The Copernicus Journal of Political Studies 2018
No. 2/2018, pp. 83–94
ISSN 2299-4335
DOI: http://dx.doi.org/10.12775/CJPS.2018.0011
www.apcz.umk.pl/czasopisma/index.php/CJPS

Piotr Majewski
Nicolaus Copernicus University in Toruń, Poland

POLISH POTENTIAL NUCLEAR POWER BASED ON PEP2040

ABSTRACT

The following paper focuses on the issue of Polish nuclear program and the prospect of its prompt implementation within the framework of the project on strategy regarding Poland's energy security until 2040. The text also shows the development of this program since the 1950s and discusses types of reactors which could be used in the potential nuclear power plant blocks.

Key words

nuclear energy, energy security, Żarnowiec nuclear power plant, PEP2040, HTGR, PWR, FBR.

Introduction

Poland's policy in the field of energy is determined by a variety of factors. Apart from the geographical issues related to the availability of deposits of natural energy resources and the possibility of using renewable sources of energy, the adopted Polish strategy on energy security was to a great extent influenced by determinants of political, legal and socio-economic nature. In the face of limits on emissions arising from the climate-energy package adopted by the European Union (the EU) and the estimated increase in costs of coal extraction by 2030

(72% of energy produced in Poland comes from coal) (Kasztelewicz, 2018), it is possible to clearly observe the growing need for diversification of sources of electrical energy which would be able to satisfy the continuously growing demand. Developing a security strategy and policy on energy that would be modern and adjusted to individual Polish conditions as well as to trends in the development of the global energy sector is a necessary condition for guaranteeing Poland's further stable development.

The idea of Polish nuclear energy program has been present in the public sphere since the second half of the 20th century; however, despite numerous declarations made by subsequent governments, the project has not been implemented yet. The date of completion of the first nuclear power plant is continuously postponed; in the public dialogue, Polish nuclear program is practically absent except the negative rhetoric that temporarily intensified after the Fukushima nuclear disaster. What is usually proposed as possible areas of expansion for Polish power and heat engineering – and which would gradually balance the dominant role of coal – are renewable sources of energy as they are most climate friendly and least problem-causing since they do not require security of delivery and continuity of supply in fuels. Another suggested area of expansion is Poland's deposits of shale gas although they are poorly explored and the research on possibilities of its cost-effective extraction on industrial scale is in the early stages. Therefore, although declared as a direction for expansion in Polish policy on energy security, the idea of nuclear energy due to numerous factors does not play an important role in the mentioned strategy. However, using nuclear reactors seems to be a chance both for producing a great amount of pure energy and for maintaining a state in which Polish power engineering relies on domestic deposits supplied regularly with minimal price fluctuations. Thus what appears to be vital is the analysis of potential benefits and possibilities of implementation of the planned Polish nuclear energy program within the framework of the announce in November 2018 project on Energy Policy of Poland until 2040 (PEP2040) and with regard to real possibilities of its prompt implementation.

The article consists of three parts. Firstly, it presents a historical overview of the Polish nuclear energy program as well as experiences and institutional-legal solutions in this field. The second part is devoted to the analysis of the presented PEP2040 project, particularly to the part devoted to implementation of the fifth declared direction, that is the development of nuclear energy. The last part is an analysis of possible development paths of Polish nuclear energy within the PEP2040 program with regard to its potential benefits and risks related to using specific types of reactors. In order to achieve it, it would be necessary to refer to the most serious challenges for Polish energy security indicated in the project and assess the possibility of facing them in Polish geographical, economic and social conditions.

1. Overview of the idea of Polish nuclear power plants

The origins of the Polish nuclear power program date back to 1955, when the Andrzej Sołtan Institute of Nuclear Research at Świerk was established. Three years later the first experimental nuclear reactor EWA (the acronym for: experimental, water, atomic) was launchedthere. This was a Soviet WWR-S type construction; thermal light-water reactor with the initial output 2 MW, eventually reaching 10 MW, fuelled by uranium enriched to 36%, using water as coolant and moderator (Matysiak, 2015, p. 9). EWA was used until 24 February 1995 (Jezierski, 2006, p. 2.), when it was decided to shut it down. In the subsequent years, four other experimental reactors were launched there: ANNA (1963), MARYLA (1963), AGATA (1973) and MARIA (1974). Currently, only one of them is active – MARIA, with thermal output 30 MW. It is used mainly for experimental and training purposes as well as for production of isotopes for medical purposes.

