Part 4

# DOCUMENTATION FOR THE PURPOSES OF THE TRANSBOUNDARY IMPACT PROCEDURE

## for the project consisting in the construction and operation of the first Nuclear Power Plant in Poland with the capacity of up to 3,750 MWe, on the territory of the following communes: Choczewo or Gniewino and Krokowa

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## Excerpt from Volume II of the EIA Report - Characteristics of the Project and Emission

Language version: EN

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July, 2022

świadomie o atomie
energia jądrowa w Polsce

Polskie Elektrownie Jądrowe sp. z o.o.

**Glossary**

| Term / Abbreviation | Definition |
|---|---|
| ACC | Accumulator |
| ADS | Automatic Depressurization System |
| ALARA | The principle of optimization in radiological protection, which involves reducing exposure to ionizing radiation to a level as low as reasonably achievable |
| ALARP | The principle of radiological protection - minimum, as low as reasonably practicable |
| DBAs | Design basis accidents |
| AP1000 | Generation III/III+ PWR, with advanced safety systems *(Advanced Passive 1000*) |
| ASME | Standards specifying requirements for nuclear power plant equipment with light water reactors *(American Society of Mechanical Engineers*) |
| BAT | Best available techniques/technology |
| BDB | Beyond Design Basis faults |
| BIOZ | Safety and health plan |
| BWR | Boiling Water Reactor |
| CA | Severe accident of a nuclear facility |
| CCS | Component cooling water system |
| CDF | Core damage frequency |
| CDS | Condensate system |
| CMT | Core make-up tank |
| CVS | Chemical and Volume Control System |
| CWS | Circulating water system |
| DB0 | All other faults, where no radiation effects are expected |
| DB1 | Infrequent design basis faults |
| DB2 | Frequent Design basis faults |
| DBL | Low-probability design basis faults |
| Technical Advisor | Jacobs Clean Energy Limited - technical advisor to the Investor |
| AP1000 reactor technology supplier | Westinghouse Electric Company |
| NPP/Nuclear Power Plant | The first Polish Nuclear Power Plant comprising three nuclear power units with AP1000 reactors with the capacity of up to 3,750 MWe, in the territory of the following communes: Choczewo or Gniewino and Krokowa |
| Nuclear Power Plant | A nuclear facility within the meaning of the Atomic Law Act of 29 November 2000 |
| FWS | Feedwater system |
| GDOŚ | General Directorate for Environmental Protection |
| GIOŚ | Chief Inspectorate for Environmental Protection |
| GPZ | Main power supply point |
| HFLC | High frequency, low consequence faults |
| ICRP | International Commission for Radiological Protection |
| ILW | Intermediate level waste |
| IRWST | In-containment refuelling water storage tank |
| IWRST | Nuclear refuelling |
| KSE | National Power System |
| LIC | Local Information Centre |
| LLW | Low-level waste |
| LOOP | Loss of offsite power |

| Term / Abbreviation | Definition |
|---|---|
| LRF / LERF | The frequency index of large releases of radioactive substances into the NPP environment *(Large release frequency* or *Large rarly release Frequency*) |
| LWR | Light Water Reactors |
| IAEA | International Atomic Energy Agency |
| Macroregion | Area with a radius of 300 km around the Boundary of the planned site of the nuclear facility determined in accordance with the guidelines of PAA and IAEA, with due consideration of the geological and seismotectonic conditions of the given area |
| MOLF | Marine Off-loading facility |
| MSS | *Main steam system* |
| NPSOP | New Surface Disposal Facility for Radioactive Waste |
| NRC | U.S. Nuclear Regulatory Commission |
| NSSS | Nuclear steam supply system |
| Site Area | The area within a 5-kilometre distance from the boundaries of the planned site of the nuclear facility, and, in justified cases related to the ground structure of crucial importance for its stability during the construction of the facility and after, the area extended insofar as needed to obtain sufficient data and to assess ground stability |
| Project Area | An area within which the construction and subsequent operations of the NPP are planned |
| OCS | Open cooling water system |
| OECD | Organization for Economic Cooperation and Development |
| FPA | Flood-prone areas |
| ONR | UK Office for Nuclear Regulatory Affairs |
| PAA | President of the State Atomic Energy Agency/State Atomic Energy Agency |
| PCCAWST | Additional auxiliary water supply tank for passive cooling of the safety housing |
| PCCWST | A reservoir used for passive cooling of the safety enclosure (PCS water storage tank) |
| PCS | Passive reactor safety containment cooling system |
| PCSR | Pre-implementation safety report |
| PGA | Peak ground vibration acceleration *(Peak ground acceleration*) |
| PHWR | Pressurized Heavy Water Reactor |
| PMS | Protection and safety monitoring system |
| Decision/GDOŚ Decision | Decision of the General Director for Environmental Protection of 25 May 2016, ref. No.: DOOŚ-OA.4205.1.2015.23) on the determination of the scope of the report on environmental impact |
| PNPP | The Polish Nuclear Power Programme - Resolution No. 141 of the Council of Ministers of 2 October 2020 on updating the multi-annual program called "The Polish Nuclear Power Programme" |
| PRHR | Passive aftercooling system ( *Passive residual heat removal system*) |
| PRHR HX | Passive reactor post-switch heat removal system (English. *Passive residual heat removal*) |
| Project/EJ | Construction and operation of the first Polish Nuclear Power Plant with the capacity of up to 3,750 MWe, on the territory of the following communes: Choczewo or Gniewino and Krokowa |
| PSA | Probabilistic safety assessment, probabilistic safety analysis ( *Probabilistic safety assessment*) |
| PSAR/WRB | Pre-Construction Safety Report |

| Term / Abbreviation | Definition |
|---|---|
| PSE | Polskie Sieci Elektroenergetyczne S.A. |
| PSHA | Probabilistic seismic hazard assessment |
| PWR | Pressurized Water Reactor |
| PXS | Passive reactor core cooling system |
| AOO | Anticipated operational occurrence |
| PZI | Postulated initiating events |
| EIA Report | Report on environmental impact regarding the Project involving the construction and operation of the first Polish Nuclear Power Plant with the capacity of up to 3,750 MWe on the territory of the following communes: Choczewo or Gniewino and Krokowa |
| Site Region | The land within a 30 kilometre distance from the boundaries of the planned location of a nuclear facility |
| RNS | Normal post-switching heat dissipation system ( *Normal residual heat removal system*) |
| RPV | *Reactor pressure vessel* |
| RWP | Extended Design Conditions *(Design extension conditions, DEC*) |
| SBO | Total loss of external AC electrical power *(Station black-out*) |
| SFP | Spent fuel pool. |
| SFS | Spent fuel cooling system |
| SG | Steam generator (*Steam generators*) |
| SGOP | Geological Disposal Facility for Radioactive Waste |
| SUW | Water treatment plant |
| SWS | Service Water System |
| SZ | Complex Sequences |
| TBM | A construction method associated with constructing inflow and discharge channels/pipelines of an open cooling system; Tunnel Boring machine |
| TCS | Closed-loop cooling system for engine room equipment ( *Turbine building closed cooling water system)* |
| TEN-T | Trans-European transport networks of the European Union *(Trans-European Transport Networks*) |
| UDT | Office of Technical Inspection |
| UHS | Ultimate Heat Sink System to air or sea |
| WGS | Radioactive gas waste system |
| WLS | Liquid Radwaste System (LRS) |
| WPJ | Spent nuclear fuel |

## TABLE OF CONTENTS

**Notice:** In the table of contents of this part of the documentation the **blue** colour and page number are used to highlight those chapters, which in whole or in part constitute an excerpt from the EIA Report

# Introduction

The present volume of the EIA Report presents the detailed characteristics and description of the technology of the Project involving the construction and operation of a nuclear power plant consisting of three nuclear power units with AP1000 reactors, with a total capacity of up to 3,750MWe (megawatt electrical) along with infrastructure supporting their operation. A description of the nuclear technology and site development and implementation of the work was prepared based on data obtained from the nuclear technology (reactor) supplier AP1000, in conjunction with the Technical Advisor (Jacobs Clean Energy Limited).

The development of Volume II was based on the assumption that the presented Project characteristics and the analysis of the current state of the environment will serve as a starting point for the determination of the Project's environmental impact, and, as a consequence, for the determination of the optimum conditions for its implementation in the decision on environmental conditions. In view of the above, effort has been made to ensure that Volume II contains information on the Project that is detailed enough to make it possible to grasp its specific features. Thus, the individual phases of the Project have been described in detail, with the description of the construction phase being presented with regard to the three stages that it is divided into, i.e. development stage, construction stage, and commissioning stage (which are distinguished due to the nature of the activities that they involve and due to the formal and legal requirements). This part of the EIA Report presents information that is key for establishing the type, scope, and scale of the Project, as well as its specific features, including:

- description and site of the Project,
- description of nuclear technology, together with characteristics of nuclear power plant facilities, and NPP site arrangement,
- Project implementation schedule together with a projected number of workers involved in the implementation of the Project,
- discussion of the probability of severe accidents, natural disasters, and construction disasters.

Moreover, Volume II also contains information on the demand for natural resources, electric power, chemical materials and products at individual stages of Project implementation, and it discusses the projected emissions in this context, recognising them as an important part of the Project characteristics. This part of the EIA Report also includes the issue of proposed solutions in the context of the requirements arising from the *best available techniques (BAT*), as well as a detailed description of the accompanying infrastructure of the Project, i.e. investments not covered by the application for the decision on environmental conditions, requiring separate administrative decisions.

Additionally, to comply with the Decision of the General Director of Environmental Protection dated May 25, 2016 (No.: DOOŚ - OA.4205.1.2015.23) (Decision, GDOŚ Decision) further addresses external and internal events that may pose a threat to the safety of the nuclear power plant, probabilistic safety analyses, and discusses possible emergency states of the nuclear power plant and the probability of their occurrence, as well as actions that will be taken to limit and mitigate the effects of severe accidents.

The individual issues in Volume II are discussed with regard to the considered site variants and their sub-variants, as well as the phases of the Project. A summary of the considered site variants and sub-variants is also presented in Volume I.

Given the fact that the topics addressed in Volume II are complex, highly specialised issues, every effort has been made to ensure that the information included in the Volume is specific, reliable, and comprehensive, and that it is presented in a transparent and logical manner.

# II.1 Project description

## II.1.1 Responsible entity (Investor)

The special purpose entity PEJ sp. z o.o. (formerly PGE EJ1 sp. z o.o.) is the entity responsible for direct preparation of the investment process, performance of site characterization and environmental studies in order to determine the site of a future nuclear power plant, and obtaining all necessary decisions for construction and possible future operation of the NPP.

## II.1.2 Selection of nuclear technology

The overriding criterion for the selection of technology is to ensure the highest level of nuclear safety and radiological protection, ensuring protection of people and the environment from harmful effects of ionizing radiation, which enables the use of nuclear reactors of Generation III/III+. Moreover, at this time all the planned and implemented commercial nuclear projects involve large, safe, and economic reactors of this generation.

The market offers several main types of generation III/III+ nuclear reactors, which may be divided as follows:

- Pressurized Water Reactors - PWRs. These are tank-type reactors, cooled and moderated with light water, and using low-enriched fuel (3-5% of U-235), which heats water to 300-330 degrees Celsius but prevents it from boiling by maintaining high pressure (over 15 MPa). The steam needed to power the turbines is produced in steam generators, located between two water circuits – the primary (water under high pressure circulates through the reactor core receiving heat) and the secondary (water turns to steam inside the steam generator and is then used to power the turbines). The steam generator allows for heat exchange between the primary and secondary circuit. Nuclear fuel is replaced once the reactor is shut down. Control rods and safety rods used for the start-up and shutdown of the reactor, as well as controlling its power, are inserted from the top of the reactor vessel;
- Boiling Water Reactors (BWR). Tank-type reactors, cooled and moderated with light water, and using low-enriched fuel (3-5% of U-235). Water evaporates inside the reactor (not in a steam generator, as in the pressurised water reactor), which results in the fact that the pressure in the primary circuit does not need to be as high (around 7-8MPa) as in the case of the PWRs. Steam then passes directly to the turbine. For this reason there only is one cooling circuit. Fuel is replaced once the reactor is shut down. Safety and control rods used for the start-up/shutdown of the reactor, as well as for controlling its power levels, are inserted from the bottom of the reactor vessel;
- Pressurized Heavy Water Reactors - PHWRs. Tank-type channel reactors, cooled and moderated with heavy water ($D_2O$), and using fuel based on natural uranium (0.7% of U-235) or low-enriched uranium. As in PWRs, the water circulates in two circuits – primary (heavy water) and secondary (light water). Steam generators function as heat exchangers. Heavy water is a better moderator than light water, therefore there is no need for uranium enrichment, and the fuel can be based on natural or low-enriched uranium. Fuel assemblies are situated in horizontal fuel channels inside the vessel. Fuel assemblies can be replaced in individual channels while the reactor is in operation.

According to the Company Agreement, Polskie Elektrownie Jądrowe sp. z o.o. performs tasks which aim at ensuring energy security of the Republic of Poland by, among others, supporting government administration in activities aimed at:

1) implementation of the Polish Nuclear Power Programme,
2) implementation of the Agreement between the Government of the Republic of Poland and the Government of the United States of America on cooperation to advance the civil nuclear power program and the civil nuclear industry in the Republic of Poland, signed in Upper Marlboro on October 19, 2020, and in Warsaw on October 22, 2020. (Intergovernmental Agreement) [135], including by acting as a Special Purpose Vehicle within the meaning of the Intergovernmental Agreement.

Re 1. The goal of the Polish Nuclear Power Program (PPEJ) [120] is to build 6-9 GWe of nuclear power based on large, proven pressurized water reactors (PWR). The justification for basing PPEJ on PWRs is the fact that PWR units predominate among the nuclear units in operation as well as among the new nuclear units currently under construction or planned for construction. In addition, arguments identified by the PPEJ were also the common knowledge of the technology by the nuclear regulators and the lack of accidents with large releases to the environment in the past operations. According to the PPEJ schedule, the decision on environmental conditions for the first nuclear power plant in Poland should be obtained in 2022.

Re 2. Pursuant to Article 2.4(a) of the Intergovernmental Agreement, the parties, i.e. The Government of the Republic of Poland and the Government of the United States of America shall facilitate, encourage and/or promote the development, construction and financing of the first nuclear power plant in Poland by a Special Purpose Vehicle or Polish and U.S. entities engaged for this purpose. Under Article 4 of the Intergovernmental Agreement, "Poland encourages the Project Company to select a U.S. nuclear reactor design and to engage U.S. entities as the primary nuclear reactor technology provider and prime EPC contractor to the Program, and the United States encourages such participation by U.S. entities, taking into account the strategic importance of the bilateral relationship between the Parties, their shared governmental objectives under this Agreement, and maximizing the efficient and effective contribution of U.S. technical, regulatory, safety and security expertise." In addition, under Article 7 of the Intergovernmental Agreement, the governments of both countries "recognize that the U.S. technical, regulatory, safety and security expertise offered under this Agreement will be most effective if the main nuclear reactor technology vendor and main Engineering, Procurement and Construction (EPC) contractor to the Program are U.S. entitiesalready operating under U.S. regulatory regimes."

With these considerations in mind, this report is based on Westinghouse Electric Company LLC's AP1000 technology, i.e., the only available U.S. technology that meets the PPEJ criteria (proven water-pressure reactors). At the same time, it should be stressed that submission of the report in this form does not mean that the reactor technology of the first nuclear power plant in Poland has been selected, but it constitutes a preparatory stage for implementation of the NPPF and execution of the Intergovernmental Agreement. Advancement of activities leading to obtaining the decision on environmental conditions for the first nuclear power plant in Poland will allow avoiding or limiting deviations from the investment implementation schedule adopted in PPEJ in case the Council of Ministers selects AP1000 technology in the future. The above does not preclude the possibility of using the data collected by the Company to prepare a report based on other technology in the event that the Council of Ministers enters into cooperation on the joint implementation of a nuclear power plant construction project with a country other than the United States of America

# II.2 Description of the NPP technology and infrastructure

## II.2.1 Nuclear power plant description

In each thermal power plant, electricity is generated through the conversion of fuel energy into heat energy, which then generates steam that propels the blades of the electricity generator's turbine. This system is basically the same irrespective of what the source of heat is: burnt coal, gas, or biomass [Figure II.2.1- 1]. The basic difference between a nuclear power plant and other thermal power plants is the source of heat generation - in the case of a nuclear power plant, the heat source is not a fired boiler, but a reactor generating heat as a result of fission of the nuclei of nuclear fuel.

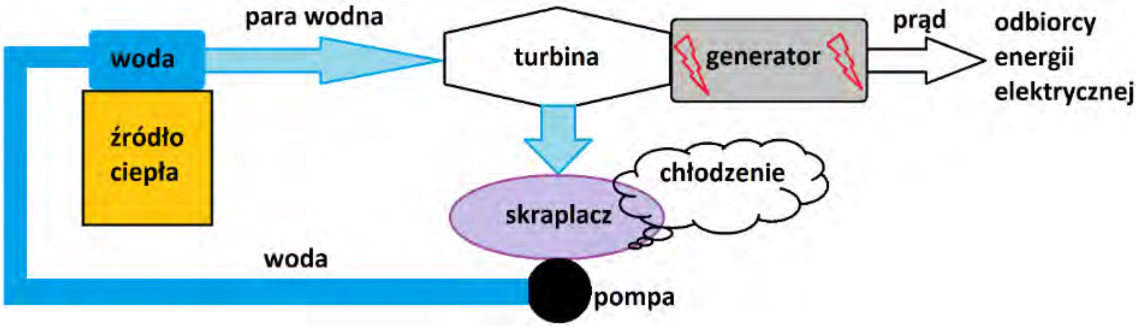


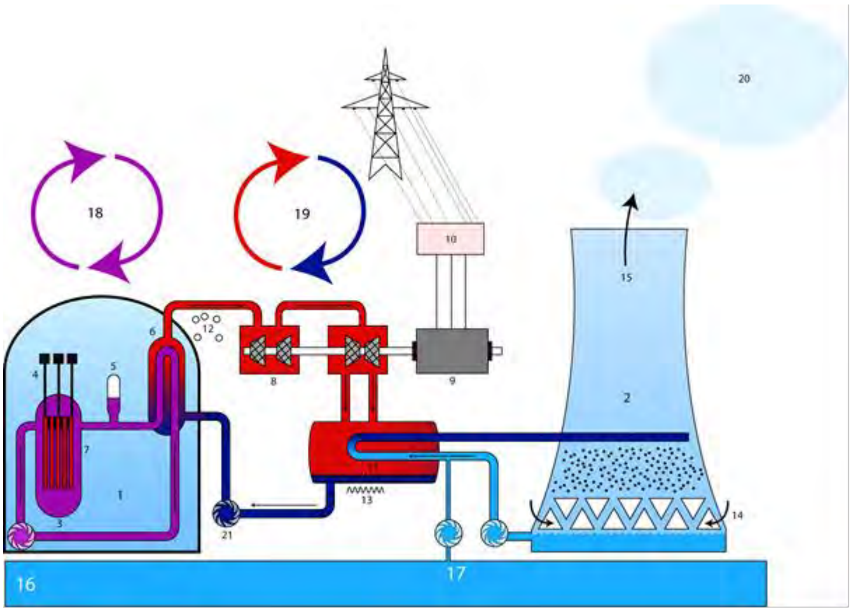

Figure II.2.1- 1 Diagram of thermal power plant operation

| | |
|---|---|
| Woda – Water | Para wodna – Steam |
| Turbina – Turbine | Generator - Generator |
| Prąd – Current | Odbiorcy energii electrycznej – Elctricity consumers |
| Żródło ciepła – Hwat source | Skraplacz – Condenser |
| Chłodzenie – Cooling | Pompa - Pump |

*Source: In-house study*

The technical description of the AP1000 reactor [118] provided the basis for this chapter.

The technological process of generating electricity in a nuclear power unit with a pressurised water reactor is schematically presented in the figure below [Figure II.2.1- 2].




*1. Reactor cooling system, 2. Cooling tower, 3. Reactor, 4. Control rods, 5. Pressuriser, 6. Steam generator, 7. Reactor core, 8. Steam turbine, 9. Generator, 10. Unit transformer, 11. Condenser, 12. Main steam, 13. Condensate, 14. Air, 15. Humid air, 16. The Baltic Sea, 17. Supply of make-up for water losses in the closed cooling system, 18. Primary circuit, 19. Secondary circuit, 20. Vapours, 21. Feedwater pumps.*

Figure II.2.1- 2 Diagram of the operation of a nuclear unit with a pressurised water reactor

*Source: Wikimedia Commons: http://commons.wikimedia.org (accessed 28-09-2021)*

The project involves the construction and operation of a nuclear power plant with three nuclear power units equipped with innovative AP1000 reactors (Advanced Passive 1000) generation III/III+ with passive safety systems, along with plant facilities and systems, common to he entire NPP.

## II.2.1.1 Power unit with the AP1000 reactor

The main facilities and components of a nuclear power unit with the AP1000 reactor are presented in the figure below [Figure II.2.1-3].


| | |
|---|---|
| Obudowa bezpieczeństwa reaktora z budynkiem osłonowym – Containment and shield building<br>Strefa operacji z paliwem jądrowym (w budynku pomocniczym) – Nuclear fuel handling area (in auxiliary building)<br>Budynek pomocniczy – Auxiliary building<br>Budynek maszynowni – Turbine building<br>Budynek zaplecza reaktora – Annex building<br>Budynek odpadów promieniotwórczych – Radwaste building<br>Budynek awaryjnych generatorów dieslowskich – Diesel generator building | 1 – fuel handling area (in the auxiliary building)<br>2 – shield building made of reinforced concrete<br>3 – reactor's [reinforced] steel containment building<br>4 – passive containment cooling water storage tank<br>5 – steam generators<br>6 – reactor coolant pumps<br>7 – reactor pressure vessel<br>8 – integrated head package<br>9 – pressuriser<br>10 – main control room [building]<br>11 – feedwater pumps<br>12 – turbogenerator set |

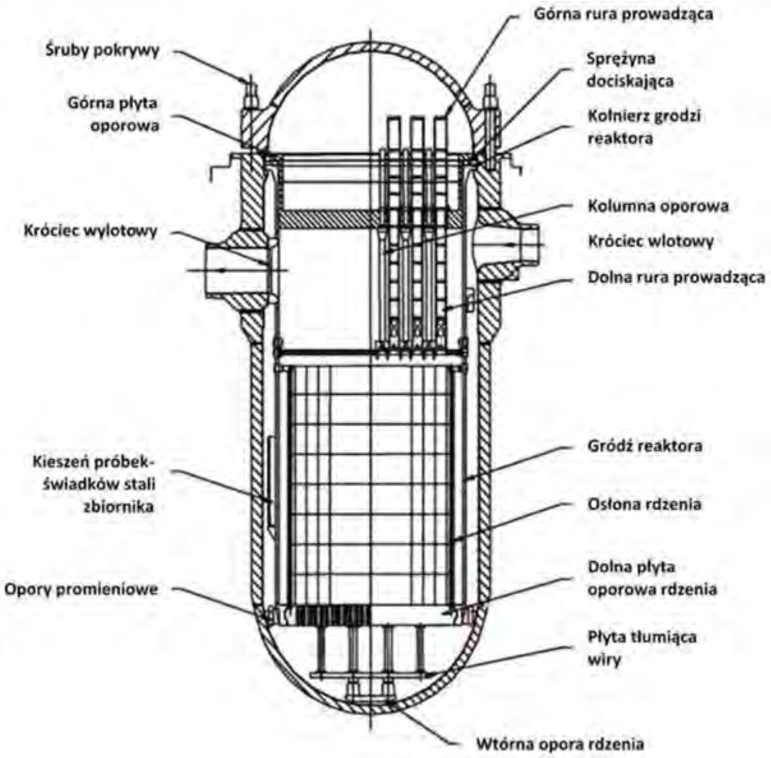
Figure II.2.1- 3 Main structures of a nuclear power unit with the AP1000 reactor (left) and the layout of the main facilities and components of a nuclear power unit with the AP1000 reactor (right)
*Sources: [134], [153]*

### II.2.1.1.1 AP1000 nuclear power reactor

AP1000 (Advanced Passive 1000) is a reactor with inherent safety features and passive safety systems that do not require any action on the part of the operator or external power supply in the event of an accident. It is characterised by a broad use of passive safety features in safety systems, relying on natural phenomena and forces (natural convection, evaporation and condensation, force of gravity, spring forces, pressure of compressed gases). Pumps and fans are not used in its safety systems. Thus, the operation of these systems does not require the operation of auxiliary systems such as: alternating current power supply system, cooling of safety system components (CCS), essential service water system (ESWS), heating, ventilation, and air conditioning system (HVAC). In the event of an accident, the AP1000 *reactor*'s passive safety systems provide heat removal from the reactor core, *containment* cooling, no AC power, and operator activity for 3 days.

Light water is used as the moderator and coolant in the reactor, and the basic fuel is uranium fuel in the form of uranium dioxide ($UO_2$), enriched to 4.8% (in the $^{235}U$ isotope), and refuelling will normally take place every 18 months.

Figure [Figure II.2.1- 4] shows the longitudinal section of the AP1000 reactor.




| | |
|---|---|
| Śruby pokrywy – Closure studs<br>Górna płyta oporowa – Upper suport plate<br>Króciec wylotowy – Core barrel nozzle<br>Kieszeń róbek światków stali zbiornika – Specimen holder<br>Opory promieniowe – Radial supports | Górna rura prowadząca – Upper guide tube<br>Sprężyna dociskająca – Hold down spring<br>Kołnierz grodzi reaktora – Core barrel flange<br>Kolumna oporowa – Support column<br>Króciec wylotowy –Core barrel nozzle<br>Dolna rura prowadząca - Lower guide tube<br>Gródź reaktora – Core barrel<br>Osłona rdzenia – Core shroud<br>Dolna płyta oporowa rdzenia – Lower core suport plate<br>Płyta tłumiąca wiry – Vortex suppression plate<br>Wtórna opora rdzenia – Secondary core support |

Figure II.2.1- 4 Longitudinal section of the AP1000 reactor
*Source: [111]*

The reactor pressure vessel (RPV) contains the reactor core and the reactor internals, especially the core-support structures, and many other components of the technological system.

The reactor core contains 157 fuel assemblies type 17x17 XL Robust (Westinghouse), each of which contains 264 fuel rods in a square array.

The reactor's power is adjusted (controlled) with the help of two systems:

- The **reactor power control system** which coordinates the operation of various core reactivity control mechanisms. This system allows for daily load following.
- **The rod control system** that, together with the reactor power control system, maintains the reactor core power and reactor coolant temperature within set limits during normal transients as described in chapter [Chapter II.5.1], without the need for safety systems.

### II.2.1.1.2 Reactor coolant system

The reactor coolant system (RCS) ensures the transfer of the heat generated in the process of controlled nuclear fission reaction in the reactor core to the steam generators (SGs), from which the generated steam passes through the main steam system (MSS) pipelines to the steam turbine. Steam generators (SGs) are diaphragm heat exchangers in which the heat generated in the reactor, transferred through the reactor cooling circuit (primary circuit, RCS), is transferred to the water of the working circuit (water-steam secondary circuit), resulting in the water boiling, evaporating, and producing saturated steam. Steam generators (SGs) are vertical, and the heat exchange between the primary and secondary part is achieved through the U-shaped tubes of the tube bundle).

The pressuriser is also an important element of the coolant system. It is a device that serves to maintain a constant pressure in the reactor coolant system, compensating changes in the coolant volume associated with the changes in its temperature. Two groups of pressurizer safety valves and relief valves are connected to the upper part of the pressuriser, protecting the reactor coolant system from excessive pressure and ensuring its physical integrity.

All the components of the reactor coolant system are located within the reactor containment.

The other functions of the reactor coolant system are:

- to remove the heat generated in the fuel as a result of the decay of fission products after the shutdown of the reactor (decay heat),
- to transfer the dissolvable neutron absorber (boric acid),
- to serve as a second protective barrier preventing the release of fission products into the environment,
- to slow down and thermalise neutrons (moderator function).

In order to ensure conditions for the normal operation of the core and to protect the core from any damage, appropriate temperature, pressure, and coolant flow intensity are maintained in the reactor coolant system.

The reactor and the reactor coolant system (RCS) are often referred to as the nuclear steam supply system (NSSS).

The reactor coolant system (RCS) is presented in the figure [Figure II.2.1- 5].

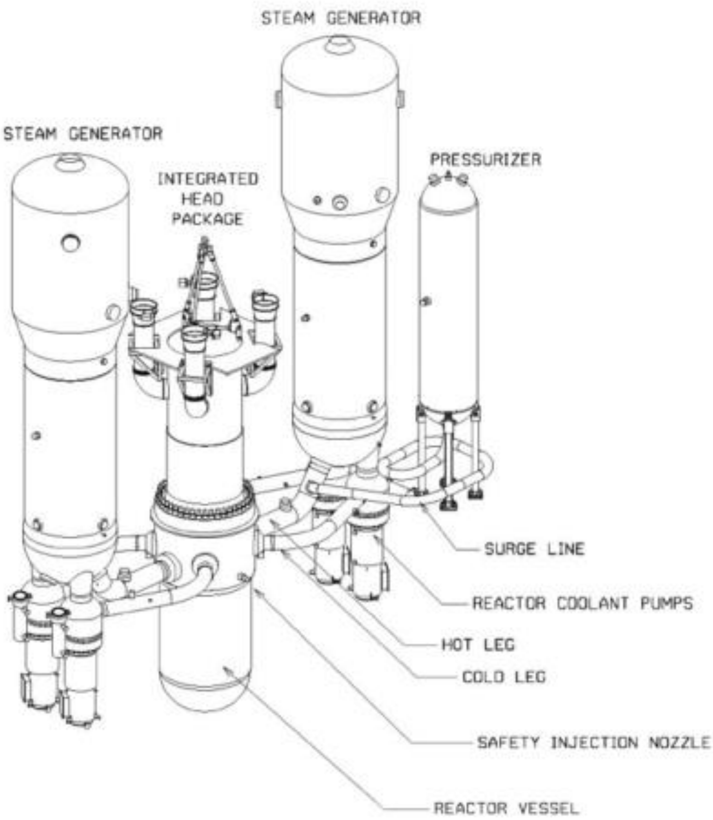



Figure II.2.1- 5 Reactor coolant system (RCS) of the AP1000 reactor
*Source: [8]*

#### II.2.1.1.3 Main systems and auxiliary components of the reactor

Multiple auxiliary systems and equipment and safety systems are connected to the reactor coolant system, especially:

1) Chemical and volume control system (CVS);
2) Normal residual heat removal system (RNS);
3) The passive core cooling system (*PXS*) of the reactor core, in particular the connections to:
    a) core make-up tank (CMT),
    b) accumulators of the passive borated water injection into the reactor (ACC),
    c) valves of the automatic depressurization system (*ADS*) in the reactor coolant system,
    d) heat exchanger of the passive residual heat removal (PRHR HX).

### II.2.1.2 Nuclear safety concept and safety systems of the AP1000 reactor

The general approach to ensuring the safety of a nuclear power plant with the AP1000 reactor involves the use of passive safety systems (no reliance on active systems in accident conditions), which aim to eliminate the need for actions on the part of the operator (instead of automating them) and to reduce to a minimum the number and complexity of operator actions required to control and supervise the safety systems. Thus, the passive safety systems of the AP1000 reactor:

- are dedicated to ensuring safety and not used for normal operation of the unit,
- rely on passive processes only, without the need of using pumps, emergency diesel generators etc.,
- greatly reduce the reliance on operator actions thanks to largely spontaneous (autonomous) processes,
- limit the effects of design failures [Chapter II.11.1.2],
- meet the nuclear safety objectives defined in the regulations.

The active systems in a nuclear power plant are not intended to contain or reduce the effects of an accident, though they reliably perform their functions during normal operation of the power unit, and their activity is not necessary in order to limit the effects of design basis accidents [Chapter II.11.1.2] or to meet the safety objectives.

Advantages of passive systems from the safety standpoint:

- independence from alternate current power supply;
- automatic reaction to accident conditions, which provides a higher level of safety,
- providing long-term safety of the nuclear power plant in accidents conditions without the use of active components (use of the laws of physics only - natural forces),
- greatly improved reliability of the containment - due to its passive cooling,
- in the event of a severe accident - core melt is retained within the reactor vessel,
- large safety margins.

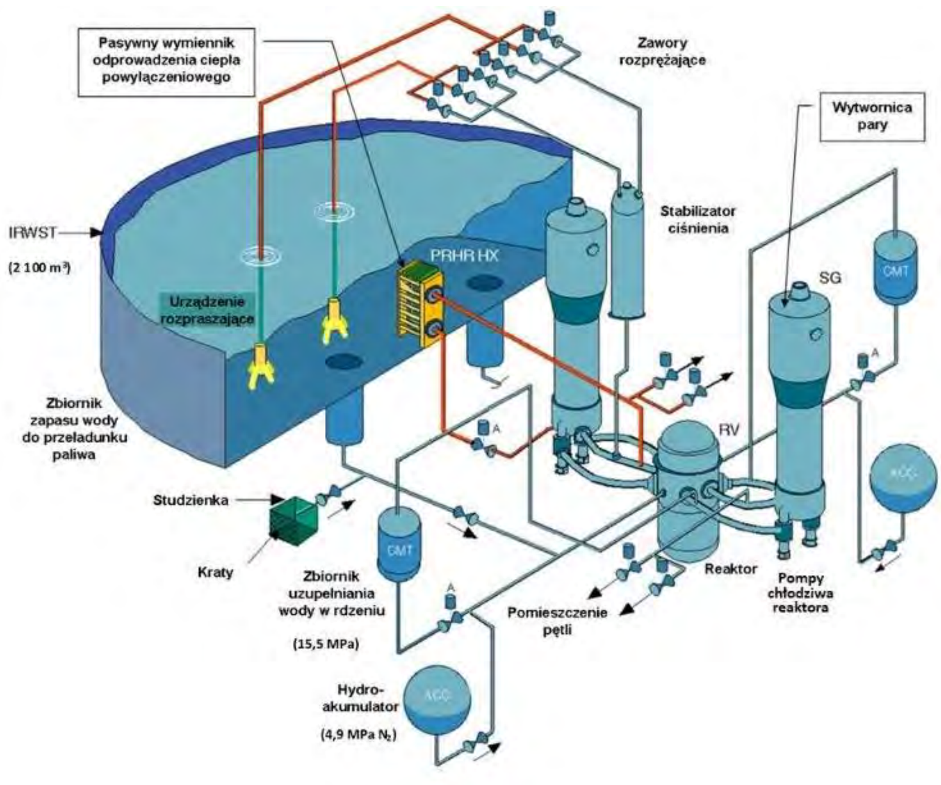
The safety systems of the AP1000 reactor along with a description of how they operate are presented in the part that follows. Descriptions of severe accidents - limiting in terms of the radiation impact of accidents without core melt and severe accidents with core melt, are included in [Chapter II.11.4].

### II.2.1.2.1 Passive core cooling system

A schematic of the passive core cooling system (PXS) of the AP1000 reactor is shown in figure [Figure II.2.1- 6]. The functioning of this system relies on gravity, energy of compressed gas, and natural convection. No alternating current power supply is required, and all the processes take place spontaneously.

In the event of a pressure drop in the reactor coolant system (RCS), a spontaneous "passive safety injection" of water into the reactor occurs:

- first - a high pressure injection: from the core makeup tanks (CMT) containing borated water, driven by pressure difference (between the pipelines connecting the tanks: with the RV direct injection nozzles, and with the RCS hot legs),
- then - an intermediate pressure injection: from the accumulators (ACC), driven by the pressure of the cover gas (nitrogen),
- finally - low-pressure injection: gravity-driven injection of water from the in-containment refuelling water storage tank (IRWST; with storage capacity of 2,100m$^3$) into the reactor.

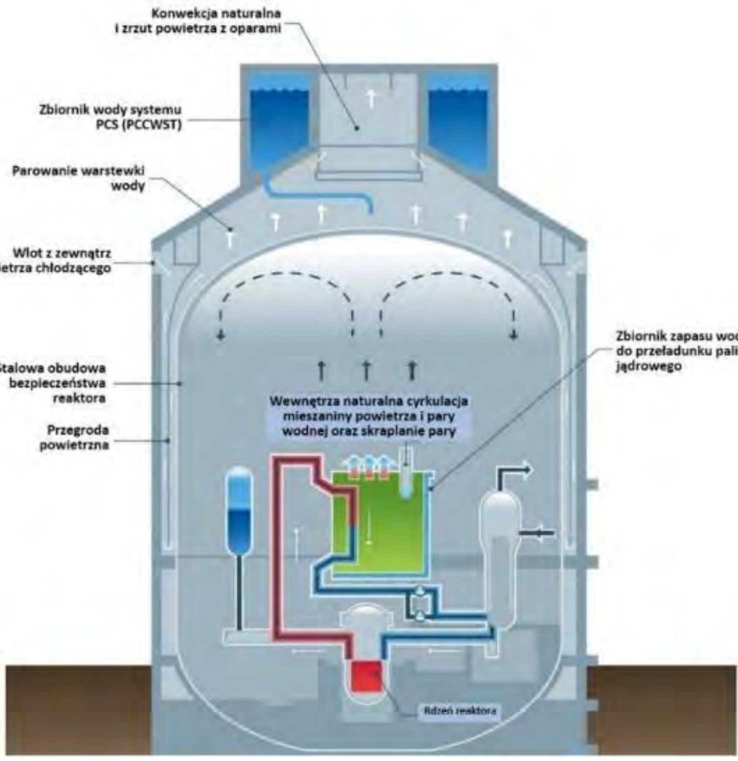



| | |
|---|---|
| Pasywny wymiennik odprowadzania ciepła powyłączeniowego – Passive residua heat removal system<br>Zbiornik zapasu wody do przeładunku paliwa – Refuelling water storage tank<br>Studzienka - Sump<br>Kraty - Screens<br>Zbiornik uzupełniania wody w rdzeniu – Core make-up tank | Hydro-akumulator - Accumulator<br>Zawory rozprężające – Depressurization valves<br>Wytwornica pary – Steam generator<br>Stabilizator ciśnienia - Pressurizer<br>Reaktor - Reactor<br>Pompy chłodziwa reaktora – Cooling water pumps<br>Pomieszczenie pętli – Loop compartment |

Figure II.2.1- 6 Scheme of the passive core cooling system (PXS) of the AP1000 reactor
*Source: In-house study based on [52]*

The passive emergency core cooling system (PXS) of the AP1000 reactor is equipped with **an automatic depressurization system in** the reactor cooling circuit (ADS) to allow long-term supply of water flowing into the reactor from the IRWST tank only under gravity. In the event of a station blackout (SBO) or a failure of both RNS trains, the removal of residual heat from the reactor occurs with the hep of natural convection through the **passive residual heat removal system** (PRHR), the heat exchanger of which (PRHR HX) is immersed in the refuelling water storage tank.

The manner of heat removal from inside the containment building into the environment is presented in the figure [Figure II.2.1- 7]. The removal of heat into the environment (atmosphere) released into the containment building from the passive residual heat removal system occurs through the passive containment cooling system (PCS), described in detail in the latter part of the chapter [Chapter II.2.1.2.3].




(IRWST)

| | |
|---|---|
| Konwekcja naturalna i zrzut powietrza z oparami – Natural Convection air discharge<br>Zbiornik wody systemu PCS – PCCS Gravity drain water tank<br>Parowanie warstwy wody – Water film evaporation<br>Wlot z zewnątrz powietrza chłodzącego – Outside cooling air intake<br>Stalowa obudowa bezpiecznśtwa – Steel containment vessel<br>Przegroda powietrzna – Air baffle | Zbiornik zapasu wody do przeładunku paliwa jądrowego – In-containment refuelling water storage tank<br>Wewnętrzna naturalna recyrkulacja i skraplanie pary – Internal condensation and natural recirculation |

Figure II.2.1- 7 Passive removal of heat from the containment building into the environment
*Source: [9]*

## II.2.1.2.2 Retention of the core melt within the AP1000 reactor vessel

In the event of a severe accident with core melt, the design safety concept of the AP1000 reactor assumes in-vessel melt retention. The types of severe accidents are described in the document AP1000 technology for Poland [118]. Given the constant presence of water, and hence the assurance of cooling, it is impossible for the integrity of the reactor to be compromised, and thus for the core melt to break out of the reactor vessel. This concept is presented in the figure below [Figure II.2.1- 8].

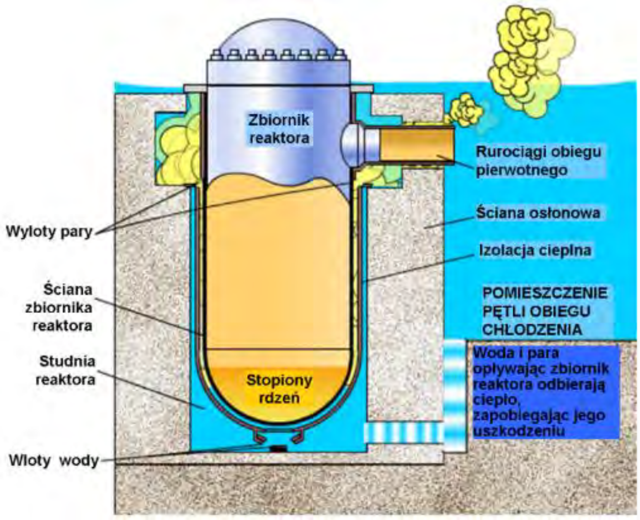



Figure II.2.1- 8 Cooling of the core melt in the AP1000 reactor vessel

| | |
|---|---|
| Zbiornik reaktora – Containment | Rurociąg obiegu pierwotnego – PCS pipeline |
| Wyloty pary – Steam vents | Ściana zbiornia rektora – Containment wall |
| Studnia reaktora – Reactor well | Stopiony rdzeń – Core melt |
| Wloty wody – Water intake | Ściana osłonowa – Shield wall |
| Izolacja cieplna – Thermal shield | Pomieszczenie pętli obiegu chłodzenia – PCCS room |
| Woda i para opływająca zbiornik reaktora obierają ciepło, zapobiegając jego uszkodzeniu – Water and steam flow cooling the containment and preventing its damage. | |

*Source: Own elaboration based on animation https://www.ukap1000application.com/safety_ircd.aspx(Accessed: 12 April 2012)*

The safety of the AP1000 reactor, also during severe accidents, is based on the use of natural forces and phenomena such as gravity, evaporation and natural convection. This prevents the reactor pressure vessel and nuclear fuel from overheating. The heat emitted in the core does not lead to excessive overheating of fuel, but only results in the boiling and evaporation of water. However, when the steam fills the containment building and the heat in the containment building needs to be evacuated into the environment, it also occurs in a passive manner.

### II.2.1.2.3 Containment building with passive cooling

The AP1000 reactor is equipped with a containment building surrounded by a shield building made of reinforced concrete. The design features of the containment building and the shield building are presented in the figure below [Figure II.2.1- 9].

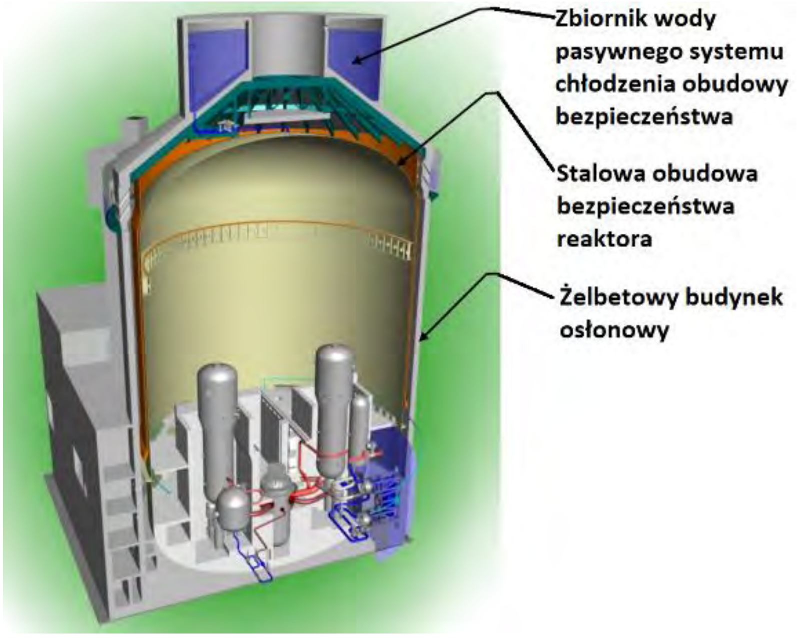



Figure II.2.1- 9 Cross-section of the containment building and shield building of the AP1000 reactor

| | |
|---|---|
| Zbiornik pasywnego systemu chłodzenia obudowy bezpieczeństwa | PCCS water tank |
| Stalowa obudowa bezpieczeństwa reaktora | Steel containment vessel |
| Żelbetowy budynek osłonowy | Concrete shield building |

*Source: [29]*

The internal steel containment ensures high tightness, preventing large uncontrolled releases of radioactive substances into the environment. The reinforced concrete containment building is topped with a type of chimney around which a tank is placed for passive cooling of the containment. *(PCS water storage tank, PCCWST*), holding approximately 3,000m$^3$ of water. The shield building provides the protection of components and systems important to safety against external hazards (especially extreme human-induced hazards such as the impact of large commercial aircraft and external explosions), and provides an additional biological barrier against the systems and components containing radioactive substances, and a shield against direct radiation in accident conditions [Chapter II.11.1.2].

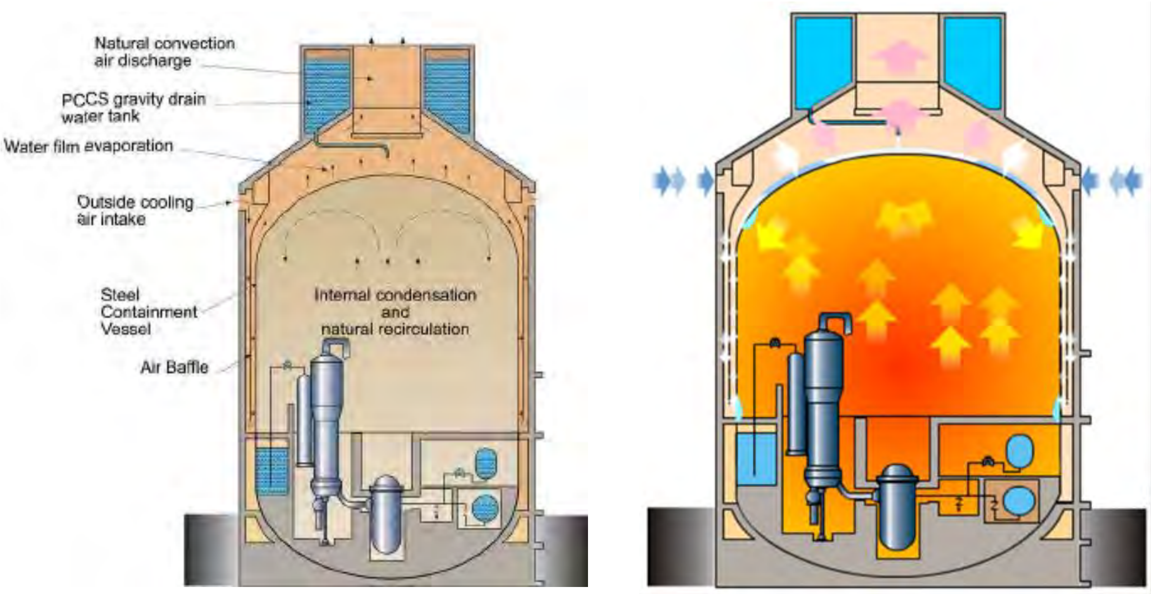



Figure II.2.1- 10 Passive cooling system (PCS) of the AP1000 reactor safety containment: system description (left side) and example of emergency operation (right side)

*Sources: In-house study based on [52] https://www.ukap1000application.com/psrs_pcs.aspx (Accessed: 12 April 2012)*

System (PXS) and System (PCS) provide reactor safety for a period of 72 hours from the initiation of the accident without any operator involvement and in the absence of AC electrical power.

In turn, after 72 hours from the time the accident occurred, the actions needed to ensure the safe removal of heat from the containment building boil down to the supply of makeup of water in the passive containment cooling system water storage tank (PCCWST) located at the top of the shield building. The water tanks located in the power unit and, if needed, other water sources at the NPP site may serve as the source of makeup water.

### II.2.1.3 Cooling of the unit's systems and components during power operation

During the unit's normal power operation, the reactor unit is cooled by the steam turbine's system and its auxiliary components, with the waste heat (from the condensation of the outflow steam in the turbine condenser) discharged into the environment through the cooling water system (CWS). However, many other important auxiliary systems and components (mostly of the reactor) also require cooling. The heat from these components is removed through the component cooling water system (CCS), from which it is removed through the CCS heat exchanger to the service water system (SWS) and evacuated into the environment (i.e. the atmospheric air in the case of a closed system or sea water in the case of an open system).

Apart from the major systems and components (mostly of the reactor) specified above, which are cooled by the CCS, also the auxiliary components of the turbogenerator set have to be cooled -- through the turbine building closed cooling water system (TCS).

It should be underlined that there is no way for the cooling water to contaminate surface water (as well as groundwater) with radioactive substances. This is due to the applied technical solutions.

### II.2.1.4 Cooling of the power unit's systems and components in states other than power operation

#### II.2.1.4.1 Cooling of the power unit's systems and components in normal operational states other than power operation

After the shutdown of a reactor, the heat from the RCS, i.e. residual heat, needs to be evacuated into the environment.

Decay heat which is generated not only in the reactor, but also in the nuclear fuel stored in the spent fuel pool, has the largest share in residual heat due to its amount and the timeline of its generation.

The timeline of the relative changes in decay heat after the shutdown of a reactor is normally determined with the ANSI/ANS 5.1 American standard [6].

The standard indicates that the decay heat power initially drops very quickly (with the decay of short-lived isotopes) - within the first minute after the shutdown of the reactor it drops from around 6.7% to around 2.3% of the thermal power of the reactor (compared to the pre-shutdown power). This drop is then increasingly slower: after an hour from the shutdown of the reactor the decay heat power drops to around 1.2%, and after a day to around 0.5% of the pre-shutdown thermal power of the reactor.

As mentioned above, the applied technical solutions exclude the possibility of the surface water (and groundwater) being contaminated with radioactive substances by the cooling water, also in normal operational states other than power operation [Chapter II.5.1].

