A Review on the Impacts of Climate Change on the Power Systems

Rakshit Jakhar, Ravi Raj

Abstract*: Significant development of the global power system is needed to mitigate climate change. However, patterns of power demand and transmission systems themselves depend upon the impacts of environmental change. These effects will variously hinder and help adaptation and mitigation efforts; thus, it is essential they are fully acknowledged and consolidated into models utilized for the illustration of decarbonization pathways of power systems. Climate change and global warming affect the quality of power, generation of power, and transmission of power. One of the major problems is islanding is also generated due to climate change. To recognize the present state of climate change impacts on the power systems will be discussed in detail in this paper. This paper mainly studies the effects of the environment on power generation and transmission systems. Also, the application of artificial intelligence to mitigate the issue of climate change and their corresponding impacts on the power system has been discussed.

Keywords: Artificial Intelligence (AI), Global Warming, Power Quality, Power Generations, Power Transmissions, Power System Protection.

I. INTRODUCTION

The Power system consists mainly of three steps generation of power, the transmission of power, and consumption of power. These three parts of the power system can be affected by changes in the environment's ideal condition. Variations in climate such as temperature increased, and unpredictable weather are the main factors behind the power quality and harmonics issues of power systems. The reason for changing the climate is mostly due to the huge amount of greenhouse and carbon gas generated by us. The major problem associated with the Power system which is called "Islanding" is also due to the environmental effects [1]. However, our understanding of environmental change effects on power systems has enhanced rapidly over the recent decades, but a comprehensive study of the impacts has not been done yet. Various research has been shown that the power system not only responsible for changes in climate, but it is also vulnerable to environmental change. These impacts are associated with various perspectives of power systems, including supply and demand of energy, and power quality, but also transport and cost of power. On the supply part, non-conventional energy resources including wind, solar, bio, and hydropower are affected by environmental change in degrees of variation because of variability and changes in temperature, precipitation, solar irradiation, and speed of wind. Thermal energy resources such as nuclear, fossil fuel, and biomass, the impact of face temperature on the systems of cooling and, also on the efficiency of the turbine. With climate change, effects on thermal energy generation systems might be intensified due to regional and national regulations of the environment on withdrawal of cooling water, release, and consumption into environmental water resources, which might outcome in the generation of power curtailments. Climate extremes and climate change might also impact the resilience of power systems and the power supply reliability via effects on supply systems or siting of infrastructure [2]. Furthermore, changes in the environment might affect the potential of power supply although effects on use of land. On the consumer side, the change in climate affects the demand for power by impacting the magnitude and duration of diurnal and occasional cooling and heating requirements. Lastly, environmental change might affect power systems indirectly by impacting competition of cross-sectoral sources, including water for generating hydropower, which is necessary in the thermal power plant cooling systems, and utilizes as regional supply, the ecosystems of freshwater, manufacturing, and irrigation. The Power systems might also adapt to the impacts of climate change. Mechanisms of adaptation might include decreasing the demands of power, decreasing the demands of water for cooling functionalities through alternative technologies of cooling, and enhancing the capacity of energy generation and storage of power. The susceptibility of the sector of power might also be decreased by variations for the combination of generation of electricity technology [3]. In recent decades, a number of increased studies and research have explored the possible impacts of environmental variations on the power sector. Although, a deep literature analysis is lacking. Here, we review a wide range of research that happens in this field. Overall, this research paper discusses local and global range understanding gaps on the impact of environmental change on power systems and delivers deeper knowledge that might provide guidance for future assessment and research frameworks. Fig. 1 demonstrates a framework for the assessment of the impacts of climate change on power systems. Power systems contain supplies for initial power from wind power, bioenergy, hydropower, solar power, other renewables, fossil fuels, and nuclear power.

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It also contains the transformation to secondary sources of energy, power grids, and transport, together with power demand in industry, transport, and buildings. Elements of box runoff and power plants of thermal types are mostly run by the temperature of the water, and thus with corresponding matching colors. The air temperature of the box element has not coincided with an unique another part because of its capability of power systems impact in greater than another box. Cold degree days (CDD), Heating degree days are also affecting the power systems and mostly power quality.

