Releasing wind farm equity via post-construction yield analysis

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Abstract

During pre-construction yield analysis, an extrapolated site wind regime is applied to a site model in order to produce estimated yield figures. However, once the site has been operational, many of the uncertainties involved in this modelling, such as electrical losses, wake losses, turbulence and power performance, may be resolved into measured operational parameters.

This means that off-site anemometry may be directly related to power production on the site.

In a post-construction yield analysis, the pre-construction figures are refined using actual operational data. This allows:

a) The initial yield report figures to be reassessed in the light of wind farm performance, and

b) The uncertainties associated with annual yield figures to be reduced and understood more fully.

This increasing reduction in uncertainty allows improvements in financial modelling to take place over the operational life of the wind farm, releasing equity from the wind farm investment.

Introduction

A pre-construction yield analysis predicts the long-term mean annual energy yield of the wind farm using data collected prior to the construction of the wind farm. This analysis is based on on- and off-site wind speed data and is combined with various numerical and physical modelling techniques which, by the nature of the methodology, leads to considerable uncertainty in the resulting prediction.

The flow of data and modelling involved in the Natural Power Consultants pre-construction yield analysis is given in figure 1, illustrating how uncertainty builds up from both the initial datasets and subsequent modelling.

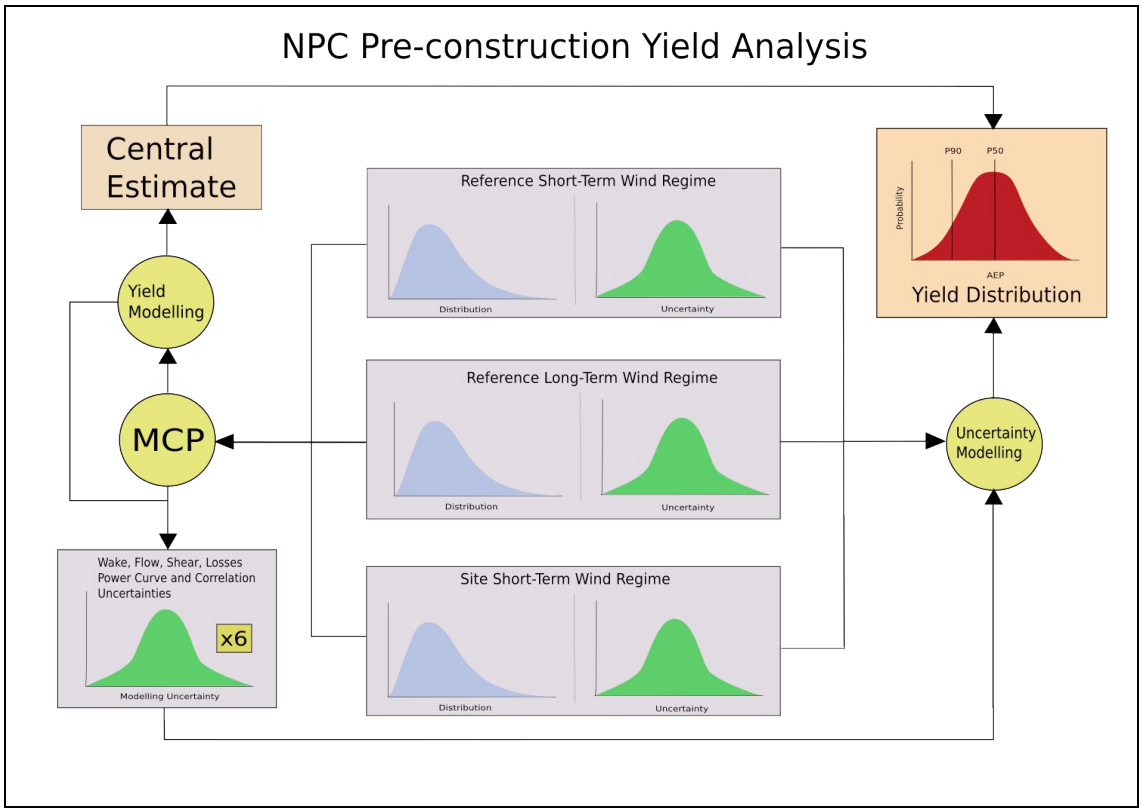

Figure 1: Pre-construction yield analysis data model

In order to predict more accurately the long-term mean energy yield of the wind farm, a further analysis may be carried out of the wind farm energy yield using measured post-construction energy production data and reference wind speed from an appropriate reference Meteorological Station.