## II.2.1.4.2 Cooling in the event of a total loss of AC power supply

The chapter describes the methods of cooling the reactor, the containment building, and the spent fuel pool in the event of a total loss of AC power supply from all sources, i.e. in the event of the so-called station blackout (SBO), which aim to ensure nuclear safety and prevent the aggravation of the plant state to accident conditions.

Station blackout (SBO) is defined as the complete loss of external power supply from the power system, with a concurrent shutdown of the turbogenerator set and no emergency internal AC power supply. An accident of such type does not involve the loss of AC power supply from other power sources (that are not connected permanently) or from batteries (through frequency converters, UPS). Concurrent individual accidents or design basis accidents (e.g. leakage of the pipelines) are not assumed.

**Cooling of the reactor**

In the event of a complete loss of AC power supply from all sources, the reactor will be automatically shut down. Given the fact that the reactor cannot be cooled, as in the case of its planned shutdown [Chapter II.2.1.1.3], the safety valves will open and, as a result, the protection and safety monitoring system (PMS) of the reactor will automatically actuate the passive residual heat removal system (PRHRS). In this way, the residual heat discharged from the reactor via steam from the water supply vessel (IRWST) will be transferred to the reactor containment, from where it will be discharged to the atmosphere via the passive containment cooling system (PCS).

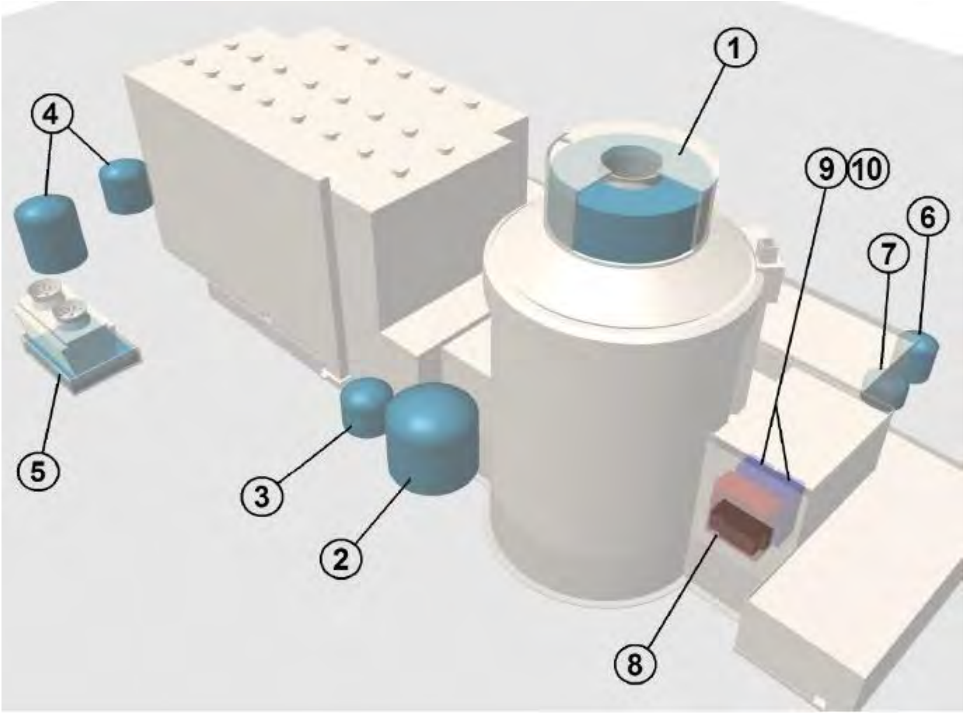
**Cooling of the spent fuel pool**

The spent fuel stored in the spent fuel pool still generates decay heat that needs to be removed in a failsafe manner. The cooling and makeup of water in the spent fuel pool is ensured by the SFS, which cannot perform its functions in the event of the loss of power supply [29].

During the first 72 hours from the complete loss of power supply, the passive safety systems ensure that the fuel assemblies remain under water at all times, preventing them from being damaged.

If AC power is not restored within 72 hours (3 days), a low voltage emergency generator is activated. One of the two PCS pumps powered by the generator will supply water from the passive containment cooling ancillary water storage tank (PCCAWST) to the spent fuel pool [Figure II.2.1- 11]. This storage tank contains a four-day water supply both for the purpose of supply of makeup water to the spent fuel pool, and for the cooling of the containment building.

If AC power supply is not restored within 7 days, the supply of makeup water at a consumption rate of around 8 $m^3$/h will be ensured in order to maintain the required water level in the spent fuel pool. If the PCCAWST is emptied, water from other storage tanks presented in the figure [Figure II.2.1- 11] will be used to maintain the water level in the spent fuel pool. The water will be pumped with the use of the fire protection system pump or with the use of the motor pumps available at the power unit or with the use of fire engines (through the hydrant outlets on the external wall of the building).




***1**- PCS water storage tank (PCCWST); **2** – passive containment cooling ancillary water storage tank (PCCAWST); **3** – condensate tank; **4** – fire protection tanks; **5** – SWS cooling tower basins; **6** – demineralised water tank; **7** – boric acid solution tank; **8** – spent fuel pool; **9** – cask washdown pit; **10** – cask loading pit;*

Figure II.2.1- 11 Location of water tanks within the power unit
*Source: [29]*

### II.2.1.4.3 Cooling of the reactor and the containment building in accident conditions

Under *accident conditions*, the residual heat is discharged from the reactor core, through the system (PXS) and the system (PCS), to the final heat outlet (UHS), which in this case is atmospheric air [118]. The passive core cooling system (PXS) removes the residual heat from the reactor core to the inside of the steel containment vessel, which is cooled from the outside by the passive containment cooling system (PCS). It holds a water supply (around 3,000m³) in the PCS water storage tank (PCCWST) located at the top of the shield building, allowing for the cooling of containment for 72h (3 days) from the accident, without the need for supplying makeup water, power supply or operator actions.

Apart from the PCCWST, at the NPP site there is also an additional (ancillary) passive containment cooling water storage tank (PCCAWST) - with a storage capacity of around 3,500m³, presented in the figure [Figure II.2.1- 11], which ensures the supply of cooling water for additional 4 days. In the absence of AC electrical power, the PCSWST tank make-up pump can be powered by a low voltage emergency generator. If neither of the two emergency power generators can be switched on, the pump may be powered with a mobile or portable power generator with the use of the existing connections.

In the event that the above proves insufficient, in order to ensure cooling of the containment building (after 7 days from the accident), the make-up water in the PCCWST will be supplied with the use of the fire-fighting system motor pump, portable pumps, or with the use of fire engines (using the hydrant outlets on the external wall of the building), from other water storage tanks presented in the figure [Figure II.2.1- 11], the total storage capacity of which exceeds 10,000m³. It is also possible to use the sources of water located at the NPP site (located outside of the area of the power unit in which the accident occurred).

As a result of the above actions, residual heat will be safely discharged from the reactor into the atmosphere, the reactor will remain in a safe shutdown condition, (Chapter II.5.1) and its structural integrity and the functionality of the containment building will be preserved, thus reducing the radiological impact of the nuclear plant on the environment to a level acceptable in accident conditions.

## II.2.1.5 Other important installations/systems

## II.2.1.5.1 Description of electric power generation porcess

### II.2.1.5.1.1 General description of the unit's operation

During normal operation of a nuclear power unit, the heat generated in the reactor is transferred from the reactor coolant system, with the use of two steam generators, and converted into electricity in the turbogenerator set with the help of the steam and power conversion system, consisting of the following main components/systems:

- steam generators, SGs;
- feedwater system (FWS), and condensate system (CDS);
- main steam system;
- turbogenerator;
- condenser,
- circulating water system, CWS (including ST condenser and turbo set auxiliary equipment)

In nuclear power plants with pressurised water reactors, of which the AP1000 reactor is an example, the reactor coolant system is normally called the "primary circuit", while the turbine's water-steam working circuit (which consists of: feedwater and condensate systems, secondary part of the steam generators, main steam system, turbine, and condenser) is referred to as the "secondary circuit".

The technological process of electricity generation in a nuclear power unit with a water-pressure reactor is schematically shown in the figure [Figure II.2.1- 2].

As part of Project implementation, three sub-variants are considered for the condenser cooling system in Variant 1 - Lubiatowo - Kopalino site, and two sub-variants for Variant 2 - Żarnowiec site. A detailed description of all the cooling subvariants is presented in [Chapter II.2.1.5.1.3].

In operational states, a small amount of heat is also transferred from the reactor auxiliary components and other facilities and components of the nuclear island through the closed component cooling water system (CCS). The heat is discharged to the ultimate heat sink - air or sea (depending on the technical sub-variant) - through the service water system.

At this stage of the project, various options are being considered to reduce the amount of thermal energy emitted to the atmosphere or cooling water receiver, e.g. operation of the NPP in cogeneration (which will involve a reduced amount of electricity generation by the NPP). The technical details and feasibility of operating a NPP in cogeneration can be analysed in detail during the building permit design preparation stage with the involvement of the nuclear technology vendor and taking into account the nuclear facility safety requirements.

### II.2.1.5.1.2 Steam and energy conversion system

### II.2.1.5.1.3 Cooling water system

Several cooling possibilities (sub-variants) are being considered. Irrespective of the method of heat removal, the remaining part of the system, including the condenser, is identical. The ultimate recipient of heat, in turn, is the environment, i.e. sea water (in the case of an open cooling system) or the air passing through the cooling tower (in the case of a closed cooling system).

Apart from the turbine condenser, in the power plant there are also other operating components that generate heat that has to be discharged into the environment (through the turbine building closed cooling system (TCS) and the component cooling water system (CCS).

Two site variants are being considered for the implementation of the Project (Variant 1 – the Lubiatowo - Kopalino site and Variant 2 - Żarnowiec site) as well as the following cooling system sub-variants:

a) open system (only Variant 1 - location Lubiatowo - Kopalino) - sub-variant 1A;

b) closed cooling system (for both site variants) in two sub-variants:

- cooling tower, natural draft evaporation tower using sea water, and an evaporation cooling tower using desalinated sea water for the service water system (SWS) - sub-variants 1B and 2A;
- cooling tower, natural draft evaporation tower using desalinated sea water, and an evaporation cooling tower using desalinated sea water for the service water system (SWS) - sub-variants 1C and 2B.

The analyses carried out indicated that the optimal technical solution in a closed cooling system would be to use cooling towers with natural draught. In terms of the types of cooling considered, it was decided to abandon the use of mechanical draft coolers and hybrid wet-dry coolers with fan-assisted or fan-forced drafts. The decision was influenced by three factors. The first is the unlimited availability of water, through the direct use of seawater or desalinated seawater to supplement the cooling circuits (thus eliminating hybrid cooling towers). The second aspect is the expected low failure rate and long life of the coolers (hybrid and mechanical draught coolers have been eliminated). The third factor is no limit to the height of coolers at sites (hybrid and mechanical draught coolers have been eliminated).

**Open cooling system using seawater (sub-variant 1A)**

In the open cooling system: the condensers, the turbine building closed cooling system (TCS), and the component cooling water system (CCS) will be cooled with sea water. The distribution of sea water for the purpose of conventional island cooling (i.e. condensers and components of the turbine building) as well as for the component cooling water system (CCS) will take place in the inflow basin (facility No. 72 - in NPP site general arrangements [Appendix II.2.4-3]). The water in this basin is collected gravitationally, directly from the sea, through a system of channels/pipelines, and then filtered and extracted by two groups of pumps in the direction of the condenser and components of the turbine building, and in the direction of the exchangers of the component cooling system [CCS] (pumping station - facility No. 76 [Appendix II.2.4-3]). After passing through the turbine condenser, heat exchangers of the turbine building closed cooling system, and heat exchangers of the component cooling system (CCS), the water is directed to the outflow basin (facility No. 77 [Appendix II.2.4-3]), from which it returns to the sea due to gravity.

**Closed cooling system using sea water (sub-variants: 1B, 2A)**

The closed cooling system will include a cooling tower with seawater as make-up water and two fan cooling towers (facilities Nos 5.1 and 5.2 [Appendix II.2.4-3] and [Appendix II.2.4-6], operating in the 2x100% system), supplied with desalinated seawater. The first circuit will cool the heat exchanger of the turbine building closed cooling system (TCS) and the turbine condenser (i.e. in the cooling tower circuit).

The second cooling system/circuit independent of the first one will be the system removing heat from the closed component cooling system (CCS), i.e. the service water system (SWS), which will use desalinated sea water.

**Closed cooling system using desalinated sea water (sub-variants 1C and 2B)**

Two circuits with separate cooling towers will be employed within the discussed sub-variant. The first circuit (cooling tower) will cool the heat exchanger of the turbine building closed cooling system (TCS) and the turbine condenser (i.e. in the cooling tower circuit).

The second cooling circuit independent of the first one (cooling towers - facilities Nos. 5.1 and 5.2 [Appendix II.2.4-3] and [Appendix II.2.4-6], operating in configuration 2x100%), will be the system removing heat from the closed component cooling system (CCS), i.e. the service water system (SWS).

The two cooling systems in this technical sub-variant will be supplied with desalinated sea water.

#### II.2.1.5.1.4 Selected auxiliary systems

**Water treatment system**

Irrespective of the technical sub-variant, sea water will be mechanically filtered before being used in the process.

The technological setup of the desalination plant is the same irrespective of the technical sub-variant – it is based on reverse osmosis. The differences between the technical sub-variants only concern the efficiency of the desalination plant. The brine generated during desalination will be discharged into the sea.

It is assumed that reverse osmosis and electrodeionization systems will be used to produce demineralized water. This [demin] water will be used in the technological processes of the NPP outside of the cooling circuits, and the concentrated solution (sea salt and other ions of the elements dissolved in sea water) generated during demineralization will also be discharged into the sea.

Water treatment systems will be optimized at the draft building permit design stage.

**Auxiliary boiler house**

The facility will be equipped with an auxiliary boiler (one for the entire NPP), fired with light oil, generating auxiliary steam and/or heating water. Its maximum (rated) thermal input will be lower than 50MW. If needed, it will be used to supplement or replace the electric steam generators located in each turbine hall of a nuclear unit.

**Compressor room**

The nuclear power plant will be equipped with a compressed air production system. The system will consist of compressors, filtering and drying equipment, as well as compressed air tanks.

### II.2.1.5.2 Power evacuation from the unit and main electrical system of the unit

Electricity from the medium-voltage synchronous generator (at the 20-30kV level) is transferred, individually from each nuclear unit, to the unit transformer increasing the voltage to 400kV. The electricity will then flow from the unit transformer to the unit's electrical substation, from which it is sent to the National Power System [KSE].

Beyond the unit's transformer, where the voltage will be 400kV, there will be two cable lines leading to the switchyard in the NPP area:

- first cable line – primary, will be the main power evacuation line,
- second cable line – secondary, its objective will be to ensure NPP safety in the event of an emergency or planned shutdown of the primary cable line.

The switchyard, located at the NPP site and marked as facility No. 25 [Appendix II.2.4-3]), in the site general arrangement, is a power connection node, in which the lines from unit transformers of all nuclear units intersect. Power will be transmitted from the switchyard with the use of three overhead 400kV cable lines, constructed as part of the associated infrastructure, which is described in detail in the latter part of Volume II [Chapter II.12].

A very important component of the unit's electrical system is its general purpose (house load) power supply system, which is based on the standby transformer.

During normal operation of the NPP, the standby transformer is powered by the unit's generator and it supplies power to auxiliaries busbars, to which all the power supply circuits at the power plant site are connected.

## II.2.1.5.3 Description of safety systems and installations

### II.2.1.5.3.1 Backup electric power supply - external grid and emergency generators

**Backup power supply from the grid**

One of the extra high voltage power lines connecting the NPP unit with the NPS [KSE] will serve as the unit's backup power supply. Moreover, two independent high voltage power lines will be connected to the NPP in order to power the backup transformers. Another measure employed to secure power supply to the NPP will be the use of two independent high voltage 110kV cable lines connected to the NPP from the distribution network.

**Emergency power supply**

Medium-voltage backup power generators (a total of 6 in the NPP) will be connected to the unit's general purpose busbars, two per each unit of the NPP, with each of the generators having a capacity of 5,200kWe (12.8MW in fuel).

These generators are adapted to continuous operation (fuel can be refilled during their operation), but it was assumed that in case of a power failure on the side of the 400 kVPower System, a power failure on the side of the 110 kV line (2 lines), as well as the impossibility of power supply from another NPP unit, these generators will operate for up to two days. The emergency generators are 100-percent, which means that a single generator is sufficient as backup power supply for auxiliary systems of the nuclear unit. Additionally, 6 smaller low-voltage emergency power generators (two per nuclear unit) with a capacity of around 80kW each will be installed (thermal efficiency around 40%, electrical efficiency 95%). Auxiliary generators are located in the Reactor facility building (annex building) – facility No. 6 [Appendix II.2.4-3] in Site General Arrangement (SGA) of the NPP.

### II.2.1.5.3.2 Fire protection measures

Non-combustible and fire-resistant materials will be used in the construction of all NPP facilities. The distances between the buildings will comply with the relevant, current Polish fire protection regulations. Fire roads will guarantee unimpeded access to the facilities in the event of fire-fighting. By the same token, an appropriate number of access gates to the NPP site and the necessary maneuvering areas for the fire brigades are considered. Additionally, in order to protect the NPP against unwanted fire events originating offsite, a firebreak will be established around the NPP fence.

The NPP site will have the following measures: water supply system for fire-fighting purposes (equipped with internal and external fire hydrants), lightning protection systems, emergency lighting systems, fire detection and alarm systems, evacuation and warning signs, and manual fire extinguishing equipment.

The comprehensive fire protection system will cover all the components that may pose a fire hazard. This will be a monitoring system and automatic fire extinguishing installations. Fire protection will cover all the facilities and premises: reactor buildings, turbine buildings, control stations, electrical components (cable ducts, switchyards, control rooms), premises of the administrative buildings, workshops, warehouses, and others in the case of which the provision of fire protection equipment is required by relevant regulations.

The power plant will be equipped with fire extinguishing systems and equipment in accordance with the current norms and provisions of the law. Some facilities, such as the turbine building or reactor containment, will be continuously monitored for the presence of explosive gases. Venting system will prevent the occurrence of explosive atmosphere.

There will be an on-site fire service at the NPP site, which, if needed, will take action before the State Fire Service arrives. The on-site fire service will be equipped with heavy fire extinguishing equipment and chemical and radio-chemical rescue kits.

### II.2.1.5.3.3 Other protective measures

The NPP will be equipped with traditional protective elements and systems, including valves, barriers, detection and alarm systems, and protection systems of mechanical and electrical components. Additionally, the components will be held in reserve and equipped with protective measures in emergency situations, such as: power supply failure, lack of water, compressed air, failure of the main equipment, or atmospheric discharges.

The integrated monitoring and surveillance system installed in the power plant will ensure continuous surveillance, security, and alarms. The monitoring of all technological processes will be ensured. The system will also monitor air quality, the quality and quantity of water, and emission of pollutants. The system will be controlled from units' control rooms.

## II.2.4 Description of nuclear power plant facilities and their location

### II.2.4.1 NPP site general arrangement

**NPP site general arrangements for the operational phase**, covering the land and marine part, present the locations of facilities and key installations of all three NPP units - including conventional facilities, nuclear infrastructure components, Balance of Plant, as well as technical infrastructure components located onsite and offsite. They also present the channels/pipelines of the cooling system (on their planned routes) constructed on the land and marine parts. Moreover, the said site general arrangements contain information about ground elevation, the location of the underground technological ducts, the location of the fencing (along with gates) and the parking lot, the locations of the roads at the NPP site and their connection to the external road infrastructure, as well as the route of the railway line. Each facility has its own number in the site general arrangement, and its name, function, equipment, and structure are described in the final part of the appendices [Appendix II.2.4-3] and [Appendix II.2.4-6]. The nomenclature adopted in the drawings in the abovementioned site general arrangements and the numbering of the NPP facilities are used consistently in the present EIA Report.

#### II.2.4.1.1 Variant 1 – Lubiatowo – Kopalino site

In the analysed site variant, the Project Area, and thus also the location of all the NPP facilities, will be concentrated in the coastal belt of the Baltic Sea (an area of around 688ha) and in the sea (an area of around 1,880 ha).

#### II.2.4.1.2 Variant 2 – Żarnowiec site

In the analysed site variant, the Project Area has an irregular, elongated shape and it extends southward from the sea for around 10km. The land part area is approx. 464 ha, and the marine part area is approx. 463 ha.

# II.3 Comparison of the proposed solution with the best available technique (BAT)

According to the Regulation of the Minister of the Environment of 27 August 2014 on types of installations that may cause significant pollution of individual natural elements or the environment as a whole, a nuclear power plant (NPP) is not considered an installation required to obtain an integrated permit. No BAT reference document (BREF), which describes technologies applied in the nuclear power sector, current emission and consumption levels, and technologies considered best in the sector, has been developed for the NPP, either. The human safety and environmental protection is ensured by the application of regulations dedicated especially to this sector. They concern primarily nuclear safety and radiological protection issues, that is, first of all protection of humans and the environment against the radiological impact associated with the electricity generation using nuclear fuel.

Under the Treaty regarding the European Atomic Energy Community (EURATOM), the European Community was entrusted with a task to establish uniform safety standards to protect the health of workers and of the general public in all the Member States against the exposure to ionising radiation (Council Directive 2013/59/Euratom laying down basic safety standards for protection of the health of workers and the general public against the dangers arising from ionising radiation. Official Journal of the European Communities). In 1996, the European Council issued a directive which laid down basic safety standards for protection of health of workers and the general public against the exposure to ionising radiation. The directive took into account the recommendations issued by the International Commission on Radiological Protection (ICRP). The latest ICRP recommendations (The 2007 Recommendations of the International Commission on Radiological Protection. ICRP Publication 103. Annals of the ICRP) regarding the practices involving radioactive substances, provide for the following principles:

- justification of the application,
- optimisation of radiological protection (the basic international principle of radiological protection, ALARA [As Low As Reasonably Achievable], known as the optimisation principle in Poland),
- application of individual doses that do not exceed dose limits or dose constraints.

Optimisation is a process in which the operator selects a technology or management option which bests meets the full scope of appropriate objectives regarding health, safety, environment and protection, with economic and societal factors being taken into account. As regards the optimisation, it is stated that "*with respect to each specific source within the practice, the magnitude of individual doses, number of people exposed and the likelihood of incurring exposures, where these are not certain to be received, should be kept as low as reasonably achievable, taking economic and societal factors into account*." As regards the impact related to the ionising radiation, we refer to optimisation of radiological protection, which is widely known in the world as the ALARA principle (As Low As Reasonably Achievable) or ALARP principle (As Low As Reasonably Practicable).

In Poland, any activity related to a design, construction and operation of a nuclear power plant is governed by the Atomic Law Act [147] along with implementing acts. As mentioned above, the ALARA principle in Polish law is known as the optimisation principle.

At the same time, pursuant to the Environmental Protection Law (EPL) Act, the technology applied in the newly commissioned installations should meet the requirements set out in Article 143 of the said Act. The comparison of the technology to be applied in the NPP installation with the requirements of Article 143 is discussed below:

- Use of substances with low hazard potential

  The proposed technology of power generation is based on the use of nuclear fuel, namely the uranium oxide, which is a substance of a high hazard potential due to its radioactivity. The hazard arising from this application is contained by reducing the exposure to radiation to the level as low as reasonably achievable, taking economic and societal factors into account - in line with the aforesaid optimisation principle.

Other chemical substances will also be applied on the NPP site, but their type, concentration and application method will be determined and assessed at the stage of design works.

- Effective power generation and use

  The installation planned is to generate power. One of the crucial assumptions of the project is an effective use of power for house load needs which is directly translated into the viability/profitability of investment. Furthermore, the constant technological progress in the nuclear power sector enables an ongoing improvement of parameters of the operation of nuclear reactors and efficiency of the entire installation for power generation. Technological improvements used enable for example reaching higher levels of fuel conversion and burnup. The applied technology with the AP1000 reactor is the proven latest generation III+ which should result in the optimal power generation.

- Ensuring the rational use of water and other resources, materials and fuels

  The consumption of water in installations on the NPP site will be constantly monitored and whenever possible [without compromising the nuclear safety], the water consumption will be minimised. Raw materials for production will be used in quantities required by the technology regime.

- The use of zero-waste and low-waste technologies as well as options of recovery of the waste generated

  The correct management of resources and materials will prevent generation of excessive quantities of waste. Quantitative and qualitative records of waste generated, including radioactive waste and spent nuclear fuel, will be kept. All waste will be collected selectively and transferred primarily for recovery (whenever possible). An appropriate waste management hierarchy will be applied. As for the spent fuel, the Polish Nuclear Power Programme (PPEJ) does not provide for its processing and final disposal in a deep repository, to take place at the end of the assumed life cycle of the nuclear power plant.

- Type, range and magnitude of emissions

  The planned project involves the following emissions: gaseous and particulate substances (including radioactive) introduced into air; noise, waste heat into the air and water, industrial wastewater and waste, including emissions of liquid radioactive substances. The magnitude and range of the impact of those emissions are described in this Report. The emissions will not result in either exceeding environmental standards or any exposure of people and the environment to radiation to an unacceptable level.

  In order to control the emissions, that is, to monitor them and reduce their magnitude, a system of integrated management of the NPP operations will be implemented.

- Use of comparable processes and methods which have been effectively applied on an industrial scale

  Ensuring a high level of nuclear safety and radiological protection that would guarantee that the people and the environment are protected against the harmful effects of ionising radiation, underpins the ultimate selection of technical solutions available on the market. Out of the structures considered, based on a pressurized water reactor (PWR) solution, nuclear power plants with a nuclear unit in the AP1000 technology by Westinghouse, stand out for their very high level of safety and functionality. They are also characterised by high efficiency ratio. Currently, the PWR technology is the basis for the majority of nuclear power plants operating worldwide. Out of all the generation III/III+ PWR reactors available on the market, indeed only AP1000 is equipped in the emergency core cooling system which operates fully on the passive safety principle. The basic principle is the use of technical solutions based on natural physical phenomena, such as the coolant circulation, and making the safety system independent of the [availability of] power supply.

- Scientific and technical progress

  The technology discussed in the study is one of the most modern ones in the world, which results from the scientific and technical progress in this scope.

In the EPL Act, Best Available Techniques are defined as the most effective and advanced level of technology and methods for carrying out an activity. Where:

- “Technique/technology" is both the technology used in the installation and the manner in which the installation was designed, constructed, operated, and decommissioned,
- “available techniques/technologies” are those with a degree of development that ensures that they can be practically applied in industry, taking into account the economic and technical conditions and the balance of investment costs and environmental benefits obtained through their implementation,
- “best technologies” are the most effective techniques in protecting the environment as a whole.

In the determination what is BAT, the following are taken into account:

1. comparable periods, facilities or methods, which have been successfully tested,
2. technological progress and changes in the scientific knowledge and understanding,
3. economic viability of such technologies.

It follows that BAT will change over time in the light of technological progress, economic and social factors and changes in scientific understanding.

The detailed identification and application of BAT solutions will be a necessary task to be carried out at a later stage of the project, i.e. In the procedure for reassessing the environmental impact of the Project.

# II.5 Operational phase

## II.5.4 Inspections and repairs

In the operational phase, the technical condition will be controlled, tested, measured and monitored, chiefly with regard to the safety of the structures, systems, and components. Furthermore, as part of the normal operation, repair and maintenance works will be performed as part of the fuel campaign during the shutdown of a given unit.

An essential element is planning the unit outages (shutdown states) for the period of refuelling and repairs (routine and interim repairs, and overhaul), which is related to the requirements concerning intervals and scopes of the in-service inspection and Operation & Maintenance (O&M) tests set out in the regulation of the Minister of Economic Development on technical conditions for technical inspection of technical equipment or equipment subject to technical inspection in a nuclear power plant [88] and in the relevant nuclear technical standards. They will be conducted based on a plan for ensuring safe operation of nuclear power plant equipment, the scope of which is defined in §5 item 2 of the above mentioned regulation.

Polish legal regulations in force do not specify in detail the requirements for testing, examination, inspection, and repair and replacement during the operation of nuclear power plant equipment. In connection with the above, it has been assumed that they will be carried out according to the ASME (American Society of Mechanical Engineers) standards:

- ASME Boiler and Pressure Vessel Code. An International Code. Section XI: Rules for In-service Inspection of Nuclear Facility Components. Division 1 – Rules for Light-Water Nuclear Power Plant Components;
- ASME OM-2020: Operation and Maintenance of Nuclear Power Plants.

The requirements laid down in those standards are essential for determining the repair cycles during which an in-service inspection of pressure equipment is conducted.

The first of the ASME standards listed above includes detailed requirements regarding the examination, in-service testing and inspection, and repairs and replacement during the operation of pressure equipment of light-water reactor nuclear power plants. The standard determines the obligatory programme of the periodical examination, in-service testing and inspection in order to demonstrate the adequate level of safety. The standard also defines methods of non-destructive testing and defects characteristics.

According to the first ASME standard, in nuclear power plants with light-water reactors (LWR), inspections of pressure components are carried out at ten-year intervals (which is also consistent with the EUR requirements [33]). Each inspection interval is divided into three inspection periods. Typically, the inspections take place every: 3, 4, and 3 calendar years. Given that inspections of the technical condition of the pressure components are possible only during the unit outage, the inspection periods actually determine the interim repair cycles. At the end of the interval, i.e., every ten years, a repair is carried out along with an inspection of the main components of the nuclear steam generation system, including the reactor (combined with the removal of the entire core) - overhaul.

As at the EIA Report date, the duration of specific maintenance and repair intervals cannot be precisely estimated yet. Such intervals/periods will be specified in the *NPP Equipment Inspection and Technical Testing Plan* to be developed and agreed upon with the Office of Technical Inspection (UDT) and the PAA. For the purposes of this study, it has been assumed, in line with the assumption adopted above for the duration of refueling for each fuel campaign, that the duration of routine repairs will be one month, and that routine repairs will be performed immediately before the refueling. It has been assumed that interim repairs will last two months, while overhauls which take place every ten years - three months.

The second standard - ASME OM-2020: Operation and Maintenance of Nuclear Power Plants lays down requirements for pre-operational and operational tests for certain components of nuclear power plants with light water reactors:

a) pumps and fittings which are required to perform specific safety functions during:
   - shutting down the reactor to the safe state,
   - maintaining the reactor safe shutdown state, or
   - mitigating the effects of accidents;

b) depressurization components protecting systems or their parts that perform one or more of the three functions enumerated in item a),

c) dynamic arresters (shock absorbers) used in the systems that perform one or more of the three functions enumerated in item a).

The required frequency of such in-service testing and examinations (for various components) is: every three months (in-service testing of pumps and fittings), every two years, every five years and every ten years; therefore they can be fitted into intervals and periods of inspection of the technical condition of the components. In-service testing and examinations to be conducted every three months do not require a unit outage.

In addition, the following will be performed:

- Periodical in-service testing of medium and low-voltage emergency generators;
- Periodical, i.e. once a year after each repair, in-service testing of the handling equipment (UTB).

Types of technical components or components that can pose a hazard for human life or health, and property and environment, will be subject to technical inspection according to the regulation of the Council of Ministers on types of nuclear power plant technical components subject to technical inspection [104].

For the last 70 months of the nuclear power unit operation (out of the 60-year period), it was assumed that the following will be conducted:

- 2 routine repairs;
- 1 interim repair;
- 3 refuelling processes.

Irrespective of the above, under Article 62 of the Construction Law Act [150], during the lifetime of the NPP facilities, permanent supervision of the technical condition of buildings, and the technical condition of all the building structures and their technical equipment will be maintained (periodic construction inspections). Periodic and routine maintenance and repairs will also be carried out.

# II.6 Decommissioning phase

Bearing in mind that the decommissioning process will not commence for another 70 years, while national and international regulations on decommissioning and disassembly of nuclear facilities may change before that time together with technologies and methods involved in the process, the chapter comprises general terms of NPP decommissioning based on general regulations.

Pursuant to Article 3(9) of the Atomic Law Act [147], the decommissioning of a nuclear facility is understood as bringing such a facility to a condition not requiring restrictions from the point of view of nuclear safety and radiological protection in the performance of any activity.

NPP decommissioning will be executed by the NPP operating entity on the basis of a permit issued by the President of PAA and in line with an NPP decommissioning plan approved by the President of PAA, pursuant to art. 38a and 38b of the Atomic Law Act, and [§ 2 – 11 of the Regulation of the Council of Ministers on the requirements of nuclear safety and radiological protection during decommissioning phase of nuclear facilities, and the content of a nuclear facility decommissioning report [100]. Tasks executed in the course of decommissioning will depend on the strategy accepted by the NPP operator. The strategy, set out in the NPP decommissioning plan, may provide for immediate as well as delayed, and gradual decommissioning. As assumed by the Investor, the nuclear facility decommissioning will be completed once the NPP site is restored to conditions similar to the pre-construction state. What it means is that upon completion of decommissioning, the NPP site will be returned to a condition it was in prior to the commencement of construction.

Pursuant to Art. 38b.1 of the Atomic Law, the head of an organizational unit, prior to submitting an application for a construction license, start-up/commissioning permit or operating license of a nuclear facility, prepares a nuclear facility decommissioning program and submits it to the PAA President for approval, together with the license application. Moreover, art. 35b item 2 of the Atomic Law requires the decommissioning plan to be updated a minimum of once every five years, and in the case of the operation of the facility being terminated irrespective of the plan - immediately upon the end of its operation.

The costs related to the financing of the disposal of spent fuel and radioactive waste, as well as the costs of NPP decommissioning itself, will be covered from the decommissioning fund, as set out in art. 38d of the Atomic Law Act. The contributions to the fund, per every MWh of electrical power generated by the NPP, are specified in §1 of the Regulation of the Council of Ministers regarding the contribution to cover the cost of disposal of spent nuclear fuel, management of radioactive waste and the cost of decommissioning of a nuclear power plant by the entity licensed to operate the nuclear power plant [97].

The IAEA [45] recommends consideration of two basic strategies for decommissioning a nuclear facility: immediate disassembly and delayed disassembly. Immediate disassembly prevents shifting the burden of decommissioning to future generations. However, in the case where nuclear units end their lifespan at different times while using the same systems for operation, immediate disassembly may not be possible - and delayed disassembly is used instead. Also the provisions of the Regulation of the Council of Ministers on nuclear safety and radiation protection requirements for the decommissioning stage of nuclear facilities and the content of the report on the decommissioning of a nuclear facility indicate the above mentioned decommissioning strategies, without specifying any criteria for their evaluation or selection. Upon development of this EIA Report no strategy exists for the decommissioning of the NPP.

Decommissioning of a nuclear facility is based on the following general assumptions:

- irradiated nuclear fuel from the NPP is kept on site - within the Project execution area, in a suitable building and throughout the operation of the nuclear facility. At the end of the operation period a decision will be made, whether the irradiated fuel is to be kept at the NPP or sent to a suitable deep repository;

- intermediate level waste (ILW) from the operation is to be placed in suitable containers for permanent removal. Such waste is to be transported to a local low level waste storage facility, where they are stored safely until they are dispatched to the New Surface Radioactive Waste Repository (NPSOP),
- generation of low-level waste within the Project Area is managed in line with standard techniques to minimize waste volume. Low-level waste is placed in suitable containers and dispatched out of the Project area to the National repository (NSPOP).

The process of decommissioning a NPP with AP1000 reactors is set out in the "AP1000 Pre-Construction Safety Report" [10], under which the AP1000 unit decommissioning process is broken down into the following three stages.

The first stage covers approximately 10 years and includes the following works:

- transferring fuel from the reactor to the spent fuel pool,
- removal of radioactive elements of equipment and systems which are not used during decommissioning,
- inspection of activity levels of all systems which are actually or potentially radioactive,
- post-operation cleaning and decontamination of the reactor cooling system (RCS) and other process systems which are not used during decommissioning,
- designation of new outlines of restricted area on the basis of the above activities,
- review of existing process systems and plans for their use/modification for decommissioning activities,
- transfer of spent nuclear fuel from the spent fuel pool to store.

The second stage covers approximately 6 years and includes the following works:

- modification of existing process systems and installation of temporary process systems for better compliance with decommissioning requirements,
- removal of radioactive equipment, post-operational decontamination and cleanup of the spent fuel pool and fuel handling system,
- disassembly of non-radioactive systems, and systems which are not used during decommissioning,
- re-purposing of the fuel handling area in the auxiliary building into a temporary storage area of waste and a decontamination station for handling intermediate level waste (ILW),
- verification of contamination levels, disassembly, decontamination and removal of process systems which are not used during decommissioning,
- inspection of activity (contamination) levels of remaining systems which are actually or potentially radioactive
- physical and radiation inspection.

The third stage covers approximately 6 years and includes the following works:

- removal, demolition, decontamination and storage of the reactor pressure vessel and its equipment;
- removal of radioactive elements of the process systems, post-operation cleanup, decontamination, disassembly and storage of remaining elements of radioactive systems;
- disassembly and removal of remaining non-radioactive systems,
- inspection of contamination levels of remaining radioactive systems and potentially radioactive structural elements of containment building;

- cutting, processing and removal of radioactive and non-radioactive elements of containment and auxiliary building;
- demolition, decontamination and storage of containment elements, containment building and turbine building;
- removal of radioactive equipment components, post-operation cleanup, decontamination, disassembly and storage of radioactive systems employed during decommissioning,
- demolition, decontamination and storage of auxiliary facilities,
- demolition, decontamination and storage of auxiliary building and radioactive waste storage building,
- demolition, decontamination and storage of temporary decommissioning facilities,
- demolition, decontamination and storage of wastewater system, emergency diesel generator hall and remaining buildings.

For the purposes of the study it was assumed that equipment and machinery used during decommissioning corresponds to the types used during construction.

# II.7 Project execution schedule

The Project execution schedule presented in this chapter reflects the state of knowledge on the Project at the time of preparation of the EIA Report. The schedule takes into account information obtained from the NPP Plant Vendor and from publically available information sources, *i.a.* the websites of the US (NRC) and British (ONR) regulators (as part of the general design assessment - GDA). Furthermore, assumptions arising from the provisions of Council Directive 2013/59/Euratom of 5 December 2013 [27], Atomic Law Act [147] and implementing regulations to the above Act, were taken into consideration to fulfill requirements of the above legislation which must be included in the EIA Report – such as detailed information concerning pre-operational tests, start-up/commissioning and operational phase. In order to better illustrate the course of works, including their sequence and specific nature, the Project execution schedule was divided into the Project execution phases and stages, i.e., the following were specified: construction phase (which includes development stage, construction stage, and commissioning stage), operational phase, and finally, decommissioning phase.

In both site variants, the schedule assumes that the works will start in 2023 (as part of development stage of the construction phase), which is consistent with the Polish Nuclear Power Program [120], adopted in October 2020. It is assumed that the construction stage of a single unit, irrespective of the selected site variant, will last six years. At the construction stage, pre-operational tests will be carried out immediately before the physical commissioning and active commissioning of the nuclear reactor which will formally begin shortly after completion of the construction stage for a given nuclear unit. It is assumed that the operational phase will commence individually for each unit.

In this EIA Report, the specific nature and scope of the works covered by the Project execution schedule are described in detail in previous chapters of Volume II. The construction phase is described in [Chapter II.4], including the Development stage [Chapter II.4.1], construction stage [Chapter II.4.2], while the physical and active commissioning of a nuclear reactor is described in [Chapter II.4.3]. Details concerning normal operation are presented in [Chapter II.5], while the decommissioning phase is described in [Chapter II.6].

## II.7.1 Variant 1 – Lubiatowo – Kopalino site

As indicated at the beginning, the development stage (within the construction phase) will start in 2023 and will last for three years, until 2026, when the NPP construction stage will commence. The construction of the first nuclear power plant unit will take six years, i.e. will be performed in the years 2026-2032, and the reactor physical and active commissioning (as part of nuclear commissioning) will take about one year and will be completed in 2033. It is assumed that in the same year, the PAA President will issue an operating license and thus the operational phase of the first NPP unit will begin. It is assumed that the subsequent units of the nuclear power plant will be built one year later than the construction of the previous unit. It means a shorter interval between the construction of subsequent units than assumed in the Polish Nuclear Power Program, which assumes that construction works on each subsequent NPP unit will be begin two years after the completion of the previous unit.

Considering the above, according to the schedule for Variant 1 Lubiatowo – Kopalino site, the total Project execution period in specific phases and stages will be as follows:

- Construction phase:
  - Development stage: **3** years;
  - Construction stage: **8** years in total for three NPP units (1 year between the commencement of the construction of each unit);
  - Commissioning stage: **1** year for each of the three NPP units;
- Operational phase: each of three NPP units - **60** years (the operational phase of the first unit will begin in the 11th year of the Project execution);

- Decommissioning phase: in total, for three NPP units - **24** years.

The duration of the specific phases and stages of the Project is also shown in the figure below [Figure II.7.1- 1].


Figure II.7.1- 1 Planned Project schedule for Variant 1 - Lubiatowo – Kopalino site

[Rok – Year (from left to right), Etap prac prygotowawczych – Preparartory stage, Faza budowy – Construction Phase, Blok – Unit, Etap budowy EJ – Construction stage, Rozruch – Commissioning, Faza eksploatacji – Operational Phase, Faza likwidacji – Decommissioning Phase]

*Source: In-house study*

It should be highlighted that depending on the technical condition of the NPP, the NPP operational phase can be extended, beyond the currently planned 60 years.

### II.7.1.2 Operational phase

The NPP operational phase in Variant 1 - Lubiatowo-Kopalino site will begin in the eleventh year of Project implementation, i.e. with the commencement of the operation of the first NPP unit and will end with decommissioning (shutdown aimed at decommissioning) of the last nuclear unit (the sequence of decommissioning of specific units is not known at this stage of Project implementation). The adopted generation III/III+ technology makes it possible for the NPP to operate for 60 years from the start up of each nuclear reactor unit, irrespective of the analysed Project site variants and sub-variants. Details of the operating modes for normal operation are presented in chapter [Chapter II.5].

Based on the experience from the current operation of generation II nuclear power plants, which have been designed for 30-40 years of operation, and the operational life cycle of which has been substantially extended by nuclear regulators (up to 60 years, or even more), it can be assumed that the operational phase can be considerably extended as long as the technical condition of the main process components proves to be satisfactory (obviously, once relevant analyses are conducted and necessary maintenance/repairs/upgrades are carried out).

The figure below [Figure II.7.1- 5] presents a schedule of the NPP operational phase for the first 130 months until the overhaul, with indication of the periods for refueling as well as inspections and repairs.

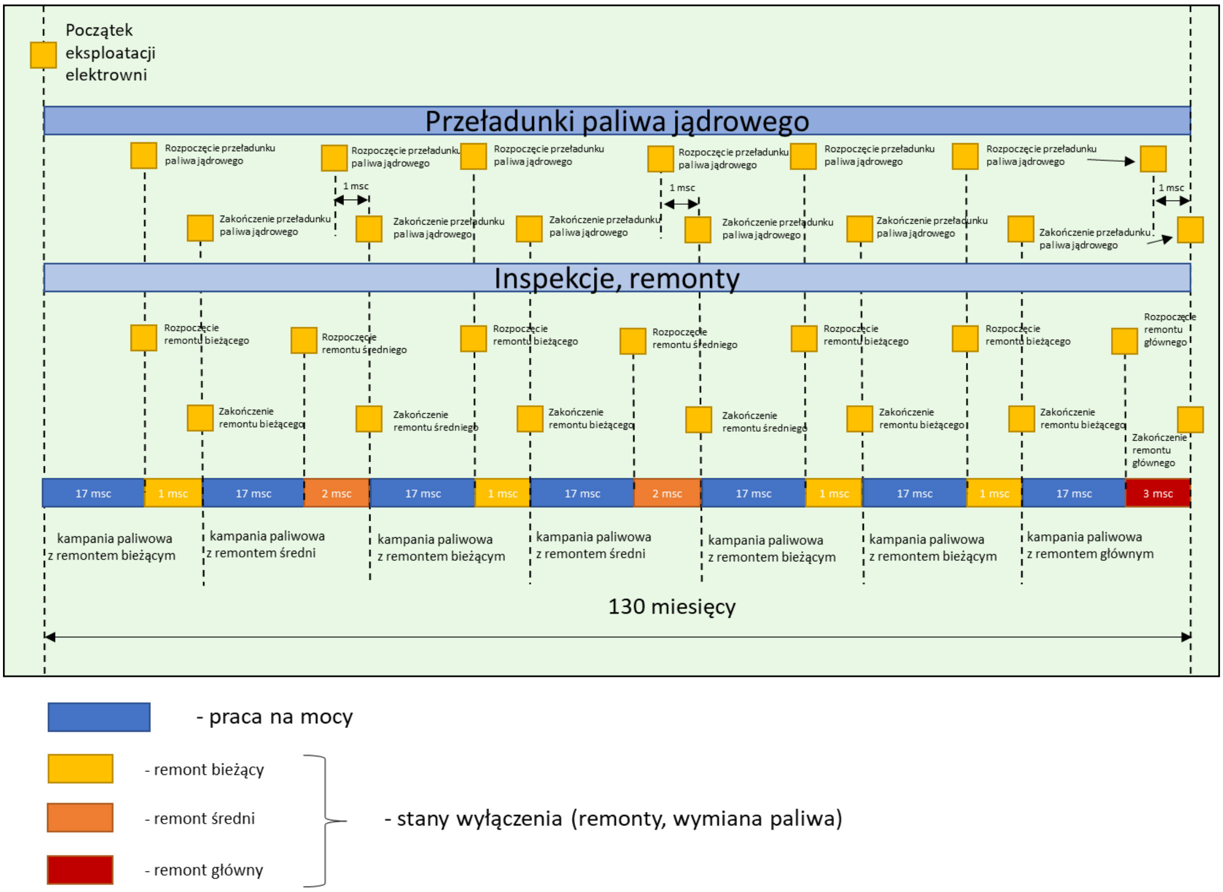



Figure II.7.1- 5 Schedule of the operational phase of a nuclear power plant unit – the first 130 months to the overhaul
[Początek eksploatacji elektrowni – Start of operation, Przeładunki paliwa jądrowego – Fuel reloading, Rozpoczęcie przeładunku paliwa jądrowego – Nuclear fuel reload commencement, Zakończenie przeładunku paliwa jądrowego – Nuclear fuel reload completed, 1 msc – 1 month, Inspekcje Remonty – Inspections and repairs, Rozpoczecie remontu bieżącego – Scheduled maintenance commencement, Zakończenie remontu bieżącego – Scheduled maintenance completed, Kampania paliwowa z remontem bieżącym – Fuel campaign with scheduled maintenance, Kampania paliwowa z remontem średnim – Fuel campaign with major maintenance, Kampania paliwowa z remontem głównym – Fuel campaign with main overhaul, 130 miesięcy – 130 mnths, Praca na mocy – Power generation, Remont bieżący - scheduled maintenance, Remont średni – Major maintenance, Remont główny – Main overhaul, Stany wyłączenia (remonty, wymiana paliwa) – Shut-off state (maintenance, fuel reload)]

*Source: In-house study*

### II.7.1.3 Decommissioning phase

The decommissioning phase of a single nuclear unit is about 22 years while decommissioning works are conducted independently for each nuclear unit. It is assumed that all the units will be decommissioned one after another with a one year interval, so the decommissioning phase of the entire NPP for Variant 1 – Lubiatowo-Kopalino site will last about 24 years. Pursuant to Article 38c items 1 and 2 of the Atomic Law Act [147], the decommissioning phase begins on the date of obtaining a license to decommission a nuclear facility (NPP), while the completion of the decommissioning phase of a nuclear facility is considered to be the date of approval of its decommissioning report by the PAA President.

The decommissioning process of a single nuclear unit is presented in the figure [Figure II.7.1- 6], while detailed works conducted at each decommissioning stage are described in a previous chapter [Chapter II.6].

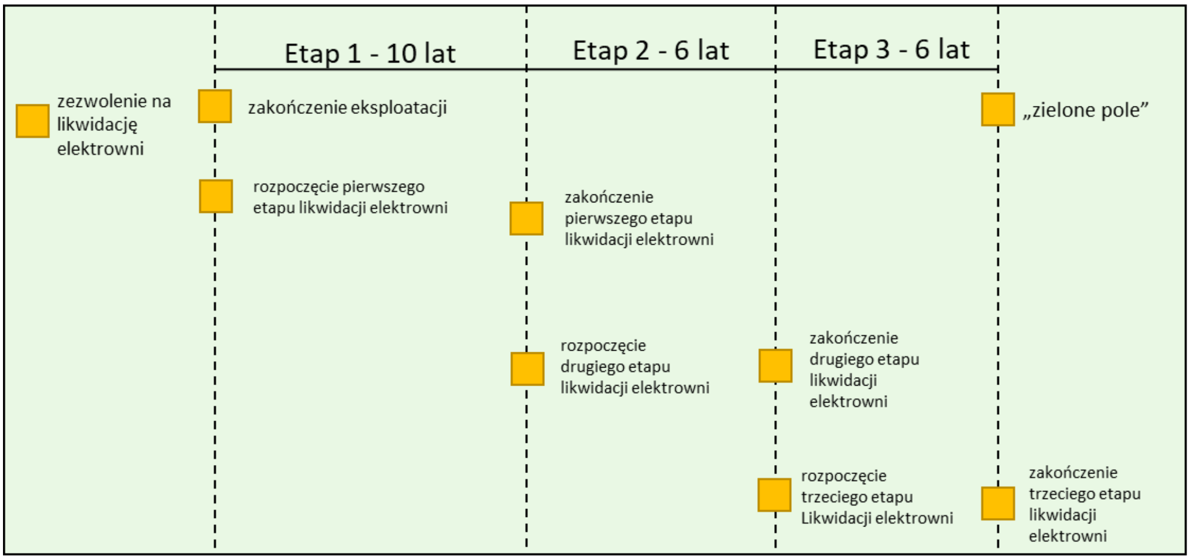



Figure II.7.1- 6 Decommissioning phase of a single NPP unit
[Etap 1-10 lat – Stage 1-10 years, Zezwolenie na likwidację – Decommissioning permit, Zakończenie eksploatacji – Operation ends, Rozpoczęcie pierwszego etapu likwidacji – First stage of decommissioning commences, Zakończenie pierwszego etapu likwidacji – First stage of decommissioning completed, Rozpoczęcie drugiego etapu likwidacji – Second stage of decommissioning commences, Zakończenie drugiego etapu likwidacji – Second stage of decommissioning completed, Rozpoczęcie trzeciego etapu likwidacji – Third stage of decommissioning commences, Zielone pole – Greenfield, Zakończenie trzeciego etapu likwidacji – Third stage of decommissioning completed]

*Source: In-house study*

### II.7.2 Variant 2 – Żarnowiec site

For Variant 2 – Żarnowiec site, the extent of the required demolition works is significantly broader. Additionally, an expropriation process must be carried out with respect to the existing enterprises which operate in the area of the Pomeranian Special Economic Zone. In the Żarnowiec site, development works would begin in 2023, as assumed for the Lubiatowo-Kopalino site, but they would last one year longer than in Variant 1. Therefore, the construction of the first unit would begin in 2027. Due to spatial limitations (significant elevations on the eastern side of the site and lake Żarnowieckie on the west side), the construction of the NPP in Variant 2 must be carried out in sequence, starting from the construction of the unit situated in the northern part of the site (unit 1), and ending with the units located in the southern part of the site (units 2 and 3). Due to the above, the date of the commencement of the construction of unit 2 and, as a consequence, of unit 3, has to be changed. The construction of the second unit can start five years after the beginning of the construction of unit 1, while the construction of unit 3 can commence six years after the construction of unit 1 begins. Five years after the commencement of the construction stage, the main workload can be shifted to units 2 and 3. As a result, the construction stage together with the commissioning for Variant 2 - Żarnowiec site would be longer than in Variant 1 and would last 13 years.

