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Managing organisational resilience in the onshore wind energy sector in Poland

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Introduction

Onshore wind energy is one of the key pillars of Poland's energy transition process today. In the light of the EU's climate and energy targets, such as reducing greenhouse gas emissions by 55% by 2030 ("Fit for 55" package) and increasing the share of renewable energy sources (RES) to at least 42.5% in the energy mix, Poland has committed to the dynamic development of the RES sector. According to the updated *Energy Policy of Poland until 2040* (Ministry of Climate and Environment, 2021), the installed capacity of onshore wind farms is expected to be approx. 14 GW by 2030 and reach up to 20 GW in 2040. This is a significant leap compared to the approximately 9.6 GW at the end of 2023, confirming that the development of this RES segment is among the fastest advancing. As of 2024, wind power was already the largest renewable energy source in the Polish electricity system, accounting for approximately 14.7% of total installed capacity (Ministry of Climate and Environment, 2021).

The increase in power also translates into an increasing share of electricity production from wind. In 2022, onshore wind farms produced almost 19 TWh of energy, accounting for 10.8% of national generation. In 2023, this figure rises to 22.12 TWh, or 14.6% of total production. Importantly, the combined share of wind and solar energy exceeded 20% of total national production for the first time, and the share of all renewable energy sources in the energy mix reached 27%. These figures indicate that Poland is getting closer to meeting the EU's climate targets and, according to the *National Energy and Climate Plan* (Ministry of Climate and Environment, 2025), the share of RES could reach up to 50% by 2030. However, such growth requires not only investment in new sources but also ensuring their stable functioning.

Despite the dynamic growth of the sector, wind farm operations are exposed to numerous risks that can disrupt their operational continuity. Although wind turbines are high-tech installations, they are prone to failure – including damage to gearboxes, rotor blades or control systems. The operation of wind farms is also affected by weather conditions: icing of the blades leads to downtime and loss of production, and lightning and fires can cause serious damage to the infrastructure. Grid constraints are also becoming an increasingly serious problem – the transmission and distribution infrastructure, which is not adapted to the scale of RES development, forces temporary restrictions on wind farm generation, especially during peak production periods. Transmission system operators are increasingly forced to issue orders to reduce turbine operation to avoid overloading the grid, resulting in operational losses and a lack of utilisation of available generation potential.

In the onshore wind sector, this relationship emerges particularly clearly in situations of grid constraints. Even high technical resistance of turbines does not eliminate operational losses if the farm operator's organisation does not have procedures for quick response to generation reduction commands, communication mechanisms with the system operator and flexible production management models. In such cases, it is not a technical failure but rather insufficient organisational resilience that determines the scale of the disruption.

All these factors show that the further development of wind energy cannot be based solely on the expansion of generation capacity. It is essential to strengthen simultaneously the functional resilience of wind farms, i.e. their ability to respond to unforeseen situations and maintain operational stability. The traditional approach has mainly focused on technical aspects – improving turbine design, developing condition monitoring systems or improving network balancing methods. Meanwhile, today's approach to operational security requires a much broader perspective – encompassing not only technology, but also how organisations manage disruption and adapt to changing conditions.

In this context, there is more and more talk about the need to implement the concept of organisational resilience, understood as the ability of an organisation to

prepare for disruptions, respond effectively to crisis situations and quickly regain operational capacity after their occurrence. A resilient organisation is not only one that has reliable technologies, but also one that can anticipate risks, learn from mistakes and adapt structures and procedures in a flexible way.

For the onshore wind sector, this means the need to seek out and implement organisational solutions that support business continuity – such as risk management systems, Business Continuity Planning, rapid response structures or an organisational culture that promotes learning and resilience. Managing organisational resilience thus becomes a key element in ensuring not only operational security, but also the long-term sustainability of the sector.

This article undertakes an analysis of this very issue – asking how organisations operating in the Polish onshore wind energy sector manage organisational resilience in the face of increasing technical, environmental and systemic challenges. The article proposes a look beyond technical snapshots, focusing on the managerial and organisational mechanisms that can underpin the building of operational resilience of wind farms. The aim is to identify practices that enable you not only to survive disruptive incidents, but also to recover quickly to full capacity and to learn in order to reduce the impact of similar incidents in the future. This approach puts forward a hypothesis that resilience management is not an addition to the functioning of the organisation, but one of the conditions for its durability and responsibility towards the power system and society.

