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# Climate risk as a key risk for the energy sector

## Ryzyko klimatyczne jako kluczowy rodzaj ryzyka w sektorze energetycznym

**Abstract:** The ongoing energy transition is irreversibly changing the nature and functioning of the energy sector and emerging new types of risks, with climate risk standing out in particular, being a result of the EU's energy and climate policy as well as global trends related to sustainable development. The materialisation of climate risk gives rise to a number of mutually interpenetrating new types of risk, among which financial, regulatory and social risks can be distinguished. Climate risk also manifests itself in the performance of the EU ETS CO<sub>2</sub> emissions trading scheme, as well as in weather risks. The purpose of this paper is to define accurately the types of risk affecting the activities of energy entities and to indicate the impact of climate risk on them. The methods used in this research are literature review and data analysis. Climate risk is therefore an accelerator of new risks in the electric power sector and should thus be duly taken into account and mitigated, as ignoring it can have serious consequences. Hence, climate risk management is becoming one of the key elements of risk management across the energy sector. Decisions made by energy companies in line with the sustainable development paradigm will catalyse their growth and allow them to increase their value.

**Keywords:** climate risk, sustainability, financial risk, climate action, energy sector

**Streszczenie:** Tocząca się transformacja energetyczna nieodwracalnie zmienia charakter i funkcjonowanie sektora energetycznego oraz powoduje powstawanie nowych rodzajów ryzyka, wśród których na szczególną uwagę zasługuje ryzyko klimatyczne, będące wynikiem polityki energetyczno-klimatycznej UE oraz światowych trendów związanych ze zrównoważonym rozwojem. Materializacja ryzyka klimatycznego

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powoduje powstanie szeregu wzajemnie przenikających się nowych rodzajów ryzyka, wśród których można wyróżnić ryzyko finansowe, regulacyjne i społeczne. Ryzyko klimatyczne przejawia się również w działaniu systemu handlu emisjami CO<sub>2</sub> EU ETS, jak również w ryzyku pogodowym. Celem niniejszej publikacji jest dokładne zdefiniowanie rodzajów ryzyka wpływających na działalność podmiotów energetycznych oraz udokumentowanie szczególnej istotności ryzyka klimatycznego. Metodologia prac naukowych obejmowała przegląd literatury i analizę danych. Ryzyko klimatyczne jest akceleratorem nowych zagrożeń w sektorze elektroenergetycznym, dlatego powinno być należycie uwzględniane przez podmioty energetyczne i mitygowane, gdyż jego ignorowanie może mieć poważne konsekwencje. Tym samym zarządzanie ryzykiem klimatycznym staje się jednym z kluczowych elementów zarządzania ryzykiem w całym sektorze energetycznym. Decyzje podejmowane przez firmy energetyczne, zgodnie z paradygmatem zrównoważonego rozwoju, będą katalizowały ich rozwój i pozwolą na zwiększenie ich wartości.

**Słowa kluczowe:** ryzyko klimatyczne, zrównoważony rozwój, ryzyko finansowe, klimat, energetyka

**JEL:** Q40, Q54, G32, O13

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Electricity and heat generation as well as energy security are key roles played by the energy sector in the economy. The energy sector is currently undergoing a major transformation, which materializes a new set of risks. The energy transition, triggered by climate change mitigation, the fight against greenhouse gas and particulate emissions, as well as current trends in global markets, means that energy companies are facing a number of technical, economic, legal and social challenges. Transformations taking place in the energy market and trends towards wider implementation of low- and zero-emission energy sources influence the situation of energy companies, making the environment in which they currently operate completely different than it was 10–20 years ago. Care for the environment is also manifested in the emergence of new instruments aimed at accelerating the pace of decarbonisation of economies – an example is the creation of a market for CO<sub>2</sub> emission allowances. This makes it necessary to change the current development strategies of energy companies, especially those based on fossil fuels. The result are new types of risks, as well as an increasingly clear blending of climate and financial aspects. As a result of all the processes taking place in the energy market, energy companies are faced with the need to adapt to the new market environment, which entails a number of risks.

Climate risk is one of the new risks that is materialising in a particular way in industry [Kouloukoui et al., 2019]. The energy sector, involving the generation, transmission and distribution of electricity, is particularly exposed to climate risk. In the following,

the energy sector will be further defined as the electricity sector, limited to the generation, transmission and distribution of electricity. The challenges of the energy transition and the ongoing decarbonisation of the energy sector have a clear impact on the functioning of the entire sector [Papadis, Tsatsaronis, 2020, p. 2]. The energy transition is also a shift towards sustainable energy system, which is related to the paradigm of sustainable development. Sustainability is not only in the energy sector but also in the economy as a whole is based on three pillars: social, ecological and economic [Papadis, Tsatsaronis, 2020, p. 8]. These three pillars demonstrate the interweaving of social, ecological and economic aspects.