The duration of the different phases and stages of the Project for Variant 2 - Żarnowiec site is reflected in the schedule presented in figure [Figure II.7.2- 1].

In view of the above, according to the schedule for Variant 2 - Żarnowiec site, the total Project execution time in specific phases and stages will be as follows:

- Construction phase:
  - Development stage: **4** years;

– Construction stage: **12** years in total for three NPP units (an interval of 5 years between the commencement of the construction of Unit 1 and Unit 2, and an interval of one year between the commencement of the construction of Unit 2 and Unit 3);

– Commissioning stage: **1** year for each of the three NPP units;

- Operational phase: each of three NPP units - **60** years (the operational phase of the first unit will start in the 12th year of the Project execution);
- Decommissioning phase: in total for three NPP units - **28** years;

Below, the planned Project schedule for Variant 2 - Żarnowiec site is presented.


Figure II.7.2- 1 Planned Project schedule for Variant 2 - Żarnowiec site

[Rok – Year (from left to right), Etap prac prygotowawczych – Preparartory stage, Faza budowy – Construction Phase, Blok – Unit, Etap budowy EJ – Construction stage, Rozruch – Commissioning, Faza eksploatacji – Operational Phase, Faza likwidacji – Decommissioning Phase]

*Source: In-house study*

### II.7.2.2 Operational phase

The schedule for the NPP operational phase is 4 years longer than that presented in chapter [Chapter II.7.1.2] (longer intervals between the commencement of the construction and operation of subsequent units than in Variant 1).

### II.7.2.3 Decommissioning phase

The schedule for the NPP decommissioning phase is 4 years longer than that presented in chapter [Chapter II.7.1.3] (longer intervals between the commencement of the construction and operation of subsequent units than in Variant 1).

# II.10 Predicted types and volumes of emmisions, including waste, resulting from the implementation of the project

## II.10.2 Emission of radioactive pollutants into the air

### II.10.2.1 Construction phase

#### II.10.2.1.1 Development stage

At the development stage, it is not expected that any actions resulting in atmospheric emissions that contain radioactive substances will be undertaken.

#### II.10.2.1.2 Construction stage

At the construction stage, it is not expected that any actions resulting in atmospheric emissions that contain radioactive substances will be undertaken. Nevertheless, it should be emphasized that at the construction stage, devices containing small amounts of radioactive materials will be installed in NPP facilities, e.g. commonly used smoke detectors or NDT instruments (for NDT testing of welds and structural materials). Ionization smoke detectors contain small amounts of the americium-241 isotopes (less commonly of other isotopes) that is primarily a source of alpha radiation (that does not reach beyond the casing of the detector). Flaw detectors (NDT instruments) also may (but not necessarily) use ionizing radiation - X-rays or gamma radiation (used especially in the case of thicker materials), the source of which is normally the iridium-192 isotope, albeit in such case, the emissions of radioactive substances may be practically ruled out.

Additionally, at the construction stage, one cannot exclude the use of short-life isotope markers for the purpose of conducting a diffusion experiment to identify the parameters of the model of dispersion of radionuclides in the air which are typical for the Project Area (in the selected site variant). Yet, the activity of the emitted isotope markers is very low and their radiation impact on the environment is negligible. At the same time, it should be noted that no activities of this sort are planned at this time.

#### II.10.2.1.3 Commissioning stage

The quantity of radioactive substances emitted into the environment at the commissioning stage does not depend on the considered site variant of the Project or on its sub-variant, i.e. the type of the cooling water system used.

The first atmospheric emissions of radioactive substances from the NPP will occur at the time of nuclear commissioning, after reactor criticality is reached, and, in practice, after synchronization of the first nuclear power unit's generator with the National Power System; emission levels will increase along with a gradual increase in power. However, these emissions are significantly less than the average emissions from the operational phase, described further [Chapter II.10.2.2].

### II.10.2.2 Operational phase

It is assumed that the volume of radioactive substances emitted into the atmosphere during the operational phase will be similar for both site variants and the associated sub-variants considered. In view of the above, the emissions of radioactive substances into the atmosphere in operational states are presented jointly for both site variants and the associated sub-variants considered.

It should be explained that the total activities of radioactive substances emitted into the air depend on the quantity of thermal power generated in the reactor, which, in turn, depends on the quantity of used fissile materials contained in nuclear fuel. On the other hand, the (net) amount of power evacuated to the grid depends on the gross generation efficiency of the unit and the consumption of electricity by its auxiliaries.

During the operational stage, emissions of radioactive substances are a regular and standard element of NPP operation, while the quantity and activity of these substances is relatively low.

In operational states, radioactive substances are emitted into the atmosphere through the main plant vent which is integrated with the wall of the shield building, and, to a limited extent, through the turbine building vent. The emissions will mostly include the most volatile radioactive substances in the form of gases (radioactive noble gases) or aerosols generated in the nuclear reactor and in its cooling system (RCS). The types of substances and their total annual activity for a nuclear power plant with an AP1000 reactor are presented in the table below [Table II.10.2- 1]. Given the short half-life of the majority of these isotopes (usually several minutes) and the high point of their release into the atmosphere (the standard height of the main plant vent is around 75m) they do not pose a threat from the perspective of radiological protection, neither for the public, nor for the plant personnel.

Table II.10.2- 1 Emissions of radioactive substances from a nuclear power plant with AP1000 reactors into the atmosphere in operational states

| Isotopes | TBq/year | |
|---|---|---|
| | 1 unit | 3 units |
| I-131 | 2.10E-04 | 6.30E-04 |
| I-133 | 3.50E-04 | 1.05E-03 |
| Total iodines[1] | 5.60E-04 | 1.68E-03 |
| Kr-85m | 2.40E-02 | 7.20E-02 |
| Kr-85 | 3.10E+00 | 9.30E+00 |
| Kr-87 | 1.90E-02 | 5.70E-02 |
| Kr-88 | 2.70E-02 | 8.10E-02 |
| Xe-131m | 1.40E+00 | 4.20E+00 |
| Xe-133m | 1.20E-01 | 3.60E-01 |
| Xe-133 | 1.30E+00 | 3.90E+00 |
| Xe-135m | 1.90E-01 | 5.70E-01 |
| Xe-135 | 4.40E-01 | 1.32E+00 |
| Xe-137 | 4.80E-02 | 1.44E-01 |
| Xe-138 | 8.90E-02 | 2.67E-01 |
| Inert gases (excluding argon)[2] | 6.70E+00 | 2.01E+01 |
| Tritium | 1.78E+00 | 5.34E+00 |
| C-14 | 6.07E-01 | 1.82E+00 |
| Ar-41 | 1.26E+00 | 3.78E+00 |
| Cr-51 | 2.30E-07 | 6.90E-07 |
| Mn-54 | 1.60E-07 | 4.80E-07 |
| Co-58 | 8.50E-06 | 2.55E-05 |
| Co-60 | 3.20E-06 | 9.60E-06 |
| Sr-89 | 1.10E-06 | 3.30E-06 |
| Sr-90 | 4.40E-07 | 1.32E-06 |
| Zr-95 | 3.70E-07 | 1.11E-06 |
| Nb-95 | 9.30E-07 | 2.79E-06 |
| Cs-134 | 8.50E-07 | 2.55E-06 |
| Cs-137 | 1.30E-06 | 3.90E-06 |
| Ba-140 | 1.60E-07 | 4.80E-07 |
| Co-57, Fe-59, Ru-103, Ru-106, Sb-125, Cs-136, Ce-141 | negligible*) | negligible |
| Total beta-radioactive (particles)[3] | 1.70E-05 | 5.10E-05 |
| Total w/o noble gases and Ar-41 | 3.65E+00 | 1.10E+01 |

**) negligible* means values lower than
3.7E-8 TBq/year

*1. They contain I-131 and I-133.*

*2. Contain Kr-85m, Kr-85, Kr-87, Kr-88, Kr-85, Xe-131m, Xe-133m, Xe-133, Xe-135m, Xe-135, Xe-137, Xe-138.*

*3. They contain the molecular form Co-60 + Sr-90 + Cs-137 + others.*

*Sources: [78], [134]*

### II.10.2.3 Decommissioning phase

Given the fact that fission reactions no longer take place in the reactor during the decommissioning phase, the amount of radioactive substances emitted into the environment during the decommissioning will be much lower than in the operational phase. In particular, once the reactor is shut down, the generation and the atmospheric emissions of radioactive substances in the form of gases and aerosols will rapidly decrease. The remaining radioactive emissions into the atmosphere will drop to a minimum once the nuclear fuel is removed from the reactor and from the spent fuel pool. Ultimately, the decommissioned NPP will be restored to a state that would not require any monitoring with regard to radiological protection, i.e. one in which the level of ionizing radiation will not differ significantly from the natural background fluctuation. The decommissioning phase is described earlier in Volume II [Chapter II.6].

The expected emissions of radioactive substances during the process of NPP decommissioning will be determined in the safety report for the decommissioning stage [105] and in the decommissioning program [147], [96].

## II.10.4 Radioactive wastewater emissions

### II.10.4.1 Construction phase

#### II.10.4.1.1 Development stage

At the development stage, it is not expected that any actions resulting in emissions of wastewater containing radioactive substances will be undertaken.

#### II.10.4.1.2 Construction stage

At the construction stage, it is not expected that any actions resulting in emissions of wastewater containing radioactive substances will be undertaken.

#### II.10.4.1.3 Commissioning stage

The volume of wastewater containing radioactive substances generated at the commissioning stage does not depend on the Project site (i.e. the selected site Variant) or on the type of cooling system (i.e. the selected Sub-variant).

The first emissions of wastewater containing radioactive substances will take place at the time of nuclear commissioning, during active commissioning of the unit, and their levels will increase as the power is gradually increased. However, these emissions would be lower than the average emissions generated during the operational phase [Chapter II.10.4.2].

### II.10.4.2 Operational phase

It is assumed that the volume of wastewater containing radioactive substances generated during the operational phase will be similar in both site variants and the associated sub-variants.

During the operational phase of the nuclear power plant, emissions of radioactive substances are a constant and routine element of operation, while their quantity and activity is fairly small.

In the operating states, the effluent containing radioactive substances will be discharged into the Baltic Sea: in the case of an open cooling water system (OCS), via heated cooling water discharge pipelines; in the case of a closed cooling water system, via desalination discharge pipelines [Chapter II.2.1.5.1.3].

The types of radionuclides emitted into surface waters along with their total annual activities in a nuclear power plant with AP1000 reactors is presented in the table below [Table II.10.4- 1].

Table II.10.4- 1 Radioactive substances emissions into surface waters from a nuclear power plant with AP1000 reactors in operational states

| Isotopes | TBq/year | |
|---|---|---|
| | 1 unit | 3 units |
| H-3 (tritium) | 3.34E+01 | 1.00E+02 |
| C-14 | 3.30E-03 | 9.90E-03 |
| Na-24 | 3.80E-05 | 1.14E-04 |
| Cr-51 | 4.60E-05 | 1.38E-04 |
| Mn-54 | 3.20E-05 | 9.60E-05 |
| Fe-55 | 4.90E-04 | 1.47E-03 |
| Fe-59 | 5.00E-06 | 1.50E-05 |
| Co-58 | 4.10E-04 | 1.23E-03 |
| Co-60 | 2.30E-04 | 6.90E-04 |
| Ni-63 | 5.40E-04 | 1.62E-03 |
| Zn-65 | 1.00E-05 | 3.00E-05 |
| W-187 | 3.00E-06 | 9.00E-06 |
| Pu-241 | 8.00E-08 | 2.40E-07 |
| Rb-88 | 3.90E-07 | 1.17E-06 |
| Sr-89 | 2.40E-06 | 7.20E-06 |
| Sr-90 | 2.50E-07 | 7.50E-07 |
| Y-91 | 9.10E-08 | 2.73E-07 |
| Zr-95 | 6.90E-06 | 2.07E-05 |
| Nb-95 | 6.10E-06 | 1.83E-05 |
| Mo-99 | 1.90E-05 | 5.70E-05 |
| Tc-99m | 1.80E-05 | 5.40E-05 |
| Ru-103 | 1.20E-04 | 3.60E-04 |
| Ag-110m | 2.60E-05 | 7.80E-05 |
| I-131 | 1.50E-05 | 4.50E-05 |
| I-132 | 2.00E-05 | 6.00E-05 |
| I-133 | 2.90E-05 | 8.70E-05 |
| I-134 | 5.90E-06 | 1.77E-05 |
| Cs-134 | 7.60E-06 | 2.28E-05 |
| I-135 | 2.40E-05 | 7.20E-05 |
| Cs-136 | 9.30E-06 | 2.79E-05 |
| Cs-137 | 2.30E-05 | 6.90E-05 |
| Ba-140 | 1.40E-05 | 4.20E-05 |
| La-140 | 1.80E-05 | 5.40E-05 |
| Ce-144 | 8.00E-05 | 2.40E-04 |
| Pr-144 | 8.00E-05 | 2.40E-04 |
| Cl-36, Nb-94, U-234, U-235, U-238, Np-237, Pu-238, Pu-239, Pu-240, Pu-242, Am-241, Am-243, Cm-242, Cm-244, As-76, Br-82, Rb-86, Tc-99, Ru-106, and other | negligible | negligible |
| total (without H-3 tritium) | 5.59E-03 | 1.68E-02 |

**) negligible means less than 3.7E-8 TBq/year*

*Source: [78], [134]*

As demonstrated in the table above, tritium is the dominant radioactive substance in the wastewater, with a share of as much as 99.98% of the total activity. The second most active radionuclide emitted into surface waters is the C-14 carbon isotope which represents 59% of the activity of the remaining (excluding tritium) radionuclides. Apart from tritium and C-14 carbon, relatively small amounts of activated products of erosion and corrosion of structural materials of the reactor and its cooling system (RCS) will be emitted.

Tritium and C-14 carbon occur naturally in the environment: in the air (both of the radionuclides) and in sea water (tritium). Tritium is a radioactive hydrogen isotope (H-3) that emits low-energy beta radiation and its half-life is 12.33 years. C-14 carbon also emits beta radiation and its half-life is 5,730 years. The discharge of these radionuclides (emitting mildly penetrating beta radiation) into the environment, where they will quickly disperse in sea water, will not pose any radiation-related hazard to the general public. The radiological impact of the remaining radionuclides discharged in small quantities will also be negligible [Chapter IV.14].

### II.10.4.3 Decommissioning phase

Due to the fact that there will be no fission reactions taking place any more in the reactor during the decommissioning stage, the quantity of radioactive substances emitted into the environment during decommissioning of the NPP will be significantly lower than in the operation stage. Upon completion of the NPP operational phase, a certain amount of liquid or solid radioactive waste, generated during the operation of the NPP (or a nuclear power unit) will remain and will have to be processed. The subsequent generation of radioactive waste – in liquid or in solid form – will be associated with the NPP dismantling works, including decontamination. Ultimately, the NPP (or a particular nuclear power unit) subject to decommissioning, will be brought to such state, in which it will not require any monitoring from the perspective of radiological protection, i.e. where the level of ionizing radiation will not differ significantly from the fluctuations of the natural background. The decommissioning phase is described in a previous chapter [Chapter II.6].

The expected emissions of radioactive substances during the process of NPP decommissioning will be determined in the safety report for the decommissioning stage [105] and in the decommissioning program [147], [99].

## II.10.5 Waste (other than radioactive)

The design features and specifics of the AP1000 technology, combined with the best industry practice, enable compliance with the following hierarchy of waste management measures, which comprise the following activities: avoidance of waste generation, minimization of waste generation, waste reuse, recycling, and recovery to limit controlled releases into the environment and ensure protection against ionizing radiation in accordance with the ALARA (as low as reasonably achievable) principle.

The waste generated during individual phases of Project implementation are classified as follows [Figure II.10.5-1]:

1) Waste other than radioactive (conventional waste) - discussed in detail in this chapter [Chapter II.10.5];
2) Radioactive waste, potentially radioactive waste, and waste resulting from processes that transform radioactive waste into non-radioactive waste is discussed in detail in the next chapter [Chapter II.10.6].

Spent nuclear fuel is also discussed in detail in chapter [Chapter II.10.6].

The following waste zones were established due to different waste management principles:

1) Waste zone 1, where radioactive waste or potentially radioactive waste will be produced and where low level radioactive waste is transformed into non-radioactive waste. Spent nuclear fuel will also be generated in this zone. The zone will be located in the monitored part of the NPP, with restricted access;
2) Waste zone 2, where conventional waste will be generated, located outside of the monitored part of the NPP with restricted access, in which the possibility of contamination is ruled out.

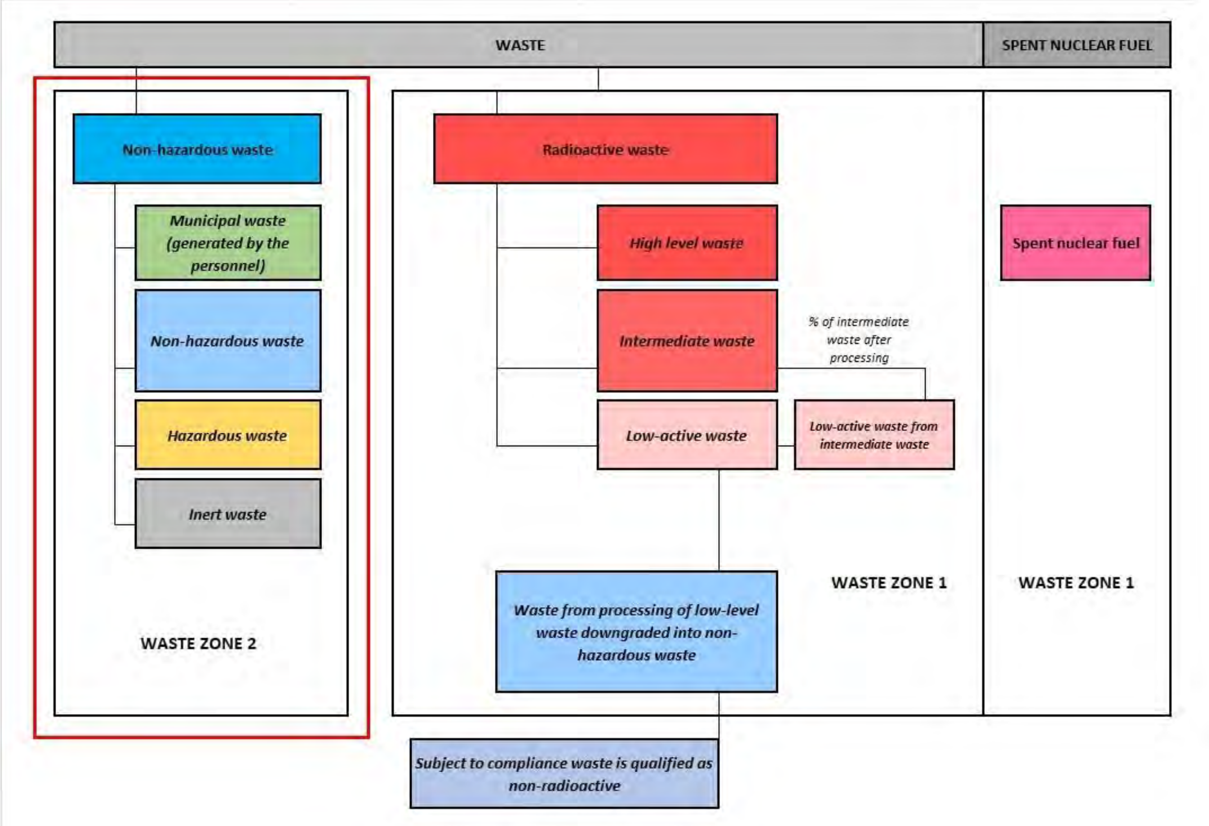



Figure II.10.5- 1 Types of waste generated during the implementation of the Project
*Source: In-house study*

## II.10.6 Nuclear waste and spent nuclear fuel

Radioactive waste will be produced during the commissioning stage of the construction phase (during nuclear commissioning) and then during the operational and decommissioning phases of the Project. Spent fuel, in turn, will only appear during the operational phase (at the time of the first fuel reloading).

Spent fuel belongs to a separate category of nuclear materials and, according to Article 3(22) of the Atomic Law Act [147] (and international approach), it is regarded as high activity radioactive waste when it is qualified for disposal (i.e., as of the time it is decided that it should be emplaced in a repository).

### II.10.6.1 Classification of radioactive waste in Poland

Pursuant to Article 47(1) of the Atomic Law Act radioactive waste (which may take a solid, liquid or gaseous form), is classified, depending on the radioactive concentration of the radioactive isotopes contained in the waste, into the following categories: 1) low level waste (LLW); 2) intermediate level waste (ILW); 3) high level waste (HLW).The specific breakdown and rules for the classification of radioactive waste are set out in the Atomic Law Act [147]. The simplified classification of radioactive waste is shown in figure [Figure II.10.6- 1].

Also, the individual categories of radioactive waste may be broken down into sub-categories depending on its radioactive half-life (transitional, short lived and long lived) and on the radioactive concentration of the radioactive isotopes contained in the waste, while liquid radioactive waste is additionally classified depending on the activity of the radioactive isotopes contained in the waste. Spent fuel intended for disposal is classified as high level radioactive waste. Spent sealed radioactive sources are an additional category of radioactive waste.

Short-lived waste, the activity of which is reduced by a half or more after every 30 years, makes up 90% of the total quantity of radioactive waste produced by a nuclear power plant, and accounts for 0.1% of radioactive activity.

Radionuclides contained in long-lived waste have much longer half-lives, which is why their activity decreases at a much slower rate. Long-lived waste makes up approx. 10% of the total quantity of waste produced by a nuclear power plant, and it accounts for approx. 99.9% of radioactive activity. Some of the long-lived radionuclides of great importance for the radwaste management and disposal include some transuranides, known as minor actinides (isotopes of neptunium, americium and curium), as well as some fission products (e.g. I-129, Tc-99, Sn-126, Cs-135, Zr-93 and Se-79).

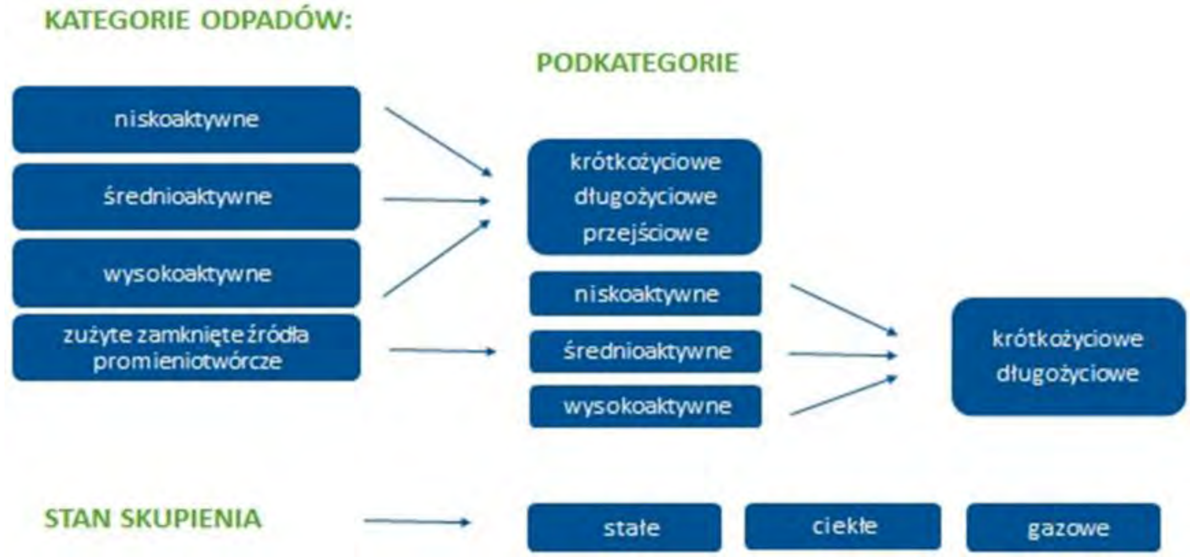



Figure II.10.6- 1 Classification of radioactive waste in Poland

[Kategorie odpadów – Waste Categories, Podkategorie – Sub-categories, Niskoaktywne – Low level waste, Średnioasktywne – Intermediate level waste, Wysokoaktywne – high- level waste, Zużyte zamknięte źródła promieniowania – Spent sealed radioactive sources, Krótkożyciowe długożyciowe przejściowe – Long-lived short-lived transitional, Stan skupienia – State, Stałe ciekłe gazowe – Solid liquid gas.]

*Source: [63]*

Detailed criteria for qualifying radioactive waste into the above categories and subcategories are specified in the Regulation of the Council of Ministers on radioactive waste and spent nuclear fuel [102]. These criteria are specified in tables [Table II.10.6- 1] and [Table II.10.6- 2].

Table II.10.6- 1 Classification of radioactive waste

| **Category** | | **Sub-category** | | |
|---|---|---|---|---|
| | | **Transitional** | **Short-lived** | **Long-lived** |
| Low level waste | EAC < a ≤ $10^4$ EAC | After three years, the radioactive concentration of the isotopes will fall below the level specified for low activity waste | $t_{1/2}$ ≤ 30 years A ≤ 400 kBq/kg for long-lived isotopes | $t_{1/2}$ > 30 years A > 400 kBq/kg for long-lived isotopes |
| Intermediate level waste | $10^4$ EAC < a ≤ $10^7$ EAC | | | |
| High level waste | A > $10^7$ EAC | | | |

*Source: [62]*

Table II.10.6- 2 Classification of spent sealed radioactive sources

| **Spent sealed radioactive sources** | **Sub-category** | | | |
|---|---|---|---|---|
| | **Low level** | **Intermediate level** | **High level** | |
| | EA < a ≤ $10^8$ Bq | $10^8$ < a ≤ $10^{12}$ Bq | A > $10^{12}$ Bq | Short-lived $t_{1/2}$ ≤ 30 years |
| | | | | Long-lived $t_{1/2}$ > 30 years |

*A - radioactive concentration of the isotope in the waste (kBq/kg) or activity of the isotopes contained in the source (Bq)*
*EAC - the value of the radioactive concentration of the isotope constituting the basis for classifying waste as radioactive waste (kBq/kg)*
*EA - activity value which is the basis for classifying waste to the radioactive waste category (Bq)*

*Source: [147]*

## II.10.6.2 Spent fuel

Spent fuel is a special type of radioactive material. Pursuant to Article 3(22) of the Atomic Law Act [147] (and international approach), spent fuel is regarded as high activity radioactive waste when it is qualified for disposal i.e., as of the time it is decided that spent fuel should be emplaced in a (deep, geological) repository for high level radioactive waste. The design of the NPP, in accordance with Polish regulations, will ensure that spent nuclear fuel (SNF) from the entire operating life can be stored at the NPP site. The issue of the spent fuel disposal itself is discussed further in [Chapter IV.16].

The estimated annual amount of spent fuel generated in the NPP will be 9m$^3$/year for a single unit with the AP1000 reactor, and 27m$^3$/year for the entire NPP (with three units). This is the average value calculated based on the total quantity of waste estimated for 60 years of the reactor operation.

### II.10.6.2.1 Construction phase

No spent fuel will be generated at the development stage or construction stage.

The burnup of nuclear fuel in the NPP will commence at the commissioning stage, upon the commencement of the nuclear commissioning of the first nuclear power unit – reactor start-up [101]. However, spent fuel will not be produced at the NPP until the first reloading of fuel in the reactor of the first unit, which will not take place (considering the 18-month duration of a fuel cycle) before the operational phase of the Project.

### II.10.6.2.2 Operational phase

#### II.10.6.2.2.1 Spent fuel management

The National Plan of Radioactive Waste and Spent Fuel Management [121] includes provisions concerning the selection of the fuel cycle option. In the current situation, the selection of a partially closed fuel cycle with reprocessing of spent fuel is very unlikely. Therefore, it is necessary to assume that spent fuel will be temporarily stored at the NPP site for many years pursuant to the requirements of the Atomic Law Act [147], and of the Regulation of the Council of Ministers on radioactive waste and spent fuel [102]. The spent fuel management, assuming that it will not be reprocessed, is shown in the diagram below [Figure II.10.6- 2].

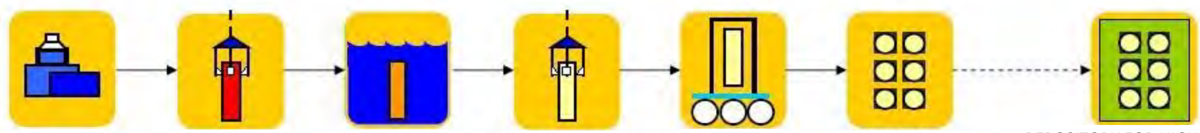



Figure II.10.6- 2 Spent fuel management for AP1000
*Source: [1]*

#### II.10.6.2.2.2 Storage of spent nuclear fuel

**Storage of spent fuel in the spent fuel pool**

When the energy output of nuclear fuel is no longer adequate (due to the burnup of fissile isotopes, accumulation of neutron-absorbing isotopes, physical and chemical changes, and loss of integrity of the fuel cladding), the fuel is unloaded from the reactor core and transferred to the spent fuel pool located in the auxiliary building. Excluding the first reloading of fuel, approximately 66 spent fuel assemblies are unloaded from the reactor core at intervals of approx. 18 months.

Spent fuel assemblies unloaded from the reactor core are strongly radioactive, and, due to radioactive decay, they release significant amounts of heat. Water provides effective protection against radiation and enables the transfer of heat from spent fuel. Over time, the number of radioactive decays (starting from the most active, short-lived isotopes in the spent fuel) decreases, significantly reducing the amount of heat generated by spent fuel assemblies. It is assumed that spent fuel will be kept in the spent fuel pool for up to 10 years.

The spent fuel pool (with a depth of approx. 13 m) is filled with water and boric acid. The water in the pool is treated on particulate filters and ion exchangers, which remove radioactive fission and corrosion products to maintain a suitable transparency and activity of water. The spent fuel cooling system (SFS) is a reliable way of removing heat into the environment and maintaining the required temperature and water level in the pool.

The racks in spent fuel pools are used to store fresh fuel assemblies before they are loaded into the reactor core and spent fuel assemblies after they are unloaded from the reactor core.

**Temporary long-term storage of spent fuel**

The maximum expected number of spent fuel assemblies to be unloaded from the reactor core within the design lifetime of 60 years from a single nuclear power unit with the AP1000 reactor will be approximately 157+(39*66)=2,730 pcs., where: 157 – number of nuclear fuel assemblies from the initial loading, 66 – average number of fuel assemblies unloaded from the core after completion of each fuel campaign, and 39 – number of fuel campaigns, apart from the initial campaign, during the 60-year design lifetime of the nuclear power unit with the AP1000 reactor.

Considering the above, it can be established that 2,730 spent fuel assemblies will have to be transferred into the dry spent fuel storage facility in the entire design lifetime of a single nuclear power unit with the AP1000 reactor.

One of possible concepts of a dry spent fuel storage facility, Holtec HI STORM 100U, recommended for the United Kingdom by the supplier of the AP1000 technology, is presented below.

Spent fuel assemblies will be transferred from spent fuel pools into canisters for the dry storage of spent fuel, which will then be placed in an underground storage facility that also provides protection against ionizing radiation.

Spent fuel assemblies are stored upright inside sealed multi-purpose canisters (MPCs) made from stainless steel and filled with inert gas (helium). The canisters are cooled with outside air in natural circulation [Figure II.10.6-3].

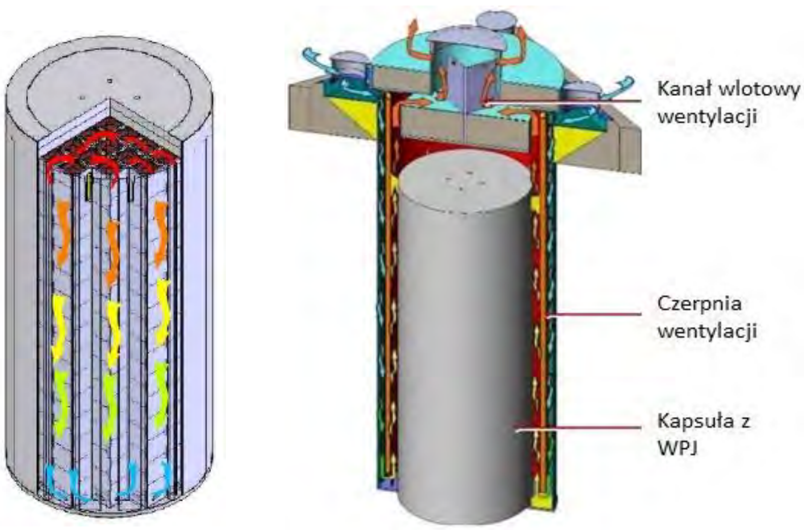



Figure II.10.6-3 Diagram of ventilation of the Hi-Storm 100U storage modules
[Kanał wlotowy wentylacji – Exit vent, Czerpnia wentylacji – Inlet vent, Kapsuła z WPJ – SNF canister]

*Source: [41]*

Operations of loading spent fuel assemblies into MPCs and their preparation take place in the cask loading pit of the spent fuel pool. After the loading of spent fuel assemblies (24 pcs.), the MPC is filled with helium and welded. Then, it is transferred (using special handling equipment) into the spent fuel storage facility and placed in the socket of the storage facility [Figure II.10.6- 4].

The Holtec HI STORM 100U dry spent fuel storage can accommodate 3,000 pcs. SF assemblies [62], [41], and it can be easily expanded if necessary.

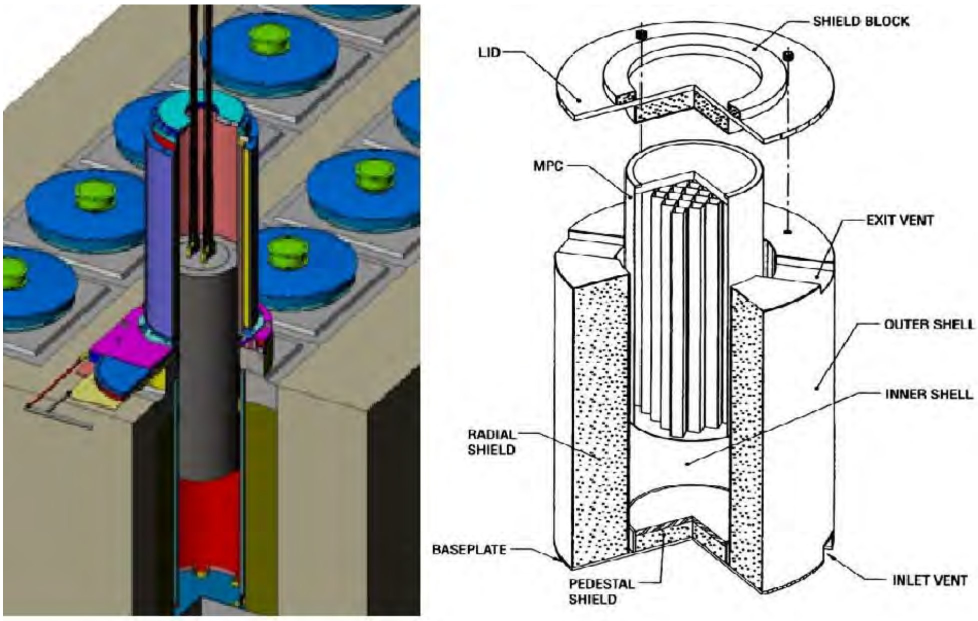



Figure II.10.6- 4 Cross-section of the storage modules of the Hi-Storm 100U storage facility
*Source: [62], [41], [1]*

A suitable area has been reserved in the NPP Site General Arrangement for both site variants considered for the spent fuel storage facility (facility No. 29 in the figures included in appendices [Appendix II.2.4-3] and [Appendix II.2.4-6]), so that spent fuel from the entire NPP lifetime can be stored.

### II.10.6.2.3 Decommissioning phase

Spent fuel during the decommissioning of the nuclear power plant will be managed according to applicable Polish law [147], [102], [99], MAEA guidelines [16], [17] and assumptions adopted by the supplier of the AP1000 technology [10]. Chapter [Chapter II.7] describes the plan of activities during the decommissioning of the nuclear power plant.

The first activity of the decommissioning works will be the transfer of fuel from the reactor into the spent fuel pool, and the final activity will be the transfer of spent fuel from the spent fuel pool into the interim dry spent fuel store and, eventually, into the built Deep Radioactive Waste Repository (DRWR). Construction of the SGOP on the premises of the NPP site or in its vicinity is not foreseen.

## II.10.6.3 Radioactive waste

### II.10.6.3.1 Construction phase

#### II.10.6.3.1.1 Development stage and construction stage

No radioactive waste can be generated at the development stage or construction stage (given that the source that could generate such waste, i.e. the NPP, does not yet exist).

#### II.10.6.3.1.2 Commissioning stage

Generation of radioactive waste at a nuclear power plant begins at the commissioning stage, i.e. at the start of nuclear commissioning - the first nuclear fuel loading test. However, the quantities of radioactive waste generated at the commissioning stage are much smaller than the average waste quantities in the operational phase.

## II.10.6.3.2 Operational phase

Radioactive waste at the nuclear power plant will be produced primarily during the operation of the nuclear power plant, during fission, transmutation and activation. Fission products can leak into the reactor coolant through leaks in the fuel cladding, but because the primary circuit is a closed circuit, they do not leak out. Water in the primary circuit (reactor cooling system, RCS) may also contain dissolved or suspended corrosion products and non-radioactive erosion products, particularly from the structural materials used in the nuclear steam supply system (NSSS), which may be activated by neutrons in the reactor core. Radioactive waste is generated during the treatment of the reactor coolant, as leakage from its cooling circuit, and also during maintenance/repair works.

It should be noted here that the quantities of radioactive waste (and spent fuel) generated in the operational phase will be similar for both site variants and their sub-variants. That is because the type of the cooling system (in the selected sub-variant) does not significantly affect the quantity of radioactive waste (and spent fuel) generated by the power plant. Assuming the generation of exactly the same amount of electricity, the amounts of radioactive waste and spent nuclear fuel in the sub-variant with a closed cooling water system could theoretically be 3% higher than in the sub-variant with an open system which does not constitute a significant difference.

### II.10.6.3.2.1 Gaseous Radioactive Waste

The main sources of gaseous radioactive waste are: leaks from the reactor cooling system (RCS), degassing of the reactor coolant associated with purification and chemical adjustment (through the chemical dosing and volume regulation system, CVS), and contaminated air from ventilation systems of monitored areas. The sources of waste generation referred to above are discussed further in the appendix [Appendix II.10.6-1].

The handling of gaseous radioactive waste will be based on the principles of minimizing their generation (appropriate water-chemical regime of the coolant in the reactor cooling system), limiting leakages and spreading of radioactive substances, minimizing and controlling releases into the environment, and filtering or delaying gases prior to their release. The treatment of gases to remove radioactive substances will be performed by the filtration system. Since these substances deposit on filter cartridges, the latter are regarded as solid radioactive waste. The anticipated quantities of such wastes are considered in chapter [Chapter II.10.6.3.2.3] which discusses solid waste.

The release of gaseous radioactive waste will be limited by reducing the leakage of coolant from the reactor and the coolant change (related to boron dosing).

The risk of spreading of gaseous radioactive waste produced in the buildings and areas of the nuclear power plant will be minimized by designing ventilation systems that ensure the flow of air from zones/rooms with lower radioactive contamination to zones/rooms with higher contamination levels (from which the air will be removed via ventilation duct/exhaust system). This is achieved by maintaining a pressure difference, so that pressure in the zone/room with lower radioactive contamination of air is higher that in the zone/room where the contamination is potentially higher. Ventilation systems will also ensure the required air exchange rate and maintain lower pressure to avoid uncontrolled and non-filtered releases of radioactive substances into the environment.

Gaseous radioactive waste will be discharged using ventilation systems, where it will be filtered in systems adapted to the level of risk, activity and type of radioisotopes in the air (their efficiency will be over 99%, and the estimated quantities of used filter cartridges are considered in chapter [Chapter II.10.6.3.2.3], which discusses solid radioactive waste) or delayed (in the case of noble gases), and then released in a controlled manner into the environment (through the ventilation stack). The entire emission process will be monitored to make sure that the limits defined in the permit issued by the President of PAA are not exceeded. The anticipated quantities of radioactive substances emitted in a controlled manner into the atmosphere are presented in chapter [Chapter II.10.2].

The handling of gaseous radioactive waste is discussed further in the appendix [Appendix II.10.6-1].

#### II.10.6.3.2.2 Liquid radioactive waste

Liquid radioactive waste results mainly from the activation of the primary circuit coolant and its contamination due to the micro-leakage of fuel cladding in the reactor and, to a lesser degree, in the spent fuel pool and auxiliary systems (leaks, releases and drainage). The sources of waste generation referred to above are discussed further in the appendix [Appendix II.10.6-1].

The management of liquid radioactive waste will be based on minimizing waste generation, reduction of the quantity of waste water and spreading of radioactive substances.

Both the reactor coolant and water from the spent fuel storage pools is channeled to appropriate treatment systems that remove contaminants (including radioactive contamination). The water is recovered, and the separated contaminants are sent to the radioactive waste processing plant. The predicted quantities of solid radioactive waste arising from the processing and treatment of liquid radioactive waste are given in Chapter [Chapter II.10.6.3.2.3]. The anticipated quantities of liquid radioactive substances emitted (following their treatment) in a controlled manner into the surface waters are presented in chapter [Chapter II.10.4].

The handling of liquid radioactive waste is discussed further in the appendix [Appendix II.10.6-1].

#### II.10.6.3.2.3 Solid Radioactive Waste

Solid radioactive waste is generated during regular operation of a nuclear power plant, maintenance, servicing and repair works, housekeeping works and during the decontamination of equipment and systems contaminated with radioactive substances. The sources of waste generation referred to above are discussed further in the appendix [Appendix II.10.6-1].

The solid radioactive waste handling will be based on the principle of minimizing their generation and segregating them at the source of their generation. The system will include the collection, separation, treatment and decontamination of waste. It will be equipped with technologies ensuring the maximum possible reduction of the amount of waste intended for disposal.

Handling of solid low level radioactive waste, including spent ion-exchange resins is presented further in [Appendix II.10.6-1]. It should be highlighted that during segregation some of such waste (very low level and short lived) may be qualified, under the criteria set out by the President of NAEA in the NPP operation license, as conventional waste which may be stored in appropriate household or industrial waste landfills.

Handling of solid intermediate radioactive waste (ion-exchange resins and filter cartridges) is presented further in the diagram [Appendix II.10.6-1].

The annual total amount of unprocessed radioactive solid waste produced for a representative technology of the AP1000 reactor is approx. 195 m3/year, i.e. in a 3-unit NPP it is approx. 585 m3/year. [134]. The table below [Table II.10.6- 3] shows the amounts of treated solid radioactive waste (before treatment and after treatment) broken down by radioactive waste categories.

Table II.10.6- 3 Annual amounts of solid radioactive waste generated in NPPs with AP1000 reactors

| Category of radioactive waste | Quantity of solid radioactive waste per unit | | Quantity of solid radioactive waste for the NPP with 3 units | |
|---|---|---|---|---|
| | Before treatment | After treatment | Before treatment | After treatment |
| | $m^3$/year | $m^3$/year | $m^3$/year | $m^3$/year |
| Low level | 176 | 73 | 528 | 219 |
| Intermediate level | 10 | 41* | 30 | 123 |
| High level | 9** | - | 27** | - |

**volume increases due to packaging*
***average value calculated from the whole quantity of waste estimated for 60 years of reactor's operation*
*Source: [134]*

#### II.10.6.3.2.4 Facilities designated for processing and storage of radioactive waste

Below a list of facilities located on NPP premises designated for processing and storage of radioactive waste. Such facilities are also described in Appendices [Appendix II.2.4-3 and Appendix II.2.4-6].

Auxiliary building (facility No. 2)

Inside the auxiliary building the waste gas systems (WGS) and waste liquid systems (WLS) will be located, as well as some of the solid waste systems (equipment for processing wet process waste). The building may also have a mobile encapsulation unit for intermediate level radioactive waste. Also available (in the nuclear fuel handling area) are: pool for storing fresh nuclear fuel, spent fuel pool (SFP) with its cooling system, and other components for handling nuclear fuel.

Radioactive waste building (facility No. 7)

The radioactive waste building (radwaste beuilding) will house process equipment for low-level radioactive waste handling. The building will be used for sorting, conditioning and treatment of various types of low-level waste before their processing, as well as loading into transport and storage containers. In addition, there are also 6 liquid waste monitoring tanks in the radioactive waste building, which contain treated waste waters containing radioactive substances, ready for discharge into the environment. The liquid waste treatment zones are equipped with floor drains to intercept any spills and direct them to the storage tanks of the liquid radwaste system (WLS).

Low level radioactive waste storage facility (facility No. 30)

In the radwaste building, low level waste will be packaged in containers and transported to the low level (processed) radioactive waste storage, from which they will be subsequently sent off to the location of final disposal at the planned new national low and intermediate level radioactive waste repository.

Intermediate level radioactive waste storage facility (facility No. 31)

Treated intermediate level radioactive waste (placed in boxes with a volume of 3m$^3$ and drums with a volume of 3m$^3$), will be kept at this storage facility until it is sent for disposal. The estimated quantity of packaging ranges from 15 to 29 pieces per year. A warehouse space for storing 372 packages, which is roughly equivalent to waste generation over a 20-year period, is planned. It is expected that its subsequent expansion will be carried out every 20 years (as needed). The site development plan for the NPP site provides for vacant area to be used for the future expansion of the storage facility.

The figures in appendices [Appendix II.2.4-3] and [Appendix II.2.4-6] presentlocation of radioactive waste processing facilities on NPP's site general arrangement for both site variants.

### II.10.6.3.3 Decommissioning phase

The NPP decommissioning processes generate the following types of waste, only some of which are radioactive [10]:

- small process equipment (various types of electrical equipment, filters, ion exchangers, etc.) classified as low-level [radioactive] waste (LLW).
- large process equipment (reactor upper unit, reactor pressure vessel and internal vessel structures, pressure stabilizer, steam generators, tanks, pumps, etc.), classified as intermediate or low-level radioactive waste,
- decontamination waste (e.g. spent ion-exchange resins and filter cartridges) classified as intermediate level waste (ILW),
- dry (compressible) radioactive waste (such as cleaning rags, suits, gloves and packaging), classified as low level radioactive waste – the volume of such waste (after compressing) from 3 years of decontamination is estimated to be 81 m$^3$/year per power unit,

- waste from demolition of the facilities – only a small portion of such waste is radioactive and classified as low level radioactive waste. The volumes of such LLW are as follows: 2165 $m^3$ of concrete (from structures and buildings), 158 $m^3$ of steel and approx. 400–600 $m^3$ of concrete from the radiation shield of the reactor core.

Radioactive waste produced during the decommissioning of the NPP will be managed according to the IAEA guidelines and assumptions adopted by the supplier of the AP1000 technology. The decommissioning phase of the Project has been described in detail in [Chapter II.6].

According to the requirements of the Polish regulations, such as the Atomic Law Act [147] (Article 38b) and the “decommissioning regulation” [99] (§ 11), the method of managing the waste produced during the decommissioning of a nuclear facility has to be indicated in the facility decommissioning program, which should be submitted for approval to the President of PAA, together with an application for issuing a building permit for the nuclear facility. The decommissioning program will be periodically updated during the operation of the nuclear facility (at least once every 5 years). Updated decommissioning programme for the nuclear facility, including a forecast of the decommissioning costs, should be submitted for approval to the President of PAA.

The management of radioactive waste generated during the decommissioning of the NPP is shown schematically in the figure below [Figure II.10.6-5].

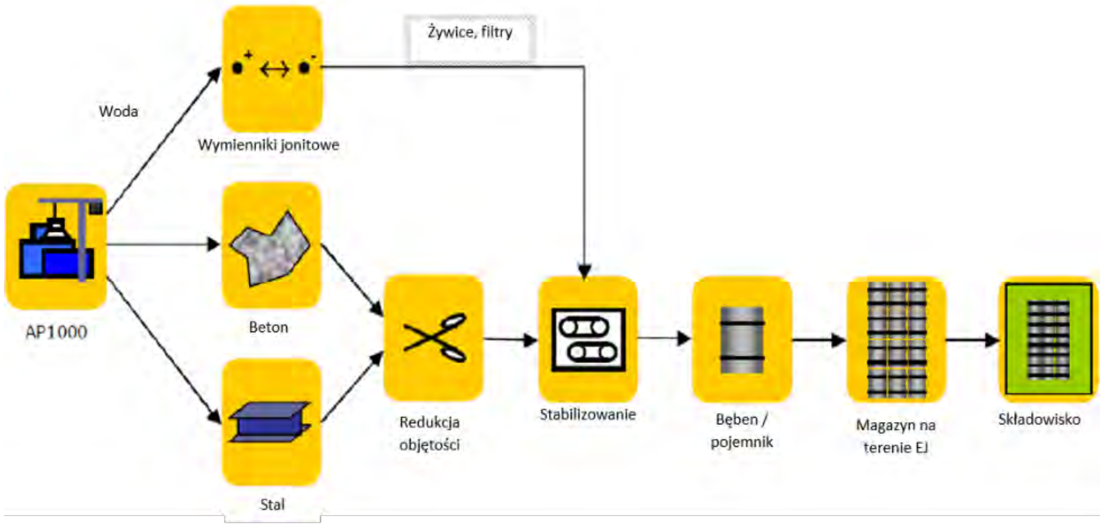



Figure II.10.6- 5 Management of radioactive waste from the decommissioning of the NPP
[Woda – Water, Wymienniki jonitowe – Ion exchange, Żywice filtry – Resins and filters, Beton – Concrete, Stal – Steel, Redukcja objętości – Compacting, Stabilizowanie – Stabilization, Bęben/Pojemnik – Drum/Container, magazyn na terenie EJ – On-site storage, Składowisko – Repository]

*Source: [133]*

The amount of waste produced during the decommissioning of the NPP, the vast majority of which will be produced by the demolition of the facilities, is approximately several hundred thousand $m^3$. As a result of the classification and segregation of such waste as per the defined criteria and limits [102], the volume of waste classified as radioactive waste (usually low level waste) may be reduced to 10% or less.

