



Use of the BWRX-300 technology in Poland – benefits for the economy and local authorities

Warsaw, September 2023



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01 Executive Summary



Executive Summary (1/5)

The SMR technology is a more flexible approach to nuclear power:

SMRs are small modular reactors with the capacity of **up to 300 MWe per unit**. They are smaller, which translates into a shorter construction time, a lower financial threshold and a gradual possibility to expand the power plant as demand increases.

SMRs use **passive safety systems** that ensure reactor safety without accessing power and without human intervention. Given their smaller emergency planning zone, SMRs can be deployed closer to human settlements in the areas inaccessible to larger nuclear power plants.



Low system costs and approximately 3 times longer lifetime of SMRs mean that over the life of the power plant, with the right operating profile, **atomic energy can be cheaper than RES energy for the end user⁽¹⁾**.



Currently, the most advanced SMRs with the steam of approximately 280°C–325°C are used in the production of electricity and heat **for municipal needs and some energy-intensive industries**.



Because of Poland's high provision of district heating, **SMRs have a great potential of using cogeneration** for municipal and industrial applications.



Among the various designs and concepts of SMRs, the **BWRX-300** is the reactor with the greatest declared commercial sophistication. The first plant is expected to begin operation in Canada in 2028, while in Poland the first plant could become operational in 2029.

1. An assessment of the Levelized Cost Of Energy (LCOE) increased by system costs shows that atomic energy is cheaper for the end user than wind energy, both onshore and offshore, photovoltaic energy, biomass and biogas energy. The conclusions have been developed on the basis of: Biznes Alert, Jak finansować elektrownię jądrową [How to finance a nuclear power plant], by dr inż. Andrzej Strupczewski, prof. nadzw. [Ph. D., Eng., Associate Professor] NCBJ, 2021.

Executive Summary (2/5)

Energy transition using SMRs can take place in three areas:



Professional power sector

SMRs could replace coal-fired power plants that are being phased out. Both the locations and infrastructure used by today’s coal-fired power plants are suitable for the adaptation for the construction of SMRs.



District heating

Achieving the status of **efficient district heating networks** and **avoiding pollutant emissions** with limited use of gas is possible by using the SMR as a cogeneration source.

The cost of heat generated in cogeneration with the SMR is independent of fluctuations in the prices of coal, gas and CO₂ emission allowances by which it offers **a stable price for end users**.



Industry

The most mature SMR technologies can play a key role in the **electrification of the domestic industry** (e.g., by introducing electric furnaces in metallurgy). It turn, direct use of process steam with lower parameters will be possible in **a limited number of industrial processes** (mainly in the paper industry), but **in cooperation with other conventional heat sources**, process steam may have wider applications (e.g., in the chemical industry).

As the SMR technology advances and matures, new types of reactors with higher steam parameters will be able to find applications in decarbonizing more industries (e.g., hydrogen, cement, glass production).

“

The district heating sector based in

70%

on coal will have to be retrofitted to comply with the IED Directive.

Executive Summary (3/5)

Methodology and assumptions

- The economic impact of the BWRX-300 reactor was estimated using the Input-Output model, which allows for the analysis of dependencies between sectors of the economy and the estimation of the **impact of the operations on the entire Polish economy**.
- The impact on the economy was calculated for the following categories: **gross value added, wages and employment**.
- There are three levels of economic impact: **direct** (resulting from the direct actions of the entity), **indirect** (resulting from the activities of suppliers and sub-suppliers), and **induced** (resulting from the additional consumption of employees).
- In addition, potential tax revenues were estimated, specifying revenues to local authority units.
- The impact period was divided into two phases – an **investment phase** lasting **7 years**, with **construction work** lasting about **3 years**, and an **operational phase** lasting about **60 years**.
- The analysis shows the economic impact generated by a single **reference** BWRX-300 reactor and the multiplication of the results when building a fleet of **4, 10 and 30** reactors with a learning curve.

Investment phase:

- The investment phase of a single reference reactor can generate a total of **PLN 3.2 billion in gross value added**, PLN 1.2 billion in wages **throughout the phase**, and can **sustain 2,719 jobs annually**.

Operational phase

- The operational phase can generate **PLN 746 million in gross value added annually**, PLN 73 million in wages, and sustain 737 jobs annually.
- According to estimates, in a standard year of the operational phase, a power plant with a single reactor can sustain 100 jobs (direct impact on employment).
- Over its lifetime (60 years), a power plant with a single reactor could generate gross value added of PLN 20.9 billion and contribute to an increase in wages estimated at PLN 2.0 billion.

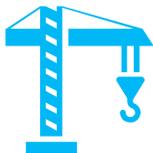


Executive Summary (4/5)



Tax revenues

- It is estimated that the annual revenue from the PIT with a single reference reactor will be more than PLN 8 million, of which more than PLN 4 million is the potential revenue for the local authority units.
- The potential annual revenue from the CIT is estimated at more than PLN 80 million, of which nearly PLN 19 million would be allocated to the budgets of local authority units.
- The potential real property tax revenue would add about PLN 360,000 to the local government budget per year.
- The total potential tax revenue to the budgets of local governments is about PLN 9.0 million per year.
- In the event that the full value of structures assumed by OSGE were subject to the tax on structures, this could mean additional revenues to the local government budget in the amount of PLN 12 million per year.



Fleet construction – accumulated benefits

- If a fleet of units is built, the estimated effects can be multiplied.
- The investment phase for the construction of a fleet of 4, 10 and 30 reactors could generate PLN 11,100, 25,500 and 73,400 million in added value, PLN 4,250, 9,700 and 28,000 million in wages, respectively, as well as sustain 9,550, 21,900 and 63,050 jobs annually for the duration of the phase.
- During one averaged year of operation, a fleet of 4, 10 and 30 reactors could generate PLN 3,000, 7,000 and 22,000 million in added value, PLN 300, 700 and 2,000 million in wages, sustain 3,000, 7,000 and 22,000 jobs annually, and generate PLN 400, 900 and 3,000 million in tax revenues.



Non-financial benefits

- The estimated economic effects are not limited to monetary values. The prospect of building an entire fleet of reactors means increased demand for highly qualified employees.
- Programs for training technical personnel for the nuclear power industry are planned, as well as cooperation with the academic community to launch a new academic majors.

Executive Summary (5/5)

Climate goals contained in the regulatory package known as the challenge for Poland in terms of decarbonizing the economy.

Regulatory pressure is causing European financial institutions to implementation does not support the achievement of ESG goals.

Nuclear power complies with the EU Taxonomy as an activity that is safe and contributes to environmental goals and therefore guided by ESG policies.

The BWRX-300-type SMR allows to avoid emissions of 175 million tons of CO₂ and approximately 170,000 tons of dust and nitrogen oxides over its lifetime, compared to a single coal-fired unit.

For regions affected by the gradual phasing out of coal-fired power plants, the construction of SMRs will provide new jobs and development of local businesses and infrastructure. The SMR is also an opportunity to attract investments from energy-intensive industries, such as chemical plants, the paper industry and metallurgy based on the use of arc furnaces.



Poland has the **second highest ratio of CO₂ emissions** to GDP per capita in the European Union, second only to Bulgaria⁽¹⁾, which means that meeting climate goals will require significant investments in generation sources and transmission infrastructure.

1. World Bank as cited in Climate Watch. 2020. GHG Emissions. Washington, DC: World Resources Institute.

02 Introduction



Introduction

Most countries now recognize the need to decarbonize their economies to slow down climate change. In Poland, the energy transition is focused on the need to phase out coal-fired power plants by 2050 and to invest in the development of renewable energy.

Renewable sources are increasingly filling the gap left by coal and other fossil fuels, but although they have an important role to play, they also have some limitations. Wind energy is intermittent and affects the local environment, by requiring wind turbines to be located over vast areas of land and sea. Solar energy is predictable, but requires significant amounts of land to place photovoltaic panel farms, making it less suitable for areas with high population densities. Hydropower, as the most developed renewable energy source, can provide constant and controlled power, but the location of such hydropower plants is limited by the presence of rivers and suitable terrain.

This means that countries should consider including nuclear energy in their plans to replace fossil fuel power generation. Nuclear power is an emission-free source of energy, which results from the fact that it does not emit gases that are harmful to the environment and health, in particular carbon dioxide (CO₂), nitrogen and sulfur compounds (SO_x and NO_x) or dust during the energy production process. Only a small amount of emissions arise from uranium mining and refining, transportation and waste storage, and represents a small fraction of the emissions produced by coal and natural gas.

Small Modular Reactors (SMRs) can replace existing coal- and gas-fired power plants. These three sources generate electricity in very similar ways. This means that some parts of existing power plants can be reused, such as land, grid connections, power outputs, infrastructure and buildings. Converting existing plants into nuclear power plants, rather than closing them, will reduce job losses and drops in tax revenues and local authority budgets.

In addition to replacing worn-out power units, SMRs can provide process steam or electricity for energy-intensive industrial processes, such as the chemical industry, steel, cement, glass or hydrogen fuel production, as well as for transport purposes, contributing to the achievement of climate neutrality for the entire economy.

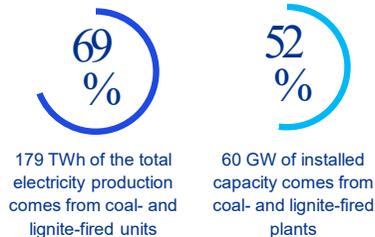
Whether SMRs replace fossil fuels in power plants or supply industrial processes, they can be installed in a modular way based on standardized designs and processes. This means they can be implemented faster, cheaper and much more extensively than is currently the case with traditional nuclear projects.



Poland's climate goal is to phase out coal by 2050

The Polish electricity generation sector is based on conventional, centrally located generating units that produce electricity from coal and lignite.

Production from coal-fired units in 2022:



1.  the largest EU coal producer and consumer

67% of CO₂ emissions under EU ETS come from power plants and combined heat and power plants in 2021.⁽¹⁾

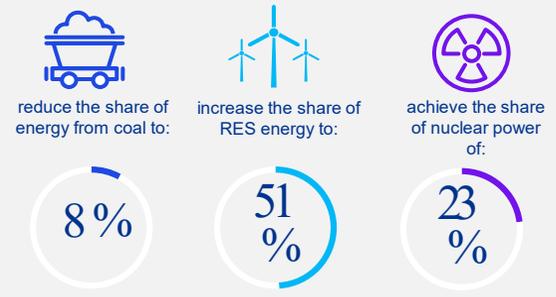
1. KOBIZE, "Raport z Rynku CO₂" [CO₂ Market Report], 2022

The EU policy sets clear milestones for the energy transition:

reduction of greenhouse gas emissions by at least **55 %** by 2030 compared to 1990 (and full climate neutrality by 2050)

at least **42.5 %** share of renewable energy sources in the final energy consumption by 2030.

Poland is subject to EU goals, but has not committed itself to individual climate neutrality goals. "The Energy Policy of Poland until 2040" (EPP2040) adopted in February 2021 is being updated² for the third time and assumes that Poland by 2040 will:



According to the agreement reached by the government with the miners, the last mine in Poland is to close in

2049

The estimated cost of the energy transition by 2040 was estimated to be

PLN 726 billion⁽³⁾

3. Generating sources only

The official position of the EU and Poland on SMRs



The European Commission (EC) notices the interest of member states in using SMRs for power generation, production in cogeneration and providing hybrid operation of power systems, which integrate nuclear and renewable energy.

