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# Impact of climate risk on long-term core activity management in the power sector

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**Summary**

The global economy faces the challenges of climate change that generates the climate risk, which essentially affects the operational activity of power companies. The power sector is both, one of the most important greenhouse gases emitters, and an industry especially exposed to widely perceived climate risk. Changes in the natural environment cause negative impacts on the energy infrastructure (physical risk), while regulatory changes and society sentiments (transition risk) reshape the conditions of operational profitability of power companies. These phenomena, currently accelerating changes in the global economy, persuaded the authors to undertake a study on necessary changes in the core activities of power companies, which should secure the resilience of their profits in an uncertain future. The authors performed a comprehensive study of literature concerning climate risk exposure in the power sector by researching operational adjustments made by leading power companies in the green transformation process. To meet the abovementioned objectives of the article, the authors present the results of their research in the part of the article that discusses the recommendations for the necessary changes of the core activities of power companies. They intend to identify universal solutions that can be applied by power companies operating in the globalized economy. This requires a long-term approach to the process of re-designing the operational activities of power companies,

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which would secure physical assets responsible for the continuity of their operations, and hedge future profits against transition risk.

**Słowa kluczowe:** management; power company; strategy; climate risk; climate change; core activity; power market.

**JEL:** M1, M4, F23, L21

## I. Introduction

As a global phenomenon, climate change has a significant impact on the economy. High temperatures, or the change in the structure of precipitation, affect not only agriculture and fisheries, but also other industries, such as energy, tourism, construction and financial institutions. The effects of the manifestation of climate risk are already being identified, although it is the distant future that is usually indicated as the period of the impact of climate change on the economy. The severity of that manifestation causes serious financial losses that amount to billions of USD each year. Hence, there is a growing interest concerning the economic side of climate change, not only from climatologists, but also from companies surprised by unprecedented disasters and regulatory changes.

Increasing climate risk exposure, resulting from advancing climate change, creates also a significant challenge for the future structure of the core activities of power companies. To stop climate change, OECD countries should eliminate greenhouse gas emissions by 2035, the rest of the world should follow by 2040. Climate risk fundamentally affects all aspects of the power sector, starting with power production and consumption, to transmission and distribution. Hence, power companies introducing "climate risk reaction instruments" should change their energy mix, moving away from fossil fuels and towards renewable energy sources (hereinafter: RES), green hydrogen and power storage. They must support energy efficiency of customers and flexible demand-side management. It is also necessary to adapt power grids to the new requirements of bi-directional electricity transmission, serving numerous input sources that produce electricity. The change of the core activities of power companies must meet the goals of green transformation, that is, the process of creating such an economic system that operates in a manner friendly to the natural environment, ensuring its sustainable development, thanks to the development of production methods based on energy efficiency and zero-emission technologies.

The authors describe the challenges facing power companies that are caused by climate risk. Presented are also necessary long-term developments in the core activities of power companies, and in elements of their business models, securing future success in the reality of green transition. The authors, pursuing the aim of the article, seek to present their own conclusions resulting not only from an analysis of relevant literature, but also, primarily, from their own observations. They analyze the experiences of the leaders of green transition within the power sector, which concern the necessary changes of the core activities of power companies, designed to hedge their future economic results against the impact of widely perceived climate risk. In this context, necessary adjustments must take place with respect to the operational activity and investments of power

companies, their cooperation with customers, development of power generation technologies and power grid upgrades. Hence, summarizing considerations of the article and completing its objective, the authors propose recommendations concerning long-term developments of the operational activities of power companies. The authors strive to fill a certain gap in literature in this field, taking a holistic approach to the necessary changes in the management of the core activities of power companies. These changes, caused by all aspects of climate risk, should ensure the future profitability of the operations of power companies under conditions of the progressing climate risk.

## II. Global impact of climate risk on the power sector

Meeting global climate goals and achieving climate neutrality requires a fundamental transformation of the global economy and a fundamental change of the way of power production and consumption [more in Reference 34]. Power is essential for the functioning of modern economies, but at the same time, greenhouse gases (hereinafter: GHG) emissions resulting from energy production are by far the largest contributor to global warming [Reference 15]. The target of green transition is the de-coupling of global economic growth from GHG emissions. Green transition means a change not only for the real economy, but also for the power sector, exposing power companies to certain risks as well as opportunities, as they are forced to adapt to the new reality. Green transition impacts the power market, which is shifting away from fossil-fuel dominated system and towards renewable energy sources (RES) and carbon-free solutions. These changes pose a huge challenge for power companies, as well as for society, creating an opportunity for new entrants to enter the power sector that become a catalyst in this context. Green transition requires high levels of de-carbonization and electrification of the economy, backed by green fuels, in areas that are difficult to electrify. It creates a high degree of operational complexity, which must be solved by adjustments of the core activities of power companies preparing them for the new challenges generated by technological change, climate-focusing revolution, climate risk, new market participants and societal expectations.

*Climate risk* in the power sector shall be defined as the impact as well as economic and financial consequences of risk that may arise from climate change or from the efforts to mitigate climate change [Reference 4]. The response to climate risk is the de-carbonization of the value chain and “greening” the core activities of power companies. Green transition increases risk in areas of regulatory and market pressure, forcing changes in market strategy or operational techniques. It generates also opportunities for well-prepared organizations that can emerge in the area of changing power production methods (mainly clean technologies, aiming to reduce GHG emissions), a digital revolution on the power market, digitalization of operations, or new elements of the financial market. There is a crucial need to strike a proper balance of the short-term risk of inappropriate activities influencing economies, with the long-term risk of insufficient or overdue actions, preventing the catastrophic economic and social impacts of climate change. Taking this approach into account is essential to the success of both, particular industries and power companies. That is why progressing climate change, and intensive human activity directed at mitigating its effects, has made environmental protection and the need to transform the economy

a priority[1]. The de-carbonization of the economy is at the starting point [Reference 35], but one can observe even today the basic shift in the power production mix towards RES, securing the increase of green power utilization by industry and by society.

