



Early reduction of uncertainty in wind projects  
Siting to improve your business case certainty

# Which are the general conditions to make a project bankable?

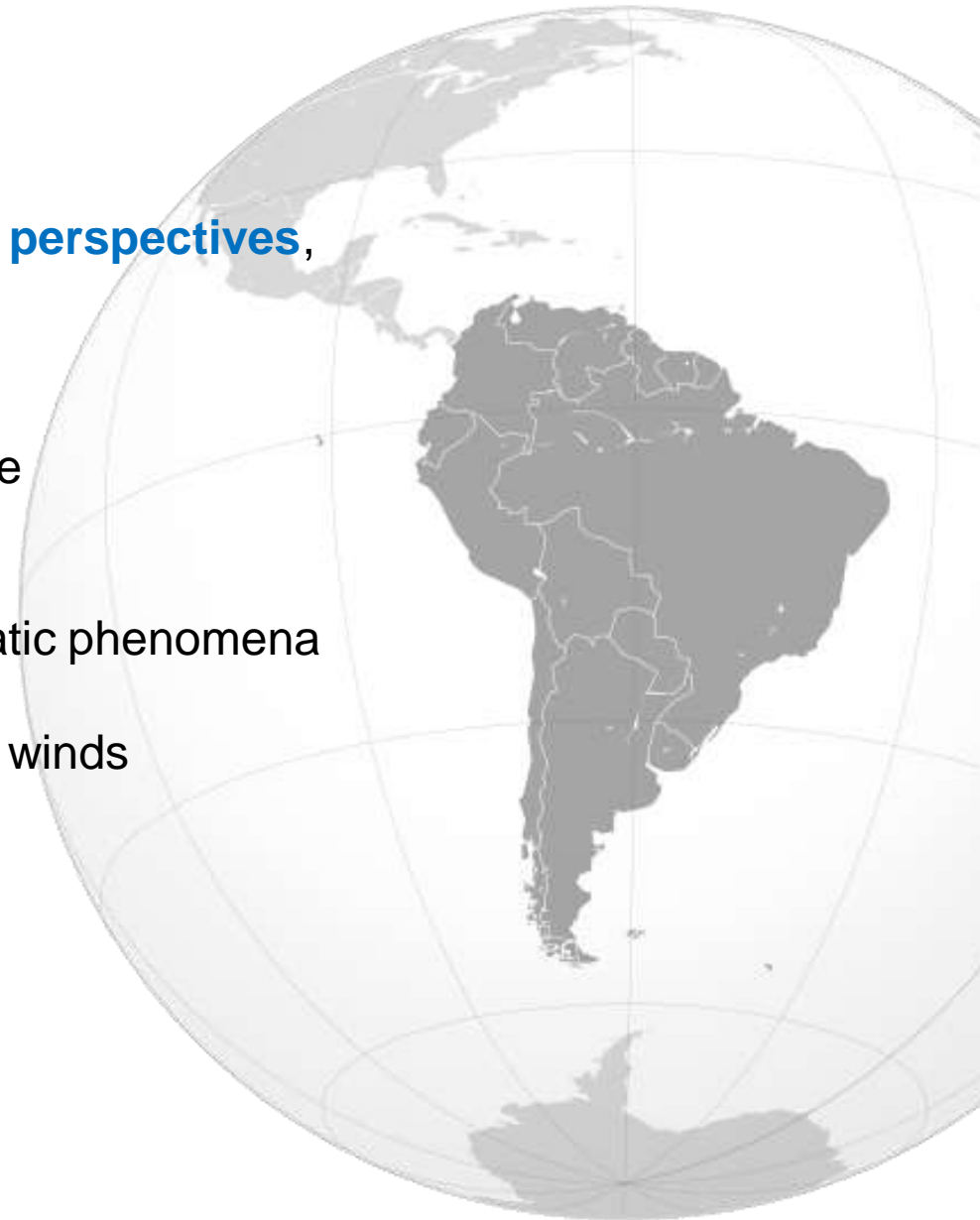
- Electricity Sector Regulatory Framework adequate and stable
- Due Diligence administrative, corporate, contractual, labor, legal and tax favorable in the opinion of the financing banks
- **Technical Due Diligence favorable in the opinion of the financing banks (in relation to the Wind resource, technology used, the technology supplier...)**
- Insurance Due Diligence favorable in opinion of the financing banks
- “Shareholders Due diligence” favourable opinion from banks
- Total availability of the land you will locate the Project and its assets
- Contractual structures where construction risk is transferred to a single counterparty, through closed term and price contracts. This contracts must be secured and the penalties to apply to the Contractor in case of any default, equivalent to the damage caused. Additionally, the contractor must have adequate technical and financial capacity to develop the Project
- O & M long term contracts with fix price and specifications satisfactory to banks

