SPENT FUEL AND RADIOACTIVE WASTE MANAGEMENT IN ARMENIA

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Abstract

The one third of power generation in Armenia is from the Armenian Nuclear Power Plant (ANPP). Currently is under operation only second unit of ANPP. The safety of the ANPP is a top priority for the Government of Armenia. Strategy on the Safe Management of Radioactive Waste and Spent Nuclear Fuel and the Action Plan on its implementation was approved by Government Decrees in 2017 and 2019. The source of spent fuel is the ANPP. When its service life is expired, during refueling of the reactor core, fuel assembly is discharged from the reactor core and placed in cell of the Unit № 2 storage pool. Refueling is performed once in a year, when the reactor is shut down, depressurized and cooled down. Following discharge of spent fuel assembly from the reactor core it is tested for leak tightness. In case it is tight, a spent fuel assembly is placed in a cell of the storage pool. In case failed assemblies are detected they are placed in tight casings and stored in them. Following the required storage time (3-5 years), spent fuel assemblies are relocated into the spent fuel storage pool of № 1, where they are stored until reaching the parameters required for their 2 transferring to Dry Spent Nuclear Fuel Storage facility (DSNFSF) of NUHOMS-56 type located on Armenian NPP site. Spent fuel assemblies are placed in Dry Shielding Canister (DSC), which is filled with nuclear purity helium of retained overpressure. The DSC shielding and insulation are provided by massive reinforced concrete Horizontal Storage Module (HSM). Radioactive decay heat caused by DSC and HSM is removed using draught ventilation system, which operation is based on a passive natural convection. There are two buildings of the HSM built on the Armenian NPP site.

1. INTRODUCTION

Official Name:	Republic of Armenia
Capital:	Yerevan
President	Armen Sargsyan
Prime Minister	Nikol Pashinyan
Area:	29,800 square kilometers

Armenia is the smallest one of the Caucasus countries, which is bordering with Georgia in north, Azerbaijan in west and southwest, Turkey and Iran in east and south consequently.

FIG. 1. Country at a glance.

1.1. Short information about Armenian energy sector

Armenian energy sector had passed through difficult reforms. At the result of the experience obtained during the energy crisis the energy policy was created, which provides reasonable level of energy security. The Government of Armenia pays special attention to energy security and energy independence of the country for securing sustainable development of the economy of country.

Loss of energy security is a subject of great risk for our country, which is situated in hard geopolitical zone but for all that is keeping its political and economic stability. What will be the impact of energy security loss on social-economic life of the country could be assessed by the bitter experience gained during energy crisis in Armenia during 1993-1995.

Armenia energy sector is characterized as well balanced and functioning system, which is more typical for the developed countries. The shares of power generation from nuclear, thermal and renewable capacities are almost equal, i.e. one third each. Two gas pipelines from Russia and Iran provide diversification to the system. Well-functioning institutional structure, as well as transmission and distribution network provides stable energy supply and services extended to all population and sectors of economy.

The only domestically produced primary energy is electricity mainly from the hydroelectric plants and, conditionally from the single nuclear power plant.

Nevertheless taking into account lack of fossil fuel and dependence on import of primary energy resources, the Government of Armenia is continuously looking for new opportunities to increase energy security through diversification of supply, energy efficiency, new investments, new technologies, regional cooperation, as well as sustainable infrastructure.

"Armenia adopted a policy of sustainable economic development, which assumes concurrent development of the economy, in the context of which energy, as the most important sector, is called to ensure such a progress for the state that through coordination and balancing of environmental issues will create preconditions for sustainable development of future generations while reducing the loss of energy. All energy resources, including renewable energy, need to be widely utilized, and included in the energy balance for the purpose of energy supply. As Armenia lacks own resources of fossil fuel, raising the energy efficiency of the economy, development of nuclear energy and efficient use of renewable energy resources are a prerequisite for energy security." [1]

1.2. Nuclear energy in Armenia

The one third of power generation in Armenia is from the Armenian Nuclear Power Plant (ANPP).

