ANNEX I. **NATIONAL REPORTS OF PARTICIPATING MEMBER STATES**

This Annex contains the overviews of national practices at WWER sites which were to a large extent prepared using the BMS, namely national reports of Armenia, Bulgaria, Czech Republic, Finland, Slovakia and Turkey.

I-1. NATIONAL REPORT OF ARMENIA

I-1.1. Site information

The Republic of Armenia operates one nuclear power plant (NPP) at Metsamor that is operated in accordance with the license issued by the Armenian Nuclear Regulatory Authority (ANRA). Metsamor is located in the west part of the Ararat valley, 10km north-east ofthe Armavir region and 28km west of the capital of Armenia, Yerevan, near the town of Metsamor.

The site consists of two units with the V-270 WWER reactor model, which is a seismically upgraded version of the V-230 model. Unit 1 was commissioned in 1976 and Unit 2 in 1980. The NPP was shut down shortly after the Spitak earthquake of 7 December 1988, with its epicenter located 80km north of the plant site. Though the plant did not suffer any damage and both units of the Armenian NPP remained in operation, the USSR Board of Ministers adopted a decree to shut down the plant. Unit 1 was shut down on 25.02.1989 and the Unit 2 was shut down on 18.03.89. Both units were in long-term shutdown condition, but not decommissioned.

To overcome the energy crisis, on 07.04.93 the Republic of Armenia Government adopted decree to restart Unit 2; it was restarted on 05.11.1995. ANRA set the limit for Unit 2 at 92% of its rated power.

I-1.2. Operational lifetime extension activities

The Government of the Republic of Armenia decided to construct Unit 3, as outlined in the "Energy Development Strategy in the Context of Economic Development of the Republic of Armenia". At the same time it undertook actions to keep Unit 2 operational at least until new Unit came on line. On 19 April 2012, the Government of the Republic of Armenia adopted decree № 461-N on the lifetime extension of Unit 2.

A number of actions to be undertaken were identified, in particular development of the Armenian NPP long-term operation program. Following the decree, ANRA established requirements for the design lifetime extension.

I-1.3. Policy and strategy on radioactive waste management

The National Policy is defined in Republic of Armenia Government Decree No. 43 as of 4 November 2010 on approval of the "Concept on safe management of radioactive waste and spent nuclear fuel in Republic of Armenia" and all the topics/typical elements highlighted in the IAEA Nuclear Energy Series No. NW–G–1.1 document on "Policies and strategies for radioactive waste management" were taken into consideration.

According to Government Decree No. 631-N as of 04.06.2009 on approval of the procedure on radioactive waste management, the Ministry of Energy and Natural Resources is the designated Republic of Armenia state competent authority empowered with radioactive waste

management and the National operator (RW management organization) is to be established within the structure of the Ministry and to be responsible for RW processing, storage, disposal.

The development of "National Strategy on Radioactive Waste and Spent Fuel Management" has started and is expected to be finalized at the end of 2015.

I-1.4. Definition, categorization and classification of radioactive waste

The Article 3 of the Law on Safe Utilization of Atomic Energy for Peaceful Purposes provides the definition of radioactive waste as a radioactive material or as a surface contaminated radioactive material for which no further use is foreseen and which is subject to isolation from environment.

The Government Decree № 1489 as of 18.08.2006 on approval of Radiation Safety Rules includes the categorization of radioactive waste based on the following criteria:

- Aggregate state (Solid, Liquid, Gaseous)
- Radiation type (Alpha, Beta, Gamma)
- Activity content (LLW, ILW, HLW)
- Half-lives of the radionuclides contained in the waste (short-lived and long-lived).

The definitions of the different type of radioactive waste regarding its aggregate state are the followings:

Gaseous radioactive wastes are not useful radioactive gases and aerosols generated during industrial processes the specific activity of which exceed the permissible levels of specific activities specified in the Radiation Safety Norms.

Liquid radioactive wastes are organic and non-organic liquids, pulps and slag for which no further use is foreseen and the specific activity of radioactive isotopes in case of interaction with water exceed the intervention levels specified by the Radiation Safety Norms for more than 10 times.

Solid radioactive wastes are radioactive isotope sources with expired lifetime, materials, goods, equipment, industrial objects, soil, as well as solidified liquid radioactive wastes for which no further use is foreseen and the specific activity of contained radioactive isotopes is above the clearance levels specified in the Radiation Safety Norms, and in case of indefinite composition of radioactive isotopes the specific activity exceed:

- 100 Bq/g for beta radiation,
- 10 Bq/g for alpha radiation,
- 1,0 Bq/g for transuranic radioactive isotopes.

Based on the activity concentration of beta, alpha and transuranic isotopes in solid and liquid radioactive wastes, those are divided into 3 classes: low level activity, intermediate level activity and high level activity waste (see Table I.1).

TABLE I.1. RADIOACTIVE WASTE CLASSIFICATION ACCORDING TO SPECIFIC ACTIVITY

Waste class	Specific activity of beta emitting radionuclides (Bq/g)	Specific activity of alpha emitting radionuclides (except for transuranic) (Bq/g)	Specific activity of transuranic radionuclides (Bq/g)
low level activity	Less than 10^3	Less than 10^2	Less than 10^1
Intermediate level activity	10^3-10^7	10^2-10^6	10^1-10^5
High level activity	$>10^7$	$>10^6$	$>10^5$

In addition, regarding operational practices, radioactive waste can also be classified according to dose rate (see Table I.2) and to surface contamination (see Table I.3).

TABLE I.2. RADIOACTIVE WASTE CLASSIFICATION ACCORDING TO DOSE RATE

Waste class	Dose rate (mSv/h)
Low Level Activity	0.001-0.3
Intermediate Level Activity	0.3-10
High Level Activity	>10

TABLE I.3. RADIOACTIVE WASTE CLASSIFICATION ACCORDING TO SURFACE CONTAMINATION

Waste class	Activity Concentration of beta-emitting radionuclides (count/(cm^2 × min)	Activity Concentration of alpha-emitting radionuclides (except for transuranic) (count/(cm^2 × min)	Activity Concentration of transuranic radionuclides (count/(cm^2 × min)
Low level activity	500-10^4	50-10^3	5-10^2
Intermediate level activity	10^4 – 10^7	10^3 – 10^6	10^2 – 10^5
High level activity	$>10^7$	$>10^6$	$>10^5$

The RW classification is currently being revised by the ANRA in order to harmonize with the IAEA proposed one stated in General Safety Guide No. GSG-1.

I-1.5. Basic storage and disposal data

There are three as-designed Dry Solid Wastes (DSW) storage facilities on site that have been operated since 1979. DSW are not treated (see DSW Processing below).Packaged waste is placed in storage.

The low level sold radioactive waste (LL SRW) storage area is 12000 m^2. Total capacity of cells is 17051 m^3. The dimensions of each cell are 27×36×8,9 m. The cell bottom and walls are constructed of 0,6m thickness reinforced concrete with three-layer hydraulic insulation. The cells are covered with reinforced concrete plates and asphalted. The SRW is loaded into the cells through the hatches of 0,75 × 0,75m. Totally there are 108 hatches. As of January 2014 the storage facility is 35,7 % filled.

Solid intermediate level waste storage facility is located in the auxiliary building, representing separate compartments covered with hatches. The total capacity of the storage is 1001 m^3 and as of January 2014 the 48.2% of the facility is filled.

The UGU containers are partly stored on the roof of auxiliary building where the temporary storage place under metallic shelter was designed. The useful storage capacity is not more than 3000 DEF drums based on working area of 655 m^2.

Solid HLW storage facility is located in the central hall of reactor building. The facility consists of 380 cells of 0,18 m diameter, 8,9 m length, closed with 0,72m height plugs. A cell represents a metal tube of 6 mm wall thickness with a welded bottom. The capacity of HLW storage facility is 78.34 $m^3$and as of January 2014 the 44,2% is filled.

System of collection and processing of liquid radioactive waste on site, as designed, includes(Fig. I.1):

- System of drain gully water`s collection and processing, which includes:
  - 2 tanks of low level sorbents – of 192 m^3 each
  - 3 tanks of drain gully water – of 170 m^3 each
  - 2 evaporator units of 6 m^3 per hour capacity
  - 2 lines of special water purification - 3 (SWP-3)
- Liquid radioactive wastes storage system, which includes:
  - 2 tanks of high level sorbents – of 420 m^3 each
  - 6 tanks of evaporator concentrate – 550 m^3 each
  - 2 montejus of liquid waste storages.

There are no off-site storage or disposal facilities. Waste mass data have not been collected, currently all reporting of waste quantities is by volume. There are no storage facilities for waste processed for disposal. There are no established waste acceptance criteria for waste processed for disposal.

Treatment	2006	2007	2008	2009	2010	2011	2012	2013	2014
Centrifugation									
Chemical Oxidation									
Compaction									
Decontamination	✓	✓	✓	✓	✓	✓	✓	✓	
Deep evaporation (UGU)	✓	✓	✓	✓	✓	✓	✓	✓	
Evaporation	✓	✓	✓	✓	✓	✓	✓	✓	
Fragmentation	✓	✓	✓	✓	✓	✓	✓	✓	
Incineration									
Ion Exchange	✓	✓	✓	✓	✓	✓	✓	✓	
Liquid Filtration									
Membrane Technology									
Metal Melting									
Organic Destruction									
Radionuclide Separation (e.g., Selective Sorbents)									
Shredding and Compaction									
Sludge washing									
Solvent Extraction									
Sorting	✓	✓	✓	✓	✓	✓	✓	✓	
Super Compaction									
Thermal Treatment (non incineration)									

FIG. I.1. Report on waste processing options (must have report) created by BMS

I-1.6. Waste processing

I-1.6.1. Dry Solid Waste Processing

DSW are not processed (treated or conditioned), however, they undergo pre-treatment:

- collection;
- classification according to activity;
- fragmentation (if needed);
- packaging;
- placement in interim DSW containers;
- transport to and placement in storage.

I-1.6.2. Liquid waste processing

Drain gully water from tanks is pumped to an evaporator, where salts are separated and accumulated in the lower part of the evaporator and, by means of montejus, they are drained to tanks of evaporator concentrate. Secondary steam, generated during evaporation, undergoes degasification and after condensation and purification on SWP-3, is collected in a control tank. From there water could be used for technological processes or released.

In accordance with initial design, the tanks for evaporator concentrate and tanks for high level sorbents are the end point of liquid waste storage until NPP decommissioning, but in the course of the units' operation, the need arose to drain these tanks. As a result, in 1982 deep evaporation unit UGU-200 was assembled on site. UGU-200 processes evaporator concentrates accumulated in the evaporator concentrate tanks (Fig. I.2). Deep evaporation is an effective method for processing liquid wastes to provide a large volume reduction factor. Water is removed in the vapour phase of the process leaving behind non-volatile components such as salts containing most of the radioactivity. The originated after deep evaporation salt fusion ("salt cake") is collected in carbon steel (type 3 steel) metal containers of approximately 150-200L volume, where it is solidified (crystallized). The spent ion exchange resins are stored in the high level sorbent tank. No processing is currently undertaken on spent ion exchange.

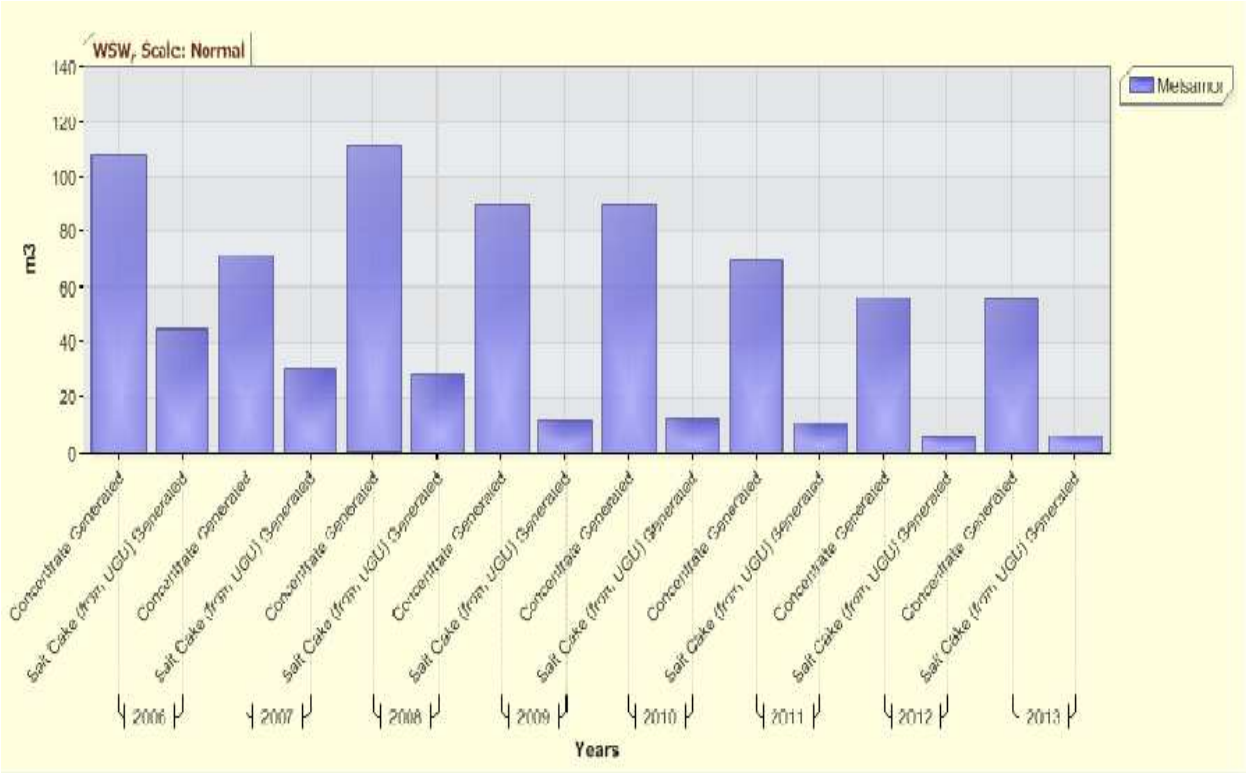


FIG. I.2. Report on concentrate generated vs. salt cake

Fig. I.2 shows a comparison of the volumes of evaporator concentrate generated vs. salt cake (after UGU). It illustrates liquid radioactive waste (concentrate) treatment activities performed. At the same time it indicates indirectly the trending of concentrate generation minimization as a result of activities implemented at Armenian NPP and of the salt cake (from UGU) generation minimization due to the ANRA requirement set as well.

I-1.7. Radioactive waste characterization

Scope of radioactive waste characterization performed at Armenian NPP based on the operational requirements and performed to ensure the compliance with the technological parameters of systems, e.g. of treatment facilities, storage facilities, etc., and to provide the radiation protection of workers.

I-1.7.1. Evaporator concentrate

- Chemical characterization (pH, H_3BO_3, NH4+, Cl^-, Fe^3+, K+, Na+, density, specific salt content)
- Radiological characterization (total activity)
- Gamma spectral analysis (Cs-134, Cs-137, Co-60)

I-1.7.2. Salt cake

- Chemical characterization (humidity)
- Radiological characterization (total activity
- Gamma spectral analysis (Cs-134, Cs-137, Co-60)
- Radiological characterization of metal containers with salt cake(dose rate, surface contamination)

I-1.7.3. Ion exchange resin slurries

- Radiological characterization (total activity, dose rate)
- Spectral analysis (Cs-134, Cs-137, Co-58, Co-60, Mn-54, Ag-110m)

I-1.7.4. Solid radioactive waste

- Radiological characterization (dose rate)

I-1.8. Clearance& Releases to Environment

The below listed legislation sets the criteria for decision making on whether a material containing radioactive isotopes is not required to be under radiological regulatory control:

- The Section XI of Government Decree № 1489 as of 18.08.2006 on approval of Radiation Safety Rules describes the conditions of clearance of materials and specifies the radiological criteria used for the development of the clearance levels that is not to exceed an annual effective dose of 10μSv due to the use of materials containing radioactive isotopes in industrial practices.

- The Government Decree № 1219 as of 18.08.2006 on approval of Radiation Safety Norms includes the levels for clearance of moderate amounts of radioactive materials and as amended by Government Decree № 1552 as of 25.11.2010 establishes the levels for clearance of bulk amounts of radioactive materials.

There are two approaches based on the knowledge about material radionuclides composition: cases with a known radiological profile, and cases with an unknown radiological profile.

I-1.8.1. Cases with a known radiological profile

There is no limitation on those used in practice solid materials, raw materials and goods which contain radioactive isotopes the specific activity of which doesn't exceed 0.3 Bq/g. In agreement with the regulatory authority there may be specified higher levels of specific activities for specific beta radiation isotopes contained in materials, raw materials and goods useful for use without any limitation.

Under authorization of the regulatory authority materials, raw materials and goods containing radioactive isotopes with specific beta activity 0.3-100 Bq/g or specific alpha activity

0.3-10 Bq/g or transuranic radioactive isotopes with specific activity 0.3-1.0 Bq/g may be used in limited amounts for specific purposes. These materials are subject to the mandatory radiation control.

I-1.8.2. Cases with an unknown radiological profile

1. **Moderate amounts** of materials can be cleared from regulatory control if the values of specific activity and activity of artificial radioactive isotopes preset in these radioactive materials are below the levels specified by the Radiation Safety Norms (the values of specific activity and activity are identical with the values of exempt activity concentrations and exempt activities specified in the Table I-I of "International Basic Safety Standards for protection against Ionizing Radiation for the Safety of Radiation Sources").

2. **Bulk amounts** (more than 1 tonne) of materials can be cleared from regulatory control if the values of specific activity of artificial radioactive isotopes preset in these radioactive materials are below the levels specified by the Radiation Safety Norms (the values of specific activities are identical with the values of activity concentration for radionuclides of artificial origin in bulk specified in the Table 2 of IAEA "Application of the Concepts of Exclusion, Exemption and Clearance"(IAEA Safety Guide No.RS-G-1.7).

3. **Radioactive materials containing radioactive isotopes of natural origin** can be cleared from regulatory control if the values of specific activity of the radionuclides are below the levels specified by the Radiation safety Norms (the values of specific activities are identical with the values of activity concentration for radionuclides of natural origin specified in the Table 1 of IAEA "Application of the Concepts of Exclusion, Exemption and Clearance"(IAEA Safety Guide No.RS-G-1.7).

4. **Radioactive materials containing a mixture of radioactive isotopes of artificial origin** can be cleared from regulatory control if the requirement (formula) specified by the Radiation Safety Norms is complied with (formula is identical with the one specified in the paragraph 4.7 of IAEA "Application of the Concepts of Exclusion, Exemption and Clearance" No.RS-G-1.7).

5. **Radioactive materials containing a mixture of radioactive isotopes of natural origin** can be cleared from regulatory control if the specific activity of each radioactive isotope preset in these radioactive materials is less than the relevant value of the specific activity specified by the Radiation Safety Norms (see 3rd bullet).

The exemption and clearance levels of radioactive materials are currently being revised by the ANRA in order to bring in the line with IAEA General Safety Requirements Part 3 No. GSR Part3.

I-2. NATIONAL REPORT OF BULGARIA

I-2.1. Site information

Kozloduy NPP Plc. is located in north-western Bulgaria at about 3 km from the Danube River, which serves as a source of cooling water and a receiver of liquid released from the plant (Fig. I.3).

FIG. I.3. General view of Kozloduy NPP site

Six nuclear units were constructed on Kozloduy NPP site. Units 1 to 4 are WWER-440/230 reactors and Units 5 and 6 are WWER-1000/320 reactors. Units 1 to 4 were commissioned from 1974 to 1982. Units 5 and 6 were commissioned in 1987 and 1991, respectively.

On December 31, 2002 Units 1 and 2 were shut down and on December 31, 2006 Units 3 and 4 were shut down as well. Spent Nuclear Fuel was removed from the pre-reactor pools and the reactors have been prepared for decommissioning. Units 1 and 2 (in 2008) and Units 3 and 4 (in 2012) were declared as Decommissioning Facilities by Ministerial Decree and outsourced from the plant.

A separate complex consisting of facilities for treatment and conditioning of wet and dry solid radioactive waste (RAW) and a facility for storage of conditioned RAW was commissioned in 2001 on site. The complex is situated next to the Auxiliary Building of Units 5 and 6. In 2005 this complex was outsourced as a separate enterprise called the Specialized Enterprise for Radioactive Waste (SE RAW).

There are two Spent Fuel Storage Facilities (SFSF) for wet and dry storage located on the plant site as well.

I-2.2. Basic Storage and Disposal Data

The as-designed storage facilities for Units 5 and 6 (not changed until now) are situated in the Auxiliary Building (AB) and consist of:

- Low Level Dry Solid Waste Storage: 18 well type cells with a total net volume 2 486 m^3;
- Intermediate Level Dry Solid Waste Storage: 3 well type cells with total net volume 213 m^3;
- Evaporator Concentrate Storage: 6 stainless tanks with total net volume 2850 m^3;
- Emergency Storage Capacity of Wet Solid Waste: one stainless tank with net volume 750 m^3;
- Ion Exchange Resin Storage: 2 stainless tanks with net volume 100 m^3 each.

The SE RAW has a storage facility designed for pre-disposal storage of conditioned RAW. It is a surface, steel-concrete facility with a capacity of 1 920 steel-concrete containers with conditioned waste (5 m^3 net and 7.4 m^3 total container volume).

A repository for low- and intermediate-level radioactive waste (LILW) has not yet been constructed in Bulgaria.

I-2.3. Wet Solid Waste

I-2.3.1. Liquid Radioactive Waste

Between 15 000 and 20 000 m^3 radioactive waste water is generated during the operation of Units 5 and 6 annually. The main contributors to waste water generation are regeneration and washing of water purification filers, decontamination of equipment and rooms in the controlled area and leaks. The waste water is collected in tanks with a total net volume 200 m^3 where the major particulate impurities are sedimented. The smaller particulate impurities are removed by mechanical filters. Subsequently the water is processed by an evaporator working at atmospheric pressure. The evaporator output is about 4 m^3/h.

The distillation water undergoes additional cleaning by ion exchange (IX) and is released into the environment after radiation monitoring. According to the national environmental legislation the release of boron containing compounds to the environment is banned.

I-2.3.2. Concentrate

The concentrate from evaporation is stored in tanks located in the AB.The annual generation of concentrate is between 150 and 250 m^3. The concentrate salt content is between 200 and 300 g/L. The boric acid content is about 60 g/L. The activity of ^{60}Co is about 7.10^4Bq/L and the activity of ^{137}Cs is about 8.10^6Bq/L. The total alpha activity is less than 30 Bq/L (detection level of measuring equipment).

The annual generations of concentrate within the period 2006-2013 and normalized to 200 g/L are presented in Fig. I.4.