At the same time, the EC acknowledges that in addition to electricity generation, SMRs can play an important role in sectors particularly difficult to decarbonize, i.e. industry, district heating or transportation. The EC also recognizes that the deployment of SMRs in Europe can imply positive socio-economic impacts in the form of new jobs for highly qualified employees in the EU and the creation of enterprises of high value added for the economy.

EC declaration on EU SMR 2030

On April 4, 2023, the EC published the **Declaration on EU SMR 2030** *The role of Research, Innovation, Education and Training in the safety of Small Modular Reactors (SMRs) in the European Union*, which emphasizes that the deployment of SMRs in Europe:

complements existing assets	improves nuclear safety through passive safety systems
increases the stability of the grid, contributing to the growth of RES generation	improves concreteness in the nuclear industry especially in the context of the shift away from Russian technologies

At the same time, the EC encourages new entities, including SMEs and spin-offs, to enter the civilian nuclear sector, attracting additional investment in demonstration and deployment. It also emphasizes the need to experiment, test and qualify new fuels, materials and technologies for the entire life cycle of advanced SMRs, knowledge dissemination, training and human capacity building.

Source: https://research-and-innovation.ec.europa.eu/system/files/2023-04/ec_rtd_eu-smr-declaration-2030.pdf

Euratom Work Program 2023-2025

On March 17, 2023, the EC adopted the **Euratom** Work Program for 2023-2025, allocating the first funds for research on the safety of European SMR technologies, specifically the most mature ones, i.e. light-water reactors. The EC expects complementary directions to support the development of SMR technologies in various sectors (health, industry, space) and education and training activities under other EU programs: **Horizon Europe** and the **Digital Europe Program**.



Poland, as well, in view of the macroeconomic situation, already in March 2022, decided that it needed to change its approach to ensuring energy security towards greater diversification and independence.

EPP2040 update

The assumptions of the update to the Energy Policy of Poland until 2040 (EPP2040) envisage activities aimed at the prospective implementation of the SMR technology towards process heat generation in the industry and district heating as an alternative to conventional units. Such solutions can add to the diversification of the electricity generation structure, creating a factor for strengthening energy security at the local level. The draft EPP2040 update of June 2023 assumes the construction of the first SMR by 2030.

03

Concept of the SMR development in Poland



The SMR technology is a more flexible approach to nuclear power:

Small modular reactors are advanced nuclear reactors with the capacity of up to 300 MWe per unit, with lower capital requirements compared to the traditional nuclear power plant.

The modular nature of SMRs means that the reactor design is optimized and consists of compatible components that can be manufactured under factory conditions, transported and assembled on site, unlike large nuclear power plants.

SMRs also have fewer requirements regarding access to cooling water and can be built closer to human settlements than large-scale reactors, which facilitates their deployment.

Due to the modularity of SMRs and the potential for scaling, investments can be made in stages over time, thus reducing initial costs.

Small

with a footprint area that allows up to 4 modules to be installed in the same footprint as a single coal-fired power plant

Modular

modules (components) can be manufactured at the factory and transported to the site, additional modules (units) can be added as energy demand increases

Reactors

use nuclear fission to generate heat and produce energy



15–300 MWe

power per unit, which is about a third of the generating capacity of traditional nuclear reactors



Scalability

modules can be mounted next to others and scaled to meet local electricity needs



< 1 km

an emergency planning zone that allows SMRs to be deployed in areas inaccessible to larger power plants



2–5 years

anticipated construction time, while a large reactor is built from 6 to 12 years



Lower financial threshold

compared to a large nuclear reactor (USD 5.3 billion for a 1 GWe reactor, against USD 1.3 billion for a BWRX-300 MWe)



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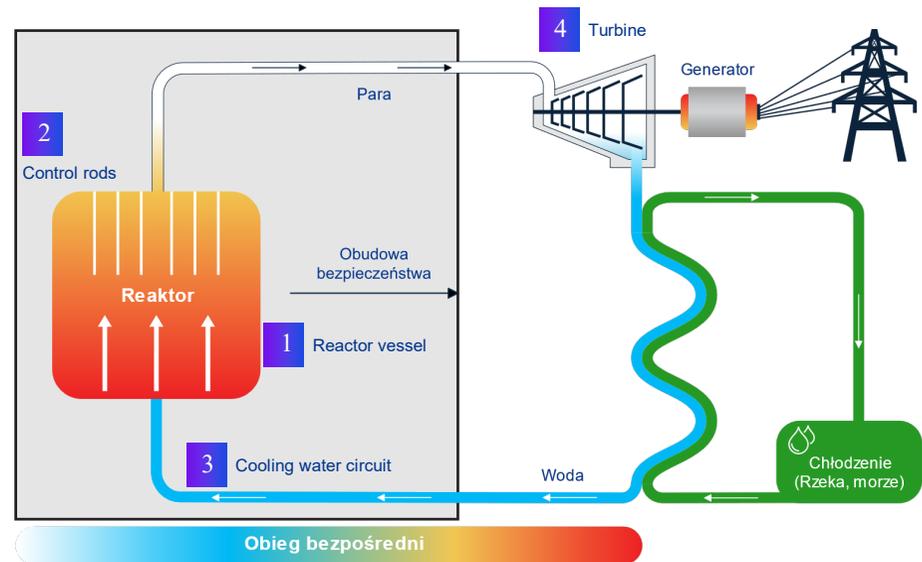
CO₂ emissions from electricity generation

SMRs use the same principle as large nuclear reactors

Nuclear reactors of all sizes use a nuclear fission chain reaction, accompanied by the release of large amounts of energy. For the world power industry, the most important are Light Water Reactors (LWRs), cooled and moderated by ordinary water, which together account for more than 82% of all operating reactors and produce 90% of the electricity generated by the nuclear power industry. A diagram of the Boiling Water Reactor (BWR) operation is presented below:

- 1** Nuclear power plants **generate heat through nuclear fission**. The process begins in the reactor core, where atoms are split – releasing energy and generating heat. The process occurs continuously through a fully controlled chain reaction
- 2** **Control rods** made of neutron absorbing material are inserted into or extracted from the reactor core to safely regulate the amount of heat generated by the chain reaction
- 3** **Cooling water** flowing through the reactor core collects heat generated by the fission process, changing its physical state to steam
- 4** Pressurized steam drives **the turbine** that generates electricity
- 5** Generation III+ nuclear power plants use **passive safety systems** that reduce the risk of accidents caused by the loss of cooling water and ensure reactor safety without human intervention

Figure: Operating diagram of the BWR-type reactor



Source: Compiled by KPMG on the basis of the educational page of the National Center for Nuclear Research, LWR – light water reactors (PWR, BWR)

Nuclear fuel could replace fossil fuels from 2029

The energy crisis and the increased pace of implementing EU climate goals are accelerating the development of renewable and nuclear power sector.

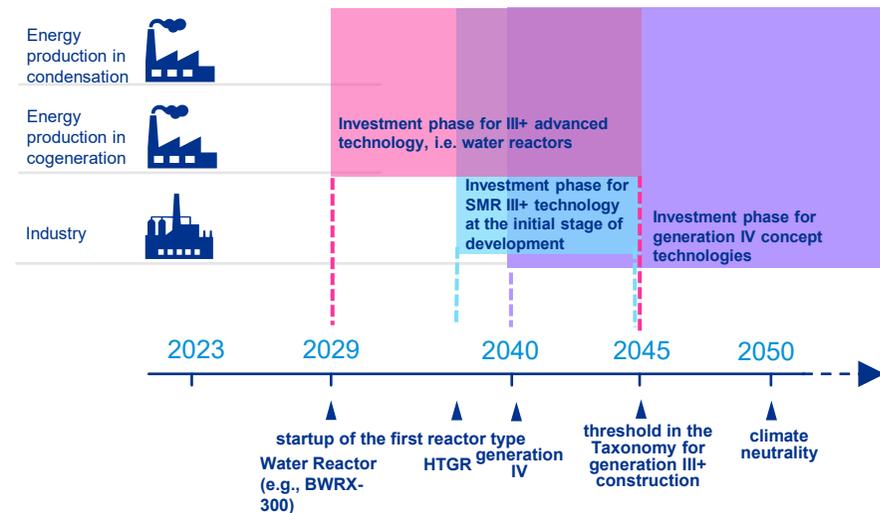
Uncertainty regarding the availability and prices of imported raw materials, high prices of CO₂ emission allowances, as well as regulatory requirements related to the implementation of the EU climate policy, such as emission limits, the need to apply decarbonization components, e.g.: low-emission fuels, renewables, CCS, pose a challenge to conventional units, meaning coal and gas. Therefore, the future role of natural gas in the energy transition is somewhat questionable.

Despite the rapid development of renewable, non-controllable sources with low power availability factor, the power system needs technologies that work in the base, as well as relatively quickly respond to ensure system balancing.

Nuclear power, like gas power, is an available and controllable source with the added advantage of being emission-free. Thus, it is perfect for stabilizing the operation of the power system.

Based on the results of research and development works and assurances from technology suppliers, it is possible to obtain the first operating experience in Poland as early as in 2029. Therefore, it is worth considering the possibility of eliminating the need for transitional fuel in the form of gas and replacing it with the target fuel in the form of nuclear fuel. As a result, nuclear power can become a complementary, stabilizing and integrating source of energy in view of shutting down conventional units and dynamically developing RES units, replacing gas, which is unstable in terms of volume and price.

Like conventional power plants, SMRs produce steam that can be used for:



The technological readiness of the low-temperature SMR, or Water Reactor, technology enables its application in the energy sector as early as in 2029 in connection with:

- planned coal power shutdowns,
 - the need to retrofit the heating sector in accordance with the IED directive,
- and as high-temperature technologies and generation IV reactors develop, it will become possible to transform the industry to a low-emission one aiming for climate neutrality in 2050.

Source: Own study

District heating needs urgent systemic solutions

Efficient district heating systems and reduction of air pollutant emissions are possible from 2029 with SMRs as cogeneration sources.

Supporting cogeneration is an important part of the energy transition. As in the professional power industry, the dominant fuel in district heating is hard coal (70%), followed by gas (10%).⁽¹⁾ System heat is produced and supplied by licensed energy undertakings operating in district heating systems with a contracted power of more than 5 MW. System heat is generated

- mainly in coal-fired water boilers, which is why as many as 83% of the licensed district heating systems (red points on the map) do not meet the criteria of an efficient district heating system as defined in Article 7b section 4 of the Energy Law. This criterion, once the investment is completed, is one of the factors determining the possibility of obtaining financial support from public funds for the modernization of district heating systems,⁽²⁾
- in cogeneration and forms the basis for the recognition of 17% of district heating systems as energy efficient (green points on the map). They are located in major cities and are powered mainly by coal fuel.

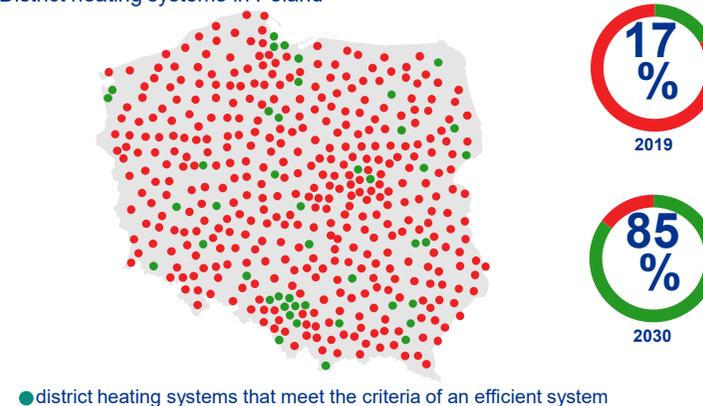
The problem with inefficient district heating systems should be solved by 2030. According to draft strategic documents for Poland⁽³⁾, the goal is to achieve the status of efficient district heating networks at the level of 85% by:

- replacing heating plants with cogeneration sources of about 5.1 GWe;
- retrofitting existing cogeneration sources of about 5 GWe.

