Baker McKenzie.

Polish Energy Sector Investment Potential

2024–2025

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INTRODUCTION

MAIN CONCLUSIONS

Over the next 15 years, i.e., until around 2040, we will see an **increase in electricity consumption in Poland**. We will also have to radically change the structure of electricity generation by phasing out fossil fuels (hard coal and lignite) and switching to emission-free and low-emission energy sources. Such a trend has been observed recently and is expected to intensify and accelerate.

One fossil fuel that is expected to become a transitional fuel is natural gas. However, due to the significant investments needed to rebuild the national gas system in order to terminate the long-term dependence on Russian supplies, the role of natural gas can be expected to remain important in the long-term perspective (after 2040).

Increasing the share of emission-free electricity sources is to be achieved through investments in the following types of installations:

- **Onshore and offshore wind farms**
- **Photovoltaic power plants**
- **Nuclear power plants**
- **Gas-fired power plants** (as low-emission and transitional sources)

At the same time, the increasing share of non-steerable renewables (wind and photovoltaic) poses significant challenges for the entire electric power system. There is a need both to extend and adapt this system to the increasing share of smaller and uncontrollable renewable sources, and to implement solutions and technologies that limit the negative impact of increased electricity generation during periods of favourable weather and allow the full potential of uncontrollable sources to be exploited. Such electric power system stabilising solutions include electricity storage facilities (including pumped-storage power plants), nuclear (including SMRs) and gas-fired power plants, as well as controllable RES plants based on biomass and biogas.

Various available estimates of the cost of the investments required to meet the above-mentioned needs in the electricity sector indicate amounts in the order of tens of billions of USD by 2040, of which, for example, **USD 84–89 billion** (PLN 320–340 billion) is to be invested in electricity generation alone.

As far as investments in nuclear power generation are concerned, currently, the most advanced project is being developed by PEJ (owned by the State Treasury) to build an electricity power plant at the Choczewo site in cooperation with the US consortium Westinghouse-Bechtel. This project envisages the construction of three units, each with a capacity of 1–1.6 GW, with the first unit to be commissioned in 2035. The investment cost is at least **USD 40 billion** (PLN 150 billion) and it is expected that this amount will be exceeded. This project is to be financed by a capital injection from the State Treasury to PEJ, the provision of state guarantees and, in the operational phase, the use of a contract for difference.

No decision has yet been taken on the construction of a second nuclear power plant of a similar size, which is also to be built under the government programme and most likely by PEJ. No site or technology partner has been selected. No cost estimates are available.

PGE/PAK's potential investment, based on Korean technology, is the least advanced and most questionable in terms of large nuclear projects. This project seems to have lost political support and may face problems in obtaining financing. Disagreements between KHNP and Westinghouse over the possibility of using Korean reactors in Poland play a significant role.

The use of small modular reactors (SMRs) is a promising solution. However, there is no large-scale experience in implementing such investments. Activities in this area in Poland are being led by **ORLEN Synthos Green Energy, which plans to build 7 SMRs** that will operate in a variety of capacities: as energy suppliers for large industrial consumers, as energy suppliers (including district heat suppliers) for urban areas, and as the main activity electricity power plant in an area with an underdeveloped electricity grid. Barriers to development include unknown final costs and the need to meet the same regulatory requirements as large nuclear electricity power plants.

Investment in offshore wind electricity generation is well advanced. According to various estimates, Poland has great potential in this area, in the order of 33 GW of installed capacity, which is only beginning to be exploited. The key will be the completion and market entry of so-called phase one investments with an installed capacity of nearly 6 GW. The skills and service base built up for these projects can be used to lower the barriers to entry for other investors. Dedicated legislation (special law) and support mechanisms (contracts for difference) provide a relatively stable legal environment.

Energy storage facilities will become an essential element in the near future to maximise the utilisation of the electricity generation potential of non-steering renewable sources. Their role will grow as new technologies are developed. They can also act as system service providers for grid operators and take advantage of price arbitrage. Participation in the capacity market can also be an important source of revenue.

The district heating sector also faces major challenges related to the need to switch to low-emission and zero-emission heat sources. **Poland is one of the largest district heating markets in the European Union.** This sector is subject to strict regulations, including the requirement for tariffs to be approved by the President of the Energy Regulatory Office (URE). The total investment needs in this sector are estimated at **USD 79–105 billion** (PLN 300–400 billion). Potentially important areas of investment in this sector will be heat storage technologies and the construction of new generation units based on low-emission sources (natural gas) and renewable sources (biomass, geothermal energy, large-scale heat pumps and electrode boilers).

In practice, pumped storage power plants are energy storage facilities and participate in the market as such. Investments in this area are planned in several locations. **The regulatory framework is facilitated by special legislation.** Barriers: high investment costs and, at the same time, risks resulting from environmental interference. The potential technological development and wider use of conventional energy storage may also have a negative impact on the development prospects of pumped storage electricity generation.

Biogas and biomethane plants theoretically have significant development potential in Poland due to the availability of raw materials. Barriers to development include the lack of specific regulatory solutions and support mechanisms for large investments. The lack of a national strategy to support the technology is also significant.

CCS technology is indispensable in certain industrial sectors (cement works, metallurgy) where process-related CO_2 emissions are unavoidable. Initial projects in this area are being developed, but the implementation of large-scale investments in this area is hampered by potential public resistance, the lack of a government strategy and regulatory facilitation and support mechanisms.

The development of hydrogen technologies is strictly dependent on the availability of large amounts of low-cost electricity from emission-free sources – offshore wind farms or possibly nuclear power are optimal in this respect.

Summary

In our view, the following areas are recommended for further analysis in terms of potential investment opportunities:

- Nuclear power, given the political and public support and the progress of activities towards the construction of the first nuclear power plant.
- Offshore wind, due to its high potential, relatively stable regulatory environment and support system, as well as the possibility of leveraging the infrastructure and skills created in connection with the implementation of the first projects in the so-called phase one of development.
- Energy storage facilities, due to the stable regulatory environment and its growing role in the electricity system in the context of RES development.
- The district heating sector, due to its importance as a supplier of district heat, a stable regulatory environment, huge investment needs related to the requirement to switch to low and zero emission generation sources.
- Onshore wind power and photovoltaic installations can still be attractive investments, due to the market maturity of the technologies and, in the case of photovoltaic installations, the relatively short investment cycle if connection conditions are in place. In the case of onshore wind, distance regulations have been relaxed and further measures are planned. However, the final shape of the regulations remains unknown, which creates regulatory uncertainty and holds up investment decisions.

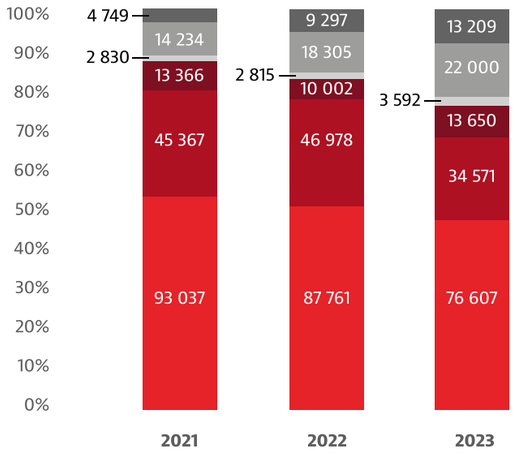
OVERVIEW OF THE ELECTRICITY SECTOR

A ELECTRICITY GENERATION

As regards the structure of electricity generation, fossil fuels (hard coal, lignite and natural gas) will continue to dominate, with the share of coal gradually decreasing. The breakdown of the different sources of energy generation in 2021–2023 is as follows:[1]

The amount of electricity produced in 2023 was approximately 163 TWh (with a consumption of 167.5 TWh). At the same time, it should be noted that, according to the projections of PSE (Polish Power Grid), the demand for electricity in Poland in 2040 will be between 215 and 231 TWh, depending on the scenario chosen.

Comparison of electricity generation mix between 2021 and 2023 [GMk]



Source: URE based on data from PSE S.A.

