Development and demonstration of the Operation & Maintenance Cost Estimator (OMCE) to estimate the future O&M costs

FLOW Final Presentation

R&D Theme 1: Far offshore wind farm design

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TU Delft, 4 March 2015

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Introduction

Introduction:
O&M Cost Estimator (OMCE)

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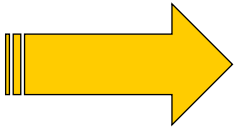
- ECN has a long experience in developing and providing training/services with OPEX Cost Modeling Tools
- Many inputs are required for O&M cost modelling
- These inputs can be derived from operational experiences
- ECN's conclusions from past experience:
  - Data from offshore wind farms is being collected, but in an unstructured way
  - Data needs to be analysed for reliability engineering and O&M optimisation (**data ≠ information!!**)
  - Operators and OEM's own the data → responsible for data collection and analysis



Approach: Operation & Maintenance Cost Estimator (OMCE)

Introduction:
O&M Cost Estimator (OMCE)

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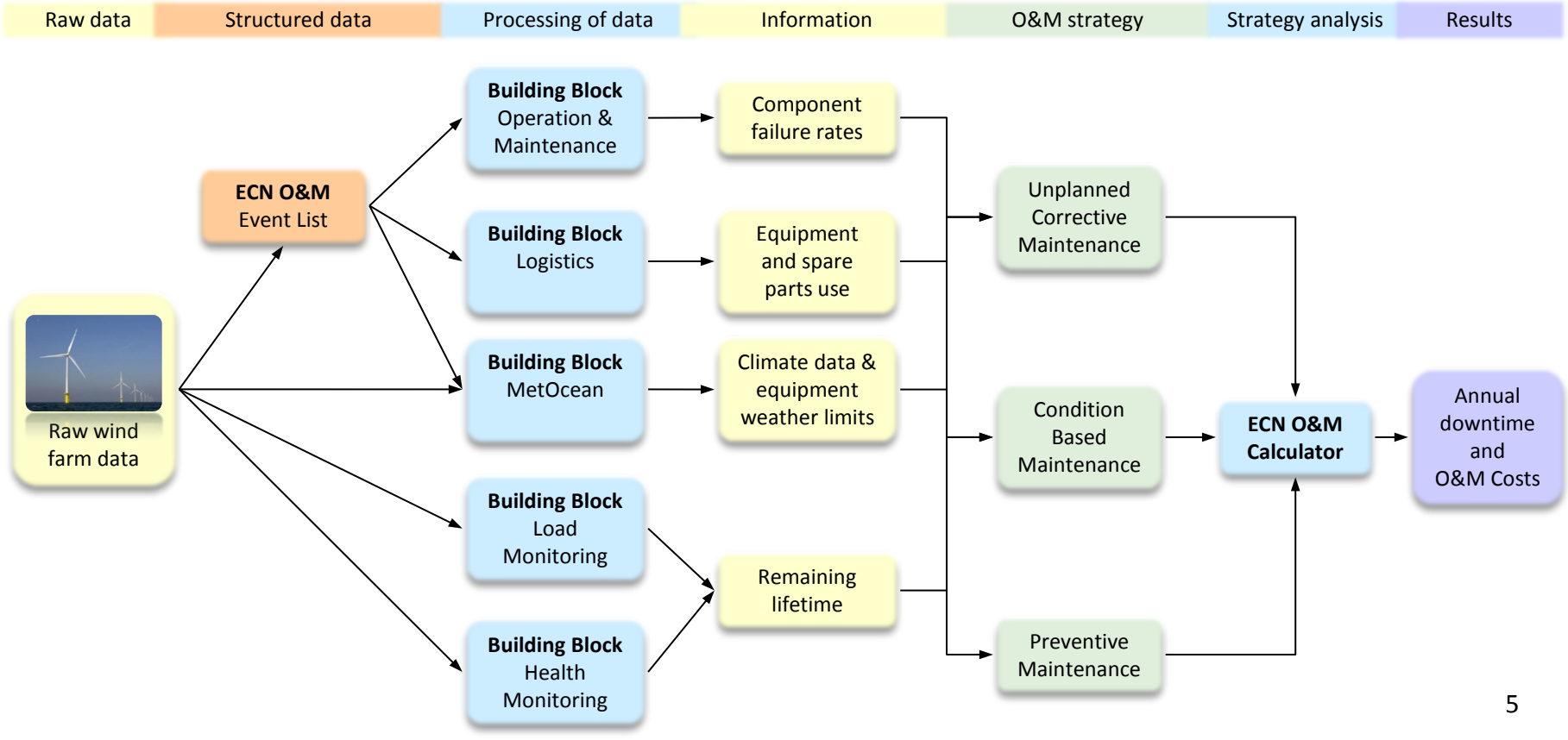

