

Belarusian Nuclear Power Plant – Overview

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Executive summary

The Belarusian Nuclear Power Plant is being constructed nearby Ostrovets, Belarus and the distance to the Republic of Lithuania is 23km. The Belarusian NPP will consist of two third-generation VVER-1200 type reactors (AES-2006), Russian design. The first unit will be for commissioned in November 2018, followed by the second unit in July 2020. . An intergovernmental agreement between Belarus and Russia concerning the plant was signed in March 2011. A turnkey construction contract was signed with Russian company Atomstroyexport.

VVER-1200, AES-2006 is a third generation nuclear power plant design. The strategy of coping with the design basis accidents is based on using both the active and passive safety systems.

The strategy of coping with the beyond design basis accidents is based on using preferably the passive safety systems.

Since 2013 EU has been supporting the Belarusian nuclear regulatory authority through Instrument for Nuclear Safety Cooperation. The on-going programme includes permanent presence of experts of European Technical Safety Organisations. The objective is to strengthen the capabilities of the Belarus nuclear safety regulator in licensing, regulatory supervision and specialised regulatory activities related to nuclear safety.

The EU and Republic of Belarus held bilateral meetings on 19-20 September in Minsk. The discussion on nuclear safety and "Stress tests" exercise for new NPP was conducted.

Belarus has commenced stress-tests for the Belarusian NPP and is planning to complete them by the end of 2016. Stress-tests will be performed in accordance with the Joint Declaration on comprehensive risk and safety assessments of nuclear plants endorsed in 2011 by the European Commission and EU neighboring countries, including Belarus.

In general Belarussian side confirmed their support to the stress test process but more details on their plans regarding full Stress Test process (self-assessment by the operator, preparation of a national report by the regulatory body and peer review by an EU expert) are still pending.

Introduction¹

The Belarusian Nuclear Power Plant is being constructed approximately 18km away from Ostrovets, Grodno Oblast. The nearest bordering state to the project site is the Republic of Lithuania, the distance being 23km.

The Belarusian NPP will consist of two third-generation VVER-1200 type reactors (AES-2006), Russian design. It is planned to build two additional reactors by 2025. Similar reactors are also being used at the Leningradskaya NPP-2 in Russia, Hanhikivi-1 NPP in Finland and Paks 2 NPP in Hungary. It will be the first Nuclear Power Plant in Belarus.

According to the schedule the first unit will be commissioned in November 2018, followed by the second unit in July 2020.

The project is being overseen by the state enterprise Directorate for Nuclear Power Plant Construction under the Ministry of Energy, who will also be the operator.

The overall investment for the development of the power plant is estimated to be \$11bn.

Nuclear Power in Belarus ²

Belarus produces 31 TWh/yr from 8 GWe of generating installed capacity, almost entirely gas-fired. It has net imports of 8 TWh (2012) giving consumption of 30 TWh.

Belarus is seeking to reduce its dependence on Russia as a major energy supplier.

The country imports 90% of its gas from Russia (estimate of 22.5 billion m³ in 2012) – much of it for electricity. The proposed 2400 MWe nuclear plant is expected to reduce gas imports by 5 billion m³ per year. In the past there had been studies on both a domestic nuclear power plant using Russian technology, and Belarus participation in a new nuclear unit at Smolensk or Kursk in Russia.

Belarus used IAEA INPRO's Nuclear Energy Systems Assessment methodology covering economics, infrastructure, waste management, proliferation resistance, physical protection, environment, and safety to confirm its investment decision. The results showed that nuclear would be competitive, with overnight costs US\$1960/kW and levelized electricity price 5.81 cent/kWh (compared with coal \$1175/kW and 6.52 cent/kWh, and gas \$805/kW and 6.76 cent/kWh).³

Project background

In mid-2006 the Belarusian government approved a plan for the construction of an initial 2000 MWe PWR nuclear power plant in the Mogilev region of eastern Belarus.

¹ This report is based on publicly available information and data.

