AEOLUS TOOLBOX for dynamic wind farm modeling, simulation, and control

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Sim Wind Farm

Features of Aeolus simulation tool:

- Toolbox is open source
- Based on MATLAB/SIMULINK
- Suitable for wind farm control design
- Flexible for any wind farm layout and number of wind turbines
- Flexible for different wind condition simulations (Turbulence generation uses Veers method)
- Usable for all pitch regulated turbines
- Wake effects are included by means of dynamic wake meandering
- Fatigue load analysis on turbine components

Main components for wind farm simulation

The model includes four main blocks in the top level which operate in a closed loop:

- **Wind Turbine Dynamics**

  includes electromechanical model of pitch regulated wind turbine, simplified aero-elastic model, and fatigue load analysis

- **Wind Field Dynamics**

  includes ambient wind field generation, wake deficit, meandering and merging

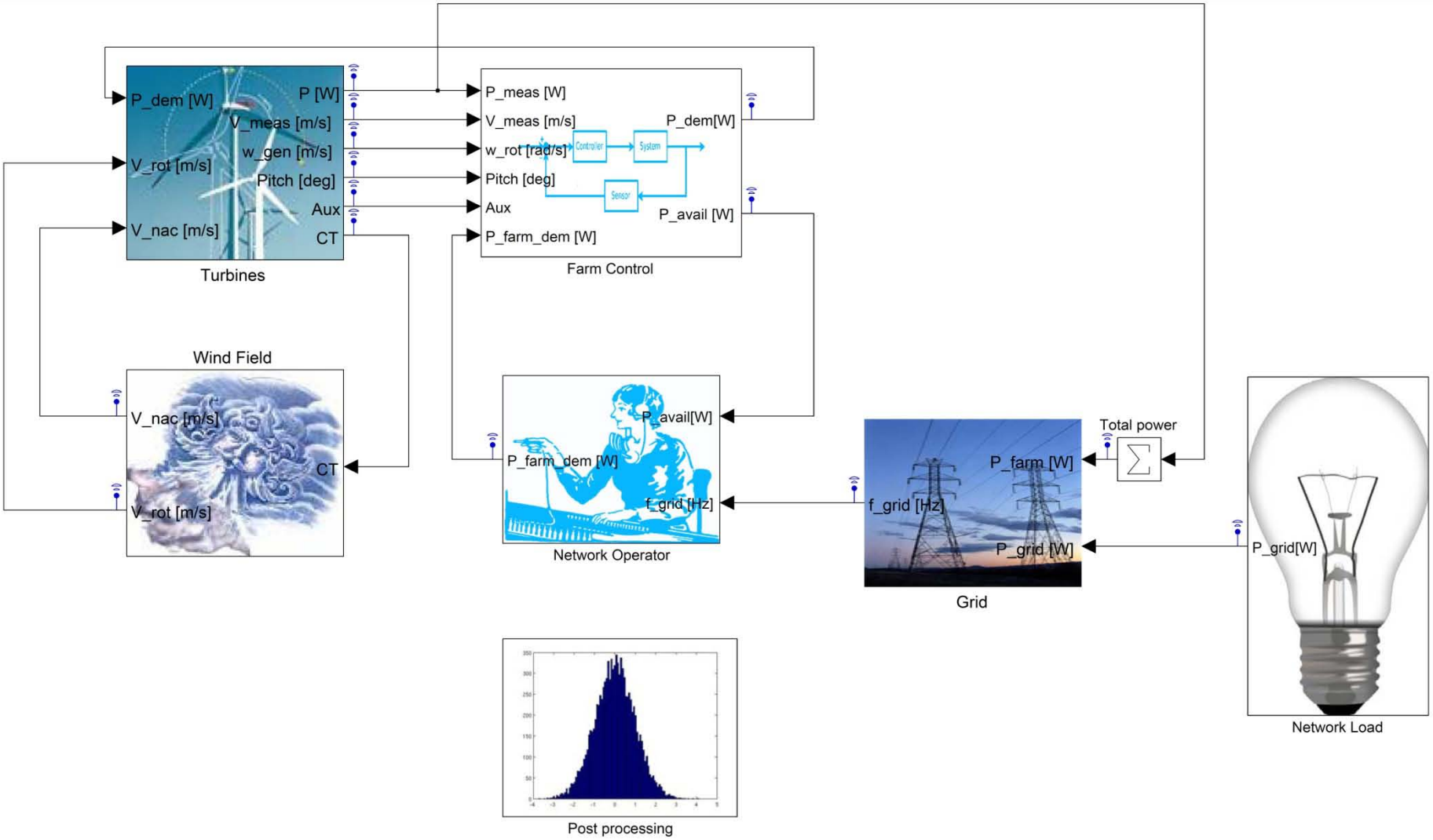
- **Wind Farm Controller**

  Simple proportional controller as well as dedicated centralized controllers and decentralized controllers