CONCLUSIONS

- DECLINING ROLE OF FOSSIL FUELS (HARD COAL/LIGNITE)
- RENEWABLE ENERGY SOURCES (WIND, PV) ARE ON THE RISE
- A PLACE FOR NATURAL GAS AS A (TEMPORARY) SYSTEM STABILISER

1: Sprawozdania z działalności Prezesa URE (ure.gov.pl)

REGULATORY REQUIREMENTS FOR ELECTRICITY GENERATION

Electricity generation licence
(issued by the President of the Energy Regulatory Office):

- For an installed capacity **exceeding 50 MW**, except for RES sources and CHP
- For RES sources – for an installed capacity **exceeding 1 MW**

A promise to grant a licence does not entitle the holder to carry out business activities or apply for support, but facilitates obtaining funding for the planned investment and future efforts to obtain a licence.

Electricity generation is **covered by differentiated support mechanisms.** These include in particular:

Capacity market

- Approved by a European Commission decision in 2018 for 10 years
- Additional revenue for generating unit owners for maintaining standby electricity generation capacity or, possibly, readiness for demand side response (DSR)
- Possibility for storage facility operators to participate
- The development of electrochemical battery energy storage technology has resulted in a significant increase in the volume of capacity contracted by capacity providers planning to build this type of units in the 2028 auction, more than ten times the volume contracted for 2027.
- Contracting under the auction system unit
- USD 1.5 billion (PLN 5.5) billion paid in 2023 for the performance of contracts for capacity

Support for RES sources (onshore)

FIT/FIP guaranteed tariffs
Limited to 500 MW (FIT) and certain technologies (biogas, biomass and hydropower electricity generation).

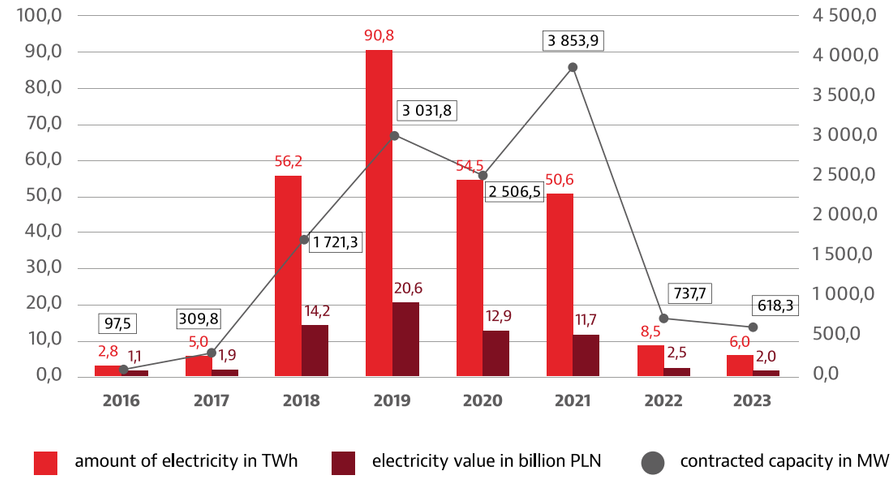
Auction system – bilateral contracts for difference
Certificate of admission to the auction, issued by the President of the Energy Regulatory Office (for new installations – verification of compliance of the planned installation with the requirements of the RES Act).

The number of certificates of admission to the auction is steadily falling:

- 2021: **1 472**
- 2022: **502**
- 2023: **397**

Auctions are losing their attractiveness due to the popularity of cPPAs concluded by operators of RES installations, as also illustrated by the following:[2]

Total installed electricity capacity of installations [MW], volume of electricity sold [TWh], and value of electricity sold [PLN billion] of producers that won auctions in 2016–2023



Source: URE

- Green certificates – for installations from which electricity was first fed into the grid before 1 July 2016 – can be granted for 15 years – no longer than until 2035.

Support scheme for offshore wind farms (OWF)

- Bilateral contract for difference with a support period of up to 25 years
- In so-called Phase One – aid granted at the request of the future producer/operator, by a decision that should have been issued by 30 June 2021 at the latest. The President of the Energy Regulatory Office has issued seven such decisions:[3]

List of offshore wind farm projects that have been granted the right to cover the negative balance under the first phase of the dedicated offshore support system.

Name of the applicant	Name of the offshore wind farm	Total installed electricity capacity (primary) [MW]
Baltic Trade and Invest Sp. z o.o.	Morska Farma Wiatrowa Baltic II	350,000
Elektrownia Wiatrowa Baltica - 2 Sp. z o.o.	Elektrownia Wiatrowa Baltica - 2	1 498,000
Elektrownia Wiatrowa Baltica - 3 Sp. z o.o.	Elektrownia Wiatrowa Baltica - 3	1 045,500
MFW Bałtyk II Sp. z o.o.	MFW Bałtyk II	720,000
MFW Bałtyk III Sp. z o.o.	MFW Bałtyk III	720,000
Baltic Power Sp. z o.o.	Baltic Power	1 197,000
C-Wind Polska Sp. z o.o.	BC-Wind	369,500

Source: Energy Regulatory Office

2–3: Sprawozdania z działalności Prezesa URE (ure.gov.pl)

The European Commission has approved three of these projects as complying with EU state aid rules. In other cases, procedures are ongoing.

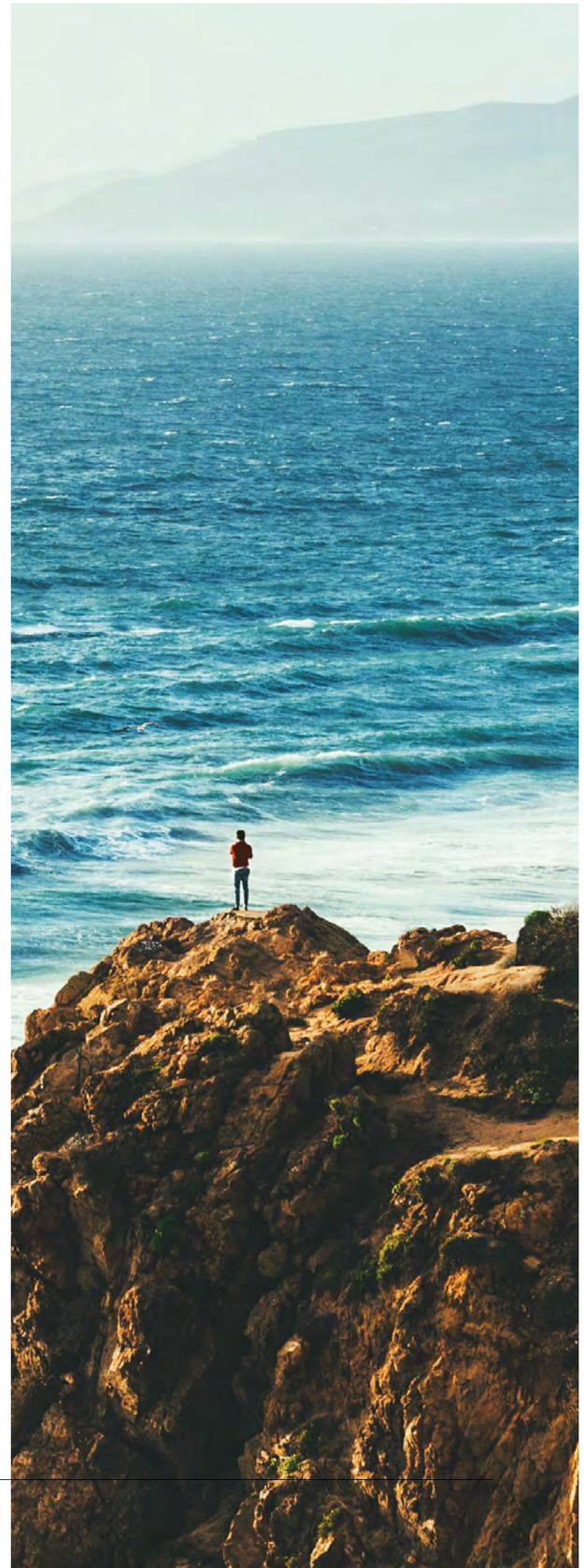
In the so-called Phase Two, support will be granted according to the outcome of the auction procedures carried out by the President of the Energy Regulatory Office. Such auctions are planned to take place over the years:

