EERA DeepWind'18 conference

Trondheim, Norway

The LEANWIND suite of logistics optimisation & full lifecycle simulation models for offshore wind farms

Presenter: Fiona Devoy McAuliffe

Project supported within the Ocean of Tomorrow call of the European Commission Seventh Framework Programme

Presentation overview

- Introduction
- Methodology
- Logistics optimisation models
- Financial simulation model
- Combined use
- Potential end-users

Introduction

Significant cost reductions to date:

Vattenfall's 2016 offshore wind price bid of €49.9/MWh for the Kriegers Flak project set a record LCOE forecast of €40/MWh

Current and future challenges to maintain & surpass savings:

- Increased industry competition to find cost reductions
- New markets yet to achieve LCOE forecasts
- Sites further from shore in deeper waters and harsher conditions
- Larger turbines and farms with new equipment and logistical requirements
- Facing the unknown – the decommissioning phase

Introduction

What progress needs to be made?

Turbine	Foundation & tower	Transmission	Installation	OMS	Development
Technology contributions to reducing LCOE					
10%	1.5%	3%	1.5%	2%	2%
Supply chain contributions to reducing LCOE					
2%	1.5%	2%	1.5%	1%	1%

Source: BVG Associates 2016 The supply-chain' s role in LCOE reduction, Belgo-British offshore wind farm supply-chain seminar Brussels

Introduction

Logistic Efficiencies And Naval architecture for Wind Installations with Novel Developments

OBJECTIVE: *to provide cost reductions across the offshore wind farm lifecycle and supply chain through the application of lean principles and the development of state of the art technologies and tools*.

- UCC is coordinator
- 31 partner organisations
  - 52% industry partners
  - Representing 11 countries;
- €14.9m total funding;
- €10m EC funding;
- 4 year duration
  - December 2013-November 2017

Project Partners

Introduction

Modelling is a safe and cost-effective way to evaluate and optimise operations. However, there is a lack of comprehensive decision-support tools, detailed enough to provide insight into the effects of technological innovations and novel strategies.

They can reduce costs by identifying potential savings and fostering effective decision-making for a wide range of stakeholders.

LEANWIND developed a suite of logistics and financial tools, which can optimise the entire supply-chain and simulate the full wind farm lifecycle, providing in-depth cost and time analysis.

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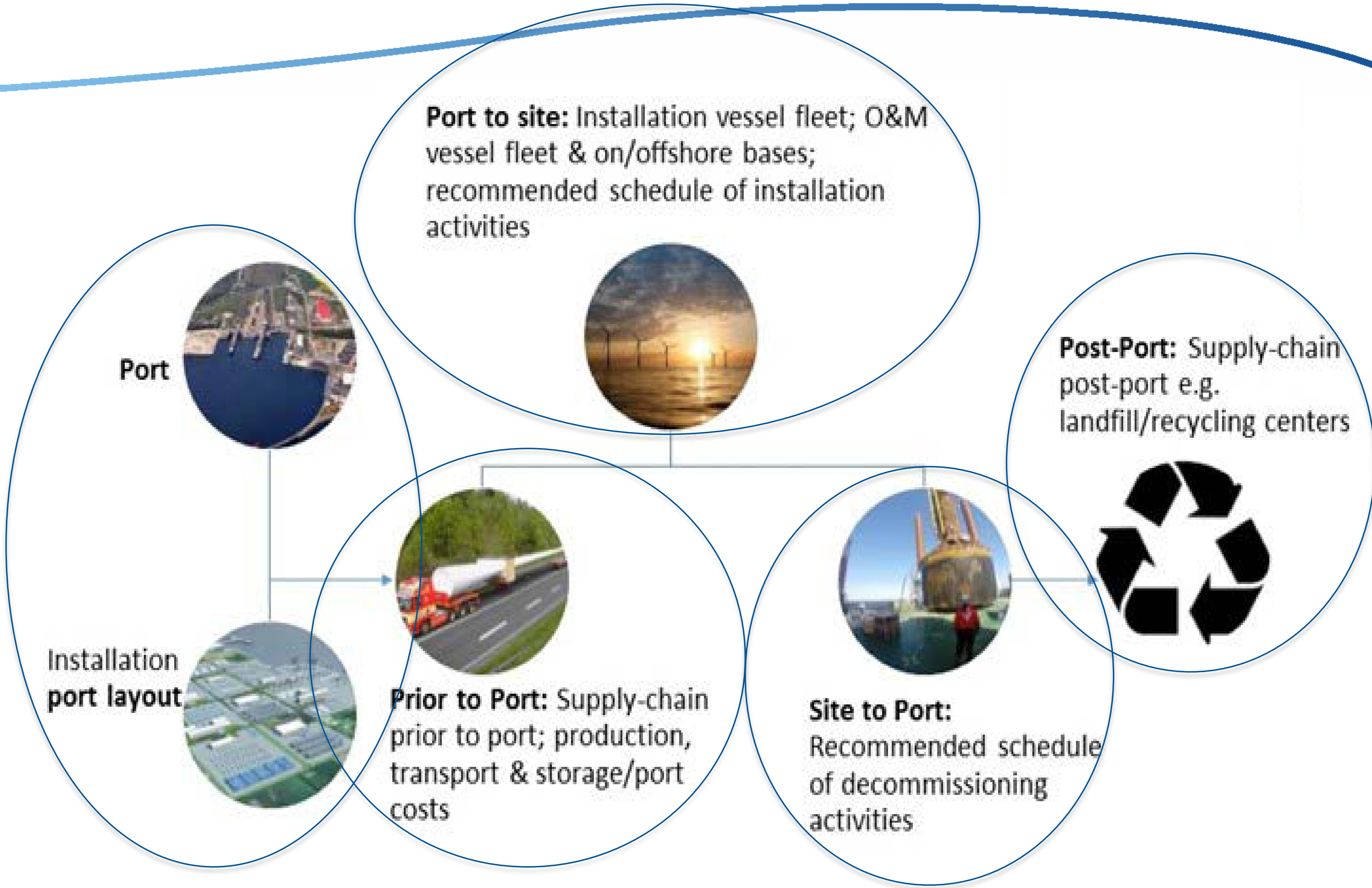
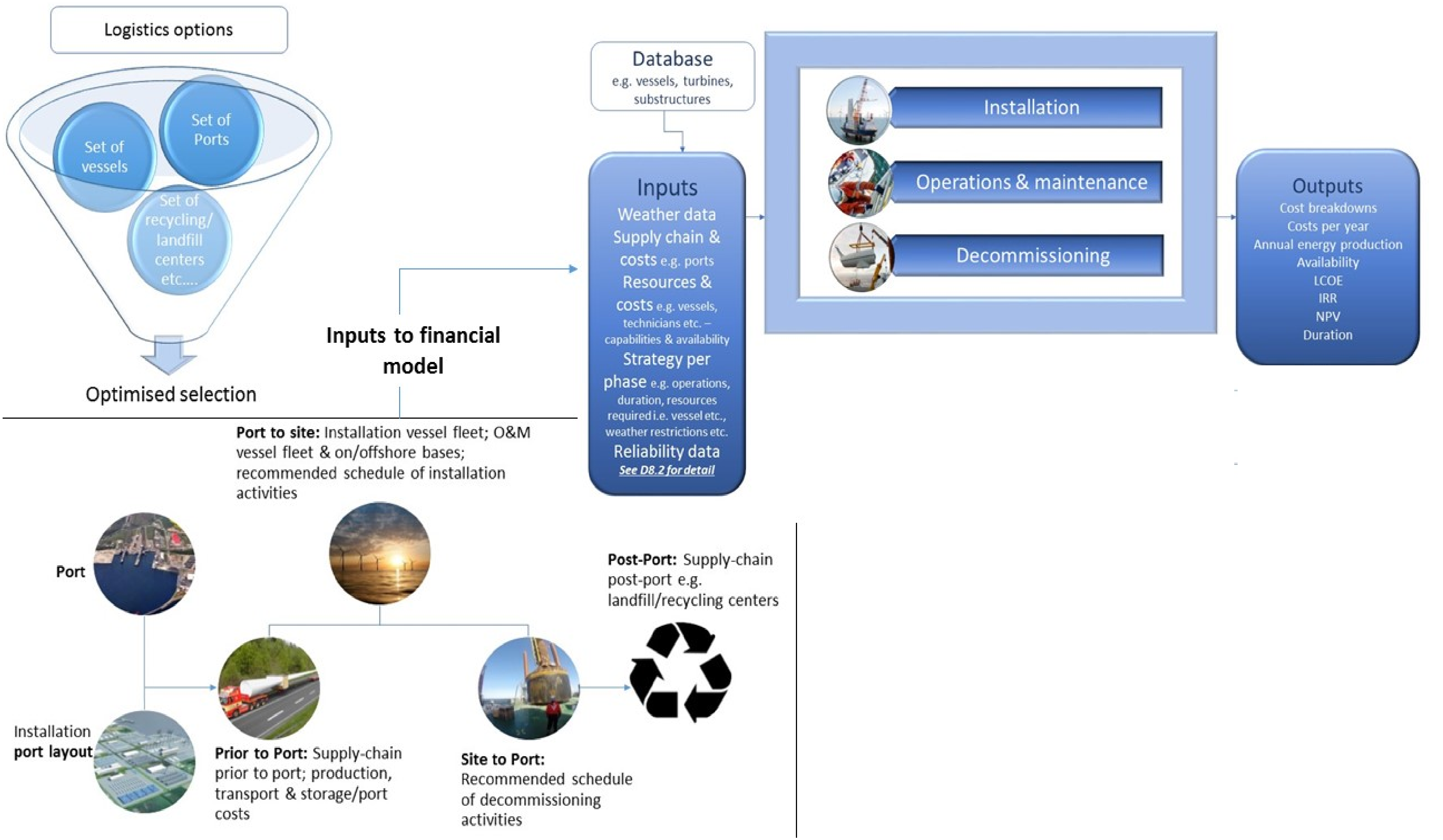
Methodology



