
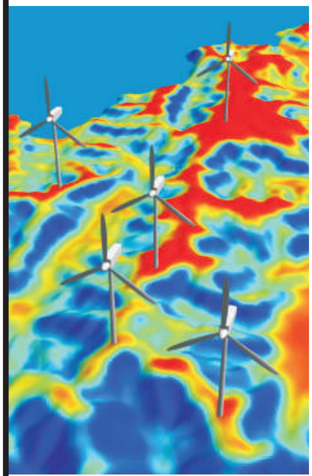


Wind Energy Modelling

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Wind Energy Modelling

Spatial Modelling to Locate Wind Farm Sites

Kenex uses advanced spatial modelling techniques to create maps of the critical elements required for wind farm development. We combine these maps using multi-variable modelling to produce predictive maps and targets for new wind farm areas or to guide turbine placement.

Our modelling is one of the most advanced site selection tools in the industry because:

- We incorporate wind speed, terrain analysis, infrastructure, environment, land use and population details into a single predictive map that shows the most suitable locations to explore for wind energy.
- The modelling can be undertaken across entire countries for locating suitable wind farm areas, in local regions for more detailed mapping of wind farm extent, or at the wind-farm scale for assisting with turbine placement.
- Our wind speed and direction data comes from our strategic partners who analyse atmospheric data using advanced meso-scale wind modelling technology.
- Using detailed terrain analysis that incorporates slope, aspect, terrain complexity, upwind terrain effects, and ridgelines, we can produce maps of suitable terrain for wind farm and turbine placement.
- Incorporating land ownership, environmental and planning information ensures the most suitable wind farm sites are selected for development first, eliminating wasted time, money and effort.
- Our modelling techniques have been mastered in New Zealand, one of the worlds most challenging wind energy environments, and are currently being used for exploration by Genesis Energy, one of New Zealand's leading energy suppliers.

Kenex

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About the Modelling, Kenex, and Our Partners

With global energy trends moving towards sustainable solutions, energy explorers are seeking new ways to effectively search for potential wind farm sites. In the past, wind prospecting has been undertaken using limited tools and data. Explorers are often left asking if all the sites are taken, and if not, where will the next new site be? Our new advanced spatial modelling tools can provide a fresh perspective on these questions. Using sophisticated meso-scale wind speed modelling, advanced terrain analysis, and current land use knowledge, we undertake probabilistic analysis and intelligent spatial modelling of the wind energy resource in a country or region.

This spatial modelling allows you to combine data and knowledge about wind farm sites in a way to target more effectively. It takes advantage of the wealth of digital data now available to the industry and deals with the data overload issues that plague many developers. Modelling can save time and money by putting resources into the most likely places first allowing you to undertake value and risk assessment of assets.

Kenex is a company that provides targeting, management, and GIS (Geographic Information Systems) services for the mineral exploration and environmental industries in Australia, New Zealand, Oman, Korea, and Africa. Adopting the latest GIS technologies, Kenex have undertaken predictive modelling to identify prospective areas for potential mineral deposits, wildlife habitats, and wind farm locations. For wind energy modelling Kenex have collaborated with Aurecon, a leading global group created by the recent coming together of three world-class companies, namely, Africon, Connell Wagner and Ninham Shand. Aurecon provide Kenex with technical expertise on wind farm terrain, design, and wind speed modelling. Kenex expertise in spatial data analysis and modelling is used to apply this knowledge to predictive targeting for ideal wind farm sites.

Together, Kenex and Aurecon have developed spatial modelling techniques that combine wind speed and direction data, advanced terrain analysis, and land use variables to define the extent of potential wind farms at regional and country-wide scales. Our modelling can quickly and cost effectively target and rank new wind farm opportunities and define the potential extent of an individual wind farm. It allows for easy approximation of the number of turbines that the wind farm can hold, can be a guide for turbine and monitoring mast placement, and can be used to identify the land owners that need to be approached early on in the development process. This is the most comprehensive spatial modelling method being used for wind energy prospecting.

Our modelling has been used by a leading New Zealand energy supplier to locate new sites for wind farm development and determine possible turbine sites at current prospects. It is also being considered by a major Australian electricity provider to assess a new wind farm layout and undertake state-wide modelling for new projects throughout southern Australia.

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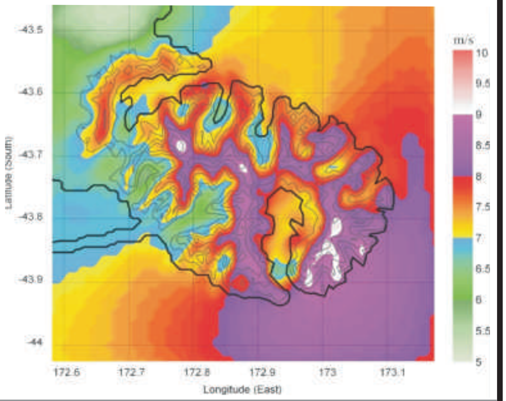
Mesoscale Modelling of Wind Resource

