Part 1

DOCUMENTATION FOR THE PURPOSES OF THE TRANSBOUNDARY IMPACT ASSESSMENT PROCEDURE

for the Project involving the construction and operation of the First Nuclear Power Plant in Poland with a capacity of up to 3,750MWe, in the territory of the following communes: Choczewo, or Gniewino and Krokowa

Introduction

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świadomie o atomie
energia jądrowa w Polsce

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In case of any discrepancy between the English and Polish versions of the documentation, the Polish version shall prevail.

Glossary

Term/ Abbreviation	Definition
NPP/ Nuclear Power Plant	The First Polish Nuclear Power Plant comprising three nuclear power units with AP1000 reactors with a total capacity of up to 3,750 MWe, in the territory of the following communes: Choczewo, or Gniewino and Krokowa
Nuclear power plant	Nuclear facility within the meaning of the Act of 29 November 2000 Atomic Law
GDOŚ	Director General for Environmental Protection
ICRP	International Commission on Radiological Protection established in Sweden
IMGW - PIB	Institute of Meteorology and Water Management – National Research Institute (*Instytut Meteorologii i Gospodarki Wodnej - Państwowy Instytut Badawczy*)
IAEA	International Atomic Energy Agency
Project	Construction and operation of the First Polish Nuclear Power Plant with a capacity of up to 3,750 MWe, in the territory of the following communes: Choczewo, or Gniewino and Krokowa
Atomic Law Act	Act of 29 November 2000 Atomic Law
MOLF	Marine off-loading facility
Decision/GDOŚ Decision/Scoping Decision	Decision of the General Director for Environmental Protection of 25 May 2016 (DOOŚ-OA.4205.1.2015.23) determining the scope of the environmental impact assessment report regarding the Project involving the construction and operation of the First Nuclear Power Plant in Poland with a capacity of up to 3,750MWe, in the territory of the following communes: Choczewo, or Gniewino and Krokowa
EIA Report	Environmental Impact Assessment Report for the Project involving the construction and operation of the First Nuclear Power Plant in Poland with a capacity of up to 3,750MWe, in the territory of the following communes: Choczewo, or Gniewino and Krokowa
MSFD	Marine Strategy Framework Directive – Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy
WFD	Water Framework Directive – Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy
RODOS	Real-time Online Decision Support system

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1 Document purpose

The definition of transboundary impact was set out in Article 1 (viii) of the Espoo Convention of 25 February 1991 on Environmental Impact Assessment in a Transboundary Context [183]. According to the definition, *"transboundary impact means any impact, not exclusively of a global nature, within an area under the jurisdiction of a Party caused by a proposed activity the physical origin of which is situated wholly or in part within the area under the jurisdiction of another Party".* Transboundary environmental impact due to the "functioning" of the Project can thus be said to exist only where adverse environmental impact can extend beyond the Polish borders.

This document has been prepared for the purposes of a transboundary procedure and it reflects the provisions of the Decision of the Director General for Environmental Protection of 22 September 2015 on the conduct of the procedure for the transboundary environmental impact of the Project involving the construction and operation of the First Polish Nuclear Power Plant with a capacity of up to 3,750 MWe, in the territory of the following communes: Choczewo, or Gniewino and Krokowa in the Pomorskie voivodeship [184] and the following laws and regulations, international agreements and national legislation:

- Convention on Environmental Impact Assessments in a Transboundary Context done at Espoo on 25 February 1991 [183];
- Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment [185];
- Agreement between the Government of the Republic of Poland and the Government of the Federal Republic of Germany on environmental impact assessments and strategic environmental impact assessments in the transboundary context, signed in Neuhardenberg on 10 October 2018 [186];
- Agreement between the Government of the Republic of Poland and the Government of the Republic of Lithuania on environmental impact assessments in the transboundary context, signed in Warsaw on 27 May 2004 [187];
- Article 108(4)(4) of 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 [188].

In the aforementioned Decision [184], the Director General for Environmental Protection imposed obligations including the translation into English, German and Lithuanian of *"those parts of the report on the environmental impact of the Project that will enable the states whose territories may be affected by the planned project to assess any possible significant transboundary environmental impact, in paper and electronic form".*

To satisfy the above requirements, the Investor has included in this document a non-technical summary of the environmental impact assessment documentation (EIA Report) referred to in Article 4, paragraph 1 of the Espoo Convention [183] and those parts of the EIA Report that will enable the affected Party to assess the potential significant adverse transboundary environmental impact and take a position on the matter.

2 Document structure

The structure of this document is identical as that of the EIA Report prepared for the purposes of the procedure for the transboundary impact of the Project involving the construction and operation of the first Polish Nuclear Power Plant with the capacity of up to 3,750 MWe in the communes of Choczewo or Gniewino and Krokowa (EIA Report). The Report consists of 6 volumes and appendices to each volume.

The documentation for the purposes of the transboundary impact procedure forms a collection of detailed information selected from individual volumes of the EIA Report. If no content of any chapter/subchapter is quoted in the extracts from Volumes I, II, III, IV and V of the Report, this is due to the fact that the information provided in the chapter/subchapter concerned does not affect the assessment of the potential significant adverse transboundary environmental impact. However, a description of the aspect concerned is presented in Part 2 of the documentation forming Volume VI of the EIA Report, i.e. in the Non-technical Summary.

This document consists of 7 parts:

Part 1 – Introduction, which presents:

- document purpose,
- document structure,
- justification for the implementation of the Project,
- description of nuclear fuel cycles;
- description of emissions and releases of radioactive substances;
- description of the possible transboundary environmental impact forming an extract from Volume V [Chapter V.4] of the EIA Report together with two appendices in which the values of maximum ionising radiation dose rates are given for the neighbouring countries, resulting from calculations in the MATCH and FDMT models. For the sake of clarity of the document structure, Chapter V.4 of the EIA Report has new numbering, in accordance with the structure of Part 1 - Introduction.

  This part of the document presents an overview of biotic and abiotic areas for possible potential transboundary impacts. It is also pointed out that there are no transboundary impacts, taking into account individual and cumulative impacts of the Project and the proposed minimising measures.

Part 2 – Volume VI of the EIA Report – Non-technical Summary, which includes:

- glossary and table of contents,
- non-technical summary of the whole EIA Report (complete Volume VI),
- references.

Part 3 – Extracts from Volume I of the EIA Report – Preliminary Information, which presents:

- document revision information,
- team of authors,
- glossary and table of contents,
- Investor’s details,
- classification of the Project,
- administrative procedure and current status of the Project,
- Project staging,
- associated infrastructure necessary for the functioning of the Project,

- Project rationale in the context of the benefits of the introduction of nuclear energy in Poland, as well as economic and technological aspects,
- the Project in the context of strategic documents (in the international and national setting),
- assumptions and methodology of the EIA Report,
- Project variants under consideration, including a description of the expected effects on the environment in the event the Project is not undertaken; this chapter presents, among other things, a description of the process for the selection of the site variants under consideration, a description of the sub-variants to be analysed, as well as descriptions of the variant proposed by the Investor, a rational alternative variant and a rational variant most beneficial for the environment,
- legal framework of the Project (at the national and international level),
- references.

Part 4 – Extract from Volume II of the EIA Report – Characteristics of the Project and Emissions, which presents:

- glossary and table of contents,
- description of the Project, and a description of the nuclear power plant technology and infrastructure,
- description of the nuclear power plant including a description of the NPP facilities and site general arrangement,
- comparison of the proposed solution with the best available technique (BAT),
- description of investment implementation phases (operational and decommissioning phases),
- Project execution schedule,
- predicted types and quantities of emissions, including waste, arising from the Project implementation (emissions of pollutants to air, and emission of radioactive wastewater),
- waste, including radioactive waste and spent nuclear fuel,
- analysis of hazards and severe accidents - nuclear power plant states and probability of their occurrence, internal events that may threaten the NPP safety, external events that may threaten the NPP safety (including an analysis of the vulnerability of the Project to extreme events, phenomena and natural conditions, with particular focus on primary and secondary effects of climate change, along with appendix entitled "Results of the analysis of the effect of extreme events, phenomena and natural conditions on the NPP safety along with adaptive (preventive) measures"), risk of a severe accident resulting in environmental contamination.

  An accident with a core melt and a simultaneous failure of the containment was not considered in the report due to the fact that such an accident is an event that is practically eliminated and is extremely improbable (the probability of its occurrence is lower than once in 10,000,000 years).
- description of associated infrastructure (general information and electric power infrastructure),
- references.

Part 5 – Extract from Volume III of the EIA Report – Environmental Characteristics, which presents:

- table of contents of Volume III of the EIA Report.

Part 6 – Extract from Volume IV of the EIA Report - Impact Assessment, which presents:

- glossary and table of contents,
- impact on protected areas and facilities (offshore part),
- impact on natural elements (marine environment),

- assessment of impact on surface (marine) waters,
- ionising radiation impact,
- impact on human health and life – in the context of the safety of seafood in connection with the discharge into waters of liquid radioactive substances and the use of chemicals in the cooling water system, the safety of food other than seafood in connection with gaseous radioactive emissions and the impact of ionising radiation on health,
- impacts associated with waste management (radioactive waste and spent fuel),
- definition of anticipated environmental impact in the event of a severe accident,
- cumulative impact context of the natural environment and marine waters,
- references,
- appendices.

<u>Part 7 – Extract from Volume V of the EIA Report – Summary – Assessment Results and Conclusions</u>, which presents:

- glossary and table of contents,
- description of the forecasting methods applied to impact analyses concerning the marine natural environment, marine surface waters, ionising radiation, including the appendix titled “Description of the models used to analyse radioactive impact, human health and life, and a severe accident”, and the appendix titled “Description of the models used to analyse radioactive impact in accident conditions”,
- selection of the variant proposed by the investor, reasonable variant most favourable for the environment, and reasonable alternative variant, along with reasoning for their selection, including a comparative analysis of site variants, multi-criteria analysis,
- description of the anticipated minimising measures, including avoidance, prevention, reduction or offsetting measures with regard to impacts on the marine natural environment, marine surface waters, and human health and life in the context of ionising radiation,
- description of communication activities,
- predicted range of the restricted use area planned,
- the proposed scope of monitoring for individual components of the environment, such as the marine natural environment, marine surface waters, ionising radiation, human health and life,
- indication of difficulties arising from deficiencies in knowledge or technology, or gaps in the contemporary knowledge, which were encountered while preparing the EIA Report,
- references.

It should be noted that at the beginning of each part of the document (containing an extract from Volumes I, II, III, IV or V) a complete table of contents of the respective volume of the EIA Report is provided. To indicate to the reader the chapters which form an extract from the EIA Report in whole or in part, they are <u>marked in blue color</u> in the table of contents.

Additionally, a table of responses to the remarks of the Affected Parties submitted at the scoping stage was prepared and attached to the documentation for the purposes of the transboundary impact assessment procedure (Table of responses).

The comments submitted by the Affected Parties at the 2016 scoping stage are indicated in the scoping table which constitutes an appendix to the Transboundary Documentation. The last column of the table refers to the questions by indicating the answer, as well as the specific Parts and chapters of the Transboundary Documentation that contain information relevant to understanding the issue. One of Sweden's comments included in item 9 of the table concerned the description of the fuel cycle. Due to the importance of this issue, additional information was provided to expand the contents of the EIA Report in this regard. Additional information is presented in **Part 1 Introduction - in Chapter 4 "Description of nuclear fuel cycles."**

Another issue raised by the Affected Parties that needed special emphasis in this study was the justification for the Project execution. An important part of this process is to address the manner in which the selection of the nuclear technology will affect the implementation of both national and international strategies, what emission reduction scenarios have been considered, and what climate impact the choice of a particular scenario will involve. In order to comprehensively present the information, this justification is presented already in **Part 1 Introduction - Chapter 3 "Justification for the Project execution"**. Furthermore, it is indicated in which subsequent Parts and Chapters of the EIA Report specific issues are discussed in detail.

In the Investor's opinion, the scope of detailed information from the EIA Report presented in this document <u>represents optimum material in the context of the transboundary procedure</u>, i.e. the disclosure to the affected Parties of necessary information on the Project involving the construction and operation of the first Polish Nuclear Power Plant.

Attention should be drawn to the fact that <u>numerous studies and analyses performed for the purposes of the procedure for issuing the Decision on Environmental Conditions for the Nuclear Power Plant have not shown any threats indicating any possible transboundary impacts resulting from the functioning of the Project, either in Variant 1 - Lubiatowo – Kopalino site (including in sub-variant 1A with the open cooling system recommended by the Investor for implementation), or in Variant 2 – Żarnowiec site.</u> It is only due to the precautionary approach adopted by the Investor and due to the nature of the Project that potential issues are indicated which require an in-depth insight into biotic and abiotic aspects. The relevant fragments of the EIA Report have been translated and presented in this document.

At the stage of the re-assessment of environmental impact, which is obligatory for the Project concerned, the analyses of environmental impact of the Project will be repeated. The analyses will be performed on the basis of detailed design data which is not available at the present stage of the Project. At the stage of re-assessment of environmental impact, proposed minimising measures and monitoring scopes will also be specified in more detail. This will allow the environment to be effectively protected, including human health and life, from any, even potential, significant national or transboundary impact. In addition, the EIA Report draws attention to the rationale for a post-project analysis.

The obligatory re-assessment of the environmental impact of the NPP arises from the national law, i.e. Article 82(1)(4a) of 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 [188], which stipulates that the body competent to issue an environmental decision is always required to impose on the Investor the obligation to conduct an environmental impact assessment as part of the procedure for issuing the construction permit for a project involving the construction of a nuclear power facility or its associated project, referred to in the Act of 29 June 2011 on the preparation and implementation of nuclear power facility projects and associated projects [189].

3 Justification for the Project execution

Construction of a nuclear power plant is an investment project that supports the implementation of environmental goals assumed by Poland and required by the European Union. These goals are reflected in a number of strategic and planning documents - both international and national.