Methodology

Methodology

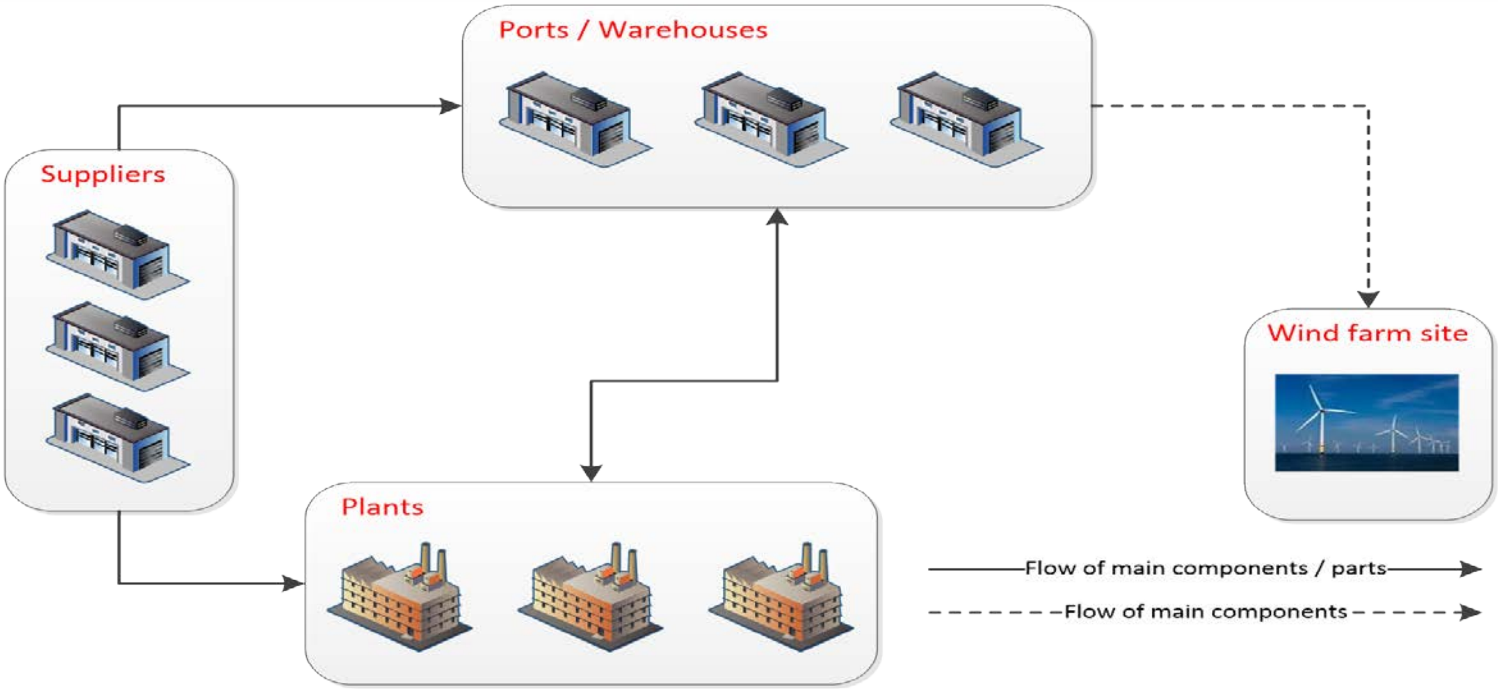


Logistics optimisation models

	Installation	O&M	Decommissioning
Prior to/post port	PTPIns	PTPOM	IntDis
At port	Portlay, PortIns	PortOM	PortDis
To/from offshore site	VMIns	VMOM	IntDis