Climate risk is a key challenge for the energy sector [Kouloukoui et al., 2019, pp. 1–2]. The current situation of the energy-geopolitical crisis in Europe, together with the ongoing energy transition, means that the energy industry must pay special attention to mitigating climate risks in its operations and adapting its business strategies to changing market conditions. The energy-geopolitical crisis has highlighted the complex nature of risk in the energy sector. In addition to risk and uncertainty, there is also a combination of these phenomena – a clearest example is the situation created by the war in the Ukraine. Functioning in a highly volatile market reality, turbulent economic environment and high inflation requires a high degree of adaptability from business entities to the current market and geopolitical situation.

This paper focuses on the types of risks affecting the activities of energy companies and indicates the importance of climate risk in the energy sector. Energy companies' approach to climate risk is a key area of their operations and business strategy. In addition, there is an observed link between risk and financial performance and company value [Jonek-Kowalska, 2019, p. 414], which means that the issue of climate risk in the energy sector should be taken seriously. The subject matter of this publication fits into the current and important discussion on the implementation of sustainable development in the energy sector and its consequences in the form of risk. The article also fills an existing research gap in relation to the definition of climate risk in the energy sector and its characteristics, focusing particularly on the emergence of new risks resulting from the materialisation of climate risk. There is a lack of publications in the literature dealing holistically with the impact of climate risk on the energy sector, and this article therefore contributes to filling this gap.

The purpose of this paper is to define accurately the types of risk affecting the activities of energy entities and to indicate the impact of climate risk on them. The intention of the article is to fill the existing research gap in the literature as indicated above. The originality of the research lies in the identification the process that climate risk is affecting in the emerge the new types of risks. Climate risk is a broad concept, thus it is responsible for many types of risk which is presented in this paper. Climate risk is inherently linked to the materialisation of a number of new risks. Author's intention

is to indicated a set of risks which are related to climate risk. Particularly important are correlation between climate risk and finance risk, which is depicted in the paper. The aim is to theoretically define climate risk in the energy sector and present their affection on energy entities' business activity. The topic of this article is vital in current market situation, therefore it intends to be a useful source of knowledge for assume the climate risk influence on energy sector.

The paper is divided into five paragraphs. Literature review present the current state of scientific debate about climate-related risk in the energy sector. Further chapter focuses on the issue of climate risk in energy sector – defines it and characterises its influence on energy entities. Conclusions contains the key findings from the research, particularly related to the importance of climate risk and its influence on energy sector.

## Literature review

In the literature, there is a research gap related to the characteristics of the risks faced by energy entities today. There are publications addressing the issue of investment risk in the energy sector [Michalak, 2014], regulatory risk for energy companies [Leisen, Steffen, Weber, 2019], evaluation aspects of the implementation of ERM (Enterprise Risk Management) systems in energy companies [Jonek-Kowalska, 2019] or publications related to the issue of weather risk in the energy sector [Blachowski, 2011], [Iwaszczuk, Łamasz, 2014; Wiczorek-Kosmala, 2020].

Interesting research was presented in the paper Kouloukoui et al. [Kouloukoui et al., 2019] related to corporate climate risk management for world's largest emitters. Authors pointed out the importance of mitigation climate risk, particularly in the industry characterized by high volume of CO<sub>2</sub> emissions. Among other conclusions, there is unfortunately a smaller concern of world's biggest polluters on climate. Additionally, this research focused on a variety of industries, not only on energy sector. Thus, could be treated as an baseline for further research.

Other publication [Kolk, Levy, Pinkse, 2008] stressed out that climate risk must not be ignored by energy companies and dependence on coal could pose a real impact on markets and costs what was highlighted in this publication.

Seltzer et al. [Seltzer, Starks, Zhu, 2021] presented the correlation between company's environmental profile and credit rating. Authors depicted that companies with a high level of CO<sub>2</sub> emissions or high carbon emission intensity have lower credit rating in compare to environment-friendly entities. Additionally, entities which are highly emitting CO<sub>2</sub> are exposed to a risk which is priced in capital market and is reflected in share prices.

