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Management of Transmission and Distribution Infrastructure as Part of the National Energy Security System

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Abstract:

Purpose: *The purpose of the article is to identify the importance of transmission and distribution infrastructure management for ensuring national energy security. The authors analyse the role of planning, organisation and supervision of energy networks in the context of the security of electricity, gas and heat supply. The article aims to assess the impact of infrastructure quality and management activities on the energy system's resilience to technical, economic, and political threats. It provides guidance on enhancing Poland's energy security management.*
Design/methodology/approach: *The research involved an analysis of literature sources, legal acts, strategic documents, and reports from national and international institutions. The analysis covered, among other things, the provisions of the Energy Law, European Union directives and regulations on energy supply security, as well as the case law of the Court of Justice of the European Union. Comparative analysis and critical literature review were also used to identify key factors in transmission and distribution infrastructure management. The research question was formulated as follows: How do the condition and management of transmission and distribution networks affect a country's energy security? Based on this problem, the following research hypothesis was formulated: Effective management of transmission and distribution infrastructure, including development planning, protection and modernisation of networks, significantly increases the level of national energy security by ensuring the continuity and stability of energy supply.*
Practical implications: *The analysis results indicate several practical implications for managing transmission and distribution infrastructure. First and foremost, the need for integrated planning of energy network development based on national energy strategies, climate policy and EU regulations was emphasised. It is essential to strengthen the risk management capabilities of transmission system operators and to introduce practical tools for monitoring technical and cyber threats. The article also highlights the need to establish national sources of financing for infrastructure investments and to ensure the balanced*

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development of the network throughout the country, particularly in less industrialised regions. Another important implication is the need to strengthen the physical and ICT protection of critical infrastructure and to limit its excessive visibility, which may prevent acts of sabotage or external interference. The need to develop the competences of management and technical staff in the areas of cybersecurity, crisis management and incident response was also highlighted. All these measures should lead to the creation of an integrated transmission infrastructure security management system based on cooperation between public administration, system operators and energy supervisory institutions.
Findings: *The analysis confirmed that effective management of transmission and distribution infrastructure is a key element of the national energy security system. An efficient, fail-safe, and modern transmission network guarantees the continuity of energy supply and the stability of the economy. It has been demonstrated that a lack of investment, insufficient long-term planning, and weak ICT security can result in reduced transmission capacity and an increased risk of energy crises. The results of the study also indicate that effective infrastructure management requires synergy between national policy and European Union regulations, as well as consistent action in the areas of network development, investment and risk management.*
Practical implications: *The article brings new cognitive value through its interdisciplinary approach to the issue of energy infrastructure management in the context of national security. The authors combine technical, legal, and organisational perspectives, highlighting the relationship between network management efficiency and a country's resilience to energy threats.*
Originality/value: *The originality of the work is evident in its comprehensive analysis of the organisational and regulatory factors of critical infrastructure management, as well as in the formulation of practical recommendations of significance for public administration, system operators, and entities responsible for the country's energy security.*

Keywords: *Management of transmission and distribution infrastructure, national energy security.*

JEL Codes: *Q40, Q48.*

Paper type: *Research article.*

1. Introduction

The current political and economic situation in Poland and globally suggests that the energy sector is a crucial component of national security policy. In addition to typical military issues, security policy should also consider energy security issues, encompassing both the security of supply and the security of the infrastructure through which supplies are delivered.

The existing directions of energy supplies – especially gas – from the east have naturally shifted their focus to other possible sources of supply. "In February 2022, the European Union's (EU) approach to energy security changed radically. In the current geopolitical context, particularly in the context of the conflict between Russia and Ukraine, EU energy security issues are becoming increasingly important. Taking steps to reduce dependence on Russian gas and switching to alternative energy sources are the main challenges facing the EU in this area" (Pavlenko, 2024).

The energy sector, especially in Poland, is currently undergoing the most significant changes in its history. Energy companies are struggling both.

With the need to take action to meet the obligations of the so-called European Green Deal (Sikora, 2022) and the energy transition, they are also faced with the challenge of ensuring the security of electricity, heat and gas supplies for all consumers threatened by the outbreak of war in Ukraine.