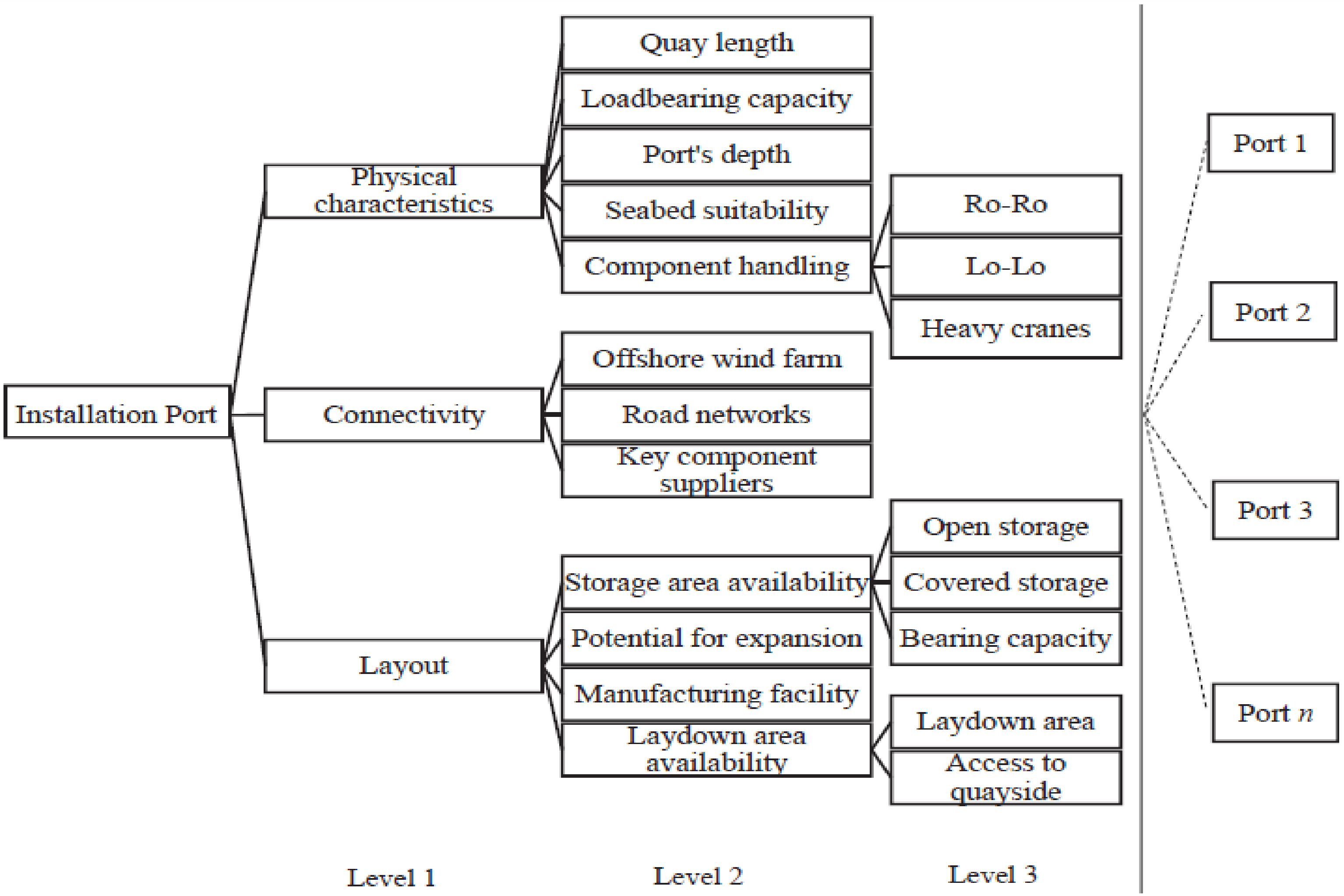
- Prior to/post port: manufacturing, transportation, storage, and assembly.
- At port: selection of the port(s) for each lifecycle phase & optimal layout (installation phase).
- Supply to/from offshore site: transportation of parts to/from the port to the site.

PTPIns PTPOM – prior to port models



Optimal arrangement of supply chain (suppliers, manufacturers/plants, and warehouses (ports)) and schedule from the production of turbine parts to delivery at port.

PortIns PortOM PortDis – port selection



Source: Akbari N, Irawan C, Jones D and Menachof D 2017 A multi-criteria port suitability assessment for developments in the offshore wind industry Renewable Energy 102 pp 118-133

Portlay - port layout

Inputs:

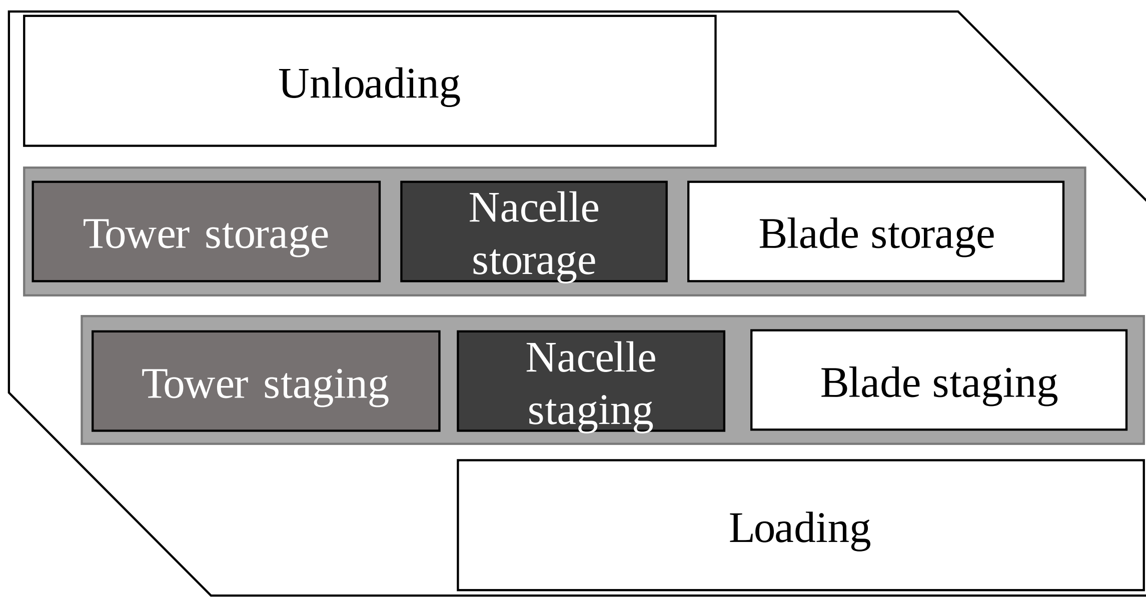
- Set of edges that make up a polygon (the port area)
- Set of subareas
- Set of possible rectangles for each subarea
- Set of predefined subareas
- Set of components
- The unit transportation cost of each component