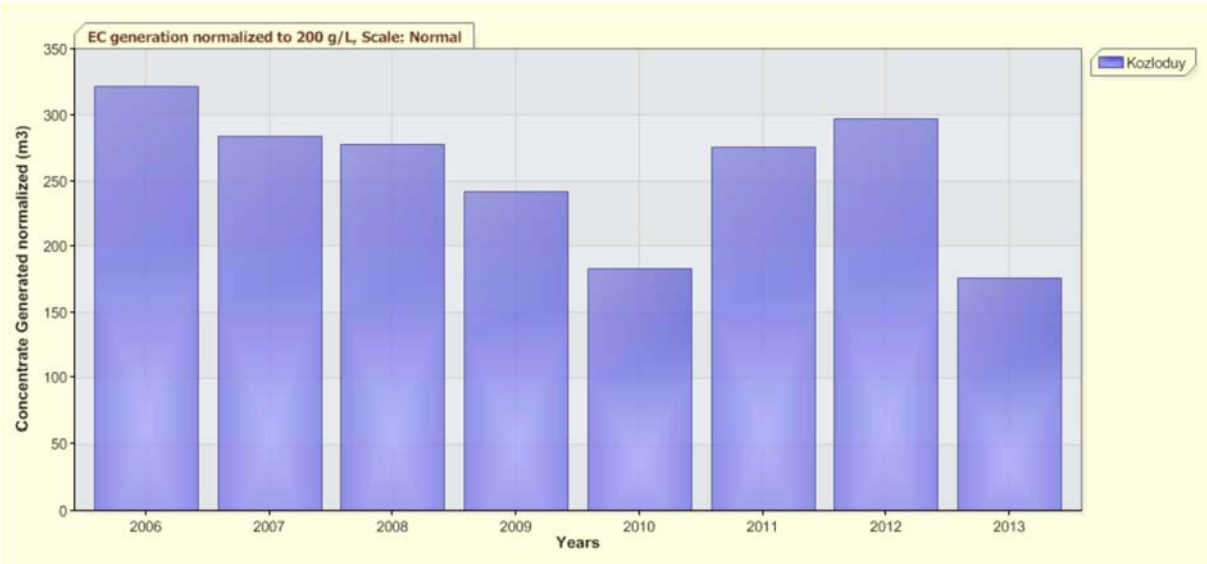
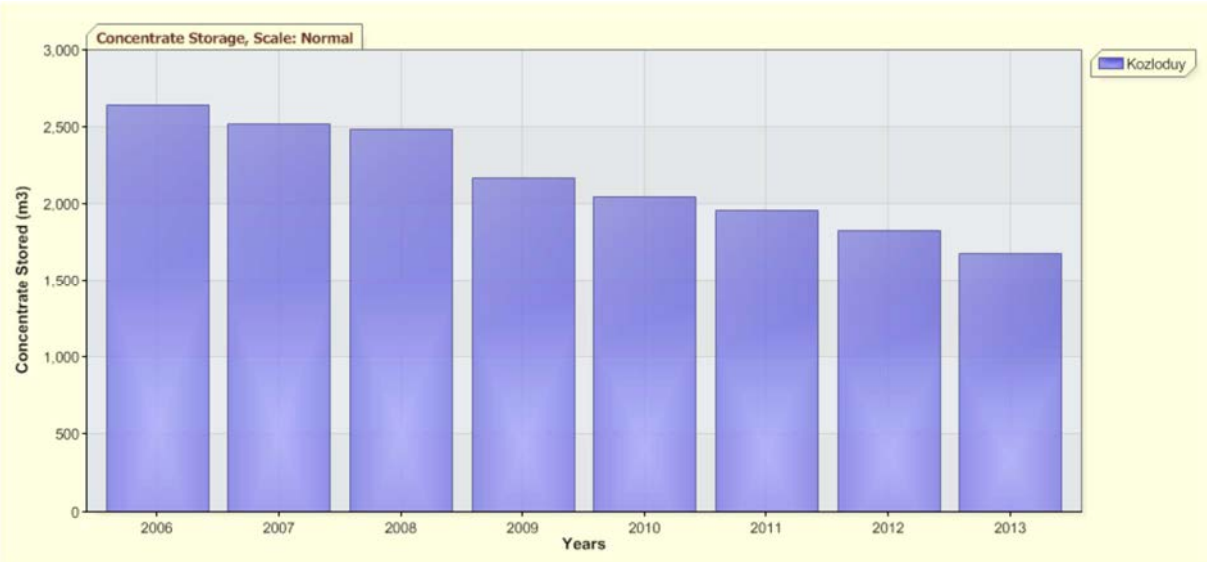


FIG. I.4. Annual generation of concentrate, normalized to 200 g/L.

Since 2004, concentrate is periodically pumped out from the storage tanks and transferred by a pipeline for processing to the SE RAW, where it is processed by further concentration, conditioned into a cement matrix and loaded into steel-concrete containers.

The status of the concentrate storage tanks up to the end of 2013 is presented in Fig. I.5.



FIGI.5. Status of the concentrate storage tanks up to the end of 2013

Compliance of the concentrate with the Waste Acceptance Criteria (WAC) established by SE RAW is verified by measurement of the total salt content, boric acid content, surface active substance content and radionuclide content (gamma-emitters and total alpha activity).

The final characterization of the concentrate is performed before conditioning. All chemical parameters important for the conditioning technology are controlled. The content of the following radionuclides is controlled by gamma-spectrometry measurements and application of scaling factors: ^{60}Co, ^{94}Nb, ^{134}Cs, ^{137}Cs, ^{54}Mn, ^{57} Co, ^{58}Co, ^{14}C, ^{55}Fe, ^{63}Ni, ^{59}Ni, ^{90}Sr, ^{99}Tc, ^{129}I, ^{233}U, ^{234}U, ^{235}U, ^{238}U, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{241}Am, ^{242}Cm, ^{244}Cm.

The quantities of generated concentrate versus concentrate processed for disposal are presented in Fig. I.6.

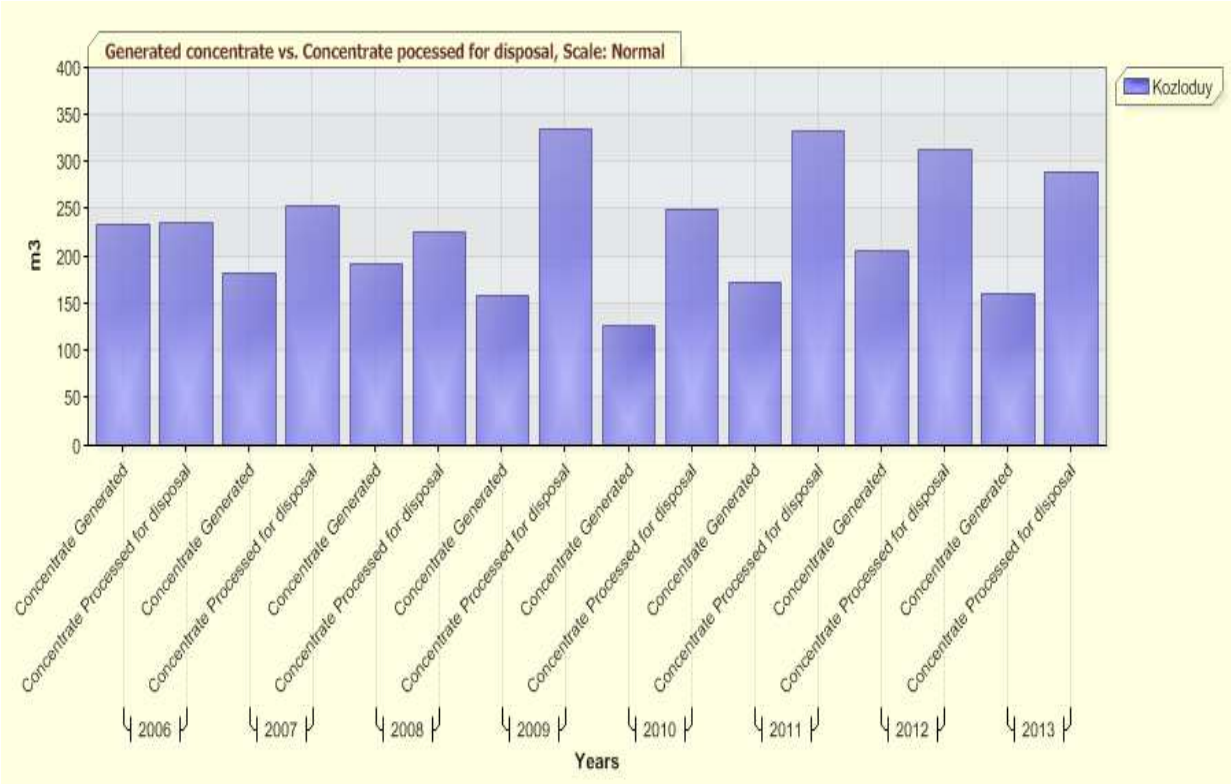


FIG.I.6. Generated concentrate versus concentrate processed for disposal

I-2.3.3. Ion Exchange Resins

IX resins are stored in the AB in two 100 m^3 stainless steel tanks. A method has not yet been chosen for IX resins treatment and processing yet. The annual generation of IX resins is between 1 and 6 m^3 during the last several years. The IX generation rate in the period 2006-2013 is presented in Fig. I.7.

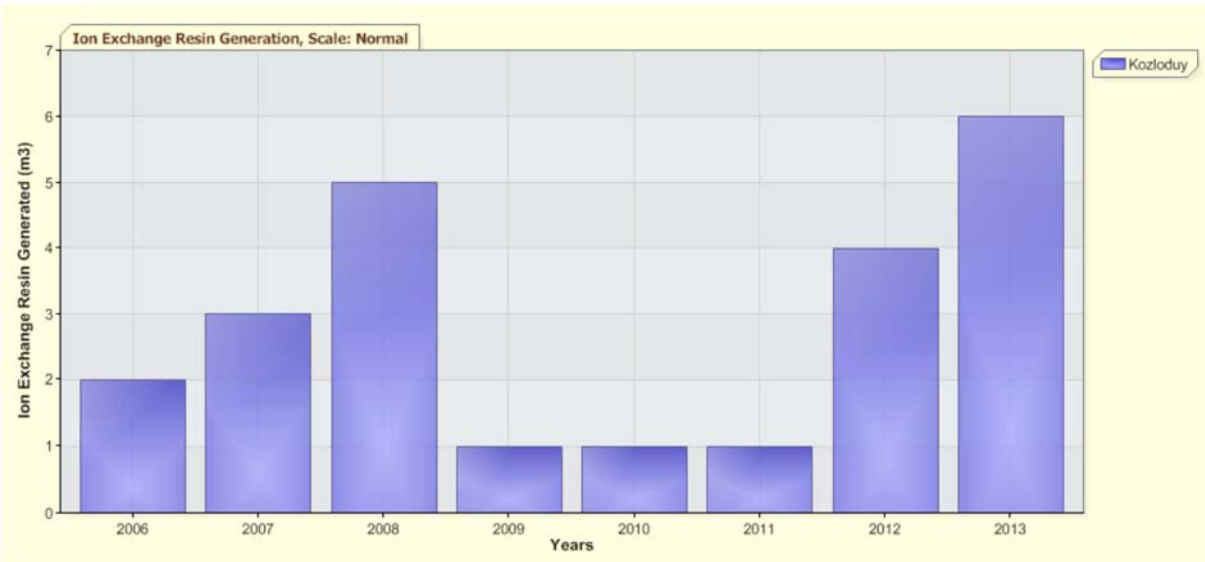


FIG. I.7. Annual generation of IX

I-2.3.4. Sludges

The estimated amount of sludge stored in the technological systems by now is about 55 m^3. Currently the Kozloduy NPP is assessing technologies for sludge removal and processing.

I-2.3.5. Spent Oils

About 1 m^3 radioactive contaminated spent oils are generated at Kozloduy NPP yearly. They are decontaminated by bubbling technology, cleared and released.

I-2.4. Dry Solid Radioactive Waste (DS RAW)

I-2.4.1. Generation of DSRAW

All waste generated in the controlled area of Units 5 and 6 are considered radioactive and originate from:

- the waste generated during the daily operation of the units;
- the historical waste stored in the temporary dry solid waste storage.

DS RAW is segregated at the point of generation into three groups:

- compactible;
- non-metal non-compactible;
- metal.

According to Bulgarian legislation, the Low and Intermediate Level RAW are called Category 2 waste. With respect to radiation protection considerations and in connection with the further processing, operational subcategories for DS RAW have been introduced in Kozloduy NPP. These subcategories are based on the dose-rate of gamma-radiation measured at the waste surface:

- Category 2-I – dose rate in the range from 1 μSv/h to 300 μSv/h;
- Category 2-II – dose rate in the range from 300 μSv/h to 10 mSv/h;
- Category 2-III – dose rate above 10 mSv/h.

The various subcategories are stored in separate wells. Wastes with dose rates less than 1 μSv/h is stored as candidates for clearance in seven separate wells pending implementation of a clearance procedure.

Since 2005, DS RAW management has focused on the following:

- newly generated waste categories 2-I and 2-II transferred to the SE RAW for processing;
- stage-by-stage retrieval of historical waste from the AB and transfer to the SE RAW for processing;
- storage of newly generated waste category 2-III in the AB .

The Kozloduy NPP annual generation of DS RAW includes :

- less than 1 m^3 of category 2-III;
- 400 to 700 m^3 of processible waste categories 2-I and 2-II; and
- 10 to 50 t of metals.

The quantities of processible DS RAW, generated within the period 2006-2013, are shown in Fig. I.8. Originally the quantities of the processible DS RAW were measured in cubic meters. For the purposes of the benchmarking a conversion from volume to mass was introduced in

the beginning of 2013 by introducing a conversion factor 1 m^3= 0.18 t. This conversion factor was established by measuring and averaging of the mass of a large number of packages containing various routinely generated waste.

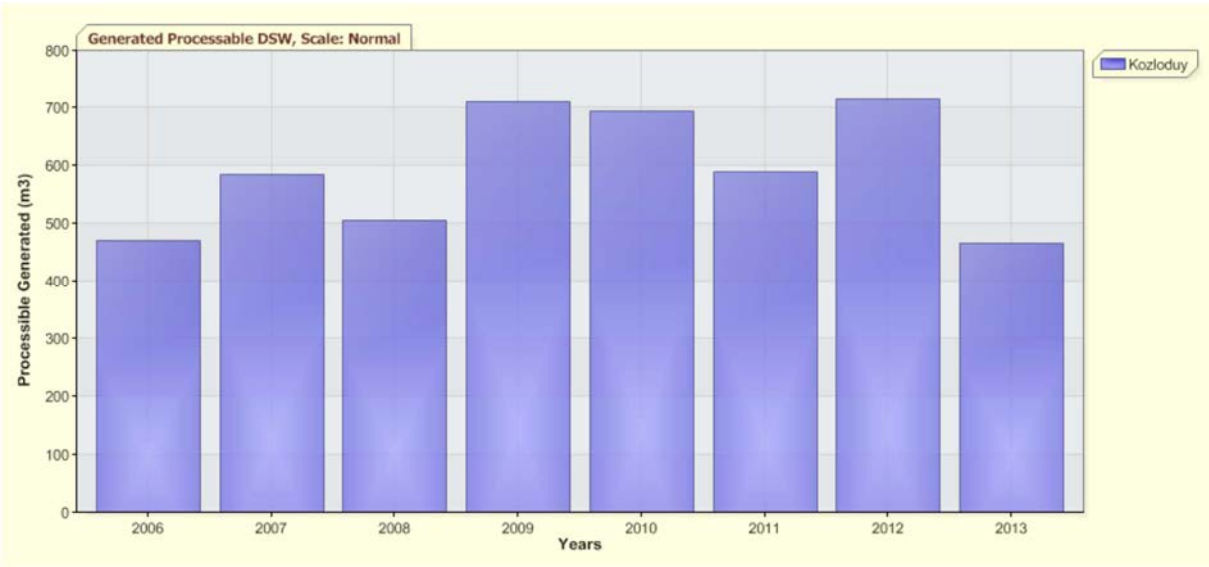


FIG. I.8. Annual generation of processible DS RAW

The quantities of the metal RAW generated within the period 2006-2013, are presented in Fig. I.9.

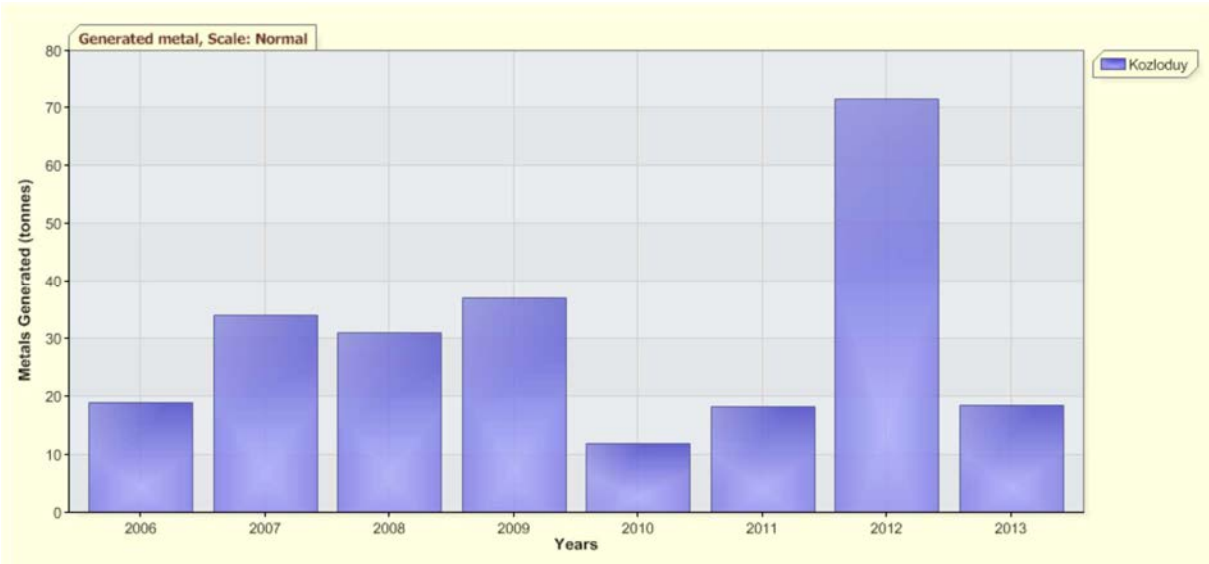


FIG. I.9. Annual generation of metal RAW

More than 70 t radioactive metal waste was generated in 2012. This quantities exceeded the typical annual generation because of some life extension activities such as discarding old equipment and instrumentation, refurnishing of workshops and laboratories and housekeeping of rooms in the controlled area.

I-2.4.2. DSRAW Storage

Currently, about 10 m^3 of category 2-III and 600 m^3 of categories 2-I and 2-II RAW are stored in the AB.

The quantities of the dry solid RAW, stored in the temporary AB storage within the period 2006-2013 are presented in Fig. I.10.

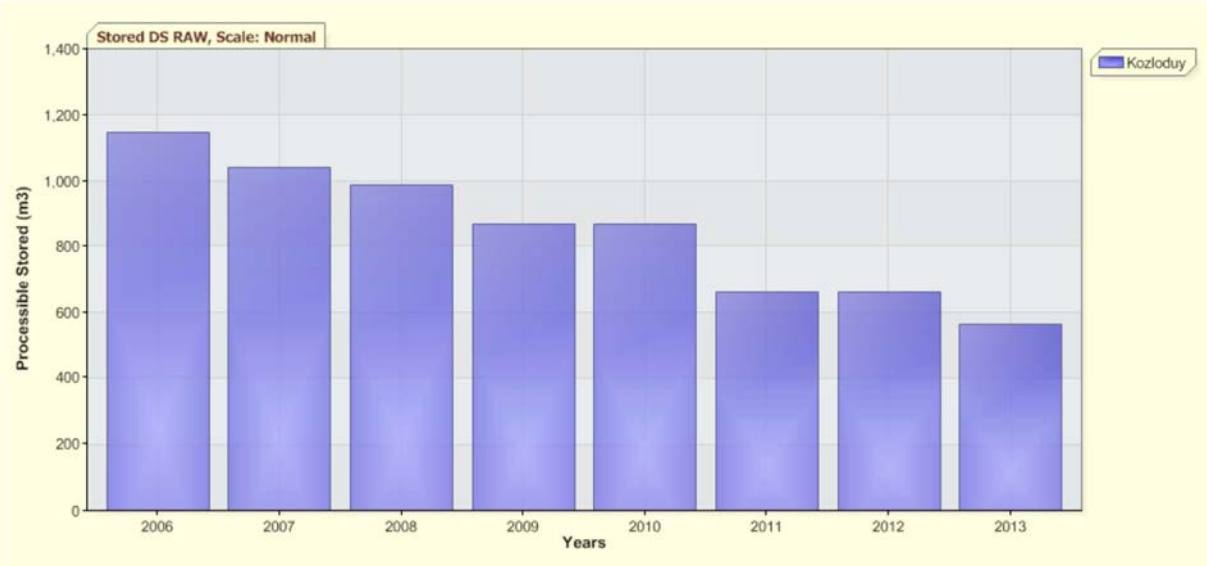


FIG. I.10. Status of DSRAW storage

I-2.4.3. DSRAW Processing

The SE RAW receives waste in compliance with WAC approved by the Bulgarian Nuclear Regulatory Agency.

DS RAW processing includes packing and compacting in 200 L drums, super-compaction of the drums, immobilization in a cement matrix and over packing in steel-concrete containers. The non-metal, non-compactable waste is chopped in pieces and cemented as well.

The SE RAW has a metal decontamination shop where some metal RAW are decontaminated and cleared from regulatory control. For the purposes of DSRAW processing optimization, three conditioning options have been developed, see Table I.4.

TABLE I.4: OPTIONS FOR DS RAW CONDITIONING

Type of Container	Characteristics
Type 1	• super-compacted drums, not immobilized in a cement matrix; • total activity no more than 5 GBq; • dose rate at the surface < 1 mSv/h; • storage period 25 years; • final issue: clearance.
Type 2	• super-compacted drums immobilized in a cement matrix; • total activity no more than 10 GBq; • dose rate at the surface < 1 mSv/h; • storage time no more than 30 years; • final issue: clearance or disposal
Type 3	• super-compacted drums immobilized in a cement matrix; • total activity no more than 100 GBq; • dose rate at the surface < 2 mSv/h; • storage time no more than 30 years; • final issue: disposal.

The conditioning option choice depends on the radionuclide content in waste. This approach allows adjustment and implementation of clearance practices for the conditioned waste after certain period of storage.

The containers with the conditioned waste are stored (see Fig. I.11) and are subject to further clearance or disposal without any additional processing and packing.

