# EERA-DTOC: Validation and demonstration

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EERA DTOC

THE EUROPEAN ENERGY RESEARCH ALLIANCE
DESIGN TOOLS FOR OFFSHORE WIND FARM CLUSTER

Support by

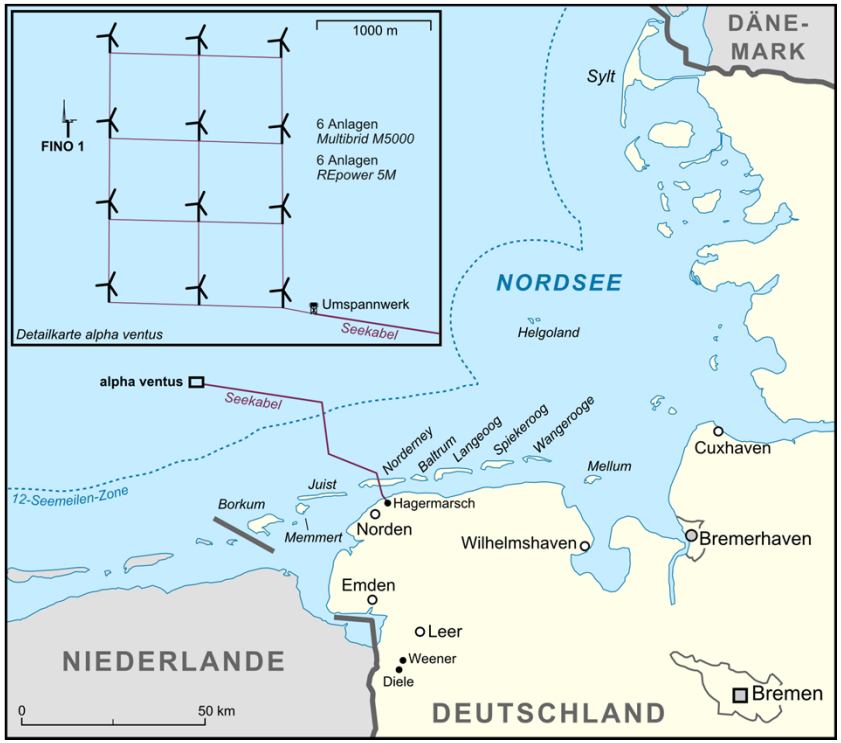
SEVENTH FRAMEWORK PROGRAMME

# Validation and demonstration takes place in the WP5 tasks of EERA-DTOC

1. Deliver the experimental data to validate the integrated off-shore wind farm design tool from WP4 using measurements in the largest offshore wind farms existing today
   - WP 5.1 (Experiment)
     *Note: Wake models were validated in WP1*
2. Validate that the developed tool from WP4 is accurate-by means of comparison with measuremets
   - WP 5.2 (Validation)
3. Demonstrate that the tool from WP4 is useful to the industrial partners- by calculating scenarios of large wind farm clusters in close collaboration with industrial partners
   - WP 5.3 (Demonstration)

# Validation: EERA-DTOC partners requested Alpha Ventus wind farm measurements through Forwind and Fraunhofer IWES

- Forwind: Long range wind scanner measurements from fixed positions: Windfarm inflow, top and wake
- Fraunhofer: Ship based LIDAR measurements in the wake of the farm
- Production and SCADA data of wind farm



# Rodsand-II data supplied by E.On

10 minute statistical data from meteorological mast and Rodsand-II turbines
No data from neighbouring Nysted farm


# WP5.3: SCENARIOS

- Participants: *ECN*, Overspeed, Iberdrola, Statoil, Carbon Trust, Hexicon, Statkraft, E.ON. RES, Fraunhofer-IWES and DTU

# Background

- Demonstration of **INTEGRATED** design tool from WP4
- Measurement data are scarce and measurement data for wind farm clusters are fully missing
  - Tools will be demonstrated on basis of likely scenarios.
- **Industry should be heavily involved in the definition of scenarios**

# PURPOSE OF THE SCENARIOS

- The tool should fullfill the previously defined user requirements from WP4, e.g.
  - The tool should be useful, easy to use, complete and robust
- Functionality of all modules in EERA-DTOC should be proven → All parts of the tool should be activated during the scenarios
- Inventory of user experiences:
  - How steep is the learning curve?
  - Which tutorials should be added ?
- The results should LOOK realistic from an expert point of view