- **Network Operator**

  Capable for simulating different options such as absolute active power mode, Delta mode, balance model, rate limiting mode, frequency control mode

SimWindFarm Overview



Ambient wind field

Inputs:

Mean wind speed

Turbulence intensity

Lateral displacement

Simulation time

Sample time

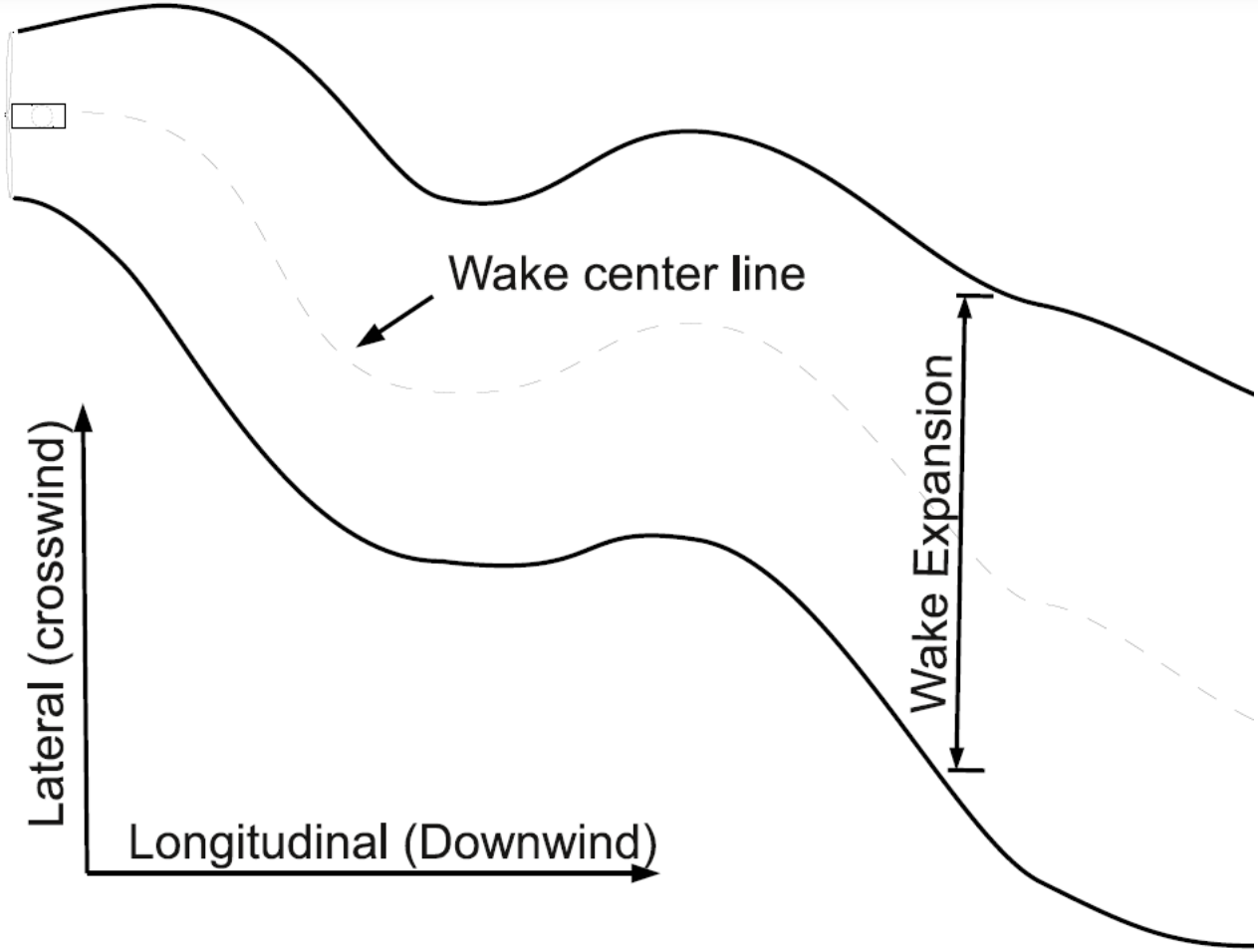
Processing:

Two spectral matrices are provided

Output:

Lateral and longitudinal wind speed matrices

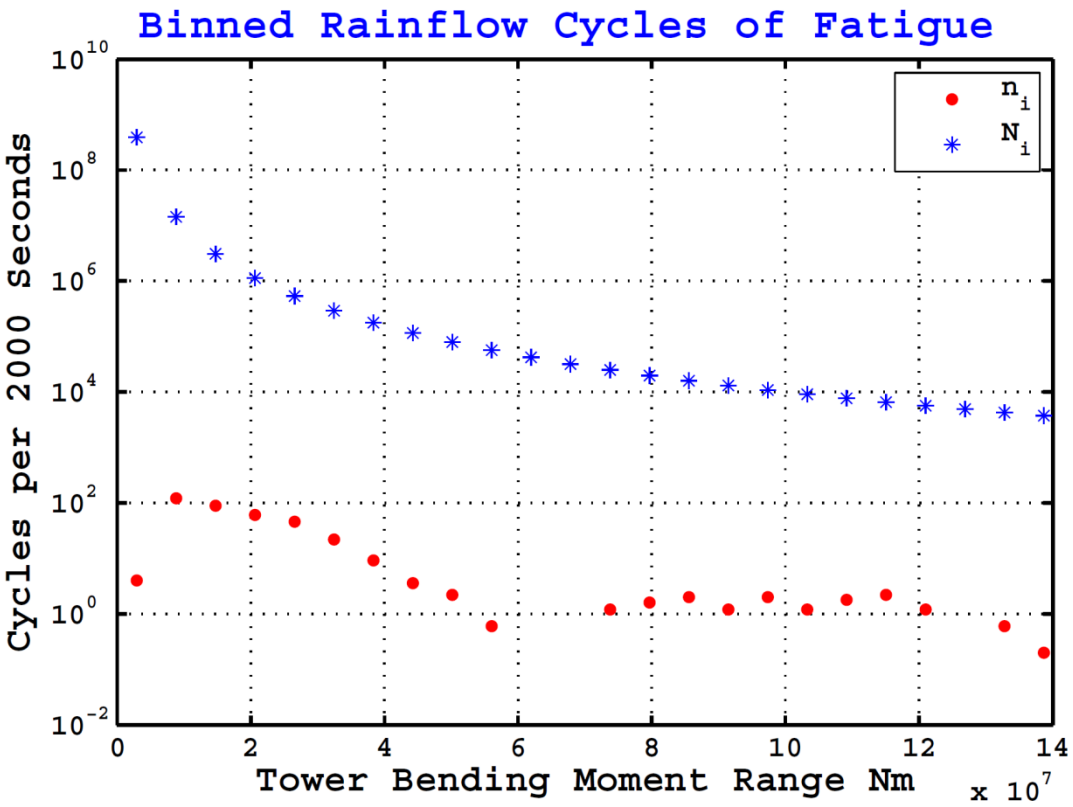
Wake deficit and wake meandering



Wake meandering of a turbine defined by the wake center location and the wake expansion.