- 2025: maximum capacity to be supported – **4 GW**
- 2027: maximum capacity to be supported – **4 GW**
- 2029: maximum capacity to be supported – **2 GW**
- 2031: maximum capacity to be supported – **2 GW**
- conditionally in 2032: provided the above capacity pool is not auctioned off

The settlement price under the contract for difference in this phase will be determined by the outcome of the above auction. Consultations are underway on setting a maximum price for the first auction in 2025: potential participants consider it too low.[4]

Support scheme for the combined production of heat and power

- Auction support system: in the form of a CHP bonus for units with capacity from 1 MW to 50 MW that win the auctions announced, held and decided by the President of the Energy Regulatory Office.
- Guaranteed premium (the amount of which is to be set by a regulation) for units with a capacity of up to 50 MW.
- Individual guaranteed premium set by the President of the Energy Regulatory Office for units (existing or modernised) with a capacity exceeding 50 MW.
- Individual CHP premium – awarded by the President of the Energy Regulatory Office following a competitive tender for new units with a capacity exceeding 50 MW.



4: Rząd musi podnieść cenę prądu. Grozi nam dotkliwa porażka (wnp.pl)

B ELECTRICITY STORAGE

Factors influencing the gradual increase in interest in electricity storage:

- Optimising energy consumption
- Reducing the load on electricity grids and making them more flexible
- Independence of electricity supplies from the grid
- Increased self-consumption of electricity from micro-installations
- The electrification of transport

The current situation is as follows:

- Twelve storage facilities connected to the grid of the Transmission System Operator (TSO) and the largest Distribution System Operators (DSOs) (six storage facilities using lithium-ion batteries; six pumped storage power plants).
- The capacity of these storage facilities is almost 1.5 GW.

Carrying out electricity storage operations requires obtaining:

- A licence for operating a storage facility with a capacity exceeding 10 MW
- Entry in the register for a storage facility with a capacity exceeding 50 KW up to 10 MW (registers are kept by the relevant DSOs)

Electricity storage facilities can benefit from the support mechanism in the form of a capacity market.

C ELECTRICITY TRANSMISSION AND DISTRIBUTION

Poland currently has one transmission system operator (PSE S.A.) and 191 distribution system operators, of which five (the largest ones) are companies carved out of integrated capital groups.

Operators play a key role, as they connect new installations to the grid. At present, the main challenge for renewable energy investments is to obtain connection conditions and then to conclude a connection agreement, as the development of the electricity grid has not kept pace with the needs arising from the construction of new generation plants.

Since 2021, an initiative entitled the Charter for the Efficient Transformation of the Distribution Networks of the Polish Power Industry (CET) has been carried out under the aegis of the President of the Energy Regulatory Office. Work in this area is expected to result in investments related to:[5]

- Increasing installed RES capacity to approximately 50 GW, i.e., by around 230%, taking into account the planned 50% share of RES in the electricity mix by 2030.
- The digitisation and automation of networks and services, which will result in increased network flexibility, support for energy market transformation (activity of market participants, development of new products and services).
- Installing approximately 18 million smart electricity meters by the end of 2030.

In addition, DSOs are expected to make investments worth almost USD 19 billion (PLN 73 billion) based on the conclusions and assumptions resulting from the CET.

5: PURE report

EU CLIMATE REQUIREMENTS

IMPLICATIONS FOR POLAND

A ELIMINATION OF FOSSIL FUELS, PARTICULARLY HARD COAL

According to the update of the National Energy and Climate Plan (KPEiK),[6] the share of coal-fired units (hard coal and lignite) in:

- Generation capacity was 47% in 2023 and is expected to fall to 23% by 2030
- The volume of electricity generated was 61% in 2023 and is expected to fall to 29% by 2030

B NATURAL GAS AS A TRANSITIONAL FUEL

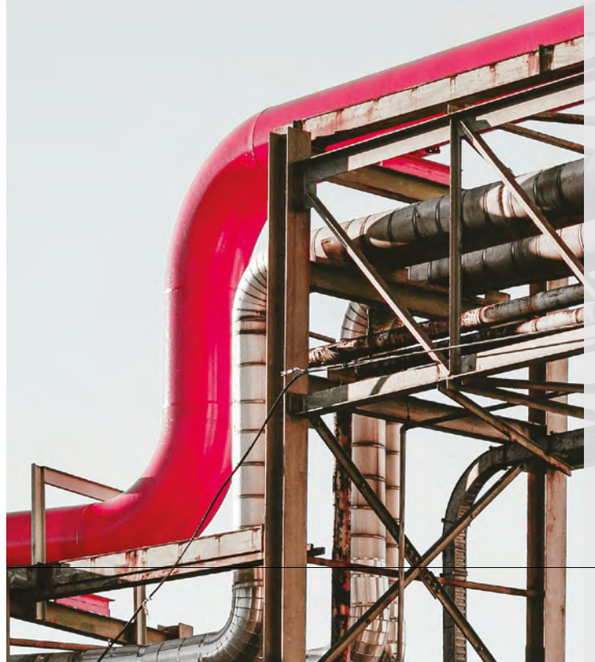
The update of the National Energy and Climate Plan includes the following data on the share of natural gas:

- Generation capacity in 2023 at 6%, and this is expected to **rise to 13% by 2030**
- Volume of electricity generated in 2023 at 10%, and this is expected to **rise to 16% by 2030**

According to Poland's Energy Policy until 2024 (PEP2040),[7] natural gas should be a bridge fuel in the energy transition. However, it should be remembered that Poland has invested and continues to invest heavily in the development of infrastructure related to the diversification of natural gas supply routes (LNG terminal in Świnoujście, Baltic Pipe, deposits in Norway).

It is to be expected that – in the case of pressure and plans to abandon natural gas as an energy source – one of the arguments against such moves will be precisely the economic viability of further use of this infrastructure.

One additional point to consider could be the viability of maintaining gas-fired combined heat and power plants and heating plants as sources of so-called district heat. This will be of particular importance if the emission intensity of current heat sources cannot be reduced based on RES technologies alone and if doubts and uncertainties arise regarding the applicability of still untested technologies such as the use of hydrogen in cogeneration or SMRs.

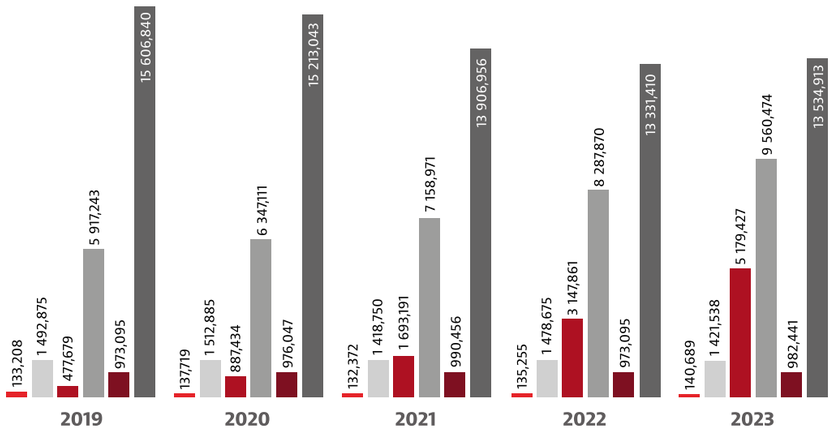


6: Krajowy plan na rzecz energii i klimatu na lata 2021-2030 (gov.pl)
7: Polityka energetyczna Polski do 2040 r. (gov.pl)

C THE RAPID DEVELOPMENT OF RES

The 2023 Report of the President of the Energy Regulatory Office[8] indicates the following volumes of installed capacity in RES sources between 2019 and 2023:

Total installed capacity of RES installations in 2019–2023 [MW]