There are also a plenty of publications which depicts the issue of energy transition and decarbonization as a challenge for energy sector and energy entities [Papadis, Tsatsaronis, 2020; Timilsina, Shah, 2020; Morawiecka, 2015]. Some of them are focused on the financial aspects of sustainable development implementation in energy sector [Ryszawska, 2016]. These publications conclude that the energy transition represents a major challenge for the entire energy sector and economy at the level of energy security, economics, environment and society. They also identify new sources of financing these investments, which are derived from the concept of sustainable finance system. However, they do not sufficiently address the issue of climate risk.

Climate change has been recognized as a crucial risk for financial system [Battiston et al., 2021, p. 1], thus climate finance and climate risk are key areas of interest not only for academics but also (even particularly) for energy industry, financial corporations and governments. Ignoring climate risk can pose a serious threat to energy entities and they should implement a proactive attitude and take measures to mitigate it [Kouloukoui et al., 2019, p. 2]. In other case they functioning and market position will be threatened. As an example, ignoring climate risk led to the cancellation of the construction of the Ostrołęka coal power plant in Poland and significant sunk costs [Krupiński, Kuszewski, Paska, 2019].

Climate change is a source of a new financial risks, therefore nowadays climate risk is a part of the assessment of financial institutions' risk [Battiston et al., 2021, p. 2]. Climate risk affects financial stability in two ways: as a *climate physical risk* (related to damaging physical assets and production capacity, resulting in increased credit risk and financial losses for the insurance sector) and as a *climate transition risk* (companies dependent on fossil fuels could suffer from financial losses, giving rise to the “stranded assets”) [Battiston et al., 2021, p. 2].

Among the scientific articles identified in the literature review, there is a noticeable lack of comprehensive publications on climate risk in relation to the energy sector, particularly in terms of ongoing energy transition. Most of them deal only with particular aspects of climate risk and its impact on broader sectors or branches of the economy. Some of them deal with the topic of energy transition and decarbonisation, but they focus mainly on the challenges related to it, marginalizing the issue of climate risk for energy companies. Due to the fact that there is no comprehensive publication which aimed to climate risk for energy entities as it was mentioned above, there is a literature gap in that field.

## Risks in the energy sector

The specific nature of the energy sector means that entities operating in it have to cope with a specific risk caused by factors that are characteristic for a given market or type of investment. The specific risk is different and individualized for each energy investment – it results from the applied engineering, organizational or economic solutions. This risk results from individual characteristics of a given investment, therefore its impact on the value of the entire investment project varies [Rogowski, 2018, p. 185]. Investments in the energy sector are usually characterized by [Sobik, 2021, pp. 181–182]:

- high capital intensity;
- location dependent on raw material base or prevailing meteorological conditions
- long investment period (often around 5 years) and economic lifetime (up to 50 years for nuclear);
- long payback period;
- wide range of stakeholders (investors, capital providers, customers, local communities);
- high exposure to risk related to prices of energy raw materials, energy carriers or climate policy (EU ETS market).

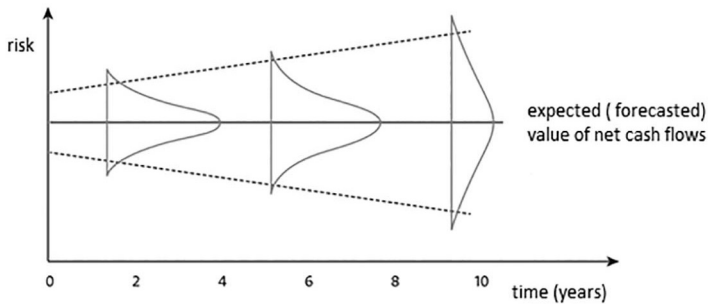
The above mentioned characteristics of energy investments imply the emergence of specific risks, which in a particular way influence the economic efficiency of these investments as well as the functioning of energy enterprises and their competitive advantage in the market. The implementation of energy investments is closely related to the exposure to specific risks, among which can be distinguished [Sobik, 2021, pp. 183–184]:

- the risk of investment realization delay affecting negatively the forecasted investment revenues;
- the risk of significant exceeding of the assumed CAPEX resulting from unexpected events during the investment implementation phase;
- risk related to the long duration of the investment realization and operation phases;
- the risk of the value of the volume of energy produced in the phase of investment operation, which translates into the risk of deviation of future cash flows generated from the investment from the values assumed in the investment efficiency account;
- market risk of unfavourable prices in the energy raw materials market, energy carriers market and CO<sub>2</sub> emission allowances market (ETS);
- the risk of social and environmental conflicts resulting, in extreme cases, in the need to abandon the project.

