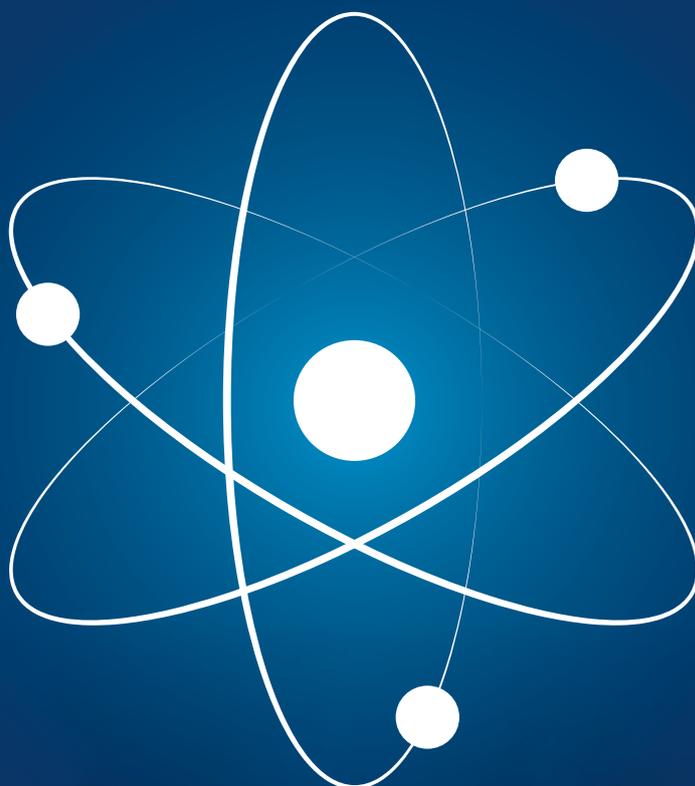


# COAL-TO-NUCLEAR FOR POLAND NATIONAL POTENTIAL

REPORT



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**NATIONAL POTENTIAL**

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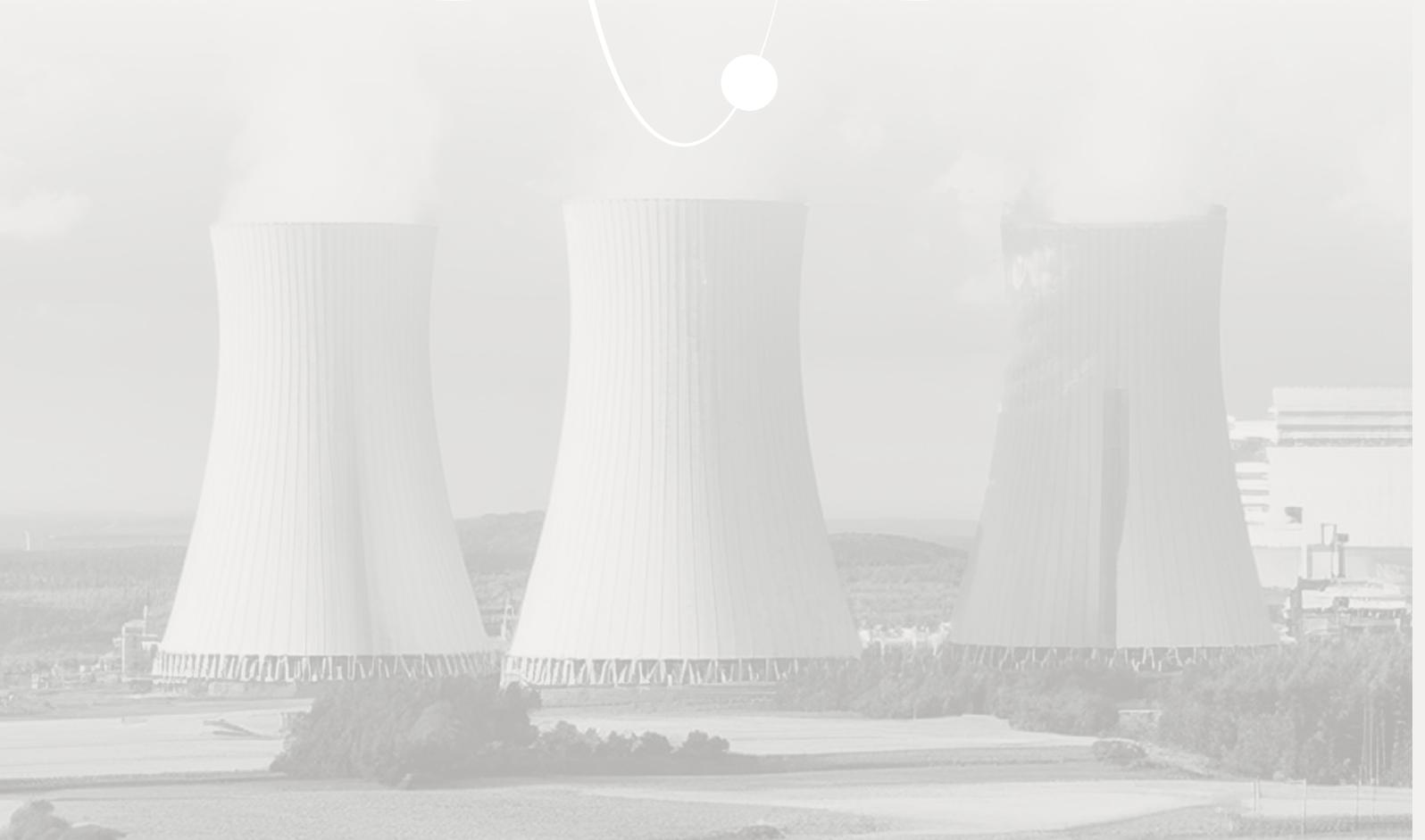
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# EXECUTIVE SUMMARY



## PURPOSE OF THE REPORT

Decarbonization of the power industry is the key challenge for the Polish energy policy. It results from the need to reduce greenhouse gas emissions and ensure the country's energy security. The report analyzes the potential for implementation of the Coal-to-Nuclear technology in Poland, outlining opportunities to modernize the existing coal infrastructure by adapting it to the needs of the nuclear technology. The study builds on the results of the DEsire project and highlights the benefits and challenges of such transition.

## ENERGY TRANSITION

- Despite the growing share of RES (27%) in energy production, Poland stands out for its high reliance on coal in energy generation (63% in 2024). This situation results from Poland's historical dependence on coal and failure to implement comprehensive modernization of its energy generation sector after 1989. More than 60% of Poland's turbine sets have already gone beyond their operational lifespans, and by 2030 their number will reach 70% of the national fleet. Unlike other V4 countries, faced with similar difficulties of political and economic transformation as Poland, Poland has not introduced nuclear power into its energy mix, which has led to the continued reliance on coal, and consequently - rising costs of CO<sub>2</sub> emissions and the need to import fuel.
- The European Union aims for climate neutrality by 2050 and a 55% reduction in CO<sub>2</sub> emissions by 2030. The European Green Deal is a strategy for achieving these goals, which in the new geopolitical reality is however steadily losing support of European capitals and needs to be revised. Moreover, in recent years there has been a noticeable decline in the competitiveness, productivity and innovation of the European Union vis-à-vis the US and China. One of the main problems is very high energy prices, which lead to a sharp drop in values of internal investments, an outflow of external investors, and the phenomenon called deindustrialization of the EU.
- Europe's fossil resources are limited. European countries are therefore largely dependent on imports, exposing the continent to price fluctuations and geopolitical risks. In view of this, it is crucial to invest in technologies with the lowest fuel costs, which will ensure price stability and energy security. Nuclear power certainly is such a technology. The development of renewable energy sources and nuclear power can become the foundation of the transition, minimizing dependence on imported fuels.

- In 2022 the European Commission recognized nuclear power as a solution supporting decarbonization in the transition period. Despite this, the European Union has been very slow to allow the development of nuclear technologies as one of the low-carbon energy sources. Specific financial mechanisms to support the development of nuclear technologies in Europe are still lacking. Thanks to the new taxonomy, the European Investment Bank (EIB) can already engage in financing nuclear power projects, but the more restrictive 2013 criteria still apply to these investments.

## ROLE OF NUCLEAR FOR THE ECONOMY

- Driven by the growing demand for stable and low-carbon energy sources, nuclear power is playing an increasingly important role in the global energy sector. The rapid development of nuclear technologies, including small modular reactors (SMRs), Generation III+ and IV reactors, translates to a growing number of suppliers on the market, and the governments of many countries, including France, the UK, the US, Canada and China, are heavily supporting research, development and investments in the sector. According to the International Atomic Energy Agency (IAEA), nuclear capacity could more than double by 2050, reaching as much as 890 GW, with small modular reactors (SMRs) accounting for about 25% of this growth.
- One of the key drivers of the growing interest in nuclear power is the development of data centers and IT infrastructure, especially in the context of artificial intelligence. Renewable energy sources (RES) can cover a significant portion of energy demand, but their dependence on weather conditions requires a stable baseload that nuclear power can successfully provide.
- In Poland, despite the lack of operating nuclear power plants, interest in the sector has grown significantly in recent years. The government is implementing the Polish Nuclear Power Program (PPEJ), which calls for the construction of the first power plants by 2036, with a target capacity of 6-9 GW. Poland is intensifying cooperation with international partners, such as the US, Canada, France, the UK and South Korea, and exploring the possibility of implementing SMR technology. Increased activity is also being observed in the private sector – PGE PAK Energia Jądrowa is conducting studies on the construction of a nuclear power plant with a full-scale reactor, while ORLEN, KGHM and Industria are planning SMR-based investments. TAURON and Enea are also analyzing the potential for application of the nuclear technology.
- The changing geopolitical situation and growing industrial and digital energy needs are accelerating decisions to invest in the nuclear. The year 2025 will be crucial for redefining Poland's nuclear energy strategy to align it with global trends and challenges.

## POLISH POTENTIAL FOR COAL-TO-NUCLEAR

- Poland is facing the challenge of energy transition arising from the necessity to retire outdated coal-fired units and move in the direction of decarbonization. The DESIRE project analyzed feasibility of implementing the Coal-to-Nuclear (CtN) concept, i.e. replacing coal-fired power plants with nuclear sources to provide stable energy supply and reduce greenhouse gas emissions.

- Phase A of the DEsire project, carried out by the Silesian University of Technology and Energoprojekt Katowice, included an analysis of the infrastructure of the domestic power sector from the perspective of its potential adaptation to the use of Generation III/III+ and Generation IV reactors. In the case of Generation III+ technology, the existing turbine infrastructure cannot be preserved, while in the case of Generation IV reactors, there is some limited potential for reuse exists (depending on the parameters of the steam produced in the reactor and feeding the steam turbine), which could allow for a reduction in investment costs. In Poland, however, such retrofits can only be treated as hypothetical solutions. Based on the list of criteria developed for the project, key locations for potential nuclear retrofits have been selected to undergo further technical analyses, such as the Kozienice, Połaniec, Dolna Odra and Ostrołęka Power Plants (for Gen. III+ reactors), as well as the Opole Power Plant (unit No. 5) and Puławy EC (for Generation IV reactors).
- The DEsire project also included an analysis of legal regulations and international nuclear safety standards. The Institute of Chemistry and Nuclear Technology has developed a catalog of formal key requirements and organizational guidelines necessary for the implementation of the C2N pathway, covering the questions of reactor safety system design, radioactive waste management and nuclear risk assessment.
- Deciding on whether to implement the Coal-to-Nuclear approach requires further in-depth analysis including economic, environmental and legal aspects. However, preliminary results from Phase A of the DEsire project indicate that Poland has significant potential to carry out an energy transition using nuclear technology, which could be a key step towards a stable, low-carbon energy future.
- Phase A of the project assumed that in the process of modernizing the plant with Generation III+ reactors, all major technological parts of the existing plant will be replaced. This means that the old infrastructure will be left practically unused. With Generation III reactors, only the transmission infrastructure and associated systems can be reused. Replacing the boiler entails the necessity to replace the turbine island as well, which limits the degree of integration and reduces the economic benefits of using the power part of a coal-fired unit. In contrast, modern solutions based on Generation IV reactors would enable a higher degree of integration. In selected reactor concepts, capable of generating steam of over 550°C (without the need for additional systems to increase the enthalpy), the generated steam could be directly used by the turbines installed in the coal-fired power plants.
- Generation IV reactors allow for production of high-temperature steam, which is an asset when replacing traditional coal-fired units. This approach speeds up the energy transition process and reduces the cost of modernization, as it does not require the replacement of the entire infrastructure. In addition, the high steam temperature allows for increased energy efficiency and reduced CO<sub>2</sub> emissions. The Coal-to-Nuclear path, which assumes replacing only the boiler islands of power plants with nuclear reactors, should be treated as a hypothetical solution in the Polish conditions since at present there are no commercially available high-temperature reactors on the European market. Since there are no new investments observed in the domestic coal power sector, in the 30s and 40s modernization of the existing coal-fired units, even those of the highest technological standard, will not be economically justified due to advanced degree of their exploitation.

- Application of a new evaluation parameter - the “emission intensity per energy production unit” - in the context of CO<sub>2</sub> emissions for the power plant being replaced – was proposed as part of Phase A of the project. The efficiency of emission reductions will thus be assessed, which will help promote retrofits, especially where current energy sources emit the most CO<sub>2</sub> per unit of energy produced.
- According to a report by the Polish grid operator (Polskie Sieci Elektroenergetyczne, PSE), the generation gap will reach 6.4 GW in 2031, rising to 18 GW in 2040. The Coal-to-Nuclear pathway can help fill part of the gap, especially for older coal units that can be converted to low-emission nuclear power plants. The analyses conducted under Phase A of the DEsire project show that the estimated potential of the C2N pathway in Poland is at about 17 GW. The government’s planned investments in nuclear power (6-9 GW) may partially reduce this gap, but 8-11 GW of capacity will still be lacking in the system.
- Successful implementation of the Coal-to-Nuclear path requires active support by the State and a favorable investment environment. The conservative scenario predicts investment in 3.4 GW of nuclear power in the 2030s. Failure to provide adequate support and clearly defined policy may lead to a situation where Poland waits to make more ambitious investments in nuclear power until around 2040.
- One possible solution is the application of small nuclear reactors (SMRs), which are more flexible in terms of infrastructure requirements, especially when it comes to access to water. This technology minimizes the need for access to large bodies of water, which is an important advantage in the context of the rising importance of environmental issues. In a balanced scenario, the development of SMR technology could contribute to the Coal-to-Nuclear pathway in Poland, accounting for both security requirements and potential interest in financing models alternative to the traditional contracts for difference. The optimistic scenario assumes greater support for nuclear power and the execution of more investments on the Coal-to-Nuclear path, which could contribute to the development of the sector and at least partially close Poland’s capacity gap in the 2030s.

# 1. PURPOSE OF THE REPORT



Decarbonization of the energy industry is one of the most important challenges of Poland's energy policy today. In view of the growing need to reduce greenhouse gas emissions and ensure the country's energy security, it is necessary to develop and implement innovative solutions to support the transition to climate neutrality.