# SCENARIOS: APPROACH

- Scenario calculation can only start after an EERA-DTOC prototype version is ready from WP4 (i.e. in the first half of 2014) and we know precisely what it does.
- Preliminary description of first scenarios is finished
- A preliminary scenario is calculated with ECN tools to 'test' the description
    - Also other tool developers  use the scenario to test the functionality of their models in the scenarios
- We are very well prepared to start up the scenario as soon as the DTOC is available

  → refinement of description

# SCENARIOS

Scenarios:

1. **Base and near future scenario**
   - *Base scenario*: 1 single wind farm, close to present wind farms
   - *Near future scenario*:
     - Builds upon base scenario
     - Carried out in steps starting with 1 single wind farm, farms of increasing complexity are added
2. **Far future** scenario

**Scenario 1→2** reflects:

- A shift towards the future.
- Increasing complexity of the modeling problem
- A shift in target group:
  - Developers (base scenario)
  - Developers and strategic planners (far future scenario)

# BASE AND NEAR FUTURE SCENARIO

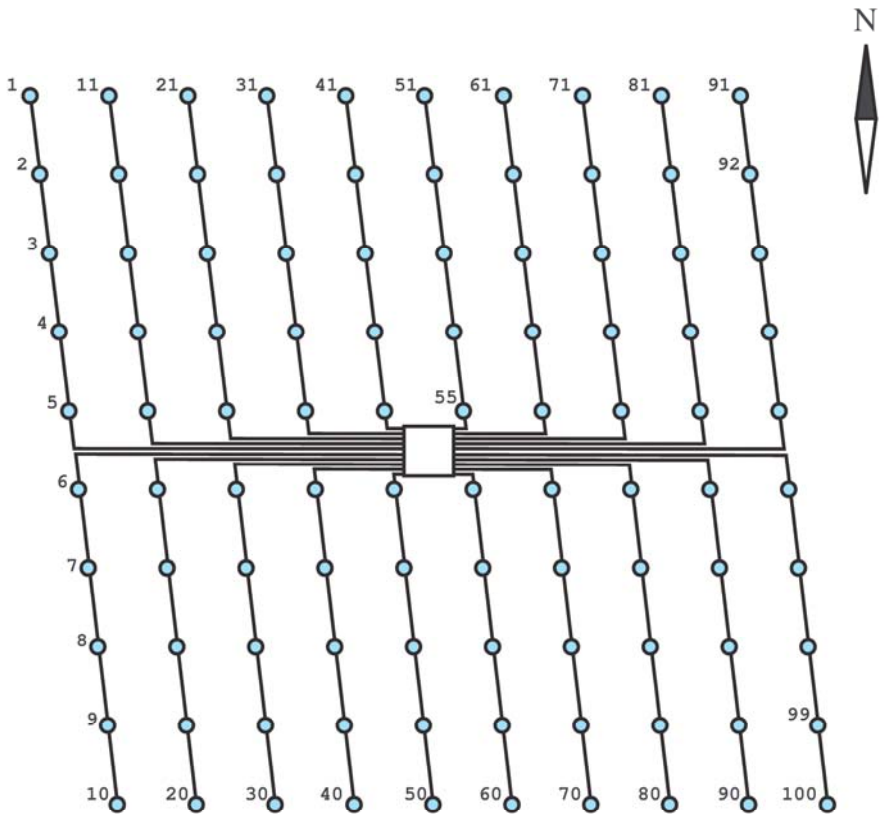
- Base scenario:
  - Single 1000 MW wind farm
  - 100*10 MW turbines close to present state of the art
    - Innwind.EU reference turbine
  - North Sea wind climate
  - Distance to shore: ~125 km
  - Water depth: ~40 m
- Near future scenario: incremental approach
  1. Single wind farm of 100*10 MW modern turbines
     - Avatar reference turbine
  2. Add other wind farms until 10 GW:
     - Differently sized wind farms
     - Floating turbines

# WP5.3: Demonstration

- Preliminary scenario calculated by ECN
  - Demonstrate value of **INTEGRATED** electrical-aerodynamic tool
    - Farmflow/EEFARM calculates the aerodynamic wind farm losses, the electrical losses and the costs for the electrical infrastructure
  - 1 GW wind farm from base scenario
  - Start with 10D distance between the turbines (low aerodynamic losses/high electrical losses and high costs for electrical infrastructure)→ high COE
  - Decrease distance (piecewise) leading to higher aerodynamic losses but less electrical losses and lower costs for electrical infrastructure
    - Find optimum distance in terms of COE