The long period of realization and operation of energy investments influences the level of risk of achieving its net benefits. Forecasted future cash flows from investments, used in the investment efficiency calculation, show a certain expected value,

but the level of their deviation increases with the lengthening of the investment life cycle [Rogowski, 2018, p. 189]. The longer the implementation and operation period of the investment, the forecasted risk becomes higher and causes an increase in the probability of deviation of the value of future cash flows (Fig. 1).

**Figure 1** The dependence of the time and level of investment risk



Source: Ostrowska, 1999, p. 31.

There is a very high inertia in the energy sector – investment decision-making can take up to several years, as can the investment implementation phase. During this time, significant political and geopolitical changes may completely change the investment environment. The specificity of the functioning of energy entities requires them to create long-term development strategies, often with a time horizon longer than 20–25 years, due to the ongoing energy transformation and the long period of investment implementation, their economic exploitation and the long period of return on investment, in order to remain competitive in the energy market and maintain or increase market shares. The current situation in the energy sector requires actors to have an innovative approach to energy transition and the development of low- and zero-carbon technologies. The energy sector is closely linked to economic policy at national and international level, thus its exposure to regulatory risk is significant. State intervention is also a characteristic feature, which affects the inability to guarantee a free energy markets.

As indicated above, the functioning of energy companies and their investments are affected by specific types of risk resulting from the unique nature of this branch of the economy. In the following part of the article, the most important types of risk materialising in the operations of energy companies will be characterised. Climate risk is a catalyst for new types of risk, of which financial, regulatory and social risks are particularly noteworthy, as well as the risk resulting from the operation of the EU ETS CO<sub>2</sub> emission allowance trading scheme and the weather risk associated with the occurrence of climatic anomalies and natural disasters.

## Climate risk and its specifics

Estimating the risk associated with the impact of climate change on the functioning of society and the economy is a major challenge [Burchard-Dziubińska, 2020, p. 159]. Climate risk is a complex concept and research forecasts are subject to large uncertainty [Obersteiner et al., 2001, p. 12]. Climate risk is understood as the effect of the interaction of hazards, vulnerability and exposure, according to the approach outlined by IPCC<sup>1</sup> [Jurgilevich et al., 2017, p. 3]. Shortly, climate risk could be defined as a set of risks induced by climate change [Charpentier, 2008, p. 91]. Nevertheless, climate risk, due to its complicated nature, cannot be clearly defined and simply estimated as a function of probability [Taebi et al., 2020, p. 1]. Climate risk in the energy sector can be classified as a systematic risk, i.e. an undiversified risk (energy entities have no direct influence on natural forces) and as a complex risk involves uncertainty and ambiguity [Ibidem]. However, in the case of the energy sector, its specific nature should also be emphasised – due to the previously mentioned nature of the energy sector as well as the individual character of energy investments. The energy sector is also one of the most exposed sectors to the effects of climate change [Burchard-Dziubińska, 2020, p. 169], and climate risk is one of the biggest challenges facing the energy industry [Kouloukoui et al., 2019, pp. 1–2].

Climate change is the biggest threat to entities that do not intend to change their business strategy in the face of climate risk and choose the ‘business as usual’ path [Henderson et al., 2018, p. 10]. In the worst case, this approach can lead these business entities to collapse. Thus, ignoring climate risk can pose a serious threat to energy entities and they should implement a proactive attitude and take measures to mitigate it [Kouloukoui et al., 2019, p. 2; Kolk, Levy, Pinkse, 2008, p. 724]. Unfortunately, Poland still suffers from the problem of underestimating or even underestimating climate risks [Burchard-Dziubińska, 2020, p. 171], which may have a negative impact on the functioning of the energy sector.