It should be noted that the conducted analysis has certain limitations. The study does not include empirical research, and the conclusions are based on the desk research method, involving a systematic review of the literature and the analysis of secondary data. The literature review covered scientific publications (articles and monographs) indexed in selected academic databases, as well as reports from public institutions and industry organisations. The analysis of national conditions was carried out on the basis of strategic documents, legal acts, and statistical reports concerning the analyzed area in Poland. The selection of materials was purposeful and aimed at identifying key institutional, legal, and socio-economic factors influencing the phenomenon under study.

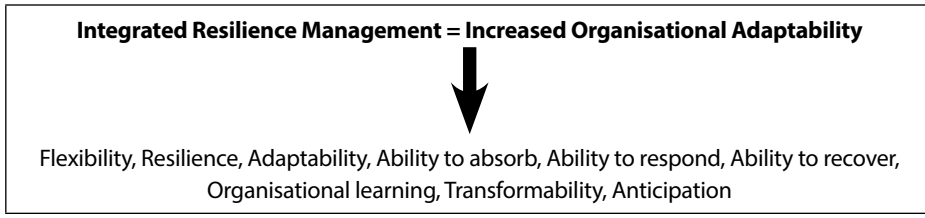
Organisational resilience as management category

The concept and evolution of the organisational resilience

Organisational resilience is understood as the ability of an organisation to absorb disruptions, adapt to changing conditions, and maintain or quickly recover key operational functions in the face of crises (Davidson, 2025). International standards emphasise that it is the ability of an organisation to withstand disruptions and

continuously achieve its goals and even grow despite adversity. For example, the ISO 22316 standard defines organisational resilience as the ability to "absorb" the impact of change and adapt to it, so that the organisation can continue to achieve its goals, survive disruption and evolve. Resilience is therefore treated as a strategic competence of the organisation – not a static state, but a continuous result of good management and adaptability (DesJardine et al., 2019). Unlike traditional risk management (focused mainly on avoiding threats), the concept of resilience emphasizes active learning from difficult experiences and the use of crises as development opportunities (Davidson, 2025). In other words, a resilient organisation not only protects itself from threats, but is able to emerge from them strengthened, building competitive advantages thanks to the experience gained (Figure 1).

Figure 1. Resilience definition approach



Source: authors' own elaboration.

The concept of resilience originated in the natural sciences and psychology but was adapted in management science in the early 21st century in response to the need to better understand why some organisations handle crises more effectively than others. The literature indicates that organisational resilience manifests two complementary behavioural dimensions: stability (the ability to maintain continuity of core functions despite shocks) and flexibility (the ability to adapt and change in response to disruption) (Chodyński, 2025). Stability involves the preservation of an organisation's key features and identity even during extreme turbulence in the environment (e.g. wars, disasters, terrorist attacks), which is particularly important for entities providing uninterrupted services such as critical infrastructure (Chodyński, 2021).

Flexibility, on the other hand, manifests itself in adapting the organisation to new conditions – enhancing its ability to adapt and innovate in response to change. As part of the concept of resilience, both these perspectives complement each other: the organisation must be resilient to shocks to some extent, but at the same time malleable and capable of transformation to meet unpredictable challenges (Chodyński, 2025).

The development of the concept of organisational resilience has been fostered by numerous empirical studies conducted in the aftermath of disasters and economic

crises. For example, the experience after the devastating tornado in New Zealand in 2005 initiated pioneering work on business resilience models (Chodyński, 2021).

In her doctoral dissertation, Amy Stephenson (2010) proposed a model for benchmarking organisational resilience, identifying two pillars: (1) strategic and operational planning (including strategy planning, contingency plans and exercises, proactive attitudes, partnerships with stakeholders, and clarity of objectives) and (2) adaptive capacity (including avoiding "tunnel vision," effective use of internal resources, employee engagement, a learning culture, flexible leadership, innovation, and efficient decision-making). Similar resilience models emphasized that organisations capable of surviving and developing despite shocks are characterised by both solid plans and resources for the crisis and a culture conducive to continuous adaptation and improvement (Stephenson, 2010).

In the following years, organisational resilience gained in importance as an element of management standards. The British standard BS 65000 (2014) and the international standard ISO 22316 (2017) systematised the approach to resilience by presenting sets of principles and attributes of resilient organisations. Resilience has come to be seen as an umbrella strategic concept that integrates different areas of risk management, business continuity, security and innovation. This means that instead of treating resilience as a single programme (e.g. business continuity planning only), organisations are learning to shape it holistically – through leadership, organisational culture, process improvement and the ability to learn from mistakes. This trend particularly intensified during and after the COVID-19 pandemic, when many businesses were painfully affected by the disruption and began to look for ways to increase their resilience to future crises (Skrzypek, Skrzypek, 2023).