Power is an essential reaction to climate risk. The use of green power produced by RES supports the creation of a de-carbonized, sustainable energy framework – growing contribution of clean energy sources alongside improvements of energy efficiency [Reference 18]. Electricity demand is expected to triple by 2050, due to the electrification of the economy and the increased use of hydrogen produced from green energy (green hydrogen). The development of new, climate neutral power production techniques is essential to ensure the necessary reduction of investments in fossil fuel-based assets in the power sector. The development of new climate neutral technologies is necessary in this context, as well as ensuring competition in supply chains, support for R&D, and instruments financing required investments. RES shall be developed by increasing the capacity of wind and solar farms – it should hold an approximately 90% share in the production of electricity by 2050.

These trends will generate a significant reduction of the use of fossil fuels in the power sector in particular, and in other industries in general. Power companies face a transformation of their business environment, a significant change in competition, and new expectations and needs of customers aiming to de-carbonize their activities. Competition is increased by technological revolution. It is necessary to point out the constant change in the profitability of various power sources, and the uncertainty as to their future profitability (especially return on capital). The need to reduce the usage of fossil fuels will create the risk of demand reduction for fossil fuels-based power, and the deterioration of the competitiveness of the traditional (pre-existing) power industry. However, power companies strive to reduce the emission of GHG per MWh produced, a fact that gives, globally a competitive advantage to RES. Furthermore, RES is usually characterized by a zero marginal production cost – on the wholesale market, RES are immediately more competitive than fossil fuel-based power plants. As a result, many power plants were decommissioned globally in recent years. On the other hand, this situation creates an opportunity for the managers of energy storage systems (batteries, pumped storage power plants, etc.), as the high volatility of prices makes it possible to maximise options provided by such installation. Hence, the pre-existing power industry invests both in RES and systems of a flexible energy supply management. Thus, a paradox arises whereby green transition can be accelerated by traditional power companies as they become “greener” in order to defend their pre-existing market shares and future profitability.

The entire system of power production and consumption will have to be transformed in the decades ahead – from fossil fuels to RES – in order to ensure a sustainable future. Hence, power companies have to re-design their core activities in order to secure their future profitability. These changes must involve, at least:

- the available portfolio of products and services that support customers’ needs towards minimizing their carbon footprint and green electrification of production processes, heating and transportation;
- a radical change of production technologies towards a carbon-neutral production portfolio;

[1] Climate change shall be perceived as a change in climate over time due to human activity and natural variability. It impacts natural and human systems [More in Reference 4].

- the surplus of renewable production, which needs to be also used by heating systems and green hydrogen production;
- wind, solar, bio-mass and waste surpassing fossil fuels as energy sources [Reference 21];
- rethinking the role of old carbon-neutral technologies in the portfolio of power companies, that is, nuclear, geo-thermal, hydro power; storage of green power and electricity production, based on green hydrogen, operating as peak power producers replacing gas power plants;
- innovation in power trading on customers' behalf backed by the usage of power storage, connecting the RES production with power storage systems, and the formation of virtual power plants (trading, ancillary services);
- making the power grid ready to accommodate intermittent sources of power from wind, solar, and offshore farms;
- replacing gas power plants by power storage systems as well as demand side management solutions;
- power generation having to be increasingly spread among many suppliers, from large, centralized power plants to individual "prosumers" (consumers that are also producers) making it necessary for the power grid to be ready for bi-directional power transmission – based on the optimization of power supply supported by the digitalization of operations;
- radical digitalization of operations in areas where it creates added value;
- power companies, used to operate in markets characterized by predictable and inflexible demand, needing to adapt to changing demand patterns with respect to the use of RES, electric vehicles, power storage systems and, for example, heat pumps;
- new elements of power systems offering some flexibility in demand-side management – for example, electric vehicle can be treated as elements of power storage systems (vehicle-to-grid).

Power companies face a radical change of profit drivers. RES technology maturation and market innovations require changes both in business strategies and in business models of power companies. The choice of the proper production technology of green power becomes an important issue here. Various renewables production technologies enter the market, and there is an observed continuous change of their competitiveness alongside a continuous worsening of the market position of fossil fuels-based assets, which can, in the future, go completely out of business. The development of RES must be linked to the development and upgrade of the power grid, which should secure the optimization of power grid operations and the creation of smart, bi-directional power transmission. There are several prerequisites for the change of the core activities of power companies, meant to ensure their future profitability. They include the necessity of adjustment to the demands of green transition, right infrastructure investments, changes in business models, as well as securing a decrease in costs. As a reaction to climate risk, it is necessary to set operational activity changes within a framework of strategic answers to the appearance of new, complex business environments of the power system. The development of new business models is a reaction to this situation and the acceleration of demand for fossil-free power.

## III. Importance of climate risk for operations' management in power companies

Power companies operate in a global economy that exposes them to a continuously changing business environment of green transition, which not only concerns the company, but also affects the activities of other entities. Hence, each company is exposed to climate change and to the measures taken as part of wider climate policies, which cumulatively aim to reach global climate neutrality. The impact of climate risk in an increasingly global economy becomes critical to the structure of the core activities of power companies, which face progressing complexity and instability of markets. The fundamental management challenge here is to adapt to the new conditions of operational activities that are shaped by an increasing effort to achieve carbon neutrality. This will require power companies to adjust to the new circumstances present in the business environment, in order to flexibly react in new situations characterized by increasing discontinuity and absolute uncertainty [more in Reference 17].