# South American Region

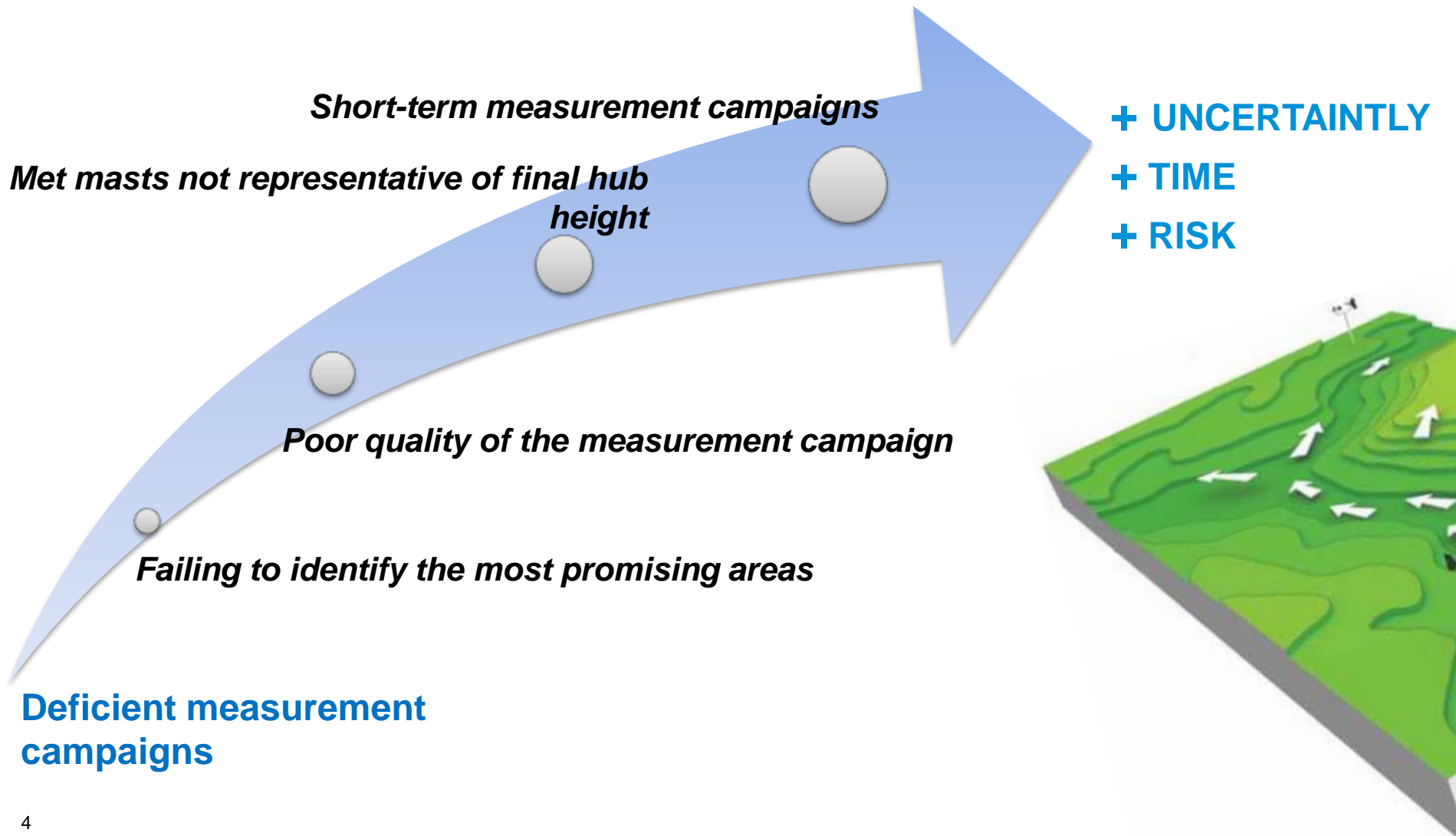
**Good wind resource and excellent perspectives,**

but

- Reduced wind power tradition
- Poor wind data reference database
- Very complex terrain
- Isolated and rural areas
- Complex meteorological and climatic phenomena
  - Niño/Niña
  - Thermal inversions, katabatic winds
  - Coastal jet flow, etc...



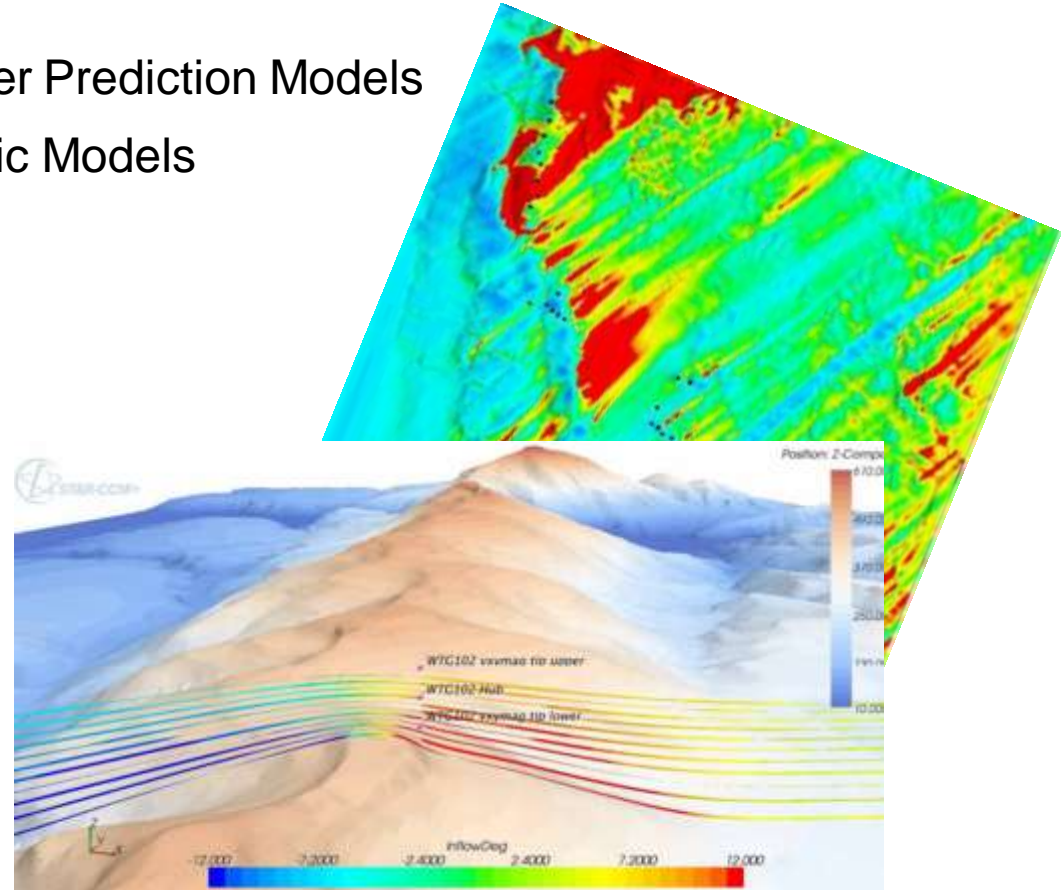
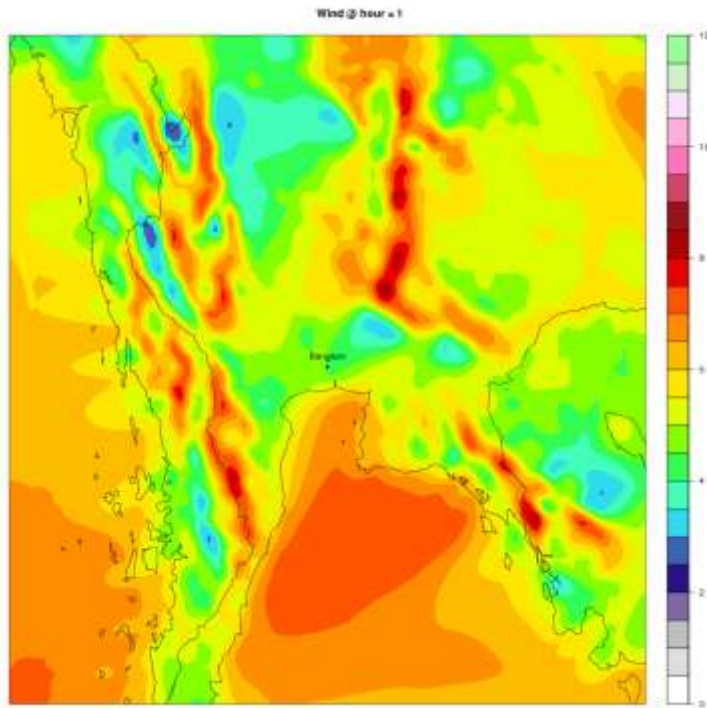
# Traditional approach: The measurement campaign