FLOW OMCE project

FLOW OMCE project: Summary

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Project title :	**Development and demonstration of the Operation & Maintenance Cost Estimator (OMCE) to estimate the future O&M costs**
Proposal number :	P201102_001
Project coordinator :	ECN
Project partners :	RWE
R&D line :	1.3
Total project budget	€ 1.564.385,-
Starting date:	01/07/2011
End date	31/12/2014

FLOW OMCE project: Objectives

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- Project objectives:

A. Development of a baseline model of the OMCE by development of software and working procedures using data and feedback from an existing RWE wind farm.

B. Make baseline model available to other offshore operators (commercial).

C. Apply model for analysis of expected O&M costs FLOW demonstration (or alternative) offshore wind farm.

D. Validate the model by implementation of the OMCE in the FLOW demonstration (or alternative) wind farm.

FLOW OMCE project: Work Packages

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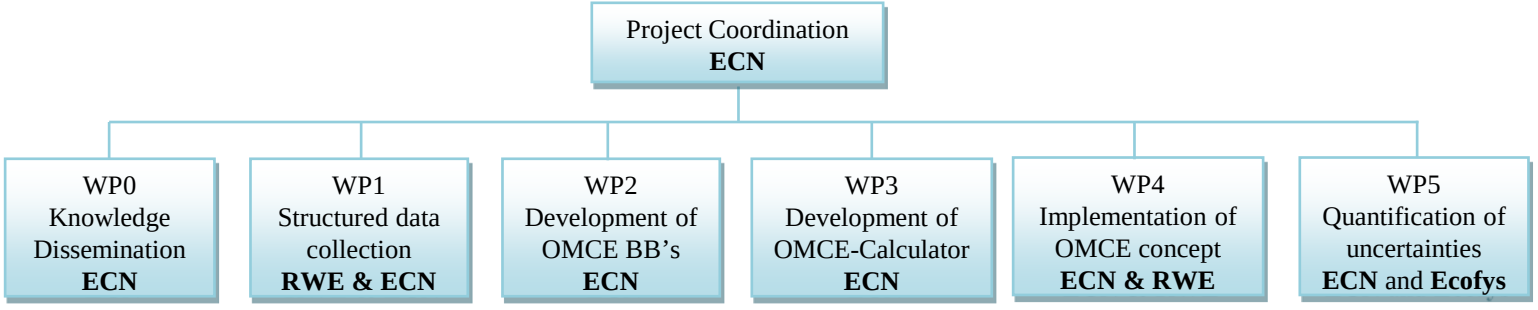

Five work packages defined:

1. Structured data collection ('Event List')
2. Development of OMCE Building Blocks
3. Development of OMCE-Calculator
4. Implementation of total OMCE concept
5. Quantification of uncertainties

