPP with VVER-440 reactors is about 1600 m3. Their average specific activity is - 1×10^{-4} Ci/l.

Generation of solid radioactive waste (SRW)

The main source of SRW production is the scheduled replacement of equipment, the maintenance/repairs of rooms and equipment, etc. The SRW composition is very diverse. These are different metals, cables, thermal insulation, contaminated protective clothes, elastron, paper, etc.

In terms of SRW treatment it is divided into compactable, incinerable and metallic, and in terms of the contamination level[11] – into 3 groups:

- low-level – up to 30 millirem/h
- medium-level - from 30 to 1,000 millirem /h
- high-level – above 1,000 millirem /h

The high-level SRW includes reactor com-

[11] The measurements are made from 0.1m distance from the surface of package with waste having ~300 kg mass and dimensions of 1.2×0.7×0.7 m.

Greifswald NPP. RW management in the temporary storage

Oleg Bodrov makes measurement of the capacity of equivalent dose of the car with radioactive metal which has arrived illegally at Ecomet-S.

ponents. In the total volume of operational SRW their share is no more than 4 %.

The total amount of SRW annually generated at a four power unit NPP is approximately ~ 1200 t, about 90 % of it is low-level waste.

At the normal operation of a NPP with four RBMK-1000 reactors ~1200 m^3 of SRW is produced. In order to reduce the SRW volume, when the measures on lifecycle extension are taken, a program for solid waste conditioning has been developed and implemented, which enables the reduction of waste volume from 1200 to 300 m^3.

The SRW category also includes bitumen compounds, which are produced at the LRW solidification, at the stage of its initial treatment. By now Leningrad NPP has accumulated 23518 m^3 of them.

Within the framework of TACIS-94 program the LRW cementing unit has been built. Its operation will enable an efficient and safe conditioning of LRW into more stable SRW. After the LRW cementing unit is put into operation in 2008 the total volume of waste will be reduced 4 times thanks to the conversion of LRW into SRW. After that a bituminization unit will be installed.

At present the state regulatory body of Russia is considering the possibility of introducing the "very low-level waste" category (similar to France). If the RW specific activity is below 1.0×10^5 Bq/kg for artificial and 5.0×10^5 Bq/kg for natural radionuclides, it can be included into this category and under certain conditions this waste can be exempt from the regulatory control. Further handling can be restricted by the nuclear industry sites.

[12] RF Government Decree № 1197-r of 1 September 1995 on approval of the target program "Reprocessing and recycling of radioactive metallic waste" proposed by the Minatom of Russia.

Ecomet-S –plant for the metallic radioactive waste reprocessing in Sosnovy Bor

Recycling of metallic radioactive waste

The recycling of metallic RW and its return to economy is a promising strategy, if the safety of this technology is guaranteed and the users of the recycled metal know the details of its origin.

In some countries the metal produced by recycling radioactive metallic waste is used for manufacturing containers for the RW transportation.

In accordance with expert assessment Russia has accumulated about 600000 t of radioactive waste as high-alloy steels, nonferrous metals and alloys.

In 1995 the Decree of RF Government[12] enacted the target federal program "Recycling of radioactive metallic waste" proposed by the Minatom of Russia.

The RF Government entrusted the Program implementation to the "main contractor", a private company ZAO "Ecomet-S". It was planned that, in accordance with the

Program, during the period of 1998 – 2002, not less than 4 facilities for the radioactive metal recycling would be put into operation each year, which would have the capacity of up to 35000 t/year. By year 2000 their total capacity would be up to 150 000 t/year. The facilities were to be started near the sources of metallic RW concentration.

The Program was not implemented.

Starting from 1995 in the framework of the Program Ecomet-S engaged in experimental melting of radioactive metal on the territory of LSK Radon (Sosnovy Bor, Leningrad Oblast).

In violation of Russian legislation, that is without the mandatory environmental examination before 2002 Ecomet-S was built and put into operation[13]. Only one plant for industrial recycling of metallic RW was constructed. The capacity of this plant built on the territory of Leningrad NPP is 6000 t/year.

In the Ecomet-S Declaration of Intent, it was stated that it would melt radioactive metal from Leningrad NPP. But actually the Ecomet-S plant on the LNPP territory accepts radioactive metal from Kursk NPP, nuclear companies of Udmurtia, Murmansk, St. Petersburg, Moscow and Moscow Oblast, also from the oil & gas facilities of Kaliningrad Oblast and Stavropol Territory.

In accordance with different sources the facility operated on the Baltic coast in Sosnovy Bor has reprocessed from 7500 to 11000 t of radioactive metal[14]

The recycled metal goes to the world market without any restrictions on its use and without any information about its origin.

The low level of safety culture at the company has repeatedly led to explosions at melters, personnel injuries and deaths[15] .

There are reliable scientific data on the negative environmental impact in the area of Ecomet-S. The many-year studies (1997 - 2002) of geneticists from the Russian Institute of Agricultural Radiology and Agroecology (Obninsk) and ecologists of the Khlopin Radium Institute (St. Petersburg) in the Ecomet-S area have revealed the statistically relevant a 2.0 - 2.8 times increase in the occurrence of cytogenetic malformations in tissues of the pine tree seeds and needles in comparison with pine trees growing 40 km East to St. Petersburg[16].

Similar cytogenetic malformations (occurrence 2 times higher than normal) were registered in pine trees growing in Sosnovy Bor (5 km to the east from Ecomet-S).

In spite of this the company operation continues, and starting from 2007 Ecomet-S is planning a refurbishment to increase its capacity, widen the inventory of processed RW and geography of contaminated metal shipments.

The refurbishment plan has been approved by the State environmental examination of Rostekhnadzor in spite of the public protests against the import of radioactive waste from all over Russia and other countries to the Baltic coast.

Ecomet-S has signed a contract with Rosenergoatom for the recycling of metallic waste from NPPs operating in other Russian regions. It is also planned to recycle RW from the decommissioned NPPs of Western countries.

In the nearest future it is planned to bring waste from Kola, Novovoronezh, Smolensk, Balakovo and Kalinin NPPs[14,17].

Essentials and recommendations:

- *Due to the non-fulfillment of the Federal target program "Recycling of radioactive metallic waste" proposed by the Minatom of Russia the reprocessing of radioactive metal coming from all Rosatom companies and oil & gas industry is carried out at the only private company Ecomet-S on the Baltic coast, near St. Petersburg.*
- *The reprocessing of metallic RW has resulted in the cytogenetic changes of pine tree seeds and needles in the area around the plant. At this the state regulatory bodies do not inform the general public about the violation of emission and discharge*

[16] S.A. Geras'kin, L.M. Zimina et al. Biomonitoring the toxicity of populations of Scots pine in the vicinity of a radioactive waste storage facility, Mutation Research, 2005, 583, 55-66, www.elsevier.com/locate/genotox .

[13] Act on putting into operation the Complex on reprocessing and recycling of radioactive metallic waste ZAO Ecomet-S (bld. 461/1, 461/2, 461/3). Approved by the stats-secretary – deputy of the RF Atomic Energy Minister on 19 February 2002.

[14] www.ecomet-S.ru

[17] D.E. Andreev, B.G. Gelbutovsky et al., Experience of ZAO Ecomet-S on handling metallic waste contaminated with radioactive substances of nuclear plants. Materials of the II International Nuclear Forum, St. Petersburg, 2-5 October 2007, SPb. 2007, p.111-113.

[15] Baltic Newsletter of the Green World, № 89, 19 December 2005, www.greenworld.org.ru/?q=bv89

limits, which have cased such negative consequences, by the company.

- *If it is proven that the applied technology of metallic RW reprocessing is not harmful for environment, it is recommended to organize recycling plants near sources of the RW generation, as it was foreseen by the federal program, and abandon the practice of waste transportation to the distance of thousands km for recycling on the Baltic Sea coast.*

- *It is necessary to organize independent regional environmental monitoring near the RW reprocessing plant in order to evaluate the current situation and forecast consequences for the health of nature and people.*

Spent nuclear fuel (SNF)

Spent nuclear fuel is a special type of waste. SNF from RBMK reactors is kept in a temporary storage on the plant site.

The SNF of VVER-440 reactors is brought to the "Mayak" industrial company, facility RT-1 in the town of Ozersk, Chelyabinsk Oblast. Unlike Germany Russia reprocesses SNF from all VVER-440 reactors in one place. The plant also takes SNF from Russian nuclear submarines and fast-breeder reactor BN-600.

Temporary storage for RW and SNF from the Greifswald NPP (Germany).

The plant which has a design capacity of 400 t/year was put into operation in 1977. The SNF coming to the plant is kept in the buffer storage of the 1440 t capacity. The SNF reprocessing gives the following products:

- molten uranyl nitrate, the raw material for producing new fuel for the RBMK-1000 reactors;

- plutonium dioxide goes to the storage facility (due to the lack of demand on it).

SNF is reprocessed by the technology of extraction, which produces a large volume of liquid RW.

For many years PO "Mayak" discharged huge volume of LRW into the environment. This practice continues today. Every year about ~10 mln. m^3 RW is discharged into the environment, which poses a threat not only to Chelyabinsk, but also to neighboring regions. It is also a threat to the seas of the Arctic Ocean, to which flow the rivers from the catchment area hosting SNF reprocessing facilities.

After an improvement of the technological process, the discharges of low- and middle-level liquid waste into water were reduced by 10%. Still, taking into account the catastrophic environmental situation resulting from PO "Mayak" operation (its radiochemical plants in particular), the Legislative Assembly of Chelyabinsk Oblast took a decision to restrict the production capacity of RT-1 facility by 50%.

This reduced an impact on the South Urals habitat, and resulted in the SNF accumulation on the temporary storage site of PO "Mayak". This produces new problems for safe storage.

As SNF reprocessing requires still safer and more expensive technologies of its isolation, its reprocessing cost is not compensated by selling the regenerated uranium.

SNF of RBMK-1000 reactors is concentrated in the temporary storages near NPPs. By now 9500 t of it has been accumulated. Almost half of this is the SNF of Leningrad NPP.

Every year about 3000 spent fuel assemblies have been transferred to the temporary wet storage of the plant. Starting from 2005 Leningrad NPP uses uranium-erbium fuel, which has a 2,8 % enrichment. Its burn-out resource is much larger. Therefore, the yearly dispatch of SNF to the storage will be reduced to 1000. It means that in case of the 15-year lifecycle extension of all four power units an additional number of fuel assemblies will be 15000.

At present LNPP is finishing the construction of a cutting unit for fuel assemblies. Each half of an assembly, which is cut into two parts, will be placed into the metal-concrete container on the plant territory. This will be the intermediate "dry" storage of SNF. Later, when the Krasnoyarsk Mining-Chemical Combine completes the national SNF storage, LNPP will start the transfer of its spent fuel there (up to 2300 assemblies annually).

Essentials and recommendations:

The current technology of SNF reprocessing from VVER-440 reactors practiced at RT-1 plant in Ozersk, Chelyabinsk oblast, does not provide the adequate level of environmental safety on the regional level and produces additional risks of global scale.

The planned transfer of RBMK-1000 SNF from near-plant dry storages to the similar national storage on the bank of the Yenisei river in Krasnoyarsk Territory does not solve the problem of its long-term isolation from the living environment, it only transports problems from one region of Russia to another. In view of this, it is necessary to:

- Terminate SNF reprocessing at RT-1 plant until the efficient technology is developed.
- Build monitored dry storages of SNF from VVER-440 and RBMK-1000 reactors on NPP sites.
- Develop the national Concept of SNF management. It must be socially and environmentally acceptable, comply with national legislation and international commitments of Russia. SNF should be transported around Russia only after the Concept enactment.

2.3 Radioactive waste produced at NPP decommissioning

RW volume will considerably grow during the NPP decommissioning, which will bring dramatic changes in the total RW situation. That is why the establishment of unified efficient system of RW management is a key task within the decommissioning program.

Solid radioactive waste (SRW) during NPP decommissioning

SRW produced at NPP decommissioning can be grouped into three large categories of different activity levels and having a number of specific properties:

- metallic waste;
- construction waste;
- waste arising at dismantling, resulting from the destruction of protective barriers.

SRW of decommissioned VVER-440

The radioactivity of decommissioned VVER-440 structures is ~ 2,5 mln. Ci, including the radioactivity of in-vessel instrumentation – 1,2 mln. Ci. The mass of reactor structures and in-vessel instrumentation is ~ 300 t. Metallic waste formed by dismantled pipelines, fittings, etc, belongs to the me-

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[18] P. VIalimiaki. Activity inventory and quantitative evaluation of NPP Loviisa dismantling waste. – Report YJT-87-12, AO :Imatran Voima", Helsinki, 1987.

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Table 4
SRW amount and activity arising from dismantled VVER-440 power unit[18]

Material	Activity, Ci	Radionuclides	Waste mass, t т	Waste volume, m3
Radioactive material	$2,5\times10^6$	^{55}Fe ^{60}Co ^{63}Ni	2600	4460
Contaminated material	30	^{60}Co ^{110}Ag ^{54}Mn	5100	7940
Waste arising at dismantling	Low	^{60}Co ^{54}Mn ^{110}Ag	760	840

[19] Radioactive waste handling in Russia and in the countries with developed atomic power industry /Editor V.A. Vasilenko. – SPb., Morintekh, 2005. – 303 p.

dium- and low-level waste group. Its activity results mostly from corrosion products, and it ranges from 1×10^{-8} to 1×10^{-4} Ci/kg.