→ **Port Layout Optimisation** →

Outputs:

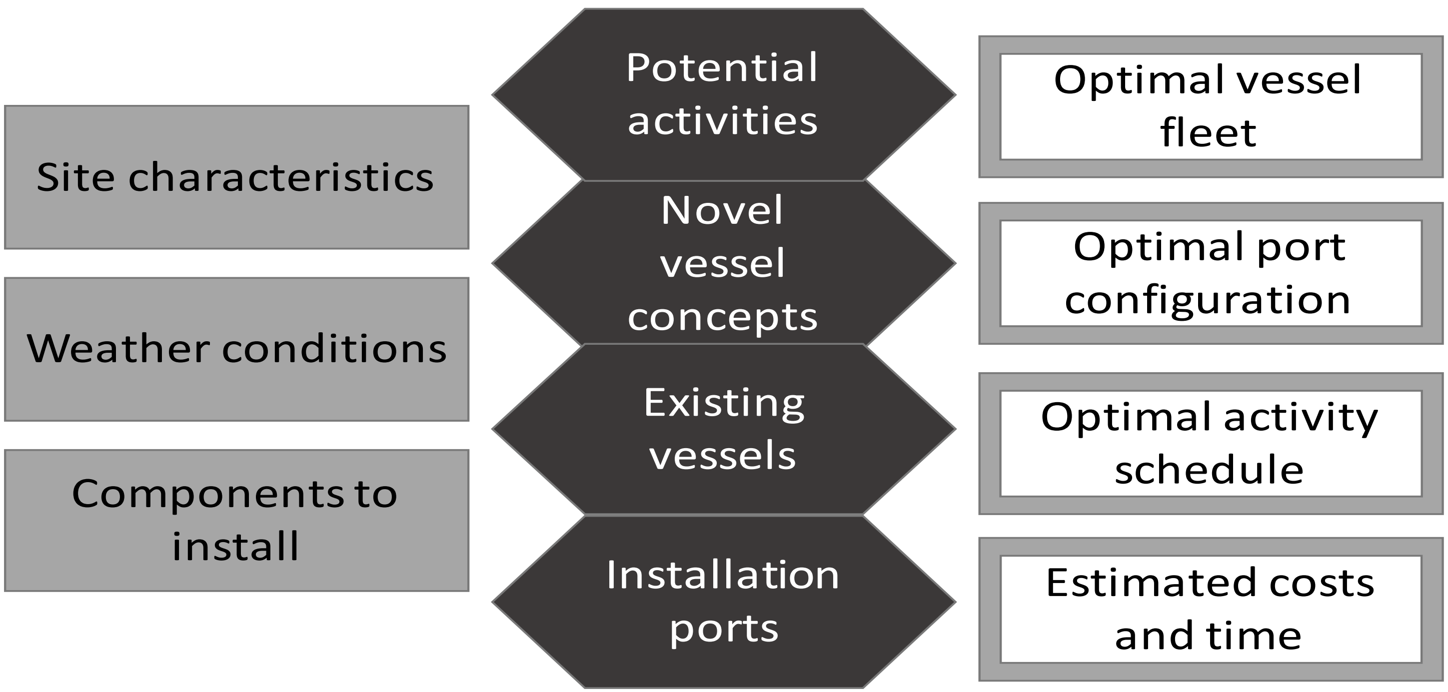
- Port layout for offshore wind farm
- Total travel cost of components