The concept of "management" should be defined as the activities of company managers that aim to take informed decisions to execute business plans that use company resources in order to achieve the organization's goals [Reference 24] Hence, the importance of a proper change in operations' management in power companies, that face climate risk, is imperative for securing an undisturbed, continuous increase of future company profits. These developments should enable a conscious and effective steering of the impact of climate risk on the functioning of power companies. Disregarding climate risk may lead to faulty business decision-making when it comes to contracts, loss of market opportunities, and the failure to hedge against significant deviations of the power companies' operational activities. The main task of company management is thus to strive to take properly reasoned decisions when the company is at risk in the highly volatile business environment of green transition. Managers cannot accurately predict the future shaped by climate risk, which should be dealt with mostly by changing the operational activity of power companies. It requires the development of new competences supporting the implementation of new elements to operational management.

The concept of "risk" shall be perceived as a potential deviation from the expected values, and is associated with the possibility of not achieving the intended results or a deviation from their predicted value [Reference 12]. Hence, it creates both negative consequences and opportunities for extra profits [Reference 12]. The same applies to "climate risk" that can generate opportunities for the creation of new profit streams, but also high costs of climate risk actually materializing. Climate risk consists of two elements [Reference 14]:

1) *Transition risk* that influences power companies due to changes in the business and regulatory environments towards a climate neutral economy. Transition risk influences the situation on the power market, making some of pre-existing business models unprofitable. However, it also creates opportunities for efficient risk management that supports the formation of new possibilities for generating profits;

2) *Physical risk* that results from the undesirable influence of unpredictable weather conditions on fixed assets and on the operations of power companies. Physical risk covers following factors [References 1, 4]:
   - extreme weather phenomena – heatwaves, landslides, floods, wildfires, storms,
   - long-term gradual shifts of the climate – changes in precipitation, unfavourable weather variability, rising average temperatures,
   - indirect effects of climate change.

This creates the necessity to hedge profits of power companies against physical factors such as wind, temperature, flood or drought [Reference 16]. Physical risk also causes price movements in the commodity and financial markets.

Climate risk is increasingly important in the world of global unpredictability and volatility caused by climate change and green transition. The manifestation of climate risk, often triggered by global processes or local weather events, may result in many power companies going out of business. However, the occurrence of risk may become an opportunity for power companies that are properly prepared to develop and expand their business. The proper execution of a change of the core activities of power companies should facilitate the use of the opportunities of climate change to their benefit. Such change, can provide a sustainable improvement of economic results under conditions where climate risk actually materializes, and where the global green revolution is characterized by high economic risk. Well prepared power companies will be able to take advantage of these opportunities. Climate risk varies in terms of geographic factors, sectors of the economy, and regulatory and legal conditions. Power companies are exposed to climate risk resulting from: increasing severity and frequency of physical risk factors, changes in government policies [Reference 7], technological developments, and changes in the sentiment of societies seeking to reduce GHG emission. Physical risk factors are not linear and increase uncertainty as to the location, frequency and severity of weather conditions.

Transition risk creates uncertainty concerning future developments of climate policies, power sector regulation, technology innovations, and changes in customer sentiment towards de-carbonization [Reference 7]. Green transition exposes power companies to potential disruptions, which can be very abrupt, especially if they are not prepared for them in advance. One of the most important factors of transition risk is technological change related to energy-saving, carbon neutral power production and to climate neutral economy. It requires a withdrawal of business models based on technologies using fossil fuel-based energy sources, which might very well become more expensive in the future as a result of climate protection measures. Climate-friendly technological development complies with the sentiment of the society to move towards climate-friendly production and consumption models. This creates a need for power companies to adapt to new conditions, in order to minimize the negative impact of climate risk and to remain competitive. Power companies are exposed to increasing legal and regulatory changes. Green transition generates transition risk, and should be analyzed from the perspective of the discontinuation of expected development trends, and deviations from planned scenarios [more in Reference 3]. Hence, the management of power companies, when taking any decision concerning changes in their operational activities, should always be aware of the possibility of the occurrence of unexpected results, because transition risk creates uncertainty of the conditions in which power companies will operate. Transition risk

should be treated as a very broad concept, without excluding any risk factors, even those that are considered to affect the economic results of power companies indirectly.

The concept of *physical risk* should define the consequences of incidents in the natural world that may lead to unexpected fluctuations in the results of the functioning of power companies. It can even cause disturbances with respect to the continuity of their operational activities [Reference 3] – having a negative impact on power production [Reference 6], the power grid, and causing undesirable price movements. Hence, physical risk shall be perceived very broadly, without excluding any risk factors, even considered to be indirectly influencing power companies. Therefore, physical climate risk should be defined as the consequences of events that may lead to unexpected disturbances in the execution of the plans of power companies, resulting both from the impact of the extreme dynamics of natural factors, and from changes in the global economy related to green transition.

Potential manifestation of climate risk requires proper management with a long-term transformation of the core activities of power companies. Not only must physical risk be considered, which has mainly negative consequences for the operations of power companies, but also transition risk. Unlike the former, the latter may give rise to opportunities as well, which include so-called *clean technologies*, in particular GHG emission reduction technologies. Relevant for the reshaping of core activities are also the development of renewable energy sources, a digital revolution on the energy market or the introduction of new financial market solutions. The manifestation of transition risk has "outdated" some of the older business models. The pre-existing power industry, which is based on burning fossil fuels, will lose its competitive advantage and will cease to be the guarantee of the stability of the power system. At the same time, the development of competitive power storage on a large scale, and in quantities significant for the wholesale power market, will allow RES to become the basic means to achieve the security of supply. The cost of power becomes now one of the most important success factors of economies in the time of continuous automation and robotization.