All in all, during the decommissioning of VVER-440 power unit ~ 14 th. t of metallic RW and ~ 10 th. t of contaminated concrete and building structures is produced. In addition to that RW listed in the table, reactor structures and in-vessel instrumentation metallic waste includes:

- equipment of RW processing units;
- RW kept in the plant site storages;
- Structures of RW storages and other auxiliary equipment.

SRW at RBMK-1000 decommissioning

The situation with SRW produced at the decommissioning of RBMK-1000 power unit is more complex, because the amount of waste arising during its dismantling is still larger. It is about 100 th. t of concrete and 10 th. t of steel with a total radioactivity of 2.8 mln. Ci (105 TBq). Beside metallic SRW and demolished structures, it is also necessary to manage 1700 t of radioactive graphite, the reprocessing technology of which is still unavailable.

LRW at NPP decommissioning

LRW produced at decommissioning Russian NPPs include:

- equipment and rooms decontamination and washing liquids – 25 th. m^3;
- water from emptied reactor systems – 1000 m^3;
- water from the sanitary checkpoints, bathrooms, laundry rooms – 30 th. m^3;
- pulps of pearlite, ion-exchange resins, bottom sludge – 200 m^3;
- vat residues, condensate from the LRW evaporation units – 20 th. m^3.

This waste belongs to the low-level category. The specific activity of the most is from 1×10^{-6} to 1×10^{-4} Ci/l, and the total volume of the whole inventory of such waste is up to 100 th. m^3 [19] .

Essentials and recommendations

- *Due to the absence of infrastructure for the safe RW immobilization (repositories) the decommissioning of power units cannot be started. Until now the principal solutions on repositories have not been taken.*
- *The Decommissioning Plan should include an integrated analysis of the SNF and RW safe handling during the decommissioning. The Plan should be discussed with all stakeholders including the people living in the regions of decommissioned NPPs and regions, where SNF/RW is processed and disposed of.*

2.4 Necessity of establishing a unified RW management system

Financing of the RW management system has always been the matter of least priority for the RF nuclear industry. It has not worked out standard solutions for the RW treatment and pre-disposal conditioning.

The technologies of RW reprocessing and conditioning and, consequently, RW treatment facilities were built taking into account the waste generated at each company. Most of them are non-standard and cannot be universally used.

The available RW treatment facilities are inefficient, have design and technological deficiencies. Most of waste is kept in temporary storages of different types, which do not meet the modern safety requirements and do not have the necessary service equipment. This is explained by the absence of conceptual approach to the RW management. The problem grows in urgency in view of the coming NPP decommissioning and the avalanche-like RW piling up.

The acting regulatory and legal provisions (nuclear legislation) of the federal level leaves the safe RW management behind.

Essentials and recommendations:

The acting Russian legislation on the RW handling is deficient. It will not provide the effective RW management during the decommissioning of power units, which have reached their design lifecycle limit.

The long-term storage, as well as the final disposal of RW should be sited based on its maximum vicinity to the source of waste generation, in the suitable geological formations of the region, where the nuclear power in consumed.

The safe decommissioning of NPPs with expired lifecycle needs:

- Federal Act on RW handling.
- A national system for managing the RW handling activities.
- Regional centers of RW management near each of the decommissioned NPPs.

The systematic approach will enable to solve numerous problems of RW handling activities including:

- Developed legislative basis on all aspects of RW handling;
- RW accounting and control of its condition, including storage and disposal facilities
- Methodological support of studies on the RW disposal site selection and analysis, establishment and development of the database on the characteristics of the natural barriers of the site planned for hosting the waste repository;
- Coordinated activities aimed at establishing standard technologies for the disposal of all kinds of waste; optimized technical solutions for the waste pre-disposal conditioning; safety analysis of regional waste repositories; analyzed situation with available local storages of liquid and solid waste at companies; considered option for establishing local RW repositories;
- Tenders on design, research and construction projects and other activities directed at improving the RW handling system;
- Public awareness about the RW management in accordance with the acting RF legislation;
- International cooperation on RW management.

Temporary RW and SNF storage constructed near Greifswald NPP and designed for 200 th. m³ of waste.

2.5 Proposals for establishing regional RW repository in the North-West Russia

The Northwest of Russia faces the urgent necessity of establishing a regional RW repository. The main challenge to the new facility will be the development and introduction of a system of advanced technological and organizational principles, and development of standard and reproducible approaches to the decommissioning problem.

Those RW management approaches which have proven their efficiency will be adjusted and used for other toxic waste.

As acknowledged by the IAEA, the most effective and safe solution of the RW final disposal is its burial in repositories at the depth not less than 300-500 m in the deep geological strata using the concept of multi-barrier protection and mandatory solidification of LRW.

Geological formations of three types are suitable for the RW isolation from the biosphere:

- magmatic and metamorphic rocks;
- clays;
- rock salts.

German activists try to stop the transport of SNF to Gorleben Storage

RW repository option in Northwest Russia

The comparison of geomechanical, hydro-geochemical, thermo-physical and other properties of these formations has shown that salts have the best combination of characteristics as a hosting structure. Distinct features of salt rocks are: a very low speed (or immobility) of groundwater flow and a gradual self-sealing of gaps due to the salt creeping characteristics. Beside that salt deposits have a very high stability, which is proven by their age, most of them are not younger than 200 million years.

The regional repository for North-West Russia could be built in the exhausted salt mines in the Komi Republic. The abundance of salt rocks with exhausted salt mines in the North-West Region of Russia provides conditions for a pilot repository project implementation.

The analysis made by the Mining Institute of the Kola Scientific Research Center of the Russian Academy of Sciences provided three candidate salt rock sites. In the opinion of the authors these sites most fully meet the requirements of the radiation and ecological safety; they are quite far from residential places, but are located in the region with developed transport and engineering infrastructure. That is, they meet the geological and mining, socio-demographic, transport and technology critertia for hosting suchlike facilities. More detailed studies are necessary for the final choice of RW repository siting.

RW repository option in the Baltic Russia

An option of a repository (controlled storage) for low- and medium-level waste is offered by Lenspetskombinat Radon (a waste-management company) located near Leningrad NPP, 1 km from the shoreline of the Gulf of Finland. By now the company, which runs the North-West storage of low- and medium-level waste, has accumulated more than 60000 m3 of radioactive waste kept in surface vaulted concrete storages.

In the opinion of A.A. Ignatov, LSK Radon Director, a possible disposal option can be offered by the Cambrian clay stratum under the company site. A trial borehole was drilled to the depth of 130 meters. In the opinion of Radon administration the drilling results confirm the feasibility of such an option; they are supported by the experts of SGN (France), AEAT (Great Britain), IVIE (Finland), SCK-CEN (Belgium).

It is known that the choice of a site can bring violent public protests. That is what happened in Gorleben (Germany), where the young people are actively protesting against the transportation of SNF from German NPPs to the repository made in the former salt mines. The public protests even resulted in casualties.

Essentials and recommendations:

The plans for regional RW repositories cannot be developed in secret from the local authorities and public. Before the design work *starts, such plans, as well as the project concept, should get an approval after the discussion by concerned public; they should comply with Russian legislation and international commitments of the country.*

It is necessary to organize public hearings and mandatory environmental assessments. The environmental impact assessment as well as the future repository design should be made available for the public environmental impact examination conducted by all stakeholder organizations.

The burden of RW management costs should be carried by the producers of this waste.

The social and ecological aspects of proposed options should be acceptable.

2.6 Legal provisions for RW management in Russia

At present the management of radioactive waste is regulated by the clauses of twenty eight Federal acts, including the Civil, Administrative and Criminal Codes, twenty Presidential decrees, forty decrees and regulations of the RF Government. There are also 18 legal acts issued by the ministries. These documents were developed in accordance with the IAEA "Joint Convention on the safe handling of spent nuclear fuel and radioactive waste" and "Principles of radioactive waste handling".

During last 15 years Russia took efforts to regulate nuclear industry activities. But one of the most important parts of the nuclear fuel cycle – safe RW handling – was left outside the framework of legal regulation by federal acts. Most experts acknowledge the necessity of having the appropriate law. At present a draft of the Federal Act "On handling radioactive waste" is being considered by the Government, and by the end of 2008 it will go to the State Duma.

By now Rosatom has produced the following three documents:

2.6.1 Doctrine of radioactive waste management in the Russian Federation.

The Doctrine (the guideline from the Government) clauses serve as the basis for formulating the governmental policy and developing proposals for the integrated RW management system. It is also a basis for development and implementation of target programs aimed at establishing and sustainable functioning of the integrated public RW management system. This document is based on existing legal acts and international RF commitments.

The Doctrine takes into account the recommendations of the UN Rio-de-Janeiro Conference, 1992. It acknowledges that "necessity to optimize work on the RW management gets a special relevance in view of more extensive activities on the decommissioning of nuclear facilities".

The Doctrine also acknowledges that in addition to the running costs of RW handling, which should be included into the price paid by the customer using the atomic energy or sources of ionizing radiation, there must be target allocations to a specialized fund (reserve). The fund will be used for capital investment into the design and building of final repositories, etc. It is also noted that the special fund (reserve) will be accumulating the necessary means, spending of which will be carried out in compliance with acting legislation.

Therefore, public participation in such control is possible, if there are appropriate provisions in the legal acts. One of the principles declared by the Doctrine on the integrated RW management system is "openness, glasnost, fullness and reliability of information on the RW management in accordance with the acting legislation". The importance of "organizing a systematic work with the public on the issues of the RW management system" is noted. But these principles are just declared, and it is not clear how they will be specified in the Act on RW management and put into practice.

2.6.2 Concept and draft of the Federal Act "On radioactive waste management"

Two versions of the concept and, correspondingly, two versions of the draft have been developed; they have substantial differences. The first version was developed by an independent non-governmental organization of legal research "Institute of law and legal-legislative development"; it was issued on April 2007.

Developers of the first Concept had the main task of determining working organizational and financial mechanisms of RW management. Important provisions of the first draft are:

a) introduction of the integrated system of RW management;

b) determination of the federal executive body responsible for the RW management appointed by the RF President or, on behalf of him, by the RF government (other documents say that it must be the executive body, which is responsible for the production of the largest part of RW). The competence of this body includes the legal-legislative regulation of RF handling, control of safety at RW handling, control of activities related to the RW handling (as we can see, even before the enactment of the act "On safe RW handling" this function was performed by the Federal Atomic Energy Agency, that is, if the new act follows this concept, this agency will become an authorized RW management body or, which is more likely, a separated part of the agency will get this responsibility);

c) determination of the regulatory body responsible for the safety of RW management appointed by the RF President or, on behalf of him, by the RF government to regulate nuclear, radiological, technical and fire safety (Rostekhnadzor).

These bodies will have the following responsibilities:

- filing requests to the bodies having the right of legislative initiative;
- proposals on legal acts development and on safety provisions during RW handling;
- oversight of nuclear, radiological, technical and fire safety;
- examination of the safety of projects on RW management, also by inviting independent experts;
- control in the field of environmental protection and use of natural resources at the RW handling;
- control over expenditures of money and materials assigned for activities on regulating nuclear, radiological and fire safety.

Therefore, it is evident that responsibilities of a body responsible for the RW management and of the regulatory body coincide, and a question arises about a possible conflict of interests and insufficient independence of the governmental body regulating issues of nuclear and radiation safety. This contradicts the provisions of the Convention on nuclear safety and Joint Convention on safe handling of nuclear fuel and radioactive waste (both conventions were ratified by Russia); it also contradicts the Federal Act "On nuclear energy utilization". In accordance with these documents the development of federal norms and rules in the field of nuclear energy utilization is within the competence of specially authorized bodies responsible for the safety regulation during the utilization of nuclear energy.

It is important that the draft have a dedicated chapter on decommissioning and provisions for establishing decommissioning infrastructure.

In view of this, there is an interesting proposal on funding of the RW handling. The document proposes that RW should be managed by an assigned governmental organization.

In accordance with the RF Civil Code a governmental company should account for budgetary and non-budgetary means spent by it. An essential condition for establishing such a special organization is the transparency of its activities, close control of the state and the public, personal responsibility of its managers.

In order to provide the public control it is proposed to have the Supervisory Council, members of which represent authorities, RW producers and non-governmental organizations. The Supervisory Council should have the following functions:

- control of justified, effective and objective-oriented use of money by the specialized organization;
- initiation of revision of tariffs on the long-term storage or disposal of RW (procedure to be formalized by the statutory document of the organization);
- development of recommendations to the federal executive body, which controls the RW management, on the planning and organization of the federal budgeting earmarked for the RW handling.

The budgetary means, which are not spent during the current year, are channeled to a special reserve fund. The Supervisory council takes a decision on the reserve money spending, to avoid the reserve fund embezzlement members of the Supervisory Council bear the subsidiary responsibility for the reimbursement of losses.

The act also takes into account the huge "historical legacy" of RW resulting from the military programs and during many decades of using atomic energy without proper financial allocations on the RW management activities.