Sobieski Institute was drawing attention to the key importance of these activities as early as 2019 and 2020, in its reports *SMR for Poland* and *Nuclear Power for Poland* (available in Polish on Sobieski Institute's website). These publications diagnosed the scale of the challenges Poland would face when implementing nuclear technologies, and pointed to the need to adopt a comprehensive approach, including planning, organizing enterprises and financing, and developing a coherent strategy. The main overarching goal should be to create a modern, competitive and climate-neutral economy.

Participation in the project **"DEsire - Plan for decarbonization of the national utility power industry through modernization with nuclear reactors"** and work on the Coal-to-Nuclear are a continuation of this engagement by the Sobieski Institute. The idea behind the Coal-to-Nuclear pathway is to transform the existing energy infrastructure based on coal-fired units into modern facilities using nuclear technology as part of a retrofit. This process offers a number of potential benefits, such as emission reductions, energy efficiency improvements, cost reductions and support for local economies. It is part of a just energy transition. This issue is widely discussed in the series of reports "Coal-to-Nuclear".

The purpose of this report is to identify the national potential in the area of Coal-to-Nuclear technology deployment, based on the results of the DEsire project. The report analyzes the challenges and benefits of the energy transition. It focuses on the current state of the existing energy infrastructure and progress in the development of nuclear power in Poland, also pointing to the current European context.

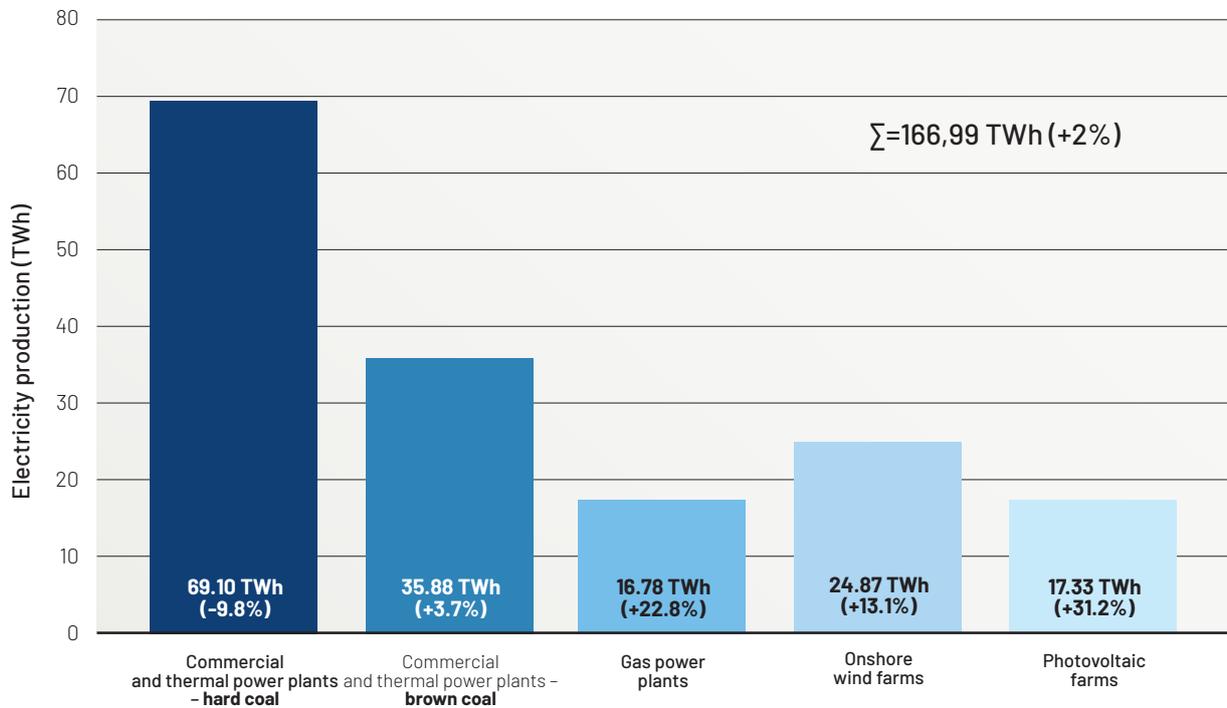
## 2. ENERGY TRANSITION



## 2.1 THE NEED TO TRANSFORM THE FLEET OF POWER AND CHP PLANTS IN POLAND – IS POLAND A UNIQUE CASE?

With its large share of hard coal and lignite in the country’s energy production, Poland stands out when compared to other EU countries. In 2024, the national electric energy consumption rose by about 2% compared to 2023 and reached 166.99 TWh. The Polish grid operator’s full-year data shows that coal’s share in electric energy generation fell to nearly 63%, while the share of RES increased to over 27%. Despite the changes in the energy mix, coal still plays an important role, due in part to the long tradition of coal mining and Poland’s historically large coal reserves. In the past, especially during the communist period, almost all electric energy production, as well as heat generation, was based on coal.

FIG. 1 **ELECTRICITY PRODUCTION IN POLAND IN 2024<sup>1</sup>**



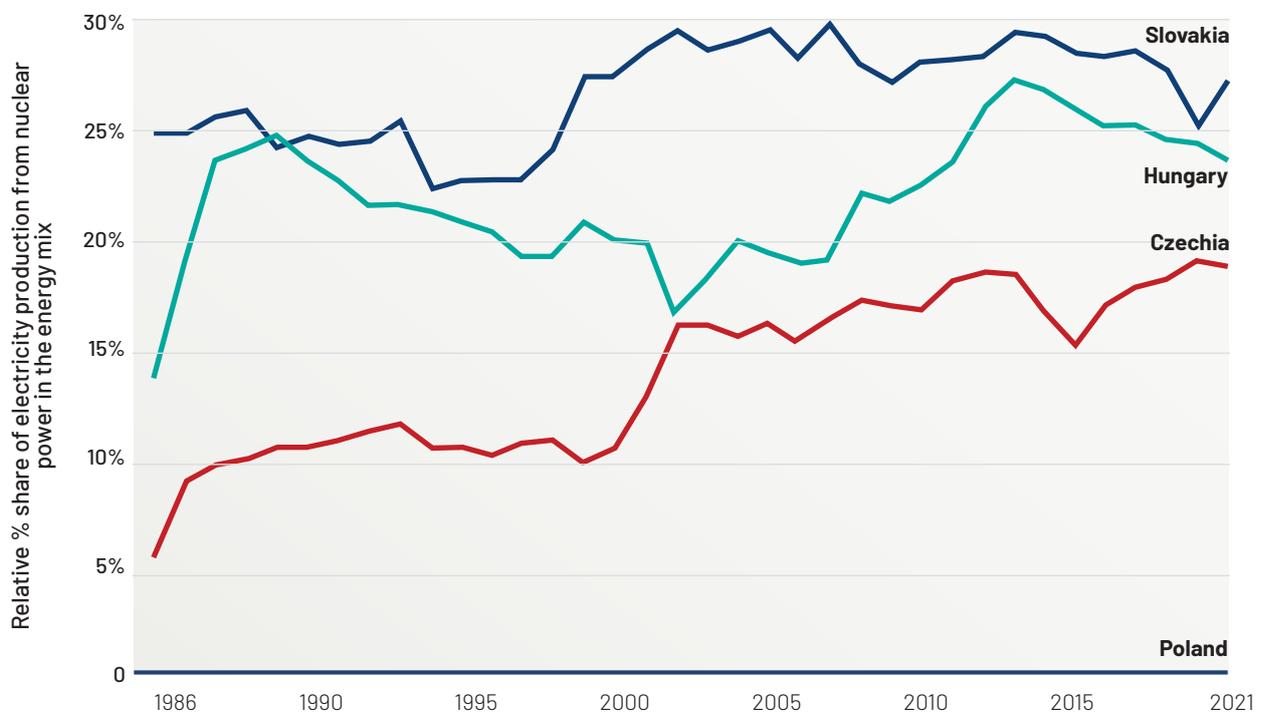
SOURCE: PSE

1 PSE: Produkcja energii el. wzrosła o 2,1% do 14,76 TWh w 2024, z OZE 27,1% całości, 3.02.2025, <https://wysokienapiecie.pl/krotkie-spiecie/pse-produkcja-energii-el-wzros-a-o-2-1-do-14-76-twh-w-2024-z-oze-27-1-ca-o-ci/>

Thus, the current park of power plants and combined heat and power plants in Poland is the results of the decisions made in in the 1960s and 1970s by the then people’s government who implemented the plan to make the People’s Republic of Poland a highly industrialized and therefore energy-intensive economy.

However, this is only part of the truth, for the same process of industrialization and capacity expansion was taking place at the same time in Western European countries, including Germany, which also had significant coal resources of its own. What is particular to Poland when compared to Western Europe, but also to other V4 countries (the Visegrad Group composed of Poland, the Czech Republic, Slovakia and Hungary), is the fact that, unlike other countries, Poland has never carried out a comprehensive modernization of its CHP fleet. We are the only V4 country with no nuclear power plants that could provide baseload energy. The comparing Poland to other V4 countries is all the more justified that after the fall of communism in 1989 we all began at the same starting point and faced similar challenges related to systemic, political transition and leaving behind the era of the central-planned economy.

FIG. 2 **SHARE OF ELECTRICITY PRODUCTION FROM NUCLEAR POWER PLANTS IN THE V4 COUNTRIES<sup>2</sup>**



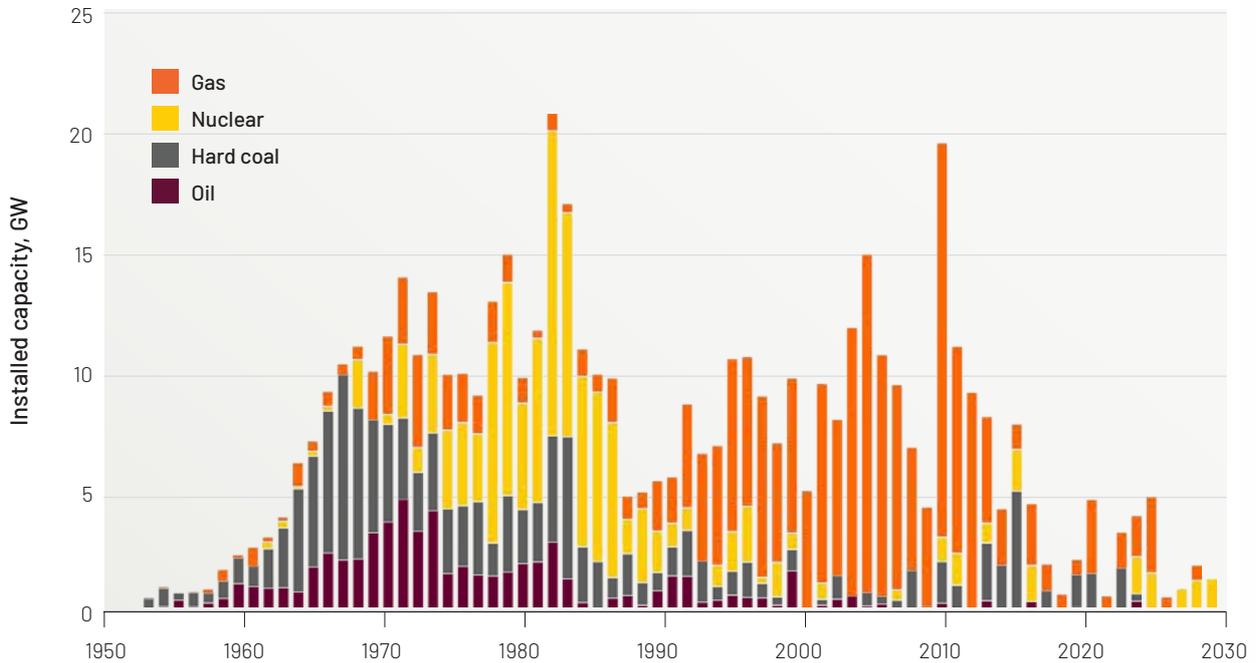
SOURCE: Statistical Review of World Energy, 2022

The planned nuclear power plant in Żarnowiec was supposed to change the face of the Polish energy industry, taking advantage of the favorable geographic and demographic conditions of the selected site. The work, already at an advanced stage (completed at 40%), came to a halt after the Chernobyl disaster in 1986, which triggered a wave of protests and a campaign against the construction of the facility. As a result of a referendum held in 1990, as well as political changes and the economic crisis, the project was aborted, and the unfinished investment became a symbol of the unrealized plans of the People’s Republic of Poland<sup>3</sup>.

<sup>2</sup> Statistical Review of World Energy, 2022, <https://ourworldindata.org/energy>.

<sup>3</sup> 41. Anniversary of the decision on the construction of Żarnowiec NPP, 17.01.2023, <https://ipn.gov.pl/pl/dla-mediow/komunikaty/177252,41-rocznica-podjecia-przez-rzad-PRL-uchwaly-w-sprawie-budowy-Elektrowni-Jadrowej.html>.

FIG. 3 **GENERATION CAPACITIES OF CONVENTIONAL POWER PLANTS CONNECTED TO THE GRID IN A GIVEN YEAR IN EUROPE, CATEGORIZED BY ENERGY SOURCE, BASED ON ENERGY BRAINPOOL<sup>4</sup>**



SOURCE: Joint Research Centre – Power Plants Database), 3.07.2019.

Looking at other European countries, we see that there, too, there have been changes in the energy mix compared to the 1970s. The Messmer Plan Implemented in France, aimed to rapidly develop nuclear power in response to the oil crisis. The program envisaged the construction of a large number of nuclear power plants to make the country independent of oil imports and ensure energy stability. With the implementation of this plan, France became one of the leaders in the world nuclear power industry. The process of nuclear development in Germany and the UK was more gradual and dispersed, executed without a centrally coordinated program.

As can be seen in Figure 3 – Energy Brainpool, starting second half of the 1970s, coal-fired power plants began to give way first to nuclear and then to gas-fired plants. Poland remained faithful to coal practically until the end of the first decade of the 21st century.