An efficient district heating system, is a system that uses

- at least 50% energy from renewable sources, or
- at least 50% waste heat, or
- at least 75% heat from cogeneration, or
- at least 50% combination of such energy and heat.

Fig. District heating systems in Poland



Achieving a significant improvement in the efficiency of the district heating system in Poland with a limited share of coal and gas fuels will be possible, provided that mature SMR technologies are used starting from 2029 onwards cooperating with RES

1. Energetyka ciepła w liczbach [Thermal power sector in numbers], 2022, ERO [Energy Regulatory Office]
2. Raport o ciepłownictwie [Report on district heating], 2020, IGCP [Chamber of Commerce Polish District Heating]
3. Projekt strategii dla ciepłownictwa do 2030 r. z perspektywą do 2040 r. [Draft strategy for the district heating sector until 2030 with an outlook to 2040], 2022, MKiS [Ministry of Climate and Environment]

158 heat sources urgently need to be retrofitted or replaced

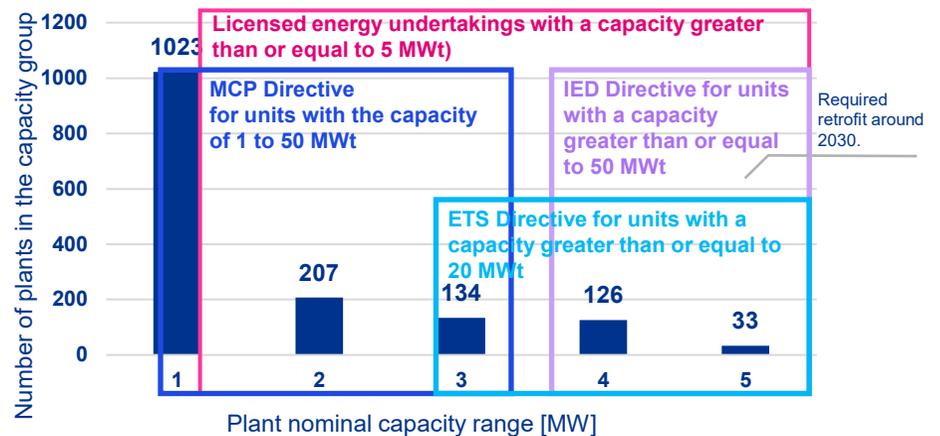
SMRs can replace district heating and CHP plants of the capacity over 50 MWt requiring retrofit to comply with the IED Directive.

Existing combined heat and power plants need to be retrofitted due to the emission requirements of EU directives: MCP Directive and IED Directive. In the long term, it is planned to phase out coal fuels in district heating and generate system heat mainly through cogeneration based on less emitting gaseous fuels. Ultimately, a complete transition to zero-emission fuels will be necessary to achieve climate neutrality in 2050.

In the Polish district heating system:

- in terms of numbers, small sources of less than 1 MWt and medium capacities of 1 to 50 MWt located mainly in smaller cities with up to 100,000 residents, dominate. They do not provide the basis for further analysis of the SMR development in the perspective until 2040 due to the small volume of heat consumption and the need to bring these units into compliance with the emission standards set by the MCP Directive (Medium Combustion Plants), i.e. sulfur dioxide (SO₂), nitrogen oxides (NO_x) and particulate matter (dust) by 2025,
- there are 158 large commercial sources with thermal power greater than or equal to 50 MWt. These sources will require retrofitting starting from around 2030, when new emission standards set by the Industrial Emissions Directive (IED) will take effect. The directive could be an additional impediment to extending the operation of existing coal-fired sources – in addition to the restrictions already in place due to, among others, limitations on the support from the Capacity Market from 2025, or very high CO₂ price forecasts in the EU ETS. These sources are the potential for the development of SMRs as nuclear cogeneration in Poland.

Fig. Number of “commercial heating plants” and “commercial combined heat and power plants” by thermal capacity⁽¹⁾



Source: Own study

According to estimates, the expenditures required to adjust existing sources to new standards are:

- approx. PLN 100–150 million (for a source of about 500 MWt)
- approx. PLN 300–600 million (for a source of about 1,000 MWt)⁽²⁾

In addition, the lack of revenues from the Capacity Market, high costs of carbon emissions and fluctuations in prices of fossil fuels will drive investment decisions towards zero-emission target solutions for district heating.

1. Projekt strategii dla ciepłownictwa do 2030 r. z perspektywą do 2040 r. [Draft strategy for the district heating sector until 2030 with an outlook to 2040], 2022, MKiS [Ministry of Climate and Environment]
 2. Nowy program pilotażowy „Ciepłownictwo powiatowe”, 2019, Nowoczesne ciepłownictwo [New district heating pilot program, 2019, Modern district heating]

In industry, SMRs can provide 1.5 GW of process steam

As the technology develops, SMRs will find application in more and more industries.

Steam generated in Water Reactors (temperature around 300°C at the turbine inlet) has limited industrial use. It can be used:

- for seawater desalination or
- in cooperation with other sources of high-temperature heat
 - in the paper industry,
 - for methanol production, and even
 - in the chemical industry.

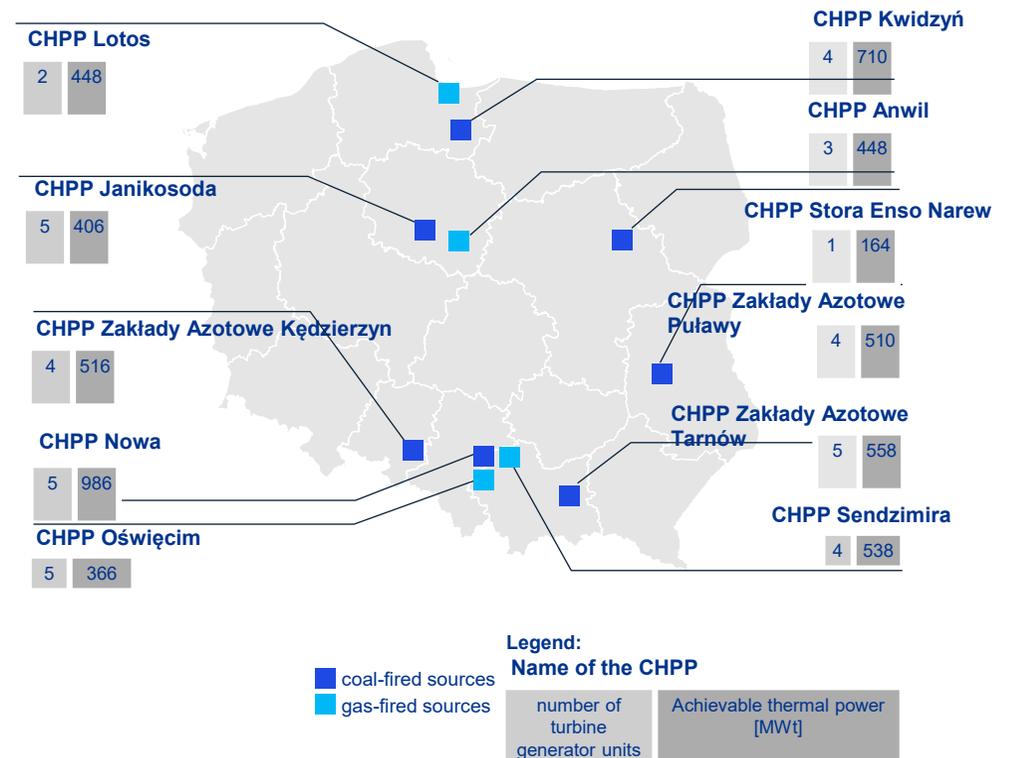
Considering the high level of technological readiness, Water Reactors (BWRX-300 type) can find application from 2029 in:

- paper plants, i.e: CHPP Kwidziń, CHPP Stora Enso Narew (774 MWt)
- heat sources working in tandem with gas-fired units and, in the future, nuclear high-temperature reactors, i.e: CHPP Oświęcim, CHPP Sendzimir, CHPP Anwil, CHPP Lotos (at the level of about 50% of needs, i.e. about 700 MWt) replacing thermal capacities of 1.5 GWt.

Steam at ~ 500°C is a standard heat carrier in many large industrial plants, mainly chemical plants. The Polish industry's demand for steam with such parameters is about 6.5 GWt at a dozen locations. The optimal technology for such steam parameters will be HTGR-type reactors. Their application would be facilitated by the fact that they would replace end-of-life gas or coal-fired boilers while preserving existing facilities, including turbines that produce electricity for the plant. Technical readiness for these technologies is expected to be achieved after 2040. ⁽¹⁾

Steam at temperatures above 1,000°C has key application potential due to the production of hydrogen and hydrogen-derived fuels. Research work on suitable VHTR reactors is still ongoing.

Map: Poland's largest industrial combined heat and power plants



1. Report of the Team for Analysis and Preparation of Conditions for Implementation of High-Temperature Nuclear Reactors, Department of Nuclear Energy of the Ministry of Energy, 2017

Examples of the BWRX-300 application in industry

Combined heat and power plant in the paper industry

- Similarly to cement plants or glass factories, the pulp and paper industry is an energy-intensive industry with an estimated consumption of 2.7 MWh of energy for every ton of paper produced.
- Paper plants use steam produced from coal-fired boilers, fluidized bed boilers firing e.g.: forest or agricultural biomass, sewage sludge and waste paper sludge, soda boilers firing black liquor, and gas-fired heating boilers.
- The total capacity of the example paper plants is about 600 MWt and 100 MWe can also be used to supply local residents with heat.
- The required process heat temperature is 120°C, which is within the range of parameters of the steam produced by the BWRX-300.



Combined heat and power plant in the chemical industry

- The chemical industry in Poland is an economically important industry, but it operates in a highly competitive international market. Increasing competitiveness by reducing energy intensity is therefore particularly important.
- Chemical plants use steam produced mainly from coal-fired boilers or combined cycle gas turbines.
- The total capacity of the example chemical plants is about 400 MWt and 100 MWe can also be used to supply local residents with heat.
- The cooperation of high-temperature combined cycle gas turbines with the BWRX-300 will allow to achieve steam parameters required for the chemical industry.



Steelworks in the metallurgical industry

- The metallurgical industry is an energy-intensive industry. High prices of coal, gas and CO₂ emission allowances, have resulted in the prices of EU-produced steel to achieve record levels, contributing to high industrial inflation.
- Among other things, the metallurgical plants are equipped with blast furnaces fired by coking coal, the price of which fluctuated wildly after the outbreak of the war in Ukraine.
- The electrification of the steel industry under consideration, aimed at adjusting the sector to environmental requirements and maintaining steel production in Europe, will increase the demand for electricity fivefold.
- BWRX-300 reactors can be located right next to steelworks, ensuring stable energy supply and reducing transmission losses.