The standard deviation of the signal and its derivative

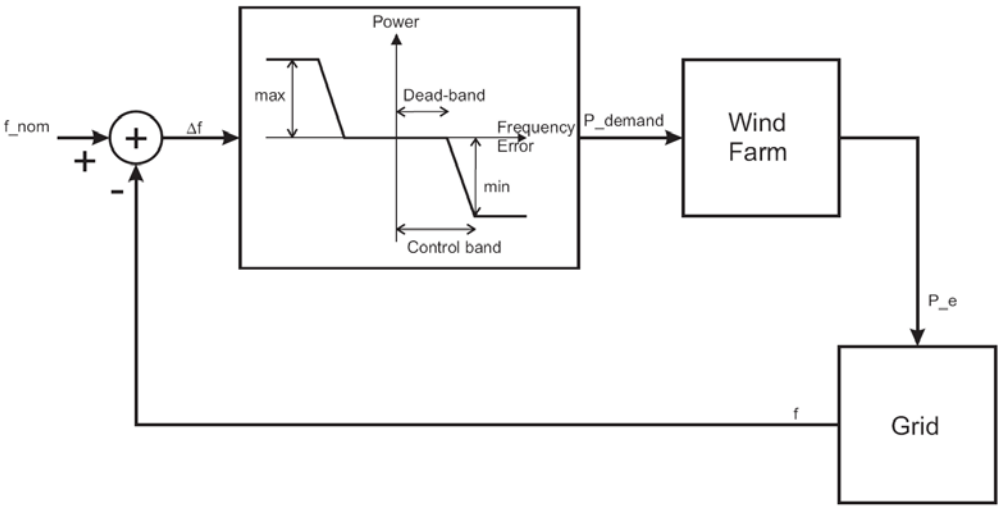
In SimWindFarm, fatigue loads are evaluated in a post processing tool using rain-flow counting where the stress cycles and their ranges are counted in order to create a histogram of cycles. For each stress range, the partial damage can be computed as $D_i = n_i/N_i$ where n_i is the number of cycles for the i'th stress range, and N_i is the number of cycles to failure.



Operating Modes

The main operating modes:

- Absolute active power cont
- Frequency control
- Delta mode
- Power rate limiter
- Balance mode

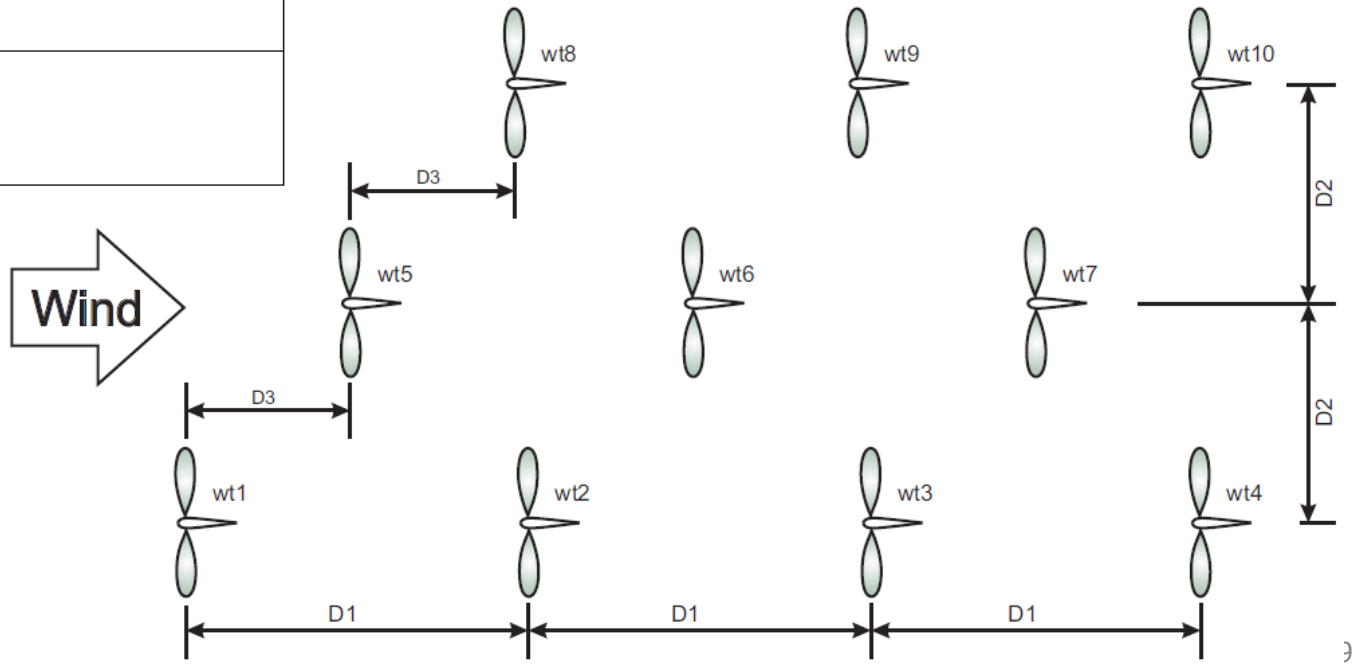


mode number	mode	settings
1	Active power control	power demand [kW]
2	Delta mode	Delta [kW]
3	Balance mode	power level [kW]
4	Rate limit	max power rate [kW/s]
5	Frequency control	(dead-band [Hz], Control band [Hz], min/max power [kW])

