KONGSBERG

Wind Farm Management System

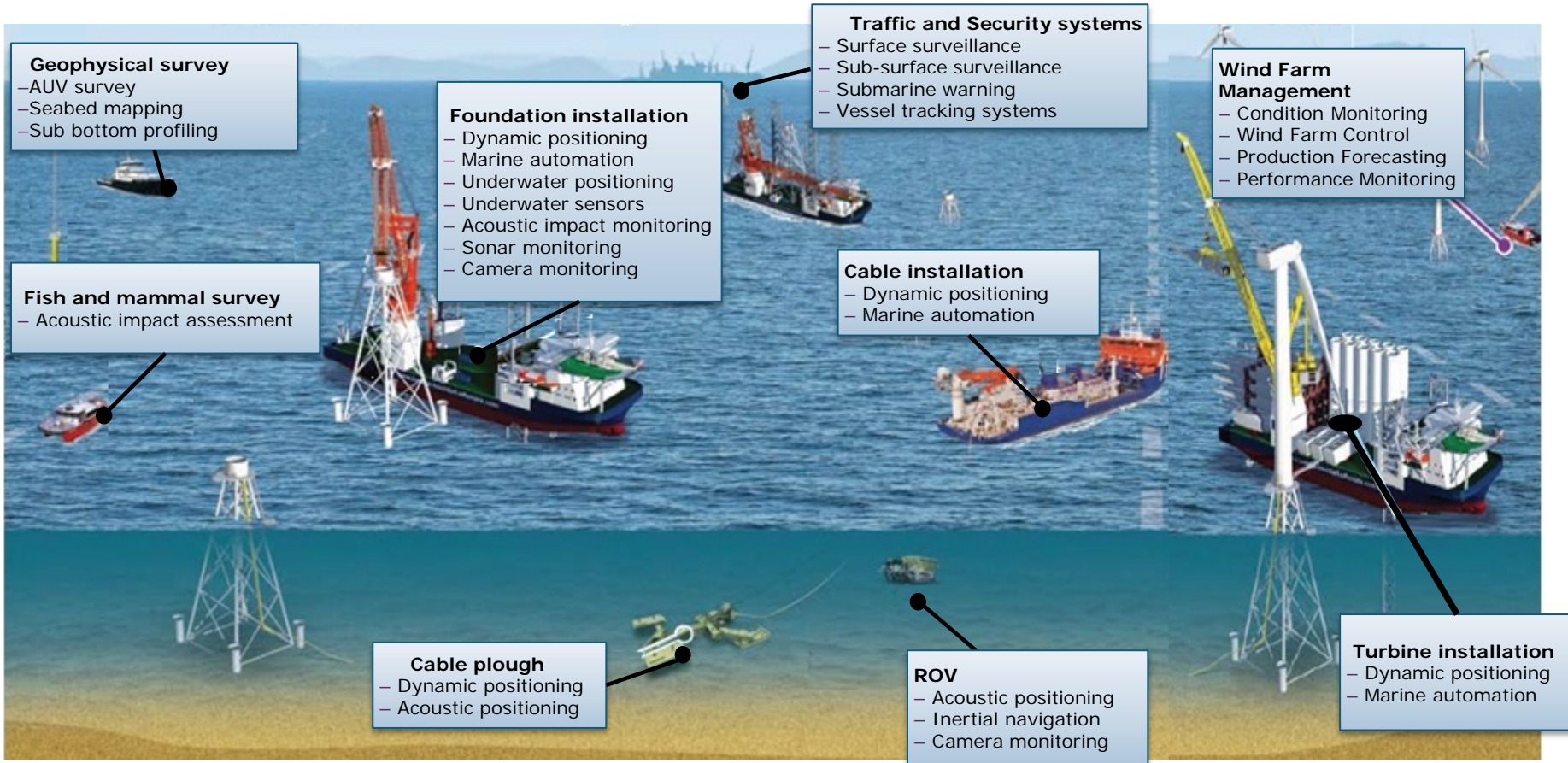## 2014.11.20 Industry meets Science

Presentation overview

- **Kongsberg Wind Farm Management System (WFMS)**
  - Performance Monitoring
  - Condition Monitoring
  - Wind Farm Control
  - Production Forecast

- Challenges for the entrepreneurs..