Project results

Results:
WP1 Structured data collection

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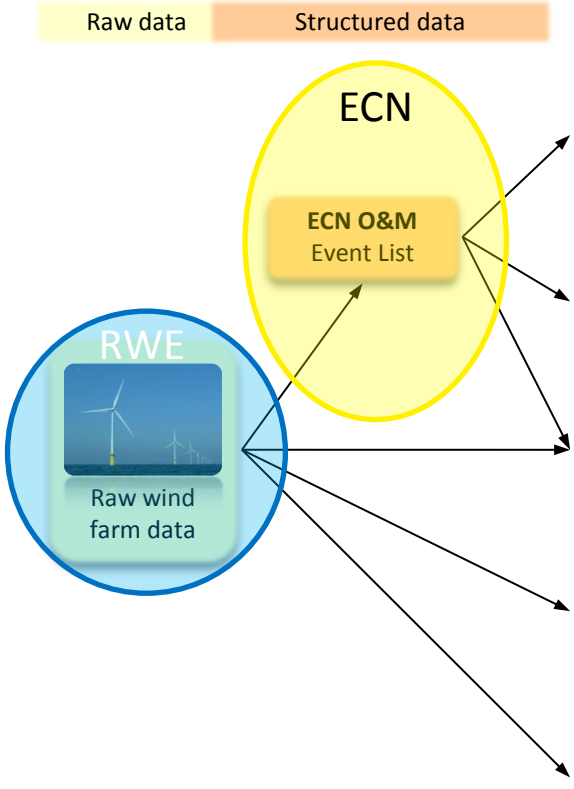
- Objective of Event List is to structure data and list maintenance events
- Data sources supplied by RWE for 3 month period *(Rhyl Flats)*
  - Alarm list
  - Monthly downtime summary reports
  - Daily work reports
  - List of SCADA parameters
  - Meteo and wave data
  - Vessel transfer sheets
  - Turbine breakdown in RDS-PP coding
- Observations and results
  - ECN used supplied O&M data to manually fill Event List format => Labour intensive
  - Sufficient (92%) data available for further development of and analysis by OMCE BBs



Results:
WP1 Structured data collection

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- Based on results the specifications for the Event List are updated
  - Updated 7/38 fields: Labour hours, Travel time, Fuel consumption, etc.

- Reviewed procedures for automated data collection
  - Automated data collection not feasible for Rhyl Flats as to no CMMS
  - Implement procedures for RWE's new 576 MW Gwynt y Môr wind farm as part of WP4
  - Detailed specifications Event List fields and link to CMMS reported by ECN

Deliverable	Delivery date	Status
D1 – Improved and expanded event list format ready	Dec 2012	V
D2 – Automated procedures for structured data collection developed	Jun 2014	V
D3 – Public report with recommendations for data collection	Dec 2013	V

Results:
WP2 Development of OMCE BB's

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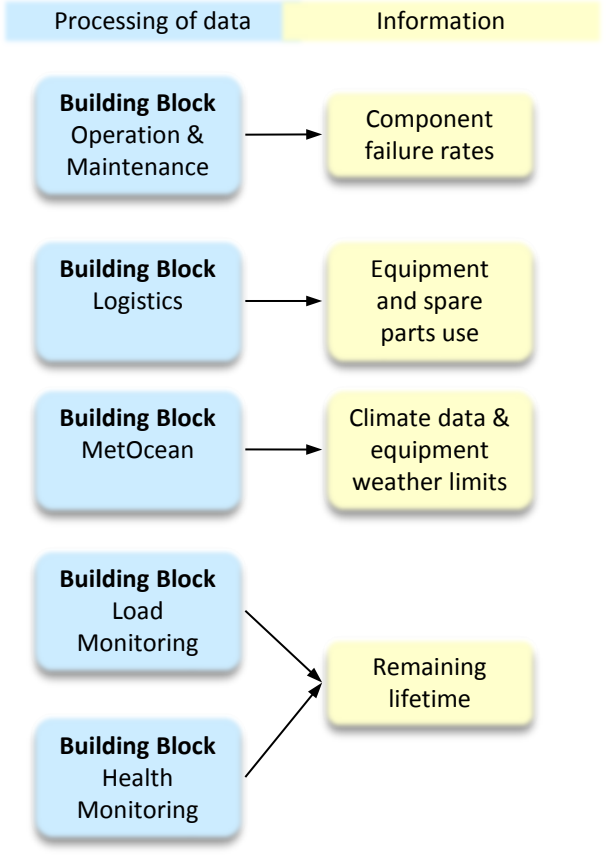
- Objective of Building Blocks is to generate:
  1. Input parameters OPEX Cost Modelling Tools
  2. Insight in failure and repair behaviour
- Based on reviewed Event List demo's of BB's 'O&M' and 'Logistics' updated:
  - Adjusted software to read updated Event List
  - Integrated both BB's in single tool
  - Analysis results consistent to OMCE-Calculator
  - Created reporting module to export results
- BB's 'Load Monitoring' and 'Health Monitoring' not further developed in the scope of this project
- Specifications and examples created for BB 'MetOcean' for the first time



