WindGEMINI

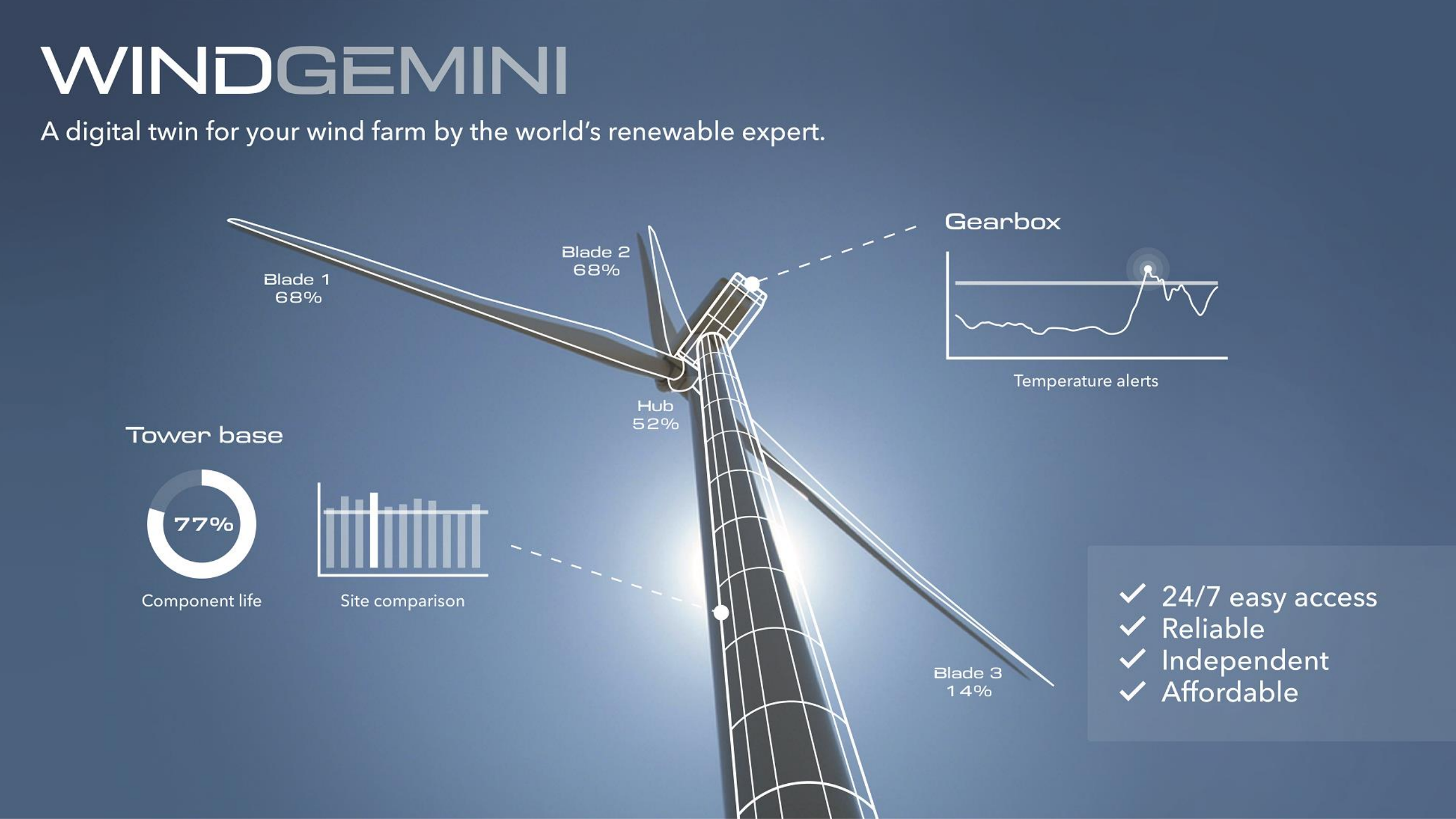
An Online Digital Twin for Wind Farm Operations

Global Wind Day Seoul

22 June 2018

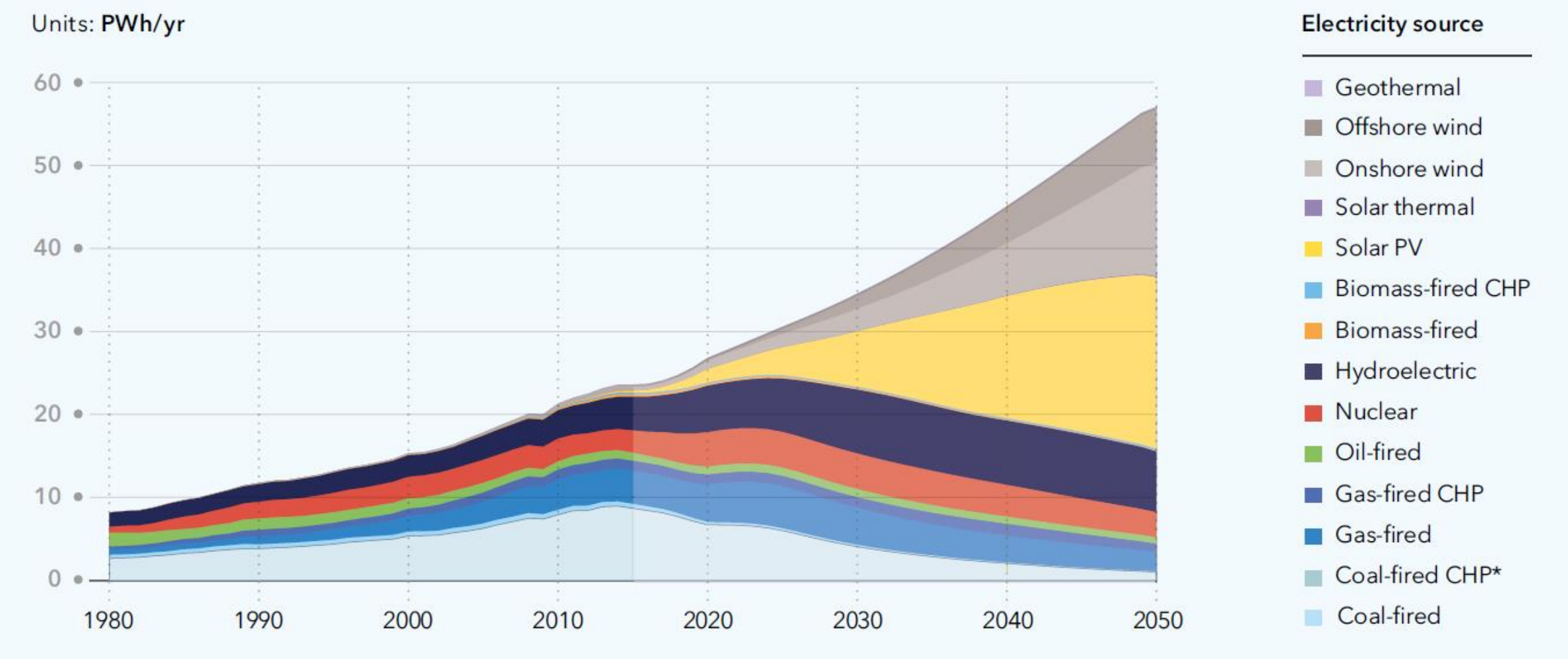
WINDGEMINI

A digital twin for your wind farm by the world's renewable expert.



- ✓ 24/7 easy access
- ✓ Reliable
- ✓ Independent
- ✓ Affordable

DNV GL Energy Transition Outlook



https://www.dnvgl.com/technology-innovation/sri/climate-action/research-projects/energy-transition-outlook.html

How to make operations smarter?

- Typical “pains” of an Owner/Operator
  - Are my turbines operating as well as they could?
  - How many failures can I expect over the next year?
  - Which turbines should be inspected first?
  - Will I be able to operate my wind farm past year 20?
  - Is my budget realistic?
- Owners and operators have different constraints from designers:
  - Limited capability to invest in large studies or optimisation campaigns
  - Short decision making time
- WindGEMINI is a digital twin designed to increase revenue and reduce O&M costs

Introduction

The Digital Twin framework

Reliability

- Drivetrain Integrity Module
- Structural Integrity Module

Performance

- Performance Watchdog Module
- Pattern of Production Module

Lifetime

- Turbine Life Estimator Module
- Online Energy Estimate Module

Conclusions

What is a digital twin – and how does it help?