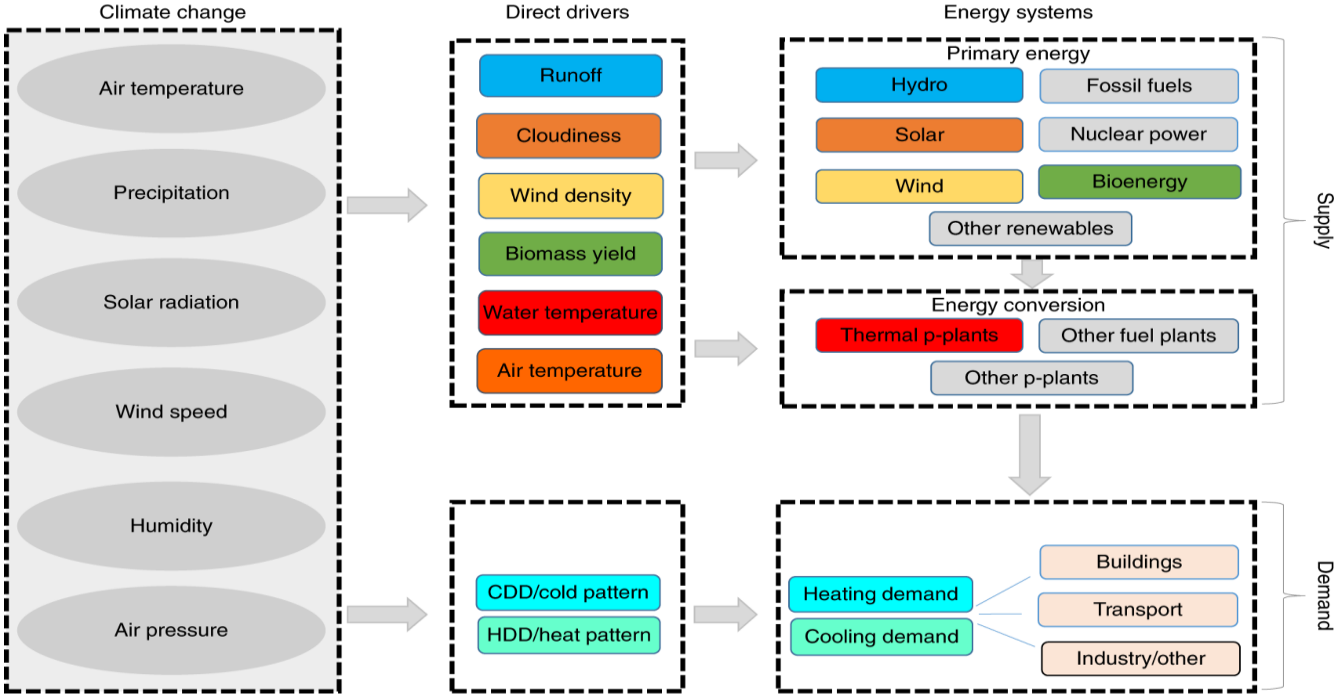

Fig. 1. The Conceptual Framework and Architecture Estimation for the Climate Change on Power Systems [4]

II. LITERATURE SURVEY

In the last two decades, researchers have been focusing on the issue of environmental change's impacts on power systems. J. Cronin *et al.* [5] present a review of gaps and trends in the impacts of environmental variations on energy systems. To provide the present state of knowledge of this area and find the priorities of research, this article mostly reviews the previous research topics on the effects of environmental change on the supply system of power, summarizing the local area of studies, locates in their outcomes and disagreement resources. S. N. Chandramowli *et al.* [6] discuss the impact of environmental variation on energy systems and their markets. This article highlights the areas of research where the frontiers of knowledge have progressed potentially like a significant increase in air temperature; estimation of temperature-sensitive demand; the localized effect of variations in environment on the resources of wind; vulnerabilities of supply due to reduced availability of water; effects of cooling water at plant-level for the generation of power etc. This research review provides the future design of electricity markets and models of the system. G. M. Tina *et al.* [7] discuss a wide range of impacts of change in climate on power systems, by analyzing a proposed model of power generation and demand systems. This paper also interprets the variables of meteorological on power demands and generations. The research is mostly focused on Italian future perspectives of the power system's means of energy production and demand. This article concentrates on the effect of environmental change on the present, and future, the power system of Italy.