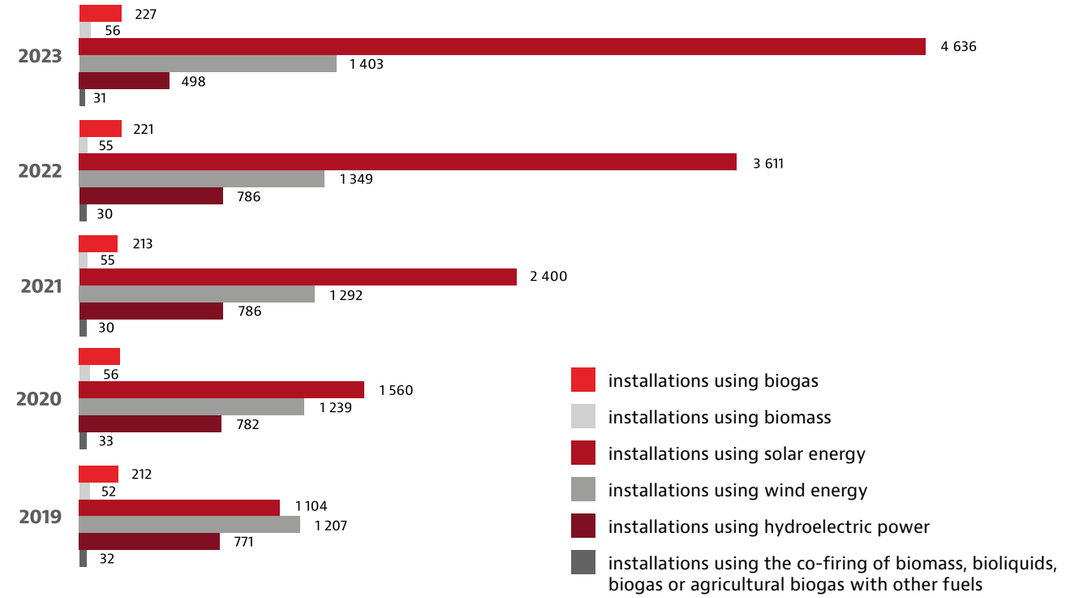


- installations using biogas
- installations using biomass
- installations using solar energy
- installations using wind energy
- installations using hydroelectric power
- installations using the co-firing of biomass, bioliquids, biogas or agricultural biogas with other fuels

Source: URE

On the other hand, regarding the number of RES installations between 2019 and 2023, the same source[9] gives the following figures:

Number of RES installations between 2019 and 2023



Source: URE

According to KPEiK update, the share of RES installations in:

- The generation capacity was 44% in 2023 and is expected to **rise to 57% by 2030**
- The volume of electricity generated was 27% in 2023, and is expected to **rise to 50% by 2030**

8: Sprawozdania z działalności Prezesa URE (ure.gov.pl)

9: Sprawozdania z działalności Prezesa URE (ure.gov.pl)

PHOTOVOLTAIC POWER PLANTS

At the end of August 2024, the installed capacity of photovoltaic power plants in Poland was 19.6 GW.

In turn, according to the KPEiK update:

- In 2030, the installed capacity is expected to be **9.3 GW** (in 2023 – about 17 GW)
- The volume of energy generated is expected to be **24.8 TWh** (in 2023 – 14.6 TWh)

ONSHORE WIND FARMS

Installed capacity, as of August 2024: **10.4 GW**

In line with the plans contained in the KPEiK:

- In 2030, the installed capacity is expected to be 5.8 GW (in 2023 – about 10 GW)
- The volume of electricity generated is expected to be 38.2 TWh (in 2023 – 24 TWh)

Further development of onshore wind electricity generation will undoubtedly be influenced by the loosening of regulatory restrictions on the maximum distance of wind farms from residential buildings (currently, this distance is 700 m, with a further reduction to 500 m planned).

OFFSHORE WIND FARMS

According to the KPEiK, the plans until 2030:

- The installed capacity is expected to be **5.9 GW**
- The volume of electricity generated is expected to be **21.7 TWh**

In turn, according to PEP2040:

- In 2030, the installed capacity is also expected to be about **5.9 GW**
- In 2040, however, this capacity is expected to reach 11 GW, and the volume of electricity generated is expected to be **39.4 TWh**

Furthermore, it should be noted that, according to PEP2040, the deployment of offshore wind electricity generation is one of the **strategic projects** and offshore electricity is expected to account for the **largest share of the overall renewable electricity volume**.

There are estimates[10] indicating even greater potential for offshore wind power:

- Installed capacity – 33 GW
- The volume of electricity generated – 133 TWh

In this scenario, electricity generated by offshore wind farms would be able to meet approximately 57% of overall electricity demand in Poland.

10: Nowy potencjał Bałtyku: 33 GW mocy i 20 nowych obszarów pod MFW (psew.pl)

IMPACT ON THE NATIONAL POWER SYSTEM

Increase in the importance of non-controllable sources

The observed increase in the share of non-controllable renewable sources, as well as their planned further development, means that, on the one hand, it is necessary to ensure that these sources can be connected to the electricity system (hence the plans to extend this network, including by means of introducing solutions based on digitalisation, automation and smart metering for users). In the meantime, however, a tool that is unfortunately being increasingly used is shutting down RES installations by grid operators. This situation raises the issue of the possibility for producers in disconnected installations to claim compensation from electricity grid operators.

However, this situation should be considered as temporary, and a significant improvement of these circumstances should be expected in a few years' time, both through investments (as mentioned above) and legislative changes (cable pooling, the possibility of financing grid development by the grid user applying for connection).

Need for solutions to stabilise the system / enable control of RES

The scenario described above means that solutions that either control the operation of RES or predict their performance characteristics as accurately as possible will become increasingly popular. Notwithstanding the above measures (which are expected to include the use of AI, digitalisation and automation), it will be increasingly necessary to deploy technologies that provide the ability to supplement/replace electricity generated by non-controllable sources.

Hence the growing importance of 'back-up' installations that allow for a relatively rapid supply of electricity at times when production from uncontrollable renewable sources declines or even disappears. Such solutions could be:

- Electricity storage facilities
- Nuclear power plants
- Gas-fired power plants
- RES installations based on biogas and biomass

PLANNED EXPENDITURE

According to PEP2040, as amended in 2021 (to be updated at the turn of 2024/25), the total expenditure on energy transformation by 2030 from EU and national funds, taking into account various mechanisms and forms of support, will amount to around USD 69 billion (PLN 260 billion).

It is estimated that the total cost of the transformation will amount to EUR 135 billion by 2030[11] (however, this analysis also takes into account shielding measures for the mining sector).

In turn, in the 2040 timeframe, according to PEP2040, the overall capital expenditure related to the energy transformation is expected to be at the following levels:

- **USD 420 million (PLN 1.6 billion) of total capital expenditure:**
  - Investments of nearly USD 236 billion (PLN 900 billion) in the fuel and nergy sector
  - Investment in the electricity generation sector: USD 84–89 billion (PLN 320–340 billion) of which approximately 80% is to be allocated to emission-free sources (RES and nuclear power)