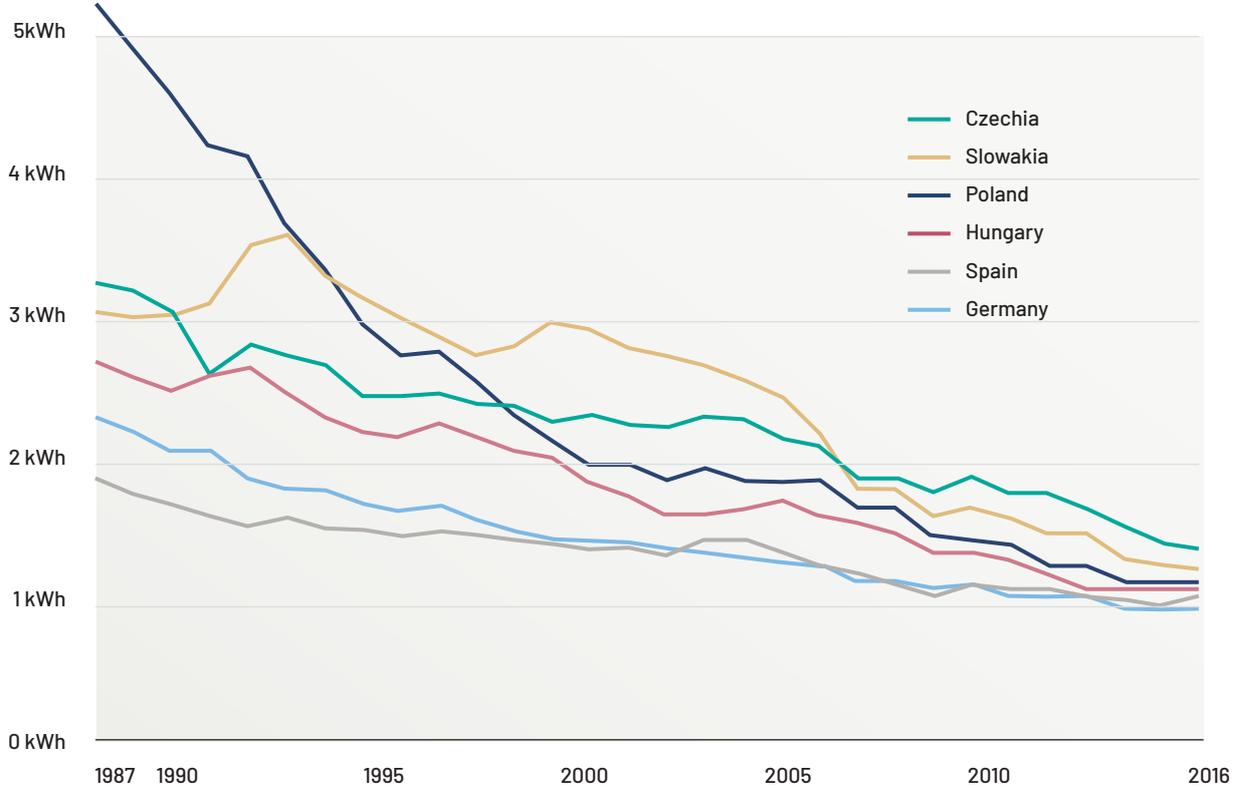
It must be noted here that after 1989, the Polish economic model underwent a thorough metamorphosis – after the collapse of the USSR, large energy-intensive production plants lost their markets and thus their raison d'être. In the new model, the existing production capacity was entirely sufficient, and thus the motivation to invest in new generation capacities did not exist. Economic development in the Republic of Poland (unlike in Spain, for example) was never based on increasing energy consumption. Poland's energy intensity fell 5-fold between 1987 and 2016, with GDP growth of 827% over the same period<sup>5</sup>.

4 Based on the EU database JRC-PPDB (Joint Research Centre – Power Plants Database), 3.07.2019, <https://data.jrc.ec.europa.eu/dataset/9810feeb-f062-49cd-8e76-8d8cfd488a05>.

5 Our World In Data based on BP, World Bank, and Maddison Project Database, <https://ourworldindata.org/co2-and-greenhouse-gas-emissions>, CCBY.

FIG. 4 ENERGY INTENSITY OF SELECTED EUROPEAN ECONOMIES<sup>6</sup>

Energy intensity is measured as primary energy consumption per unit of gross domestic product. This is measured in kilowatt-hours per 2011\$ (PPP).



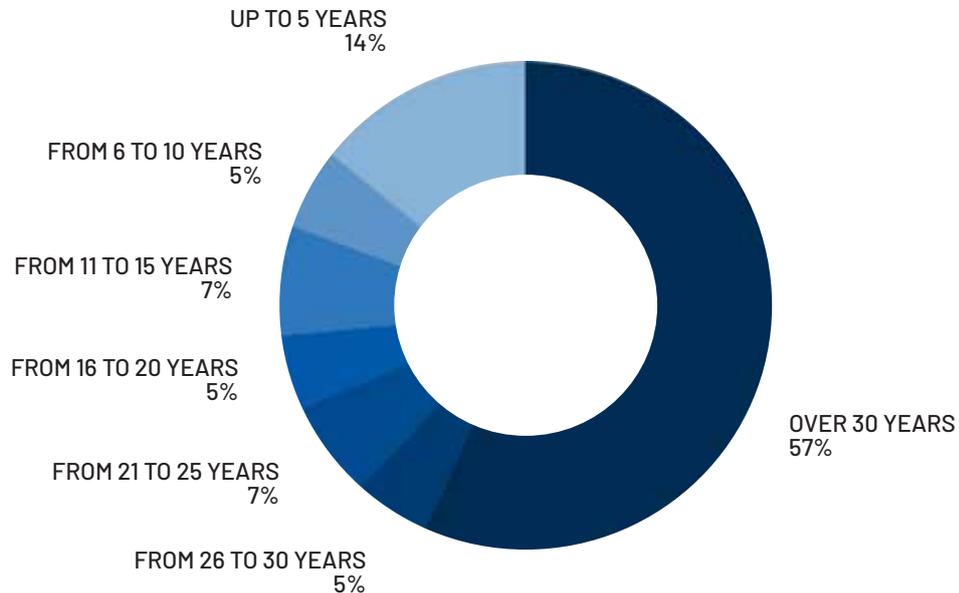
SOURCE: Our World In Data<sup>6</sup>

This is undoubtedly a huge success of Poland’s political and economic transformation. However, it resulted in a lack of adequate (domestic) incentives to carry out the energy transition. According to data by the Polish Energy Market Agency for 2022, more than 60% of Poland’s turbine sets have already gone beyond their operational lifespans and by 2030 their number will go up to 70% of the national fleet<sup>7</sup>.

6 Our World In Data based on BP, World Bank, and Maddison Project Database, <https://ourworldindata.org/co2-and-greenhouse-gas-emissions>, CCBY.

7 Attachment 2 to the update of the National Plan for Energy and Climate, Energy transition scenario on a path „business as usual”, Warsaw, Oct.2024

FIG. 5 **AGE STRUCTURE OF TURBO GENERATORS IN RELATION TO INSTALLED CAPACITY IN THE NATIONAL POWER SYSTEM (AS OF 31.12.2022)<sup>8</sup>**



SOURCE: ARE S.A.

While our neighbors diversified their energy systems in the previous century (with the use of nuclear power, among other things), it was only in the last decade that Poland decided to replace coal capacity in the system with gas and RES sources, decision largely made due to external pressure, such as the EU climate policy and foreign investors' appetite for low-carbon power sources.

Poland's long-lasting refusal to introduce nuclear (in contrast to the rest of the V4) has allowed it to prolong its coal monoculture and keep relying on coal despite increasingly high cost of domestically sourced fuel, offset by boosting coal imports from abroad<sup>9</sup>.

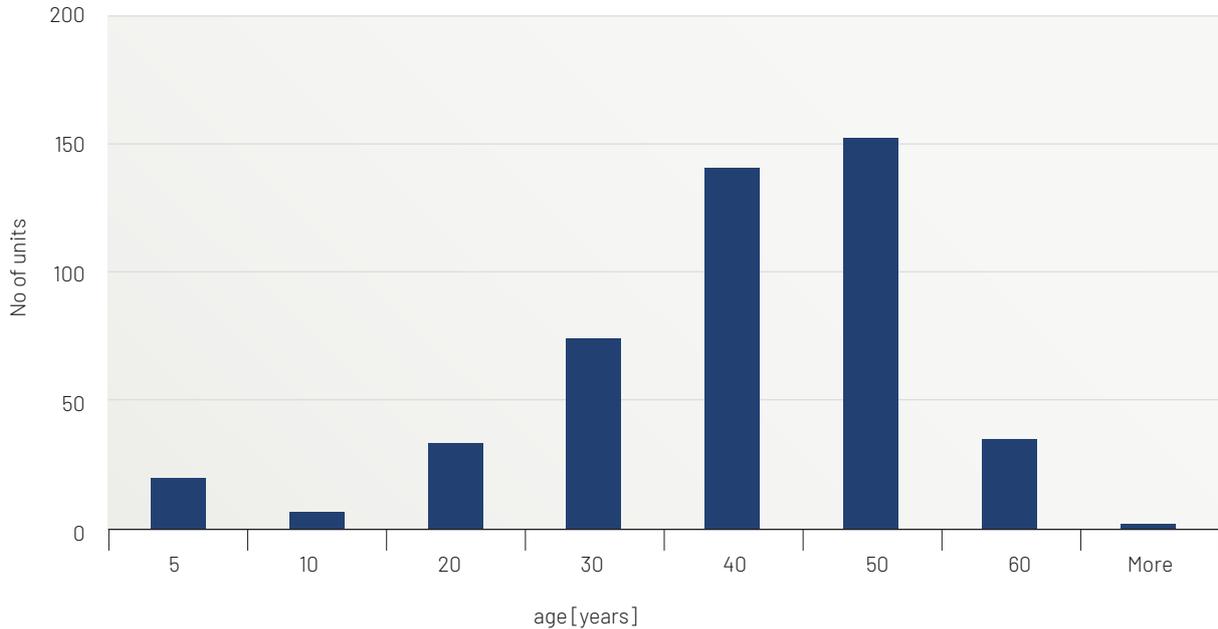
The fact that Poland's coal-fired units are so old and run-down is not in itself an unprecedented phenomenon on a European scale (the average age of a coal-fired power plant in the EU is 38 years<sup>10</sup>). On the other hand, the fact that a modern country, betting on the development of new technologies, is still more than 60% dependent on coal - a fuel it increasingly needs to import - urgently needs to change.

8 Attachment 2 to the update of the National Plan for Energy and Climate, Energy transition scenario on a path „business as usual”, Warsaw, Oct.2024

9 B. Oksińska, *Drogi polski węgiel. Oto dlaczego przegrywa na światowym rynku*, 14.04.2024, <https://businessinsider.com.pl/gospodarka/drogi-polski-wegiel-oto-dlaczego-przegrywa-na-swiatowym-rynku/v9833yp>.

10 Tygodnik Gospodarczy PIE 2021, nr 11.

FIG. 6 **AGE DISTRIBUTION OF THE EUROPEAN COAL POWER PLANT FLEET (AS OF 2018)**



SOURCE: JRC Technical Reports, 2018.

**Poland should learn from the positive example of our neighbors by introducing nuclear power plants into the energy mix<sup>11</sup>.**

It is clear is that **an active support by the State** is needed in the context of the Coal-to-Nuclear (C2N) decarbonization program in order to **encourage repurposing of the decades-old coal power infrastructure for new nuclear investments**. For more on potential support mechanisms, see the report Coal-to-Nuclear for Poland. Support mechanisms.

For Poland, the energy transition is a major challenge due to the large share of high-carbon coal-fired power plants and absence of nuclear power plants in the country's energy mix. Three aspects are key to the success of Poland's energy transition

1. lowering investment costs - creating conditions that will attract private capital.
2. Supporting innovation - investing in new technologies.
3. Ensuring political and regulatory stability - companies need to know the direction regulations are seeking to outline.

**The government should take on a stabilizing role, supporting the development of new technologies and innovative solutions, while at the same time providing the private sector with space to operate, as well as a stable and predictable regulatory framework.**

<sup>11</sup> K. Kanellopoulos, *Scenario analysis of accelerated coal phase-out by 2030. A study on the European power system based on the EUCO27 scenario using the METIS model*, JRC Technical Reports, 2018, [https://publications.jrc.ec.europa.eu/repository/bitstream/JRC111438/acd\\_in\\_metis\\_final.pdf](https://publications.jrc.ec.europa.eu/repository/bitstream/JRC111438/acd_in_metis_final.pdf).

## 2.2 INTERNATIONAL DECARBONISATION INITIATIVES

### 2.2.1 EUROPEAN APPROACH TO DECARBONISATION AND NUCLEAR POWER

The year 2022 saw somewhat of a breakthrough in the attitudes to nuclear power. It was in 2022 that the European Commission recognized that private investments in nuclear and gas fueled generation sources could play an important role in the energy transition process and proposed that certain forms of such investments be classified as transitional activities in support of climate change mitigation efforts. Therefore, some nuclear and natural gas activities have been provisionally included in the taxonomy i.e. list of green economic activities<sup>12</sup>. However, they must meet specific conditions and transparency requirements.

The legal basis for Poland's decarbonization efforts is rooted in actions taken at the international level. The European Union has pledged to achieve climate neutrality by 2050 and to reduce greenhouse gas emissions by at least 55% (as compared to 1990) by 2030. The EU's climate law was adopted in 2021 and is the foundation for other measures taken at the international level, such as the Fit for 55 package, the Renewable Energy Directive (RED III), and the Carbon Border Adjustment Mechanism (CBAM).

Generally speaking, the Green Deal was a laudable strategy aiming at achieving climate neutrality and simultaneously strengthening the competitiveness of the EU economy by supporting innovation and investment in the green technologies. However, it seems that in the new geopolitical reality of 2024/2025, it cannot be implemented as intended and is gradually losing acceptance in the European capitals. In his first speech in the European Parliament, marking the beginning of Poland's presidency of the Council of the European Union (January 2025), the Polish Prime Minister, Donald Tusk, pointed out that Europe, through exorbitant regulations related to climate neutrality and resulting in high energy prices, is losing its competitiveness on the global market. The Polish Prime Minister called for a diligent approach "to a full and very critical review of all regulations, including those resulting from the Green Deal"<sup>13</sup>. Many MEPs also argued that European security as well requires European energy independence. They pressed for continued EU efforts to reduce dependence on Russian energy supplies while providing citizens with access to affordable energy<sup>14</sup>. In January 2025, the head of European Commission declared that their readiness to be flexible on the matter does not mean climate ambitions would be abandoned. She stressed that the EU would still strive for climate neutrality by 2050<sup>15</sup>, while the tools to achieve this goal may change.

The last three years of operating under the existing regulations have highlighted the Old Continent's non competitiveness and showed how misguided the path outlined in the Green Deal is. Examples of failures include outflow of investments that were supposed to drive an innovative green economy in Europe, such as the relocation of photovoltaic cell factories from Germany to the US<sup>16</sup> and shutdown of the Vestas wind turbine factory<sup>17</sup>. As a consequence of the misplaced emphasis on supporting a low-carbon economy, for which modern technologies were supposed to be the engine of growth, China has become the main economic

12 *Taksonomia: posłowie za włączeniem gazu i energii jądrowej*, 6.07.2022, <https://www.europarl.europa.eu/news/pl/press-room/20220701IPR34365/taksonomia-poslowie-za-wlaczaniem-gazu-i-energii-jadrowej>.

13 *Donald Tusk chce zmian w Zielonym Ładzie*, 22.01.2025, <https://esg.pl/2025/01/22/donald-tusk-chce-zmian-w-zielonym-ladzie/>.