# Modern Energy Approach: MESOSCALE + CFD

The use of mesoscale and CFD data in siting

- Mesoscale Numerical Weather Prediction Models
- Computational Fluids Dynamic Models

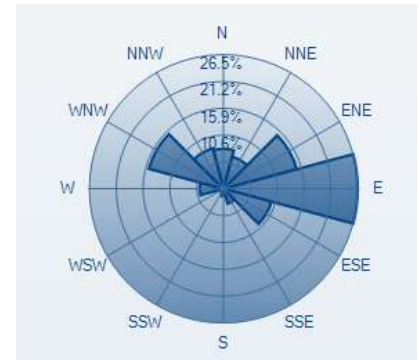


The use of Mesoscale and CFD DOES NOT REPLACE the on site measurement

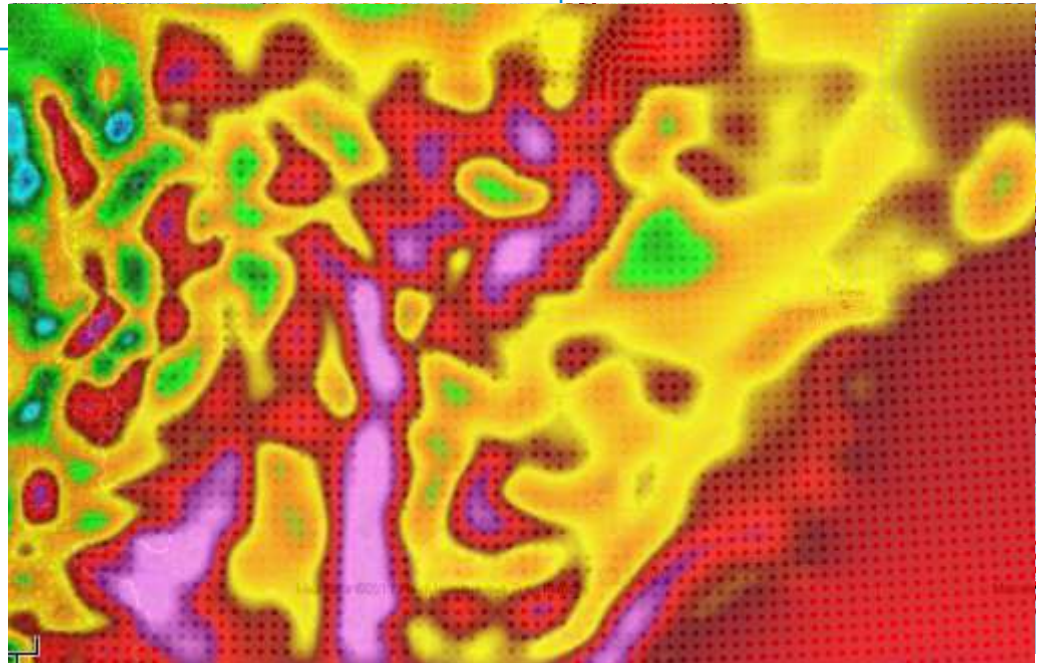
# Understanding the Mesoscale

## MESOSCALE used to

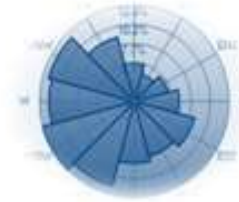
- Global wind database
- Regional and Local Planning
- Resource mapping
- Wind information in areas with severe lack of data
- Fill in data gaps in observational data series
- Long-term correlations: narrowing uncertainties
- Seasonal and Daily Effects



Vestas' Mesoscale simulations are performed by the [WRF model](#), modified by Vestas for optimal performance with respect to wind energy purposes.