04

Analysis of the impact of SMRs on the Polish economy

Using the reference reactor as
an example



The impact of the BWRX-300 on the Polish economy using the reference reactor as an example

The economic impact of the BWRX-300 on the Polish economy* was estimated based on the **Input-Output (Leontief) model** and data provided by OSGE using a **sample reference reactor**.

The estimates covered both the **investment phase** and the **operational phase**.

The impact on the economy was calculated for the following categories:

- **Gross value added**
- **Wages**
- **Employment**

In addition, potential tax revenues to local authority units were estimated.



Gross value added

The analysis of gross value added helped to determine the contribution to the production process of goods and services in the Polish economy. The investment phase, together with the BWRX-300 reactor's 60-year operating life, could generate more than PLN 24 billion in gross (discounted) value added.



Wages

The analysis also aimed to estimate the potential value of wages generated in the Polish economy. Over the full time horizon, the operation of the BWRX-300 reactor could generate more than PLN 3 billion in wages.



Employment

The estimates also included the number of jobs created in the Polish economy. The start-up and operation of the BWRX-300 reactor could potentially generate more than 2,700 and 730 new jobs in Poland, respectively, sustained annually.



Taxes

The operating activities of the BWRX-300 can also generate positive impact on tax incomes, especially at the local level.

Investment phase

Over PLN 3.2 billion

Gross value added during the entire phase

Over PLN 1.2 billion

Wages during the entire phase

Even 2,700 jobs Sustained annually

Operational phase of the BWRX-300 reactor

Almost PLN 750 million

Average annual impact on gross value added

Over PLN 73 million

Average annual impact on wages

Over 730 jobs sustained annually

Over PLN 23 million

Potential annual impact for local authority units

*RESERVATION: The economy impact assessment based on OSGE data and assumptions; KPMG did not verify their accuracy. The impact estimated based on expenses assumed to be incurred in Poland.

Methodology for calculating the economic impact

The economic impact of the BWRX-300 reference reactor on the Polish economy was estimated using the **Input-Output model**, also known as the Wassily Leontief model, and based on data and assumptions provided by OSGE.

The model makes it possible to **analyze the relationship between industries**. Dependency and flow analysis makes it possible to estimate the impact of the company's activities on the Polish economy as a whole.

The calculation of the economic impact on the Polish economy at each level covered three main aspects: **gross value added, employment and wages**.

The analysis made it possible to determine:

- the contribution to the process of production of goods and services in the Polish economy,
- the **number of jobs** sustained in the economy,
- the **level of wages** generated in the economy.

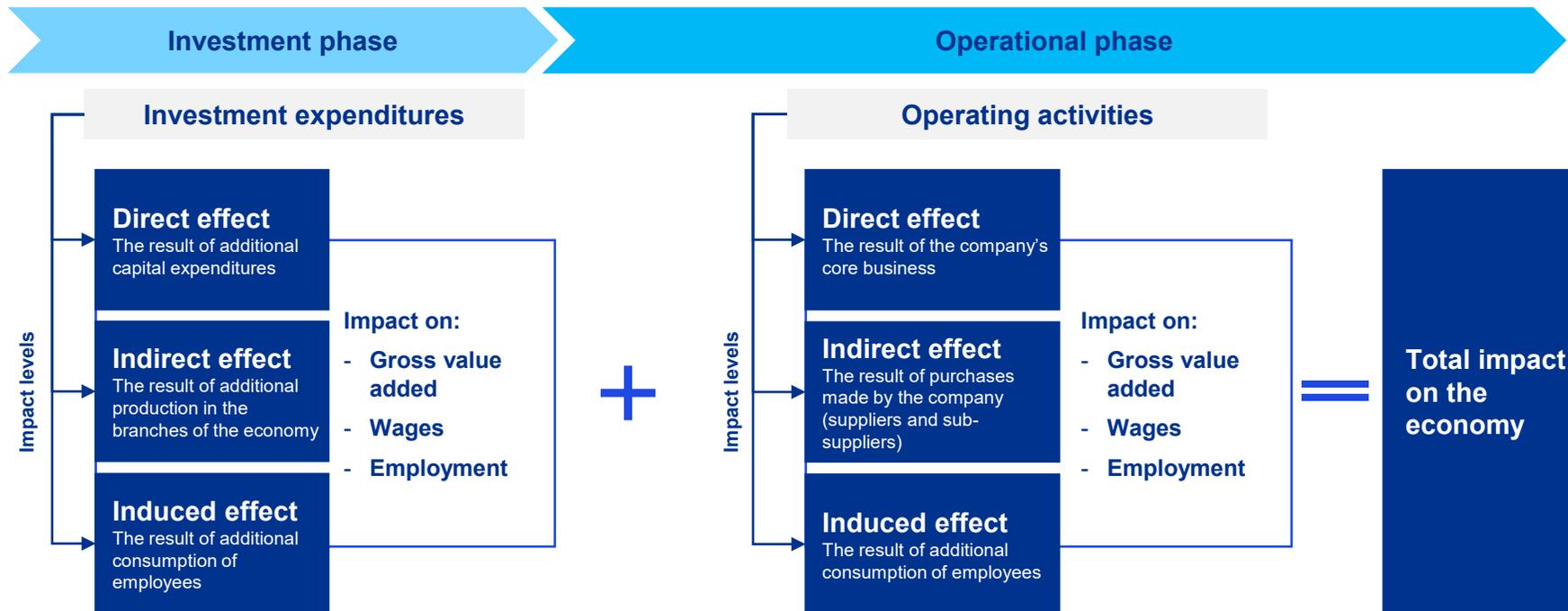
The model was used to estimate both the effects of investments and the effects of operations.

When **estimating the effects of investments**, the main determinant of the results achieved is **capital expenditures**.

In the case of **operations**, the effect is created by both the **surpluses generated by the company** and the **expenses generated**.

The economic impact diagram is shown on the next page.

Introduction to economic impact calculations



Based on the Input-Output (Leontief) model, **the expenditures incurred in the investment phase**, as well as those **incurred in the operational phase**, result in **increased production** at suppliers, and consequently increased production at sub-suppliers. Increased production also generates effects in terms of **employment and wages**, which in turn translates into **increased consumer spending**.

The economy impact assessment based on OSGE data and assumptions; KPMG did not verify their accuracy. The impact estimated based on expenses assumed to be incurred in Poland.

General assumptions of the analysis of the impact of SMRs on the Polish economy

- I. Analysis of the economic impact generated by a **single BWRX-300 reference reactor**
- II. The economic impact is divided into two phases:
 - The investment phase lasts 7 years, with construction work taking about 3 years,
 - The operational phase of about 60 years.



Investment phase
7 years

Operational phase
60 years

- III. The values estimated for the operating phase were **discounted** over 60 years using a **discount rate of 3%**.

Data sources for the economic effect analysis:



- **Data provided by OSGE**, including estimates of capital expenditures, estimates of revenues and costs, assumed employment structure, as well as specialized source data developed by GE Hitachi
- **Publicly available data** such as:
 - **Statistics Poland data**, including the latest available inter-sectoral flows,
 - **wage and industry reports**
- Applicable **tax rates** under the law

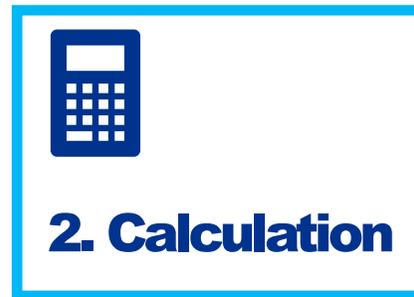
*The economy impact assessment based on OSGE data and assumptions.

The course of the analysis carried out

The process of the analysis conducted was divided into three stages:



- Data and assumptions provided by OSGE.
- Data acquired from available public sources: Statistics Poland, wage reports, tax rates.



- The dataset for the Input-Output model.
- Calculation of the reference impact of a single BWRX-300 reactor.



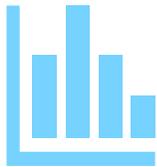
- Results of the calculation of the impact generated by a single BWRX-300 reactor. If more units are built, the impact estimates may be multiplied.

*The economy impact assessment based on OSGE data and assumptions.

The total estimated impact of the BWRX-300 reactor on the Polish economy

Investment phase

Operational phase



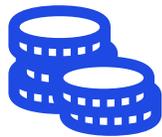
Over PLN 24 billion of gross added value generated



Over 3,400 jobs

Construction phase: about 2,700 jobs sustained annually

Operational phase: about 730 jobs sustained annually



About PLN 3.2 billion of wages paid

*The economy impact assessment based on OSGE data and assumptions.

The total estimated economic impact of the BWRX-300 reactor



Approximately **PLN 7 billion** capital expenditures during the entire phase

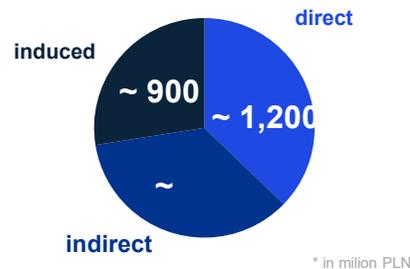


approximately **50%** of all expenses can be incurred in Poland



Impact on gross value added

The direct impact generated by the project may be the most significant in terms of adding value to the economy.



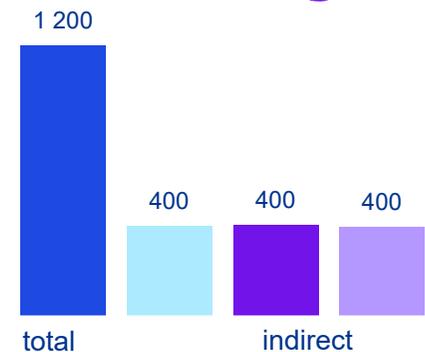
* in million PLN

approx. **3.2** (PLN billion) gross value added growth

Approx. **2,700** jobs sustained annually



Total wages approx. **PLN 1.2 billion**



* in PLN million, rounded

*The economy impact assessment based on OSGE data and assumptions.

Investment phase



Economic impact values for the entire investment phase

Impact	Gross value added [PLN million]	Wages [PLN million]	Employment [jobs sustained annually]
Direct	1,178	405	893
Indirect	1,117	406	955
Induced	871	398	871
TOTAL entire phase	3,165	1,209	2,719

* Due to the use of rounding, the total for 7 years may differ slightly from the total in the column

The investment phase can generate **PLN 3,165 million in gross value added**, **PLN 1,209 million in wages** and sustain **2,719 jobs** annually.

As shown in the table above, the **direct impact** of the investment phase is expected to sustain **893 jobs** per year, which could translate into **PLN 405 million** in wages for the entire investment period.

Indirect and induced impacts during the investment phase are expected to sustain **955 and 871 additional jobs each year**, respectively. Over seven years, these impacts could generate an additional **PLN 804 million in wages**.

*The economy impact assessment based on OSGE data and assumptions.

Economic impact values for the averaged year of the investment phase

Impact	Gross value added [PLN million]	Wages [PLN million]
Direct	168	58
Indirect	160	58
Induced	124	57
TOTAL annual average	452	173

* Due to the use of rounding, the total annual average may differ slightly from the total in the column

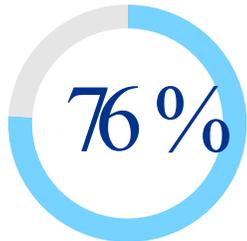
The total estimated economic impact of the BWRX-300 reactor Operational phase in Poland



Approximately
PLN 160 million
expenses on average per year



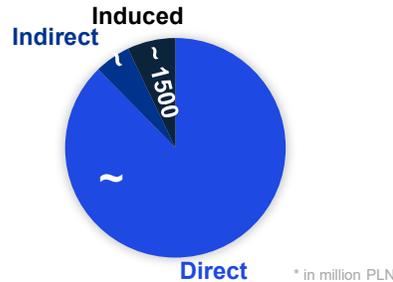
approximately **76%** of all expenses can be incurred in Poland



*The economy impact assessment based on OSGE data and assumptions.

