

# Wind Study

## Part 1 – Assessment of site and project potential

### Objective

The objective is to provide the Client with a first general assessment of the potential of the project area based on a site visit by an wind energy expert from Ingham Consult and subsequent analyses of long term wind data for the area. A digital 3D terrain model of the site is set up and an energy map for the site established. The energy map is used basis for a preliminary micro-siting taking into account constraints regarding land use, protected areas, noise and visual impact. A short report is compiled showing the energy map, the preliminary wind and climate conditions, the proposed micro-siting and estimated energy yield range.

### Work included

- Site visit and terrain assessment including aerial survey from a small airplane if possible
- Establishment of a digital 3D terrain model for flow modelling
- Acquiring long term wind data for the area and processing these data
- Establishment of an energy map for the site showing the specific energy at expected hub height
- Meetings with the Client and authorities to identify constraints for the project
- Recommendation for WTG size and hub height and selection of 2-3 candidate WTGs
- Proposal for micro-siting and meetings with the Client to make necessary adjustment
- Estimation of preliminary annual energy production range for the wind farm
- Compilation of a short report holding the above findings plus recommendation for on-site measurements

### Time frame

The Client is to provide topographic maps in paper format and/or digital format (image file). Long term data will be acquired by Ingham Consult, and the lead time for such data is typically 2-4 weeks. Having all necessary data and other necessary information in-house, the work can be completed in approx. 3-4 weeks.

# Wind Study

## Part 2 – On-site measurements

### Objective

In order to verify the wind conditions at the site, on-site good quality measurements covering a period of typically 12 months are needed. Ingham Consult will propose a measuring set-up and a plan for the measurements to ensure that the measurements are in agreement with IEC61400-12 or similar codes. Ingham Consult will also coordinate and supervise the installation. Data will be retrieved and processed on a regular basis and monthly data summary reports will be issued. The rawdata will be kept in a separate database and the processed data stored in standard text file ready for import into standard wind analysis software. All data and progress reports will be available on Ingham Consult's server through password protected access.

### Work included

- Specifying needed measuring equipment, the measuring position(s) and a measuring plan
- Supply of measuring equipment (if agreed) or otherwise define and coordinate the purchase of the equipment
- Supervise the installation of measuring equipment and the removal at the end of the measuring period
- Regular retrieval of data, quality check and processing
- Compilation of a installation report and monthly progress reports holding the aggregate data summary

### Time frame

Specification of equipment, measuring position(s) and measuring plan will be ready approx 2-3 weeks from start-up. Delivery of equipment depends on the supplier but will typically be 6-8 weeks from placing the order. Installation of the mast(s) takes 3-4 days per mast and the supervisor is required during this period. If SODAR or LIDAR is used, moving it to another position within the site is done over 1-2 days.

The installation report will be ready 2-3 weeks after completion of installation. The monthly progress reports will, in general, be available by the 14<sup>th</sup> of the following month.

# Wind Study

## Part 3 – On-site long term wind and climate – the wind atlas

### Objective

Based on the on-site data and available long term reference data, the long term wind conditions for the site are established using flow modelling and Measure-Correlate-Predict techniques. Aside from establishing the long term average wind and climate conditions, also the extreme wind and climate conditions are estimated. The key outcome of this work is the generation of a final regional long term wind atlas which is used to calculate the energy output for a given micro-siting and a given WTG, see part 4.

### Work included

- Statistical analysis of historical long term reference data including trend analysis to establish the long term basis
- Processing of short term parallel data from reference station and performing MCP analyses to the on-site data
- Establishing the final digital terrain model including a refined roughness mapping and all local obstacles
- Establishing the final long term wind atlas for the site for the final wind study
- Establishing the uncertainties in accordance with IEC61400-12 and the ISO guide to uncertainties
- Compile interim reports with updated interim wind atlases every 3 months (or as otherwise agreed)
- Compile final wind and climate report after 12 months (or as otherwise agreed) including the final wind atlas

### Time frame

Interim reports will be submitted normally by the 14<sup>th</sup> in the month following the period reported (only full calendar months are considered). Final wind and climate report will be submitted 3-4 weeks after end of the 12 month period (or as otherwise agreed)

# Wind Study

## Part 4 – Micro-siting and energy production

### Objective

The objective of this work is to optimize the micro-siting of the turbines from an overall feasibility point of view and to estimate the associated annual energy production (AEP) for selected WTGs. The work will be done in close cooperation with the Client and will be of an iterative character. While the micro-siting will probably be fixed early in the project in order to move on with the planning application etc, the AEP calculations will be updated regularly as the results from the on-going measurements updates the wind atlas.

### Work included

- Proposal of final micro-siting and meetings with the Client to adjust this
- Determining the final micro-siting. The results are given in ACAD drawing format and in tables (UTM system)
- Establishing the project in the flow model and calculating AEP with the latest wind atlas
- Compiling interim AEP reports in parallel with the interim wind and climate reports
- Compile the final micro-siting and AEP report after 12 months (or as otherwise agreed)

*The AEP estimate will include shadowing effects from one WTG to another (array losses). Other losses will need to be assessed as well to calculate the net energy delivered to the grid.*

### Time frame

Interim reports will be submitted normally by the 14<sup>th</sup> in the month following the period reported (only full calendar months are considered). Final micro-siting and AEP report will be submitted 3-4 weeks after end of the 12 month period (or as otherwise agreed). All reports will be made available on the Client's Area on Ingham Consult's server.

# Wind Study

## Part 5 – Manufacturer’s Info Package (MIP)

### Objective

The objective is to establish at an early stage the necessary information for the WTG supplier to assess the site, as well as the general and extreme wind and climate conditions so he can verify his design for the actual site. The MIP includes very detailed information from the measurements and should only be submitted to the WTG supplier under strict confidentiality. The final MIP will form part of the tender documents when sending out the invitation to tender for the supply of WTGs.

### Work included

- Compiling interim MIP that is made available on the password protected Client’s Area. A separate password protected page can be made for each WTG supplier
- Compile the final MIP at the end of the measurements

### Time frame

Interim reports will be submitted normally by the 14<sup>th</sup> in the month following the period reported (only full calendar months are considered). Final MIP will be submitted 3-4 weeks after end of the 12 month period on a CD. Ingham Consult can send the MIP CD directly to selected WTG suppliers if so requested by the Client. All reports will be made available on the Client’s Area on Ingham Consult’s server.