# SOME RESULTS FROM ECN'S AERODYNAMIC/ELECTRICAL TOOLS

(courtesy A van Garrel, E. Wiggelinkhuizen and J. Pierik, ECN)




**Lay-out of farm (note: inter turbine distance is a variable)**

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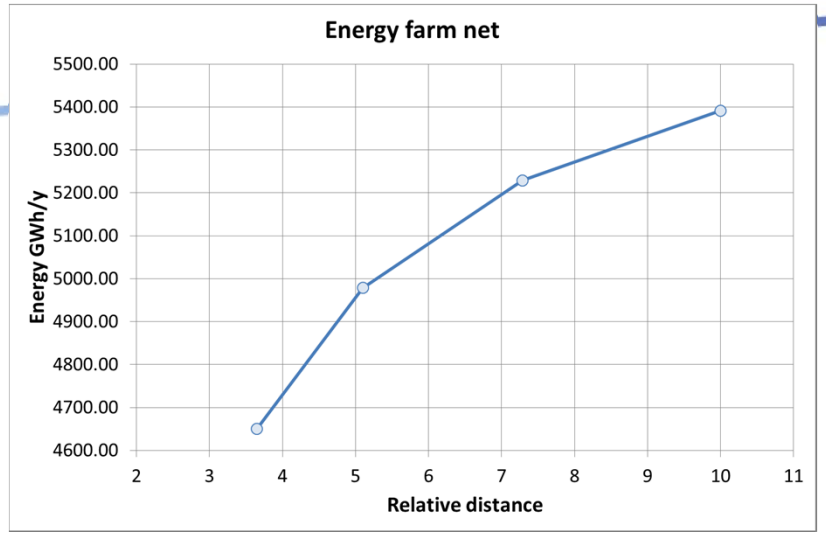
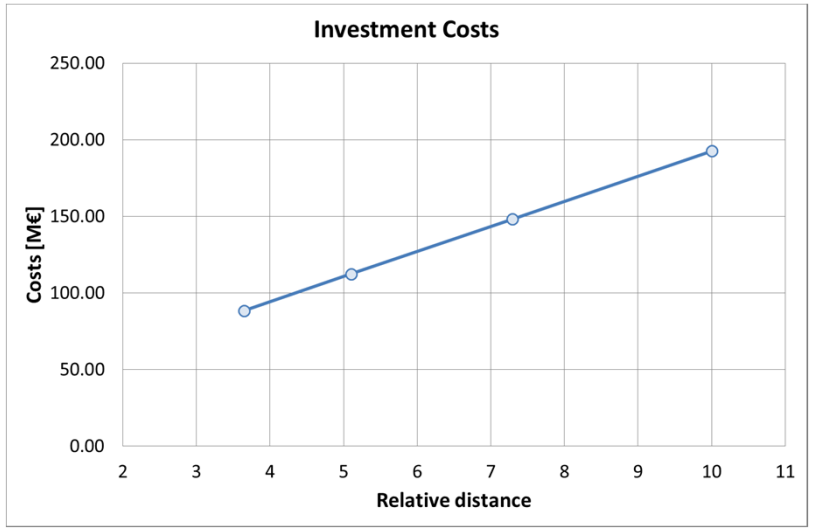



**Net energy farm production**
(including aerodynamic **and** electrical losses)
**Increase** with distance




**Investment costs** of electrical infrastructure
Increase ~ linearly with distance

# FAR FUTURE SCENARIOS

- Very far future  wind farm clusters
- Fully open for discussion and suggestions from in and outside the project!

# SUMMARY

- **Validation** of EERA-DTOC tool will (hopefully) be based on Alpha Ventus and Rodsand-II measurements
- Scenarios are defined to **demonstrate** the EERA-DTOC tool
  - *Base scenario*: 1GW farm
  - *Near future scenario*: 1GW→10 GW clusters with modern wind turbine concepts
  - *Far future scenario*: To be defined
- Some trial calculations with a combination of ECN's aerodynamic/electrical tools have already been performed and showed the usefulness of the base scenario and the value of integrating aerodynamic with electrical wind farm tools:
  - Net wind farm power (including aerodynamic and electrical losses) can be assessed versus the costs of the electrical infrastructure for various inter-turbine distances (using assumptions on energy prices and pay back time)
- **Definition of far future scenarios is open for discussions/suggestions outside the project!**

Thank you very much for your attention