- If time allows - brief demo of Kongsberg Wind Farm Management System

Offshore Wind – KONGSBERGs maritime footprint..

Geophysical survey
- AUV survey
- Seabed mapping
- Sub bottom profiling

Traffic and Security systems
- Surface surveillance
- Sub-surface surveillance
- Submarine warning
- Vessel tracking systems

Wind Farm Management
- Condition Monitoring
- Wind Farm Control
- Production Forecasting
- Performance Monitoring

Foundation installation
- Dynamic positioning
- Marine automation
- Underwater positioning
- Underwater sensors
- Acoustic impact monitoring
- Sonar monitoring
- Camera monitoring

Fish and mammal survey
- Acoustic impact assessment

Cable installation
- Dynamic positioning
- Marine automation

Cable plough
- Dynamic positioning
- Acoustic positioning

ROV
- Acoustic positioning
- Inertial navigation
- Camera monitoring

Turbine installation
- Dynamic positioning
- Marine automation

Kongsberg Wind Farm Management System

I N T E G R A T I O N

Condition Monitoring	Production Forecasting	Wind Farm Control	Performance Monitoring
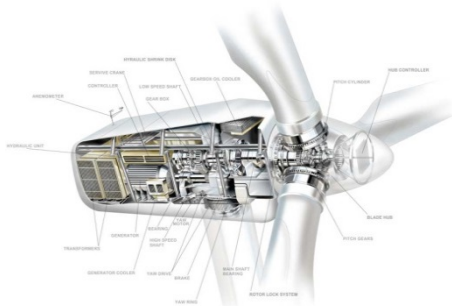
Conditioning Monitoring and state control of wind turbine, reduced down time

Online analysis of Turbine data
Temperature
Vibration
Acoustic emission

Sensor fusion
Artificial Neural Network
Temperature models
Wind and load estimation

Early Failure Detection
Turbine Condition Overview
Condition based Maintenance

Production Forecasting through improved weather analysing tools, reduced imbalance cost

Weather data gathering
Production Forecast models
Wind estimation

Reduced imbalance cost
48 hours predictions

Predictions of maintenance weather windows
Minimize production losses due to maintenance stops

Wind Farm Control with production optimizer functionality reducing wake and turbine loads

Dynamic Wind Farm Optimizer
Individual set points for each turbine based on:
Actual wind condition
Turbine state/condition

Reduce Turbine Wear
Balancing of loads
Load mitigation
Reduced turbulence wear

Performance Monitoring through fault analyses, trending and benchmarking of turbines and wind farms

Collects and calculate performance data
KPIs, Power curves
Turbine availability
Trending