Results:
WP2 Development of OMCE BB's

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- Observations Rhyl Flats data Mar-May 2011 using updated BB's tools:
  - Many small one-off repairs
  - Corrective maintenance cause of majority downtime
  - 9 corrective failures observed (λ_{wt}=1,44 y^{-1})
  - Average travel time is about 1 hour
  - Weather limits work: H_s=1.8 m, V_w=18.8 m/s

Deliverable	Delivery date	Status
D4 – Confidential report with specifications for OMCE Building Blocks	Jul 2014	V
D5 – OMCE Building Blocks ready for implementation at RWE	Jun 2014	V
D6 – Public report specs and descriptions OMCE Building Blocks*	Jul 2014	V

* Deliverables D6 and D9 are combined in a single publication.

Results:
WP3 OMCE-Calculator

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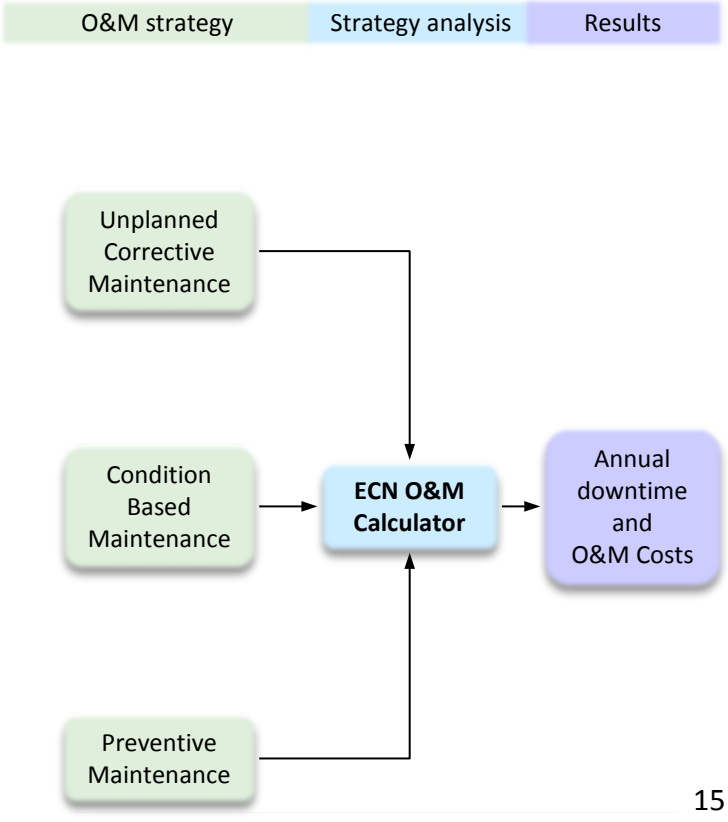
- Objectives of OMCE-Calculator:
  1. Assess near future O&M effort based on generic input or input derived from BB's data analysis
  2. Platform to perform maintenance strategy optimisation
- Allow for detailed O&M modelling
  - Time simulation tool
  - Logistic aspects
  - Flexible maintenance model
- Input well-founded decision making:
  - Identify options for increasing production and reducing costs
  - New O&M contracts, vessels and equipment
  - Solid background for O&M budget
  - Assist in planning predictive maintenance