The Project execution will implement the climate and energy policy of the European Union, defined in the following documents:

- Green Paper. The 2030 climate and energy policy framework - which sets targets to limit the global average temperature increase to a maximum of 2°C compared to levels recorded before the industrial era; the European Union's climate and energy policy aims to reduce greenhouse gas (GHG) emissions, secure energy supply or support economic growth, competitiveness and jobs through "*a high technology, cost effective and resource efficient approach*";
- The European Green Deal - which includes an EU commitment to achieve climate neutrality by 2050. To achieve that goal, a social and economic transformation in Europe will be needed: cost-effective and just, and socially sustainable;
- The Energy Roadmap 2050 - which assumes the accomplishment of the goals with respect to low emissions of carbon dioxide by 2050, taking into consideration the improvement of competitiveness and security of supplies in Europe; it specifies ten structural changes necessary to transform the power system, including the share of nuclear energy as a material contribution into the process of the energy system transformation in the Member States;
- A policy framework for climate and energy in the period from 2020 to 2030 - where it is planned to achieve the GHG emission reduction by 40% until 2030, compared to the level recorded in 1990, and to increase the share of renewable energy to 27% in the total balance of energy consumption in the EU until 2030;
- European Energy Security Strategy- where it is indicated that one of the major aspects is the increase in the energy production in the European Union using the nuclear energy, along with the necessary development of the relevant infrastructure;
- Energy Efficiency and its contribution to energy security and the 2030 Framework for climate and energy policy - where it is confirmed that energy efficiency contributes to the development of a competitive, sustainable and secure energy system in the European Union;
- Conclusions of the European Council of 24 October 2015 on 2030 Climate and Energy Policy Framework - where it is indicated that the European Council agreed on the EU climate and energy policy framework until 2030, and approved the binding EU target that assumed the reduction of internal greenhouse gas emissions and
- A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy - which determines principles governing development of an energy union (national energy markets integrated into one common market), the basic goal of which is to provide consumers with secure, competitive, and sustainable (in terms of sources) energy at affordable prices.

In terms of strategic documents at the national level, in which nuclear energy is directly mentioned and contributes to their implementation, the following should be indicated:

- Polish Nuclear Power Program (PNPP) - which constitutes the basis for and the plan of activities for the construction of the first Polish nuclear power plant; the general objective of the PNPP is consistent with the "Energy Policy of Poland until 2040" and the National Plan for Energy and Climate Plan for the years 2021-2030;
- Energy Policy of Poland until 2040 (see below for key information);

- National Energy and Climate Plan for the years 2021-2030 - which presents the national assumptions and goals that translate into policies and activities in individual areas, and that will result in increasing the broadly understood energy security of the country while respecting the environmental protection principles, including the protection of the climate;
- Strategic Adaptation Plan for Sectors and Areas Sensitive to Climate Change by 2020 with a Perspective until 2030 - which is the first national strategic document that directly addresses the issue of adaptation to ongoing climate change and seeks to ensure sustainable development and effective functioning of the economy and society;
- The 2030 National Environmental Policy – the Development Strategy in the Area of the Environment and Water Management - which indicates that its main objective is "to develop the environmental potential for citizens and undertakings" and its specific objectives include environment and health (improving environmental quality and ecological safety), environment and economy (sustainable management of environmental resources), and environment and climate (mitigation of and adaptation to climate change, and natural disaster risk management);
- 2030 Productivity Strategy - a draft of a document that sets the directions of interventions and support instruments to stimulate the increase in the level of investments and productivity of companies; it stresses the need to develop zero carbon energy sources and technologies that also include nuclear energy - carried out within task I “Natural resources (land and resources)”;
- Assumptions for the National Programme for Development of Low-Carbon Economy - which indicate that one of the six specific objectives is to develop low-carbon energy sources (including also the nuclear energy); development of this area will enable the achievement of the main objective (“Development of low-carbon economy while ensuring sustainable development of the country”) and specific objectives, and will bring about positive changes in the country’s economy.
- National Plan of Management of Radioactive Waste and Spent Nuclear Fuel - which in its entirety deals with nuclear energy; in particular, it lays down the tasks necessary for the proper management of radioactive waste not only in the context of the protection of natural resources, but also the protection of human life and health;
- Strategy for Responsible Development for the period up to 2020 (including the perspective up to 2030) - which indicates energy generation, including nuclear power, as the area that affects the achievement of the objectives laid down in the strategy; the document lists two nuclear power plant site variants - Lubiatowo-Kopalino and Żarnowiec; the document contains indirect references to aspects important from the perspective of the Project, including with regard to energy efficiency, innovation aimed at further reducing the negative impact on the natural environment due to production processes; another direction of intervention is, indirectly, the removal of sources of air pollution emissions or significant reduction of their impact, which will be undoubtedly ensured by the Project implementation;
- National Strategy of Regional Development until 2030 - which indicates the need to modernise the transmission and distribution infrastructure and power units in power plants; attention was drawn also to the need to invest in new generation capacity, including 6 nuclear power plant units, and
- National Security Strategy of the Republic of Poland 2020 - which points to the need to ensure the ecological security of the state, and one of the directions of action suggests that the development of energy industry based on the use of zero-emission energy sources should be supported, and nuclear energy is certainly one of such sources.

The introduction of nuclear generation sources to the Polish power system (in addition to the existing and planned renewable energy sources (RES), natural gas units in cogeneration and gas-fired power plants, and taking into account the reduction in hard coal and lignite-fired power plants) is a direct implementation of the energy strategy of the Polish state (Energy Policy of Poland until 2040, PEP2040), and is a tool for the implementation of a low-carbon energy transformation, which according to the PEP2040 "*will initiate broader modernisation changes for the entire economy, guaranteeing energy security, ensuring a fair distribution of costs and protection of the most vulnerable social groups*."

The PEP2040, in line with the climate and energy policy goals of the European Union (EU), including its long-term objective of climate neutrality by 2050, sets three pillars of the Polish energy transformation, namely:

- just transition - including the potential to transform and develop the regions most affected by the transition effects (coal regions), reduction of energy poverty, modernisation changes that provide the opportunity to create up to 300 thousand new jobs in industries of high potential - renewable energy sources - RES, nuclear energy, electromobility, network infrastructure, digitalization, thermal modernisation of buildings, and others,
- target zero-emission energy system - through "implementation of nuclear energy and offshore wind energy, as well as increasing the role of distributed and civic energy, while ensuring energy security (through the temporary use of energy technologies based, among others, on gaseous fuels),
- good air quality - through the transformation of the heating sector (district and individual), electrification of transport and promotion of passive and zero-emission houses (using local energy sources).

The Energy Policy of Poland until 2040, having in mind the main objective of ensuring energy security, i.e. meeting the current and future demand for fuels and energy in a technically and economically justified manner, while maintaining the requirements of environmental protection, also strategically determines which technologies (including nuclear technology) will serve to build a low-carbon energy system. Implementation of nuclear power with the implementation of the Polish Nuclear Power Program (PNPP) is one of the eight specific objectives (along with other low-carbon sources, including in particular development of RES). According to the PNPP, the implementation of nuclear power and implementation of offshore wind power are considered equally as actions of the same rank which are to achieve the same strategic goal.

Key elements of Poland's energy transition, which assumes the construction of six nuclear units, additionally include:

- increase in the share of RES in all sectors and technologies with about 10-16 GW in PV capacity in 2040 (in 2030 the share of RES in gross final energy consumption is to be at least 23%, with no less than 32% in electricity, including mainly wind and photovoltaic energy, 28% in heating, and 14% in transport (with a large contribution of electromobility),
- increase in energy efficiency - a target of 23% reduction in primary energy consumption by 2030 has been assumed,
- withdrawal of conventional energy sources from the system - in 2030, the share of coal in electricity generation will not exceed 56%,
- by 2030, reduction of greenhouse gas (GHG) emissions by approximately 30% compared to 1990.

Nuclear power, as a low-carbon source with low environmental and system costs, is a necessary part of the energy mix. It was pointed out that nuclear energy will allow both to achieve significant decarbonisation of the power system (to the extent required by the EU), and to minimise the social cost of operation of the National Power System.

The project regarding the construction of a nuclear power plant in Poland is consistent with two pillars of Poland's energy transition described in PEP2040. According to the Investor, a failure to implement the project and thus the PEP2040 strategy would lead to a further deterioration of the environment. Similar conclusions were found in the Strategic Environmental Impact Assessment included in PEP2040, and the importance of issues "*especially related to non-compliance with air quality standards arising from the Polish and EU law*" was highlighted. Thus, the contribution of nuclear power to reducing air pollutant emissions will translate into improved air quality parameters, and hence will benefit human health and the environment.

Assumptions to the update of the Energy Policy of Poland until 2040, published on 29 March 2022, also confirm that Poland will implement nuclear power based primarily on large reactors (above 1000 MW), which demonstrates low vulnerability to fuel supply interruptions and ensures supply of stable and clean energy. At the same time, stringent global standards for nuclear safety and radiation protection ensure the safe operation of nuclear power plants and help to eliminate potential risks in emergency situations.

Additionally, taking into account the provisions of the Polish Nuclear Power Programme (PPEJ) updated in 2020, it should be stated that:

- in terms of energy security, the construction and operation of nuclear power plants will increase the level of diversification of both the fuel base in the power sector and the directions of supply of primary energy carriers,
- in terms of environment and climate (carbon footprint in the life cycle of a nuclear power plant), “environmental advantages of nuclear power mainly include: no direct CO_2 emissions during operation (...) as well as no emissions of other substances harmful for the environment and human health: NOx, SO2, CO, particulate matter (PM), mercury and other heavy metals, and polycyclic aromatic hydrocarbons (PAHs),”
- in terms of economy (stability of electricity prices and improvement of economic competitiveness), the implementation of nuclear power can contribute to stopping the increase in energy costs for end users (both individual and industrial ones).

It should be pointed out that the analyses used in the development of the PNPP present the future scenarios of changes in the National Power System and greenhouse gas emissions in each scenario. Four simulations were prepared, of which two are future scenarios under which Poland implements the nuclear programme and encourages the development of renewable energy sources and gas energy sector. The first scenario is the optimum approach in terms of costs, which assumes a larger share of gas, while the second assumes a higher degree of market regulation. The remaining two scenarios do not account for nuclear energy; instead, they assume an increased utilisation of renewable energy sources and fossil fuels. In one of those scenarios, gas is of key importance, while in the other, coal is crucial. All four scenarios are consistent with the National Energy and Climate Plan which assumes that carbon intensity of electricity will decrease by 20% until 2030 and by 50% until 2040.

The largest reduction of CO_2 emissions would be possible if the strategic scenario was implemented (under which Poland implements the nuclear programme) – the final volume of annual emissions would decrease from 134 million tonnes of CO_2 in 2020 to 41 million tonnes of CO_2 in 2045 (reduction by almost 70%). In the case of the scenario which does not take into account nuclear energy and is optimised in the total cost model, 93 million tonnes of CO_2 could be avoided for over 25 years.

Taking into account the “nuclear scenarios” is consistent with the conservative approach to the analyses conducted, because it decreases the carbon intensity in comparison to the reference level which does not include the nuclear power.

Therefore, when analysing all aspects of the Project, attention was also paid to the impact of the Project on climate, and the impact of climatic factors on the Project. In this respect, the analysis included impacts on both the global climate (assessment of greenhouse gas emissions) and on the local climate (microclimate) (assessment of changes in meteorological parameters).

Estimation of greenhouse gas emissions was conducted for all phases of the Project life cycle, from all sources and in all processes (including e.g. emissions related to the production of steel, concrete, equipment, and transport emissions, or even the need to replace installations). The results obtained were also compared to GHG emissions from alternative technologies of the electricity generation.

The outcomes indicate that the AP1000 reactor would be a low-emission variant for Poland which would emit greenhouse gases at a level comparable to or lower than alternative renewable energy technologies, even taking into account conservative assumptions of the life cycle assessment.

Irrespective of the sub-variant, the Project would generate electricity of much lower carbon intensity than the predicted average carbon intensity of the power grid throughout the Project's entire design life of 60 years. This favourable impact means that each kWh generated will bring net savings in carbon emissions through the replacement of a more carbon intensive power generation source.

As at the date of analysis, the emission reduction commitments do not extend beyond 2045. Poland is likely to undertake further measures to cut emissions after 2045. Based on Poland's commitments to reduce emissions as at the date of the documentation, the Project is expected to save approximately 380 million tonnes of CO_2 emissions, which is equivalent to almost 1 billion of oil barrels.

Greenhouse gas emissions in the Project life cycle would be two orders of magnitude (10^{-2}) smaller than life cycle emissions of an analogous project using gas or coal. The only stable source of electric power in the decarbonisation analysis with life cycle GHG emissions comparable to nuclear power is hydropower, but the available analyses indicate that the development of hydropower in Poland on a larger scale is impossible.

The Project materially contributes to significant reduction of the above emissions, with favourable outcomes for the climate. In conclusion, however, it is important to recall the broader context of the assessment of the Project impact on climate, namely:

- Polish energy policy sets the objective of energy independence and improved competitiveness, which points to another strategic dimension associated with the Project, apart from the reduction of emissions in the energy sector,
- technical guidelines of reputable institutions, which set out technology pathways leading to deep decarbonisation that support the significance of the Project in the process of achievement of CO_2 emission reduction objectives by Poland in the future,
- the experience of the EU Member States which confirms that the implementation of nuclear projects contributed to a reduction in the greenhouse gas emissions.

It should also be noted that the potential choice of the zero variant (abandonment of the Project) should be considered most unfavourable for the environment. This is an important, but not critical element of the transformation process, or even of the energy revolution that is taking place before our eyes. The revolution is not only about profit; although it will certainly bring immense economic benefits to its direct beneficiaries, it is mostly a race against time. Metaphorically, the zero variant may be seen as indifference and lack of concern for future generations, as the lack of the will to introduce change. Finally, it is also the act of stubborn and irrational clinging to the past.

It should be concluded with full confidence that the decision not to implement the Project in Poland would result in the need to acquire huge amounts of power that will have to be generated primarily through the combustion of fossil fuels, i.e. bituminous coal or lignite, as well as a significant increase in the use of natural gas. In the Investor's opinion, there is no justification for this approach other than the lack of a reasonable alternative that we have clearly had for a long time. Today, generation of the amount of energy that Poland requires with the use of other sources (including sources that are informally referred to as renewable) is unrealistic (which does not mean that it should not be gradually implemented), but there is a real and rational alternative in the form of nuclear energy - even despite the opinion that some still express (and which is contradicted by the balance of all the aspects of the extraction and combustion of fossil fuels), namely that the energy generated through the combustion of the abovementioned fuels is a much cheaper, or even one of the cheapest, energy sources.