## IV. Relevance of physical risk for long-term changes of operational activities of power companies

The response to climate risk of the power industry is based on linking: a radical re-design of core activities, with the creation of new financial instruments, changes of market conditions, investments in fixed assets and the development of new green products and services, which meet new needs and expectations of industrial customers and societies. Necessary adjustments must take place in the area of funding operational activities and investments, cooperation with customers, production technologies and power grid upgrades.

Power companies unable to flexibly adjust their operational activities will not survive. In order to survive in the volatile environment of climate risk, it is crucial to be able to adapt to the radically changing business environment and market conditions. This is, however, always connected to the spending of funds. Power companies should ensure constant inflow of funds exceeding the costs of the manifestation of climate risk, and divest current strategic resources that don't guarantee future profitability. They must also adapt to the new needs of customers following green transition

developments, and increase their business complexity in order to secure future profitability. Management facing climate risk should be future-oriented, focusing the attention of top level managers on the main areas and main factors relevant to profit generation, and on the criteria for the assessment of their company's success. Climate risk changes the conditions for success of power companies making it risky to continue to pursue pre-existing business models. Hence, climate risk arising in the globalized green business environment cannot be ignored during the development of strategic changes of core activities of power companies, which have to be aligned to long-term trends of the world economy developing towards climate neutrality. Global climate risk disrupts many current strategies. A correct climate risk analysis becomes crucial for the success of business strategies, because it is the basis for creating variants of the decision to change operational activities to secure the highest possible rate of return on investments in the context of specific risk. It requires a radical change of the operational activities of power companies, in order to implement effective tools facilitating future goals, in a business environment characterized by the randomness and discontinuity of market trends. Climate risk becomes a systematic risk for the global economy, because climate change increases macro-economic and investment risks. Climate risk management becomes therefore an important success factor in the power sector [Reference 13].

The severity of climate risk increases due to the growing frequency of extreme temperatures, fires, storms or floods[2]. Researches indicate that more than 65% of extreme weather events since 2011 were the result of human activity [Reference 32]. Although one can observe a fundamental increase in severe, although not catastrophic, weather events, which are becoming the norm – the sum of small weather events creates high costs of the manifestation of risk [Reference 6, 13]. The most important physical risk factors for power companies are wind, fire and water. Physical risk, as the effect of extreme weather dynamics, may also lead to a reduction of the overall value of power companies, following the destruction of technical infrastructure and damage to real estate in exposed areas. Heatwaves increase the demand for electricity in the summer and, at the same time, they reduce the cooling capacity of power plants and water supplies in hydropower plants. There is also the danger of a reduction of the efficiency of solar power plants, which influences the power market [More in Reference 9, 27] because of changes in the demand-supply balance. Heatwaves can also be the cause of low water levels in rivers used to fuel transportation while higher temperatures reduce the efficiency of power production, due to lower availability of water.

The available production capacity of power plants is reduced and power grids are overloaded, which in turn leads to breakdowns, fires and interruptions in electricity supplies, which additionally leads to losses in the rest of the economy. Fires have not only reduced bio-diversity in many areas, but also bankrupted power companies that had to settle claims following fires related to their operations, which burdened public finances with the costs of extinguishing them.

Wind is another physical risk factor. Hurricanes can significantly reduce the production in traditional- as well as wind-power plants. Extreme storms can reduce the supplies and quality of fuel, or damage power infrastructure (power plants, power grid) [Reference 5]. Floods can damage the transmission and distribution networks as well as power plants. Hence, power companies

[2] The Florida governor announced in 2019 that the state would have to spend $ 2.5 billion over a 4-year period to be protected from climate risk, including rising water levels. [More in References 19, 3, 8].

started to reinforce their infrastructure, treating this type of investment as one of the instruments of climate risk management, constituting the process of selecting and applying methods of mitigating the level of their risk exposure [Reference 35]. The instruments of climate risk management should ensure continuity and flexibility of the power companies' operations in the event of unexpected market events and extreme weather phenomena. Power companies should analyze the costs and impact of different measures on climate risk, and choose the most effective investments based on the relation between investment costs and the reduction of risk specific to existing characteristics of their assets [References 28, 30].

Examples of measures aimed to reduce physical risk include: reinforcement of overhead transmission and distribution lines; installation of flood-proof equipment in power plants and transformer stations; using temperature forecasting systems in rivers; creating cooling systems ensuring the continuity of production in power plants; re-designing wind turbines to handle higher wind speeds and passive airflow beneath mounting structures to reduce solar power temperatures; as well as a generally more robust design of power systems. There can be a necessity to consider a relocation of assets if net climate risk exposure (after risk reaction) is unacceptable. The costs of such activities can range from USD 100 million (strengthening overhead transmission lines) to even USD 1 billion (protecting power plants against flooding). The necessity to finance the investment activities of the power sector means that the risk affecting the functioning of individual power companies becomes also an element of risk of investments and credit portfolios of financial institutions.

