Why Accuracy in Wind Resource Modeling Matters

The Challenge: Unleashing the Full Potential of Wind Energy

Wind energy projects depend on precise wind resource assessments to optimize site selection, turbine placement, and energy yield. However, traditional linear models struggle in complex terrains, leading to inaccurate predictions that can impact energy production, financing, and operational efficiency.

Key Pain Points in Wind Resource Modeling:

- **Underestimation or Overestimation of Energy Yield** – Inaccurate wind assessments can lead to revenue shortfalls or project inefficiencies.
- **Bankability Risks** – Investors and financiers demand validated, high-accuracy forecasts for secure funding.
- **Complex Terrain Challenges** – Wind behavior over hills, forests, and ridges is highly nonlinear, making simple models insufficient.
- **Slow Computation Speed** – Traditional CFD simulations, while accurate, can be computationally expensive and time-consuming.

Bolund Experiment: Methodology and Findings

WindSim participated in the **Bolund Experiment**, a benchmark study conducted by Risø to validate wind flow models over complex terrain. The methodology involved:

- **Full-Scale Field Measurements** – Wind speed and turbulence data were collected at multiple heights (2m, 5m, 10m) across the Bolund Island.
- **Blind Test Comparison** – More than 50 modeling teams submitted results without prior knowledge of experimental measurements.
- **Evaluation of Various Methods** – CFD models, including WindSim, were compared against traditional linear methods.

Key Findings:

- **CFD methods, including WindSim, showed the lowest errors**, significantly outperforming linear models.
- **WindSim's RANS k-epsilon turbulence model achieved accuracy within 5-6% of measured data**, reinforcing its reliability in complex terrains.

- The study validated CFD's ability to accurately predict wind patterns over real-world terrain formations, making it a crucial tool for wind engineers.

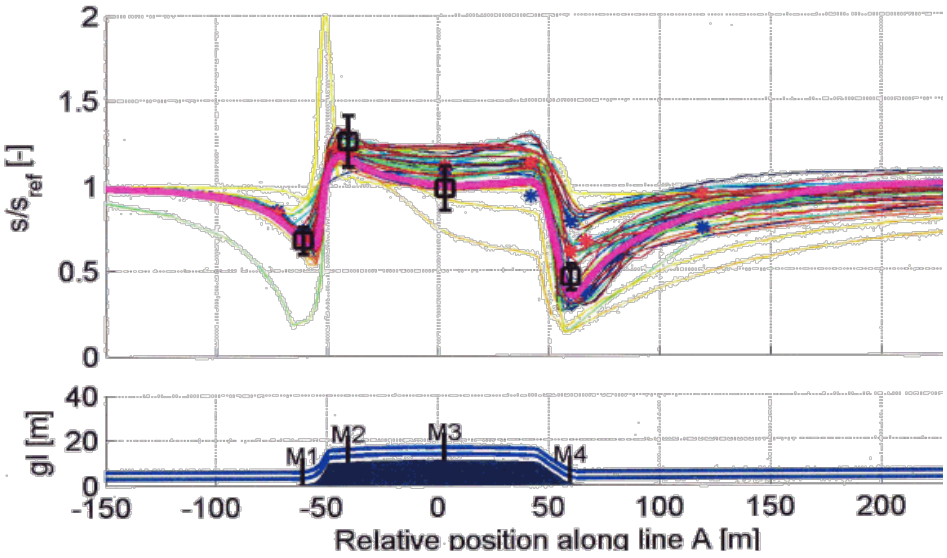

Figure: Normalized wind speed at 5 meters height, measurements are given by black boxes, solid pink line is the WindSim results, while the other lines are results from other methods

The Solution: Computational Fluid Dynamics (CFD) and WindSim Accelerator

WindSim's CFD-based approach models wind flow using the Navier-Stokes equations, accounting for turbulence, terrain effects, and local atmospheric conditions with **superior accuracy compared to traditional linear models**. WindSim users have several levers at their disposal to fine-tune accuracy based on project requirements;

✅ **Model Size** – Increase the number of cells/resolution, made easier through cloud computing with WindSim Accelerator.

