OPPORTUNITIES AND THREATS FOR THE INTRODUCTION OF NUCLEAR POWER IN POLAND

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Abstract

The goal of the study is to show the potential for nuclear power development in Poland. SWOT and PEEST analyses were used, which in a multifaceted way showed the opportunities and threats of investment in this project. Based on the draft document Energy Policy of Poland until 2040 (PEP2040), the plans and actions aimed at the construction of the first Polish nuclear power plant are presented. The review of the operating costs of a nuclear power plant has made it possible to analyse the efficiency of nuclear investment by comparing the expected costs with the achievable results. It has been shown that obtaining energy from uranium will contribute to the country's energy security, competitiveness of the economy, and improvement in air quality in the long term. Diversification of energy sources will allow Poland to become more energy independent and adapt its energy sector to climate challenges.

Keywords: nuclear power engineering, first nuclear power plant in Poland, energy security, diversification of energy sources, Polish energy policy

Introduction

Electricity is seen by many as one of the elementary goods. It is therefore difficult to imagine functioning without access to it, especially in industrialised countries, which include Poland. In the 1950s, the first nuclear power plants were commissioned: Obninsk (1954, USSR) and Calder Hall (1956, UK), which initiated the energy revolution. Worldwide, nuclear power plants are located in more than 30 countries – in the European Union (EU) 14 countries alone use nuclear power, which accounts for half of all EU member states. Poland is one of the few developed countries in Europe where no nuclear power plant operates.

Restrictions on access to fossil fuels (which include coal, oil and natural gas), insufficiently developed renewable energy sources, climate change caused by excessive environmental pollution and progressive global warming of the planet, growing demand for electricity – these are just a few of the problems that Poland is currently struggling with. In order to solve these difficulties, diversification of energy sources is necessary. This is possible, inter alia, through the construction of a nuclear power plant, from which energy would be obtained as a result of nuclear reactions (nuclear fission or fusion). The development of nuclear energy will allow Poland to become more energy-independent. Moreover, it would make it possible to achieve all the objectives of the national energy policy:

- energy security;
- energy competitiveness and efficiency;
- limited impact of power engineering on the environment.

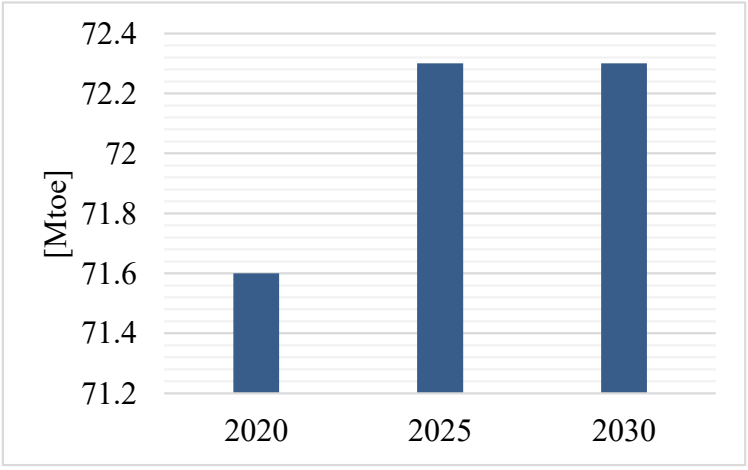
Interest in nuclear energy in Poland

For years, the subject of nuclear power development in Poland has been the subject of intense public discussion. The first plans and talks began in 1956, when the Office of the Government Plenipotentiary for the Use of Nuclear Energy was established on 6 July to coordinate organisational and administrative work in the field of nuclear science and technology. It was composed of 40 members and its term of office lasted 2 years. In 1973 this office was transformed into the Atomic Energy Office, which worked until 1980. In 1972, it was decided that the first nuclear power plant in Poland would be located in Żarnowiec. In 1975, the Government Presidium issued a decision no. 20/75 of 14 February on the directions of using nuclear energy in the national economy, according to which the power plant in Żarnowiec was to be commissioned in 1983, but two years after this decision the date was postponed to 1985. At that time, a decision was also made to locate another power plant in Klempicz. Despite the advancement of the construction work in 1990, the work was interrupted. One of the reasons for this was the concern about the safety of the power plant caused by the Chernobyl disaster. This event slowed down the development of nuclear power in Poland for many years. It was only in 2005 that a document entitled "Energy Policy of Poland until 2025" considered the possibility of building nuclear power plants in Poland. In 2009, the Council of Ministers published the document entitled "Energy Policy of Poland until 2030", which provided for the construction of a power plant. According to this document, it would be opened in 2024. On 28 January 2014, it was decided to adopt the Polish Nuclear Energy Programme (PNEP). The main tasks of the PNEP include defining the objectives for the implementation of nuclear energy in Poland.