Digital Twins

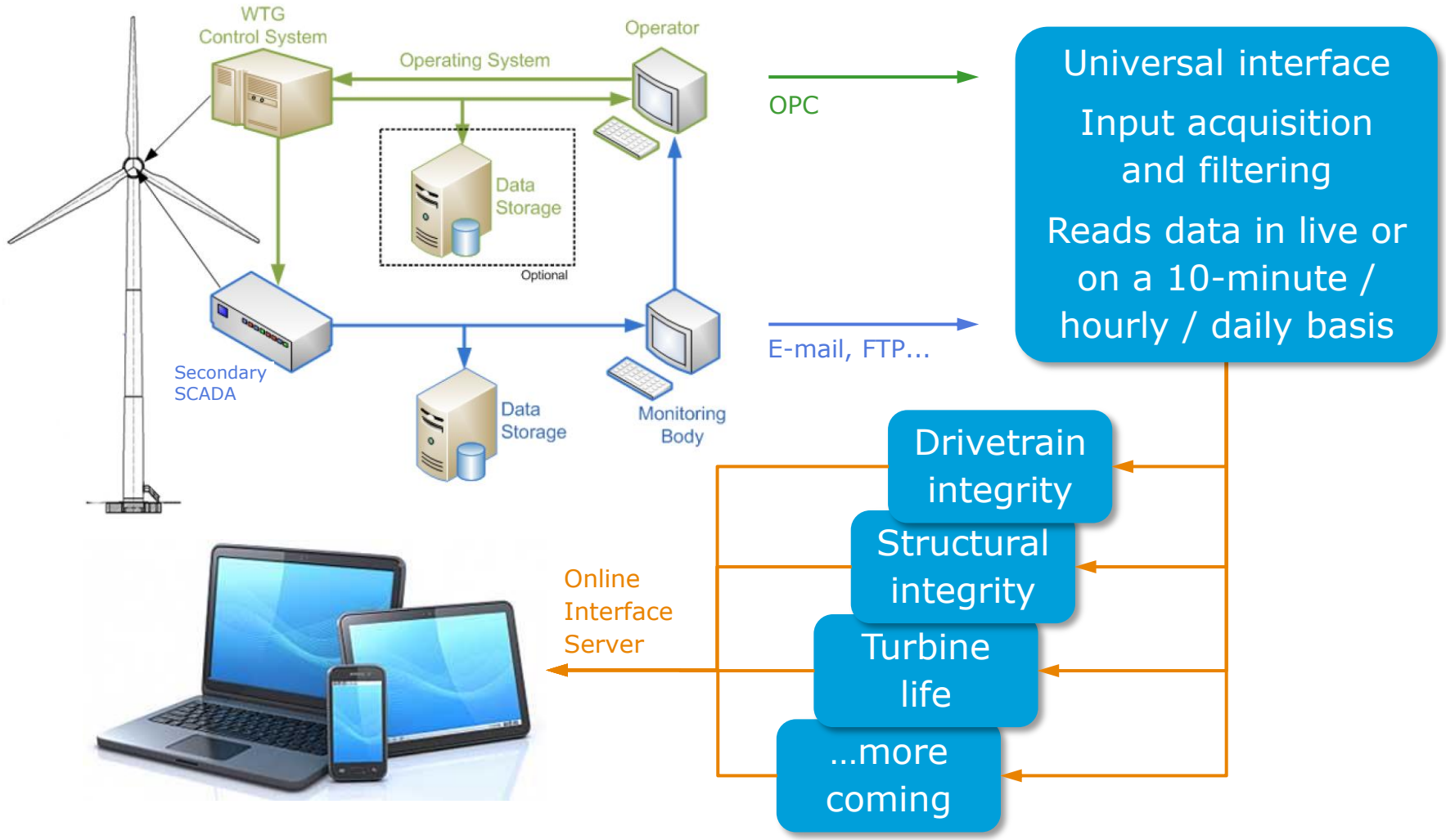
From Wikipedia, the free encyclopedia

Digital twins refer to computerized companions of physical assets that can be used for various purposes.

Digital twins use data from sensors installed on physical objects to represent their near real-time status, working condition or position.

- WindGEMINI is a framework rather than an algorithm
- It is a physics-based "multi-system" model of an operating turbine
- Updated in "near" real-time, making use of SCADA data from the turbine and wind farm sensors
- Provides at any given time an indication of the condition and value of each individual wind turbine
- Assists owners and operators in predicting failures and in optimising servicing and inspections
- Alerts are raised automatically and can be reviewed by an analyst before being published

Structure of the online digital twin



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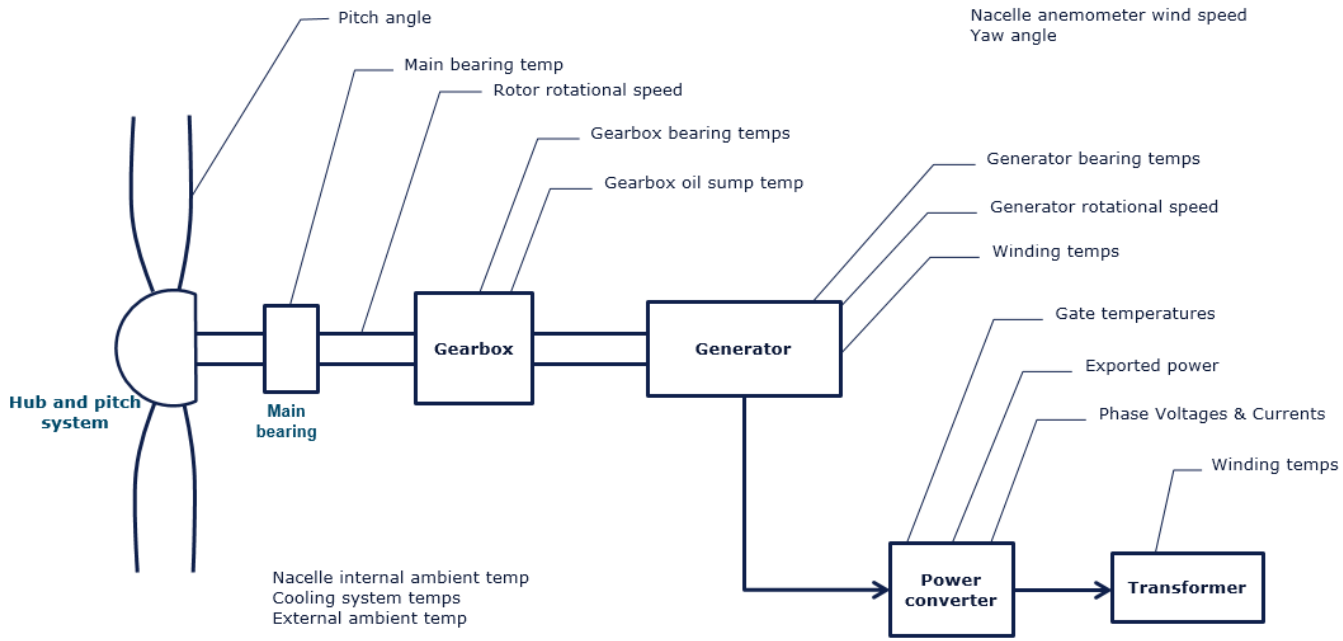
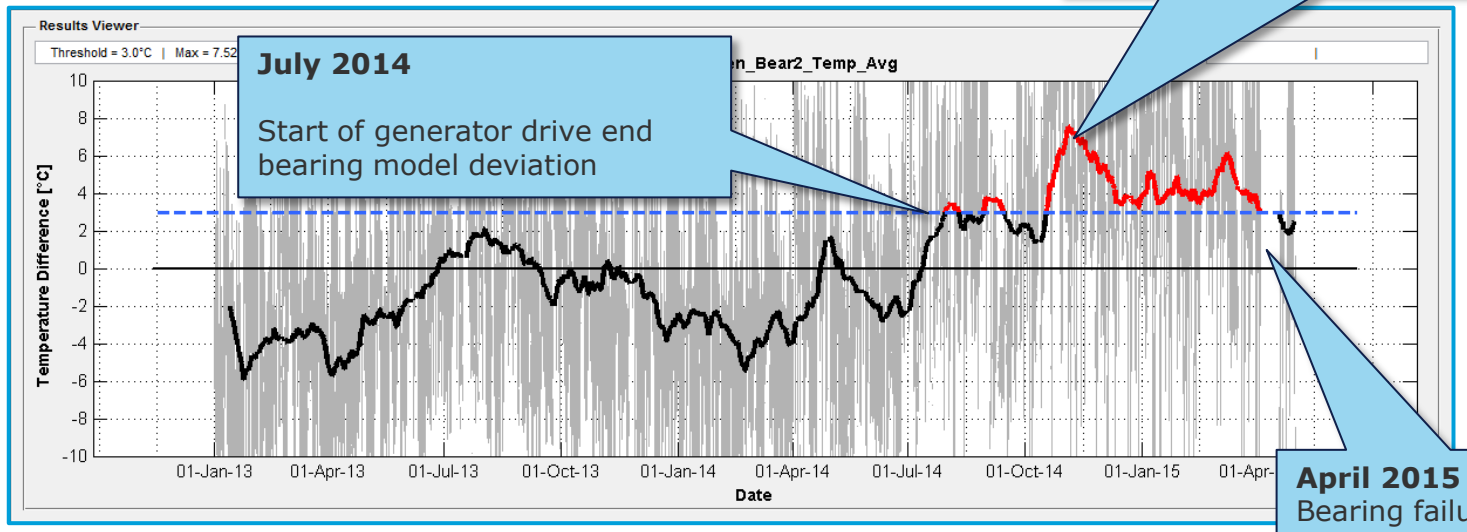
Drivetrain Condition Monitoring

