ECN
Your energy. Our passion.

Introduction ECN Wind and ECN test site

Bezoek KIVI aan “Leven van de Wind” en ECN test site Wieringermeer

15 Maart 2017

Piet Warnaar

www.ecn.nl

Programma

• Presentatie ECN – ECN Wind – testveld	ca 30-45 minuten
• Film “Wind”	8 minuten
• Rondleiding testveld (geen foto’s!)	15 – 30 minuten
– Zo min mogelijk auto’s	
– Terug langs meetcentrum	

ECN

ECN: A rich and evolving history

~600 employees

~20 patents a year

~500 reports in 2011

~370 conferences in 2016

~5 licenses a year

We are in our 62nd year of pushing technology boundaries

Mission:
With and for the market, we develop knowledge and technology that enable a transition to a sustainable energy system

Locations

ECN Petten
(Head office)

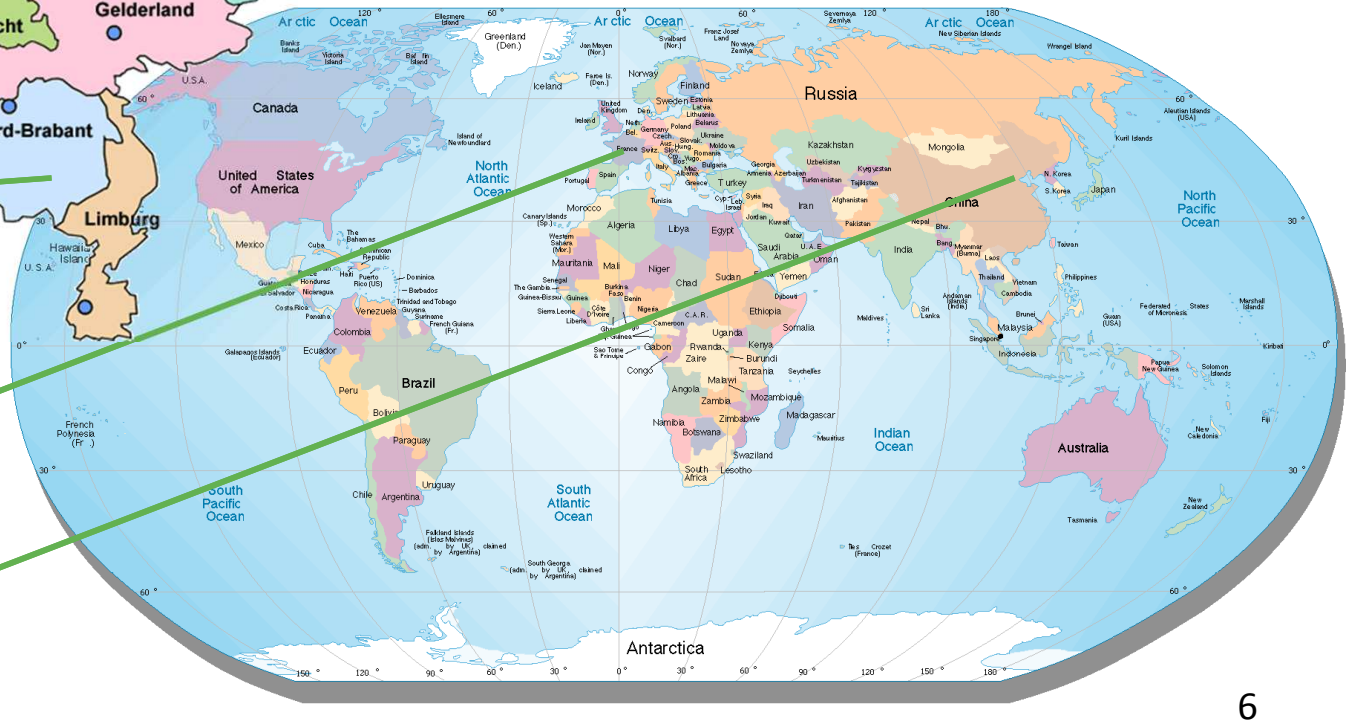
ECN Wieringerwerf

ECN Amsterdam

ECN Eindhoven

ECN Brussels

ECN Beijing



What we do and who we are

- Strategic & Technological studies

  Creating insights in energy technology and policy

- Problem solving

  Using our knowledge, technology, and facilities to solve our clients' issues

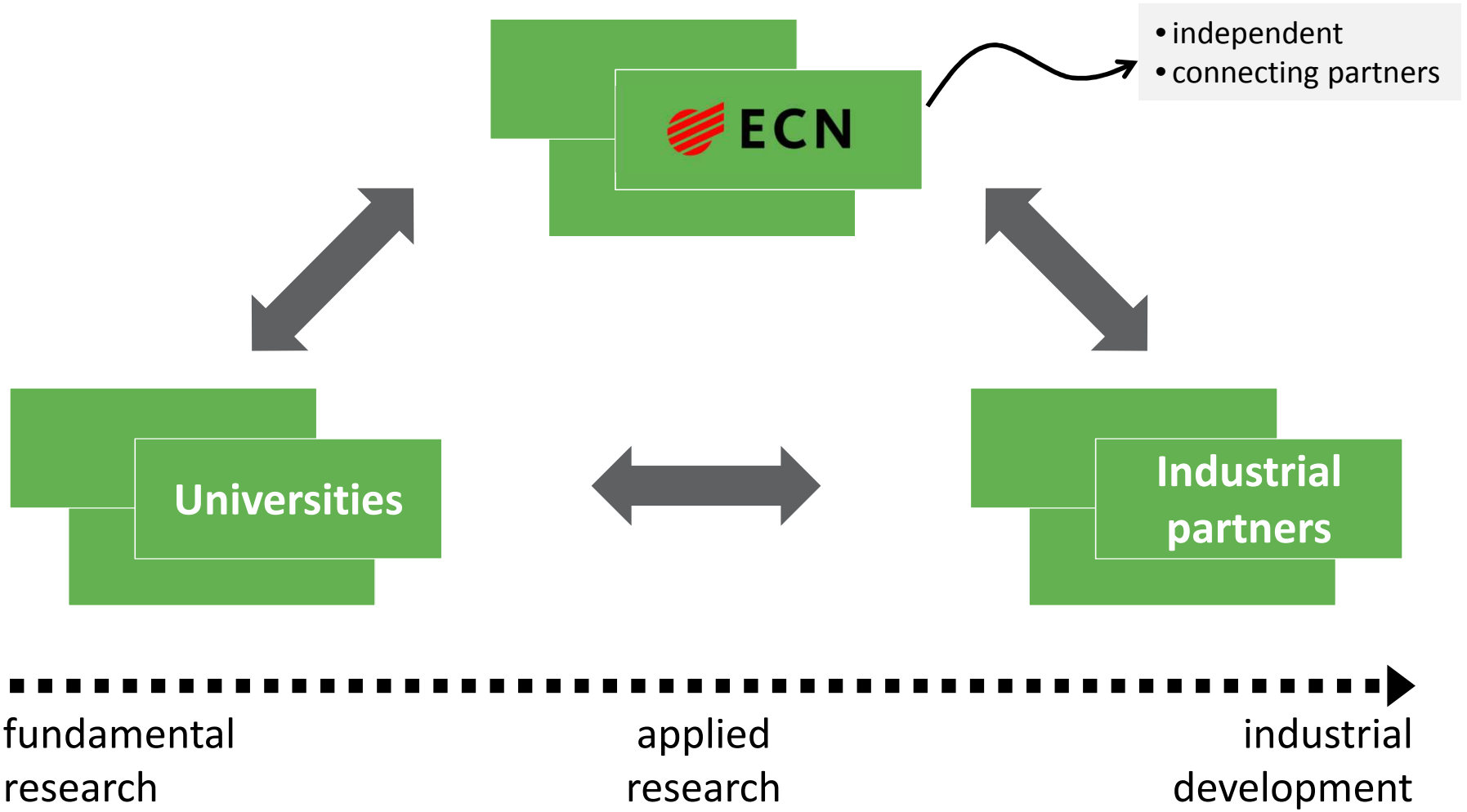
- Technology development

  Developing technology into prototypes and industrial application

- Not for profit organisation

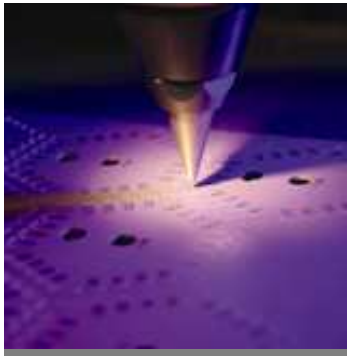
  Turnover 70 mio Euro, 20 mio from Dutch Government

Position


• independent
• connecting partners
ECN
Universities
Industrial partners
fundamental research
applied research
industrial development

