Power Forecasting – WindSim Add-on Module

1 Introduction

The Power Forecasting Add-on Module of WindSim uses Computational Fluid Dynamics (CFD) and machine learning algorithms to downscale weather forecast in order to minimize the errors in the prediction of wind power production. You can use this module on your operational wind farms when wind measurements at the site are available. WindSim may also support you to set-up the CFD model for the wind farm, and assure installation of the complete forecasting software solution on your computer.

2 WindSim Company

WindSim AS is the developer of the software WindSim. WindSim is a simulator based on Computational Fluid Dynamics (CFD) for prediction of local wind fields. WindSim is used within the wind energy sector to maximize the energy production and minimize the loads on the turbines. The CFD technique solves the fundamental equations of fluid flow, which allows WindSim to accurately predict local wind fields, even in cases with complex terrain and complex atmospheric conditions.

In addition to developing the WindSim software WindSim AS also offers comprehensive consulting services throughout the wind farm life cycle from first site screening to post construction services.

3 WindSim Forecasting

3.1 WindSim Forecasting Procedure

In our forecasting we use the standard WindSim procedure: The wind flow over the area is modeled from at least 12 different wind directions for different wind speeds and different atmospheric stability classes to create look-up tables. The predicted time series from the mesoscale meteorological model at a point inside the park are then scaled by the CFD to every turbine position using the CFD results. During the downscaling process a wake model is applied for obtaining realistic forecasts of the energy production at each turbine position, see Fig. 1.

It is well known that the highest error in such a forecasting solution comes from the mesoscale model due to the failure of the model to correctly predict the wind speed. The model forecasts accurately predict the relative amount of wind speed variability but the prediction is often shifted temporally resulting in what are referred to as phase errors and there can also be large model bias errors in wind speed.

To overcome such forecast errors we developed a correction procedure based on Artificial Neural Networks (ANN). With historical measurement data from the site and mesoscale hindcasts for the same

period the ANNs can be trained to recognize very complex and nonlinear patterns between the wind conditions modeled and the wind conditions observed. These trained networks can then be used to correct each forecast time series. This correction yields more accurate point-forecasts which are then used to scale the CFD simulations. In case online data from the site is available the correction can be even more precise.

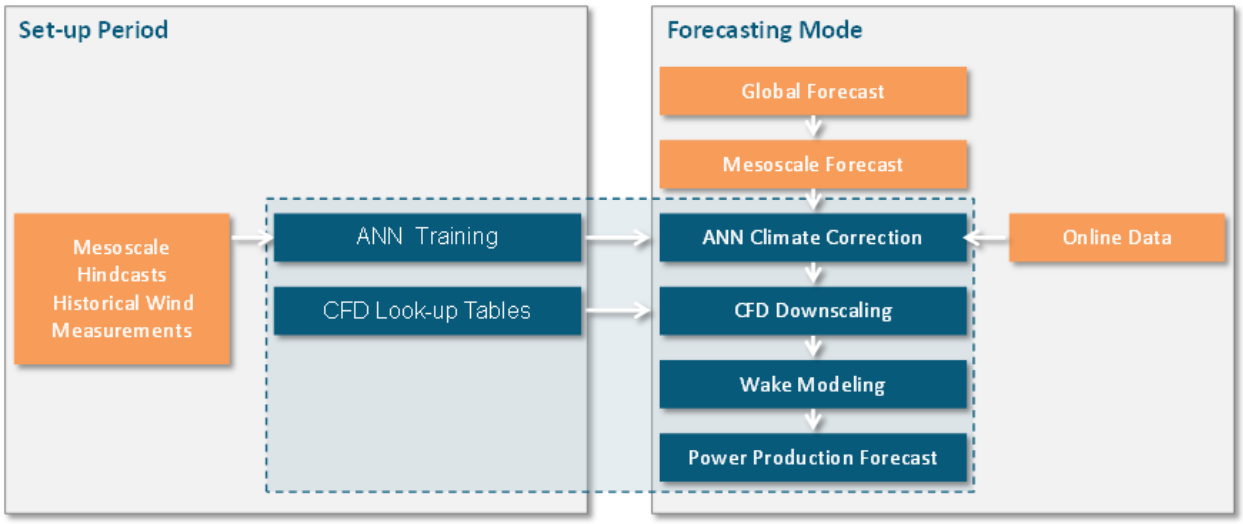

Fig. 1: WindSim Power Forecasting Add-on module: *Coupling procedure between meso- and microscale models. The parts in blue are processed inside the module and the parts in orange are data for training and running the module.*

WindSim Power Forecasting is an Add-on module which works in conjunction with the normal WindSim license. The normal WindSim license is used to set-up the CFD projects and to create the look-up tables. Afterwards the Add-on module is configured for each individual wind farm:

- Mesoscale weather prediction data will be automatically downloaded
- The Neural Network correction is trained according to the available data
- The forecast is run fully automatic

The Neural Networks can be trained on wind speed and soon also power production data. In case the wind farm has just recently been built or production data is not available the training would rely on historical wind measurements only and include production in a later stage when the wind farm has been producing long enough to guarantee a good training quality.

Feeding online data into the system during the forecasting period improves results and it should be checked if this is possible for your wind farm.

4 Software and consulting services delivery from WindSim experts

WindSim or the customer can take care of the project Phases 1 and 2 below following the approach described. For people not known to neural networks, ftp access and/or CFD we propose that WindSim delivers Phase 1 and 2 for the customer.

Phase 1: Consulting service - CFD
WindSim will set-up and run the complete CFD model for the wind farm. All necessary CFD input for the Power Forecasting Module will be provided.

Phase 2: Consulting service - Forecasting
WindSim will train and deliver a running forecasting solution on the Customer workstation for one specific wind farm. The neural network will be trained using historical forecast and historical wind data. After the training phase actual forecast will be corrected and downscaled automatically when available.

Phase 3: Consulting service – Online data

In case online SCADA data of the wind farm is available the Power Forecasting Module can be improved by using this data. The data stream is adjusted to fit into the forecasting module and the necessary corrections are done.

Option 1
WindSim can optionally take care of the purchase of the historical and actual forecast for the area of the wind farm under test from a third party partner provider.

4.1 Results

The outcome for the project is:

- Mesoscale weather forecast for one point in the wind farm area
- Microscale Production forecast based on Mesoscale/NN/WindSim coupling for every single turbine and for the whole wind farm. Available as ascii files stating the date, the wind speed and the production and in a graphical visualization in the add-on module

4.2 Required input from the Customer

Required and optional inputs are reported below by phase number:

Input	Type	Phase
WindSim CFD model run by WindSim or by the Customer	Required	Phase 2
Historical measurement data of wind speed and wind direction (best also temperature and pressure) from the site for at least one year	Required	Phase 2
Historical and actual weather forecast from meso scale data provider	Required	Phase 2
On line production and wind data every 6-12hours	Required	Phase 3

Photos from the site, the measurement masts and the wind farm are welcome.