Despite the growing popularity of the concept of organisational resilience, there is still no single consistent definition in the literature that is universally accepted as superior. Different authors emphasise different aspects – from approaches focusing on "rebounding" after a crisis, to perspectives on dynamic adaptability, to treating resilience as a result of the organisation's various competences. Research efforts are underway to develop a well-established theory of organisational resilience with high application values. Numerous case studies in recent years (e.g. during pandemics) have provided data on the drivers of corporate resilience and the tools for building it in practice. However, there are still noticeable research gaps that need to be deepened, for example in the links between the level of resilience and long-term organisational effectiveness and maturity. There is a lack of comprehensive research showing how resilience translates into business results, innovation or sustainable development of the organisation. This points to the need for further, systematic research into measuring organisational resilience and the integration of this concept with other areas of management (e.g. business continuity, process improvement) (Skrzypek & Skrzypek, 2023).

In summary, organisational resilience is still an evolving management category – it already has a well-established theoretical basis and examples of application but needs further conceptualisation and a standardised approach to realise its full practical potential.

It is worth noting that although the concept of organisational resilience has mainly developed in the context of industrial companies, the financial sector and classic critical infrastructure, its application in the onshore wind sector faces specific considerations Indeed, wind farms operate under conditions of high environmental variability, dependence on weather factors and strong integration with the electricity system, which makes the adaptability of the operator's organisation particularly important (Table 1).

Table 1. Resilience as an integrated management component

Area	Traditional approach	Resilience-based approach
Role	Management as an additional component of the management process	Integrated management as a core component of the management process
Nature of activities	After the event – reactive	Proactive and adaptive
Capacity of the organisation	Procedures	Flexible response to changes
Response to disturbances	Post-event recovery	Acquisition of adaptability
Supply Chain	Sensitive to changes	Resistant to disturbances

Source: authors' own elaboration.

Resilience versus technical resilience: A comparative approach

When analysing organisational resilience, it is useful to distinguish between its "soft" (human, organisational) and "hard" (technical) aspects. The literature highlights that the terms organisational resilience and organisational resilience are sometimes used interchangeably, although they do not always mean exactly the same thing (Pytel, 2025). Resilience accentuates an organisation's dynamic ability to recover, learn and adapt in a changing environment. Organisational resistance, on the other hand, is sometimes interpreted more broadly – as the overall ability to survive and maintain business continuity despite disruption. Resilience can thus be said to be a specific dimension of resilience: it is an adaptive and process-oriented component, whereas resilience (in technical or structural terms) is more often associated with the resilience and stability of a system (Pytel, 2025). In practice, effective crisis management requires both – both robust technical safeguards and organisational flexibility.

Technical resilience refers to the longevity and ability to quickly restore the performance of physical systems and infrastructure after a disruption. This includes the resilience of the infrastructure and the ability of engineered systems to operate

under fault conditions or to recover efficiently. For example, in the context of infrastructure networks, technical resilience can be measured by the number of critical components that have failed following an incident (e.g. the number of transformer substations shut down or percentage of pipelines damaged) and the time taken to repair them (Zhao et al., 2015).

Organisational resilience, on the other hand, is concerned with the human and process dimensions of system functioning – that is, the ability of an organisation's management structure to respond effectively to crisis situations, maintain continuity of key services and adapt in the face of new circumstances (Moteff et al., 2003). In practice, a measure of organisational resilience could be, for example, the percentage of users or areas that lost access to a service due to a failure: the smaller the scale of the service disruption (thanks to the organisation's efficient response), the higher the assessment of the organisational resilience of that structure (Zhao et al., 2015). In other words, technical resilience answers the question of how well equipment and systems can withstand an impact (e.g. a natural disaster) and how quickly it can be repaired, while organisational resilience answers the question of how well people and procedures can respond to minimise the effects of a disruption on the continued operation of the overall system.