R&D fields/ technology fields

Policy Studies



Energy Engineering

Environment

Energy Efficiency

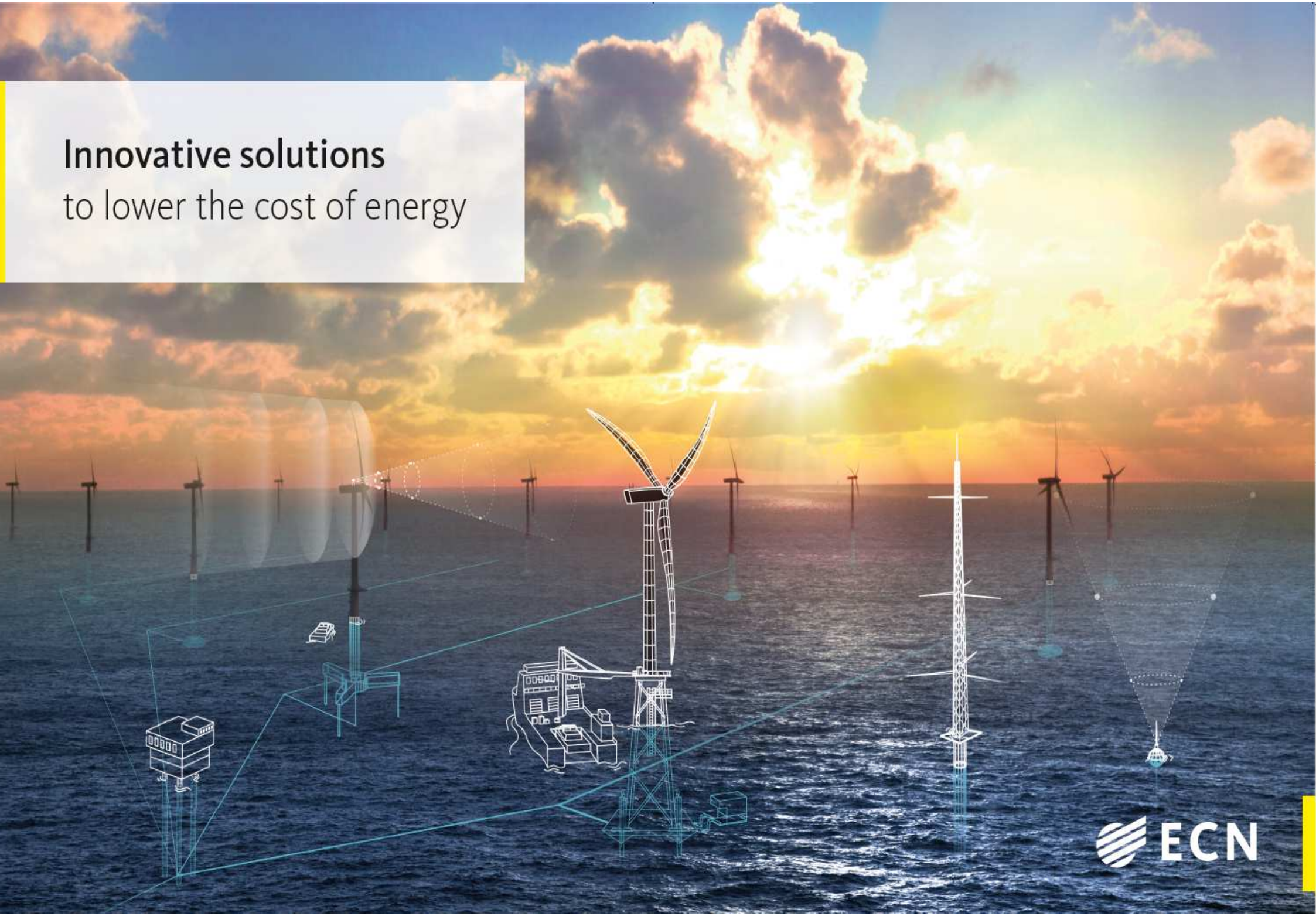
Process & Energy Industry

Solar Energy

Wind Energy

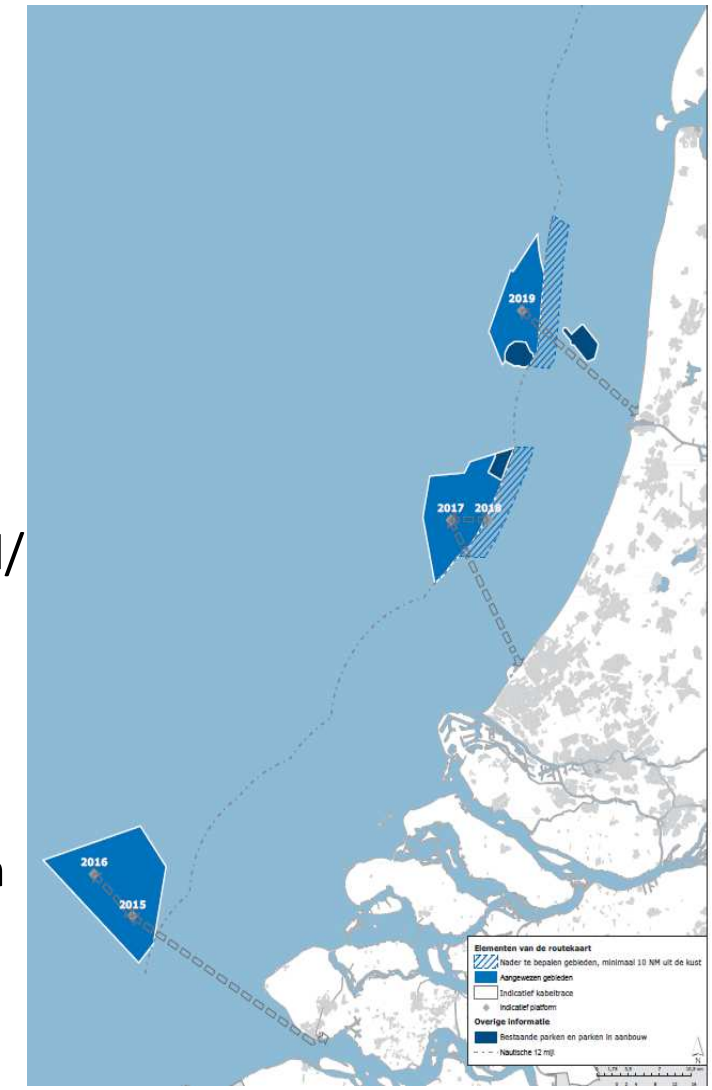
Biomass

ECN Unit Wind Energy


Innovative solutions
to lower the cost of energy
ECN

Policy Renewable Energy/ Offshore Wind

- Offshore Wind Energy until 2023:
  - Government arranges all spatial permits
  - Government collects all design brief data (metocean, prelim soil, windspeed)
  - Dutch TSO builds offshore grid and operates
  - Governments issues 10 tenders of 700 MW each:
    - 2015: 2 x 350 = 700 MW Borssele - max price 12,4 ct – DONG: 7,27 ct/kWh
      2016: 2 x 350 = 700 MW Borssele - max 11,975 ct – Shell/ Eneco/ Van Oord : 5,45 ct/kWh
      2017: 2 x 350 = 700 MW Zd-Holland - max 10,75 ct
      2018: 2 x 350 = 700 MW Zd-Holland - max 10,325 ct
      2019: 2 x 350 = 700 MW Nrd-Holland – max 10,00 ct
    - Winner applies for permit and is awarded the concession of 700 MW for 30 years and a subsidy for 15 years
    - Subsidy = bidprice -/- grey price



Vision 2016 - A Wind of Change

ECN Wind Energy as world leader institute on

Innovative Solutions for (Offshore) Wind Power Plants

- Reduce cost of energy of (offshore) wind power plants
- World leading institute on innovative products and solutions
- The critical success factors are our world leading facilities
- State of the art wind farm services

Services

- Research and Development
- Design of WTG (controllers, blades, substructures)
- Design optimization for (offshore) wind farms
- WTG type validation/ DD/ measurements
- Installation/O&M strategy model
- Yield optimization
- Power curve verification
- O&M optimization
- End of Lifetime strategy
- Partner of RHDHV: EIA, civil/ coastal engineering

Services – R&D

R&D and services focused on:

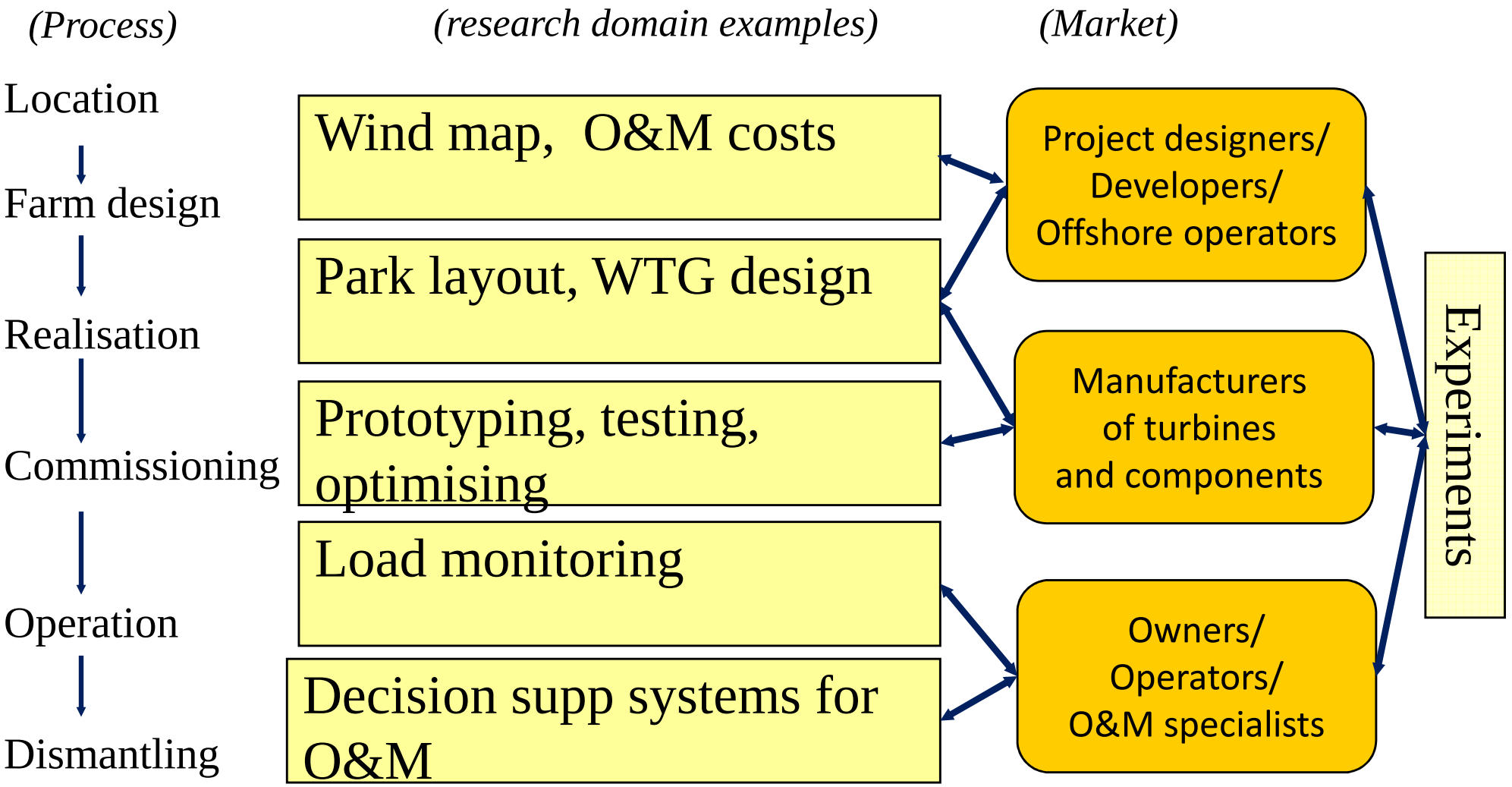
- Support structures
- Components Wind power plant and turbines
- Electrical infrastructure
- Transport, installation and logistics
- Operations and Maintenance
- Integral wind farm design
- Facilities & Experiments