Quality wind speed data is a requirement in any wind modelling project. Mesoscale modelling by Aurecon provides us with continuous detailed coverage of wind speed and wind direction, which is ideal for our spatial data modelling. The models are initiated with synoptic weather data created by a global weather model incorporating thousands of weather observations around the world, including land-based, sea-based and satellite observations. The mesoscale modelling solves the physics of the atmosphere to downscale the synoptic data and predict surface conditions including wind speed and direction. Mesoscale modelling generates hourly wind speed and direction data at a range of heights, allowing hub-height wind assessments for a range of turbine sizes and assessment of the wind profile over the entire rotor area to be completed. The variance between the mesoscale results and actual wind mast readings are typically less than 5%. With wind mast readings typically subject to around 2% uncertainty themselves and only representing the particular location measured the mesoscale modelling provides a superior spatial assessment of a site with the ability to assess long term wind trends.

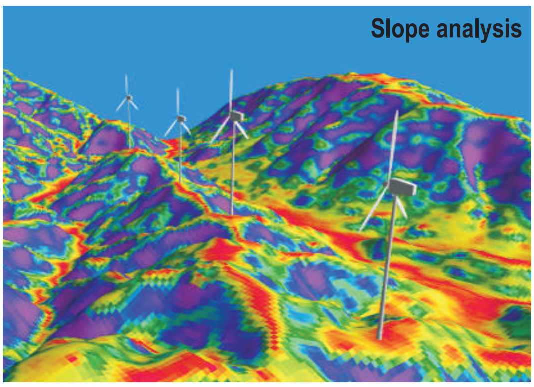
The wind speed and direction data is analysed and classified into ranges suitable for different classes of modern turbines and regional economic constraints of the study region. This wind speed map is incorporated into the predictive model with our other data to find ideal wind farm sites.



Advanced Terrain Analysis

Advanced terrain modelling techniques have been developed using digital elevation data to determine ideal locations of slope, aspect to the main wind direction, complexity of surrounding terrain, ridgelines and upwind terrain effects. Maps of these five terrain parameters are created using GIS modelling tools and each represents a key element in the positioning of a wind turbine. The requirements for each have been determined using expert industry knowledge and by studying existing wind farms and turbine placements in detail. This advanced analysis can be completed over smaller regions and in greater detail than country or state-wide wind modelling.

- Slope analysis looks at the ideal slope of the land at the site of the turbine. High slope angles influence the inflow angle of the air and affect the constructability of the turbine.
- Terrain complexity looks at the slope within a wider area around the turbine site. Smooth terrain is preferable to avoid unwanted turbulence and high construction costs.
- Analysis of terrain in an upwind direction eliminates the possibility of turbulence caused by elevated terrain features.
- Aspect looks at the alignment of the terrain with respect to the dominant wind direction. Ideally the turbine site faces the main wind direction.
- Ridgelines are mapped using hydrological modelling and are selected as favourable areas for wind farm development.



Wind Energy Modelling

Environmental & Economic Factors

As well as the wind speed and terrain parameters our wind energy modelling can take into account other factors that could affect the suitability of a site for wind farm development. These may include infrastructure, social, land use and environmental variables. The layers that are used in the model will depend on the specific requirements and economic conditions in place in the country or state being modelled and also on the digital data that is available over the area.

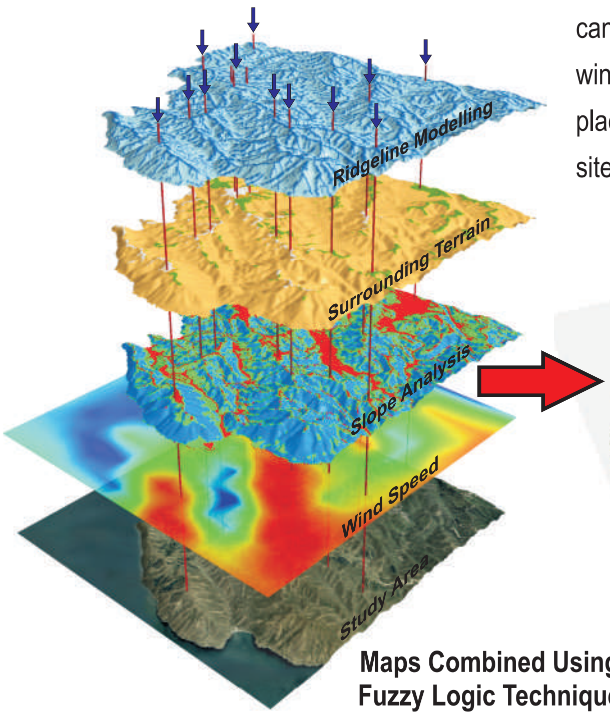
Examples of this data include:

- Proximity to transmission lines;
- Proximity to roads;
- Land use and conservation or historic land;
- Distance from built-up areas;
- Population density;
- Distance from waterways;
- Elevation.