A comparison between organisational resilience and technical resilience reveals both their distinct and complementary nature. Technical resilience tends to be more tangible and quantifiable – it depends on factors such as hardware redundancy, quality of materials, system architecture, planning for spare capacity, etc. It focuses on the prevention of physical failures and the rapid repair of damage. Organisational resilience, on the other hand, is based on soft factors: an organisational culture that promotes readiness for change, employee competencies (e.g. the ability to improvise, cooperate under pressure), an efficient crisis communication system, flexible procedures and leadership able to make decisions under conditions of uncertainty (Davidson, 2025). Technical resilience can ensure that the 'hard' infrastructure survives a hit (e.g. thanks to spare servers, the IT system will not go down with a single failure), but without resilient organisation, even the best infrastructure can be misused – for example, if action plans are missing or staff cannot respond to an alarm, the impact of a failure will still be severe. Conversely, a well-trained crisis team will do little if key equipment has no safeguards and is completely destroyed.

The risk management literature emphasises that the two dimensions – technical and organisational – must go hand in hand to achieve a truly high level of resilience (Rehak, 2020). Critical infrastructure research has even shown that resilience needs to be considered in a multidimensional perspective. For example, Bruneau et al. (2003) and Chang and Shinozuka (2004) proposed four interrelated dimensions for assessing the resilience of infrastructure systems: technical, organisational, social and economic. Importantly, they found that the technical and organisational

dimensions are key to maintaining the functionality of the infrastructure itself, while the social and economic aspects reveal themselves more at the level of the resilience of the whole community or market environment. It is clear from this that omitting any of these key dimensions (technical or organisational) impoverishes the picture of resilience. Indeed, previous studies have often focused solely on technical indicators (e.g. equipment reliability) or only on organisational aspects, leading to incomplete and sometimes contradictory conclusions on the actual level of system resilience. Zhao et al. (2015) note that it is difficult to fully assess resilience by analysing only one dimension – therefore, it is necessary to develop integrated metrics that take into account both technical and organisational perspectives to get a holistic view and avoid erroneous conclusions. In other words, future research work should focus on the links between technical resilience and organisational resilience – how one affects the other – and the creation of tools to diagnose and improve resilience in a comprehensive manner. This integration of approaches will allow organisations to develop a balance between investing in infrastructure reliability and developing an organisational culture of resilience, maximising the overall ability to survive and thrive under uncertainty.

Organisational resilience in the context of critical infrastructure

The concept of organisational resilience takes on particular relevance in relation to critical infrastructure – that is, systems and facilities whose disruption could threaten the security of the state, the lives of citizens or seriously disrupt essential services (such as energy supply, water supply, communications, transport or healthcare). Critical infrastructure forms the lifeblood of modern society, hence its ability to withstand a variety of threats is crucial. Traditionally, there has been a strong emphasis on the technical security of such systems – i.e. physical security, equipment redundancy, contingency planning, etc. However, the current state-of-the-art approach also takes into account the organisational resilience of critical infrastructure managers. Operators and owners of critical infrastructures are required to maintain not only a high level of technical reliability of their systems, but also a high level of organisational resilience of their companies (Rehak, 2020). Only then will continuity of operation of these systems be ensured even in the face of major disruption.

Although onshore wind farms are not always formally classified as critical infrastructure in the legal sense, from a functional perspective – their increasing share of the power balance and their importance for energy security – they are increasingly acting as de facto critical infrastructure, which justifies the application of advanced organisational resilience management concepts to them.

Organisational resilience in the critical infrastructure sector manifests itself on many levels. Firstly, operational and emergency preparedness is key – organisations

responsible for infrastructure must constantly monitor risk factors, train staff in emergency procedures and update business continuity plans. Research indicates that organisational resilience is an important determinant of the ability of critical infrastructure elements to adapt in the face of disruption (Rehak, 2020). In other words, even the most technically advanced system may not be very resilient if the organisation managing it cannot make accurate decisions quickly in a crisis situation or lacks coordination and situational awareness. Critical infrastructure management therefore emphasises the development of characteristics such as situational awareness of management and staff, a culture of safety and continuous learning, effective internal and external communication during emergency events, and the ability to cooperate with other actors (e.g. emergency services, suppliers, public administration) under time pressure. All these elements make up the organisational resilience of the infrastructure operator.