P. Chen *et al.* [8] present an analysis of optimal temperature as a basis to illustrate the variation of weather and changes in climate impact on the peak load in the summertime in the Harris County area of the United States. Because it is crucial to know how to alleviate the impacts of weather on long and mid-term efforts of planning to build a perfect power system. M. T. Craig *et al.* [9] present the assessment and estimation of environment change's effects on renewable energy resources such as solar and wind resources by creating solar and wind profiles of generation for a period of reference and five changes of climate projections. Then drive an economic and unit commitment dispatch model to send a highly non-conventional fleet of generators with these profiles. This article utilizes five models of global climate to illustrate the impact of environmental change on the energy sector. D. Burillo *et al.* [10] illustrates various ways in which climate change impacts the infrastructure of electric power, options for adaptation, and options for mitigation. Because climate change adaptation and mitigation are the main force driving the modernization of the infrastructure of electric power systems which will have more non-conventional energy systems. This article provides a quantitative case analysis to illustrate vulnerabilities from waves of heat in the southwest desert of the United States, including the performance of infrastructure for long-term forecasting, as well as several demand-side and supply-side strategic options to retain reliable operations.

S. Parkpoom *et al.* [11] discuss how climate change will impact Thailand's long-term, daily, and seasonal demand for electricity. Here regression models are used to gather patterns of daily load across every month in a year. The projections of temperature from the climate model of the UK Hadley Centre are then utilized to estimate sensitivity hourly to changes in the diurnal and mean temperature range. M. Panteli *et al.* [12] present comprehensive and important activities of research and findings of project Resilient Electricity Networks for Great Britain, especially focusing on possible implications of climate change related to supply and demand forecasts, ratings of components, and extreme weather impact on the reliability of the system. The main aim is to facilitate deeper insights into several weather and climate-related challenges which can be faced by Great Britain's electricity system in the future. J. N. Fidalgo *et al.* [13] illustrate the impacts of environmental change on the mix of power in Portugal in the long or medium term. This paper utilizes the climate scenarios simulation and projections of the available power plant by consumption and types to analyze the impacts. The result of this research article shows that the most favorable climate scenarios specify that a system of non-conventional energy sources is better in the medium range.

III. ARCHITECTURE OF THE POWER SYSTEMS

The power system, also known as the electrical grid, is a complex network that is designed to generate, transmit, and distribute electricity from power plants to consumers. The structure of the power system can be divided into three main components: generation, transmission, and distribution [14].

A. Generation

This is the process of producing electricity from various sources such as coal, natural gas, nuclear, hydroelectric, wind, solar, and geothermal. Power plants are responsible for generating electricity, and they are usually located near the source of the energy they use.

B. Transmission

Once electricity is generated, it needs to be transmitted over long distances from power plants to distribution centers, cities, and towns. High-voltage transmission lines are used to transport electricity over long distances, and they are typically owned and operated by transmission system operators (TSOs).

C. Distribution

The final component of the power system is distribution, which involves the delivery of electricity to end-users such as households, businesses, and industries. Distribution systems consist of low-voltage lines, transformers, and other equipment that are used to step down the voltage of the electricity so that it can be used safely by consumers. Distribution systems are typically owned and operated by local utilities.

In addition to these three main components, the power system also includes various control and monitoring systems that are used to ensure the reliability and stability of the grid. These systems include protection relays, automatic control systems, and energy management systems, among others. The power system is a complex and interconnected network, and ensuring its reliable operation requires the collaboration of various stakeholders, including power generators, TSOs, local utilities, and regulatory agencies [15]. A complete architecture of the power system is well defined in Fig. 2.

