Climate Change and the Vulnerability of Germany's Power Sector to Heat and Drought

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Being a main contributor to greenhouse gas emissions in the EU, the electricity sector itself is vulnerable to climate change. Consequently, the impacts of extreme weather events and the resilience of the energy sector have become the subject of regulatory initiatives and ongoing research. The summer of 2018 provided a preview of possible adverse developments, as it was characterized by an enduring heat wave accompanied by droughts in various regions throughout Europe that lasted until the end of autumn. During this period, France and Germany reported multiple cuts in nuclear and coal-based electricity generation.

This study aims to contribute to a better understanding of the potential effects of high temperatures and droughts on power systems, thereby improving the electricity sector's risk-preparedness. The findings highlight vulnerabilities in the operation of thermal generation capacities and identify assets that are subject to high risk. Our analysis is based on extensive meteorological and power market datasets covering temperature and drought data for the last 40 years, as well as power plant outages and locations. We present evidence of a higher frequency of power plant outages in the context of droughts and high temperatures.

Using real options analysis, we provide estimates of current economic damages as the risk-adjusted cost of outages. This allows us to assess the risk-adjusted economic costs of climate change for the German electricity sector for the current composition of the power system. Our results can be applied when assessing the need to renovate or decommission old capacities, considering the costs of renovation. The results of our analysis are essential for the further calibration and estimation of the economic damage functions for specific locations of thermal power plants, which are necessary to estimate the future economic costs from climate change.

The methodology proposed in the paper should help to navigate the transformation of the energy system based on a holistic approach to decarbonization and adaptation. Our analysis shows that an exclusive focus on cost-efficient decarbonization of power generation might result in an assets allocation that is in turn less resilient to the effects of climate change. Thus, when designing future system structures, decision makers should consider the possible effects of climate change on the system and not only the system's effects on climate change.

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