# Mesoscale outputs



## Wind speed, mean @120 m [m/s]



## Air density @80m [kg/m<sup>3</sup>]



## Icing probability @80m



## Temperature [°C]



Annual Average Wind Map  
General Climate Overview for the Region

Monthly Average Wind Maps

Annual Wind Rose

Monthly and Diurnal Variability:

- > Wind Speed
- > Wind Direction
- > Temperature
- > Pressure
- > Density

Annual and monthly Weibull maps

Annual and monthly wind shear maps

Icing Risk

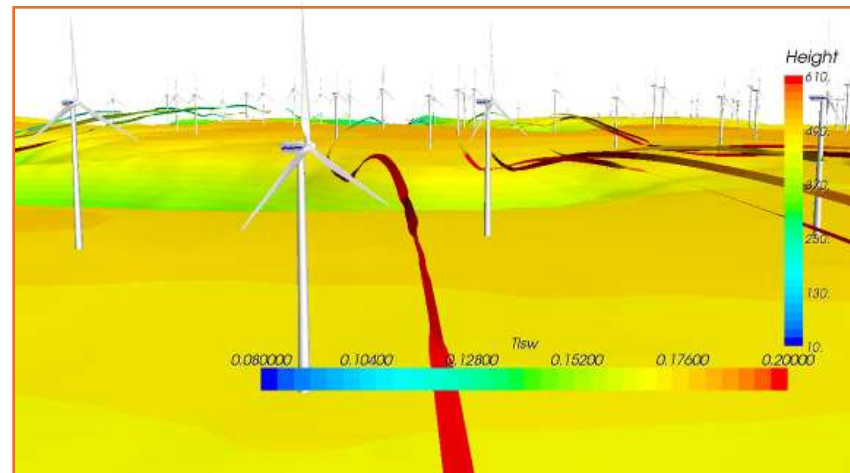
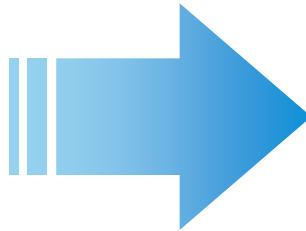
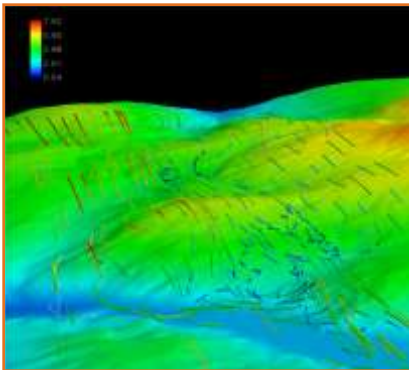
Lightning Risk

Long-Term Time Series

# Understanding the site using Computational Fluid Dynamics

## CFD used to

- Predict mean flow turbulence intensity
- Wind shear
- Turbulence
- Visualization of phenomena
- Separation zones
- Inflow angles
- Wind veer



# Converting Knowledge to Business Case Certainty

## Wind Data Analysis – Missing Data

	Year	Month	Mean	Missing High wind	Missing Low wind
1	2003	Aug	9.63	9.63	9.63
2	2003	Sep	9.83		9.83
3	2003	Oct	7.62	7.62	7.62
4	2003	Nov	7.13	7.13	7.13
5	2003	Dec	7.23	7.23	7.23
6	2004	Jan	6.80	6.80	
7	2004	Feb	6.89	6.89	6.89
8	2004	Mar	6.61	6.61	
9	2004	Apr	6.91	6.91	6.91
10	2004	May	8.22	8.22	8.22
11	2004	Jun	10.12		10.12
12	2004	Jul	8.67	8.67	8.67
	Average		7.97	7.57	8.23

# Converting Knowledge to Business Case Certainty

## Wind Data Analysis – Missing Data

Macarthur: 150 V90-3MW

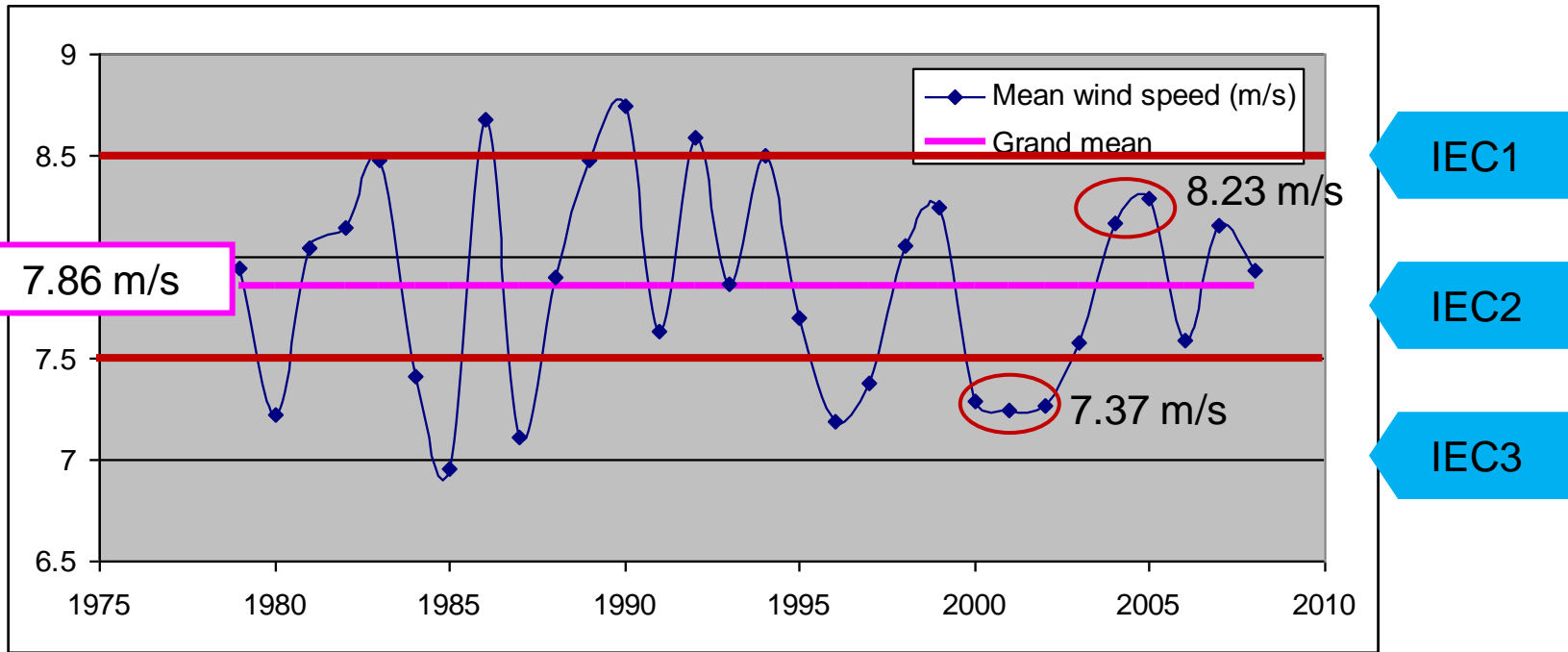
	Units	Full Data	Missing High wind	Missing Low wind
Average	m/s	7.97	7.57	8.23
Wind speed difference	m/s		-0.40	0.26
Production estimate	GWh/y	1255	1124	1340