² <http://www.world-nuclear.org/information-library/country-profiles/countries-a-f/belarus.aspx>

³ http://www-pub.iaea.org/MTCD/Publications/PDF/TE-1716_web.pdf

After expressions of interest from international reactor vendors were invited, the energy ministry announced in August 2008 that proposals had been received from Atomstroyexport, Westinghouse-Toshiba and Areva. Anything from USA would need several years for an intergovernmental agreement, and Areva's EPR was noted as being too big for the first plant. In addition, the energy ministry received a proposal from the China Guangdong Nuclear Power Corporation. Russia's Atomstroyexport emerged as the most likely supplier for the 2 x 1000 MWe plant since the others either did not provide all the information required or could not build the plant soon enough. Two further units are proposed for operation by 2025. In June 2007 Russia's Eximbank offered a US\$ 2 billion credit line to enable purchase of equipment from Russia's Power Machines company as a major part of the overall cost.

In November 2007 a presidential decree defined the organizations responsible for preparing for the construction of the country's first nuclear power plant and budgeted money for engineering and site selection. The candidate sites were Krasnopolyansk and Kukshinovsk (both in the Mogilev region) and Ostrovets in the Grodno region. Ostrovets/ Astravets, 23 km from the Lithuanian border and 55 km from Vilnius, were chosen in December 2008, despite protests from Lithuania.

The decree also aims to ensure that nuclear and radiation safety is in line with the recommendations of the International Atomic Energy Agency (IAEA). A Directorate for Construction of Nuclear Power Plants was established under the Ministry of Energy. A Nuclear & Radiation Safety Department will also be set up as part of the Emergencies Ministry to act as the state nuclear regulator and licensing authority.

In June 2009 the government announced that Atomstroyexport would be the general contractor, with Russian and Belarus subcontractors, notably St Petersburg Atomenergoproekt. An intergovernmental agreement concerning the plant was signed in March 2011. A preliminary turnkey construction contract with Atomstroyexport for a 2400 MWe plant (2 x 1200 MWe AES-2006 units using V-491 reactors) was signed in October 2011 by Belarus state-owned Nuclear Power Plant Construction Directorate, and a general construction contract was signed in July 2012. St Petersburg AEP (SPbAEP, now VNIPIET) has been involved with the project since 2004, including site selection and technology choice. In January 2014 the Nuclear Power Plant Construction Directorate became the Belarus Nuclear Power Plant state unitary enterprise.

Operation of the first unit of the Ostrovets plant is scheduled for November 2018 and the second unit in July 2020, to give 2340 MWe net on line.

The contract includes supply of the fuel and repatriation of used fuel for the life of the plant. The fuel is to be reprocessed in Russia and the separated wastes returned to the client country eventually.

Licensing status

In September 2011 the license on the NPP site was issued by the Gosatomnadzor.

In December 2011 the Nuclear Power Engineering Department of the Energy Ministry submitted an application for a construction license to state nuclear regulator GAN). Four licences have been issued by MES/Gosatomnadzor in 2013. They are as follows:

- 13 September 2013 – for erection of foundations of the buildings and structures of Unit 1 of Belarusian NPP;
- 14 February 2014 – for erection of the buildings and structures of the Belarusian NPP Unit 1 and Unit 2;
- 22 April 2014 – for construction of the Belarusian NPP Unit 1;
- 30 December 2014 – for construction of the Belarusian NPP Unit 2.

Wastes

A radioactive waste management strategy based on IAEA principles was adopted in June 2015. It builds on regulations for nuclear and radiation safety approved by the Ministry of Emergency Situations in September 2010. High-level waste (HLW) will be stored near the plant for its lifetime (though used fuel is returned to Russia). Low- and intermediate-level waste (LILW) will be stored there for up to ten years before being removed to a repository. A LILW repository is to be constructed from 2028. The strategy also considers construction of a deep geological repository for the disposal of HLW following decommissioning of the plant.

The strategy predicts that there will be about 9360 m³ of solid radioactive waste of various types and 60 m³ of HLW arising during the 60-year operating life of the twin-unit Ostrovets plant. The projected amount of solid LILW resulting from decommissioning the plant is 2050 m³ per unit and HLW is 85 m³.

Non-proliferation

Belarus joined the NPT in 1995, and in 2005 signed the additional protocol to its safeguards agreement with IAEA.