It is situated at an elevation of 930 m on the semi-desert landscape in the western part of the Ararat Valley. It was originally planned to accommodate four units of WWER-440 reactors, with Units 3 and 4 to be situated to the west of Units 1 and 2. Preliminary site clearance for Units 3 and 4 was conducted in the early 1980's, however construction of further units at ANPP was not started. ANPP consists of two power units with 407.5 MW designed capacity of each. Planned life-time is 30 years.

ANPP was the first nuclear power plant in the USSR intended to be constructed in a region of high seismicity, for which significant changes were made in VVER-440 (V-230 project) design, including construction and the whole reactor facility. The reactor was assigned with the new identification – V-270.

Currently only one unit of ANNP is operational. It produces 2,5 billion kWh electricity in the base-load regime, which is about 35% of total balance of county's power generation, and about 40% from country's demand.

After the 1988 earthquake, although the Armenia Nuclear Power Plant was not damaged, the Council of Ministers of the USSR decided shut down the ANPP as a precautionary measure. The ANPP was shutdown in 1989 without any substantial reasons. The units were not decommissioned but kept in prolonged shut down condition. This caused the severe energy crisis which brings not only collapse of economy, but also to ecological catastrophe due to mass deforestation and decrease of water level of the Lake Sevan due to the hydro power generation volume. In fact Armenia became very sensitive to the energy security threats. After independency in 1995, the Unit 2 of the ANPP was restarted and Unit 1 remained in a stand-still regime.

An agreement on cooperation for life time extension of Armenian NPP second unit was signed between the Government of the Republic of Armenia and the Government of Russian Federation on 20th December 2014.

Agreement for providing state export credit to the Government of RA for financing of the ANNP's second unit life time extension project was signed between the Government of the Republic of Armenia and the Government of Russian Federation on 5th February 2015. The above mentioned two agreements have entered into force on 12th May 2015.

Armenian NPP second unit operation extension works have already commenced.

The safety of the Armenian Nuclear Power Plant (ANPP) is a top priority for the Government of Armenia.

2. LEGISLATIVE AND REGULATORY SYSTEM

Every country should have a legislative framework comprehensive, consistent, clear, easily available, implementable, and compliant with international treaties such country has signed and practices.

A hierarchical structure of legislation, as stated in the Article 4 of the Law on Safe Utilization of Atomic Energy for Peaceful Purposes, exists in the Republic Armenia.