On 12 August 1971 the Council of Ministers of the Polish People's Republic decided to initiate the construction of the first Polish nuclear power plant, located in the village of Kartoszyno, at the lake Żarnowiec. In accordance to the 1974 contract with the USSR, the program was to be carried out using Soviet technology and production equipment. Ultimately, the power plant was to be equipped with four power blocks, using the second generation pressurized water reactors, WWER-440 type with total output 1600 MW. Construction works began in 1984 with preparing the site for the structure, which was to be situated on around 70 hectares of land. In addition to the "Żarnowiec" power plant, the program included a parallel one, approved in 1987, when a decision was made to establish a new facility called "Warta" nuclear power plant, consisting of four blocks and using reactors with a higher output than in Żarnowiec, totaling 4000 MW.

At the same time, the Polish institutional-legal system was being adapted to the development of the domestic nuclear power program. Pursuant to the Act of 27 February 1982 on the establishment of the National Atomic Energy Agency, a new central administration body was set up to coordinate and control all activities related to the developing nuclear program. On 10 April 1986, the Atomic Law was passed, which was the first nationwide act of this rank, regulating issues related to the use of nuclear technology.

On 4 September 1990, the Council of Ministers decided to abandon the construction of the "Żarnowiec" nuclear power plant. It was caused by both economic and social factors. The Polish economy, undergoing transformation at that time, was not able to sustain such an expensive undertaking. The Planning Commission of the People's Republic of Poland optimistically estimated the cost of the project as between 3.5 and 6.8 trillion PLN, at prices from 1984 (Zespół Prezesa Państwowej Agencji Atomistyki do spraw elektrowni jądrowej Żarnowiec, 1990, p. 8). Meanwhile, the country's economic situation did not make it possible to spend on the "Żarnowiec" and "Warta" power plants more than insufficient 2.2 bn PLN. The other solution would be financing the project with funds obtained from foreign loans, repayment of which would take about 12 years (with the assumed repayment plan with funds obtained from the sale of energy produced by the power plant). Another important reason for the decision to abandon the project was violent public outcry. As a result of the failure of the reactor at the Chernobyl nuclear power plant on 26 April 1986, which led to the greatest disaster in the history of nuclear energy, the support of Poles for the project of building "Żarnowiec" and "Warta" power plants dropped significantly. However, apart from the very question of the society's disapproval, the experts assessed the level of security ambiguously. In a local referendum held in the then Gdańsk Region on 26 May as many as 86% of voters at 44% attendance opposed the idea of building the power plant. Despite the fact that the construction works were at an advanced stage, the date of the shutdown of the power plant was set for December 1992. The infrastructure of the "Żarnowiec" power plant built so far has been dismantled, two of the four reactors scrapped and the remaining two re-sold to other countries (Kiełbasa, Hryszko & Kuźniarski, 2014).

For some time, the issue of the Polish nuclear power program was pushed out from the public dialogue. In the document adopted by the Sejm in 1996, "Assumptions of the Polish energy policy until 2010", a decision was made to abstain from building nuclear power plants, instead taking actions to explore the possibilities of using modern, safe and environmentally friendly technologies (Jezierski, 2006, p. 5), economic legitimacy and public opinion on the subject. The problem was practically not addressed in the document "Polish energy policy until 2025", adopted by the Council of Ministers in 2005. The strategy adopted in the new political reality related to Poland's integration with the European Union focused to a greater extent on the development of technologies and investments concerning the use of renewable energy sources. At the end of the first decade of the 21st century, nuclear power seemed to be experiencing a renaissance, as a larger number of developed countries decided to invest in this sector. This was mainly due to economic factors: with the ever-increasing demand for energy, nuclear power plants were able to guarantee energy security much better than facilities using renewable sources of energy. The development of technologies has also made it possible to use more modern, safer and better standardized third generation reactors in power plants. Soon both the need to rebuild the national energy mix, based on obsolete infrastructure and environmentally harmful coal, as well as the abovementioned economic factors resulted in the return of the nuclear power issue to the development agenda of Poland.