Toolbox for Analysis
Faults – lost production
Inefficiency – loss of production
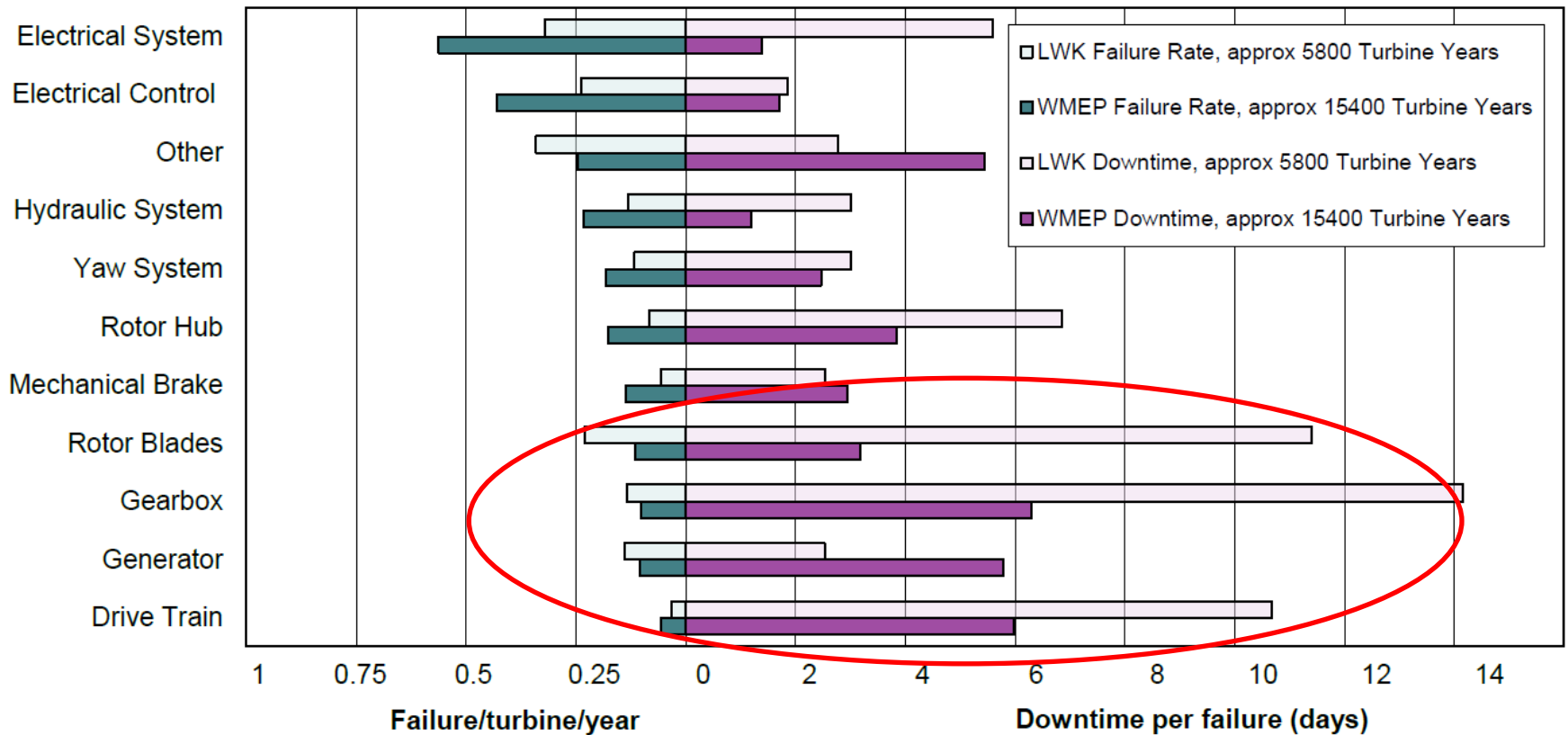Benchmarking..
Reporting