Poland's energy policy

As a result of economic growth, development of new technologies and changes in the lifestyle of citizens, the demand for energy is growing (Figure 1.). In order to ensure the satisfaction of the growing demand, it is necessary to diversify the energy sources, as well as to reduce the emission of air pollutants (above all CO_2); therefore Poland should develop low-emission energy sources (renewable energy sources (RES) and nuclear energy).

Figure 1. Projections of the structure of final energy demand in Poland in 2020-2030, in millions of tonnes of oil equivalent [Mtoe]



Source: Own study based on the document Forecast of demand for fuels and energy up to 2050, Agencja Rynku Energii S.A.

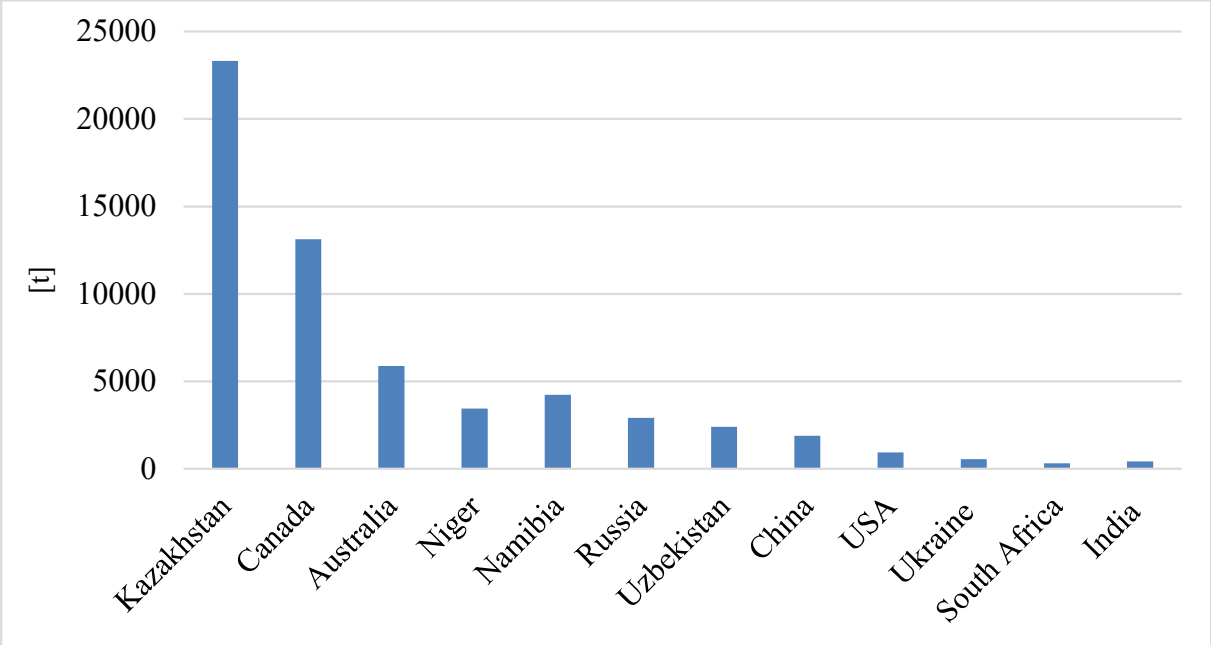
On 23 November 2018, the Ministry of Energy published a draft document entitled "Energy Policy of Poland until 2040" (PEP2040), which developed eight energy policy orientations, including the implementation of nuclear energy as the fifth. Its aim is to reduce the emissions of the energy sector and to make the system safe to operate. The commissioning of the first nuclear unit of the power plant, with a capacity of 1-1.5 GW, dates to 2033. By 2043, another five nuclear units with a total capacity of approximately 6-9 GW are planned to be opened. In order to efficiently implement the project, it is necessary to ensure and improve formal, legal and financial conditions for the construction and operation of the first Polish nuclear power plant, including the integration of part of the administrative proceedings, enabling simultaneous application for permits, and making the procedures for the participation in the contract more flexible. Another element of the fifth direction is the qualification of appropriate staff and the launch of research and development potential to provide a technical support tool for supervision units (State Atomic Energy Agency, Office of Technical Inspection). Requirements and action paths will be included in the Human Resources Development Programme for Nuclear Power. The last issue addressed in PEP2040 is the disposal of low and intermediate level waste to be collected at the national radioactive waste disposal site, but this will not be sufficient, and therefore there are plans to open a new disposal site for low and intermediate level waste in 2027.