The total volume of low level radioactive waste produced during the decommissioning of large and small process equipment and compressible dry waste as well as waste from the demolition of the facilities is estimated to be 5500–6000 $m^3$.

The total volume of intermediate level radioactive waste produced during the decommissioning of large process equipment and decontamination processes is estimated at 800 $m^3$.

### II.10.6.4 Non-radioactive waste

Radioactive waste, including the waste produced at the NPP, will be treated, which, according to the definition included in the Atomic Law Act [147], means a "process or activity aimed at waste volume minimization, waste segregation by category or sub-category, or preparation of the waste for transport or disposal". The processing results in generation of non-radioactive waste, including compacted radioactive waste earmarked directly for disposal. Pursuant to Article 52 of the above-mentioned act, "liquid or gaseous radioactive waste, (…) may be discharged into the environment if its radioactive concentration in the environment is negligible from the perspective of radiological protection".

The Polish legislation lacks an unambiguous definition of the "non-radioactive waste", and the Act [147] also refers to "other products resulting from the processing of radioactive waste". Another source of such waste can be what is known as transitional and short-lived radioactive waste which after a certain period of time, due to natural radioactive decay processes, ceases to be considered radioactive waste. The management of such waste is defined in § 14 of the Regulation of the Council of Ministers on radioactive waste and spent fuel: "for waste that is no longer regarded as radioactive waste, the inspection of conformity (…) includes verifying if it is reasonable to classify the waste as non-radioactive waste; [and] deciding on further management of such waste". This means that it is up to the owner and, consequently, also the entity operating the NPP to decide how to manage non-radioactive waste. The owner will thus be responsible for preparing a waste management strategy, including all relevant aspects and options of classifying the waste as non-radioactive.

Non-radioactive waste includes a wide range of different materials and substances. The largest and heaviest items will be produced as a result of overhauls and decommissioning – usually from the dismantling of steel from the equipment and demolition of buildings. Some of such materials may be reused, and the remaining portion will be regarded as municipal waste, unless it contains other hazardous substances (e.g., chemicals), in which case it will be regarded as hazardous but not radioactive waste.

Each waste that is ultimately classified as non-radioactive, whether due to treatment or decrease of activity over time, will be additionally and independently tested with dosimetric methods to eliminate the risk of an error.

The quantity of non-radioactive waste is included in the total amount of all waste produced in connection with the operation of the NPP, as described in detail in this chapter. Some waste can be classified as non-radioactive waste which will be further determined at a later stage.

# II.11 Hazards and severe accidents

## II.11.1 Plant states and the probability of their occurrence

### II.11.1.1 Postulated initiating events

Pursuant to the Atomic Law Act [147] and the IAEA Glossary [44] the Postulated initiating events (PIEs) are defined as events identified during the design of a nuclear facility (in this case NPP) as capable of leading to an anticipated operational occurrence or accident conditions.

The primary causes of a PIE may be equipment or systems failure, personnel error, and external natural or anthropogenic events.

Internal PIEs may lead to a sequence of events during normal operation, which in an extreme case may even cause damage to the reactor core. External PIEs, on the other hand, will be identified through detailed safety analyses, accounting for external events identified for a particular NPP site and subjected to a preliminary analysis during site surveys. The results of such analyses are included in the Site Evaluation Report.

Under the Atomic Law Act [147]:

- an Anticipated Operational Occurrence - is an operational process that deviates from normal operation and which is expected to occur at least once during the operating lifetime of the nuclear facility, but which will not lead – due to the use of appropriate design solutions – to any significant damage of systems, or structural components, or equipment important to the safety of the nuclear facility, and will not lead to the occurrence of accident conditions,
- accident conditions - a deviation from normal operation of the nuclear facility more severe than anticipated operational occurrences.

### II.11.1.2 Plant states

The plant states of a nuclear power plant are divided into **operational states and accident conditions**.

**Operational states** pose no hazard to the safety of a nuclear power plant. Operational states include normal operation and anticipated operational occurrences – **[PZE/AOO]**.

Pursuant to the Atomic Law Act [147] **normal operation** is *the operation of a nuclear facility within the operational limits and conditions,* which in turn are defined as *a set of requirements, specified in the license for carrying out activities involving exposure consisting in the commissioning or operation of a nuclear facility, determining the limit values of the nuclear facility's operational parameters, the required functional availability, the effectiveness of the components of such a facility, and staffing."* Normal plant operation [33] includes frequent operational modes such as startup, power operation, reactor trip, shutdown, maintenance, testing, and refueling, which are further described in chapter [Chapter II.5.1].

A disruption in operation, referred to as an **anticipated operational occurrence (PZE/AOO)**, is defined in the Atomic Law Act [147] as an operational process that deviates from the normal operation and which is expected to occur at least once during the operating lifetime of a nuclear facility, but which will not lead – due to the use of appropriate design solutions – to any significant damage of systems, or structural components, or components important to the safety of the nuclear facility, and will not lead to the occurrence of accident conditions. The frequency of occurrence of such disruptions may be greater than once every 100 years, and normal operating systems of the NPP (nuclear unit) are designed to contain them. This occurs at the second level of defense-in-depth, in accordance with the strategy described in [Chapter I.3.4]. The radiological impact of the NPP on its surroundings during anticipated operational occurrences may not exceed limits set for normal operation.

The Atomic Law Act [147] defines **accident conditions** as: *deviations from the normal operation of a nuclear facility that are more severe than the anticipated operational occurrences*. The contingencies considered in the design of the NPP include Design Basis Accidents **(DBA)** and Design Extension Conditions **(DEC).**

Design-basis accident are defined in the above law [147] as accident conditions of a nuclear facility that have been taken into account in the design of the nuclear facility in accordance with determined designing requirements, under which fuel damage and the release of radioactive substances are maintained within pre-determined limits. Level 3 "defense-in-depth" safety systems are a key element for containment and mitigation of the design basis accidents impact. Under the Regulation of the Council of Ministers of 31 August 2012 on the scope and methods of safety analyses preceding the application for a nuclear facility construction license and the scope of the preliminary safety assessment report for the nuclear facility [106], the above design basis accidents are divided into:

- Category 1 design basis events (DB1) nuclear power plant or research reactor accidents, with a probability of occurrence lower than once every 100 years of reactor operation, but greater or equal to once per 1,000 years of reactor operation;
- Category 2 design basis events (DB2) are nuclear power plant or research reactor accidents, with a probability of occurrence lower than once every 1,000 years of reactor operation, but greater or equal to once per 10,000 years of reactor operation.

In turn, **design extension conditions (DEC)** are defined in the above Regulation [106] and the Regulation of 31 August 2012 on the requirements of nuclear safety and radiation protection to be fulfilled by a nuclear facility design [107] as a set of accident sequences more severe than design basis accidents, where radioactive releases are within acceptable limits, considered in the design of the nuclear facility with the use of an analysis (methodology) based on best estimation, including complex sequences and severe accidents without damage to reactor containment.

Design extension conditions include: **complex sequences (CS-DEC)** and **severe accidents (SA-DEC).**

**Complex sequences** are defined in the above regulations as *sequences of events that go beyond the sequences assumed in deterministic design assumptions for a nuclear facility – in terms of component failure or operator error, which may potentially result in significant radioactive releases to the environment, but do not result in core melt.*

**Severe accident - SA** is defined in the Atomic Law Act [147] as: *accident conditions at a nuclear facility that are more severe than design basis accidents and lead to a significant degradation of the reactor core and may lead to a significant release of radioactive substances*.

Containment and mitigation of the impact of design extension conditions is the objective of additional, dedicated safety systems which are the key elements of level 4 of the "defense-in-depth".

Design basis accidents and complex sequences together make up a category of **accidents without core melt**, referred to in Art. 36f section 2 item 2 of the Atomic Law Act [147], as well as in the WENRA recommendations [152] and in EUR Rev. D [33].

Nuclear power plants with generation III+ reactors, including especially power plants with the AP1000 reactor, are designed to consider accident conditions including the design basis accidents and design extension conditions, including severe accidents with core melt.

A nuclear power unit with the AP1000 reactor is designed in line with US licensing terms for nuclear facilities [119], which currently have not implemented the classification of NPP states first introduced (in 1990s) by the EUR organization of European nuclear utilities [33], and then adopted (in 2012) by the IAEA in a document setting out the requirements for NPP design [108], as well as national regulations related to atomic law [147], [107], [106]. In particular, the US licensing regulations do not include the category of design extension conditions (DEC), while still using the concept of beyond design basis accidents (BDBA).

In consequence, the classification of NPP states adopted in the safety analyses for a power unit with an AP1000 reactor differs from the classification adopted in the national regulations related to the atomic law, which follow IAEA and EUR requirements.

States of disruption (temporary) and accident conditions in the safety documentation of AP1000 reactor [10] are defined as follows:

1) Infrequent Design Basis faults, **DB1**, with a rate of occurrence of initiating events between $10^{-3}$ and $10^{-5}$ per year. Under Polish classification, the category includes type 2 design basis accidents and complex sequences in design extension conditions. Radiological impacts of such accidents must be limited to:
   - doses to the general public <10 mSv or to the personnel <200 mSv – in the case of events with a frequency of occurrence between $10^{-3}$ and $10^{-4}$ per year;
   - doses to the general public <100 mSv or to the personnel <500 mSv – in the case of events with a frequency of occurrence between $10^{-4}$ and $10^{-5}$ per year;
2) Frequent Design Basis faults, **DB2**, with a rate of occurrence of initiating events at $>10^{-3}$ per year. Under Polish classification, the category includes type 1 design basis accidents. Radiological impact of such accidents must be limited to doses to the general public <1 mSv or to the personnel <20 mSv.
3) Low probability Design Basis faults, **DBL**, with a rate of occurrence of initiating events between $10^{-5}$ and $10^{-6}$ per year, and radiological impact limited to doses <200 mSv for the general public or <1000 mSv for the personnel. Under Polish classification, this category includes severe accidents considered in design extension conditions.
4) Beyond Design Basis faults, **BDB**, with initiating event frequency $<10^{-6}$ per year. Under Polish classification, this is a category of hypothetical severe accidents with damage to the containment, which should be excluded through the application of appropriate design features. The radiological impact of such accidents would be more severe than that of **DBL;**
5) High frequency, low consequence faults, **HFLC**, with a rate of occurrence of initiating events at $>10^{-3}$ per year and radiological impacts between the levels of the design basis accidents and normal operation. Under Polish classification, the category includes class 1 design basis accidents and anticipated operational occurrences.
6) All other faults, DB0, where no radiological impacts are expected.

In turn, safety analyses for the Preliminary Safety Analysis Report for the Project will be executed in compliance with the Polish regulations. The Preliminary Safety Analysis Report will constitute the main part of the nuclear safety documentation required to be submitted together with the application to the PAA President for the NPP construction license.

Safety systems of a nuclear power plant with the AP1000 reactor are designed to ensure that even in the event of the most severe nuclear accidents, the impact of the NPP on the environment is kept to a minimum. The analyses of the radiological impact in the vicinity of the NPP is based on the data on the discharges of radioactive substances under operational conditions, as well as on the data on the releases of radioactive substances during accidents at the limit of radiological impacts [10], [78].

The limit of design basis accidents is associated with the major LOCA accident (LB LOCA) with a frequency of occurrence of $7{,}78 \times 10^{-7} \frac{\mathbf{1}}{\boldsymbol{reactor\ x\ year}}$. The plant vendor confirms that releases of radioactive substances during accidents classified as complex sequences will not exceed the releases for a major LOCA [10], [78].

In the most serious cases, defined as severe accidents, with frequencies of occurrence estimated at $1{,}7 \times 10^{-7} \frac{\mathbf{1}}{\boldsymbol{reactor\ x\ year}}$[10], [78] the safety assessments performed on the basis of the Pre-Construction Safety Report (PCSR) for the UK's nuclear regulator (ONR) [10] have shown with high degree of certainty that design solutions used in the AP1000 safety systems account for the impacts of all phenomena occurring in a severe accident and related to core damage, core melt included. Safety systems of a nuclear unit with an AP1000 reactor, together with its other systems, are capable of bringing it into a stable state, where high energy processes that pose a hazard to the integrity of the containment are no longer present. The assessments point in particular to the robustness of the containment design. A controlled, stable state of a nuclear plant/unit is defined as a state after core damage, where the conditions within the containment are under control and their parameters remain within appropriate limits. It was also confirmed that such a severe accident is representative for the needs of emergency planning and identifies radiological impacts in their transboundary context.

### II.11.1.3 Results of probabilistic safety analyses

A probabilistic safety assessment, PSA, is defined in the IAEA glossary [44] as a comprehensive, structured approach to identifying failure scenarios, constituting a conceptual and mathematical tool for deriving numerical estimates of risk.

PSAs include the following 3 levels:

- Level 1, covering assessments of damage for the estimation of core damage frequency;
- Level 2, covering assessments of the reaction of reactor containment to processes present during an accident with core damage, leading - with the use of Level 1 results – to the estimation of the frequency of containment failures and releases of particular radionuclide fractions present in the core to the environment;
- Level 3, covering assessments of offsite radiological consequences related to the releases of radioactive substances, leading - with the use of Level 2 results – to the estimation of risk to general public from exposure to ionizing radiation.

**Core damage** is defined in the PCSR [10] as follows: exposure and heating of reactor core to a point, where long-term oxidation processes are expected together with severe damage to nuclear fuel, affecting a large part of the core and leading to potential releases of radioactive substances with severe radiological consequences to the population.

The same report defines a **large release** as a release of radioactive substances, which may occur in the event that the pressure boundary of the containment is damaged from the impacts of processes in a severe accident.

Probabilistic safety analyses are a useful tool during the NPP design process, as they allow for identification of design weaknesses in terms of nuclear safety and radiological protection, as well as the evaluation of effectiveness of different design solutions/modifications in order to select optimal solutions.

The frequencies of reactor core damage (CDF) and the frequency of large releases of radioactive substances to the environment (LRF) are synthetic indicators that characterize the results of probabilistic safety analyses (PSA) and the level of nuclear safety of power plants.

In line with the requirements of the regulation on the scope and the manner of conducting safety analyses (...) [106], in Poland - as in the majority of countries which use or develop nuclear power - probabilistic analyses are required at levels 1 and 2.

Probabilistic safety analyses for a nuclear power plant with a specific reactor technology, and on a specific site, are conducted during design works, as they are a part of the safety analyses, and their results are included in the Preliminary Safety Assessment Report (PSAR), which constitutes a key part of the nuclear safety and radiological protection documentation that is to be submitted to the President of PAA together with an application for the construction license for a nuclear facility. The above analyses will be performed during the NPP design stage.

Table [Table II.11.1-1] presents the CDF and LRF values determined on the basis of probabilistic safety analyses conducted for a generic design of an AP1000 power unit, taken from a pre-construction safety report (PCSR) [10].

Table II.11.1- 1 Results of probabilistic safety analysis for an AP1000 nuclear unit

| | **Core damage frequency (CDF)** | **Large release frequency (LRF)** |
|---|---|---|
| Power operation - all internal events | $1.7 \times 10^{-7}$ | $1.7 \times 10^{-8}$ |
| Power operation – internal flooding | $4.4 \times 10^{-9}$ | $1.2 \times 10^{-9}$ |
| Power operation – internal fire | $6.7 \times 10^{-7}$ | $5.6 \times 10^{-8}$ |
| **Overall frequency power operation** – sum of all components | $\mathbf{8.4 \times 10^{-7}}$ | $\mathbf{7.4 \times 10^{-8}}$ |

*The values in the table are given in units* $\frac{1}{reactor\ x\ year}$

*Source: [10]*

In 2015, the Investor obtained similar CDF and LRF indicator values [78], for the reference design nuclear power unit power operation with the AP1000 reactor (Vogtle 3, USA): CDF = $2{,}41 \times 10^{-7}$, LRF = $1{,}95 \times 10^{-8}$.

These values meet the probabilistic safety criteria set out in the "design regulation" [107] with a broad safety margin: CDF < $1{,}0 \times 10^{-5}$, LRF < $1{,}0 \times 10^{-6}$.

## II.11.2 Internal events that may endanger the safety of a nuclear power plant

The following internal events affecting the safety of the nuclear power plant may occur in the case of an AP1000 nuclear reactor [10], originating within the boundaries of the power plant site and outside of the external boundary of the power plant security systems (located inside the power plant buildings) [10]:

1) Internal fires;
2) Internal flooding;
3) Damage to the pressure parts of various systems at the power plant causing:
    a) Jet spray,
    b) Jet impingement,
    c) Water hammer,
    d) Steam release,
    e) Pipe whip;
4) Internal explosions;
5) Impacts of internally generated missiles, including as a result of explosions inside the buildings of the power plant;
6) Release of toxic, corrosive, and flammable substances;
7) Collapse, improper handling of loads – including accidents connected with the fall of fuel assemblies;
8) Biological pollution;
9) Transport accidents at the NPP site;
10) Electromagnetic interference from the systems and components of the power plant.

All of the above situations fall within the design conditions for an NPP. Their detailed analysis, including analysis of safety and human health impacts, will be described in detail in the PCSR.

## II.11.3 External events that may endanger the safety of a nuclear power plant

In the context of the probabilistic safety analysis (PSA) of nuclear power plants, external events are defined as events originating outside the nuclear power plant (outside of the nuclear power plant site/premises) that may become an initiating event with severe consequences to the nuclear safety of the power plant. Examples of external events include floods, extreme weather conditions and phenomena, geological and geotechnical hazards or earthquakes and fault activity. There are also on-site external events [38] the source of which is located on site of the nuclear power plant but outside the buildings connected with nuclear safety. Examples of such events include transport accidents at the power plant as well as fires from an adjacent nuclear power plant unit or other buildings of the power plant not connected with nuclear safety.

External events may occur as single events or as a combination of two or more external events. Potential combined external events are two or more external events with a random probability of occurring at the same time, e.g., strong winds coinciding with high sea levels. Combined events that may significantly reduce the safety of the nuclear power plant have been identified during the analysis.

The analysis of the impact of external events on the safety of the nuclear power plant is a complex process consisting of the following activities:

1. Project planning and preparation;
2. Identification of potential external events;
3. Deterministic screening of external events;
    - relevancy screening;
    - impact screening;
4. Probabilistic screening analysis of external events;
5. In-depth analysis of external events.

Activities 1, through 3 have been executed for the preparation of the EIA Report, while under activity 3 only the relevancy screening was carried out. The remaining stages of the impact screening (which require analyses based on the detailed design of the nuclear power plant) will be conducted during the preparation of the Preliminary Safety Analysis Report.

### II.11.3.1 Types of external events

The primary classification of external events includes a breakdown into **natural external events** (such as floods and various extreme weather conditions) and **human-induced events** (such as aircraft crashes and gas explosions).

To identify external events that may become initiating events, i.e., events relevant to nuclear safety, the following documents, regulations and guidelines concerning external events were used:

- siting regulation [98],
- safety analysis regulation [106],
- European ASAMPSA report [32],
- WENRA report [152];
- report No. 02:27 [47] prepared for the Swedish nuclear regulator,
- guidelines of the US Nuclear Regulatory Commission NUREG/CR-2300 [136];
- guidelines of the International Atomic Energy Agency No. NS-G-1.5 [35];

- European utility requirements (EUR Rev. D) [33],
- OECD/NEA report No. NEA/CSNI/R [71];
- guidelines of the International Atomic Energy Agency No. NS-G-3.1 [37].

In total 183 external events [36] have been initially identified that may affect the safety of the nuclear power plant. These events were then subject to the relevancy screening to determine if they were relevant to safety [4] for the site of the future nuclear power plant. The screening reduced the number of external events to 40 [Table II.11.3-1].

II.11.3- 1 Natural and human-induced external events potentially relevant to the safety of the NPP Variant 1 – Lubiatowo-Kopalino site and Variant 2 – Żarnowiec site

| No. | External event | Type of external event |
|---|---|---|
| 1. | Flooding caused by a tsunami | Natural |
| 2. | Flooding caused by sea level variations, tides and waves | |
| 3. | Flooding caused by groundwater level variations | |
| 4. | Flooding caused by rainfall | |
| 5. | Electromagnetic interference caused by lightning strikes | |
| 6. | Electromagnetic interference caused by solar storms | |
| 7. | Sea or lake coast erosion | |
| 8. | Unstable slopes (landslides)* | |
| 9. | Subsidence (collapse of natural caverns) | |
| 10. | Natural presence of gases | |
| 11. | Extreme ground temperatures | |
| 12. | High air temperature | |
| 13. | Low air temperature | |
| 14. | Strong wind | |
| 15. | Tornado | |
| 16. | Precipitation, including hail | |
| 17. | Ice phenomena on the sea/lake | |
| 18. | Extreme snowfall | |
| 19. | Drought | |
| 20. | High sea/lake temperature | |
| 21. | Low sea/lake temperature | |
| 22. | Seismic and faulting activitiy | |
| 23. | Volcanic dust | |
| 24. | Sand storm, dust storm | |
| 25. | Biological contamination – water environment (including the growth of seaweeds, algae and micro-organisms in sea water) | |
| 26. | Biological contamination – land and air environment (insects, birds, pests) | |
| 27. | Aircraft crash | Human-induced |
| 28. | Fires occurring outside the site of the nuclear power plant | |
| 29. | Explosions outside the site of the nuclear power plant | |
| 30. | UXOs | |
| 31. | Objects with high kinetic energy, including as a result of explosions | |
| 32. | Objects carried by the wind | |
| 33. | Gas clouds, chemical pollution from industrial plants or transport | |
| 34. | Hazards from industrial plants (pollution, noise, emissions of corrosive substances) | |
| 35. | Floating debris (including flotsam, jetsam, wood logs, leaves, grass, rubbish) – impact on cooling water channels and ultimate heat sink (UHS) systems | |
| 36. | Risks to the nuclear power plant from civil telecommunication systems and installations emitting electromagnetic waves or generating magnetic or electric fields | |
| 37. | Hazards caused by oil, gas or groundwater extraction, mine collapse | |
| 38. | Hazards caused by transport | |
| 39. | Terrorist acts or sabotage | |
| 40. | Damage to or incorrect operation of hydraulic facilities* | |

** this event may occur only for Variant 2 – Żarnowiec site*

*Source: [4]*

Many of these events only require qualitative analyses. However, suitable quantitative analyses (deterministic or statistical) have been performed for the events most critical to nuclear safety. Further detailed analyses will be performed during the preparation of the preliminary safety analysis report.

Potential hazards to the NPP connected with natural external events are described in further parts of this chapter [Chapter II.11.4.3].

### II.11.3.2 Analysis of the resilience of the Project to extreme events, phenomena and natural conditions, with a particular regard for primary and secondary effects of climate change

The Directive of the European Parliament and the Council on the assessment of the effects of certain public and private projects on the environment (EIA Directive) specifies the process and requirement for managing the environmental impact assessments of projects as part of investment/project preparation in EU member states. The directive is transposed into the national law by every member state. The EIA directive lists the environmental aspects that should be considered during that process, including sensitivity to climate change. In addition to the obligation to consider the impact of the project on climate and determine greenhouse gas emissions, it is also required to determine the sensitivity of the project to climate change. The European Commission emphasises that research carried out in Europe shows that the European infrastructure should be adapted to functioning in a changing climate. This makes it necessary to consider hazards resulting from the primary and secondary effects of climate change in the design of the project.

For the purposes of this EIA Report, based on the information shown in Chapter [Chapter II.11.4.3], information about the Project and acquired historical meteorological data, extreme events, phenomena and natural conditions were analysed in the context of their impact on the safety of the NPP. In particular, the analysis included the primary and secondary effects of climate change, including heat and droughts, extreme rainfall and floods (including coastal flooding), hurricanes and tornadoes, sea level variations, storms, coastline retreat (erosion, abrasion) and periods of extreme frost and snow. Adequate mitigating measures were also specified for the NPP to mitigate the primary and secondary effects of climate change.

The results of the analysis (conducted for both location variants), including the mitigating measures designed to mitigate the primary and secondary effects of climate change, are shown in the appendix [Appendix II.11.3-1].

Climate change adaptation measures include various measures (e.g., informative, legal, technical and organisational) designed to reduce the sensitivity of the particular facility or area to the effects of climate change. Their implementation increases broadly defined safety and ensures uninterrupted functioning of the facility or area. Based on the analysis, it was found that no adaptation measures will be required in the analysed case because the Investor will implement suitable mitigating (preventive) measures already in the conceptual design to mitigate the primary and secondary effects of climate change.

The analysis indicates that some of the natural external events will not occur or affect NPP security. In such cases, it was not necessary to indicate preventive measures. Some of the phenomena caused by climate change, in turn, may directly affect the nuclear facility and reduce structural safety. These include, in particular, high wind gust speeds and increased frequency of tornadoes, hurricanes and storms, including snow storms. Also the frequent clashes of continental and maritime air masses, which result in sudden temperature changes, may present a risk to the NPP. That is because sudden temperature changes may cause icing or catastrophic rime ice, resulting in the accumulation of ice on overhead lines and structural components, and – as a result of the ice load – causing them to break or collapse. Icing on traffic routes may create skidding hazards. Persistent rainfall or short-term intense rains (torrential rains), in turn, may cause the stormwater system to overflow and contribute to landslides. Also sudden temperature increases during periods of snow cover may result in significant outflows of melt water, which may overload the stormwater collection and distribution system.

In light of the hazards described above, all possible events and phenomena connected with climate change will be addressed at an early stage of design works. The planned buildings and infrastructure components will be designed to avoid/mitigate the negative effects of climate change on the Project. Suitable procedures will be prepared for emergencies, and will be implemented at the Project area in the selected site variant for all phases of the Project.

During the construction phase of the NPP, procedures will be implemented that include: Planned actions in case of extreme weather conditions, to counteract negative impacts on the environment, as well as on the health and life of people residing on the construction site, as well as on the workmanship and properties of construction products, including their durability.

After commissioning the NPP, continuous environmental monitoring will be applied, including Climate conditions and changes and prediction of those changes. Results of climate monitoring will be analysed regularly, so that – when the need emerges - suitable preventive measures and procedures will be introduced in advance to adapt the nuclear facility to the new environmental conditions.

## II.11.3.3 Description of selected human-induced hazards

Discussed below are issues related to man-induced hazards as specified in the GDOŚ Decision [70], including acts of terrorism or sabotage and potential external explosions.

## II.11.3.3.1 Acts of terrorism or sabotage

### II.11.3.3.1.1 Assessment of the risk of terrorist acts in Pomerania

According to the 2017 National Crisis Management Plan [49], Poland is not a primary target for potential terror attacks. As in previous years, the terrorist threat in Poland, including the Pomorskie Voivodeship, remains at a low level, despite the continuing high risk of terrorist attacks in the world, as well as an increase in the number of attacks in Europe [68].

The nuclear power plant is located within an area under the surveillance of the Maritime Polish Border Guard and the Polish Navy. Also, the site of the plant, similarly to the rest of Poland, is protected according to the National Crisis Management Plan.

The analysis of voivodeship crisis management plans [68], [69] indicates that elements of the power system (such as power plants, combined heat and power plants and transmission systems) are classified as structures that may be potential targets of attacks. The assessment of the current risk in Pomorskie voivodeship made based on these documents[68], [69] indicates the following:

- the risk of a terror attack in large agglomerations is moderate, the risk in remaining areas is minimal;
- the most probable types of terror attacks that may be carried out in the voivodeship include attacks using explosives and attacks using bacteria and viruses of highly infectious diseases.

The current assessment of the risk connected with terror acts in Pomorskie voivodeship, in turn, is as follows:

- probability of hazard occurrence: **scale 1/very rare** (on a 5-point probability **scale** from 1 - very rare to 5 - very likely),
- effect classification: scale D - major effect (on a 5-point scale A, B, C, D, E from A - insignificant to E - catastrophic),
- risk acceptance: tolerable.

The prevention of terrorist activity includes routine investigation of the relevant communities to identify persons who plan terror acts, strengthening the security of important public buildings and influencing the owners or managers of industrial plants or managers of public offices to cause them to ensure appropriate physical and technical security of their structures. Suitable procedures were prepared to improve the readiness of the bodies who prevent and remedy the consequences of the attack.

#### II.11.3.3.1.2 Vulnerability of the nuclear power plant to hostile acts

Nuclear power plants – despite their apparent appeal as a target of a terrorist attack – are not an easy target for terrorists. That is because they are carefully and heavily guarded. Every nuclear power plant has a physical security system consisting of various technical means and well-trained and outfitted professional security personnel. Also, the risk to the nuclear power plant due to sabotage is limited by introducing various design measures and through correct management of the personnel and related monitoring measures conducted in cooperation with the Ministry of the Interior and Administration, the Government Security Centre, Internal Security Agency and National Atomic Energy Agency. ICT systems are also protected with suitable security measures.

To prevent terror attacks and their potential consequences, a suitable physical security system will be designed for the nuclear power plant, and the plant will be protected by competent state authorities as critical infrastructure of the state. The physical security system will be designed based on the primary design basis threat, which will be provided for this purpose by the President of the National Atomic Energy Agency (Article 41q (1) of the Atomic Law Act [137]).

The physical security system of a nuclear power plant typically includes the following measures: physical barriers and illuminated intrusion detection areas, well-trained and equipped and armed guards, surveillance and patrolling of the outer fence, technical means of intrusion detection (several types of detectors, television systems, alarms), bulletproof barriers in particularly important areas, designated intervention squads, and a set of measures to minimize potential threats from plant personnel.

### II.11.3.3.2 Potential external explosions

#### II.11.3.3.2.1 Explosions in industrial plants and facilities

The hazards presented by industrial plants and facilities located in Pomorskie voivodeship that may be relevant to the safety of the NPP were assessed based on information received from their operators and the Chief Inspectorate of Environmental Protection (GIOŚ) [154] and based on the Crisis Management Plan of Pomorskie voivodeship [69].

Potential explosion risks are connected with the oil and gas production, storage or transmission/distribution plants and facilities located near the Project site, as listed below:

- “Kosakowo” Cavernous Gas Storage Facility;
- Oil and gas mine (OP Żarnowiec and OG Dębki, PGNiG);
- Natural gas transmission pipelines (Pomorska Spółka Gazownicza, GAZ-SYSTEM PGNiG);
- Local natural gas distribution networks (G.EN GAZ ENERGIA).

The above-mentioned facilities and plants are located far from the boundaries of the NPP site (in both sitevariants). The conducted analyses [4] showed that the plants cannot be dangerous to the NPP, considering the distances.

#### II.11.3.3.2.2 Explosions connected with transport

<u>Road transport</u>

According to the information included in the Crisis Management Plan of Pomorskie voivodeship [69], dangerous cargo (primarily fuel) at the Project area (in both site variants) is transported only by road: national road No. 6 and provincial roads No. 213 and No. 218. UXOs may be sporadically transported on various routes of Pomorskie voivodeship.

National Road No. 6 is at a distance (measured in a straight line) from the boundary of the NPP site for Variant 1 - Lubiatowo - Kopalino site ≥ 24.7 km, and for Variant 2 - Żarnowiec site ≥ 13.7 km. The nearest voivodeship roads are located at a distance of 7.25 km from the NPP site under Variant 1 - Lubiatowo - Kopalino (road no. 213 ≥) and at a distance of 3.77 km from the site under Variant 2 - Żarnowiec (road no. 218 ≥) [4].

There are other roads in the vicinity of the Project Area (in both site variants) that will initially be used by road transport vehicles to access the nuclear power plant construction area, however, these are local roads with much lower traffic volumes that are not normally used by vehicles transporting hazardous materials (this can happen only in exceptional cases). Additional access roads will be constructed in connection with the construction and operation of the NPP in the selected site variant. Suitable safety measures (access control and restrictions at a specific distance from the site of the NPP) will be used on these roads and, where necessary, also on other roads passing near the NPP, to prevent any vehicles carrying loads that may explode from approaching the site of the NPP.

The conducted analyses [4] showed that the safety of the NPP will be ensured thanks to the configuration of the road system in the area of the Project site and the planned organisational and technical measures designed to prevent vehicles carrying hazardous loads from approaching the site of the NPP.

Rail transport

One railway line (No. 202) used to carry dangerous goods was identified in the Project region based on the information included in the Crisis Management Plan of Pomorskie voivodeship [69] and acquired from PKP PLK SA [65] and the Office of Rail Transport [66]. The conducted analyses [4] showed that, since line No. 202 is located much more than 10 km from the site of the NPP, no events taking place on that line may be dangerous to the NPP.

In both site variants, the currently inactive railway line No. 230 is planned to be restored and a rail siding is to be constructed on that line next to the NPP construction site so that the line and the siding can be used for the construction and operation of the NPP. Neither that line nor the siding leading to the NPP will be used for the traffic of rail tankers containing liquified propane-butane gas, and the only fuel transported on that line will be diesel fuel. Therefore, no materials that could explode and cause a shock wave and objects with high kinetic energy will be carried near the NPP site by rail. Line No. 230 will be of local significance only, and all transport via the sidings leading to the NPP will be controlled. Consequently, hazards connected with events on line No. 230 and on the rail siding can be ruled out.

Sea transport

In order to ensure the safe and uninterrupted operation of the NPP, attention was given to various aspects connected with potential hazards, including the risk of an explosion on a vessel carrying hazardous materials [59], [3].

The risk of vessel collision has been reduced thanks to the scheme for vessel traffic separation introduced in 2021 in the vicinity of the basin where the NPP infrastructure is to be constructed. An explosion of explosives carried by even the largest vessels using that route will not be dangerous to the NPP. For Variant 1 - Lubiatowo - Kopalino site the distance is more than 7 km, while for Variant 2 - Żarnowiec site the distance is more than 16 km.

Potential risks to the NPP include a combination of events where control of a vessel carrying hazardous materials is compromised, the vessel is stranded in the immediate vicinity of the NPP and the cargo detonates. An analysis of depth contours indicates that such a combination of events may occur 760 m from the shore. The wide strip of shallow water, characteristic to this part of the Baltic Sea, protects the NPP from close proximity of a vessel with hazardous cargo that runs off course. This hazard will be mitigated by selecting suitable locations for the equipment and buildings of the power plant.

Air transport

The choice of the location of the NPP in the context of hazards presented by air transport is regulated by § 5(10) of the regulation on the detailed scope of assessment of the site intended for a nuclear facility, the cases where such location fails to meet the requirements for the site of the nuclear facility and on requirements for a site report for the nuclear facility[98], according to which the nearest civil airport should be located no closer than 10 km away from the boundaries of the planned site of the nuclear facility. The power plant should also be resistant to the immediate impact of a large civil plane that presents the risk of explosion and fire of aviation fuel. These requirements (implemented in connection with the terror attacks carried out on 11 September 2001 in the USA using large passenger planes) are formulated similarly both in European and US legislation.

Analyses were carried out to assess the location of the NPP in terms of the hazards connected with air traffic [76]. The analyses were carried using the methods described in the US DOE standard of 2006 [20] and using the UK methods [56].

According to the statistics collected by international organisations, the crash of a passenger plane at the cruising altitude is very improbable. Accidents take place more frequently during take-off and landing approach, which is why the regulations also require a specific distance to be kept between nuclear power plants and airports.

Taking into account the conducted analyses [76], at the stage of construction project a decision will be made on the necessity of making a possible exclusion of the zone from traffic for a certain category of aircraft, as one of the measures to reduce the threat from air transport. Modifications to the organisation of commercial air traffic and moving the air corridor for regular flights several kilometres away will also be considered at the same stage.

## II.11.3.3.3 Explosions connected with military operations and facilities

Based on the data provided by the Ministry of National Defence [54], it was found that in Variant 1 – Lubiatowo-Kopalino site – the nearest restricted military complex is located approximately 7 km away, and for Variant 2 – Żarnowiec site – approximately 12 km away. Based on the above information and the opinion of the General Staff of the Polish Armed Forces [117] it was found that the military facilities located far from the Project site (in both site variants) are not dangerous to the NPP due to the consequences of a potential explosion.

## II.11.3.3.4 Hazards related to human-induced seismic conditions

In order to assess the risks of external anthropogenic events, seismic hazard analyses for induced shocks were conducted for Variants 1 - Lubiatowo - Kopalino site and 2 - Żarnowiec site.

Antropogenic activities include such examples as: (1) artificial reservoir construction, (2) mining, (3) geothermal energy extraction, (4) hydrocarbon supply, (5) underground waste water injection, (6) $CO_2$ sequestration, and (7) military activities. Such activities may cause or induce seismic waves which may result in seismic hazards at the planned location of a nuclear facility.

As part of the seismic hazard assessment for induced shocks it was verified within a radius of **approximately 150 km** from the Lubiatowo - Kopalino Variant 1 and Żarnowiec Variant 2, respectively, whether seismogenic activity (which could pose a threat to nuclear safety of the nuclear facility by inducing seismic shocks) has taken place in the last 60 years, whether such activity is currently conducted or whether such activity is planned in the future. The results of the above analyses are presented below:

1. Construction of water reservoirs - water reservoirs within 150 km radius have not caused any known induced sesimic activity. Two existing reservoirs (Zalew Koronowski and Jezioro Żurskie) cause no hazard to a nuclear facility from induced seismic actvivity. There are no current investment projects involing the construction of water reservoirs of a size, which could result in induced seismic hazards.
2. Mining - mineral deposits were reviewed, which are extracted at present or could be extracted in the future. The sources of potential sesimic hazards from mining activities are: underground mining, large scale strip mining and explosions at quaries. Large scale extraction may also induce seismic activity. A significant hazard to Variant 1 and Variant 2 may result from potential extraction of potassium-magnesium deposits and salt deposits and any such extraction will require carefull monitoring, including specifically monitoring for induced seismicity and subsidence.
3. Use of geothermal energy - geothermal use within 150 km radius caused no known seismic activity. Existing geothermal installations constitute no hazards to Variant 1 or Variant 2 from induced seismicity.

There are also no plans for the operation and use of HDR (hydraulic fracturing) assisted geothermal systems;

4. Hydrocarbon extraction - the extraction of oil and gas deposits may result in induced shocks. In addition, induced seismicity may also result from hydraulic fracturing activities related to exploration or extraction of shale gas. 31 exploratory boreholes were made within 150 km radius. Hydraulic fracturing was conducted in sixteen of them. Hydrolic fracturing techniques were used between November 2010 and August 2016. Several of the boreholes where hydraulic fracturing was used were monitored for induced seismicity. The strongest shock related to exploration of hydrocarbons was an event registered in the vicinity of Wysino on 15 June 2019, with a magnitude of Mw 2.8. The shock had no impact on Variant 1 or Variant 2.

   Hydrocarbon exploitation causes micro earthquakes (i.e. Instrumentally detected earthquakes, but not felt at the surface). None of the seismic shocks identified within 150 km radius constituted a hazard to the nuclear facility.

5. Underwater storage of wastewater - there are no current or planned activities related to underwater storage of wastewater.

6. $CO_2$ sequestration - no work is or has been done on $CO_2$ sequestration. There are no plans to construct underground carbon dioxide storage facilites.

7. Military activities - military explosions may be a source of seismic waves.

**Taking into account the conducted inventories and analyses, it can be concluded that induced seismicity does not pose a threat to the planned nuclear facility for Variant 1 - Lubiatowo - Kopalino site and Variant 2 - Żarnowiec site, respectively, subject to the implementation of recommended adequate human activity practices to be followed when conducting activities with the potential to induce seismicity** [77].

### II.11.3.4 Combinations of external events

The individual external events may occur in combinations. There are three types of combined external events that should be considered:

- consequential events: one external event causes a different consequential event (resulting from the initiating event). For instance, a lightning strike outside the power plant may cause fire in the bushes/forest around the power plant. Similarly, a fire at a nearby facility or a fire in a vehicle transporting chemicals could lead to an off-site explosion with an associated high-energy projectile hazard and/or create a toxic gas release hazard. Another potential example are extreme rains that cause flooding outside the site of the power plant.
- correlated events: external events connected with meteorological and hydrological conditions that are usually highly correlated and should be considered together, taking into account their impact on the site of the nuclear power plant. For instance, storms simultaneously involve strong winds, extreme rainfall and lightning strikes.
- independent, coincidental events: although the events are uncorrelated, more than one external event may occur simultaneously or successively in the time during which the power plant is still being restored to normal functioning after the occurrence of the first event. In this case, it is necessary to consider the probability of the individual events to determine which combinations of events should be considered in the design of the power plant and which combinations can be ruled out due to the low frequency of their occurrence.

As a result of a detailed analysis of combined external events, five combinations were selected out of the many possible options – they are shown in the following table [Table II.11.3- 2].

Table II.11.3- 2 Combinations of external events that may potentially be relevant to the safety of the NPP. Variant 1 – Lubiatowo-Kopalino site and Variant 2 – Żarnowiec site

| Initiating event | Consequential event | Notes |
|---|---|---|
| **1 – Winter storm** | | |
| Low air temperature | Biological contamination – water environment (including the growth of seaweeds, algae and micro-organisms in sea, river or lake water) | 1. Rain and low temperatures resulting in hail storms can frequently block drains and gutters, leading to flooding (in or outside the site of the power plant).<br>2. Strong winds causing storm surges as well as floating debris (including flotsam, jetsam, wood logs, leaves, grass, rubbish) – impact on cooling water channels and ultimate heat sink systems.<br>3: Extreme rainfall may cause flooding in and around the site of the power plant; however, extreme rainfall occurring over a longer period may cause further consequences (e.g., failure of hydraulic facilities and high groundwater level).<br>4. Although shore erosion usually occurs over a long period, the conditions during a storm may significantly accelerate shore degradation.<br>5. A storm can also cause water foaming, resulting in a biological contamination of the water.<br>6. The total loss of power supply to a power plant from the external power grids (the *Loss-Of-Offsite Power, LOOP*) has been ruled out as a stand-alone hazard, however, a number of identified hazards (primary or secondary) could result in a complete loss of power to the power plant from external power grids and should therefore be considered in future impact assessments of these events. |
| Precipitation, including hail | Objects carried by the wind | |
| Ice effects on the sea | Damage to or incorrect operation of hydraulic facilities (only for the Żarnowiec site) | |
| Low sea temperature | Flooding caused by rainfall | |
| Strong wind | Flooding caused by groundwater level variations | |
| | Flooding caused by sea level changes and sea waves | |
| | Floating debris | |
| | Sea or lake coast erosion | |
| | Precipitation, including hail | |
| | Hazards caused by transport | |
| **2 – Extremely low temperatures** | | |
| Low air temperature | Floating debris | 7. Wind (but not extreme wind) was also considered to take into account the impact of accumulated snow on the loading of the structures of power plant buildings.<br>8. Extremely low temperatures may cause the inlets of the cooling water channels to freeze, or they may lead to the formation of ice packs, causing consequences similar to biological contamination.<br>9 Longer periods of extremely low temperature may cause certain ground movements and similar consequences to the ground as those observed during a drought. They may cause damage to underground installations and, consequently, result in the occurrence of human-induced hazards or internal hazards.<br>10. Other human-induced external events are not considered here due to the extremely low temperatures, but this is taken into account in the combination of external hazards/events No. 4, “Extremely high temperatures”.<br>11 The combination of ice and snow may increase the probability of hazards connected with transport, and difficult weather conditions may hinder emergency access to the site of the power plant. Also see note No. 6. |
| Low sea temperature | Extreme ground temperatures | |
| Extreme snowfall | Hazards caused by transport | |
| **3 – Summer storm** | | |

| **Initiating event** | **Consequential event** | **Notes** |
|---|---|---|
| High air temperature | Biological contamination – water environment (including the growth of seaweeds, algae and micro-organisms in sea water) | 12. Athmospheric discharges do not only accompany summer storms, and they may also occur during winter storms; however, the weather conditions in the summer are more likely to result in lightning strikes, which is why they have been considered here and not in the “Winter storm” scenario. A lightning strike may, in turn, lead to fires outside the site of the power plant that may be connected with vegetation or the buildings around the power plant. See also notes 2–6. |
| Precipitation, including hail | Electromagnetic interference caused by lightning strikes | |
| High sea/lake temperature | Fires occurring outside the site of the nuclear power plant | |
| Strong wind | Objects carried by the wind | |
| | Flooding caused by rainfall | |
| | Flooding caused by groundwater level variations | |
| | Damage to or incorrect operation of hydraulic facilities (only for the Żarnowiec site) | |
| | Flooding caused by sea level changes and sea waves | |
| | Floating debris | |
| | Sea coast erosion | |
| | Hazards caused by transport | |
| **4 – Extremely high temperatures** | | |
| High air temperature | Biological contamination – water environment (including the growth of seaweeds, algae and micro-organisms in sea water) | 13: Drought may potentially cause landscape desertification, where wind conditions and the impact of dust clouds on the power plant are considered.<br>14: Earth movement during a drought may cause damage to underground installations and create additional human-induced hazards.<br>15: Fires outside the power plant caused by hot dry conditions, external ignition sources, primarily due to the overheating of the equipment outside the power plant site or fires of the vegetation around the power plant.<br>16: It is assumed that warmer conditions would also increase plant and animal activity in the sea, resulting in biological contamination. Also see note 6. |
| High sea/lake temperature | Sand storm, dust storm | |
| | Drought | |
| | Explosions outside the site of the nuclear power plant | |
| | Fires outside the site of the nuclear power plant | |
| | Objects with high kinetic energy, including as a result of explosions | |
| | Extreme ground temperatures | |
| | Gas clouds and chemical pollution from industrial plants or transport | |
| **5 – Aircraft impact** | | |
| Aircraft impact | Explosions outside the site of the nuclear power plant | 17 During analysis of aircraft crashes, it is assumed that the aircraft will disintegrate in the air, with some of its fragments hitting the site of the NPP and other fragments hitting facilities outside the site of the NPP, which may thus become a source of other external human-induced hazards.<br>18. Although aircraft crash is assumed as the initiating event, a similar event may occur as a result of a major accident; however, this mostly depends on the size of the other facilities, and the impact would potentially be more local. Similarly, |
| | Fires occurring outside the site of the nuclear power plant | |
| | Impacts of objects with high kinetic energy, including as a result of explosions | |
| | Gas clouds, chemical pollution from industrial plants or transport | |
| | UXOs | |

| Initiating event | Consequential event | Notes |
|---|---|---|
| | | terrorist acts or sabotage outside the site of the power plant can also result in human-induced combined external events. However, the impact connected with aircraft crash was selected because its range was higher and because it could result in internal and external hazards.<br>19. The range of external human-induced events must reflect the location of feasible sources of such hazards (e.g., other industrial compounds) in the vicinity of the potential site of the NPP. Also see note 6. |

*Source: [4]*

### II.11.3.5 Impact of external events on the safety of a nuclear power unit with the AP1000 reactor

Probabilistic safety analyses include not only internal events, but also a set of external (site-specific) events/hazards, resulting in higher frequency values for severe core melt failures *(Core Damage Frequency, CDF*) and the frequency of large releases of radioactive substances into the NPP environment *(Large Release Frequency, LRF*, or *Large Early Release Frequency, LERF*) - because additional initiating events are included. However, this will only be possible at the stage of Preliminary Safety Report preparation for the nuclear power plant (i.e at the design stage).

In safety analyses, it is normal practice to adopt the limit values of the frequency of external events for the conditions considered in the design of the NPP (design basis external hazards):

$$1.0 \times 10^{-4} \frac{1}{reactor\ x\ year}.$$

The pre-construction safety report (PSCR) for the AP1000 nuclear reactor [10] submitted to the UK Office for Nuclear Regulation (ONR) in 2017 indicates, however, that the impact of external events on safety will be fairly small. The primary reason to expect that the increase of CDF and LRF will be small is the fact that the design of the nuclear power unit with the AP1000 reactor is particularly resilient against the loss of functions of external facilities and systems.

With the exception of seismic events (which are treated separately), the main risks from external events arise from the possibility of shutdown/damage - due to the impact of these events - to the external power grid (and the concomitant increase in the probability of failure of the backup diesel generators) or the loss of the ability to remove post-shutdown heat from the reactor to a final outlet via the service water system (SWS).

However, the significance of the risk of failure of the emergency diesel generators and loss of cooling capability of the service water system is very low because the passive safety systems of the AP1000 reactor do not require AC power to the pumps or the provision of cooling through the service water system heat exchangers. Also, the passive safety systems are located inside the reactor containment and, as such, have the best possible protection against the effects of external events. Class-1 passive safety systems are resistant to damage (they do not require electrical power supply or control). Also, they are designed in such a way that in case of failures other than the loss of coolant accidents they become fail-safe after potential damage, and they do not require any electrical supply or operation of I&C devices.

The effects of this resilience of the AP1000 reactor unit to external events are shown in the PSA analyses. Despite the fact that the frequencies of initiating events in PSA analyses are assumed to be higher than $1.0 \times 10^{-2} \frac{1}{reactor\ x\ year}$, both for the complete loss of offsite power (LOOP) and for the loss of the service water system (SWS) or component cooling water system (CCS), the share of such events in core damage frequency is fairly low (7.4% and 8.0%, respectively), which means that their contribution to the frequency of core damage is smaller than $1.0 \times 10^{-9} \frac{1}{reactor\ x\ year}$ [10].

It is therefore improbable for other external events with the same net effect (i.e., causing a LOOP accident or loss of cooling by the service water system (SWS)) to have frequencies comparable to a LOOP accident or loss of cooling by the service water system (SWS) or component cooling water system (CCS), which means that their share in CDF will be much smaller.

## II.11.4 Risk of a severe accident resulting in contamination of the environment

### II.11.4.1 Risk of a severe industrial accident

According to Article 3 items 23 and 24 of the EPL Act [145], a "serious industrial accident" is understood as an event, in particular an emission, fire or an explosion, arising during an industrial process, storage or transport, which involves one or more hazardous substances, leading to an immediate hazard to human life or health or the environment, or the same delayed hazard.