- Failure detection algorithm that uses existing 10-minute SCADA data
- Based on trending of the temperature signals from the wind turbine drivetrain
- A period of normal operation is used to establish an expected relationship between input signals (power, ambient temperature, rotor speed) and the drivetrain temperatures being monitored
- This relationship is then used on an ongoing basis to monitor the real temperatures
- No additional sensors are required



Real case study 1 – Generator drive end bearing

- Traditionally managed wind farm: 'Run to failure' maintenance strategy
- SCM applied but **without** intervention



July 2014

Start of generator drive end bearing model deviation

November 2014

Medium confidence alert raised, but no action was taken

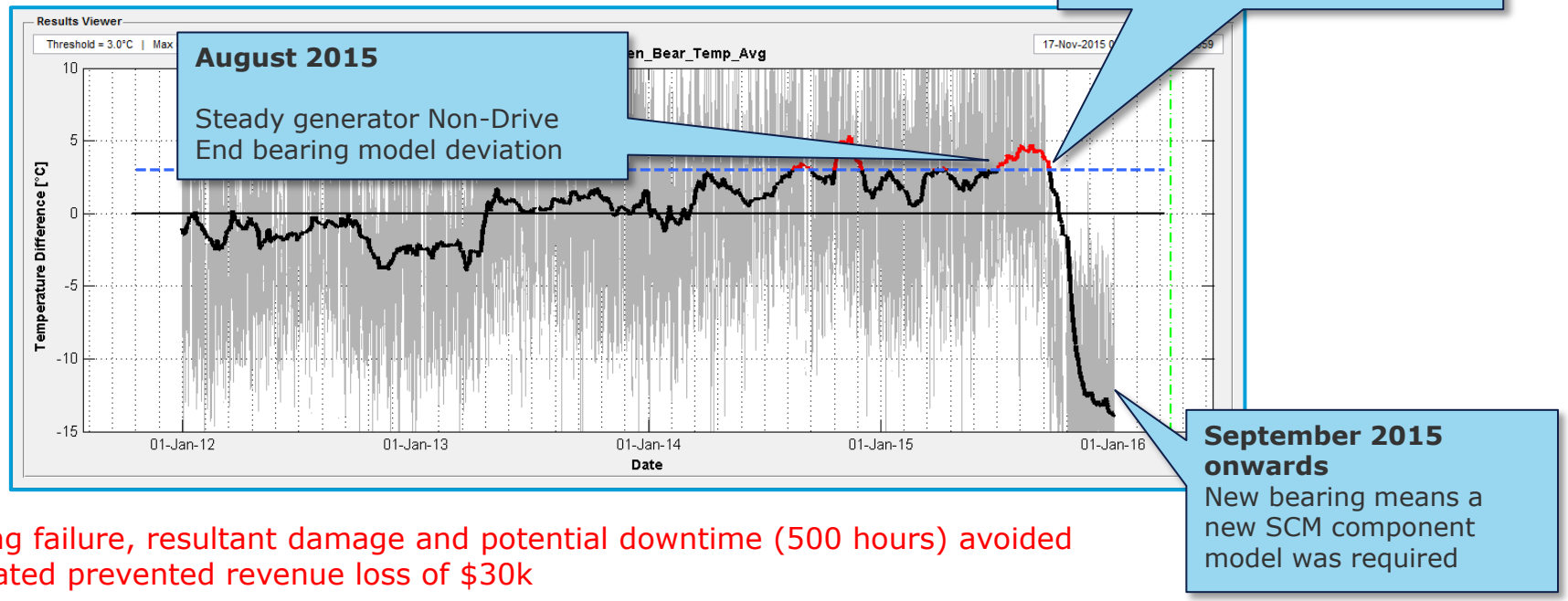
April 2015

Bearing failure and full generator replacement was required: total of 15 days downtime

- Planned bearing replacement estimated at only 2 days downtime
- Estimated preventable revenue loss of $20k. Estimated generator cost $100k.

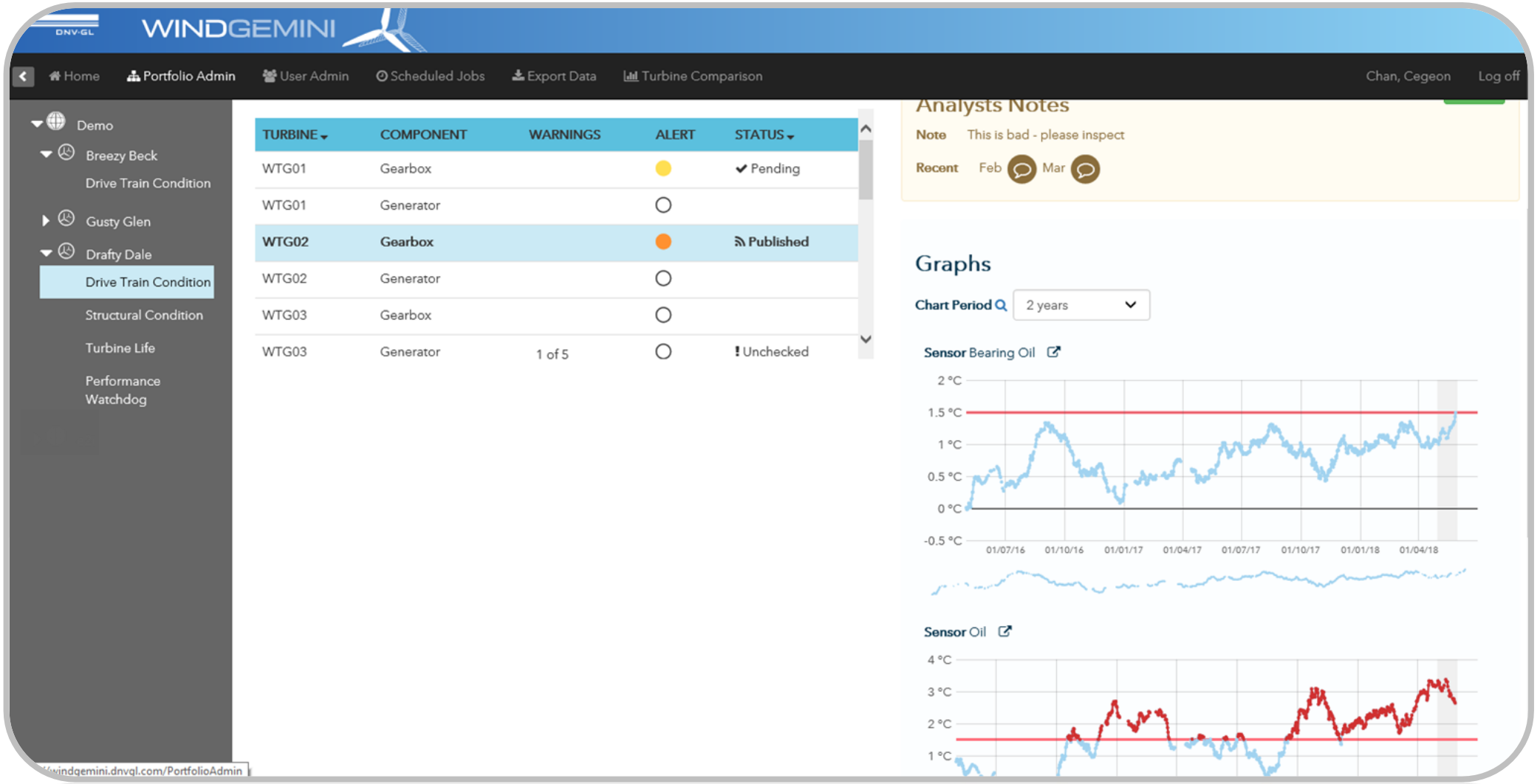
Real case study 2 – Generator non-drive end bearing