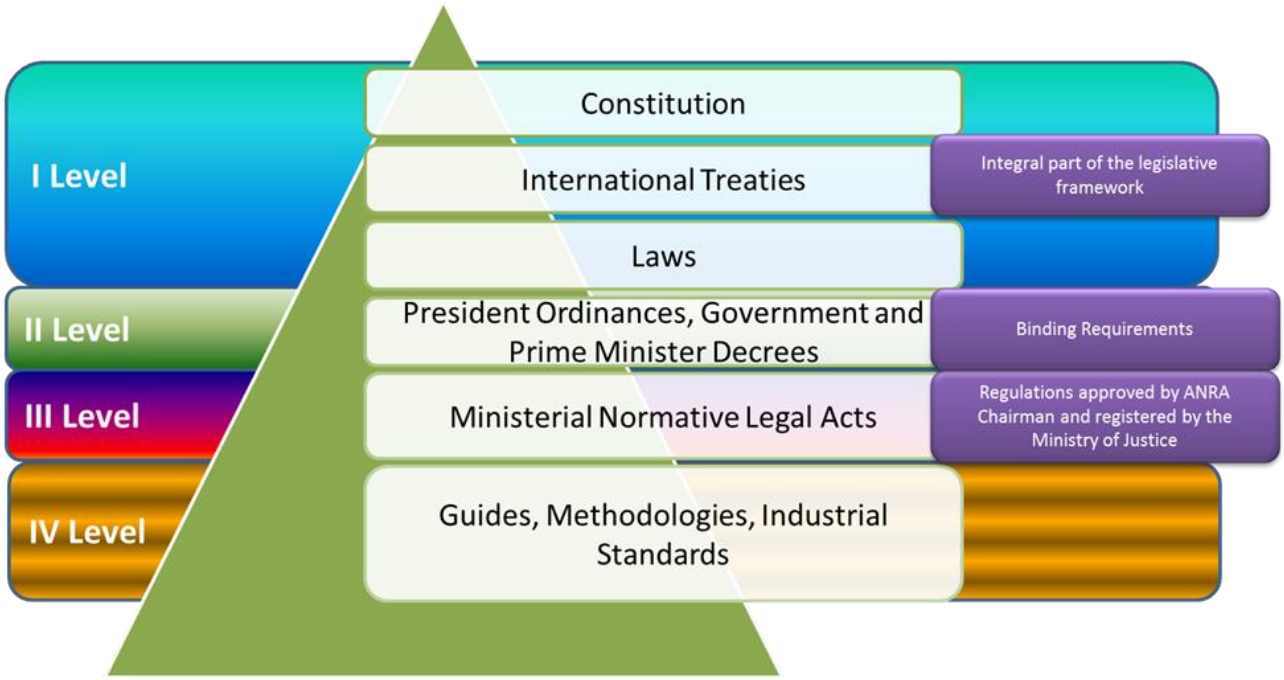

FIG. 2. A hierarchical structure of legislation.

Licensing related relations are settled under the Law of the RA on Licensing, the Law of the RA on Safe Utilization of Atomic Energy for Peaceful Purposes and the relevant licensing procedures approved by the RA Government.

The following practices in atomic energy utilization field are subject to licensing:

- Site selection, design, construction, operation, and decommissioning of nuclear installations;
- Use, transport and storage of nuclear materials;
- Physical protection of nuclear installations and nuclear materials;
- Expertise of designs and other documents of nuclear installations,
- Physical persons implementing practices and holding positions important to safety in atomic energy field and other.

2.1. Spent fuel and radioactive waste management

2.1.1. International Treaties

- Treaty on the Non-Proliferation of Nuclear Weapons ratified on 24.09.1991
- Convention on Early Notification about Nuclear Accident ratified on 22.06.1993
- Convention on Assistance in Case of a Nuclear Accident or Radiological Emergency ratified on 22.06.1993

- Vienna Convention on Civil Liability for Nuclear Damage ratified on 22.06.1993
- Convention on Physical Protection of a Nuclear Material ratified on 22.06.1993
- Amendment to the Convention on Physical Protection of Nuclear Material signed on 8 July 2005 adopted by the National Assembly as of 18.03.2013
- Agreement between the Republic Armenia and the International Atomic Energy Agency for the Application of Safeguards in connection with Treaty on the Non-Proliferation of Nuclear Weapon signed on 23.09.1993
- CTBT Comprehensive Nuclear-Test-Ban Treaty ratified on 21.12.1993
- Convention on Nuclear Safety ratified on 24.09.1997
- Revised Supplementary Agreement Concerning the Provision of Technical Assistance by the International Atomic Energy Agency to the Government of the Republic of Armenia ratified on 04.06 2003
- Protocol Additional to the Agreement between the Republic Armenia and the International Atomic Energy Agency for "The Application of Safeguards in connection with Treaty on the Non-Proliferation of Nuclear Weapon ratified on 28.06 2004

2.1.2. Laws in the field of nuclear energy utilization for the peaceful purposes

- Code of the RA on Administrative Offences (06.12.1985 and amended in 1996)
- Law of the RA on Population Protection in case of Emergencies (02.12.1998 HO-265)
- Law on Safe Utilization of Atomic Energy for Peaceful Purposes with amendments and supplements (23.03.2018 HO-266N)
- Law of the RA on Licensing (adopted 30.05. 2001 NO-193 with supplements)
- Law of the RA on Civil Service (27.12.2001 HO-272 with supplements)
- Law of the RA on Legal Acts (03.04.2002. HO-320N)
- Law of the RA on Organization and Conduct of Inspections (17.05.2000 HO-172)
- Criminal Code of the RA (18.04.2003)
- Law of the RA on Administration Principles and Procedure (18.02.2004 HO-41N)
- Law of the RA on Energy (adopted 07.03.2001 HO-148 with supplements)
- The Law of the RA on Environmental Impact Expertise (as of 22.07.2014) specifies the activities that are subject to environmental impact expertise in the atomic energy utilization field.