R&D results are verified and demonstrated on our Test Site

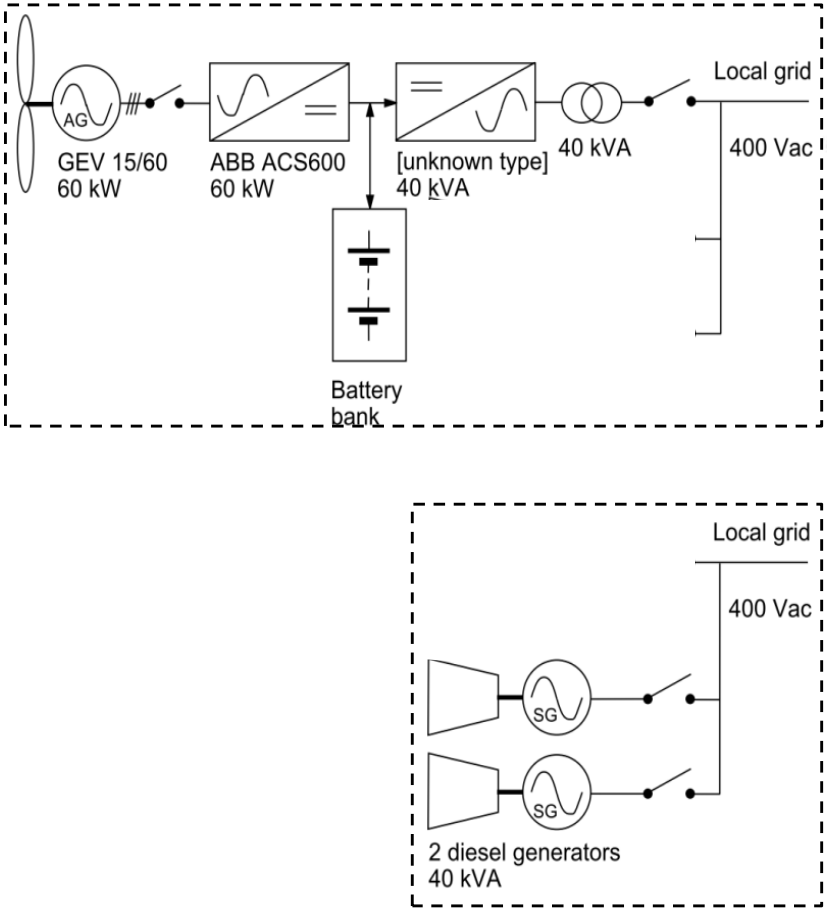
Services - Design

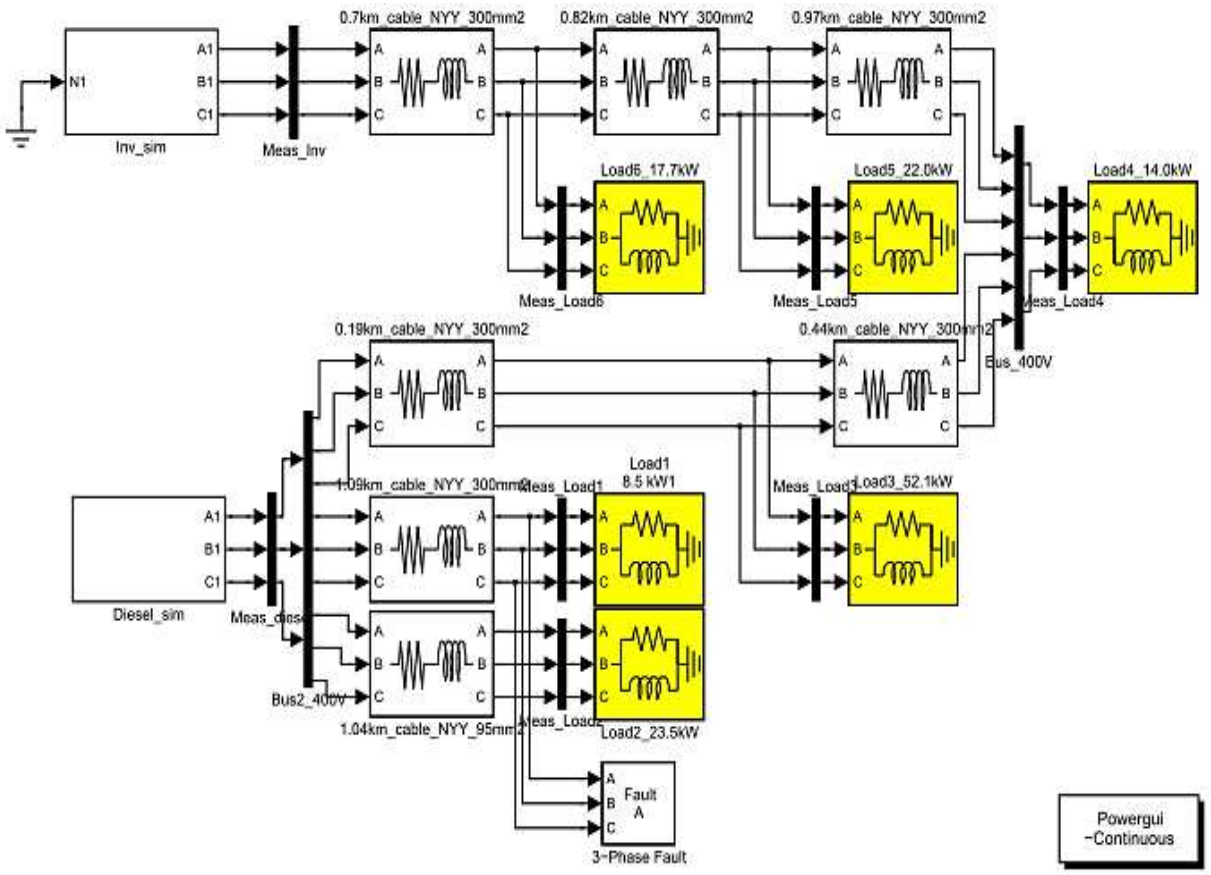
- Design optimization for (offshore) wind farms
  - Most advanced models in the field
  - 20 years experience in FarmFlow software
  - Maximise yields, minimise loads
  - Intimate knowledge of wake patterns
  - Tried and tested in ECN test site
  - Optimize max yield/ min cable lengths
  - Integral WTG/ foundation design: less iterations
  - Wind resource analysis (measurements: on/offshore metmasts, FLiDAR, LiDAR (ground/ nacelle)) - increase of P90 certainties