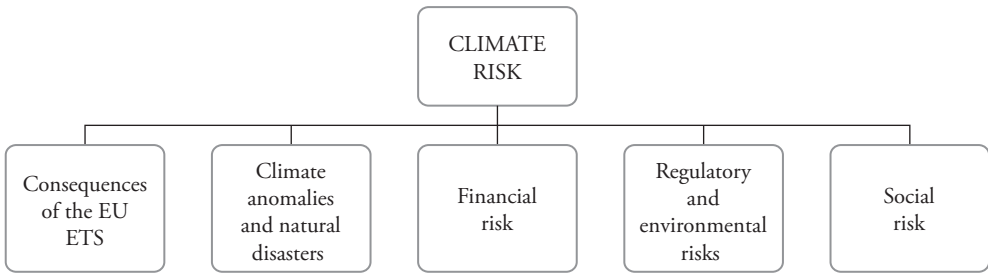
Climate risk implies the materialisation of other risks affecting the operation of energy entities. Particularly important risks associated with climate risk include financial risk, regulatory and environmental risk, as well as social risk. The functioning of the EU ETS and its consequences for electricity companies as well as the occurrence of climate anomalies and natural disasters also deserve special attention. It should be stressed that these risks are intertwined and interconnected, making the climate risk issue more complex (Fig. 2). The remainder of this chapter will characterise all these types of risk.

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<sup>1</sup> IPCC – The Intergovernmental Panel on Climate Change.



**Figure 2** Consequences of climate risk in the form of materialisation of a number of new risks



Source: Own elaboration.

Over the last years, the electric power sector in Europe has experienced major changes, which have two key features – they are mostly irreversible and they cause the need for a paradigm shift related to long-term investment conditions [Morawiecka, 2015, p. 53]. The significant impact of climate risk and, as a consequence, its inevitable integration especially with financial, regulatory and social risks mean that the initiated process of transformation of the sector will require numerous changes in the strategies of energy companies and their business structures. Resilience to the risks listed in fig. 2 and the possibility of their mitigation will determine the success of energy companies and their market share.

**Table 1** Risk exposure as a result of climate risk materialization and affected energy sectors

Type of risk	Risk exposure	Affected energy sectors
Financial risk	Severe	Whole energy sector
Regulatory and environmental risk	Very high	Whole energy sector
EU ETS	Very high	Electricity and heat generation, coal mining
Climate anomalies and natural disasters	Moderate	Electricity and heat generation, transmission and distribution of electric energy, energy trading
Social risk	Moderate	Electricity and heat generation, transmission of electric energy, energy trading

Source: Own elaboration.

The exposure to a set of new risks caused by the materialisation of climate risk, as well as their impact on individual segments of the energy sector, is shown in Table 1. Exposure to financial risk is a key area of risk that reaches the entire sector as a result of the climate risk’s impact. The entire sector is also highly affected by regulatory and environmental risks, as well as risks related to the operation of the EU ETS, which

mainly hit the electricity and heat generation segment, but also impact the mining sector, causing a progressive decline in demand for thermal coal and striking at the profitability of coal mining. In this article, however, the consideration of climate risk impacts will be limited to the electric power industry only.

The functioning of the Emission Trading System is one of the key factors creating climate risk, affecting in particular energy operators using fossil fuels to produce electricity [Kolk et al., 2008, p. 724]. The burning of fossil fuels for energy purposes leads to the emission of carbon dioxide (CO<sub>2</sub>), which is one of the gases contributing to the problem of global warming. The European Union's energy and climate policy explicitly focuses on the decarbonisation of energy and reducing the sector's dependence on fossil fuels. For this reason, energy companies generating electricity from fossil fuels (especially hard coal and lignite) are exposed to the risk of rising CO<sub>2</sub> emission allowance prices, which in turn affects the cost-effectiveness of their electricity generation and worsens their competitiveness on energy markets, especially in view of the decreasing LCOE of renewable energy sources (RES). The issue of exposure to climate risk has resulted in coal-based electricity generation assets (power plants) and coal and lignite mines being treated as 'toxic assets'. Having them in their portfolio by energy entities is perceived poorly by both lenders and the market, and by an increasingly aware society. The increase in the price of EU ETS CO<sub>2</sub> allowances in 2020–2022 was so dynamic that it far exceeded the estimates of both the European Commission [European Commission, 2021, p. 580] and the assumptions of Poland's Energy Policy until 2040 [Ministerstwo Klimatu i Środowiska, 2021, p. 7]. The former document envisaged reaching 85 EUR/t CO<sub>2</sub> in 2030 and the latter reaching 40 EUR/t CO<sub>2</sub> in 2040, both of which were reached in 2021, necessitating an update of the energy policy. The price of CO<sub>2</sub> allowances is also a critical variable that significantly influences the pace of decarbonisation as well as the overall energy transition underway, being a powerful tool to promote the transition of the energy sector away from fossil fuels.