Results:
WP3 OMCE-Calculator

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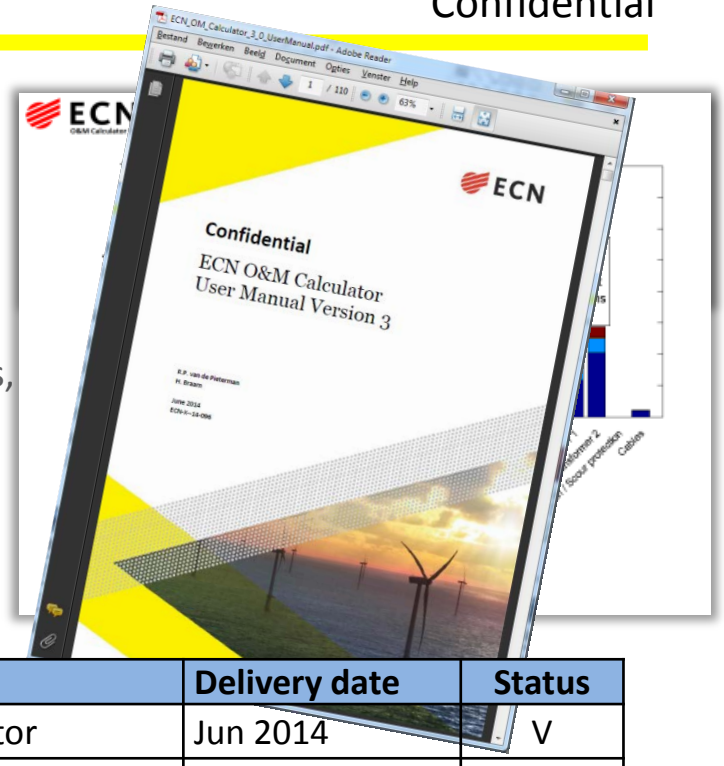
- Demonstration version finalised
  - Software review and validation ECN O&M Tool
- Feedback obtained through trial licenses and review with RWE to improve software:
  - Models developed and implemented for: crew shifts, technician availability, alternative access vessel, variable feed-in tariff, additional output etc.
  - Updated User Manual including detailed specifications and descriptions of the model



Deliverable	Delivery date	Status
D7 – Confidential report with specifications for OMCE-Calculator	Jun 2014	V
D8 – OMCE Calculator ready for implementation at RWE	Jun 2014	V
D9 – Public report specs and descriptions OMCE-Calculator*	Jul 2014	V

* Deliverables D6 and D9 are combined in a single publication.

Results:
WP4. Implementation

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- WP Objectives: Implement and validate OMCE concept at wind farm
  - Analysis of expected O&M costs using generic data and assumptions
  - Obtain Event Lists with updated data at regular intervals
  - Evaluate initial input parameters by analysis of Event List data with OMCE Building Blocks
  - Update input data OMCE-Calculator and analysis of expected O&M costs
- Implementation not possible at wind farm RWE
- ECN sent proposal to FLOW partner Eneco, which responded positive. Vestas did not want to support this project by sharing data with ECN…
- Decision Go/No Go 2 => No Go

Deliverable	Delivery date	Status
D10 – Whole OMCE concept implemented	N/A	N/A
D11 – Updated new O&M cost estimates ready	N/A	N/A
D12 – Validation of OMCE Calculator with real data ready	N/A	N/A
D13 – Public report with evaluation of added value OMCE**	N/A	N/A

** The added value of the OMCE is updated as part of the public case study in deliverable D6/D9

Results:
WP5. Quantification of uncertainties

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- Objective
  - Identify which uncertainties in input parameters used for cost modelling are driving O&M costs.
  - Compare to field observations made by implementation of OMCE
- Implementation of OMCE delayed
  - ECN and Ecofys organised meeting to discuss scope of work
  - Concluded that a larger data set than 3 months for Rhyl Flats was required to quantify uncertainties based on field data
- Implementation OMCE was not possible and work not carried out further