FIG. I.11. Storage Facility for Conditioned RAW

DS RAW is characterized radiologically in the treatment facility after their compaction into 200 L drums. The characterization is performed by gamma-spectrometry measurements and application of scaling factors for estimation of the difficult to measure radionuclides. The following radionuclides are controlled: ^{60}Co, ^{94}Nb, ^{134}Cs, ^{137}Cs, ^{54}Mn, ^{57} Co, ^{58}Co, ^{14}C, ^{55}Fe, ^{63}Ni, ^{59}Ni, ^{90}Sr, ^{99}Tc, ^{129}I, ^{233}U, ^{234}U, ^{235}U, ^{238}U, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{241}Am, ^{242}Cm, ^{244}Cm. The gamma-spectrometry scanning of the compacted drums is shown in Fig. I.12.

FIG. I.12. Gamma-spectrometry scanning of compacted drums

I-2.5. Clearance of Materials from Regulatory Control

Clearance from regulatory control is allowed by the Bulgarian legislation as an approach to optimize radiation protection and to minimize radioactive waste quantities. The requirements are set in the Regulation on the basic radiation protection standards. The regulatory framework comprises of the following main issues:

- Radioactive material can be cleared from regulation in any single case by a permit issued by the Chairman of the Bulgarian Nuclear Regulatory Agency (NRA) at the request of the licensee or permit holder.
- In each case the applicant shall justify and demonstrate compliance with the clearance criteria.
- Deliberate dilution is forbidden.
- Two types of clearance are foreseen:

  General clearance (unconditional clearance)

  Radioactive materials may be cleared from regulatory control without further limitations regarding its use if:

  - the clearance levels (expressed in specific activity, Bq/g) are not exceeded;
  - for radioactive material containing more than one artificial radionuclide, the sum of the ratios of the specific activity of each radionuclide to the clearance level of corresponding radionuclide does not exceed one.

  There is no limitation in amount of the unconditionally cleared material.

  Specific (conditional) clearance

  Radioactive material whose specific activity is greater than the clearance levels for general clearance may be cleared if the following dose criteria are fulfilled:

- in all reasonably foreseeable circumstances (realistic scenario) the effective dose expected to be received by any member of the public due to the cleared material does not exceed 10 μSv/y;
- in scenarios involving the cleared material with a very low probability of occurrence, the effective dose that can be received by any member of the public does not exceed 1 mSv per year.

The operator has to identify the specific conditions for the subsequent management of the material: characteristics of the material and the intentions for its further usage or disposal.

I-3. NATIONAL REPORT OF PEOPLE'S REPUBLIC OF CHINA

I-3.1. Introduction

Tianwan NPP is located in Gaogong Island district, Lianyungang, Jiangsu province, China. The design, construction and operation of 1# and 2# unit are based on the operational experiences activities of 20 units WWER in Russia. And, the total installed capacity of Tianwan NPP will be more than 8GW with eight units, and the generated energy will be more than 60TWh/a. A schematic of NPP is shown in FI.13.

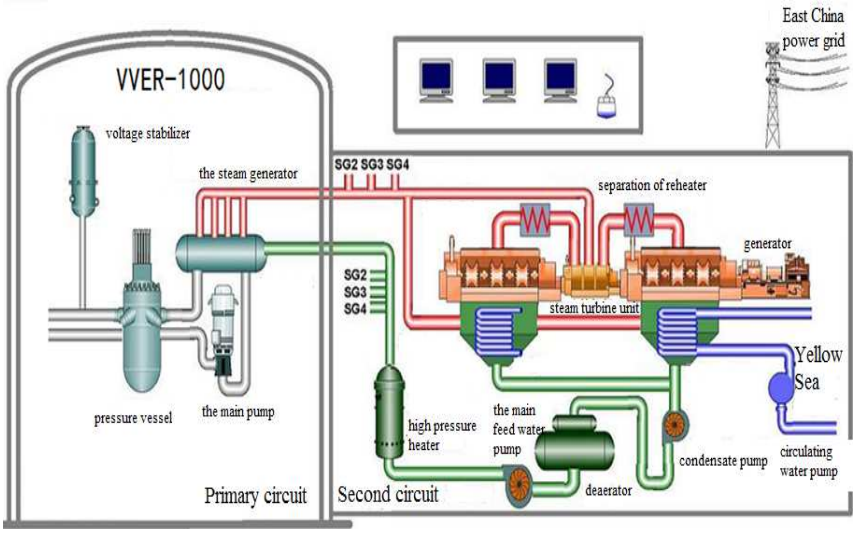


FIG. I.13. Schematic of Tianwan Nuclear Power Plant.

In Oct.1999 and Sept. 2000, the 1# and 2# unit, as the first phase engineering, were started to be constructed separately. And, in May and August 2007, they were successfully in commercial operation one after another.

I-3.2. Radioactive waste treatment system

To protect the health of personnel and public, radioactive material effluent monitor system and radioactive waste treatment system was installed and developed in 1# and 2# unit, and they include three parts (Fig. I.14):

[1]. Radioactive gaseous waste treatment

— Exhaust and air filtration system of reactor building (KLD)
— Negative pressure system under circular space of containment vessel (KLC)
— Radioactive gaseous waste treatment system (KPL)
— The main exhaust system (KLE)

[2]. Radioactive liquid waste treatment

— Special drainage system of the nuclear service building (KTT)
— Radioactive liquid waste treatment system (KPF)
— Neutralization discharge system (GCR)

[3]. Radioactive solid waste treatment

— The solidification system for radioactive liquid waste (KPC)
— Radioactive solid waste treatment system (KPA)
— The storage building for radioactive solid waste (KPE)

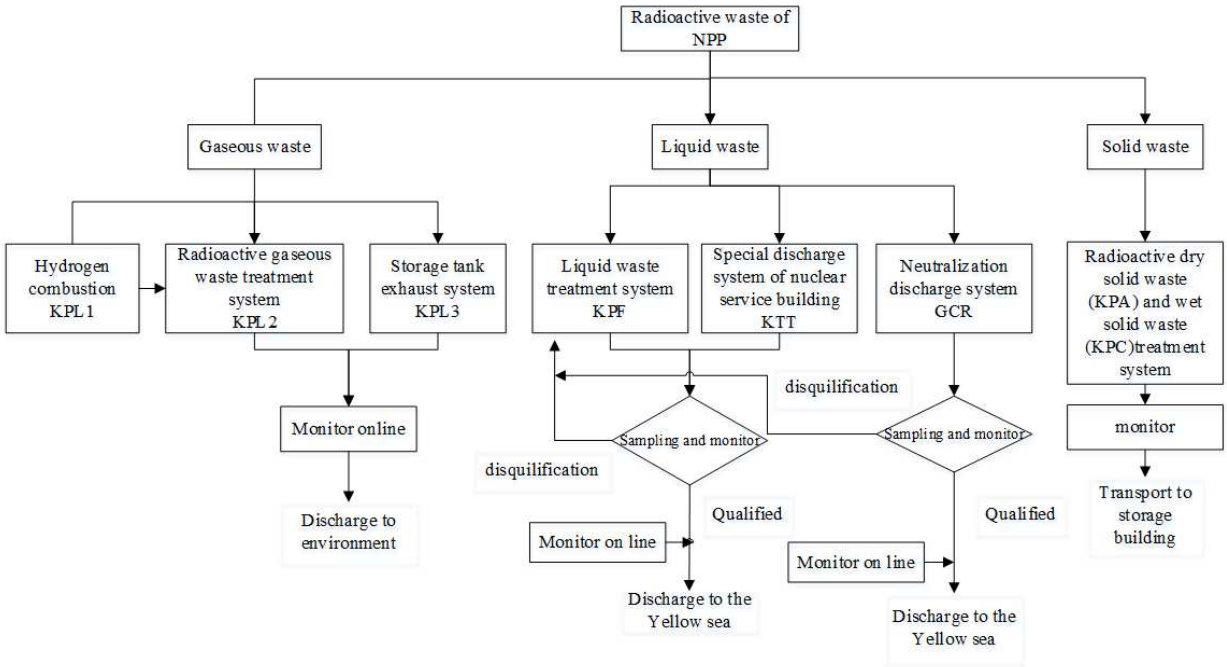


FIG. I.14. Schematic of radioactive waste treatment system

I-3.2.1. Gaseous waste treatment system

During the reactor operation of the NPP, the gaseous waste are produced from four sources [I.1]: first one is from the degaser of the primary circuit complement water system (KBA10BB001), the pressure relief device of the voltage stabilizer and (JEG10BB001) and the storage tank for the leakage collection in the primary circuit; second one is from the hydrogen combustion system (KPL1), and the coolant storage system (KBB), the complement water system in the primary circuit (KBC1) and the boron drainage collection system (KTC); the third is come from the storage tanks, except that of KBB, KBC1 and KTC system in the NPP; and, the last is from ventilation system in the reactor buildings.

The flow sheet of gaseous waste treatment system is shown in Fig. I.14, in which the gaseous waste, from the degaser of the primary circuit complement water system (KBA10BB001), the pressure relief device of the voltage stabilizer (JEG10BB001) and the storage tank for the leakage collection in the primary circuit, were compounded in the hydrogen combustion system (KPL1). After cooling, the compounded gaseous waste were sent to radioactive gaseous waste treatment system (KPL2), the exhaust and coolant storage system (KBB), the complement water system in the primary circuit (KBC1) and the boron drainage collection system (KTC), separately; at last, the gaseous waste was treated until the radioactivity is satisfied the requirements of Department of National Environment Protection, and discharged to environment.

The exhaust treatment system of the storage tank (KPL3) collects and treats the exhaust gaseous waste from the storage tanks except that of KBB, KBC1 and KTC in the plant. Then, the treated gaseous waste will be monitored before be discharged to environment.

The exhaust gaseous waste treatment system is equipped with pre-filter at the inlet, high effective particle air (HEPA) filter and Iodine filter to clean and treat the exhaust from storage building, reactor building, auxiliary building and security workshop.

The treatment facilities also have the following features:

— Radioactive gaseous waste treatment system (KPL2) has two treatment systems, one is main treatment system and another is the standby treatment system. And, each treatment system is composed of four activated carbon adsorber in series;
— Aerosol and Iodine filter are equipped in the exhaust treatment system of the storage tank (KPL3);
— The cleaned exhaust is directly discharged after filtering.

I-3.2.2. Liquid Waste Treatment System

The liquid waste were mainly included radioactive liquid waste and normal discharge from the controlled area. The radioactive liquid waste are produced from hydraulic unloading of the desalination device, room and equipment decontamination liquid waste, the uncontrolled leakage from the auxiliary equipment, evaporator chemical cleaning water, sampling and drainage from the monitor laboratory, and resin exchanger renewable liquid, etc.. The normal discharge from the controlled area includes the drainage of the ground cleaning, the laundry, the bathroom, etc..

The flow chart of liquid waste treatment system is also listed in Fig. I.14. There are three ways to collect and treat liquid waste [I.1]. The first one includes separately collection of the liquid waste and boron liquid waste from special drainage system of the nuclear service building (KTT), the security workshop (KTL) and the auxiliary building (KTH), and sent them to the liquid waste treatment system (KPF) and the boron waste dewatering collection system (KTC); the second way is the nuclear service building special drainage system (KTT) to collect the discharge from the nuclear service building, the non-radioactive drainage from the auxiliary building, the special drainage of laundry room and drainage from the public lavatory/bathroom/laboratory equipment in the controlled area. If the radioactivity of the collected liquid waste is excessed the regulation value, they will be sent to liquid waste treatment system (KPF). The third way is focused on desalination device LD renewable liquid, which are separately collected by the condensate clean filter monitor system (LDL), then sent to the neutralization/monitor/drainage system (GCR) to neutralize, and detect the radioactivity before be discharged. If the radioactivity of the collected liquid waste is accessed the discharge regulation value, they will be sent to the radioactive liquid waste treatment system (KPF).

The waste treatment method include the following features: evaporator and resin exchangers are used to clean the liquid waste in KPF. There are two evaporators (one is main evaporator (KPF30AT001) and another is standby evaporator (KPF30AT002)). Each evaporator capacity is 6t/h. The decontamination factor of evaporator is around 10^5. The decontamination factor of the condenser is around 10-100. KPF system in one unit (1# or 2#) has treated around 2350 m^3/a radioactive liquid waste. The cleaned condensate liquid will be sent to second circuit to replenish the system.

I-3.2.3. Solid Waste Treatment System

The solid waste treatment system is mainly divided into three parts:

— Process waste, including waste produced during operation, such as sludges, spent resin and residual liquid, spent disassemble ionize monitor channel (IC), neutron detection channel (NF) and neutron temperature determination channel (TMC), etc. [I.2].

— Technic waste, including the solid waste from equipment maintenance, detection and radioactive clean/decontamination activities, such as compactable waste (glove, cotton material, shoes cover, paper clothes, air-clothes, mask and plastic,etc.) and incompactable waste (wet waste, metal parts, woods, concrete, etc.)

— Others, including spent oil, spent solvent, large surface contaminated equipment and metal, etc.

The flow chart of solid waste treatment system is presented in Fig. I.14. There are five main system: KPK system is responsible to store the radioactive spent resin from NPP operation phase and maintenance activities, and the evaporation residual liquid from KPF evaporation system before they are sent to KPC system. The KPC system carries out the cementation of the radioactive liquid waste (low/intermedia level spent resin and evaporation residual liquid, and sludge from KPF system). KPA is in charge of collection, treatment of the first class and second class radioactive solid waste from NPP operation phase, maintenance activities and perspective operation incident. KPE system is focused on store the concrete drum containing cementation solid waste, the 200L stainless steel drum containing solid waste and the transportation container with IC, NF and TMC.

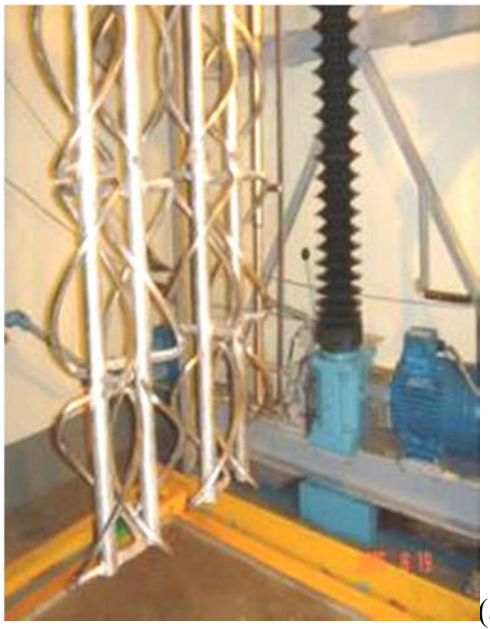
In the solid waste treatment system, the most important action is sorting and collection before the solid wastes were sent to the treatment system (FI.15). The wastes from the processing, such as spent resin and evaporated residual liquid, are temporarily storage in the radioactive liquid waste storage system (KPK) for two months, then will be sent to KPC system to be solidified. The spent IC、NF&TMC are collected in special container by the dedicated tools. As for the technic waste collection, there are some fixed or temporary waste collection points set up in the controlled area buildings, in which different wastes are collected into appointed color bags, such as red bag getting compactable radioactive waste, blue plastic bag getting non-compactable radioactive wastes, yellow plastic bag collecting the material and equipment waiting for decontamination, white plastic bag receiving clean or decontaminated materials and equipment, and the degenerated waste bag collecting the degenerated wastes.

FIG. I.15. View of the solid waste collection point in the controlled area building

I-3.3. Conditioning

To keep the radioactive liquid waste to safely transport and handling, the cementation system is installed in the NPP to solidify the evaporation residual liquid waste containing 400g/l salt or 100g/l boron, and low& intermediate radioactive level spent resin, then detect the radioactivity and seal the container before be sent to storage building or disposal site (Fig. I.16).

To match the waste minimization requirement, a compactor is installed in solid waste treatment system in each unit. The design force is at least 950KN, and the volume reduction factor is around 3~5.


(a)

(b)

FIG. I.16. View of the cementation system (a) and compactor (b)

I-3.4. Operational aspect

During the NPP operation phases, there are two types nuclide, fission products (such as, ^{124}Sb、^{131}I、^{134}Cs and ^{137}Cs) and activity corrosion products (such as, ^{54}Mn、^{58}Co、^{59}Fe、^{60}Co) in the effluent. In 2013, the average radioactivities of the main nuclides in effluent gaseous wastes are shown in Tables I.5 and I.6 shows the average radioactivities of the main nuclides in the discharged liquid wastes. Table I.7 gives the

designed discharge radioactivity value of the annual reloading. Those tables show that the average radioactivity of the effluent waste is lower than that of the designed effluent.

In the liquid waste treatment system, the decontamination factor is around $10^3 \sim 10^4$ with concentrated 50 – 100 folds of liquid waste in one single evaporator, and the total decontamination factor is around 10^5 with two evaporator. In the gaseous waste treatment system, the activity carbon retention method is employed. And, in the solid waste treatment system, the nonstandard concrete container were modified and changed to stainless steel container to reduce the package volume from 2 m^3 to 1.15m^3, containing same waste volume as 570L evaporation residual liquid waste or 342 L spent resin.

TABLE I.5. THE AVERAGE RADIOACTIVITIES OF THE EFFLUENT GASEOUS WASTE IN 2013（Bq/m^3）

^{3}H	^{14}C	^{54}Mn	^{60}Co	^{134}Cs	^{137}Cs
5.47E-02	2.85E+01	2.73E-03	4.16E-03	4.70E-04	4.00E-04
^{131}I	^{133}I	^{41}Ar	^{88}Kr	^{133}Xe	^{135}Xe
2.70E-03	6.30E-04	1.82E+03	1.83E+02	2.88E+03	4.85E+02

TABLE I.6 THE AVERAGE RADIOACTIVITIES OF THE EFFLUENT LIQUID WASTE IN 2013（Bq/m^3）

^{3}H	^{14}C	^{54}Mn	^{58}Co	^{59}Fe
13.7E+08	3.13E+04	4.13E+02	3.87E+02	8.20E+02
^{60}Co	^{124}Sb	^{131}I	^{134}Cs	^{137}Cs
6.15E+02	4.29E+02	3.71E+02	4.45E+02	4.58E+02

TABLE I.7. THE DESIGN OF ANNUAL RELOADING DISCHARGE (Bq/a)

Gaseous waste	Noble gas	2.66E+14
	Iodine	7.36E+09
	Particle (halflife≥8d)	2.20E+08
	^{14}C	6.00E+11
	^{3}H	7.80E+12
Liquid waste	^{3}H	1.84E+13
	^{14}C	-
	Other nuclides	2.46E+10
Solid waste (per unit)		163.6m^3/a

I-3.5. Conclusions

After several years operation, the waste treatment systems present the expected effect, and meet the national discharge requirement and regulation control value of Tianwan NPP. In the future, there will be more modification in the waste management to improve the system effectivity and minimize the waste radioactivity and volume.

I-4. NATIONAL REPORT OF CZECH REPUBLIC

The WWER reactors, especially WWER 440, that were installed in the 1980's have a higher generation rate for radioactive waste (RAW) compared with PWR reactors and have a limited infrastructure for RAW management. This has resulted in the accumulation of considerable volumes of RAW at WWER sites. The volume of RAW stored at some WWER sites is gradually becoming one of the limiting factors for further safe operation.

At the Czech NPP, a complex program oriented to improving RAW management efficiency has been established. The Program comprises following areas:

- Waste management information system,
- Waste characterization,
- Improvement of waste processing technologies,
- Improvement of bituminization process thermal stability,
- Co-operation with external organizations,
- Clearance procedure,
- Transport of RAW,
- Disposal of RAW, and
- Communication with the State Office for Nuclear Safety (SONS [SÚJB]) and the Radioactive Waste Repository Authority (RAWRA [SÚRAO]).

There are two operational NPPs in the Czech Republic, NPP Dukovany and NPP Temelín.

I-4.1. NPP Dukovany Site information

All units (Table I.8 and Fig. I.17) are in operation. A power uprate to increase gross capacity to 500 MWe was completed in 2012. The lifetime extension project "+10years" is in progress. Approval of an extended operating license is expected in 2015 for Unit 1.

TABLE I.8. NPP DUKOVANY UNITS

Unit	Type	Net capacity	Gross capacity	Initial criticality	Grid date
1	WWER 440/V213	>427 MWe	500 MWe	Feb 1985	Aug 1985
2	WWER 440/V213	>427 MWe	500 MWe	Jan 1986	Sep 1986
3	WWR 440/V213	>427 MWe	500 MWe	Oct 1986	May 1987
4	WWER440/V213	>427 MWe	500 MWe	Jun 1987	Dec 1987

FIG. I.17. A view of Dukovany NPP.

I-4.1.1. NPP Dukovany Basic Storage and Disposal Data

There are no off-site storage facilities for RAW generated by Czech NPP (Table I.9). There is a considerable difference in storage capacities between WWER 440 and WWER 1000.

TABLE I.9. DESIGN GEOMETRIC STORAGE VOLUME.

Waste Stream	As-Designed Capacity	Administrative Limit*
Dry Solid Waste	>9000 m^3	800 tonnes
Concentrate	>6000 m^3	4000 m^3
Ion Exchange (IX) Resin	>1800 m^3	460 m^3

* imposed by SONS as 2013

I-4.1.2. NPP Dukovany Wet Solid Waste

Fundamental technology (and the only one) for radioactive concentrates conditioning (Fig. I.18) in the NPPs is bituminization installed at both NPP.

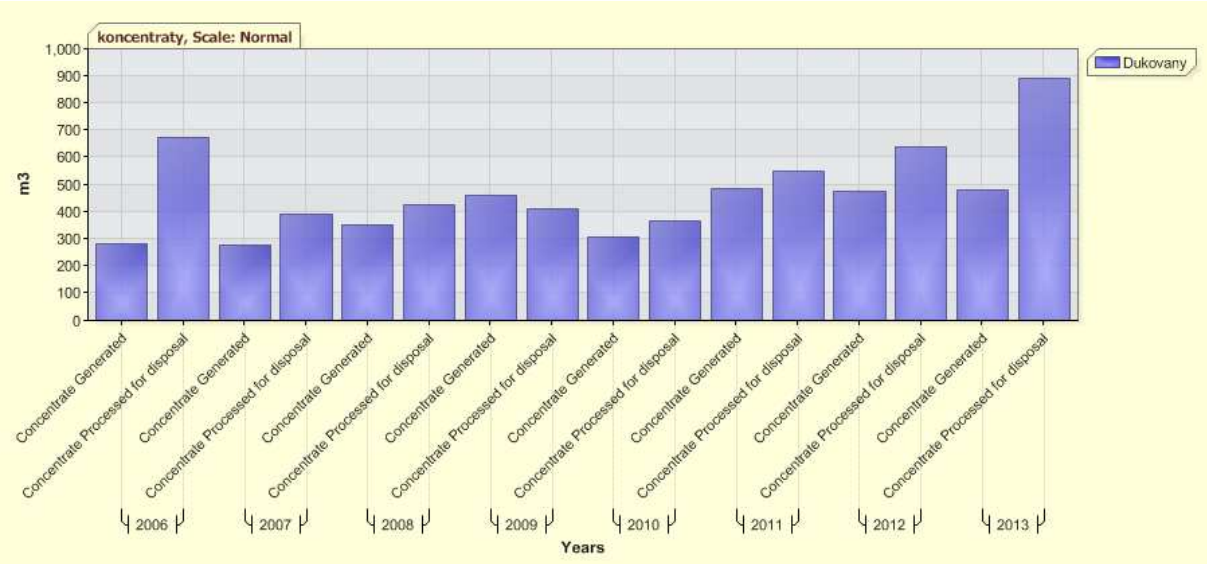


FIG. I.18. Generation and conditioning of concentrate at NPP Dukovany site (m^3).