- Actively managed wind farm: condition-based maintenance strategy
- SCADA Condition Monitoring applied **with** intervention



- Bearing failure, resultant damage and potential downtime (500 hours) avoided
- Estimated prevented revenue loss of $30k

SCADA Condition Monitoring in WindGEMINI



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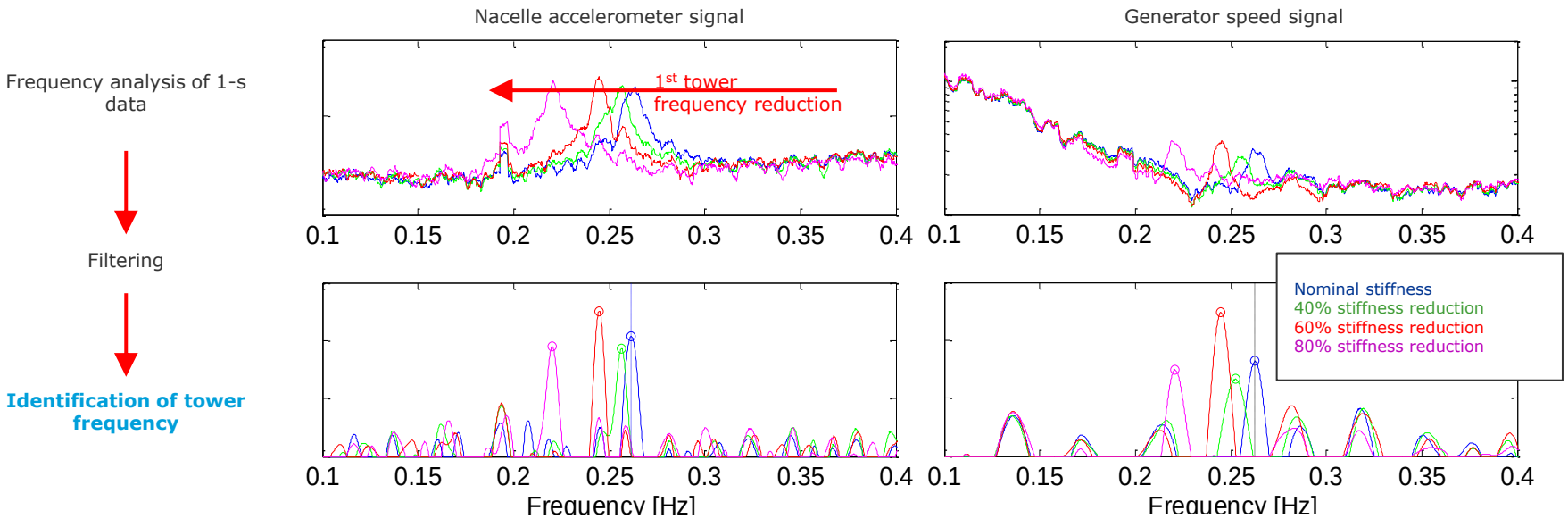
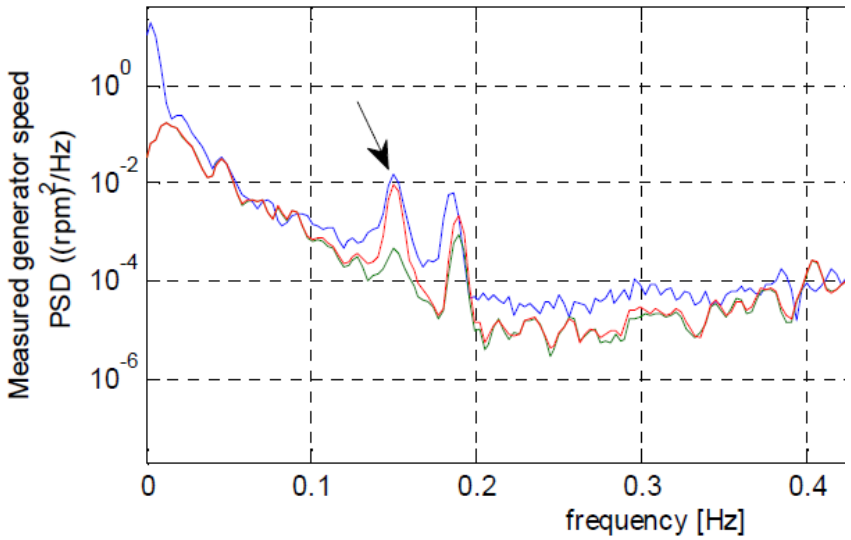
Identification of structural frequencies

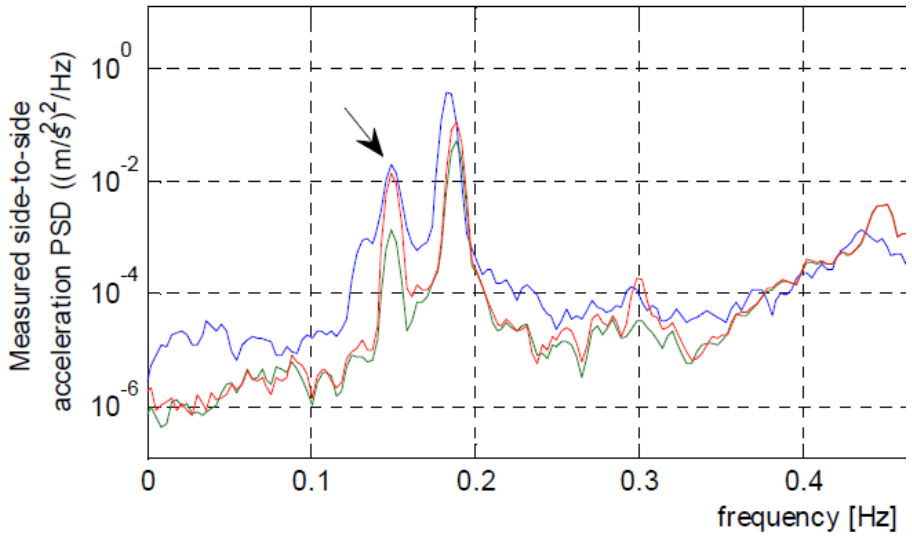
- Analysis of 1s SCADA allows tracking of tower & rotor frequency and power
- A convolution filter identifies frequency and energy levels of the main peaks
- Frequency analysis can identify a number of issues:
  - Shifts in foundation stiffness (degradation)
  - Rotor imbalance
  - Pitch misalignment