Deliverable	Delivery date	Status
D14 – Public report with recommendations on the usage of uncertainties	N/A	N/A

Contribution to FLOW targets

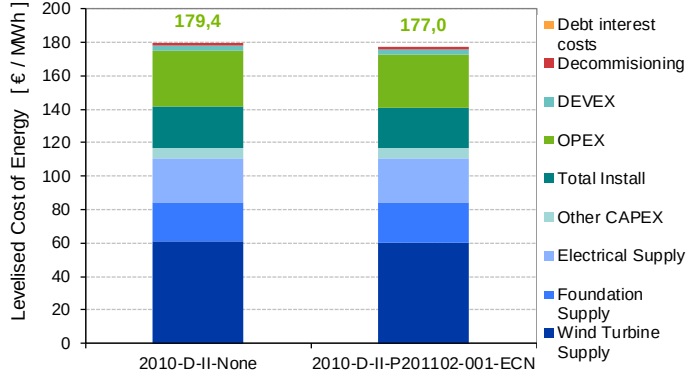
Contribution to FLOW targets

- This project addresses the FLOW objective:
  - *"… significant cost & risk reduction of far-offshore wind energy…."*
- Cost reduction updated based on limited case study for Rhyl Flats wind farm:
  - Baseline model created for Rhyl Flats
  - Updated model inputs based on BB's analyses
  - Optimisation study O&M strategy to identify possible cost reductions:
    - ➢ Reduced number of workboats
    - ➢ Reduced maintenance technicians
    - ➢ Set wind speed limit preventive maintenance
- Identified cost reductions:
  - 10.4% OPEX and 4.2% Yield result in 1.33% LCOE
  - Uncertainties OPEX = 10.4% ± 5.2%, Yield = 4.2% ± 2.1% => LCOE 0.67% - 2.00%

Wind Turbines Parameters	Initiative Name / Initiative Number	P201102-001-ECN / 1
OPEX		
	Average annual WTG O&M costs [€]	0,896
	Average annual monopile O&M costs [€]	0,896
	Average annual jacket O&M costs [€]	0,896
	Average annual E-infra O&M costs [€]	0,896
	Environmental monitoring costs (y 1 to 5) [€]	
	Average annual Owner's O&M organisation costs [€]	
Yield		
	Wind farm capacity [MW]	
	Number of WTGs [-]	
	Ideal energy yield [MWh/y]	
	Wind farm non-availability [%]	0,958
	Wake losses [%]	

Output: Main Results last single case model run

Foundation used last run:	Monopile
Cost reduction from baseline [%]	1,33%



Conclusions and recommendations

Conclusions and Recommendations

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- Baseline model of OMCE developed in FLOW OMCE project
  - Integral O&M approach available to offshore wind industry by ECN
- ECN will continue to seek interested parties to implement the OMCE
  - Added value of concept acknowledged by RWE, Centrica, Statoil, Eneco and others
  - Link between CMMS and OMCE further developed through DAISY4OFFSHORE TKI-WoZ project
- Limited case study shows potential in reducing LCOE using OMCE

Thank you for your attention

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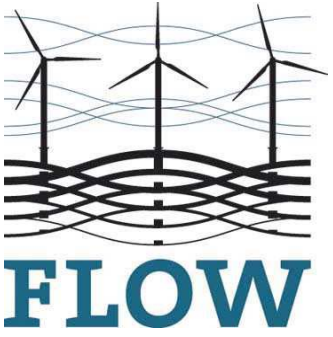
This project is sponsored by the Dutch Far and Large Offshore Wind Programme (FLOW)



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End of presentation

FLOW OMCE project: Risks

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- No suitable operational data available:
  - Small risk: RWE operates/develops several offshore wind farms
  - Large consequence: WP2, WP4, and WP5 cannot be executed
  - Go/NoGo 1 => Go
- Wind farm for implementation OMCE unavailable:
  - Medium risk: depends on availability FLOW demo wind farm or alternative
  - Medium consequence: WP4 (implementation) cannot be executed
  - Go/NoGo 2 => No Go