The main component of bituminization technology is a vertical thin film evaporator. Liquid bitumen and concentrate are pumped into heated tube, mixed and stirred on inner surface, water is evaporated and final product is filled into 200 L drums. Evaporator capacity is approximately 250 L/hour of evaporated concentrate – the final product contains 40% salts.

Annual production of bituminous product varies between 600-1000 drums/year in Dukovany.

I-4.1.3. Enhancement of safety to bituminization process

There are several precautions implemented at NPPs to eliminate related technological risks:

- Increasing the frequency and scope of chemical and radiological controls of radioactive concentrates during its filling into the storage tanks.
- Testing and verification of thermal stability of the product using actual concentrate in laboratory conditions of Nuclear Research Institute Řež. The result has been used for control of the bituminization process of a specific waste batch.
- Implementation of a continuous thermal stability control of real bituminization product samples by using the DTA method (differential thermal analysis).
    - Adoption of two independent safety systems that are on-line monitoring the course of cooling of barrels with bitumen product (one on the surface and second inside the bitumen product).
    - Modification of existing systems for air-conditioning. A special cooling tank has been added to technology for prompt stabilization of temperature of the barrel with thermally unstable product.

I-4.1.4. Sludge, IX resins

Conditioning of IX resins and sediments into a form that meets Waste Acceptance Criteria (WAC) for the repository started in 2010. Modifications of storage tanks and transport piping have been implemented for easier withdrawal and waste processing.

The waste conditioning (Fig. I.19) has been carried out at the Dukovany NPP by the external supplier AMEC Nuclear Slovakia with use of portable equipment and geopolymeric matrix. By the end of 2012, the Dukovany NPP Units 1 and 2 extracted, conditioned and disposed more than 200 t of sludge and IX resins. Withdrawal and conditioning the waste stored at

Units 3 and 4 (approx. 100 tonnes) carried out by new supplier continue. Accomplishing of IX conditioning campaign is expected at the end of 2014.

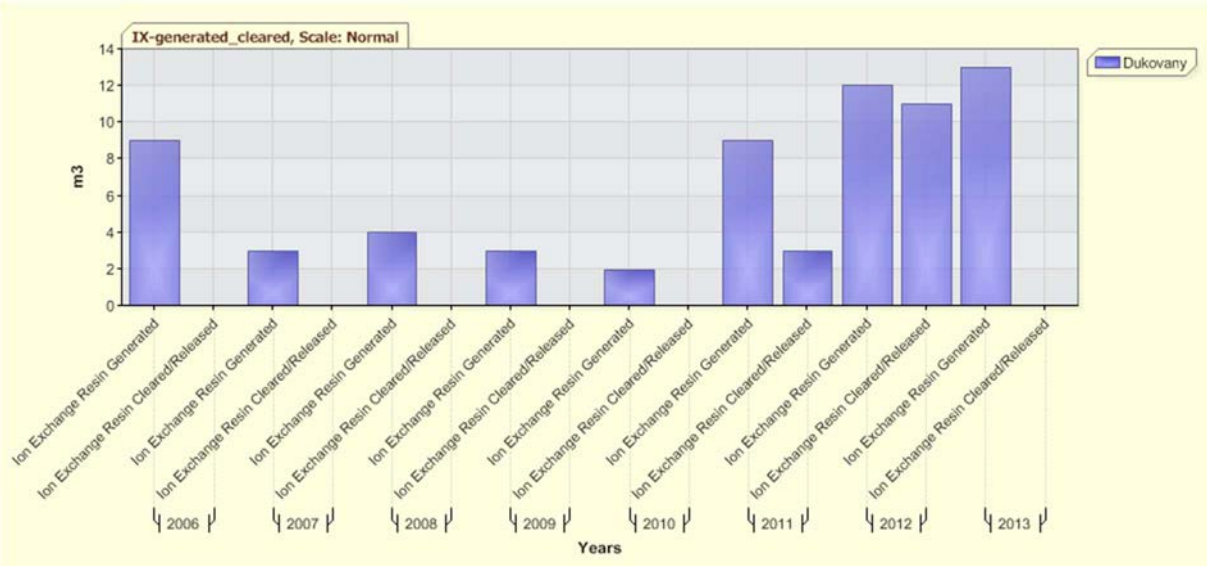


FIG. I.19. Volume of spent IX resin generated and cleared at NPP Dukovany site (m^3).

IX resins with low specific radioactivity (e.g. from purification systems SVO-3, SVO-5) are being separated, measured, cleared and released into the environment (Fig. I.20).

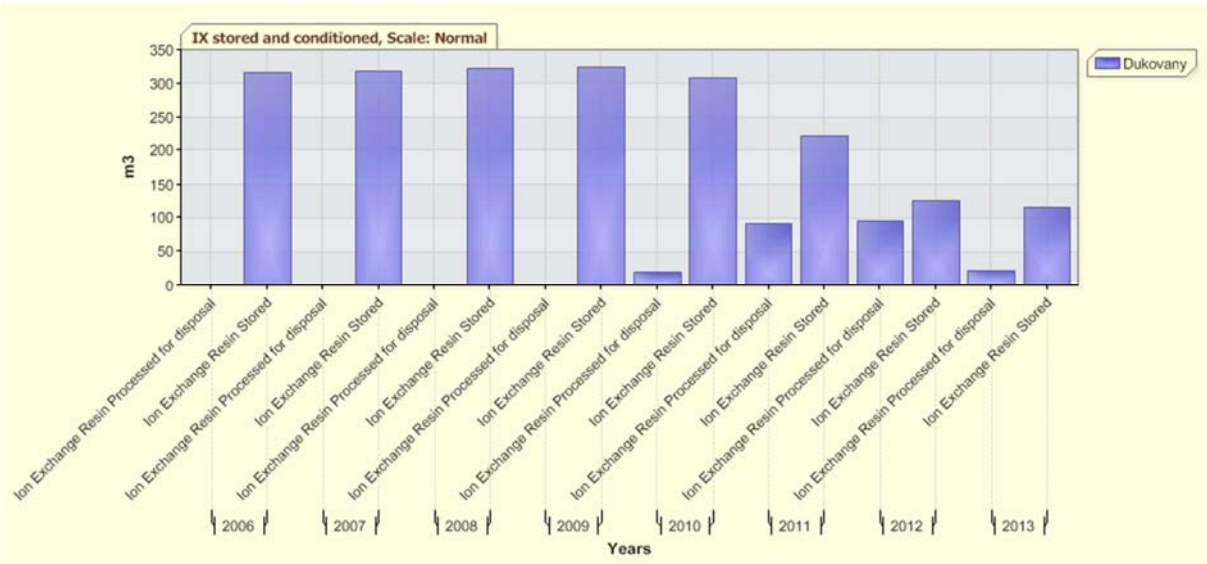


FIG. I.20. Volume of spent IX resin stored and conditioned at NPP Dukovany site (m^3)

I-4.1.5. Radioactive concentrate characterization

Radioactive concentrates are regularly analysed (filled tank once a month).

Chemical parameters:

- Specific weight
- Conductivity
- Total salt content
- H_3BO_3

- Cl^-
- CO_3^{2-}
- NH_3
- Mn
- NO_3-,
- K^+, Na^+

Biochemical oxygen demand

Gamma-spectrometric analyses

Radiochemical analyses: ^{14}C, ^{41}Ca, ^{59}Ni, ^{63}Ni, ^{90}Sr, ^{94}Nb, ^{99}Tc, ^{129}I, ^{137}Cs, ^{239}Pu, ^{241}Am are performed before processing of waste.

Additional analyses (of final products):

- Leachability
- Compressive strength
- DTA of bituminous product
- Salt content

IX resins

NH_3

Specific weight

Dry solid content (80°C)

Sludge/ion-exchange ratio

Problematic waste:

No significant deposit occurs in storage tanks as the concentration of salt is relatively low 120-150g/l and the pH is kept below 11,5.

Sets of samples have been taken from technological systems (overflowing, sedimentation tanks). Only limited data are still available for sludge characterization at NPP Dukovany. Oily layers on the water have been found in sedimentation tanks.

I-4.1.6. NPP Dukovany Dry Solid Waste

Dry solid wastes are any substances, objects or equipment generated in the control area for which no further use is foreseen. Dry solid waste is managed as radioactive until the criteria for clearance and release to the environment are met (Fig. I.21).

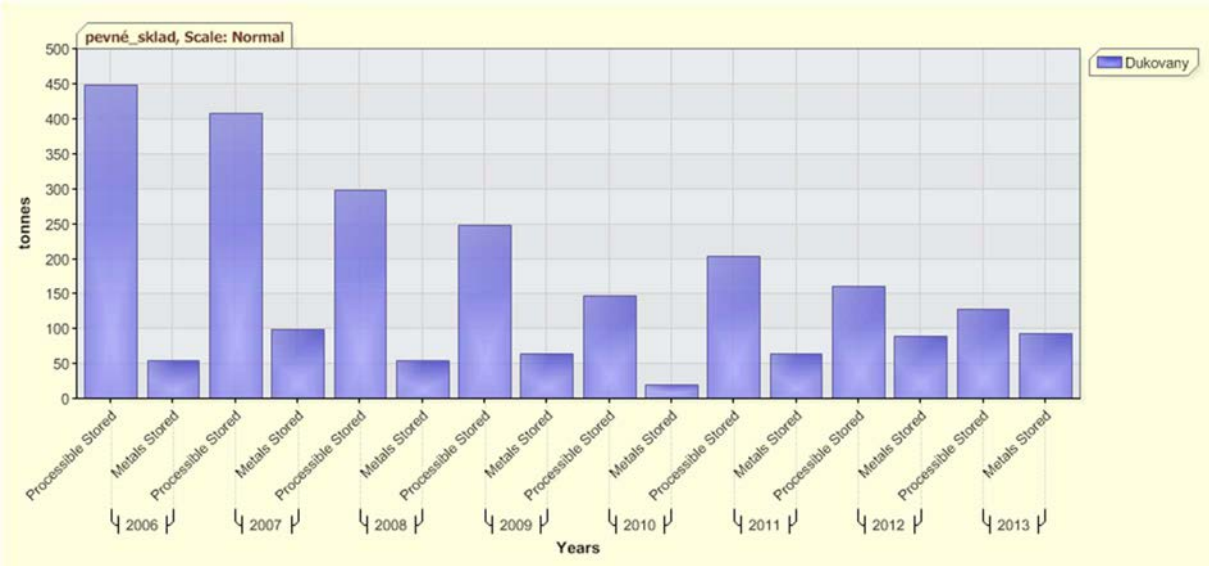


FIG. I.21. DSW stored at Dukovany NPP (tonnes).

In 2004 a complex program that focussed on increasing the effectiveness of radioactive waste management at NPPs in the Czech Republic was launched. The program is comprised of several projects that have been implemented stepwise into operation. Routinely generated new waste as well as historical waste can be processed to minimize their volumes. Key elements of the program are as follows:

I-4.1.7. Information System for Waste Management Implementation and Use

One of the first projects implemented was the Information System for Waste Management – called LOIS.

It is a specialized software with modules that cover all areas of RAW management, namely wastes from the Radiation Controlled Area (RCA) and all related activities that affect waste production such as the special laundry, decontamination, storage and control tanks, chemical spectrometry and radiochemical laboratories. Data are accessible from both NPP Dukovany and Temelín as well as from the corporate office in Prague. The system is also available for communication with other waste producers and with the RAWRA.

The system contains information on the waste from their generation to transfer to the repository. The system generates the associated documentation.

I-4.1.8. Characterization of Waste

Parameters of all waste that have been produced in the NPP, including historical waste stored at the site, have been developed and gradually implemented to operation for their characterization. A detailed codebook has been developed that is based on a waste catalogue that has been used for conventional waste.

Workplaces have been equipped with measuring devices for characterization of radionuclides in waste and sampling for radiochemical analyses of difficult to measure (DMS) radionuclides, which are limited by WAC for storage at the NPP and disposal in the repository.

Based on spectrometric and radiochemical analyses results nuclides' scaling factors have been developed and approved which have been used for characterization of specific types of waste.

I-4.1.9. Changes in Technologies for DSW Processing

Sorting:

Special equipment for primary characterization as well as for detailed waste sorting has been put into operation in a stepwise approach. Wastes are sorted according to the next steps (waste for further processing, for disposal, for decay storage, or for clearance and release into environment). Criteria for sorting are continuously updated.

Storage:

The original, as-designed practice of storage in pits has been modified. Wastes in plastic bags or 200 L drums are stored on pallets. Historic wastes have been recovered, characterized and stored in modified pits.

I-4.1.10. Volume Reduction:

Technological equipment for waste volume reduction have been continuously implemented in line with the targets of specific projects:

- Low force compactors - Used for compaction of bags with combustible waste into 200L drums before loading into ISO containers for transportation for incineration
- Shredders – Implemented for effective volume reduction and homogenization of waste that is difficult to compact.
- Portable stripping machines - Used for removal of cable insulation before clearance and recycling of used cables.
- Technology for mechanical decontamination of solid radioactive waste and their fragmentation (planning, grinding, cutting,..) - Specialized facility for the mechanical decontamination has been established and equipped with an air conditioning system with HEPA filters.
- Electrochemical decontamination tank for metal waste decontamination.
- Separated collection of contaminated damp textiles (tissues resulted from cleaning and decontamination) coupled with washing and drying. This problematic waste has been eliminated.
- Sizable plastic foils have been collected separately, decontaminated and repeatedly reused.
- Co-operation with External Suppliers (national and abroad) that have available technologies for radioactive waste processing is a significant options for solving existing problems. This is particularly important for a NPP with a limited technological background and without a radioactive waste processing centre.
- Incineration - In 2007 radioactive waste incineration started in an external incinerator (abroad). Yearly, 30 tons of combustible waste collected from both Czech NPP are incinerated. Secondary waste originated from this combustion is returned back to the Czech Republic. This contract completely eliminated an increase of the volume of combustible waste from both NPP.
- Melting of metal waste - In 2011 NPP Dukovany accomplished a pilot melting of aluminium by an external supplier. Currently the NPP is preparing the melting of contaminated stainless steel.

- High-force Compaction - Solid waste in 200 L drums that meet technical specifications have been processed by an off-site high-force compactor and returned to the NPP. Processed wastes were put into an approved container and disposed in the repository.

I-4.1.11. NPP Dukovany Clearance

A part of waste that originated in the radiologically controlled areas (RCA) of NPP the meet conditions for release to environment has been released to environment. This is a key element of waste volume reduction of stored wastes at the Dukovany. A specialized facility for waste storage and measurement was established.

Before its release to environment, the waste undergoes a certification measurement on its radionuclide content. For each batch of waste the effective dose to an individual from the general population has to be determined if the waste is considered for release to environment.

Materials, substances and objects containing radionuclides or contaminated by radionuclides can be discharged into the environment without a license issued by the Office when such activity is reasonable by the benefits and a collective effective dose related to the discharge shall not exceed 1 Sv per each calendar year, an effective dose to individuals shall not exceed 10 μSv, and the Office shall be informed at least 60 day beforehand about the kind of radionuclides, activities, location, date and method of the discharge into the environment as well as about an estimate of the related exposure

Waste that meets regulatory criteria could be released based on a permit given by the state regulatory body. In standard conditions about 50-60% of solid waste is released to the environment. Currently, when there are many modifications underway, Dukovany NPP releases about 70-80% of "clean" solid waste (Fig. I.22). Certification is performed by an independent external organization. The measurement results are guaranteed by the Czech Metrological Institute.

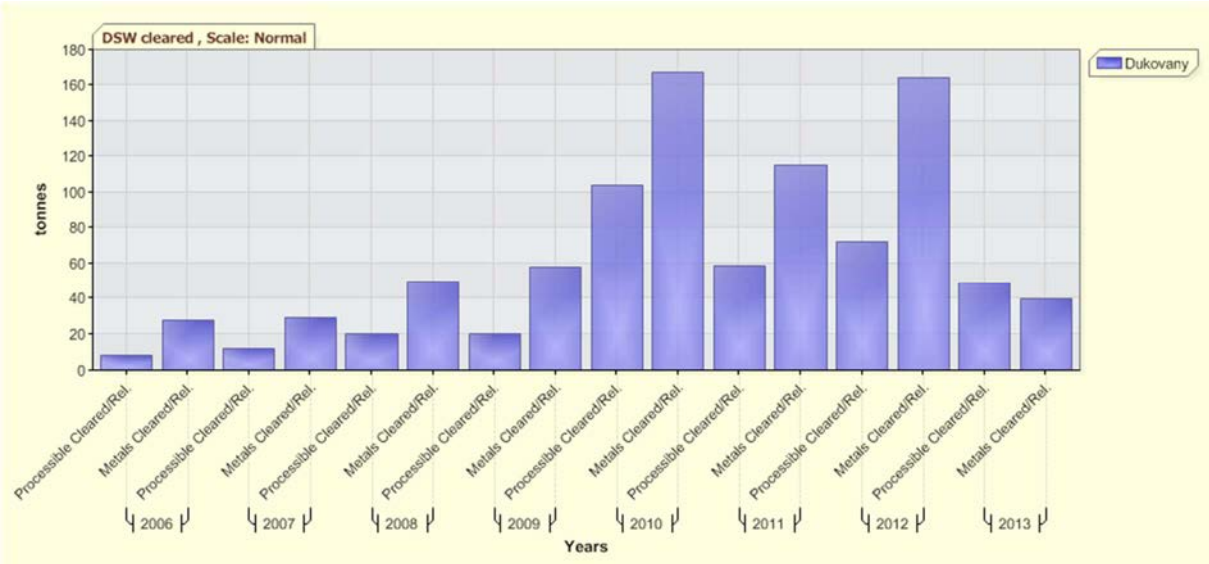


FIG. I.22. DSW cleared from NPP Dukovany (tonnes).

I-4.1.12. NPP Dukovany Transport

A significant part of radioactive wastes is transported between Dukovany and Temelín NPP for their treatment/conditioning and disposal in a repository.

Power plants instituted a system of the inter-state transport of dangerous materials (radioactive materials of class 7) in accordance with ADR requirements in licensed 20 feet ISO containers. For wastes that cannot be transported in the ISO containers special approved shielded containers are used.

For transport between EU countries, Dukovany and Temelín NPP have received EU permission for the transport of waste to external (foreign) suppliers. The waste is transported in the 6m (20 foot) ISO containers.

I-4.1.13. NPP Dukovany Disposal

Annually, about 500 m^3 of radioactive wastes from Dukovany that meet WAC have been routinely disposed in the Repository of Radioactive Waste (ÚRAO).

The facility itself consists of two double rows of reinforced concrete wells. Each row is divided into 7 expandable groups with 4 wells in each group. The total number of wells is 112. Each well is covered by 14 sloping panels of 3 types, with the thickness of 50 cm and weight of 10 t each.

Water tightness of the wells is ensured by sealing of asphalt-polypropylene. Net dimensions of each well are 17.3 x 5.3 x 5.4 m. The capacity of 1 well is 1 650 drums (200L). The capacity of the whole storage facility is 55 450 m^3. Crane tracks over which gantry crane with lifting capacity of 12.5 t and travelling canopy travel, are placed at the upper edges of side walls. This crane executes all handling connected with loading of radioactive wastes.

Waste Acceptance Criteria

Waste package	200 L metal drum
	bulk metal, stackable metal boxes (0.4m^3)
Type of waste	solidified, non-solidified waste
Dose rate on the surface	< 12mGy/h
Limited radionuclides	^{14}C, ^{41}Ca, ^{59}Ni, ^{63}Ni, ^{90}Sr, ^{94}Nb, ^{99}Tc, ^{129}I, ^{137}Cs, ^{239}Pu, ^{241}Am + each RN contributing more than 1% to total activity
Maximal weight	550 kg/package
Leachability	fixed waste 0,4%; 4% depending on total activity
Compressive strength	cement / aluminosilicate 5/10 MPa

Communication with the Authorities

Dukovany NPP and Temelín NPP keep an open, honest and constructive communication with state regulatory bodies. This has been one of basic precautions for implementing the Waste Management program, all above mentioned measures and future developments of radioactive waste management area in the Czech Nuclear Power Plants.

I-4.1.14. NPP Dukovany Summary

Czech NPP have implemented a complex program on radioactive waste management. This program allows continuous processing of newly generated wastes and at the same time to reduce effectively the volume of historically accumulated wastes at the NPP. The result of the program is that storage capacities for liquid waste have been filled for about 25% and for solid waste less than 15% (after 29 years of operation). This provides sufficient space for the optimization of technological processes and selection of most suitable solutions. The program allows the successful management a variety of non-routine situations that increase waste generation, such as massive modifications of technological systems (plant life management, life extension, power uprates, realization of stress-test recommendations) where the waste generation can rise by more than 300%.

Images of various aspects of radioactive waste management are included below (–Figures I.23 – I.30).

(a) (b) ©

FIG. I.23. Butuminization facility: Bituminization equipment (a), Closing of barrels with the product fixation (b), and Monitoring of barrel cooling (c)

(a)

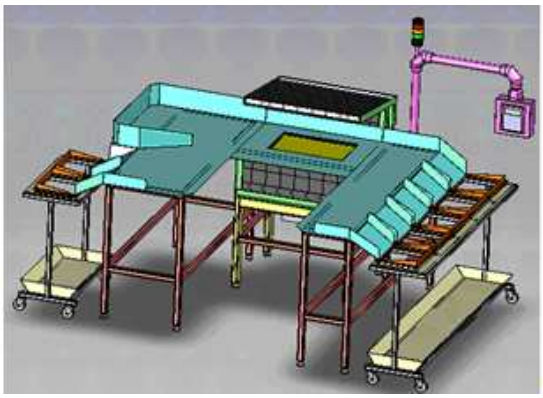
(b)

(c)

(d)

FIG.I.24. Conditioning of spent ion exchange resins (photos by AMEC Nuclear): Withdrawal of waste (a), Separation of ion exchange resins (b), Resin prepared for conditioning (c), and Fixation equipment (d).