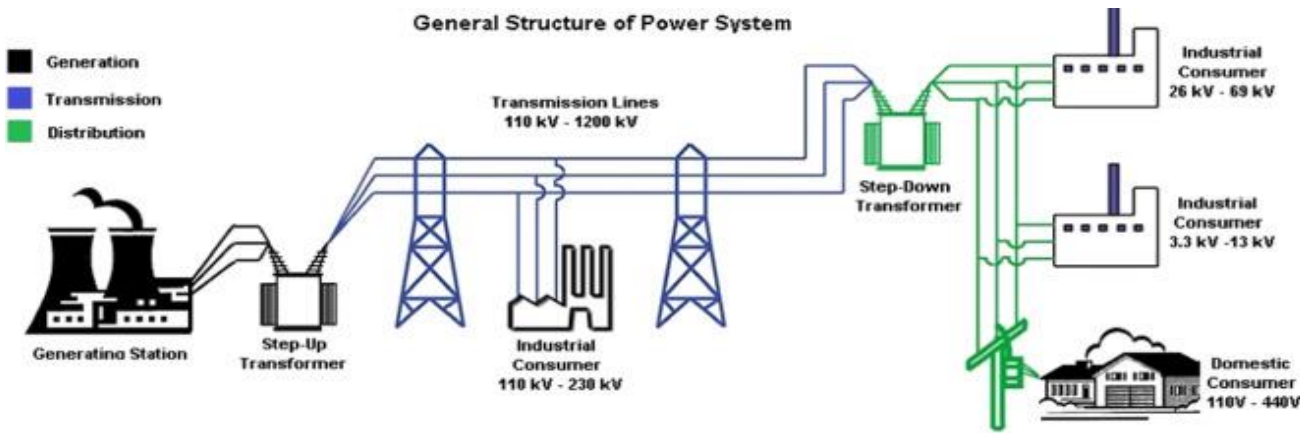

Fig. 2. An architecture of complete power system [15]

IV. MAJOR IMPACTS ON POWER GENERATION SYSTEMS

Any power systems have mostly three stages primary stage is called the generation stage, the secondary is called the transmission stage, and the third stage is called the distribution stage. There are various resources available for the generation of power. Fig. 3 illustrates almost every resource of electricity generation. At the generation stage, the impacts of environmental variation on the type of hydropower outcomes among fluctuations in evaporation, precipitation, and providing patterns of runoff that impact the volumes and variability of the flow of the stream. Almost every research on variation in climate affects hydropower emphasis on local scales and locating various impacts of environmental fluctuation across regions, with a regularity of estimated reduction in the capacity of hydropower. The climate change effects on the development of hydropower are interactive, often complex, issues.

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Environmental variation is a global issue; however, the impacts of environmental fluctuation on the generation of hydropower are not equal over various spatial scales [16]. The non-uniform impacts depend on such reasons as regional conditions of hydrological and features of geography.

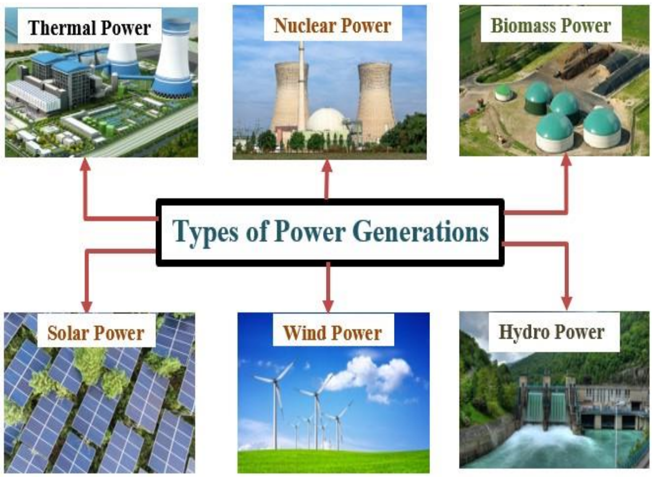

Fig. 3. Some Major Types of Power Generations

Studies generally describe unexceptional or very small positive impacts of environmental variation on local solar power capacities as an outcome of fluctuation in temperature and irradiation, with contradicting variations across associations of simulation in a few cases [17]. The outcomes of the impact of the environment on the potential of solar power are mixed, with separating outcomes and studies across various regions. The direct impacts of environmental change on solar energy are around 5% or very small yet robust. These impacts are very small because variations of irradiation remain small and bad impacts of global warming generally happen at high latitudes, which have a very low potential of photo-voltaic than the areas of low-latitude regions [18].

Environmental variation is playing a vital role in the fluctuation of variability and intensity of winds near surfaces, either through regional impacts or by redesigning the mega-scale flow. The pattern of variations is both vigorous beyond the possibility of outline, and uninterrupted: there is an almost similar sequence of variations found at the end of the 21st century later as in the earlier. The impact of environmental variation on wind resources of Europe has been estimated using the latest local model of the climate of the single model ensemble from the Centre of Rossby (RCA4) [19].

Recently, thermal power generations are at very risk due to climate variations since their performance and efficiency depend on the density of air, parameters of hydrometeorological, and ambient temperature. Also, these thermal energy generation systems are vulnerable to critical damages due to abnormal violent incidents caused by variations in climate such as hurricanes and floods [20]. Changing in climate is predicted to minimize the capacity of cooling-dependent thermal power through minimized warming ambient, reduced streamflow, and temperature of streamflow. Global evaluations of the thermal power plants project vulnerability which is more than 80 percent of trees around the globe will give few deductions in usable potential. Although, the impact of minimized available thermal power potential for the energy system, in respect of reliability, cost, and emissions, might considered as very less necessary as we approach in the direction of more non-conventional, and is therefore dependent on future potential enlargement and scenarios of the market.