In 2009 the government began working on the preparation of the first comprehensive program of building and functioning of nuclear power plants. The project, called "Polish Nuclear Power Program" was adopted in 2014. The implementation of the project was to depend on public support and be carried out only after securing human, technological and economic resources required for building and proper operation of the nuclear power plant. According to preliminary estimates, the date of commissioning the first Polish nuclear power plant was to be 2020. As a result of the research, several potential locations were selected, the final choice narrowed to Żarnowiec, Choczew and Kopalin (Ministerstwo Gospodarki, 2014, p. 105).

Diversification of energy sources through the introduction of nuclear energy into the mix became one of the objectives of the strategy declared in the "Poland's energy policy until 2030." However, the scope of activities and the project implementation plan was presented in a superficial manner, rather in the form of a declaration of purpose than a presentation of specific solutions (Ministerstwo Gospodarki, 2009, pp. 15–18). Nevertheless, the resumption of the issue of nuclear energy by the Polish government was of significant importance for the potential future transformation of the structure of energy production in Poland.

2. Project on the Energy Policy of Poland until 2014

The PEP2040 project, presented in November 2018 by the Ministry of Energy, is a long-term strategy for energy security of the country. It assumes concentration on the eight basic directions of development of the Polish energy sector, and defines the superior goals and priorities as well as activities planned for a dozen or so years to serve their implementation. The document also contains an assessment of conditioning of the national energy policy, taking into account factors of a geographical, economic and social nature, particularly in the context of high employment in mining – a branch which supplies the main fuel in the current energy policy. The directions of the state's energy policy indicated in the project are (Ministerstwo Energii, 2018, p. 7)

- Optimal use of domestic energy resources.
- Extension of electrical energy production and transmission infrastructure.
- Diversification of gas and oil supplies and development of transmission infrastructure.
- Development of energy markets.
- Implementation of nuclear energy.
- Development of renewable sources of energy.
- Development of heat engineering and cogeneration.
- Improvement of the economy's energy efficiency.

The planned energy policy is to be implemented according to three overarching guidelines, namely maintaining the state of energy security, while maintaining the competitiveness of the entire economy and reducing the impact of energy on the environment (Ministerstwo Energii, 2018, p. 6). The prospect of implementing the adopted strategy covers twenty years, and its design takes into account the guidelines included in the EU climate-energy package until 2020, as part of the implemented strategy Europe 2020. The plan implementation indicators defined by the ministry are

- Reduction of the share of coal-fired power plants as well as heat and power plants in the energy sector to 60%.
- Increase in the share of renewable sources of energy to 21% in gross energy consumption by 2030.
- Fulfilment of the nuclear power implementation plan for the Polish generation system until 2033.
- Reduction of CO2 emissions by 30% until 2033 in comparison to the emissions in 1990.
- Improvement of energy efficiency by 23% until 2033 in comparison to the prognostic situation from 2007.

The issue of increasing the share of renewable sources of energy in the Polish power industry creates quite important problems. Due to the domestic geographical conditions, the possibility of cost-effective energy production based on renewable sources of energy on an industrial scale encounters serious difficulties. In the Polish circumstances, both photovoltaics and hydroelectric or wind power plants are not able to produce enough energy to ensure energy security. Therefore, with regard to energy production based on renewable energy, biofuels are the most optimal solution in Polish conditions. Although since 2014 it has been possible to observe a growing tendency in the share of renewable energy technology in the power generation structure in Poland, the ratio of financial investment in the structure and maintenance of the power plant exceeds the value of energy obtained from it. Thus, considering the need to replace the worn out and decommissioned coal blocks, use of nuclear power seems to be a better solution.