In theory, Poland is not alone in these efforts. Article 194(1) of the Treaty on the Functioning of the European Union (Treaty on the Functioning of the European Union. OJ EU C No. 326, pp. 47-390) states that, in establishing and functioning of the internal market and taking into account the need to preserve and improve the environment, Union policy in the field of energy shall, in a spirit of solidarity between Member States, aim to:

- ensure the functioning of the energy market;
- ensuring security of energy supply in the Union;
- promoting energy efficiency and energy saving, as well as the development of new and renewable forms of energy;
- promoting interconnections between energy networks.

The energy solidarity referred to in the article mentioned above should guide all Member States of the European Union. In practice, the construction of gas transmission networks, in particular, raises doubts as to whether all Member States are investing in the networks in a spirit of solidarity. An example of putting particular interests above energy solidarity was the construction of the Nord Stream 1 and 2 gas pipelines.

Even now (despite the ongoing war in Ukraine caused by Russia's aggression), there are calls (https://www.money.pl/) for them to be put into operation, or at least secured after their partial damage as a result of explosions in 2022 (https://energetyka24.com). This is even though the causes of the gas pipeline leaks have not yet been explained (https://www.deutschlandfunk.de).

Current case law of the Court of Justice of the European Union indicates that the principle of energy solidarity has far-reaching implications. "About its content, it should be emphasised that the principle of solidarity encompasses rights and obligations for both the Union and the Member States. On the one hand, the Union is bound by an obligation of solidarity towards the Member States.

On the other hand, the Member States are bound by an obligation of solidarity among themselves and in the light of the common interest of the Union and its policies. In the context of energy policy, this entails, among other things, an obligation to provide mutual assistance if, for example, a Member State finds itself in a critical situation or a state of emergency regarding its gas supply due to natural disasters or terrorist acts. (...)

The principle of solidarity also includes a general obligation on the Union and the Member States to take into account the interests of other entities in the exercise of their respective competences" (CJEU judgment).

According to some legal scholars, this ruling may lead to closer cooperation in the energy field (Zawodziński, 2021, p. 43). However, there is also a risk that, in a situation of limited energy supply, the principle of solidarity may be restricted.

Therefore, with Poland's security in mind, despite the solidarity obligations of other Member States, it is necessary to ensure the diversification of energy sources and, on the other hand, to enable its transmission from various possible directions.

2. Current Network Security Issues

An efficient and effective transmission and distribution infrastructure ensures the security of electricity, fuel and heat supplies. This applies to both the transmission of energy imported from abroad and the uninterrupted supply of heat within the country. "The efficient functioning of the EU internal energy market requires a modern and secure energy infrastructure (energy and gas transmission and distribution networks, gas storage facilities, LPG terminals, modern power units).

The expansion of transmission infrastructure ensures the security of raw material transmission. Storage infrastructure is essential for maintaining stocks of raw materials and fuels that can be used in the event of disruptions to their supply. A well-functioning energy distribution infrastructure ensures that end-users receive uninterrupted energy supplies. It is also necessary to build interconnections between the energy systems of individual EU Member States (Nowacki, 2012, 1384).

An adequate transmission infrastructure is also essential for connecting renewable energy sources, which, in the event of a disruption to the energy system, will enable energy to be generated from renewable sources —a key component of the energy transition.

Apart from the condition of the infrastructure itself in the era of so-called hybrid warfare, it is crucial to secure transmission and distribution networks against threats to IT and communication systems, as well as against terrorist or diversionary activities.

3. Condition of Transmission and Distribution Systems

Transmission networks may face a variety of threats. An essential element of transmission and distribution network security is their proper and uninterrupted operation, as well as the ability to communicate and respond quickly, enabling transmission routes to be changed in the event of a failure or deliberate damage to parts of the transmission network. As indicated by EU regulations, "the EU's energy infrastructure should be modernised to prevent technical failures.

