EERA-DTOC: DESIGN TOOLS FOR OFF-SHORE WIND FARM CLUSTERS: Calculation of scenarios

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

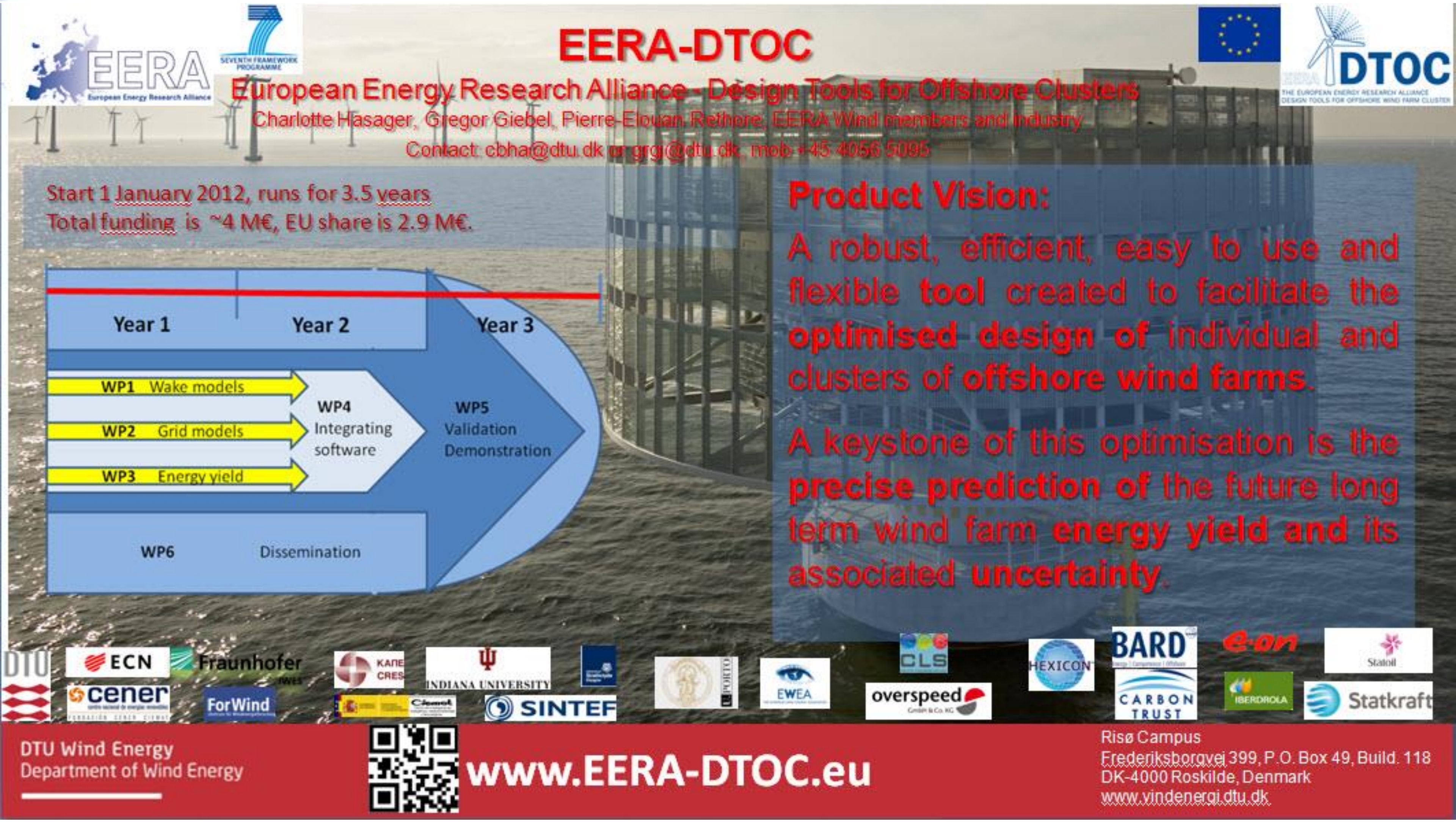
Support by

SEVENTH FRAMEWORK PROGRAMME

Contents

- *Scenarios: Why and how?*
- Scenarios: Preparations
- Scenarios: Status and summary