Irrespective of the effects associated with the extraction of coal, the processes of its combustion are considered the basic source of air pollution. Sulphur dioxide, nitrogen oxides, hydrocarbons, carbon monoxide and carbon dioxide, smoke and particulate matter, and even metals created during the combustion contribute e.g. to a significant deterioration of air quality which in turn translates to the incidence of illnesses and ailments among humans, especially with regard to the respiratory system. The combustion of coal also results in the creation of solid combustion products, i.e. ash and slag, also known as combustion waste. Emissions of greenhouse gases from the combustion of fossil fuels are considered one of the main causes of global warming.

In conclusion, paradoxically, the zero variant does not have to always be the best variant for the environment. The description of this variant should each time consider its consequences not only on the local scale (usually they seem to be obvious and yes/no outcomes), but, if justified by the project extent - also on the global scale.

Additional information regarding the extent indicated above is included in the individual chapters of the strategic documentation, that is:

- In Part 3 - Excerpt from Volume I of the EIA Report - Preliminary Information:

1) in Chapter I.6 “Justification for the Project execution”, which provides information on nuclear power as a strategic investment that implements national (e.g. PEP2040), European (e.g. Green Deal), or international strategies (IPCC), the nuclear power has been described as one of the pillars of the energy transition, along with other sources of energy such as RES, gas, etc.;
2) in Chapter I.7.1 “Strategic documents at the international level”, where it is described how the implementation of the Project will contribute to the strategic policies of the European Union (reference to eight strategic documents of the EU);
3) in Chapter I.7.2 “Strategic documents at the national level”, where eleven strategies concerning energy and climate change are described in detail, it is highlighted how nuclear power contributes to their implementation;
4) in Chapter I.9.4 “Description of predicted effects on the environment in the event that the project is not implemented”, where the scenarios in the case of not undertaking the NPP are described; conclusions from the Polish Nuclear Power Programme which is the national strategic document were quoted as presenting future scenarios of changes in the national power system and their effect on greenhouse gas emissions; and

- In Part 2 (Volume VI EIA Report - Non-Technical Summary):

5) in Chapter VI.4.3, which describes results of a comparative analysis of the carbon footprint of the proposed AP1000 nuclear technology against alternative technologies, RES was taken into account, including biomass, hydroelectric power, wind, photovoltaics, as well as conventional fossil fuel sources - coal and natural gas; The summary also includes a rundown on results of the assessment of the impact from the NPP operation on climate.

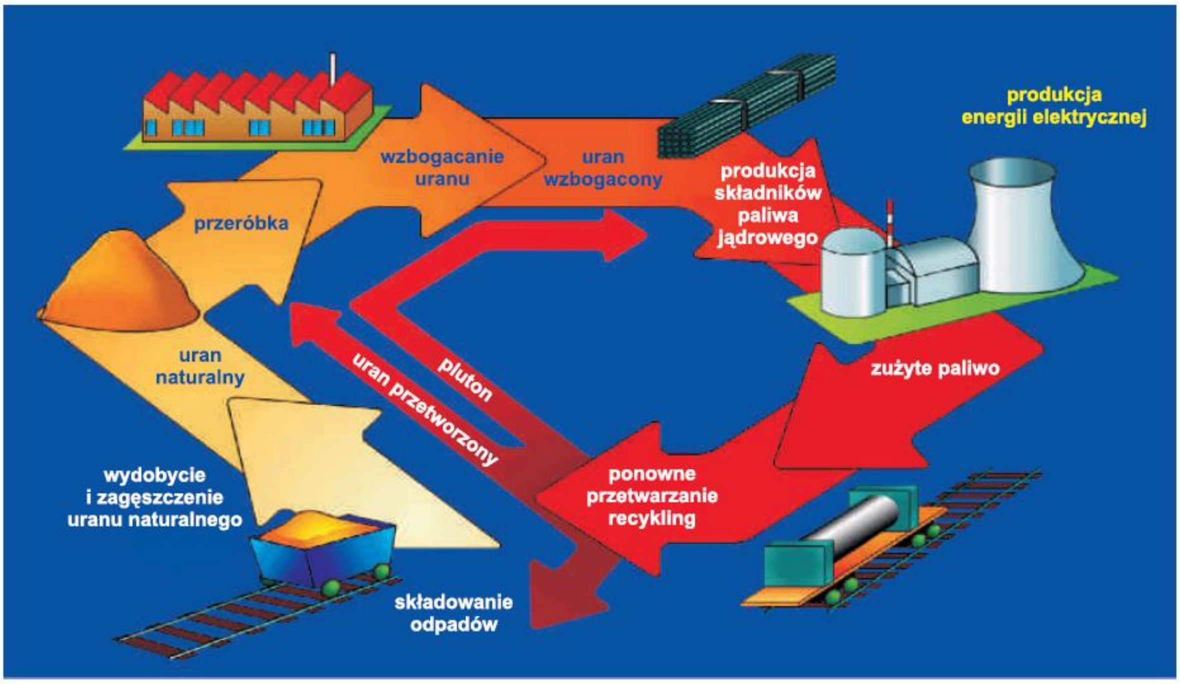
4 Description of nuclear fuel cycle

Reactor fuel cycle

Figure [Figure 1] shows (in a simplified form) a fuel cycle of a nuclear reactor, which comprises three main elements:

- “Front-end” of the cycle: from uranium extraction to fabrication of fuel assemblies ready to be introduced into the reactor core;
- Middle part of the cycle: fuel burn-up in a power reactor during the electricity production;
- “Back end" of the cycle, which consists of transporting spent fuel to a reprocessing plant or deep geological repository.

Figure 1 Fuel cycle of a nuclear reactor



Source: [1a, 2a]

Wydobycie i zagęszczanie uranu naturalnego – Natural uranium extraction and compaction	Produkcja energii elektrycznej – Power generation
Uran naturalny – Natural uranium	Zużyte paliwo – Spent fuel
Przeróbka - Milling	Ponowne przetwarzanie – Recycling, reprocessing
Wzbogacanie uranu – Uranium enrichment	Składowanie odpadów – Waste repository
Uran wzbogacony – Enriched uranium	Pluton – Plutonium
Produkcja składników paliwa jądrowego – Manufacturing of fuel elements	Uran przetworzony – Processed uranium

Generation III reactor of a nuclear power unit with electrical capacity of about 1,000 MWe uses less than 20 tonnes of nuclear fuel per year - or one freight car per year. For comparison: in the boiler of a thermal power station unit of the same capacity, fired with hard coal, as much as 3 million tonnes of coal have to be burned annually, or about 160 50-tonne freight cars on average per day.

The fuel used in nuclear power is a mixture of fissile and fertile isotopes. Fissile isotopes are the isotopes that contribute significantly to the fission chain reaction taking place in a reactor. In a light-water (thermal) reactor the fuel is typically a mixture of fissile U-235 isotope (with up to ~5% enrichment) and fertile U-238 (tail). A minor proportion of energy (~ 3%) is generated from U-238 fission by fast neutrons. However, the significance of the isotope is mainly due to its fertile nature, as it generates s sequence of new fissile plutonium isotopes, Pu-239 and Pu-241, which play a greater role in the ongoing fission.

The above cycle is also known as the ***uranium-plutonium fuel cycle***. The name derives from the fact that through a chain of reactions, the U-238 isotope, of little significance in terms of the energy produced, is the source of fissile plutonium isotopes with major contribution to energy production.

The uranium-plutonium cycle provides for the use of a variety of nuclear fuels, especially with the commonness of spent fuel reprocessing - in what is known as the closed fuel cycle and with the common use of fast breeder reactors.

Depending on the initial enrichment, the nuclear fuel stays in the reactor for three to five years. During this time, most of the fissile U-235 is "burned up" (however, about 1% still remains), and transuranic isotopes are formed from the nuclear transformations of U-238 and U-235, of which the fissile isotopes Pu-239 and Pu-241 are particularly important.

For Generation III and III+ reactors, including AP1000 technology, 18-month fuel campaigns are most typical, where 1/3 of the most spent fuel assemblies (after 3 campaigns, or about 4.5 years in the reactor) are replaced with fresh fuel during refuelling.

Fresh nuclear fuel is transported (by water, rail, and road) in special containers, each containing two or four fuel assemblies. The construction of the containers provides them with protection against mechanical damage, as well as sub-criticality (i.e. protection against accidental formation of critical mass) in case they fall into water due to an accident during transport. Also, fresh fuel storage is designed to exclude the formation of a critical mass in the event of flooding.

The ionising radiation from fresh uranium fuel is negligibly small, so no radiation shielding is needed. On the other hand, MOX-type uranium-plutonium fuel is much more radioactive and therefore must be transported and stored in shielded containers or under the cover of water. Shipments of both fresh and spent fuel are subject to physical protection, which is required by e.g. the International Convention on the Physical Protection of Nuclear Material.

For the first Polish nuclear power plant, no front-end fuel cycle components, comprising uranium ore mining and processing, chemical conversion, uranium enrichment and nuclear fuel fabrication in Poland, are planned in the foreseeable future.

Mining and processing of uranium ores

Uranium (a metal with low radioactivity) is a relatively common element on Earth, about as common as tin or zinc, and about 40 times as common as silver, being a component of most rocks and even seawater.

Technologies for extracting uranium from natural sources and enriching it for nuclear power will increasingly focus on poorer sources of uranium - as sources with easier and cheaper mining processes are getting depleted.

The fresh nuclear fuel currently in use comes mainly from mined natural minerals that are uranium ores. The most common uranium minerals include:

- pitchblende UO_2
- uraninite U_3O_8
- carnotite $K_2(UO_2)_2(VO_4)_2 \cdot 3H_2O$

- uranophane $(H_3O)Ca(UO_2)(SiO_4)_2 \cdot 3H_2O$.

Uranium occurs naturally in very different concentrations: the richest sources contain about 20% of uranium (e.g. Canadian mines).

Three basic methods are known for the extraction of primary uranium: traditional mining, including deep (underground) and open pit, hydraulic (high pressure) methods, and the underground "in situ leaching" method which is a borehole mining method of underground curing, and it involves leaching, liquefying the rock and pumping it to the surface.

The uranium ore mined, which contains small amounts of uranium (typically about 0.1% or less), is processed into a uranium concentrate containing 70-90% of triuranium octoxide (U_3O_8), in the form known as "yellowcake", which is a commercial product.

Ore extracted by mining or hydraulic methods is milled on site and then processed. Because uranium occurs in the form of minerals of varying composition, there are also many technologies for processing uranium ores, with most minerals being processed using two basic methods: acidic or alkaline.

After initial crushing, the ore is ground. The initial processing of the ore often involves beneficiation (e.g., by flotation or other methods). Curing, usually with sulfuric acid (acidic method), with the addition of oxidants, is used to obtain a uranium solution.

During normal mine operations, the materials in the tailings pond are usually covered with a layer of water to reduce surface radioactivity and radon releases (although with poor ore this does not cause a hazard). When the mining ends, the tailings are usually covered with a two-meter layer of clay and soil to reduce radioactivity to normal levels in the vicinity.

Uranium also occurs in Poland (as in other countries of the Central and Eastern Europe). The uranium resources in Poland are not considered abundant, but they are recognized and could meet the country's nuclear power demand for decades, if there is an economic or strategic need to use them.

Since the current cost of uranium fuel based on Australian, Canadian or Namibian sources is significantly lower than if it were based on domestic resources, the nuclear power industry in Poland is predicted to rely on imported fuel. The economic calculus prevails.

As uranium mining and processing of uranium ores will not take place in Poland, there will be no transboundary impacts from these activities. However, GHG emissions from natural uranium mining and processing are taken into account.

The derivation of GHG emission from this phase includes use of any fuels and electricity; raw materials; emissions and production of auxiliary substances and chemicals; transportation of wastes out and all available amounts of wastes. Underground and open pit mining and processing milling facilities are often co-located and that is why the environmental impacts are often merged.

It is estimated that GHG emissions from uranium ore mining and processing for the Polish NPP for the AP1000 technology will range from 1.40 to 1.48 gCO_2e/kWh, depending on the sub-variant selected.

Chemical conversion and enrichment of uranium

The process of preparing the enriched uranium for the production of fresh nuclear fuel for light water reactors (PWR, WWER, BWR, and their newer generations), consists of the following steps:

1. Reduction (conversion) - conversion of yellowcake (U_3O_8) to the form of UO_2;
2. Conversion of UO_2, into the gaseous uranium hexafluoride UF_6;
3. Isotopic enrichment of uranium.

The first step is the conversion of yellowcake to the UO_2 form.

Depending on the composition of the raw ore and the acidic or alkaline method used, yellowcake contains 70-90% of triuranium octoxide (U_3O_8). The other ingredients are uranium trioxide (UO_3), uranium dioxide (UO_2), uranyl hydroxide ($UO_2(OH)_2$), uranyl sulfate (UO_2SO_4), sodium uranate ($Na_2O\ (UO_3)_2\ 6H_2O$), uranium peroxide ($UO_4\ nH_2O$).

First comes the process of purifying the concentrate of any neutron-absorbing dopants. The uranium oxides (and other compounds) are then reduced using hydrogen compounds to obtain UO_2.

The second step is the conversion of UO_2 to obtain gaseous UF_6.

This process is conducted to obtain gaseous uranium hexafluoride so that the subsequent enrichment of uranium into the lighter fissile U-235 isotope can be carried out. In the hydrofluorination process, UO_2 is converted to solid UF_4, which is then converted to gaseous UF_6 by fluorination.

The third step is isotopic enrichment of uranium to the required U-235 isotope content (up to ~ 5% of total uranium weight for light water reactors, or ~ 20% for fast breeder reactors). The gaseous form of the product enables isotopic enrichment processes by centrifugation. The ability of centrifuges to achieve high rotation speeds, and the reliability of their operation have resulted in the centrifuge method now becoming the most widely used method of uranium enrichment worldwide on an industrial scale. It makes use of the difference in centrifugal force for different isotopes that are moving in the centrifuge drum. The separation factor in this case is higher and depends on the difference between isotope masses. Depending on the rotation speed, its value can range from 1.2 to 1.5.