The impacts of climate change on the potential of biomass power generation systems are generally mixed. An important key element mentions the impact of fertilization of CO2 (Carbon di-Oxide), related to precipitation and temperature impacts, and compare it with the utilization of another land as an outcome of climate fluctuation. Therefore, the impacts of climate quantification on biomass power remain complex because of uncertainties correlated with local fluctuation, and future water and land availability [21]. The generation of power from biomass is renewable and the impacts on the environment by the utilization of biomass as the resource of energy is most useful because it gives the reduction in the emission of greenhouse gases, reduction in water and air pollution, and reclamation of land.

In recent years due to awareness of variations in climate, nuclear resource of energy has got more attention. Places that attribute nuclear resources have a significant role in the mitigation of climate change emergence. Fluctuations in the climate might impact the nuclear reactors in various ways like increased temperature, high-speed wind, land erosion, and many more. As nuclear elements are radioactive, and they are very sensitive and risky, their operation needs a better stable climate which is necessary to provide better outputs.

V. MAJOR IMPACTS ON POWER TRANSMISSION SYSTEMS

Climate change can have a significant impact on power system transmission lines. One of the main impacts is the increased frequency and intensity of extreme weather events, such as hurricanes, tornadoes, and heavy snowfall, which can damage transmission lines and disrupt the electricity supply. Rising temperatures can also increase the demand for electricity as people turn to air conditioning to keep cool. This can put a strain on the power grid and increase the likelihood of power outages. In addition, climate change can affect the availability and quality of water resources, which are used in the production of hydroelectric power [22]. Droughts and heat waves can reduce the flow of water, which can lead to a decrease in hydroelectric power production. Finally, as renewable energy sources such as wind and solar power become more widespread, the power system will become more decentralized and distributed, with power generation occurring closer to where it is consumed. This can reduce the need for long-distance transmission lines but also requires more complex planning and management of the power grid. Overall, the impact of climate change on power system transmission lines is a complex issue that requires careful planning and management to ensure the reliability and resiliency of the power grid.

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VI. ARTIFICIAL INTELLIGENCE FOR THE POWER SYSTEM

AI has the potential to play a significant role in combating the impacts of climate change on power systems [23]. Here are some examples of how AI can be applied:

A. Forecasting demand and generation

AI algorithms can be used to forecast future demand for electricity based on historical data, weather patterns, and other relevant factors. This can help utilities and grid operators plan and adjust their generation and transmission capacity, accordingly, reducing the risk of power outages and improving efficiency.

B. Optimizing energy use

AI can be used to optimize energy use in buildings and other facilities, reducing energy waste and carbon emissions. Smart building systems that use AI to analyze data on occupancy, temperature, and other factors can adjust energy use in real-time to minimize waste and improve energy efficiency.

C. Improving grid efficiency

AI algorithms can be used to optimize the operation of the power grid, reducing energy losses, and improving the overall efficiency of the system. This can include tasks such as managing power flow, balancing supply, and demand, and reducing transmission losses.

D. Predicting and Mitigating Weather-Related Risks

AI can be used to predict weather patterns and identify potential risks to the power system, such as storms or extreme temperatures. This can help utilities and grid operators take proactive measures to mitigate the risks, such as reinforcing infrastructure or adjusting power generation and transmission capacity.

E. Managing Renewable Energy Sources

AI can be used to manage and optimize the use of renewable energy sources such as wind and solar power. This can include tasks such as forecasting output, managing energy storage systems, and optimizing the use of distributed generation. Overall, AI has the potential to play a significant role in combating the impacts of climate change on power systems, improving efficiency, reducing waste, and increasing the resiliency of the grid.