According to PEP2040, the choice of location is determined by the availability of cooling water and the possibility of capacity evacuation and other capacity withdrawals in individual parts of the country. Taking into account the above factors, the location of the nuclear power plant on the Polish coast – Kopalino or Żarnowiec, as well as in central Poland – in the vicinity of Bełchatów is being considered. In accordance with PEP2040, the Polish Ministry of Energy will take the final decision on the location of the first unit of the power plant in 2020.

Diversification of uranium supply sources

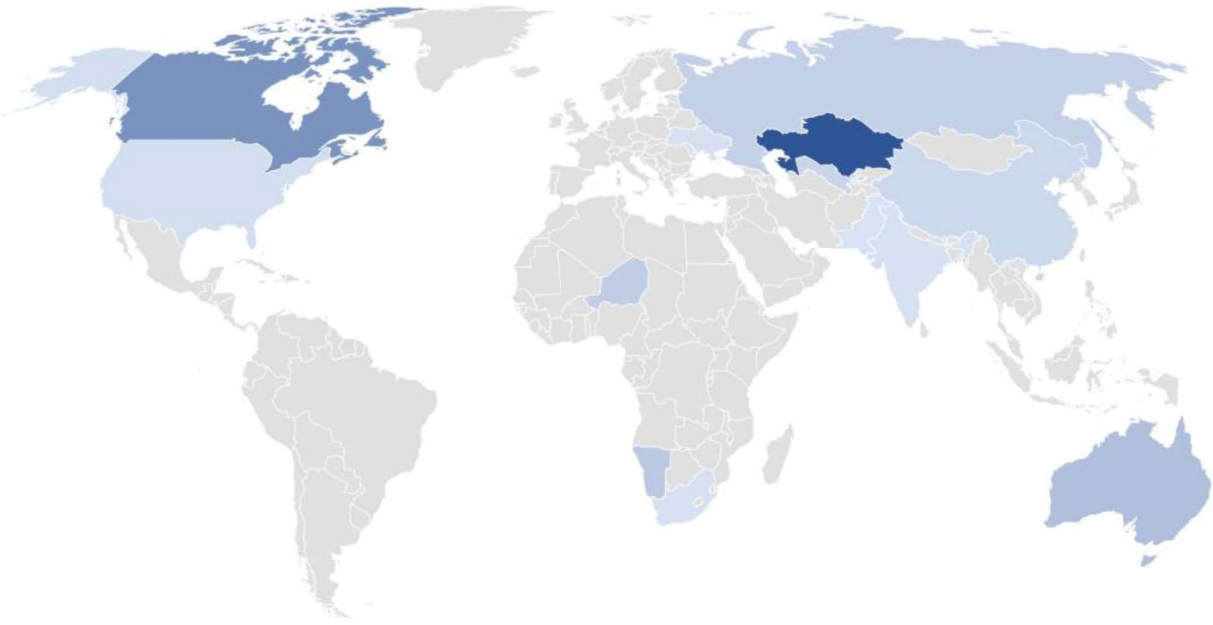
Poland only has resources of poor ores, therefore it is not possible to cover the demand for uranium from conventional and unconventional deposits (e.g. from ashes) in the context of the construction of a nuclear power plant. As a result, Poland will be obliged to obtain this element in another way, namely to import it from other countries. Australia, Kazakhstan, Russia and Canada have the largest deposits of uranium, and with the currently discovered deposits, developed technology and demand for the element, uranium should be sufficient for more than 100 years. The largest uranium producers are Kazakhstan, Canada, Australia, Niger, Namibia, Russia, Uzbekistan and China (Figure 2., Map 1.).

Figure 2. World uranium production in 2017, tonnes [t]



Source: Own study based on https://www.world-nuclear.org/information-library/nuclear-fuel-cycle/mining-of-uranium/world-uranium-mining-production.aspx (access: 10.07.2019)

Map 1. Uranium mining in 2017



Source: Own study based on https://www.world-nuclear.org/information-library/nuclear-fuel-cycle/mining-of-uranium/world-uranium-mining-production.aspx (access: 10.07.2019)