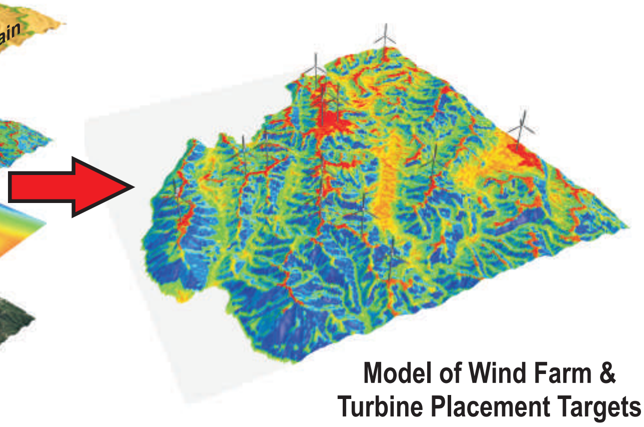
Spatial Modelling and Targeting

Our modelling uses the fuzzy logic method to combine the spatial data relevant to wind farm locations (e.g. wind speed, terrain effects, land use, etc.). It is a popular and easily understood method for combining datasets and relies on expert opinion to derive weights that rank the relative importance of the variables in the model. Each dataset to be used is weighted using a fuzzy membership function, this expresses the degree of importance of the map layer as a predictor of the feature under consideration. Predictive maps are combined by a variety of fuzzy combination operators (fuzzy AND, fuzzy OR, fuzzy gamma, etc.).

The output from the fuzzy logic model is a map showing feature favourability after combining the effects of all of the input spatial data. At a country or state-wide scale this map can be used to target new wind farm sites and rank them in order of favourablility for follow-up field investigation. At the regional or wind farm scale of modelling it can define the potential extent of an individual wind farm, be a guide for monitoring mast placement and even assist with locating turbine sites and managing development.



Maps Combined Using Fuzzy Logic Technique



Model of Wind Farm & Turbine Placement Targets

Wind Energy Modelling

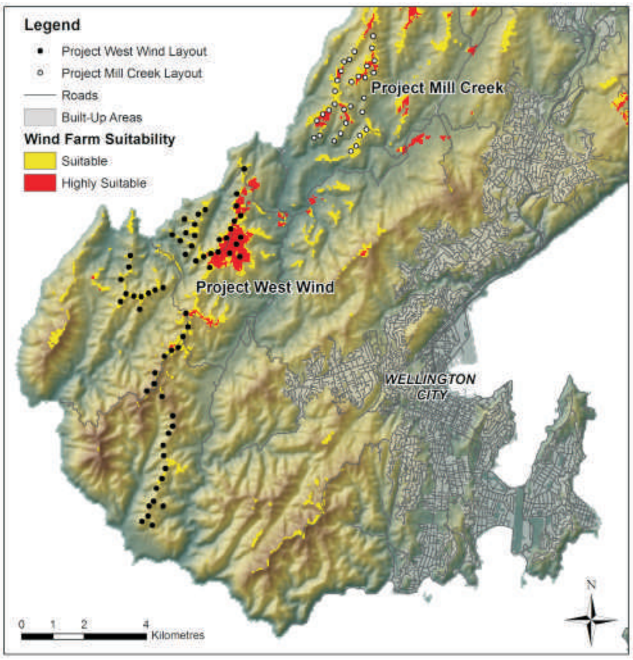
An Example from Wellington, New Zealand

Project West Wind is the Wellington Region's first wind farm and is located within Terawhiti Station and Makara Farm west of Wellington city. Construction on Project West Wind began in October 2007 and was fully operational by the end of 2009. It is Meridian's third wind farm development in New Zealand and has 62, 2.3 MW turbines over the 53 square kilometre site, providing power for the equivalent of 70,000 average New Zealand homes. Many challenges have been faced during construction of the wind farm including steep and complex terrain and difficult access to the site. These challenges have been overcome at this site so that the wind farm can take advantage of the strong and consistent wind speed due to the funnelling effect of the Cook Strait.

A spatial data model using advanced terrain analysis and fuzzy logic modelling techniques has been completed over Wellington including the Project West Wind area. The results for this model were presented at the New Zealand Wind Energy Conference in Wellington in April 2009.

The predictive maps used in the model included those created from advanced terrain analysis (slope, terrain complexity, upwind terrain effects, aspect and ridge lines), along with 1 km resolution mesoscale wind speed, distance from built-up areas, and analysis of land use. The predictive maps were assigned fuzzy membership functions based on expert knowledge and combined using fuzzy AND or fuzzy gamma operators to create a final map of wind farm suitability.

The map below displays the model results reclassified to show areas that are suitable or highly suitable for wind farm development. These are the target areas that would be tagged for follow up investigation. All of the remaining areas have at least one piece of negative evidence that would preclude the site being suitable for a wind farm based on the parameters that went into the model. The model has successfully picked out Project West Wind and Meridian's proposed Project Mill Creek to the north as suitable places for wind farms. The turbines at the southern end of Project West Wind where the terrain is steep and complex are not as favourable as those in the north where there is a broad flat plateau and much less complex terrain. This shows that although these turbines to the south are being built they are in challenging locations that are not favoured by the input parameters of this model and are likely to have higher construction costs.



Comparing the model results with wind farms in the Wellington Region has verified that our wind energy modelling technique is a valuable tool for finding suitable wind farm sites.