Interestingly, however, in the presented project the issue of nuclear energy is not elaborated in detail. The resolution of problems that are vital for the Polish nuclear program are postponed. The final date for determining the location of the first power plant was set for 2020. The document mentions two places that meet the criteria set out in the Polish nuclear power program: Żarnowiec and Lubiatowo-Kopalino, both situated in the Pomeranian Region. Importantly, the project does not specify the kind of technology and types of reactors that would be used in the first planned energy block. Without this knowledge, it is impossible to precisely estimate the costs of the whole undertaking, and similarly, the possible amount of the energy generated there. The document only says that the assumed output from the first block is to be 1–1.5 GW, and there is a plan to use Generation III or III+ reactors (Ministerstwo Energii, 2018, p. 38). The estimated date for starting the first nuclear power plant was set for 2034, indicating that the next block will be launched within several years. This date should be treated rather as a tentative one, particularly due to the fact that in previous strategies about energy policy of Poland it had been moved many times.

The analysis conducted for PEP2040 revealed that up to 60% of the whole project can be accomplished by Polish companies. One of the crucial issues, which substantially slows down the process of fulfilling the project, is the lack of trained staff that would supervise and guarantee proper functioning of the power plant.

3. Possible paths of implementation of the Polish nuclear program

It seems that in the current conditions the development of the nuclear energy program is one of the most cost-effective development paths for the Polish energy sector. High financial investments are compensated through continuous production of pure energy in high amounts. Thus introducing nuclear power plants to the Polish energy mix not only facilitates the process of decarbonization of the energy sector, which is declared in the project and forced by the circumstances, but also guarantees more energy security than renewable sources of energy. What is also important in the case of launching and operating nuclear power plants, ensuring continuity of supplies should not be a problem since except the incalculable domestic deposits of uranium in Podlasie, Poland could use resources imported from countries that are stable and not in conflict with the state.

Considering technology which should be used to generate energy in nuclear power plants, there is a number of options taken into account. Several commonly used types of reactors are presented below; each of them is discussed in terms of its strengths and weaknesses.

Fast-neutron reactors

One of the possible solutions which may be applied in the Polish nuclear energy program is to equip the power plants with reactors that use fast neutrons for nuclear fission. These reactors do not need either moderators or water-based cooling. Instead, they use liquid sodium, which has high boiling point 883°C (NCBJ, 2007, p. 13). Such type of reactors requires a relatively heavily enriched fuel for operation; however, it has several key advantages, making it quite an attractive solution for the Polish power industry. Above all, fast reactors are much more efficient than thermal reactors. This is because working with the 238U uranium isotope using fast neutrons results in production of plutonium, which can be reused. Thus fast reactors are able to not only obtain more energy from a smaller amount of the base fuel, but thanks to the production of a new one, additionally make it possible to reuse the radioactive waste, thus significantly reducing its quantity (Chwaszczewski, 2009, p. 53). As a result, two important reservations about the development of Polish nuclear energy, i.e. security of supply and prices of resources as well as issues related to the utilization of waste and its possible impact on the environment, would be less of a concern with these power plants which use such technology.

However, the use of fast reactors is connected with quite significant restrictions. Firstly, the investment and operating costs are much higher than in the case of thermal reactors. Liquid metal cooling requires the use of three circuits and the supply of coolant that is more difficult to obtain than water. Fast reactors also have a significantly lower lifespan. Thus the only economic advantage over thermal reactor technology would be noticeable in a situation in which prices of resources used as fuel were unstable and inflated. Another issue concerns security. Sodium, used as a coolant, is a highly flammable material, which significantly increases the risk of failure, particularly when there is no experience and no solid technical or personnel base. That is why it appears that choosing this type of technology in the still underdeveloped Polish nuclear energy program would not be a good solution, although in the long run, particularly in view of certain renaissance in technology concerning this type of reactors (many of the currently designed Generation IV generators are based on fast neutrons), they would be worth taking into consideration.