Potential contractors for a nuclear power plant in Poland include the United States (USA) and South Korea. During the I Polish-Korean Nuclear Forum, organised by the Polish Ministry of Energy and the Embassy of South Korea in Poland on 20 September 2018 in Warsaw, talks among representatives of nuclear energy companies on business cooperation took place. Korean concern Doosan Heavy Industries&Construction, which manufactured the most important parts of the AP1000 reactors by Westinghouse, proposed the transfer of production

technology. In November 2018, U.S. Energy Secretary Rick Perry announced that the Americans were ready to sell the technology and build a nuclear power plant, as well as to share in the costs. On 8 November 2018, the Joint Declaration of the US Department of Energy and the Polish Ministry of Energy on enhanced cooperation in the field of energy security concerning, among others, security of gas supply, nuclear energy and cyber-security was signed. On 12 June 2019, Piotr Naimski, Government Plenipotentiary for Strategic Energy Infrastructure, and Rick Perry, US Secretary of Energy, signed a Memorandum of Understanding (MoU) on cooperation in the field of civil nuclear energy. The agreement is an expression of both parties' willingness to cooperate in the fifth direction of the draft Polish Energy Policy until 2040 (PEP2040). The American candidate is Westinghouse, which has produced over 440 nuclear reactors, including four AP1000 reactors in China. According to PEP2040, the final selection of the technology and the general contractor for the first Polish nuclear power plant will take place in 2021.

Energy security and nuclear energy

A modern energy policy for the country should place emphasis on ensuring energy security, defined as the state of the economy allowing the prospective demand of consumers for fuels and energy in a technically and economically justified manner to be covered, while maintaining the requirements of environmental protection (Energy Law 1997, Journal of Laws No. 54, item 348, p. 10). Management of the country's energy security is connected with three aspects: energy, economic and ecological.

The energy aspect is related to balancing the demand and supply side and ensuring the reliability of the system. Maintaining the energy balance means guaranteeing an adequate amount of energy raw materials so as to be ready to meet the needs of useful energy consumers at any time. Ensuring the reliability of the system concerns the ability to deliver the required quantities and standards of power. The economic aspect refers to ensuring that demand for usable energy is met at socially acceptable prices, which are set in contracts/tariffs. The environmental aspect concerns the observance of the binding principles of environmental protection, which means that the energy sector should not contribute, among other things, to the degradation of the natural environment and to the creation of irreversible states. This is primarily related to investment in clean energy technologies: renewable energy sources (RES) and nuclear energy.

Nuclear energy is part of all aspects of energy security:

I. A nuclear power plant in Poland will ensure that the energy balance is maintained, as it will diversify the energy sector, which will result in less dependence on fossil fuels (to the greatest extent on coal) and on the state of the weather (in the case of renewable energy sources, including wind power plants). In the long term, coal, oil and natural gas will be insufficient to produce electricity because, given the increasing demand for energy and limited access to these raw materials, they will not be able to meet demand at some point in the future and, as a consequence, the energy balance will be interrupted. The balance between diversified energy sources affects the increase in the country's energy security. Uranium deposits are located in politically stable countries, making the supply of this fuel less endangered and systematic. In addition, uranium is a raw material that is easy to transport and store.

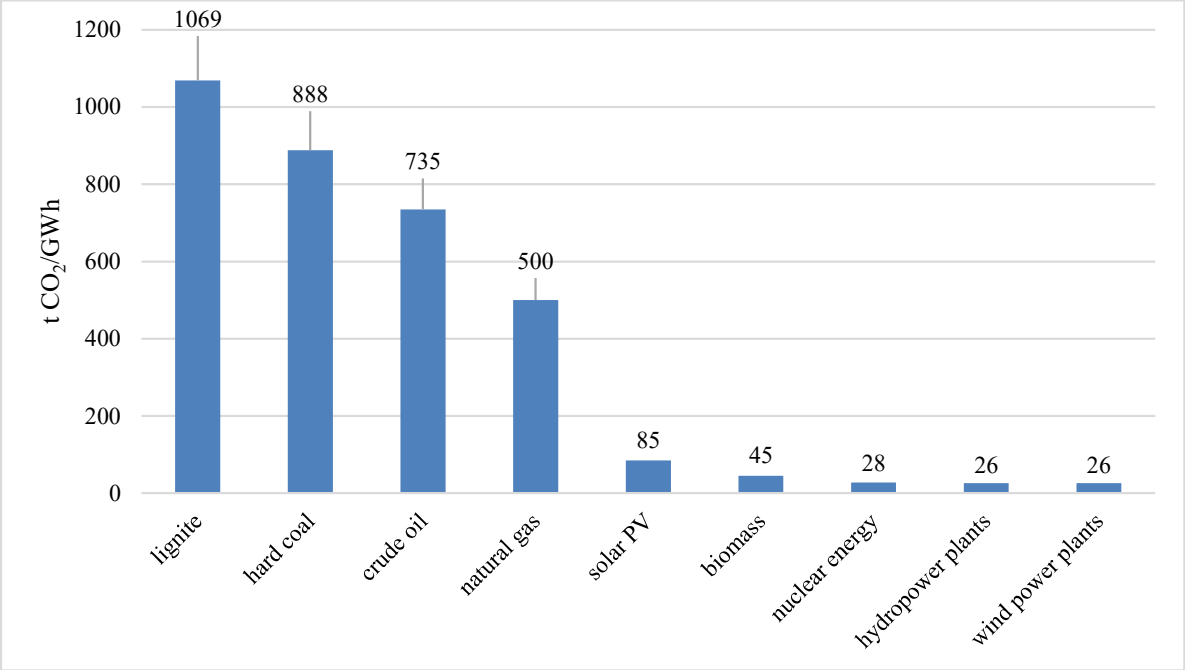
II. As shown in the chart below (Figure 3.), the price of a pound of uranium ranges from USD 23.9 to USD 26.3, nuclear reactors are cheap to operate, and the price of electricity is almost insensitive to fluctuations in uranium prices (this is due to the relatively small amount of fuel used to produce energy). In addition, contracts with uranium suppliers are mostly long-term, which is a long-term guarantee of access to fuel.