A facility which poses a hazard of an occurrence of a severe industrial accident, is deemed a "lower-tier facility" or "upper-tier facility" depending on the type, category and amount of a hazardous substance existing in the facility (Article 248 of the EPL Act [145]). The facility is classified into one of the above categories under the rules determined in the Regulation of the Minister of Economy of 29 January 2016 on the types and amounts of hazardous substances, which are critical for classifying a facility as either a lower-tier or upper-tier facility [82], while whether a specific establishment should be considered a lower-tier or upper-tier facility depends on the amount of the substances existing on the premises of the facility at the given moment (stored substances). Appendix [Appendix II.11.4-1] provides a list of chemicals used and stored at the power plant site under each sub-variant along with a description of how the nuclear power plant qualifies for the facility categories referenced above.

The analysis of the data presented in the appendix [Appendix II.11.4-1] shows that the NPP, irrespective of the Site Variant and sub-variant, will be classified as an establishment with a high risk of a major industrial accident.

### II.11.4.2 Risk of a severe accident in a nuclear context

According to provisions of the Atomic Law Act [147], its implementing regulations [107], [106] and the terminology applied in the IAEA publications, accidents in the nuclear context are referred to as accident conditions.

In Article 10 of the Regulation of the Council of Ministers on nuclear safety and radiological protection requirements to be taken into account in the design of a nuclear facility [107], probabilistic safety criteria for accident conditions taken into consideration in the NPP design were specified (consistent with the requirements of the EUR document [33]). Furthermore, Appendix No. 1 to the Regulation of the Council of Ministers on the scope and manner of performing safety analyses to be made before submitting a construction license application for a nuclear facility and the scope of the preliminary safety analysis report for a nuclear facility [106], determines the probability of occurrence of postulated initiating events (PIE) that lead to specific nuclear power plant states.

At this point it is necessary to clarify that according to point III.10 c of the GDOŚ Decision [70], this EIA Report should present the impact on humans and the environment in case of emergency conditions at the nuclear power plant. In the GDOŚ Decision [70], it is specified that accident conditions include: threshold impact design basis accident, severe accident and a postulated accident for emergency preparedness purposes. Due to the fact that the above breakdown does not fully reflect accident types specified by the plant vendor, in this chapter accident conditions, i.e. accidents in the nuclear context, are divided into the following:

- non-meltdown accidents, during which fuel elements are damaged to a certain extent, but the reactor core does not melt down,
- core meltdown accidents, during which fuel is degraded and the reactor core melts down.

The probability of a severe accident that involves the reactor core degradation, including its meltdown, in generation III/III+ NPP is smaller than one per one million years. And the probability of large releases of radioactive substances to the NPP environment in case of a severe accident is smaller than one per 10 million years.

#### II.11.4.2.1 Probability of a non-meltdown accident

Non-meltdown accidents include extreme, in terms of their radiation impact, design basis accidents and complex sequences. Such an accident is a Large Break Loss of Coolant Accident (LB LOCA). It is related to a rupture, described in detailed analyses, of the reactor coolant system pipeline (the rupture of a cold or hot pipeline of the coolant circuit loop).

According to information obtained from the NPP technology vendor [79], [10], the probability of an initiating event leading to this accident is $7.78 \times 10^{-7}$ per reactor year. Therefore the probability meets the criteria determined in the "regulation on safety analyses" [106], the EUR document [33] and the latest IAEA guidelines [18].

Analyses of the radiation impact of the LB LOCA accident on the NPP environment were performed using characteristics of radioactive substance release provided by the AP1000 reactor technology vendor [79]. Results of the analyses are presented in chapter [Chapter IV.17].

### II.11.4.2.2 Probability of a core meltdown accident

A core meltdown accident considered in extended design conditions is at the same time a representative accident for the emergency planning purposes.

According to information obtained from the NPP technology vendor [79], [10], the probability of an initiating event leading to this accident is $1.7x10^{-7}$ per reactor year. Therefore the probability meets the criteria determined in the Atomic Law Act [147], its implementing regulations [107], [106], the EUR document [33] and the latest IAEA guidelines [18] [79].

A severe reactor core meltdown accident might occur if safety systems, dedicated to contain the accident, failed upon the occurrence of a specified postulated initiating event leading to accident conditions. Then the NPP accident conditions can escalate from a design basis accident (e.g. such as the LB LOCA described above) to severe accident conditions related to the reactor core degradation, including its meltdown. Although it cannot be completely excluded, the occurrence of such a situation is extremely unlikely. But even then it is required that the technical and organisational solutions applied in the NPP should enable to control such an accident and curb its effects to the level acceptable for the public.

Based on the characteristics of radioactive substance release provided by the reactor technology supplier [79], analyses of the radiation impact of a severe core-meltdown accident on the NPP environment were performed, the results of which are presented in chapter [Chapter IV.17].

### II.11.4.3 Risk of a natural disaster

The occurrence of a natural disaster is related to the natural external events mentioned in the previous chapter [Chapter II.11.3].

External events valid from the point of view of a natural disaster are the same for both site variants, while potential flood, geological and geotechnical hazards are crucial.

Characterised below, are specific types of natural external events that can lead to natural disasters.

**1. Hazards related to seismic and tectonic conditions**

From the seismicity point of view, the Site Macroregion (an area with a radius of 300 km around the Boundary of the planned nuclear facility location, defined according to PAA and IAEA guidelines taking into account geological and seismotectonic conditions of the site) in both site variants has low natural seismicity, while the Site Region and Site Area have very low natural seismicity. No catastrophic earthquakes have occurred in the Macroregion, Region and Project area of either site variant [46].

To assess hazards related to seismic and tectonic conditions, fault activity analyses and a Probabilistic Seismic Hazard Assessment (PSHA), among others, were carried out for both site variants.

Capable faults on terms of the Siting Regulation, due to which the area could be found failing to meet the siting requirements for a nuclear facility, were not identified in the Region of either site variant.

The seismic hazard curves for Variant 1- Lubiatowo - Kopalino site are presented in Figure [Figure II.11.4- 1], while for Variant 2 - Żarnowiec site - see Figure [Figure II.11.4- 2]. In addition, the intensity values were converted to the European Macroseismic Scale - EMS-98. Intensity values for the 10,000-year return period for Variant 1 - are provided in Table [Table II.11.4- 1], and for Variant 2 in table [Table II.11.4- 3]. The intensities for the return period of 475 years for Variant 1 - Lubiatowo - Kopalino site are presented in Table [Table II.11.4- 2], while for Variant 2 - Żarnowiec site - see table [Table II.11.4- 2].

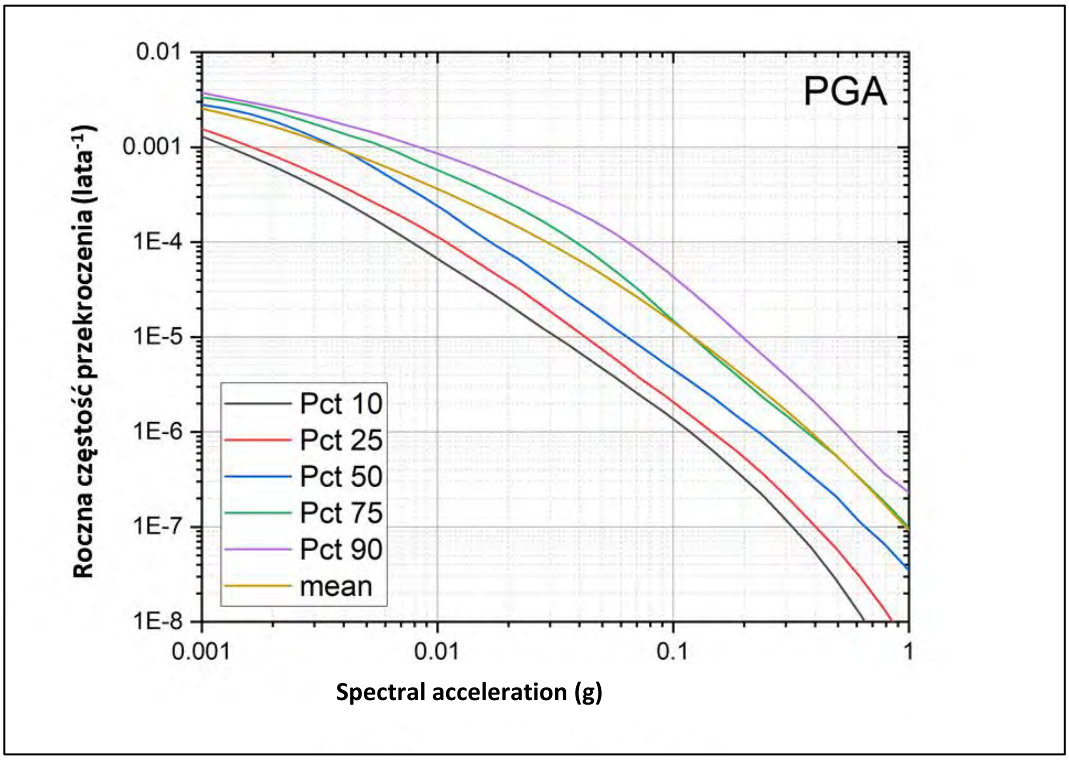



Figure II.11.4- 1 Seismic hazard curves for Variant 1 - Lubiatowo - Kopalino site
[Roczna częstość przekroczenia (lata$^{-1}$)– Exceedence annual frequency (years$^{-1}$)]

*Source: Study based on [77]*

Table II.11.4- 1 PGA values and intensity values (EMS-98) for Variant 1 - Lubiatowo - Kopalino site for a return period of 10,000 years. Minimum magnitude used in calculations $M_w$ = 4.5

| | Medium | Pct 5 | Pct 10 | Pct 25 | Pct 50 | Pct 75 | Pct 90 | Pct 95 |
|---|---|---|---|---|---|---|---|---|
| PGA (m.s$^{-2}$) | 0.299 | 0.068 | 0.080 | 0.111 | 0.172 | 0.395 | 0.657 | 0.826 |
| **PGA (g)** | **0.0305** | **0.0069** | **0.0082** | **0.0113** | **0.0175** | **0.0403** | **0.0670** | **0.0842** |
| GMICE | Average (° $I_{EMS}$) | Pct 5 (° $I_{EMS}$) | Pct 10 (° $I_{EMS}$) | Pct 25 (° $I_{EMS}$) | Pct 50 (° $I_{EMS}$) | Pct 75 (° $I_{EMS}$) | Pct 90 (° $I_{EMS}$) | Pct 95 (° $I_{EMS}$) |
| Masi et al. (2019) | 4.9 | 3.6 | 3.7 | 4.0 | 4.4 | 5.2 | 5.6 | 5.8 |
| Zanini et al. (2019) | 5.4 | 3.9 | 4.1 | 4.4 | 4.8 | 5.7 | 6.2 | 6.4 |

*Source: Study based on [77]*

Table II.11.4- 2 PGA values and intensity values (EMS-98) for Variant 1 - Lubiatowo - Kopalino site for a return period of 475 years. Minimum magnitude used in calculations $M_w$ = 4.5

| | Medium | Pct 5 | Pct 10 | Pct 25 | Pct 50 | Pct 75 | Pct 90 | Pct 95 |
|---|---|---|---|---|---|---|---|---|
| PGA (m.s$^{-2}$) | 0.0146 | 0.0035 | 0.0045 | 0.0063 | 0.0179 | 0.0243 | 0.0307 | 0.0338 |
| **PGA (g)** | **0.0015** | **0.0004** | **0.0005** | **0.0006** | **0.0018** | **0.0025** | **0.0031** | **0.0034** |
| GMICE | Average (° $I_{EMS}$) | Pct 5 (° $I_{EMS}$) | Pct 10 (° $I_{EMS}$) | Pct 25 (° $I_{EMS}$) | Pct 50 (° $I_{EMS}$) | Pct 75 (° $I_{EMS}$) | Pct 90 (° $I_{EMS}$) | Pct 95 (° $I_{EMS}$) |
| Masi et al. (2019) | 2.2 | 1.0 | 1.2 | 1.5 | 2.4 | 2.7 | 2.9 | 3.0 |
| Zanini et al. (2019) | 2.4 | 1.0 | 1.2 | 1.6 | 2.6 | 2.9 | 3.1 | 3.2 |

*Source: Study based on [77]*

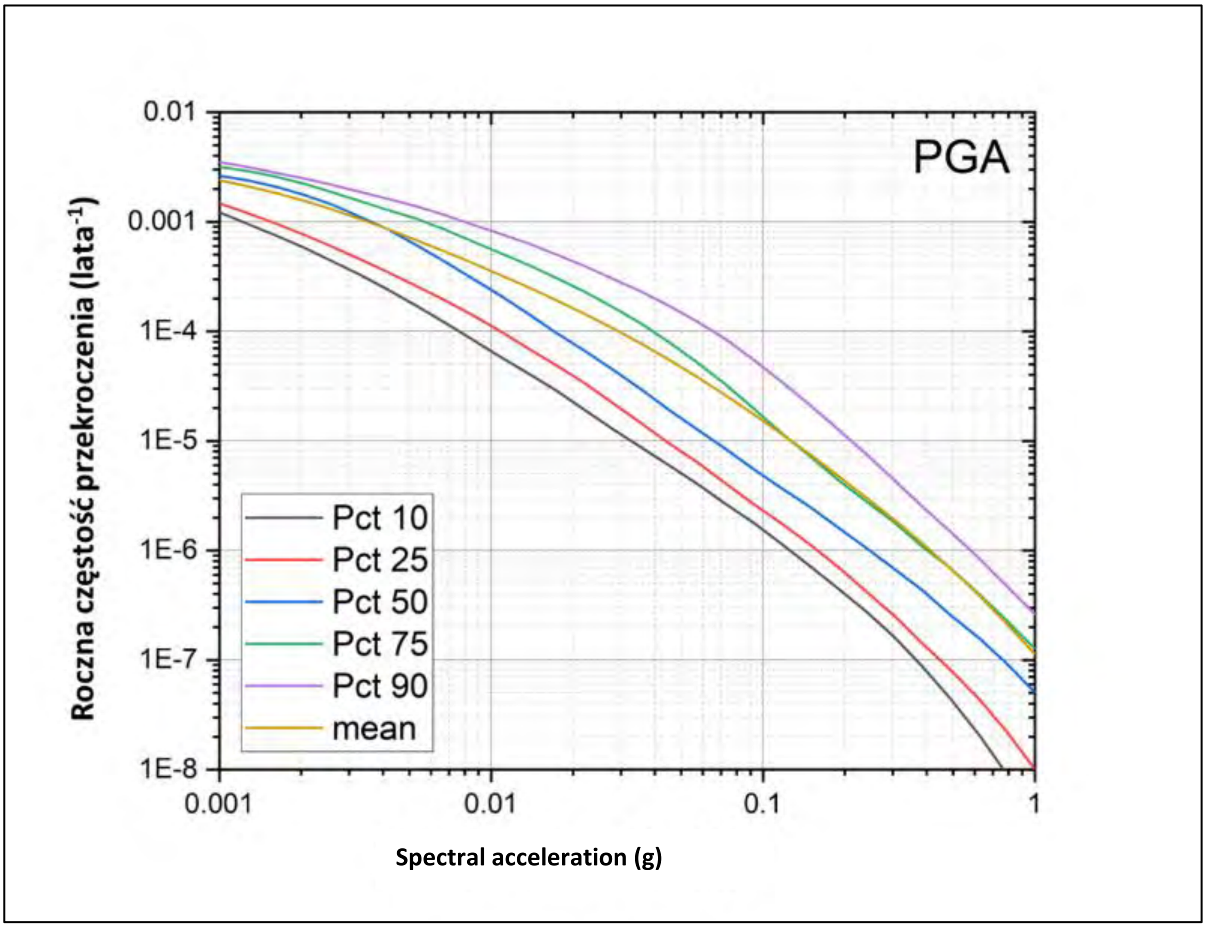



Figure II.11.4- 2 Seismic hazard curves for Variant 2 - the Lubiatowo-Kopalino Site
[Roczna częstość przekroczenia (lata$^{-1}$)– Exceedence annual frequency (years$^{-1}$)]

*Source: Study based on [77]*

Table II.11.4- 3 PGA and intensity (EMS-98) values for Variant 2 - the Żarnowiec Site for the return period of 10,000 years. Minimum magnitude used in calculations $M_w$ = 4.5

| | Medium | Pct 5 | Pct 10 | Pct 25 | Pct 50 | Pct 75 | Pct 90 | Pct 95 |
|---|---|---|---|---|---|---|---|---|
| PGA (m.s$^{-2}$) | 0.302 | 0.067 | 0.078 | 0.110 | 0.174 | 0.403 | 0.674 | 0.850 |
| **PGA (g)** | **0.0308** | **0.0068** | **0.0080** | **0.0112** | **0.0177** | **0.0411** | **0.0687** | **0.0867** |
| GMICE | Average (° $I_{EMS}$) | Pct 5 (° $I_{EMS}$) | Pct 10 (° $I_{EMS}$) | Pct 25 (° $I_{EMS}$) | Pct 50 (° $I_{EMS}$) | Pct 75 (° $I_{EMS}$) | Pct 90 (° $I_{EMS}$) | Pct 95 (° $I_{EMS}$) |
| Masi et al. (2019) | 4.9 | 3.6 | 3.7 | 4 | 4.4 | 5.2 | 5.6 | 5.9 |
| Zanini et al. (2019) | 5.4 | 3.9 | 4.1 | 4.4 | 4.9 | 5.7 | 6.2 | 6.4 |

*Source: Study based on [77]*

Table II.11.4- 4 PGA and intensity (EMS-98) values for Variant 2 - the Żarnowiec Site for the return period of 475 years. Minimum magnitude used in calculations $M_w$ = 4.5

| | Medium | Pct 5 | Pct 10 | Pct 25 | Pct 50 | Pct 75 | Pct 90 | Pct 95 |
|---|---|---|---|---|---|---|---|---|
| PGA (m.s$^{-2}$) | 0.0133 | 0.0025 | 0.0039 | 0.0055 | 0.0163 | 0.0227 | 0.0280 | 0.0318 |
| **PGA (g)** | **0.0014** | **0.0003** | **0.0004** | **0.0006** | **0.0017** | **0.0023** | **0.0029** | **0.0032** |
| GMICE | Average (° $I_{EMS}$) | Pct 5 (° $I_{EMS}$) | Pct 10 (° $I_{EMS}$) | Pct 25 (° $I_{EMS}$) | Pct 50 (° $I_{EMS}$) | Pct 75 (° $I_{EMS}$) | Pct 90 (° $I_{EMS}$) | Pct 95 (° $I_{EMS}$) |
| Masi et al. (2019) | 2.2 | 0.7 | 1.1 | 1.4 | 2.3 | 2.6 | 2.8 | 2.9 |
| Zanini et al. (2019) | 2.3 | 0.7 | 1.1 | 1.4 | 2.5 | 2.8 | 3.0 | 3.2 |

*Source: Study based on [77]*

For Variant 1- Lubiatowo - Kopalino site (according to [Table II.11.4- 1] and [Table II.11.4- 2]):

- The average PGA value for the 475-year return period is 0.0015 g;
- Intensity in the EMS-98 scale for the return period of 475 years is 2.4°;
- The average PGA value for the 10,000 year return period is 0.0305 g;
- Intensity in the EMS-98 scale for the return period of 10,000 years is 5.4°;

For Variant 2 - the Żarnowiec Site (according to [Table II.11.4 - 3] and [Table II.11.4 - 4]):

- The average PGA value for the 475-year return period is 0.0014 g;
- Intensity in the EMS-98 scale for the return period of 475 years is 2.3°;
- The average PGA value for the 10,000 year return period is 0.0308 g;
- Intensity in the EMS-98 scale for the return period of 10,000 years is 5.4°;

The peak ground shaking acceleration value in question is many times lower than the assumed PGA (Safe Shutdown Earthquake, SSE) value ( *Safe Shutdown Earthquake, SSE*)/ seismic level SL- 2), which for nuclear facilities with the AP1000 reactor is 0.3 g.

In summary, based on the seismic and tectonic hazard analyses performed to date, it has been determined that there is no tectonic zone in the Site Region of both site variants through which the site might not be considered suitable for siting a nuclear facility, and the PGA value (for the 10,000-year return period) is less than 0.1 g.

**2. Flood hazards – NPP site flooding and inundation**

According to the classification applied in the EU, the following types of floods can be identified in Poland:

- Fluvial floods of a natural exceedance mechanism (A11).
- Fluvial floods resulting from a defence exceedance, or defence or infrastructural failure (A23).
- Fluvial winter floods of a blockage/restriction mechanism (A24).
- Pluvial floods (A12).
- Groundwater floods (A13).
- Sea water floods (A14).
- Artificial water-bearing infrastructure floods (A15).

According to results of a revision of the Preliminary Flood Risk Assessment (PFRA) [72], it has been established that in either site variant, the Boundary of a planned nuclear facility site is not situated on the territory identified as a flood-prone area (FPA). In the Site Area for Variant 1 - Lubiatowo - Kopalino site, at its western end, a small FPA area was delineated - in the valley of the Chelst River, in the estuary zone to Sarbsko Lake [Figure II.11.4- 3]. In Variant 2 - Żarnowiec site, at the northern end, of the site, there is a fragment of the FPA comprising floodplains in the valley of the Piaśnica river below Żarnowieckie Lake (Project Sub-Areas 2 and 3) [Figure II.11.4- 3]. The FPAs indicated will not constitute a flood hazard in the assumed Project area. The cooling water channels/pipelines planned for Sub-Area 2 of the Project Area will run directly through the aforementioned FPA; the water pumping station and infrastructure (not critical infrastructure in terms of nuclear safety) will be located in Sub-Area 3 of the Project Area; however, its foundation at the level of 5.0 m above sea level will sufficiently protect the facility against flood hazard.

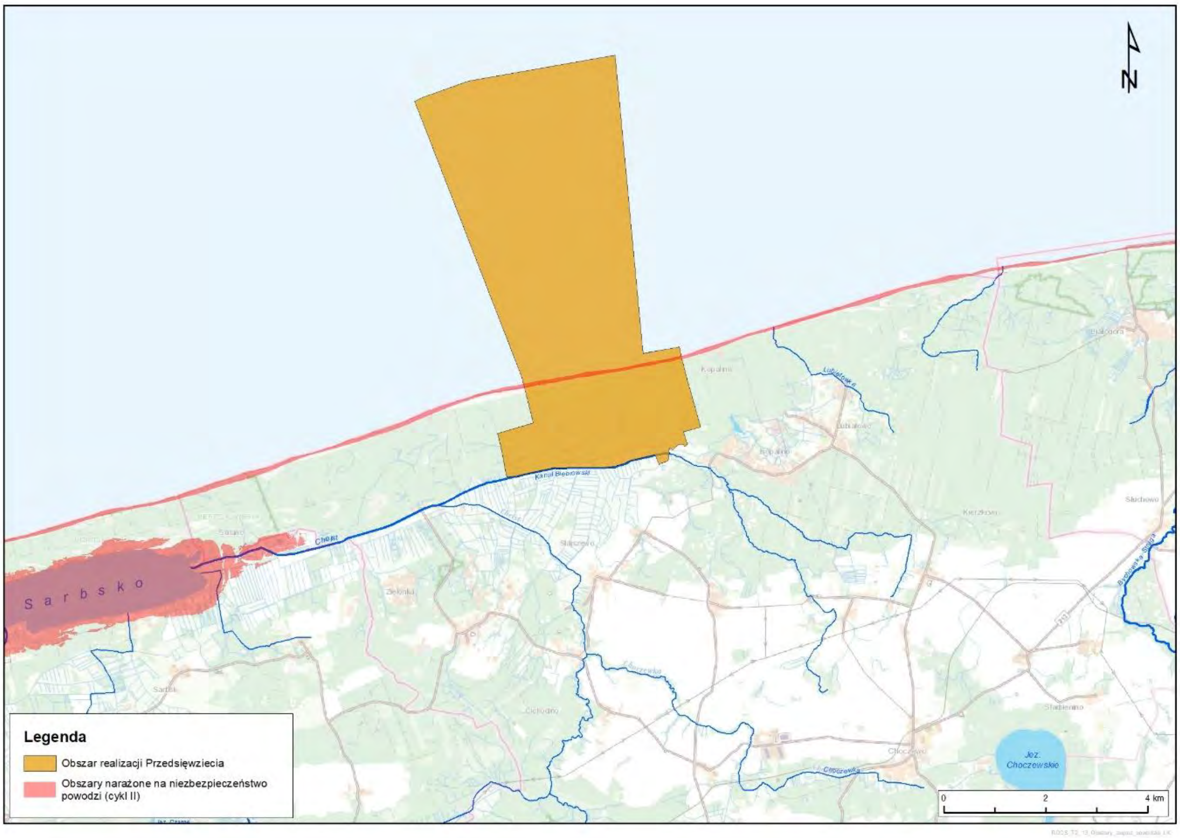



Figure II.11.4- 3 Flood-prone areas (FPAs). Variant 1 — Lubiatowo-Kopalino site
[Legend: Orange – Project area, Red – Flood-prone areas]

*Source: Own study based on geobase from: [72]*

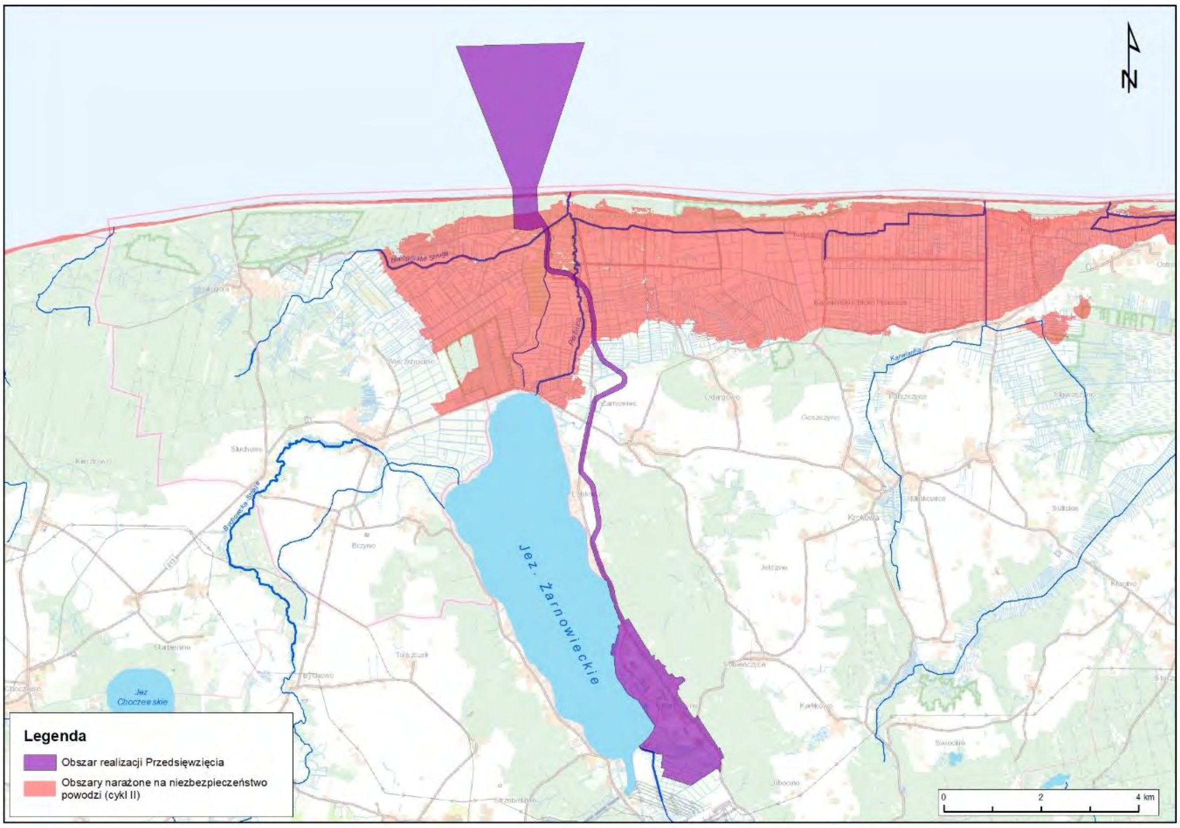



Figure II.11.4- 4 Flood-prone areas (FPAs). Variant 2 – Żarnowiec site
[Legend: Puprple – Project area, Red – Flood-prone areas]

*Source: Own study based on geobase from: [72]*

The flood hazard was also the subject-matter of the study: Site General Arrangement – Preliminary Estimate of Platform Height. Hydrological hazards at two potential Nuclear Power Plant site variants: Żarnowiec and Lubiatowo - Kopalino [109]. As in both site variants the Project Area is not situated within any significant fluvial floods (except subarea 3 and partly 4 for Variant 2), the main hazard identified is the maximum sea level than can be reached as a result of a combination of a number of phenomena and factors. Sea level rise during a 1 in 10,000 year storm surge, wave height, and sea level change from a climate change perspective to 2180 were used to determine the maximum predicted sea level. Moreover, an uncertainty of 1m for the estimates was applied. These estimations resulted in an ordinate of 8.83 m asl for Variant 1 - Lubiatowo - Kopalino and 8.3 m asl for Variant 2 - Żarnowiec as the maximum, which was the basis for determining the projected ground ordinates for both site variants.

**3. Geological and geotechnical hazards related to the existing geology and engineering conditions of siting the NPP facilities.**

Below, the following geological phenomena are discussed in relation to both site variants:

- Filtration deformations
  - Suffosion processes
  - Hydraulic uplift and hydraulic heave
  - Soil liquefaction (quicksand)
- Low bearing capacity soil
- Erosion and accumulation processes
- Landslides

- Karst processes

Geological hazards have been described on the basis of studies, designs, documentation and results of investigations conducted under the Environmental Surveys and Site Investigations Programme for the First Polish Nuclear Power Plant.

**Variant 1 - Lubiatowo-Kopalino site**

In the Project Area in Variant 1 - the Lubiatowo-Kopalino Site, the following phenomena that can cause geological hazards have been identified:

Filtration deformations

On the basis of the investigations conducted so far [23], [12] , the following soil types have been identified which, in unfavourable hydrogeological conditions or when carrying out earthworks, are prone to filtration deformations:

- silt and sandy loam (hydraulic uplift, soil liquefaction, thixotropy),
- aeolian fine sand, loamy sand and medium sand, sometimes with layers of silt and sandy loam (suffosion processes, soil liquefaction),
- fluvioglacial non-cohesive sediments of various granularity (suffosion processes),
- sandy loam and loamy sand, with gravel additions (hydraulic uplift and hydraulic heave, soil liquefaction) [23], [21].

Based on the results of geological investigations conducted in the Project Area, several aquifers have been identified (a detailed description of hydrogeological conditions is presented in Volume III [Chapter III.3.5]). The first aquifer table is situated at the depth of 1.0-1.5m below ground level.

The system of geological and engineering layers as well as the existing soil types can involve a risk of filtration deformations described above. Therefore, at the stage of the building permit design and then the NPP construction, these phenomena should be taken into account.

Erosion and accumulation

In the Baltic Sea coastal strip, active abrasion, sea accumulation and aeolian processes have been identified. For the Project Area, the active geodynamic processes are observed primarily in the coastal zone and in the costal dune belt. In the dune belt, active aeolian processes take place which affect chiefly the foredune (because other dunes are stable and covered by a pine forest). In the Baltic Sea coastal zone, the existing current active abrasion and accumulation processes are caused by undulation and sea currents. During very strong storm surges, abrasion processes become intense and the foredune belt can be undercut as a result [12], [21].

The major part of the seabed in the region of the planned construction of cooling water channels/pipelines should be deemed a dynamic zone. It covers two parts which differ in terms of the nature of the existing dynamic processes: the zone of submerged bars and a coastal slope. The zone of submerged bars is subject to a continuous impact of even a minor undulation. Here a sandy material is permanently moved and the submerged bars are remodeled, especially intensively during storms. The coastal slope area is subject to the impact of significant waves (which occur during storm surges) while the intensity of processes taking place at the bottom of the coastal slope depends on the storm intensity and duration. Considering the nature of the relief at the base of the coast slope, special attention should be paid to the area. The base is subjec to changes, which may involve exposing or covering elements of the planned infrastructure. A precise description of the coastal zone dynamics is presented in chapter [Chapter III.3].

Low bearing capacity soil

According to the surveys conducted [23], [21] in the Project Area, soils are present of low bearing capacity soil, including:

- Organic soil - mostly peat, aggregated mud and humus sand. It occurs chiefly near the surface or at the minor depths, and its thickness ranges between 0.5m and 3.5m;
- Non-cohesive soil (of aeolian, lacustrine and fluvioglacial genesis) - mostly fine, loamy and medium sand, sometimes with layers of silt and sandy loam, very loose and loose. They occur mostly to the depth of 7 m below ground level, and in some places to the depth of more than ten meters;
- Cohesive soil (of various origin) - mostly silt, sandy loam and loamy sand, also with an addition of gravel, in a soft-plastic condition. Occuring locally at the depth of over 20m, with maximum thickness of about 7 metres [23], [21].

For the purpose of NPP construction, the above soils require a detailed survey prior to design work to determine their spatial extent . Depending on the type and depth of the planned foundation of building structures, soils should be reinforced or replaced [50].

<u>Landslides</u>

Based on the analysis of collected materials [57], [21], it can be concluded that areas prone to mass movements occur at a considerable distance from the Project Area. Therefore, they will have no impact on the structures and installations built under the Project.

<u>Karst processes</u>

Analysis of the available materials regarding the geological structure [21] shows that there are no karst formations in the Project Area. No rocks susceptible to karst processes have been identified in Quaternary and Paleogene-Neogene sediments. Such rocks as limestone, gypsum, marl or chalk can occur in older substratum profiles, at significant depths, and their existence will have no impact on development of karst processes [74].

**Variant 2 – Żarnowiec site**

In the Project Area in Variant 2 - the Żarnowiec Site, the following phenomena that can cause geological hazards have been identified:

<u>Filtration deformations</u>

On the basis of the investigations conducted to date [24], [22], the following soil types have been identified in the Project Area which, in unfavourable hydrogeological conditions or during construction works, are prone to filtration deformations:

- silt and and sandy loam (hydraulic uplift, soil liquefaction, thixotropy),
- aeolian fine sand, loamy sand (suffosion processes, soil liquefaction),
- fluvioglacial and fluvial non-cohesive sediments of varying granularity (suffosion processes),
- sandy loam, silty loam and loamy sand, with gravel additions (hydraulic uplift and hydraulic heave, soil liquefaction) [24], [22].

Based on the results of geological investigations conducted in the Project Area, several aquifers have been identified (a detailed description of hydrogeological conditions is included in Volume III [Chapter III.3.5]). The first aquifer table is situated at the depth of 0.5m - 6.0m below ground level [24].

The system of geological and engineering layers as well as the existing soil types can pose a risk of filtration deformations described above. Therefore, these phenomena should be taken into accoun at the stage of the building permit design and the NPP construction.

<u>Erosion and accumulation</u>

With respect to the planned nuclear facility region (subarea 1) and in the part of the makeup water channels/pipelines (subarea 2), erosion and accumulation processes occur on the slopes around the Żarnowiec trough. The areas are prone to active erosion and slumping processes as well as to local active accumulation. On the slopes, manifestations of soil creep processes were generally observed, which include the near-surface sediment layer (about 1 m) [22].

For the region of planned makeup water channels/pipelines (subarea 4) and in the region of the cooling water pumping station (subarea 3), in the location variant analysed, the active geodynamic processes are observed primarily in the coastal zone and in the costal dune belt. In the dune belt, aeolian processes occur in some places, which include also a part of the beach plane and foredune. The remaining dunes are stable and covered by a pine wood. In the Baltic Sea coastal zone, the existing current active abrasion and accumulation processes are caused by undulation and sea currents. During very strong storm surges, abrasion processes become intense and the foredune belt can be undercut as a result [12], [22].

A major part of the seabed in the region of the planned construction of makeup water channels/pipelines should be recognised as a dynamic zone. It includes two parts which differ in the nature of existing dynamic processes: the zone of submerged bars and a coastal slope. The zone of submerged bars is subject to a continuous impact of even minor waves. Here a sandy material is permanently moved and the submerged bars are remodeled, especially during storms. The coastal slope area is subject to the impact of significant waves (which occur during storm surges) while the intensity of processes taking place at the bottom of the coastal slope depends on the storm intensity and duration. Considering the nature of the relief at the base of the coast slope, special attention should be paid to the area. The base is subjec to changes, which may involve exposing or covering elements of the planned infrastructure. A detailed description of the dynamics of the coastal zone can be found in Volume III [Section III.3.3].

Low bearing capacity soil

According to the conducted surveys [24], [22]low bearing capacity soil is present in the Project area, including:

- non-reinforced embankments - mostly non-cohesive embankments, locally consisting of cohesive and organic soil, occurring on the premises of the unfinished construction site of the Żarnowiec nuclear power plant, to the depth of 7m below ground level.
- organic soil - primarily peat, aggregated mud and humus sand. They occur mainly near the land surface or at shallow depths and their thickness varies from 1 m to over 3 m. Organic soils occur mainly in the southern part of the coastal plain, in the bottom of the Żarnowiec Trough and in depressions,
- slopewash and colluvium - sand and slopewash loam covering the surface of slopes and bottom of smaller valleys and gullies. Their thickness ranges from about 1 m to 8 m. The largest areas covered by deluviums occur on the strongly sculptured slopes of the Żarnowiec Trough,
- non-cohesive soil (of aeolian, lacustrine and fluvioglacial origin) - mostly fine, loamy and medium sand, with addition of gravel, loose. Occurs chiefly near the area surface or at low depths.
- cohesive soil (of varying origin), in a soft-plastic condition, represented by sandy loam, silty loam and loamy sand, with an addition of gravel, occurring locally, of minor thickness [24], [22].

Before starting the design works, the above soil should be thoroughly examined and its spatial extent determined. Depending on the type and depth of the planned siting of building facilities, the low bearing capacity soil should be replaced or strengthened [50].

Landslides

For Variant 2 – the Żarnowiec Site, the areas prone to mass wasting occur mostly in the zone of long slopes at the edges of uplands and at the edges of glacial troughs [12]. Due to the Project Area location, the prone areas around Lake Żarnowieckie are crucial because they can affect the Project [57], [64]. The biggest grouping of landslides occurs near Czymanowo, on the slopes descending from the upper reservoir of the pumped storage power plant to the north and north-east. Eleven landslides have been identified here, including three manifesting periodic activity [22]. In the vicinity of Kartoszyno a group of dry landslide strongly affected by denudation, originated probably shortly after the recession of the last ice sheet in the period when the groundwater table level was higher than currently [57], [64]. All the landslides are conditioned by the lithology of sediments or the existence of glaciotectonic deformations (including the surface of overthrusts). In the vicinity of landslides in the Kartoszyno region, strong glaciotectonic deformations have ben observed in Quaternary formations. In these areas, surface downcreep and flushing processes can also occur [22].

The main reasons of landslide creation in the area under analysis include natural causes, usually related to the infiltration of rainwater and meltwater. The occurrence of mass wasting and its activation is to a large extent correlated with meteorological and hydrological conditions, related to turbulent, often catastrophic rainfall [12], [57], [64].

Excavation, embankments and foundations as part of the construction of the NPP and associated infrastructure involve the risk of mass movements (landslides), which will be taken into account at the stage of NPP design works.

Karst processes

Analysis of the available materials regarding the geological structure [22] shows that there are no karst formations in the Project Area. No rocks susceptible to karst processes have been identified in Quaternary and Paleogene-Neogene sediments. Such rocks as limestone, gypsum, marl or chalk can occur in older substratum profiles, at significant depths, and their existence will have no impact on development of karst processes [74].

**4. Hazards related to extreme meteorological parameters and events**

Issues related to climatic conditions found in the Site Region and climate change are discussed in detail in Volume III [Chapter III.3.2].

For the purpose of Project implementation, an analysis was carried out of extreme meteorological events, including extreme values of meteorological parameters, occurrence of extreme and extremely rare meteorological phenomena defined in *Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations* [53]. The study used the data from the 1981-2018 period from the measurement network of the IMGW-PIB (Institute of Meteorology and Water Management – National Research Institute) [15].

The results of the analysis related to extreme external hazards are representative for both site variants. The extreme values of meteorological parameters have been determined for given probabilities of occurrence (i.a. once per 100 years, once per 10,000 years). The probabilities are theoretical and their occurrence with a given frequency entails the statistical possibility that such an event will occur, and is not a prediction that such a situation will occur once every 100 years or once every 10,000 years. However, these calculations allow for the estimation of the risk that such extreme phenomena pose for the execution of the Project. For example, once every 100 years, a maximum temperature of 36.6°C can be expected in Łeba, and 37.9°C in Lębork. In Łeba, the daily total precipitation may reach 100.9mm once every 100 years, and 235.6mm once every 10,000 years. All calculated probabilities of extreme values of meteorological parameters are presented in Volume IV [Chapter IV.3]. Extreme events will be considered during the design and individual phases of the Project.

**5. Hazards associated with solar storms**

Explosions on the Sun, resulting in low intensity solar storms, are a fairly frequent phenomenon, while superstorms occur sporadically (it is estimated that they occur once every 100 or 200 years). Most of them do not move towards the Earth, and instead travel into space [39], and only half of those that travel towards the Earth may pose a hazard. The study of such phenomena relies on the assessment of the risk of occurrence of a magnetic storm similar to that observed in 1859 (a coronal mass ejection on the Sun). It is estimated that the risk of occurrence of a phenomenon of similar intensity is 12% per decade, which corresponds to a return period of 79 years. It is, however, a random event and one should not expect a severe magnetic storm every 79 years. Instead, one should be prepared for the random occurrence of such phenomena.

Magnetic storms are linked to rapid changes in the magnetic field in a large area, and induction of an electric field on Earth. These fields, in turn, induce electric currents in the power systems and other conductors, which may result in the instability of the transmission grid and failures of transformers.

There are two ways to minimise the risk associated with magnetic storms:

- Implementing appropriate technologies and procedures to deal with these situations - e.g., increasing spare parts inventories, installing devices to block geomagnetically induced currents (GICs) - will help to reduce the risk of accidents;
- Forecasting and monitoring of solar weather, as well as gradual implementation of procedures similar to those used in risk assessment for ground events.

**6. Presence of natural resources**

Analysis of the available materials regarding the geological structure [46] shows that:

- there are no documented deposits of natural resources or active concessions in the Project Area of Variant 1 - Lubiatowo - Kopalino site,
- - in the Project Area (subarea 2) of Variant 2 - Żarnowiec site there are documented crude oil or natural gas deposits and active licenses. A 154.5 ha "Żarnowiec" oil and gas field is located approximately 4.7 km from Sub-Area 1. According to the Balance of mineral deposits in Poland as of 31.12.2019 [11], the deposit is in use for extraction. The balance of resources of the deposit is as follows: balance oil resources are 17.62 thousand tons, industrial resources - 3.65 thousand tons, and production - 0.03 thousand tons. In turn, the balance resources of natural gas are 0.65 million $m^3$, industrial resources - 0.23 million $m^3$, and production - 0.33 million $m^3$.

Moreover, at a distance of around 28km to the southeast of the Project Area of Variant 2 - Żarnowiec site, there is a cavern gas storeroom o "Kosakowo".

A description of hydrocarbon deposits found in the vicinity of the Project Area for both location options is presented in Volume III [Chapter III.3.3.1.5] and [Chapter III.3.3.2.5].

**7. Hazards associated with the presence of volcanoes**

There are no active volcanic phenomena in Poland.

**8. Hazards associated with tsunamis**

No tsunamis are anticipated, which could cause a hazard more severe than storm surges accounting for climate change.

## II.11.4.4 Risk of a building disaster

A building disaster, in accordance with Art. 73 of the Construction Law Act [150], is an unintended, sudden destruction of a construction or its part, including the structural elements of scaffolding, forming elements, tight walls, and excavation support. In turn, damage to an element built into a construction, which can be repaired or replaced, damage to construction equipment associated with buildings, or installation failure, are not building disasters.

Building disasters are mainly caused by random events, including:

- heavy precipitation,
- strong winds,
- landslides,
- atmospheric discharges,

- man-induced events, e.g. gas explosion, fire, or traffic accidents.

NPP facilities are designed with due account for static and dynamic loads (including their possible combinations) and in line with safety margins applied for this type of facilities. The power plant facilities are also required to withstand (with significant safety margins) loads exceeding design values, and avoid catastrophic damage after design loads have been narrowly exceeded - i.e. the so-called cliff-edge effect [108]. These requirements apply especially to seismic loads [107].

The NPP facilities are characterised by high resilience to extreme conditions and loads associated with normal operation as well as all external and internal events/hazards.

In the process of NPP design, the site-specific design basis is determined [98] on the basis of the analysis of the following external events/hazards:

1) Natural events/hazards:
   a. Seismic and tectonic;
   b. Flooding;
   c. Geological and geotechnical;
   d. Extreme meteorological parameters and events:
2) Man-induced events/hazards:
   a. Aircraft impact (including large commercial aircraft)
   b. External explosion;
   c. External fire (especially forest fire);
   d. Emission of hazardous substances (including as a result of fire or explosion);
   e. Other site specific hazards (such as those associated with: marine transport, prospecting for and excavation of natural resources, industrial plants and installations, and electromagnetic field emissions).

The level of service loads together with safety margins and loads from external hazards and events, which need to be accounted for in the design of the unit, will be specified by the plant vendor with due account for local conditions [156] [10].

The adopted assumptions and safety factors point to the fact that the collapse of the buildings and structures of the NPP as a result of the external events/hazards described above should be seen as practically impossible, irrespective of the selected site variant. Damage to some NPP facilities may only occur in the event of extreme events/hazards associated with the impact of a large aircraft, but the possible damage to the containment and auxiliary building would then be reduced so as to ensure the safety of the reactor and nuclear fuel. This results from the relevant requirements of both the US legislation 10CFR50 [119] (§ 50.150), and Polish legislation [107] (§ 33).

Some of the NPP facilities could potentially be damaged only as a result of internal events/hazards. These facilities include specifically:

- - <u>the containment building</u>: in severe accident conditions (excess pressure or temperature, direct heating of the containment structure, ejected elements, detonation of flammable gases), in the event that the safety systems dedicated to handling severe accidents fail. However, accident sequences leading to such conditions are highly improbable, as their probability of occurrence is lower than once per 100 million years. The large release frequency, which is normally related to the failure of the containment building, for the AP1000 reactor was estimated (including all the initiating events) at $1.7\times10^{-8}$ per reactor year, i.e. once around every 59 million years [79], [10].

- - the turbine building: in the event of a rupture of the rotors of the turbogenerator set, fire (especially of oil) or detonation of gases (especially of hydrogen used for the cooling of the generator "barrel"). The consequences of such events are estimated by nuclear safety analyses, and the technical mitigation measures applied in the design ensure nuclear safety, i.e. they prevent the loss of specific safety functions [10].

It should be noted that the NPP is designed, constructed, commissioned, and operated in keeping with especially strict technical and quality-related requirements, defined in detail in nuclear safety regulations [107], [119], [150] as well as dedicated "codes and standards". The requirements will be strictly complied with and enforced at many levels defined in the quality assurance system (which also complies with requirements specific to the nuclear power industry), by the entities executing the works and by regulatory bodies (PAA, UDT). One should also stress that the technical requirements for specific systems, structures, and components (SSCs) of the NPP are differentiated depending on the importance of the safety function that they serve, the nuclear safety class ascribed to them, and (where applicable) seismic class.

As a result, the NPP facilities are robust, resilient to all the external hazards/events, and have high construction and maintenance standards - which prevents them from damage, and even more so from collapse (a biolding disaster).

## II.11.4.5 Prevention of emergencies

## II.11.4.5.1 Construction phase

Buidling emergencies are events at the construction site resulting from an uncontrolled situation during the construction of facilities, assembly of components or installations, and during the production, storage, and transport of materials and components, leading to an incident, accident, or a disaster, either immediately or at a later time. An emergency at the construction site may be caused by fire, building or ecological disaster, environmental hazard, etc.

#### II.11.4.5.1.1 Development stage

In order to prevent accidents and emergencies during the works carried out at the development stage, the following actions will be undertaken:

- Appointing and organising teams and individuals responsible for the execution of the works at the construction site among all the participants in the construction process defined in Art. 17 of the Construction Law Act [150], i.e.: teams of the investor, investor's supervision inspector, designer, and the site manager;
- Preparing documentation and permits for the execution of the development works;
- Preparing documentation regarding the assurance of occupational health and safety (OHS) for the development works, which has been described in detail in chapter [Chapter II.11.4.5.1.2];
- Training all the employees at the construction site in OHS;
- Erecting a fence around the construction site, at least 2m in height, which will protect the area of the construction site and the facilities from unauthorised access;
- Designating and paving internal communication, transport, and fire roads, pedestrian passages, taking into account the optimal width and inclination;
- Construction of sanitary facilities with dedicated washrooms, toilets, drying room, and a locker room for work and protective clothing;
- Construction of water and sewage, fire protection, and electric power installations at the construction site;

- Construction of a first aid centre;
- Construction of fire protection facilities;
- Designating danger zones, i.e. locations at the construction site where a risk is prresent to health or life of people, e.g. from falling items.

Moreover, during the execution of the development works, the same countermeasures will be applied against accidents and emergencies as in the case of the construction stage (described below).

#### II.11.4.5.1.2 Construction stage

Efficient organisation of the construction, also including prevention of emergencies at the construction site, requires compliance with the provisions of the Construction Law Act [150], which regulate activities involving the design, constructiion, maintainance and dismantling of structures and define the principles of operation for public administration bodies in these fields. Within the meaning of the above Act, the participants in the construction process are: Investor, Investor's Supervisor, Designer and Construction Manager. In the case of an investment as large as the construction of an NPP, each of the above participants in the construction process will have a team of subordinate specialists.

The Construction Law sets out the main obligations of the above participants in the construction process related directly or indirectly to preventing temergency situations at the construction site:

- the investor is responsible for organising the construction process with due regard to safety and health protection principles included in the regulations (Art. 18);
- the designer is responsible for: developing a building permit design in accordance with the requirements of the act, arrangements defined in administrative decisions regarding the construction project, current regulations and technical knowledge, implementing in the design the safety and health protection principles for the construction process included in the regulations, preparing information on safety and health protection; securing the required opinions, decisions, and inspections of the design solutions within a scope required by the regulations; exercising project designer’s supervision (Art. 20);
- the site manager is responsible for: preparing (prior to the commencement of the construction) a safety and health protection plan (SAHP) which accounts for the specificity of the structure and the conditions of the execution of construction works, including the planned concurrent execution of construction works and industrial production, keeping the construction documentation, organising the construction and managing the construction of the structure in accordance with the design and the construction permit and regulations, including the occupational health and safety regulations, coordinating activities that ensure that the safety and health protection principles are followed during the construction works, halting the construction if a potential hazard is identified (Art. 21a, Art. 22);
- the investor’s supervision inspector is responsible for supervising the compliance of the project implementation with the design, regulations, and technical knowledge, verifying the quality of the executed construction works and verifying that permitted construction materials have been used in the execution of the works (Art. 25).