It is proposed to make a difference between the legal provisions on the previously accumulated waste and provisions for handling currently produced waste. The latter are dealt with by the "polluter pays principle." That is, a legal entity, the activities of which produce radioactive waste, should bear the financial responsibility for all RW management operations up its final disposal. All activities on waste collection, conditioning, recycling, temporary storage and transportation can be carried out independently by the "polluter" or by a specialized organization contracted to do this job.

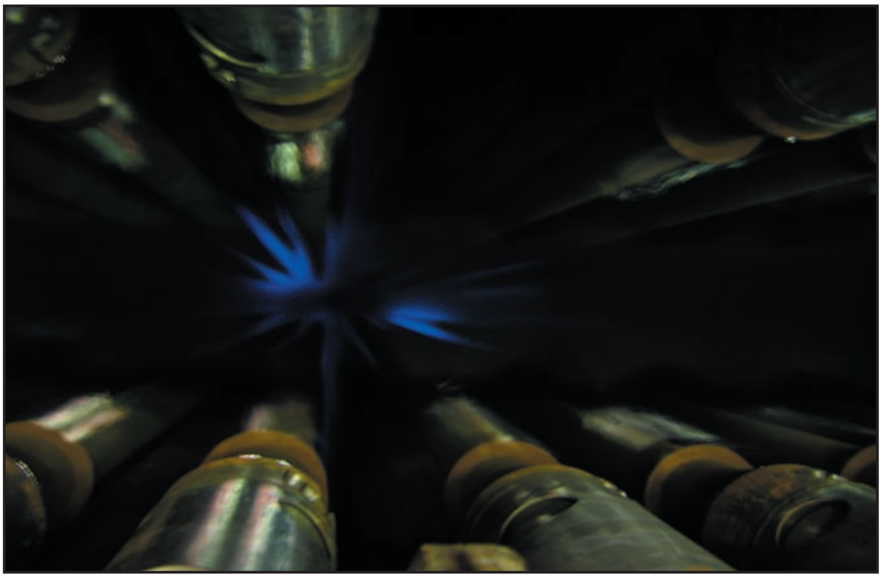
All waste, both generated before the enactment of the Act on RW management and new arisings, should be transferred to the responsibility of this specialized organization. Activities on managing previously accumulated radioactive waste should be funded from the federal budget, budgets of RF subjects and municipalities.

But the budgetary means cannot solve the problem of "historical heritage", therefore it is proposed to establish a special fund – a non-profit organization. This fund can receive money from international organizations, foreign countries, any companies including waste producers, also from private persons, local and regional budgets.

In order to work efficiently this fund should be completely transparent. In order to prevent misspending of the fund money it is proposed to include a list of activities, which can be financed from the fund, into the text of the RF Act "On safe RW management". Along with the disposal and long-term storage of previously accumulated RW it is the refurbishment of RW storages and cleanup operations after accidents in the RW storages. The fund resources are a part of the extra-budgetary means of the specialized organization.

The "historical" waste will be separated from the currently-produced by a special commission, the main function of which will be making the inventory of previously accumulated RW and its separation from the newly-generated RW using the waste-ac-

Vavilova-Cherenkova radiation from the SNF in the cooling pools near the RBMK reactors



counting system.

Developers of this draft assert that they took efforts to avoid contradictions between it and the previous documents regulating RW handing activities. Still it is proposed to bring all acting regulations in compliance with the new act within 6 months after its coming into force.

A second version of the Concept was issued in September 2007. This draft of the Federal Act "On radioactive waste handling" was developed in accordance with provisions of Point 4 of the Action plan for implementing the second stage of the State policy in the field of nuclear and radiological safety of the Russian Federation for the period up to 2010 and a long-term prospective (RF Government Regulation of 17 December 2005 № 2237-r) ordered by the RF Government. The bill was developed jointly by many ministries and agencies, but the Federal Agency for Atomic Energy was the responsible party.

The new version of the Concept states that "the draft takes into account the provisions of the Joint Convention… in particular, that the final responsibility for the safety lies with the state".

But this version dropped such important functions of the federal executive body regulating safety as nuclear energy utilization, as the oversight and control of RW management activities, and as development and enactment of norms and rules in the field of nuclear energy utilization in compliance with the Russian legislation. The Concept only mentions the responsibility of the regulatory body to license the RW management activities.

The new Concept does not explain the governmental approach to the problem of "historical" waste management.

It also misses an approach to determining the procedure for establishing the RW management fund. The Supervisory Council responsible for the Fund activities transparency and PR, which had been present in the previous version, disappeared.

The body responsible for administering the RW management should determine the levels of fees from the RW producers and be responsible for the RW management funding. In this respect the Concept pays special attention to nuclear power plants, for which the top level of allocations is set, i.e. the top limit of contribution. This is done "for the purpose of their (NPP) predictable development." That is, in accordance with the Concept, safe RW handling by NPPs (including the decommissioning period) is of less priority than building of new reactors. It inevitably leads to the aggravation of the decommissioning problem for old reactors or closed for other reasons, it also means that the decommissioning fund will not be replenished.

In the current situation of developing market relations in the industry the proposed transfer of responsibility for RW (together with the property rights on it) to the state will result in an additional burden on taxpayers, which will have to finance the RW long-term storage or disposal; and interests of future generations are likely to be violated.

The draft act specifies provisions of the Concept. But the analysis of the new draft raises many questions.

It is not clear what reference base was used in determining the following terms:

- RW temporary storage (up to 50 years);
- RW long-term storage (from 50 to 100

Construction of an underground laboratory for the study of the possibility of building a long-term storage of HRW in the granite of the Kannsky Mountains (Zheleznogorsk, Krasnoyarsk Region) years);

- "Historical" RW (all RW produced before 1 January 2010, except those generated by the commercial activities of companies not fulfilling the state order after 28 September 2008).

RW storages filled to capacity or not meeting modern safety requirements should be closed (this is currently in progress), but the draft does not explain the term "closure".

Article 4 "Main principles of the integrated RW management system functioning in the Russian Federation should include the "polluter pays principle".

The act should regulate not only the provisions for development and the formulation of federal norms and rules in the field of nuclear energy utilization, but also their putting into force (Article 5).

In the draft the regulatory function of the federal body for nuclear and radiological safety is substituted by the function of safety enforcement by a competent body on RW management. This contradicts the modern tendency of separating responsibilities between the two bodies and strengthening the independence of regulatory body - this, as it was said above, is prescribed by the provisions of the Convention on nuclear safety and Joint Convention.

The Supervisory Council mentioned in Article 45 does not have a definition. The procedure of its formation is not determined too. The control of justified spending of the fund money goes to the revision commission of the governmental competent body responsible for RW management. Therefore, the external control of the fund expenditures is not foreseen by the draft act.

The RW management at decommissioning of old power units will be funded from the joint RW management fund. This can lead to the repeated shortage of funding and result in the exponential growth of SNF and RW piles during the planned large-scale development of nuclear industry. The safe handling in accordance with modern requirement won't be possible due to the lack of funding.

In the new version the public participation in the RW safety management is reduced to the "unbiased information of the public by the mass media about the radiological situation on the territories (of municipalities neighboring nuclear facilities)".

International cooperation of the Russian Federation in the field of RW management is limited to the cooperation of the responsible body (Article 48). This cooperation should involve federal and other bodies.

Finally, some articles of the discussed draft contradict the draft Concept of the RW management. E.g. the Concept gives the function of licensing of RW management activities to the regulatory body, and the draft (Article 31) – to the governmental body responsible for RW management.

Essentials and recommendations:

- *The Federal act on the radioactive waste management should be in compliance with international standards and regulations; it should not only formalize the final responsibility of the state for the long-term RW storage and (or) disposal, it also should separate responsibilities of the governmental body for RW management and a governmental regulatory body on nuclear and radiological safety; the act should strengthen independence of the latter.*

Ignalina NPP (Lithuania). Castor containers with SNF in the temporary storage.

- *The act should regulate not only the provisions for development and the formulation of federal norms and rules in the field of nuclear energy utilization, but also their putting into force.*
- *It is necessary to bring back the clause on the Supervisory Council and determine its establishment procedure, foreseeing the active participation of the public and local authorities.*
- *It is necessary to determine the procedure for external control of the expenditures made by the RW management fund.*
- *It is necessary to give a more detailed definition of the RW management at decommissioning of the old NPPs. Probably it is more efficient to establish decommissioning funds for each NPP and regional supervisory councils, which include representatives of federal authorities, national and international NGOs.*

2.6.3 Summary of the Federal act on the special technical procedure "On requirements to the nuclear and radiation safety during radioactive waste handling".

This act regulates technical requirements to the nuclear and radiological safety of the RW management. Development of this technical procedure was necessary, because the Federal Act "On technical regulation" cannot foresee all complexities of technical problems emerging during RW management, which are much more complex than problems related to other kinds of productive activities. The development of safety norms for nuclear power utilization activities is one of the IAEA tasks.

Rosatom specialists have analyzed the regulatory basis of the Federal Act "Special technical procedure". The analysis of the whole inventory of acting Russian and IAEA documents enabled to make a conclusion that the RF regulatory documents have been basically harmonized with international guidelines. Therefore, in compliance with Act of 1 May 2007. N 65-FZ "On introducing changes into the Federal Act "On technical regulations" technical procedures in the spheres dealing with nuclear and radiation safety continue to be the acting regulatory documents.

Greifswald NPP (Germany). Radioactive waste of the temporary storage

CONCLUSIONS

In the coming 10-15 years most of the currently operated NPP units will reach their design lifecycle limit. The lifecycle extension of nuclear power units cannot be repeated again and again due to their inherent limitations explained by the deterioration of structural qualities and unfeasibility of safety measures.

It is economically unsound to modernize such facilities so that they could meet the required safety standards.

The Russian society will be forced to solve a complicated and multidimensional problem of reactor decommissioning. It is a complex, expensive and continuous process, which includes technological, social, environmental, economic and ethical components.

Current situation with preparing Russian NPPs for decommissioning.

At present Russia is not prepared for the decommissioning of its power units. In particular:

- **There are no financial mechanisms** for budgeting power unit decommissioning. Money is not accumulating in the reserves foreseen in the sales of nuclear power; and efficient control of the money accumulation and spending is absent.
- **There is no effective legislative and legal basis** for radioactive waste management, as well as for the social protection of NPP employees during the decommissioning.
- **There is no national system for efficient management** of radioactive waste (RW) and spent nuclear fuel (SNF), which is indispensable for decommissioning. No national and regional RW and SNF repositories, which can store (reprocess) the avalanche-like increase in their volumes during power unit decommissioning.
- **Socio-economic infrastructure of nuclear neighborhoods is vulnerable**, because it depends on the production of nuclear power. This is a potential source of an acute social crisis involving many hundred thousands of Russian citizens living in the nuclear neighborhoods, which will be experiencing NPP decommissioning.
- **There is no solution providing the reliable long-term (for millennia) isolation** of radioactive carbon of RBMK graphite reactors from the living matter (or its reprocessing); the currently used technology for VVER-440 SNF reprocessing causes large-scale contamination of living environment.
- **The existing system of metallic RW recycling has been unjustifiably sited** on the Baltic coast; the recycling is performed by a single of its kind private company ECOMET-C in the town of Sosnovy Bor in Leningrad Oblast. The reprocessing of metallic RW has led to cytogenetic changes in the pine trees growing near the company and in the town of Sosnovy Bor
- **There is no regional ecological monitoring around NPPs**, independent from nuclear industry and transparent for society, which should assess the current situation, forecast consequences for the health of nature and people during the NPP decommissioning.

The multi-unit design of most Russian NPPs enables to make plans for staged shut-

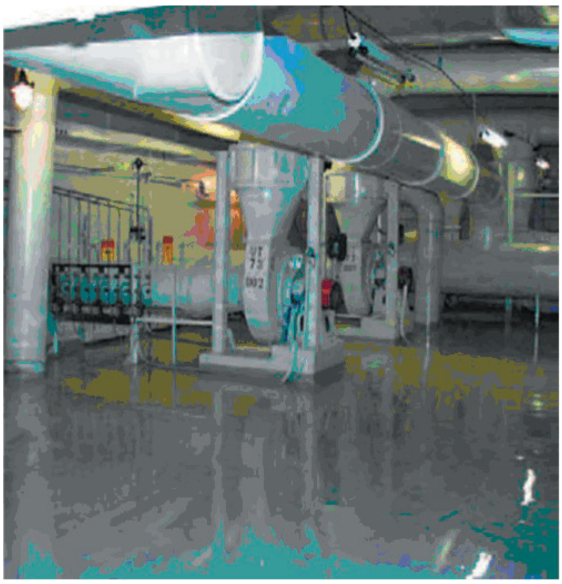
The Radon storage site of low and middle solid radioactive waste (Moscow). Metallic barrels (200-liter) with waste located in the concrete cells

Container for the transport of solid low and middle radioactive RW at the Radon site (Moscow)

down of their power units; and this will enable to mitigate social problems caused by job cuts.

The NPP decommissioning experience of other countries shows that the optimal budgeting of the process should be planned well in advance.

It is immoral for the generation of nuclear power consumers to export the decommissioning problem solution to future generations, which would not use nuclear power.



Kola NPP (Murmansk oblast, Russia). Center for the reprocessing of LRW

RECOMMENDATIONS

It is necessary to urgently start the integrated planning of decommissioning for the Russian first-generation reactors, primarily Kola, Leningrad and Novovoronezhskaya NPPs.