Optimal layout of the port given the dimensions and travel costs



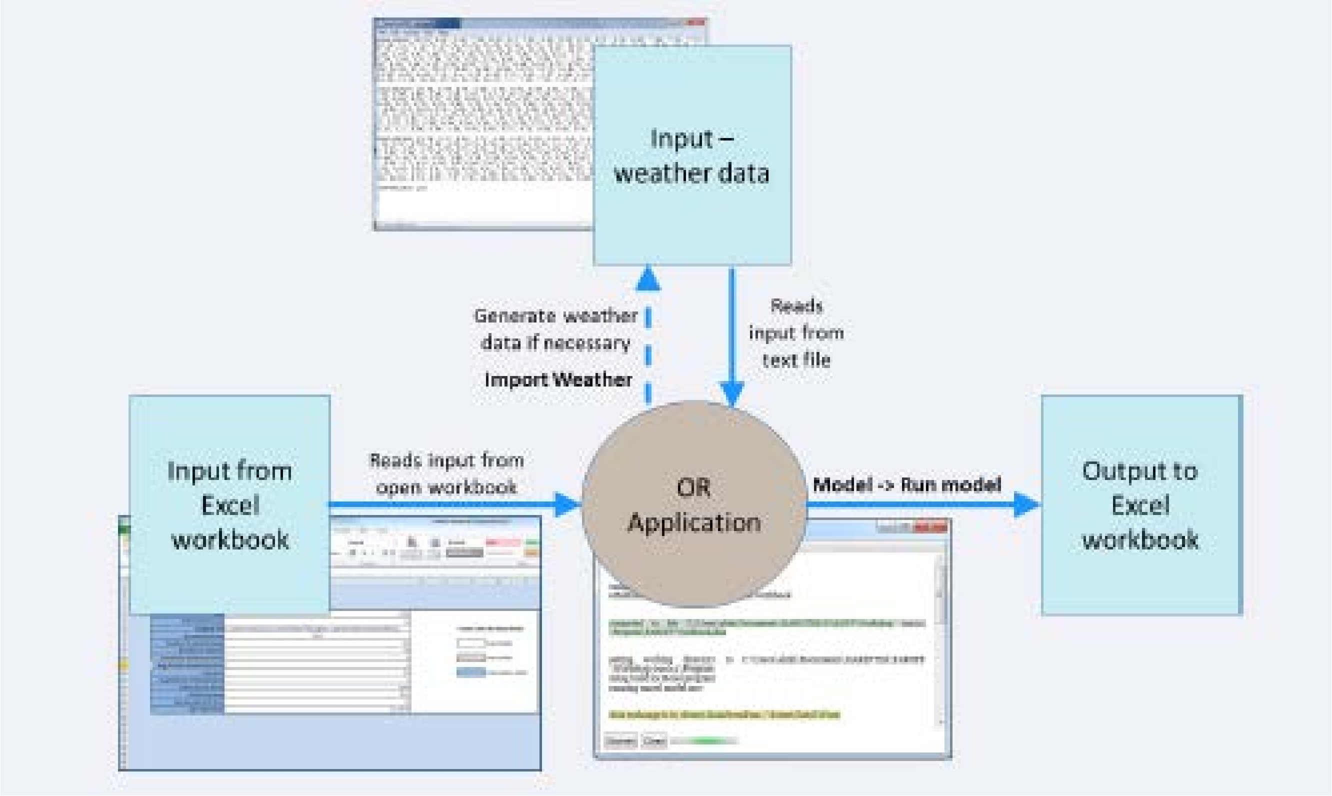
VMIns VMOM – port to site models

VMIns - optimal vessel fleet and schedule of installation activities i.e. the number of components to be installed per day.



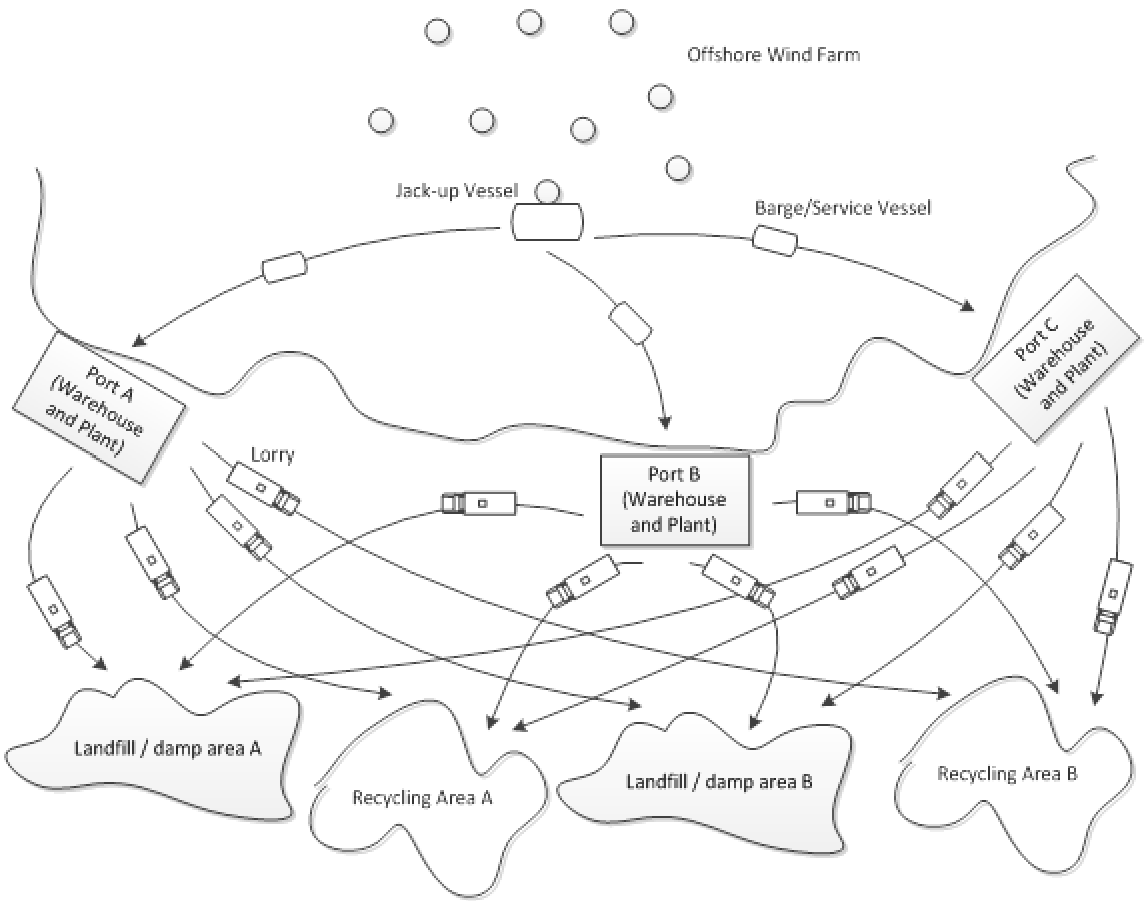
VMIns VMOM – port to site models

VMOM - Based on the generated corrective & preventive maintenance patterns, the model chooses the *number and type of vessels and* the corresponding *infrastructure (bases, platform, mothership)* needed in the offshore transport system.