14 *Plenary session of the European Parliament*, 22.01.2025, <https://www.europarl.europa.eu/plenary/en/vod.html?mode=chapter&vodLanguage=E-N&internalEPIId=2017011075798&providerMeetingId=237b9b58-0fcc-4954-ac07-08dd0e0f3eb2#>

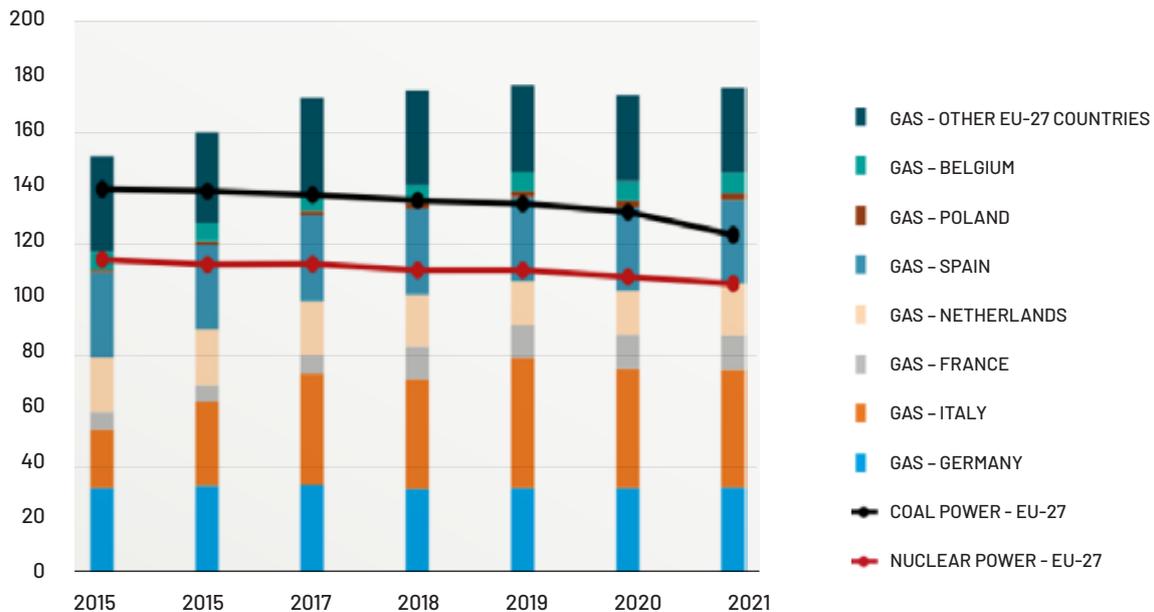
15 *Konferencja prasowa Premiera Donalda Tuska oraz Przewodniczącej KE Ursuli von der Leyen*, 7.02.2025, <https://www.youtube.com/live/fRtMvbGWhtU>

16 *M. Kaczmarczyk, Niemcy tracą dużą fabrykę ogniw PV na rzecz USA*, 28.07.2023, <https://www.forbes.pl/kompas-esg/niemcy-traca-duza-fabryke-ogniw-pv-na-rzecz-usa/m71lfcc>.

17 *Największy producent elektrowni wiatrowych zamyka trzy fabryki*, 22.09.2021, <https://www.gramzielone.pl/energia-wiatrowa/106370/najwiekszy-producent-elektrowni-wiatrowych-zamyka-trzy-fabryki>.

beneficiary of the European Green Deal<sup>18</sup>. It is also not insignificant that the role of natural gas - regarded as ideally complementary to RES and a "less carbon-intensive" fuel, has been growing<sup>19</sup>. Meanwhile, after taking steps to become independent of Russian supplies, its imports from the U.S. are on the rise. In 2023, the largest supplier of LNG to the EU was the United States (where nearly 50% of imports came from). In 2023, as compared to 2021, EU imports from the US nearly tripled<sup>20</sup>.

FIG. 7 **GENERATION CAPACITIES POWERED BY GAS, COAL, AND NUCLEAR ENERGY IN THE EU-27 FROM 2014 TO 2021<sup>21</sup>**



SOURCE: Bezpieczeństwo dostaw gazu w UE. Od kryzysu do niezależności, 30.06.2023

**Europe's fossil resources are limited, the EU thus largely depends on imports, exposing its economies to price fluctuations and geopolitical risks. It is therefore crucial to invest in the technologies with the lowest fuel costs that will ensure price stability and energy security.** The development of renewable energy sources and nuclear power can become the foundation of the transition, minimizing dependence on imported energy sources.

The European Parliament approved the European Climate Law on June 24, 2021, making the aspirations of a 55% reduction in emissions by 2030 and climate neutrality by 2050 legally binding and bringing the EU closer to achieving negative emissions after 2050 and confirming its leading role in the global fight against climate change. Since the introduction of this EU legislation, the geopolitical situation has changed significantly. The position of president in the White House was, once again, taken by Donald Trump, who already on his first day in office withdrew from the Paris Accords<sup>22</sup> and the Inflation Reduction Act as the effects

18 J. Kajmowicz, *Zielony Ład made in China. Pekin korzysta z unijnej transformacji*, 24.04.2024, <https://energetyka24.com/oze/analizy-i-komentarze/zielony-lad-made-in-china-chiny-korzystaja-z-unijnej-transformacji/>.

19 A. Fedorska, *Katańczycy grożą Europie zamknięciem gazowego kurka*, 31.12.2024, <https://biznesalert.pl/katar-europa-kurek-gaz-energetyka/>.

20 *Skąd UE czerpie gaz?*, 31.01.2025, <https://www.consilium.europa.eu/pl/infographics/where-does-the-eu-s-gas-come-from/>.

21 *Bezpieczeństwo dostaw gazu w UE. Od kryzysu do niezależności*, 30.06.2023 [https://pie.net.pl/wp-content/uploads/2023/06/PP-1-2023\\_Bezp-gazowe.pdf](https://pie.net.pl/wp-content/uploads/2023/06/PP-1-2023_Bezp-gazowe.pdf).

22 *Donald Trump wycofuje USA z porozumienia paryskiego. Ekspert ostrzega*, 22.01.2025, <https://businessinsider.com.pl/wiadomosci/prof-bogdan-chojnicky-usa-traca-w-wyscigu-o-odnawialne-zrodla-energii/8fe3yxp>.

of the latter might look even more questionable (EV chargers, offshore wind energy, among others)<sup>23</sup> than the European efforts under the Green New Deal. Additionally, as a result of Russia's attack on Ukraine, the issue of (energy) security has come to the fore.

Although the U.S. wants to rely on domestic extraction of its own oil and gas resources, the U.S. approach to nuclear power has changed and garnered momentum distinguishing itself by far greater integration of new technologies than traditional models. Technology giants such as Google and Amazon are planning to deploy small modular reactors (SMRs) and invest around \$500 billion to combine the development of artificial intelligence with the provision of stable energy supply. According to the US Department of Energy report of September 2024, the country will need an additional 200 GW of nuclear reactor capacity by 2050. The entire endeavor is expected to be implemented with a momentum comparable to that of the Manhattan Project, including the STARTGATE initiative<sup>24</sup>.

### 2.2.2 COMPETITIVENESS OF THE EU ECONOMY AND THE ENERGY TRANSITION

In recent years, there has been a marked decline in the competitiveness, productivity and innovation of the European Union vis-à-vis the US and China. One of the main problems is very high energy prices, which, in the first place, have led to a drastic decline in the value of investments, both public and private, an exodus of investors, and the phenomenon called deindustrialization of the EU. This is particularly true of energy-intensive industries, such as the metallurgical and chemical industries.

An insightful diagnosis of the state of the European economy is provided by Mario Draghi's report<sup>25</sup>. In the report, the author implicitly criticizes the previous actions under the scope of the EU climate policy. According to him, the increase in energy prices is primarily the result of defectively designed decarbonization mechanisms. European policy has placed too much of the financial burden on producers and consumers, compared to the US or China, treating them as the main mechanism for the transition. These burdens are resulting in slower economic growth. A key challenge is to implement support mechanisms to offset these negative effects and ensure the long-term benefits of the energy transition<sup>26</sup>. Despite all these developments, the European Union has been very slow to allow for the deployment of nuclear technologies as one of the low-carbon energy sources. Although the winds of political change have already blown, specific financial mechanisms to support nuclear in Europe.

The European Investment Bank (EIB) provides financing for projects that will contribute to the achievement of EU goals both inside and outside the EU. Despite this, no investment in a new nuclear power plant has been financed for the past two decades. A slight change came in 2022, when nuclear power was included in the taxonomy. This means that it was recognized as one of the technologies that can contribute to the European Union's climate goals in the transition period. As a result, the EIB can now get involved in financing those nuclear power projects that might not have previously been eligible for EU policy support. It should be noted, however, that the 2013 criteria still apply to these investments<sup>27</sup>.

23 K. Snyder, IRA: efekty, koszty i odbiór społeczny, <https://www.izg.org.pl/ira-efekty-koszty-i-odbior-spoeczny/>.

24 E. Sayegh, Stargate AI project. The \$500 billion gamble to dominate the future, 22.01.2025, <https://www.forbes.com/sites/emilsayegh/2025/01/22/stargate-ai-project-the-500-billion-gamble-to-dominate-the-future/>.

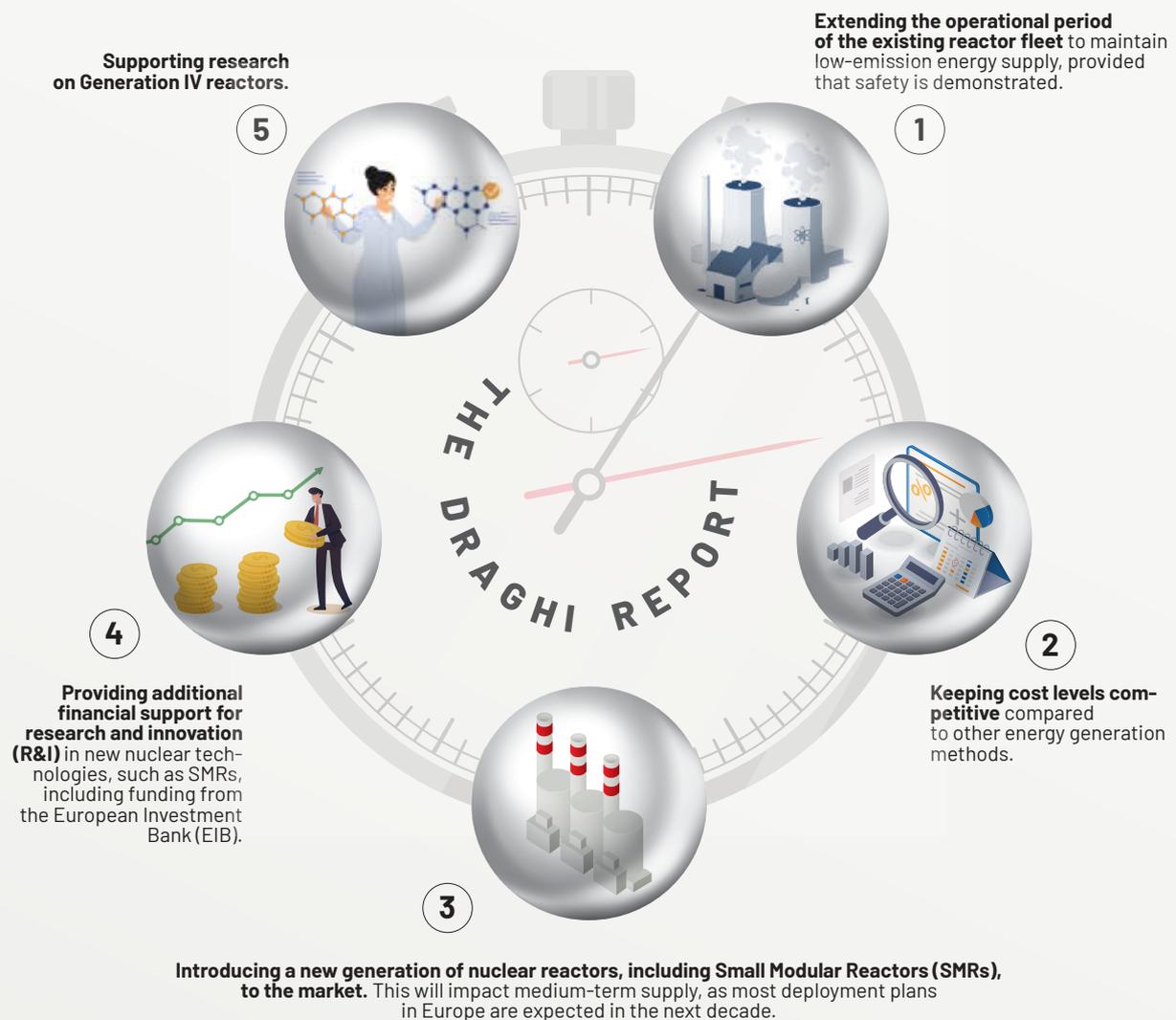
25 The future of European competitiveness: Report by Mario Draghi, 17.09.2025 [https://commission.europa.eu/topics/eu-competitiveness/draghi-report\\_en](https://commission.europa.eu/topics/eu-competitiveness/draghi-report_en).

26 T.G. Grosse, *Unia diagnozuje i nie wyciąga wniosków*, Warsaw Enterprise Institute, 2.10.2024, <https://wei.org.pl/2024/na-czym-swiat-stoi/tomaszgrosse/unia-diagnozuje-i-nie-wyciaga-wnioskow/>.

27 EIB energy lending policy, 8.05.2023, <https://www.eib.org/en/publications/20230164-eib-energy-lending-policy>.

Draghi's report indicates that to accelerate decarbonization, all available technologies and solutions (e.g., renewables, nuclear, hydrogen, energy storage) should be used and technology-neutral approach should be adopted to develop an overall system based on cost efficiency. The report also stresses that decarbonizing Europe's energy system means massive deployment of clean energy sources with low marginal production costs, such as renewables and nuclear power. The EU's decarbonization path cannot be based on a "one-size-fits-all" approach.

FIG. 8 **RECOMMENDED ACTION AREAS ACCORDING TO THE DRAGHI REPORT**



ŹRÓDŁO: Own work.

EU member states do not have sufficient budgetary resources for energy transition and boosting innovation, so the EU is considering creation of debt, along the lines of the Covid-related debt, "Next generation EU", to finance this new industrial policy. The energy transition is shifting towards the resilience of the European economy. Evolution is taking place within the European Union (in the context of both economic and energy policy) and is taking the direction of focusing on **building the economy's capacity to cope with crises and adapt to changing conditions.**

**Resilience** refers to the ability of a system, including the economy, to quickly recover from a crisis, adapt to new challenges and minimize the effects of difficult situations. In the context of the European economy, this will come to mean what:

**1. increasing resilience to crises:** the economy should be less vulnerable to external shocks such as climate change, energy crisis, pandemics, wars or geopolitical instability.

**2. transforming the industrial sector:** changing the economy towards a more sustainable one, including modernization of the industry, which can create new jobs, reduce CO<sub>2</sub> emissions, and decouple from the risks associated with traditional industries.