EERA-DTOC summary slide



EERA-DTOC: main idea

- Use and bring together existing models from the partners
- Develop open interfaces between them
- Implement a shell to integrate
- Fine-tune the wake models using dedicated measurements
- *Validate and demonstrate the final tool through likely scenarios*

Scenario calculation

- Scenarios are calculated under *WP 5.3: ‘Demonstration’*
- Participants: *ECN*, Overspeed, Iberdrola, Statoil, Carbon Trust, Hexicon, Statkraft, E.ON. RES, Fraunhofer-IWES and DTU

Motivation

- The **INTEGRATED** design tool should be demonstrated
- Measurement data are scarce and measurement data for wind farm clusters are fully missing
  - Tools will be demonstrated on basis of likely scenarios.
  - Where possible measurements are used (Rødsand-II (E.On), Bard-Offshore-1 (Forwind/Fraunhofer-IWES)
- Industry should be heavily involved in the definition of scenarios

PURPOSE OF THE SCENARIOS

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

PURPOSE OF THE SCENARIOS, ctd

- Demonstrations should prove that EERA-DTOC has industrial usefulness
- Involvement of industry is assured by active participation of industrial EERA-DTOC participants
- *Strategic developers from outside the project are invited to support the demonstration.*

SCENARIOS: APPROACH

- Scenario calculation can only start after an EERA-DTOC prototype version is ready for use and we know precisely what it does
- Nevertheless some first trial calculations are done by ECN and DTU to ‘test’ the scenario.
  - 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 scenario

SCENARIOS: APPROACH, CTD

- 3 different scenarios are considered
  - **Base scenario #1:** Considers future wind farms with characteristics similar to present wind farms
  - **Additional scenarios #2:** Including upscaled and floating turbines clusters of differently sized farms
  - **Likely scenarios #3:** For future wind farm clusters to assess the energy yield on short and long time scale

SCENARIOS, APPROACH ctd

- Sequence of 3 scenarios reflects:
  - A shift towards the future (→upscaled turbines, floating turbines, large clusters)
  - Increasing complexity of the modeling problem
  - A shift in target group:
    - Developers (base scenario)
    - Developers and strategic planners (likely scenarios)

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PREPARATIONS, BASE SCENARIO#1

- Considers future wind farms with characteristics similar to **present** wind farms at constant wind climate
  - Will be inspired by **Kriegers Flak** as used in WP2
  - Definition still needs to be worked out in the next months
    - Base scenario is a ‘stripped version’ of the additional scenario which is worked out in more detail on the next slides

PREPARATIONS: ADDITIONAL SCENARIO #2

Additional scenarios with **upscaled** and **floating** turbines and with **different sized** wind farms, both inter and intra array layouts

- Start with a wind farm of 1000 MW which consists of 100*10 MW turbines.
- An incremental approach will be followed:
  - Start with a single wind farm
  - Add other wind farms including:
    - Differently sized wind farms
    - Floating turbines

ADDITIONAL SCENARIO#2: 'BASIC' INPUT

- Turbines
  - 10 MW turbine (D ~ 200 m) with fixed jacket foundation at 40 m water depth
  - 10 MW turbines are not on the market yet but recently two other EU-FP7 projects have started/are approved which will design a 10 MW reference turbine
    - Innwind.EU and Avatar *)
      - 'Conventional induction': a~1/3-> high power (Betz!) versus 'low induction': a < 1/3 → low loads
      - Low induction gives considerably lower wind farm effects!!
  - Electrical design according to IEC 61400-27-1 under condition that desired aerodynamic turbine characteristics can be obtained