Performance Monitoring
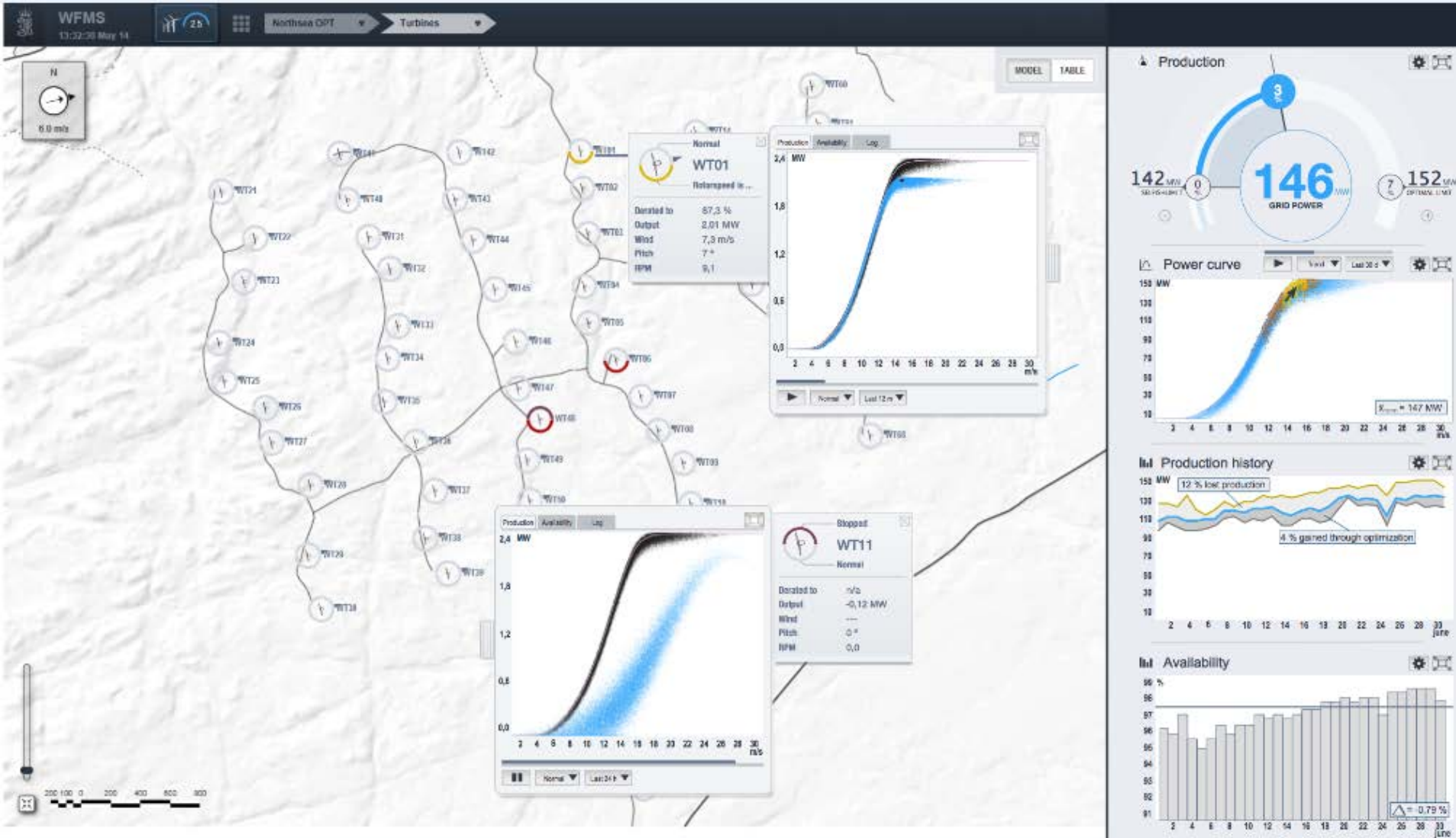
Condition Monitoring

Failure/turbine/year and downtime from two large surveys of land-based European wind turbines over 13 years

Legend:
- □ LWK Failure Rate, approx 5800 Turbine Years
- ■ WMEP Failure Rate, approx 15400 Turbine Years
- □ LWK Downtime, approx 5800 Turbine Years
- ■ WMEP Downtime, approx 15400 Turbine Years

Categories (top to bottom): Electrical System, Electrical Control, Other, Hydraulic System, Yaw System, Rotor Hub, Mechanical Brake, Rotor Blades, Gearbox, Generator, Drive Train

X-axis (left): Failure/turbine/year — 1, 0.75, 0.5, 0.25, 0
X-axis (right): Downtime per failure (days) — 0, 2, 4, 6, 8, 10, 12, 14