Thanks to this method, the enrichment process has become less energy intensive and requires plants of a much smaller footprint (the energy demand is about 50 times less than for the diffusion method, which has long since been phased out worldwide). The centrifuges are connected to each other in a cascade system where a stream of the enriched uranium is fed to the next stage, while the depleted uranium is moved back to the lower stage. The number of stages to obtain enrichment useful for nuclear power is about 20.

In recent years, there has been interest in laser enrichment, which is a less energy-intensive process. However, it is unclear whether this method will be scaled and widely used in enrichment, mainly due to concerns about nuclear non-proliferation and an oversupply of uranium products in the market.

Because neither uranium conversion nor enrichment will be conducted in Poland, there will be no transboundary impacts from these activities. However, GHG emissions during uranium conversion and enrichment are taken into account.

It is estimated that GHG emissions from the uranium conversion process for the Polish NPP will range from 0.30 to 0.32 gCO_2e/kWh, depending on the sub-variant selected. On the other hand, GHG emissions from the uranium enrichment process through the centrifuge methods for the Polish NPP will range from 0.40 to 0.42 gCO_2e/kWh, depending on the sub-variant selected.

In the event laser enrichment becomes a feasible enrichment process in the future, as the laser method is less energy-intensive, GHG emissions will be limited to the centrifuge process.

Fabrication of fresh nuclear fuel

To fabricate fresh nuclear fuel, first the gaseous UF_6 is reconverted to UO_2.

Currently, UF_6 is converted to UO_2 using three different technologies:

- ADU technology, which consists in a hydrolysis of UF_6, formation of ammonium polyuranate, thermal decomposition, and reduction to UO_2,
- AUC technology, which consists in a reaction with an ammonium carbonate solution, precipitation of uranyl-ammonium carbonate, thermal decomposition, and reduction to UO_2,
- Dry technology, which consists in a reaction at high temperatures: in a fluidised bed or flame reactor, UF_6 with steam, hydrogen and nitrogen form uranyl fluoride, which is then converted to UO_2 at high temperatures.

The UO_2 is obtained in a powder form to make fuel pellets. In the most common method applied, UO_2 is pressed and sintered at the temperature of about 2000 K in an inert gas atmosphere. The ceramic pellets thus obtained are then ground to the appropriate diameter. The diameter of the fuel pellets fabricated is about 10 mm, and their length is about 1.5÷2 of the diameter size.

These pellets are filled into zirconium alloy or stainless steel tubes that make up the fuel elements. The fuel elements are then assembled into fuel assemblies. Typically, a fuel assembly for a light-water pressure reactor contains 200 to 300 fuel elements and about 20 empty tubes to insert control or emergency safety rods. Fuel assemblies placed in the reactor matrix form the reactor core.

Since neither the reconversion of gaseous UF_6 nor the production of nuclear fuel will take place in Poland, there will be no transboundary impacts from these activities. Nevertheless, GHG emissions during the reconversion of gaseous UF_6 and the production of fuel assemblies for the Polish NPP are taken into account.

The fuel fabrication phase is a comparatively low carbon intensity process and has a largely negligible impact on the emissions from the entire nuclear lifecycle. The estimation includes transport of UF_6 from enrichment facility, use of fuels and electricity, raw materials, emissions and production of auxiliary substances and chemicals, transportation of fresh fuel to the NPP site.

It is estimated that GHG emissions from the uranium reconversion and production of fuel assemblies for the Polish NPP will range from 0.10 to 0.11 gCO_2e/kWh, depending on the sub-variant selected.

Spent fuel management

Spent fuel management encompasses all activities related to handling and storage of spent fuel (including its possible reprocessing). The scope of spent fuel management includes:

- the handling of spent fuel within a nuclear power plant site;
- storage of spent fuel in an at-reactor pool for cooling;
- repackaging of spent fuel into transport containers;
- storage of spent fuel in an external spent fuel storage facility (dry or wet);
- possible reprocessing of spent fuel (if so decided);
- storage of spent fuel in a deep repository and long-term control of spent nuclear fuel.

The scope of spent fuel management does not include the transport of such fuel away from the spent fuel fabrication / handling unit.

Spent fuel removed from the reactor is placed in a water-filled, at-reactor spent fuel pool located in the reactor auxiliary building or spent fuel building (adjacent to the reactor containment), where it remains for at least 3 years (typically up to 7-10 years). The spent nuclear fuel is cooled during this time and its activity decreases several times.

Once the spent fuel is cooled to an acceptable level of residual heat, the spent fuel, unless it is subject to reprocessing, can be transferred from the at-reactor pool to an interim, wet or dry, storage facility usually located on the nuclear power plant site, where it can be stored for the next 50-100 years. The spent fuel can then be moved to a deep repository in geological formations, for long-term storage or final disposal.

Practice shows that the most appropriate method of spent fuel (SF) storage is to use the best features of wet storage with dry storage technology. It was assumed that at the first Polish NPP, the SF would be stored in an at-reactor pool for a cooling period of several to ten ears, after which it would be transferred to dry containers that could be placed in a temporary dry storage facility or shipped to a deep repository or reprocessing facility.

A deep repository does not yet exist in Poland; however, the National Plan of the Management of Radioactive Waste and Spent Fuel assumes a selection of a location for and subsequent construction of a Deep Radioactive Waste Repository. The repository will be designed to store all nuclear fuel produced in Polish nuclear power plants, intermediate-level long-lived waste, high-level long-lived waste other than nuclear fuel, and spent sealed radioactive sources (already collected and stored at the ZUOP and those yet to be produced by the nuclear, medical, or other industries).

The currently preferred spent nuclear fuel management method for the first Polish nuclear power plant, pursuant to the National Plan of Management of Radioactive Waste and Spent Nuclear Fuel, assumes an open fuel cycle, with the issue of potential fuel reprocessing abroad still open, subject to a future decision, following a relevant further analysis. Pursuant to the Atomic Law act, the decision on the classification of spent fuel as waste or a raw material for further reprocessing will rest with the operator of nuclear power plants.

The environmental impact of radioactive waste and spent fuel management is described in the relevant chapters of the transboundary report.

5 Emissions and releases of radioactive isotopes

The analyses of the radiation impact on the environment require the determination of the characteristics of radioactive substances which, or potentially, get into the environment during the operation of a nuclear power plant in its various states. The results of analyses determining the effects of the impact of a nuclear power plant in operational states, accident conditions and during an accident representative for emergency planning depend on this characteristic. In operational states, the analyses are performed on the basis of the anticipated emissions of radioactive substances, which later constitute the basis for setting the limits defined under the operating license. In accident conditions and for the purposes of assessing the consequences of an accident representative for emergency planning, the values of releases that may occur after the occurrence of such an event are determined. The information presented below were used in the analyses of possible transboundary radiation impact on the environment, the results of which are described in Chapter 6.

5.1 Emissions during Normal Operation and Anticipated Operational Occurrences (AOOs)

Shown below [Table 1], [Table 2] and [Table 3] present information regarding annual radioactive isotopes emissions during operational states of single NPP power unit with AP1000 reactor. These emissions were used as input data for radiological consequences analysis performed for the purpose of EIA report in Poland.

Source information is based on the document prepared by Westinghouse in 2017: "Westinghouse Response to PGE EJ 1 Request for Information for Site Evaluation Data for Polish Nuclear Power Plant Projects" [1b], ([Table 1] and [Table 3]) and conservatively supplemented with additional evaluated data from UK Environment Agency report: "Generic Design Assessment. AP1000® nuclear power plant design by Westinghouse Company LLC. Final assessment report. Aqueous radioactive waste disposal and limits" [2] ([Table 2]).

Table 1. Gaseous emissions during normal operation and AOOs (WEC 2017 data)

Isotope	TBq/y
I-131	2.10E-04
I-133	3.50E-04
Iodine	**5.60E-04**
Kr-85m	2.40E-02
Kr-85	3.10E+00
Kr-87	1.90E-02
Kr-88	2.70E-02
Xe-131m	1.40E+00
Xe-133m	1.20E-01
Xe-133	1.30E+00
Xe-135m	1.90E-01
Xe-135	4.40E-01
Xe-137	4.80E-02
Xe-138	8.90E-02
Noble gases without argon	**6.70E+00**

Source: [1b]

Table 2. Gaseous emissions during normal operation and AOOs (evaluated data based on UK GDA)

Isotope	TBq/y
H-3	1.78E+00
C-14	6.07E-01
Ar-41	1.26E+00
Cr-51	2.30E-07
Mn-54	1.60E-07
Co-57	negligible
Co-58	8.50E-06
Co-60	3.20E-06
Fe-59	negligible
Sr-89	1.10E-06
Sr-90	4.40E-07
Zr-95	3.70E-07
Nb-95	9.30E-07
Ru-103	negligible
Ru-106	negligible
Sb-125	negligible
Cs-134	8.50E-07
Cs-136	negligible
Cs-137	1.30E-06
Ba-140	1.60E-07
Ce-141	negligible
Emitery beta	1.70E-05
Σ without noble gases and Ar-41	**3.65E+00**

Source: [1c]

Table 3. Liquid discharge during normal operation and AOOs

Isotope	TBq/y
H-3	**3.34E+01***
C-14	**3.30E-03***
Na-24	3.80E-05
Cl-36	negligible
Cr-51	4.60E-05
Mn-54	3.20E-05
Fe-55	4.90E-04
Fe-59	5.00E-06
Co-58	4.10E-04
Co-60	2.30E-04
Ni-63	5.40E-04
Zn-65	1.00E-05
Nb-94	negligible
W-187	3.00E-06
U-234	negligible
U-235	negligible
U-238	negligible
Np-237	negligible
Pu-238	negligible
Pu-239	negligible
Pu-240	negligible
Pu-241	8.00E-08
Pu-242	negligible
Am-241	negligible
Am-243	negligible
Cm-242	negligible
Cm-244	negligible
As-76	negligible

Isotope	TBq/y
Br-82	negligible
Rb-86	negligible
Rb-88	3.90E-07
Sr-89	2.40E-06
Sr-90	2.50E-07
Y-91	9.10E-08
Zr-95	6.90E-06
Nb-95	6.10E-06
Mo-99	1.90E-05
Tc-99m	1.80E-05
Tc-99	negligible
Ru-103	1.20E-04
Ru-106	negligible
Ag-110m	2.60E-05
I-131	1.50E-05
I-132	2.00E-05
I-133	2.90E-05
I-134	5.90E-06
Cs-134	7.60E-06
I-135	2.40E-05
Cs-136	9.30E-06
Cs-137	2.30E-05
Ba-140	1.40E-05
La-140	1.80E-05
Ce-144	8.00E-05
Pr-144	8.00E-05
Total (without H-3)	**5.59E-03**

* Evaluated data based on UK GDA
Source: [1b]

5.2 Releases during Design Basis Accidents

[Table 4] presents the information regarding radioactive isotopes releases during accidents without core melt. These releases were used as input data for radiological consequences analysis performed for the purpose of EIA report in Poland (to define Restricted Use Area).

Source information is based on the document prepared by Westinghouse in 2017: „Westinghouse Response to PGE EJ 1 Request for Information for Site Evaluation Data for Polish Nuclear Projects" [1b].

Accident under consideration is a Large Break Loss Of Coolant Accident (LBLOCA), which is a design basis accident. The releases were determined assuming 33% fuel degradation and activity release to the space between the fuel rods. It was assumed that it constitutes 5% of the inventory for each group of nuclides.

Table 4. LBLOCA Releases to the Environment

Interval	0-2hr	2-8hr	8-24hr	24-96hr	96-720hr
Isotope	Bq	Bq	Bq	Bq	Bq
Kr-85m	1.15E+12	1.85E+12	1.11E+12	1.01E+11	0.00E+00
Kr-85	1.45E+11	1.72E+11	4.58E+11	2.05E+12	1.75E+13
Kr-87	1.57E+12	7.41E+11	2.93E+10	0.00E+00	0.00E+00
Kr-88	2.77E+12	3.28E+12	9.63E+11	1.97E+10	0.00E+00
Xe-131m	9.12E+10	1.60E+11	4.16E+11	1.68E+12	6.80E+12
Xe-133m	3.54E+11	8.84E+11	2.04E+12	5.31E+12	3.33E+12
Xe-133	1.35E+13	2.92E+13	7.33E+13	2.60E+14	5.12E+14
Xe-135m	3.86E+11	1.47E+09	0.00E+00	0.00E+00	0.00E+00
Xe-135	1.95E+12	4.12E+12	5.01E+12	2.08E+12	8.34E+09
Xe-138	1.44E+12	3.53E+09	0.00E+00	0.00E+00	0.00E+00
Cs-134	1.11E+11	1.09E+11	2.14E+10	6.64E+09	5.60E+10
Cs-136	2.60E+10	2.53E+10	4.90E+09	1.37E+09	5.87E+09
Cs-137	7.34E+10	7.19E+10	1.41E+10	4.40E+09	3.75E+10
Cs-138	5.04E+11	1.91E+10	0.00E+00	0.00E+00	0.00E+00
Rb-86	1.21E+09	1.18E+09	2.30E+08	6.62E+07	3.43E+08
I-130	1.29E+10	9.69E+09	1.81E+09	4.29E+08	7.87E+06
I-131	6.93E+11	6.11E+11	1.77E+11	2.78E+11	8.35E+11
I-132	8.02E+11	2.81E+11	9.38E+09	1.60E+07	0.00E+00
I-133	1.39E+12	1.11E+12	2.50E+11	1.21E+11	1.20E+10
I-134	8.88E+11	9.23E+10	1.55E+08	0.00E+00	0.00E+00
I-135	1.23E+12	7.88E+11	1.01E+11	7.16E+09	6.67E+06

Iodine: 100 % elementary

Source: [1b]

5.3 Releases during Severe Accidents Considered In Design Extension Conditions

[Table 5] presents the information regarding radioactive isotopes releases during severe accidents with core melt. These releases were used as input data for DEC radiological consequences analysis performed for the purpose of EIA report in Poland (to define emergency zones and distances).

Source information is based on the document prepared by Westinghouse in 2017: „Westinghouse Response to PGE EJ 1 Request for Information for Site Evaluation Data for Polish Nuclear Projects” [1b], TEC_EJA_Txx03_IT_00004_AB_EN. Severe accident under consideration is related to an in-vessel core melt situation.