Main technical data of the project

(Status report 108 - VVER-1200 (V-491) (VVER-1200 (V-491)))⁴

- Full name VVER-1200 (V-491)
- Reactor type Pressurized Water Reactor (PWR)
- Coolant Light Water
- Moderator Light water
- Neutron spectrum Thermal Neutrons
- Thermal capacity 3200.00 MWth
- Gross Electrical capacity 1170.00 MWe
- Design status Under Construction
- Designers Gidropress

Project- «NPP – 2006», Generation 3+

Designer– JSC “Atomenergoproekt” Sankt-Petersburg, Russia

General contractor– JSC «Atomstroyexport» (JSC«NIAEP»), Russia

Customer – RUE «Belarusian Nuclear Power Plant», Belarus

Installed capacity for 2 NPP units– 2388 MW

Average electricity supply (in base conditions) – 17 billion KWh

Service – 50 years

Start first unit– 2018 year, second – 2020 year.

Rated reactor core thermal power	3200 MW
Thermal efficiency	~37 %
Electric power	1200 MW
Primary circuit pressure	162 bar
Number of fuel assemblies	163
Number of control rods	121
Primary circuit loops / Steam generators	4
Rated core coolant flow rate	85 600 m3/h

Safety systems

Internal containment	Pre-stressed concrete
Number of safety trains	4
Reactor trip	Passive
Emergency injection	Active
Emergency core cooling	Active
Emergency containment cooling	Active

Beyond design basis accident management

Core catcher	Yes
Passive heat removal from steam generator	Yes
Passive heat removal from the containment	Yes
Hydrogen removal system	Yes

⁴ <https://www.iaea.org/NuclearPower/Downloadable/aris/2013/36.VVER-1200%28V-491%29.pdf>

Protection from external impacts ⁵

Seismic loads

Protection against seismic hazards is provided taking into account the site specific seismic conditions.

For instance, in the Temelin 3-4 VVER-1200 offer, the buildings are designed to stay intact if the horizontal maximum ground acceleration caused by an earthquake does not exceed 0.25g.

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Hurricanes and tornados

Safety related components are designed to cope with a wind load corresponding to a wind velocity of 30 m/s at a height of 10 m. Design loads are those corresponding to a whirlwind of class 3.60 according to the Fujita scale.

Snow and ice loads

Design peak snow load is 4.1 kPa.

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Safety concept, main design principles and methods of licensing

The design was developed on the basis of the requirements of the up-to-date safety rules and standards in the nuclear power engineering of Russia considering the Safety Guides and other recommendations issued by the International Atomic Energy Agency and the requirements of the European Utilities for the NPPs with LWR (EUR Requirements, Volume 2, Chapter 2.1).

In the course of NPP design elaboration in line with the EUR requirements the generally recognized targets, principles and safety assurance criteria are met that are mutually dependent and form a single complex.

The determination of the safety system configuration in the present design is based on the application of the following principles:

- single failure principle;

⁵ The VVER today – Evolution, Design, Safety, Brochure Rosatom Oversees

- redundancy principle;
- diversity principle;
- principle of physical separation;
- protection against the operator's errors;
- RP inherent safety principle.

The simple design and reliability of the safety systems are enhanced due to the application of the active systems, passive systems that do not require involving other systems for their operation and the application of reliable equipment.

Defence-in-depth

NPP safety shall be provided by the realization of the defense-in-depth concept based on the application of a system of physical barriers to the release of the ionizing radiation and radioactive products into the environment and the systems of engineering and organizational measures to protect the barriers and maintain their efficiency, as well as to protect the personnel, the population and environment.

The system of physical barriers of a NPP Unit comprises a fuel matrix, a fuel rod cladding, reactor coolant circuit boundary, reactor plant enclosure and biological shielding.

Safety indices

The core damage frequency probability (CDF) for a one-year fuel cycle is provided in the next Table:

Conditions	CDF probability, reactor/year
Operating conditions	2.24x10 ⁻⁷
Standby conditions	3.7x10 ⁻⁷
Total	5.94x10 ⁻⁷

Safety systems to cope with the design basis- and beyond design basis accidents

The strategy of coping with the design basis accidents is based on using both the active and passive safety systems.

The strategy of coping with the beyond design basis accidents is based on using preferably the passive safety systems.