# Converting Knowledge to Business Case Certainty

Exploit mesoscale model data to construct synthetic data for long term correction

Mesoscale data → Synthetic data → Long term correction

Example: 2 years of good measurements prolonged to 30 years



What if a low wind year was monitored??  
What if a high wind year was monitored??

→ 18% under estimation  
→ 15% over estimation

# SiteHunt

Advanced analysis that adds certainty to your business case

Identifying the most suitable location for your wind power plant as early in the process as possible, provides a solid foundation for your business case.

SiteHunt® is an advanced analytical tool that examines a broad spectrum of wind and weather data to evaluate potential sites and establish which of these provides optimum conditions for your project.

SiteHunt® report enables you to allocate resources to the most promising sites.

Site Hunt® may include an indicative layout for optimal AEP based on mesoscale data and the proposed design of optimal measurement campaign



# SiteHunt<sup>®</sup> provides you with...

## Early identification of most promising sites

- Reduced time to market
- Most efficient allocation of development resources

## Comprehensive long term data

- Higher business case certainty
- Reduced project risk



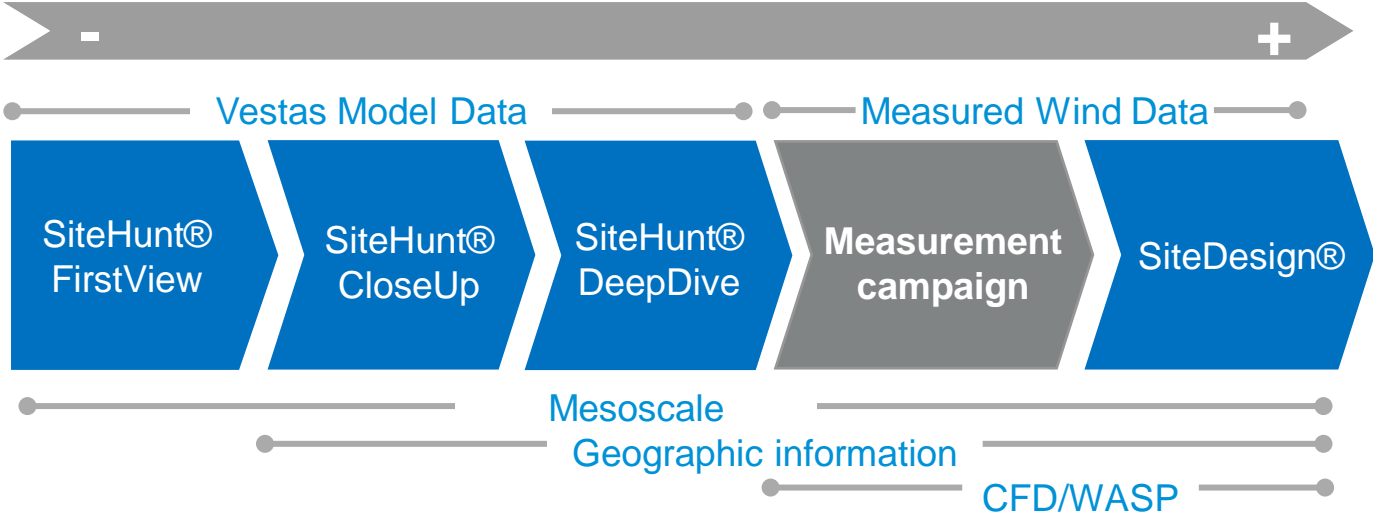
Site options



Site selection

# SiteHunt Levels

From Global Scale to Micrositing



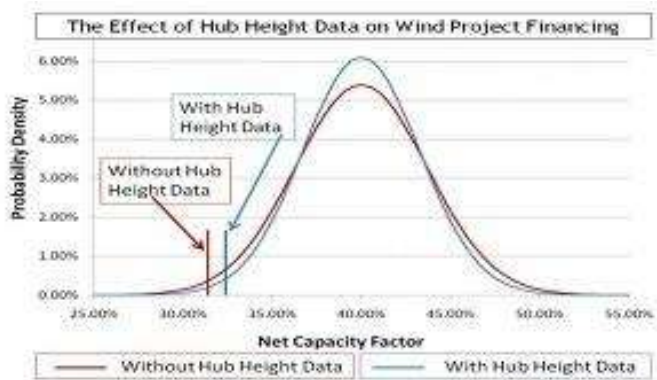
The Vestas logo is positioned in the top left corner of the image. It features the word "Vestas" in a white, italicized, sans-serif font, followed by a registered trademark symbol (®). The background of the top half of the image is a vibrant blue sky with wispy white clouds, suggesting a clear, sunny day.