(a)



(b)

(c)

FIG. I.25. Waste Sorting (photos by AMEC Nuclear): Sorting carrousel – first step of sorting (a), Sorting table – detailed waste sorting (b), and Waste characterization before storing (c).

(a)

(b)

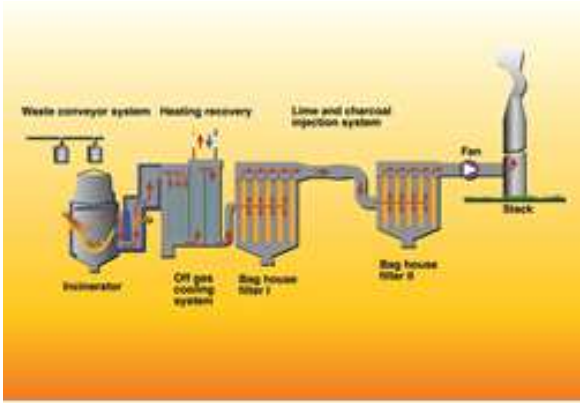
(c)

(d)

FIG. I.26. Waste Measurement for Release to Environment (photos by AMEC Nuclear): Measuring equipment for 200 L drums (a), Precise measurement of activity in an shielded box (b), Monitored Waste, and Waste Prepared for Monitoring (d).

(a)

(b)



(c)

(d)

FIG. I.27. Incineration of Waste (photos by Studsvik Nuclear AB): . Waste sorted out for combustion (a), Loading of waste into furnace (b), Incinerator Schematic (c), and Measurement of Ash Drums (d).

(a)

(b)

FIG. I.28. Metal Melting (photos by Studsvik Nuclear AB: Furnace (a), and Final product – metal ingots (b).

(a) (b)

FIG. I.29. Waste Storage: Storage palette with manipulation arm (a), and Storage pits (b).

(a) (b)

FIG. I.30. Waste Disposal: Transport of waste for disposal (a), and Drums in disposal vault (b).

I-4.2. NPP Temelin Site information

Site information is given in Table I.10 and Fig. I.31. No power uprate or lifetime extension is in progress.

TABLE I.10. NPP TEMELIN UNITS

Unit	Type	Net capacity	Gross capacity	Initial criticality	Grid date
1	WWER 1000/V320	1000 MWe	1013 MWe	Dec 2000	Jun 2002
2	WWER 1000/V320	1000 MWe	1013 MWe	Dec 2002	Apr 2003

FIG. I.31. A view of NPP Temelin.

I-4.2.1. NPP Temelin Basic Storage and Disposal Data

There are no off-site storage facilities for RAW generated by Czech NPP (Table I.11). There is a considerable difference in storage capacities between WWER 440 and WWER 1000.

TABLE I.11. DESIGN GEOMETRIC STORAGE VOLUME.

Waste Stream	As-Designed Capacity	Administrative Limit*
Dry Solid Waste	600 m^3	500 tonnes
Concentrate	>520 m^3	520 m^3
Ion Exchange (IX) Resin	>200 m^3	200 m^3

I-4.2.2. NPP Temelin Wet Solid Waste

Fundamental technology (and the only one) for radioactive concentrates conditioning in the NPPs is bituminization installed at both NPP's.

The main component of bituminization technology is a vertical thin film evaporator. Liquid bitumen and concentrate are pumped into oil heated tube, mixed and stirred on inner surface, water is evaporated and final product is filled into 200 L drums. Evaporator capacity is approximately 250 L/hour of evaporated concentrate – the final product contains 40% salts.

Annual production of bituminous product varies between 300-400 drums/year (Fig. I.32).

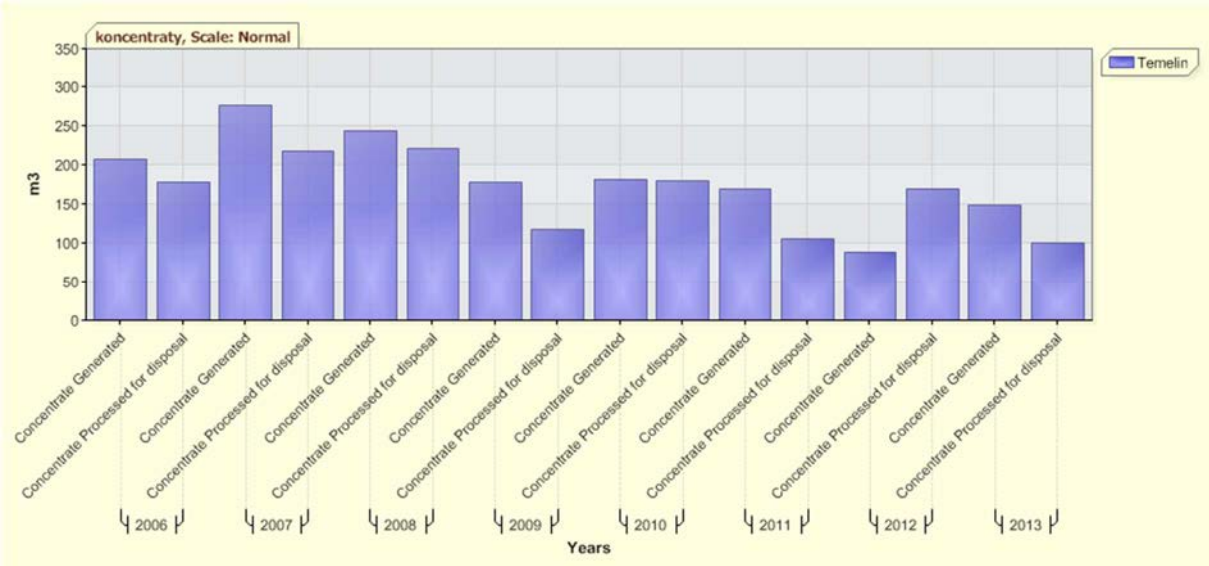


FIG. I.32. Generation and conditioning of concentrate at NPP Temelín site (m^3)

I-4.2.3. Enhancement of safety to bituminization process

See the text for Dukovany NPP for the precautions implemented to eliminate related technological risks.

I-4.2.4. Sludge, IX resins

Conditioning of sludge generated by liquid waste treatment (centrifugation) technology into a form that meets Waste Acceptance Criteria (WAC) for the repository started in 2008 (Figures I.33 and I.34).

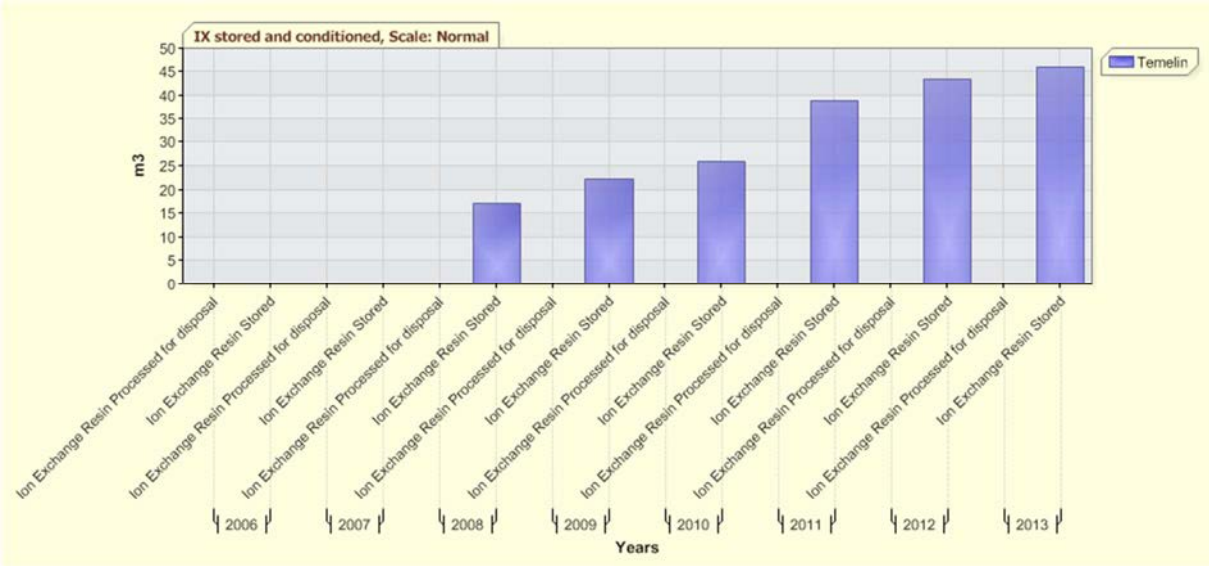


FIG. I.33. Volume of spent IX resin stored and conditioned at NPP Temelín site (m^3).

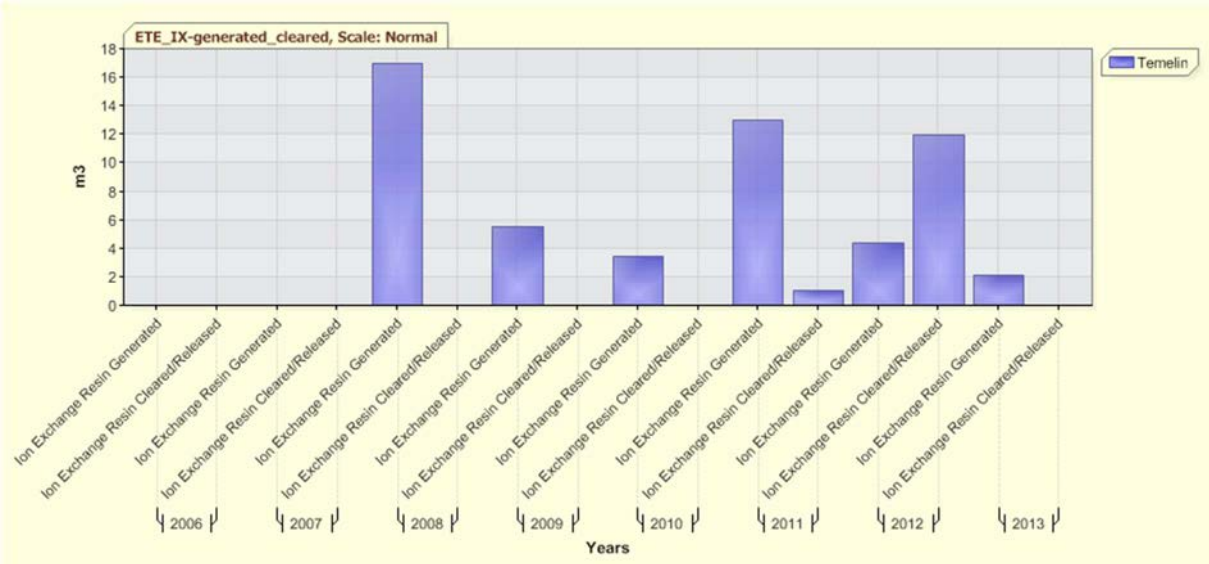


FIG. I.34. Volume of spent IX resin generated and cleared at NPP Temelín site (m^3).

IX resins with low specific radioactivity (e.g. from purification systems SVO-3, SVO-5) have been separated, measured, cleared and released into the environment. For radioactive concentrate and IX resin characterization, see the text for Dukovany NPP.

I-4.2.5. Problematic Waste

No significant deposit occurs in storage tanks, concentration of salt is relatively low 120-150g/L, pH value is kept below 11.5.

I-4.2.6. NPP Temelin Dry Solid Waste

See the text for Dukovany NPP, waste packages approved for DSW storage at NPP Temelín are PE bags and 200 L drums and Fig. I.35.

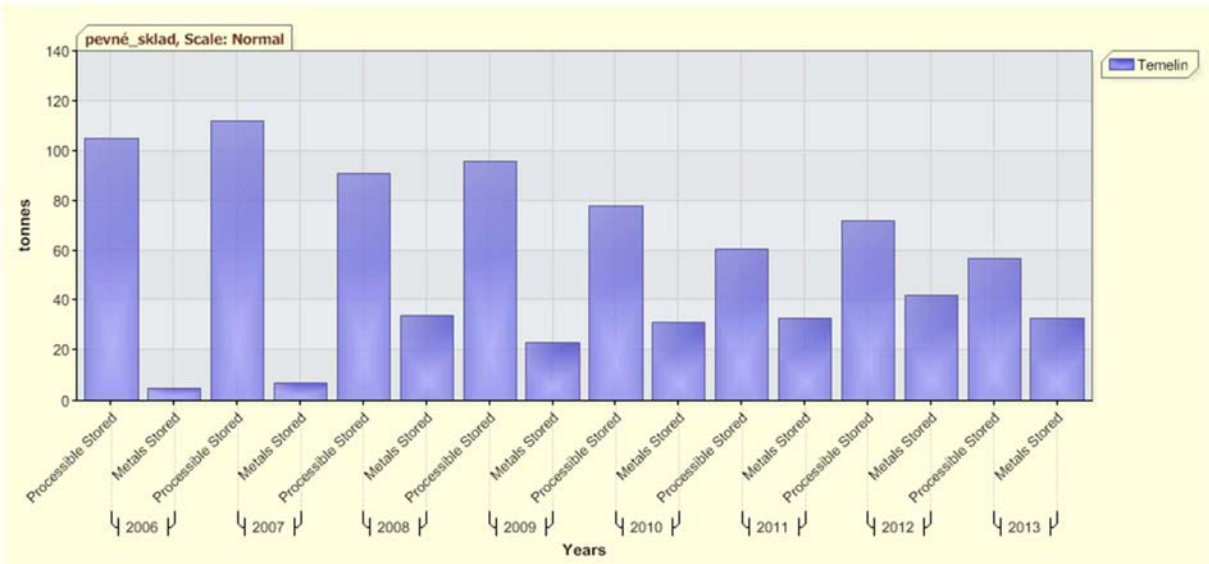


FIG. I.35. DSW stored at NPP Temelín site (tonnes).

I-5. NATIONAL REPORT OF FINLAND

I-5.1. Site information

Loviisa Nuclear Power Plant) is owned by Fortum Power and Heat Ltd and consists of two WWER-440 units, model 213. The commercial operation of Loviisa 1 (LO1) began in 1977 and Loviisa 2 (LO2) in 1981 (FI.36).

FIG. I.36. Loviisa Power Plant.

A power up-rating by turbine modernization was carried out at both units between 1997-2002. The up-rated power of each unit is now 510 MWe .

Compliance with the directions of the authorities is the main point of lifetime extension. The plant life management and the continual improvement process of safety are under implementation. Lifetime has been extended from 30 up to 50 years of operation for both units.

I-5.1.1. Basic storage and disposal data

Wet solid waste

Liquid waste storage is situated in a separate building connected by an underground tunnel to the auxiliary building of LO1. This storage is used for both LO1 and LO2. Seven 300 m^3 stainless steel storage tanks (plus one 300 m^3 tank used as a sedimentation tank for drain waters) are located in concrete blocks with inside stainless steel linings.

Dry solid waste

On-site storage capacity for dry low-level waste is 5 200 m^3. Part of this storage capacity, 1 800 m^3, is in the controlled area.

Intermediate level wastes are stored in the dry silos in LO1 and LO2 reactor halls and in the spent fuel storage. The final packaging and disposal of wastes will take place during decommissioning. Total storage capacity of the silos is 74 m^3.

Disposal

The on-site final repository has two 3200 m^3 tunnels for solid low level waste. The new expansion, the third hall for dry low-level waste 6200v m^3 is in the first operational phase only licenced for use as an intermediate storage. The cavern for of immobilized intermediate level waste is 11000 m^3.

The final repository is described in more detail in Chapter 4.6.

I-5.1.2. WET SOLID WASTE PROCESSING

Drain water purification

From drain waters (treated in LO1), annually about 12 000 m^3 major mechanical impurities are sedimented in a 300 m^3 overflow tank in the liquid waste storage facility. After this, these waters are filtered and evaporated. Concentrates are removed from the evaporator system into the liquid waste storage when a total salt content of 400 g/L or a boric acid content of 100 g/L is reached.

Special sewerage waters of the laboratory building (e.g. laundry waters, ~ 2 000 m^3/year) are monitored with on-line activity measurement, and, if the activity level exceeds the release limit, they are routed to the drain water purification plant, but normally they are discharged into the sea.

Boric waters are treated in a separate boron recovery system (treated in LO2).

Evaporator concentrate

Evaporator concentrates are generated ~50-70 m^3/year and stored in three 300 m^3 tanks in the liquid waste storage (Fig. I.37). Every few years a Cs-removal campaign is performed on one of the tanks and the purified liquid can be released to the sea. The bottom layer of the evaporator concentrate tanks (~50 m^3) is not treated but will be solidified later due to the high solid content and activity related to other nuclides than Caesium. Also the tank containing evaporator concentrates from the primary circuit decontamination in 1994 will likely be solidified due to high corrosion product content.

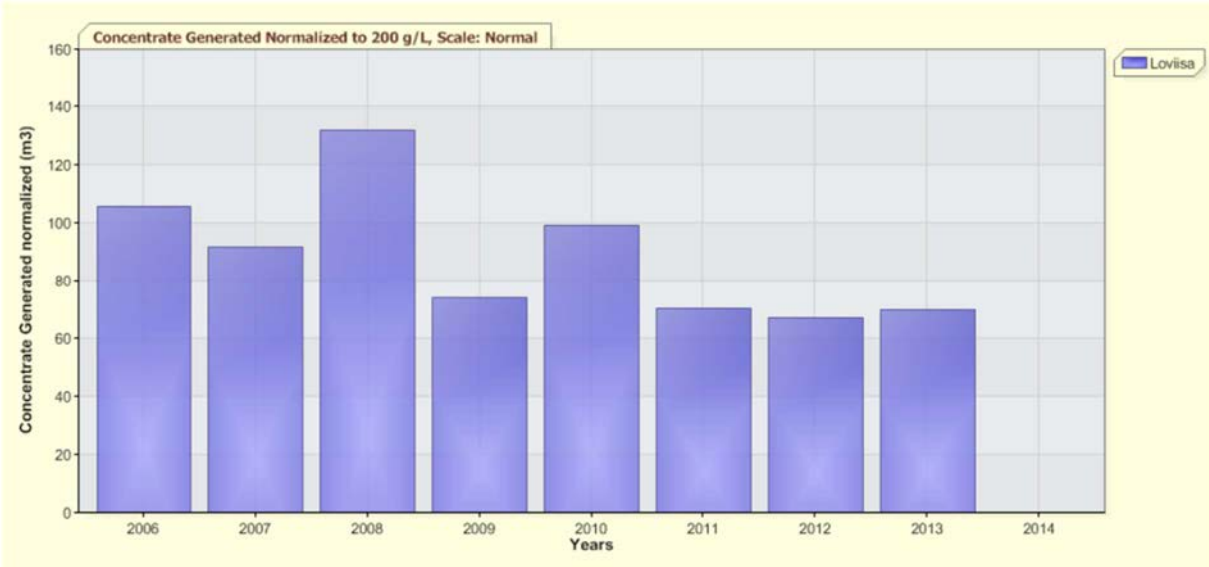


FIG. I.37: Annual generated evaporator concentrate normalized to 200 g/l

1.1.1.1.Caesium removal system

In the beginning of 1980's after a regeneration of primary circuit coolant cation filters, it was found that over 50% of the content of radionuclides in the evaporator concentrate consisted of Cs-137 and Cs-134, and over 90 % of total soluble activity was of Cs. The second dominating radionuclide, Co-60, was associated with the solid precipitates on the tank bottom. By removing Cesium from the tank solution, the purified liquid could be released within licensed release limits, and Co-60 would be left in a small waste volume on the bottom of the tank. As a consequence, a decision was also made to not perform any regeneration on filters from the primary circuit to avoid diluting the once concentrated activity.

Fortum and the Radiochemistry Laboratory of the University of Helsinki have together developed a Caesium selective inorganic ion exchange material CsTreat®. In the nuclide removal system there are particle filters to remove all possible particle-bound activity and to protect the ion exchange bed from plugging. After that, there is an 8-liter ion exchange column that removes ionic Cs-nuclides. The nuclide removal system has operated successfully at the Loviisa NPP since 1991 (Fig. I.38). A total of 1 450 m^3 of evaporator concentrates have been treated so far, resulting in 29 columns, i.e. 5.2 m^3 of waste packaged, ready for disposal.

Investigations are on-going on additional filtering of Co, Ni and Sb.

FIG. I.38. Caesium removal system.

I-5.1.3. Spent ion exchange resins

Annually ~10-15 m^3 of ILW spent resins are collected (Fig. I.39). These are stored in three 300 m^3 tanks in the liquid waste storage. Previously, one 300 m^3 tank was designated for low activity resins and active carbon. Recently a project to convert this tank for use of intermediate level resins was completed. The low level resins are removed directly from the process and low level resins and active carbon will be immobilized with clay based materials into 200 L drums. Drums will be analysed gamma-spectrometrically and disposed to final repository. The intermediate level resins will be cemented in the solidification plant.

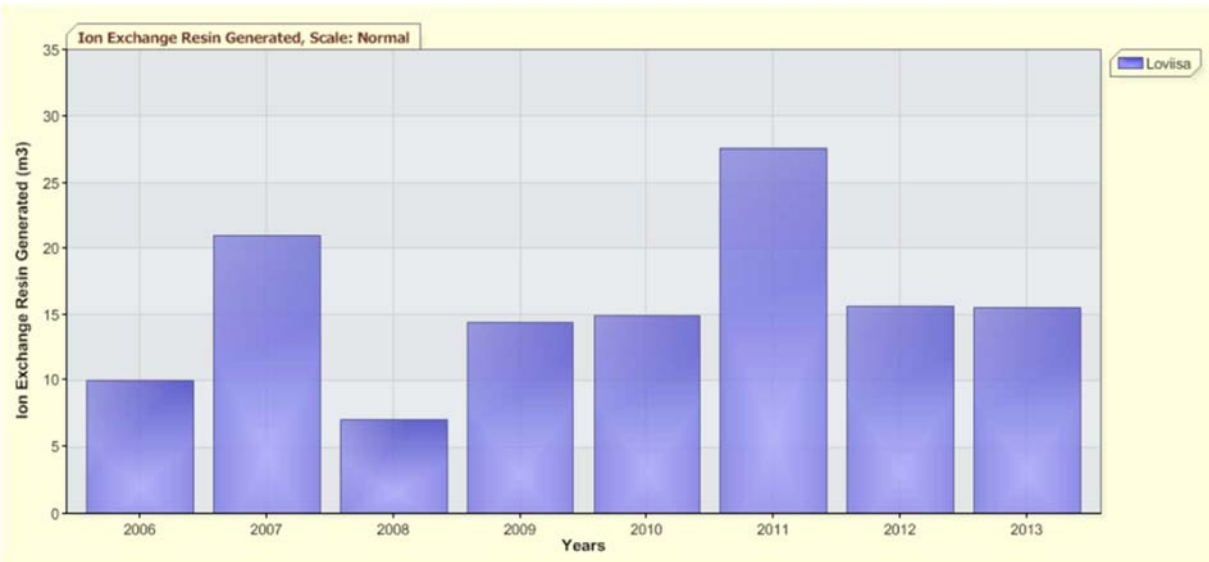


FIG. I.39. Annual generated ion exchange resins

I-5.1.4. Solidification plant

Construction of the liquid waste solidification plant (Fig. I.40) in Loviisa is complete but the plant is not yet operational. It is located next to the liquid waste storage on-site. Resins and evaporator concentrates are transferred to the solidification from the liquid waste storage in their own separate pipe lines. Both waste types have their own intermediate storage and proportioning tanks and one shared solidification line in the solidification plant. Characterization will be made by a sample of every waste batch.