And increase the resilience of infrastructure to such failures, as well as to natural and artificial disasters, the adverse effects of climate change, and threats to infrastructure security, particularly regarding European critical infrastructure (Council Directive 2008/114/EC).

The trans-European networks play an essential role in this regard. The European Union supports investments in transmission networks in accordance with the principle of sustainable development. Initially, the objectives for the development of these networks and the manner in which they were defined were set out in a decision (Decision No 1364/2006/EC), and subsequently in subsequent regulations of the European Parliament and of the Council (Regulation (EU) No 347/2013 of the European Parliament and of the Council).

The development priorities in accordance with the principle of sustainable development in 2006 were aimed at increasing the efficiency of energy networks, eliminating bottlenecks, transmission constraints and missing links, creating energy networks in isolated areas, increasing connection capacity, and ensuring the operational cooperation of electricity networks within the Community and with the networks of countries applying for membership of the European Union.

About gas networks, the decision provided for the development of natural gas networks to meet the Community's demand for natural gas and to control natural gas supply systems, as well as to ensure the operational cooperation of gas networks within the Community and with the networks of acceding and candidate countries and other countries in Europe, the Mediterranean, Black Sea and Caspian Sea countries, as well as the Middle East and Persian Gulf region, and the diversification of sources and routes for natural gas supply. In subsequent years, regulations were adopted specifying the Community's objectives for the development of transmission networks, taking into account the current energy.

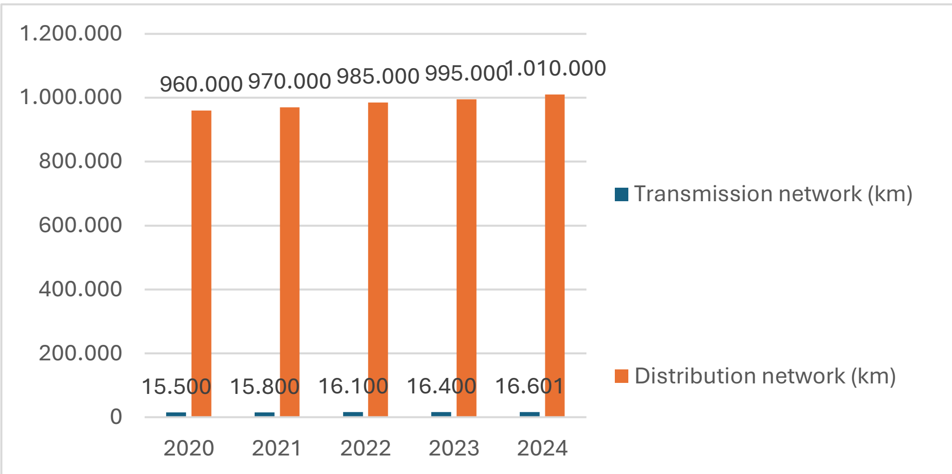
And climate policy, including the completion of the internal energy market, ensuring security of supply, particularly for gas and oil, reducing greenhouse gas emissions, increasing the share of energy from renewable sources in final energy consumption, and achieving energy efficiency gains. The regulations mentioned above introduce rules for implementing joint projects concerning trans-European networks that connect several countries. The rules for implementing projects included in the EU list of projects of common interest, which EU Member States are responsible for, and projects of mutual interest, which EU Member States and third countries may implement, have been defined.

The Commission prepares a list of these projects in accordance with the procedure outlined in the Regulation. The list includes many Polish projects, most of which have already been completed.

In practice, the inclusion of projects on the EU list accelerates their implementation through separate procedures and facilitates the acquisition of external financing, particularly in the form of EU funds. The inclusion of a project on the EU list has therefore enabled the implementation of key transmission investments, enabling the transmission of energy between Member States. The current European electricity and gas transmission systems, and in particular cross-border connections, are not sufficient to ensure the effective functioning of the internal energy market and to connect existing energy islands to the main gas and electricity networks.