The following active and passive safety systems are implemented in V-491 design:

Low pressure emergency injection system is designed for boric acid solution supply to the reactor coolant system in case of loss-of-coolant accidents including the break RCS with a maximum DN 850 when the pressure in the system goes below the working parameters of the given low pressure emergency injection system;

High pressure emergency injection system is designed for boric acid solution supply to the reactor coolant system in case of loss-of-coolant accidents that exceed the compensatory capability of

the normal make-up system at the pressure in the reactor coolant system below the working pressure of the high pressure emergency injection system (below 7.9 MPa);

Residual heat removal system is designed for the decay heat removal and reactor plant cooldown during a normal NPP trip, under the conditions of anticipated operational occurrences and under design basis accidents on condition of retaining the primary-side integrity together with the low-pressure emergency injection system;

Emergency core cooling system, passive part is designed for boric acid solution supply with a concentration not less than 16 g/kg at primary pressure below 5.9 MPa in the amount sufficient for reactor core cooling before the low-pressure emergency injection pumps actuate in design-basis loss-of-coolant accidents;

Quick boron injection system is designed for boric acid injection into the pressurizer in case of a primary to secondary leak to reduce the primary pressure and to create the necessary concentration of boric acid in the primary coolant under a BDBA without scram;

Emergency gas removal system is designed to remove the steam-gas mixture out of the RP primary side (reactor, PRZ and SG collectors) and to reduce the primary pressure in order to mitigate the consequences at design basis- and beyond design basis accidents;

Primary overpressure protection system is designed to protect the RP equipment and pipelines from the gauge pressure on the primary side under the design basis conditions of Category 2 – 4 and beyond-design basis accidents due to the operation of the PRZ pilot-operated relief valves installed on the line for steam discharge out of the PRZ steam space into the relief tank;

Secondary overpressure protection system is designed to protect the RP equipment and pipelines from the gauge pressure on the secondary side under the design basis conditions of Category 2 – 4 and beyond-design basis accidents due to the operation of the SG pilot-operated relief valves installed on the steamline sections between the steam generators as far as shut-off electric motor-operated gate valves, considering the advance actuation of BRU-A and reactor trip system;

Passive heat removal system via steam generators is designed for long-time residual heat removal from the core to the ultimate heat sink via the secondary side at beyond design basis accidents. The system of passive heat removal through the steam generators backs up the appropriate active system of heat removal to the ultimate sink in case it is impossible for it to perform its design functions.

Emergency feedwater system is designed to supply the steam generators with feedwater under the conditions of anticipated operational occurrences and design basis accidents when feedwater supply by the standard system and auxiliary systems is impossible;

System of passive heat removal from the containment refers to the engineered safety features for coping with BDBA and is designed for long-time heat removal from containment at beyond design basis accidents;

Main steam line isolation system is designed for quick and reliable steam generator isolation from a leaky section:

- At pipeline breaks downstream of the SGs as far as the turbine stop valves in the pipeline sections that either can be isolated or cannot be isolated from the SG;
- At feedwater pipeline breaks downstream of the SGs as far as the check valves;
- At primary-to-secondary leak;

Double-envelope containment and core catcher are designed to retain the radioactive substances and ionizing radiation within the limits envisaged in the design.

Cooperation with IAEA

INIR Mission to Belarus

The INIR Mission to Belarus was held from 18 to 29 June 2012. The results of the Integrated Nuclear Infrastructure Review (INIR) report available on the IAEA Website ⁶. It reviewed the 19 issues of Phase 1 and Phase 2 identified in the IAEA publication *Milestones in the Development of a National Infrastructure for Nuclear Power*. The mission team consisted of 12 IAEA staff and international experts who conducted interviews and observations over a two week period.

The INIR mission team had concluded that Belarus is on its way to being well-prepared with its infrastructure to support the construction of a nuclear power plant and made a number of recommendations and specific suggestions to assist the national authorities in planning their future activities.

The report indicated that some actions should be taken in the areas of national legislation and regulatory framework, strengthening of the regulatory body, nuclear security and management systems. The report also recognized that Belarus has strong expertise in the areas of radiation protection and environmental monitoring, and good coordination among the national organizations involved in the development of its nuclear power programme.

There has been cooperation with the IAEA in the form of two limited siting missions in 2008 and one EPREV Mission to assess national capabilities in Belarus in October 2010. The national hazard response system has been established based on dedicated emergency and management systems. Available resources (both technical and personal/professional) for response to emergency situations are high in the country because Belarus has a long experience with management of radiological

⁶ [https://www.iaea.org/NuclearPower/Downloadable/News/2013-03-15-NENP/2013-01-23 Approved INIR Report Belarus.pdf](https://www.iaea.org/NuclearPower/Downloadable/News/2013-03-15-NENP/2013-01-23%20Approved%20INIR%20Report%20Belarus.pdf)

consequences after the Chernobyl accident and the special arrangements are reflecting the situation in this area.