Core focus area: Reducing Cost of Energy



Example
Canna island wind-diesel feed-in study

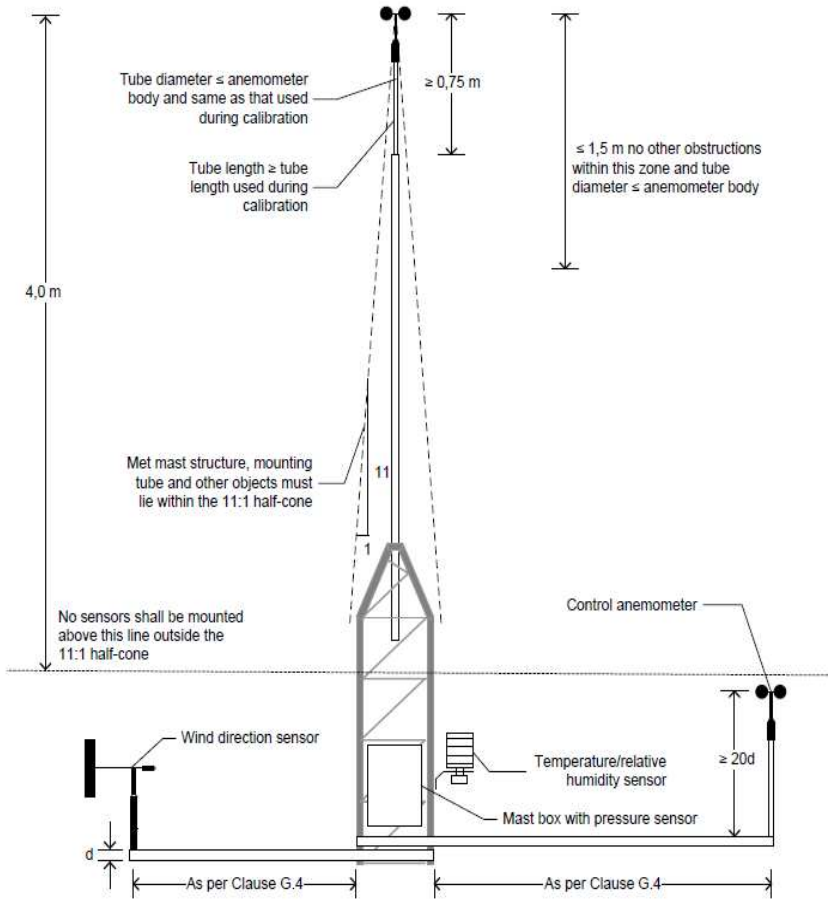




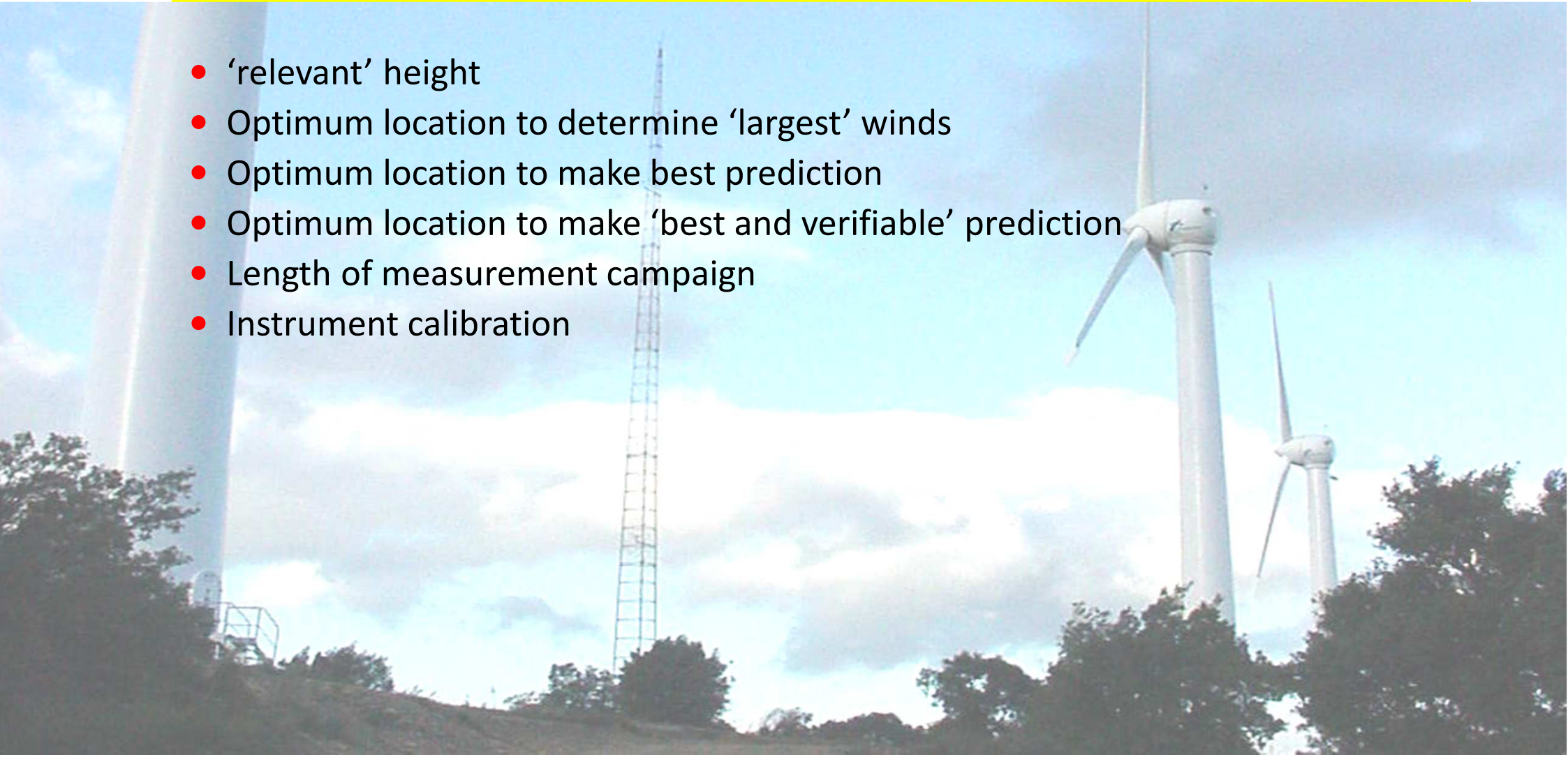
Model of Canna wind-diesel system for load flow simulation

Wind Measurement Sensors IEC 61400

- 2x Anemometer (Better than Class 1.7A)
- Wind vane
- Temperature & Relative Humidity
- Air Pressure
- Precipitation