Work on infrastructure projects has gained momentum in recent years, particularly in light of recent events on the eastern border of the European Union. In 2013, the European Union identified 248 energy infrastructure projects of common interest (PCI). This list will be reviewed and updated later this year and then every two years. In 2014, the European energy security strategy identified 33 infrastructure projects essential for improving the security of supply and enhancing the integration of energy markets (Energy Union Package). Figure 1 illustrates the length of electricity transmission and distribution networks in Poland from 2020 to 2024.

Figure 1. *Length of electricity transmission and distribution networks in Poland (2020–2024).*



Source: *Polish Power Grid (PSE), Information on the Power System as of 31 December 2024.*

The increase in the length of the network reflects investments in transmission infrastructure and medium-voltage cabling, which translates into improved reliability of energy supplies and enhanced energy security nationwide.

In addition to trans-European networks, national transmission networks play a crucial role in ensuring energy security. Their operation, in accordance with the provisions of the Energy Law (Act of 10 April 1997, Energy Law, Journal of Laws 2024, Article 9c), requires transmission system operators to be responsible for their operation – currently, Polskie Sieci Elektroenergetyczne S.A. for electricity and Gaz System S.A. for gas.

In addition to the ongoing operation and maintenance of the transmission network, operators are also responsible for its expansion and development. Network expansion is one of the significant costs of operating a transmission system. Regarding national security, the proper planning of network construction plays a crucial role in ensuring adequate protection. In this regard, operators develop long-term plans in the form of national development plans (Transmission System Development Plan until 2032) to meet current and future demand for gas fuels or electricity for a period of 10 years.

This plan is updated every 2 years. "Development plans are of fundamental importance for both energy companies and consumers, as they have a direct impact on determining the necessary revenues of network companies to cover their justified costs. Pursuant to Article 16(10) of the Energy Law, development plans should ensure the long-term maximisation of the efficiency of expenditures and expenses incurred by an energy company, so that spending and costs do not cause excessive increases in prices and rates for the supply of gas fuels or energy in individual years, while ensuring the continuity, reliability and quality of their supply (Zawiska, 2016, Article 16).

As part of their planning, operators are also required to draw up network development plans to meet future and the current demand for gas fuels or energy. Development plans are drawn up for a period of not less than three years and take into account local spatial development plans, the provisions of provincial spatial development plans, or, in the absence of such a plan, the provincial development strategy. They also take into account the state's energy policy and the ten-year EU-wide network development plan (Regulation (EU) 2019/943 of the European Parliament and of the Council).

The policy for the development of infrastructure and the market for alternative fuels in transport, the preventive action plan developed by the minister responsible for energy resources, and the national energy and climate plan.

The balanced development of the country depends on an efficient and effective transmission infrastructure, especially since eastern Poland has historically been poorer in terms of network development. Currently, some in the industry accuse operators of developing networks only in areas with large concentrations of businesses and population. However, it is essential to ensure network availability in all directions in the event of potential threats.

Next, it should be emphasised that development plans allow consumers and producers to obtain information about where connections are possible. However, full disclosure is not beneficial from a security perspective. This is because anyone can verify the route of every transmission network in the country.

In accordance with the provisions on crisis management (Act of 26 April 2007 on crisis management, Journal of Laws 2023.122), systems for the supply of energy, energy resources and fuels are part of critical infrastructure. This term refers to systems and their functionally related components, including buildings, equipment, installations, and services that are crucial for the security of the state and its citizens, as well as those that ensure the efficient functioning of public administration bodies, institutions, and businesses. In general terms, transmission networks therefore fall within the concept of critical infrastructure, a position adopted by part of the doctrine (Zakrzewska and Gil-Świderska, 2018, pp. 55-64).

Recognising transmission networks as critical infrastructure means that operators have an obligation to protect this infrastructure. However, despite the commitment to develop strategic documents, there are no real instruments in place to ensure the proper protection of transmission systems. In practice, the lack of regulations preventing, for example, the filming or photographing of key energy infrastructure is emphasised in this regard (Dziennik Gazeta Prawna).

Under the current legal framework, it is not possible to detain a suspect who is taking photographs or filming the network. Moreover, excessive transparency allows for the precise determination of the location of a given element within the installation. In this regard, it is necessary to take urgent legislative action to enable system operators to properly perform their duties and, above all, to ensure network security.