This post-construction yield analysis permits uncertainty associated with the modelling of the site wind regime, the wake effects of the turbines, the power production of the turbines and line losses to be replaced by known operational parameters, potentially decreasing the energy yield uncertainty as an operational dataset is built up.

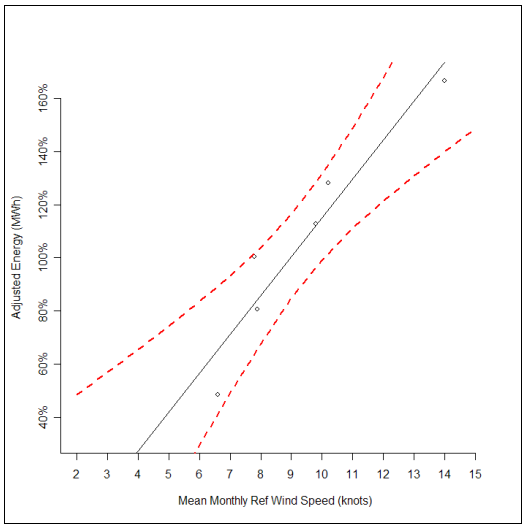

Fig. 2A: Regression with 6 months data

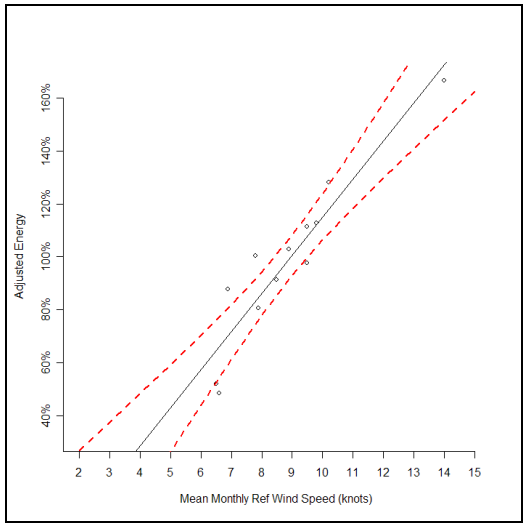

Fig. 2B: Regression with 12 months data

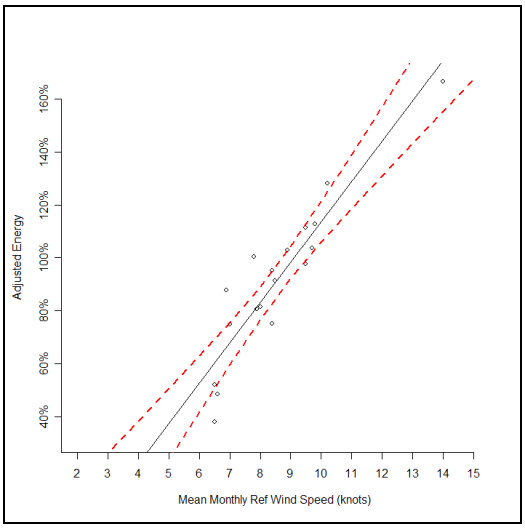

Fig. 2C: Regression with 18 months data

Methodology

Modelling

After a period of site operation, the average monthly wind speed at the off-site reference station can be plotted against the generation of the site normalised for availability (see fig. 2a).

This provides a direct relationship between reference wind speed and known site generation, with an associated uncertainty illustrated by confidence intervals.

As the size of the operational dataset increases, the uncertainty is reduced (see fig. 2b & 2c).

Interpolation

The long-term wind regime at the reference station is applied to the operational model, providing a mean monthly output prediction and an associated error of estimate.

Uncertainty Analysis

Uncertainty analysis is conducted to evaluate error due to anemometry, error in power production measurement.

Finally, an uncertainty is applied, as in the pre-construction analysis, to represent the validity of the reference dataset as a long-term estimate.