In choosing the decommissioning scenario it is necessary to take into account risks of negative socio-economic consequences, not only for the region hosting the decommissioned power unit, but also for the regions where facilities for the centralized reprocessing (storage) of SNF and RW are located; also trans-boundary consequences for the ecosystems of international value.

On the principles of NPP decommissioning planning

The decommissioning plans should be based on the condition of sustainable development of regions hosting the NPPs and proposed facilities of RW and SNF disposal and reprocessing. For that, the principles below should be followed:

- **Transparency** of all political, technological, environmental, social and economic decisions taken;
- **Involvement** of concerned public into the decision-making process;
- **Independence** of ecological, technological and financial monitoring of the decommissioning plan and projects implementation;
- **Nuclear, radiological and ecological safety** during the equipment dismantling and SNF/RW management;
- **Social protection** of the personnel, which depend on the operation of power units subjected to decommissioning; also applies to nuclear neighborhoods.
- **Social responsibility** before future generations of people, which will live in the region where NPPs have been decommissioned and near the sites where RW and SNF have been disposed.

On the choice of scenario and final condition of the site after nuclear power unit decommissioning

In order to choose a decommissioning scenario acceptable for the whole society (delayed or immediate dismantling) it is advisable to contract an organization independent from nuclear industry and take public priorities into account. This will enable to take a decision, which reflects the main societal priorities and values in the best way.

“BROWN FIELD” as the final condition of a reactor site after the decommissioning probably agrees to the highest degree with the national mentality and present-day values of Russian society; the international experience shows that it is also economically justifiable.

The immediate and staged dismantling of shutdown NPP units, without a long waiting period, has an advantage of cost reduction due to the partial use of existing social and technological infrastructure (handling and transportation equipment) and a third of highly-qualified personnel of the operating NPP.

The “brown field” strategy can stimulate new industrial development not necessarily related to atomic technologies.

It is advisable to take a decision about the scenario and final condition of the site after the NPP decommissioning after a broad public discussion of all possible options.

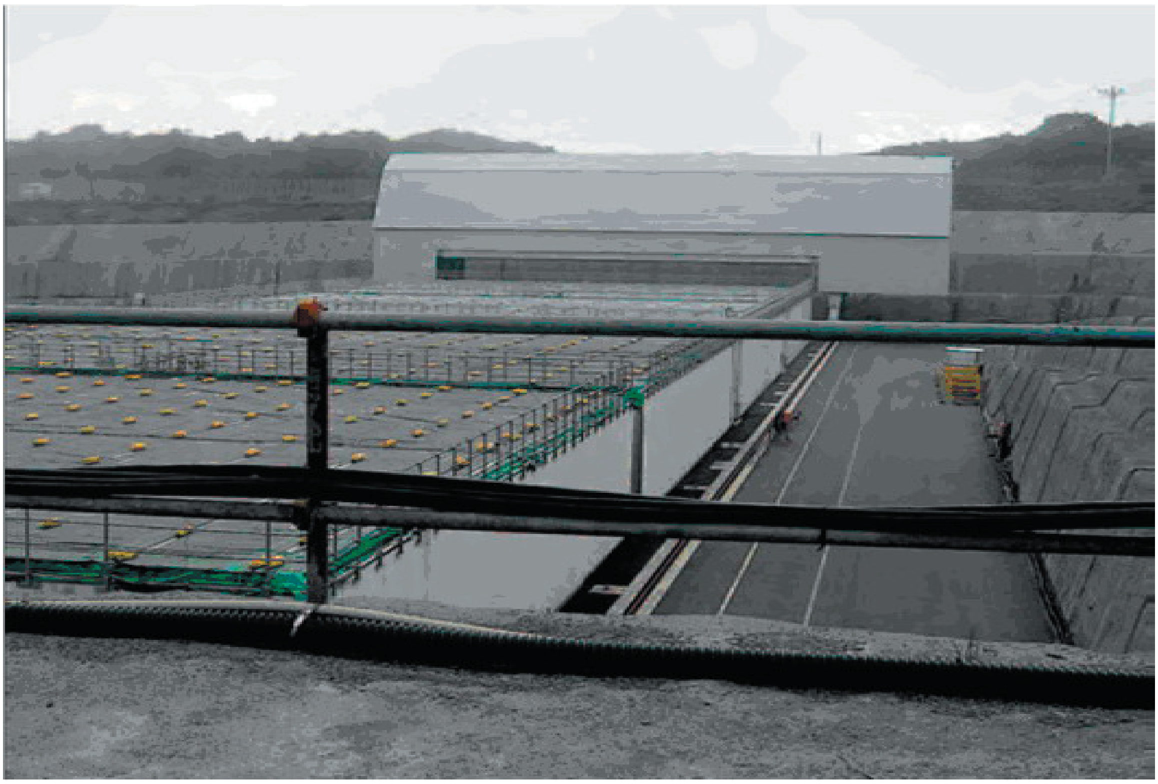
Materials of the Environmental Impact Assessment (EIA), design documents of the NPP Decommissioning Plan should be available for the pubic environmental examination. Public hearings on EIA should be organized for the concerned public.

The Plan (Project) of NPP decommissioning should be subjected to the state environmental examination.

On the decommissioning fund, its mission and management

It is necessary to adopt a legal act on the Decommissioning Fund. It is advisable to have a separate fund for each NPP, which would accumulate necessary reserves for its decommissioning.

Sources for the Fund replenishment will



Rokasho RW storage in Japan

include allocations from the sold NPP energy, as well as voluntary contributions from organizations (including international) and private persons. Voluntary donations are probably necessary for the decommissioning of power units reaching their design time limit, but not having resources for the decommissioning program.

Mission of the Fund – financial provision for meeting the whole range of technological, social and environmental challenges related to the NPP decommissioning, also including mitigation measures fir nuclear neighborhoods and locations of RW and SNF disposal.

The structure of decommissioning fund should foresee expenditures on:

- power unit dismantling, disposal or long-term immobilization of RW and SNF during the whole period of their noxiousness for living systems;
- transformation of the infrastructure used by the satellite towns of NPPs planned for decommissioning;
- solution of the social adaptation problems for people working at decommissioned NPPs.

Allocations of each NPP into its Fund should be sufficient for solving the whole range of problems related to its decommissioning by the time of its lifecycle expiry.

Mayak (Ozersk, Chelyabinsk Oblast, Russia)

The Fund should be managed by one of the federal ministries, e.g. the RF Ministry of regional development.

The Fund activities should be supervised its Board of Trustees, which will endorse annual plans for expenditures and get reports on their implementation.

It is advisable to include representatives of the Fund donors into the Board of Trustees, as well as representatives of federal, regional, municipal authorities and the public.

On the social and structural innovations in nuclear towns and protection of personnel during npp decommissioning

The closure of NPP units will require means for the diversification of socio-economic infrastructure of nuclear towns and decrease of its dependence on the nuclear facility.

In such cities it is necessary to remove all formal obstacles to the development of business not related to the atomic industry.

All restricted admission zones should be opened for establishing the competitive market environment, for that all administrative and other restrictions should be removed.

Establishment of business incubators in atomic cities is an efficient mechanism for starting new working places and developing entrepreneurship.

During the decommissioning it is expedient to restructure the plant management, transform departments into separate companies authorized to carry out independent economic activities in the region.

Opening of the Third Age University for socially active senior citizens of the nuclear town will facilitate their adaptation to new conditions and realities.

On radioactive waste and spent nuclear fuel management during npp decommissioning

It is necessary to establish a national concept and infrastructure capable of efficient RW and SNF management in the conditions of NPP decommissioning.

The long-term storage, as well as the possible final RW disposal, should be sited using the principle of maximum vicinity to the source of radioactive waste generation, in appropriate geological formations of the region, where the nuclear energy is consumed.

It is necessary to abandon the centralized recycling of all Russian metallic RW at the only specialized company Ecomet-S on the Baltic coast in Sosnovy Bor, Leningrad Oblast. If the environmental safety of the technology for reprocessing contaminated metal is confirmed, start the full-scale implementation of the Federal Target Program for the Reprocessing of Radioactive Metallic Waste[20] , establish a network of reprocessing facilities near the sources of radioactive metallic waste production.

It is necessary to suspend SNF reprocessing at the RT-1 facility in Cheliabinsk region until ecologically and socially acceptable technology is developed, which does not produce environmental contamination.

SNF transfer from plant storages to the centralized national storage does not solve the problem; it only moves it from one Russian region to another.

It is necessary to establish safe, dry and monitored storage sites of SNF from VVER-440 and RBMK-1000 reactors on NPP sites until socially and technologically acceptable technologies of its reprocessing or disposal are available.

It is necessary to ban the import of RW, SNF from other countries to Russia for its reprocessing, storage or disposal. The burden of responsibility for its handling should be carried by the country, which produced it.

On legislative provisions for npp unit decommissioning

It is necessary to adopt the following Federal Acts:

- **"On radioactive waste management"**. It must comply with international standards and rules, assign the ultimate responsibility of the government for the long-term storage and (or) disposal of RW, separate the responsibilities of a governmental body for RW management and a regulatory body for nuclear and radiological safety.

The unconditional independence of the regulatory body should be guaranteed.

The Act should foresee a possibility of establishing the Supervisory Council (SC), determine the procedure for its formation. It is necessary to foresee a representation of local authorities and concerned public in the SC. The Act should define the mechanisms for the external supervision of expenditures made to solve the RW problems.

The Act shall lay the basis for establishing the national system for managing all RW handling activities, regional centers for RW conditioning and disposal.

- **"On the social protection of employees working at decommissioned NPPs"**. The act should comply with the Constitution of Russia, as well as with the international documents, which guarantee human rights. The relevant Lithuanian act can be used as a basis for

[20] Decree of the Government of the Russian Federation №1197-r of 1 September 1995 on approving the target program "Reprocessing and recycling of metallic radioactive waste" presented by the Minatom of Russia.

Mayak (Ozersk, Chelyabinsk Oblast)

formulating appropriate regulations of the act.

On the public control of NPP units decommissioning

It is necessary to establish socially-oriented ecological monitoring of regions, where NPPs are decommissioned, and of areas around RW and SNF temporary storage or disposal sites. It must be transparent for the public and independent from nuclear industry.

Civil control of the decommissioning plan implementation can be efficiently performed by the established Regional Public Council. It can play a role of an advisory body for authorities, nuclear industry, it can also keep the society informed about the decommissioning progress.

Mission of the regional Public Council – provide social, ecological, technological and ethical acceptability of the decommissioning process, ensure its transparency and openness.

It is advisable to include the representatives of the following stakeholders into the Council:

- Rosatom,
- Rostekhnadzor
- Rosenergoatom (representatives of decommissioned NPP),
- regional authorities,
- municipal authorities,
- political parties participating in the regional legislative bodies,
- concerned non-governmental organizations,
- NPP trade unions,
- representatives of territories where RW and SNF are processed or stored.

Greifswald NPP (Germany). Transport of dismantled equipment to the temporary RW storage

Results of the Council activities should be published.

It is advisable to empower the Council and provide budgeting for independent examination of technological decisions taken and possible socio-economical consequences resulting from them.

Financial support of the Council activities should be provided from the regional budget. It is recommended that participation in the Council activities should not be remunerated. Only expenditures on trips and accommodation during the Council meetings should be covered.

The Statutory document on the Regional Public Council can be developed using the corresponding document on the Public Council in Germany.

APPENDIX 1. German experience of NPP Nord (Greifswald) decommissioning

Introduction

The nuclear power plant Nord near the town of Greifswald was built using the Soviet design on the coast of the Baltic Sea. The first power unit with the first-generation VVER-440/230 reactor was put into operation in 1973. Later three more power units were built with reactors of the same type. Construction of four more second-generation power units with VVER-440/213 reactors was started. But only one of them was put into operation in 1989, it was the fifth power unit of NPP Nord.

Reasons of NPP closure

In 1990, after the East and West Germany was united, secret reports on the safety of the first four Nord power units were published. They contained information about the unacceptably high risk of further operation of the first four power units; main problems – high degree of neutron embitterment and corrosion pits of reactor vessels, design drawbacks of steam generators, erroneous orientation of turbines versus reactor and a number of others.

Modernization of the first four power units was estimated as economically unfeasible.

The fifth power unit with VVER-440/213 reactor could be improved and upgraded to the safety standards of West Germany, because it belonged to the latest generation of this reactor type. But about 50.000 changes was made in the design documentation of this reactor during its construction. At this there was not a single document describing those changes. It seriously complicated the job on safety upgrade of the fifth power unit. As a result, the SIEMENS company, West German NPP developer, refused to take the responsibility for the power unit modernization in accordance with accepted standards.

Decision about decommissioning

In view of the above-mentioned in 1990 the government of unified Germany took a political decision about the shutdown of all operating power units. The construction of remaining three power units, which were in different degrees of preparedness, was suspended.

Absence of previously developed decommissioning programs resulted in high decommissioning costs at the first stage (1.3 bln. Euro from 1990 till 1995.). Provisions were made to ensure public and technological safety; the development of decommissioning strategy, technological procedures and legislative norms was accelerated.