Infrastructure may be subject to various threats, including those from foreign countries. To counter the possibility of foreign countries influencing the energy network, in 2020, the US administration decided to seize Chinese transformers based on an executive order.

Subsequently, various countries raised concerns about communication systems, particularly those involving Huawei and 5 G, in the context of the possibility of controlling these systems. As part of the investment process, the threat may consist of irregularities related to the improper functioning of the installation. For this reason, as part of the investment, components should be supplied by experienced and reliable contractors.

In addition to the security of the energy infrastructure itself, it is also essential to consider that transmission networks provide a means of communication (https://e-elektryczna.pl/). Damage to the network may also result in damage to communication systems, significantly hampering the management of failures.

Operators also use IT systems. "OT systems responsible for monitoring and controlling technological processes, such as SCADA (Supervisory Control and Data Acquisition), DMS (Distribution Management System) and EMS (Energy Management System) in the case of energy, play a key role in entities in these sectors. Production facilities (e.g. power units in power plants or refinery installations) are controlled by DCS (Distributed Control System) solutions, which are comprehensive integrated systems responsible for maintaining and visualising industrial processes.

Sometimes, to increase the efficiency of the production process, APC (Advanced Process Control) solutions are used, in particular those related to reducing downtime, optimising the maintenance process of installations, and better adapting the volume and type of production to current macroeconomic needs (https://ik.org.pl/). IT systems are crucial to the operation of operators.

Cases of cyber attacks are now commonly observed. "Russian-backed cyber attacks on energy resources have been identified in several other Alliance member states, including Poland, Turkey, the United Kingdom and the United States. In some cases, these cyber campaigns were carried out in parallel with other hybrid threats targeting energy resources, such as attempts to exert hostile influence and cut off natural gas supplies.

In this context, the security of ICT networks and data processing is critical (Ciekanowski, 2013, pp. 182-185). In summary, it is clear that over the past decade, Russia has been increasingly vigorous in its pursuit of synchronised campaigns aimed at undermining the Alliance's energy security (https://www.nato.int). For example, in December 2015, Ukrainian energy companies were infected with malware called BlackEnergy. International services indicate that this virus may still be in use (https://www.cisa.gov).

Countering cyber attacks should involve purchasing from trusted and reliable suppliers. The competence of personnel operating ICT systems is also crucial in preventing harmful social engineering techniques that enable the penetration of ICT systems used by entities managing critical infrastructure; this applies, for example, to ATP attacks (Nowicka, 2023, p. 77).

In Poland, transmission system operators are state-owned companies and are therefore required to comply with public procurement regulations. In the energy sector, such contracts are referred to as sectoral contracts. Unlike other contracting authorities, pursuant to Article 393(1)(4) of the Public Procurement Law (Act of 11

September 2019, Public Procurement Law, Journal of Laws 2023. 1605), in a sectoral procurement procedure, an energy company may, in the case of a supply contract, reject a tender in which the share of products, including software used in telecommunications network equipment, originating in Member States of the European Union, countries with which the European Union has concluded agreements on equal treatment of entrepreneurs, or countries to which, by virtue of a Council decision, the provisions of Directive 2014/25/EU apply, does not exceed 50%.

This solution may be used if the contracting authority has specified it in the contract notice and, if the procedure is not initiated by means of a contract notice, in the contract specifications.

The principle in public procurement is free competition and equal opportunities for contractors. In the case of ordinary contracting authorities, if a given product meets the expectations of the contracting authority as described in the tender documentation, the contracting authority must select the most advantageous tender and enter into a contract with the relevant contractor. However, public procurement law allows energy companies to reject a contractor's bid if it is found that the software used in the device could be used against the contracting authority.