High-temperature reactors

This type of reactors uses graphite as a moderator and helium as a coolant. Thanks to this, it is able to produce, apart from electrical energy, a substantial amount of heat. Therefore Poland has been increasingly interested in high temperature reactors (HTR) and high-temperature gas-cooled reactors (HTGR). The Ministry of Energy has included in the draft of the Responsible Development Strategy a program for the implementation of high-temperature reactors, independently of the program for building nuclear power plants (Bracha-Rutkowska, 2018). A cost-effective cogeneration of electrical and heat energy from high-temperature reactors would be a good substitute for coal, particularly due to small energy losses. HTGR can also replace previously used coal boilers without the need to replace the rest of the installation. The unquestionable advantages of the HTR / HTGR technology include also its high safety and small size, which makes it possible to build them quickly even in the vicinity of human settlements (Terlikowski & Paska, 2018, pp. 43–44). These devices are also able to produce large amounts of hydrogen and synthetic fuels.

However, these installations produce a relatively small amount of electricity, with quite high fuel costs. Although HTGR reactors for their work may use its different form, the fuel must be first highly processed (Kujiper et al., 2006, p. 616). There are also issues related to investment costs, which due to the degree of technology experimentation are difficult to precisely estimate. The economic analysis attached to the project by the Ministry of Energy shows that, including the cost of licence, the cost of building the first block would be about 1.4 billion PLN for a reactor optimized to 165 MWH (Ministerstwo Energii, 2017, p. 23). Nevertheless, the government's growing interest in this technology and the opportunities resulting from its application in domestic conditions suggest that building this type of reactors in Poland is highly probable in the future.

Light water reactors

Among the presented options, pressurized water reactors or boiling water reactors seem most likely to be used in the first Polish nuclear power plant as the analysis conducted by the Polish Energy Group in 2015 suggested three types of these as the best solution. These are a pressurized water reactor (PWR), a boiling water reactor (BWR) and a pressurized heavy-water reactor (PHWR) (PGE EJ 1, 2015). Due to its high safety and widespread use in the world, it can be assumed that the PWR type is the most advantageous option, particularly with regard to the potential social resistance against the use of boiling reactors, which have lost a great deal of public trust after the Chernobyl disaster. What is more, Poland has experience with this technology, gained thanks to the experimental reactors and during the construction of the "Żarnowiec" power plant. Naturally, the guidelines emphasize the need for more modern versions of light water reactors, suggesting Generation III or III+; however, with regard to personnel and technology, these devices would be much easier to use than fast reactors.

The flaws of PWR include high investment costs and problems related to the utilization of radioactive waste; however, from the economic point of view these encumbrances are more acceptable than the use of experimental technology, at least for the process of building the first block of a nuclear power plant.

Conclusions

To summarize, the PEP 2040 project does not provide sufficient information which would make it possible to unambiguously determine the direction of development of the Polish nuclear energy program. The forecast about the energy structure until 2040, which was attached to the strategy, shows that the main direction of development are to be renewable sources of energy, particularly photovoltaics and sea wind power plants. The expected share of net installed power in nuclear power plants in 2040 is only 5.6 GW (Ministerstwo Energii, 2018b, p. 5). Considering the balance of potential benefits, this seems little; however, it should not be forgotten that the Polish nuclear energy program is only developing its shape. Thus in the case of a successful launch of the first blocks of nuclear power plants, further expansion of power engineering and heat engineering in this area should be considered. The demand for energy is increasing, together with the need to ensure its uninterrupted supplies in growing amounts; thus it seems legitimate to increase in its production through nuclear power station not only in Poland but also in other European countries. The hopes of world economy currently rest in hypothetical fusion power plants; however, the works on the international thermonuclear experimental reactor (ITER) still do not give certain answers regarding the possibility of implementing this technology on a larger scale in the near future.

REFERENCES

Bracha-Rutkowska, J. (2018). Wysokotemperaturowe reaktory jądrowe chłodzone gazem (HTGR). Retrieved from https://www.gov.pl/web/energia/wysokotemperaturowe-reaktory-jadrowe-chlodzone-gazem-htgr

Chwaszczewski, S. (2009). Technologie energetyki jądrowej w XXI wieku. *Polityka energetyczna*, *12*(2), 43–55.