**3. enhancing society's adaptive capacity:** increasing social resilience by developing skills, education and technological innovations that will help citizens and companies better cope with difficult conditions.

**Energy transition is thus to continue to be key element of the European Union's competitiveness strategy.** The European Commission continues to focus on the development of renewable energy sources, the modernization of transmission infrastructure and hydrogen technologies, which aim not only to reduce CO<sub>2</sub> emissions, but also to increase energy and economic security in Europe. It has been noted that nuclear power can be both a supporting element and a component of a new energy strategy. An example is the nuclear initiatives being developed in Poland. PGE PAK Energia Jądrowa, which aims to build a nuclear power plant in Konin/Pątnów in Greater Poland, and Orlen Synthos Green Energy, which is implementing the SMR BWRX-300 project in several locations, are the first public-private partnership initiatives in the nuclear sector in the EU.

### **3. ROLE OF NUCLEAR ENERGY IN THE ECONOMY**



### 3.1 RISING SIGNIFICANCE OF NUCLEAR

The market for nuclear power solutions providers is growing rapidly, with more companies offering cutting-edge technologies and services around the world. This is mainly due to the growing interest in small modular reactors (SMRs) and new generation technologies (III+ and IV), with many new players entering the market. Major corporations such as GE Hitachi, Rolls-Royce and EDF are investing heavily in the development of SMRs and innovative solutions to improve efficiency, safety and the ability to integrate with renewable energy sources.

Nuclear technology suppliers are focusing on developing flexible solutions tailored to the needs of local power generation and the environmental and climate change requirements we currently face. New nuclear technology concepts are strongly supported by the governments of many countries (France, UK, USA, Canada, China), which contributes to the intense development of the sector and growing competition among suppliers. **The current renaissance of nuclear power in the world is driven by the need for stable, low-carbon energy sources that can support not only the energy transition, but also the growing energy demand resulting from the electrification of many sectors.** The growing number of nuclear-related companies and projects shows that the sector has entered a phase of intense development, becoming one of the pillars of decarbonization and stabilization of energy systems around the world. According to the International Atomic Energy Agency (IAEA), nuclear capacity could more than double by 2050, reaching as much as 890 GW, with small modular reactors (SMRs) accounting for about 25% of this growth. Such growth is driven by the increasing demand for stable, low-carbon energy sources coupled by the drive to maintain energy security<sup>28</sup>.

According to a Goldman Sachs Research<sup>29</sup> report, nuclear power will become key component of the new energy infrastructure built to meet the growing energy demands of AI-powered data centers. Currently, data centers account for about 2% of electricity consumption in the US and Europe. It is projected that "only" by 2030, energy demand in data centers will increase by 160% compared to 2023.

Renewable energy sources can supply the majority of data center-driven demand, but their intermittent production makes the provision of stable power supply impossible. Combined with energy storage, they can provide up to about 80% of the power needed, but a stable base load source is still required. Nuclear power is the preferred option, but the time-consuming and complexity of new NPP builds means that natural gas and RES will continue to be a temporary, short-term solution. Ultimately, nuclear power will be the primary preferred source of power for technology giants. **It is the global digitization that may accelerate**

28 IAEA outlook for nuclear power increases for fourth straight year, adding to global momentum for nuclear expansion, 16.09.2024, <https://www.iaea.org/newscenter/pressreleases/iaea-outlook-for-nuclear-power-increases-for-fourth-straight-year-adding-to-global-momentum-for-nuclear-expansion>.

29 Is nuclear energy the answer to AI data centers' power consumption?, 23.01.2025, <https://www.goldmansachs.com/insights/articles/is-nuclear-energy-the-answer-to-ai-data-centers-power-consumption>.

**investment in nuclear power**, as the lack of a stable energy supply will be one of the main factors limiting the growth of the IT sector.

Energy consumption in Europe is on the rise again, following 15 years of a steady decline, the rebound being mainly due to the growing demand driven by data centers, resulting from investments in artificial intelligence. If a similar trend of data center growth continues across Europe, the number of newly built data centers could reach 170 GW, about one-third of peak energy demand in 2024. If all these data centers are indeed constructed, the increase in peak energy demand in major EU regions could reach 60%. In such a scenario, energy consumption in Europe is projected to increase by 10-15% over the next 15 years<sup>30</sup>.

### 3.2 INTEREST IN NUCLEAR POWER IN POLAND

In 2024 nuclear power remains absent from the Polish energy mix, despite Poland's long history in nuclear-related activities remains long. Poland noticed the potential of the nuclear power and research, and their importance for the science, medical and military applications, as well as energy supply as early as mid-20<sup>th</sup> century.

In 1955, upon the initiative by a nuclear physicist from Łódź, professor Andrzej Sołtan, the Institute for Nuclear Research was established. Initially it functioned within the Polish Academy of Sciences, and later came under the management of the Government Plenipotentiary for the Utilization of Nuclear Energy. The first nuclear reactor in Poland, EWA (Experimental, Water-Cooled, Atomic), purchased in Moscow and assembled by Polish specialists, was put into operation at the Świerk research center in 1958. This accomplishment was soon followed by the start-up of other devices designed and built by the Polish scientists<sup>31 32 33</sup>.

For more information on the history of nuclear power, including in the Polish context, see the calendar attached to this report.

In recent years, in the face of the global challenges of decarbonization and ensuring energy security, Poland has noticeably increased its involvement in nuclear power deployment. In this context, interest in this field has centered around large-scale Generation III+ reactors, but also around SMRs, especially in the last five years. Poland has recognized the need to diversify its energy sources and reduce its dependence on fossil fuels, especially imported ones. The Polish government is working intensively on the implementation of the Polish Nuclear Power Program, which envisages the construction of the first nuclear power plants with larger capacity by 2036<sup>34</sup>. At the same time, it should be noted that the Polish Nuclear Power Program includes only projects to remain under the strict control of the State Treasury, and envisages the possibility of building only large-scale Generation III (+) pressurized water reactors of proven designs (as of February 2025) - so it does not include the project by PGE PAK Energia Jądrowa and SMR-based investments. The

30 *Data centers could boost European power demand by 30%*, 7.02.2025, <https://www.goldmansachs.com/insights/articles/data-centers-could-boost-european-power-demand-by-30-percent>.

31 A.K. Wróblewski, *Soltan Andrzej*, Biogramy [w:] *Giganci nauki*, <https://gigancinauki.pl/gn/biogramy/82634,Soltan-Andrzej.html>;

32 *Pół wieku badań jądrowych w Polsce*, 17.06.2005, <https://wiadomosci.gazeta.pl/wiadomosci/7,114873,2773265.html>; I. Cieszykowska (Puchalska), K.W. Fornalski,

33 D. Gajda, P. Gajda, *Polska atomistyka / Polish Nuclear Science*, Wydawnictwo Instytutu Zrównoważonej Energetyki, grudzień 2017.

34 Wiceminister Przemysłu i Pełnomocnik Rządu ds. Strategicznej Infrastruktury Energetycznej Wojciech Wrochna o aktualizacji PPEJ na spotkaniu prasowym, 12.12.2024, <https://www.gov.pl/web/przemysl/wiceminister-przemyslu-i-pelnomocnik-rzadu-ds-strategicznej-infrastruktury-energetycznej-wojciech-wrochna-o-aktualizacji-ppiej-na-spotkaniu-prasowym>.

goal of the Polish Nuclear Power Program (PEJ Program) is to build and commission nuclear power plants in Poland with a total installed capacity of about 6 to about 9 GWe.

In recent years, however, particular emphasis has been placed on cooperation with foreign partners (including the US, Canada, South Korea, France and the UK), consideration of SMR technology, and building the industrial supply chain as well as nuclear-related competencies in Poland. It is expected the Polish Nuclear Power Program will be modified in response to new challenges and the changing geopolitical situation.

Nuclear power has so far been a victim of the liberal energy market, as it did not guarantee a quick return on investment and was hostage of a heated discussion about the necessary “either-or” choice. There was no compromise between different energy sources, and RES was presented as an alternative not only to fossil fuels but nuclear as well. After 2022, the perspective has changed. The first signs came already during the pandemic, when the disruption of supply chains affected the development of RES, and another breakthrough came after Russia’s aggression against Ukraine, highlighting the importance of stable energy sources. Most European countries have matured in their decision to reduce their dependence on Russian gas, oil and other raw materials. However, they are still in a vulnerable position due to their dependence on imports from China. Until nuclear energy was included in the EU taxonomy, it had been considered a risky investment. As a result of changes in the European context, however, it has begun to be considered key element of energy security and an excellent solution in times of crisis. Current energy discussions should therefore center on the premise:

**„Nuclear baseload is key to energy and economic security,  
as well as a way to achieve climate goals“.**

From this perspective, Polish investments in nuclear generation sources are all the more justified, with energy security aspects, already underlying these investments, now being of utmost importance.

**The year 2025 will undoubtedly be an opportunity to redefine the Polish Nuclear Power Program** so as to account for the dynamic changes in circumstances and the expectations of industry and business not only at the national, but also at the global level.

### **3.3 IDENTIFICATION OF MARKET ACTIVITIES BY THE ENERGY SECTOR AND OTHER COMPANIES IN POLAND**

A wide range of activities related to energy transition and the shift to low-carbon sources is to be observed in the Polish energy sector. As far as the renewable energy sources go, there has been a rapid increase in investments in wind farms, photovoltaics and energy storage technologies. Polish energy companies are involved in the development of new gas plant projects and the planning of small modular reactors (SMRs) built to support the stability of the energy system while reducing CO<sub>2</sub> emissions and lowering energy prices.

Poland has made a strategic decision to deploy nuclear so as to boost stability of energy supply and its Energy security. Under the Polish Nuclear Power Program, Polskie Elektrownie Jądrowe (a State-owned enterprise) is executing the project to construct AP1000 (Westinghouse) reactors in the Choczewo commune, on the Lubiatowo-Kopalino site<sup>35</sup>. Also PGE PAK Energia Jądrowa as a company, considering an NPP

35 Polskie Elektrownie Jądrowe, <https://pej.pl/strona-glowna>.

built in the Konin region, set its eyes on a full-scale reactor<sup>36</sup>. PGE on its own in analysing Bełchatów from the perspective of a potential NPP built and is actively seeking to have Bełchatów indicated as the second nuclear site under the Polish Nuclear Power Program, the work set to begin right after Choczewo<sup>37</sup>.

ORLEN, KGHM and Industria are, on the other hand, working on the SMR projects, with SMRs to be implemented on a smaller scale and allowing for more flexibility in adapting to local conditions. Also TAURON and Enea seem interested in the nuclear analyzing investment potential for SMRs after 2035. These projects do fall under the national plan to diversity generation sources and transition to low emission energy production. They also constitute an important factor in attracting foreign investments and developing local technological competencies.

36 PGE PAK Energia Jądrowa otrzymała decyzję zasadniczą w sprawie budowy elektrowni jądrowej, 27.11.2024, <https://www.zepak.com.pl/pl/o-firmie/biuro-prasowe/aktualnosci/15212-pge-pak-energia-jadrowa-otrzymala-decyzje-zasadnicza-w-sprawie-budowy-elektrowni-jadrowej.html>.

37 PGE rekomenduje rządowi Bełchatów jako lokalizację elektrowni jądrowej, 4.12.2024, <https://www.bankier.pl/wiadomosc/PGE-rekomenduje-rzadowi-Belchatow-jako-lokalizacje-elektrowni-jadrowej>

# 4 POLAND'S COAL-TO-NUCLEAR POTENTIAL



## 4.1 RESULTS OF PHASE A OF THE DESIRE PROJECT

The changes occurring in Poland's energy sector necessitate the development of a coherent transformation plan to be implemented along various pathways. **"DEsire - Plan for decarbonization of the national utility power industry through modernization with nuclear reactors"** – addresses this need<sup>38</sup>.

The average operational age of coal-fired power units in Poland is over 40 years, and many of them, despite numerous modernisations, are nearing the end of their service life. By 2040, these units will be gradually phased out, posing a challenge for Poland in ensuring stable and sustainable energy sources.

**'Coal-to-Nuclear' is the concept of replacing coal-fired power plants with nuclear sources to reduce greenhouse gas emissions. This process involves converting existing coal infrastructure into nuclear power facilities, allowing existing transmission networks and personnel to be utilised**<sup>39</sup>.

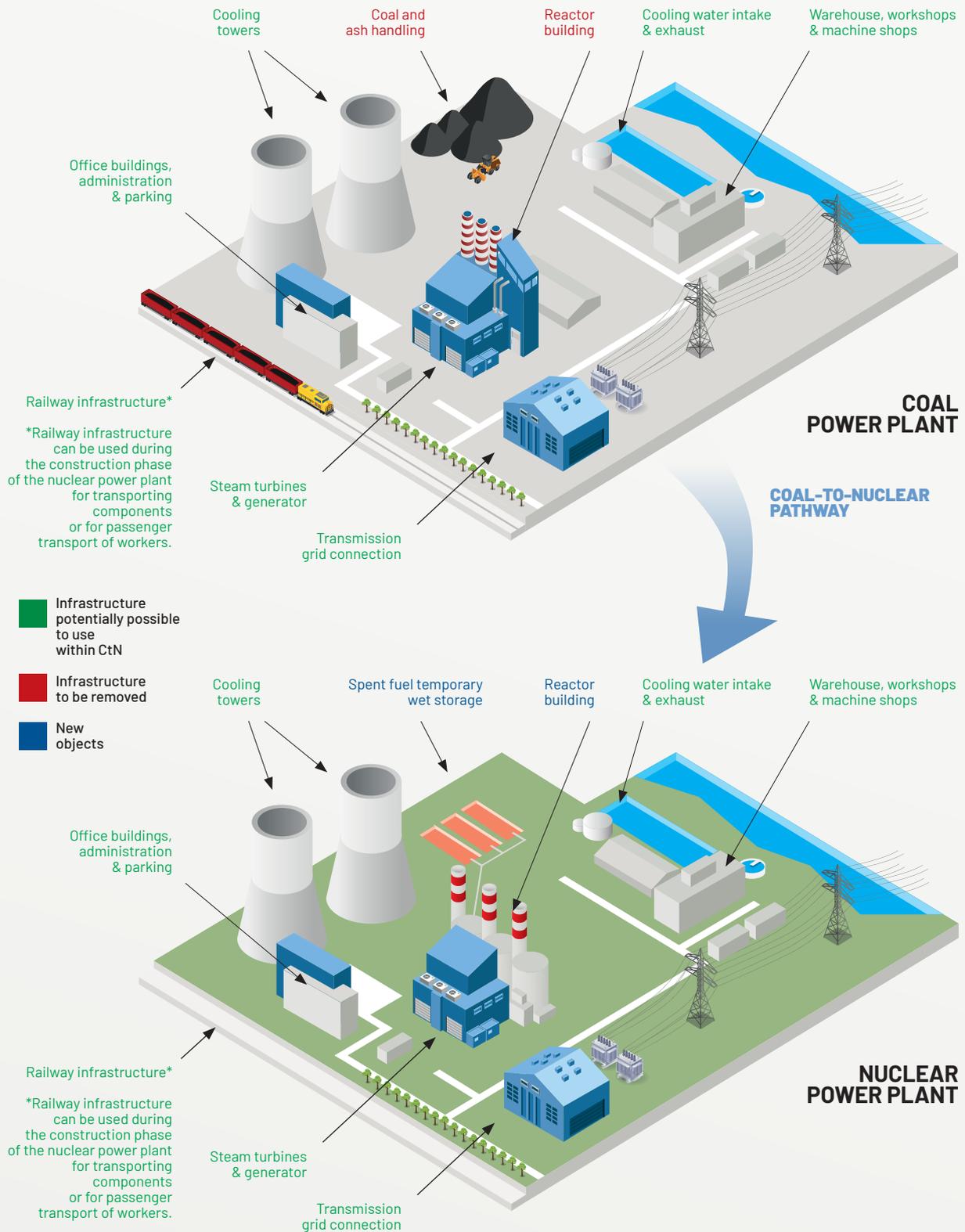
A **brownfield** investment in the context of nuclear energy refers to the construction of a new nuclear facility on the site of an existing power plant or combined heat and power plant, usually a coal-fired plant. This means using an already urbanised industrial area that possesses developed technical infrastructure, grid connections, and access to skilled personnel. This pathway is one of the available and most frequently analysed Coal-to-Nuclear transition strategies globally.