**Wind.** It means the world to us.™

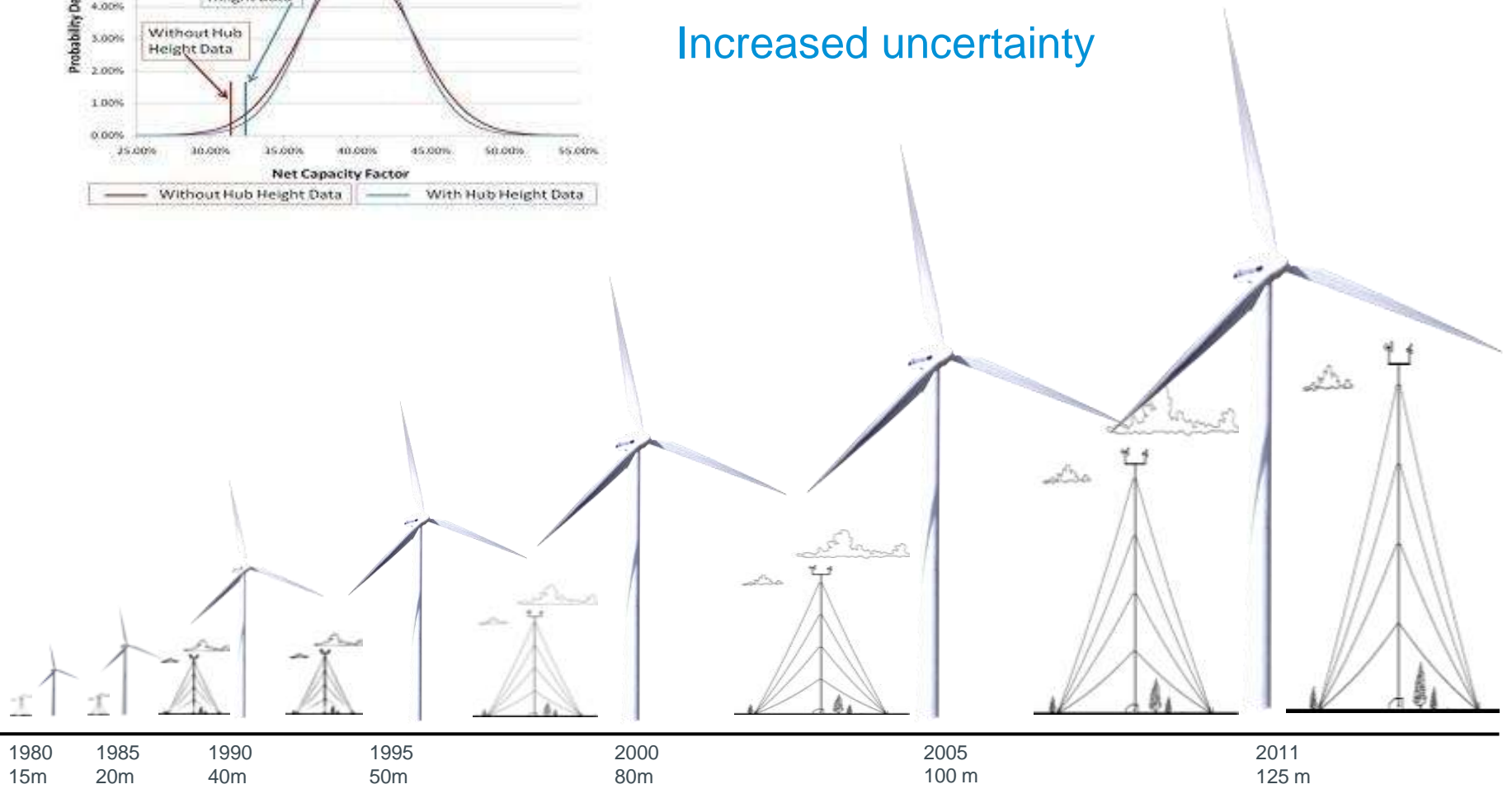
# Thank you for your attention

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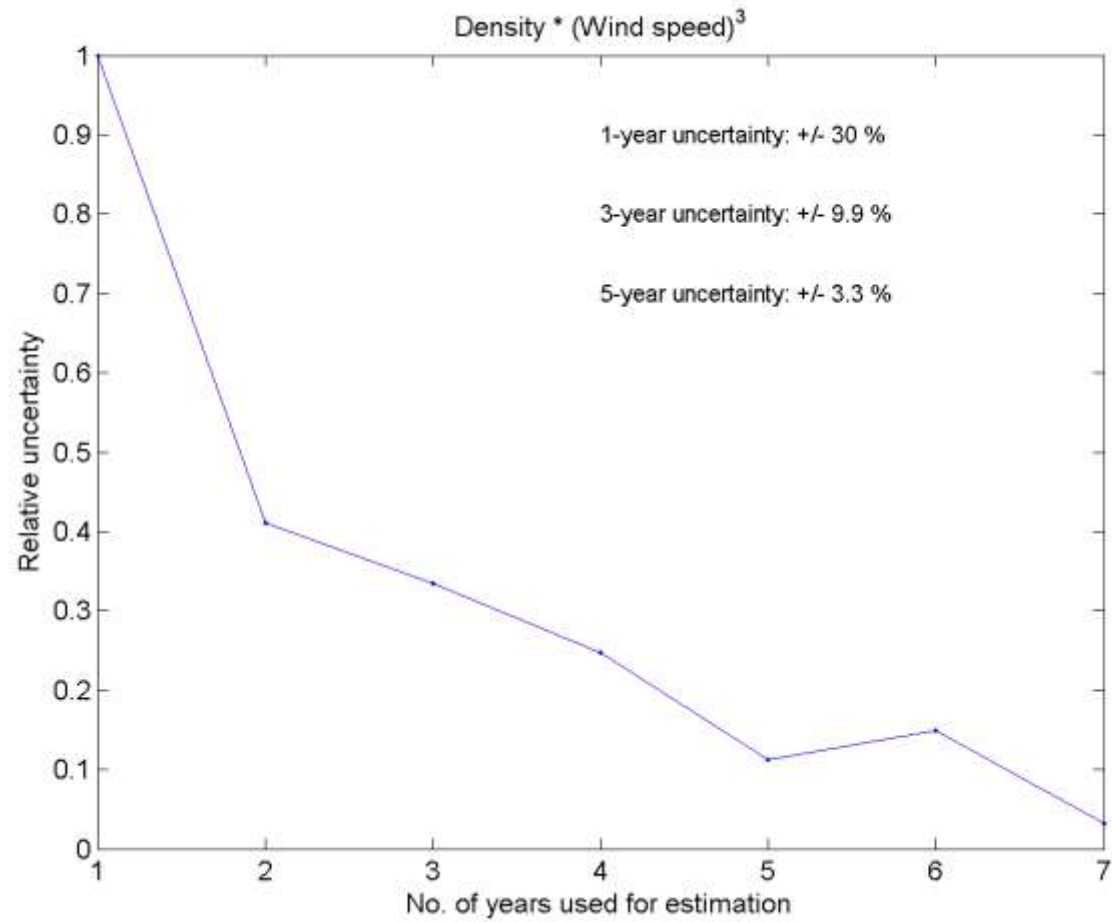