In the context of critical infrastructure, it has proved very useful to frame resilience through these four dimensions: technical, organisational, social and economic (Zhao et al., 2015). This approach means that when assessing the resilience of, for example, an electricity system, one should consider not only the efficiency of the equipment (technical dimension), but also the preparedness of the managing organisation (organisational dimension), the impact of a potential failure on society (social dimension, e.g., the consequences of power outages for the population), and the ability to minimise financial losses and achieve a rapid economic recovery (economic dimension). Chang and Shinozuka's (2004) research on lifeline networks (water, power) showed that the first two dimensions, technical and organisational, are key to keeping the critical infrastructure itself functioning. This means that the organisation operating the infrastructure is integral to its resilience – it cannot be assumed that a strong equipment design alone will suffice if the human and organisational factor is neglected (Zhao et al., 2015).

Examples from recent years have vividly demonstrated the importance of organisational resilience for critical infrastructure. The 2021 Texas energy crisis (caused by extreme cold weather) revealed that some energy companies were only focused on surviving without power, while others were able to use the crisis as an impetus for growth – winning new customers and investing in strengthening their systems (Davidson, 2025). This difference was largely due to different organisational attitudes: the more resilient companies had a culture of responding proactively to disruption, so that at the moment of trial they were able not only to secure basic operations but even to improve their position in the market (Davidson, 2025). This case showed that managing critical infrastructure requires thinking beyond simply restoring the status quo after a disaster – it is necessary to learn from crises and make changes that will increase resilience for the future (e.g. diversifying supplies, modernising procedures, investing in intelligent control systems).

In response to such challenges, organisations in critical infrastructure sectors are increasingly implementing comprehensive resilience strengthening programmes. These include, inter alia, regular assessments of organisational resilience-identifying weaknesses in the management structure, safety culture, supply chain, etc. – so that corrective action can be taken in advance (Rehak, 2020). An example is the ASOR (Assessing and Strengthening Organisational Resilience) method developed for the infrastructure sector to systematically assess the determinants of organisational resilience and identify areas for improvement. In addition, governance standards recommend that resilience issues should be integrated into existing business continuity, risk and security management systems. A holistic approach is recommended, in which emergency planning, risk management, infrastructure maintenance and organisational improvement are coordinated within an overarching resilience strategy. Such an integrated system avoids a siloed approach to security issues – every relevant business process is also assessed for its impact on resilience, and strategic decisions take into account the risks and opportunities associated with potential disruptions.

In summary, in the context of critical infrastructure, organisational resilience is an integral component of system security. It is the people, decision-making structures and organisational culture that determine whether even a perfectly designed infrastructure survives a crisis without a breakdown in function. Current challenges (e.g. climate change generating extreme weather events, cyber threats, global pandemics) confirm that investing in hard defences alone is not enough – it is also necessary to develop resilience on a "soft" level. The literature points to the need to further systematise knowledge on best practices for building organisational resilience in critical infrastructure and measuring its effects. An open research question remains, for example, the quantification of the impact of high organisational resilience on the reduction of the consequences of failure (in socio-economic terms) or on the speed of recovery of full system functionality. There are also gaps in understanding the long-term economic benefits of investing in organisational resilience – do more resilient organisations achieve better financial performance and innovation over stable periods due to their adaptability? These questions point to directions for further research. However, it is already clear that organisational resilience is a critical success factor in critical infrastructure management and should be treated on a par with technical resilience in strategies to ensure security and business continuity of essential public services.

Table 2. Technical and organisational resistance and the impact of resilience on critical infrastructure

Area	Technical resistance	Organisational resistance	Resilience	Impact of resilience on the management of critical infrastructure
Elements	Technology	Structures, procedures, competences	A systemic approach, taking into account the period before and after the event	Cooperation in technology, organisational resilience and systems approach
Purpose	Resistance to technical incidents	Resilience to organisational events	System restoration after an event	Ensuring continuity of management
Response to disturbances	Yes	Yes	Yes – adaptation, learning	The ability of critical infrastructure elements to adapt in the face of disruption
Recovery	Yes	Yes	The ability of the organisation's management structure to respond effectively to crisis situations, maintain continuity of key services and adapt	Speed of recovery of full system functionality
Risk management approach	Process-oriented approach	Organisational and process-oriented approach	A systemic approach	Management consistency; learning from crises and implementing changes that increase future resilience

Source: authors' own elaboration.

The failure of wind turbines results from various technical and environmental factors. In Poland, there have been cases of mechanical damage, such as turbines collapsing under strong winds, like in Korzkwy, or fires in the nacelles. Abroad, lightning often damages the blades, as seen at Vineyard Wind in the USA or Lal Lal Wind Farm in Australia. Mechanical problems, such as gearbox or brake failures, have caused partial collapses of turbines in Denmark and the USA. Extreme weather conditions, including hurricane-force winds, also pose a threat to the structures, as shown in Germany. All these events highlight the importance of monitoring, predictive maintenance, and designing resilient wind energy systems.