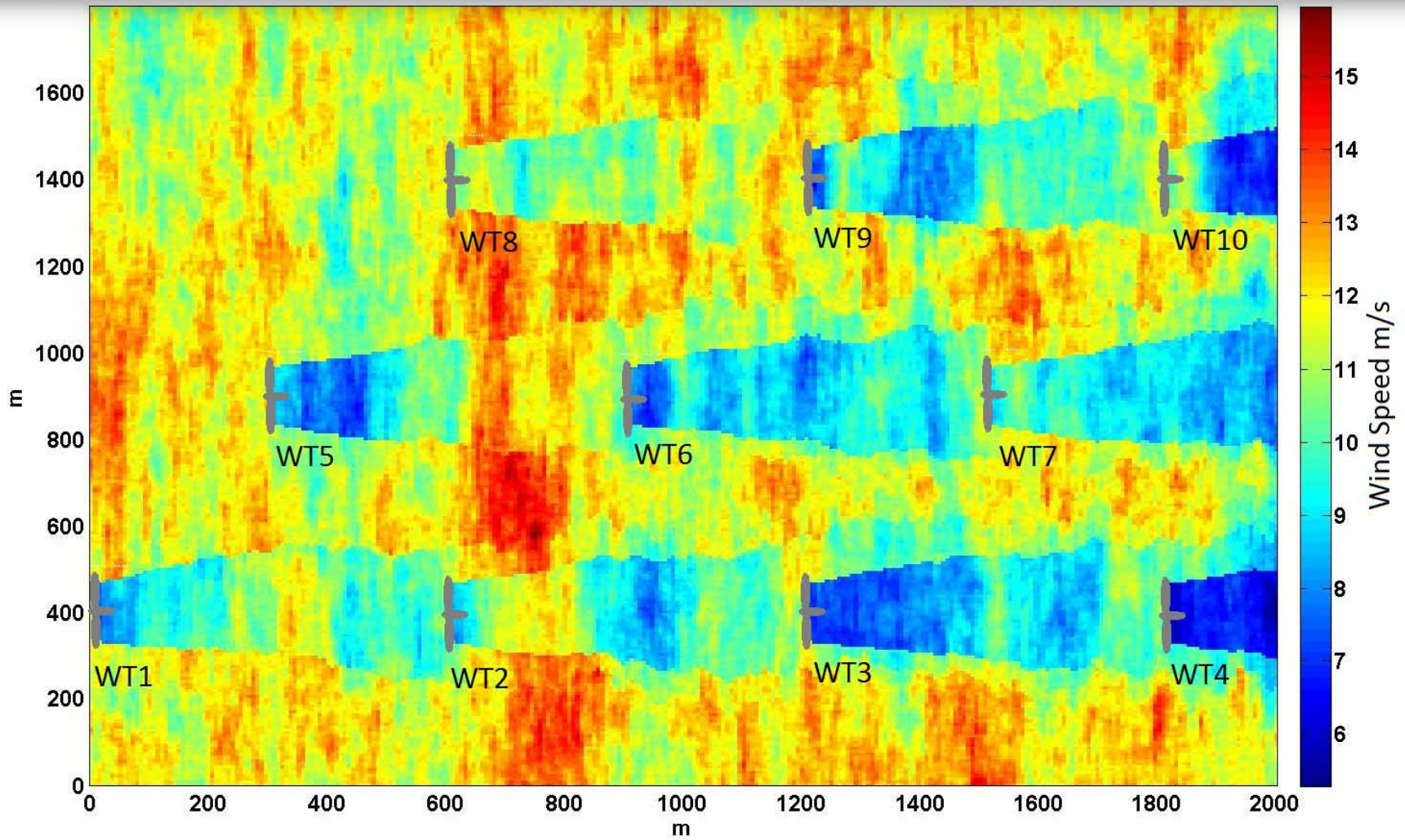
Benchmark

Rated power	$5MW$
Configuration	Upwind, 3 Blades
Control	Variable speed, collective pitch
Wind	
Cut-in	$3\frac{m}{s}$
Rated	$11.4\frac{m}{s}$
Cut-Out	$25\frac{m}{s}$
Rotor	
Cut-in	$6.9rpm$
Rated	$12.1rpm$
diameter	$126m$
Hub	
Diameter	$3m$
Height	$90m$

Turbine properties and layout of the benchmark for simulation in SimWindFarm.