Moreover, apart from the safety and health protection plan, instructions for the safe execution of construction works (ISEW) are developed before the commencement of construction works, defining the ways of preventing hazards associated with the execution of construction works specified in Art. 21a item 2 of the Construction Law Act [150] and specifying the ways of dealing with these hazards. The requirement to develop the ISEW is imposed on the Contractor by the provisions of the Regulation of the Minister of Infrastructure of 6 February 2003 on occupational safety and health during the performance of construction works [86].

In the event that an emergency occurs, it should be contained as soon as possible, so as to reduce the risk of a serious threat for human health and/or environment. It is also crucial to ensure secure evacuation routes from every location in the facility in which people will be present. The employer must take measures to minimise the risk of emergencies at the construction site, and ensure the safety of their workers by complying with the OHS obligations and applying best practices. The best way to prevent emergencies and accidents is to take diversified actions, i.e. maintaining the machinery, improving the general organisation and methods for the execution of works, and raising the awareness of employees responsible for individual activities. The employer should engage in activities that concentrate on the appropriate fulfillment of occupational health and safety responsibilities. These include:

- appropriate preparation of works with regard to organisation and technical equipment,
- provision of documentation necessary for the executed activities and acquainting the employees with it (e.g. ISEW),
- equipping the workers with appropriate working clothes, footwear, and personal protective equipment,
- only admitting to work the personnel who have a valid medical certificate and a valid OHS training.

To facilitate the process of risk management and emergency prevention, it is best practice to:

- hold regular briefings with the employees (i.e. before commencing work),
- organise induction training for all the participants of the investment process entering the construction site (general contractor, subcontractors, external companies).

The above points to the fact that safety at the construction site is an extremely important management area. To this end, separate, independent health and safety units will be set up at the construction site, consisting of health and safety inspectors to develop a health and safety plan and instructions for the construction site, to train employees working on the site, and to provide health and safety supervision at all sections of the construction site.

In the construction of individual NPP facilities, strict technical and quality requirements will be complied with, as defined in the regulations of the Construction Law Act [150], nuclear safety regulations [147], [119], [150], and in construction standards, as well as nuclear codes and standards. These requirements will be strictly complied with and enforced at many levels defined in the quality assurance system (which also complies with requirements particular to the nuclear power industry), both by the entities executing the works and by the regulatory bodies (PAA, UDT).

As a result, the construction of the NPP facilities will be characterised by high quality of execution of individual works and will be carried out safely, i.e. in a way that minimises the risk of emergencies and disasters.

## II.11.4.5.2 Operational phase

### II.11.4.5.2.1 Prevention of a severe industrial accident

As can be seen from the analysis carried out earlier in this chapter, the NPP, irrespective of the technical sub-variant considered (type of cooling system), meets the criteria for being qualified as a facility with a high risk of a serious industrial accident.

In order to reduce the risk of emergencies, the following is additionally planned at the stage of designing and constructing new facilities:

- using components that are certified and included in the compliance system, especially those powered by electricity,
- implementing an electric installation that includes fire and overload protection, complying with the requirements of the relevant provisions,
- applying the ergonomics and OHS principles in the design of the location of individual components and their surroundings.

- application of the provisions of the ordinance of the Minister of Internal Affairs and Administration of 30 June 2010 on fire protection of buildings, other structures and sites [90], concerning the construction of buildings and fire protection equipment.

Chemicals will be stored in tanks placed on safety tubs of volume greater than the volume of the secured tank, with strict observance of the current regulations. All premises used for storage and tanks placed overground will be fitted with appropriate instruments and protected against fire, while tanks placed below ground will have double walls.

As a precaution against severe industrial accidents, and accounting for the nature of auxiliary materials and resources, appropriate documentation will be developed presenting the safety system, with adequate protection of the population and the environment in the event of a fire. The documentation will comprise instructions in case of fire, including:

- terms of notification, stating who to notify, in what way and with what information,
- instructions to personnel in the event of a fire, including responsibilities of the staff engaging in a rescue operation.

The NPP site will have a mobile communication system in place. Explosion hazard areas will be fitted with phones allowing for immediate notification of a threat. The locations of the phones will be carefully planned at construction design stage.

Emergency procedures will be put in place as part of the safety management plan for the plant. Integrated instrumentation and control systems will be designed in a manner allowing for isolation of installation components or the entire plant in an emergency.

Irrespective of the technical measures, the personnel manning the installations will receive basic training, OHS training and appropriate power generation trainings where required.

#### II.11.4.5.2.2 Prevention of a severe accident in a nuclear context

Prevention of accident conditions in a NPP (as per the Atomic Law act [147]) includes a series of means as well as technical and organisational solutions, described in detail in chapter [Chapter I.3.4].

Technical means and solutions facilitating the prevention of accident conditions within the NPP comprise the following:

1. Implementation of a “defence-in-depth” strategy - as a key concept of ensuring nuclear safety [147], [107], comprising the application of five independent levels of defense, designed in a manner ensuring that the loss of any one level of defense does not lead to the loss of any other level or levels of defense. The nature of “defence-in-depth” is alway to compensate for possible failure of systems, structures or equipment of the NPP as well as for human error.

   The levels can be briefly characterised as follows:

   I. Prevention of deviations from normal operation and damage of systems, structures and components of the NPP, achieved by means of:

      i. application in the design of the NPP of broad safety margins, design safety features (stability, self-regulation), redundancies, diversity of technical solutions, separation, and functional independence of systems important to safety;

      ii. ensuring high quality during NPP design and construction;

      iii. NPP operation in a manner ensuring fault-free performance of all systems, structures and components, by ensuring and maintaining high qualifications of the staff and high quality of operation procedures;

iv. implementing and maintaining high safety culture – in which ensuring safety is the overriding priority over any other tasks and goals, especially production goals - at all stages (site selection and evaluation, design, construction, commissioning, operation, and decommissioning);

II. Technical oversight, involving detection and handling of deviations from normal operation so as to prevent the escalation to accident conditions, through the operation of I&C equipment and (in case intervention is needed) also through operator actions, with the use of appropriate operation procedures;

III. Containing design basis accidents so as to prevent them from escalating into more severe accidents, and reduce their radiological effects to such an extent that it would not be necessary to make any offsite intervention - thanks to inherent safety features, operation of the appropriately designed (passive) safety systems, and operator actions with the use of accident operation procedures;

IV. Handling and limiting the radiological effects of severe accidents so that the interventions made in order to protect the health of the public are limited in space to the immediate vicinity of the NPP and limited in time (especially so that it is not necessary to permanently relocate the population or apply long-term restrictions on the consumption of locally produced food and goods); especially by preserving the integrity and the highest possible efficiency of the containment. To this end, it is assumed that additional safety systems dedicated to handling severe accidents, and some other NPP systems that are not safety systems will be used to a degree that goes beyond their design functions.

V. Reducing and mitigating the radiological effects of large releases of radioactive substances in the vicinity of the NPP, which may potentially occur during accidents (especially severe accidents), by applying additional technical and organisational measures and carrying out the actions laid down in contingency plans.

2. Using a system of protective barriers containing/preventing the spread of radioactive substances: 1) material of the fuel pellet, 2) cladding of the fuel element, 3) pressure limit for the reactor's cooling system, 4) containment.
3. Ensuring that the NPP is resilient to external impacts associated with external (natural and man-induced) extreme events/hazards and internal events.
4. Practical exclusion of accident sequences that may lead to early and/or large releases of radioactive substances into the environment.
5. Mitigating and reducing the radiological effects of accidents that cannot be ruled out.

Apart from the above solutions, chapter [Chapter I.3.4] describes the following requirements related to:

- the design, construction, commissioning and operation of the NPP, including lifecycle and aging management of its systems, structures, and components;
- handling accidents and the protection of the public's health in the event of large releases of radioactive substances from the NPP into the environment;
- accident management.

The potential accidents and radiological events that may occur at the operational stage will be identified and analysed, including the determination of measures preventing their occurrence, in the preliminary safety analysis report (PSAR), which will be submitted to the President of the PAA along with an application for the construction licence for the NPP [106], and in the pre-construction safety report (PCSR), which will be submitted to the President of the PAA along with an application for the NPP commissioning permit [105]. The results of these analyses and the measures for the prevention of accidents and radiological events will also be duly taken into consideration in operational procedures for the NPP.

## II.11.4.5.3 Decommissioning stage

### II.11.4.5.3.1 Prevention of a severe industrial accident

Reducing (as successive units are taken out of operation) the amount of stored chemicals used at the power plant until they are fully removed from the NPP site should be one of the first actions in the process of NPP decommissioning.

The excessive amounts of stored chemicals could be a possible cause of unexpected emergencies for the nuclear power units that were taken out of operation, and thus it will be important to reduce the reserve to the amount necessary.

### II.11.4.5.3.2 Prevention of a severe accident in a nuclear context

The technical measures and solutions as well as organisational arrangements described in detail in [Chapter I.3.4] also apply at the decommissioning stage. Moreover, the requirements laid down in the decommissioning regulation [99] have to be met, and this applies especially to the requirement related to the prevention of accidents during the dismantling of systems, structures, and components of the NPP. In accordance to § 10 item 2 of the above regulation [99], decommissioning activities such as decontamination, cutting and displacement of large elements of structures or components, successive dismantling or removal of safety systems, which may cause a hazard, are evaluated with regard to their impact on nuclear safety and radiological protection, and they are only conducted in such a way as to mitigate the hazard and keep it within acceptable limits. This pertains especially to the preservation of the functions of the containment systems – in a nuclear power plant or a research reactor - preventing uncontrolled discharge of radioactive substances into the environment during the dismantling works.

In this context, it is especially important to determine the correct order in which the individual systems and NPP components that perform safety functions, and especially the safety systems, are taken out of operation and dismantled. This sequence is determined using tools that are the same or similar to those used for maintenance, test and overhaul planning at the NPP, i.e. using probabilistic safety analysis (*risk-informed maintenance planning*) methodologies.

Moreover, it is also necessary to ensure the continuity of expert knowledge on detailed technical solutions and conditions at the decommissioned plant within the decommissioning organisation. This is especially important in the case of NPP decommissioning, which is divided into phases that are separated by long intervals.

The decommissioning plan will be developed in accordance with the IAEA recommendations [17], which are based on the extensive experience and good practices of IAEA member countries, with particular regard to measures to mitigate a number of risks such as:

- risk of an unintended release of radioactive substances,
- risk of radiological and non-radiological hazards,
- risk associated with the aging of barriers preventing the spread of radioactive substances,
- risk of radioactive contamination during the dismantling of systems, structures, and components of the NPP,
- risk of a fire or explosion (especially in the event of a hydrogen release) during the execution of dismantling works.

Risks associated with the process of NPP decommissioning will be identified and analysed, including their muitigation measures, in the safety report that will be developed for the decommissioning phase. They will also be included in the decommissioning programme of the NPP [105].

# II.12 Associated infrastructure not covered by an application for the decision on environmental conditions

## II.12.1 General information

The following chapter includes information on the existing and future investments associated with the NPP, which are necessary for its construction and further operation. The planned associated investments will be executed as separate projects, independent of the main Project and under separate administrative decisions. Article 2 section 1 of the Act on preparing and implementing investments in nuclear power facilities and associated investments [146] defines an associated investment as an investment to build or expand transmission lines, as defined in Article 3 Item 11a of the Energy Law Act of 10 April 1997 (Dz. U. [Journal of Laws] of 2018, item 755, 650, 685, 771, 1000 and 1356), necessary to evacuate power from the nuclear power plant or another investment necessary to build or ensure proper operation of a nuclear power facility. In turn, under Article 52(1) of the above Act [146], the minister in charge of economy decides on awarding the status of an associated investment to the investment related to the construction of a nuclear power facility, upon the request of the investor of the associated investment project. It should be emphasised that according to Article 3(1) of the above Act [146], both nuclear power facilities and associated investments are public utility investments within the meaning of the provisions on real estate management. Whereas Article 61 section 1 item 3b of the EIA Law [149] provides that the environmental impact assessment, which is a part of the procedure of issuing a building permit decision for an associated investment, is carried out by a Regional Director for Environmental Protection.

Associated investments to be carried out for the purpose of construction and operation of the NPP will include the following:

- Maritime transport infrastructure – MOLF (Marine Off-Loading Facility);
- Road transport infrastructure – construction of new sections of roads and rebuilding of the existing roads (this applies to roads outside the NPP premises);
- Road transport infrastructure – a service road connecting MOLF with NPP premises. In Variant 2 - Żarnowiec site, pipelines for cooling water intake and discharge will be constructed along the road together with the necessary infrastructure, thus the construction time of the road itself is extended compared to the standard construction of this type of facility;
- Railroad transport infrastructure – reconstruction of the existing section and construction of a new siding/railway to the NPP – electrified railway (this applies to railway sections outside of the NPP premises);
- Accommodation facilities for the NPP employees, including securing the area and connecting the utilities (water, sewage, power, gas, telecommunication, etc.);
- High and medium voltage electrical power grids – ultimately, the construction site will be supplied from a 110 kV power line, and a temporary 15 kV power line will be available at the stage of preparatory works;
- The highest voltage electrical power grids – the power to be evacuated through the 400 kV power line from the NPP to the National Power System, including a 400 kV connection substation for the NPP;
- Water supply and wastewater infrastructure;
  - Sewage system – removal and treatment of sewage from the construction site (construction of a new sewage treatment plant including a sewage system and a system for discharging treated sewage);
  - Water supply system – supplying potable and household water to the construction site (construction of new water intake stations and a Water Treatment Plant including a water supply system);

- Telecommunications and IT networks;
- Local Information Centre (LIC), which will also serve as a hotel and conference centre.

Apart from the above-mentioned planned investments, the associated infrastructure for the NPP will also include the already existing investments, which will be used at the stage of construction and operation of the Project, which do not require modernization or rebuilding. The investments have been taken into account within the analyses related to the adopted maritime and air transport strategies. These include the following:

- Seaports in Gdańsk and Gdynia;
- Gdańsk Lech Wałęsa Airport.

The following figures present the schedule of execution (excluding the time needed for designing, obtaining relevant permits and decisions) of individual associated investments for both site variants [Figure II.12.1- 1; Figure II.12.1- 2]. The timeline for the schedule reflects the years of the Project execution.

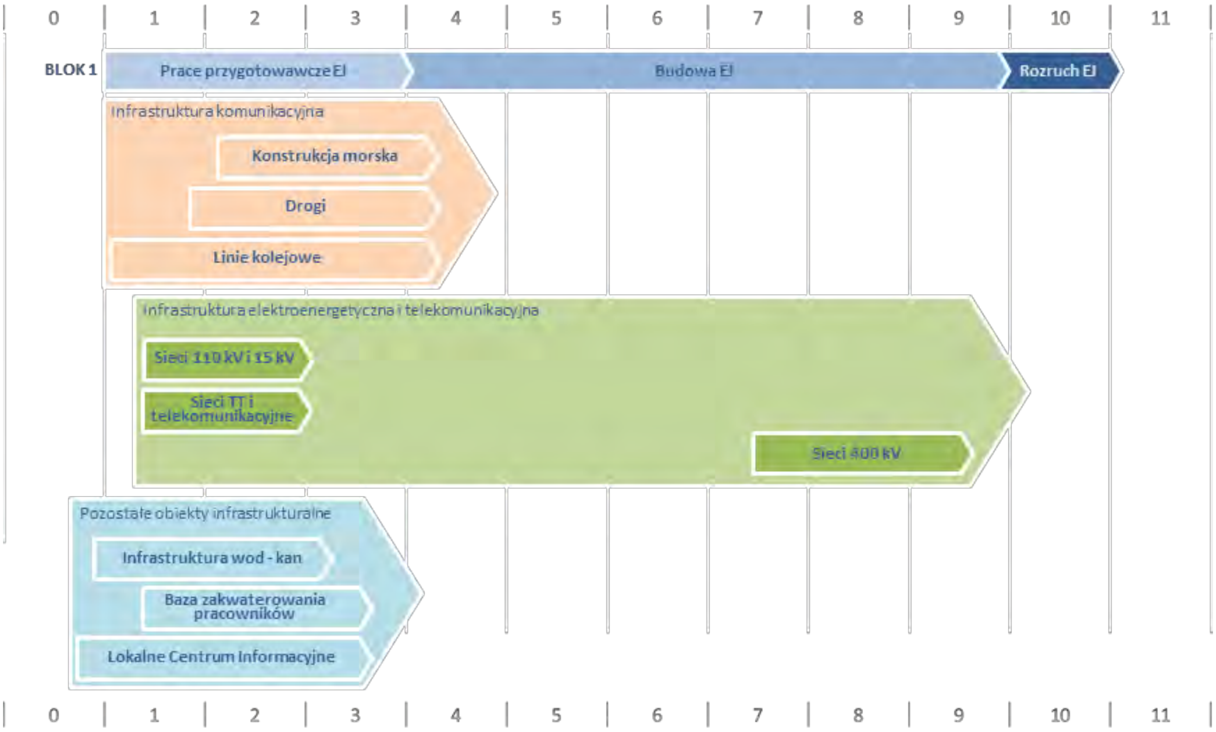



Figure II.12.1- 1 Schedule of execution of associated investments – Variant 1 – Lubiatowo-Kopalino site

[Blok – Unit, Prace przygotowawcze – Preparatory works – Budow EJ – NPP Construction, Rozruch EJ – Commissioning, Infrastruktura komunikacyjna – Transportation infrastructure, Konstrukcja morska – MOLF, Drogi – Roads, Linie kolejowe – Railways, Infrastruktura elektroenergetyczna I telekomunikacyjna - Power and communications infrastructure, Sieci 110kV I 15kV, 110kV and 15kV networks, Sieci IT I telekomunikacyjne – IT ene telecom networks, Seci 400kV – 400kV networks, Pozostałe obiekty infrastrukturalne – Other infrastructure, Infrastruktura wod-kan – Water supply and sewage infrastructure, Baza zkwaterowania pracowników – Personnel accomodation, Lokalne centrum informacyjne – Local information center]

*Source: In-house study*

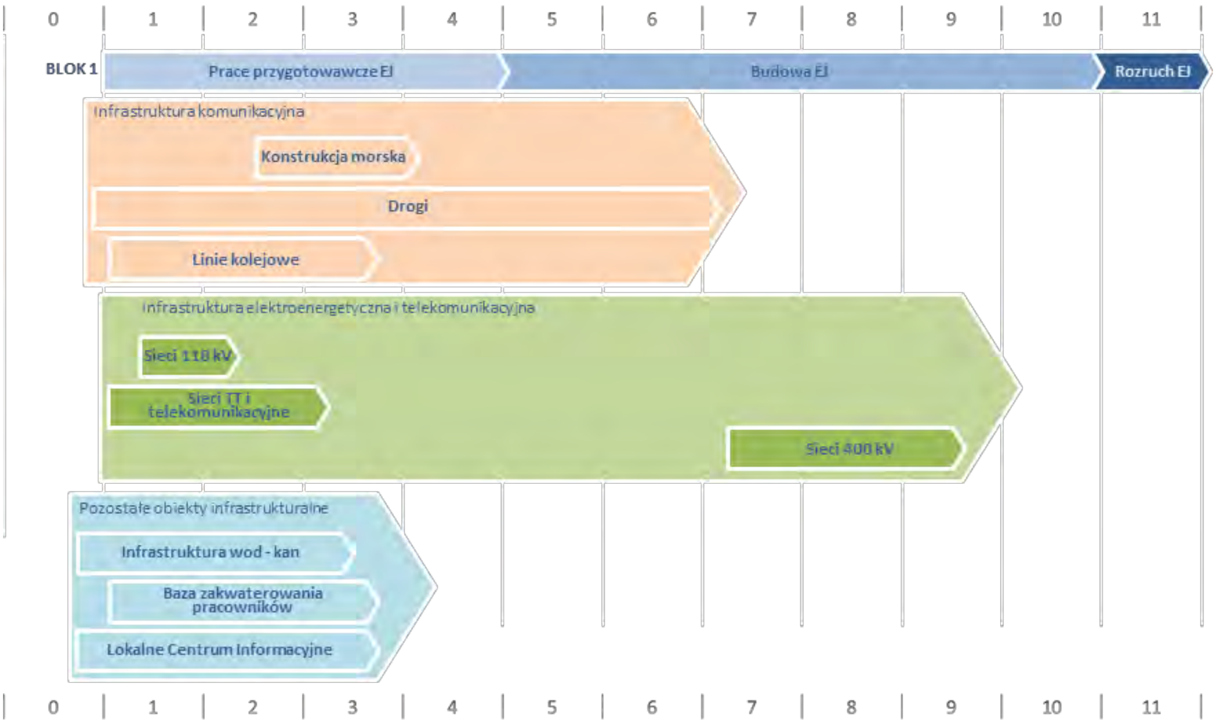



Fig. II.12.1- 2 Schedule of execution of associated investments – Variant 2 – Żarnowiec site
[Blok – Unit, Prace przygotowawcze – Preparatory works – Budow EJ – NPP Construction, Rozruch EJ – Commissioning, Infrastruktura komunikacyjna – Transportation infrastructure, Konstrukcja morska – MOLF, Drogi – Roads, Linie kolejowe – Railways, Infrastruktura elektroenergetyczna I telekomunikacyjna - Power and communications infrastructure, Sieci 110kV I 15kV, 110kV and 15kV networks, Sieci IT I telekomunikacyjne – IT ene telecom networks, Seci 400kV – 400kV networks, Pozostałe obiekty infrastrukturalne – Other infrastructure, Infrastruktura wod-kan – Water supply and sewage infrastructure, Baza zkwaterowania pracowników – Personnel accomodation, Lokalne centrum informacyjne – Local information center]

*Source: In-house study*

## II.12.3 Electric power infrastructure

In order to estimate solutions for power evacuation from the NPP (NPP) and site power supply, a feasibility study was commissioned by the EIA Report Contractor in December 2020, entitled "The study of evacuation of 400 kV power and supplying the construction site with 110 kV power" [112] - referred to below as the Study. The analyzed conditions and directions of development of the power transmission grid necessary for power evacuation from the NPP to the National Power System (NPS) were established under the assumption that power evacuation up to 3,750 MWe from the NPP will be transmitted to the existing 400 kV transmission infrastructure in its immediate vicinity. It was assumed that this will be done in the direction of the 400 kV line between Żarnowiec and Słupsk, located approx. 20 km south of the Project Area for Variant 1 - Lubiatowo - Kopalino site, by means of a connection point in the form of a new 400 kV substation from the extreme eastern location (name: Rekowo), to the extreme western location (name: Janowice). For power evacuation from the NPP four 400 kV double-circuit overhead lines were then assumed, where, depending on the choice of variant and technical possibilities, the corridor may contain one, two, three or four 400 kV lines. Furthermore, the Study included an assumption that the power supply to the construction site will be provided by 110 kV power lines (initially a cable solution was adopted) from the existing 400/110 kV Żarnowiec substation and GPZ Jackowo substation to the NPP at the above two locations.

Analyses conducted as part of the Study form the basis for this EIA Report and presented in the following subsections, allow for illustration of the scale and scope of associated infrastructure development in the transmission networks. However, due to the scharacter of NPS development planning which requires ongoing and detailed network analyses taking into account the current status of transmission grid development to ensure optimal and secure power flow, the final concept of power evacuation from the NPP and provision of power for the construction site will be determined at the stage of obtaining connection conditions issued upon the request of the NPP investor. After detailed analyses resulting from the needs of the power system development and the selected NPP technology, it may be reasonable to consider other connection points for the NPP to the NPS. The basis for further analysis will come from the Transmission System Operator's regular Development Plan for meeting current and future electricity demand.

### II.12.3.1 High and medium voltage electrical power grids (110 kV and 15 kV)

#### II.12.3.1.1 Variant 1 – Lubiatowo – Kopalino site

For the purpose of determining the feasibility of evacuating power from the NPP and supplying the construction site a feasibility study was commissioned by the author of the EIA Report, titled "The study of evacuation of 400 kV power and supplying the construction site with 110 kV power" [112]. This subsection discusses only the elements of the power grid necessary for power supply of the construction site during the construction phase and the backup power supply during the operation phase of the NPP.

During the operation stage, in the event the connection between the NPP and the 400 kV transmission network is interrupted, a backup power supply will be necessary for the purpose of sustaining the technological processes related to the shutdown of NPP units. The backup power supply will be ensured by the 110 kV distribution network offering the capacity of at least 100 MW. On the other hand, the construction phase of the NPP will require a connection capacity of 50 MW, so the same power supply source was assumed for backup power supply during the operation phase of the NPP and for the construction site power supply, i.e. The power is supplied via a 110 kV underground cable line from two independent supply points: one from the 400 kV Żarnowiec substation (directly from the 110 kV switching station), and the other from the 110 kV GPZ Jackowo substation (from the 110 kV switching station from the Lębork direction - it is the Main Supply Point for the distribution network). Both underground 110 kV cable lines will terminate at the 110/15 kV electrical substation to be installed within the Project execution area and forming an element of the NPP infrastructure (described in more detail in [Chapter II.9.3] of this report). It should be emphasized that the above assumptions may be subject to verification and possible modification at the stage of design works.

Based on the conducted analyses as well as the site visit, with reference to the first of the above power supply points, several variants for routing the underground cable line along the section from the 400 kV Żarnowiec electrical substation to the Project execution area in Variant 1 – Lubiatowo-Kopalino site have been proposed, and an optimum variant was selected through a multi-criteria analysis, as presented below [Figure II.12.3- 1]. This variant is, to a large extent, based on the railway No. 230 scheduled for reconstruction between Wejherowo and Choczewo and on the newly designed railway line between Choczewo and the Project execution area. Along the remaining section, the route of the optimal variant stretches along a forest road and public roads (to the 400 kV Żarnowiec electrical substation). The total length of the cable line in the analysed variant is approx. 30 km. There will be an optic fiber cable line routed above the 110 kV electrical power cables in the same trench excavation (for the purpose of remote data communication between electrical substations as well as ICT communication with the NPP).

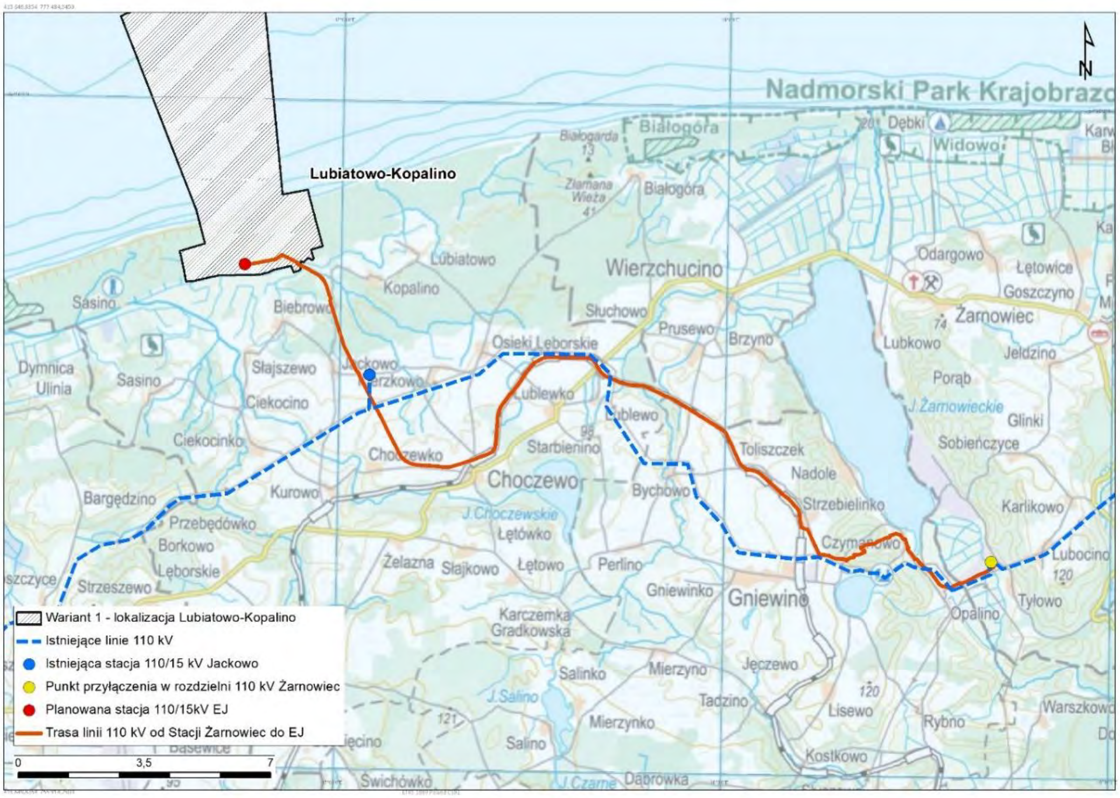



Fig. II.12.3- 1 Proposed routing of the 110 kV cable line along the section from the 400 kV Żarnowiec electrical substation to the Project execution area. Variant 1 – Lubiatowo – Kopalino site
[Legend: Grey – Variant 1 Lubiatowo-Kopalino site, Blue line – existing 110kV line, Red line – 100kV route from Żarnowiec substation to NPP, Blue dot – Existing Jackowo 110/15kV substation, Yellow dot – Connection point at 100kV Żarnowiec substation]

*Source: In-house study based on [112]*

For the second feeding point, i.e. the 110 kV Jackowo substation (GPZ Jackowo), the route of the 110 kV underground cable line was proposed: largely based on the route of the 110 kV cable line from the 110 kV Żarnowiec substation, along the railroad tracks to the Project Area - Variant 1 - Lubiatowo - Kopalino site. The route of the cable line is presented below [Figure II.12.3- 2]. The length of the cable line in the analysed variant is approx. 6 km.

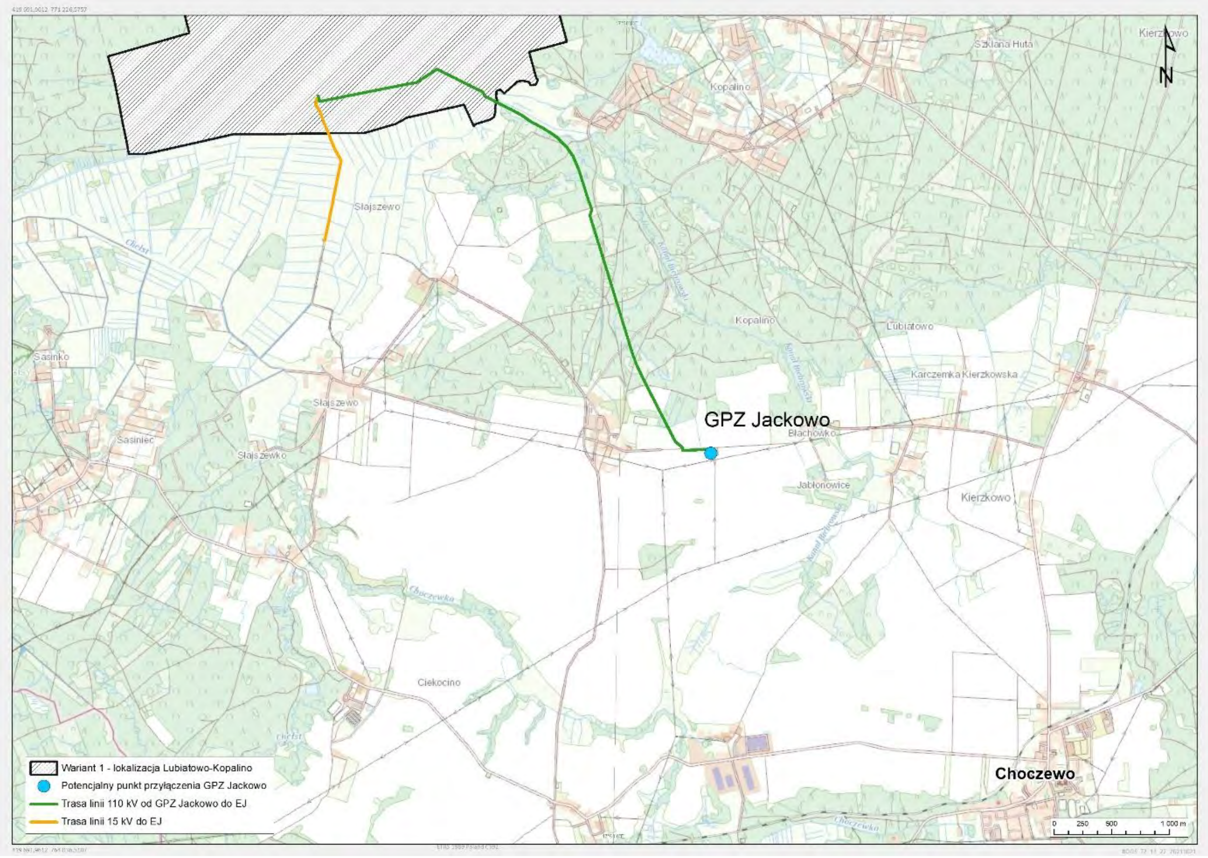



Figure II.12.3- 2 Proposed routing of the 110 kV cable line along the section from the 110 kV Jackowo electrical substation (GPZ Jackowo) and the 15 kV line to the Project area. Variant 1 – Lubiatowo – Kopalino site [Legend: Grey – Variant 1 Lubiatowo-Kopalino site, Blue dot – Potential connection point at Jackowo substation, Blue line – 100kV linbe route from Jackowo substation to NP, Red line – 15kV line route to NPP]

*Source: In-house study based on [112]*

The length of the cable line in the analysed variant is approx. 6 km.

At the stage of preparatory works, it may be necessary to provide a connection to the local 15 kV medium voltage distribution network. The above problem will be the subject of analyses to be carried out by the contractor of the preparatory works, once electricity demand for this stage has been determined. It will be possible to route 15 kV power supply via an underground cable line from the existing 15 kV overhead network located in Słajszewo, approx. 1.6 km from the Project execution area. The route of the 15 kV cable line is presented below [Figure II.12.3- 2].

As a result of the reconfiguration of the 400 kV transmission or 110 kV distribution network, which may occur in the future regardless of the analysis presented in the study [112], the power supply to the NPP site may be brought from another direction of the power system. The final locations of the 110 kV and 15 kV connection points will depend on the transmission system operator and distribution network operators and will be specified in the connection conditions issued at the request of the NPP investor, whilethe routes of 110 kV and 15 kV lines towards the NPP will depend on those points and will be subject to later analyses.

## II.12.3.1.2 Variant 2 – Żarnowiec site

During the operation stage, in the event the connection between the NPP and the 400 kV transmission network is interrupted, a backup power supply will be necessary for the purpose of sustaining the technological processes related to the shutdown of NPP units. The backup power supply will be ensured by the 110 kV distribution network offering the capacity of at least 100 MW. Whereas during the NPP construction stage, 50 MW connection power will be required and thus it has been assumed that for the purpose of providing backup power supply during the NPP operational phase and for the purpose of supplying power to the construction site, the same power supply source will be used, i.e. power supply via a two-circuit underground 110 kV cable line connected with a 110 kV switching station of the 400 kV Żarnowiec electrical substation, with two separate current sections of the substation. There will be an optic fiber cable line routed above the 110 kV electrical power cables in the same trench excavation (for the purpose of remote data communication between electrical substations as well as ICT communication with the NPP).

Taking into consideration the terrain conditions in the vicinity of the Project execution area as well as the close distance between the NPP and the 400 kV Żarnowiec electrical substation, only one route of the 110 kV cable line has been identified as optimal from the perspective of its length and bends [Figure II.12.3- 3]. The length of the cable line will be approx. 1.5 km.

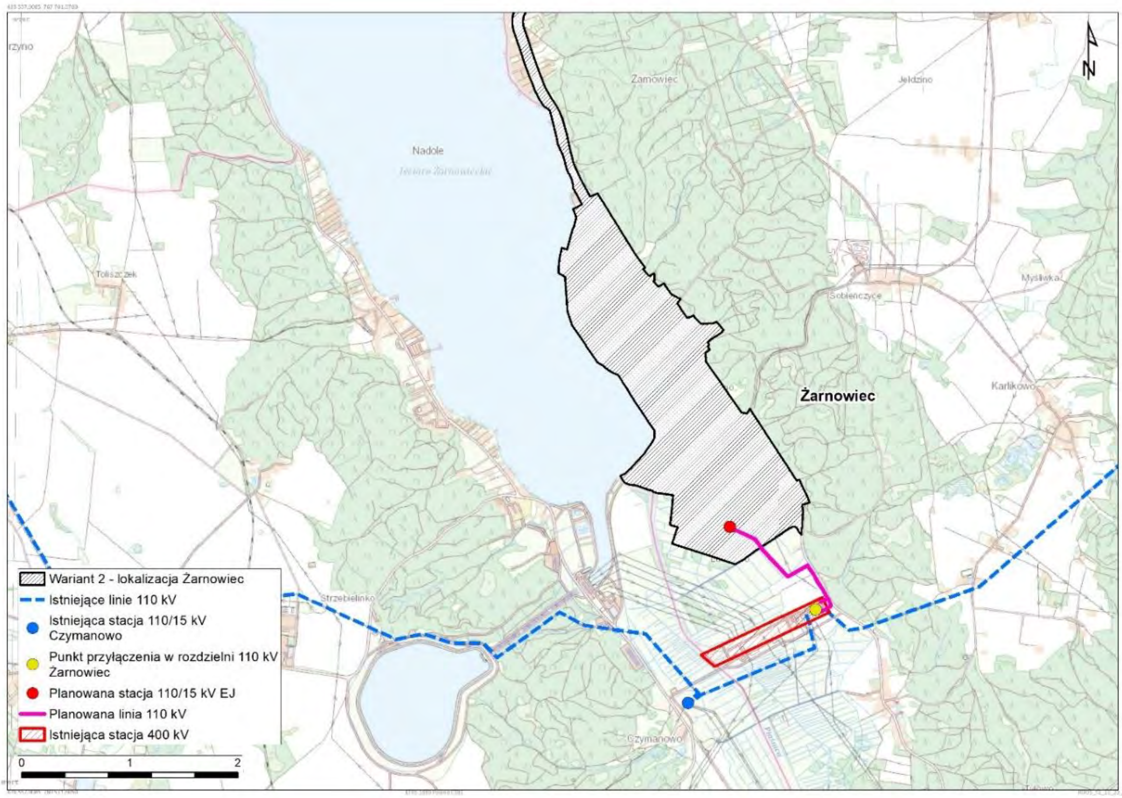



Figure II.12.3- 3 Proposed route of the 110 kV cable line from the 400 kV Żarnowiec electrical substation to the Project execution area. Variant 2 – Żarnowiec site
[Legend: Grey – Variant 2 Żarnowiec site, Blue line – existing 110kV line, Red line – planned 110kV line, Blue dot – Existing Czymanowo 110/15kV substation, Yellow dot – Connection point at 110kV Żarnowiec substation, Red dot – Planned 110/15 kV NPP substation, Red field – Existing 400kV substation]

*Source: In-house study based on [112]*

Additionally, at the preparatory works stage (depending on the applied method of demolition works), it may become necessary to obtain a connection to the local 15 kV medium voltage distribution network. The above problem will be the subject of analyses to be carried out by the executor of the preparatory works, once electricity demand for this stage of the NPP has been determined. It will be possible to route the 15 kV power supply via an underground cable line from a number of the existing 15/0.4 kV substations located in this area.

## II.12.3.2 Electrical power grids of the highest voltage (400 kV)

### II.12.3.2.1 Variant 1 – Lubiatowo – Kopalino site

For the purpose of determining the feasibility of evacuating power from the NPP and supplying the construction site a feasibility study was commissioned by the author of the EIA Report, titled "The study of evacuation of 400 kV power and supplying the construction site with 110 kV power" [112]. This subchapter describes conditions for and directions of the extension of electrical power transmission grid necessary for feeding the 400 kV power from the NPP into the National Power System.

The operation of the extra-high voltage transmission grid is the responsibility of the transmission system operator in Poland, i.e. Polskie Sieci Elektroenergetyczne S.A. (PSE).

Based on the analysis of the current location of the elements of infrastructure of the transmission grid of the highest voltages in the vicinity of the Project execution area, it has been assumed that up to 3750 MWe of power will be fed from the NPP to the existing 400 kV transmission infrastructure located it the vicinity of the NPP, i.e. towards the 400 kV line between Żarnowiec and Słupsk, located approx. 20 km south of the Project execution area in Variant 1 – Lubiatowo-Kopalino site, via a connection point in the form of a new 400 kV electrical substation. Further expansion of the electrical power grid within the National Power System remains the area of operation of PSE.

The EIA Contractor also stipulates that as a result of the National Power System (NPS) expansion or changes to the existing transmission grid configuration, which may occur after the feasibility study deadline [112], the direction of power evacuation from the nuclear power plant to the NPS may change.

Based on the standards and guidelines for the location of power infrastructure facilities applied by PSE, taking into account the location of the substation in the vicinity of the existing 400 kV Żarnowiec - Słupsk power line, four alternatives for the location of a potential 400 kV connection point were identified [Drawing II.12.3- 4] in the area between Rekowo and Janowice.

Due to the expected collisions with the transmission grid infrastructure related to the evacuation of power from offshore wind farms, the location of the electrical substation at the site situated west of the Rekowo substation was not taken into consideration.

The location of the substation forming a connection point between the NPP and the National Power System depends on the ability to lead a 400kV line corridor from the NPP to the substation and the ability to evacuate power further south. Nevertheless, the ultimate location of the connection point between the NPP and the National Power System will require conducting in-depth grid analyses and will result from the conditions for connecting the source to the transmission grid, which the NPP Investor may request PSE to identify once the decision regarding the location of the NPP has been obtained. The transmission system operator may indicate other directions for connecting NPPs to the NPS, even assuming that each nuclear unit may be connected to a different network node in the power system.


Figure II.12.3-4 Potential variants for the location of the 400 kV electrical substation forming a connection point between the NPP and the National Power System. Variant 1 – Lubiatowo – Kopalino site
[Legend: Grey – Variant 1 Lubiatowo-Kopalino site, Red line – existing 400kV line, Blue – Potential locations for NPP connection]

*Source: In-house study based on [112]*

The initial assumptions and recommendations [112] suggest that it would be reasonable to use three two-circuit 400 kV lines to evacuate power from the NPP, while the use of two-circuit lines is recommended to optimize the footprint, construction cost as well as the environmental impact. Based on the above assumptions, in terms of constructing the transmission grid for the purpose of evacuating power from the NPP, two 400 kV circuits will be constructed independently for each nuclear power unit, where one circuit will be a basic power evacuation circuit and the other, back-up circuit will provide redundancy for the connection with the National Power System. Each of the circuits will offer the capacity of 1800 MW of electric power and will be capable of independent operation. Taking into account the possible expansion of the NPP by adding another, i.e. fourth, power unit, sufficient area should be reserved, at the stage of designing the lines necessary for the evacuation of power from the NPP, for the fourth two-circuit power line. This assumption has been adopted in the Feasibility Study for the evacuation of power from the NPP and power supply for the construction site [112]. The following figure [Fig. II.12.3- 5] presents a corridor of four two-circuit power lines suspended on galvanized steel truss pylons modelled after typical structures used for similar power lines.

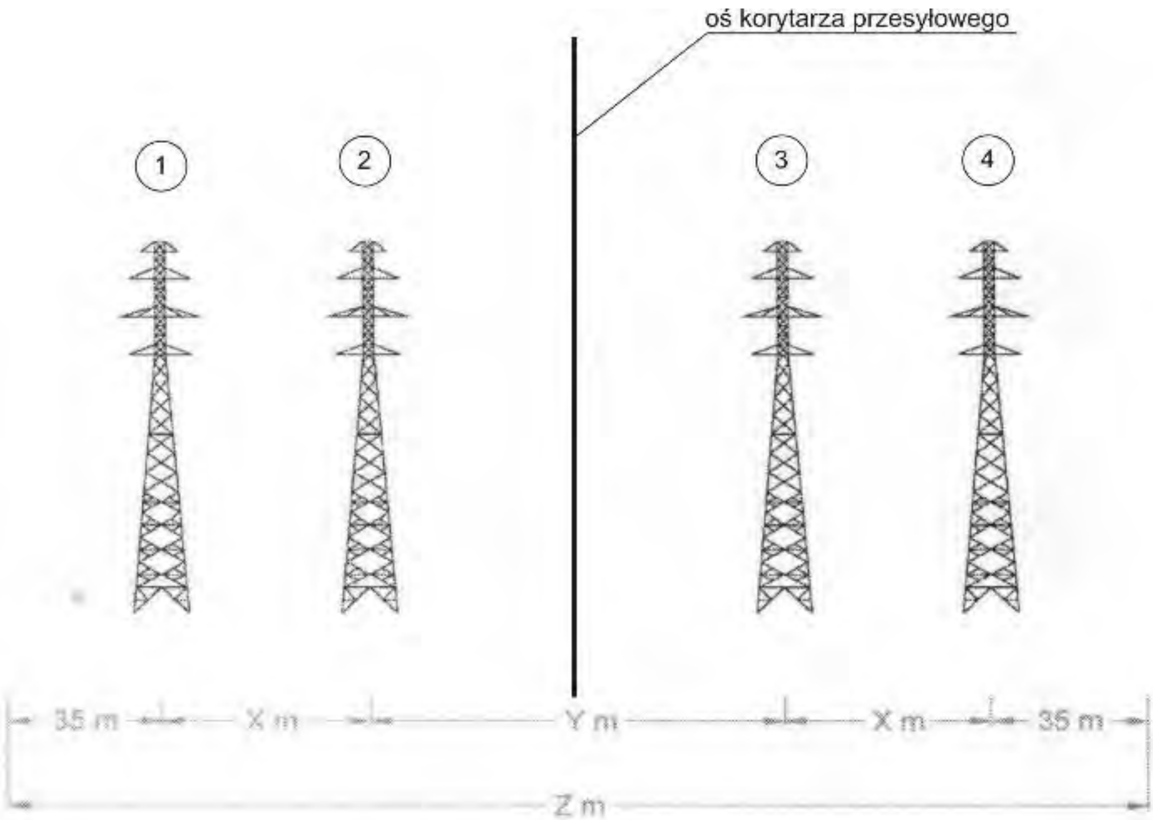
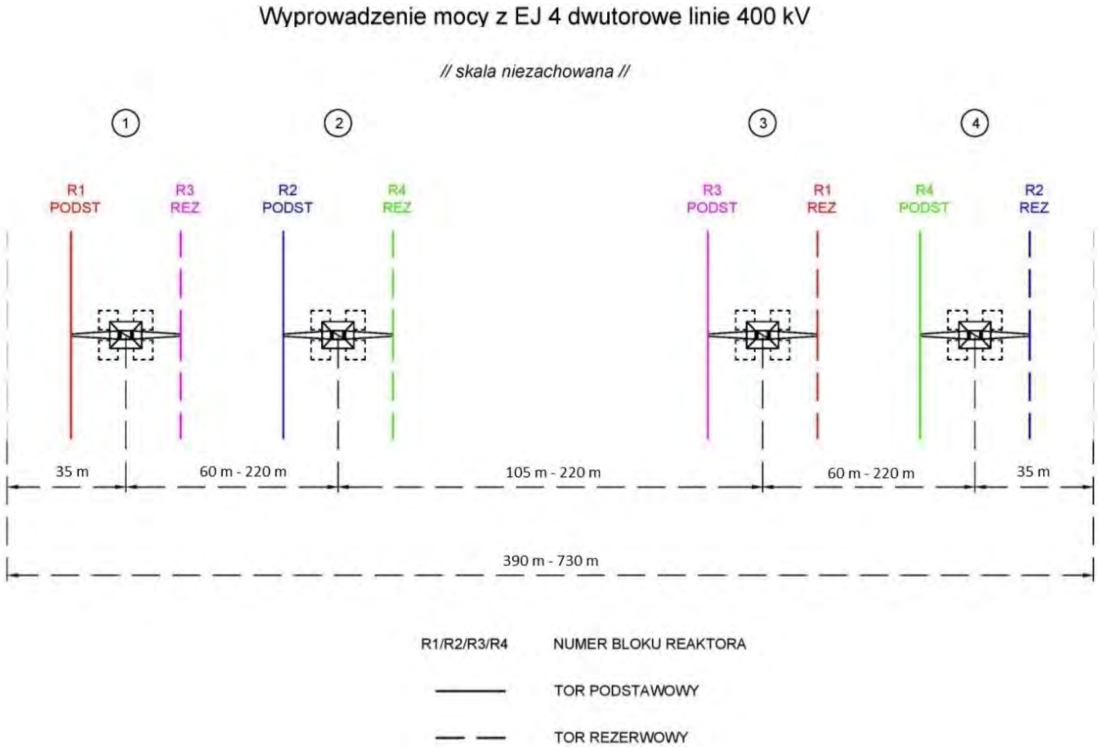



Fig. II.12.3- 5 Corridor of four two-circuit 400 kV power lines on truss pylons
[Oś korytarza przesyłowego – HV corridor axis]

*Source: [112]*

As a result of the power evacuation corridor analyses, and assuming certain simplifications, a rationale for determining the minimum width of the 400 kV line corridor was developed [Figure II.12.3- 6].




*Not to scale*

Figure II.12.3- 6 Width of the corridor of four two-circuit 400 kV power lines

[Skala niezachowana – Not to scale, Numer bloku reactora – Unit numer, Tor podstawowy – Main line, Tor rezerwowy – Reserve line]

*Source: [112]*

Regarding the technical parameters indicated in the figure above [Figure II.12.3- 6], it should be clarified that the Study included the following assumptions:

- the value of 35 m from the edge of the buffer zone to the axis of the outer line results from the requirement to maintain a safe distance, above which the admissible levels of 50 Hz electric andmagnetic fields applicable to areas intended for residential buildings are not exceeded [94];
- the value of 60 m between lines 1 and 2 as well as 3 and 4 is the smallest distance resulting from the requirement to maintain a safe distance to phase wires of two neighbouring lines when repairs are carried out on one line while the other line is active without any tension work,
- the value of 105 m between lines 2 and 3 is the smallest distance resulting from the requirement to maintain a safe distance to the phase wires of two neighbouring lines when repairs are carried out on one line while the other line is active without any tension work, however this condition can be fulfilled only in the case of designing a new series of power pylons with a specially reinforced structure,
- the value of 220 m between lines 1, 2, 3 and 4 is the distance used by the Transmission System Operator to lay parallel transmission lines, built on typical pylon structures, which enables safe operation of the lines both during normal operation and during maintenance work.