VII. RESULT AND DISCUSSION

This article reviews the impacts of climate change on power systems and highlights the significant challenges faced by the power sector in adapting to the changing climate. The review has identified the following key results and discussion points:

1) ***Increased demand for electricity***: As temperatures rise, the demand for air conditioning and refrigeration increases, leading to a surge in electricity demand. This puts pressure on the power system to generate and distribute more electricity, which can strain the system, leading to power outages.
2) ***Reduced power generation***: Climate change can also affect the availability of traditional sources of power generation such as hydroelectricity and thermal power plants. Reduced water availability can reduce hydroelectricity generation, while increased temperatures can reduce the efficiency of thermal power plants.
3) ***Damage to infrastructure:*** Severe weather events such as hurricanes, typhoons, and floods can cause significant damage to power infrastructure, including transmission and distribution lines, power stations, and transformers. This can result in prolonged power outages, affecting the reliability of the power system.
4) ***Changes in water availability:*** Climate change can also cause changes in water availability, which can impact the operation of power systems that rely on water for power generation. For example, reduced water availability can limit the operation of hydroelectric power plants, while increased water levels can cause flooding and damage to power infrastructure.
5) ***Need for adaptation and investment:*** To address the impacts of climate change on power systems, there is a growing need for planning and investment to ensure the resilience of the power system. This includes strategies such as improving the efficiency of the power system, increasing the use of renewable energy sources, and developing AI-powered solutions to optimize energy use and manage risks.

This review highlights the need for the power sector to adapt to the changing climate to maintain a reliable supply of electricity. The challenges faced by power systems due to climate change require a comprehensive and collaborative approach involving various stakeholders to ensure the resilience and sustainability of the power system.

VIII. CONCLUSION

Climate change has significant impacts on power systems, affecting generation, transmission, and distribution of electricity. The increased demand for electricity due to rising temperatures, reduced power generation from traditional sources, and the damage to infrastructure caused by severe weather events are some of the main challenges faced by power systems. Moreover, changes in water availability and demand patterns further complicate the situation. To combat these impacts, there is a growing need for planning and investment to ensure that power systems can adapt to the changing climate and maintain a reliable supply of electricity. This includes implementing strategies such as improving the efficiency of the power system, increasing the use of renewable energy sources, and developing AI-powered solutions to optimize energy use and manage risks. In summary, addressing the impacts of climate change on power systems requires a comprehensive and collaborative approach involving various stakeholders, including power generators, TSOs, local utilities, and regulatory agencies. With careful planning and investment, it is possible to build more resilient and sustainable power systems that can adapt to the changing climate and provide reliable electricity to consumers. This paper provides an outstanding review on the impacts of climate change on power systems and on various parts of power systems.

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Authors Contributions	All authors have equal participation in this article.