Table 5. Severe Accident Environmental Releases

Interval	0-24hr	25-720hr	Total 0-720hr	Interval	0-24hr	25-720hr	Total 0-720hr
Isotope	(Bq)	Bq	(Bq)	Isotope	(Bq)	Bq	(Bq)
Kr-85m	1.40E+14	6.00E+12	1.46E+14	Sr-92	2.42E+12	0.00E+00	2.42E+12
Kr-85	3.31E+13	1.10E+15	1.13E+15	Ba-139	1.10E+12	0.00E+00	1.10E+12
Kr-87	2.39E+13	0.00E+00	2.39E+13	Ba-140	1.21E+13	1.00E+11	1.22E+13
Kr-88	1.82E+14	1.00E+12	1.83E+14	Ru-103	4.64E+10	4.00E+08	4.68E+10
Xe-131m	3.12E+13	4.89E+14	5.20E+14	Ru-105	1.39E+10	0.00E+00	1.39E+10
Xe-133m	1.65E+14	5.24E+14	6.89E+14	Ru-106	1.47E+10	2.00E+08	1.49E+10
Xe-133	5.65E+15	4.60E+16	5.16E+16	Rh-105	2.88E+10	0.00E+00	2.88E+10
Xe-135m	3.65E+13	1.00E+11	3.66E+13	Mo-99	3.86E+13	1.00E+11	3.87E+13
Xe-135	1.14E+15	3.10E+14	1.45E+15	Tc-99m	3.55E+13	1.00E+11	3.56E+13
Xe-138	2.45E+10	0.00E+00	2.45E+10	Ce-141	1.74E+11	2.00E+09	1.76E+11
I-130	5.26E+11	1.40E+10	5.40E+11	Ce-143	1.45E+11	0.00E+00	1.45E+11
I-131	3.80E+13	8.10E+13	1.19E+14	Ce-144	1.34E+11	2.00E+09	1.36E+11
I-132	3.74E+13	2.00E+11	3.76E+13	Pu-238	2.45E+08	3.00E+06	2.48E+08
I-133	6.25E+13	4.20E+12	6.67E+13	Pu-239	2.79E+07	4.00E+05	2.83E+07
I-134	2.36E+12	0.00E+00	2.36E+12	Pu-240	4.37E+07	5.00E+05	4.42E+07
I-135	3.97E+13	3.00E+11	4.00E+13	Pu-241	1.11E+10	2.00E+08	1.13E+10
Cs-134	4.87E+12	7.00E+10	4.94E+12	Np-239	2.05E+12	0.00E+00	2.05E+12
Cs-136	1.13E+12	1.00E+10	1.14E+12	Y-90	2.74E+10	7.20E+09	3.46E+10
Cs-137	3.22E+12	4.00E+10	3.26E+12	Y-91	1.80E+11	2.00E+09	1.82E+11
Cs-138	4.32E+11	0.00E+00	4.32E+11	Y-92	9.37E+11	0.00E+00	9.37E+11
Rb-86	5.27E+10	4.00E+08	5.31E+10	Y-93	1.37E+11	0.00E+00	1.37E+11
Te-127m	1.77E+11	2.00E+09	1.79E+11	Nb-95	2.32E+11	3.00E+09	2.35E+11
Te-127	1.09E+12	0.00E+00	1.09E+12	Zr-95	2.29E+11	2.00E+09	2.31E+11
Te-129m	6.12E+11	6.00E+09	6.18E+11	Zr-97	1.81E+11	0.00E+00	1.81E+11
Te-129	1.95E+12	0.00E+00	1.95E+12	La-140	7.18E+11	7.90E+10	7.97E+11
Te-131m	2.13E+12	0.00E+00	2.13E+12	La-142	2.34E+10	0.00E+00	2.34E+10
Te-132	1.66E+13	0.00E+00	1.66E+13	Nd-147	8.48E+10	5.00E+08	8.53E+10
Sb-127	1.08E+12	0.00E+00	1.08E+12	Pr-143	2.02E+11	2.00E+09	2.04E+11
Sb-129	1.46E+12	0.00E+00	1.46E+12	Am-241	1.46E+07	2.00E+05	1.48E+07
Sr-89	6.89E+12	7.00E+10	6.96E+12	Cm-242	3.95E+09	5.00E+07	4.00E+09
Sr-90	6.08E+11	8.00E+09	6.16E+11	Cm-244	3.40E+08	5.00E+06	3.45E+08
Sr-91	5.70E+12	0.00E+00	5.70E+12				

Source: [1b]

For information on impacts related to ionising radiation, see Part 6, Chapter IV.14, "Impacts related to ionising radiation," and Part 1, Chapter 6, "Possible transboundary environmental impact," along with Appendix V.1.13-1.

6 Possible transboundary environmental impact

6.1 Possible transboundary radiological impact on the environment

Transboundary impact also means the environmental impact of a nuclear power plant that has a direct effect on areas beyond the Polish borders. Thus, the impact concerns countries situated in the immediate vicinity, i.e. bordering on Poland, as well as countries which are not immediate neighbours but are situated close enough to be also taken into account (e.g. Sweden).

Owing to the fact that both site variants: Variant 1 – Lubiatowo - Kopalino site and Variant 2 – Żarnowiec site are located at a significant distance from the countries taken into consideration (more than 100 km from the nearest Kaliningrad Oblast of the Russian Federation), conventional impacts of the nuclear power plant (e.g. noise) are not taken into account for obvious reasons.

The assessment of impact on the marine natural environment in marine survey areas for both site variants under consideration, including the transboundary impact assessment, is presented in detail in Volume IV [Chapter IV.2]. According to the methodology adopted, the spatial range of impacts on the natural elements of the marine environment was analysed in accordance with the following definitions:

- local range includes impacts occurring in the buffer zone of 100m from the Project site,
- regional range includes impacts occurring in the jurisdiction region (voivodeship) and <30km from the Project site, and
- national range includes impacts occurring within the territory of the Republic of Poland and >30km from the Project site, and
- transboundary range includes impacts that would affect the environment in another state outside the territory of the Republic of Poland.

According to the result of the assessment of the impact of the Project on individual biological receptors in marine survey areas for Variant 1 – Lubiatowo - Kopalino site and for Variant 2 – Żarnowiec site, it was shown that the anticipated impacts, considered at the development and construction stages and in the operational and decommissioning phases, both for the open and closed cooling systems, would be at most of a local or regional nature. No transboundary impacts were found for any of the analysed biological elements.

In view of the above, this chapter considers radiological impacts for an accident representative for emergency planning purposes. The basic objective of calculating doses at a significant distance from the nuclear power plant in the event of a severe accident representative for emergency planning purposes is to assess the degree of threat to the population in areas distant from the NPP, in particular in the neighbouring countries. Calculations and analyses take into account releases of radioactive substances into the air and all pathways of exposure (i.e. external and internal) of members of the public to ionising radiation associated with those releases.

The following calculation scheme was adopted for the analysis:

- The affected states are specified in the GDOŚ Decision setting out the scope of the EIA Report [87];
- For each receptor (i.e. the border of the affected states situated the closest to the analysed site), an analysis of meteorological data was carried out by determining trajectories in order to select meteorological sequences that would cause a contaminated cloud to move to the receptor concerned within the shortest possible time;
- Based on such a trajectory analysis, meteorological data sets were prepared for long-range calculations by means of the MATCH model, which is one of the modules of the RODOS system;
- Simulation calculations of the transport and dispersion of radioactive substances in the atmosphere were made with the use of the MATCH model, assuming accidental release data representative for emergency planning purposes for the AP1000 reactor technology for two sites: Lubiatowo - Kopalino and Żarnowiec;

- MATCH model simulation results were than used to calculate doses by ingestion using the FDMT model of the RODOS system, so that all exposure pathways (i.e. including ingestion) are taken into account in dose estimation.

All the above calculations were made by (NCBJ) in collaboration with (IMGW). The calculation methodology is set out in [Chapter V.1], while this chapter presents and discusses only the calculation results.

The basic conclusion arising from the analysis is that transboundary impacts of radioactive emissions for accidents representative for emergency planning are completely insignificant.

6.1.1 Analysis of results

Detailed model results are provided in [Appendix V.4-1] and [Appendix V.4.-2] for the MATCH and FDMT models, respectively. In the case of a release representative for emergency planning purposes (data made available for the AP1000 technology), attention must be paid to the following factors:

- The release is long-lasting (720 hours, i.e. 1 month), which means that whatever realistic meteorological scenario is taken into account, no situation is likely to occur where weather conditions would remain almost constant over the period, i.e. the same as at the beginning of emissions;
- The calculation of doses (2-day, 7-day, monthly, annual and lifetime) is made in the FDMT model, which takes the MATCH model results as inputs. Thus, full variability of meteorological conditions is taken into account in accordance with the length of the MATCH model simulation period, which was extended two weeks beyond the end of emissions;
- For the above reason, focus was placed on the selection of meteorological sequences that create conditions in the first phase of release for a contaminated cloud to quickly reach the receptor concerned. Of course, it cannot be ruled out that contamination of the analysed area would occur in a later phase but, firstly, the early phase of an accident is the most critical and, secondly, almost continuous calculations would then actually have to be performed, which is impracticable owing to the huge amount of time this would involve;
- Long-range models (for states) must by nature use a coarser grid (i.e. one with larger mesh cells) than short-range models.

Apart from maximum dose quantities or dose rates determined for receptors, the calculation results provided in [Appendix V.4.-1] and [Appendix V.4-2] include information on the date of hypothetical release (the meteorological sequence is identified this way) and geographical coordinates of the computational grid cell centre which at least partly overlaps the receptor area. This means that the grid cell centre itself can be situated outside the receptor area but in its close vicinity.

6.1.1.1 MATCH model results

The basic results that can be obtained from the MATCH model are dose rates and estimations of doses from external exposure. The doses are determined at the end of exposure. In contrast, doses from all exposure pathways in different time periods are determined by means of the FDMT model. Analysing the calculation results for both nuclear power plant sites for Variant 1 – Lubiatowo - Kopalino site and Variant 2 – Żarnowiec site, the following conclusions can be drawn regarding the exposure of the neighbouring countries:

- the maximum dose rates for the neighbouring countries range between 2.97E-07 mSv/h for Slovakia and 2.43E-05 mSv/h for Germany. Values similar to those for Germany can also be observed for Bornholm, Lithuania, Russia (Kaliningrad Oblast) and Sweden. It is worth noting here that the average annual background dose rate in Poland is approximately 2.74E-04 mSv/h (that is, the annual background dose is 2.4 mSv/a, i.e. for 365 d x 24 h);

- the maximum external exposure doses range between 1.2E-06 mSv and 2.89E-04 mSv, again for Slovakia and Germany, respectively. Values similar to those for Germany were also obtained for Bornholm and Russia.

It should be noted that while instantaneous dose rate values can be similar to those for receptors situated closer to the NPP (especially with rapid atmospheric transport of contaminants or with the occurrence of additional factors such as precipitation [Chapter V.1]), or just an order of magnitude lower than the doses themselves, the exposure is so short-lived that the aggregate radiological impact is negligibly low compared to background ionising radiation doses.

Of course, estimated maximum dose quantities are many orders of magnitude below any limits triggering any countermeasures after a nuclear accident.

[Figure V.4.- 1] and [Figure V.4- 2] show border points for the states, where maximum doses and dose rates are reached for releases from both potential nuclear power plant sites. The geographical coordinates for those border points represented by the computational grid cell centres and the values of dose rates and doses are specified in [Appendix V .4-1], stating release dates, which allows the specific meteorological scenario to be identified.

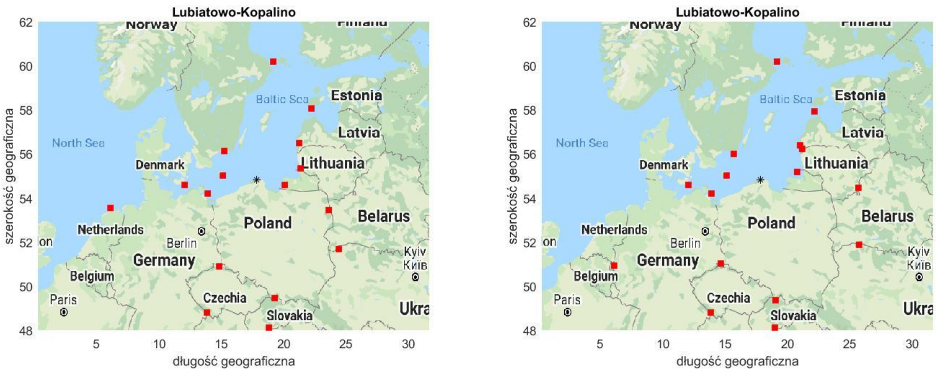


Figure V.4- 1 Points of maximum dose rates (left) and doses (right) for accidental releases of radioactive material from the nuclear power plant at the Lubiatowo - Kopalino site for states (note: for Finland, these are the Aland Islands in the Baltic Sea)

Source: [65]

Polish	English
szerokość geograficzna	latitude
długość geograficzna	longitude

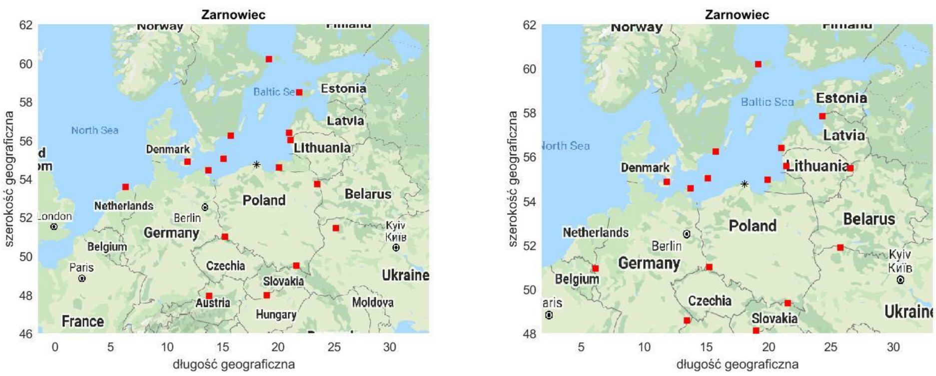


Figure V.4- 2 Points of maximum dose rates (left) and doses (right) for accidental releases of radioactive material from the nuclear power plant at the Żarnowiec site for states (note: for Finland, these are the Aland Islands in the Baltic Sea)

Source: [65]

Polish	English
szerokość geograficzna	latitude
długość geograficzna	longitude

6.1.1.2 FDMT model results

The results of the long-range MATCH model were used as inputs for the basic dose model in the RODOS system, i.e. FDMT. By means of the FDMT model, doses from all exposure pathways can be estimated for different time periods, and for both adults and children. For the thyroid, equivalent doses are determined as a standard. As regulations refer to absorbed doses, effective doses were converted into absorbed doses using dose conversion coefficients from the ICRP-116 publication "Conversion Coefficients for Radiological Protection Quantities for External Radiation Exposures" (Annexes A and B including data corrected in Corrigenda for Publication ICRP 116) [15].