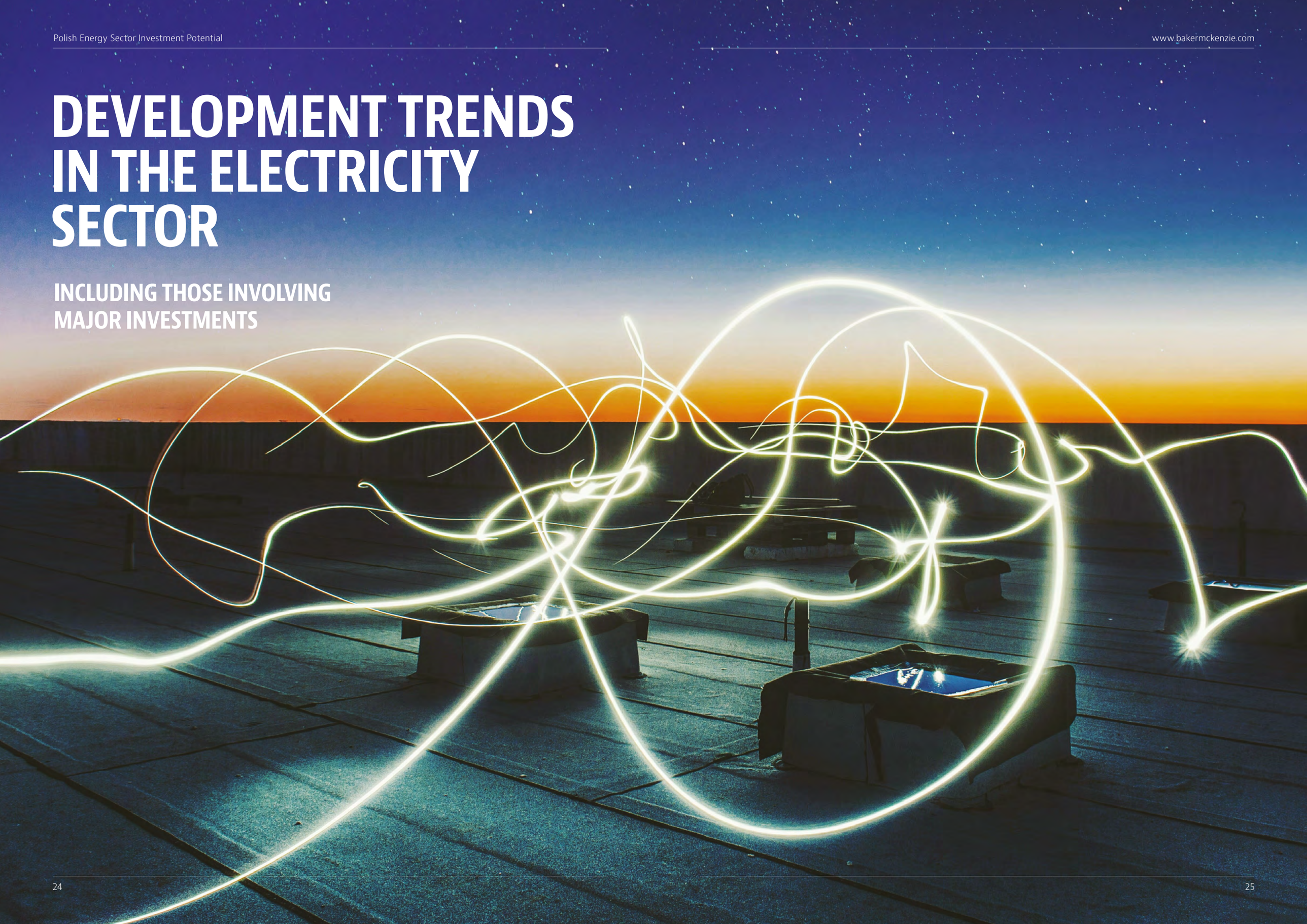
Potential sources of funding:

- The Energy Transformation Fund
- The National Reconstruction Plan

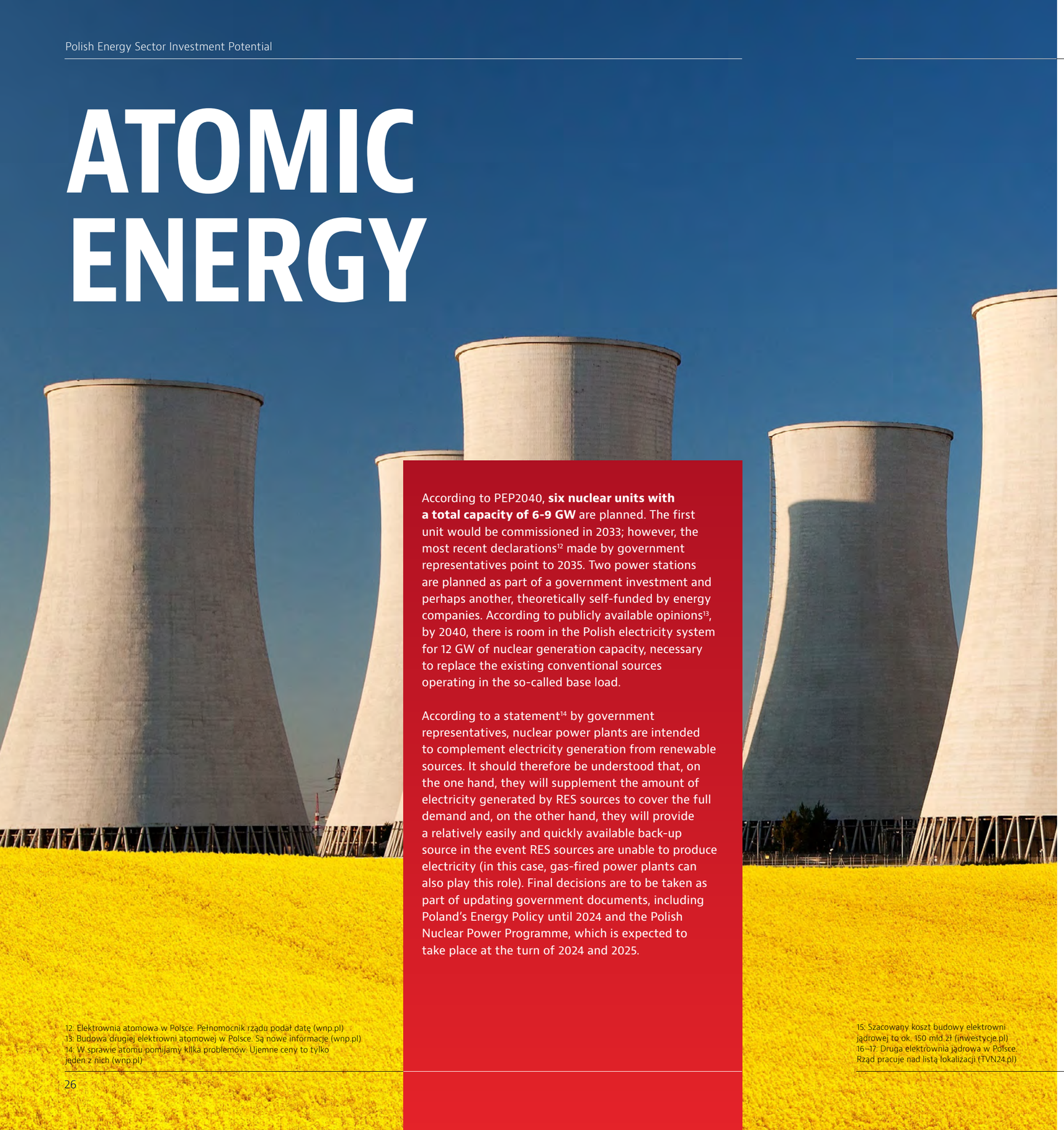
11: Polska ścieżka transformacji energetycznej – najnowszy raport EY i PKEE (pkee.pl)

DEVELOPMENT TRENDS IN THE ELECTRICITY SECTOR

INCLUDING THOSE INVOLVING MAJOR INVESTMENTS



ATOMIC ENERGY



According to PEP2040, **six nuclear units with a total capacity of 6-9 GW** are planned. The first unit would be commissioned in 2033; however, the most recent declarations[12] made by government representatives point to 2035. Two power stations are planned as part of a government investment and perhaps another, theoretically self-funded by energy companies. According to publicly available opinions[13], by 2040, there is room in the Polish electricity system for 12 GW of nuclear generation capacity, necessary to replace the existing conventional sources operating in the so-called base load.

According to a statement[14] by government representatives, nuclear power plants are intended to complement electricity generation from renewable sources. It should therefore be understood that, on the one hand, they will supplement the amount of electricity generated by RES sources to cover the full demand and, on the other hand, they will provide a relatively easily and quickly available back-up source in the event RES sources are unable to produce electricity (in this case, gas-fired power plants can also play this role). Final decisions are to be taken as part of updating government documents, including Poland's Energy Policy until 2024 and the Polish Nuclear Power Programme, which is expected to take place at the turn of 2024 and 2025.