The process is based on cementation. The waste portions and auxiliary materials are cast in reinforced concrete containers equipped with mixing heads. The mixture is allowed to solidify after mixing in the containers. At the end of the solidification process, a concrete cover is casted on each container at the cover casting point. When the waste package has reached adequate solidity, it is moved from the solidification line to the solidification plant's monthly storage to wait for transportation to the repository.

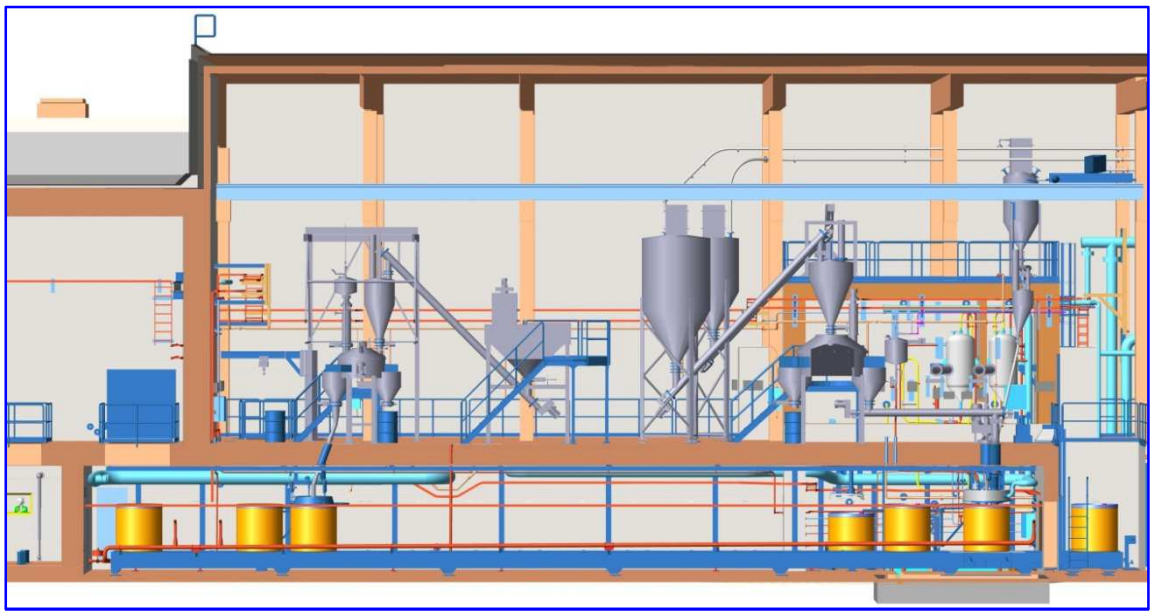


FIG. I.40. Solidification plant

I-5.1.5. Oils and solvents

Majority of oils can be cleared. Oils and solvents will be measured by a gamma spectrometer. Contaminated solvents and oils that cannot be cleared are immobilized with clay based materials into 200 L drums and placed in the repository.

I-5.1.6. Dry solid waste Processing

Predisposal management of LILW takes place at the NPP under its operating license and other provisions.

All waste originating in the controlled area is handled as radioactive waste. After sorting and monitoring, a part of the waste can be cleared as non-active (meeting authority limits) and sent to conventional waste handling either directly or after a few years of storage time for decay. Waste that cannot be cleared is packed/compressed/conditioned and disposed in the final repository.

I-5.1.7. Low level waste

Low-level dry wastes are separated at the point of origin into four categories:

1. combustible/compressible
2. non-combustible/compressible
3. non-combustible/non-compressible
4. combustible/non-compressible

Separate collection points are provided for metals, cables, hazardous wastes such as batteries, fluorescent lamps, chemicals, oily clothes, asbestos and empty aerosol cans.

The personnel of the waste department correct any crude sorting errors and make pre-sorting based on activity (contamination/dose rate measurement) before packing the waste into 200 L steel drums. The purpose of the sorting is to reduce the amount of waste in the repository.

Solid wastes are mainly collected into plastic bags and packed into 200 L steel drums. The compressible fractions are compressed with 27-ton in-drum-compactors. After compaction, the nuclide content of each drum is measured by a gamma spectrometer. Each year some ~400-800 drums of waste are generated (Fig.l I.41) About a half of these can be cleared and the other half disposed.

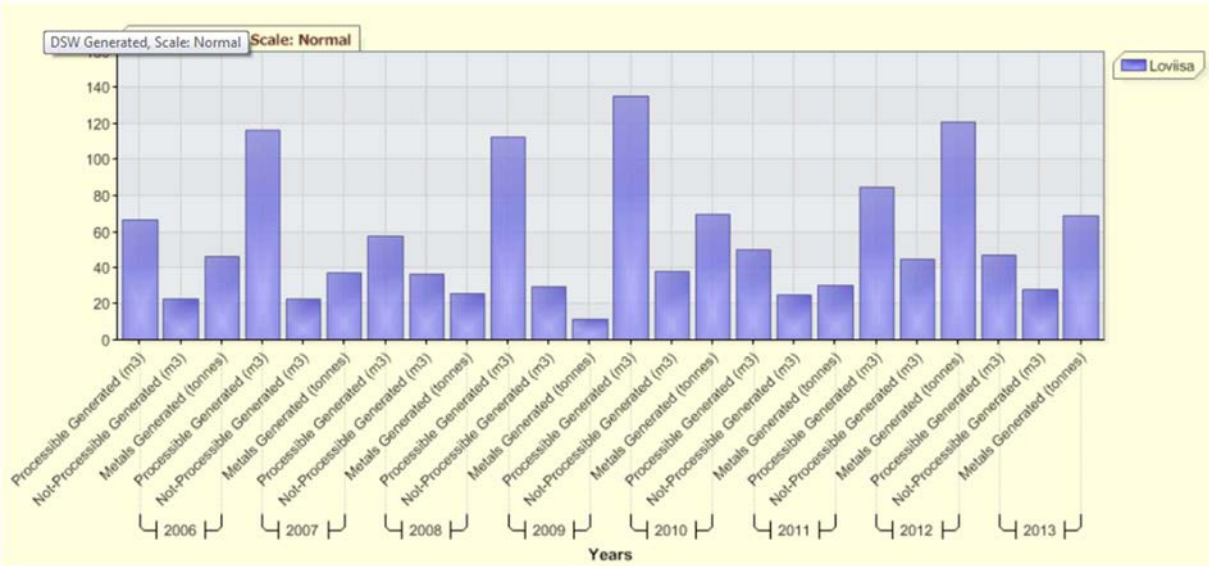


Fig.I.41. : Annual generated dry solid waste

The majority of large pieces of metal are monitored with contamination gauges and after control measurements, cleared for recycling. Contaminated parts are cut into smaller pieces and packed in drums.

I-5.1.8. Intermediate level waste

Intermediate-level dry waste consists of activated metals, mechanical filters and other dry wastes with high specific activity. ILW stored to silos will be disposed during decommissioning. Mechanical filters will be packed into concrete containers equal to solidified waste packages after gamma spectrometer measurement. Concrete containers will be disposed.

I-5.1.9. Clearance

Finnish Radiation and Nuclear Safety Authority (STUK) gives the guidelines for the clearance of wastes. Options for management of waste below clearance level are either general or case-specific clearance. Such waste can be reused, recycled or disposed at landfills. Loviisa NPP has an agreement with regional landfill to dispose cleared waste.

General clearance can be applied to wastes, which are formed in the use of nuclear power plant or in a decommission stage of the plant. In the general clearance the end point of cleared wastes can be left undefined or it can be defined essentially and the applied clearance level is fixed. General clearance doesn't apply for easily volatile or easily flammable wastes or wastes which may cause especially easily exposure to radiation. For waste amounts exceeding 100 tons/year, the clearance criteria are based directly on Table II of IAEA Safety Guide RS-G-1.7. For smaller amounts a slightly different criteria (Table I.12) may be applied.

TABLE I.12. THE NUCLIDE GROUP SPECIFIC ACTIVITY CONCENTRATION AND CONTAMINATION CONSTRAINTS TO BE APPLIED FOR CLEARANCE OF WASTE (ANNUALLY 100 000 KG AT MOST FOR EACH NUCLEAR FACILITY).

Nuclide group	**Activity concentration**	**Surface contamination**
Alpha emitters	0,1 Bq/g	0,4 Bq/cm²
Significant beta and gamma emitters *	1 Bq/g	4 Bq/cm²
Weak beta and gamma emitters **	10 Bq/g	40 Bq/cm²

* e.g. ^{54}Mn, ^{58}Co, ^{60}Co, ^{65}Zn, ^{90}Sr, ^{106}Ru, ^{110m}Ag, ^{124}Sb, ^{125}Sb, ^{134}Cs, ^{137}Cs, ^{144}Ce and nuclides having similar radiation emission energy
** e.g. ^{3}H, ^{14}C, ^{51}Cr, ^{55}Fe, ^{63}Ni and nuclides having similar radiation emission energy

In the case-specific clearance the material receiver and treatment procedures are being defined and activity limits are set on the grounds of a case-specific consideration.

Both general and case-specific clearance has as a general radiation safety requirement, that the radiation dose from cleared waste from NPP doesn't exceed 10 µSv to the most exposed individuals (so-called critical group) as an effective dose. In general the radiation dose from cleared waste should be as low as reasonably achievable (ALARA).

I-5.1.10. Disposal

Low- and intermediate-level operating waste produced at the Loviisa NPP is disposed of in a repository constructed in the bedrock of the power plant site on the island of Hästholmen. In 1988 Finnish Radiation and Nuclear Safety Authority (STUK) granted the permission for the construction of the final repository. The repository was taken into operation as an storage in spring 1997 and as a final disposal facility in 1998.

The Loviisa repository is located at the depth of approximately 110 m (Fig. I.42). It consists of two tunnels for solid low-level waste (in steel drums) (Fig. I.43) and a cavern for immobilized intermediate level waste (in concrete packages, FIG. Fig. I.44). Inside the cavern for ILW, the waste packages will be emplaced in a pool-shaped structure made of reinforced concrete. An enlargement project of the repository started in 2010. A new storage tunnel for LLW was constructed and will be used initially only for storage.

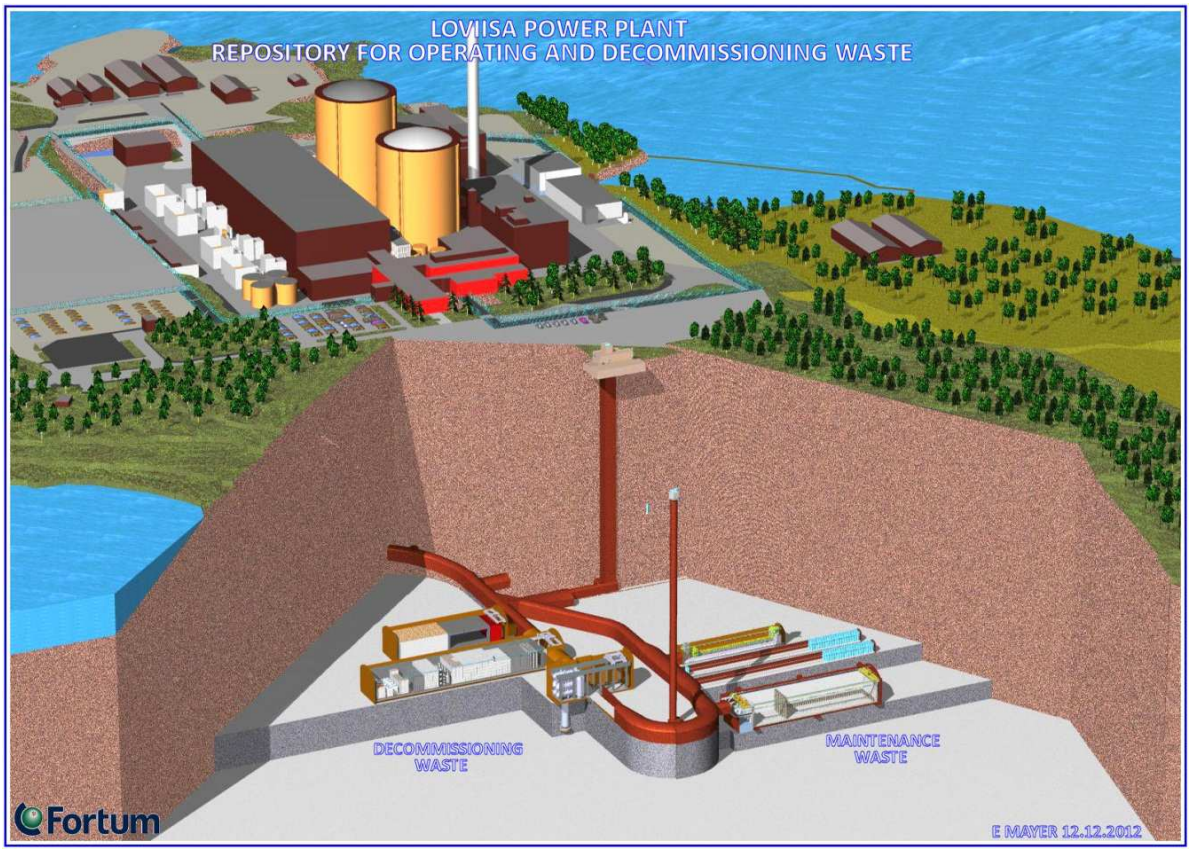


FIG. I.42. Loviisa repository

FIG. I.43. LLW tunnel

FIG.I.44. ILW cavern

This storage facilitates the sorting of waste drums and makes a longer storage time possible, allowing more waste to decay and be cleared from regulatory control. The tunnel is planned to be used later for disposal of operational and decommissioning waste (Fig. I.45).

FIG. I.45. Storage For LLW

I-6. NATIONAL REPORT OF SLOVAKIA

I-6.1. NPP EBO V-2 Site information

NPP EBO V-2 (Fig. I.46 1) has two WWER 440/V-213 reactors that were connected to the grid in 1984 and 1985. From 2011 power output was increased to 505 MWe for each unit.

FIG. I.46. NPP EBO V-2 in Jaslovske Bohunice

I-6.1.1. Basic Storage Data

Liquid waste in the NPP is collected, treated (evaporated) and stored in one 460 m^3 and eight 550 m^3 tanks. At the end of 2013, 1 560 m^3 of concentrate was stored in EBO V2, which represents 35 % of the total storage capacity. In addition, 155 m^3 of ion exchange resins were stored in NPP EBO V-2.

Solid waste in the control area is collected, monitored (dose rate, surface contamination) and divided to radioactive and conditionally active waste. The active waste is sorted into combustible, compactable, metal and other waste streams.

The storage capacity for solid waste is 1 920 stackable 400 L metal boxes and 11 490 drums (200 L). At the end of 2013, 234 t were stored. In addition 35 t of conditionally active wastes (wastes waiting for clearance) were stored.

I-6.1.2. Wet Solid Waste Processing

Liquid Radioactive Wastes (Concentrates)

Annual concentrate generation decreased to under 50 m^3 (the salts content ranges from 150 to 200 g/L), as a result of various many technical and organizational changes (Figures I.47 – I.49). From NPP EBO V2 concentrates are transported to the complex of Bohunice Radioactive Waste Treatment Centre (BRWTC). Concentrates are cemented or bituminized.

A film rotary evaporator is used to condition concentrate. The cementation and bituminization line capacity of the BRWTC is approximately 800 m^3 of conditioned concentrates per year.

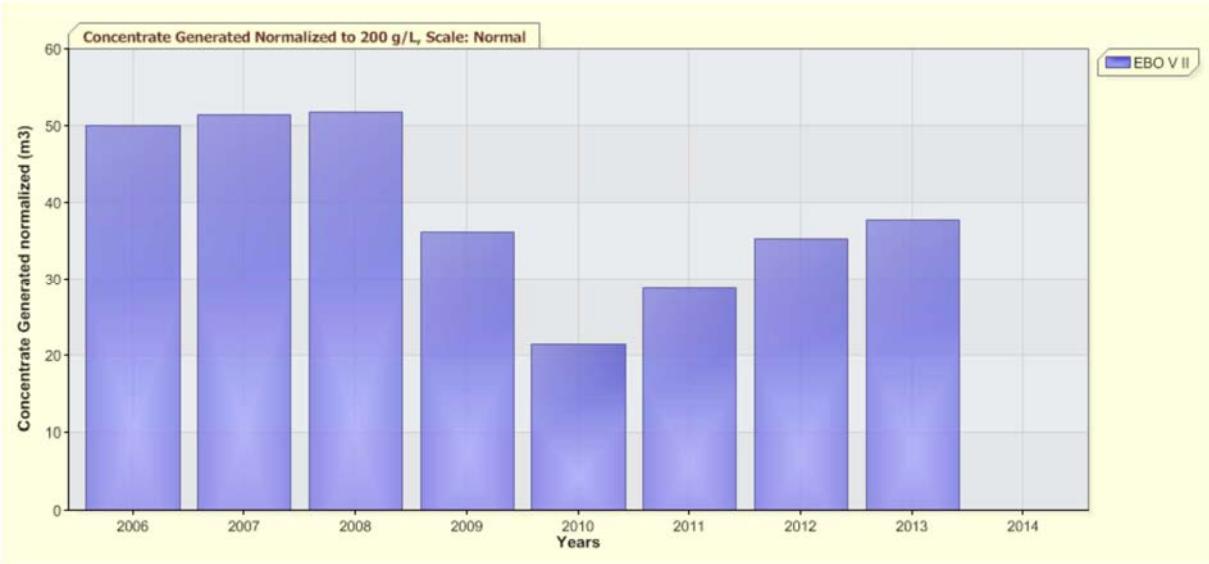


FIG. I.47 Concentrate Generated – Volume Normalized to content of 200 g/L of total salinity

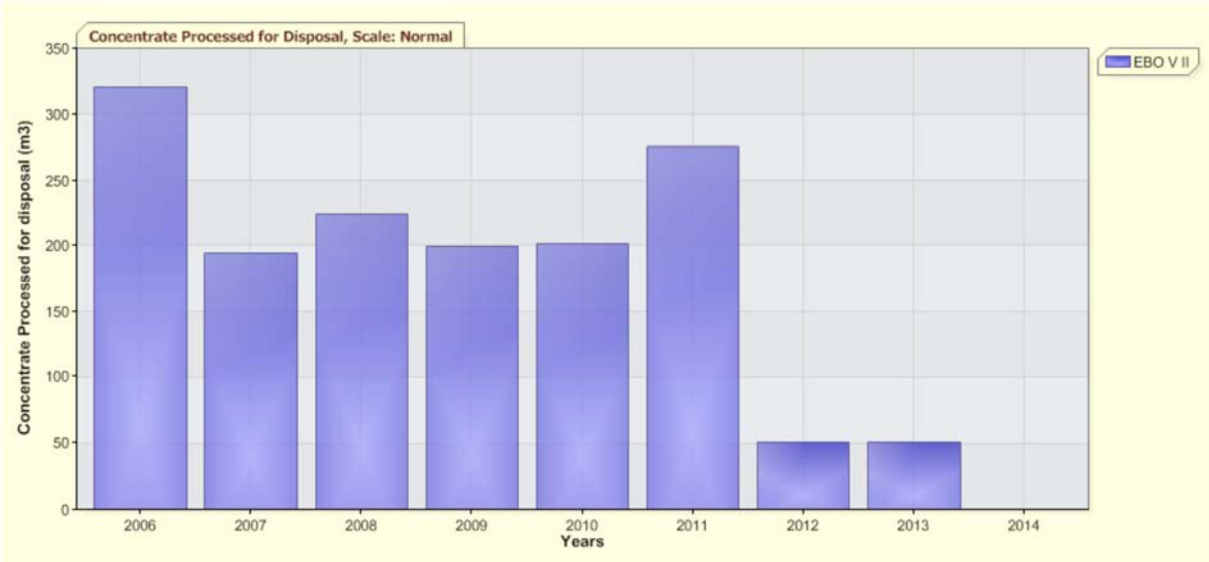


FIG. I.48. Concentrate Processed for Disposal

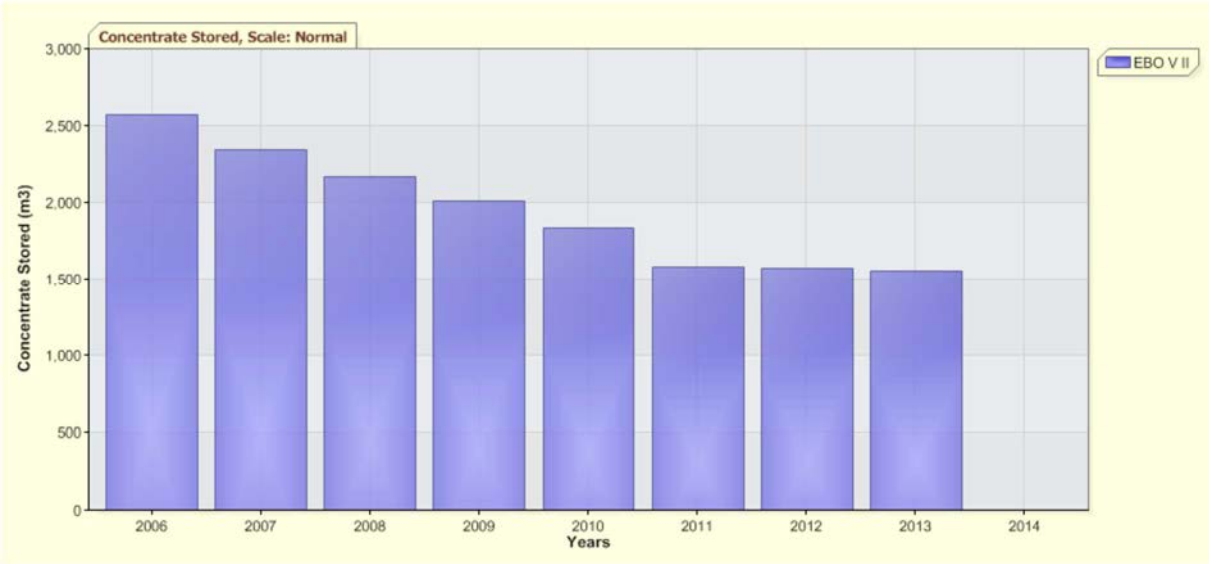


FIG. I.49. Concentrate Stored

Ion Exchange Resins (Degraded Sorbents)