Thus, the following doses were determined:

- effective dose: 2-day, 7-day, annual and lifetime,
- thyroid absorbed dose: 2-day, 7-day, annual and lifetime.

The results are specified in [Appendix V.4-2] – in addition, 14-day and monthly doses are determined.

In the case of effective doses for adults:

- the maximum 2-day doses range between 8.36E-03 mSv for Lithuania and 4.70E-05 mSv for the Netherlands, with quantities on the order of E-03 observed in a number of countries (Germany, Sweden, Russia, Latvia, Estonia, Denmark - Bornholm),
- the maximum 7-day doses are the highest in Lithuania (1.75E-02 mSv) and Sweden (1.35E-02 mSv) and the lowest in Slovakia (1.15E-05 mSv),
- the maximum annual doses were the highest in Lithuania (8.94E-02 mSv), with similar dose quantities found in a number of other countries (Sweden, Austria, Czechia, Bornholm, Estonia, Germany, Russia). The lowest values were found in Slovakia (1.02E-04 mSv),
- the maximum lifetime doses were the highest in Lithuania (1.85E-01 mSv), and slightly lower in several other countries (Germany, Russia, Estonia, Sweden, Czechia), with the lowest values found in Slovakia (4.74E-04 mSv).

All those values are much below the thresholds that require the introduction of remedial measures - e.g. sheltering is ordered with two-day equivalent doses above 10 mSv (under Polish regulations, the dose of 10 mSv is also applied to action termination criteria) and other remedial measures are introduced at much higher doses [111]. It should be noted that in certain situations, even in more distant countries, doses can be observed which are only slightly lower than those in countries situated closer to the place of release. This is attributable, on the one hand, to the duration of the release and variability of meteorological conditions and, on the other hand, the possibility of special situations occurring, such as precipitation (this applies e.g. to Czechia) or cloud return.

In the case of effective doses for children:

- the maximum 2-day doses range from 2.79E-02 mSv for Sweden to 1.51E-05 for Slovakia, with doses on the order of E-03 mSv found for most countries,
- the maximum 7-day doses were found to be the lowest in Sweden (5.07E-02 mSv) and Lithuania (2.97E-02 mSv) and the lowest in Slovakia (2.77E-05 mSv),
- the maximum annual doses were the highest in Sweden (1.49E-01 mSv) and Lithuania (1.34E-01 mSv), with slightly lower quantities found in several other countries (Czechia, Denmark - Bornholm, Estonia, Germany, Russia). The lowest values were obtained for Slovakia (1.70E-04 mSv),
- the maximum lifetime doses were observed in Lithuania (2.26E-01 mSv), and slightly lower in several other countries (Germany, Russia, Estonia, Sweden, Czechia), with the lowest values found in Slovakia (6.08E-04 mSv).

As regards the thyroid absorbed dose for adults, the results are as follows:

- the maximum 2-day doses range from 9.36E-03 mGy for Lithuania to 7.13E-06 mGy for Slovakia, with doses on the order of E-03 mGy found for most countries,
- the maximum 7-day doses were found to be the highest in Lithuania (1.96E-02 mGy) and Sweden (1.51E-02 mGy) and the lowest in Slovakia (1.29E-05 mGy),
- the maximum annual doses were found in Lithuania (1.00E-01 mGy) and slightly lower in several other countries (Sweden, Czechia, Denmark, Estonia, Germany, Russia). The lowest values were obtained for Slovakia (1.14E-04 mGy),
- the highest maximum lifetime doses were observed in Lithuania (2,07E-01 mGy), and slightly lower in several other countries (Germany, Estonia, Russia, Sweden, Czechia), with the lowest values found in Slovakia (5.31E-04 mGy).

In the case of thyroid absorbed doses for children:

- the maximum 2-day doses range from 3.38E-02 mGy for Sweden and 1.51E-02 mGy for Lithuania to 1.83E-05 mGy for Slovakia, with doses on the order of E-02÷E-03 mSv found for most countries.
- the maximum 7-day doses were found to be the highest in Sweden (6.13E-02 mGy) and Lithuania (3.59E-02mGy mSv) and the lowest for Slovakia (3.29E-05 mSv),
- the maximum annual doses were found in Sweden (1.89E-01 mSv) and Lithuania (1,62E-01 mGy) and slightly lower in several other countries (Germany, Russia, Czechia). The lowest values were obtained in Slovakia (2.06E-04 mGy),
- the highest maximum lifetime doses were observed in Lithuania (2.07E-01 mGy) and in Sweden (2.44E-01 mGy), and slightly lower in several other countries (Austria, Czechia, Denmark, Latvia, Germany, Estonia, Russia), with the lowest values found in Slovakia (7.36E-04 mGy).

The summary for the neighbouring countries shows that all calculated dose quantities are significantly below the thresholds that require countermeasures. The maximum lifetime doses from all exposure pathways for children and adults are below 0.5 mSv.

6.1.2 Summary

The calculation methodology adopted for the purposes of estimation of dose quantities at a far distance from the planned nuclear power plant site, in the case of a severe accident representative for emergency planning, was based on the selection, for each source-receptor pair, of real meteorological sequences that would guarantee that the receptor is reached within as short time as possible from accident start. The selection of those sequences was based on an in-depth analysis of meteorological conditions from a period of 10 years, conducted by IMGW. Based on that data, a number of simulations of the atmospheric spread of contamination were then performed, followed by dose assessments with the use of basic tools of the RODOS decision support system. However, it should be noted that due to the long duration of the release period weather conditions may change significantly over that time, and alternative adoption of a simple assumption of constant weather conditions is completely unrealistic. Overall, several hundred simulations were performed, which ensures good representativeness of the results obtained with such a selection of meteorological sequences. The results show that even for receptors situated the closest to the planned site of the first Polish Nuclear Power Plant the expected maximum doses from all exposure pathways are low – e.g. lifetime effective doses for adults and children are much below 1 mSv, and the maximum thyroid absorbed dose is approximately 1mGy. Thus, the doses are even below the annual limits for the planned exposure situation (i.e. operational states of the NPP) defined for members of the public in IAEA GSR Part 3 [149], Directive 2013/59/EURATOM [26] and in the Atomic Law Act [46]. The doses are also significantly lower than the average natural background radiation dose for Poland, which is approximately 2.4mSv/year. **Thus, the main conclusion from the calculations is that an accident representative for emergency planning will not pose any threat to human health in areas distant from the site,**

in particular in the neighbouring states. Thus, the transboundary impact of the Polish Nuclear Power Plant will be completely insignificant.

6.2 Alignment of the implementation of the Project with the objectives of the HELCOM Baltic Action Plan

6.2.1 Introduction

The Convention on the Protection of the Marine Environment of the Baltic Sea Area, known as the Helsinki Convention, was signed in 1974 by all states situated on the Baltic Sea, having regard to the protection of the Baltic from pollution from all sources. The Convention obligates the signatories to take measures for the protection of habitats and biodiversity and to ensure the sustainable use of marine resources [35]. The executive body of the Convention is HELCOM (Baltic Marine Environment Protection Commission, also known as the Helsinki Commission), an international organisation which operates as a regional policymaking platform for environmental protection.

The key aspect of HELCOM's operation was the development of the Baltic Sea Action Plan (BSAP) adopted by the Contracting Parties in 2007 and updated in 2021, which is a strategic programme of measures and actions for achieving good environmental status of the marine area. The four specific goals set out in the Baltic Action Plan (and the related segments) are as follows:

- Biodiversity, with its goal: "Baltic Sea ecosystem is healthy and resilient";
- Eutrophication, with its goal: "Baltic Sea unaffected by eutrophication";
- Hazardous substances and litter, with its goal: "Baltic Sea unaffected by hazardous substances and litter", and
- Sea-based activities, with its goal: "Environmentally sustainable sea-based activities"

Each of the above goals is structured around the HELCOM ecological and management objectives and contains concrete measures and actions to be implemented by 2030 at the latest.

The chapters below provide an overview of the key issues raised when performing the impact assessments of the first Polish Nuclear Power Plant (NPP) in both site variants: Variant 1 – Lubiatowo - Kopalino site and Variant 2 – Żarnowiec site, as well as conclusions from environmental reports on marine hydrodynamics and water quality, and then marine biodiversity, where applicable.

6.2.2 Biodiversity

The chapters prepared as part of the EIA concerning marine hydrodynamics and water quality provide a general assessment of the potential effects on marine environment receptors, which is sufficient for the assessment to be made in accordance with the WFD [19] and the MSFD [24].

The assessment showed that if appropriate mitigating measures are taken in the course of the Project and additional measures are implemented to tackle specific key issues, there will be no negative impact on the status of single water bodies identified by the WFD or the Marine Strategy Framework Directive, which directly apply to the planned Project site.

The assessment of effects on marine environment receptors was performed taking into account detailed data contained in the chapters prepared as part of the environmental impact assessment concerning the biodiversity of the marine environment. As in the case of marine hydrodynamics and water quality, the effects will be negligible or small-scale and insignificant with regard to the two sites under consideration and the related variants.

Presented below are specific examples of cases where additional information was included in the chapters prepared as part of the environmental impact assessment concerning marine biodiversity.

6.2.2.1 Underwater noise impact on marine mammals and fish

The potential effects of underwater noise generated by construction works at sea – mainly in the vicinity of the marine off-loading facility (MOLF), are discussed in the chapters prepared as part of the environmental impact assessment on marine hydrodynamics and water quality, based on the findings of the assessment of the impact of noise and vibration transmitted by water (on marine mammals and fish), which was being finalised at the time of drawing up the reports on marine hydrodynamics and water quality.

Additional information from the assessment of waterborne noise was included in the chapters on marine biodiversity. This included a more detailed review of the ability of key species to hear sounds (primarily the porpoise, grey seal, common seal and ringed seal) and consideration of the populations of these species in the Baltic Sea (and the sensitivity of these species). The assessment confirmed the conclusion that no significant impact on marine mammal populations is foreseen if the relevant mitigation measures planned under the Project are applied. The mitigation measures required are described in [Chapter IV.2], [Chapter IV.10.2] and [Chapter V.3].

6.2.2.2 Effects on benthic habitats and species resulting from the construction and operation of marine infrastructure

Benthic communities are a key element of the marine environment and are used as a source of food for numerous predatory species, including several of nature conservation significance. This is particularly important for the Project, taking into account that both sites (Variant 1 – Lubiatowo - Kopalino site and Variant 2 – Żarnowiec site) are located within the Special Protection Area (SPA) "Coastal Waters of the Baltic Sea".

The direct effects of habitat loss were assessed in [Chapter IV.2] and [Chapter IV.8] prepared as part of the environmental impact assessment on marine hydrodynamics and water quality, identifying, on the basis of the EUNIS habitat maps, the habitats to be affected by the installation and construction of infrastructure. The assessment showed that the effects would not be significant, given the loss of a small area from a much larger zone of similar habitats near one of the sites under consideration and the fact that benthic populations can recover from habitat disturbance/loss.

This assessment is part of the environmental impact assessment of marine biodiversity and it focuses on additional details contained in the Marine Environment Evaluation Report, using information on the sensitivity of key species found in the Lubiatowo - Kopalino and Żarnowiec marine survey areas. The assessment of potential effects on benthic complexes included physical changes (e.g. backfilling, increased levels of sediment suspension in the water column and washout) and chemical changes (including temperature, salinity, chemicals and nutrients). These changes were considered in particular for the dominant species within each marine survey area (primarily polychaetes such as *Pygospio elegans* and *Hediste diversicolor*, mussels including *Limecola balthica* and crustaceans such as *Bathyporeia pilosa* and *Crangon crangon*).

These species are generally tolerant to both physical and chemical disturbances and are unlikely to be significantly affected by the development of marine infrastructure related to the project. Therefore, the effects were assessed as insignificant.

6.2.2.3 Impact on fish populations associated with fish impingement, entrainment and entrapment in the cooling system (and related effects on birds, through changes in food availability)

[Chapter IV.8] on marine hydrodynamics and water quality states that piscivorous birds (in particular those for which the “Coastal Baltic Waters” SPA has been established) and marine mammals may be exposed to local changes in the availability of their main food. The potential effects on fish related to cooling water intake (in particular related to Sub-variant 1A) were found to be moderate and potentially significant and likely to be of a transboundary nature. On this basis, potential indirect effects, especially on piscivorous birds, were also considered moderate and potentially significant.

The development of this assessment was therefore a key element described in [Chapter IV.2] on marine biodiversity, both in terms of direct effects on fish and indirect effects on birds. The potential impact assessment used a wider range of data, including detailed calculations of potential mortality levels established for key species such as sprat, and used information on power plants for which long-term data sets were available. Additional information such as swimming speeds, spawning seasons and behaviour of key species (identified through nature inventory in specific survey areas) was also included in the assessment. The assessment showed that in the case of Sub-variant 1A (worst-case scenario in terms of fish entrainment), the effects would be regional and small (insignificant). The conclusion of the detailed assessment was that the effects on birds resulting from the change in food availability would be negligible (insignificant). These conclusions were taken into account in the assessment of habitat legislation for both sites, which also concluded that there was no likely significant impact on the integrity of Europe's natural areas.

6.2.3 Eutrophication

Eutrophication is a major problem for the Baltic Sea and it is also a qualitative descriptor in the MSFD [24] (qualitative descriptor 5: eutrophication). As the discharge of sewage from the power plant during the operational phase in all variants and at both sites may result in an increased heat and nutrient load, it was also a key element of [Chapter IV.8] on marine hydrodynamics and water quality.