Public control of decommissioning

Federal authorities founded the Public Council for the monitoring of NPP decommissioning. It included the representatives of federal, regional, municipal authorities, experts, representatives of NPP workers, political parties and NGOs. The Council members (16 persons) work on a voluntary basis (no salaries paid) and its activities are regulated by the Council Charter. Budget of the Council is about 250 th. euro/year. It covers the transport expenses of the Council members to take part in its work and organization of independent examinations and surveys. Council activities are open for mass media. Such approach relieved social tension in the beginning of decommissioning work. Document regulating the Public Council activities is presented in Appendix 2.

Decommissioning scenario justification

After the analysis of possible decommissioning scenarios (delayed for decades or immediate decommissioning) a concept of immediate decommissioning was chosen. This decision enabled to employ about one third of 5564 (1990) NPP workers for decommissioning operations. This prevented the social crisis of a simultaneous loss of jobs by thousands people, and the decades of waiting period until the short-lived radionuclides decay was finished..

Another argument for the immediate decommissioning is the possibility to use the handling and lifting equipment of operating power units. Such equipment loses its operational qualities after a long period of waiting, if the delayed decommissioning strategy is chosen. On the other hand, such decision required the development of high-tech dismantling methods for radioactive equipment. The decisions gave an impetus for developing such technologies, which can be useful for other NPPs. The new dismantling technologies ensured personnel dose rates lower than NPP operators .

Decommissioning

The program of NPP personnel adaptation was prepared in order to keep qualified specialists at the plant, and help to most socially vulnerable. Retraining courses were started.

In 1995 after the legal and regulatory base was finalized, a permit for staged power unit dismantling was received. Public company Energiewerke Nord GMBh was entrusted with the management of this process.

An intermediate RW and SNF storage facility was built on the plant territory; advanced methods of cutting radioactive equipment were introduced. After SNF was cooled in the reactor room storage pools it was transferred to Kastor containers and transported to the intermediate storage.

Halls and workshops freed after equipment dismantling were offered to new businesses. At present the territory of former NPP hosts a technopark, which uses some of old infrastructure. The discharge channel connected to the Baltic Sea, which had been used for cooling turbine condensers, was converted into a sea port. It is used by the new business, which is developed on the territory of former NPP shops. For example, the 1200 m-long turbine hall is used for the production of pontoons, which can be shipped via the port in the former discharge channel.

In the period of 1990 - 2035 about 3.2bln. euro will be spent on the decommissioning of 5 operated VVER-440 power units. By this time all reactor buildings, other equipment, parts of other structures will be dismantled, cut and transferred to the intermediate storage.

The issue of final SNF repository or long-term monitored storage has not been decided about yet; it will need additional budgeting.

Replacing sources of power

The power lost after NPP Nord (Greifswald) closure is compensated in accordance with the strategy of priority development of renewable energy (wind energy) and import of gas from Russia via the Baltic "Nord-stream" gas pipeline.

The gas line will come to the surface from the Baltic Sea bottom near the decommissioned NPP. A gas power plant is planned on the site, which will have the steam-gas cycle and efficiency coefficient of approx. 50%..

Evaluation of results

German experience shows that the use of NPP infrastructure at its decommissioning can reduce the cost of dismantling. The dismantling of contaminated equipment is possible without waiting for 50-70 years until most radioisotopes decay. The dose rate of personnel engaged in decommissioning is lower than during the plant operation.

The employment of plant personnel for decommissioning operations mitigates the problem of unemployment, which is better in comparison with the delayed decommissioning option – in the latter case nearly all workforce employed a the plant lose their jobs. There is no need in extensive decommissioning training, because the personnel knows the plant well. This is also the factor of cost reduction in comparison with the decommissioning delayed for several decades, in the latter case full-scale training is necessary.

The NPP Nord (Greifswald) decommissioning experience is the world-largest project of this kind. The acquired technological experience is in demand in other countries.

Table 5
Decommissioning cost structure for NPP Nord having 5 VVER-440 units having the Soviet-type design

№	Procedures	Cost (bln. Euro)
1	1990 - 1995 waiting period and preparation for fuel retrieval from reactors	1.3
2	SNF retrieval and handling stages resulting in its placement in containers in the dry storage	0.5
3	Dismantling of 6 power units, construction of intermediate RW storages	1.2 (approx. 200 mln Euro per unit)
4	Other expenses	0.2
	Total for 45 years (1990 - 2035)	**3.2 (~$4 bln.)**

Additional information on the German experience of decommissioning NPP Nord in Greifswald can be found in the documentary **"NPP Greifswald: Halted at Request"**, see Attachment 9.

Another documentary «**Quest For Partnership"** (same video attachment) shows a study trip to Greifswald. In the documentary the trip participants tell about the usefulness of German experience for Russia. Among them are :

- Serghey Subbotin – Vice-Governor of Murmansk Oblast;
- Nikolay Goldobin – Head of Poliarnye Zori Administration of (satellite town of Kola NPP);
- Dmitry Puliaevsky – Head of Sosnovy Bor Administration (satellite town of Leningrad NPP);
- Oleg Muratov – Head of radiation technologies department of JSC Tvell in St. Petersburg, the Executive secretary of the North-West Branch of the Russian Nuclear Society, mwbwbr of the coordination council for nuclear, radiation and ecological safety under the Rusian President representative office in North-West Russian federal circuit;
- Alexey Smelov – Head of Laboratory for ecology and radiation safety of NPP Kola ;

A study visit by Russian officials, nuclear experts and NGO representatives to the Greifswald NPP Nord (Germany). May 2007

- Nadezhda Shastina –engineer of the NPP Kola Information center;
- Julia Korshunova – sociologist, NGO GAIA, Apatiti, Murmansk Oblast;
- Oleg Bodrov – physicist, environmentalist, Head of NGO Green World, Sosnovy Bor, Leningrad Oblast;
- Igor Katerinichev, journalist, Murmansk.

Norbert Meyer, Chairman of the Public Council for the monitoring of NPP Greifswald Nord decommissioning

APPENDIX 2. Charter of the Public Council on the nuclear energy issues in the Land of Meklenburg, Vorpommern, Germany.

1. Responsibilities

1.1. The Council is a consultative body under the Land Government, it informs the public and resolves arguable issues related to the nuclear industry phase-out , also those related to the technological safety in the Land Meklenburg, Vorpommern, NPP Lubmin in particular. It also considers technical and legal issues related to the plant safety, radiological safety and conditioning of spent nuclear fuel.

The Council does not issue permits on the legal supervisory functions.

1.2. Consultative activities have the form of recommendations and opinion exchanges with the appropriate ministry – the permitting and supervisory authority in this field. The public is informed on the council recommendations and decisions via the Chairman of the Council or its deputy.

1.3. The Council is authorized to raise and consider questions related to the issues listed in Point 1.1.

1.4. In the course of its consultative activities the Council can invite experts (Council members) and external experts depending on the available budget.

2. Council Members and Chairman

2.1. The council on the nuclear energy issues has 16 members, which have no deputies (substitutes). Council members are independent in their activists and not bound by any legal acts or directives.

2.2 Each fraction of the Landtag [Parliament of the Land] delegates two representatives to the Council. Head of Lubmin Administration, Greifswald citizens, Kreistag [district council] of the East Vorpommern, Nature and Environment Protection Society, the Green League, Trade Union Council of

Energiewerke Nord and Civil Initiative on the Issues of Nuclear Energy delegate one representative each.

The Land Government delegates to the Council two independent specialists, which are not involved into the permitting or supervisory activities on nuclear installations.

2.3. Members of the council are approved by the appropriate Minister of Meklenburg, Vorpommern, the candidates are nominated by the organizations listed in point 2.2, term of their office coincides with that of Landtag of Meklenburg, Vorpommern, i.e. they work until new elections.

2.4. Members of the Council get no salaries. All costs including travel and accommodation expenses related to the fulfillment of the Council functions are reimbursed in accordance with the Land regulation on trip reimbursables. All payments are made via the Council office.

3. Record Keeping and Accounting

All record keeping and accounting is performed by the Council office, which functions under the Minister of appropriate body within the Meklenburg, Vorpommern government.

4. Council Work Procedures

The Chairman invites members of the Council to the meeting in the written form and informs them about the agenda. All documents and materials necessary for the discussion are attached to the invitation. If the meeting does not result in a decision, the Chairman appoints the time and place for the next meeting.

The council meetings are held not les than twice a year behind closed doors. Time and place are discussed at a preceding meeting. The unplanned meeting should be called within next 6 weeks, if at least 6 members ask for it.

If there is no quorum, the Council Chairman appoint the time and place of another meeting.

The period between the invitation handing to the addressee and the date of meeting is 14 days. This period is observed even if the invitations are sent out 17 days before the meeting. Proposals on the issues from the Minister or Council members to be included into the agenda should be received by the Chairman in the written form 22 days before the meeting. Requests for issues to be included into the agenda, which come later, or are proposed at the meetings, are discussed only if agreed by the two-thirds of the present Council members.

Meetings are conducted by the Chairman. In accordance with the established procedure he sends invitations, prepares agenda and checks quorum for the meetings.

During meetings Council members formulate and justify their recommendations and opinions, which are sent to the minister.

Annually before 30.09 the Council Chairman produces the annual report on the results of Council work during previous 12 months. The report is to be approved by the Council.

5. Decision-making Mechanisms

The quorum is reached, if the meeting is attended by more than a half of Council members including the Chairman and his deputy.

The Council takes decisions by the majority of voices at the open voting. If the number of voices "for" and "against" are equal, the decisive voice belongs to the Council Chairman. Members abstaining from voting are included into quorum, but not counted in voting results.

Each council member has a right to demand inclusion into the minutes the information on how this or that decision was taken and enter names of those against the decision, which should be made public in accordance with point 1.2.

Decisions can be taken only if the point of discussion has been included into the agenda.

6. Minutes

Minutes are kept at each meeting; they reflect results of the meeting. The council decisions and recommendations are recorded in detail. The minutes are printed by the office assistant, signed by the Chairman and sent to the Council members within two months after the meeting.

7. Confidentiality

Council members are obliged to keep confidentiality about the information received in the course of their activities within the Council. This also applies to the minutes of the Council meetings. Decisions and recommendations (p. 1.1, Appendix 2) also should be formulated taking confidentiality issues into account.

8. Council Awareness

In accordance with the Council decision the Land Government submits all information necessary for performing responsibilities of point 1 to the Council.

Decision on the way of information transfer (reference information, acquaintance with documents or delivery of documents) is taken by the Minister after hearing the Council members. The Minister explains his decision about the information transfer and submits it to the Council in the written form.

The Council can also take a decision about listening to experts, which are employed in the permitting and supervisory bodies, also to specialists on certain issues and representatives of authorities.

9. Changes in the Council Charter

In order to make changes in the Council Charter it is necessary to get the approval of two thirds of Council members. For that it is also necessary to get the approval of the Land Government.

10. Enactment

The council Charter comes into force immediately after the Council decision and approval of the land Government.

The current Charter was enacted on 3 December 1999 at the meeting of the Public Council on the nuclear energy issues in the Land of Meklenburg, Vorpommern [East Germany]; following that it was approved by the land Government.

(Translated from German by the Green World)

Greifswald NPP Nord. Castor containers with SNF from the VVER-440 reactors in temporary storage.

Greifswald NPP Nord (Germany). Dismantling of a reactor

APPENDIX 3. Lithuanian experience of Ignalina NPP decommissioning

Introduction

The first power unit of Ignalina NPP was put into operation in 1983, the second - in 1987. The design lifecycle of RBMK-1500 power units is 30 years. After the replacement of technological channels it is possible to operate the reactor for another 30 years.

After the collapse of the Soviet Union the nuclear industry of East European countries became an object of interest of the international community. During the first decade after Ignalina NPP was transferred to the jurisdiction of Lithuanian Republic a number of safety upgrade measures was performed.

Many West European countries having a considerable experience in nuclear power engineering provided large financial and technological support for implementation of the safety upgrade program of Ignalina NPP. The final objective of this program was to ensure compliance of Ignalina NPP with the international nuclear safety standards. In that period a number of detailed safety analysis studies was performed together with experts from different countries. The studies resulted in the identification of certain technically non-upgradeable structural deficiencies of RBMK rectors. E.g. the absence of containment, absence of secondary standby system and others.

Reasons for NPP closure

In the middle of 1990s by the initiative of G-7 and European Community leaders, the Western governmental authorities responsible for nuclear safety made the examination of nuclear facilities in the former Eastern bloc countries and assigned certain categories to all of nuclear reactors. Each category received recommendations on measures to be implemented to raise the safety level of nuclear power plant to the Western standards. Later the classification of East European NPP in terms of safety and recommendations for its upgrading were considered on the political level. In 1997 they were included into the strategic document of the European Commission related to the accession of the European Union. This document known as "Agenda 2000" says:

- The first, most dangerous category of nuclear reactors includes power units with the first-generation reactors (VVER-440/230 and RBMK). Modernization of these reactors to the acceptable safety level is not feasible; therefore they cannot be operated for long periods of time. These are power units 1 and 2 at Bohunice NPP (Slovakia), Ignalina 1 and 2 (Lithuania) and Kozloduy NPP power units 1-4 in Bulgaria.
- The second category of NPPs with lower level of danger, includes power units with second-generation reactors. They are VVER-440/213 and VVER-1000, which, if properly funded, can be upgraded to meet the Western safety standards. At this the modernization program of these plants should be completed within 10 years. This category includes Dukovano and Temelin NPPs in the Czech Republic, Bohunice NPP (units 2, 3) and Mohovce NPP in Slovakia, Paksh in Hungary and Kozloduy NPP units 5, 6 in Bulgaria
- The third, least dangerous category of nuclear reactors, includes NPPs designed by Western companies – Krsko NPP in Slovenia and Cernovoda NPP in Romania. For them organizational measures were suggested to meet Western safety requirements.