2.1.3. Legislation and important government decrees related to the SNF and RWM

A number of RA Government Decrees have been adopted in the sphere of nuclear energy on physical protection and security of the ANPP, nuclear materials and rules on physical protection of nuclear installations and nuclear materials, on licensing procedures and different types of license forms, procedure on spent fuel and radioactive waste management, including:

- President Order № NK-7-A (19.01.2017) on approval of concept on safe management of radioactive waste and spent nuclear fuel RA
- Government Protocol Decree № 42 as of 05.10.2017 on approval of Strategy on the Safe Management of Radioactive Waste and Spent Nuclear Fuel
- Government Decree № 3-L as of 10.01.2019 on approval of Action Plan for implementation of Strategy on the Safe Management of Radioactive Waste and Spent Nuclear Fuel.

3. SPENT FUEL MANAGEMENT PRACTICES

Open nuclear fuel cycle scheme is used in Armenia. Currently the spent nuclear fuel is not reprocessed in Armenia and therefore spent nuclear fuel reprocessing is not declared to be part of spent nuclear fuel management, pursuant to Article 3(1). The source of spent fuel is the Armenian NPP.

When its service life is expired, during refueling of the reactor core, fuel assembly is discharged from the reactor core and placed in cell of the Unit № 2 storage pool. Refueling is performed once in a year, when the reactor is shut down, depressurized and cooled down.

Following discharge of spent fuel assembly from the reactor core it is tested for leak tightness. In case it is tight, a spent fuel assembly is placed in a cell of the storage pool. In case failed assemblies are detected they are placed in tight casings and stored in them.

During storage of spent fuel assemblies in the storage pool the following is periodically inspected:

— Level of coolant;
— Coolant temperature;
— Quality (chemical and radiochemical composition) of coolant.

Following the required storage time (3-5 years), spent fuel assemblies are relocated into the spent fuel storage pool of Unit № 1, where they are stored until reaching the parameters required for their transferring to Dry Spent Nuclear Fuel Storage (DSNFS) facility.

TABLE 1. LIST OF SPENT FUEL FACILITIES

Name of Facility	Location Main	Main purpose	Comment
Armenian NPP	Reactor Building Armenian NPP,	SNF temporary storage	In operation
Dry Spent Nuclear Fuel Storage Facility	DSNFS facility Armenian NPP site	Interim SNF storage	In operation

4. SAFETY OF SPENT FUEL MANAGEMENT

— General Safety Requirements;
— Minimization of radioactive waste generation;
— Interdependencies among the different steps in spent fuel management;
— Radiation protection of personnel, population and the environment;
— Consideration of biological, chemical and other hazards;
— Avoiding actions that impose reasonably predictable impacts on future generations greater than those permitted for the current generation;
— Reduction of burdens on future generations.

4.1. Armenian NPP dry spent nuclear fuel storage facility (ANPP DSNFS facility)

Storage of spent fuel assemblies following adequate storing in storage pools is performed in Dry Spent Nuclear Fuel Storage (DSNFS) Facility designed and built according to the standard NUHOMS-56 system foreseen for a long-term interim storage of spent fuel assemblies of WWER-440 type reactors. Spent fuel assemblies are placed in Dry Shielding Canister (DSC), which is filled with nuclear purity helium of retained overpressure. The DSC shielding and insulation are provided by massive reinforced concrete Horizontal Storage Module (HSM). Radioactive decay heat

caused by DSC and HSM is removed using draught ventilation system, which operation is based on a passive natural convection.