Figure 3. Evolution of the price of the uranium per pound [in USD], from May 24 to July 24 2019

Source: https://tradingeconomics.com/commodity/uranium (access: 24.07.2019)

III. In Poland, radioactive waste due to the activity of radioactive elements is divided into three groups: highly active, medium active and low active. Each of these groups requires different treatment for transport, disposal and storage. The disposal of radioactive waste takes place in specially designated areas at the National Radioactive Waste Repository (an additional repository is planned to be opened in 2027). Another issue is the concern about a major accident at a nuclear power plant and radioactive contamination. These are justified (Chernobyl (1986) and Fukushima (2011)); however, the power plants currently under construction are equipped with modern protection systems, and moreover, the previous failures were caused mainly by human error or natural disasters, and not by technological defects. Nuclear energy is low-emission energy, emitting an average of 28 tonnes of CO_2/GWh (Figure 4.), which contributes to improving air quality; however, the discharge of cooling water from reactors results in thermal pollution, and there is also a risk of radioactive contamination of waters. In terms of the overall picture, nuclear power plants are one of the most environmentally friendly ways of generating energy and meet the requirements of the environmental aspect of energy security.

Figure 4. Average greenhouse gas emission intensity, by energy source [tons CO_2/GWh]



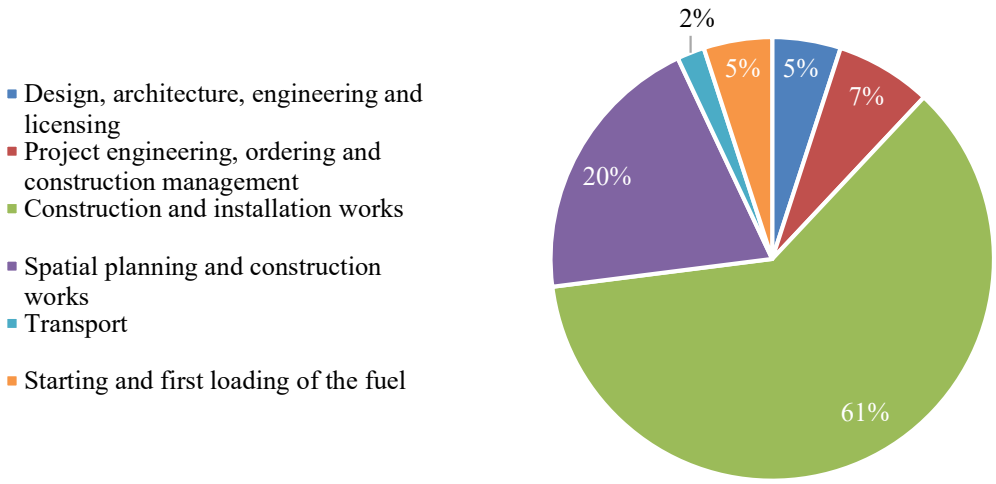
Source: Own study based on Nuclear Power Engineering in the face of global challenges of energy security and non-proliferation regime in the era of climate change, Młynarski T., Wydawnictwo Uniwersytetu Jagiellońskiego Kraków 2016. p.185

Analysis of the operating costs of a nuclear power plant

Nuclear power generation costs include:

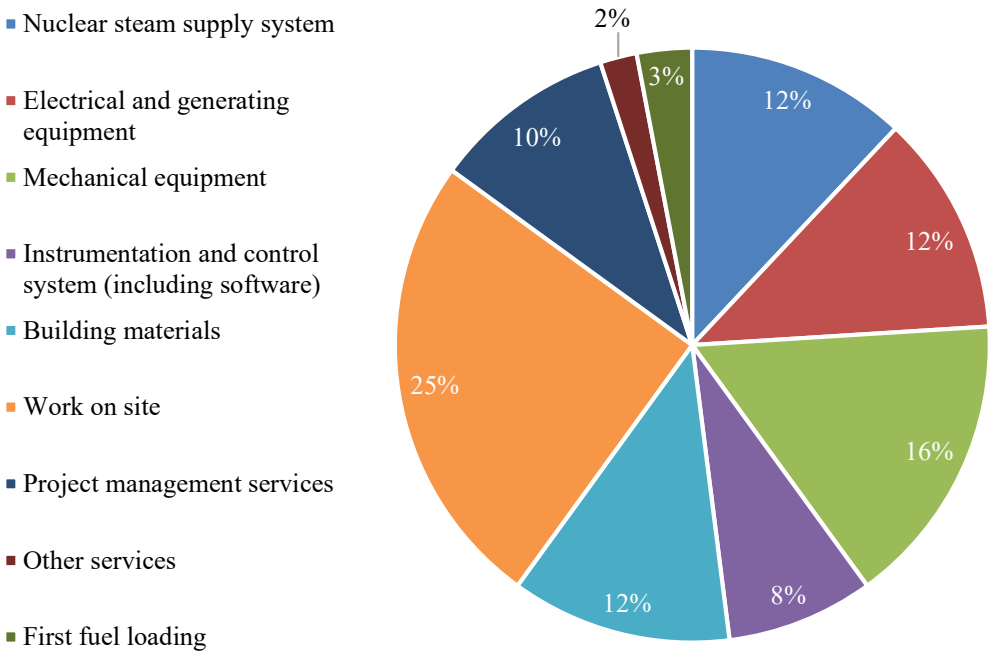
1. Internal costs:
   - Investment costs – represent more than 50% of the cost of energy generation (Pach-Gurgul 2015: 257). They are divided by activity (Figure 5) and in terms of labour, goods and materials (Figure 6);

Figure 5. Investment costs by activity



Source: Own study based on The World Nuclear Supply Chain: Outlook 2035, 2016.

Figure 6. Investment costs in terms of labour, goods and materials



Source: Own study based on The World Nuclear Supply Chain: Outlook 2035, 2016.

- O&M costs include maintenance and repairs. They constitute about 18% of the costs of energy generation (Pach-Gurgul 2015: 257);
- Decommissioning costs – represent about 4% of the costs of energy generation (Pach-Gurgul 2015: 257);
- Fuel cycle costs – include uranium prices, conversion, enrichment, fuel fabrication and waste disposal. They account for about 20% of the costs of energy generation (Pach-Gurgul 2015: 257).

2. External costs:
   - Grid costs (related to transmission and distribution of energy);
   - Social costs and environmental losses (including health funds);
   - Costs incurred for environmental protection (e.g. fees for CO_2 emissions);
   - Taxes;
   - Costs incurred for security of energy supply;
   - Costs incurred to ensure social acceptance.

The largest group of costs are investment costs, which are higher than in the case of a coal or gas-fired power plant. In addition, these costs are difficult to estimate, which increases the investment risk. The construction time of a nuclear power plant is longer and its operation carries the risk of high social costs and environmental losses in the event of a reactor accident. The fuel cycle costs are relatively low (reactor power generation requires little fuel; reactors are cheap to operate) and stable, and would therefore ensure the competitiveness of the economy. Charges for CO_2 emissions are much lower compared to other conventional energy sources.

Given the overall cost of a nuclear power plant, it is the cheapest low carbon energy source in the world, as high investment costs are offset by low fuel cycle costs.

Analysis of the potential for development of nuclear energy

The SWOT analysis consists in comparing the strengths, weaknesses, opportunities and threats of a given project (Table 1.).

Table 1. SWOT analysis of the introduction of nuclear power in Poland

Strengths	Weaknesses
– Investment in nuclear energy is in line with the objectives of the national energy policy and the EU climate and energy package. – Achievement of the environmental effect (in the case of nuclear power – avoided emissions). – Adapting the production process to a changing climate (low carbon energy source). – Electricity prices are insensitive to fluctuations in uranium prices and reactors are cheap to operate. – Once in operation, a nuclear power plant can run continuously for about 60 years.	– High investment costs accounting for over 50% of all costs. – Thermal water pollution caused by the release of cooling water. – Long construction time of the power plant. – Need for disposal and storage of radioactive waste. – No domestic uranium deposits. – External costs are difficult to quantify.
Opportunities	**Threats**
– Securing the expected increase in demand for final energy. – Long-term guarantee of uranium supplies (resources will last for more than 100 years). – Development of national research and development facilities. – Increase in local employment (new jobs). – Diversification of the national energy sector. – Continued development of the nuclear power industry.	– Risk of terrorist threat. – Strong lobby for the development of renewable energy sources (RES). – Negative public perception of nuclear energy (concerns about accidents and radioactive contamination). – Risk of using nuclear energy for military purposes (dual use technology).