4. Distribution Networks

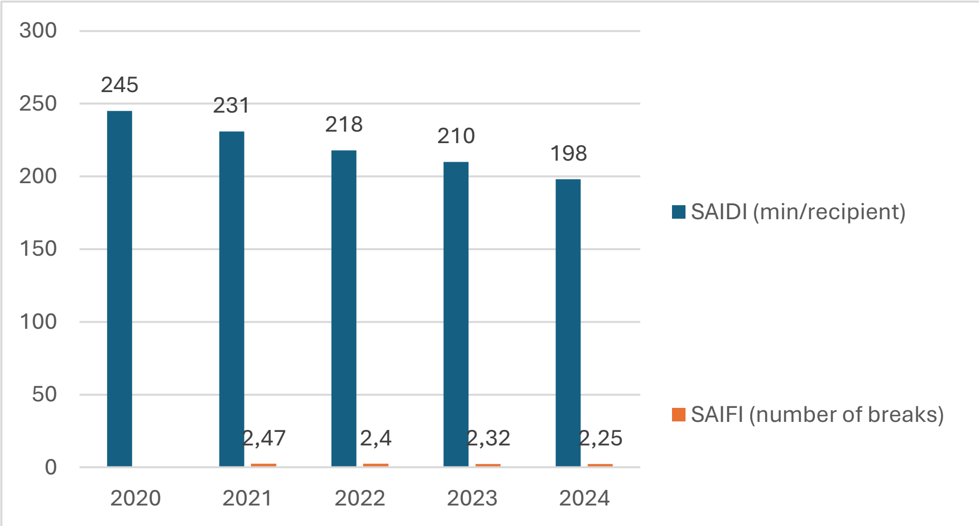
At the level closest to consumers, distribution networks play an essential role. Their quality determines the supply of energy that meets quality requirements. In this regard, however, the Supreme Audit Office (NIK) assessed the electricity distribution system quite negatively.

The information on the audit results, specifically the development of the electricity distribution network (https://www.nik.gov.pl), highlights several issues faced by distribution companies. The Chamber pointed out, first and foremost, that the network is outdated, unbundled and does not ensure the proper quality of the energy transmitted.

From the perspective of the national power system's functioning, one key measure of distribution network management effectiveness is the energy supply reliability indicators – SAIDI (System Average Interruption Duration Index) and SAIFI (System Average Interruption Frequency Index). They correspond to the average duration and number of power outages per customer, respectively.

A regular decline in these indicators indicates increasing network stability, more effective investment planning, and increased infrastructure resilience to technical failures and extreme events. Data published by the Energy Regulatory Office indicate that in recent years, there has been a marked improvement in the reliability of energy supply in Poland, confirming the effectiveness of the modernisation and cabling of distribution networks carried out by distribution system operators. Figure 2 displays the energy supply reliability indicators in Poland (SAIDI and SAIFI) for the period from 2020 to 2024.

Figure 2. *Energy supply reliability indicators in Poland (SAIDI and SAIFI) from 2020 to 2024.*



Source: *Energy Regulatory Office, National Report 2024 – Power Industry, Warsaw 2024.*

The data presented indicates a systematic decrease in both the average interruption duration (SAIDI) and frequency (SAIFI) between 2020 and 2024. This means that the measures taken by distribution system operators are bringing measurable results in terms of improving the quality and continuity of energy supply.

The reduction in the values of these indicators can be attributed primarily to increased investment in the modernisation and cabling of medium-voltage networks, as well as the development of telemetry and network automation tools. In the context of national energy security, this trend should be considered positive, as reducing power outages has a direct impact on the stability of the economy, public institutions and critical infrastructure.

Although energy companies declare in their plans and strategies that they will expand or modernise the network, in the Chamber's opinion, they have not achieved their objectives and plans. Moreover, they have not undertaken tasks that enable the development of the network towards producers and consumers. This further means that it is not possible to connect new entities.

A positive result of the audit is that the Ministry of Climate and Environment has taken steps to improve the situation, emphasising that "to achieve greater network reliability, it is advisable to cable the medium-voltage network gradually, and the

SAIDI and SAIFI indicators are strongly correlated with the cabling of the medium-voltage network (MV), ", as stated in Poland's Energy Policy until 2040. One of the priorities of the Minister of Climate and Environment is to strive to improve the quality of distribution services provided to customers, among other things, by enhancing the quality and reliability of electricity supply, improving customer service, and ensuring an optimal level of investment efficiency.

