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Integration of Photovoltaics into Microgrids for resilient Backup Power Supply of critical Infrastructure

The decarbonization of energy systems requires not only the substitution of fossil fuels with renewable sources but also the development of robust supply concepts for crisis scenarios. In particular, during a prolonged blackout, the continued power supply of critical infrastructure (CRITIS) is essential to mitigate societal and economic damage. As part of the research project SiSKIN Applied at the University of Wuppertal, the potential contribution of photovoltaic (PV) systems to the partial supply of CRITIS within microgrids is being investigated. The objective is to integrate decentralized, emission-free generation capacities and modern storage technologies into the grid restoration process following a blackout.

To this end, a realistic low-voltage test grid was established at the university's Smart Grid Laboratory, enabling the integration of PV systems in an isolated grid environment. Various control and regulation concepts were developed and implemented to maximize the grid-supportive potential of volatile PV feed-in. The results demonstrate that PV systems, when operated with frequency-dependent feed-in characteristics, can effectively support and relieve conventional black-start capable power plants during blackout scenarios. This contributes to prolonging the operational duration of these units given their limited fossil fuel reserves, thereby improving the overall carbon footprint. Furthermore, PV-based energy supply was shown to enable the stepwise expansion of the microgrid, allowing the temporary inclusion of additional CRITIS elements.

The findings underscore that the use of renewable energy sources in emergency scenarios is not only feasible but also beneficial to grid resilience. However, successful implementation at the distribution grid level requires comprehensive contingency planning and improved controllability of decentralized energy resources. These results contribute to the development of low-emission, resilient energy systems and support the goals of the initiative towards Zero Waste and Zero Carbon.

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