Source: Own elaboration

The PEEST analysis, otherwise known as general ambient segmentation, is based on the analysis of political, environmental, economic, socio-cultural and technological factors (Table 2.).

Table 2. PEEST analysis of the introduction of nuclear power in Poland

Political factors	– Inevitability of improving energy security and diversification of energy sources. – Implementation of nuclear energy with the fifth direction of the Polish Energy Policy until 2040. – The reduction of CO_2 emissions required by the European Union (EU). – Limited impact of energy on the environment as a goal of the national energy policy.
Environmental factors	– Nuclear power is a low-carbon energy source (28 tonnes of CO_2/GWh). – As a result of the release of cooling water, thermal pollution occurs. – Risk of radioactive contamination of humans and the environment as a result of accidents. – Nuclear power plants generate large quantities of radioactive waste.
Economic factors	– High investment costs of building a nuclear power plant. – Economic development and projected increase in energy demand. – Limited access to depleted fossil fuel resources. – Risk of high social costs and environmental losses. – A stable global uranium market. – Decrease in unemployment due to the creation of new jobs in the construction and operation of the nuclear power plant. – Gross domestic product (GDP) growth. – Costs incurred for the education of the staff.
Socio-cultural factors	– Negative attitude of society and ecologists. – Lack of public education on the benefits of nuclear energy, as well as in the field of energy (identifying nuclear energy with nuclear weapons). – Concerns about reactor failure. – Insufficient number of qualified people to work at the power plant (need for training).

Technological factors	– The technologies used to build power stations are now modern, but in 60 years' time they will be outdated. – Long-term construction process of the power plant. – Insufficiently developed transmission grid.

Source: Own elaboration

Summary

As a result of climate change caused by excessive human activity, the projected increase in demand for final energy and the inevitable depletion of fossil fuel resources, diversification of energy sources is justified and advisable. It creates an opportunity for the development of nuclear power, which will contribute to the implementation of all the objectives of Poland's energy policy:

- energy security, which includes ensuring that the energy balance is maintained, cheap and stable supplies of uranium, and electricity prices that are not sensitive to fluctuations in uranium prices.
- competitiveness and energy efficiency, understood as the reduction in the use of fossil fuels to produce electricity by starting production at a nuclear power plant.
- limited impact of the energy sector on the environment resulting from low emission of the energy source emitting 28 t CO_2/GWh.

Investment in nuclear energy could be an excellent complement to renewable energy sources (RES), especially given the dependence of RES on weather conditions. Undoubtedly, the best scenario for the Polish energy sector of the future is to obtain energy from renewable sources and nuclear power plants, as they are the answer to climate challenges.

The SWOT and PEEST analyses carried out allow us to conclude that there are prospects for nuclear power development in Poland. The political, economic and environmental environment is characterised by favourable strategic conditions, which may change the attitude of society and lead to a positive assessment of its potential. The multidimensional and multi-faceted approach makes it possible to come to the conclusion that the inclusion of nuclear energy in the Polish energy sector is the right thing to do.

Bibliography

1. Cieśliński P., Korzeniowska K., Pawłowska D., Czy Europie opłaca się inwestować w atom?, „Nasza Europa", dodatek do „Gazety Wyborczej" 2019, 29 czerwca, nr.17, s. 10–11
2. elektrownia-jadrowa.pl (access: 10.07.2019)
3. Energetyka – bezpieczeństwo w wyzwaniach badawczych: Tom 1: Polska i Świat – Energetyka Jądrowa – Bezpieczeństwo – Logistyka, P. Kwiatkiewicz, R. Szczerbowski, Wydawnictwo Fundacja na rzecz Czystej Energii, Poznań 2017
4. Energetyka – wybrane zagadnienia Część I. Zasoby i prognoza zapotrzebowania na energię, Kancelaria Senatu Biuro Analiz i Dokumentacji Dział Analiz i Opracowań Tematycznych, https://www.senat.gov.pl/gfx/senat/pl/senatopracowania/92/plik/ot-580.pdf (access: 10.07.2019)
5. Energetyka węglowa i jądrowa Wybrane aspekty, R. Szczerbowski, Wydawnictwo Fundacja na rzecz Czystej Energii, Poznań 2017