The following assumptions were adopted in the Study to determine the width of the technological corridor (subject to additional verification at the stage of design works for the 400 kV line infrastructure):

- the height of the deviation pylons would not exceed 60 meters,
- the height of the suspeniosn pylons would not exceed 80 meters,

- the lines would be built on a new series of pylons allowing cable tensioning at a distance of 1 times the height of the pylon, and the location of the tensioning sets could be shifted by an angle of 15 degrees with respect to the axis of tension,
- the deviation pylons of adjacent lines would be positioned in the bisector of the bend angle of the line.

It should be emphasized that the above assumptions may be subject to verification and possible modification at the stage of design works of the 400kV powerline infrastructure, during design works of the grid operator.

However, running 400 kV overhead transmission lines in such close proximity to each other involves some risk of external factors affecting the continuity of the connection between the NPP and the NPS. Therefore, consideration should be given to diversifying the direction of overhead lines in the field, such that each line of power output from the NPP were located in an independent corridor.

At the present stage of the Study an analysis was codnucted, covering:

- environmental conditions – the existing forms of nature conservation;
- planning conditions – draft studies on the conditions and directions of area development of the commune as well as the development plans on the local and regional level;
- real property value and forms of land ownership;
- the location of residential buildings along the corridors and within 100 m from the buffer zone of the line;
- the general suitability of land for the investment in terms of construction of the foundations and construction of temporary roads;
- technical conditions – the type of pylon structure and erection technology.

Based on the analysis of the above conditions, four potential corridors for the location of the NPP power line were selected along with possible sub-variants. Depending on the corridor option selected, it may include one, two, three or four 400 kV lines. Potential routes of the 400 kV corrindors are presented in figure [Figure II.12.3-7]. In the case of siting the connection of the NPP to a point in the NPS located below the 400 kV Słupsk - Żarnowiec line (analyses to be performed as part of NPS development by the Transmission System Operator), potential corridors may (but do not have to) constitute the initial section of the 400 kV line evacuating power from the power plant southwards to the national power system. After a comparative analysis of the above variants, conducted under the feasibility study [112], assuming potential siting of the new substation in the Rekowo-Janowice area, the W1 variant was selected as optimal , i.e. the most favourable from the environmental, technical and economic perspective. Additionally, this is the shortest of the analysed variants (approx. 20 km), which limits its exposure in the landscape and its impact on the current land development.

It should be noted that in case of the above method of connecting the NPP to the NPS, the location of the W1 corridor will take into account the power evacuation infrastructure from offshore wind farms, executed by the transmission system operator.

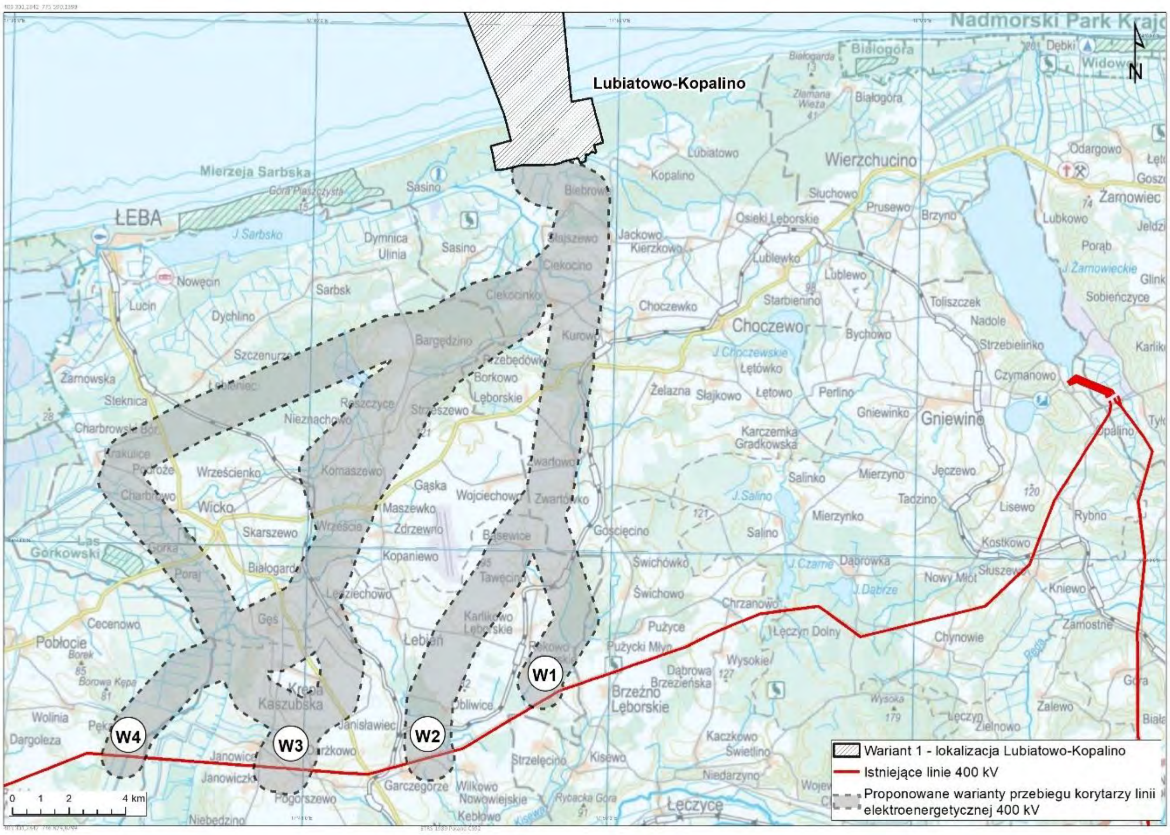



Figure II.12.3- 7 Proposed variants (W1, W2 and W3) for the routing of the corridors of the 400 kV electrical power line along the section from the NPP to the potential connection substations. Variant 1 – Lubiatowo – Kopalino site
[Legend: Black line – Varant 1 Lubiatowo-Kopalino site, Red line – existing 400kV lines, Dotted black line – Proposed route variants for 400kV corridors]

*Source: In-house study based on [112]*

### II.12.3.2.2 Variant 2 – Żarnowiec site

Based on the analysis of the current location of the infrastructure elements of the UHV transmission grid in the vicinity of the Project execution area, it has been initially assumed that up to 3750 MWe of power will be fed from the NPP to the existing 400 kV transmission infrastructure located in the vicinity of NPP, i.e. to the 400 kV Żarnowiec electrical substation located approx. 1.5 km south of the Project execution area in Variant 2 – Żarnowiec site. However, due to the high short-circuit parameters of the new power units, significantly exceeding the technical parameters of the existing 400 kV Żarnowiec electrical substation, the above solution was abandoned and it has been assumed that the potential connection point between the NPP and the National Power system will be a new 400 kV electrical substation adjoining the existing 400 kV Żarnowiec electrical substation. A potential location for the electrical substation connecting the NPP to the National Power system has been identified, taking into account the conditions described in the section pertaining to Variant 1 – Lubiatowo-Kopalino site, [Fig. II.12.3- 8]. Further expansion of the electrical power grid within the National Power System remains with PSE. It should be emphasized that the potential site for the new 400 kV electrical substation is located south of the Project execution area in Variant 2 – Żarnowiec site and is bounded by hills from the East (elevation difference of up to 100 m) as well as the top reservoir of Żarnowiec Hydroelectric Power Plant and by more hills (located within the Natura 2000 Opalińskie Buczyny PLH220099 site) from the West. What is more, there is a dense network of existing overhead power lines (110 kV and 400 kV) in the area. Therefore, locating the electrical substation in this location would require working out the overlaps between the power line (connecting the substation with the NPP) and the four existing 400 kV overhead power lines connecting Żarnowiec Hydroelectric Power Plant with the 400 kV Żarnowiec electrical substation. Therefore, the ultimate location of the connection point between the NPP and the National Power System will require conducting in-depth grid analyses driven the conditions for connecting the source to the transmission grid, which the PSE Operateor may identify for the NPP Investor only once the decision regarding the location of the NPP is known.

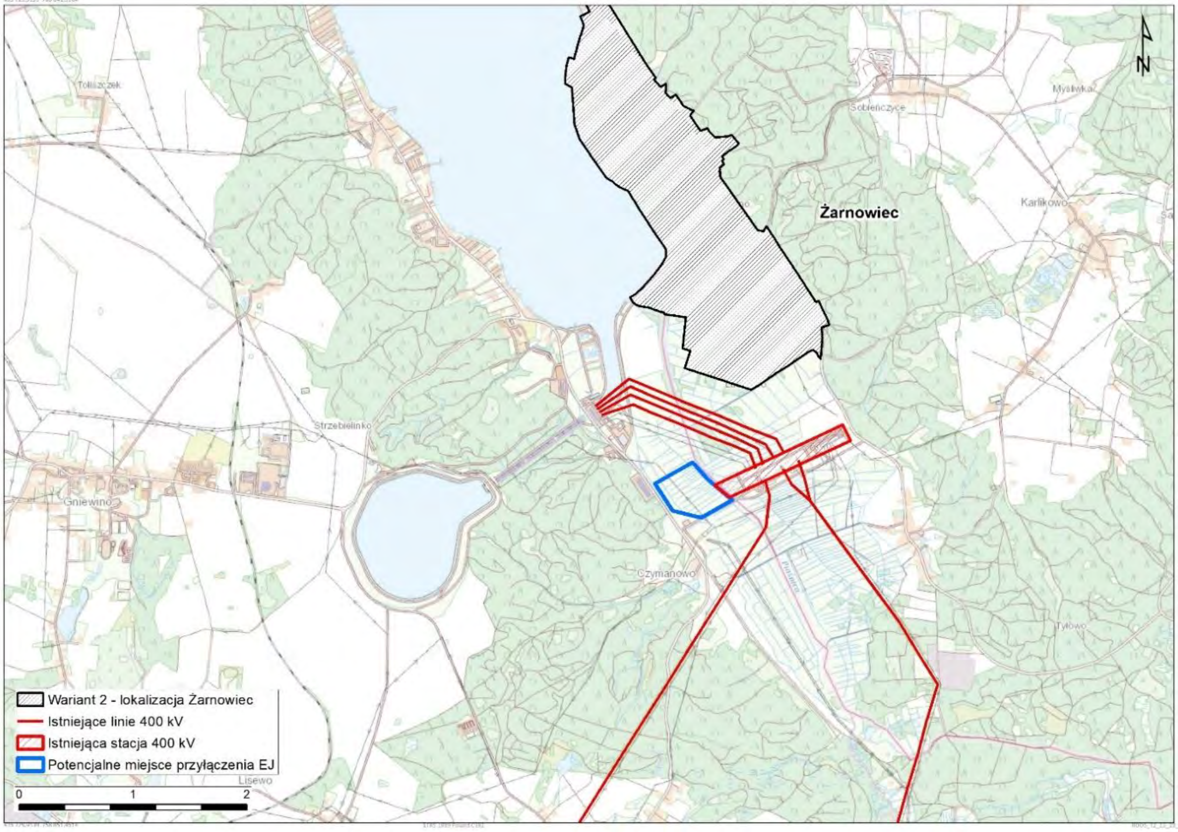



Figure II.12.3- 8 Potential location of the 400 kV electrical substation forming a connection point between the NPP and the National Power System. Variant 2 — Żarnowiec site
[Legend: Grey - Variant 2 Żarnowiec site, Red line – Existing 400kV lines, Red field – Existing 400kV substation, Blue field – potential NPP connection point]

*Source: In-house study based on [112]*

In the light of technical assumptions for routing the corridors for the highest voltage (400 kV) power lines described in the section devoted to Variant 1 – Lubiatowo-Kopalino site, several variants have been analysed for the course of the 400 kV power line connecting the NPP with the planned 400 kV electrical substation. Yet, due to the above-mentioned terrain conditions as well as the short distance between the NPP and the planned electrical substation, only one corridor for the 400 kV power line has been identified, optimal in terms of the length of the route as well as the curve angles of the line [Fig. II.12.3- 9].

Due to the safety of the power system, in the event two 400 kV line routes are to cross each other, it will be necessary to partially place (replace the overhead infrastructure with an underground one) one of the 400 kV line routes underground. Due to the fact that underground technology for 400kV power lines at the point of evacuation of power from the NPP units is highly complex, the technical solution in this respect will be defined in detail at the building design stage for this line.

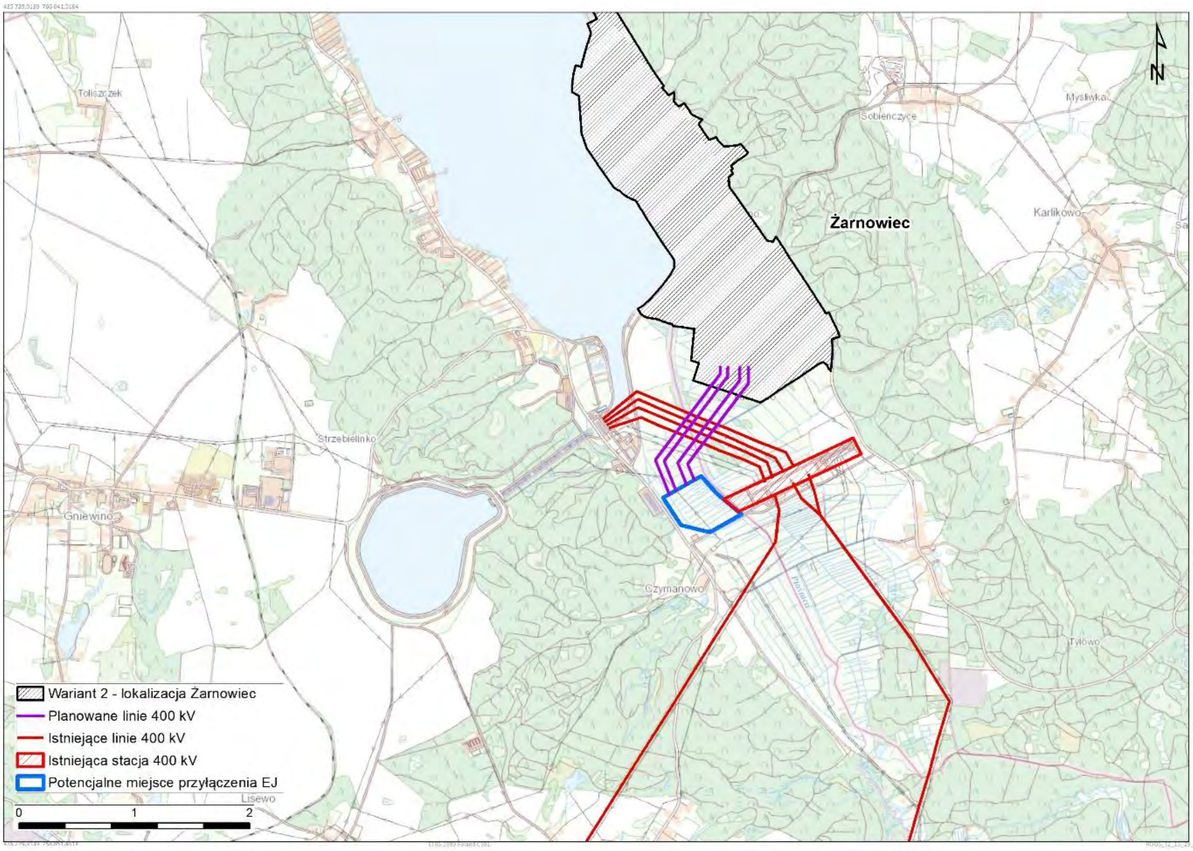



Figure II.12.3- 9 The course of the 400 kV electrical power line corridor along the section from the NPP to the potential connection substation. Variant 2 – Żarnowiec site
[Legend: Grey – Variant 2 Żarnowiec site, Purple lines – Planned 400kV lines, Red lines – Existing 400 kV lines, Red field – Existing 400kV substation, Blue field – Potential NPP connection point]

*Source: In-house study based on [112]*

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## Appendix II.2.4-3

# Land development plans for operational phase - Variant 1 – Lubiatowo-Kopalino site
# Marine and land area

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## Excerpt from Appendices to Volume II of the EIA Report

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Language version: EN

July 2022

świadomie o atomie
energia jądrowa w Polsce

Polskie Elektrownie Jądrowe sp. z o.o.

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| Facility number | Facility name |
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| 2. | Auxiliary building; |
| 3. | Engine Room |
| 4. | Turbine building first bay |
| 6. | Reactor facility building |
| 7. | Radioactive waste building |
| 9. | Radwaste spent fuel transport pad |
| 10. | Diesel Generator Building |
| 5.1, 5.2 | Cooling circuits of the service water system (SWS) |
| 11 | Fire safety tank |
| 12 | Passive containment cooling system ancillary storage tank |
| 13 | Fire safety tank (auxiliary) |
| 14 | Diesel driven fire pump enclosure (primary) |
| 15 | Transformer stations |
| 16 | Turbine laydown area |
| 17 | Condensate storage tank |
| 18 | Diesel oil storage tanks for generators |
| 19 | Demineralised water storage tank (DWST) |
| 20 | Boric acid storage tank (BAST) |
| 22 | Heavy lift crane foundation |
| 25 | Switchyard |
| 26 | Condenser removal area |
| 27.1, 27.2, 27.3 | Wastewater tank |
| 27.4 | Wastewater system blowdown sump |
| 29 | Interim spent nuclear fuel storage |
| 30 | Low level radioactive waste storage |
| 31 | Intermediate level radioactive waste storage |
| 32 | Inner gatehouse |
| 33 | Warehouse A |
| 34 | Warehouse B |
| 35 | Warehouse C |
| 36 | Service and repair workshop |
| 37 | Auxiliary boiler plant |
| 38 | Fire station |
| 41 | Solid radioactive waste treatment building |
| 42 | Security (guardhouse) |
| 43 | Main gatehouse |
| 44 | Meteorological station |
| 45 | Chemical laboratory |
| 46 | Radioactive chemistry laboratory |
| 47 | Fire safety tanks |
| 49 | Training facility |
| 50 | Office building |
| 51 | Wastewater monitoring building |
| 52 | Oil interceptor |
| 53 | Sea discharge sump |
| 54 | Simulator building |
| 55 | Information point |
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| 79 | Sewage treatment plant |
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| 84 | Rainwater tank |
| 85 | Passenger transport terminal |
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| 87 | Storage tanks (sub-variant 1A) |
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| 93 | Light oil storage tanks |
| 94 | Technical gas storage |
| 95 | First aid/medical centre |
| 97 | Guard house/vehicle control |
| 98 | Helicopter landing pad |
| D1 | Preliminary screen building (technical sub-options 1B, 1C, 2A,2B) |
| D2 | Pre-treatment building with pumping station and influent basin |
| D3 | Reverse osmosis building |
| D4 | Saline tanks |
| D5 | Technology uilding |
| D6 | Solid waste treatment plant |
| D7 | Desalination plant office building |
| D8 | Chemical storage (general) |
| D9 | Utility buildings |
| D10 | Water treatment plant with a raw water tank |
| n/a | External fence with increased security |
| n/a | Internal fence with increased security |

| PL | EN |
|---|---|
| PLAC MANEWROWY | MANEUVER LOT |
| 8,3 m n.p.m. | 8.3 m. AOD |
| DROGA EWAKUACYJNA | ESCAPE ROAD |
| DROGA REZERWOWA | RESERVE ROAD |
| DROGA TECHNICZNA | TECHNICAL ROAD |
| KOLEJOWY PERON PASAŻERSKI | RAILWAY PASSENGER PLATFORM |
| KOLEJOWY PERON TOWAROWY | RAILWAY CARGO PLATFORM |
| MORZE BAŁTYCKIE | BALTIC SEA |
| PARKING | CAR PARK |
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| WJAZD/WYJAZD GŁÓWNY | MAIN ENTRY/EXIT POINT |
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| REZERWA TERENU DLA CHŁODNI BLOK 4 | LAND RESERVE FOR COOLING TOWER (UNIT 4) |
| PUNKT ZRZUTU OCZYSZCZONYCH ŚCIEKÓW PRZEMYSŁOWYCH | TREATED INDUSTRIAL WASTE WATER DISCHARGE POINT |
| PUNKT POBORU WODY CHŁODZĄCEJ | COOLING WATER INTAKE POINT |
| PUNKT ZWROTU RYB | FRRS (FISH RETURN AND RCOVERY SYSTEM) POINT |
| STANOWISKO ROZŁADUNKU MORSKIEGO | MOLF (MARINE OFF-LOADING FACILITY) |
| Jezioro Żarnowieckie | Żarnowieckie lake |
| PRZYŁĄCZE WOD-KAN DO SIECI MIEJSKIEJ | WATER AND SEWAGE CONNECTION TO MUNICIPAL NETWORK |
| TRASA KABLI ELEKTRYCZNYCH I TELETECHNICZNYCH | TELECOM AND TECHNICAL CABLE ROUTE |
| TRASA KANAŁÓW/RUROCIĄGÓW WODY UZUPEŁNIAJĄCEJ | MAKE-UP WATER CHANNEL/PIPELINE ROUTE |
| TRASA RUROCIĄGÓW OCZYSZCZONYCH ŚCIEKÓW PRZEMYSŁOWYCH | TREATED WASTEWATER PIPELINE ROUTE |
| PUNKT POBORU WODY | WATER INTAKE POINT |
| PARKING AUTOBUSOWY | BUS PARKING LOT |


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| | |
|---|---|
| Appendix number | **Appendix II.2.4-3-1** |
| Appendix title | **Variant 1 - Lubiatowo-Kopalino site, sub-variant 1A<br>Land development plan: Project operational phase** |
| Scale | **1:4 000** |

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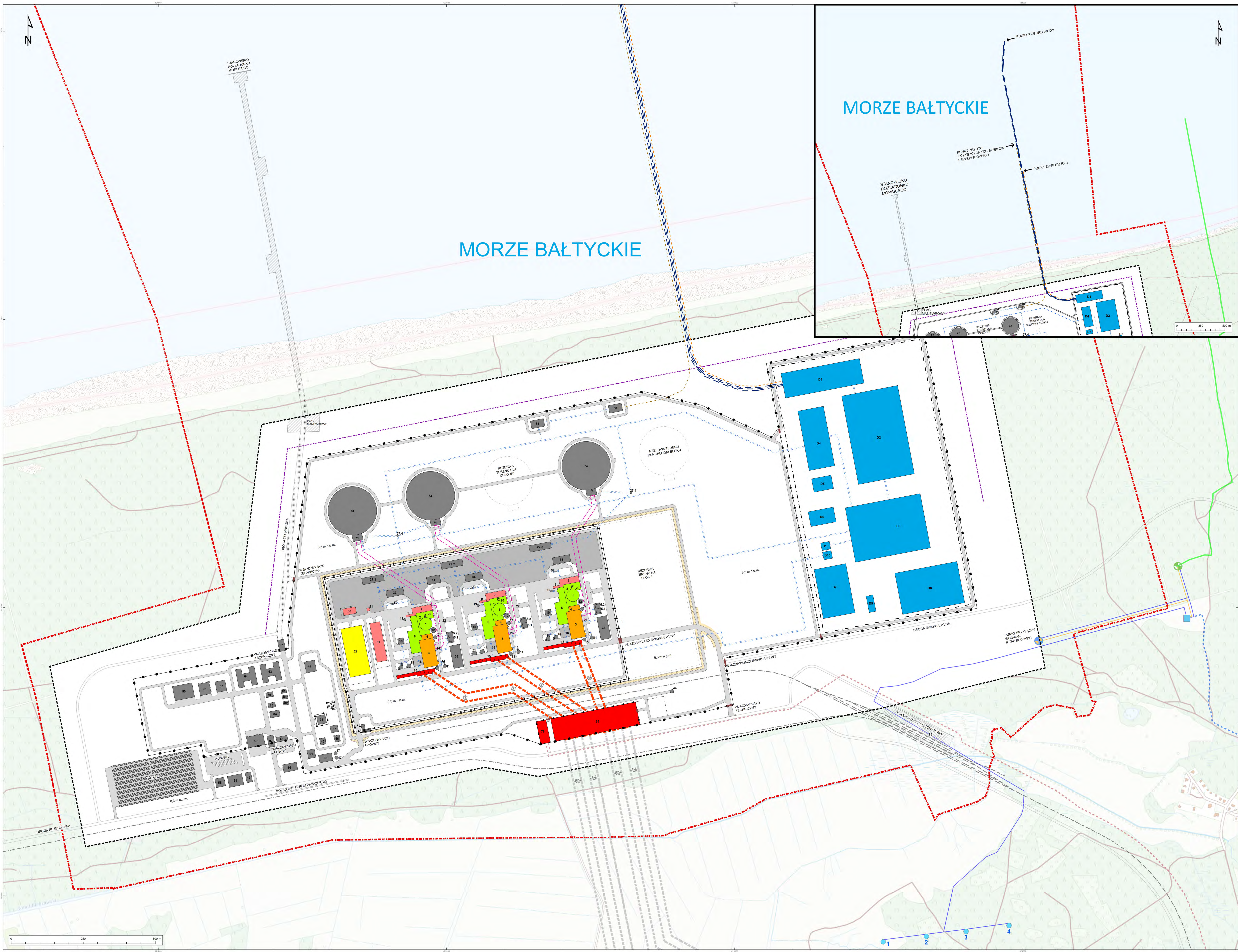
| | |
|---|---|
| Appendix number | **Appendix II.2.4-3-2** |
| Appendix title | **Variant 1 - Lubiatowo-Kopalino site, sub-variant 1B<br>Land development plan: Project operational phase** |
| Scale | **1:4 000** |

ROOS_T2_4_3026_eksploatacja_1B_LK_A0

PL-1992 (EPSG-2180)




**Legend**

- NPP site fence
- Inner fence
- Clear zone
- Retaining wall
- Cooling water pipeline route
- Fish return tunnel
- Entry gate
- Underground installations
- Overhead 400kV line
- Trated wastewater channel/pipeline route
- Make-up water channel/pipeline route
- Variant 1 - Lubiatowo-Kopalino site
- Reactor building and reactor auxiliary buildings
- Turbine hall
- EHV and HV transformer and substation
- Radioactive waste management building
- On-site spent fuel storage
- Desalination plant, Pump station
- Auxiliary building
- Grass or gravel surface
- Road - 17,0 m, 15,0 m, 9,0 m and 8,0 m width

**Associated infrastructure not covered by the application for decision on environmental**

- Intake station
- NPP water supply and sewage connection
- Water supply and sewage connection to the NPP
- Water Treatment Plant
- Planned treated wastewater discharge sewage system
- Waste water sewage system
- Water supply network
- Potential supply of the municipal water supply network
- Railway line
- Road
- Power supply via underground 110kV line
- 400kV overhead transmission lines to national grid
- Train platform
- MOLF
- Technical road

1:100 000

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| | |
|---|---|
| Appendix number | **Appendix II.2.4-3-3** |
| Appendix title | **Variant 1 - Lubiatowo-Kopalino site, sub-variant 1C Land development plan: Project operational phase** |
| Scale | **1:4 000** |

ROOS_T2_4_3025_eksploatacja_1C_LK_A0

Appendix II.2.4-6

# Land development plans for operational phase - Variant 2 - Żarnowiec site
# Marine and land area

## Excerpt from Appendices to Volume II of the EIA Report

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## List of Tables



## List of Figures

Table II.2.4-6- 1 List of facilities

| Facility number | Facility name |
|---|---|
| 1. | Reactor Building, consisting of the Reactor Containment and the Reactor Shield Building. |
| 2. | Auxiliary building; |
| 3. | Engine Room |
| 4. | Turbine building first bay |
| 6. | Reactor facility building |
| 7. | Radioactive waste building |
| 9. | Radwaste spent fuel transport pad |
| 10. | Diesel Generator Building |
| 5.1, 5.2 | Cooling circuits of the service water system (SWS) |
| 11 | Fire safety tank |
| 12 | Passive containment cooling system ancillary storage tank |
| 13 | Fire safety tank (auxiliary) |
| 14 | Diesel driven fire pump enclosure (primary) |
| 15 | Transformer stations |
| 16 | Turbine laydown area |
| 17 | Condensate storage tank |
| 18 | Diesel oil storage tanks for generators |
| 19 | Demineralised water storage tank (DWST) |
| 20 | Boric acid storage tank (BAST) |
| 22 | Heavy lift crane foundation |
| 25 | Switchyard |
| 26 | Condenser removal area |
| 27.1, 27.2, 27.3 | Wastewater tank |
| 27.4 | Wastewater system blowdown sump |
| 29 | Interim spent nuclear fuel storage |
| 30 | Low level radioactive waste storage |
| 31 | Intermediate level radioactive waste storage |
| 32 | Inner gatehouse |
| 33 | Warehouse A |
| 34 | Warehouse B |
| 35 | Warehouse C |
| 36 | Service and repair workshop |
| 37 | Auxiliary boiler plant |
| 38 | Fire station |
| 41 | Solid radioactive waste treatment building |
| 42 | Security (guardhouse) |
| 43 | Main gatehouse |
| 44 | Meteorological station |
| 45 | Chemical laboratory |
| 46 | Radioactive chemistry laboratory |
| 47 | Fire safety tanks |
| 49 | Training facility |
| 50 | Office building |
| 51 | Wastewater monitoring building |
| 52 | Oil interceptor |
| 53 | Sea discharge sump |
| 54 | Simulator building |
| 55 | Information point |
| 56 | Outfall pumphouse |
| 57 | Garage for heavy vehicles |
| 58 | Household Waste Treatment |
| 63 | Investor’s outage management office |
| 64 | EPC/PV outage management office |
| 71 | Cooling Water Pump Station (CWS) (Technical sub-options 1B, 1C, 2A, 2B) |
| 72 | Forebay |
| 73 | Cooling tower |
| 74 | Filtering debris recovery pit |
| 76 | Cooling Water Pump Station (Technical sub-variant 1A) |
| 77 | Outfall pond |
| 78 | 110 kV substation |
| 79 | Sewage treatment plant |
| 80 | Buffer tanks |
| 81 | Household wastewater buffer tanks |
| 82 | Rainwater buffer tanks |
| 83 | Rainwater treatment plant / pumping station |
| 84 | Rainwater tank |
| 85 | Passenger transport terminal |
| 86 | Cargo unloading terminal |
| 87 | Storage tanks (sub-variant 1A) |
| 91 | Central alarm station |
| 93 | Light oil storage tanks |
| 94 | Technical gas storage |
| 95 | First aid/medical centre |
| 97 | Guard house/vehicle control |
| 98 | Helicopter landing pad |
| D1 | Preliminary screen building (technical sub-options 1B, 1C, 2A,2B) |
| D2 | Pre-treatment building with pumping station and influent basin |
| D3 | Reverse osmosis building |
| D4 | Saline tanks |
| D5 | Technology uilding |
| D6 | Solid waste treatment plant |
| D7 | Desalination plant office building |
| D8 | Chemical storage (general) |
| D9 | Utility buildings |
| D10 | Water treatment plant with a raw water tank |
| n/a | External fence with increased security |
| n/a | Internal fence with increased security |

Table II.2.4-6- 2 List of facilities

| Facility number | Facility name |
|---|---|
| P1 | Żarnowiec pumping station |
| P2 | Forebay |
| P3 | Technical and social facilities |
| P3.1 | Guardhouse |
| P5.1 | Vehicle bay |
| P6.1 | Drainage well |
| P9 | Fire reservoir and fire pumps |

| PL | EN |
|---|---|
| PLAC MANEWROWY | MANEUVER LOT |
| 8,3 m n.p.m. | 8.3 m. AOD |
| DROGA EWAKUACYJNA | ESCAPE ROAD |
| DROGA REZERWOWA | RESERVE ROAD |
| DROGA TECHNICZNA | TECHNICAL ROAD |
| KOLEJOWY PERON PASAŻERSKI | RAILWAY PASSENGER PLATFORM |
| KOLEJOWY PERON TOWAROWY | RAILWAY CARGO PLATFORM |
| MORZE BAŁTYCKIE | BALTIC SEA |
| PARKING | CAR PARK |
| PUNKT PRZYŁĄCZY WOD-KAN (ETAP BUDOWY) | WATER AND SEWAGE CONNECTION (CONSTRUCTION STAGE) |
| REZERWA TERENU NA BLOK 4 | LAND RESERVE FOR UNIT 4 |
| STANOWISKO ROZŁADUNKU MORSKIEGO | MOLF (MARINE OFF-LOADING FACILITY) |
| WJAZD/WYJAZD EWAKUACYJNY | ESCAPE EXIT POINT |
| WJAZD/WYJAZD GŁÓWNY | MAIN ENTRY/EXIT POINT |
| WJAZD/WYJAZD TECHNICZNY | TECHNICAL ENTRY/EXIT POINT |
| REZERWA TERENU DLA CHŁODNI | LAND RESERVE FOR COOLING TOWER |
| REZERWA TERENU DLA CHŁODNI BLOK 4 | LAND RESERVE FOR COOLING TOWER (UNIT 4) |
| PUNKT ZRZUTU OCZYSZCZONYCH ŚCIEKÓW PRZEMYSŁOWYCH | TREATED INDUSTRIAL WASTE WATER DISCHARGE POINT |
| PUNKT POBORU WODY CHŁODZĄCEJ | COOLING WATER INTAKE POINT |
| PUNKT ZWROTU RYB | FRRS (FISH RETURN AND RCOVERY SYSTEM) POINT |
| STANOWISKO ROZŁADUNKU MORSKIEGO | MOLF (MARINE OFF-LOADING FACILITY) |
| Jezioro Żarnowieckie | Żarnowieckie lake |
| PRZYŁĄCZE WOD-KAN DO SIECI MIEJSKIEJ | WATER AND SEWAGE CONNECTION TO MUNICIPAL NETWORK |
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| TRASA KANAŁÓW/RUROCIĄGÓW WODY UZUPEŁNIAJĄCEJ | MAKE-UP WATER CHANNEL/PIPELINE ROUTE |
| TRASA RUROCIĄGÓW OCZYSZCZONYCH ŚCIEKÓW PRZEMYSŁOWYCH | TREATED WASTEWATER PIPELINE ROUTE |
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| | |
|---|---|
| Appendix number | **Appendix II.2.4-6-1** |
| Appendix title | **Variant 2 - Żarnowiec site, sub-variant 2A**<br>**Land development plan: Project operational phase** |
| Scale | **1:3 500** |

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|---|---|
| Environmental impact assessment report for the investment project comprising the construction and operation of the first Polish nuclear power plant of 3750 MWe capacity within the communes of Choczewo or Gniewino and Krokowa | |
| Appendix number | **Appendix II.2.4-6-2** |
| Appendix title | **Variant 2 - Żarnowiec site, sub-variant 2B<br>Land development plan: Project operational phase** |
| Scale | **1:3 500** |

ROOS_T2_04_3047_eksploatacja_2B_ZAR_A0

Appendix II.10.6-1:

# Sources of radioactive waste and radioactive waste management during Operational phase

## Excerpt from Appendices to Volume II of the EIA Report

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## Glossary

| Term / Abbreviation | Definition |
|---|---|
| BDS | steam generator blowdown system |
| CDS | condensate system |
| CPS | condensate polishing system |
| CFA | criteria for acceptance |
| COP | liquid radioactive waste |
| CVS | chemical and volume control system |
| DAW | dry active waste |
| DTS | demineralised water treatment system |
| ILW | intermediate level waste |
| HHISO | half height ISO container |
| HVAC | heating, ventilation, air conditioning system |
| LLW | low level waste |
| Lop | life of plant |
| PAA | National Atomic Energy Agency/ President of the National Atomic Energy Agency |
| RCDT | reactor coolant drain tank |
| RCS | reactor coolant system |
| SFS | spent fuel pool cooling system |
| SWS | service water system |
| WGS | gaseous radioactive waste system |
| WLS | liquid radioactive waste system |
| WSS | solid radioactive waste system |
| WWS | waste water system |
| WPJ | spent fuel |

# I Sources of radioactive waste during Operational phase

## I.1. Sources of gaseous radioactive waste

The main sources of gaseous radioactive waste are: leaks from the reactor cooling system (RCS), degassing of the reactor coolant associated with purification and chemical adjustment (through the chemical dosing and volume regulation system, CVS), and contaminated air from ventilation systems of monitored areas. Radionuclides produced during the operation of a nuclear power plant are the products of fission and activation of corrosion and erosion products of structural materials of the nuclear steam generation system.

During these processes, the following are formed:

- Radioactive noble gases: these are mainly xenon-133, xenon-135 radionuclides and, to a lesser extent, krypton-85. They are generated in the nuclear fuel and via micro-fissures in cladding of fuel elements they travel to the coolant of the reactor cooling systems, from which they are released when coolant is degassed. Due to their short half-life, noble gases are delayed (during this time the noble gases decompose, significantly reducing their overall activity) before being released into the environment.
- Argon-41, as a product of neutron activation of naturally occurring argon-40 contained in the air in the reactor building, which dissolves in the reactor coolant during fuel reloading.
- Tritium as a product of nuclear fuel fission and the reaction of neutrons with boron B-10 contained in the reactor coolant and subsequent radioactive decay; tritium is also produced from trace amounts of lithium-6 which is present in the lithium compound used to regulate the pH. Tritium is present in tanks and fuel basins as tritium water and its vapors enter the ventilation systems.
- Carbon-14, as a product of the neutron activation of oxygen and nitrogen dissolved in the reactor coolant and released from it in the degassing process. It is present in the form of methane (80%) and to a lesser extent as carbon dioxide (20%).
- Iodine radioisotopes, mainly iodine-131 and iodine-133, are produced by the fission process. Iodine radionuclides pass from the nuclear fuel through micro-fissures in cladding to the reactor coolant and iafte its degassing are purified and delayed on the carbon filters.

Aerosols - the main radionuclides include cobalt-58 and cobalt-60 produced in the process of activation of corrosion / erosion products, and cesium-134 and cesium-137 produced in the fission process. Aerosols are treated by filtration in ventilation systems.

## I.2 Sources of radioactive liquid waste

Fission products may get into the reactor coolant through leaks in the fuel cladding. The water in the reactor cooling circuit also contains dissolved and suspended products of corrosion and erosion of construction materials, which are activated in the reactor core by neutrons. Liquid radioactive waste results mainly from the activation of the primary circuit coolant and its contamination due to the micro-leakage of fuel cladding in the reactor and, to a lesser degree, in the spent fuel pool and auxiliary systems (leaks, releases and drainage). Both the reactor coolant and water from the spent fuel storage basins is directed to appropriate purification systems cleaning it from contaminants (including radioactive contamination). The water is recovered, and the separated contaminants are sent to the radioactive waste processing plant.

The source of liquid radwaste are also liquids from the sewage system of the controlled zone, from the laboratory, from the laundry of contaminated clothes, hygienic showers and from decontamination works. Liquid waste of this type is potentially contaminated. Depending on the place of generation, wastewater has different characteristics (low / high salinity, organic matter content, activity, type of radiation) and taking it into account, it is collected in appropriate tanks, from where it is directed for processing. The largest stream of liquid waste is low-salinity sewage, which comes from the reactor cooling circuit and the spent fuel pool. This stream may contain boron compounds, which, depending on the reactor technology, are either used in the coolant or come from damaged control rods.

## I.3 Sources of solid radioactive waste

Solid radioactive waste is produced during normal operation of the nuclear power plant, maintenance, repair and overhaul works, clean-up works and decontamination of equipment and systems contaminated with radioactive substances.

During the operation and repairs of a nuclear power unit with an AP1000 reactor the following type of wastes are produced:

- solid, low-level radioactive waste (LLW), is mixed waste containing materials such as paper, tapes, clothing, plastics, metal, wood, glass, ion exchange resins, dry granulated coal, pumps and filters of ventilation and air conditioning (HVAC) systems;
- solid intermediate-level radioactive waste (ILW), which includes used: ion exchange resins, activated carbon, filters and control rods.

Spent nuclear fuel on the other hand is a high-level waste (HLW), when it is not used for reprocessing but placed in a repository [ChapterII.10.6.4].

# II. Management of radioactive waste generated during operational phase

## II.1 Management of gaseous radioactive waste

**Management of gaseous radioactive waste from degassing of reactor coolant**

The below figure [Figure II.11.6-11] presents the general method of treatment of the gaseous radioactive waste released during degassing of reactor coolant.

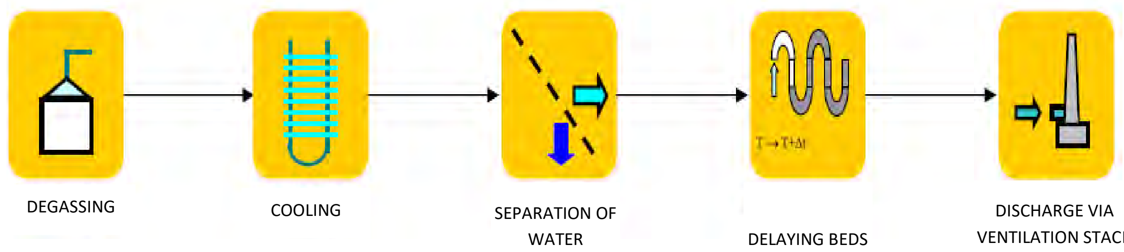


**Figure II.11.6-11 Management of gaseous radioactive waste from degassing of reactor coolant.**
*Source: [32]*

The above schematic diagram presents the Gaseous radwaste system (WGS) [6].

This system is intended for:

- Collection of gaseous radioactive waste or waste containing hydrogen,
- processing and releasing gases within the applicable limits.

The radioactive gas system (WGS) is a flow system based on an activated carbon delay system, operating at ambient temperature. Its main task is to prevent uncontrolled emission of radioactive gases into the environment. Technical details are available in Company documentation [29]. The volumes of contaminated coal beds are specified in the appendix.

**Removal of radioactive gases and aerosols from facilities and process rooms**

There are five basic sources of radioactive gases and aerosols [33]:

- Reactor coolant system (RCS);
- Containment building;
- Auxiliary building;
- Turbine building;
- Turbine condenser air removal system.

Radioactive gaseous emissions from the reactor coolant system vary with time, depending on the moment of the fuel cycle. A similar relationship is also true for liquid radioactive releases. On the other hand, gaseous emissions from systems not related to the reactor cooling system do not depend on the timing of the fuel campaign.

Figure [Figure II.10.6-1- **2**]shows schematically the sources of radioactive contamination of AP1000 systems, facilities and rooms discharged into the atmosphere. The monitoring point in the stack is chosen to ensure that the sample is representative of the total volume of gas released.

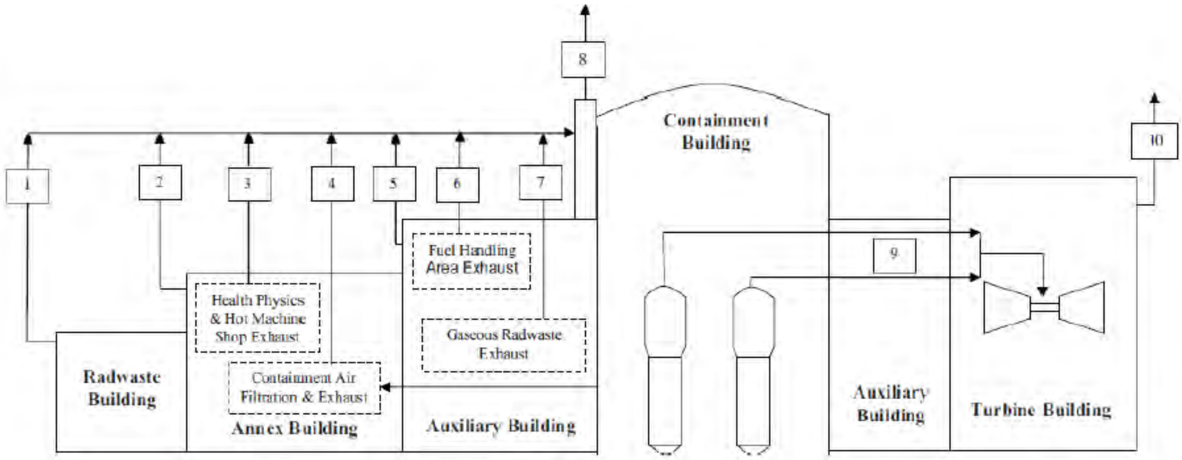


**Figure II.10.6-1- 2 Sources and monitoring points for radioactive emissions to the atmosphere**
1 - radwaste building exhaust, 2 - annex building exhaust, 3 - health physics & hot machine shop exhaust, 4 - containment air filtration exhaust, 5 - auxiliary building exhaust, 6 - fuel handling area exhaust, 7 - gaseous radwaste exhaust (WGS), 8 - ventilation stack, 9 - leaks from the main steam pipelines and from the primary to the secondary system of the steam generators (N-16 isotope), 10 - discharge from the turbine building.
*Sources: [33], [19]*

All the exhaust points in the diagram (no. 1-7, 10) are fitted with filters. The volumes of contaminated coal beds are specified in the appendix.

## II.2 Management of liquid radioactive waste

The below figure [Figure II.11.6- 3] presents the general method of treatment of the liquid radioactive waste.

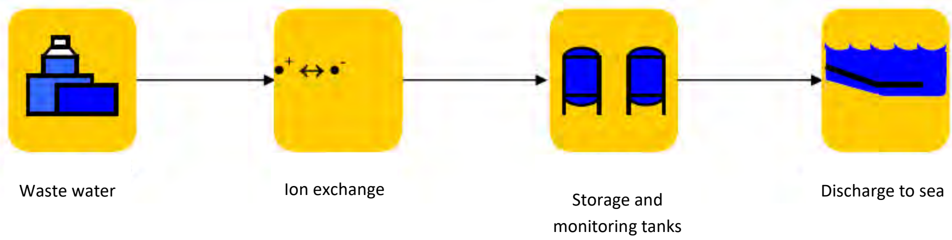


**Figure II.11.6- 3 Treatment of liquid radioactive waste.**
*Source: [1]*

In the course of liquid waste processing, secondary waste is generated - filter sludge, used filter cartridges, used ion exchangers or carbon beds. These wastes are placed in tanks, after precipitation of the solid particles to the bottom the liquid is returned for treatment, and the solid sediment is directed to the solid waste treatment system.

Wastewater that meets the conditions for discharge into the environment will be discharged into the sea: in the case of an open cooling system (condensers and equipment of the "conventional island") - by the discharge of heated cooling water, and in the case of a closed cooling system - by discharge of blowdown and waste water to the sea.

Discharge to the environment is allowed only if the examination of the tank contents did not show any contraindications. If the requirements are not met, the contents of this tank can be pumped to a waste holding tank or sent directly to the start of the treatment process. A radiation detector is installed on the joint discharge line and signals for discharge to stop when activity levels exceed a set limit.

The liquid radwaste processing system is designed to process most of the liquid radwaste and other waste water using in-house facilities. However, it may happen that the produced wastewater cannot be processed with the installed devices. In this case, it is possible to connect temporary devices in the truck stand of the mobile treatment plant.

Technical details of the liquid radwaste system for an AP1000 reactor are presented in internal documentation of the Investor [29].

## II.3 Management of solid radioactive waste

Processing of solid low and medium level radioactive waste is used to reduce its volume and transform the waste into a form suitable for its storage or disposal.

Management of solid low radioactive waste is presented in the diagram [Figure II.10.6-1- 4].

In the case of used ion exchange resins from the condensate polishing system (CPS) of the turbine, which are normally non-radioactive, these may be contaminated via leakage in the pipes of a heat exchanger in the steam generator and may this way become low active waste. The below figure [Figure II.10.6-1- 5 presents the general method of treatment of used ion exchange resins. Main method when the resins are not contaminated is to collect, store and dispatch them to an incineration facility. In case of radioactive contamination, the resins are qualified and processed as low active waste.

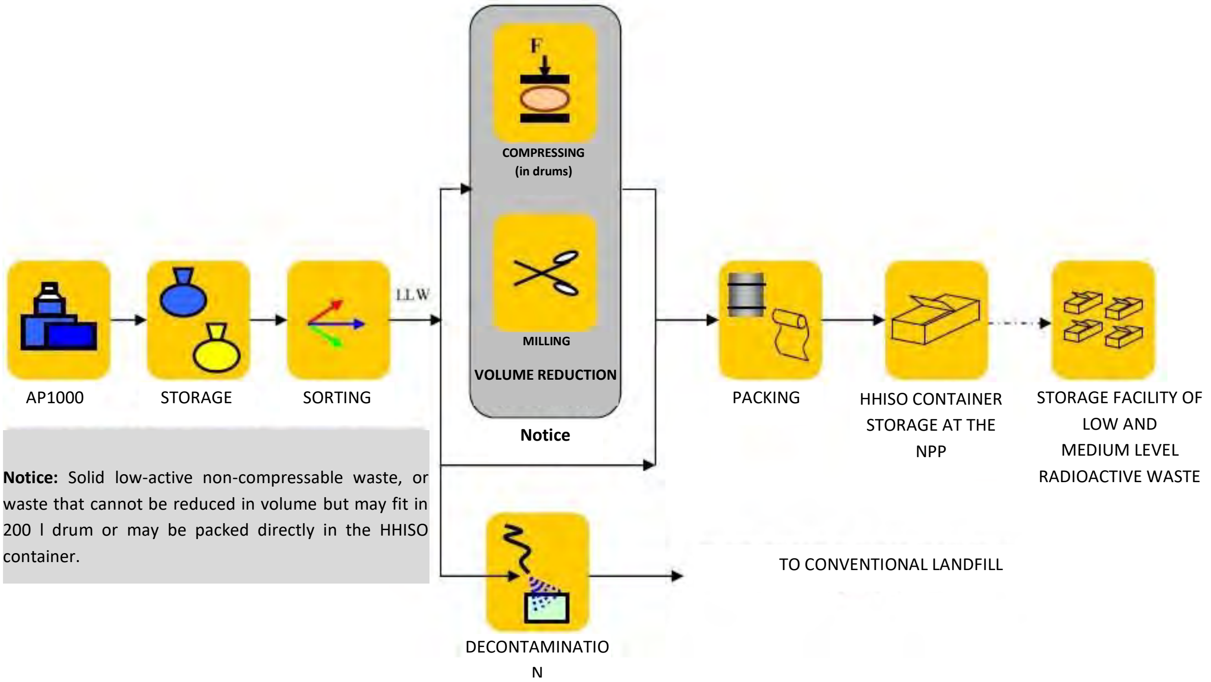


**Figure II.10.6-1- 4 Management of solid low level waste**

*Source: [32]*

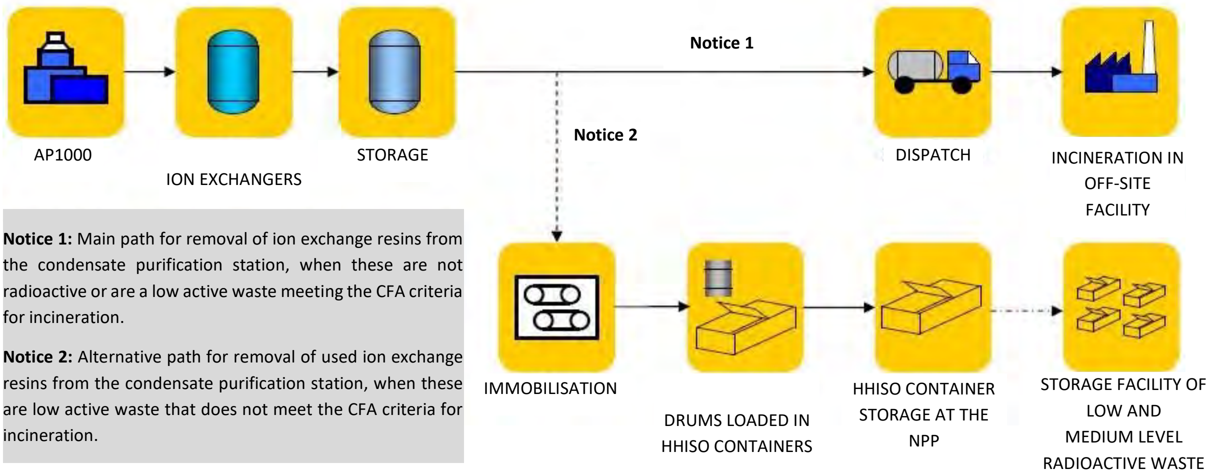


**Figure II.10.6-1- 5 Treatment of used ion exchange resins from the condensate purification system**

*Source: [32]*

Management of solid low radioactive waste (ion exchange resins and filtration elements) is presented in the diagram [Figure II.10.6-1- 6].