Increased uncertainty



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## Increased uncertainty



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# SiteHunt Features, Advantages & Benefits

## FirstView Report

Features	Advantages	Benefits
Virtual reality study	<ul style="list-style-type: none"><li>Detailed understanding of climatic conditions and Wind Quality</li></ul>	Fast identification of high potential areas, without the need for comprehensive measurement campaigns
Annual average wind map.	<ul style="list-style-type: none"><li>Estimation of wind quantity</li></ul>	
General climate overview for the region	<ul style="list-style-type: none"><li>Understanding the drivers of variability on site/region (e.g. variation due to Monsoons, El Nino)</li></ul>	
Met mast installation best practice guide	<ul style="list-style-type: none"><li>Ensure quality measurements</li><li>Detects degree of complexity of windflow (turbulence, windshear, inflow angle, etc.)</li></ul>	Improve BCC by minimise uncertainties in wind resource estimates
Uncertainty and mesoscale model verification	<ul style="list-style-type: none"><li>Quantify the uncertainties of the SiteHunt® outcomes</li></ul>	Clear understanding of the quality of the data

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# SiteHunt Features, Advantages & Benefits

## CloseUp Report

Features	Advantages	Benefits
Annual wind rose	Enables first cut on site layout	Early engagement of permitting authorities
Seasonal variability	Low wind/high seasons identified	Early identification of impacts on production & (fatigue) loads
Diurnal variability	Daily variations	Early identification of impacts on production & (fatigue & extreme) loadings
Icing risk		Early identification of impacts on production & safety
Lightning risk		Early identification of impacts on production & safety. Required level of lightning protection can be identified
Map overlays	Identification of obstacles, grid and access road proximity	Supports decision making

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# SiteHunt Features, Advantages & Benefits

## DeepDive Report

Features	Advantages	Benefits
Downscaling to 10m (CFD calculations based on mesoscale data)	Detects degree of complexity of windflow (turbulence, windshear, inflow angle etc.)	Reduces uncertainties in wind resource estimates
Turbulence indicator map (CFD simulated TI)	Enables preliminary turbine type selection	Provides required input to business case draft and permitting process
Indicative turbine layout (Optimised for maximal AEP)	Input to permitting process	Early engagement of permitting authorities
Design of measurement campaign	Ensures quality measurements on optimal locations	Ensures optimal input to SiteDesign® process

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## Site Characteristics

We include analysis of site topography, setbacks and other site constraints as well as site complexity to achieve the best results.

## Wind Resources

We analyse and estimate the wind speed and direction the site would be expected to experience over the long term, including low wind years and high wind years.

The optimisation of a power plant layout is a complex process requiring precise data input, thousands of calculations, sophisticated analyses and advanced computer modelling techniques

## Turbulence

An analysis and estimate of the expected wind turbulence levels will help ensure your site is designed to minimize this risk.

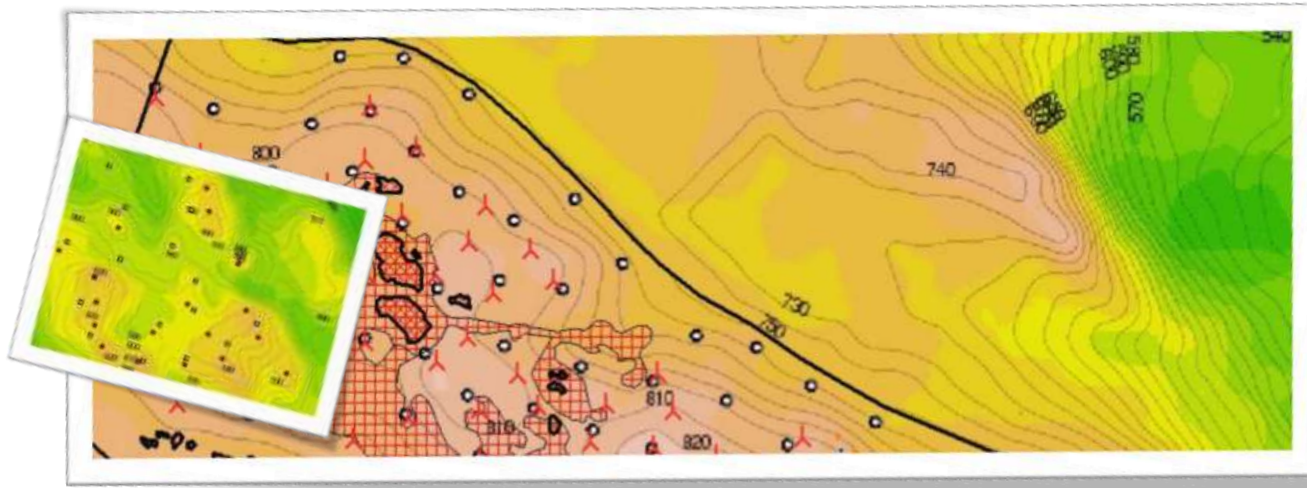
## Service Cost

We assess the total cost to service the wind power plant, including direct wind turbine generator maintenance costs related to the estimated loading at the given site position, taking mean wind speed and turbulence into account.

