Algorithm for optimizing the operation of wind turbines based on electricity prices

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Employing the novel algorithm, we can ingeniously orchestrate a software-driven simulation that strategically forecasts viable operational tactics and the consequent revenue streams for wind turbines. This approach facilitates the pinnacle of lifespan optimization and profit maximization for these energy assets.

- Optimizing revenues from the sale of electricity
- Avoiding overload of the power grid
- Software-based solution, therefore low hardware investment
- Avoiding negative electricity price
- Possible to integrate monitoring of wind turbines
- Reducing uncertainty in terms of power prediction through flow measurement in wind farms
- Monitoring of service life with condition monitoring reduces uncertainty in terms of estimated remaining service life

Fields of application

This method is poised to revolutionize the optimization of wind turbine operations, particularly in adapting to fluctuating electricity prices.

Background

Renewable energies are becoming increasingly vital in meeting daily power needs. Electricity from sources like wind, hydropower, biomass, or photovoltaics is crucial for energy providers, forming a foundational component of the ongoing energy transition.

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Service

Technologie-Lizenz-Büro GmbH has been entrusted with exploiting this technology and assisting companies in obtaining licenses.

Problem

The dilemma at hand is the inherent unpredictability of energy yields from renewable sources like photovoltaic and wind energy systems. These systems are significantly influenced by meteorological conditions, leading to substantial fluctuations in output. Currently, wind power is directly integrated into the electrical grid, irrespective of prevailing electricity prices. Under the existing framework, network operators remunerate generators based on a feed-in tariff system, as stipulated by the EEG (Erneuerbare-Energien-Gesetz), guaranteeing a minimum price for the supplied energy.

Solution

Looking towards the future, there's a paradigm shift anticipated in how renewable energy producers will interact with the electricity market. They are expected to sell their electricity directly, navigating through market dynamics. This shift presents a unique challenge during periods of favorable weather conditions, where wind and solar energy supply can significantly exceed demand. Consequently, this oversupply can lead to instances where electricity prices plummet, at times even turning negative, particularly during periods of low demand for 'green electricity'.

To capitalize on the potential of electricity marketing and ensure maximized revenue, it's imperative to fine-tune the feed-in of wind power in response to market signals. This approach requires a strategic alignment of energy production with real-time market dynamics, ensuring that renewable energy sources not only contribute to a sustainable future but also remain economically viable and market-competitive."

The University of Stuttgart has made a significant leap forward in renewable energy technology with the development of a groundbreaking method for the real-time optimization of wind turbine operation strategies. This innovative approach, powered by a proprietary algorithm, allows for a detailed simulation of various operational strategies. These simulations, supported by advanced software, enable wind turbines to achieve optimal service life utilization and maximize revenue generation.

Wind turbines are typically capable of functioning in multiple modes. 'Uprating' allows the system to temporarily operate above its nominal output, a process that demands meticulous monitoring of the system's service life due to the resultant increase in operational load. Conversely, 'downrating' involves running the system below its nominal load during periods of low electricity prices. This strategy not only prevents grid overload but also conserves the turbine's lifespan by reducing wear and tear.

The 'Power Shifting' operational strategy is central to this method. It involves storing the energy generated during low electricity price periods at nominal output. Additionally, 'Wake Management' enhances wind turbine efficiency by manipulating the wake effect. However, this increase in performance necessitates integrated follow-up controls within the service life monitoring system to manage the additional load.

Flow modeling plays a critical role in this approach, forecasting the available wind power for upcoming time blocks (e.g., 15 minutes). Enhancing these predictions through empirical measurements or advanced flow models is critical, as market conditions – the supply and demand of electricity – directly influence the electricity price in the subsequent time block.

The algorithm simulates possible operating strategies under given flow conditions, considering both service life and potential revenue. From these simulations, the strategy yielding the highest returns is identified and implemented. Consequently, the wind turbine operates in the most economically advantageous mode as calculated by the algorithm, optimizing the proceeds from electricity sales.

Publication and links

Eguinoa, I, Göçmen, T, Garcia-Rosa, PB, et al. Wind farm flow control oriented to electricity markets and grid integration: Initial perspective analysis. Adv Control Appl. 2021;e80.

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