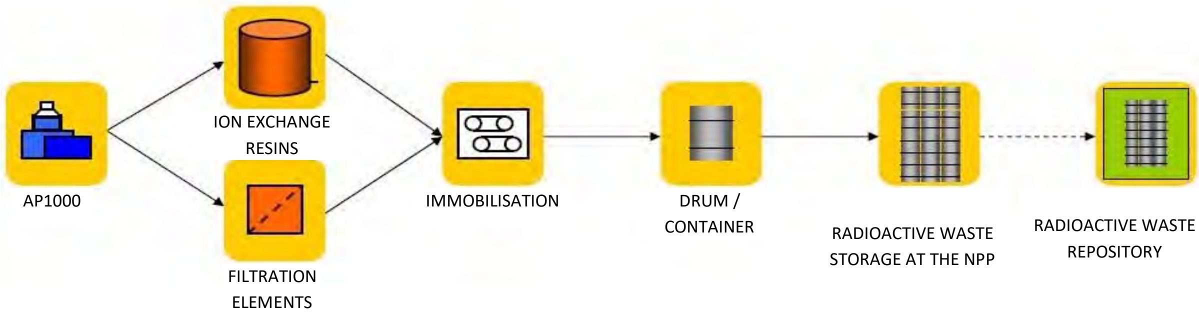


**Figure II.10.6-1- 6 Management of solid low level waste**

*Source: [32]*

Solid radioactive waste treatment technologies include:

- Pressing: consists in reducing the volume of radioactive waste by applying a mechanical force. Depending on the characteristics of the solid radioactive waste, the volume is reduced by 3 to 8 times. Items prepared for compaction (pressing) are segregated and compacted in the drum. Larger items will be cut into pieces and packed into drums;
- Incineration: reduces the volume of radioactive waste and converts the combustible material to ash, which is more stable and safer to store and dispose of. By using this method, the volume of radioactive waste can be reduced by 30 to 100 times;
- Immobilization: provides adequate protection against the spread of radioactive substances. It is a form of protection against the influence of radiation on the environment. The most commonly used materials in this process are concrete, polymers and glass.

Once sealed, all packaging with processed radioactive waste is decontaminated and subjected to dosimetric control. Controlled parameters include dose on the surface of the package  and at 1m distance, as well as contamination on the waste packs. The dose and volume of contamination may not exceed maximums set out in § 37 of the Regulation of Council of Ministers of 14 December 2015 on radioactive waste and spent nuclear fuel [25].

**Packaging of solidified radioactive waste**

Solidification of radioactive waste is one of the methods of neutralizing liquid radioactive waste. Solid form of the waste is obtained by adding a binder (binding material) to the liquid waste. The most common binder used in the case of low- and medium-level radioactive waste is cement. The waste is solidified in a container which is a package prepared for storage or disposal.

Sludges and ion exchange resins are solidified in 3 m3 containers. The packages take the form of drums and containers [Figure II.10.6-1-7]. It is possible to solidify the waste in them directly, i.e. by mixing the waste and the binder in a container. The empty weight of such a container does not exceed 8 tons.

Basic properties of containers for solidified radioactive waste:

- standardized lifting features,
- physical enclosure including the box, cover, and sealing system
- standardized laying properties,
- filtering vent as needed.

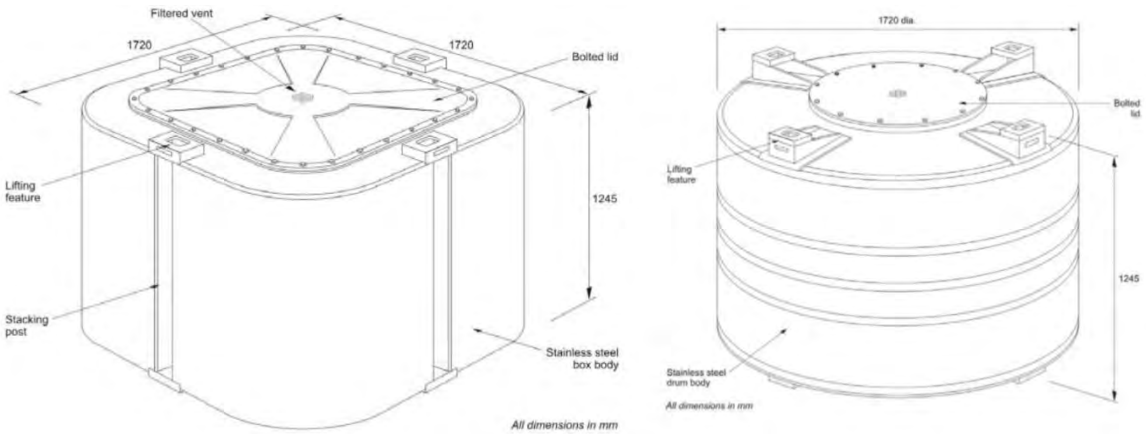


**Figure II.10.6-1-7 Sample technical data of a metal drum**
*Source: [19]*

Additionally, ion exchange resins can be solidified in 200 l steel drums. Figure [Figure II.10.6-1-8] shows the basic dimensions of a sample 200 l drum. The drums are transported to the repository in HHISO (Half Height ISO container), and a single container can hold 39 drums of 200 l each [19].

*Przykładowe dane techniczne;*

| | |
|---|---|
| *wysokość* | *887 mm* |
| *ciężar* | *15 kg* |
| *średnica* | *610 mm* |
| *materiał* | *blacha stalowa* |
| *grubość pokrywy* | *0,9 mm* |
| *pojemność* | *212 l* |
| *wykonanie ścian* | *pełne* |
| *wykonanie dna* | *pełne* |
| *otwór wlotowy* | *nie* |
| *zam. z dźwignią* | *tak* |
| *grubość dna* | *0,9 mm* |
| *grubość płaszcza* | *0,8 mm* |

**Figure II.10.6-1-8 Sample technical data of a metal drum**
Height – 887 mm, Weight – 15kg, Diameter – 610 mm, Material – steel, Cover thickness – 0.9 mm, Volume – 212 litres, Wall finish – full, Bottom finnish – full, Inlet – none, Seal with lever – yes, Bottom thickness – 0.9 mm, Coat thickness – 0.8 mm.

*Source: [19]*

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## List of figures

Appendix II.11.3-1

# Results of the analysis of impact from extreme natural events, phenomena and conditions on NPP safety together with adaptive (preventive) measures

Excerpt from Appendices to Volume II of the EIA Report

Language version: EN

July, 2022

świadomie|o|atomie
energia jądrowa w Polsce

Polskie Elektrownie Jądrowe sp. z o.o.

## Table of contents

## Glossary

| Term / Abbreviation | Definition |
|---|---|
| NPP/Project | Investment consisting in the construction and operation of the first Nuclear Power Plant in Poland with the capacity of up to 3750 MWe, in the territory of the following communes: Choczewo or Gniewino and Krokowa |
| IMGW | Institute of Meteorology and Water Management |

**Table II.11.1-1- 1 Results of the analysis of impact from extreme natural events, phenomena and conditions on NPP safety together with adaptive (preventive) measures. Variant 1 – Lubiatowo-Kopalino site**

| No. | Climate and environmental factors | Adaptive (preventive) measures |
|---|---|---|
| 1. | **Flooding caused by a tsunami**<br>No tsunamis, which could cause a hazard more severe than extreme storm surges accounting for climate change, are anticipated. | No adaptive measures are planned. |
| 2. | **Flooding caused by sea level variations, tide and waves**<br>The risk analysis for the nuclear island assumes sea level rise due to climate change. It is an assumption in the calculation of extreme high sea levels including storm surges. | Taking into account uncertainty of 1 m in the estimations, the ordinate of 8.8 m above sea level for the Lubiatowo-Kopalino location was derived as the maximum sea level.<br>As a result of the analyses carried out, in order to prevent the effects of sea level changes, tides and wave action, the nuclear island site was planned to be elevated to a level of approximately 9.5 m above sea level. |
| 3. | **Flooding caused by groundwater level variations**<br>Flooding due to changes in groundwater levels would only be a risk if the site is depressed, i.e. below sea level, which is not the case at the site in question. | No adaptive measures are planned. |
| 4. | **Precipitation (including hail), flooding caused by rainfall (waterlogging)**<br>Climate change is projected to increase precipitation intensity and increase the number of days with precipitation above 10 mm, increase storm activity, and increase the number of days with hail over 2 cm in diameter.<br>Extreme rainfall, if the absorption of undeveloped land is not sufficient, may cause undesired flooding of the NPP site and the area around the plant site. | In order to prevent the accumulation of rainwater within the NPP site, a stormwater drainage system will be designed which will discharge the rainwater to a receiver (Baltic Sea or Kanał Biebrowski), described in more detail in chapter [Chapter II.10.12].<br>All components of the site drainage system, such as the retention basin, channels and pipes, will be designed taking into account the need to ensure the flow capacity of the drainage system in the event of extreme events, e.g. heavy rainfall. The stormwater drainage system will be equipped with wastewater treatment facilities (separators, settling tanks, neutralisers) to meet the quality parameters permitted by the standards.<br>Extreme rainfall, if the absorption of undeveloped land is not sufficient, may cause undesired flooding of the NPP site and the area around the plant site. Apart from damaging buildings, floods can lead to, among other things, failure of installations and equipment, contamination of the ground, and rising groundwater levels.<br>One of the important elements preventing the aforementioned events will be leaving within the Project Area the possibly large biologically active surface.<br>In addition, all NPP facilities will be designed with measures to prevent damage in the event of possible site flooding, e.g:<br>• ground floor levels of buildings will be elevated above ground level to a safe height,<br>• the buildings will have concrete plinths with an appropriate height above ground level,<br>• the access roads to the building gates will have appropriately shaped slopes - outwards from the building,<br>• containment tubs for collecting any potential chemical or oil spills will have plinths around them at an appropriate height above ground level,<br>• all free-standing steel structures will be set on concrete plinths with a sufficiently chosen height above ground level to prevent possible direct contact of the steel structures with water. |

| No. | Climate and environmental factors | Adaptive (preventive) measures |
|---|---|---|
| | | During the Operational phase, it will be necessary to maintain the sewerage system in a good state of repair to ensure full flow capacity of the system and proper operation of all equipment. Periodic inspections of the technical condition, including patency of ducts and equipment, cleaning of gullies, gutters, troughs, and inspections of the technical condition of roof cladding (water resistant insulation) will be necessary. An important element will also be the forecasting of upcoming weather phenomena, and a system for communicating impending threats. By installing rain gauges in the meteorological station at the NPP site, it will be possible to forecast the effects of phenomena, based on real rainfall data and to prepare in advance for possible risks, and to carry out preventive actions. |
| 5. | **Electromagnetic interference caused by lightning strikes**<br>The risk analysis concluded that there is no link between electromagnetic interference caused by lightning and climate change. | The NPP will be protected against lightning in accordance with Polish regulations for power facilities. This type of protection will also safeguard all NPP equipment from potentially occurring electromagnetic interference. |
| 6. | **Sea or lake coast erosion**<br>Following risk analysis, it was concluded that there is no relationship between coastal erosion processes and climate change over the time horizon of the NPP operating period. However, there is a possibility that erosive processes may intensify in coastal sections where such phenomena have already been identified, and that erosive processes may be triggered in coastal sections assessed as cumulative. | The ground level of the nuclear island foundation will be raised to approximately 9.5 m above sea level. In addition, the slopes of the raised area will be protected against erosion processes by retaining walls. |
| 7. | **Instability of slopes or embankments (landslides)**<br>The designed ground levels of the future power station will require embankments and excavations in existing hills. During further construction works, and operation of the power plant there is a probability of loss of slope stability, landslides (surface mass movements) during e.g. loading of embankments and slopes by e.g. fallen trees, intense and/or prolonged precipitation and winds. | At the design stage, provision will be made for the protection/stabilisation of the subsoil of slopes and hillsides against the loss of their stability. Natural methods such as terracing the slopes and covering them with vegetation, special geotechnical nets or biological mats will be used to protect low slopes and hillsides. With higher slopes, construction methods will be used, e.g. palisade or gabion construction, anchoring or soil nailing, pressure injections, the use of grids, nets or buttresses on the surface of slopes. A reinforced concrete retaining wall is planned on the seaward side to protect the slopes. All slopes and hillsides will have a drainage system for rainwater or snowmelt running down their surfaces.<br>During the operation of the power plant, it will be necessary to periodically inspect the technical condition of the slope protection. If damage or other abnormalities are detected, maintenance or repair works of protective structures will have to be carried out. It will also be necessary to periodically clean the drainage system/channels from slopes and embankments to ensure that they do not lose flowability. |
| 8. | **Subsidence (collapse of natural caverns)**<br>The results of geological surveys indicate that there are no carbonate rocks in the shallow subsurface (to a depth of up to 200 m below sea level) at the NPP site, so there is no likelihood of karst phenomena or the formation of natural caverns, and therefore no danger to the NPP facilities from sinkholes is anticipated. | No adaptive measures are planned. |

| No. | Climate and environmental factors | Adaptive (preventive) measures |
|---|---|---|
| 9. | **Extreme ground temperatures**<br><br>The lowest ground temperature recorded at the measurement points located closest to the NPP site (i.e. Łeba and Lębork) was - 25 °C and - 32 °C, respectively.<br>In the site region, temperatures of around -34°C once every 100 years and -41°C once every 10,000 years are to be expected.<br>Prolonged periods of extreme cold can lead to some ground movements. They may cause damage to underground installations and, consequently, result in the occurrence of human-induced hazards or internal hazards. The phenomena occurring in the ground under the influence of extremely low temperatures can be similar to those caused by droughts.<br>Extremely low temperatures can also cause the underground installations of NPPs to freeze. | Adaptive measures will include frost protection for structures and underground installations. Such measures will be applied in the construction of the NPP. Due to the negligible impact of climate change on ground temperatures, no special strengthening of the thermal insulation is envisaged for this reason.<br>Extremely high ground temperatures in the vicinity of the NPP, which may occur in the Polish climatic zone, will not pose any threat to the power plant components and adaptation measures have not been indicated in this respect. |
| 10. | **High air temperature**<br><br>Current climate change is leading to an increase in average air temperatures. This will be reflected, inter alia, in an increase in the number of hot days and an increase in the intensity of heat waves (as further discussed in [Chapter IV.3]) | The buildings are planned to be properly thermally insulated in accordance with current standards, as well as properly equipped with ventilation and air-conditioning [HVAC] equipment designed and manufactured in accordance with regulations in force.<br>Technical and social rooms will be equipped with appropriately selected air supply and exhaust systems or air conditioning systems, in accordance with the climate requirements and the needs of employees, allowing to maintain the appropriate temperature and air humidity in the rooms. |
| 11. | **Low air temperature**<br><br>The number of frosty days per year is projected to decrease as a result of climate change. Nevertheless, analyses show that once every 100 years temperatures can be expected as low as -25°C, and once every 10,000 years as low as -38°C (further discussed in [Chapter IV.3]). | Facilities and installations will be thermally insulated and the buildings will be equipped with appropriate ventilation and air-conditioning installations, designed and manufactured according to regulations in force.<br>Likewise, the design of heating installations of the NPP will ensure the maintenance of required temperatures in all NPP facilities under winter conditions.<br>During operation, the heating of NPP facilities will be ensured by steam from steam turbine vents. In the time of winter outages with there being no discharge of steam, the supply of heating installations will be ensured by electric boilers installed at each unit. Additionally, a collective auxiliary boiler house is provided as another reserve supply source for the heating installations of the NPP. |
| 12. | **Strong winds**<br><br>The highest recorded maximum wind speed in the measuring station closest to the NPP area in Łeba is approximately 94km/h. Once in 100 years it may reach 140 km/h and once in 10,000 years it may reach 186km/h (further discussed in [Chapter IV.3]).<br>Strong winds at sea may cause storm waves and thus lead to the occurrence of floating debris like floating cargo from a wrecked ship, timber logs, leaves, plant and animal remains, refuse etc. This debris may have an influence on the functioning of the cooling system facilities at sea (water intake, diffusers, cooling water channels).<br>Wind pressure and suction on walls and roofs of buildings and other objects will constitute an essential load on NPP facilities. Moreover, when wind affects large surfaces, friction occurs and it may be significant with regard to the load on buildings. | During the design process all loads on the NPP induced by weather conditions will be adopted in accordance with European PN-EN standards introduced in Poland. Measurement results for the wind speed recorded by the meteorological monitoring in the NPP area will be calculated along with historic data from the Meteorological and Water Management Institute (IMGW). The standard EN 1991-1-4 Eurocode 1 Wind actions determines the method of calculating the wind load on structures. According to this standard, the Project Area is located in the 2nd zone of wind load for which the basic wind speed amounts to 26m/s, whereas the wind pressure amounts to 0.42 kN/m$^2$.<br>The structure and cladding of each facility will be resistant to the maximum expected wind pressure and suction.<br>The load on cooling system components will be determined in the design process, with consideration of |

| No. | Climate and environmental factors | Adaptive (preventive) measures |
|---|---|---|
| | | the load/additional forces caused by the impact of large elements.<br>Intakes and diffusers will be equipped with filters preventing small debris from entering the water channels.<br>During operation, periodic inspections of the technical condition of the structure and the protective elements of facilities will be undertaken. Inspection reports will note all the irregularities and include instructions on further actions to be taken. Repairs and refurbishments will be undertaken when required. |
| 13. | **Tornadoes and whirlwinds**<br><br>In the years 2014-2020, 104 cases of a whirlwind were observed in Poland, approximately 26 of which occurred in the Pomeranian voivodeship and involved the formation of waterspouts in the Baltic Sea. An assumption can be made that due to climate change the frequency and intensity of whirlwinds in the survey area will slightly increase.<br>Disastrous effects of a whirlwind are caused not only by the immense velocity of the whirling wind (up to 360km/h) but also to its strong suction force. Effects of a tornado include uprooting trees, windows and doors falling out, tearing up roofs of houses and lifting heavy objects: cars and people, and carrying those over tens of metres. | Adaptive actions intended as protection against the effects of whirlwinds will be undertaken during the design of facilities, their construction and operation. The safety of people, components and power plant facilities will be ensured by:<br>• keeping an adequate distance between the objects,<br>• use of fortified connections between the structural elements of buildings,<br>• reducing the number of windows to the essential minimum, i.e. the design will only allow to place them in rooms in which daylight is required according to construction law, such as offices, social and training spaces etc. Windows with large sections of glazing will be inadmissible,<br>• installation of entrance doors and gates with strong resilience to wind pressure and suction,<br>• not applying small, light elements that might be torn off by strong wind to wall or roof cladding,<br>• use of fortified mounting for lining elements on walls, roofs, entrance doors and gates,<br>• the landscaping project will include planting of low vegetation (no trees).<br>The reactor building will be built as a heavy, reinforced concrete structure, placed on piles, resistant to wind action in the event of whirlwinds.<br>During the NPP operation, apart from due care for the technical state of the facilities, appropriate procedures will be implemented including, i.a., ban on storing loose elements in the NPP area. Forecasting, i.e. the early detection of hazards, will also be important to maintain safety, helping to minimise their impact. |
| 14. | **Ice phenomena on the sea**<br><br>Ice phenomena occur in the Southern Baltic, but mostly in the area of the Gdańsk Bay, Puck Bay, and in the Vistula and Szczecin lagoons. They are increasingly rare and short-lasting, with a thinner ice cover or ice floe. In the open sea in the Project Area, ice phenomena may occur only sporadically in the coastal zone (at the interface of sea and land). Neither ice cover, nor ice floe occur at a distance of 1 or 1.5km. Nevertheless, even if icing occurs in the event of an exceptionally severe winter, the thickness of the ice cover should not exceed 20cm.<br>Thus, no external threats are anticipated to maritime structures located more than 1km from the coastline resulting from the ice phenomena. | No adaptive measures are planned. |
| 15. | **Extreme snowfall**<br><br>In the Pomorskie voivodeship, the number of days with snow cover is one of the lowest in Poland – it ranges | In the designing process all the weather-related loads on NPP objects will be adopted in accordance with European PN-EN standards introduced in Poland (according to the standard, it is the 3rd zone of threat |

| No. | Climate and environmental factors | Adaptive (preventive) measures |
|---|---|---|
| | from 40 days to slightly over 60 days in the area with higher elevation ASL. The maximum thickness of the snow cover ranges from 39 cm to a maximum of 94 cm. Once in 100 years a snow cover may be expected with a thickness over 60 cm. Climate scenarios suggest a decrease in snow cover in future decades (discussed in detail under [Chapter IV.3]).<br>Remaining snow cover will constitute a very significant load on the roofs and elements of NPP objects. | caused by snow), and the largest snowfall measured in the NPP area will also be taken into account.<br>Finally, the structure of the roof of each facility in the NPP area will be designed with due consideration of the maximum anticipated snow load, with an adequate slope allowing for drainage of meltwater to the rainwater system. The structure and cladding of the facilities will be made of materials with certificates and approvals confirming their quality and resilience to atmospheric factors.<br>During the operation snowfall will be monitored by a meteorological station in the NPP area, where snow gauges and devices marking the snow density will be installed. Snow removal from roofs will be indispensable in the event of heavy snowfall. For this purpose, each facility will have an appropriate procedure for the removal of snow from the roof. Periodic inspections of technical condition of cladding (waterproof isolation) and of the roof structure will be performed. Inspection reports will note all the occurring irregularities and include instructions on further actions to be taken. Repairs and refurbishments will be undertaken as required.<br>Surface slopes in the direction of drains or road gutters will be included in road, yard or parking space design. Meltwater from these surfaces will be directed to the underground rainwater system designed to collect the wastewater from melted snow. For the construction of roads, yards and parking spaces and also pavements, materials resilient to low temperatures and to de-icing agents (salt solutions) and universally available detergents will be used.<br>During the operation of the NPP in winter conditions, it will be very important to keep the roads, yards and parking spaces in proper condition. The combination of ice and snow may increase the probability of hazards connected with transport, and may make moving around the NPP site difficult. Appropriate procedures for dealing with snowfall will be developed and implemented for the operation period. In accordance with these procedures, all roads (including emergency roads), yards and parking spaces will be continuously cleared of snow and ice. |
| 16. | **Drought (affecting the availability of process water)**<br>Climate change is not expected to cause a decrease in sea level that would result in a shortage of cooling water for the NPP.<br>Therefore, it is not forecasted that the occurring droughts would pose a hazard for the NPP. | No adaptive measures are planned. |
| 17. | **High sea/lake temperature**<br>Increase in water temperature of the Baltic sea is forecasted. According to the data recorded in the marine station in Władysławowo in the years 1981-2018, an upward trend is visible with regard to seawater temperature. Once in 100 years the water temperature in Władysławowo may rise to 27.7°C, and once in 10,000 to 32.9 °C.<br>Depending on the selected cooling variant, the rise of the temperature of the cooling water will lower the efficiency of the nuclear units. Though, even in the case | No adaptive measures are planned. |

| No. | Climate and environmental factors | Adaptive (preventive) measures |
|---|---|---|
| | of an open cooling system (highest impact of temperature rise) no noticeable impact on the NPP is forecasted for the projected rise. | |
| 18. | **Low sea/lake temperature**<br>As explained under item 17, a rise in the temperature of seawater in the Baltic is forecasted. No threats to the safety of the NPP are forecasted in relation to the occurrence of low water temperatures in the Baltic sea. | No adaptive measures are planned. |
| 19. | **Sand storm, dust storm**<br>A large-scale occurrence of these phenomena is not forecasted, yet a description of preventive actions to be used for the needs of the NPP was prepared. | It is assumed, as adaptive measure for the negative impact of dust on NPP installations, that the NPP area and its surroundings will be maintained in a state that does not create opportunity of sand or dust blasts (well-arranged green areas, cleaned/washed pavings). Additionally, in order to eliminate the undesired dust pollution, if required, air filters will be installed on the air intake, and they will be periodically inspected and replaced. |
| 20. | **Biological contamination – water environment (including growth of seaweeds, algae, and micro-organisms in sea water)**<br>As a result of the rise in seawater temperature and possible changes in physical and chemical properties of seawater, there is a probability that the primary production will increase (increased growth of phytoplankton), and especially that there will be an increase in the bloom of filamentous algae, which, particularly in the summer, form a dense biomass overgrowing underwater elements of the cooling system that may obstruct or reduce the flow of water (biofouling).<br>In the event of changes in the properties of seawaters, there is the possibility of an increased reproduction of microorganisms and sea animals, especially the common jellyfish (scyphozoa) and bivalves (e.g. common mussels) and of the appearance of non-native and invasive species with significant reproductive potential. With their increased biomass the animals may contribute to the obstruction/reduction of water flow in the cooling systems or cause its temporary switch-off. | Formation of epiphytic layers is prevented with a technological process of anti-fouling. The industrial processes to control biofouling use chemical substances (biocides). Another helpful, non-toxic, practicable mechanical strategy preventing the attachment of organisms is the choice of a non-adhesive, slippery material or coating. The solution will be considered at the stage of project documentation development. The application mechanical cleaning/removal of biological contamination formed in intake and discharge installations of sea water will also be possible during plant operation. |
| 21. | **Biological contamination – land and air environment (plant pollens, swarms of insects, flocks of birds, pests)**<br>The operation of ventilation systems can be disturbed as a result of obstruction caused to ventilation ducts and screens by leaves, pollen or insects that settle on the filters.<br>Climate change can result in new threats, for example from swarming insects. However at present, following analyses of swarming insects such the families of Vespidae, Apidae, and Ephemeroptera, the threat is considered to be very low.<br>No threat from small rodents or rats has been identified, either. | The use of special filters and their ongoing maintenance, as well as periodic replacement in line with technical requirements. If required, rodent control will also include prophylactic periodic deratization measures. |
| 22. | **Atmospheric dispersion**<br>At present, north-west winds prevail in the region of Pomorze Gdańskie.<br>As a result of climate change, the average speed and prevailing direction of wind can change. This may affect the radionuclide dispersion and its direction. | The adaptive measure applied in this respect will be an ongoing radiological monitoring in the vicinity of the NPP. |

| No. | Climate and environmental factors | Adaptive (preventive) measures |
|---|---|---|
| 23. | **Corrosion from sea spray**<br><br>The probability of water corrosion for unalloyed steel and low-alloy steel in the underwater environment is small for the general corrosion, and medium for pitting corrosion and for corrosion on large surfaces. The probability of corrosion for unalloyed steel and low-alloy steel at the water-air interface is medium for the general corrosion, and high for pitting corrosion and for corrosion on large surfaces. The probability of corrosion cells forming as a result of cathode inclusions is medium for the general corrosion, and high for pitting corrosion and for corrosion on large surfaces. On the basis of computed coefficients, the corrosion speed was also determined for hot-dip galvanised steel under water, which is 0.02 mm/year, while the maximum penetration at the interface of environments can be even 0.5 mm/year. The corrosion speed resulting from cathode inclusions is 0.05 mm/year. | Corrosion is one of threats for the NPP equipment, which needs to be prevented at each stage of the power plant lifetime. To this end, all the structures at risk of corrosion will be duly secured in line with the applicable Polish regulations and requirements of the plant vendor. The inspection and maintenance schedule will also be adjusted accordingly.<br>Furthermore, sea spray can result in salt buildup on elements of insulation for the power evacuation from the NPP, which can lead to its weakening. At the stage of the power plant design and preparation of service timeline, the schedule of inspections and cleaning of electrical insulation elemnts will be adjusted to the conditions prevailing in the vicinity. |
| 24. | **Forest fires**<br><br>Forest fires represent a particular risk as the power plant will be surrounded by a coniferous forest typical for the Baltic Sea dune areas. Forest fires can be started by atmospheric discharges (lightning strike), from dry grass catching fire from sun operation on dry sunny days, or due to arson. | Around the NPP area, outside its fence, a 100 metres wide mineralised zone will be created, covered by gravel and without vegetation. During the NPP operation, this belt will be monitored and maintained as described above.<br>There will be an on-site fire unit situated in the NPP area, with the required fire extinguishing measures and equipment. Tasks of the unit will include monitoring fire risks in the forest surrounding the NPP, and responding in emergencies. Adequate procedures will be implemented in consultation with the local fire department, to govern actions in case of a forest fire. |

*Source: In-house study*

**Table II.11.1-1- 2 Results of the analysis of impact from extreme natural events, phenomena and conditions on NPP safety together with adaptive (preventive) measures. Variant 2 – Żarnowiec site**

| No. | Climate and environmental factors | Adaptive (preventive) measures |
|---|---|---|
| 1. | **Flooding caused by a tsunami**<br><br>No tsunamis, which could cause a hazard more severe than extreme storm surges accounting for climate change, are anticipated. | No adaptive measures are planned. |
| 2. | **Flooding caused by sea level variations, tide and waves**<br><br>The description is the same as the description for Variant 1 – Lubiatowo-Kopalino site. | Taking into account uncertainty of 1m in the estimations, the ordinate of 8.3m AMSL was derived as the maximum sea level.<br><br>The nuclear island site was planned to be elevated to a level of approximately 9m above sea level. |
| 3. | **Flooding caused by groundwater level variations**<br><br>Flooding due to changes in groundwater levels would only be a risk if the site is depressed, that is, below sea level, which is not the case at the site analysed. | No adaptive measures are planned. |
| 4. | **Precipitation (including hail), flooding caused by rainfall (waterlogging)**<br><br>The description is the same as the description for Variant 1 – Lubiatowo-Kopalino site. | In order to prevent the accumulation of rainwater within the NPP site, a stormwater drainage system will be designed (described in detail in chapter [Chapter II.10.12]), which will discharge the rainwater to a receiver: Lake Żarnowieckie (from Subarea 1), and the Baltic Sea or Kanał Biebrowski (from Subarea 3).<br>A significant biologically active surface area is assumed to remain on the NPP site.<br>All NPP facilities will be designed with measures to prevent damage in the event of possible site flooding. |

| No. | Climate and environmental factors | Adaptive (preventive) measures |
|---|---|---|
| | | An adequately designed cladding of the facilities will constitute protection against intense hail. To this end, hail impact on external walls will be accounted for. |
| 5. | **<u>Electromagnetic interference caused by lightning strikes</u>**<br>The risk analysis concluded that there is no link between electromagnetic interference caused by lightning and climate change. | The NPP will be protected against lightning in accordance with Polish regulations for power facilities. This type of protection will also safeguard all NPP equipment from potentially occurring electromagnetic interference. |
| 6. | **<u>Sea or lake coast erosion</u>**<br>Following the risk analysis, it was concluded that over the time horizon of the NPP operation, there was no relationship between erosion processes of the coast of Lake Żarnowieckie or the marine coast, and climate change. | The pumping station area level will be raised to approximately 5m AMSL.<br>The level of the nuclear island will be raised to approximately 9m AMSL, to secure it against potential floods. |
| 7. | **<u>Instability of slopes or embankments (landslides)</u>**<br>The designed ground levels of the future power station will require embankments and excavations in existing hills. During further construction works and operation of the power plant there is a probability of loss of slope stability, landslides (surface mass movements) from e.g. loads on embankments and slopes from fallen trees, intense and/or prolonged precipitation and winds. | Protection/stabilisation of the subsoil of slopes and hillsides against the loss of their stability.<br>All slopes and hillsides will have a drainage system for rainwater or snowmelt running down their surfaces.<br>During the operation of the power plant, it will be necessary to periodically inspect the technical condition of the slope protection.<br>Periodic cleaning of the drainage system/channels from slopes and embankments to prevent any obstruction of their flow.<br>A reinforced concrete retaining wall is planned to be built on the seaward side, on the site of the cooling water pumping station, in Subarea 3. |
| 8. | **<u>Subsidence (collapse of natural caverns)</u>**<br>The results of geological surveys indicate that there are no carbonate rocks in the shallow subsurface (to a depth of up to 200m below sea level) at the NPP site, so there is no likelihood of karst phenomena or the formation of natural caverns. | No adaptive measures are planned. |
| 9. | **<u>Extreme ground temperatures</u>**<br>The description is the same as the description for Variant 1 – Lubiatowo-Kopalino site. | No adaptive measures are planned. |
| 10. | **<u>High air temperature</u>**<br>The description is the same as the description for Variant 1 – Lubiatowo-Kopalino site. | The description is the same as the description for Variant 1 – Lubiatowo-Kopalino site. |
| 11. | **<u>Low air temperature</u>**<br>The description is the same as the description for Variant 1 – Lubiatowo-Kopalino site. | The description is the same as the description for Variant 1 – Lubiatowo-Kopalino site. |
| 12. | **<u>Strong winds</u>**<br>The description is the same as the description for Variant 1 – Lubiatowo-Kopalino site. | The description is the same as the description for Variant 1 – Lubiatowo-Kopalino site. |
| 13. | **<u>Tornadoes and whirlwinds</u>**<br>The description is the same as the description for Variant 1 – Lubiatowo-Kopalino site. | The description is the same as the description for Variant 1 – Lubiatowo-Kopalino site. |
| 14. | **<u>Ice phenomena on the sea</u>**<br>The description is the same as the description for Variant 1 – Lubiatowo-Kopalino site. | The description is the same as the description for Variant 1 – Lubiatowo-Kopalino site.<br>No risk of ice phenomena on Lake Żarnowieckie is identified, either. In light of the above, no adaptive measures are specified. |
| 15. | **<u>Extreme snowfall</u>**<br>The description is the same as the description for Variant 1 – Lubiatowo-Kopalino site. | The description is the same as the description for Variant 1 – Lubiatowo-Kopalino site.<br>According to standard PN-EN 1991-1-3, the Project Area is situated in zone III of the snow load. |

| No. | Climate and environmental factors | Adaptive (preventive) measures |
|---|---|---|
| 16. | **<u>Drought (affecting the availability of process water)</u>**<br>The description is the same as the description for Variant 1 – Lubiatowo-Kopalino site. | The description is the same as the description for Variant 1 – Lubiatowo-Kopalino site. |
| 17. | **<u>High sea/lake temperature</u>**<br>The description is the same as the description for Variant 1 – Lubiatowo-Kopalino site. | The description is the same as the description for Variant 1 – Lubiatowo-Kopalino site. |
| 18. | **<u>Low sea/lake temperature</u>**<br>The description is the same as the description for Variant 1 – Lubiatowo-Kopalino site. | The description is the same as the description for Variant 1 – Lubiatowo-Kopalino site. |
| 19. | **<u>Sand storm, dust storm</u>**<br>The description is the same as the description for Variant 1 – Lubiatowo-Kopalino site. | The description is the same as the description for Variant 1 – Lubiatowo-Kopalino site. |
| 20. | **<u>Biological contamination – water environment (including growth of seaweeds, algae, and micro-organisms in sea water)</u>**<br>The description is the same as the description for Variant 1 – Lubiatowo-Kopalino site. | The description is the same as the description for Variant 1 – Lubiatowo-Kopalino site. |
| 21. | **<u>Biological contamination – land and air environment (insects, birds, pests)</u>**<br>The description is the same as the description for Variant 1 – Lubiatowo-Kopalino site. | The use of special filters and their ongoing maintenance, as well as periodic replacement in line with technical requirements. If required, rodent control will also include prophylactic periodic deratization measures.<br>Due to the existing infrastructure (a fish processing plant), an increased risk of unwanted rodents is anticipated, and therefore intensified deratization activities may be necessary. |
| 22. | **<u>Atmospheric dispersion</u>**<br>The description is the same as the description for Variant 1 – Lubiatowo-Kopalino site. | The description is the same as the description for Variant 1 – Lubiatowo-Kopalino site. |
| 23. | **<u>Corrosion from sea spray</u>**<br>The description is the same as the description for Variant 1 – Lubiatowo-Kopalino site. | The description is the same as the description for Variant 1 – Lubiatowo-Kopalino site. |
| 24. | **<u>Forest fires</u>**<br>Forest fires can pose a threat, especially from the east side of the NPP site, where there are wooded hills. Forest fires can be started by atmospheric discharges (lightning strike), and also because of catching fire by dry grass from the sun on dry sunny days, or due to arson. | The description is the same as the description for Variant 1 – Lubiatowo-Kopalino site. |

*Source: In-house study*

# Appendix II.11.4-1

## Chemical agents used and stored at the NPP site

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## Excerpt from Appendices to Volume II of the EIA Report

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Language version: EN

July, 2022

świadomie o atomie
energia jądrowa w Polsce

Polskie Elektrownie Jądrowe sp. z o.o.

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## Glossary

| Term / Abbreviation | Definition |
|---|---|
| ASS | auxiliary steam supply system |
| BDS | steam generator blowdown system |
| CDS | condensate system |
| CVS | chemical and volume control system |
| CWS | circulating water system including ST condenser and turbo set auxiliary equipment |
| DOS | *diesel fuel oil* system |
| DP | desalination plant |
| DTS | demineralised water treatment system |
| NPP/Project | Investment consisting in the construction and operation of the first Nuclear Power Plant in Poland with the capacity of up to 3750 MWe, in the territory of the following communes: Choczewo or Gniewino and Krokowa |
| FPS | fire protection system |
| FWS | feedwater system |
| PGS | plant gas system (for nitrogen, hydrogen and carbon dioxide) |
| EIA Report | Environmental Impact Assessment Report for a project comprising the construction and operation of the first Polish Nuclear Power Plant with the capacity of up to 3,750 MWe, in the territory of the following communes: Choczewo or Gniewino and Krokowa, pursuant to the act of 3 October 2008 on providing access to information about the environment and its protection, participation of the public in environmental protection and assessments of the environmental impact |
| SWS | service water system |
| VWS | central chilled water system |

# 1. Introduction

The analyses carried out indicate, that in line with the Regulation of the Minister of Economy of 29 January 2016 on the types and amounts of hazardous substances, which are critical for classifying a facility as for increased or high risk of a severe industrial accident [1], during the operation of the NPP hazardous substances will be used, which may qualify the facility for increased or high risk of a severe industrial accident.

According to the regulation [1], it is the quantity of substances present at any given time (stored substances) that determines whether a facility/installation should be classified as increased or high risk.

If the individual hazardous substances at the establishment are not present in quantities greater than or equal to the respective quantities specified in columns 2 and 3 of Table 1 of the above Regulation [1] or the corresponding quantities in columns 2 or 3 of table 2, the summation rule specified in the above regulation shall apply [1] shall apply.

At the stage of preparing this EIA Report, chemicals were identified as used and stored at the NPP site and were listed in the tables below.

# 2. Sub-variant 1A - open cooling system using seawater

Table III.11.4-2- 1 Chemicals stored on NPP site. technical sub-variant 1A

| Chemical substance | Concentration [%] | Expected quantity for single unit (Mg)* | Expected quantity for three units (Mg)* | Intended use ** | Hazards in accordance with the Regulation | | |
|---|---|---|---|---|---|---|---|
| | | | | | To health | Physical | To environment |
| Boric acid | 0.4375 | 302.6 | 907.8 | CVS | - | - | - |
| Lithium hydroxide | 12 | 0.017 | 0.051 | CVS | - | - | - |
| Hydrazine | 35 | 3.08 | 9.25 | ASS, FWS,CDS, BDS, CVS | X | X | X |
| Zinc acetate | 40 | 5.71 | 17.14 | CVS | - | - | X |
| Monoethanolamine | 40 | 3.08 | 9.24 | FWS, CDS, BDS | - | - | - |
| Ammonia water | 30 | 42.24 | 126.72 | CWS, SWS, DTS, ASS, FWS, CDS, BDS | - | - | |
| Sodium hydroxide/sulfate | 30 | 1.38 | 4.13 | ASS | - | X | - |
| Sodium polyacrylate/polyphosphate | 100 | 40.85 | 163.4 | DTS, SWS, CWS, DP | - | - | - |
| Ammonium chloride | 25 | 3.2 | 9.6 | SWS | - | - | - |
| Liquefied nitrogen | 100 | 4.6 | 13.8 | PGS | - | - | - |
| Compressed nitrogen | 100 | 0.9 | 2.7 | PGS | - | - | - |
| Liquefied hydrogen | 100 | 0.4 | 1.2 | PGS, CVS | - | X | - |
| Compressed hydrogen | 100 | 0.99 | 2.97 | PGS, CVS | - | X | - |
| Carbon dioxide | 100 | 7 | 21 | PGS, DP | - | - | - |
| Sodium molybdate / tolyltriazole | 50 | 0.2 | 0.6 | VWS | - | - | - |

| Chemical substance | Concentration [%] | Expected quantity for single unit (Mg)* | Expected quantity for three units (Mg)* | Intended use ** | Hazards in accordance with the Regulation | | |
|---|---|---|---|---|---|---|---|
| | | | | | To health | Physical | To environment |
| Sodium hypochlorite | 30 | 45.8 | 137.4 | CWS, SWS | - | X | X |
| Light oil / diesel fuel | 100 | 413 | 432.8 | DOS, FPS | - | - | X |
| Sodium hypochlorite | 12.5 | 0.4 | 1.2 | DP | - | X | X |
| Iron sulfate | 12 | 0.3 | 1 | DP | - | - | - |
| Sodium hydrosulfite | 40 | 0.4 | 1.3 | DP | - | - | - |
| Sulphuric acid | 98 | 0.6 | 1.8 | DP | - | - | - |
| Limestone dust | 100 | 1 | 3 | DP | - | - | - |
| The list of chemicals can be modified according to the requirements of the plant operator. | | | | | | | |

**Total mass of solution containing chemicals*
*** Symbols of systems using hazardous substances*
*Source: In-house study based on [1], [3], [2]*

# 3. Technical Sub-variants 1B and 2A – closed cooling water system using seawater

Table III.11.4-2- 2 Chemicals stored on NPP site. technical sub-variant 1B and 2A

| Chemical substance | Concentration [%] | Expected quantity for single unit (Mg)* | Expected quantity for three units (Mg)* | Intended use ** | Hazards in accordance with the Regulation | | |
|---|---|---|---|---|---|---|---|
| | | | | | To health | Physical | To environment |
| Boric acid | 0.4375 | 302.6 | 907.8 | CVS | - | - | - |
| Lithium hydroxide | 12 | 0.017 | 0.051 | CVS | - | - | - |
| Hydrazine | 35 | 3.08 | 9.25 | ASS, FWS,CDS, BDS, CVS | X | X | X |
| Zinc acetate | 40 | 5.71 | 17.14 | CVS | - | - | X |
| Monoethanolamine | 40 | 3.08 | 9.24 | FWS, CDS, BDS | - | - | - |
| Ammonia water | 30 | 8.1 | 24.3 | DTS, ASS, FWS, CDS, BDS | - | - | X |
| Sodium hydroxide/sulfate | 30 | 1.38 | 4.13 | ASS | - | X | - |
| Sodium polyacrylate/polyphosp hate | 100 | 45 | 135 | DTS, SWS, CWS, DP | - | - | - |
| Ammonium chloride | 25 | 3.2 | 9.6 | SWS | - | - | - |
| Liquefied nitrogen | 100 | 4.6 | 13.8 | PGS | - | - | - |
| Compressed nitrogen | 100 | 0.9 | 2.7 | PGS | - | - | - |
| Liquefied hydrogen | 100 | 0.4 | 1.2 | PGS, CVS | - | X | - |
| Compressed hydrogen | 100 | 0.99 | 2.97 | PGS, CVS | - | X | - |
| Carbon dioxide | 100 | 8 | 24 | PGS, DP | - | - | - |
| Sodium molybdate / tolyltriazole | 50 | 0.2 | 0.6 | VWS | - | - | - |

| Chemical substance | Concentration [%] | Expected quantity for single unit (Mg)* | Expected quantity for three units (Mg)* | Intended use ** | Hazards in accordance with the Regulation | | |
|---|---|---|---|---|---|---|---|
| | | | | | To health | Physical | To environment |
| Sodium hypochlorite | 30 | 139.9 | 419.6 | CWS, SWS | - | X | X |
| Quaternary amine (algicide - Mexel 432) | - | 3.2 | 9.6 | CWS, SWS | - | - | - |
| Sulphuric acid | 98 | 39.8 | 119.5 | CWS, SWS, DP | - | - | - |
| Phosphonate (anti-scalant) | 10 | 3.2 | 9.6 | CWS, SWS | - | - | - |
| Light oil / diesel fuel | 100 | 413 | 432.8 | DOS, FPS | - | - | X |
| Sodium hypochlorite | 12.5 | 0.8 | 2.4 | DP | - | X | X |
| Iron sulfate | 12 | 0.7 | 2 | DP | - | - | - |
| Sodium hydrosulfite | 40 | 0.6 | 1.3 | DP | - | - | - |
| Limestone dust | 100 | 2 | 5 | DP | - | - | - |
| The list of chemicals can be modified according to the requirements of the plant operator. | | | | | | | |

**Total mass of solution containing chemicals*
*** Symbols of systems using hazardous substances*
*Source: In-house study based on [1], [3], [2]*

# 4. Technical Sub-variant 1C and 2B - open cooling system using desalinated seawater

Table III.11.4-2- 3 Chemicals stored on NPP site. technical sub-variant 1C and 2B

| Chemical substance | Concentration [%] | Expected quantity for single unit (Mg)* | Expected quantity for three units (Mg)* | Intended use ** | Hazards in accordance with the Regulation | | |
|---|---|---|---|---|---|---|---|
| | | | | | To health | Physical | To environment |
| Boric acid | 0.4375 | 302.6 | 907.8 | CVS | - | - | - |
| Lithium hydroxide | 12 | 0.017 | 0.051 | CVS | - | - | - |
| Hydrazine | 35 | 3.08 | 9.25 | ASS, FWS,CDS, BDS, CVS | X | X | X |
| Zinc acetate | 40 | 5.71 | 17.14 | CVS | - | - | X |
| Monoethanolamine | 40 | 3.08 | 9.24 | FWS, CDS, BDS | - | - | - |
| Ammonia water | 30 | 8.1 | 24.3 | DTS, ASS, FWS, CDS, BDS | - | - | X |
| Sodium hydroxide/sulfate | 30 | 1.38 | 4.13 | ASS | - | X | - |
| Sodium polyacrylate/polyphosphate | 100 | 48.6 | 146 | DTS, SWS, CWS, DP | - | - | - |
| Ammonium chloride | 25 | 3.2 | 9.6 | SWS | - | - | - |
| Liquefied nitrogen | 100 | 4.6 | 13.8 | PGS | - | - | - |
| Compressed nitrogen | 100 | 0.9 | 2.7 | PGS | - | - | - |
| Liquefied hydrogen | 100 | 0.4 | 1.2 | PGS, CVS | - | X | - |
| Compressed hydrogen | 100 | 0.99 | 2.97 | PGS, CVS | - | X | - |

| **Chemical substance** | **Concentration [%]** | **Expected quantity for single unit (Mg)*** | **Expected quantity for three units (Mg)*** | **Intended use **** | **Hazards in accordance with the Regulation** | | |
|---|---|---|---|---|---|---|---|
| | | | | | **To health** | **Physical** | **To environment** |
| Carbon dioxide | 100 | 22.7 | 68 | PGS, DP | - | - | - |
| Sodium molybdate / tolyltriazole | 50 | 0.2 | 0.6 | VWS | - | - | - |
| Sodium hypochlorite | 30 | 138.9 | 419.6 | CWS, SWS | - | X | X |
| Quaternary amine (algicide - Mexel 432) | - | 3.2 | 9.6 | CWS, SWS | - | - | X |
| Sulphuric acid | 98 | 24.6 | 73.8 | CWS, SWS, DP | - | - | - |
| Phosphonate (anti-scalant) | 10 | 3.2 | 9.6 | CWS, SWS | - | - | - |
| Light oil / diesel fuel | 100 | 413 | 432.8 | DOS, FPS | - | - | X |
| Sodium hypochlorite | 12.5 | 139.9 | 419.58 | DP | - | X | X |
| Iron sulfate | 12 | 12.6 | 38 | DP | - | - | - |
| Sodium hydrosulfite | 40 | 16.5 | 49.6 | DP | - | - | - |
| Limestone dust | 100 | 100 | 300 | DP | - | - | - |
| The list of chemicals can be modified according to the requirements of the plant operator. | | | | | | | |

**Total mass of solution containing chemicals*
*** Symbols of systems using hazardous substances*
*Source: In-house study based on [1], [3], [2]*

# Source materials

## References

1. Regulation of the Minister of Economy of 29 January 2016 on the types and amounts of hazardous substances which are critical for classifying an establishment as either a lower-tier or an upper-tier establishment (Dz. U. of 2 Feb 2016, item 138).
2. Technical Note - Marine Hydrodynamics and Water Pollution - Task 3 - Onsite Chemical Storage. TEC_EJA_Pxxxx_RT_03009_03_EN.
3. UK AP1000® Environment Report UKP-GW-GL-790, Revision 7, 2017. Westinghouse Electric Company LLC. 2017. https://www.westinghousenuclear.com/Portals/5/Documents/documentation%20pdfs/UKP-GW- GL-790.pdf (accessed: 19 April 2018).

## List of Tables