Space4Wind

Surface roughness from earth observations to improve site assessment for wind energy converters

Programm / Ausschreibung	Weltraum, Weltraum, ASAP Ausschreibung 2022	**Status**	abgeschlossen
Projektstart	01.11.2023	**Projektende**	31.10.2025
Zeitraum	2023 - 2025	**Projektlaufzeit**	24 Monate
Keywords	Wind site assessment energy yield planning precision		

Projektbeschreibung

/Zusammenfassung der Projektidee/

Kleinwindkraftanlagen kombiniert mit, in unseren Breiten jahreszeitlich ergänzender, Photovoltaik und Batteriespeichern könnten zukünftge Hebel für dezentrale Microgrid-Lösungen sein. Dies ist ein gangbarer Weg zu erneuerbarer, nachhaltiger und leistbarer elektrischer Energie und Energiegemeinschaften zur lokalen Nutzung, Speicherung und Produktion.

Kleinwindkraftanlagen (Klein-WKA) laufen vergleichsweise viel bodennaher als Groß-WKA mit typischen Nabenhöhen von 80-120m über Boden. Windaufwärts liegende Störungen in der Topographie, Vegetation, natürlichen und menschlich gemachten Strukturen haben deutlich stärkere Auswirkungen auf den erzielbaren Jahresertrag auf Nabenhöhe verglichen zu Groß-WKA.

Dadurch ist die genaue Ertragsprognose für bodennahe Klein-WKA auch deutlich schwieriger als für Groß-WKA wo sich die Störungen stärker gedämpft auswirken. Besonders für Klein-WKA müssen die Planungskosten (inklusive Standorteignung und Ertragsprognose) um Größenordnungen geringer sein im Vergleich zu Groß-WKA um wirtschaftlich zu sein.

/Ziele und Innovationen/

- Kombination von digitalem Oberflächenmodell (DSM) und digitalem Terrainmodell (DTM) mit Landnutzungsklassen (LULC) zur Ableitung von

- Hochauflösenden zonalen Rauhigkeitslängen (z0)

- Entwicklung einer Prozesskette und der Automatisierung von Satellitendaten-Fusion und Export bis zur Windertragsprognose basierend auf CFD (numerischer Strömungssimulation)

/Erwartete Resultate und Ergebnisse/

- Erreichung höchster Vorhersagequalität für die Ertragsprognose eines Standortes zur erfolgreichen Planung und den Betrieb von (Klein-)WKA

- Kostenreduktion in der Ertagsprognose für Klein-WKA um Größenordnungen

- Erschliessung eines riesigen, potentiellen Marktes für dezentrale Energieproduktion und Energiegemeinschaften, der a) die hochwertigesten Planungsinstrumente benötigt bei b) vergleichbar geringen Kosten

Abstract

/Project summary/

Small scale wind-power installations, combined with complementary photovoltaic energy conversion and battery storage could be one of the future levers for decentralised microgrid solutions. This is a viable pathway towards renewable, sustainable and affordable electricity for collective use, storage and production.

Small scale wind energy converters (WEC) operate much closer to the ground level compared to large scale WEC (hub height typically 80-120m a.g.l.). Up-stream disturbances in topography, vegetation, natural and human created structures have much bigger impact on the energy yield at hub-height compared to large scale WEC.

Annual energy yield accuracy is much harder to get right for small scale WEC close to ground level compared to large scale WEC where surface disturbances are much more damped. Especially for small scale WEC total planning costs (including site assessment and annual energy yield calculations) have to be orders of magnitude cheaper compared to large scale WEC.

/Goals and innovation content/

- Combination of digital surface model (DSM) and digital terrain model (DTM) with land use and land cover data (LULC) to produce

- High resolution roughness lengths (z0)

- Development of a process pipeline and automation from satellite data-fusion and export to annual energy production calculations base on CFD (Computational Fluid Dynamics)

/Desired results and findings/

- Achieving the highest prediction accuracy of electricity yield for successful planning and operation of small scale wind energy applications

- Orders of magnitude lower costs for small scale WEC assessment

- Opening a a huge, untapped market for decentralised energy production and energy communities that need a) highest quality planning tools at b) comparatively low costs

Endberichtkurzfassung

FFG ASAP Space4Wind - Summary of the project results

Rheologic GmbH, Joanneum Research

Executive summary

Within the two year research project Space4Wind a fully automated method for accurate prediction of wind speeds in complex terrain was developed. The precision of the model strives to rival state of the art wind mast measurements for both low (small wind power) and higher up hub heights of large scale wind energy converters. Space4Wind not only provides comparable accuracy to long term wind mast measurements but yields data in 3D space, i.e. at all relevant heights and within a 1km radius from the central target.

Space4Wind results are currently available within 5 to 15 work days, a fraction of the time compared to wind mast measurement campaigns, and at significantly lower costs compared to mast measurements.

All this was achieved by employing a complex data pipeline that fuses satellite data, global circulation model data, tailor made and automated 3D geometry generation and state of the art computational fluid dynamics simulations.

Most important results

It was found that surface roughness mapping (by itself) is not modeling close to ground wind speeds accurately enough in complex terrain or close to vegetation zones. Forests need to be 3D resolved in the CFD model to produce consistent results close to the ground and higher up at hub heights typical for large wind power installations.

Transient, eddy resolved CFD models are suitable and have become affordable considering the high quality demands in the wind industry. There are no known sufficiently accurate substitute models, i.e. RANS or linearised NS models, at complex sites in mountainous areas. The used CFD models and methods of Space4Wind produce highly accurate results given physically correct input conditions.

Dynamic down scaling of global circulation model data enabled us to produce realistic wind speeds and sector wise frequency weighting to correct initial simulation results of speed-up ratios. Two high resolution validation runs for Handalm and Lichtenegg test sites yielded results within an acceptable error range for wind engineering applications, site assessment and investment risk management.

Numerical optimisations allowed the consortium to double computational efficiency and finish two validation runs instead of initially planned one run with available HPC (hich performance computing) resources.

Projektkoordinator

- Rheologic GmbH

Projektpartner

- JOANNEUM RESEARCH Forschungsgesellschaft mbH