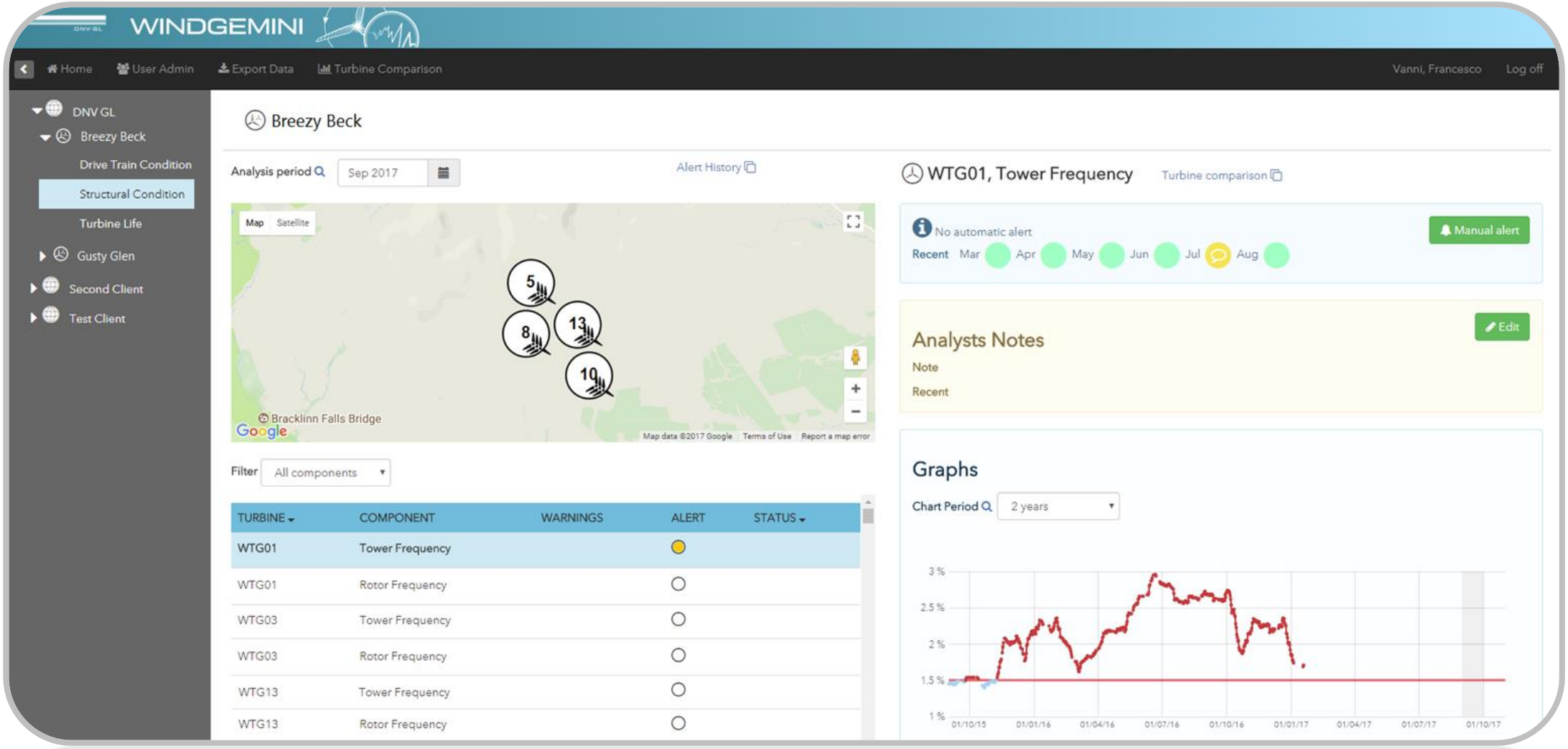
Real case study – identification of rotor imbalance

- 2015 study on soft-tower turbines
- T1 autospectra shows more energy than T2 (and other turbines) at the rotor frequency
- Speed / side-side acceleration points to aerodynamic (pitch) imbalance
- Autospectra were matched by modelling a 2° pitch misalignment
- Inspections confirmed a 1.8° pitch misalignment, later corrected





Structural condition monitoring in WindGEMINI



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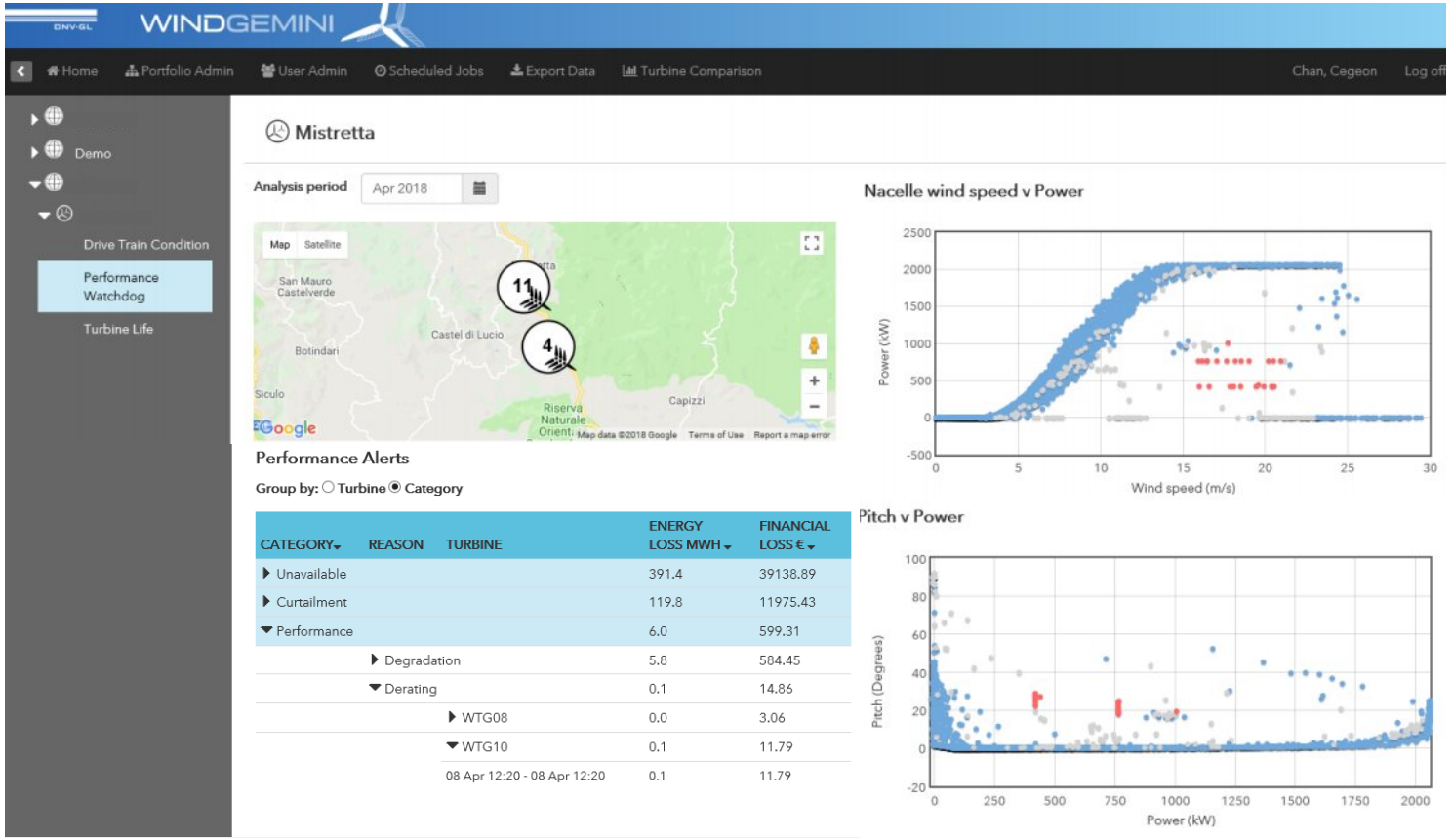
Performance Watchdog

- DNV GL has analysed over 65 GW of SCADA data
- The Performance Watchdog leverages the knowledge of examining blade pitch vs. power and rotor speed vs. power profiles and flags these issues
- This captures sub-optimal turbine condition issues such as turbine de-rates and incorrect pitch and/or rotor torque settings