## V. Importance of adapting the operations of power companies in order to neutralize transition risk

Climate risk impacts the power sector, especially the transition to a climate neutral economy, which influences negatively the value of power companies' assets, and radical weather phenomena [Reference 26]. Climate risk influences the economic conditions of power companies also through green finance – for example, insurance and re-insurance of companies, banks, pension funds. The severity of extreme conditions, resulting from advancing climate change, has a specific financial dimension for the power sector. In order to limit climate change, OECD countries should eliminate GHG emissions by 2035, and the rest of the world by 2040. The analysis of current RES growth rates also indicates that fossil fuels should be squeezed out of the power system by 2030. Hence, power companies face the challenge of adjusting their core activities to new market conditions that reduce the profitability of the traditional power sector. The maturation of RES technologies, and the related reduction of investment costs, affects the situation on the power market, changing the competitiveness of particular production technologies. Existing patterns of executing the operational activities of power companies become useless. For example, a wind farm, when investment costs are reduced, becomes more competitive than traditional fossil fuels-based power production, and can also obtain additional "green" support. The market price of electricity is the same, and the variable cost of production in a wind farm is assumed to be zero[3]. That is why climate change creates strategic risk for power companies, which must define the future structure

[3] The largest greenhouse gas emitters in Europe are the following power companies: RWE, EPH, Uniper, Steag, CEZ, Bulgarian Energy Holding, Endesa, ZE PAK, PGE, Enea.

of their production assets, and allocate funds for investments in generation assets as well as the power grid. In this way, the climate risk issue finds a new perspective reflected in the decisions of power companies concerning the shape of their core activities. They must consider the profitability of various options for RESs' development, and low-emission power generation, in a constantly changing environment (the so-called 3P approach – Planet, Profit, People) and the impact it has on the efficiency of the operations of power companies. Therefore, the issue arises of determining the optimal model of the core activities of power companies by 2050. Such time perspective creates the risk of faulty investment decisions. Assets in the power sector are characterized by a very long period of operation (up to 30 years) while changes in available technologies are already under way and the maturity of RES, facilitated by investments in RES, has contributed to the reduction of their costs. This creates a need to design an effective strategy ensuring the maintenance of the profitability of operational activities of power companies in the new conditions of the power sector.

The power sector is notably exposed to the impact of climate change policies that affects the long-term operational activity of power companies, identifying the high risk of stranded assets in their balance sheets. The term "stranded assets" describes assets that face a high risk of having to be discarded earlier than planned. Stranded assets can lead to a reduction of the overall value of power companies, as a result of having to write off the value of assets related to the use of fossil fuels. Another result of such a situation may be identified as a sudden deterioration of financial ratings and an increased cost of debt. Therefore, it can be argued that there is currently a major risk to the business scenarios facing the power sector. It can already be stated that the current trends are not adequate for the period covered by this risk. This means a fundamental change must take place in the conditions for the functioning of power companies that must determine the path to achieve climate neutrality. Each of their investment decisions covers a period of at least a dozen (to several dozen) years of capital involvement. This makes them exposed to high strategic risk, which results from climate risk and revolutionary technological changes, increasing the importance for the power market of RES and power storage. As a result, finance institutions take a negative outlook on funding fossil-based investments and operations. Delaying the adaptation process to the new operating conditions of the power industry generates additional costs, and will be accelerated by technological innovations, reducing the costs of implementing zero-emission technologies.

Climate risk influences also customer expectations towards power companies with respect to: de-carbonization of the economy, reduced usage of products with high carbon footprints, electrification of transportation [Reference 11], and electrification of heating. The power sector must thus have the potential to use renewable energy to power transport, industry and heating, as well as hydrogen production. This means defining new ways of meeting customer needs as a response to climate risk. It increases strategic risk, the manifestation of which is particularly severe for power companies. The changes affecting their operating activities arise outside the power sector and destroy the previous status quo. Younger managers, computer scientists and entrepreneurs strive to transition the power industry into climate-friendly power supplies. Rigid and immobile, old-fashioned, concern-based power companies should shift towards a start-up culture. This approach becomes standard for all power market participants. Market dynamics shall be identified as an opportunity for profitability increases, and reflected in the change of the core

activities of power companies. Ignoring climate risk can lead to losses resulting from incorrect long-term business planning. While green transition accelerates, responding and adjusting to fundamental changes in the business environment becomes increasingly important. The exit of companies from coal-based power production makes them more resistant to transition risk. Power companies must consider the development of smart solutions, as an instrument of reacting to such risk, which also support better customer connectivity.

The long-term changes of core activities of power companies shall cover: initiatives developing prosumers, green electric mobility, using electricity to meet energy demands, green heating using RES, and an electrification of industrial processes.

The next important area is the development of products of demand-side management and demand flexibility, offered to households as well as industry. These developments are the basis for new directions of capital investments. Climate risk management, and the use of new opportunities, becomes an instrument protecting the future success of existing power companies. This situation has direct impact on their strategic decisions concerning asset development (making assets greener), and reflected in their operations. Power companies responded to this challenge, deciding to cut GHG emissions or even to develop carbon-neutral production, supported by investments in power storage, pumped-storage plants, new types of nuclear power plants, and green hydrogen. Some power companies decided even to turn carbon-neutral already by 2025, requiring the same from their suppliers, demanding a carbon footprint minimalization schedule.