12: Elektrownia atomowa w Polsce. Pełnomocnik rządu podał datę (wnp.pl)
13: Budowa drugiej elektrowni atomowej w Polsce. Są nowe informacje (wnp.pl)
14: W sprawie atomu pomijamy kilka problemów. Ujemne ceny to tylko jeden z nich (wnp.pl)

PEJ – CHOCZEWO

The investment is to comprise three units with a capacity of 1–1.6 GW each, based on Westinghouse technology. The investor is the state-owned company Polskie Elektrownie Jądrowe (PEJ sp. z o.o.). The contractor is the Westinghouse-Bechtel consortium.
The expected financial outlay fluctuates around USD 40 billion (PLN 150 billion)[15] (figures as of June 2024). Experience to date with the construction of other nuclear units (Hinkley Point, Flamanville) gives a conservative estimate that the actual outlay will be significantly higher.

Funding is to come from two sources (based on current information):

- Direct support from the state budget to the tune of **USD 16 billion** (PLN 60 billion) (in the form of co-financing and guarantees).
- The rest is to be provided by a contract for difference.

Administrative decisions and actions taken to date in relation to the construction of the NPP:

- In July 2023, PEJ obtained the so-called decision in principle on the compatibility of the investment with the public interest and the state's energy policy.
- An environmental decision (decision on environmental conditions) was issued in September 2023.
- An Engineering Services Contract for the Lubiatowo-Kopalino power station was also signed in September 2023.
- In October 2023, PEJ obtained a siting decision for the construction of a nuclear power plant at the Lubiatowo-Kopalino site.

SECOND POWER PLANT TO BE BUILT BY THE STATE TREASURY

There is no specific and confirmed information as to:

- The political decision to build the plant itself (although the planned capacity of the first plant compared to the planned share of nuclear power in the generation mix indicates the need for at least one more nuclear plant).
- **Investor:** most likely to be PEJ (this is based on the current version of PEP2040, which will be updated).
- **Capacity:** it can be assumed that it will be close to the capacity of the first nuclear power plant (i.e., between 3 and 4.5 GW).
- **Sites:** PEJ is currently working on narrowing down the possible sites;[16] according to earlier information (published by the previous government), five such sites were considered, one of which is Bełchatów, with ready connection infrastructure after the lignite-fired power plant;[17]
- **The chosen technology and implementing partner:** again, most likely this will be the Westinghouse-Bechtel consortium (supported by cost and process optimisation), but the ambition and activity of the French stakeholder, EDF, must be taken into account (it cannot be ruled out that it will seek concessions to be able to implement the investment).

15: Szacowany koszt budowy elektrowni jądrowej to ok. 150 mld zł (inwestycje.pl)
16–17: Druga elektrownia jądrowa w Polsce. Rząd pracuje nad listą lokalizacji (TVN24.pl)

PGE/PAK PROJECT

An initiative of a company controlled by the State Treasury (PGE) and a private energy group (PAK). Project details:

- Based on Korean technology (KHNP)
- The planned capacity is a total of 2.8 GW
- Site: in the vicinity of Konin (central Poland)

In November 2023 (just before the change of government following the elections), a decision in principle was issued for the project, indicating government support. Since then, the project has not moved forward, and the available public information suggests that PGE (a company controlled by the State Treasury) has frozen the project, and therefore a de facto loss of political support.[18] An important indicator of the project's credibility will be its inclusion (or not) in the PEP2040 update, which is expected to be available in 2024/2025.

An additional obstacle may be the fact that the project is to be based on Korean reactors, which has given rise to a dispute between KHNP and Westinghouse (the Korean reactors are based on Westinghouse solutions) as to whether they can be offered outside Korea without Westinghouse's consent.

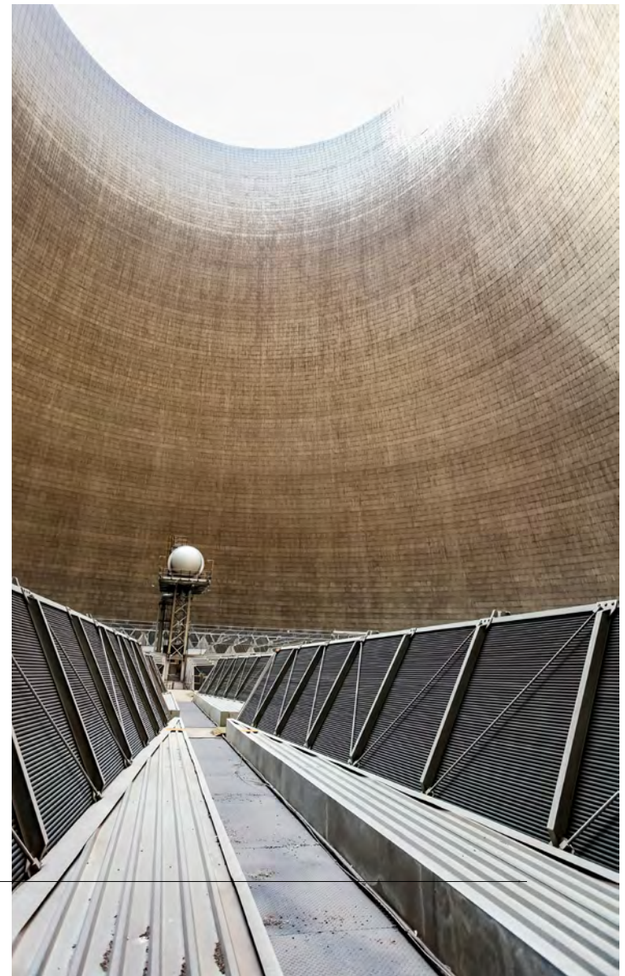
SMR – ORLEN SYNTHOS GREEN ENERGY COMPANY

SMR – Small Modular Reactors. Technology at an early stage of development. Nuclear power plants with relatively small installed capacity (up to 300 MWe, while standard nuclear power plants are around 1 000 MWe). Modular, as they are assembled from prefabricated modules previously manufactured in the factory. In addition to size, the differences from large nuclear power plants are related to:[19]

- Theoretically higher levels of safety (passive systems that operate automatically, without human intervention or external power: they use physical phenomena such as gravity, convection, natural circulation); reduced possibility or even elimination of dangerous radioactive isotope emissions in the event of an accident – reduced requirements for complex and large-scale safety systems.
- Simpler construction should theoretically result in lower costs and shorter construction times.
- Lower fuel requirements: less frequent replacement of nuclear fuel (from three to seven years: standard nuclear power plant: every 1–2 years), designed SMRs that can operate without fuel replacement for 30 years.
- Fewer requirements for access to coolant (natural waters), which means that the choice of a site is much more flexible: they can be placed, for example, close to industrial plants but far from the coast or inland waters.
- To be constructed commercially, no information on the need for public (financial) support.

Planned use as zero-emission:

- Ordinary source of electricity, especially in areas with an underdeveloped transmission network (in the case of Poland, this could be, for example, the north-east region).
- Source of district heat (important in the case of efforts to decarbonise sources of such heat in Poland, given the high saturation of district heat in large urban centres).
- Source of electricity for large, energy-intensive industrial plants that currently rely on their own fossil-fuel-based generation facilities (coal, natural gas).



18: Co dalej z elektrownią atomową miliardera i polskiego rządu? PGE mówi o kluczowy decyzjach politycznych (bankier.pl)
19: Małe reaktory modułowe (SMR) (forumatomowe.org)

ORLEN Synthos Green Energy (OSGE) plans

Co-operation between a company under the control of the State Treasury and a private company. Planned 'fleet' of SMRs in at least seven sites:

- **Włocławek:** electricity to be used for an industrial customer (ORLEN plants)
- **Ostrołęka:** as a main activity electricity power plant
- **Warsaw:** as a source of district heat (combined heat and power plant)
- **Dąbrowa Górnicza:** for an industrial customer
- **Stawy Monowskie:** for an industrial customer
- **Kraków:** a source of district heat (combined heat and power plant)
- **Tarnobrzeg/Stalowa Wola:** for an industrial customer

Decisions in principle have been issued for six of the above sites (December 2023). According to current plans, an application for a building permit decision is expected to be submitted to the State Atomic Energy Agency (PAA) in 2026.