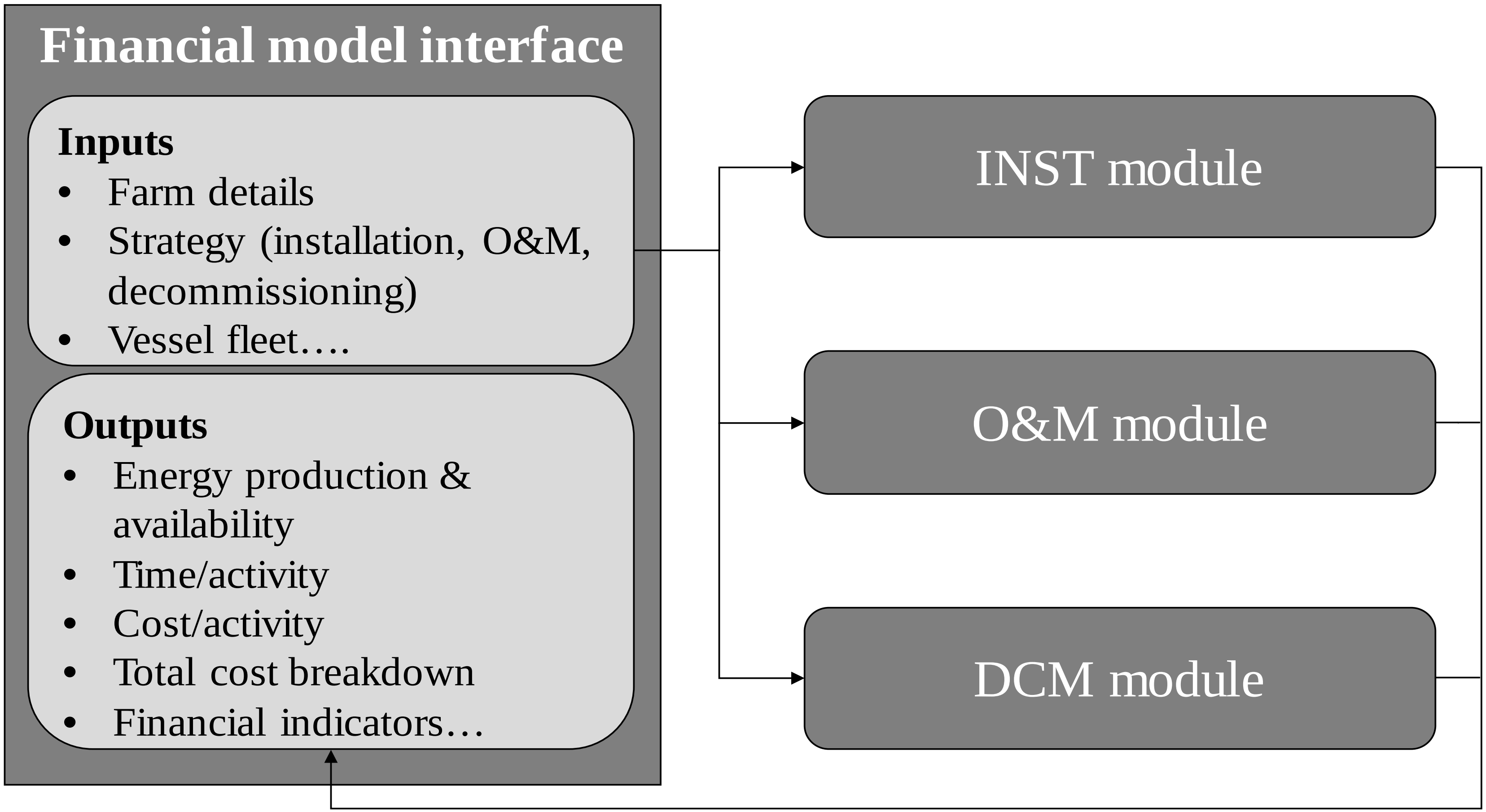
Source: Nonås L, Halvorsen-Weare E E and Stålhane M 2015 *Finding cost-optimal solutions for the maritime logistic challenges for maintenance operations at Offshore Wind Farms* (Denmark: Poster presentation at EWEA Offshore Wind Conference)

IntDis – integrated dismantling model



Vessel schedule and flow of components for decommissioning. The objective function is to minimise the total cost of activities.

Financial simulation model



Financial simulation models

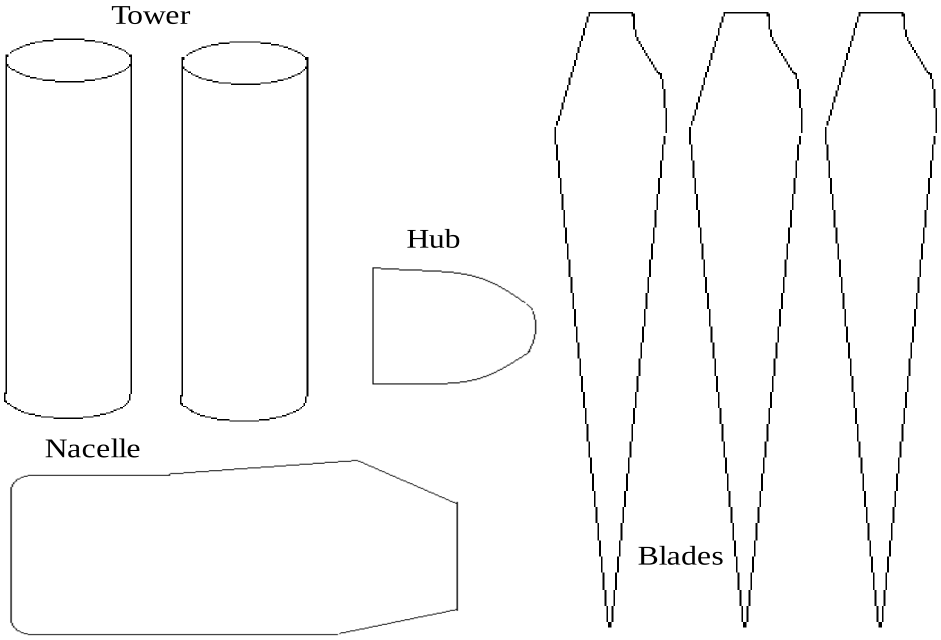
Key Outputs

- Full project timeline i.e. duration of activities across the lifecycle
- Energy yield and availability
- Detailed breakdown of
  - capital & installation costs (CAPEX)
  - operation & maintenance costs (OPEX)
  - decommissioning costs (DECEX)
- LCOE, NPV, IRR and payback period
- Cashflow with project profit and loss sheet
- Balance sheet to evaluate debt and equity