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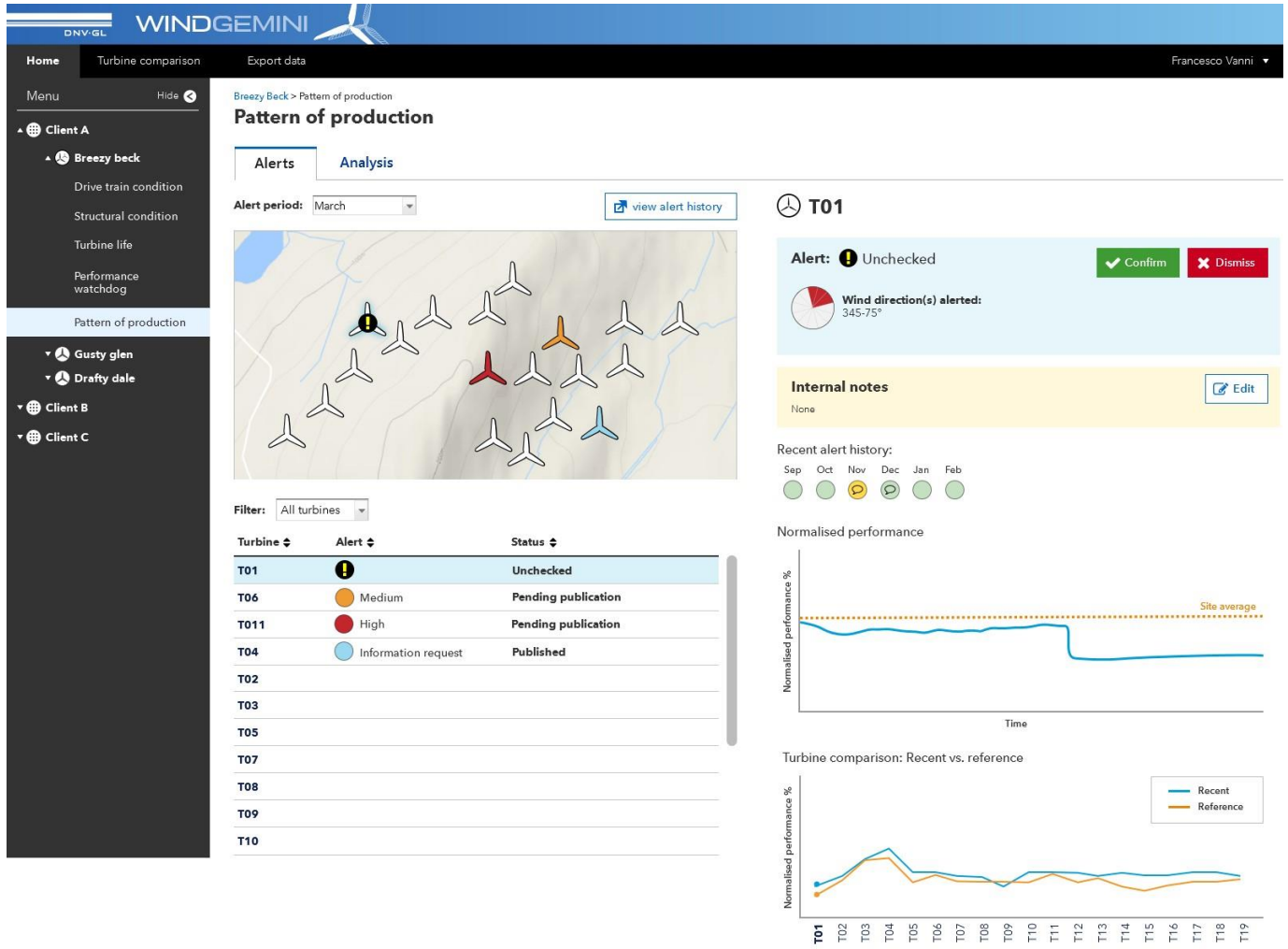
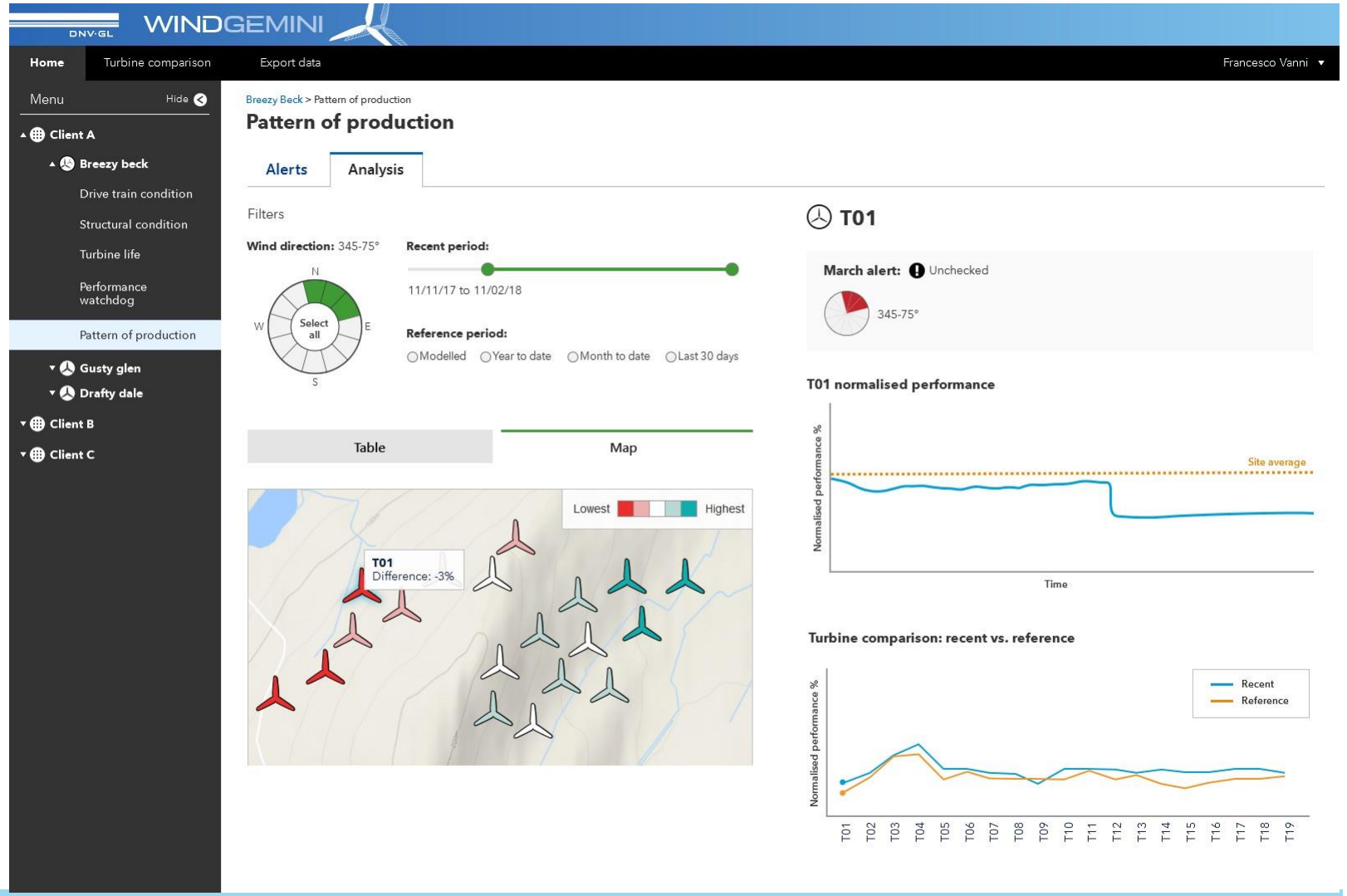
Pattern of Production - Alerts

- Comparison of turbine production with neighbors
- Ability to compare by wind direction
- Automatic alerts of turbine production that has dipped relative to the park-average



Pattern of Production - Analysis

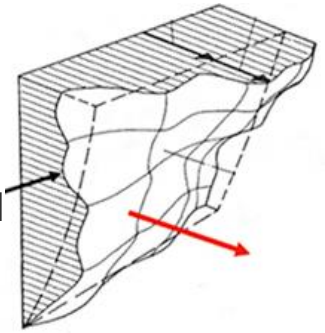
- A tool to customize wind direction sectors and time periods
- Map view of the turbine production



Fatigue lifetime estimator

1.

2.



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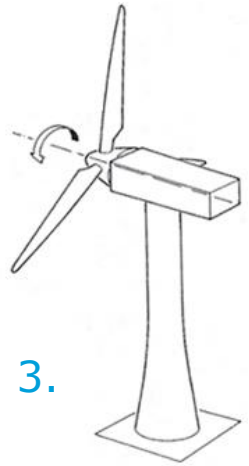
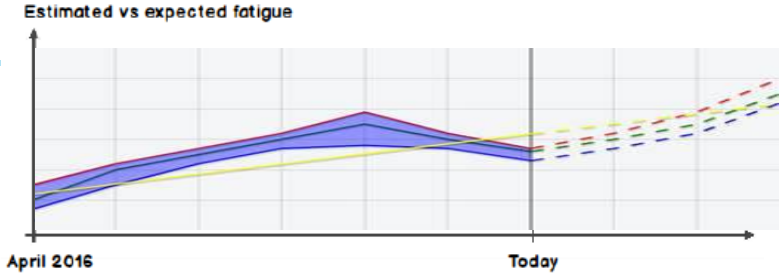


1. Acquire field data
2. Model site conditions based on real data
3. Estimate turbine state
4. Calculate loading and estimate uncertainty
5. Calculate Damage Equivalent Loads

5.