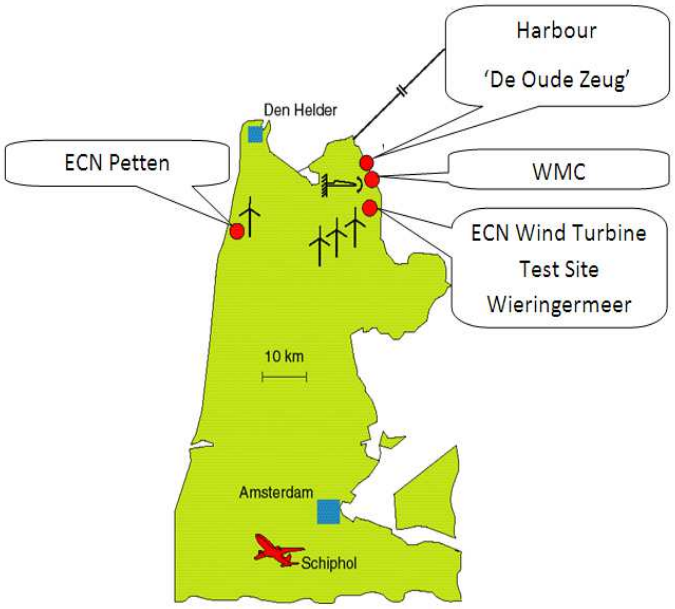
Measurements at site

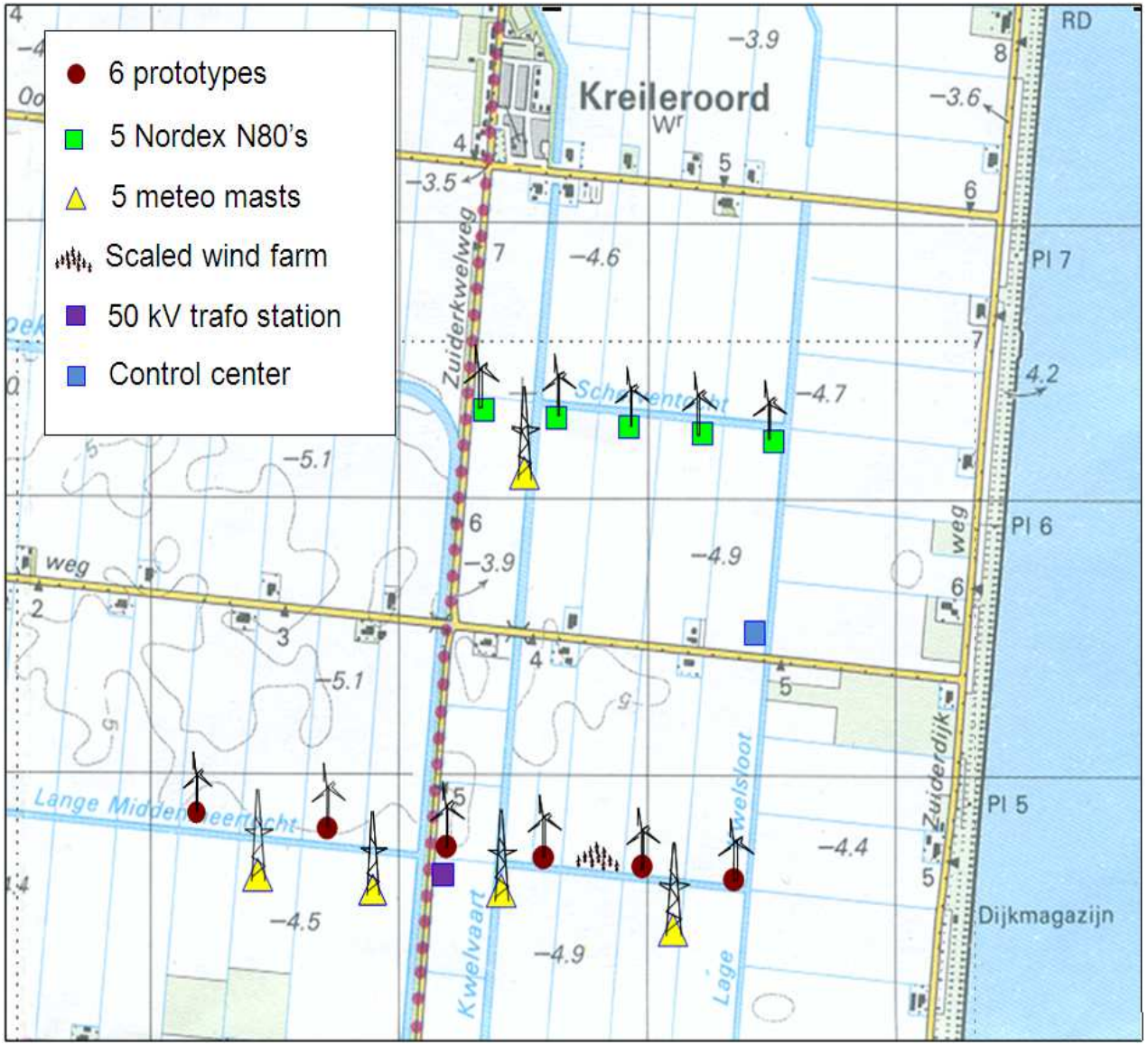


- ‘relevant’ height
- Optimum location to determine ‘largest’ winds
- Optimum location to make best prediction
- Optimum location to make ‘best and verifiable’ prediction
- Length of measurement campaign
- Instrument calibration

Services - testsite

- WTG testsite/ WTG type validation
  - on ECN testsite Wieringermeer NL: WTG prototypes are certified, controller performance is enhanced, root cause for issues is sought and resolved





services - Measurements on prototypes

Certification measurements

- Power performance
- Mechanical loads
- Meteo

Engineering measurements

- Turbine behaviour
- Vibratrions
- Temperatures
- Load reductions by Indiv Pitch Control
- Load reductions by Lidar control

Research turbines

- Why does ECN own research turbines?
  - Verification of aerodynamic models
  - Verification of control strategies for turbines and farms
  - Development and testing of innovative measurement and monitoring systems

- Difficult to carry out experiments at commercial wind farms
- Solution: Our own research windfarm
  - 5 commercial windturbines
  - 2.5 MW rated power
  - 80 m hub height
  - 80 m rotor diameter

Services – WTG type validation

- WTG type validation/ component validation/ DD
  - On ECN testlab WMC Wieringermeer NL: large components are tested with life time simulation