The assessment undertaken as part of the environmental impact assessment included calculations of annual nitrogen and phosphorus loads to Polish waters from the Vistula River basin area, where two potential NPP sites are located. Potential additional N and P loads resulting from the implementation of the Project in both site variants were also determined. For example, for Sub-variant 1A, the N load was defined as an increase of 0.007% from current levels, while for P an increase of 0.00007% from current loads was determined. The potential combined impacts of added nutrients and elevated temperature were analysed and their effects were considered negligible and insignificant in the case of Sub-variant 1A. For all other variants, increased P loads are foreseen due to the need for additional use of polyphosphates to control scale deposition in the cooling tower system. If the mitigation measures envisaged under the Project are applied, the effects will be moderate and potentially significant; however, additional mitigation measures have also been identified, the full implementation of which may reduce the effects to negligible and insignificant levels.

This assessment is taken into account in [Chapter IV.2] as part of the environmental impact assessment on marine biodiversity, which also demonstrates that the implementation of additional mitigation measures would make the effects negligible and insignificant.

6.2.4 Hazardous substances and littering

The introduction of hazardous substances and waste into the marine environment as a result of activities related to the Project can be divided into two key areas: accidental spillage/release of material into the marine environment at the development/construction stage and sewage discharge at the operational stage.

The assessment of accidental releases into the marine environment (including littering) was the same in both [Chapter IV.8] on marine hydrodynamics and [Chapter IV.2] on marine biodiversity, and it was noted that compliance with relevant international and national laws and project-specific pollution control measures would minimise the risk of such events occurring, as well as minimise any consequences if they did occur. On this basis, the effects were found to be negligible and insignificant in the areas of marine hydrodynamics and water quality.

Both sites were assessed for qualitative descriptor 10 (marine litter) as part of the MSFD assessment [24], presented in the environmental reports on marine hydrodynamics and water quality. The assessment showed that the potential effects of the Project would not have a negative impact on the waters of Area No. 62 designated under the MSFD (coastal waters according to the MSFD) or prevent the achievement of good environmental status (GES) as defined in the MSFD.

For sewage discharged in the operational phase, the assessment was based on a comparison of the concentrations in the final section of the discharge tunnel with the existing environmental quality standards (EQS) and emission limit values (ELV), where they were established. A detailed assessment was carried out, the results of which are presented in [Chapter IV.8] prepared as part of the environmental impact assessment on marine hydrodynamics and water quality. The assessment was used in an environmental report on marine biodiversity, which included an additional interpretation from an ecological perspective with regard to the sensitivity of key benthic and fish species.

The assessments show that for all variants some components of the discharge would exceed the EQS/ELV values. This was discussed in more detail, with an indication of the proposed additional mitigation measures, in environmental reports on marine hydrodynamics and water quality, and reiterated in reports on marine biodiversity. Examples include mitigating the effects of excess chlorine (assumed biocide), in particular for Sub-variant 1A. In practice, chlorine discharged from the power plants during the operational stage would react with substances contained in sea water as well as with other components of combined process sewage. These reactions can be rapid and cause a significant decrease in the concentration of substances even before release at the point of discharge. However, it is not known what exactly can happen to chlorine in the Baltic Sea, so the assessment as part of all environmental reports should be considered precautionary. Several options were proposed as part of the EIAs concerning marine hydrodynamics and water quality, including detailed surveys of chlorine behaviour in the Baltic Sea, as well as options for other potential biological pollution control methods that would minimise or eliminate the need for chlorine dosing. It was concluded that the application of such measures would allow a biological pollution control system to be developed that would not have a significant negative impact on the marine environment.

Hydrazine levels in discharged wastewater were also identified as a potential problem for all variants and additional mitigation measures would be needed to sufficiently reduce its levels. Also in this case, in order to accurately determine hydrazine behaviour, it would be necessary to conduct surveys to determine the rate of its decay in the Baltic Sea waters, as well as the reaction of hydrazine with other components of sewage discharge. This would allow an appropriate dosing system to be developed and additional mitigation measures to be selected, such as oxidation using hydrogen peroxide or chlorine/hypochlorite. It can be concluded that if such measures were introduced, hydrazine levels could be reduced to such an extent that there would be no significant adverse effects on the environment.

6.2.5 Sea-based activities

Potential effects on maritime activities, resulting from the implementation of the Project at the Lubiatowo - Kopalino or Żarnowiec sites were not included in the scope of the environmental reports on marine hydrodynamics and water quality or reports on marine biodiversity.

6.2.6 Summary

Detailed impact assessments resulting from the implementation of the Project were carried out for both site variants: Variant 1 – Lubiatowo - Kopalino site and Variant 2 – Żarnowiec site, taking into account all related variants and their potential impact on:

- Marine hydrodynamics;
- Seawater quality; and
- Biodiversity of the marine environment.

For some elements of the Project, potentially significant effects have been identified in both site variants, but if additional mitigation measures (as set out in [Chapter V.3]) are introduced, they can be reduced to a level that avoids significant adverse effects on the marine environment. Therefore, it can be concluded that the implementation of the Project in either of the two sites under consideration will not have a negative impact on the HELCOM goals set out in the Baltic Sea Action Plan.

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MATCH model results

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Table V.4-1- 1 Maximum dose rates with release start date and geographical coefficients of the computational grid cell centre

Destination	Emission source	Start of release	MV – Maximum Value of dose rate [mSv/h]	MV Longitude	MV Latitude
Austria	Lubiatowo	15-May-2014 12:30:00	6.06321E-07	13.847	48.802
Austria	Żarnowiec	15-May-2014 12:30:00	6.95524E-07	13.773	47.929
Belarus	Lubiatowo	27-Nov-2011 21:30:00	2.52477E-06	23.596	53.442
Belarus	Żarnowiec	26-Jan-2008 12:30:00	1.72982E-06	23.473	53.711
Bornholm	Lubiatowo	16-March-2011 12:30:00	1.40453E-05	15.123	55.014
Bornholm	Żarnowiec	24-March-2007 06:30:00	1.90012E-05	15.123	55.014
Czechia	Lubiatowo	23-Jun-2009 00:30:00	1.68188E-06	14.826	50.891
Czechia	Żarnowiec	23-Jun-2009 00:30:00	3.37944E-06	15.234	50.997
Denmark	Lubiatowo	19-Jan-2014 12:30:00	3.9319E-06	12.047	54.607
Denmark	Żarnowiec	19-Jan-2014 15:30:00	3.72194E-06	11.843	54.861
Estonia	Lubiatowo	13-Dec-2011 15:30:00	5.14461E-06	22.227	58.045
Estonia	Żarnowiec	19-Jan-2008 00:30:00	1.77273E-06	21.885	58.458
Finland	Lubiatowo	05-Oct-2008 12:30:00	4.01588E-06	19.194	60.191
Finland	Żarnowiec	05-Oct-2008 12:30:00	6.08317E-06	19.194	60.191
Netherlands	Lubiatowo	09-Mar-2013 12:30:00	5.8063E-07	6.113	53.559
Netherlands	Żarnowiec	10-Mar-2013 00:30:00	5.8905E-07	6.3227	53.566
Lithuania	Lubiatowo	07-Jan-2009 00:30:00	1.06611E-05	21.364	55.336
Lithuania	Żarnowiec	10-Aug-2005 06:30:00	1.21734E-05	21.109	55.993
Latvia	Lubiatowo	28-Oct-2013 12:30:00	5.63204E-06	21.256	56.487
Latvia	Żarnowiec	05-Aug-2008 00:30:00	9.84924E-06	20.996	56.384
Germany	Lubiatowo	09-Jan-2010 12:30:00	6.85938E-06	13.946	54.183
Germany	Żarnowiec	23-March-2007 12:30:00	2.43167E-05	13.757	54.439
Russia	Lubiatowo	06-Mar-2008 00:30:00	1.9200E-05	20.080	54.588
Russia	Żarnowiec	13-Jan-2007 00:30:00	1.6200E-05	20.050	54.570
Slovakia	Lubiatowo	14-Oct-2009 09:30:00	2.96893E-07	19.267	49.461
Slovakia	Żarnowiec	11-Feb-2011 18:30:00	8.75784E-08	21.588	49.479
Sweden	Lubiatowo	02-May-2005 12:30:00	2.48142E-05	15.275	56.136
Sweden	Żarnowiec	02-May-2005 12:30:00	1.05016E-05	15.741	56.240

Destination	Emission source	Start of release	MV – Maximum Value of dose rate [mSv/h]	MV Longitude	MV Latitude
Ukraine	Lubiatowo	08-Apr-2011 12:30:00	6.4700E-07	24.450	51.670
Ukraine	Żarnowiec	08-Apr-2011 15:30:00	6.4700E-07	25.190	51.440
Hungary	Lubiatowo	24-Nov-2013 09:30:00	4.93611E-07	18.802	48.115
Hungary	Żarnowiec	24-Nov-2013 09:30:00	4.26645E-07	18.960	47.975

Source: Modelling of contamination and calculation of dose values at a distance of more than 30km from the NPP for accidents representative for emergency planning.

Table V.4-1- 2 Maximum dose rates with release start date and geographical coefficients of the computational grid cell centre

Destination	Emission source	Start of release	MV – Maximum Value of doses [mSv]	MV Longitude	MV Latitude
Austria	Lubiatowo	15-May-2014 12:30:00	5.2000E-06	13.847	48.802
Austria	Żarnowiec	15-May-2014 12:30:00	4.6000E-06	13.453	48.566
Belarus	Lubiatowo	27-Nov-2011 21:30:00	1.1400E-05	25.708	54.450
Belarus	Żarnowiec	26-Jan-2008 12:30:00	1.0900E-05	26.591	55.485
Bornholm	Lubiatowo	16-March-2011 12:30:00	1.2720E-04	15.123	55.014
Bornholm	Żarnowiec	24-March-2007 06:30:00	1.9680E-04	15.123	55.014
Czechia	Lubiatowo	23-Jun-2009 00:30:00	2.2300E-05	14.644	51.025
Czechia	Żarnowiec	23-Jun-2009 00:30:00	3.0400E-05	15.234	50.997
Denmark	Lubiatowo	19-Jan-2014 12:30:00	4.00884E-05	12.047	54.607
Denmark	Żarnowiec	19-Jan-2014 15:30:00	6.3187E-05	11.843	54.861
Estonia	Lubiatowo	13-Dec-2011 15:30:00	1.5900E-05	22.185	57.922
Estonia	Żarnowiec	19-Jan-2008 00:30:00	4.1000E-06	24.306	57.827
Finland	Lubiatowo	05-Oct-2008 12:30:00	1.2800E-05	19.194	60.191
Finland	Żarnowiec	05-Oct-2008 12:30:00	1.7200E-05	19.194	60.191
Netherlands	Lubiatowo	29-Apr-2011 18:30:00	3.8901E-06	6.1549	50.931
Netherlands	Żarnowiec	10-Mar-2013 00:30:00	2.2036E-06	6.1549	50.931
Lithuania	Lubiatowo	07-Jan-2009 00:30:00	5.7700E-05	21.182	56.240
Lithuania	Żarnowiec	10-Aug-2005 06:30:00	6.9600E-05	21.437	55.582
Latvia	Lubiatowo	28-Oct-2013 12:30:00	2.6700E-05	20.996	56.384
Latvia	Żarnowiec	05-Aug-2008 00:30:00	2.8500E-05	20.996	56.384
Germany	Lubiatowo	09-Jan-2010 12:30:00	5.5500E-05	13.946	54.183

Destination	Emission source	Start of release	MV – Maximum Value of doses [mSv]	MV Longitude	MV Latitude
Germany	Żarnowiec	23-March-2007 12:30:00	2.8930E-04	13.769	54.564
Russia	Lubiatowo	08-Feb-2011 18:30:00	1.2400E-04	20.789	55.186
Russia	Żarnowiec	01-Jan-2007 18:30:00	2.1100E-04	19.931	54.959
Slovakia	Lubiatowo	14-Oct-2009 09:30:00	5.0000E-07	19.053	49.354
Slovakia	Żarnowiec	11-Feb-2011 18:30:00	1.2000E-06	21.555	49.356
Sweden	Lubiatowo	02-May-2005 12:30:00	7.9300E-05	15.703	55.991
Sweden	Żarnowiec	02-May-2005 12:30:00	5.1200E-05	15.741	56.240
Ukraine	Lubiatowo	08-Apr-2011 12:30:00	8.8000E-06	25.765	51.873
Ukraine	Żarnowiec	08-Apr-2011 15:30:00	1.0000E-05	25.765	51.873
Hungary	Lubiatowo	24-Nov-2013 09:30:00	5.2000E-06	18.985	48.099
Hungary	Żarnowiec	24-Nov-2013 09:30:00	5.1000E-06	18.985	48.099

Source: Modelling of contamination and calculation of dose values at a distance of more than 30km from the NPP for accidents representative for emergency planning.

Appendix V.4-2

FDMT model results

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Table V.4-2- 1 Ranges of maximum effective doses for adults from all exposure pathways for neighbouring countries based on results for both sites on the basis of FDMT model results

Receptor	Ranges of maximum effective doses [mSv] for adults from all exposure pathways based on calculations for both sites			
	2-day dose	7-day dose	Annual dose	Lifetime dose
Austria	9.38E-04 -1.88E-03	2.10E-03-4.22E-03	1.54E-02-3.04E-02	3.03E-02-6.10E-02
Belarus	1.07E-04-1.78E-04	1.92E-04-2.21E-04	1.28E-03-1.70E-03	3.28E-03-8.05E-03
Bornholm	9.42E-04-1.80E-03	1.31E-03-2.43E-03	7.78E-03-1.49E-02	2.78E-02-4.74E-02
Czechia	2.69E-03-3.35E-03	5.80E-03-7.37E-03	5.13E-02-6.79E-02	8.83E-02-1.12E-01
Denmark	1.05E-03-1.41E-03	1.79E-03-2.42E-03	1.39E-02-1.91E-02	5.89E-02-7.80E-02
Estonia	3.73E-05-1.08E-03	6.85E-05-2.05E-03	6.85E-04-2.07E-02	2.98E-03-1.03E-01
Finland	5.17E-05-1.37E-04	9.54E-05-2.53E-04	9.03E-04-2.42E-03	4.41E-03-1.22E-02
Netherlands	3.96E-05-4.70E-05	4.82E-05-8.50E-05	2.23E-04-8.44E-04	5.72E-04-3.81E-03
Lithuania	5.98E-04-8.36E-03	1.08E-03-1.75E-02	9.55E-03-8.94E-02	4.14E-02-1.85E-01
Latvia	2.24E-04-2.00E-03	3.99E-04-2.43E-03	3.53E-03-6.01E-03	1.70E-02-1.81E-02
Germany	1.49E-03-2.35E-03	2.59E-03-4.11E-03	2.23E-02-3.45E-02	9.85E-02-1.47E-01
Russia	7.11E-04-1.93E-03	1.27E-03-3.05E-03	1.03E-02-2.36E-02	4.07E-02-9.91E-02
Slovakia	6.37E-06-2.05E-04	1.15E-05-4.61E-04	1.02E-04-1.18E-03	4.74E-04-2.47E-03
Sweden	4.31E-03-6.56E-03	8.92E-03-1.35E-02	3.43E-02-5.23E-02	6.57E-02-9.97E-02
Ukraine	4.50E-05-6.48E-05	4.64E-05-7.40E-05	6.69E-04-9.82E-04	2.34E-03-3.37E-03
Hungary	4.74E-05-5.70E-05	5.94E-05-7.14E-05	3.34E-04-4.30E-04	8.87E-04-1.27E-03

Source: Contamination modelling and calculation of dose values at a distance of more than 30km from the NPP for accidents representative for emergency planning.