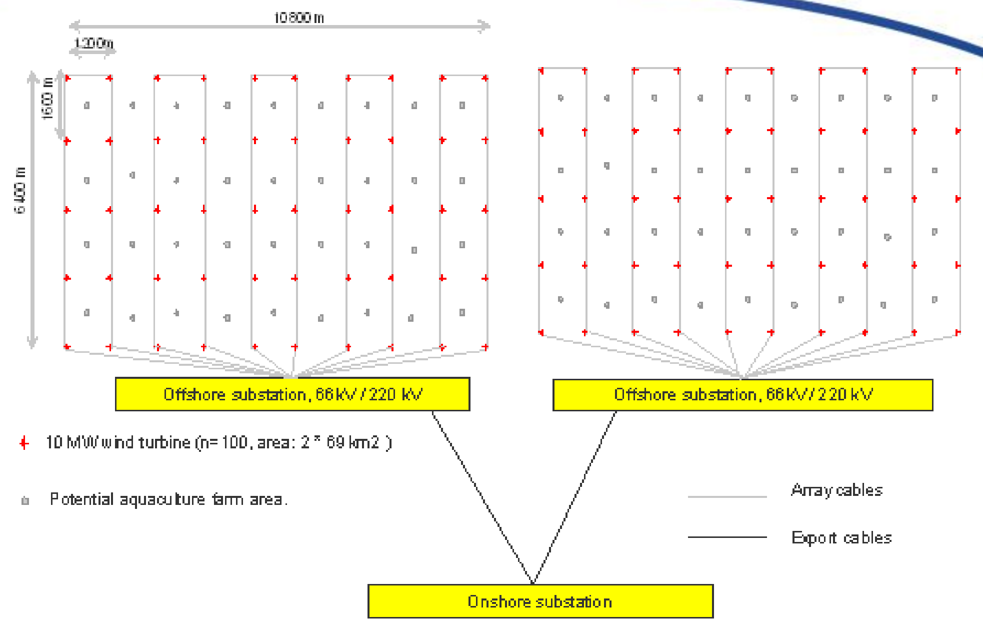
*) Note: Most wake models only need rotor characteristics from these turbines

ADDITIONAL SCENARIO #2: ‘BASIC’ INPUT, CTD

- **Wind climate** known from
  - Array of wind profiling (LIDAR)
  - Satellite data
  - Mesoscale modelling
    - Sufficient data for wake models
    - Long term correlated time series from Corwind

ADDITIONAL SCENARIO#2: 'BASIC' INPUT, CTD

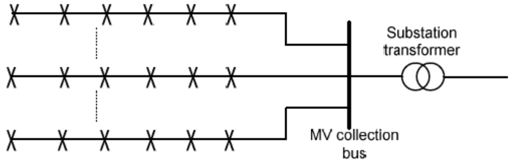
Layout of single 1 GW wind farm.

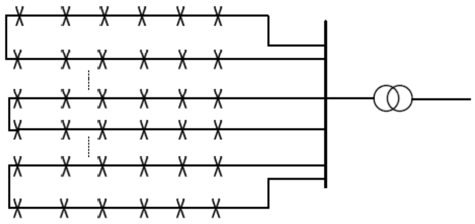


Note:
Electrical infrastructure will be optimised by EERA-DTOC from given on-shore nodes and HVDC between farm and onshore node, where distance farm-shore ~ 150 km
Next steps: Clusters will be built of 2 GW, 5GW (including floating turbines) and 10GW (also differently sized farms)

ADDITIONAL SCENARIO#2: OUTPUT

- Wind farm power (aerodynamic minus electrical losses)
- Grid optimisation (e.g. radial or double sided, voltage levels, inter and intra connections)





- Ancillary services (Frequency support services, Voltage support services, Congestion analysis, Provision of balancing power)
- Costs