✅ **Elevation and Roughness Data** – Automatic access through pre-processing in WindSim Accelerator, with standardized high quality datasets available.

✅ **Canopy/Forest Height** – Integrated forest modeling improves flow predictions.

✅ **Number of Sectors** – Option to increase beyond the industry-standard **36 sectors**, surpassing other tools.

✅ **Sensitivity Studies** – Fine-tune resolution (e.g., 10m vs lower), with access to multiple physical models for comparison.

✅ **Convergence Criteria** – Move to tighter criteria for improved accuracy; unlike competitors, WindSim does not stop early.

✅ **Nesting** – Move from low to higher resolution, creating a **grid-independent solution** not available other tools.

✅ **Forest Impact** – Advanced modeling techniques to capture the impact of vegetation on wind flow.

✅ **Stability Effects** – Combined with measurement data to offer a **unique solution**.

✅ **Turbulence Modeling** – Uses a **2-equation model**, offering greater accuracy than a **single-equation** approach.

✅ **Flow Model Validation** – Enables shear inspection, vertical profile exports, and **cross-prediction error analysis**, improving extrapolation accuracy.

Key Features & Benefits

WindSim provides a set of advanced tools that enhance the accuracy of wind resource assessments, ensuring precise modeling of complex terrain and atmospheric conditions. These capabilities help wind engineers optimize site selection, reduce uncertainty, and improve energy yield predictions. Key features and benefits include;

✅ **High-Resolution Terrain Modeling** – Generates **detailed 3D models** incorporating elevation, roughness, and obstructions like forests or buildings, improving wind flow prediction.

✅ **Advanced Wind Flow Simulation** – Uses **validated turbulence models** to accurately predict wind speed-ups, directional shifts, and turbulence intensity across varying landscapes.

✅ **Optimized Measurement Integration** – Incorporates **multiple measurement points** into the simulation, using **interpolation techniques** to refine wind resource mapping for greater accuracy.

✅ **Accurate Wake Modeling** – Accounts for wake effects and turbulence to provide a **more precise estimation of energy yield**, reducing uncertainties in power production.

✅ **Energy Production and Layout Optimization** – Enables **comparison of different wind farm layouts** to maximize AEP while minimizing wake losses.

✅ **Transparent Validation Process** – Built on **real-world validation cases** like the Bolund Experiment, ensuring CFD simulations reflect actual field measurements.

What Customers Say

📌 **Ryan Kyle, Wind & Site Engineer, Nadara:**

*"We have used WindSim's Accelerator since June of 2022. Not only has it **reduced the solution time** for our operational sites dramatically without the need for an in-house high-performance computer, it lets all of our WindSim users build their projects separately and then store and run them in **one place** so we can share projects easily. The benefits it brings in terms of CFD accuracy, efficiency and utility are great for us, such that we have already secured credits for the **next three years**!"*

📌 **Tony Rovers, Senior Wind Development Specialist, Contact Energy:**

*"We chose WindSim as our computational fluid dynamics tool for its use in complex terrain and forested sites. We have been using this package since December 2022 and have found the Accelerator product a useful way to gain access to **significant computational power**. We have had good success in using this product with smaller models in WindSim Accelerator and have found the remote sensing correction tool to be a valuable addition to our tool suite. Training courses provided and support services have been of high quality and very helpful."*

Why Switch to WindSim Accelerator?

🔷 **Validated Accuracy** – CFD-based modeling with peer-reviewed validation from studies like the Bolund Experiment.

🔷 **Optimized Performance** – Better predictions lead to improved project financing and energy production.

🔷 **Faster Decision-Making** – Rapid cloud simulations accelerate wind project timelines.

Choose WindSim Accelerator as standalone software or opt for our Consulting team's full-service expertise.

Unlock the Full Potential of Wind Energy

🔗 Curious about WindSim Accelerator? Request a quick, no-obligation demo of WindSim Accelerator.

🔗 Learn More about WindSim Accelerator.

📩 Contact us at sales@windsim.com or consulting@windsim.com.