This approach offers the potential to minimise costs, reduce downtime, and enable faster *repowering*, which is significant both from an economic standpoint and for ensuring the continuity of energy supply. However, this approach may also involve challenges and risks associated with adapting legacy infrastructure to new technology.

38 DEsire, <https://projektdesire.pl/>.

39 Energetyka jądrowa – jak to działa?, 12.08.2024, <https://sobieski.org.pl/broszura-informacyjna-pt-energetyka-jadrowa-jak-to-dziala/>.

FIG. 9 **RETROFIT VIA THE COAL-TO-NUCLEAR PATHWAY  
- FROM COAL POWER PLANT TO NUCLEAR POWER PLANT**



SOURCE: Own work.

In the case of **greenfield investments**, a new facility is built on undeveloped land, which means that all infrastructure must be prepared from scratch, including connections to the power grid, access roads, and other key elements. Although this solution is more time-consuming and costly than a brownfield investment, it allows for optimal design of the facility in accordance with the latest standards. In the case of the Coal-to-Nuclear pathway, this type of investment can be considered when the retrofit takes place within a region and not necessarily at a specific site. In this case, the potential and resources of the region are utilised, i.e. its 'readiness' for a relatively large investment in a new energy source – existing transport infrastructure, potential local subcontractors, personnel and skilled personnel (for non-nuclear specialities), and energy consumers.

When planning a large-scale nuclear retrofit, it is advisable to begin preparations now and conduct a preliminary analysis of the technical potential of the existing infrastructure. When selecting potential sites for replacing coal-fired units with nuclear units, it is crucial to take into account measures aimed at maintaining the infrastructure in good condition. Early preparations will enable the identification of units eligible for modernisation using nuclear reactors, as well as the development of an implementation schedule to minimise the risk of downtime and optimise the allocation of investment costs. They will also allow for the creation of an acceptable plan for retraining and retaining staff from closing decommissioned power plants. Taking action now will enable a smooth transition from coal-based energy to more sustainable solutions, securing Poland's energy future.

The Coal-to-Nuclear pathway allows for the use of existing coal-fired power plant sites, which already have the necessary transmission infrastructure and grid connections, leveraging the potential of the region. This strategy allows for the efficient use of resources and reduces the investment costs associated with the construction of new facilities.

As part of phase A of the **DEsire project**, Energoprojekt-Katowice prepared a report entitled '*Identification and analysis of national energy and accompanying infrastructure in terms of its adaptation for the use of Generation III/III+ and IV nuclear reactors*'.

The aim of the report was to provide an assessment of **the technical condition of the national energy infrastructure** and associated infrastructure, considering its potential use in the modernization (decarbonization) processes of **centralized electricity (and heat) generation systems, namely power plants and combined heat and power plants**. The assessment evaluated the technical condition not only of the power generating units but also of auxiliary infrastructure, power evacuation systems, and land transport networks. The analyses aimed to determine the scope of work required for a nuclear retrofit of the Polish power generation fleet and to identify which locations offer the best potential for such decarbonization. **The analysis covered 107 generating units within 23 power plants / combined heat and power plants, with electrical capacities ranging from 50 MWe to 1075 MWe.** The information catalogue for these units was compiled primarily using publicly available or commercially available data.

The analysis conducted by Energoprojekt-Katowice concluded that for a retrofit using Generation III+ reactors, no key technological components of an existing power plant can be retained. Differences in the thermodynamic parameters of steam generated by the **Generation III+ reactor** system compared to the requirements of steam turbines in existing power plants preclude the continued use of the existing turbine island. **The greatest potential of existing power plant sites lies in the reuse of electrical infrastructure and the cooling system.**

The analyses also considered the aspect of water availability. It is estimated that a nuclear power plant requires approximately twice as much cooling water as a coal-fired power plant. Therefore, the availability of cooling water is a crucial factor for the operation of a nuclear power plant and is also significant for ensuring its safe operation.

For a power plant unit retrofit using a **Generation IV reactor, the ability to retain the steam turbine system largely unchanged compared to its current operating condition is crucial.** This option allows for a significant reduction in the investment costs associated with the planned retrofit. For the existing steam turbine to be adapted for use with steam generated by a nuclear reactor, the steam parameters – such as temperature, pressure, and the flow rates of main and reheat steam – must match the turbine’s requirements.

As part of the project preparations, a portion of the research team (Prof. Łukasz Bartela, Eng., PhD, and Paweł Gładysz, Eng., PhD) identified three Generation IV reactors capable of operating effectively with the typical turbine sets used in Polish coal-fired power units. The results of this analysis are presented in the publication Re-using coal power plant assets in a fully decarbonized Polish power sector. The following reactors were analysed: Kairos Power Fluoride salt-cooled High temperature Reactor (KP-FHR), ThorCon Molten Salt Reactor (MSC ThorCon), and High-Temperature Gas-cooled Reactor Pebble-bed Module (HTR-PM). The study assessed their compatibility with power units operating with steam temperatures ranging from 538°C to 583°C. The HTR-PM reactor can achieve 600°C, and through modifications to the turbine set, the steam temperature can be adjusted to the required values. It should be noted that although this solution seems attractive, it remains conceptual due to the technological readiness of Generation IV reactors. Full commercial application is expected between the late 2030s and early 2040s.

The analysis assumed that limiting its scope to **relatively new units would increase the likelihood that the condition of the existing infrastructure, particularly the generator and turbine set (which would continue to be operated post-retrofit), is in good condition.** A prerequisite for a unit to qualify for a Generation IV reactor retrofit was a commissioning date no earlier than 2007.

As a result of the analysis of the data obtained and the application of the criteria described in detail in the research task – ‘Identification and analysis of the national energy and associated infrastructure regarding its adaptation using Generation III/III+ and IV nuclear reactors’ – **the following sites/units were selected for further in-depth technical analysis:**

- **for retrofitting with Generation III+ reactors:**
  - Koźlenice Power Plant,
  - Połaniec Power Plant,
  - Dolna Odra Power Plant,
  - Ostrołęka Power Plant,
  
- **for retrofitting with Generation IV reactors:**
  - Unit No. 5 at the Opole Power Plant,
  - Power unit – Puławy Combined Heat and Power Plant.

**The above locations identified within the DESire project are considered the most promising from a technical perspective for nuclear retrofitting.**

The database of coal-fired units and the retrofit ranking are valuable tools that can potentially identify the most promising investment directions for the modernization of the energy sector in Poland. Supported by detailed technical analysis, this tool can help identify units with the greatest potential for conversion into modern, low-carbon energy sources, e.g., through the use of nuclear reactors.

However, **before making final investment decisions, each coal-fired unit owner must conduct in-depth analyses considering additional factors not covered in this report, such as the condition of local infrastructure, resource availability, environmental aspects, and economic and legal frameworks, which often involve non-publicly available information. Investment plans should also consider the investor's capacity to implement a nuclear investment alongside other planned projects, particularly those by state-owned companies, up to 2040. Only a comprehensive approach will enable the selection of optimal Coal-to-Nuclear strategies beneficial to both investors and the Polish energy sector.**

In Poland, implementing investments aligned with the Coal-to-Nuclear concept requires meeting numerous legal and regulatory requirements, which are particularly stringent for nuclear facilities. Their primary aim is to ensure safety. These requirements include obtaining permits for the construction, operation, and decommissioning of a nuclear power plant, as well as conducting detailed environmental impact assessments.

The principal legal acts regulating the formal requirements and administrative procedure for obtaining a permit to construct a nuclear power plant in Poland are:

- The Atomic Law Act of 29 November 2000,
- Act of 9 March 2023 amending the Act on the preparation and implementation of investments in nuclear power facilities and associated investments, and certain other acts.

Polish Atomic Law is strongly linked to international standards and is based on the recommendations of the International Atomic Energy Agency (IAEA). This agency, alongside other international institutions such as the European Atomic Energy Community (EURATOM), issues safety recommendations which are implemented in national legislation. The IAEA's key guidelines include safety standards that cover fundamental principles, requirements, and recommendations aimed at ensuring nuclear safety. These standards provide a global reference point for the protection of people and the environment, supporting the harmonization of high safety levels worldwide. The International Atomic Energy Agency has developed three sets of publications as part of its safety standards:

- **Safety Fundamentals**, defining the fundamental objectives and principles of protection and safety.
- **Safety Requirements**, defining the requirements that must be met to ensure the safety of people and the environment, both now and in the future.
- **Safety Guides**, providing detailed recommendations and guidance on meeting specific requirements.

In Poland, particular emphasis is placed on compliance with international standards, which is a sine qua non for the implementation of nuclear projects, including Coal-to-Nuclear initiatives.

As part of Phase A of the DEsire project, the Institute of Nuclear Chemistry and Technology (Instytut Chemii i Techniki Jądrowej) conducted an analysis of the aforementioned legal regulations, formal requirements, and international and national recommendations. This resulted in the development of a document entitled *'Catalogue of essential design and organisational solutions for the nuclear safety of power units planned for*

*modernisation through the use of nuclear reactors*’. The analysis covered areas relevant to the safety of the entire Coal-to-Nuclear modernization process, including issues such as:

- a) formal requirements and recommendations imposed by international and national organizations on the design and operation of nuclear power systems;
- b) safety system solutions applied to the reactor itself, the steam turbine thermal cycle, and the auxiliary infrastructure;
- c) potential nuclear hazards to plant personnel and the local population;
- d) management of spent nuclear fuel and radioactive waste.

Based on these findings, a set of criteria was identified that must be taken into account when assessing the safety of the entire process of modernizing existing coal-fired units.

The adopted assessment criteria showed that key safety aspects largely depend on the location of the planned modernization. The analysis also took into account investment exclusion factors, such as ‘the presence of mineral deposits in the site area, the location of a mine, or mining activity conducted in the region within the last 60 years’.

Given the high nuclear safety standards, all technologies assessed achieved comparable results. It is worth noting that **under current Polish law, SMR designs are treated on par with large-scale reactors currently available on the market. This stems from regulations that assume technological neutrality – the type of reactor (PWR vs. BWR) and its size (large-scale vs. SMR) are irrelevant.**

An analysis of factors affecting the nuclear safety of coal-fired units planned for modernization using nuclear reactors showed that, from a safety perspective, **the most advantageous sites/units for nuclear retrofitting are:**

**– for retrofitting with Generation III+ reactors:**

- Kozienice,
- Połaniec,
- Dolna Odra,
- Ostrołęka;

**– for retrofitting with Generation IV reactors:**

- Opole,
- Puławy.

The analyses conducted within the project assumed that the nuclear investment would be carried out on the site of an existing coal-fired power plant or combined heat and power plant. This means that the scenario under consideration corresponds to the Coal-to-Nuclear path, referred to in specialist literature as the ‘brownfield’ approach.

However, it should be noted that **this analysis was carried out based on the legal regulations in force as of 2022 and 2023. Changes are currently planned that may affect the requirements for future nuclear power plants, and requirements previously considered exclusionary may be relaxed** if supported by analyses of the proposed solutions demonstrating the feasibility of safe operation and mitigation of the

consequences of a nuclear reactor accident. In March 2024, a draft regulation of the Council of Ministers was submitted for public consultation on the detailed scope of the preliminary assessment of land designated for the location of a nuclear power facility that is also a nuclear facility, cases precluding the possibility of recognising the site as suitable for the location of a nuclear power facility which is also a nuclear facility, and the detailed scope of the preliminary siting report for such a facility. The draft is still undergoing review (as of February 2025), but the regulation is expected to enter into force in 2025<sup>40</sup>.

## 4.2 POTENTIAL OF THE NATIONAL POWER SECTOR IN THE COAL-TO-NUCLEAR PATHWAY

**A key finding of Phase A of the project** was the determination that **for power plant modernization using Generation III+ reactors, all main technological components of the existing power plant are replaced**, meaning the old infrastructure is virtually unused. **In the case of retrofitting with Generation III reactors, only the transmission infrastructure and associated systems can be reused.** Along with replacing the boiler, the turbine island must also be replaced, significantly reducing the degree of integration and the economic benefits derived from using the power generation assets of the coal-fired unit. On the other hand, using modern solutions based on Generation IV reactors allows for a higher degree of integration in selected cases. Technical literature classifies the so-called 'direct' pathway as a retrofit approach, assuming the possibility of reusing key infrastructure elements of existing coal units, including turbine islands, in nuclear investments. However, experts from the Silesian University of Technology and Energoprojekt-Katowice concluded that this pathway is purely hypothetical in the Polish context. The main barrier is the lack of Generation IV reactors available on the European market, which are necessary for implementing this concept. Additionally, there are currently no plans in Poland to build new coal-fired units that could be candidates for such retrofits in the future.

For this reason, Phase A of the project proposes introducing a new assessment parameter: 'specific CO<sub>2</sub> emissions per unit of energy production for the replaced power plant'. This means that the effectiveness of carbon dioxide reduction will be considered when assessing the cost-effectiveness and benefits of modernization. Such a parameter would aim to promote modernization primarily where current energy sources produce the most CO<sub>2</sub> per unit of energy generated. In practice, this means that nuclear retrofits will be more cost-effective in locations where old coal-fired power plants or other high-emission energy sources are replaced by modern, low-emission nuclear technologies, contributing to a significant reduction in greenhouse gas emissions. This Coal-to-Nuclear approach supports global efforts to limit global warming by reducing carbon dioxide emissions.

The Polish grid operator (Polskie Sieci Elektroenergetyczne, PSE), published a report in December 2024 on the development of the Polish power grid between 2025–2034<sup>41</sup>. The generation gap is projected to reach 6.4 GW in 2031, increasing subsequently to as much as 18 GW by 2040. The Polish grid operator's report notes that the required additional dispatchable capacity may be higher due to the pace of the energy transition, the occurrence of extremely unfavourable climatic conditions, uncertainty regarding the timely completion of investments contracted under the capacity market, and uncertainty regarding the timing of permanent decommissioning of existing generation units participating in system balancing.