The gas distribution network faces similar problems. In this regard, in 2018, the Programme for Accelerating Investments in the Polish Gas Network was adopted to increase the number of municipalities with access to gas (Dziennik Gazeta Prawna), thereby facilitating the effective development of access to the gas network.

However, the lack of external financing may pose a challenge to the network's development. According to current EU regulations, support for gas infrastructure is only possible if it can be used for hydrogen, leads to an increase in the use of renewable sources, does not create a technological barrier, and contributes to the EU's climate objectives.

The lack of external financing may significantly slow down the development of the gas network. For this reason, it would be advisable to consider, on the one hand, creating a national source of financing for the network, but at the same time supporting or undertaking research and development activities to modernise the existing gas network towards the use of renewable sources.

5. Obligation to Plan the Security of Supply Risks

As mentioned in the introduction, gas issues are currently of particular interest to Poland, due to the need to become independent from Russian gas supplies as a result of the war. In April/May 2022 (https://www.gov.pl). Gazprom suspended gas supplies via the Yamal pipeline. Poland was therefore forced to obtain gas from Western sources. Currently, gas supplies are primarily in the form of liquefied natural gas, transported via the Świnoujście terminal, through a cross-border connection with Lithuania and Slovakia, and via the Baltic Pipe from Norway (https://www.orlen.pl).

The European Union is introducing regulations concerning actions to be taken in the event of a cut-off of one of the gas supply sources in Member States (Regulation (EU) 2017/1938 of the European Parliament and of the Council). By 1 September 2022, the European Network of Transmission System Operators for Gas (ENTSOG) was to conduct an EU-wide simulation of gas supply and infrastructure disruption scenarios.

This involved identifying and assessing emergency gas supply corridors and determining which Member States are capable of coping with the identified threat. The simulations are to be repeated every four years, or more frequently if necessary.

The first EU-wide simulation in 2017 concerned gas infrastructure in the operation of various gas corridors. In October 2020, a supplement to the simulation was prepared (https://www.entsog.eu). Currently, the simulation encompasses 20 scenarios for multiple types of gas supply disruptions, 19 of which are subject to practical verification (in one case, related to the eastern Mediterranean, the relevant infrastructure has not yet been constructed).

The simulation also included an assessment of Poland's infrastructure, including the LNG terminal in Świnoujście, the Poland-Slovakia interconnector, the Poland-Lithuania gas connection, and the Poland-Denmark connection, known as the Baltic Pipe, both onshore and offshore. Most scenarios predict no reduction in demand in the event of an unforeseen emergency. However, the report emphasises that demand for gas in Poland is increasing due to the decrease in coal sources. This circumstance should be taken into account in planning.

In accordance with European regulations, the competent authority of a given Member State – in Poland, this is the Minister responsible for energy resources – is required to conduct a national risk assessment of all significant risks affecting the security of gas and electricity supply.

EU regulations (Regulation of the European Parliament and of the Council (EU) 2017/1938) require each Member State to develop a preventive action plan, including the measures necessary to eliminate or mitigate the identified risks, relating to the effects of energy efficiency measures and demand-side measures in joint and national risk assessments. In addition, they shall develop a contingency plan that includes measures to be taken to remove or mitigate the effects of a gas supply disruption.

Joint contingency planning is crucial for ensuring the security of supply. Planned and implemented contingency scenarios will enable a rapid response in the event of an actual supply disruption, regardless of its cause. In this respect, the principle of solidarity mentioned above finds its practical and critical application.

6. Connection of New Units to the Network

As indicated above, the current state of power transmission systems makes it practically impossible to connect new energy producers to the power grid. Currently, no new units are being connected, and the operation of those already connected is subject to restrictions. The system is inefficient and unable to cope with current market challenges.

This poses a significant risk to the security of the electricity supply, leading to a situation where the transmission system operator (as per the Act of 10 April 1997, Energy Law, Journal of Laws 2024, Article 3(24)) must restrict energy generation.

