Talk : About the power production of the wind farm, depending on the wind characteristics of the local site

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Abstract:

The presentation provides an overview of IFPEN's research in the wind energy sector, highlighting the challenges that can potentially be addressed using reduced order models. Wind farms, which cluster multiple turbines together, face a significant issue: some turbines operate in the wake of others, leading to energy production losses and increased structural fatigue. This makes understanding wake behavior crucial for predicting both performance and structural reliability of wind turbines.

A key aspect is the recognition that wake characteristics are heavily dependent on wind conditions. Consequently, accurate prediction of site-specific wind patterns is essential for optimal wind farm operation. Traditionally, this prediction requires time-consuming Computational Fluid Dynamics simulations to link large-scale weather patterns to local wind characteristics. Reduced order models could present a promising opportunity to potentially enhance this process, possibly offering a more efficient method for wind prediction in the future.

Enhancing wind farm performance during operation requires effective strategies to mitigate wake losses, such as wake steering. This necessitates the evaluation of farm-level control strategies. To test, validate, and refine these approaches, a virtual wind farm model could be invaluable, and this is an area where reduced order models (ROMs) could offer significant benefits.However, implementing control strategies like wake steering may involve changes in turbine orientation, potentially increasing loads and fatigue on wind turbines. To ensure the long-term reliability of the wind farm, it's crucial to conduct structural-wind coupling simulations. These simulations are typically time-consuming, and the application of ROMs could potentially streamline this process, accelerating the development and implementation of improvement strategies.The benefits of ROMs extend to the structural design phase, where numerous environmental conditions affecting wind turbines need to be evaluated efficiently. Additionally, ROMs could play a role in asset monitoring, particularly in detecting underperformance or failures. While operational mode analysis can identify issues, pinpointing the exact location and origin of faults requires mapping between parameters and failures - a process that currently demands numerous costly structural simulations.

Ultimately, the key factors in improving wind project profitability are understanding wind characteristics, mitigating wake losses, and ensuring structural reliability. Each of these areas could potentially benefit from the integration of ROM strategies into the wind farm design and operation toolchain. By enabling faster, more efficient simulations and analyses, ROMs could accelerate innovation and optimization in wind energy technology, leading to more productive and reliable wind farms.