Impact on gross value added

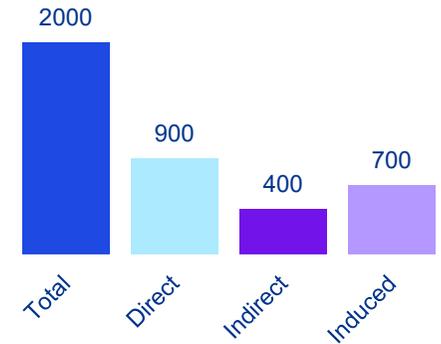
The direct impact generated by the project may be the most significant in terms of adding value to the economy



Approximately
PLN 21 billion gross value added growth

Approximately 
730 jobs sustained annually

Total wages approx.
PLN 2 billion



* in PLN million, rounded

Operational phase



Economic impact values for one averaged year of the BWRX-300 reactor operation

Impact	Gross value added [PLN million]	Wages [PLN million]	Employment [jobs sustained annually]
Direct	654	33	100
Indirect	39	16	271
Induced	52	24	366
TOTAL annual average	746	73	737

* Due to the use of rounding, the total annual average may differ slightly from the total in the column

Economic impact values for 60 years of the BWRX-300 reactor operation

Impact	Gross value added [PLN million]	Wages [PLN million]
Direct	18,303	923
Indirect	1,093	439
Induced	1,462	669
TOTAL entire phase	20,859	2,031

* Due to the use of rounding, the total annual average may differ slightly from the total in the column

*Discounted over 60 years using a discount rate of 3%

The operational phase can generate **PLN 746 million in gross value added annually**, **PLN 73 million in wages**, and sustain **737 jobs** annually.

According to estimates, in a standard year of the operational phase, a power plant with a single BWRX-300 reactor can sustain **100 jobs** (direct impact on employment).

As shown in the table above, direct employment can generate **PLN 33 million** worth of wages **annually**. Indirect and induced effects may additionally generate wages of **PLN 16 million** per year and **PLN 24 million per year**, respectively. Wage amounts are given in nominal terms. Due to the increase in wages in the economy, the quoted amounts may increase.

Over its lifetime (60 years), a power plant with a single BWRX-300 reactor could generate **gross value added of PLN 20,859 million** and contribute to an increase in wages estimated at **PLN 2,031 million**.

*The economy impact assessment based on OSGE data and assumptions.

Potential cumulative benefits - investment phase

Investment phase

Operational phase

Initially, the economic impact of the BWRX-300 on the Polish economy was estimated in terms of a model reference reactor.

If a fleet of units is built, the estimated effects can be multiplied. The values of the potential cumulative economic impact for the investment phase were estimated for the construction of 4, 10 and 30 BWRX-300 reactors.

	1 reactor	4 reactors	10 reactors	30 reactors
				
 Gross value added [PLN million]	3,165	11,100	25,500	73,400
 Wages [PLN million]	1,209	4,250	9,700	28,000
 Employment [jobs sustained annually]	2,719	9,550	21,900	63,050
		The figures are rounded		

multiplication →

Comment:

- The results of the economic impact generated by a single reference BWRX-300 reactor were used to estimate potential cumulative benefits.
- To estimate the value of the cumulative economic effect, a learning curve was used. It is a simulation of the occurrence of the learning effect, that is, an increase in the potential efficiency of the entire production process, and therefore also a potential reduction in the level of expenditures. This effect is diminishing in nature; it is greatest for the first few investments and diminishes with each subsequent investment.
- A learning curve effect was assumed: **NOAK 1: -26%** (the first reactor to be built in Poland is estimated to cost about 26% less than the FOAK reactor to be built in Canada), **NOAK 2: -9.5%** (it is estimated that the cost of building the second reactor in Poland will be lower by about 9.5% than NOAK 1), **NOAK 3: -9%** (estimated cost lower than NOAK 2 by about 9%), **NOAK 4: -5%** (estimated cost lower than NOAK 3 by about 5%), **NOAK 5: -3%** (estimated cost lower than NOAK 4 by about 3%). It is estimated that the learning effect and the resulting savings will stabilize after the construction of the 5th reactor – the cost of each additional reactor built in Poland is estimated to equal the cost of NOAK 5.

Potential cumulative benefits - operational phase

Investment phase

Operational phase

The values of the potential cumulative economic impact were also estimated for the operational phase, assuming construction of 4, 10 and 30 BWRX-300 reactors (for one averaged year of operation and for the entire duration of the phase).

	1 reactor	4 reactors	10 reactors	30 reactors
Economic impact values for one averaged year of the BWRX-300 reactor operation				
 Gross value added [PLN million]	746	3,000	7,000	22,000
 Wages [PLN million]	73	300	700	2,000
 Employment [jobs sustained annually]	737	3,000	7,000	22,000
 Taxes [PLN million]	91	400	900	3,000
Economic impact values for 60 years of the BWRX-300 reactor operation*				
 Gross value added [PLN million]	20,859	83,000	209,000	626,000
 Wages [PLN million]	2,031	8,000	20,000	61,000
 Taxes [PLN million]	2,550	10,000	26,000	77,000

multiplication

multiplication

*Discounted over 60 years using a discount rate of 3%

The figures are rounded

SMRs are an opportunity to increase the competitiveness of the Polish economy

The electrification of households, industry and transportation, as well as the progressive implementation of climate goals, mean that electricity costs will play a key role for the competitive position of the country in global markets.

Despite the increase in energy efficiency of the Polish economy, the rate of growth of electricity demand until 2040 is estimated at 1.7% per year⁽¹⁾. The increase in the use of electric cars, heat pumps, air conditioners, or the electrification of the industry itself with the simultaneous increase in the share of RES will make balancing the electricity grid more difficult.

The effect of the changes may be the high volatility of electricity prices already observed in the markets on a long-term (annual) and short-term (daily) basis. With individual consumption being prioritized, the costs associated with market fluctuations are more than proportionately applied to industrial consumers, as exemplified by lower tariffs for private and small energy consumers, *scarcity pricing* mechanisms or the use of the so-called power supply levels.

The construction of stable generating capacities such as SMRs will help to reduce the negative impact of the energy transition on the Polish industry and improve competitiveness in global markets.

SMR benefits for the industry and the Polish economy:

- Ensuring a stable price over the long term

By ensuring a stable energy supply and price, businesses become more confident about their costs and are able to plan their budgets in the long term. This is of particular importance for Polish companies in the manufacturing and construction sector that operate on the basis of long-term contracts for the supply of their products. Historically, greater volatility in energy prices has led to a decline in their profitability, resulting in the need to reduce employment, investments or, in extreme cases, even bankruptcy.

- Reducing the risk of the so-called *blackout*

The SMR is characterized by high availability, which, with increasing market volatility caused by the growing share of RES, will be a factor that facilitates balancing the power system without resorting to forcing reductions in consumption by industrial consumers negatively affecting the profitability of plants and production costs.

- Development of Polish production for the nuclear industry

Nearly half of the expenses associated with the construction of the SMR can be realized in the Polish market. Polish companies, including primarily those that have so far operated for the coal power industry, will be able to supply components for nuclear power plants outside the so-called "nuclear island" once they have adapted to safety requirements and obtained appropriate certifications of production for the nuclear industry.

- Limiting the scale of investments in the grid and reducing transmission losses

SMRs located directly next to manufacturing plants or at the site of old coal-fired power plants with efficient power output will not require significant investments in the construction of transmission networks. As opposed to distributed power generation models, the proximity of SMRs to end-consumers of energy will reduce losses caused by long-distance transmission of electricity.

Preparing for the introduction of the Carbon Duty

The industrial production based on zero-emission energy from SMRs will help reduce the potential effects of the *Carbon Border Adjustment Mechanism* (CBAM) or the so-called carbon duties imposed on the export and import of Polish products by Poland's trading partners.

(1) Energy Policy of Poland until 2040.

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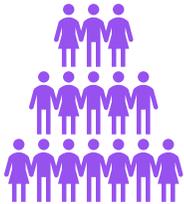
**Job creation
potential of
the SMR
development
in Poland**



Employment and wages Using the BWRX-300 reference reactor as an example

Investment phase

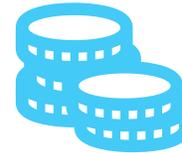
Operational phase



**Over
3,400
new jobs**

It is expected that the investment phase, throughout its duration, can generate and sustain about **2,700 jobs annually**, and the operational phase about **730 jobs**.

The planned 60-year life of the reactor makes it possible to assume that during this time there may be **one generational change** in the personnel employed.



**Approximately
PLN 3.2 billion
of wages paid**

The potential **average total annual impact on wages during the investment phase** could be about **PLN 173 million** (undiscounted).

The potential **total value of the annual wage effect in the operational phase** could amount to about **PLN 73 million**.

The total impact on wages during the entire duration of both phases could be as high as **PLN 3.2 billion**.

Long-term impact on employment levels. Using the BWRX-300 reference reactor as an example

Investment phase

Operational phase



It is estimated that about **2,700 jobs**, sustained for 7 years, can be created in the investment phase.



A **total of about 730 jobs** could be created as a result of the BWRX-300 reactor's operating activities.

100 of them will result directly from the employment at the facility. Others as a result of indirect and induced effects. **It is assumed that the jobs will be sustained throughout the operational phase.**

The planned 60-year life of the reactor makes it possible to assume that during this time there may be one generational change in the personnel employed.

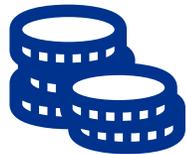
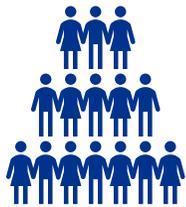


Employment and wages – impact of the BWRX-300 reactor

Investment phase

Investment phase

Operational phase



The potential **increase in employment** associated with a **single BWRX-300 investment** could amount to as **many as 2,700 additional jobs**.

Dividing the growth into the types of economic impact that generated it – **the direct impact** can contribute to the creation of about **900 jobs** and **increase in wages** by almost **PLN 60 million**, the **indirect and induced impact** can together **increase employment** in the economy by **about 1,800 jobs** with the **wage increase of about PLN 115 million per year**.

The level of wages was assumed to be about 30% higher than that in the Polish conventional power sector, taking into account insights from the U.S. market based on the report by the International Atomic Energy Agency.

The investment phase could **increase annual wages** by a total of **more than PLN 170 million**.

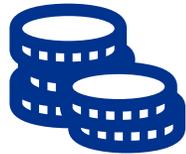
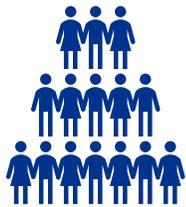
The investment phase will generate **the most jobs for specialists from the construction and energy industry**.

Employment and wages – impact of the BWRX-300 reactor

Operational phase

Investment phase

Operational phase



During the operational phase, it is expected that **the average annual direct** employment will amount to **100 people per one BWRX-300 unit**.

Specialists in radiation protection, safety and environmental protection, as well as reactor operators, chemists and scientists will find employment.