REFERENCES

1. R. Raj, and A. Kos, "A Novel Method of Islanding Detection in a Distributed Power Generation System Integrated with Photovoltaic-Array", Przegląd Elektrotechniczny, Vol. 2022, Issue 7, pp. 88-94, July 2022. Doi: 10.15199/48.2022.07.15. [CrossRef]
2. L. Liu, M. Hejazi, H. Li, B. Forman, & X. Zhang, "Vulnerability of US thermoelectric power generation to climate change when incorporating state-level environmental regulations", Nature Energy 2, 17109, 2017, doi: 10.1038/nenergy.2017.109. [CrossRef]
3. J. Ebinger,& W. Vergara, "Climate Impacts on Energy Systems: Key Issues for Energy Sector Adaptation", by The World Bank, 2011. [CrossRef]
4. S. G. Yalew et al., "Impacts of climate change on energy systems in global and regional scenarios", Nature Energy 5, pp. 794-802, 2020, doi: 10.1038/s41560-020-0664-z. [CrossRef]
5. J. Cronin, G. Anandarajah, and O. Dessens, "Climate change impacts on the energy system: a review of trends and gaps", Climate Change 151, pp. 79-93, 2018, doi: 10.1007/s10584-018-2265-4. [CrossRef]
6. S. N. Chandramowli, and F. A. Felder, "Impact of climate change on electricity systems and markets- A review of models and forecasts", Sustainable Energy Technologies and Assessments, vol. 5, pp. 62-74, March 2014, doi: 10.1016/j.seta.2013.11.003. [CrossRef]
7. G. M. Tina, and C. F. Nicolosi, "Assessment of the Impacts of climate change on Power Systems: The Italion Case Study", Applied Sciences (MDPI), vol. 11, no. 11821, 2021, doi: 10.3390/app112411821. [CrossRef]
8. P. Chen and M. Kezunovic, "Weather variation and climate change impacts on power system," 2017 IEEE Power & Energy Society General Meeting, 2017, pp. 1-5, doi: 10.1109/PESGM.2017.8274116. [CrossRef]
9. M. T. Craig, I. L. Carreno, M. Rossol, B. M. Hodge, and C. Brancucci, "Effects on power system operations of potential changes in wind and solar generation potential under climate change", Environmental Research Letters, vol. 14, no. 3, March 2019, doi: 10.1088/1748-9326/aaf93b. [CrossRef]
10. D. Burillo, "Effects of Climate Change in Electric Power Infrastructures", in Power System Stability. London, United Kingdom: IntechOpen, 2018 [Online]. Available at: https://www.intechopen.com/chapters/64723 [CrossRef]
11. S. Parkpoom and G. P. Harrison, "Analyzing the Impact of Climate Change on Future Electricity Demand in Thailand," in IEEE Transactions on Power Systems, vol. 23, no. 3, pp. 1441-1448, Aug. 2008, doi: 10.1109/TPWRS.2008.922254. [CrossRef]
12. M. Panteli et al., "Impact of climate change on the resilience of the UK power system," IET International Conference on Resilience of Transmission and Distribution Networks (RTDN) 2015, 2015, pp. 1-6, doi: 10.1049/cp.2015.0878. [CrossRef]
13. J. N. Fidalgo, D. de São José and C. Silva, "Impact of Climate Changes on the Portuguese Energy Generation Mix," 2019 16th International Conference on the European Energy Market (EEM), 2019, pp. 1-6, doi: 10.1109/EEM.2019.8916539. [CrossRef]
14. G. Parise, L. Martirano and L. Parise, "The architecture of electric power systems: Some special cases," 2014 IEEE/IAS 50th Industrial & Commercial Power Systems Technical Conference, Fort Worth, TX, USA, 2014, pp. 1-6, doi: 10.1109/ICPS.2014.6839153. [CrossRef]
15. T. S. Kishore and S. K. Singal, "Optimal economic planning of power transmission lines: A review," Renewable and Sustainable Energy Reviews, vol. 39, pp. 949–974, Nov. 2014, doi: 10.1016/j.rser.2014.07.125. [CrossRef]
16. J. Shu, J. J. Qu, R. Motha, J. C. Xu, and D. F. Dong, "Impacts of climate change on hydropower development and sustainability: a review", IOP Conference Series: Earth and Env. Science, vol. 163, 2018, doi: 10.1088/1755-1315/163/1/012126. [CrossRef]
17. B. Bartók et al., "Projected changes in surface solar radiation in CMIP5 global climate models and in EURO-CORDEX regional climate models for Europe", Climate Dynamics 49, pp. 2665–2683, 2017. [CrossRef]
18. D. E. H. J. Gernaat, H. S. D. Boer, V. Daioglou, S. G. Yalew, C. Muller, and D. P. V. Vuuren, "Climate change impacts on renewable energy supply", Nature climate change 11, pp. 119-125, 2021. [CrossRef]
19. R. Davy, N. Gnatiuk, L. Pettersson, and L. Bobylev, "Climate change impacts on wind energy potential in the European domain with a focus on the Black sea", Renewable and Sustainable Energy Reviews, vol. 81, part- 2, pp. 1652-1659, January 2018, doi: 10.1016/j.rser.2017.05.253. [CrossRef]
20. M. Makky, and H. Kalash, "Potential Risk of Climate Change on Thermal Power Plants", April 2013, available at- https://www.researchgate.net/publication/236174007_Potential_Risks_of_Climate_Change_on_Thermal_Power_Plants (accessed on March 20, 2022).
21. G. Berndes, M. Hoogwijk, & R. Van den Broek, "The contribution of biomass in the future global energy supply: a review of 17 studies", Biomass Bioenery, vol. 25, issue-1, pp. 1–28, 2003, doi: 10.1016/S0961-9534(02)00185-X. [CrossRef]
22. P. -C. Chen and M. Kezunovic, "Weather variation and climate change impacts on power system," 2017 IEEE Power & Energy Society General Meeting, Chicago, IL, USA, 2017, pp. 1-5, doi: 10.1109/PESGM.2017.8274116. [CrossRef]
23. R. Raj, and A. Kos, "Artificial Intelligence: Evolution, Developments, Applications, and Future Scope", Przegląd Elektrotechniczny, Vol. 2023, Issue 2, pp. 1-13, February 2023. Doi: 10.15199/48.2023.02.01. [CrossRef]

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