Currently the issue of spent nuclear fuel disposal from ANPP operation is still open.
There is no transboundary movement of spent nuclear fuel. All spent fuel is stored at ANPP site. According to the Law of Republic of Armenia "On Safe Utilization of Atomic Energy for Peaceful Purposes" import of radioactive waste to Armenia is prohibited.

5. RADIOACTIVE WASTE MANAGEMENT

— General safety requirements
- Minimization of radioactive waste generation
- Radiation protection of personnel, population and the environment
- Avoiding actions that impose reasonably predictable impacts on future generations greater than those permitted for the current generation
- Reduction of burdens on future generations

— Existing facilities and past practices

There are two management facilities in Armenia:
- Armenian NPP
- Near surface institutional radioactive waste storage facility (Radon type facility).

5.1. Armenian NPP

Radioactive waste at the Armenian NPP are generated during daily cleaning and decontamination of rooms in the controlled area, during decontamination and repair of equipment, implementation of repair works in the controlled area, etc.

RW include also parts of process equipment not subject to decontamination or irradiated in the reactor, I&C, pipelines or safety valves, protective clothes and personnel protection equipment contaminated above the permissible values, filters of ventilation systems, selected sources of ionizing irradiation, instruments, waters from laundry, hatches, showers, etc.

According to the aggregate state radioactive wastes are divided into solid radioactive wastes (SRW) and liquid radioactive wastes (LRW) which in turn are classified according their activity to low level, intermediate level and high level radioactive waste.

Solid radioactive waste before transfer for storage to the storage systems undergoes preliminary treatment, including:

— Collection;
— Classification according to activity;
— Fragmentation (if needed);
— Packaging;
— Placement in interim SRW containers;
— Transportation and placement of SRW in corresponding storage systems.
— Solid radioactive wastes are not processed at the Armenian NPP.

Liquid radioactive waste at the Armenian NPP are processed at the deep evaporation facility (DEF), the originated product ("salt cake") is packed in metal containers (drums), where it is solidified (crystallized) and placed for temporary storage in the solid intermediate level waste storage system and on the roof of auxiliary building under the metallic shelter.

5.2. Other organizations (medical, industrial, etc.) which produce radioactive waste

Some radioactive waste (institutional waste), mainly spent sealed sources and radioactive waste from medical, industry, research activities are also generated in Armenia, but the volume of such waste are much lower than that generated at Armenian NPP. This type of waste is stored in near surface radioactive waste storage facility (Radon type facility). Radioactive waste before transfer to the near surface storage facility have to be packed in appropriate way and transferred to storage facility in special equipped truck to satisfy the transportation requirements established by Government Decree N 931 N as of 27.06.2002.

5.3. Facilities

5.3.1. Siting of proposed facilities

Currently there is no intention in Armenia for siting any additional facility for RW management. Siting of existing buildings for RW management at Armenian NPP took place within the siting of the entire NPP, as described in the design documentation.

5.3.2. Design and construction of facilities

Currently there is no plan to design and construct any radioactive waste management facility in Armenia.

5.3.3. Assessment of safety of facilities

All radioactive waste storage systems at Armenian NPP are included into the Armenian NPP design. For this reason, the issues of the safety assessment are presented in the Safety Analysis Report for ANPP Unit 2. The safety assessment of near surface institutional waste storage facility was performed in 2006 in the frame of EU support project.

5.3.4. Operation of facilities

The RA Government decree N 702-N as of 19.05.2005 on approval of the licensing procedure and license form for operation of the radioactive waste storage facility has specified all necessary activities for obtaining the license for operation of radioactive waste storage facility. The systems for radioactive waste storage existing at ANPP are fully compliant with the requirements of this document.

5.3.5. Institutional measures after closure

There is no disposal facility in Armenia.

REFERENCES

[1] “Energy Security Concept of Armenia” approved by the President of Armenia on October 23, 2013, Yerevan /NK-182-N/