6. europarl.europa.eu (access: 10.07.2019)
7. Fornalski K. W., Energetyka jądrowa a bezpieczeństwo energetyczne, [w:] Geopolityka współczesnego bezpieczeństwa energetycznego Wybrane aspekty, M. Ilnicki, Ł. Nowakowski, I. Protasowicki, Wydawnictwo Towarzystwo Naukowe Powszechne, Warszawa 2017
8. Frączek P., Energetyka jądrowa a modernizacja sektora energii w Polsce, Nierówności Społeczne a Wzrost Gospodarczy, nr 37 (1/2014)
9. Kowgier H., Energetyka jądrowa we współczesnym świecie – szanse rozwoju i zagrożenia, Zeszyty Naukowe Uniwersytetu Szczecińskiego, Studia i Prace Wydziału Nauk Ekonomicznych i Zarządzania nr 36 T.2 Metody ilościowe w ekonomii, 2014
10. Leszczyński T., Energetyka jądrowa w państwach Unii Europejskiej, Biuletyn Urzędu Regulacji Energetyki, nr 5/2008
11. Ligus M., Identyfikacja gospodarczych, społecznych i środowiskowych oddziaływań rozwoju technologii energetyki niskoemisyjnej w Polsce, Studia i Prace Wydziału Nauk Ekonomicznych i Zarządzania 47/2, 89-98, nr 47/2 2017
12. Ligus M., Trudno wymierne koszty zewnętrzne energetyki jądrowej, Wydział Zarządzania – Uniwersytet Gdański, Zarządzanie i finanse, 2 (2013)
13. Michalak J., Wpływ elektrowni jądrowych na środowisko, Poznan University of Technology Academic Journals, Electrical Engineering, No 74, 2013
14. Michalski M., Development of nuclear power as an alternative to fossil fuels, Acta Innovations, No. 30, 2019
15. Młynarski T., Energetyka jądrowa wobec globalnych problemów bezpieczeństwa energetycznego i zmian klimatu w XXI wieku, Krakowska Akademia im. Andrzeja Frycza Modrzewskiego / Oficyna Wydawnicza AFM KAAFM, Bezpieczeństwo. Teoria i Praktyka, 1 (2016)
16. Młynarski T., Energetyka jądrowa wobec globalnych wyzwań bezpieczeństwa energetycznego i reżimu nieproliferacji w erze zmian klimatu, Wydawnictwo Uniwersytetu Jagiellońskiego, Kraków 2016
17. Motowidlak T., Energetyka jądrowa w Unii Europejskiej, Polityka Energetyczna, tom 12 (2009), zeszyt 2/1
18. Murray R. L., Nuclear Energy: An Introduction to the Concepts, Systems, and Applications of Nuclear Processes: Sixth Edition, Publisher Butterworth-Heinemann, 2009
19. Nuclear Power Reactors in the World, IAEA, https://www-pub.iaea.org/MTCD/Publications/PDF/RDS-2-38_web.pdf (access: 10.07.2019)
20. nuclear.pl (access: 10.07.2019)
21. oecd-nea.org (access: 10.07.2019)
22. Pach-Gurgul A., Perspektywy rozwoju energetyki jądrowej w Unii Europejskiej po katastrofie w Fukushimie, Studia i Materiały Wydziału Zarządzania i Administracji Wyższej Szkoły Pedagogicznej im. Jana Kochanowskiego w Kielcach, 19 (2015), nr 1 Globalizacja i regionalizacja we współczesnym świecie - doświadczenia i wyzwania.
23. Pearce J. M., Limitations of Nuclear Power as a Sustainable Energy Source, Special Issue Sustainable Nuclear Energy, *Sustainability* 2012, *4*(6)
24. Pindór T., Uwarunkowania i perspektywy rozwoju energetyki jądrowej w świecie i w Polsce, Prace naukowe Uniwersytetu Ekonomicznego we Wrocławiu, nr 523, 2018

25. Projekt Polityka Energetyczna Polski do 2040 roku (PEP2040), 23.11.2018 r., Warszawa 2018, https://www.gov.pl/documents/33372/436746/PEP2040_projekt_v12_2018-11-23.pdf/ee3374f4-10c3-5ad8-1843-f58dae119936 (access: 10.07.2019)
26. Strupczewski A., Aspekty ekonomiczne wprowadzania energetyki jądrowej, Energetyka Cieplna i Zawodowa, nr 11/2009
27. Strupczewski A., ZA I PRZECIW – Dyskusja o energetyce jądrowej, Biuletyn Miesięczny PSE, 6/06 2006
28. swiadomieoatomie.pl (access: 10.07.2019)
29. Trubalska J., Znaczenie elektrowni jądrowych dla bezpieczeństwa energetycznego państw Unii Europejskiej, [w:] Geopolityka współczesnego bezpieczeństwa energetycznego Wybrane aspekty, M. Ilnicki, Ł. Nowakowski, I. Protasowicki, Wydawnictwo Towarzystwo Naukowe Powszechne, Warszawa 2017

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