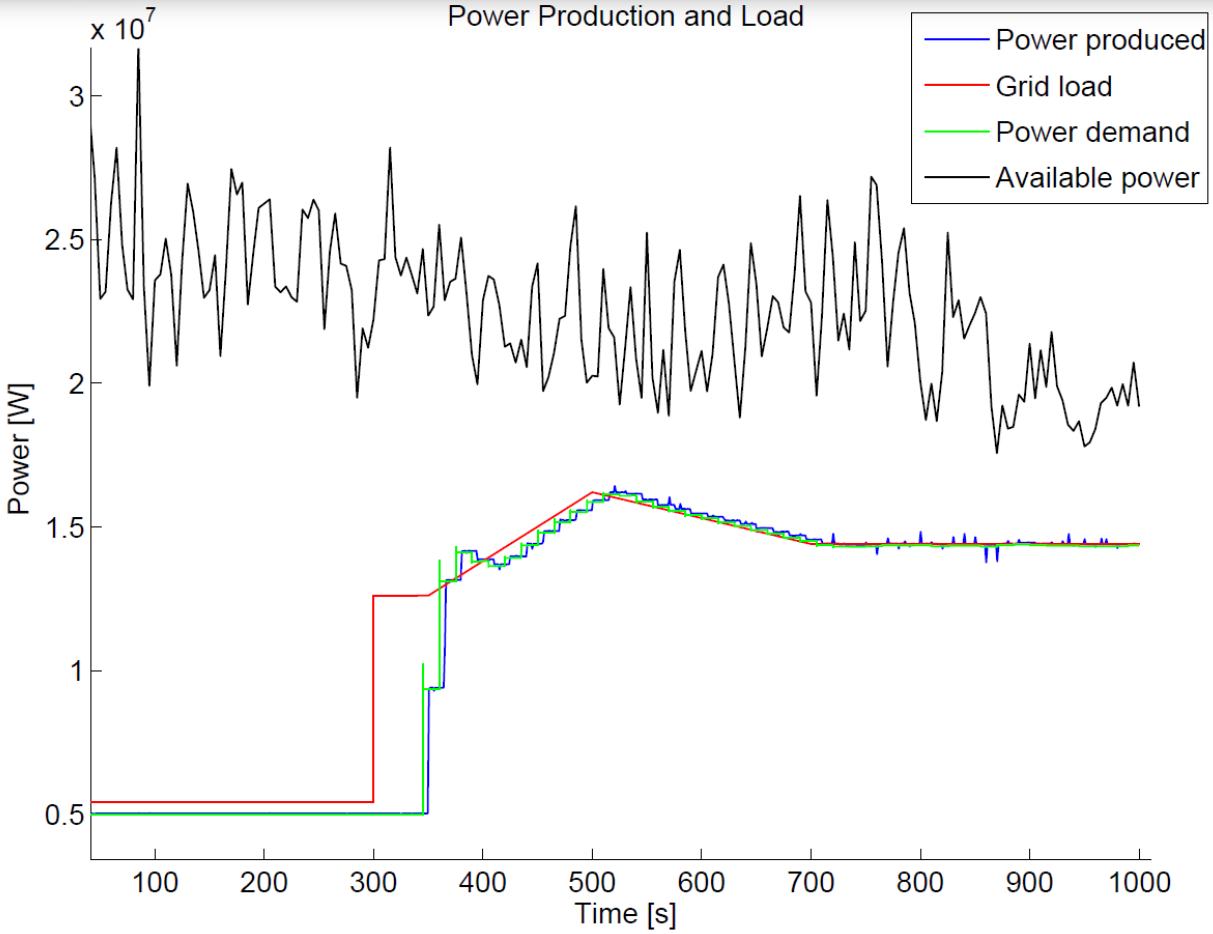


Benchmark



A snap shot of the wind flow in SimWindFarm.

Power production



Power and load during the simulation. The available power is the farm controller estimate, the power demand is the network operates desired farm production.