Services – Installation/ O&M Strategy

- Installation/O&M strategy model

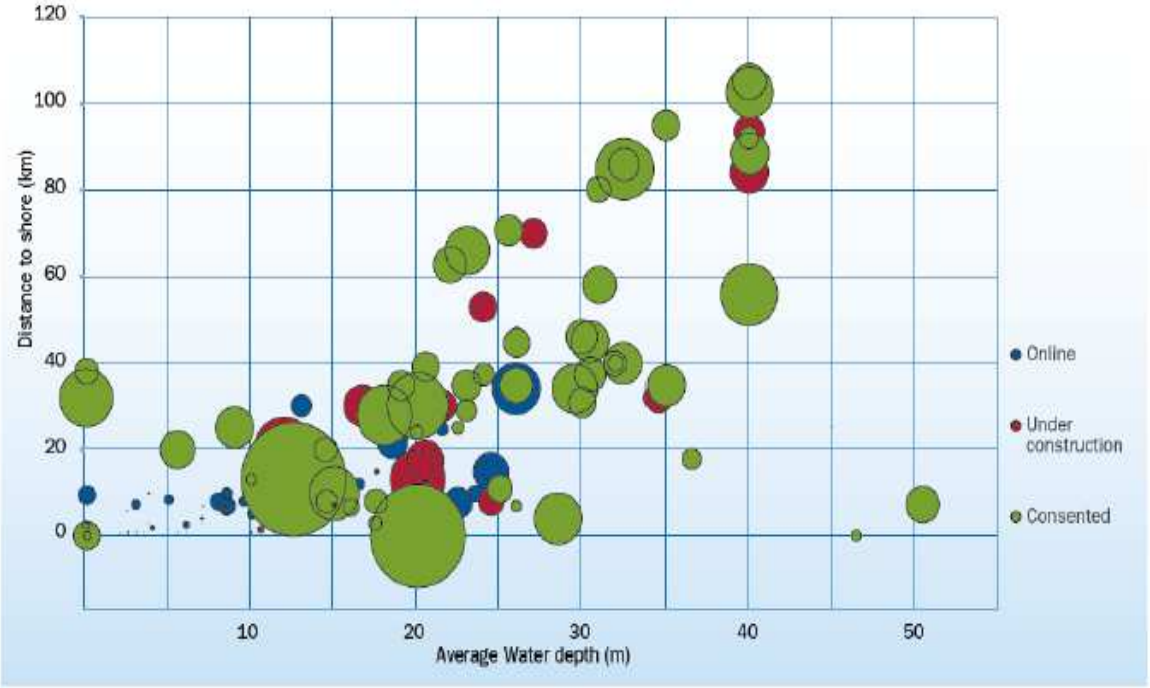
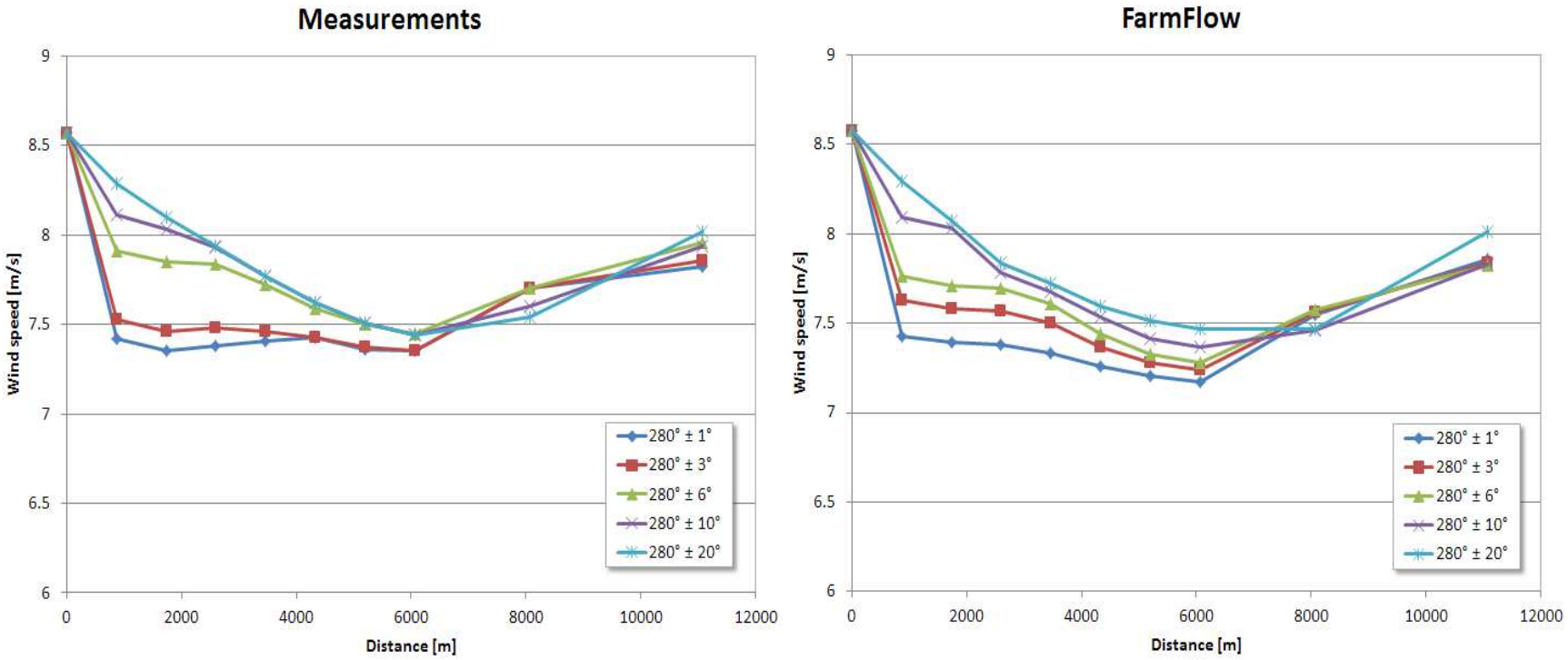


Figure 1: *Graph illustrating the distance to shore and average water depth for offshore wind farms currently being online, under construction and consented [1].*

Services – yield optimization

- Yield optimization



Services – Measurements plus

- Power curve verification
  - Nacelle based LiDAR measurements (calibrated)
  - FLiDAR (calibrated)
  - TP based LiDAR measurements (calibrated)

Services – O&M system

- O&M optimization
  - Record actual data
  - Implement, evaluate improvement plans
  - Diagnose loads/ WTG health
  - Schedule predictive maintenance campaigns
  - Update / finetune strategy

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Dudgeon Offshore Wind Farm contracts to Siemens plc

As operator, Statoil has awarded two contracts to Siemens plc for the engineering, supply, assembly, commissioning and service of 67 wind turbine generators for the Dudgeon Offshore Wind Farm project.

The Sheringham Shoal Offshore Wind Farm. (Photo: Alan O'Neill)

Services – bird impact monitoring

- Real time bird impact monitoring
  - Vibration sensors continuously monitor the sounds coming from the blades. The entire rotor is monitored.
  - Wide-angle, high resolution offshore grade cameras are recording the full sweep of the rotor area. Images are recorded.
  - When the trigger occurs the recorded images are saved before, during, and after the suspected bird collision. When desired, the operator is notified by email.

Services – total wind farm design

- Partner of RHDHV: EIA, civil/ coastal engineering
  - Offshore Wind
  - Onshore Wind
  - Wave & Tidal

- Gives a wide experience base with many variations in
  - Regulations
  - Soil conditions
  - Wind and Wave climate
  - Ecology

Services – end of lifetime

- End of Lifetime strategy
  - In development stage: for permitting
  - In development stage: for financial reservations
  - End of operations: for contracting/ procuring

Thank you very much for your attention
Questions?

Piet Warnaar
Business Developer
warnaar@ecn.nl
+31-6-1332,0852

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