Decision on NPP closure

In this way, Ignalina NPP got into the list of dangerous facilities and its modernization for the long-term operation was decided to be economically unfeasible.

Taking this into account Lithuanian authorities made a decision about the closure of the first Ignalina first unit at Ignalina NPP before the beginning of 2005, and second – by 2010. Following this decision, the preparation for decommissioning was started in 2000. The Low on decommissioning of unit 1 was passed in Lithuanian Parliament in 2000 and the Program for Decommissioning of unit 1 was passed in 2001 (updated in 2005).

Main objectives of this program are ensuring the safety of decommissioning process, mitigation of adverse socio-economic consequences, also provisions for development and implementation of decommissioning projects within the Program.

Following this Program in 2001-2004 the Ignalina NPP Administration developed, and the Ministry of Economy approved the Final decommissioning plan of unit 1 Ignalina power plant.

Next steps in preparing for decommissioning were: preparation of Decommissioning project, safety analysis of these procedures. The environmental impact assessment from this project was also made.

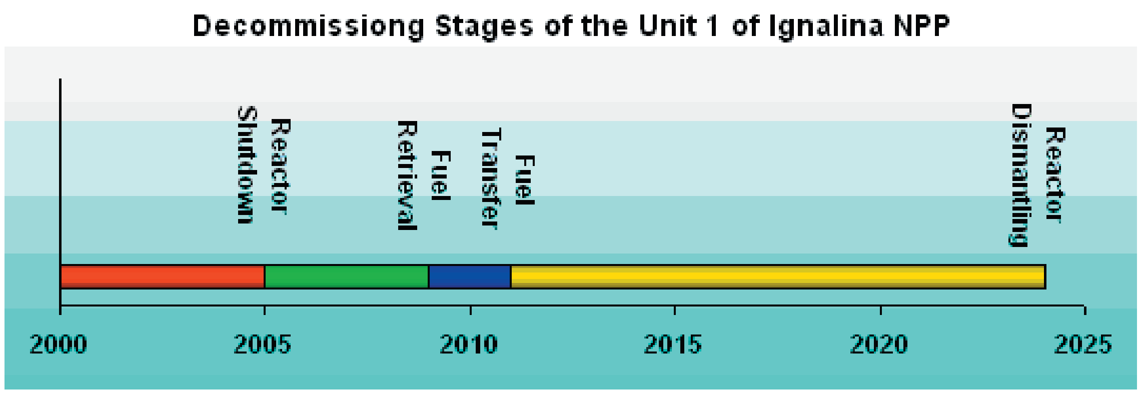
Decision about decommissioning strategy

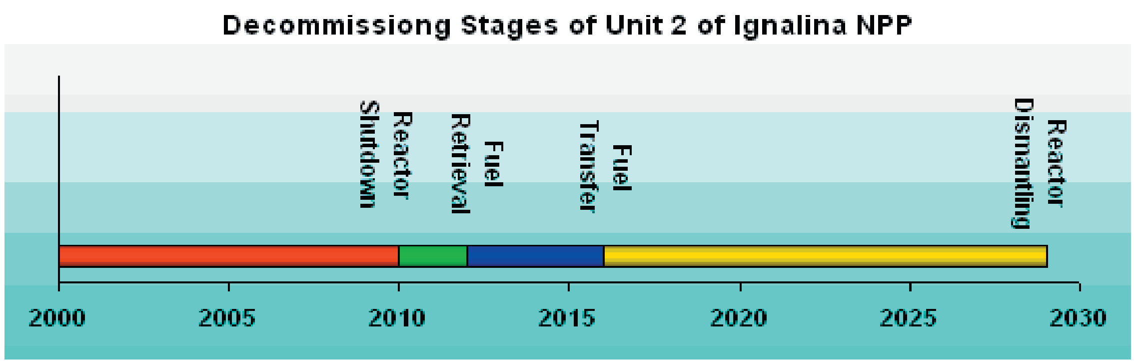
For choosing a strategy for decommissioning was analyzed international experiences on different decommissioning strategies, two of them were analyzed in depth – the strategy with immediate decommissioning and disposal of radioactive waste and the strategy with delay period followed by disposal of radioactive waste.

Before taking the final decision an analysis of general socio-economic situation in Lithuania was made, technical potential and financial capacities of the country were estimated. The final decision criterion for the choice of strategy was the minimization of severe and long-term social, economic, financial and environmental consequences. As a result of this analysis in 2002 the Lithuanian Government took a decision on decommissioning strategy for unit 1 of Ignalina NPP in favour of immediate decommissioning and disposal of radioactive waste.

The strategy of immediate power unit decommissioning has certain drawbacks in comparison with delayed dismantling. In this case, the dismantling activities are performed in presence of higher radiation levels. This requires more serious and costly measures for protecting personnel carrying out these operations.

On the other hand, in the immediate decommissioning option the power unit personnel can be employed, which reduces





social problems related to the simultaneous loss of many jobs – which is the case, if a decision on the delayed dismantling is taken. Beside this, the lifting and transportation equipment of the power unit can be used for immediate dismantling. This equipment loses its operational qualities after the waiting period lasting for decades.

The period of time, within which the Ignalina NPP dismantling will get to the "brown field" condition depends on the chosen decommissioning strategy; it is 30 in case of immediate dismantling and 75 years for delayed decommissioning.

Finally the strategy of immediate decommissioning was admitted to be most advantageous for Ignalina NPP in terms of social, economic and environmental priorities.

In accordance with the chosen immediate decommissioning strategy for the unit 1 the majority of activities including processing of radioactive waste, SNF retrieval and transportation to the temporary storage, dismantling of equipment, pulling down of buildings, etc. will be completed within first twenty five years. This period will be followed by activities mostly dealing with radioactive waste monitoring and disposal.

In terms of nuclear safety most hazardous activities, i.e. SNF management, decontamination, isolation of radioactive equipment and systems, etc. will be performed during first 10 years after reactor shutdown.

The "brown field" strategy for the Ignalina RBMK-1500 power units turned out to be the most acceptable for engineering, economic and social reasons. It enables to use the available NPP infrastructure, provides employment of ex-operators, stimulates the socio-economic development of the NPP neighborhood.

APPENDIX 4. Lithuanian experience of Iganlina NPP Decommissioning Fund establishment and running

History of the Fund establishment

Ignalina NPP decommissioning is funded by the National Decommissioning Fund of Ignalina NPP (NF) and by the International Decommissioning Support Fund of Ignalina NPP (IF).

The NF was founded in 1995 by the decision of Lithuanian Government. It is designed for accumulating money for Ignalina NPP decommissions and safe RW handling. The NF is administrated by the Board. It was established by a special decision of Lithuanian Government.

Sources of allocations to the National Fund

The NF gets 6 % of revenues from the sold power produced by Ignalina NPP. This money is transferred on a quarterly basis to a special bank account.

Beside that the NF gets:

- Voluntary contributions from legal entities and private persons both from Lithuania and foreign countries and international financial institutions;
- Money from selling the property of decommissioned Ignalina NPP;
- Bank interest accumulated on the NF account, also means raised by buying and selling state bonds.

Procedures for payments from the National Fund

The NF means are spent only on the projects related to the Ignalina NPP decommissioning. The Decommissioning Program was endorsed by the Parliament of Lithuania. Before April 1 of the current year a legal body, which is responsible for the implementation of an activity in the Program planned for the next year, addresses the Fund Board with a request to provide a budget for implementing the next year activities.

Appendix

The Fund Board takes a decision to this extent before July 1 of the current year. On the basis of this decision the Lithuanian Ministry of Economy prepares the year estimate of the Fund expenditures. This NF expenditure estimate goes to the Lithuanian Ministry of Finance for filing payments to be made to the Program implementers in the next year.

Implementers of a specific point in the Program send quarterly progress reports to the Ministry of Economy, in which they give a detailed statement of expenditures.

Ministers of Economy and Finance make the annual report on the NF money spent on Ignalina NPP decommissioning, get the agreement of he Fund Board and submit it for approval by the Government of Lithuania.

On the International Fund

The International Fund was founded in June 2000 at the initiative of European Commission. The European bank of Reconstruction and Development (EBRD) is entrusted with the task of the Fund administration. The European Commission and other international donors made a commitment to contribute 210 mln. Euro to the Fund.

The IF has two parts. The first, so-called "nuclear part" is earmarked for funding decommissioning projects. The second, "non-nuclear part" is foreseen for funding projects, which compensate the loss of power units, environmental protection projects in the energy sector and other projects not directly related to the NPP decommissioning.

The IF operates on the basis of the Framework Agreement between EBRD and republic of Lithuania. it is managed by the Donors Assembly.

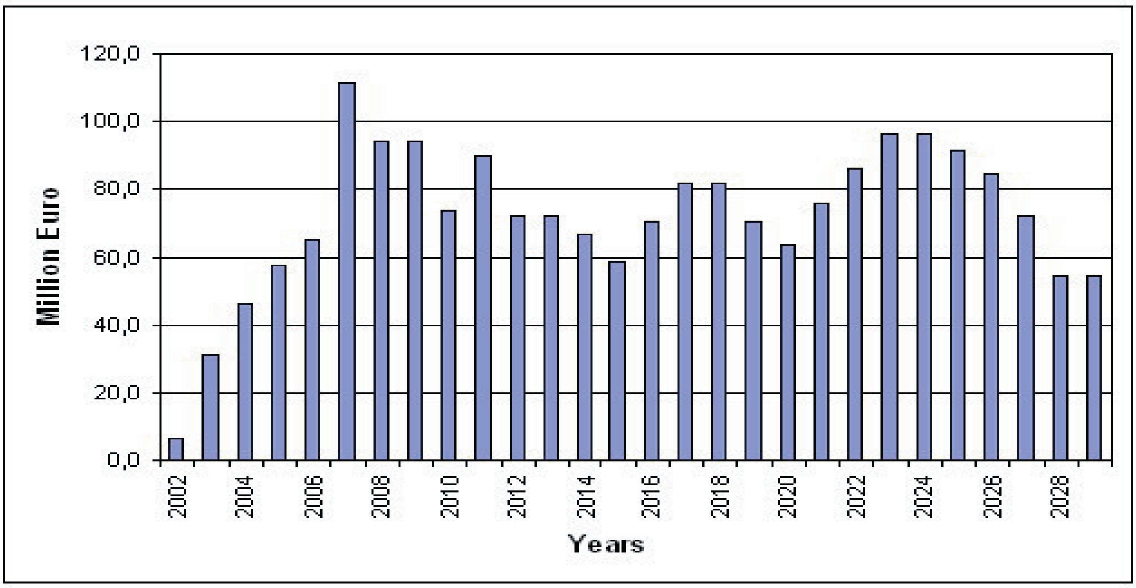
On the cost of Ignalina NPP decommissioning

In the period of Ignalina NPP preparation for decommissioning several reports were prepared, in which the decommissioning expenses were evaluated. The preliminary estimates made by different Western consultancies using different methodologies had a great divergence. In accordance with them the decommissioning cost of two Ignalina RBMK-1500 power units would be from 1,5 to 6,0 bln Euro.

The finally accepted Ignalina NPP decommissioning plan following the scenario with immediate dismantling is for 25 years. Taking into account expenditures on the social adaptation of Visaginas inhabitants, for which the NPP is the main job- and infrastructure-providing company, the decommissioning cost will amount to 1.134 bln. Euro ($1.5 bln.).

Therefore, the average annual expendi-

Decommission investments for Ignalina NPP



tures on this project will be 45 mln. Euro.

The table below presents the planned annual expenditures on Ignalina NPP decommissioning following the scenario of immediate dismantling.

At the initial stage of Ignalina power unit 1 decommissioning (2002 – 2006) more than 280 mln. euro was spent. A part of this money (about 40 mln. Euro) was spent on the organizational measures – restructuring and strengthening of decommissioning services. About 250 mln. Euro was spent on engineering projects, e.g. the construction of a temporary (for 50 years) dry storage of SNF, acquisition of equipment for the solidification of spent ion-exchange resins, building of a new boiler house for the town heating, etc.

5 mln. Euro was spent on the development of projects and programs oriented on the solution of social and environmental protection problems.

It is estimated that the NF will cover about 10% of Ignalina NPP decommissioning costs. The rest will be financed by the IF.

APPENDIX 5. Act on social guarantees for the employees of decommissioned Ignalina NPP

ACT of

REPUBLIC OF LITHUANIA

of 29 April 2000. № IX-1541, Vilnius

ON ADDITIONAL EMPLOYMENT GUARANTEES AND SOCIAL GUARANTEES FOR THE EMPLOYEES OF THE PUBLIC COMPANY IGNALINA NUCLEAR POWER PLANT

CHAPTER ONE

GENERAL CLAUSES

Article 1. Mission of the Act

1. The current Act establishes additional employment guarantees and social guarantees for the workers of the public company – Ignalina Nuclear Power Plant (further on – Ignalina NPP), which are discharged or to be discharged from the company due to the decommissioning of the 1st and 2nd power units, also to the members of their families. Hereby an intention is expressed to mitigate adverse social consequences in order to maintain safe and continuous operation of Ignalina NPP until its decommissioning.