Belarus has also been active in the IAEA's Technical Cooperation Programme with national projects in nuclear power infrastructure development, human resource development and NPP staff training programmes, and strengthening the effectiveness of the regulatory authority.

Next IAEA review missions

Republican Unitary Enterprise "Belarusian Nuclear power Plant" – the entity responsible for construction and operation of Belarusian NPP announced that seven IAEA missions yet to examine Belarusian nuclear power plant.

"Belarus intends to welcome seven assessment missions of the International Atomic Energy Agency (IAEA) before the first power-generating unit of the Belarusian nuclear power plant goes online in 2018." The statement was made by Belarusian Deputy Energy Minister Mikhail Mikhadyuk.

An IAEA Integrated Regulatory Review Service (IRRS) is planned to take place in Belarus in October 2016⁷ The official also pointed out that the Belarusian side had asked the IAEA to send a mission to Belarus to evaluate the Site and External Events Design, the so-called SEED mission.

Cooperation with European Union

Since 2013 EU has been supporting the Belarusian nuclear regulatory authority through Instrument for Nuclear Safety Cooperation. The on-going programme includes permanent presence of experts of European Technical Safety Organisations. The objective is to strengthen the capabilities of the Belarus nuclear safety regulator in licensing, regulatory supervision and assessment of the Nuclear power plant under construction, commissioning and trial operation concerning complex and specialised regulatory activities related to nuclear safety.

International Conventions ⁸

Civil Liability for Nuclear Damage - Belarus ratified the 1963 Vienna Convention on Civil Liability for Nuclear Damage on 9 February 1998, and it entered into force on 9 May 1998. Belarus signed the 1997 Protocol to Amend the Vienna Convention on 14 September 1998.

Belarus ratified the 1960 *Convention concerning the Protection of Workers against Ionising Radiation* on 29 July 1969 and it entered into force on the same date.

⁷ <https://gnssn.iaea.org/regnet/irrs/Lists/Calendar/DispForm.aspx?ID=49>

⁸ OECD-NEA study

Belarus ratified the 1963 *Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and under Water* on 16 December 1963.

Belarus acceded to the 1968 *Treaty on the Non-Proliferation of Nuclear Weapons* on 22 July 1993 and it entered into force on the same date.

Belarus acceded to the 1971 *Treaty on the Prohibition of the Emplacement of Nuclear Weapons and other Weapons of Mass Destruction on the Sea Bed and the Ocean Floor and in the Subsoil* thereof on 14 September 1971 and it entered into force on 18 May 1972.

Belarus succeeded to the 1979 *Convention on the Physical Protection of Nuclear Material* on 9 September 1993 with effect from 14 June 1993.

Belarus ratified the 1986 *Convention on Early Notification of a Nuclear Accident* on 26 January 1987 and it entered into force on 26 February 1987.

Belarus ratified the 1986 *Convention on Assistance in Case of a Nuclear Accident or Radiological Emergency* on 26 January 1987 and it entered into force on 26 February 1987.

Belarus acceded to the 1994 *Convention on Nuclear Safety* on 29 October 1998 and it entered into force on 27 January 1999.

Belarus signed the *1996 Comprehensive Nuclear Test Ban Treaty* on 24 September 1996.

Belarus signed the 1997 Joint Convention on the *Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management* on 13 October 1999.

Incident at Belarus Nuclear Power Plant Raises Safety Concerns⁹

An incident occurred on the 10 July at Belarus Nuclear Power Plant as the construction workers preparing to install the reactor pressure vessel failed to secure it properly. According to Associated Press, the vessel "slipped down slowly and touched the ground softly" in the 10 July incident. The reactor was not damaged, Rosatom's deputy director general, Alexander Lokshin said, but Rosatom "stands ready" to replace it with another if that would help restore public confidence in the project

Rosatom subsidiaries OKB Hidropress and Atomstroyexport are inspecting the reactor vessel. The results of the inspection will be sent to the project's customer - the Belarusian Nuclear Power Plant Company - and to Gosatomnadzor, specifically, the Nuclear and Radiation Safety Department of the Belarusian Emergencies Ministry.

⁹ <http://www.world-nuclear-news.org/NN-Belarus-plant-suspended-after-installation-mishap-02081601.html>