ADDITIONAL SCENARIO#2: PREPARATORY RUNS

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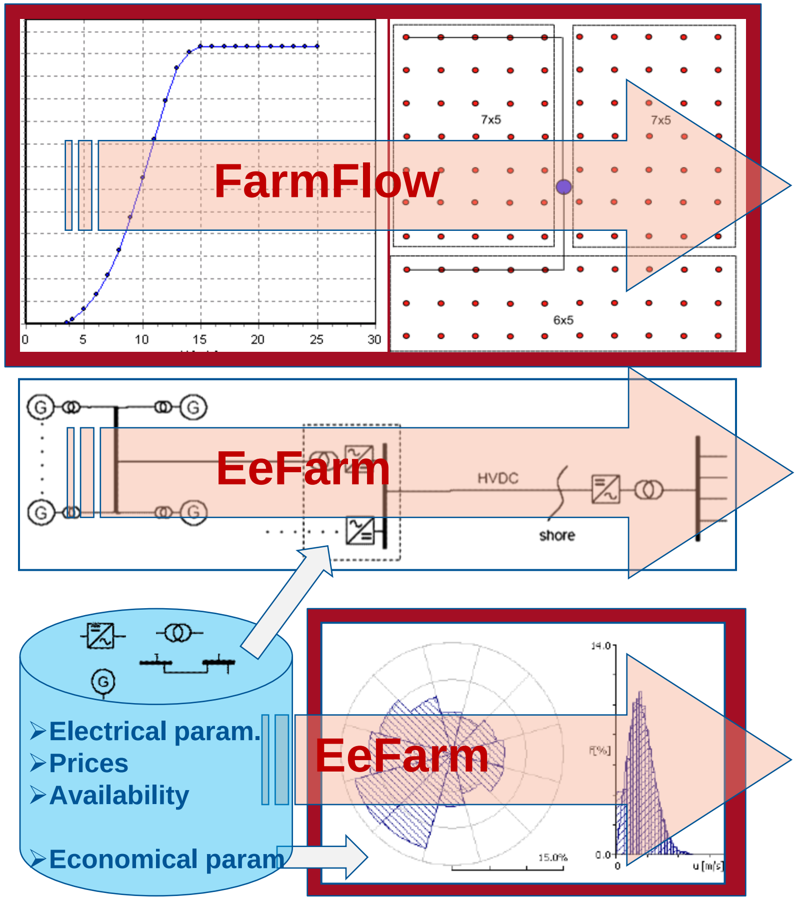
- Demonstrate value of **INTEGRATED** electrical-aerodynamic tool
  - Farmflow/EEFARM calculates the aerodynamic wind farm losses, the electrical losses and the costs for the electrical infrastructure
- 1 GW wind farm
- Start with 20D distance between the turbines
  - low aerodynamic losses versus high electrical losses and high costs for electrical infrastructure)
  - high COE
- Decrease distance (piecewise with 1.0D)
  - Higher aerodynamic losses versus lower electrical losses and lower costs for electrical infrastructure
  - Find optimum distance in terms of COE

ADDITIONAL SCENARIO#2, PREPARATORY RUNS, CTD



Aerodynamic power:

$P_{WT1} \ldots P_{WTN} = f\,(Vw,\ Vdir)$

Investments
P_{loss}
P_{fail}
} per component

Levelized Production Costs

LIKELY SCENARIOS #3

- For future wind farm clusters to assess the energy yield on short and long time scale
- Fully open for discussion and suggestions from outside the project!

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SUMMARY

- Scenarios need to be defined to demonstrate the EERA-DTOC
- Calculation can only start when an EERA-DTOC version is ready but the definition of scenarios is underway
- Main activity has been on the description of the additional scenario for which some trial calculations will start soon
- Definition of scenarios is open for discussions/suggestions outside the project!

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Thank you very much for your attention