# SiteDesign<sup>®</sup> provides you with...

Optimum placement of turbines both in terms of revenue and costs

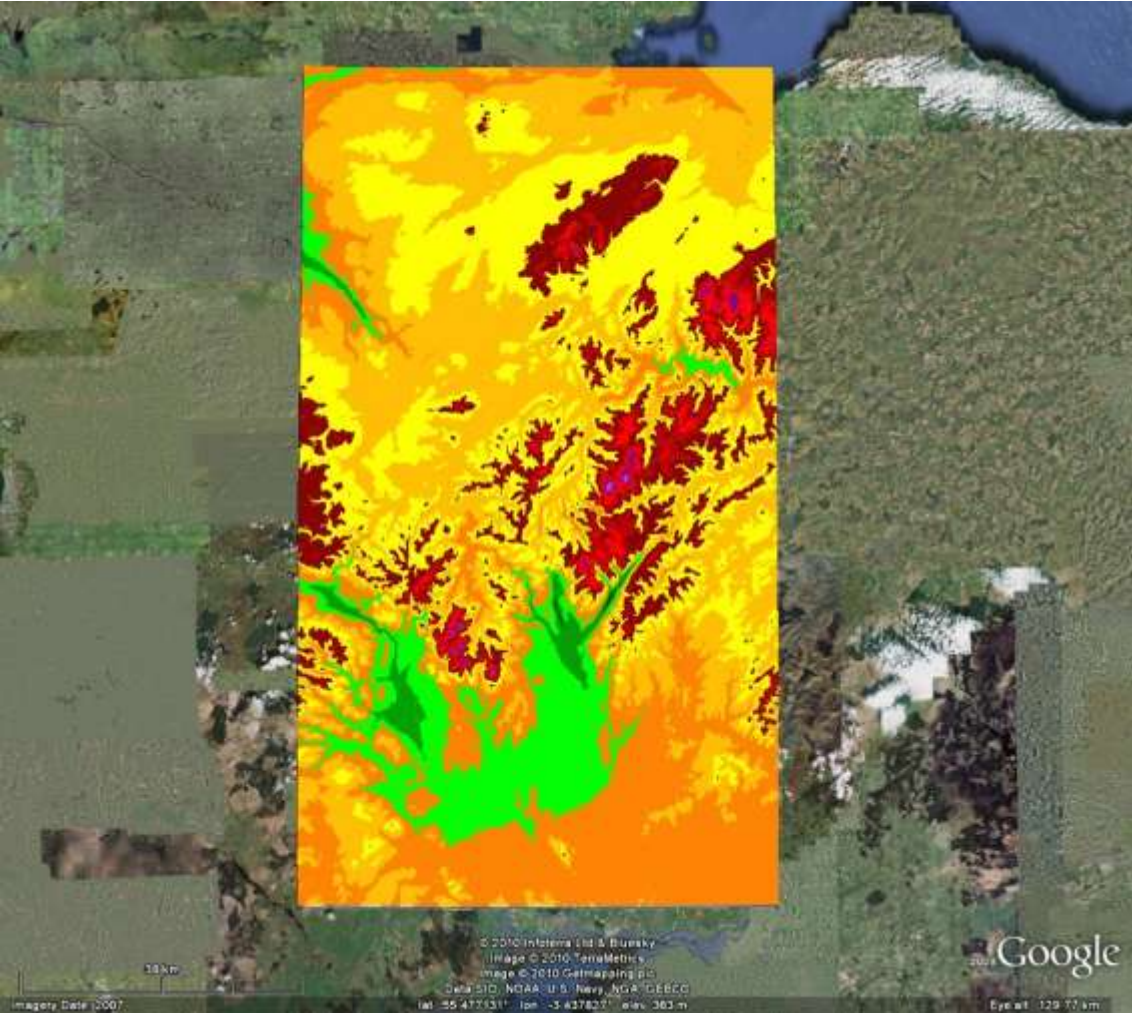
Long term optimisation of revenue and of lowest operating cost (OPEX)



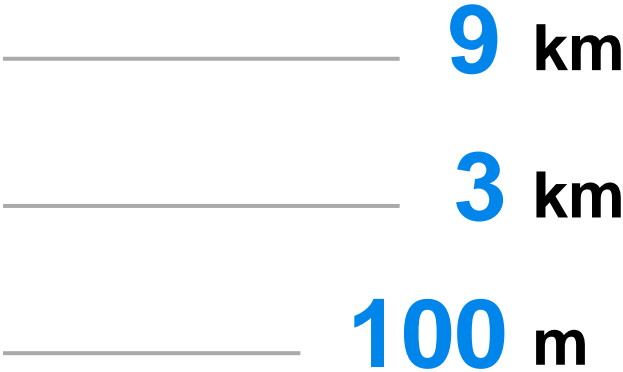
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# SiteHunt® – This is how it works!

## Downscaling example



Further downscaling with CFD to turbine level using modelled or measured data as input.



Global resolution, long-term database ranging from 10m x 10m to 9km x 9km