Potential barriers:

- Unknown final cost (likely to exceed original estimates) and construction period.
- The need to meet the same requirements as for a standard nuclear power plant (regulations and legal requirements are the same regardless of the size or modularity of the nuclear power plant).

OFFSHORE WIND ENERGY

The erection of offshore wind farms (OWF) is only possible in the exclusive Polish economic zone. The key and first documents are a permit to erect and exploit artificial islands, structures and equipment for offshore wind farms (PSZW). Then, an environmental decision and a building permit must be obtained.

The developer is responsible not only for the construction of the generating facility itself, but also for the provision of offshore transmission infrastructure and the connection to the electricity system itself; the TSO (PSE) is required to adapt the onshore transmission infrastructure. (In Europe, in principle, a model is used in which the transmission operator is also responsible for the offshore part of the transmission infrastructure and the connection of the farm to the transmission system itself)[20].

20: Wyścig z czasem. Kiedy morska energetyka wiatrowa wejdzie do gry? (forum-energii.eu)

INVESTMENTS IN PROGRESS

Under Phase One of support (based on individual decisions by the President of the Energy Regulatory Office and the European ommission), the following investments with a total capacity of 5.9 GW are to be implemented:

- **Baltic Power (ORLEN + Northland Power[21]):** capacity 1.2 GW, planned commissioning 2026
- **BC – Wind (Ocean Winds[22]):** capacity 0.5 GW, planned commissioning 2027
- **FEW Baltic II (RWE):** capacity 0.35 GW, planned commissioning by 2030
- **Baltic 2 (PGE + Orsted)**: capacity 1.5 GW, planned commissioning 2027
- **Baltic 3 (PGE + Orsted)**: capacity 1.05 GW, planned commissioning 2029
- **MFW Baltic II (Polenergia + Equinor[23])**: capacity 0.72 GW, planned commissioning by 2028
- **MFW Bałtyk III (Polenergia + Equinor)**: capacity 0.72 GW, planned commissioning by 2028

PLANNED INVESTMENTS

As part of phase two of support, the following investors are preparing for the auction planned for 2025 (available capacity – 4 GW):

- **Baltica 1 (PGE Group):** with a project of approximately 0.9 GW (PGE has five siting decisions for an installed capacity potential of approximately 3.9 GW)
- **Baltic 1 (Polenergia/Equinor)**: with a capacity of up to 1.56 GW
- **ORLEN – least advanced project:** capacity unknown (all that is known is that ORLEN has been issued siting decisions covering an installed capacity potential in the region of 5 GW).

A minimum of three projects must take part in the auction. The projects that submit the lowest price, which is below the published so-called maximum price, win. The winner is expected to feed the electricity into the grid within seven years of the outcome of the auction. The deadline may be extended.

21: The Canadian company active in the design, implementation and management of energy projects, has three wind farms in the North Sea
22: Joint venture between ENGIE (France) and EDPR (Portugal)
23: Former Statoil (Norway)

Polish Energy Sector Investment Potential

ENERGY STORAGE FACILITIES

Energy storage facilities have been described as "the missing link on the road to zero emissions" and the decarbonisation of[24] the energy sector and the wider economy. Predictions of the growing role of such storage facilities are based in part on PSE's published Transmission Grid Development Plan to 2034[25], which states that without energy storage facilities, the full potential of existing and yet to be connected renewable sources will not be realised.

The advantage of energy storage facilities as an installation used by operators to stabilise the operation of the electricity grid is the rapid response time (compared, for example, to conventional power plants, also providing such services) and thus the immediate improvement in grid performance. In practice, energy storage facilities can be expected to become as indispensable a component of the electricity system in the future as, for example, generation sources.

24: Magazyny energii – brakujące ogniwo dekarbonizacji (WysokieNapiecie.pl)
25: Projekt nowego planu rozwoju sieci przesyłowej na lata 2025–2034 (pse.pl)

In addition to acting as a stabiliser of the operation of the electricity grid, i.e., providing so-called system services to the transmission or distribution operator, energy storage facilities can earn money from so-called price arbitrage:

- Buying and storing electricity on the market when prices are low and selling when prices rise.
- The storage of electricity generated from own RES sources (whose increased use most often results in lower prices on the market or even the occurrence of so-called negative prices)[26] and their sale when prices are high.
- Providing services to ensure the security/safety of electricity supplies to entities whose operation requires such security: hospitals, server rooms, etc., which often have their own back-up generators running on e.g., petroleum products (there is a trend towards increased disruptions to electricity supply due to weather conditions).
- Provision of services under capacity mechanisms (capacity market).

The introduced reform of balancing market rules, which prices electricity in shorter, 15-minute periods, will also increase the profitability of investments in energy storage facilities.

At the end of 2023, according to PSE data, connection terms and conditions were issued for energy storage facilities with a capacity of 11.5 GW.

Support is planned for the construction of energy storage facilities with a capacity of more than 2 MW, with a budget of USD 1.1 billion (PLN 4 billion) (by 2028), which is expected to guarantee the construction of at least 2.5 GW of storage capacity.[27]

26: When the generator de facto pays for the energy fed into the grid
27: NFOŚiGW planuje zwiększyć finansowanie magazynów energiil (gov.pl)

HEATING SECTOR

A specific feature of the Polish heating sector is the large share of so-called district heating, which is understood as the supply of heat to individual consumers by specialised energy companies with heat sources (heat plants or combined heat and power plants) and heating networks. In this respect, the Polish heat market, with 40% of consumers connected to heating networks, is at the forefront of EU countries and, in terms of volume of heat sold to end consumers, is the undisputed leader. Due to the high heat losses that occur during heat transport via heat pipelines, heat sources need to be located relatively close to users – in towns or even on individual housing estates.

At the same time, the business of generating, distributing and selling heat to end users is more tightly regulated compared to other energy sectors. In particular, generation, transmission and distribution as well as trading in heat, i.e., sales to end users, are subject to tariffs by the President of the Energy Regulatory Office.[28]

28: Sprawozdania z działalności Prezesa URE (ure.gov.pl)

As of 2022 (the latest available data), the level of coal fuels used in district heating was over 66%[29] and the share of fossil fuels in district heating reached 80%.

Potential challenges for the district heating sector in Poland:

- A projected overall decrease in heat demand due to, on the one hand, increasing energy efficiency requirements for buildings and, on the other, a generally warming climate with milder winters.
- Less demand will have to be met by low- and zero-emission heat sources, requiring costly investments.
- A planned increase of 1.5 million households using district heating.

According to PEP2040, by 2030, 85% of district heating systems should be so-called efficient district heating systems, i.e., in practice, they should operate on the basis of emission-free (green) energy sources, combined heat and power or waste heat. EU requirements in this respect will increase and eventually (2050) district heating systems should be based exclusively on heat from renewable sources or waste heat.

Overall, the investment needs for the transition to low- and zero-emission district heating are estimated at USD 73–110 billion (PLN 276–418 billion)[30].

Potential investments include:

- Developing technologies for storing heat and electricity from RES for district heating systems – the investment market in this area is estimated at around USD 7.9 billion (PLN 30 billion):
- For example, the potential for 2030 is estimated to be 200 large seasonal heat storage facilities, capable of transferring nearly 11.5 TWh of RES energy from the summer to the heating season.
- Construction of new heat generation units based on low-emission and renewable sources:
  - natural gas
  - biomass
  - geothermal energy
  - power to heat (large-scale heat pumps and electrode boilers powered by RES electricity)

  with the necessary outlays for generation installations estimated at between USD 25–47 billion (PLN 94–178 billion).[3]

In the longer term, assuming commercialisation, the possibility of using hydrogen technologies (working in a cogeneration formula) and nuclear technologies in the form of SMRs is indicated.