These uncertainties are combined to produce a set of P90 figures for the predicted future output of the wind farm.

The following uncertainties, present in the pre-construction methodology, have been removed from the analysis:

- Site wind correlation
- Flow modelling
- Wake modelling
- Shear modelling
- Turbine power performance
- Line losses

Results

For an example forested site with semi-complex terrain, Figure 3 illustrates the comparison between the pre- and post-construction P50 and 10-year P90 figures after 18 months of operation.

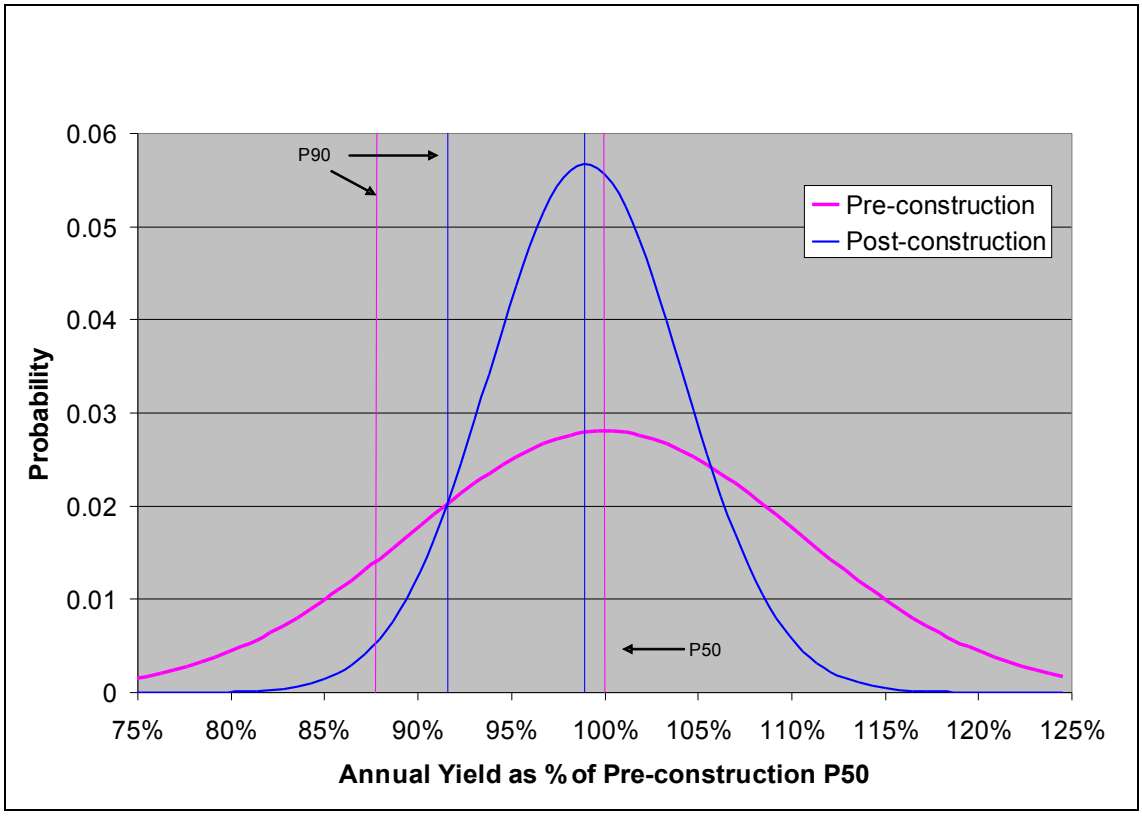

Fig. 3: Pre- and post-construction comparison for a semi-complex forested site with 18 months operational data

It can be seen that while the P50 figure has altered very little between the two analyses, the reduction in uncertainty has resulted in a significantly higher 10-year P90 figure.

In the pre-construction analysis, the difference between P50 and 10-year P90 was 15% of the pre-construction P50.

In the post-construction analysis, this has been reduced to 8%.

This increase in the P90 allows the project finance to be re-assessed for the remaining lifetime of the project, releasing equity from the investment.

In addition, this analysis can be revisited on an ongoing basis, allowing continuous revision of the project budget according to site performance.