The engineering staff will include nuclear engineers, structural engineers, mechanical engineers, electrical engineers and chemical technology engineers.

The personnel will also include maintenance personnel, support personnel, emergency response and cybersecurity services.

The potential direct impact on wages could amount to **PLN 33 million** per year.

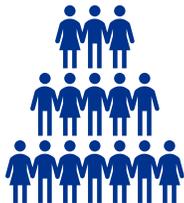
The indirect and induced impact of the operational phase could generate an average of **about 270 and 370 jobs**, respectively, and increase wages by about **PLN 40 million per year**.

The level of wages was assumed to be about 30% higher than that in the Polish conventional power sector, taking into account insights from the U.S. market based on the report by the International Atomic Energy Agency.

Impact on employment in different areas of the economy



Approximately
730
jobs
Sustained
annually



Operating activities can directly generate 100 jobs. These will be mostly specialized positions with above-average wages.

As a result of the reactor's operations and orders placed by the unit, the employment at suppliers and sub-suppliers will also increase. The analysis estimates that about **270 jobs** will be created and sustained annually at the intermediate level. The specific nature of the operations may result in increased employment with suppliers and sub-suppliers primarily in the areas of industrial production, such as: **manufacturing of parts and components** or in **repair and maintenance services**.

Induced employment refers to the number of people employed in the national economy, **as a result of additional consumption** made possible by wages created by the impact of direct and indirect effects. Increased employment can be expected in, for example, **health care, education or services related to food, entertainment and recreation**.

Employment structure in the operational phase

Using the BWRX-300 reference reactor as an example

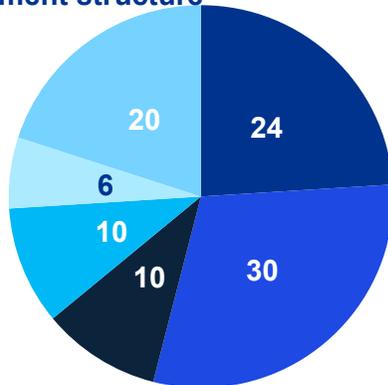
Investment phase

Operational phase

The operational phase will increase the need for qualified personnel.

The table and chart show the specifications of the required positions, the assumed number of FTEs, and the expected level of education.

Employment structure



- Operators, Engineers, health physics (radiation protection) specialists, Managerial staff
- Chemists, Scientists, Safety and environmental protection specialists, Other engineers
- Maintenance and technical services
- Emergency response and cybersecurity services
- Shift technicians
- Support staff

Position	Level of education	Number of FTEs
<ul style="list-style-type: none"> • Reactor operators • Nuclear engineers • Health physics specialists • Managerial staff 	Higher	24
<ul style="list-style-type: none"> • Chemists • Scientists • Safety and environmental protection specialists • Other engineers 	Higher	30
<ul style="list-style-type: none"> • Maintenance and technical services 	Higher or Secondary	10
<ul style="list-style-type: none"> • Emergency response and cybersecurity services 	Higher or Secondary	10
<ul style="list-style-type: none"> • Shift technicians 	Secondary	6
<ul style="list-style-type: none"> • Support staff 	Secondary	20
TOTAL		100

Additional quality effects for the economy

Investment phase

Operational phase

The construction of the reactor fleet generates demand for qualified personnel



The estimated economic effects are not limited to monetary values. The prospect of building an entire fleet of reactors means increased demand for highly qualified employees.

As a result, for example, initiatives are being developed for cooperation between science and business to support the development of nuclear power in the preparation of highly qualified personnel. Such initiatives include agreements with universities, on the basis of which it is assumed that appropriate educational programs will be launched.

An example of such an initiative is the letter of intent signed between the Ministry of Education and Science and the rectors of six Polish universities. One of the main goals of the signed letter of intent is to develop an educational program in the field of nuclear power engineering, as well as to organize and launch studies in this field as early as in the 2023/2024 academic year. The cost of the new major of study per university is estimated at PLN 12 million.

It is noteworthy that such programs include personnel training not only for the SMR industry, but for the entire developing nuclear power industry in Poland.

The BWRX-300 is an opportunity for the Polish industry...

GE Power Polska builds Polish supply chains for the BWRX-300

GE Group, as a supplier of the BWRX-300 technology, has been present in Poland for 30 years and plays an important role in the energy industry of the country:

- it employs more than 5,000 employees;
- it identified some 300 Polish suppliers as potential partners for the construction of the nuclear power plant project.

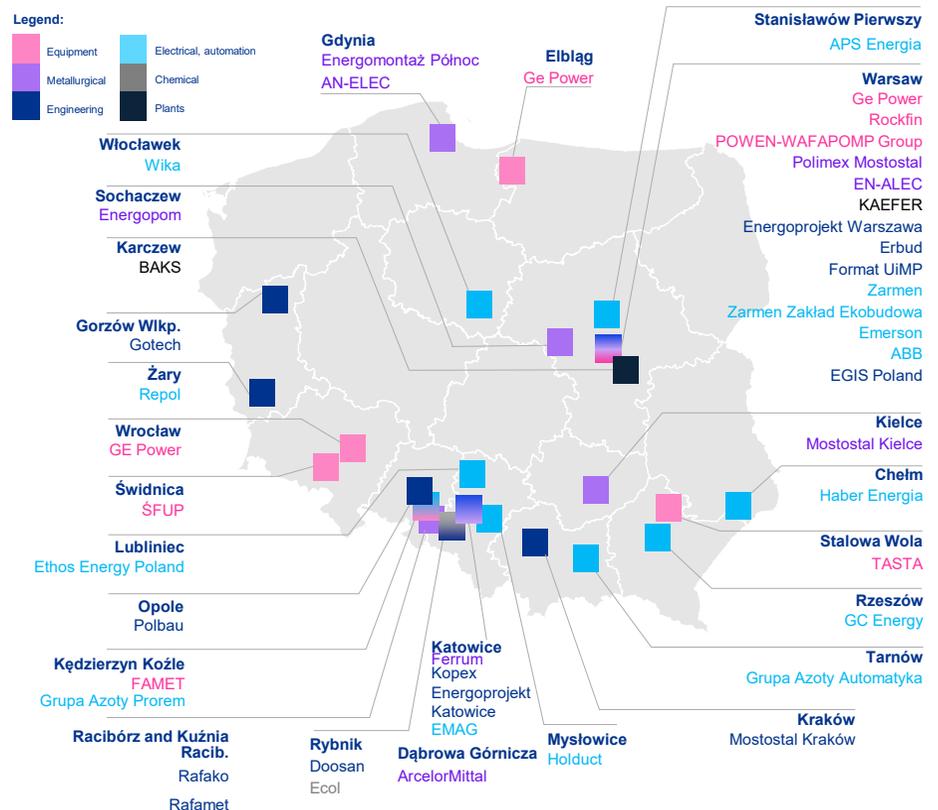
The factories of GE Power in Elbląg and Wrocław have experience in the manufacturing of:

- steam turbines for the nuclear power sector, which are installed in half of the world's nuclear power plants;
- generators of various capacities, which have been introduced to the domestic market and to countries around the world – Sweden, Saudi Arabia, the UK, Malaysia, India and Thailand;
- the stator for the reactor in the Darlington power plant.

The experience of GE Power allows it to reliably qualify Polish companies as potential sub-suppliers for the deployment of the BWRX-300 technology.

In order to ensure the greatest possible participation of domestic industry in the development of the nuclear power sector, the map opposite illustrates the country's largest companies with experience in nuclear projects. The Śląskie and Opolskie Voivodeships are home to a nuclear competence center that can play a key role in the transformation of the power transmission system. However, this requires retraining the workforce and retaining jobs for the industry, which has so far been focused on services to the conventional power industry.

Fig. Largest companies in Poland with nuclear power experience



Source: Own study based on "Polish industry for nuclear energy 2023", MKiS [Ministry of Climate and Environment]

...to benefit from the experience of coal-fired power generation

Polish companies can provide EPC services and utilize the production facilities used for coal-fired power generation.

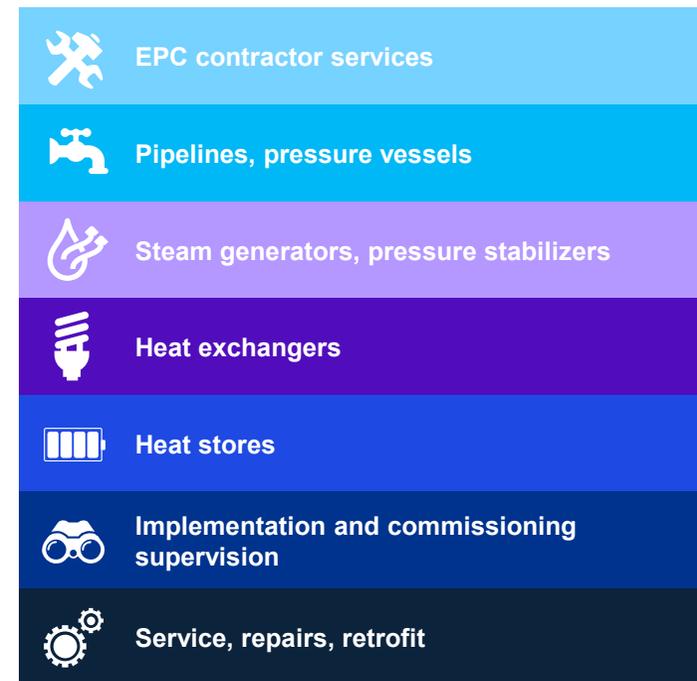
A nuclear power plant has similar energy transitions as a conventional fossil fuel (coal, oil or gas) power plant. The main difference is in the source of heat generation, namely the nuclear reactor and the power boiler. In the classic conventional power plant system, the heat of combustion is transferred to water and steam in a boiler. In the nuclear power plant system, specifically in the BWRX-300, the heat of the fission reaction is transferred to water and steam in a reactor.

Therefore, the experience, personnel and technical facilities of Polish companies gained during the construction and modernization of conventional power generation plants can be used to design and manufacture components that cooperate with a nuclear reactor.

Due to the different parameters of steam (flow rate, volume or degree of radioactive contamination), it is required to adapt production processes and quality management to strict safety requirements. Many companies are already taking steps to obtain certificates enabling them to provide services and products for the nuclear power industry, including ISO 19443, ASME certification.

Examples of companies with extensive experience in conventional power generation aspiring to participate in the design and construction of nuclear power plants are Rafako and Polimex Mostostal. The two companies have signed cooperation agreements as part of the development of the nuclear power industry in Poland with Westinghouse, Bechtel Corporation, EDF and KHNP for the potential construction of two new nuclear power plants. They also do not rule out cooperation in the construction of SMRs using existing coal infrastructure.

Potential services and products for the nuclear power industry provided by domestic EPC contractors:



06

Impact on tax revenues



Tax income impact assumptions

Potential impact on tax incomes

SMRs can also generate a positive impact on tax incomes, especially at the local level.

The main categories of taxes related to the operation of the SMR that can affect budget incomes are the PIT, CIT and real property tax.

Calculations of the potential tax impact were developed as part of the reference SMR unit model, as well as the employment structure adopted by OSGE.



PIT

The potential impact on the PIT was estimated based on the expected direct wages generated in the operational phase, current tax rates (12%/32%), and the local authority unit's percentage share in income tax revenues.



CIT

The potential impact on the CIT has been estimated based on the estimated profit achieved in the operating phase, the average tax rate (19%), and the local authority unit's percentage share in income tax revenues.