2. Persons employed for decommissioning activities at Ignalina NPP and persons

Ignalina NPP (Lithuania). Overall view of the SNF storage working at Ignalina NPP after the expiry of the 2nd unit operation license are not entitled to get additional guarantees of employment and social guarantees established by the current Act.

Article 2. Main definitions of the Act

1. Employees to be dismissed – workers of Ignalina NPP, which have received a notification about the work contract cancellation on the reasons stated in Article 129 of the Labor Code due to the decommissioning of Ignalina NPP power units 1 and 2, excluding workers employed for Ignalina NPP decommissioning.

2. Family members of the dismissed or to be dismissed employee – husband (wife) of the dismissed or to be dismissed employee, children (adopted children) below 18 years and older not working and not married trainees and full-time students until the age of 24, also parents (adopting parents) of the employee or his spouse living together with the employee.

3. Dismissed employees – workers of Ignalina NPP, with which the work contract has been annulled on the reasons stated in Article 129 of the Labor Code due to the decommissioning of Ignalina NPP power units 1 and 2.

Ignalina NPP (Lithuania). Equipment for fuel management of the RBMK-1500 reactor

4. Ignalina NPP decommissioning – implementation of legal, organizational and technical measures aimed at safe decontamination and dismantling of Ignalina NPP, disposal of radioactive substances, waste, components and residues.

5. Completion of Ignalina NPP units 1 and 2 operation – process, which starts from the enactment of the governmental decision about the date of power unit 1 shutdown, and ends on the expiry date of power unit 2 operation license issued by the Governmental inspection on the nuclear industry safety.

6. Compensated work places – work places, primarily in the region of Ignalina NPP, for employing the dismissed workers, which correspond to their education and qualifications.

7. Additional guarantees of employment and social guarantees – guarantees of employment and social guarantees established by the current Act, which are not established by the legislative and legal acts regulating employment, work relations and social guarantees.

CHAPTER TWO

EMPLOYMENT GUARANTEES

Article 3. Encouragement of employment for discharged or to be discharged workers

In order to guarantee employment of dismissed and to be dismissed employees and members of their families the governmental measures and target programs of employment, Ignalina NPP region development, human resource management and entrepreneurship promotion are implemented.

Article 4. Employment support for discharged or to be discharged workers

1. A discharged or to be discharged worker gets an individual plan, which foresees measures for his employment and social guarantees.

2. The dismissed workers registered at the local labor exchange get the guarantees for the unemployed mentioned in points 2-7, part 2, Article 7 of Act on the support of unemployed persons, which get additional support at the labor market.

3. Professional training of discharged or to be discharged workers outside working hours and lasting up to 10 months is performed following the procedure established by the Act on the support of the unemployed. Professional training lasting longer is provided on the decision of the local labor exchange.

4. If the retraining or additional training of dismissed workers to be employed in decommissioning activities of Ignalina NPP is arranged in educational institutions during working hours, the employees get a training leave. During it they get average salary and reimbursement of expenses of trips to the place of studies. Workers get retraining or increase the level of expertise for performing Ignalina NPP decommissioning work in accordance with individual plans.

5. Employers, which provide the compensating jobs, to be taken by the dismissed workers in accordance with their individual plans, get a compensation equal to 24 minimum salaries (MS) for each work place:

1. 12 MS are transferred after the work contract conclusion;
2. after 12 months since the date of work contract conclusion 1 MS is transferred monthly during the period of a new employment of dismissed workers.

6. Discharged or to be discharged workers are provided with an opportunity to study Lithuanian at the 12 month courses in accordance with their individual plans.

Article 5. Employment guarantees for the not working family members

1. The unemployed members of the family of discharged or to be discharged workers, which are registered at the local labor exchange, have the guarantees of supported unemployed persons, which are explained in points 2-7, part 2, Article 7 of the Act on support to the unemployed people. The unemployed members of the family of discharged or to be discharged workers, which are registered at the local labor exchange, not having the regulated social insurance record for getting the unemployment relief (dole), are entitled to the dole, which is paid in accordance with point 1, part 1, Article 16 of the Act on the support for unemployed people.

2. Spouses of discharged or to be discharged workers, as well as children (adopted children) under 24 years, which study in higher educational institutions to get the profession related to safe operation and decommissioning of Ignalina NPP get the grant on the decision of Ignalina NPP Administration after getting approval from the found. The list of such professions is established by the Administration of Ignalina NPP after its approval by the founder.

CHAPTER THREE

SOCIAL GUARANTEES

Article 6. peculiarities of work relations

After enacting technical plans of Ignalina NPP decommissioning the Plant Administration informs its employees about professions

Ignalina NPP (Lithuania). Turbine shop

and jobs, which can be cut in the coming 12-month period by publishing the list of jobs to be cut. The worker to be dismissed gets a written notification about it 10 months in advance.

Article 7. Insurance of employees

1. Workers of Ignalina NPP responsible for nuclear safety, the qualification and work of which is of special importance for safety and continuity of Ignalina NPP operation are to be insured for a period not les than 5 years following the procedure established by the Government or by a body empowered by it. The sum of accumulative life insurance ranges from 12 to 24 average salaries of these workers.

2. The list of positions entitled to accumulative life insurance is established by the Ignalina NPP Administration after the founder approval.

3. The insurance premium is paid to the worker. The worker, which terminated the contract with Ignalina NPP of his own accord before the end of contract term in accordance with part 1 of Article 127 of the Labor Code, or which was discharged for reasons regulated by points 1, 2, 3, part 1 and 3 of Article 136 of the Labor Code is not entitled to the insurance premium.

Article 8. Additional discharge relief

1. Discharged workers get the discharge relief set by Article 140 of the Labor Code and additional discharge relief in the order established by the Government or a body authorized by it taking into account the uninterrupted period of employment at Ignalina NPP:

1) employment of 5 - 10 years – the average salary for 3 months;

2) employment of 10 - 15 years – the average salary for 4 months;

3) employment of more than 15 - 20 years – the average salary for 5 months;

4) employment of more than 20 years – the average salary for 6 months.

2. If the discharged worker got the additional relief payment and was reemployed by Iganlina NPP, the additional relief is not paid after next dismissal.

Article 9. Granting of pre-pension payment of the unemployed person

1. Dismissed employees having the mandatory social pension insurance record of not less than 25 years and uninterrupted work record at Ignalina NPP of not less than 10 years, get the pre-pension payment of the unemployed person, if the period of time between the day of dismissal and the old-age pension date is les than 5 years.

2. The pre-pension payment of the unemployed person is paid on a monthly basis. Its amount is calculated by adding the constant component, which is 100% of income supported by the state and a variable part, which is 20% from the average monthly salary of the person. The monthly pre-pension payment of the unemployed cannot be more than 70% of insurable income of the current year, which are assigned for the month of payment .

3. Persons mentioned in point 1 of this section are entitled to the benefits of point 2, part 4 Article 6 of the Act on health insurance.

4. The pre-pension payment of the unemployed is terminated, if the person gets a job, gets unemployment relief (dole) or emigrates abroad.

Article 10. Employment conditions at the compensating work places

Dismissed employees, which got jobs in accordance with individual plans or found jobs at compensating work places, are not entitled to get additional; social guarantees foreseen by Articles 8 and 9 of the current Act.

Article 11. Payment for resettlement

Dismissed employees, which take a decision on moving to another location in Lithuania or abroad within 3 years since the discharge from Ignalina NPP, get a reimbursement for actual resettlement expenditures, but not more than 3 AS per each family member, in accordance with the procedure determined by the Government or a body authorized by it.

CHAPTER FOUR

FUNDING OF EMPLOYMENT GUARANTEES

AND SOCIAL GUARANTEE

Article 12. Funding of employment guarantees and social guarantees

1. Employment guarantees and social guarantees determined in Article 4, part 2 of Article 5, Articles 7, 8, 9, 11 are funded by the means from the Ignalina NPP Decommissioning Fund, by the international support funds and other sources.

2. Employment guarantees and social guarantees determined in part 1 of Article 5 of the current Act are financed from the Employment Fund.

3. Employment programs and social programs mentioned in Article 3 of the current Act, as well as relevant projects, are funded from the state budget of Republic of Lithuania and local budgets, funds of European Union, international organizations and other sources

CHAPTER FIVE

FINAL CLAUSES

Article 13. Implementation of the Act

The Government or a body authorized by it establish the following:

1) procedure for formulating individual plans;

2) procedure for getting premium of accumulative life insurance;

3) procedure for paying additional dismissal relief payment;

4) procedure for paying pre-pension unemployed payment;

5) procedure for reimbursing resettlement expenses .

Hereby publishing the current Act passed by the Seym of republic of Lithuania.

PRESIDENT OF THE REPUBLIC
ROLANDAS PAKSAS

APPENDIX 6. Swedish decommissioning experience

The most relevant aspects of the Swedish nuclear decommissioning experience are the specific conditions for the decommissioning of the reactors. The Swedish authorities have specified different sets of conditions in two cases, at the nuclear facilities of Barsebäck and in Studsvik. The permission for Barsebäck allows the owners to wait with the actual dismantling of the reactors till 2017, despite the fact that the reactors where taken out of production already several years ago. The permission for Studsvik requires that the dismantling of the reactors start as soon as possible after the final shutdown of the reactors. The permission for Barsebäck was given by the monitoring authorities of the nuclear industry and ultimately by the Swedish government. In Studsvik, the permission was given by the Swedish Environmental Court.

So far, two commercial reactors in Barsebäck in Southwestern Sweden are the only reactors in Sweden that have started their decommissioning. In Barsebäck the nuclear fuel rods have been removed and placed in a temporary storage, and other minor parts of the process has been carried out after the shutdown. The actual dismantling of the reactors will not start until 2017. The decommissioning process is expected to be finished in 2030.

In Studsvik on the Baltic Sea coast south of Stockholm, two research reactors have received their decommissioning permission in March 2007. The permission specifies that decommissioning should start as soon as the reactors have been closed down. The decommissioning process is expected to be finished in 2015.

The arguments for delaying the decommissioning of Barsebäck

The official reason for the delay in the dismantling of the reactors in Barsebäck is technical, and has do with the lack of permanent storage for the highly radioactive waste from the reactors. Sweden does not have a permanent storage for this type of radioactive waste, and no date is set for the building of such a storage. Neither has a site for such a storage been selected. The plans for a permanent storage for spent nuclear fuel are in a similar situation, but the process of selecting a site is slightly more advanced.

The arguments for delaying decommissioning in Studsvik

In Studsvik the owners have applied for permission to wait with the start-up of the actual dismantling. In their application, the Studsvik Company used different arguments, among them the lack of permanent storage for the highly radioactive waste, as well as economic arguments. The economic argument in the case of Studsvik was that the interest earned on the capital in their decommissioning fund would increase the size of the fund[21] . This would give the company a better economic base for the decommissioning process. However, the Environmental Court[22] that considered their application did not accept the arguments for delaying the decommissioning process. Instead, the Environmental Court set as a condition for the decommissioning permission that the dismantling of the reactors should start immediately after the shutdown.

Arguments in favour of early dismantling

In Studsvik, the Swedish Radiation Safety Directorate, SSI, was one of the government institutions that gave their views to the Environmental Court. SSI argued in favour of granting permission to start decommissioning of the reactors on the condition that the process should start immediately after shutdown. SSI argued that this made it possible to use the competence and qualifications of the present personnel. This argument was also supported by several other governmental institutions/organizations. (An implicit assumption is in this case that if the process was delayed, one can expect that a number of key personnel would find work elsewhere, and would not be available when the actual dismantling would start.)

SSI also addressed the question of sufficient storage space for the radioactive waste from the dismantling of the reactors. The owners of the Studsvik reactors had used the

[21] The Swedish government has allocated separate funds for the decommissioning of Barsebäck, as well as for the reactors in Studsvik. Each fund is administered separately by the owners of the reactors..

[22] In Sweden, a separate Environmental Court considers certain environmental issues of great public interest. A judgement by this court is considered binding for the parties, just as a decision made by the Swedish government would be. A judgement can only be overturned by the Swedish government at the top level.

lack of permanent storage as an argument in favour of postponing the dismantling. SSI argued that this radioactive waste could be stored temporarily at the site, while waiting for a permanent storage to be built. SSI did not see any serious objection against a temporary storage for short-lived as well as long-lived radioactive waste in an existing temporary storage space built into the rocks at Studsvik. This position was also supported by the Swedish Nuclear Inspection Agency, another government organization with responsibilities for the safety of the operation of the Swedish nuclear reactors. Since the Environmental Court ruled in favour of immediate start-up of dismantling, the owners of Studsvik did not get the Court's support in this case.

The Environmental Court also evaluated the economic argument in favour of delaying the decommissioning of the Studsvik reactors, but stated that the cost to society as a whole would be higher if the decommissioning was delayed. A late start could lead to a higher total cost for society as there may be other costs incurred by a delay that are not passed on to the owners. The Court therefore set as a condition for the decommissioning permit that the process should start immediately after closing the reactors and be continued until it was finished in 2015.