Table V.4-2- 2 Ranges of maximum effective doses for children from all exposure pathways for neighbouring countries based on results for both sites on the basis of FDMT model results

Receptor	Ranges of maximum effective doses [mSv] for children from all exposure pathways based on calculations for both sites			
	2-day dose	7-day dose	Annual dose	Lifetime dose
Austria	4.21E-03-8.12E-03	8.13E-03-1.61E-02	2.84E-02-5.77E-02	4.35E-02-8.92E-02
Belarus	1.27E-04-2.42E-04	2.05E-04-4.33E-04	1.55E-03-2.78E-03	3.81E-03-1.01E-02
Bornholm	2.13E-03-3.30E-03	3.48E-03-5.38E-03	2.17E-02-3.36E-02	5.77E-02-8.93E-02
Czechia	1.14E-02-1.54E-02	2.23E-02-3.04E-02	7.97E-02-1.07E-01	1.17E-01-1.50E-01
Denmark	2.26E-03-3.12E-03	4.03E-03-5.56E-03	2.31E-02-3.20E-02	7.45E-02-9.87E-02
Estonia	8.44E-05-2.48E-03	1.57E-04-4.65E-03	1.12E-03-3.36E-02	3.74E-03-1.29E-01
Finland	1.20E-04-3.20E-04	2.20E-04-5.90E-04	4.04E-03-1.50E-03	5.53E-03-1.54E-02
Netherlands	3.24E-05-1.08E-04	5.86E-05-1.96E-04	3.61E-04-1.37E-03	1.36E-03-4.78E-03
Lithuania	1.41E-03-1.25E-02	2.55E-03-2.97E-02	1.60E-02-1.34E-01	5.22E-02-2.26E-01
Latvia	2.10E-03-6.99E-03	3.93E-03-8.35E-03	1.30E-02-1.20E-02	1.58E-02-2.31E-02
Germany	2.99E-03-4.99E-03	5.42E-03-8.99E-03	3.55E-02-5.60E-02	1.22E-01-1.84E-01
Russia	1.69E-03-3.63E-03	2.99E-03-6.47E-03	1.71E-02-3.75E-02	5.08E-02-1.24E-01
Slovakia	1.51E-05-1.22E-03	2.72E-05-2.29E-03	1.70E-04-4.17E-03	6.08E-04-5.65E-03
Sweden	1.90E-02-2.79E-02	3.85E-02-5.07E-02	1.00E-01-1.49E-01	1.36E-01-2.02E-01
Ukraine	9.93E-05-1.71E-04	9.32E-05-1.66E-04	1.31E-03-1.91E-03	3.24E-03-4.60E-03
Hungary	3.48E-05-4.52E-05	5.09E-05-7.00E-05	3.92E-04-5.34E-04	9.39E-04-1.40E-03

Source: Contamination modelling and calculation of dose values at a distance of more than 30km from the NPP for accidents representative for emergency planning.

Table V.4-2- 3 Thyroid absorbed doses for adults in the event of a severe accident representative for emergency planning at nuclear power plant situated at the Lubiatowo - Kopalino site (L-K) or Żarnowiec site (Ż)

Receptor	Source	Longitude	Latitude	Thyroid absorbed dose mGy					
				2-day	7-day	14-day	30-day	annual	lifetime
Austria	L-K	12.677	48.089	1.05E-03	2.35E-03	3.81E-03	5.57E-03	1.72E-02	3.39E-02
Austria	Ż	13.046	48.079	2.11E-03	4.73E-03	7.68E-03	1.12E-02	3.40E-02	6.83E-02
Belarus	L-K	25.807	54.693	1.99E-04	2.48E-04	3.07E-04	4.03E-04	1.43E-03	3.67E-03
Belarus	Ż	23.596	53.442	1.20E-04	2.15E-04	3.30E-04	5.13E-04	1.90E-03	9.02E-03
Bornholm	L-K	14.688	55.032	2.02E-03	2.72E-03	3.58E-03	4.96E-03	1.67E-02	5.31E-02
Bornholm	Ż	14.905	55.023	1.06E-03	1.47E-03	1.96E-03	2.73E-03	8.71E-03	3.11E-02
Czechia	L-K	14.447	51.033	3.01E-03	6.50E-03	1.04E-02	1.52E-02	5.75E-02	9.89E-02
Czechia	Ż	14.81	49.012	3.75E-03	8.25E-03	1.33E-02	1.94E-02	7.60E-02	1.25E-01
Denmark	L-K	12.067	54.982	1.58E-03	2.71E-03	4.07E-03	6.22E-03	2.14E-02	8.74E-02
Denmark	Ż	11.849	54.985	1.18E-03	2.00E-03	3.01E-03	4.58E-03	1.56E-02	6.60E-02
Estonia	L-K	22.546	58.268	1.21E-03	2.30E-03	3.62E-03	5.80E-03	2.32E-02	1.15E-01
Estonia	Ż	24.839	58.533	4.18E-05	7.67E-05	1.20E-04	1.89E-04	7.67E-04	3.34E-03
Finland	L-K	23.431	59.963	1.53E-04	2.83E-04	4.42E-04	6.99E-04	2.71E-03	1.37E-02
Finland	Ż	23.431	59.963	5.79E-05	1.07E-04	1.66E-04	2.61E-04	1.01E-03	4.94E-03
Netherlands	L-K	6.657	52.074	6.33E-05	9.92E-05	1.37E-04	1.71E-04	3.11E-04	9.60E-04
Netherlands	Ż	6.132	51.181	2.07E-04	3.27E-04	4.54E-04	5.66E-04	1.12E-03	3.28E-03
Lithuania	L-K	21.474	55.706	6.70E-04	1.21E-03	1.87E-03	2.92E-03	1.07E-02	4.64E-02
Lithuania	Ż	21.834	55.417	9.36E-03	1.96E-02	3.11E-02	4.54E-02	1.00E-01	2.07E-01
Latvia	L-K	21.219	56.363	2.51E-04	4.47E-04	6.83E-04	1.06E-03	3.95E-03	1.90E-02
Latvia	Ż	25.062	56.201	2.24E-03	2.72E-03	3.24E-03	3.73E-03	6.73E-03	2.03E-02
Germany	L-K	13.722	54.065	2.63E-03	4.60E-03	6.99E-03	1.08E-02	3.86E-02	1.65E-01
Germany	Ż	13.71	53.94	1.67E-03	2.90E-03	4.40E-03	6.81E-03	2.50E-02	1.10E-01
Russia	L-K	21.785	54.533	7.96E-04	1.42E-03	2.17E-03	3.36E-03	1.15E-02	4.56E-02
Russia	Ż	20.476	54.532	2.16E-03	3.42E-03	4.94E-03	7.37E-03	2.64E-02	1.11E-01
Slovakia	L-K	19.294	49.585	2.30E-04	5.16E-04	8.02E-04	9.42E-04	1.32E-03	2.77E-03
Slovakia	Ż	21.776	49.458	7.13E-06	1.29E-05	1.98E-05	3.07E-05	1.14E-04	5.31E-04
Sweden	L-K	15.741	56.24	4.83E-03	9.99E-03	1.57E-02	2.23E-02	3.84E-02	7.36E-02
Sweden	Ż	15.741	56.24	7.35E-03	1.51E-02	2.37E-02	3.36E-02	5.86E-02	1.12E-01
Ukraine	L-K	24.991	50.318	5.04E-05	5.20E-05	7.41E-05	2.13E-04	7.49E-04	2.62E-03
Ukraine	Ż	23.546	51.407	7.26E-05	8.29E-05	1.22E-04	3.19E-04	1.10E-03	3.77E-03
Hungary	L-K	18.116	47.418	5.31E-05	6.65E-05	8.29E-05	1.09E-04	3.74E-04	9.93E-04
Hungary	Ż	19.173	47.198	6.38E-05	8.00E-05	1.00E-04	1.37E-04	4.82E-04	1.42E-03

Source: Contamination modelling and calculation of dose values at a distance of more than 30km from the NPP for accidents representative for emergency planning.

Table V.4-2- 4 Thyroid absorbed doses for children in the event of a severe accident representative for emergency planning at nuclear power plant situated at the Lubiatowo - Kopalino site (L-K) or Żarnowiec site (Ż)

Receptor	Source	Longitude	Latitude	Thyroid absorbed dose mGy					
				2-day	7-day	14-day	30-day	annual	lifetime
Austria	L-K	12.677	48.089	5.09E-03	9.84E-03	1.49E-02	1.98E-02	3.44E-02	5.26E-02
Austria	Ż	13.046	48.079	9.83E-03	1.95E-02	3.00E-02	4.03E-02	6.98E-02	1.08E-01
Belarus	L-K	25.807	54.693	1.54E-04	2.48E-04	3.57E-04	5.02E-04	1.88E-03	4.61E-03
Belarus	Ż	23.596	53.442	2.93E-04	5.24E-04	7.95E-04	1.19E-03	3.36E-03	1.22E-02
Bornholm	L-K	14.688	55.032	2.58E-03	4.21E-03	6.12E-03	8.92E-03	2.63E-02	6.98E-02
Bornholm	Ż	15.123	55.014	3.99E-03	6.51E-03	9.47E-03	1.38E-02	4.06E-02	1.08E-01
Czechia	L-K	14.447	51.033	1.38E-02	2.70E-02	4.13E-02	5.57E-02	9.64E-02	1.42E-01
Czechia	Ż	14.81	49.012	1.86E-02	3.68E-02	5.64E-02	7.57E-02	1.29E-01	1.82E-01
Denmark	L-K	12.067	54.982	3.78E-03	6.73E-03	1.02E-02	1.50E-02	3.87E-02	1.19E-01
Denmark	Ż	11.849	54.985	2.73E-03	4.88E-03	7.37E-03	1.09E-02	2.80E-02	9.01E-02
Estonia	L-K	22.546	58.268	3.00E-03	5.63E-03	8.76E-03	1.34E-02	4.07E-02	1.56E-01
Estonia	Ż	24.839	58.533	1.02E-04	1.90E-04	2.93E-04	4.50E-04	1.36E-03	4.53E-03
Finland	L-K	23.431	59.963	3.87E-04	7.14E-04	1.10E-03	1.68E-03	4.89E-03	1.86E-02
Finland	Ż	23.431	59.963	1.45E-04	2.66E-04	4.10E-04	6.24E-04	1.82E-03	6.69E-03
Netherlands	L-K	6.657	52.074	3.02E-04	4.64E-04	6.33E-04	7.58E-04	9.45E-04	1.64E-03
Netherlands	Ż	6.132	51.181	9.80E-04	1.52E-03	2.09E-03	2.51E-03	3.31E-03	5.62E-03
Lithuania	L-K	21.474	55.706	1.71E-03	3.09E-03	4.73E-03	7.14E-03	1.94E-02	6.32E-02
Lithuania	Ż	21.834	55.417	1.51E-02	3.59E-02	6.07E-02	8.94E-02	1.62E-01	2.74E-01
Latvia	L-K	25.062	56.201	8.46E-03	1.01E-02	1.17E-02	1.25E-02	1.57E-02	2.80E-02
Latvia	Ż	21.663	56.322	2.54E-03	4.76E-03	7.14E-03	9.44E-03	1.45E-02	1.91E-02
Germany	L-K	13.722	54.065	6.04E-03	1.09E-02	1.66E-02	2.49E-02	6.78E-02	2.23E-01
Germany	Ż	13.71	53.94	3.62E-03	6.56E-03	1.00E-02	1.51E-02	4.30E-02	1.48E-01
Russia	L-K	21.785	54.533	2.04E-03	3.62E-03	5.47E-03	8.07E-03	2.07E-02	6.15E-02
Russia	Ż	20.476	54.532	4.39E-03	7.83E-03	1.18E-02	1.61E-02	4.54E-02	1.50E-01
Slovakia	L-K	19.294	49.585	1.48E-03	2.77E-03	4.05E-03	4.54E-03	5.05E-03	6.84E-03
Slovakia	Ż	21.776	49.458	1.83E-05	3.29E-05	5.00E-05	7.37E-05	2.06E-04	7.36E-04
Sweden	L-K	15.741	56.24	2.30E-02	4.66E-02	7.18E-02	9.46E-02	1.21E-01	1.65E-01
Sweden	Ż	15.741	56.24	3.38E-02	6.13E-02	1.06E-01	1.39E-01	1.80E-01	2.44E-01
Ukraine	L-K	24.991	50.318	1.20E-04	1.13E-04	1.73E-04	6.18E-04	1.59E-03	3.92E-03
Ukraine	Ż	23.546	51.407	2.07E-04	2.01E-04	2.96E-04	9.62E-04	2.31E-03	5.57E-03
Hungary	L-K	18.116	47.418	4.21E-05	6.16E-05	8.51E-05	1.22E-04	4.74E-04	1.14E-03
Hungary	Ż	19.173	47.198	5.47E-05	8.47E-05	1.21E-04	1.77E-04	6.46E-04	1.69E-03

Source: Contamination modelling and calculation of dose values at a distance of more than 30km from the NPP for accidents representative for emergency planning.