Real property tax

The potential impact on real property tax revenues was calculated based on the estimated size of the investment area, as well as the maximum tax rates set for local government units (districts).

Impact on tax incomes



**Over
PLN 8 million**

Potential annual PIT income.

In the 60-year perspective of operating activities, the total value generated could reach about PLN 228 million (discounted).



**Over
PLN 80 million**

Potential annual CIT income.

In the 60-year perspective of operating activities, the overall value generated could exceed about PLN 2,300 million (discounted).



**Over
PLN 360 thousand**

Potential annual real property tax income.

In the 60-year perspective of operating activities, the total value generated could reach about PLN 10 million (discounted).

Estimation of the potential PIT revenue

The increase in the PIT revenue of local authority units will depend on the number of employees registered as tax residents in each unit. OSGE assumes about 100 employees in the unit.



PLN 3.1 million

Potential annual PIT revenue of the district.

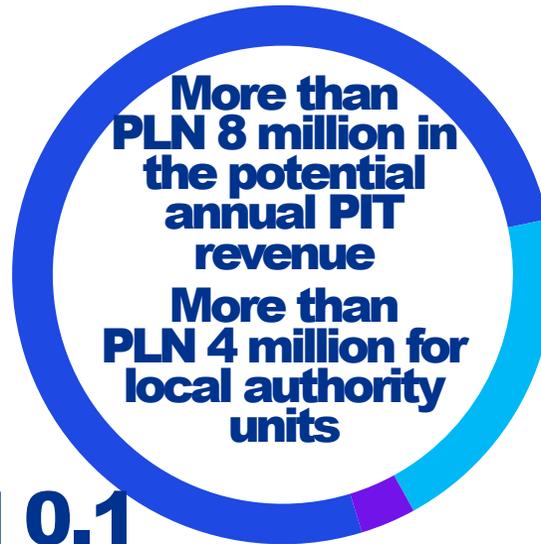
In the 60-year perspective of operating activities, the revenue could amount to more than PLN 88 million (discounted).



PLN 0.1 million

Potential annual PIT revenue of the voivodeship.

In the 60-year perspective of operating activities, the revenue could amount to more than PLN 3.6 million (discounted).



PLN 0.8 million

Potential annual PIT revenue of the county (powiat).

In the 60-year perspective of operating activities, the revenue could amount to more than PLN 23 million (discounted).

Share in the income from the personal income tax*:

- District (Borough) – 38.4%
- County (Powiat) – 10.3%
- Voivodeship – 1.6%

Source: Legal Act (Act of November 13, 2003 on incomes of local authority units)

Estimation of the potential CIT revenue

The increase in CIT revenues of local authority units will depend on the incomes from power plants. Based on prudential estimates of profitability, potential CIT revenues were determined



PLN 5.5 million

Potential annual PIT revenue of the district.

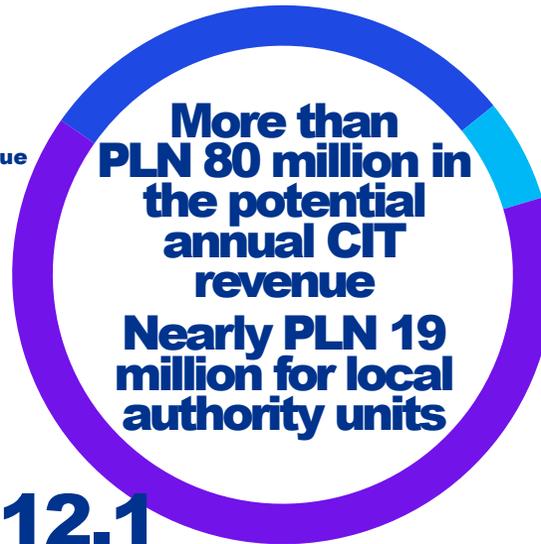
In the 60-year perspective of operating activities, the revenue could amount to more than PLN 155 million (discounted).



PLN 12.1 million

Potential annual CIT revenue of the voivodeship.

In the 60-year perspective of operating activities, the revenue could amount to more than PLN 340 million (discounted).



PLN 1.2 million

Potential annual CIT revenue of the county (powiat).

In the 60-year perspective of operating activities, the revenue could amount to more than PLN 32 million (discounted).

Share in the income from corporate income tax*:

- District (Borough) – 6.7 %
- County (Powiat) – 1.4%
- Voivodeship – 14.8 %

*Source: Legal Act (Act of November 13, 2003 on incomes of local authority units)

Estimation of the potential real property tax revenue

The increase in real property tax revenues of local communities will depend on the investment area and applicable tax rates. Based on the estimated volume of investments and the current maximum rates set by law, a preliminary estimate of revenues was made.

BWRX-300 GE Hitachi



**Power plant
building
8–9 thousand m²**

**Area
approx. 138
thousand m²**

Potential real property tax revenue



**PLN 360 thousand
PLN per year of the to
districts (boroughs)**

In the 60-year perspective of operating activities, the revenue could amount to more than PLN 10 million (discounted).

Calculations based on the upper limits of the specified rates of local taxes and business-related fees generated by a single BWRX-300** unit

*Source: Legal Act (Announcement of the Minister of Finance, Funds and Regional Policy of July 22, 2021 on the upper limits of the rates of local taxes and fees for the year 2022)

Estimation of potential tax revenues of the district (borough)

Based on the assumptions presented on the previous pages, an estimate was made of the potential tax revenue to the budget of a district (borough) from a single BWRX-300 reference reactor.

PLN 3.1 million
potential annual revenue from the PIT

In the 60-year perspective of operating activities, the revenue could amount to more than PLN 88 million (discounted).

PLN 5.5 million
potential annual revenue from the CIT

In the 60-year perspective of operating activities, the revenue could amount to more than PLN 155 million (discounted).



PLN 360 thousand
potential annual revenue from the real property tax

In the 60-year perspective of operating activities, the revenue could amount to more than PLN 10 million (discounted).

Calculations based on the upper limits of the specified rates of local taxes and business-related fees generated by a single BWRX-300** unit

Source: Legal Act (Act of November 13, 2003 on incomes of local authority units)

Tax on structures as potential additional revenues of the district (borough)

Under Article 2 section 1 point 1 and 2 of the Act of January 12, 1991, on local taxes and fees, the real property tax is levied on, among others, buildings or parts thereof, as well as structures or parts thereof related to the conduct of business activities.

Definition of a structure according to regulations

Under Article 1a section 1 point 2 of the Act on local taxes and fees, a structure is a **civil structure within the meaning of the Construction Law, which is not a building or a landscaping structure**, as well as a **construction device, within the meaning of the Construction Law**, associated with a construction structure, **which ensures that the facility can be used in accordance with its purpose.**

In turn, the Construction Law (Article 3 point 3) **defines a model catalog of structures.** These include such facilities as: “[...] free-standing industrial plants or technical equipment, [...] as well as the construction parts of technical equipment (boilers, industrial furnaces, nuclear power plants, wind power plants, offshore wind turbines and other equipment) and foundations for machinery and equipment, as technically separate parts of objects that make up a functional whole.”

The tax base for structures and their parts is defined in the Act on local taxes and fees. Article 4 section 1 point 3 of that Act defines “the value determined as of January 1 of the fiscal year, which is the basis for calculating depreciation in that year, not reduced by depreciation write-offs” as the tax base for structures and parts thereof. If, the tax liability arose during the year, “the tax base is the value that is the basis for calculating depreciation as of the date the tax liability arose” (the Act also specifies, for example, situations where no depreciation write-off is made).

According to Article 1a section 1 point 2 of the Act on local taxes and fees, “**The district (borough) council, by resolution, determines the amount of real property tax rates, except that the rates may not annually exceed 2% of their value** as determined pursuant to Article 4 section 1 point 3.”

Source: Legal Acts (Act of January 12, 1991 on local taxes and fees, Act of July 7, 1994 Construction Law)

According to ORLEN Synthos Green Energy assumptions, **up to 9% of the investment, estimated at EUR 1.5 billion, is the hypothetical value of the structure.**

If the value of the structure assumed by OSGE was subject to the full tax on structures, this could mean additional revenues to the budget of the district (borough) from the operation of the BWRX-300 reactor of as much as PLN 12 million per year.

07

Impact on the climate and the local community



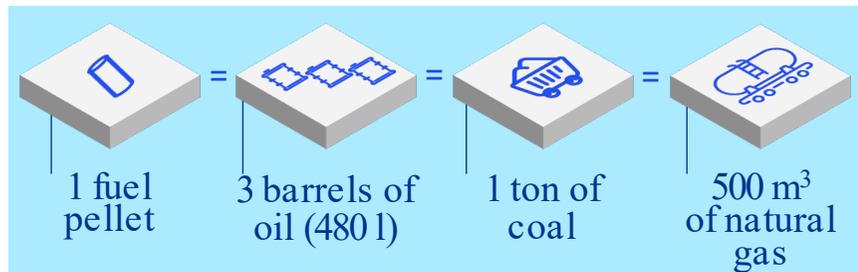
A single BWRX-300 makes it possible to avoid 175 million tons of CO₂ emissions from coal

Greenhouse gas emissions from nuclear power generation are estimated at 5.5 kg CO₂/MWh, with most emissions occurring in fuel creation processes (mining, conversion, uranium enrichment and fuel production). This is 200 times less than the average greenhouse gas emissions during the life cycle of coal-fired power plants, which are estimated at 1,130 kg CO₂/MWh. ⁽¹⁾

The energy generated is characterized by the absence of emissions of sulfur oxides (SO_x) and nitrogen oxides (NO_x) or other harmful gases and solid particles.

The nuclear power has the least land- and material-intensity requirements, and thus influences the protection of land, forests and ecosystems. By using less space, nuclear power has the lowest consumption of concrete and steel per unit of energy produced of all current technologies.

The nuclear fuel has the highest energy density of among all other fuels (coal, gas, biomass, fuel oil, hydrogen). The ratio of energy contained in the nuclear fuel to its volume and mass is incomparably better than in other fuels, so the nuclear fuel is easier to store and does not require constant transportation.



1. UNECE, Carbon Neutrality in the UNECE Region, 2022
2. Assuming an average of 4,000 t per single freight train and an average transport distance of 100 km

A single BWRX-300 over 60 years makes it possible to avoid:



175 million
tons of CO₂ emissions



82.7 thousand / 82.7 thousand / 3.5 thousand
tons of SO_x / NO_x / dust emissions



65 million
tons of coal



1.7 million km⁽²⁾
rail transport of coal

Nuclear power meets EU taxonomy criteria

After analyses, the EU has classified nuclear activities to the list of economic activities compliant with the European taxonomy. SMRs meet safety criteria and contribute to achieving environmental goals

The EU taxonomy sets the directions of transition and defines the timeframes. The following **nuclear power-related** activities are included in the list of economic activities covered by the **EU taxonomy**:

- 1 Retrofits and modifications of existing nuclear power plants to extend their period of operation.
- 2 New nuclear power plant projects using existing technologies (“Generation III+”)
- 3 Research, development and deployment of advanced technologies (“Generation IV”) that minimize waste and improve safety



“ The nuclear power can be financed by European financial institutions

-  **Significantly contribute to achieving environmental goals**
due to low greenhouse gas emissions
-  **Does not harm any other environmental goal**
due to the lack of evidence that nuclear power causes greater harm to the human health or the environment than other power generation technologies already covered by the taxonomy
-  **Compliance with minimum social and government safeguards**
will be subject to strict safety and environmental conditions, including waste disposal
-  **Meets the technical control criteria**
by establishing technical requirements beyond the existing regulatory framework

SMRs as an element of a sustainable transition are an opportunity for local communities

The introduction of the SMR technology can provide a number of positive socio-economic impacts for the regions affected by the phasing out of coal-fired power plants

Regions that are economically dependent on coal-fired power plants may struggle with low rates of economic development, social problems (such as rising unemployment rates) and infrastructure degradation.