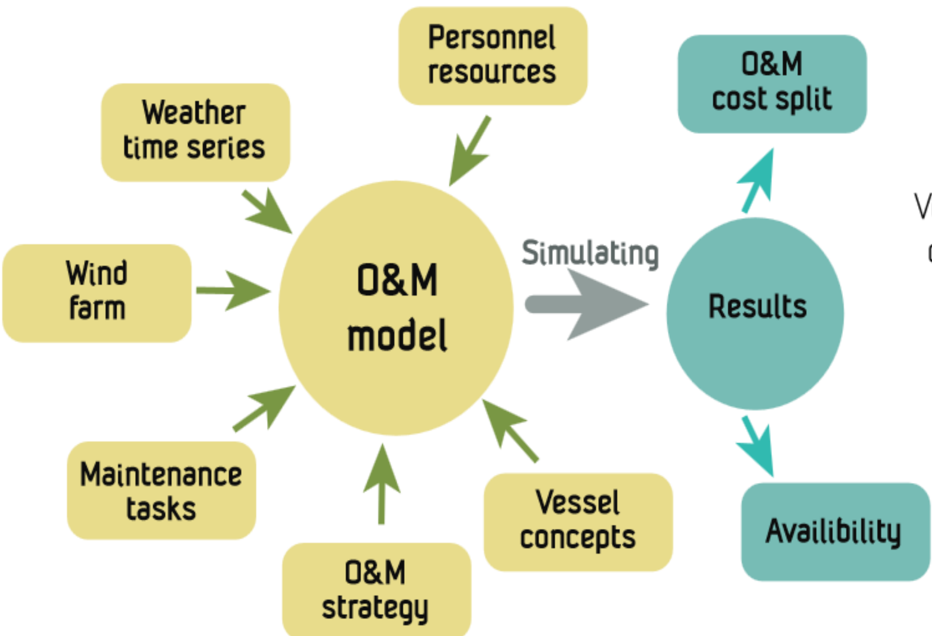
INST module

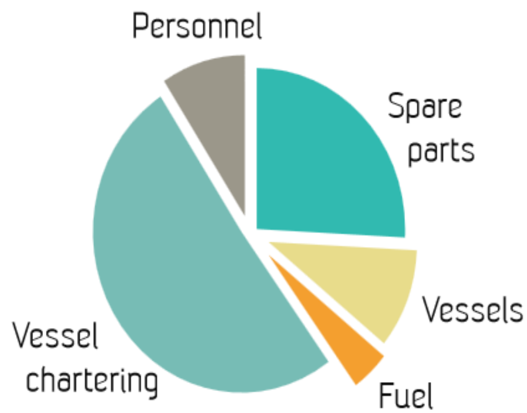
Scope: the turbine, foundation, substation, substation foundation, export and inter-array cabling. The user can specify or use a pre-defined selection of assets. Different operations are then associated with the installation of each asset e.g.

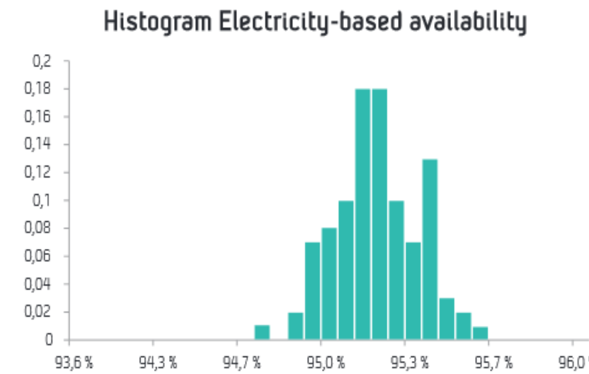
Installation method	Lifts
2 tower parts, nacelle and hub pre-assembled	6
Tower parts and nacelle and hub pre-assembled	5
Blades and hub pre-assembled	4
Nacelle, hub and 2 blades (bunny ears) pre-assembled	4
Tower parts and nacelle, hub and 2 blades (bunny ears) pre-assembled	3
Pre-assembled	1
Pre-installed on substructure	0



O&M module


Personnel resources
Weather time series
Wind farm
O&M model
Maintenance tasks
O&M strategy
Vessel concepts
Simulating
Results
O&M cost split
Availibility

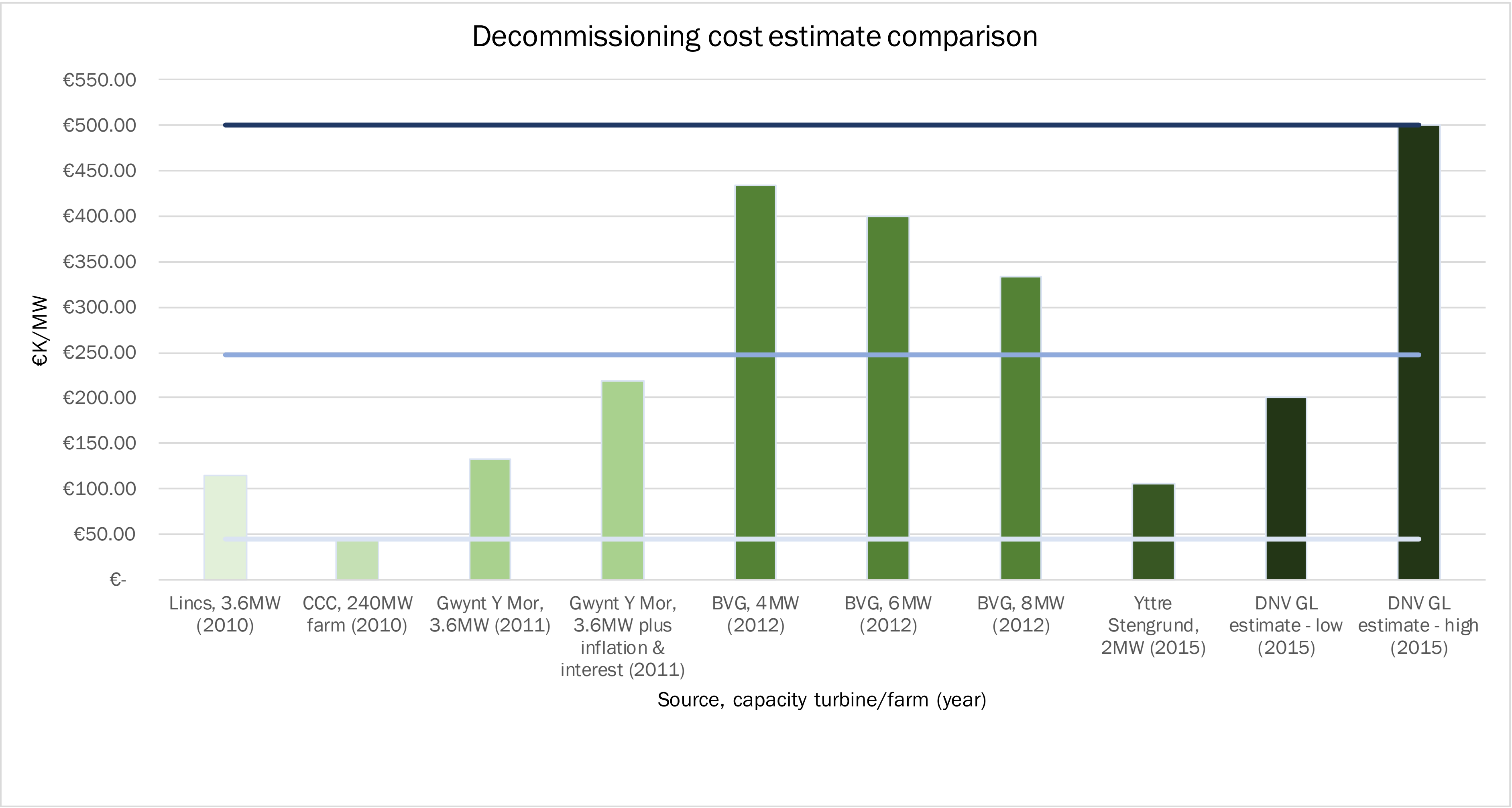

Personnel
Spare parts
Vessels
Fuel
Vessel chartering


Histogram Electricity-based availability
0,2
0,18
0,16
0,14
0,12
0,1
0,08
0,06
0,04
0,02
0
93,6 %
94,3 %
94,7 %
95,0 %
95,3 %
95,7 %
96,0 %