IX resins are collected in storage tanks. The annual generation of IX resins varies from 1 to 15 m^3 per year. No significant amount from EBO V-2 has not yet been processed and disposed in the National Repository at Mochovce (Figures I.50 and I.51)

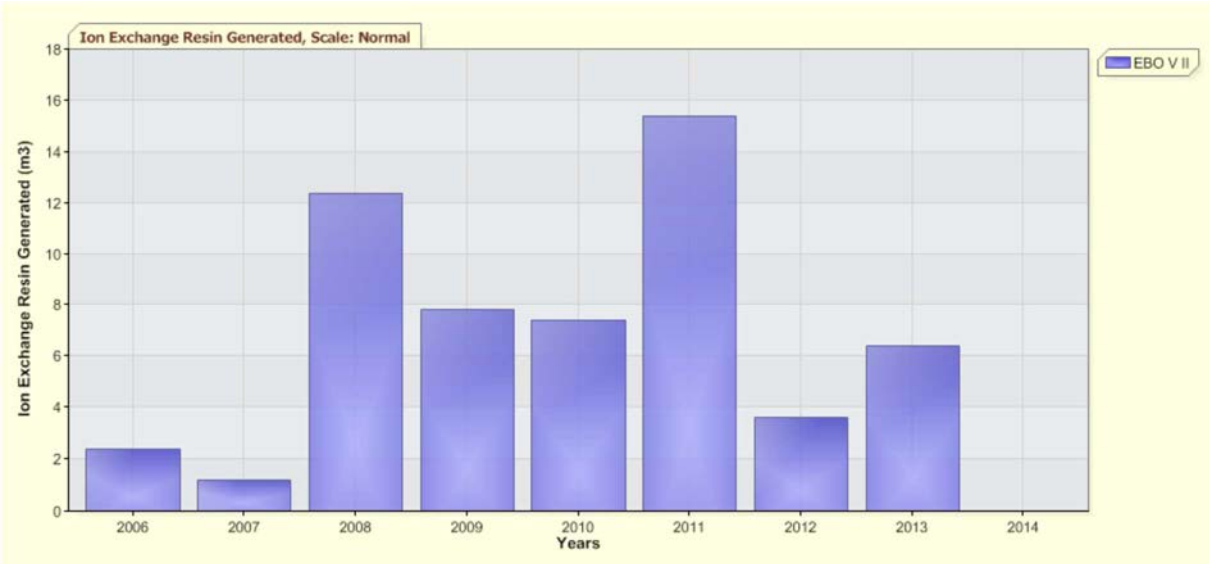


FIG. I.50. Ion Exchange Resin Generated

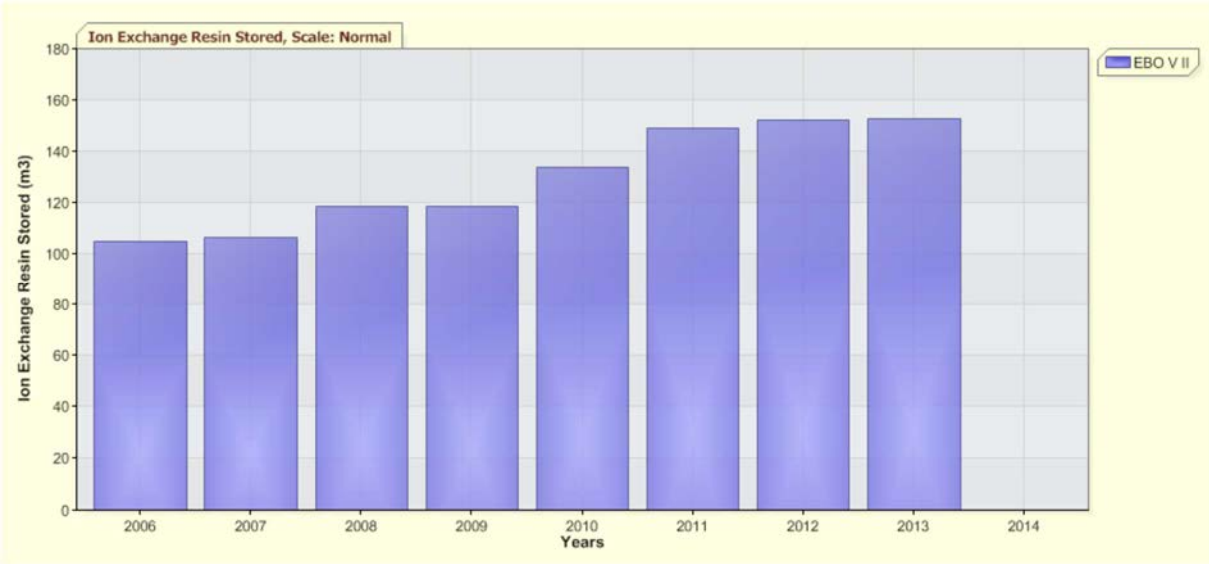


FIG. I.51. Ion Exchange Resin Stored

I-6.1.3. Dry Solid Wastes Processing

The annual waste generation of dry solid wastes at EBO varies from 12 t to 25 t. Annual generation of conditionally active waste varies from 2 t to 7 t (Figures I.52 – I.54). Approximately 85% of conditionally active wastes can be released into the environment and 15% is reclassified as radioactive waste.

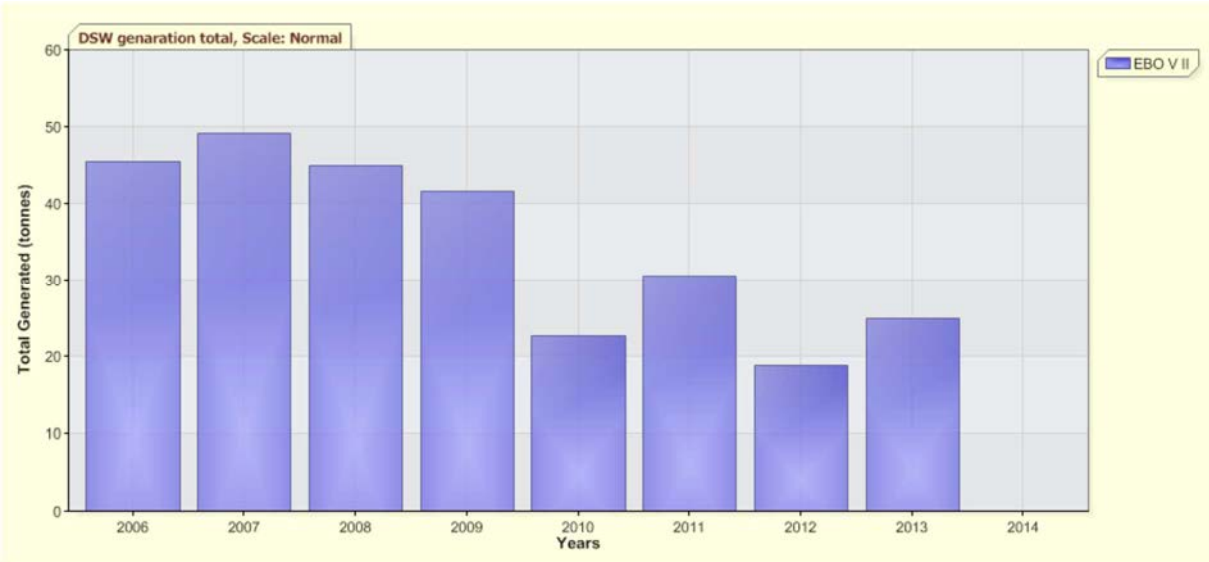


FIG. I.52. Dry Solid Waste Generated

Nearly all technologies for processing solid waste are in the BRWTC, located near Jaslovské Bohunice. The main technologies available in BRWTC are:

- separation facility,
- high-force compactor,
- incinerator,
- cementation facility,
- bituminization facility.

After processing, waste in drums is placed inside 3m^3 fibre-concrete containers and backfilled.

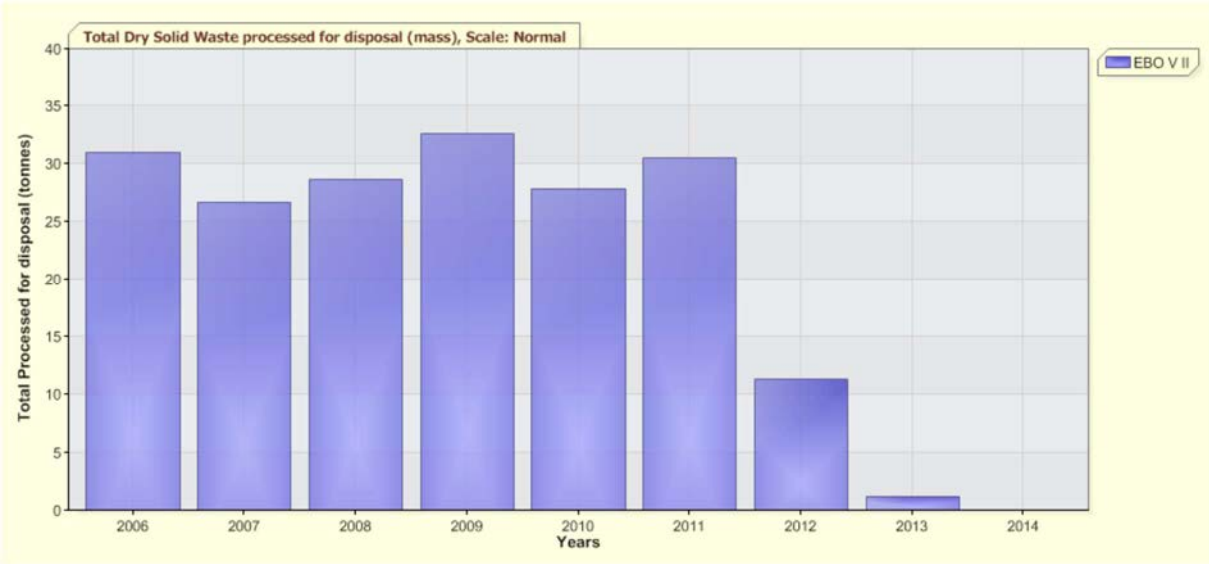


FIG. I.53. Dry Solid Waste Processed for Disposal

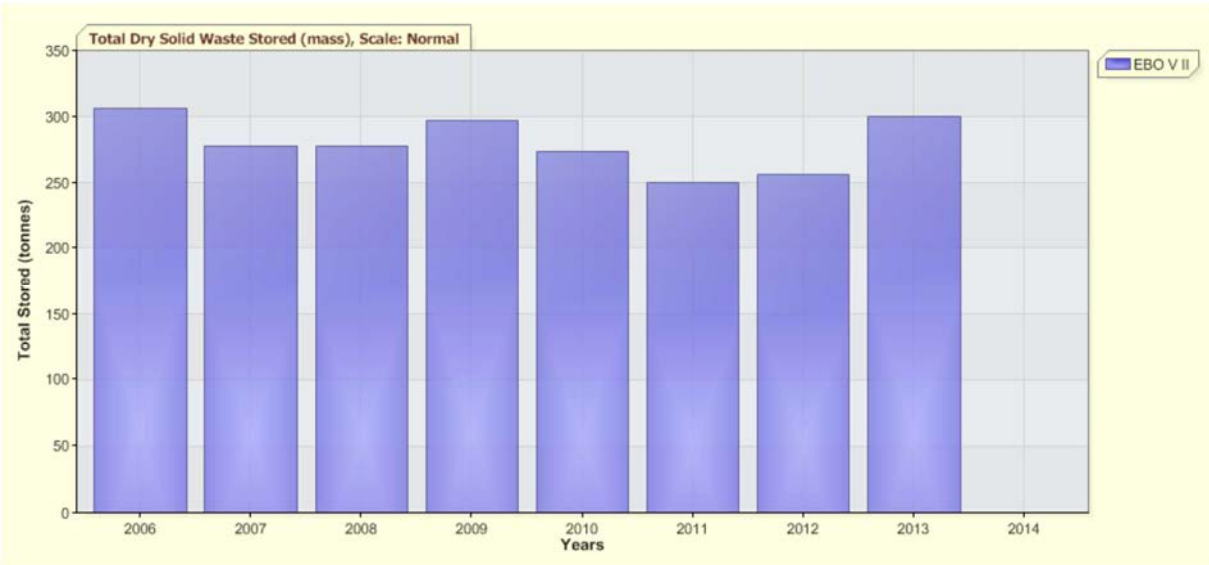


FIG. I.54. Dry Solid Waste Stored

I-6.1.4. Storage/Disposal

Processed waste in drums with fibre-concrete over packs is transported to the National repository in Mochovce. The repository consists of storage vaults arranged in rows that are filled with multiple layers of containers. The first row of the vault is weather protected by a movable steel cover. Within stage 1, two rows with 80 storage vaults were constructed. It is possible to emplace 90 concrete containers per vault. Overall capacity is 7 200 containers with total volume of 22 320m^3. Currently less than 50% of the total volume has been used.

I-6.1.5. Clearance and Release to Environment

Waste containing radionuclides or contaminated by them can be released from NPP into the environment if they meet specific release criteria (Fig. I.55). The strictest criteria require designated radionuclides to have specific activities lower than 300 Bq/kg. The NPP EBO has permission to release 120 t of waste annually. A variety of monitoring equipment is used for quick checks of dose rates. Gamma spectrometry is used for an official spectrometric determination of the radionuclide content.

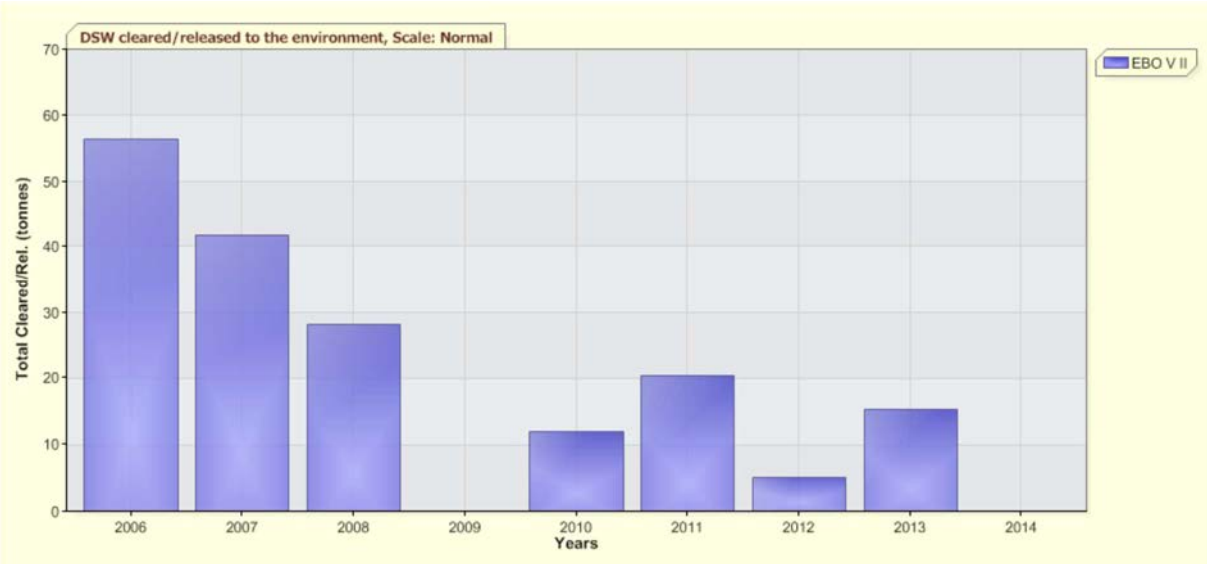


FIG. I.55. Dry Solid Waste Released to the Environment

I-6.2. NPP EMO 1, 2 Site information

NPP EMO 1,2 (Fig. I.56) has two WWER 440/V-213 reactors that were connected to the grid in 1998 and 2000. From 2008 power output was increased to 470 MWe for each unit.

FIG. I.56. NPP EMO 1,2 in Mochovce. In the Background is NPP EMO 3,4 under construction.

I-6.2.1. Basic Storage Data

Liquid waste in the NPP is collected, treated (evaporated) and stored in one 460 m^3 and four 550 m^3 tanks. At the end of 2013, 983 m^3 of concentrate was stored, which represents 45% of the total storage capacity. Ion exchange resins have been collected and stored in two 460 m^3 tanks. In addition, 85 m^3 of IX resins had been stored.

Solid waste in the control area is collected, monitored (dose rate, surface contamination) and divided to radioactive and conditionally active waste. The active waste is sorted into combustible, compactable, metal and other waste streams.

The storage capacity for solid waste is 640 stackable 400 L metal boxes and 2 640 drums (200 L). At the end of 2013, 47 t were stored. In addition 13 t of conditionally active wastes (wastes waiting for clearance) were stored.

I-6.2.2. Wet Solid Waste Processing

Liquid Radioactive Wastes (Concentrates)

Annual concentrate generation decreased to under 50 m^3 (the salts content ranges from 150 to 200 g/L), as a result of various many technical and organizational changes (Figures I.57 – I.59).

EMO 1,2 concentrates are pumped from storage tanks into the Liquid Radioactive Waste Final Treatment Facility (LRFTF), where they are cemented or bituminized. The final form suitable for the National Repository at Mochovce is concrete container.

A film rotary evaporator is used to condition concentrate. The cementation and bituminization line capacity of the LRFTF is approximately 800 m^3 of conditioned concentrates per year.

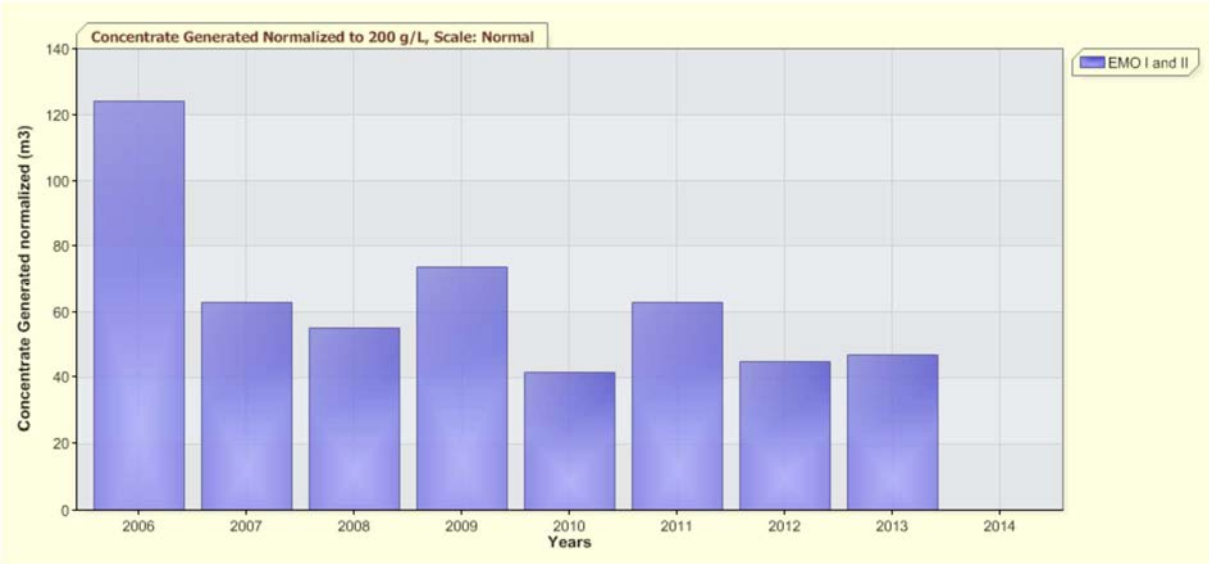


FIG. I.57. Concentrate Generated – Volume Normalized to content of 200 g/L of total salinity

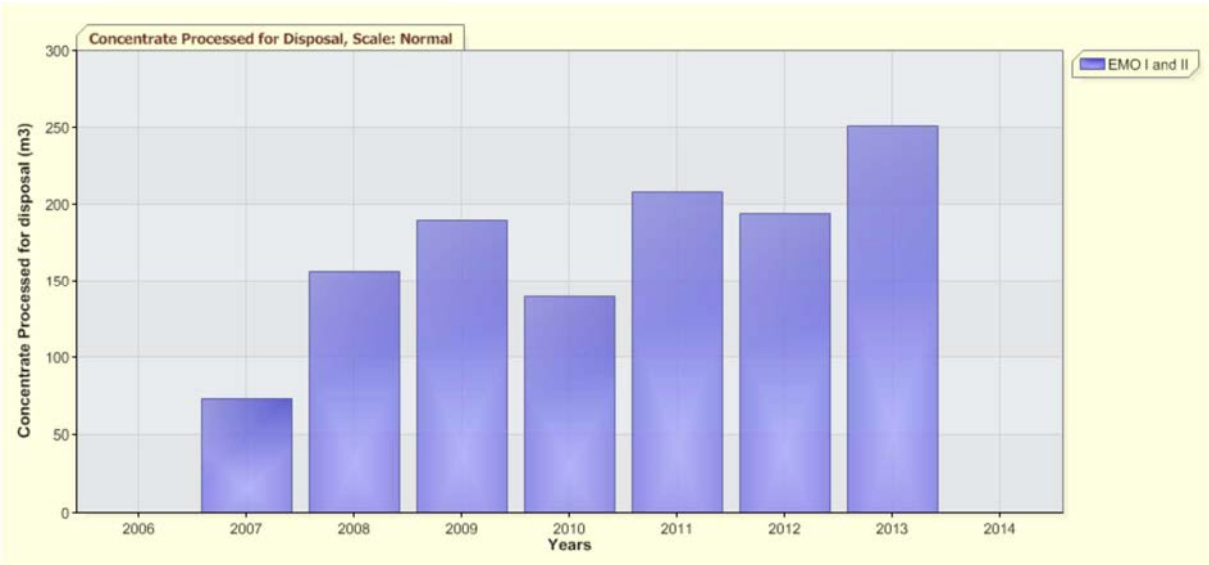


FIG. I.58. Concentrate Processed for Disposal

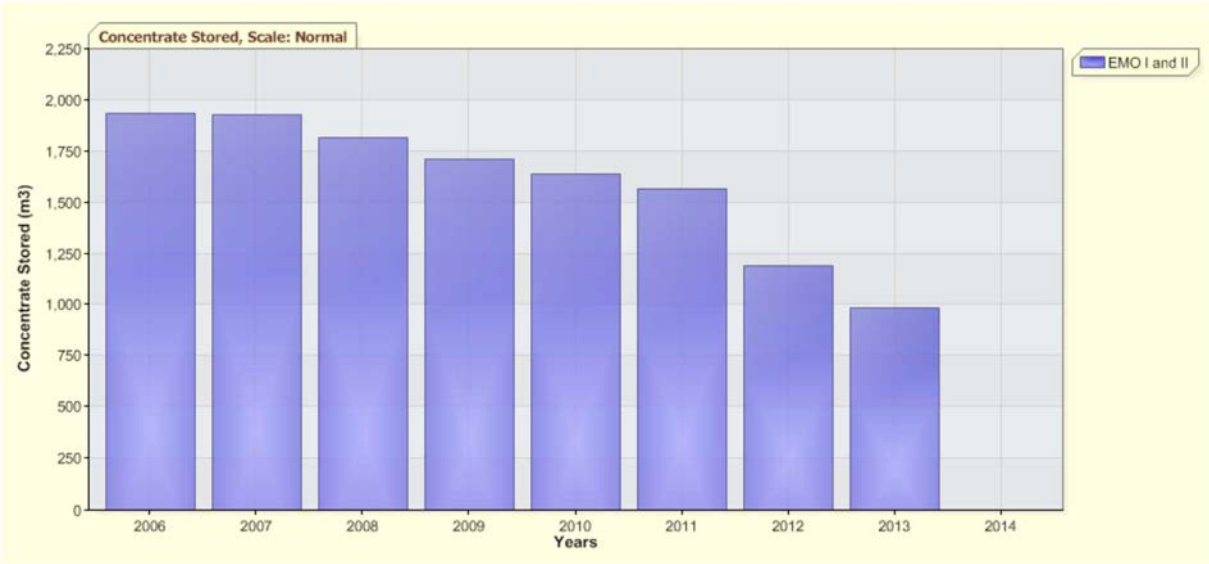


FIG. I.59. Concentrate Stored

I-6.2.3. Ion Exchange Resins

Annually, approximately 5 m^3 of IX resin is bituminized, and then disposed. The annual generation of IX resins varies from 0 to 13 m^3 per year (Figures I.60 – I.62).