To meet these challenges, investments are needed to mitigate the socio-economic effects of the transition. Energy investments based on low-emission or zero-emission technologies (e.g. SMRs), replacing coal-fired heat sources, would enable the reuse of locations, infrastructure and human resources.

This could stabilize employment during the transition and create new jobs in green, climate-neutral sectors.

The development of new industries, the creation of new innovative companies in the region and local value chains will also be part of this transition.

The works associated with the adaptation of land and infrastructure of decommissioned coal-fired power plants could create additional employment opportunities in the area.

Adoption of the nuclear technology by local communities. . .



“ One of the key challenges of introducing SMRs is to make the public aware of the benefits of the nuclear technology and its reliability.

With more than 86%⁽¹⁾ of the Polish public in favor of developing the nuclear technology, Poland could become one of the biggest supporters of the SMR technology in Europe.

1. The study of the Ministry of Climate and Environment, November 2022.

Appendix 1

List of Acronyms and Abbreviations



List of Acronyms and Abbreviations

BWR	Boiling Water Reactor	EC	European Commission
R&D	Research and Development	KPMG	KPMG Advisory Spółka z ograniczoną odpowiedzialnością sp. k.
CAPEX	Capital Expenditures	LWR	Light Water Reactor
CAGR	Compound Annual Growth Rate	MCP	Directive on Medium Combustion Plants
C2N	The process of switching from coal to nuclear power (Coal to Nuclear)	NASE	National Energy Security Agency
EUR	Euro	NOAK	Next of a Kind
FOAK	First of a Kind	RES	Renewable Energy Sources
GEH	GE-Hitachi Nuclear Energy	NAEA	National Atomic Energy Agency
GW, GWe	Gigawatt, Electric gigawatt	PEP2040	Energy Policy of Poland until 2040
HTGR	High-Temperature Gas-Cooled Reactor	PWR	Pressurized Water Reactor
IED	Industrial Emissions Directive	SMR	Small Modular Reactor
CDGU	Centrally Dispatched Generating Unit	USD	U.S. dollar

Appendix 2

Supplement to the Executive Summary



Supplement to the Executive Summary (1/6)

Despite the fact that nuclear power involves the highest capital expenditures per unit of installed capacity (15–25 thousand PLN/kW) among commonly used generation technologies, its cost to its end user will be one of the lowest due to limited operating and system costs.

Historically, due to a number of project risks, the burden of financing the construction of nuclear power plants has been borne primarily by taxpayers as part of the national budget or fees for the funds collected as part of electricity bills.

The characteristics of SMRs make it easier to structure their financing. A modular design, based largely on the assembly of previously manufactured components, significantly reduces the risk of cost and construction time overruns.

Potential **sources of funding for SMR projects are the countries behind its exports**, and the instruments with the greatest potential for use include:

1

Government loan guarantees, allowing to avoid direct expenditures from the state budget, but involving the need to examine whether their use would not constitute unauthorized state aid,

2

Loans and equity from technology providers, which, although a small part of the financing structure, allow investors and technology providers to align their interests,

3

Loans and guarantees provided by export agencies allowing lower debt service costs than commercial financing. As a rule, export financing covers only that part of a project that is produced in the exporter's country and complements other financing instruments.

Supplement to the Executive Summary (2/6)

The high volatility of energy prices, combined with deregulation of energy markets, has made long-term financial planning difficult, reducing the pool of players willing to undertake nuclear projects.

- In order to mobilize and encourage private investors, governments around the world have introduced **mechanisms to mitigate the long-term market risk of projects**.

Support models are divided **according to the degree of state guarantees**:

1

Contract for Difference (CfD) – guaranteeing the selling price

2

Power Purchase Agreement (PPA) – guaranteeing the level of revenues

3

Tariff model – guaranteeing the rate of return on investment

- **With the state's involvement**, the **nuclear project has a better chance of financial closure**, and as the level of guarantees increases, the number of investors interested in providing financing for the construction or refinancing the construction costs of the project increases.
- When designing support mechanisms for nuclear power, governments are guided by the balance between the costs to the society and the economy and the benefits of ensuring energy security.
- Nuclear power plants are characterized by a long operating period of more than 60 years, during which revenues from energy sales must allow for debt servicing and return on investment.

Supplement to the Executive Summary (3/6)

The origins of civilian nuclear power go back to the 1950s, when the world's largest economies began using the first nuclear reactors with a capacity of less than 100 MW. 70 years later, the total capacity of nuclear power plants exceeds 392 GW installed in 31 countries around the world.

As the experience has evolved, governments around the world have developed regulations and mechanisms to improve the construction of new and maintenance of old nuclear power plants. Drawing on that experience, key areas for Poland's SMR development strategy have been identified:



Certification processes – the construction of the Polish SMR fleet, estimated at several tens of gigawatts of power, requires an efficient nuclear power supervisory entity. The experience of France and the U.S. indicates that the creation of transparent rules and efficient processes for the certification and approval of projects can significantly accelerate the pace and scale of investments made.



Fiscal incentives – in addition to the project risk-reducing support mechanisms described in the “Support Models” section, governments around the world use incentives such as investment reliefs, special economic zones or production tax credits to encourage investors to locate investments in particular countries or regions.



Coal-2-Nuclear – in September 2022, the U.S. government (Department of Energy) conducted a study the results of which indicated that 80% of U.S. coal-fired power plants could be converted to new nuclear power plants. The report recommended this solution as cost-effective and ensuring the maintenance of the economic status of coal regions.



Securing the supply of uranium – due to the war in Ukraine, countries importing uranium from Russia (France, Germany, Finland, Hungary, the U.S., Japan), have begun to take steps to secure the supply of nuclear fuel. Fear of withholding supplies from Russia and the general rise in popularity of nuclear power is causing countries to introduce restrictions on uranium exports (Japan), open previously closed mines (Australia, Honeymoon) or build new supply chains relying on producers such as Kazakhstan or Canada.

Supplement to the Executive Summary (4/6)

Waste Management

Among waste management strategies, the approaches used depend on a planning horizon of a country. Countries such as Finland and Sweden use temporary waste disposal facilities where spent fuel is stored for decades, after which the waste will have to be moved to target storage sites. Countries such as the U.S., France or Russia decided to recycle spent uranium fuel, recover useful isotopes and reuse some of the material as nuclear fuel. The economic viability of creating and maintaining the operating costs of recycling plants is questioned, pointing to Finland as an example of a country with underground storage facilities designed to meet Finland's current consumption for at least 450 years⁽¹⁾. An additional element under consideration, is the development of technology. As part of their research work on generation IV reactors, the U.S. and Canada are investigating the possibility of using spent uranium to supply breeder reactors potentially making stocks of spent uranium a valuable source of fuel in the future.

Research and Development

Recognizing the great importance that the SMR technology can have for lowering energy costs and thus for the competitiveness of economies, governments around the world are actively involved in financing development projects. As of the time of this study, there are approximately 70 research programs, including funding of demonstration projects.

Government development programs

The U.S. and Canada have created dedicated funds (Canada Growth Fund, Loan Program Office) and programs run by development banks (SMR Funding Awards, Project Phoenix) to provide financing in the form of loans or guarantees specifically for the construction and maintenance of nuclear projects that meet the criteria set forth in government strategies.

Decommissioning of nuclear power plants

As with the domestic coal power sector, governments around the world have created special funds fed by contributions from nuclear plant operators. Independent government agencies are responsible for setting the amounts of fees and collecting them, and until the funds are spent on decommissioning the plants, they invest the collected funds in safe financial instruments such as treasury bonds.

1. The Onkalo underground storage facility has an estimated capacity of 78,000 tons. According to the Nuclear Energy Agency, in 2019, Finland produced 167 t of spent fuel.

Recommendations

Supplement to the Executive Summary (5/6)

In the context of the fight against climate change, the deployment of SMRs is an opportunity to maintain and strengthen the competitive position of the Polish economy and its gradual transition towards zero-emissions. **Identified activities for the SMR development in Poland include:**

Regulatory area

- **Focus of the Polish regulatory authority on a few selected SMR technologies.** Of the 6 entities (GEH, NuScale, Last Energy, EDF, Rolls-Royce, USNC) that are listed as potential suppliers of SMR technologies to Poland, regulatory and process efforts should be selected and focused around a selection of 2–3 technologies depending on the application. The extensive scope and complexity of the technical issues require time and great competence of the nuclear regulator to be able to verify each reported technology. The fact that the regulatory process is very time-consuming significantly affects the costs and schedule of the project. SMR technologies will be evaluated by the regulatory authority and decision-making bodies as second to large-scale nuclear projects, so to speak, and current plans indicate that at least two large-scale technologies (Westinghouse AP1000 and KHNP APR1400) will be selected. Moreover, taking into account, among others, their adaptation to the selected application, the existing infrastructure, the level of participation of the domestic industry in the technology supply chain, and the security of fuel supplies, limiting the number of SMR technologies is a strategic decision for the energy security of the country, which will ensure an adequate level of competition among suppliers, while providing an opportunity for specialization of the bodies certifying and approving investment projects.
- **Development of a regulatory package** including a support model, rules for certification of technologies and investment projects as well as location guidelines. Location guidelines can be a policy tool for the industry development in selected areas.

Aspect of ESG and Coal-2-Nuclear

- **Leveraging the status of nuclear power as an energy source to support the energy transition.** SMR projects should be promoted as solutions compliant with the *European Green Deal* strategy, which will increase their attractiveness to ESG-driven investors and financial institutions.
- **Adaptation of coal assets for SMRs.** The use of infrastructure facilities, created for coal-fired power plants, will reduce the cost of building a fleet of SMR power plants by 15 to 30%.

Recommendations

Supplement to the Executive Summary (6/6)

Social Strategy

- **General public education and promotion of nuclear power.** In order to achieve the greatest production efficiency, SMRs as sources of system heat should be located close to large population centers. Despite the percentage of support for nuclear power in Poland⁽¹⁾ of more than 86%, acceptance of the investment by local communities requires knowledge and understanding of the SMR technology, especially the stringent safety systems used in it.
- **Creating qualified human resources.** In light of the development of large-scale nuclear power and SMR technology programs, Polish universities of technology need to increase the number of study programs and places for students in physics, nuclear engineering or environmental protection.

International activities

- **Establishing relationships and dialog with international institutions.** The Polish government should actively cooperate with the European Commission in the area of state aid regulations with regard to project financing from the state budget and revenue guarantee models. Due to high safety and reporting requirements, Poland will have to strengthen cooperation with the International Atomic Energy Agency and prepare for reporting and auditing standards.
- **Using foreign development programs.** Poland may be a beneficiary of:

1

Development programs, such as the Phoenix project,

2

Institutions financing technology implementation, such as the Export-Import Bank of the United States (EXIM) and the U.S. International Development Finance Corporation (U.S. DFC),

3

Government agencies funding project preparation and partnership building, such as the U.S. Trade and Development Agency (USTDA).

1. The study of the Ministry of Climate and Environment, November 2022.



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