The problem has been noted by the President of the Energy Regulatory Office (Information from the President of the Energy Regulatory Office No. 15/2024). In his opinion, one

One of the reasons for the lack of connection of new generation units, especially renewable energy sources, is financial issues.

Planned investments in the network are carried out by transmission and distribution system operators using funds from tariffs approved by the President of the Energy Regulatory Office, which aim to cover justified business costs (Act of 10 April 1997, Energy Law, Journal of Laws 2024, 266, Article 45). In addition to funds from tariffs, operators may utilise funds from external financing sources, such as subsidies, special-purpose funds, EU aid programs, or other funds, including connection fees pursuant to Article 7(9) of the Energy Law. However, these funds are not sufficient. The lack of investment in transmission networks means that the network is unable to transmit the energy generated by new entities. Therefore, the technical and economic capacity necessary for connection is lacki.

As a rule, connecting new entities is a public law obligation of transmission and distribution system operators, which means that these operators are obliged to connect new entities to the network at the expense of the company, and refusal to connect can only be based on technical or economic reasons. If the operator refuses to connect to the network, the applicant has the right to appeal to the President of the Energy Regulatory Office.

In the absence of suitable conditions for connection, a possible solution would be to enter into so-called commercial grid connection agreements, whereby the producers themselves would finance the construction of a specific section of the grid. This would expedite the implementation of the investment and ensure the security of supply from domestic sources. However, this solution is more feasible for larger entities with sufficient funds that can be allocated for network construction.

An alternative solution to network construction is so-called cable pooling, i.e. the possibility of connecting two or more renewable energy installations to the network at a single point, introduced by the amendment to the Energy Law of 1 October. 2023.

According to the current Energy Law, two or more renewable energy installations belonging to one or more entities may be connected to the power grid with a rated voltage higher than 1 kV at a single connection point. This solution enables the use of existing connection points, allowing more producers to access the grid. It is also possible to connect several different energy sources.

However, even if a renewable source is successfully connected, there is no guarantee of uninterrupted and unlimited operation given the current state of the grid. This is not only due to the specific nature of a given renewable source resulting from the lack of wind or sun, but also to considerations arising from the state of the grid.

According to the current Article 11d) of the Energy Law, in the event of a threat to the security of the electricity supply, the electricity transmission system operator may, in particular, issue instructions to the producer or owner of an electricity storage facility to start up, shut down, change the load or disconnect from the grid a generation unit or electricity storage facility connected to the transmission grid or a generation unit or electricity storage facility connected to a coordinated 110 kV grid.

To issue instructions to the relevant electricity distribution system operator to reduce the amount of electricity consumed by end users connected to the grid, or, after exhausting all possible measures to meet the electricity demand, issue orders to end users directly connected to the transmission network.

To reduce the amount of electricity consumed or to disconnect the equipment and installations belonging to those users from the network, in accordance with the restriction implementation plan.

During a period of threat to the security of the electricity supply, electricity system operators may introduce restrictions on the transmission or distribution of electricity to the extent necessary to remove that threat. Cases of restriction, known as redispatching, have been quite frequent recently (https://www.pse.pl), which is due to the quality of the network.

7. Conclusions

Transmission and distribution infrastructure is crucial for the security of supply. An efficient and effective network with uninterrupted communication capabilities and resilience to failures, as well as the ability to respond in the event of a failure, ensures uninterrupted energy supplies and thus enables the functioning of critical entities, such as healthcare units, military units, and businesses, thereby confirming the research hypothesis.

The principle of solidarity in its broadest sense requires EU Member States to cooperate in ensuring that energy supplies are available to all consumers. However, this does not mean that action should be limited to the EU level.

Planning and financing the construction and modernisation of infrastructure should become a priority for the state in the near future. In addition to investment measures, legislative measures must be taken to ensure the security of IT systems and the network itself. The openness of the network should encourage new entities to join, but the risk of deliberate damage to the network must also be considered. In this regard, solutions are needed that reconcile market needs with security issues.

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