29: 2022 - Energetyka cieplna w liczbach (ure.gov.pl)
30 – 31: Ocena wpływu rozstrzygnięć unijnego pakietu „Fit for 55" na transformację sektora ciepłownictwa systemowego w Polsce (ptez.pl)

PUMPED STORAGE POWER PLANTS

Pumped Storage Power Plants (PSPPs) use two reservoirs at different elevations connected by a system of pipes, pumps and turbines to move water between the reservoirs. When the upper reservoir is filled (pumped), the PSPP draws electricity from the grid (using, for example, excess energy from optimum weather conditions for wind and photovoltaic power plants). When water is released from the upper reservoir into the lower reservoir, the PSPP generates electricity (generation mode) and feeds it back into the grid (e.g., when the electricity system needs to be balanced very quickly)[32].

Pumped storage power plants are treated as energy storage facilities and are subject to the same regulations. As PSPPs are, in principle, large installations (with an installed capacity of more than 10 MW), it can be assumed that an electricity storage licence will be required to operate a PSPP.

In addition to participating in the energy market (which includes the sale of electricity produced in the generation mode), PSPPs can provide a source of revenue from:

- Participation in the balancing market (which includes solutions tailored to the flexible operating characteristics of PSPPs)
- Provision of system services to the TSO
- Participation in the capacity market (as zero emission units entitled to an extended period of support – 17 years; caveat: the capacity market is a time-limited mechanism – last auction in 2025)

The construction of PSPPs is to be facilitated by a dedicated statutory regulation - the so-called special law, according to which, the following must be obtained:

- Siting decision
- Water permit
- Environmental permit
- Building permit
- Operating permit

The service life of PSPPs is estimated to be around 40 years.

Planned investments in the PSPP construction:

- **PSPP Tolkmicko** (investor: ORLEN; planned capacity: 1040 MW)
- **PSPP Młoty** (most advanced; investor: PGE; planned capacity: 750 MW; cost estimate: USD 1.1 billion (PLN 4 billion))
- **PSPP Rożnów II** (investor: TAURON Group company; planned capacity: 700 MW; cost estimate: USD 1.6 billion (PLN 6 billion))

Other potential PSPP sites[33]:

- **PSPP Sobel/Sobol** – 1000 MW
- **PSPP Niewiastka** – 1000 MW
- **PSPP Pilchowice III** – 612 MW
- **ESP Smolniki** – 200 MW
- **PSPP Włocławek** – 1000 MW
- **PSPP Bełchatów** – 10006 MW
- **PSPP Chojna** – 5.6 MW

Investing in the construction of a PSPP is relatively expensive and, at the same time, fraught with risks associated with the need for extensive environmental intervention.

32: Komunikat CIR: raport Zespołu Eksperckiego ds. Budowy Elektrowni Szczytowo-Pompowych (gov.pl)

33: Komunikat CIR: raport Zespołu Eksperckiego ds. Budowy Elektrowni Szczytowo-Pompowych (gov.pl)

BIOGAS (BIOMETHANE) PLANTS

Poland has one of the largest potentials in the use of substrates for biogas and biomethane production. Raw materials are mainly provided by agricultural activities and the municipal sector. There are currently around 380 biogas plants with a total capacity of 280 MW, the majority of which are municipal biogas plants.

The potential is estimated at 300 large plants (over 1 MW installed capacity). Presently, it is estimated that only 3% of the potential biogas production in Poland is used (0.37 billion m³, with a national annual natural gas consumption of around 16–17 billion m³ in 2022–2023[34])[35].

34: According to PEP 2040, natural gas consumption is expected to increase to 23–28 billion m3 in 2030.
35: Raport: Biometan w Polsce Raport Strategy& (pwc.pl)

The technical potential (i.e., considering all existing resources) is estimated at around 8 billion m3 of biomethane.

The deployment potential (considering recoverable resources) is 4.7 billion m3 of biomethane.

The investment potential (considering possible sites where suitably large biogas plants can be realised) is 3.2 billion m3 of biomethane.[36]

The advantages of biomethane are:[37]

- A controllable source of renewable energy to support the stability of the electricity system operation
- Surface water protection
- Safe (green) fertilisers
- Implementation of the principles of the circular economy
- Reducing greenhouse gas emissions
- Potential for use as a fuel in transport (bioLNG and bioCNG) by land and sea

Barriers to development:

- The lack of dedicated regulatory and legislative solutions for large investments (above 1 MW)
- The lack of support schemes for large investments

Overall, the lack of a unified and coordinated state approach and strategy to support biogas and biomethane production is highlighted.

36–37: Realny potencjał biometanu w Polsce (gov.pl)

CARBON CAPTURE & STORAGE

(CCS)

Carbon capture and storage technologies are part of the drive to decarbonise the economy. They involve installing equipment to capture carbon dioxide before it is emitted into the atmosphere and then transporting and storing it in underground storage facilities (geological structures). The idea is to use depleted natural gas reserves, for example. This technology has been in use for 30 years or so, but on a limited scale (e.g. in Norway).[38]

CCS technology is particularly important for so-called process emissions that cannot be avoided, for example, in cement production or metallurgy.

38: Warunki rozwoju technologii CCS w Polsce (polskikongresklimatyczny.pl)

The rationale for developing CCS technology in Poland (and even creating a regional hub for importing CO_2 from neighbouring countries) is based on:

- Experience in carrying out activities related to geological structures and research and development activities in this field.
- The geological potential of structures capable of storing CO_2 (according to various estimates: between 10 and 15 Gt, with annual emissions in the order of 400 Mt)[39].

Barriers:

- The potential for storage capacity in Poland is almost entirely located onshore – at the same time, CCS technology faces relatively high public resistance.
- The lack of a government strategy and programme for the development and implementation of CCS technology.
- The lack of dedicated funding sources.
- The lack of regulatory facilitation (special law?).
- The need to build a transmission system to transport CO_2 from emission sources to storage sites.

Planned investments:

- **Kujawy Cement Plant (Inowrocław):** a CO_2 capture facility is to be built by 2027; plans to send 1 million tonnes of liquefied CO_2 to Gdańsk and on to sub-seabed storage facilities.
- **ECO_2CEE project** (cooperation between ORLEN, Holcim and Air Liquide): common transfer area for captured CO_2 from plants located in northern Poland and Lithuania with a transhipment terminal in Gdańsk.

39: Mapa drogowa wdrażania technologii CCS w Polsce (wise-europa.eu)

HYDROGEN

Hydrogen can be used as a zero-emission fuel in the electricity and heating sectors as well as in transport. This requires the use of so-called green hydrogen in the combustion process, i.e., hydrogen produced by using electricity from renewable energy sources in the electrolysis process. However, this type of hydrogen production requires significant amounts of electricity, making it uneconomical at present. The use of hydrogen as a fuel also has the advantage of complete geopolitical independence – hydrogen can be produced virtually anywhere. All that is needed is access to water and electricity.

Currently, Poland ranks third in Europe and fifth in the world in terms of producing so-called grey hydrogen, i.e., hydrogen produced using electricity generated from conventional sources (hydrogen is needed, for example, to produce ammonia – a key raw material for the fertiliser industry).

Hydrogen production using surplus electricity from uncontrolled renewable energy sources (wind, solar) in the so-called Power2X (P2X) technology can also be a form of energy storage, which is then used as hydrogen fuel in transport or industry. Electricity generated in a nuclear power plant can also be used in this way. In general, Power2X (P2X) is the use of electricity generated from renewable energy sources to produce other energy carriers or raw materials (ammonia, liquid fuels, gaseous fuels).

Green hydrogen production using electricity from offshore wind farms is estimated to be the fastest to reach economic viability.[40]

According to EU targets, green hydrogen should account for more than 40% of hydrogen used in industry by 2030.

ORLEN plans to build electrolysers (facilities to produce hydrogen using electricity from renewable sources) with a capacity of 1 GW by 2030.[41]

According to the Polish Hydrogen Strategy adopted in 2021,[42] the installed capacity for green hydrogen production is expected to reach a maximum of 2 GW by 2030.

40: Polska Strategia Wodorowa do roku 2030 (gov.pl)
41: Za paliwo przyszłości zapłacimy wysoką cenę. Bez tego rewolucji nie będzie (wnp.pl)
42: Polska Strategia Wodorowa do roku 2030 (gov.pl)

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