40 Draft Regulation of the Council of Ministers on the detailed scope of the preliminary assessment of land designated for the location of a nuclear power facility that is also a nuclear facility, cases precluding the possibility of recognising a site as suitable for the location of a nuclear power facility which is also a nuclear facility, and the detailed scope of the preliminary siting report for such a facility, 29 March 2024, <https://legislacja.rcl.gov.pl/projekt/12383601>.

41 *Plan rozwoju sieci przesyłowej na lata 2025–2034 uzgodniony*, 2.01.2025, <https://www.pse.pl/-/projekt-nowego-planu-rozwoju-sieci-przesylowej-na-lata-2025-2034-uzgodniony>.

This situation stems from, among other factors, ageing infrastructure, rising operating costs, and the cessation of financial support for coal-fired power plants. It is estimated that approximately 8 GW of coal-fired capacity may be decommissioned after 2025, with a further 6 GW between 2029 and 2030. The closure of additional coal-fired units is planned by 2035 at the latest, signifying the gradual phasing out of most of these power plants. These decisions are influenced by both economic and environmental factors, including rising prices of CO<sub>2</sub> emission allowances. **Under new regulations, from 2025, coal-fired power plants will not be eligible for support under the capacity market mechanism if they emit more than 550 g of CO<sub>2</sub> per kWh.** At the beginning of 2025, the government adopted a draft law allowing additional capacity market auctions until 2028, especially for coal-fired power plants. The Polish government believes that due to dynamic changes in the power system related to the increase in generation from renewables, it is necessary to continue the capacity market mechanism, which ensures sufficiency of generation resources<sup>42</sup>. However, when remunerating power generators and energy storage facilities for their readiness to supply power – crucial for system stability during the energy transition – it is important that **support costs, such as contracts for difference and capacity payments, do not translate into significant increases in energy bills.** It should also be remembered that, starting in 2026, the EU will gradually phase out free CO<sub>2</sub> emission allowances under the ETS, with complete elimination by 2034.

However, there is still a lack of clarity regarding the long-term role of coal-based energy in Poland, and the question of its continued operation within the current energy groups remains open. Work on the future strategy for the coal sector is ongoing, and major companies such as PGE and TAURON Polska Energia are preparing for various possible scenarios. It is clear that conventional energy sources are and will continue to be displaced by cheaper energy from renewable sources. However, the displacement of dispatchable coal-fired sources (mainly 200 MWe class units) from the market is not being offset by the development of new, stable, and dispatchable sources. The National Energy Security Agency (NABE) was intended to take over coal assets from large energy companies such as PGE, TAURON, Enea, and ORLEN to enable their continued development towards low- and zero-emission sources. The process involved consolidating coal-fired power plants and lignite mines into a single state-owned entity, which was intended to give these companies more freedom to invest in renewable energy sources and distribution networks by providing access to financing sources unavailable to CO<sub>2</sub> emitters. Work had been ongoing since 2022, but after the change of government, the idea was finally abandoned in early 2024, partly due to a shortfall of approximately PLN 175 billion needed to compensate state-owned companies for the takeover of coal assets. Work on a new concept for coal asset management and ensuring energy security is still ongoing<sup>43</sup>. Regardless, energy companies are developing alternative scenarios for managing their coal assets<sup>44</sup>.

Poland is currently focusing on the energy transition, including the development of renewable energy sources such as photovoltaics and wind power. Consequently, constructing new coal-fired power units is not a priority; the gradual phasing out of existing ones has become a key task. Furthermore, too few new investments are being made in dispatchable sources in Poland, resulting in a low reserve margin. **Due to the advanced age and, consequently, planned decommissioning and longer maintenance downtimes, the share of dispatchable capacity is falling, and the flexibility of generation sources is not increasing. This contributes to the deterioration of the security of the national power system<sup>45</sup>.**

42 B. Sawicki, Rząd zapowiada kontynuowanie rynku mocy zapewniającego dostawy prądu, 18.02.2025, <https://energia rp.pl/sieci-przesylowe/art41821451-rzad-zapowiada-kontynuowanie-rynku-mocy-zapewniajacego-dostawy-pradu>.

43 Rząd ma problem ze sztywnym pomysłem PiS. „Tworzymy podmiot, który jest bankrutem”, 4.12.2024, <https://www.money.pl/gospodarka/rzad-ma-problem-ze-sztandarowym-pomyslem-pis-tworzymy-podmiot-ktory-jest-bankrutem-7099570473757344a.html>.

44 B. Sawicki, Najpierw reforma rynku mocy. Później wydzielenie, 10.09.2024, <https://www.parkiet.com/energetyka/art41100051-najpierw-reforma-rynku-mocy-pozniej-wydzielenie>.

45 Transformacja energetyczna w Polsce, Forum Energii, 2024, <https://www.teraz-srodowisko.pl/media/pdf/aktualnosci/15260-forum-energii-transformacja-2024.pdf>.

Currently, the Polish power and heating sector has 303 larger coal-fired units with a total installed capacity of 33.3 GWe, of which 17.5 GWe is attributed to units built in the last 20 years (since 2000) or those that have undergone significant modernization and refurbishment during this period. The remaining 16.9 GWe comes from older power plants that have not undergone any major modernization recently and can therefore be expected to be decommissioned and replaced by new low-carbon generation<sup>46</sup>.

Many investors and financial institutions, especially European ones, are avoiding involvement in fossil fuel projects due to ESG (environmental, social, governance) policies that emphasize sustainable development. As a result, energy companies in Poland have limited creditworthiness and face difficulties in raising capital, even for non-coal investments. At the same time, the need to maintain coal-fired units and incur environmental costs worsens the financial situation of energy companies in the conventional segment<sup>47, 48</sup>.

Even if a solution is implemented that extends the operation of coal-fired units into the 2030s, there will still be a significant capacity gap around 2040 that cannot be filled by RES alone, even with solutions such as cable pooling and energy storage.

Although at first glance the LCOE of a hybrid system based on RES and energy storage is lower, it is unable to ensure stable, weather-independent supplies. The difference can be considered the cost of maintaining energy security. More information on LCOE and VALCOE indicators can be found in the report Coal-to-Nuclear for Poland. Support mechanisms.

Polish grid operator (Polskie Sieci Elektroenergetyczne, PSE) indicates that the potential of RES already exceeds the absorption capacity of the energy transmission system; i.e., peak energy demand is approx. 25–26 GW, while approximately 33 GW of RES capacity is installed in the system, and grid connection permits have been issued for an additional 25 GW, including offshore wind farms, and 27 GW for energy storage facilities<sup>49</sup>.

Based on the analysis of coal-fired units carried out in Phase A of the Project, **it can be estimated that the total potential under the Coal-to-Nuclear pathway is approx. 17 GW<sup>50</sup>. This includes units that are less than 20 years old and whose infrastructure will be suitable for modernization in the 2030s.** The remaining units are older and will be progressively phased out. After accounting for investments in large nuclear power plants (6–9 GW), originally intended to fill the capacity gap created by decommissioned units, a gap of 8–11 GW still remains. This gap aligns with Polish grid operator's forecasts for the 2030s. It is also worth noting that it corresponds roughly to a fleet of around forty 200 MW-class coal-fired units, which form the backbone of Poland's power system. As part of Phase A of the Project, 107 units with capacities ranging from 50 MWe to 1075 MWe were analysed. Based on the current legal status and technical analysis, six coal units with a total capacity of approximately 1.4 GW qualified for further recommendation. It should be noted that this analysis was based mainly on publicly available data and considered the restrictive requirements applicable to 'current types' of nuclear facilities.

46 DEsire, results of phase A work.

47 PGE pokazała wyniki. Zysk w dół, wydatki na inwestycje w górę, 10.09.2024, <https://businessinsider.com.pl/firmy/pge-pokazala-wyniki-zysk-w-dol-wydatki-na-inwestycje-w-gore/b05r0dt>.

48 Tauron wpisuje w straty elektrownie węglowe. Półtora miliarda na minusie, 9.08.2024, <https://businessinsider.com.pl/gielda/wiadomosci/tauron-wpisuje-w-straty-elektrownie-weglowe-poltora-miliarda-na-minusie/rg06szk>.

49 Potencjał OZE czterokrotnie przekracza chłonność systemu przesyłowego – PSE, 19.02.2025, <https://biznes.pap.pl/wiadomosci/energia/potencjal-oze-czterokrotnie-przekracza-chlonnosc-systemu-przesylowego-pse>.

50 D.K. Chmielewska-Śmietanko i in., *Selected legal and safety aspects of the "Coal-To-Nuclear" strategy in Poland*, „Energies” 2024, 17(5): 1128, <https://doi.org/10.3390/en17051128>.

**Creating the right enabling environment is key to implementing the Coal-to-Nuclear pathway.**

**In a conservative scenario, without policy changes and active support**, the Coal-to-Nuclear pathway will be limited to investment plans already known beyond the Polish Nuclear Energy Programme. As a result, this could translate into **the construction of a total of 3.4 GW of capacity in the 2030s**, including, with a high probability, approx. 0.6 GW by 2035 thanks to investments by ORLEN<sup>51</sup>, and 2.8 GW in the second half of the decade as part of the plans of PGE PAK Energia Jądrowa<sup>52</sup>. These would mainly be greenfield investments. By not embarking on the Coal-to-Nuclear pathway now, Poland might only decide on more ambitious investments in nuclear energy after 2040, i.e., after the concept has been proven in other countries.

One significant factor reducing the assessed potential for utilizing existing coal-fired power plant infrastructure is water access. It is worth noting that nuclear technologies allow for the use not only of conventional cooling towers but also air-cooled (dry) cooling systems. This technology uses air as the heat transfer medium instead of evaporation in the condenser. This minimizes water loss down to 10%, albeit with additional auxiliary power consumption of 0.5–1.5%<sup>53</sup>.

Water demand in nuclear power plants is generally higher than in conventional coal-fired power plants of comparable capacity. Therefore, the availability of water resources at former coal sites may significantly constrain the scale of planned nuclear investments. Consequently, conducting detailed analyses of hydrological conditions is crucial. Equally important is the assessment of possible condenser cooling system concepts. Both elements form the basis for assessing the feasibility of implementing the Coal-to-Nuclear pathway at a specific location. The decision on whether to install a conventional, hybrid, or dry cooling system should be part of the site-specific analysis, considering the chosen technology and balancing safety requirements with environmental impact. **Opting for SMR technology within the Coal-to-Nuclear pathway can be termed a sustainable scenario.** It assumes **tailoring requirements for the construction of nuclear facilities to the specifics of SMRs, in accordance with International Atomic Energy Agency safety guidelines<sup>54</sup>**. **This scenario also considers the pace of regulatory change and moderate openness to alternative financing models for nuclear energy investments, other than contracts for difference.**

As a result, in the 2030s, in addition to implementing Polish Nuclear Energy Programme, **up to 12 investments could be undertaken within the Coal-to-Nuclear framework over the decade. This could translate into an additional 3–4 Generation III+ SMR units (up to 1.2 GW) and 3–4 Generation IV units (up to 1.2 GW) compared to the conservative scenario.** This scenario is plausible as it would align with the investment plans of energy, petrochemical, and chemical companies such as Enea, Industria, KGHM, TAURON, and OSGE. Given the smaller scale compared to large nuclear projects and based on previous experience in the conventional power sector (e.g., cumulative investments in combined-cycle gas turbines), it can be assumed that the parallel implementation of multiple such investments under Polish conditions will be feasible<sup>55</sup>.

51 Strategia ORLEN 2035, <https://www.orlen.pl/pl/o-firmie/strategia>.

52 Prezes PGE PAK EJ: *budowa elektrowni jądrowej w Koninie powinna wystartować ok. 2030 r.*, 27.09.2024, <https://zielonagospodarka.pl/prezes-pge-pak-ej-budowa-elektrowni-jadrowej-w-koninie-powinna-wystartowac-ok-2030-r-17835>.

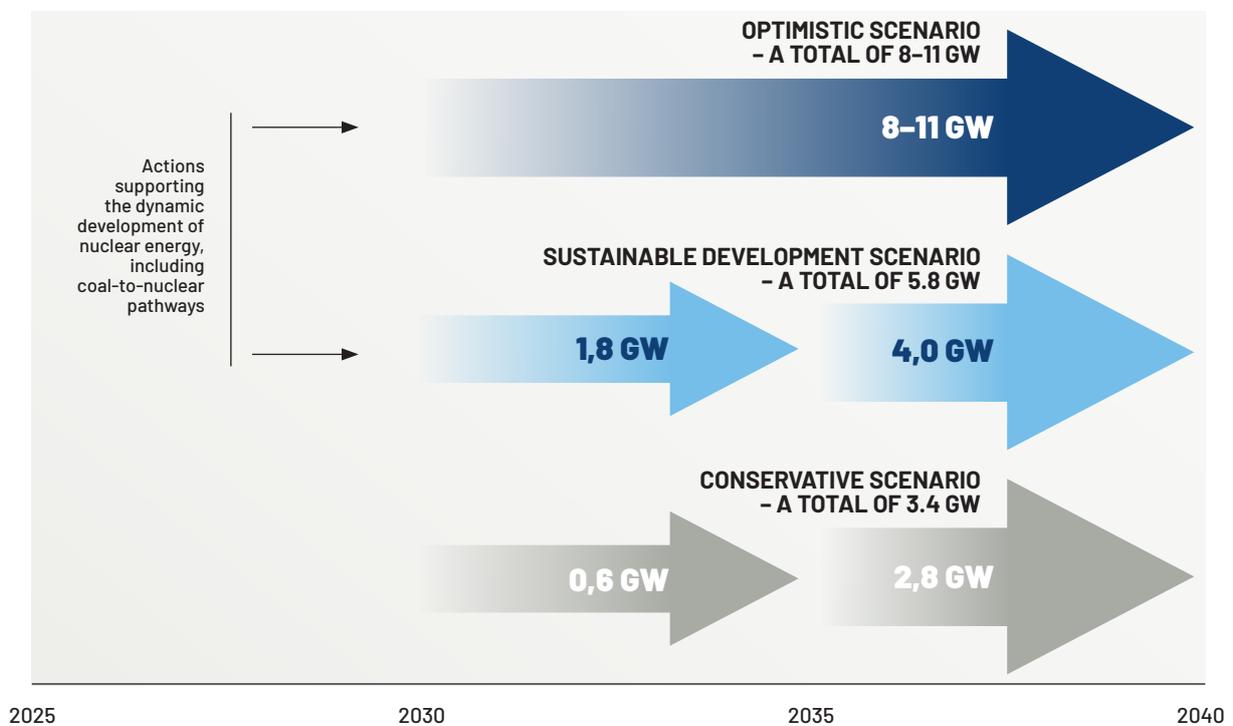
53 *Cooling power plants*, 1.10.2020, <https://world-nuclear.org/information-library/current-and-future-generation/cooling-power-plants#dry-cooling>.