- WMEP: the Wissenschaftliches Mess- und Evaluierungsprogramm (WMEP) database was accomplished from 1989 to 2006 and contains failure statistics from 1,500 wind turbines.
- LWK: failure statistics published by Landwirtschaftskammer Schleswig-Holstein (LWK) from 1993 to 2006. It contains failure data from more than 650 wind turbines.
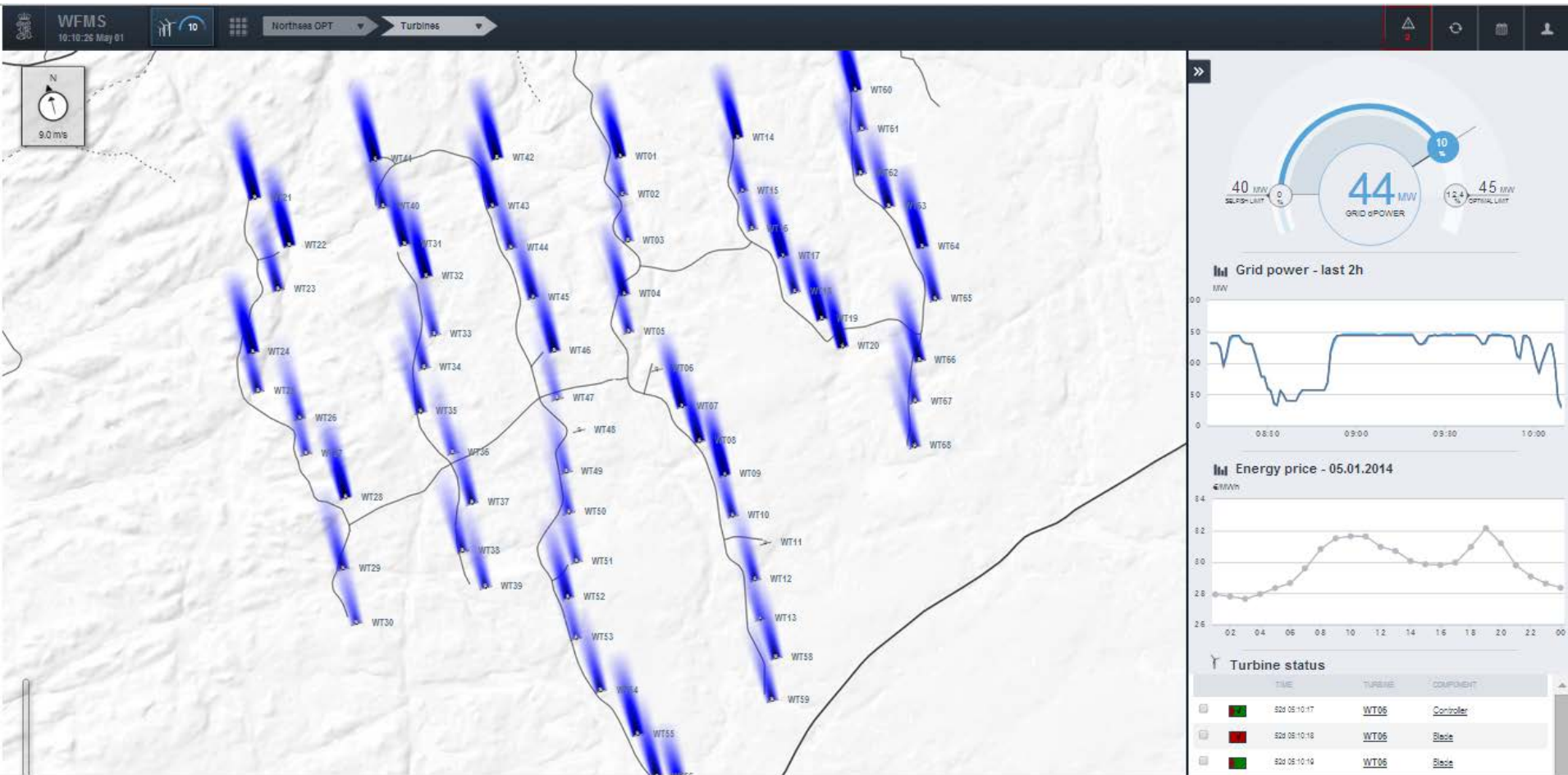
Condition Monitoring