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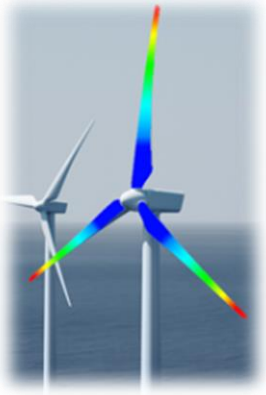
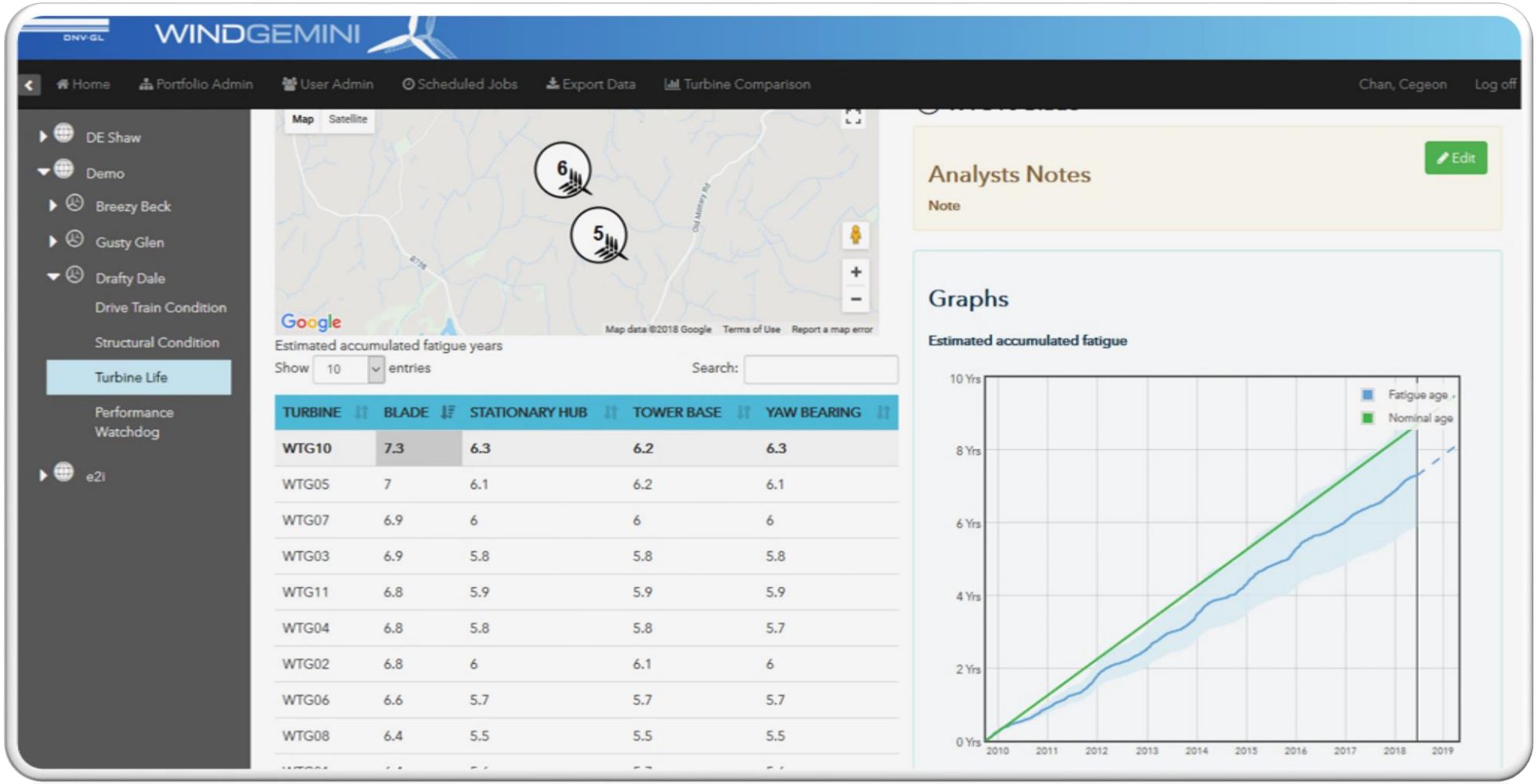


Fatigue life estimator in WindGEMINI



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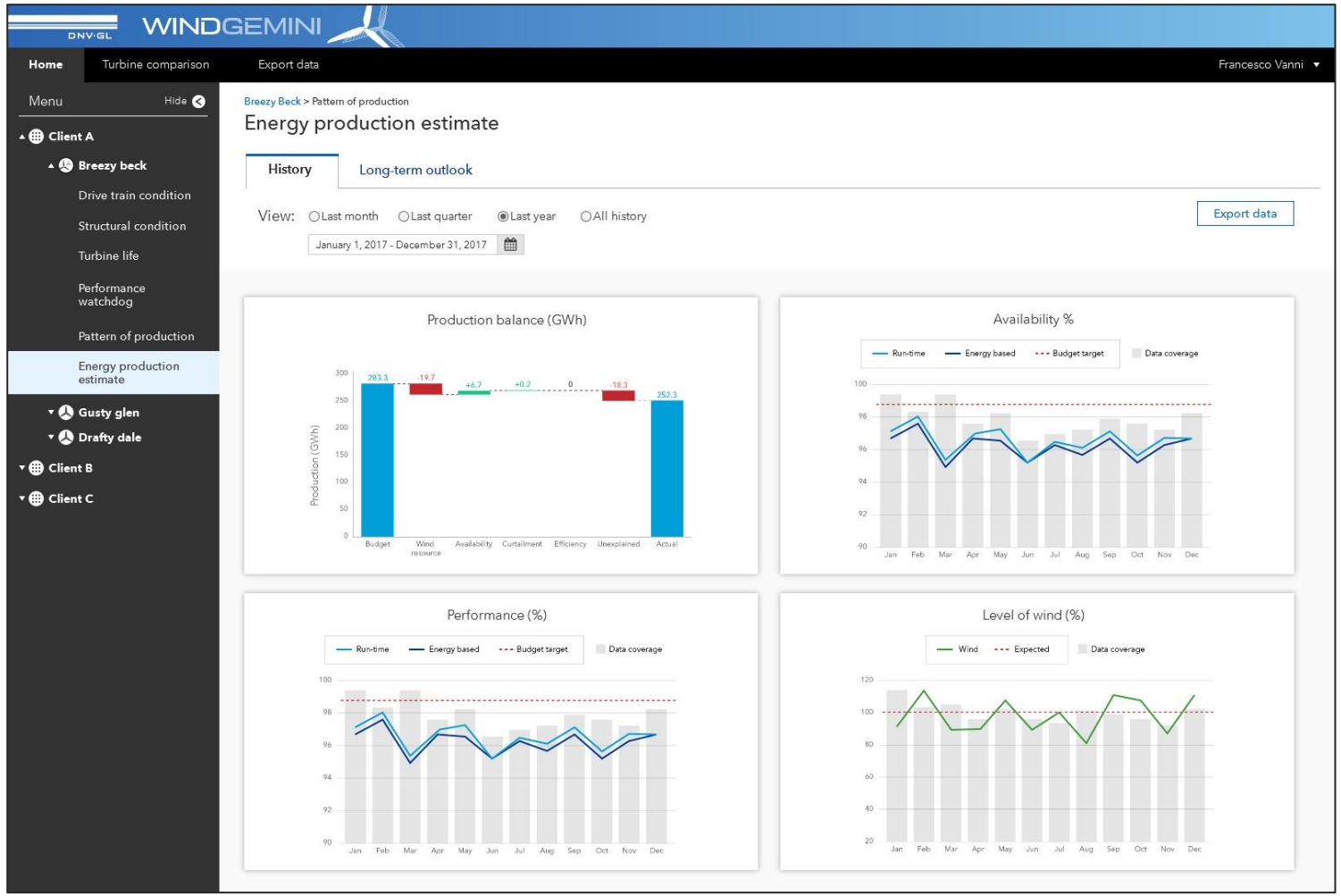
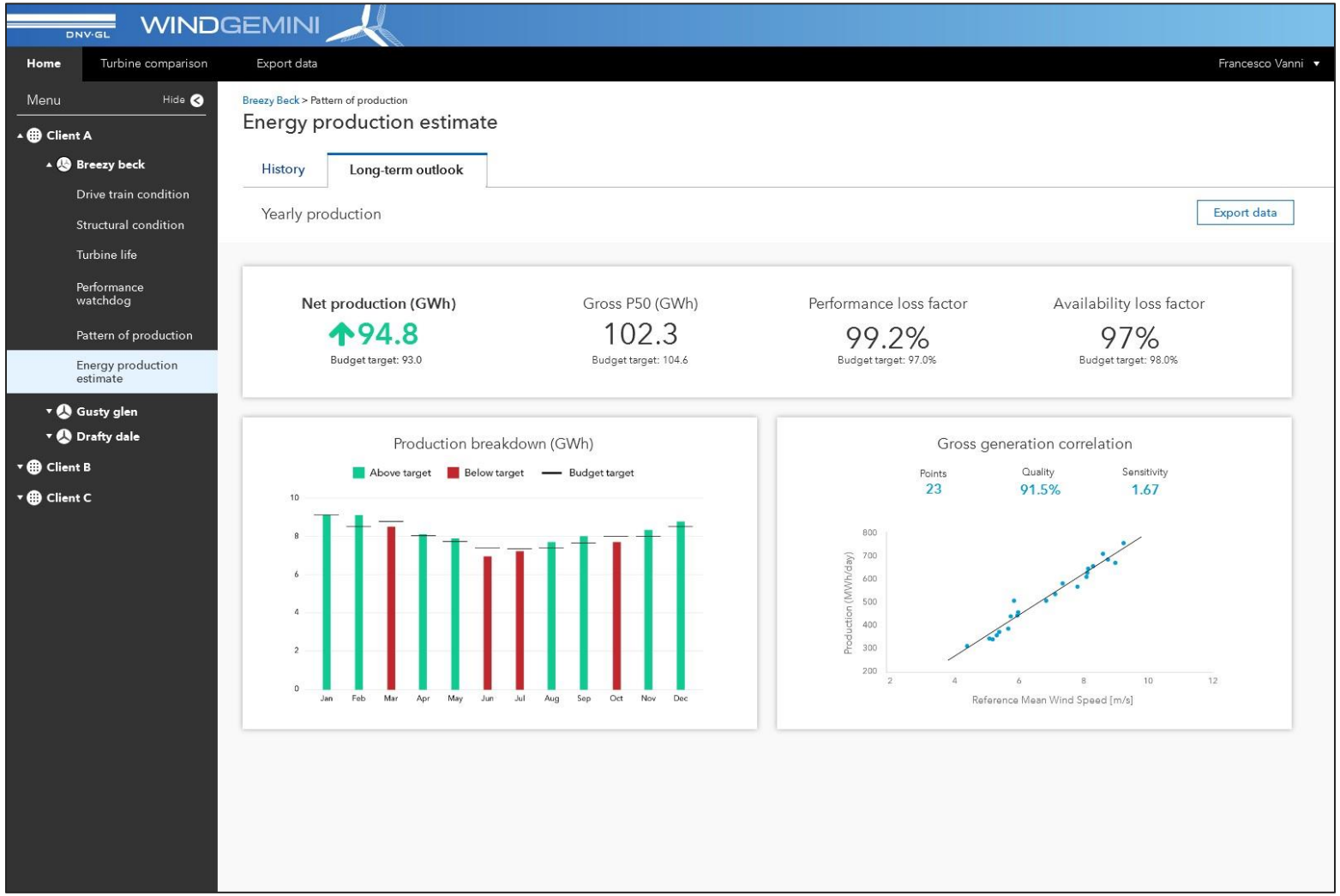
Module In development: Energy Production Estimate – Historical Production Balance