54 *IAEA initiative to streamline SMR deployment moving to implementation phase*, 23.10.2024, <https://www.iaea.org/newscenter/news/iaea-initiative-to-streamline-smr-deployment-moving-to-implementation-phase>.

55 K. Wajszczuk, *Gazu w energetyce będzie coraz więcej. W budowie nowe elektrownie*, 19.05.2023, <https://300gospodarka.pl/300klimat/gazu-w-energetyce-bedzie-coraz-wiecej-w-budowie-nowe-elektrownie>.

**The optimistic scenario assumes widespread support mechanisms for nuclear energy and the Coal-to-Nuclear pathway.** This support extends beyond the national framework and is part of a European strategy to build a strong and independent economy, potentially utilizing preferential financing for public-private partnerships/investments. In this scenario, the capacity gap, identified at 8–11 GW, is filled by nuclear technologies, with the deployment scale constrained by SMR technology contracting and the logistics of managing multiple investments<sup>56</sup>. The simultaneous construction of multiple reactors requires significant material resources and personnel. In Poland, efforts have begun to develop the workforce for this new industry, which needs to comprise skilled workers and specialists necessary for implementing the Polish Nuclear Energy Programme<sup>57, 58</sup>. If the workforce development for nuclear energy is not sufficiently rapid, the lack of personnel will slow project implementation and increase investment costs. It should be remembered that Poland is not the only European country interested in decarbonization via the Coal-to-Nuclear pathway; others are pursuing it as well.

FIG. 10 COAL-TO-NUCLEAR SCENARIOS FOR POLAND



SOURCE: Own work

56 SMR dla Polski, 20.12.2019, <https://sobieski.org.pl/smr-dla-polski/>.

57 Amerykanie budują kadry jądrowe w Polsce – to szansa dla naszej gospodarki, 27.06.2024, <https://www.rp.pl/europejski-kongres-gospodarczy/art40720891-amerykanie-buduja-kadry-jadrowe-w-polsce-to-szansa-dla-naszej-gospodarki>.

58 Energetyka jądrowa dla Polski, 27.11.2020, <https://sobieski.org.pl/energetyka-jadrowa-dla-polski/>.

### 4.3 ROADMAP FOR COAL-TO-NUCLEAR INVESTMENTS

In an era of rapid technological progress and the urgent need to decarbonize the economy, it is necessary to use a variety of tools to understand the mechanisms governing the acceptance and implementation of new technologies. Their use will help shape public acceptance and develop **appropriate structures to support the energy transition towards a sustainable future. Identifying and supporting structures for the energy transition and building public acceptance should start today, evolve as nuclear energy develops, and continue until nuclear technologies are replaced by other, currently unknown solutions.**

As part of Phase A of the **DEsire project**, a detailed analysis of the coal-fired power sector was carried out, identifying units that could potentially be modernized using nuclear reactor technologies. A key achievement at this stage was the development of analytical tools enabling, based on publicly available information, **a preliminary assessment of the location and infrastructure of existing coal-fired units regarding their suitability for retrofitting with nuclear units.** In the future, these tools can be further developed and used by potential investors **to support investment decisions.** In this context, the DEsire Energy Transition Platform<sup>59</sup> can play a key role. It is designed to foster collaboration to popularize and deepen understanding of various possible decarbonization pathways and to develop legal and technical solutions related to energy transition processes. It also aims to bring together a wide range of stakeholders – from universities and institutions to local and national governments, as well as industry.

**The potential for Coal-to-Nuclear in Poland is significant and, depending on the scenario and a favourable business environment, it may not only address the projected capacity gap and power system instability but also contribute to strengthening the Polish economy.**

The scenarios – sustainable and optimistic – can be realized provided that efforts to support investments within the Coal-to-Nuclear pathway are intensified.

**Over the next five years, the environment for such projects should become favourable if**

- I. The government motivates energy companies to analyse their coal assets regarding the potential for repowering using nuclear technologies. This could be part of a strategy to address the challenges facing the coal power sector in Poland and its restructuring. The results of feasibility studies and the initial strategic, as well as economic and political, decisions based on them should be made within 1-2 years.**
- II. The Ministry of Industry utilizes the plan developed under the DEsire project to decarbonize the national energy sector through modernization using Generation III/III+ and IV nuclear reactors. Further actions will be carried out in cooperation with other ministries. The ministries involved in implementing the Coal-to-Nuclear pathway will draw on the best practices and actions taken by the US Department of Energy<sup>55</sup> or other countries involved in implementing the aforementioned concept<sup>60</sup>.**

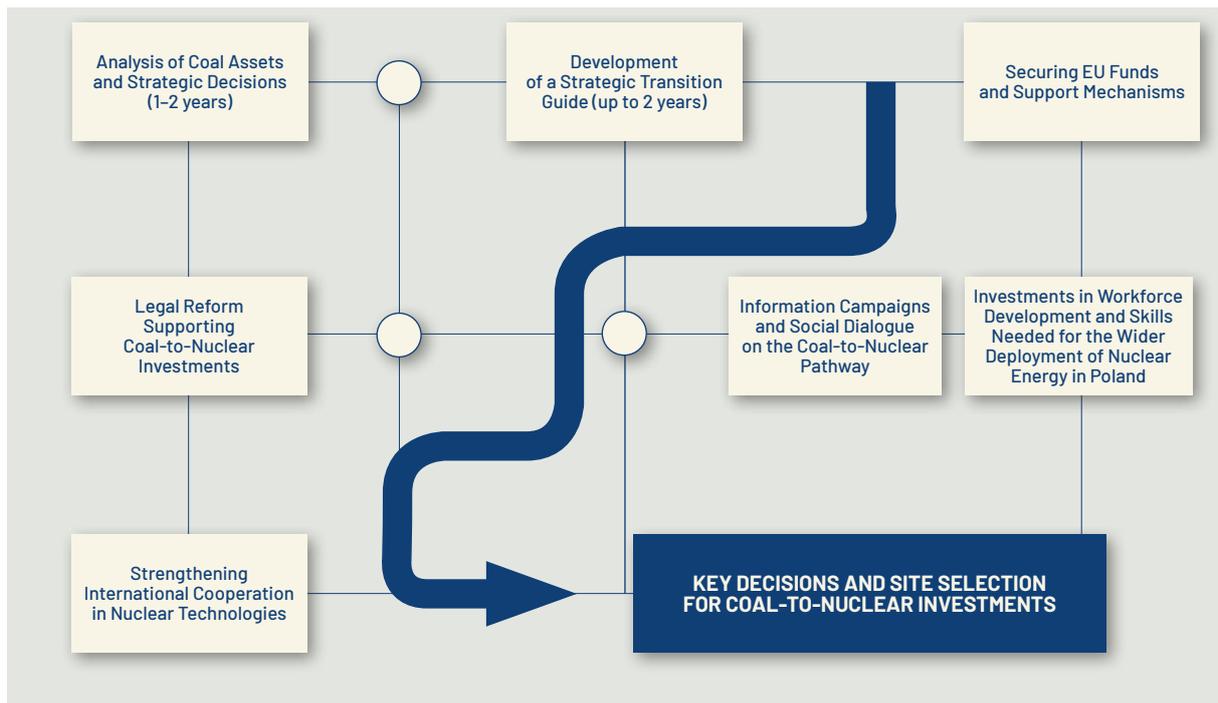
59 A. Świdorska, *Platforma Transformacji Energetyki DEsire*, 27.09.2024, [https://www.polsl.pl/ps\\_aktualnosci/platforma-transformacji-energetyki-desire/](https://www.polsl.pl/ps_aktualnosci/platforma-transformacji-energetyki-desire/).

60 *Coal-to-Nuclear transitions. An information guide*, 1.04.2024, <https://www.energy.gov/ne/articles/coal-nuclear-transitions-information-guide>.

**III. The Polish government continues its efforts to secure funding for the preparation and maintenance of existing coal assets suitable for transformation using one of the available decarbonization technologies, including nuclear technologies. Poland should also initiate and continue work on developing appropriate investment support for nuclear energy investment projects if they improve energy security, the resilience of the EU economy, and promote the mitigation of the negative effects of the energy transition in regions hitherto strongly dependent on conventional energy. Such measures should be intensively pursued in the coming years, given the time required to establish support mechanisms and the investment cycle for nuclear facilities.**

**IV. Investors encourage the government and state administration bodies to enable the energy transition using the Coal-to-Nuclear concept by revising and establishing an adequate legal framework. Actions in this area should start now so that, within 3-5 years, it will be possible to issue Decisions-in-Principle for the first facilities of this type.**

FIG. 11 **STRATEGIC ROADMAP FOR POLAND'S ENERGY TRANSITION BASED ON COAL-TO-NUCLEAR**



SOURCE: Own work

## 5. SUMMARY



The European Parliament declares its strong support for the development of SMRs as part of Europe's future energy system. In December 2023, it adopted a resolution emphasizing the importance of SMRs for decarbonizing the energy mix, ensuring energy security, and supporting hard-to-decarbonize industries. The Parliament highlighted the need to accelerate the development of these technologies and create industrial alliances for their deployment as early as the next decade. These actions send an important signal in Europe for Coal-to-Nuclear initiatives. It should be emphasized that the actions taken in Poland, initially by scientific and research institutions and subsequently by the government administration, regarding the Coal-to-Nuclear pathway are among the first in the world.

**The Coal-to-Nuclear pathway in Poland is feasible. The retrofit potential could reach up to 17 GW. Nevertheless, Poland's energy transition through 2030, considering the development of nuclear power, presents numerous challenges for this emerging economic sector. Only by tackling these challenges will it be possible, following the European trend, to decarbonize energy sources post-2030 by building stable generation assets that will form the foundation of a power system with a significant share of RES. Given the nature of the investment process for nuclear facilities, actions up to 2030 should focus on creating an enabling environment for nuclear power development through the following measures:**

- **Timely construction of the first nuclear power plant.** The construction of a large-scale nuclear power plant in Pomerania will be crucial for underpinning the development of nuclear power in Poland.
- **Securing financing.** Although there is currently no approved financing model for the first nuclear investment, the European Commission's notification regarding state aid for this investment will be valuable. This will help, firstly, to lend credibility to the State Treasury's investment and, secondly, to pave the way for two-way Contracts for Difference for such investments. Poland, alongside other countries interested in Coal-to-Nuclear (e.g., the Czech Republic, Slovakia, Sweden, Finland), should also seek investment aid from European funds within the financial perspective starting from 2030. This underscores the need for immediate action.
- **Infrastructure development.** In Poland, it will be necessary to modernize and expand the existing power infrastructure. These plans will have to consider objectives beyond the first nuclear power plant, namely the planned construction of multiple nuclear projects between 2030–2040. Therefore, it is essential to incorporate these investments into the long-term plans of the Transmission System Operator and Distribution System Operators starting now.
- **Workforce development.** Developing the workforce in the nuclear energy field – including engineers, technicians, and safety specialists – is a crucial aspect. Poland will have to invest in education and training to meet technological and safety requirements. Currently, only a few academic programs offer courses relevant to the nuclear sector's requirements. Support for specialized higher and vocational

education is necessary, considering it takes approximately 10 years to train a specialist. Implementing a coordinated program to retrain coal sector workers for the nuclear power industry is also essential.

- **Safety and regulations.** Nuclear power requires the highest safety standards. For 15 years, Poland has been adapting its regulations to international standards; however, continued adherence to the latest guidelines and ensuring adequate regulatory supervision and control are necessary. Cooperation with international nuclear regulatory authorities is necessary to deepen experience and to unify and harmonize standards and regulations.
- **Radioactive waste management.** Work must be accelerated to select a location for a second repository for short-lived low- and intermediate-level waste (LILW), following the practice of other modern countries. It is also necessary to update the National Plan for the Management of Radioactive Waste and Spent Nuclear Fuel.

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Project manager and specialist experienced in working in the international R&D, nuclear and RES projects. Graduate degree in nuclear power from the Faculty of Energy and Fuels at the AGH University in Krakow.

While working for the National Centre for Nuclear Research, she participated in projects related to nuclear cogeneration and other non-electrical nuclear power applications, Generation IV reactors, and development of requirements for next-generation nuclear reactors. Co-author of reports developed under the ALLEGRO, NC2-IR and HTR-PL reactor initiatives.

Participant of international courses: Training for foreign young researchers and engineers of Orai Research and Develop Center (2015) and Intercontinental Nuclear Institute (2016).

Manager in the DEsire project at the Sobieski Institute.

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## COOPERATION

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### **Hanna Uhl**

An expert on energy transition and investment financing, with many years of experience in public administration and the private sector. She specializes in raising funds for energy and R&D projects, as well as in issues related to climate policy, energy efficiency and clean air and sustainable transportation.

Decarbonization of the energy sector is one of the most important challenges facing Poland's energy policy today. The Sobieski Institute analysed this topic in its 2019–2020 publications SMR for Poland and Nuclear Energy for Poland. These activities are being continued through involvement in the project 'DEsire – Plan for the decarbonization of the national power sector through modernization using nuclear reactors' and work on the Coal-to-Nuclear (CtN) concept.

This has resulted in a coherent series of analyses on the energy transition in Poland using the Coal-to-Nuclear pathway, presenting practical solutions to support this process, the implementation of which would contribute to achieving decarbonization targets and increasing energy efficiency and security. The report entitled Coal-to-Nuclear for Poland. National potential is the first publication in this series.

Poland still relies heavily on coal for its power generation, which accounted for 63% of electricity production in 2024, despite an increase in the share of RES to 27%. Meanwhile, most turbine sets have exceeded their service life, and by 2030, as much as 70% of the country's power infrastructure will require modernization. Unlike other countries in the Visegrad Group (V4), Poland has not implemented nuclear power, which has contributed to the perpetuation of its dependence on coal and an increase in CO<sub>2</sub> emission costs.

By 2040, Poland will face the need to replace its obsolete coal-fired units with modern energy sources. The capacity gap in 2031 could reach 6.4 GW, and by 2040 as much as 18 GW. The Coal-to-Nuclear pathway offers a real opportunity to fill this gap by modernizing older coal-fired units.

The report indicates that the success of this transition depends on a stable legal and financial framework, state support, and adequate workforce/personnel. It is necessary to adapt regulations to international standards for nuclear safety and waste management. Poland should also actively seek EU funds for the development of nuclear power.

The implementation of Coal-to-Nuclear technology is an opportunity to reduce CO<sub>2</sub> emissions, increase energy security, and modernize the sector. It is crucial to create favourable regulatory, financial, and social conditions. The integration of nuclear power with RES can become the foundation for a stable and low-carbon energy future for Poland.

We invite you to read more!

The "Coal-to-Nuclear for Poland" series of reports includes the following publications:

- 1. National Potential. Coal-to-Nuclear for Poland.**
2. *Support Mechanisms. Coal-to-Nuclear for Poland.*
3. *Social Diagnosis. Coal-to-Nuclear for Poland.*

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