## VI. New conditions of financing long-term adjustments of core activities in power companies

Responding to climate risk means a change not only for the real economy, but also for widely perceived finance, exposing them both to risks and opportunities. New approach to financing power companies requires a long-term analysis of investments with an environmental impact, and compliance with all criteria of climate-neutral developments. It demands a fundamentally new approach to funding, and expertise going beyond current planning practice, because having the ability to adapt to the challenges of green transition demands investments and capital. A broad variety of green finance products and services has already been developed, which can be divided into investment, banking and insurance products, which can be used by power companies. The important issue here is meeting the conditions set by climate-neutrality targets – this means mostly the execution of initiatives and projects connected with sustainable development, carbon-free products and climate-neutral policies. The new approach to financing power companies, set by financial markets, focuses mostly on green sustainable investments, green technologies and carbon-free operations. It requires the creation of funding solutions for necessary investments in a green portfolio, modernization of power grids, digitalization of operations, and development of smart customer technologies. The necessity to adapt to new market situations requires also the consideration of entering into partnerships with investors (joint ventures, partnerships, green bonds) that can support the development of a new model of investment implementation. Such cooperation networks can be created also with industrial customers (e.g. on site solutions) and suppliers of heat-pumps, photovoltaics, as well as municipalities. Industrial customers can be part

of contracts hedging the market risk of RES investments by using Power Purchase Agreements (PPAs). EU funds are available dedicated to the support of green transition, which can be used to develop a green portfolio of production assets, and products supporting sustainable development. Capital can be raised from divestments of unprofitable assets (fossil-based mainly) as well.

A sustainable financial system designed this way creates and values financial assets, it enables transactions conducted in a way that builds genuine prosperity, in order to meet the long-term needs that favour sustainable development. Promoting the financing of green transition on a large and economically viable scale, should guarantee that green investments are prioritised over investments that promote non-sustainable growth patterns. For that reason, green finance encourages a long-term analysis of investments with an environmental impact, and includes the assessment of all criteria of sustainable development such as a broad variety of products and financial services that can be divided into investment, banking and insurance products. Hence, green finance includes all the financial instruments that are used for the execution of initiatives and projects connected with sustainable development – all economic products and policies within the framework of green transition. Green finance ensures funding for all sectors and asset classes, which take into account environmental, social and investment decision-making criteria, considering their climate risk, that are executed to promote sustainable development. For instance, banks see climate risk as a factor impacting new loans – they may adjust granting loans, taking into account the environmental impact of the project in their risk assessments and cost of capital.

It is essential to establish the criteria for defining assets as "ecological", or classifying financing as "green" or "sustainable", since an increasing number of financial institutions strive to support initiatives that are completely free of fossil fuels. Such a set of minimum standards for green finance is essential to ensure the transparency of capital flow towards green and sustainable investments, as well as for the analysis of the ever-changing financial market and climate risk[4]. Climate-friendly investments are prioritized over unsuitable capital spending. Power companies must begin to operate in the green financial markets, in order to raise capital for necessary investments, adjusting their operational activities to green transition worldwide. Green finance promotes long-term investments supporting climate protection targets and responding to climate risk.

## VII. Recommendations for necessary changes of the core activities of power companies. Research results

Power companies must re-design their core activities in order to hedge future profits against the severity of climate risk that radically changes profit drivers. A fundamental change of core activities is required in order to create new perspectives for operating in transforming environments, and to survive in new market conditions. This applies to power companies as well that have to meet the expectations of customers and policy makers. Power companies need to develop expertise in reacting to climate risk, in order to identify necessary infrastructure and system upgrades, operational changes and adaptation options. The need to re-design business models in the power sector, shifting them towards green developments, also results from the attitude of financial institutions

[4] An example of such a solution could be the EU taxonomy for sustainable solutions proposal published by the European Commission in November 2020, which sets out conditions that an economic activity has to meet in order to qualify as environmentally sustainable, to make it easier for investors to assess their investment as regards their impact on the climate.

and investors. They have already identified long-term benefits of investing in accordance with Environmental, Social and Governance (ESG) principles, and require for entities requesting capital to act in a way that respects the environment and climate. Activities that reduce climate risk, change globally the power production structure that becomes greener – RES-based. The future shape of the power sector differs fundamentally from the pre-existing fossil-fuels based industry.

There are various perspectives that need to be considered when designing responses to climate risk – deep and urgent decarbonization of power production, based on the increasing competitiveness of RES, as opposed to fossil-based power plants, is the most visible now. RES have globally become the "target" power sources, but it also creates challenges concerning how to fund necessary investments in the environment (that is, for green finance). It is also essential to ensure the security and flexibility of power supply via, among others, large scale power storage, decentralized power supply, peer-to-peer power trading, and highly flexible power plants. As RES technology matures alongside market innovations, it shifts the operational activity of power companies towards carbon neutrality. Pre-existing business based on fossil fuels starts to disappear and new technology determines the decisions concerning the core activities of power companies.

The challenge here lies in the determination of an optimal technological mix of core activities, with regard not only to power production, but also to power grids, customer connectivity or the digitalization of operational activities. The technological context of defining future core activities influences the long-term sustainability of economic profits in a business environment moving towards hedging against climate risk. Technological developments eliminate pre-existing competitive advantages, making it necessary to implement new, innovative technical and trading solutions. Technology can give an advantage, but when a new solution appears and technological novelties quickly become the standard, power companies must develop too. Changes in the conditions of the power market encourage new no-asset entrants, from outside the power industry, to generate profits based solely on trading. The development of RES and power storage technologies, opened the power market to new companies, supplying photovoltaic installations and power storage batteries. These have created virtual power plants, taking advantages of power sales from thousands spread out installations, during periods of prices increase in intraday (buying and selling power at a power exchange on the same day as its delivery) and balancing markets. RES gathered in such virtual power plants replaces production once limited to traditional power plants. The abovementioned trends force power companies to decommission coal power plants. Incidentally, disinvestment of assets that don't secure future profitability helps collect funds necessary for the transition of the core activities of power companies[5].