Discussion

It is interesting to note that several of the arguments in favour of postponing the dismantling of the reactors in Barsebäck were also used by the owners of the Studsvik reactors. However, the Environmental Court in Sweden did not accept the arguments ifor a delay in the Studsvik case. The Environmental Court did not handle the permit for Barsebäck, it was granted by the monitoring institutions and the Swedish Government directly. If the Environmental Court would have set the conditions for the Barsebäck decommissioning process differently, is of course only a matter of speculation. Still, it is an interesting subject considering the differences in the two sets of conditions for decommissioning.

The value of an independent evaluation of applications

The Environmental Court of Sweden evaluated the Studsvik decommissioning application. This is a government institution independent of the monitoring institutions, which have responsibility for the regular monitoring of the operations of the nuclear reactors. The Environmental Court makes decisions in matters with potentially great environmental impacts and with economic impacts above a certain limit. This organisation of the decision-making process may reflect a perceived need to counter the tendency for monitors and monitored to become too closely connected over a long period. There is often an exchange of personnel between the monitoring institutions and the industries or activities that are monitored. This may contribute to the creation of a common understanding and a common set of values and norms between the monitors and the monitored. This may in turn influence decisions made by the monitoring organization.

It is a well-known fact that sub-sectors of society, given the right circumstances, may develop values and norms that differ from those of society at large. By giving a Court (or another independent institution with the same role) the task of making decisions about decommissioning permits and conditions, one may achieve a better decision. An independent institution will in such cases probably make decisions that better reflect central societal values and norms. If institutions closely embedded in the technological complex make the decisions, chances are that the decisions will be based on values and norms of a technical and scientific sub-community, such as the nuclear sector in this case.

The economic argument for delayed decommissioning

In the case of Barsebäck, the economic argument in favour of delaying the decommissioning process is not stated explicitly by the owners. However, there is reason to believe that this is at least a contributing factor in the owner's decision. The Swedish government has allocated a sum of money to a fund that shall finance the decommissioning process of the Barsebäck reactors. As long as the money in the fund is not used for the decommissioning, it will generate an interest on the capital. This interest is an income for the owners of the nuclear reactors. As long as the service organization for the upkeep of the nuclear reactors cost less than the company earns in interest on the fund, the company will be motivated to delay the process.

In the case of Studsvik, the Court stated that increasing the size of the decommissioning fund by allowing the interest on the capital to accumulate was not enough to delay the decommissioning. The income from the interest on the capital in the decommissioning fund had to be weighed against the cost of a separate maintenance organization.

The Court found that a late start could lead to a higher total cost for society as there may be other costs incurred by a delay that are not passed on to the owners. In the case of the Studsvik reactors in Sweden the Environmental Court therefore ordered the owners to start decommissioning immediately after closing the reactors.

Lack of permanent storage

The Swedish government allowed the owners of Barsebäck to delay the decommissioning process for the two reactors. One of the official arguments for the delay was the lack of permanent storage space for highly radioactive waste from the reactors. In the case of Studsvik, the Court stated that this was not enough to delay the process. The Court found that the possibilities for temporary storage at the Studsvik , in existing facilities, was good enough to start decommissioning. Again, it is tempting to speculate what the result would have been, if the Barsebäck decommissioning plan had been the subject of the Courts decision.

Use of existing competence among the personnel

The Court cited the SSI, which stated that starting the dismantling of the reactors in Studsvik right after shutdown would enable the maximum use of the existing competence among the personnel at the research reactor in the decommissioning process[23].

In the case of Barsebäck, this argument appears not to have been decisive for the decommissioning plan. As discussed earlier, the economic benefits for the company of delaying the process may also be a contributing factor to the delay.

The use of personnel from other nuclear facilities in the decommissioning organisation will probably not be easy in Studsvik, as the reactors are research reactors and most likely have unique features suited to their purpose. Using personnel who knows the design of the Studsvik reactors will therefore reduce the time and cost of training them for the decommissioning process compared with outside recruitment of personnel. In the latter case, the personnel would have to familiarize themselves with reactor designs previously unknown to them.

If, as often is the case, some modifications done to the design have been poorly documented, an additional problem arises. In such a case, the first-hand knowledge and experience of the operating personnel with the actual reactors would be valuable for a speedy dismantling with a high level of safety for the personnel and the environment.

[23] This argument was also an important argument in the case of the nuclear reactors in Greifswald in Germany. Here, the government decided that starting the dismantling as soon as practical after shutdown would make the maximum use of the available competence among the personnel.

APPENDIX 7. French decommissioning experience

Similarly to Belgium, Sweden and Great Britain France has not made a decision on the decommissioning strategy.

11 of French power units have been shut down and are at the decommissioning stage. Most of them are gas-cooled reactors with graphite moderator (GCR), which were put into operation in the end of 1950-s – beginning of 1960-s. Later France refused from this reactor type and started the operation of PWR units.

Experts from the Commissariat for atomic energy consider it more reasonable to wait until the level of radiological hazard goes down. In the GCR reactor decommissioning the drainage of the primary circuit was followed by the dismantling of this and auxiliary circuits. The power units are kept in the regime of controlled storage.

At the decommissioning of NPP with gas-cooled reactor and graphite moderator (HWGCR) the conserved rector, primary circuit and steam generator are monitored; the full-scale dismantling is planned for the coming 40 years.

A separate case is presented by Choose, the first French NPP with PWR reactor. It is one of the few subsurface NPPs of the world. Its disposal will mean burial – filling its rooms and halls with rock.

APPENDIX 8. Norwegian experience of social infrastructure transformation in a township with single job-providing company

Introduction

Is the closing of a major industrial employer in a community with few alternative employment possibilities relevant to the decommissioning of old Russian nuclear reactors?

The decommissioning debate in Russia is mainly a discussion about the technical solutions to the decommissioning, the safety aspects of the handling of radioactive material, and the funding of the process.

But parallel to this technical and economic discussion there is also another debate. This is a debate about the fate of the workers and the communities/towns connected with the nuclear power plants. Both the workers and the communities where decommissioning of old nuclear reactors is discussed are sometimes quite naturally critical to the idea of decommissioning. The reason is simple: they do not know what kind of work and how much alternative employment that will be available in the local community after the closing of the nuclear reactor. Resistance from the labours unions and the local community against a decision to decommission an old nuclear reactor, regardless of the safety implications, is a predictable result.

The problem connected with the loss of a major employer in a community is not a specific problem for nuclear plants. On the contrary, similar problems arise after the closing of a big industrial plants or major employers all over the world. Workers loose their jobs and often their income, and there are often also no alternative, local employment opportunities. The local communities loose income from taxes, and the economic benefits from the workers spending their wage on food, clothing and housing locally. Shopkeepers, craftsmen and bureaucrats are all indirectly dependent on the major employer, and also risk loosing their income if the major employer close the gates permanently. In many cases, the workers and the communities are not given any assistance to handle the problems of transition from the government or the owners.

But there are also successful examples of local communities that have received help to handle the transition after the closing of a major employer. The success of these communities to encourage new employment possibilities can therefore point to a possible new future also for the Russian nuclear communities. In this appendix, an attempt has been made to offer a short description of a successful transition in Norway.

Background

Norway has a number of small and geographically relatively isolated industrial communities with basically one industrial plant that is the major employer in the community. The communities and the factories were established 40-100 years ago in remote places, many of them along the coast. The main factor deciding the localization was the closeness to big sources of hydroelectric power, as well as deep-water ports for the transport of raw materials such as alumina/bauxite. Some of the factories have closed during the past 20 – 30 years, due to increased competition from other countries and lack of profitability.

In most cases, the local communities have received economic and other types of assistance from the central government to help them in the transition process. The workers have also received unemployment benefits and given possibilities for re-training. In the case of older workers, they have had the possibility to become old-age pensioners earlier than usual.

The successful transformation of Mo

Some of the communities have had success in creating new economic activities.

One of these communities is a town in Northern Norway, called Mo and located in the district of Rana (therefore also called Mo i Rana). The original fishing and farming community was transformed in the late 1950`ties, early 1960`ties by a massive steel smelting plant, built and owned by the Norwegian government. The establishment of the steel mill, an iron ore mine and a coke factory was seen as a crucial element in a development plan for Northern Norway, based on the establishment of heavy industries. The iron ore was mined locally, and the coal for the smelting of the iron came initially from the Spitsbergen Island.

The steel mill was never really profitable. It required heavy direct and indirect subsidies from the taxpayers to continue its operations, and the intended development effect in the region never materialized. In 1989, the steel mill and the rest of the complex closed their operations. A government plan was made to help the community to make the transition from steel production to a more diversified industrial and economic economy.

The transition plan was a success. It created a number of new, smaller industries that were able to employ a high proportion of the workers that had lost their work at the steel mill. Today there are about 100 separate companies operating in the newly created industrial park. Four of these are bigger than the rest. Not all of the new companies established in the beginning survived, but most did and the industrial park has attracted 8-10 new companies every year.

The government also created new employment opportunities for women in the community, but outside the industrial park, by locating part of the National Archives for books, newspapers and documents to the town. The tunnels of the old iron mine has found new use as magazines for printed material and electronic media, in an environment that has stable temperature and humidity all year round.

All in all, the town of Mo with 25.500 inhabitants today have a varied and balanced economy, with new companies being established all the time, and with a good employment situation. In modern Norwegian history the transition of Mo comes in second place after a similar transition in a town in Southern Norway, Kongsberg. In Kongsberg it was a big weapons factory that went bankrupt, and the experience from this event was used when the transition process in Mo was started.

In recent Norwegian history the industrial towns of Mo, Kongsberg and the two towns of Horten and Raufoss are all examples of successful transitions in traditional industrial towns depending on a single, big factory as the main locomotive of local economy and employment.

In all these towns, use has been made of the trained manpower from the old factories and of the local infrastructure built around the old factories in creating new companies with new products.

Organisation of the Industrial Park in Mo

In Mo, the establishment of the industrial park on the land previously occupied by the steel mill and the coke factory may hold some useful lessons. The central government of Norway transferred the remnants of the steel mill, as well as the hydropower production plant, harbour facilities and other assets to a property managing company, Norsk Jern Eiendom – NJE. The property managing company NJE was charged with the task of using these assets in the creation of new economic activities in the local community of Mo. NJE in its turn created the Mo Industrial Park.

The shares of the Norsk Jern Eiendom was offered free of charge to a number of large companies that had already established themselves or was in the process of establishing themselves in the Mo Industrial Park. An agreement regulates how and to whom the shares may be sold. It is important that the shares are spread fairly equally among the companies that are located in the park. This prevents one company from getting a dominant position, and it also prevents the corporate owners of the local companies from getting a decisive influence on the running of the park. The goal is maintain local control of the resources, for the benefit of the local companies and not their corporate owners located somewhere else.

This form of organisation is also demanding, in the sense that companies may have one set of interests as co-owner of the park, but another set of interests as users of the industrial parks facilities and services. As owners, they would want highest possible profits from the ownership, but as users they have the opposite interest. The balancing of these conflicting interests is essential for the success of the park.

The results of the Mo Industrial Park

The biggest companies of the Mo Industrial Park are four metal working factories: two different companies producing ferrosilisium (one of them has stopped production), one producing steel rods for use in reinforced concrete, and one making steel profiles for use in shipbuilding. Even if these four are considerably bigger than the rest, there are about 100 separate companies in the park. The employment has grown from 1770 in 1988 (before the closing of the steel mill) to 2155 in 2002. But problems caused two of the big metal working companies to close down or reduce their activities, and in 2003 it lost 250 industrial employees.

The success of the Mo Industrial Park depends on many different factors, and the Industrial Park also face new challenges. Some of the factors, such as the big source of electric power given free of charge to the companies willing to establish new production in the park, are not so easy to reproduce in other localities. The existence of skilled manpower and an industrial infrastructure is maybe the most common resource that the Mo Industrial Park shares with other, similar establishments. Without that resource, none of the other resources would matter much in the creation of new economic activities and employment opportunities.

APPENDIX 9. Documentaries on Lithuanian and German Decommission Experience and its relevance for Russia

1. WHEN THE TIME COMES (25 minutes).

Documentary about the NPP decommissioning in Visaginas (Lithuania) and problems faced by the municipal authorities and inhabitants of the town with economy oriented on nuclear technologies

Thanks to the effective interaction of authorities, business and the public the Republic of Lithuania managed to transform the crisis of plant closure into a creative process of starting new life in the nuclear community on the basis of sustainable development strategy.

2. LOOKING FOR SOLUTION (22 minutes).

Documentary about a trip of authorities from Russian nuclear city, NPP trade-unions, atomic industry experts and representatives of the public to Lithuanian Visaginas to get acquainted with the social partnership experience at the NPP decommissioning.

3. NPP GREIFSWALD: HALTED AT REQUEST (20 minutes).

Documentary about the German experience of the 12-year project implementation on the decommissioning of five VVER-440 units of NPP Greifswald. The plant is located on the Baltic coast.

The large-scale work enlivened the region, stimulated new industrial development. The experience is valuable for regions having NPPs approaching the design lifecycle limit.

4. QUEST FOR PARTNERSHIP (22 minutes).

Documentary about the trip of Russian group to Greifswald to get acquainted with the German decommissioning experience. The group included representatives of regional and municipal authorities of nuclear neighborhoods, NPP employees and members of environmental community.

Documentary producers:

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