Also a small amount of sludge (0.2 m^3) is processed into SIAL®, an inorganic alumino-silicate matrix.

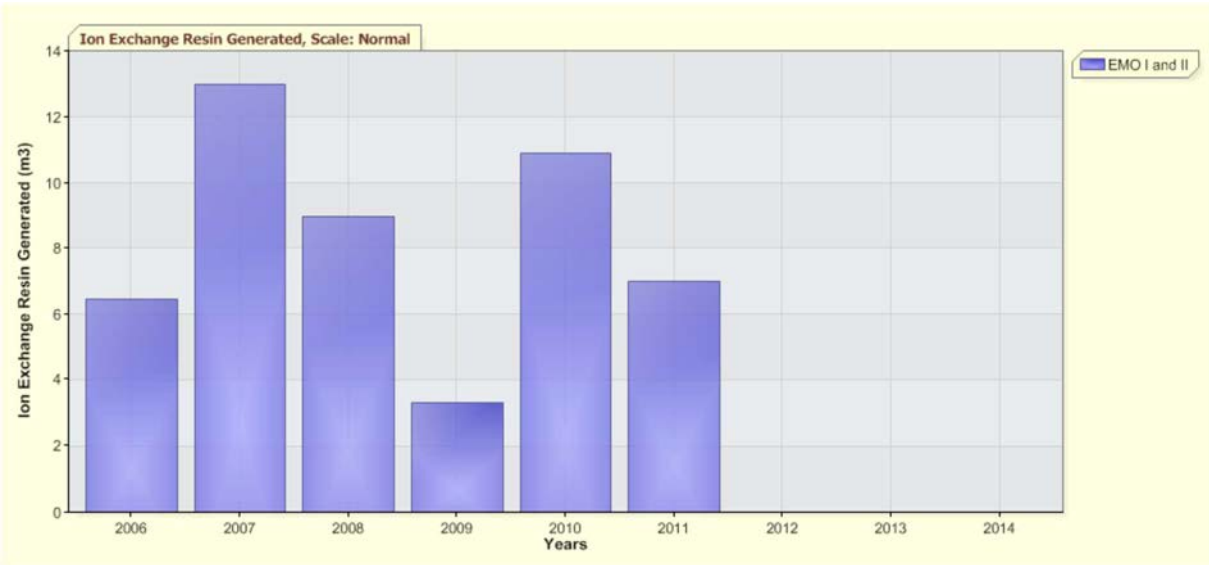


FIG. I.60. Ion Exchange Resin Generated

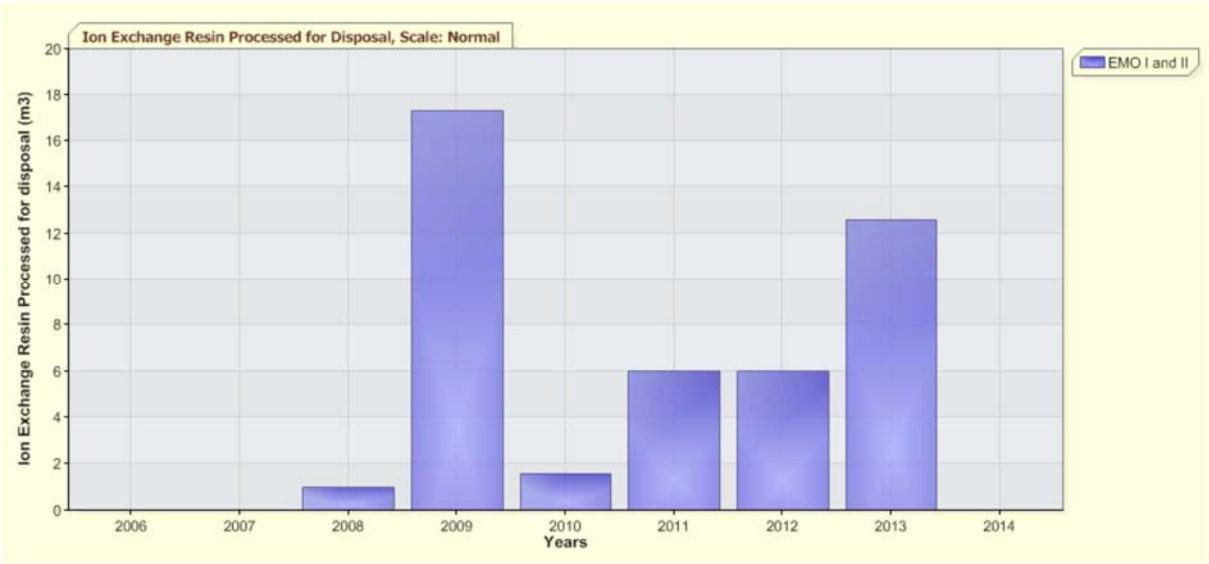


FIG. I.61. Ion Exchange Resin Processed for Disposal

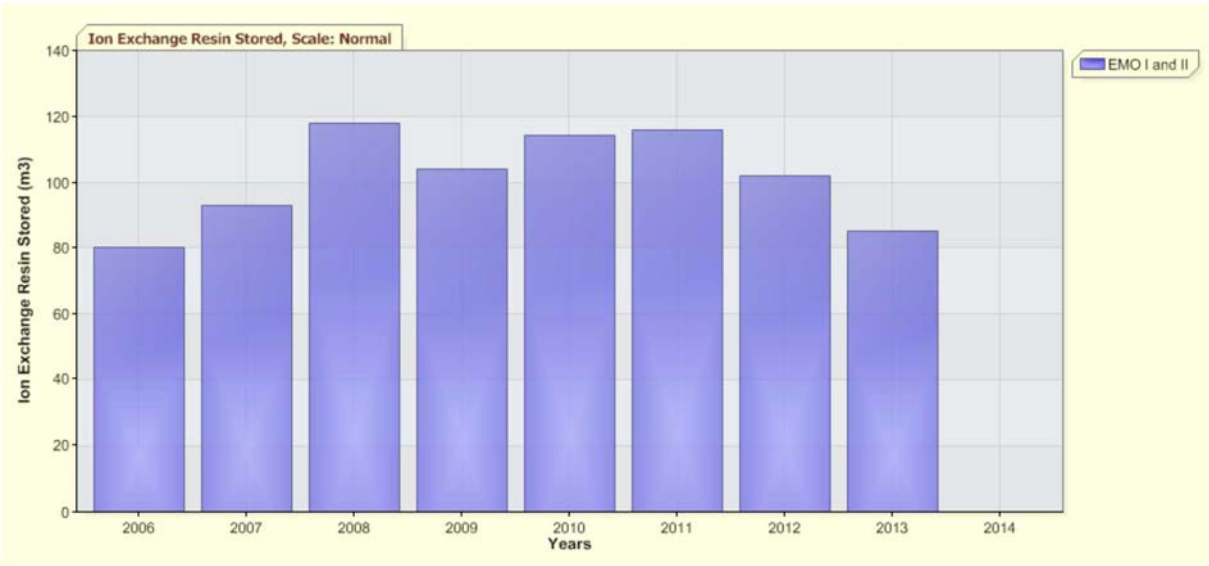


FIG. I.62. Ion Exchange Resin Stored

I-6.2.4. Dry Solid Wastes Processing

The annual waste generation of dry solid wastes at EMO varies from 12 t to 50 t (Figures I.63 – I.65). Annual generation of conditionally active waste varies from 2 t to 7 t. Approximately 85% of conditionally active wastes can be released into the environment and 15% is reclassified as radioactive waste.

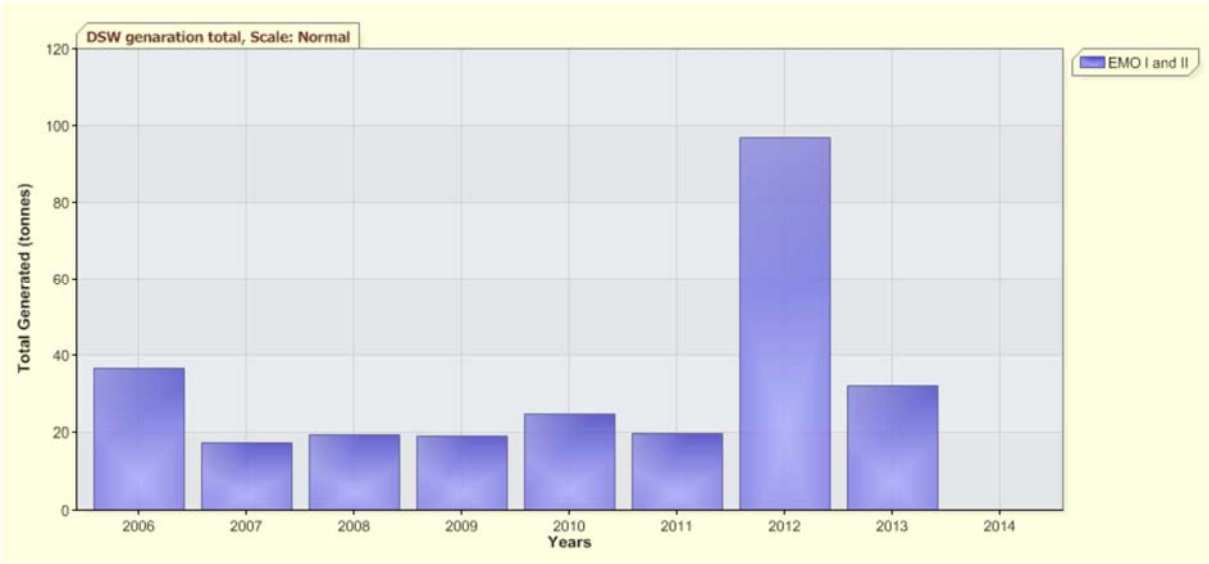


FIG. I.63. Dry Solid Waste Generated

Solid waste is transported the BRWTC. After processing, waste is placed into drums and then over packed in cubic fibre-concrete containers.

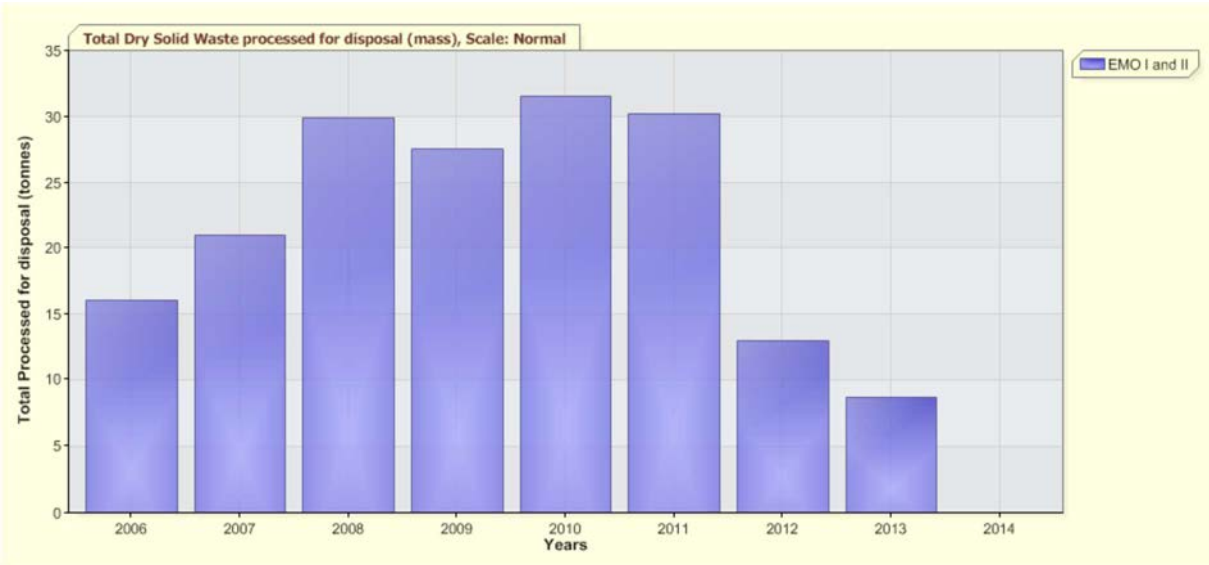


FIG. I.64. Dry Solid Waste Processed for Disposal

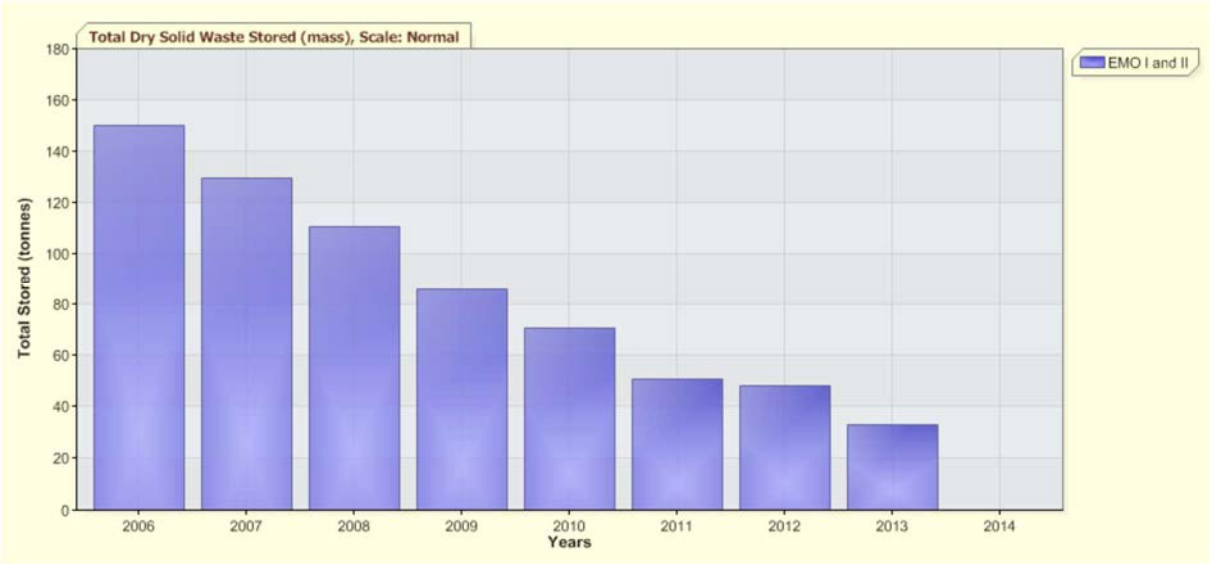


FIG. I.65. Dry Solid Waste Stored

I-6.2.5. Storage/Disposal

The final waste forms are transported from both the LRFTF and BRWTC to the National Repository in Mochovce.

I-6.2.6. Clearance and Release to the Environment

Waste containing radionuclides or contaminated by them can be released from NPP into the environment if they meet specific release criteria (Fig. I.66). The strictest criteria require designated radionuclides to have specific activities lower than 300 Bq/kg.

The EMO NPP has permission to release up to 100 t of solid waste and up to 15 m^3 of liquid waste per year.

A variety of monitoring equipment is used for quick checks of dose rates. Gamma spectrometry is used for an official spectrometric determination of the radionuclide content.

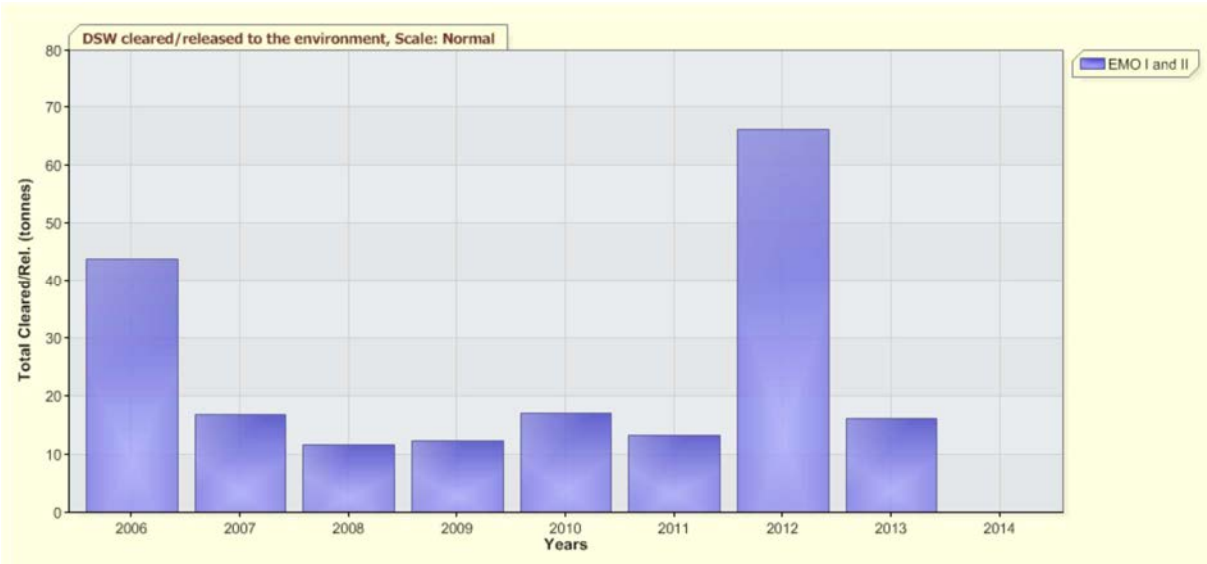


FIG. I.66. Dry Solid Waste Released to the Environment

I-7. NATIONAL REPORT OF TURKEY

I-7.1. Site Information

The Akkuyu nuclear power plant (Akkuyu NPP) will be built in Turkey, at Mersin Province on the Mediterranean coast (Fig. I.67) . An agreement on this was signed between the governments of Russia and Turkey in Ankara on May 12, 2010. The NPP will have four power units of 1200 MW each. After construction, Akkuyu NPP is expected to produce about 35 billion kilowatt-hours per year. Akkuyu NPP is a serial project of the NPP-2006 nuclear power plant based on Novovoronezh NPP-2 (Russia, Voronezh Oblast). The life cycle of Akkuyu NPP is 60 years.

FIG. I.67. A view of site.

Akkuyu NPP Construction Project in Turkey is implemented on BOO (build-own-operate) principles. Under the long-term contract, the Company assumes obligations for designing, constructing, maintaining, operating and decommissioning the plant.

- Contractor: ROSATOM
- Agreement signed 12 May 2010
- Estimated cost: 20-25 Billion USD
- Reactor Type: VVER-1200
- Number of units: 4 (4800 MW total capacity)
- Construction period: 2015-2022
- Operation time: 60 years

The following information is relevant to Akkuyu NPP:

- Akkuyu Nuclear JSC is the general customer and investor of the project.
- JSC Atomenergoproekt is the general designer of the plant.
- Atomstroyexport JSC is the general contractor for construction of the plant.

- Rosenergoatom Concern OJSC is the technical customer.
- InterRAO-Worley Parsons is the licensing consultant.
- National Research Center "Kurchatov Institute" is the scientific supervisor.

I-7.2. Project Implementation Phases

Phase 1 – Preparatory (2010-2013)

Registration of Akkuyu Electricity Generation Joint-Stock Company (AKKUYU NPP JSC), transfer of land plot for construction of the AKKUYU NPP, carrying out of engineering surveys, holding of public hearings, obtaining all permits and licenses for the AKKUYU NPP location and construction; carrying out work on the preparatory stage of the NPP construction.

Phase 2 – Construction of AKKUYU NPP (2014-2022)

2019 - Commissioning of the first power unit

2020 - Commissioning of the second power unit

2021 - Commissioning of the third power unit

2022 - Commissioning of the fourth power unit

Phase 3 – Operation and technical maintenance of AKKUYU NPP (2019-2082)
Phase 4 – Decommissioning (from 2079)

I-7.2.1. Waste Management

According to Agreement between the Government of the Republic of Turkey and the Government of the Russian Federation on Cooperation in Relation to the Construction and Operation of a Nuclear Power Plant at the Akkuyu Site in the Republic of Turkey in Article 12- "*The Project Company is responsible for decommissioning and the waste management of the NPP*."

I-8. REFERENCES

[I.1] CHEN LIANG, Introduction of the Radioactive Liquid Waste Treatment System in Tianwan NPP, 2007 National Nuclear Chemical Engineering Workshop on Radioactive Waste Treatment, Xiamen 2007.

[I.2] ZHIYIN ZHANG, Design Optimization of Spent IC, NF&TMC Transportation Container, 2007 National Nuclear Chemical Engineering Workshop on Radioactive Waste Treatment, Xiamen 2007.