Climate risk forces customers to minimize their carbon footprint and de-carbonize industrial processes in order to fight climate change. It creates a significant challenge for power companies to respond to such needs, which make financial institutions commit to fund only green investments reflecting the process of significant capital reallocation – away from assets characterized by GHG emissions and towards carbon-neutral projects. It is the confirmation of the global trend of integrating finance and environmental protection, as the after-effect of the Paris Agreement and the definition of global climate targets. This issue was confirmed during the COP-26 in Glasgow.

[5] Ownership of coal power plant requires large capital expenditure, what is unjustified in the conditions of worsening competitiveness of coal-fired power plants.

Power companies shall respond to the needs of societies and the industry by changing their operational activities towards climate neutrality, which will be an important determinant of future competitiveness. The creation of a low-emission economy becomes a key element of staying competitive when customers leave oil and fossil fuels. Power companies cooperating with other business should create partnerships with their customers, for the de-carbonization of their operational activities, by switching to renewables, bio-fuels and the use of green hydrogen, power storage, demand flexibility and energy efficiency. This will speed up the transition into climate friendly manufacturing technologies. In fact, both industry and society perceive the acceleration of green transition and minimising carbon footprints as an additional impulse to future development and to value creation [Reference 10].

The change in the power production mix generates challenges for the stability of power grids that must become bi-directional. It creates a new approach to power supply management increasingly based on decentralised power production. Power grids need further digitalization and technological advancement. Customers, using digital solutions, can increase efficiency of power usage and reducing energy costs. Hence, power companies shall use technology and available know-how (existing technical expertise, deep knowledge of power networks, capital engineering capabilities) to operate in the new environment. Only a fundamental transformation of operational activities and breakthrough technologies will secure the future success of existing power companies.

## Recommendations

The following recommendations should be made for a long-term change of the core activities of power companies based on the considerations taken in the article:

➢ **Operation area**

- creation of new business models based on the development of renewables production, power storage, smart solutions for customers and power network upgrades;
- improvement of the management of operations and the supply chain;
- development of efficient management of projects and investments;
- creation of new roles and competences along the value chain (RES, green investments management, digitalization, grid);
- development of effective R&D units;
- creation of responsibility centres (business units) for green transition and hedging against climate risk;
- compliance of investment plans with the green taxonomy;
- partnership developments with external companies and institutions in the area of green investments;
- creation of competences enabling the utilization of the possibilities offered by green finance;
- creation of competences necessary to hedge against weather risks related to RES production;
- separation of clean operations from fossil fuel-based production where the risk exists that fossil fuel-based parts of company assets can become stranded costs as they will be de-commissioned in the near future;

- decarbonization of the operational activities of power companies;
- building competences for the digitalization of operational activities in every area where it creates added-value;
- disinvestment of coal power plants to finance a strategy shift toward green transition and secure future profits, as coal-fired power production will be unprofitable in the future;
- development of local, peer-to-peer power trading outside the power system and virtual power plants based on thousands of decentralised prosumer installations backed by power batteries;
- utilization of trading possibilities based on market price volatility;
- M&A to acquire expertise and generate synergies;
- adjustment of risk and pricing models to the dynamics of market conditions.

➢ **Technological area**

- hedging fixed assets against physical risk; the execution of investments in a way that secures their resilience to physical risk;
- simplification and re-balancing of company portfolios by divesting assets no longer instrumental for future profitability;
- development of off-shore and on-shore wind farms and solar power plants;
- development of RES in proximity of current power plants in order to use their existing infrastructure and to reduce investments costs;
- development of battery storage linked to renewables;
- replacing coal in cogeneration by biomass, making heating greener and reducing carbon footprints;
- use of heat-pumps in buildings;
- improvement of power supply quality and resiliency, supported by new connections and infrastructure digitalization;
- investments in the modernization, digitalization and automation of networks, backed by the creation of potential for innovations and knowledge acquisition;
- development of smart grids;
- development of fiberglass networks;
- creation of co-investments opportunities based on platforms enabling third-party investments.

➢ **Competitiveness of customer service**

- building value for customers based on innovation and technological advances, better customer connectivity, securing increase of local green production capacity;
- development of smart, innovative solutions for customers: heat pumps, prosumers, demand flexibility, electric mobility, smart solutions, electrification of industrial processes, green hydrogen, green heating, green transportation;
- setting down the target of carbon- and climate-neutrality;
- electrification as a way to meet energy demands;
- electrification of transport;

- integration of hydrogen production with renewable energy sources to produce green hydrogen, and to create profitability based on ancillary services and sales of green hydrogen to industrial customers and transportation;
- services to third parties based on an exchange of know-how and best practices;
- support in development of carbon free green industry.

Implementing a long-term change in the core activities of power companies should let them become global players in the fight with climate change, allowing the power sector to benefit fully from the opportunities created by transition risk. However, physical risk must be identified as an increasingly more important factor in the management process of power companies. Physical risk must be accounted for in activities undertaken in reaction to such risk, and in securing an undisturbed continuity of the operations of power companies [Reference 10, 30]. It requires the execution of investments in the new conditions of green finance requirements, and to develop efficient project management. This will make it possible to quickly adapt fixed assets portfolios to the reality of green economy, as well as to hedge against physical risk. It is important to secure the resilience of fixed assets (production, power grid) with respect to physical aspects of climate risk. Another aspect of climate risk lies in the necessity to respond successfully to the challenges of transition risk, to the requirements of climate-neutral and zero-carbon regulation, or to the new needs of customers facing the green revolution. Hence, when re-designing the core activities of power companies, the latter must consider the presentation of their profitability in the shifting conditions of the green economy.