Condition Monitoring – analysing tool

Wind Farm Control – Production optimiser
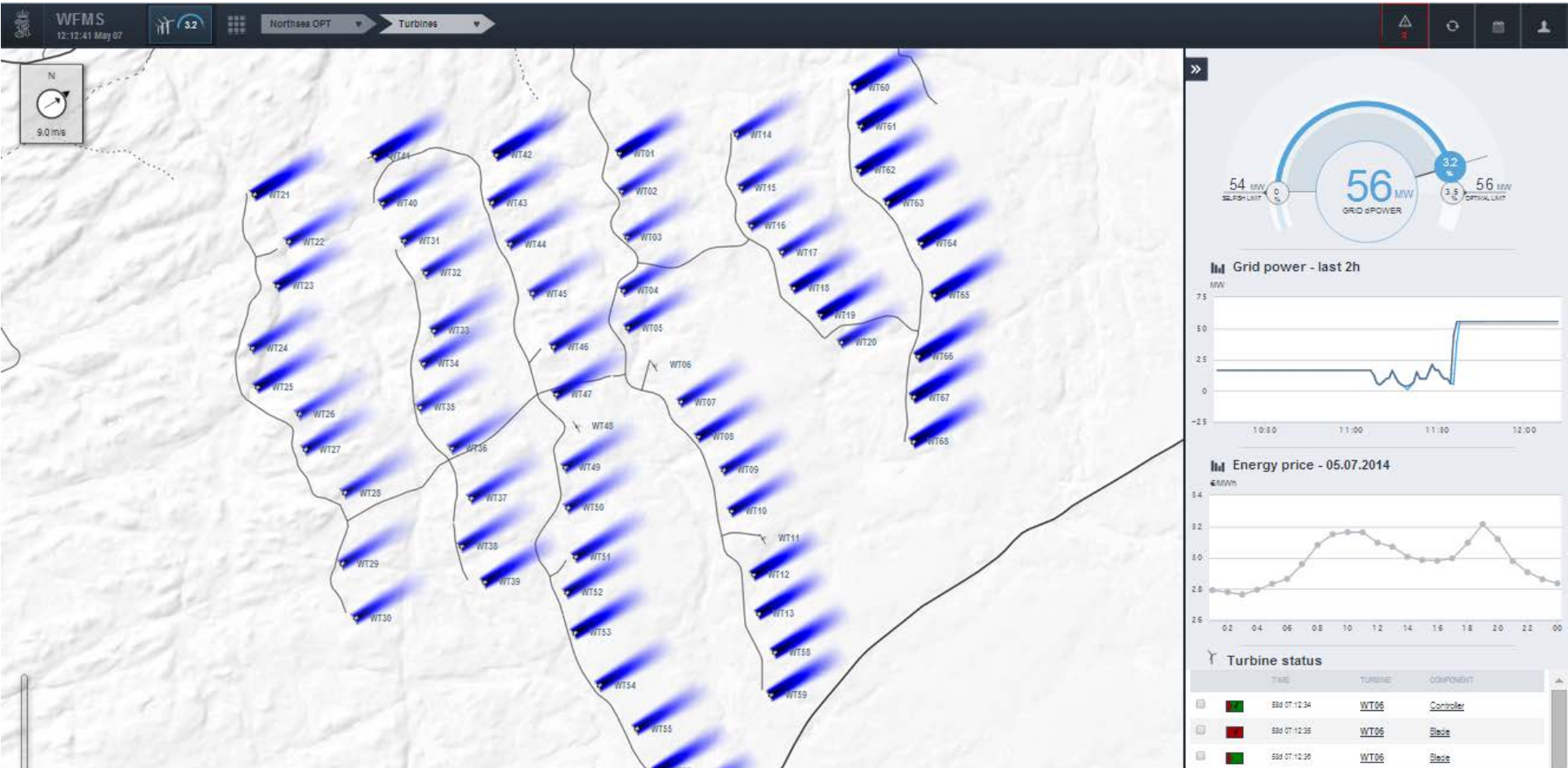
Wind Farm Control – Production optimiser

Production Forecasting

Presentation overview

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  - Performance Monitoring
  - Condition Monitoring
  - Wind Farm Control
  - Production Forecast

- Challenges for the entrepreneurs..

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Challenges - Opportunities

- Challenges for the entrepreneurs
  - Lack of access to Turbine sensor data
    - Ownership data Turbine
    - Level of instrumentation
  - Access to a test facility
  - Pilot customer

- Opportunities in HIPRWIND
  - An arena for R&D projects, verification of concepts for industry partners
  - Access to
    - Test- and operational data
    - a test facility through HIPRWIND partners
    - Instrumentation/Data acquisition

Presentation overview

- Kongsberg Wind Farm Management System (WFMS)

- Challenges for the entrepreneurs..

- Brief demo of Kongsberg Wind Farm Management System

Maximizing performance
by providing
THE FULL PICTURE