Module In development: Energy production estimate - Long-term Outlook



Conclusions

- WindGEMINI is a digital twin framework which analyzes operational data in near real time…
- …to deliver DNV GL's engineering expertise to our customers and increase their revenue
- Four algorithms are already functional within WindGEMINI
  - More algorithms are:
  - Drivetrain integrity monitor
  - Structural integrity analysis
  - Turbine life estimator
  - Performance Watchdog
- currently being developed or planned
  - Pattern of Production (2018)
  - Online energy assessments (2018)
  - Production balancing dashboard (2018)
  - ...other ideas are very welcome!
- For more info: http://go.veracity.com/windgemini

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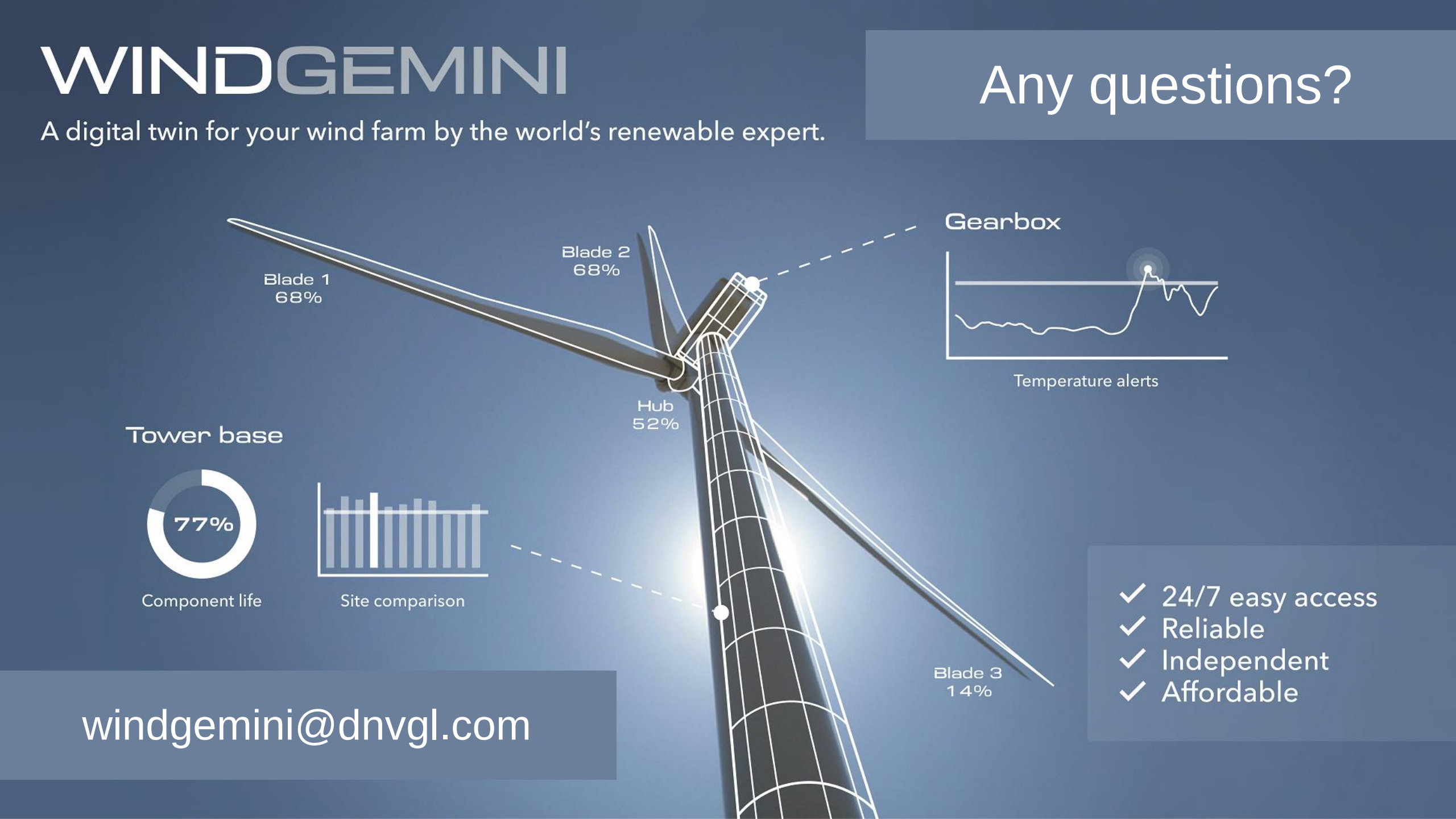
A digital twin for your wind farm by the world's renewable expert.

Any questions?



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- ✓ Reliable
- ✓ Independent
- ✓ Affordable

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