Fang, C., Morris, R., & Li, F. (2017). Safety Features of High Temperature Gas Cooled Reactor. Retrieved from https://www.researchgate.net/publication/320986219_Safety_Features_of_High_Temperature_Gas_Cooled_Reactor

Jezierski, G. (2006). Kalendarium budowy elektrowni jądrowej w Żarnowcu, czyli… jak straciliśmy swoją szansę? *Energia Gigawat*, Jan 2006. Retrieved from https://www.cire.pl/pliki/2/zarnowiec.pdf

Kasztelewicz, Z. (2018). Raport o stanie branży węgla brunatnego w Polsce i w Niemczech wraz z diagnozą działań dla rozwoju tej branży w I połowie XXI wieku. Retrieved from https://www.cire.pl/pliki/2/2018/raport_o_stanie_branzy_wegla_brunatnego_w_polsce_i_w_niemczech.pdf

Kiełbasa, W., Hryszko, J., & Kuźniarski, Ł. (2014). Elektrownia jądrowa "Żarnowiec". Retrieved from http://atom.edu.pl/index.php/program-jadrowy-w-prl/ej-zarnowiec.html

Kujiper, J. C., Raepsaet, X., de Haas, J. B. M., von Lensa, W., Ohlig, U., …, Ruetten, H.-J., …, & Seiler, R. (2006). HTGR reactor physics and fuel cycles studies. *Nuclear Engineering and Design*, *236*, 615–634.

Matysiak, T. (2015). Historia pracy reaktora EWA. *Postępy Techniki Jądrowej*, *9–10*. Retrieved from http://www.ichtj.waw.pl/ptj/Pliki/ptj2015no1.pdf

Ministerstwo Energii. (2014). *Program polskiej energetyki jądrowej*. Retrieved from https://www.cire.pl/pliki/2/ppej28_01_2014.pdf

Ministerstwo Energii. (2017). *Możliwości wdrożenia wysokotemperaturowych reaktorów jądrowych w Polsce*. Retrieved from https://www.gov.pl/documents/33372/436746/Raport_HTR+.pdf/71f5d4b9-9322-22f1-d66f-8c6be3bcccb4

Ministerstwo Energii. (2018). *Polityka energetyczna Polski do 2040 roku*. Retrieved from https://www.gov.pl/documents/33372/436746/PEP2040_projekt_v12_2018-11-23.pdf/ee3374f4-10c3-5ad8-1843-f58dae119936

Ministerstwo Energii. (2018). *Wnioski z analiz prognostycznych dla sektora energetycznego*. Retrieved from https://www.gov.pl/documents/33372/436746/Wnioski_z_analiz_do_PEP2040_2018-11-23.pdf/1481a6a9-b87f-a545-4ad8-e1ab467175cf

Ministerstwo Gospodarki. (2009). *Polityka energetyczna Polski do 2030 roku*. Retrieved from https://www.gov.pl/documents/33372/436746/DE_Polityka_energetyczna_ost_2030.pdf/78b689ec-62ec-af88-b0d7-decf95abdb70

Narodowe Centrum Badań Jądrowych. (2007). *Podstawowe rodzaje reaktorów jądrowych* [lecture materials]. Retrieved from http://ncbj.edu.pl/zasoby/wyklady/ld_en_jadr_zast/07.pdf

PGE EJ 1 sp. z o.o. (2015). *Pierwsza Polska Elektrownia Jądrowa. Karta informacyjna przedsięwzięcia*. Retrieved from http://bip.gdos.gov.pl/files/artykuly/25290/Pierwsza_Polska_Elektrownia_Jadrowa_Karta_Informacyjna_Przedsiewziecia.pdf

Terlikowski, P., & Paska, P. (2018). Analiza scenariuszowa rozwoju reaktorów wysokotemperaturowych w Polsce. *Energy Policy Journal*, *21*(1), 37–50.

Zespół Prezesa Państwowej Agencji Atomistyki do spraw elektrowni jądrowej Żarnowiec. (1990). *Raport w sprawie elektrowni jądrowej Żarnowiec*. Retrieved from http://www.paa.gov.pl/sites/default/files/archiwalne/arch31.pdf