## VII. Final remarks

The transformation of core activities of power companies towards an efficient reaction to climate risk should be classified as the most significant challenge facing power companies. Thus, power companies have to work out a long-term approach to re-designing their operational activity securing both, physical assets responsible for the continuity of their operations, and hedging future profits against transition risk. The manifestation of physical risk destroys fixed assets as a result of floods, hurricanes, fires and droughts that limit the production possibilities of hydroelectric plants. Transition risk arises from increasing pressure placed on power companies by investors, industry and societies that require them to take action to mitigate climate change. Hence, climate risk directly affects the directions of capital allocation, the development of products and services, as well as, finally, the shape of the global power sector.

The identification of such a high climate risk exposure makes it necessary to take preventive measures, which must be reflected in a fundamental change of the core activities of power companies. Power companies must also find ways to fund new investments, which should limit the impact of extreme weather conditions on the infrastructure, and to comply with new climate neutral regulations. Hence, there is an observable process of changing the profitability of value chains in the power industry, customers defining their new needs, and pre-existing assets starting to lose value as well as their potential to remain profitable in the future. Climate risk requires power

companies to change their mindsets, to use new operating models, tools and processes in order to integrate physical risk and transition risk into their decision-making process.

The analysis of long-term impact of climate risk on the operations of power companies influences decisions concerning technology and the location of power plants, the selection of suppliers of construction materials, smart grid development and the digitalization of their operational activity. Steps taken in reaction to climate risk will create a fundamental change in the power sector, and lead to the creation of a system based on RES and emission-free production technologies, which will replace pre-existing ones based mainly on fossil fuels. However, one can expect that the change caused by this process will deepen in the coming years, significantly changing the conditions of management activities in power companies. That is why the authors argued that power companies should prepare for a strategic change of their core activities, redefining their operations and the way in which they meet customer needs, towards ensuring the profitability of their future operations. The authors indicted the potential direction of the necessary changes of the operational activities of power companies, which can secure their future market success. This change is also the determinant of future success of particular economies, because the scope of carbon footprint reduction will be a determinant of their competitiveness in the global environment.

To meet the purpose of this article, the authors presented the importance of changing production technology into climate neutrality, as well as to develop green and digital competences, technologies and services. It is also necessary to create added value for customers, to digitalize operational activities and processes that support costs optimization, to create added value overall, and to ensure efficiency and productivity of future operations. There is also a need to upgrade production and grid assets, so as to prepare them for bi-directional power transmission and decentralised, but at the same time localized, energy production, and to utilize existing infrastructure alongside RES developments as a cost cutting factor.

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# Wpływ ryzyka klimatycznego na zarządzanie w długim okresie podstawową działalnością operacyjną przedsiębiorstwa elektroenergetycznego

**Streszczenie**

Jako zjawisko globalne, zmiana klimatu ma znaczący wpływ na gospodarkę. Wysokie temperatury, czy też zmiana wolumenu opadów, dotykają nie tylko rolnictwo i rybołówstwo, ale także wpływają na inne branże, takie jak energetyka, turystyka, budownictwo czy rynki finansowe. Skutki przejawiania się ryzyka klimatycznego są już obecnie identyfikowane i analizowane, chociaż jako okres oddziaływania zmian klimatycznych na gospodarkę wskazywana jest zazwyczaj odległa przyszłość. Wzrost ryzyka klimatycznego powoduje poważne straty finansowe, które sięgają miliardów dolarów rocznie. Stąd też rośnie zainteresowanie ekonomiczną stroną zmian klimatycznych nie tylko ze strony klimatologów, ale także przedsiębiorstw zaskoczonych bezprecedensowymi katastrofami i zmianami regulacyjnymi.

Realizując cele artykułu autorzy opisują wyzwania stojące przed przedsiębiorstwami elektroenergetycznymi spowodowane ryzykiem klimatycznym. Przedstawiono również niezbędne długoterminowe zmiany w zarządzaniu ich podstawową działalnością operacyjną oraz w elementach ich modeli biznesowych, konieczne dla zapewnienia przyszłego sukcesy ich gospodarowania w realiach zielonej transformacji. Autorzy starają się przedstawić własne wnioski wynikające nie tylko z analizy literatury przedmiotu, ale przede wszystkim z praktyki. Analizują doświadczenia liderów zielonej transformacji w energetyce, które dotyczą niezbędnych zmian w podstawowej działalności przedsiębiorstw energetycznych, mających na celu zabezpieczenie ich przyszłych wyników ekonomicznych przed wpływem szeroko rozumianego ryzyka klimatycznego. W tym kontekście muszą nastąpić niezbędne dostosowania w zakresie działalności operacyjnej i inwestycji przedsiębiorstw energetycznych, ich współpracy z klientami, rozwoju technologii wytwarzania energii elektrycznej oraz modernizacji sieci elektroenergetycznych. Stąd podsumowując rozważania artykułu i dopełniając jego cel, autorzy proponują rekomendacje dotyczące długookresowego rozwoju działalności operacyjnej przedsiębiorstw elektroenergetycznych. Autorzy dążą do wypełnienia pewnej luki w literaturze przedmiotu, podchodząc całościowo do niezbędnych zmian w zarządzaniu podstawową działalnością przedsiębiorstw elektroenergetycznych. Zmiany te, wywołane wszystkimi aspektami ryzyka klimatycznego, powinny zapewnić przyszłą rentowność działalności operacyjnej przedsiębiorstw elektroenergetycznych w warunkach zwiększającej się dotkliwości ryzyka klimatycznego.

**Słowa kluczowe:** zarządzanie; strategia; przedsiębiorstwo elektroenergetyczne; ryzyko klimatyczne; ryzyko; OZE.

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