Summary

The analysis carried out allows us to conclude that under conditions of the increasing share of onshore wind power in the national power balance and the increasing integration of these sources into the transmission and distribution grid, organisational

resilience is becoming a management category of comparable importance to the technical reliability of the installation. Wind farms operate in an environment characterised by high variability of operating conditions and interdependence with the electricity system, which means that the scale and persistence of operational disturbances depends not only on the technical parameters of the equipment, but also on the maturity of decision-making structures, coordination capabilities, the quality of crisis communication and the adaptive skills of the operator's organisation. Consequently, the management of organisational resilience should be considered as a strategic element, determining the sector's ability to maintain business continuity and reduce vulnerability to systemic disruptions.

The article demonstrates that resilience in the onshore wind sector is hybrid: it results from the integration of "hard" (technical) solutions with "soft" (organisational) mechanisms, including risk management, business continuity planning, competence development and the development of a safety and learning culture. Of particular importance here is the organisation's ability to rapidly transition from routine to disruptive operations mode and then to effectively rebuild operational capability, while minimising the impact on system stakeholders – including network operators, customers and the regulatory environment. This means that the organisational resilience of wind farm operators should be developed in a systemic rather than incidental way as a permanent element of corporate governance.

At the same time, the results of the analysis point to the need for further standardisation of approaches and tools to diagnose and improve organisational resilience in the RES sector. This concerns, in particular: (1) the development of sectoral organisational resilience metrics to benchmark organisational maturity and monitor the effects of improvement actions; (2) the integration of resilience management processes with compliance, cyber security and energy market participant requirements; (3) the development of models of cooperation between wind farm operators and electricity system operators that would limit the effects of grid disruptions and foster the coordination of actions in emergency situations. The empirical verification of the relationship between the level of organisational resilience and the reduction of operational losses and the ability to recover quickly from technical and system disruptions remains a particularly important research direction (Table 3).

Table 3. Technical and organisational resilience in the onshore wind sector

Technical resilience	Organisational resilience
reliability and durability of wind turbines	risk management and business continuity planning
technical monitoring and diagnostic systems (e.g., turbine condition monitoring)	procedures for responding to failures and emergency situations
redundancy of key components and control systems	competencies and training of technical personnel

Technical resilience	Organisational resilience
infrastructure resilience to weather conditions and extreme weather events	cooperation with grid operators and regulatory institutions
protection systems and automatic turbine shutdown mechanisms	safety and quality management systems
regular maintenance and servicing of technical infrastructure	organisational flexibility and the ability to adapt to regulatory and market changes
digital systems for wind farm operation management (SCADA)	supply chain management for spare parts and maintenance services
cybersecurity of control and communication systems	communication and coordination between wind farm operators, service teams, and power system operators

Source: authors' own elaboration.

In summary, effective management of organisational resilience in the onshore wind energy sector should be considered as one of the key conditions for the stable functioning of this RES segment and the strengthening of energy security in Poland. Resilience should not be seen as an "add-on" to infrastructure operation, but as an integrated management component that – through the development of an organisation's adaptive capacity – makes it possible to reduce the effects of disruptions, improve supply reliability and increase the resilience of the electricity system in the reality of the ongoing energy transition. The conclusions obtained confirm the hypothesis formulated at the outset. The article is introductory and provides a starting point for further in-depth research into the issue under consideration.

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Managing organisational resilience in the onshore wind energy sector in Poland

Abstract

The dynamic development of onshore wind energy in Poland increases its importance for the national electricity system and creates new challenges related to technical failures, system disruptions and continuity of energy supply. The article analyses organisational resilience management mechanisms in the Polish onshore wind sector, understood as practices, procedures and competences supporting business continuity, disruption

mitigation and rapid recovery. The analysis, based on literature and national conditions, highlights the managerial dimension of resilience, including decision-making structures, risk management, business continuity planning and cooperation with power system operators. The findings indicate that effective resilience management can reduce wind farm vulnerability to disruptions and requires integrating technical solutions with mature organisational mechanisms and a safety culture. The article also identifies areas for further standardisation and research.

Keywords: organisational resilience management, wind energy, energy security, business continuity, critical infrastructure

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Conflict of Interest
Both authors declare no conflict of interest.