The occurrence of climate anomalies and natural disasters results in impacts on the operation of energy entities. Natural disasters have a devastating impact on energy infrastructure and result in, among other things, interruptions to electricity supply or high financial losses. On the other hand, the occurrence of climate anomalies, which are atypical for the climate zones considered, can lead to disruption in the operations of energy entities. Examples include the occurrence of heat waves and extreme droughts in combination with very low water levels or an anomalous decrease in windiness. Climate anomalies usually have a negative impact on the power generation process. Climate risks associated with climate anomalies and natural disasters are reflected in the valuation of companies and their values. Exposure to the risk of widespread loss of infrastructure (e.g. as a result of a hurricane) or the inability to generate sufficient electricity due to weather anomalies materialises financial risk.

Climate risk is inseparably linked to financial risk [Giglio, Kelly, Stroebel, 2021, p. 16]. Indeed, as a result of climate change, new sources of financial risk has emerged, strengthening the correlation between climate and finance [Battiston et al., 2021, p. 1]. The essence of the energy and climate policy pursued is the creation of financial incentives to influence pro-climate actions. The functioning of the EU ETS affects the financial situation of energy entities and their market position. Climate risk has a direct impact on the risk of a decline in the credit rating of energy companies (especially those that base their generation activities on coal) and their valuation on the capital market. It also has an impact on the increase in the cost of raising debt – energy entities exposed to increases in the price of CO<sub>2</sub> emissions allowances, as well as those basing their energy mix on coal, have a worse credit rating and their cost of debt is higher, compared to sustainable companies. Thus, a linkage between climate risk and credit risk exposure can be concluded [Seltzer, Starks, Zhu, 2021, p. 2]. Investment in coal-fired electricity generation assets in the EU is already impossible as a result of energy and climate policy – an example is the failed construction of the Ostrołęka coal-fired power plant, for which the financial assembly was not completed.

Climate risk is also related to exposure to legal risk in connection with the implementation of new regulations on environmental aspects of energy sector activities. An unstable legal landscape is undesirable for energy companies, due to inconsistent and difficult-to-predict actions of legislators such as the introduction of the Wind Energy Investment Act in Poland (also known as “10H Rule”), which almost completely blocked the expansion of on-shore wind power plants. The characteristics of legislative action related to climate protection (regulatory risk) cause exposure to financial risk. The effectiveness of legislative action depends on the effectiveness of the impact of regulation on the financial condition of energy entities.

Climate risk has also an impact on the materialisation of social risk. This can be seen both in the increased public awareness of environmental and climate protection issues, which results in a better perception of ‘green’ energy companies. On the other hand, companies relying on fossil fuels in their manufacturing activities are viewed increasingly negatively. High emissivity or having a negative impact on the environment is perceived by the general public and affects the image of the whole company.

## Conclusions

The climate risk presented in this article, triggered by climate change mitigation and adaptation, implies the emergence of a number of other risks that specifically affect electricity actors. Climate risk is therefore an accelerator of new risks in the electricity sector and should therefore be duly taken into account and mitigated, as ignoring it

can have serious consequences, as illustrated by the failed construction of the last EU coal-fired power plant in Ostrołęka, Poland. The spectrum of impacts of climate risk on energy companies is very wide – from legal, financial, social aspects, to the consequences of natural disasters and climatic anomalies affecting the physical production and distribution of electricity. It should be emphasised that these risks, triggered by the materialisation of climate risks, are intertwined. Legal and environmental regulations affect the financial situation, climate anomalies and natural disasters influence the emergence of new regulations and affect the financial issue, and social aspects are reflected in the financial risk. Thus, all these risks intermingle and merge seamlessly. Therefore, it is essential that energy companies take measures to include climate risk and its derivatives in the energy sector risk identification process.

In the context of the challenges presented in this article, the long-term investment strategies of energy companies, especially in conventional power generation, should address in particular a number of new climate, regulatory and financial risks [Morawiecka, 2015, p. 64]. The implementation of investment projects in new generation assets is also a major challenge, as a result of the presence of regulatory risks arising from climate risks. In turn, investments in emission-intensive conventional power generation are subject to additional financial risks related to the position of the unit in the so-called merit order, and consequently to future cash flows and profitability of the entire investment.

As shown in this article, climate risk leaves its mark on the operation of the entire energy sector, especially on electricity companies. Hence, climate risk management is becoming one of the key elements of risk management across the power company. The changes taking place in the whole sector, resulting from the ongoing energy transition and the EU climate policy, are mostly irreversible and lead to continued transformation of the whole energy sector and, consequently, to a paradigm shift in thinking about energy. Decisions made by energy companies in line with the sustainable development paradigm will catalyse their growth and allow them to increase their value.

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