O&M module

1. Hofmann M and Sperstad I B 2013 NOWIcob – A tool for reducing the maintenance costs of offshore wind farms *Energy Procedia* **35** pp 177–186
2. Sperstad I B, Kolstad M and Hofmann M 2017 *Technical Documentation of Version 3.3 of the NOWIcob Tool Report no. TR A7374, v. 4.0* (Trondheim: SINTEF Energy Research)
3. Sperstad I B, Stålhane M. Dinwoodie I, Endrerud O.-E. V., Martin R and Warner E 2017 Testing the robustness of optimal access vessel fleet selection for operation and maintenance of offshore wind farms Ocean Engineering **145** pp 334–343
4. Sperstad I B, Devoy McAuliffe F, Kolstad M L and S Sjømark 2016 Investigating Key Decision Problems to Optimize the Operation and Maintenance Strategy of Offshore Wind Farms Energy Procedia **94** pp 261-268

DCM module



Decommissioning cost estimate comparison
€550.00
€500.00
€450.00
€400.00
€350.00
€300.00
€250.00
€200.00
€150.00
€100.00
€50.00
€-
€K/MW
Lincs, 3.6MW (2010)
CCC, 240MW farm (2010)
Gwynt Y Mor, 3.6MW (2011)
Gwynt Y Mor, 3.6MW plus inflation & interest (2011)
BVG, 4 MW (2012)
BVG, 6 MW (2012)
BVG, 8 MW (2012)
Yttre Stengrund, 2MW (2015)
DNV GL estimate - low (2015)
DNV GL estimate - high (2015)
Source, capacity turbine/farm (year)

DCM module

Scope: Turbine and foundation.

Inputs: The component (e.g. blades, nacelle, gearbox etc.) and order in which they are dismantled; component materials and weight; operation durations; up to three destination ports; landfill or recycling centre locations; number of technicians; vessels available etc.

Outputs: Costs; time and revenue e.g. salvage

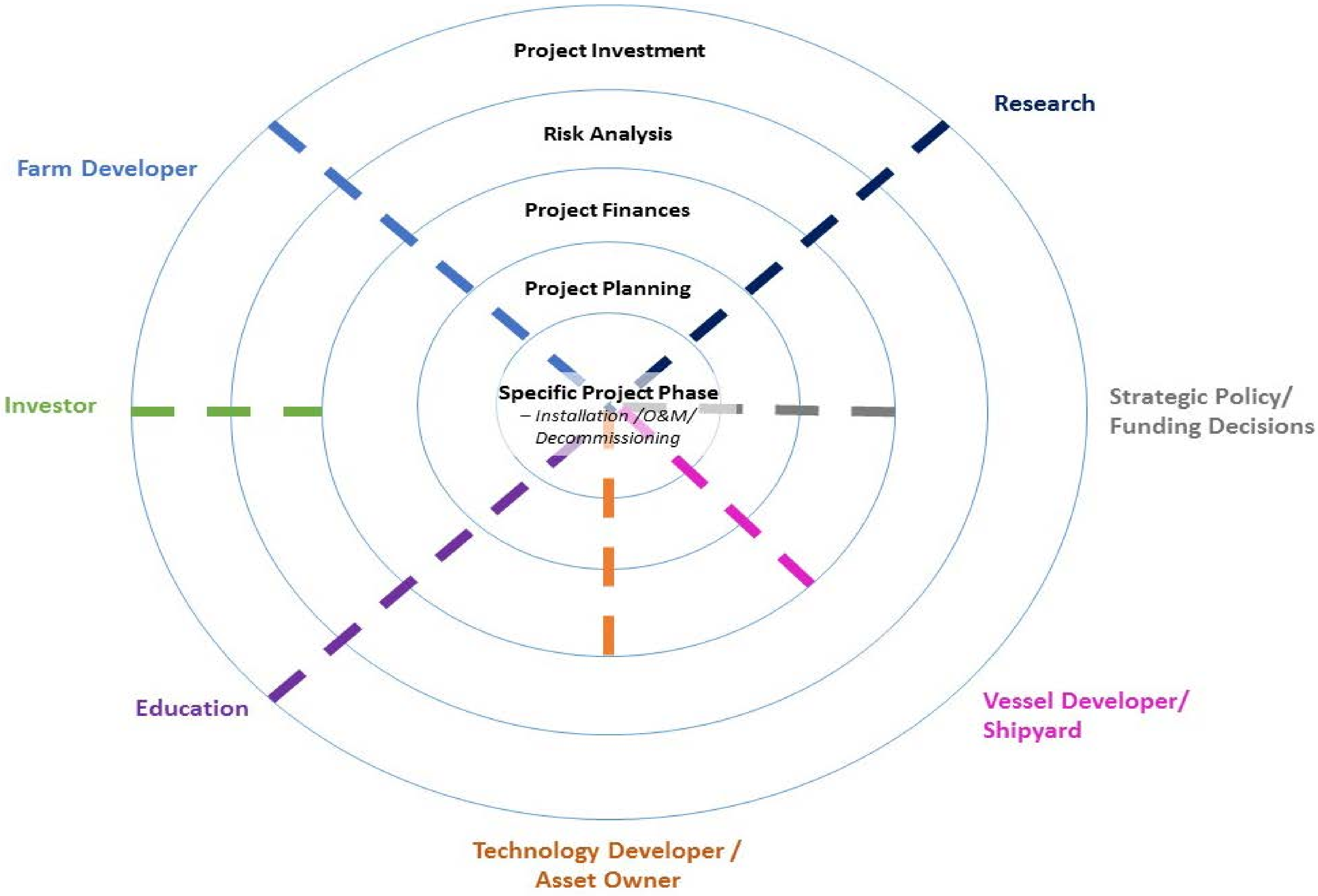
Validation: Results for the C-Power OWF were €513,000 per MW within range estimated by DNV GL of €200,000-€600,000/MW (Source: Chamberlain K 2016 *Offshore Operators Act on Early Decommissioning* (http://newenergyupdate.com/wind-energy-update/offshore-operators-act-early-decommissioning-data-limit-costs: New Energy Update)

Combined use – the benefits

Different objectives and methodologies but complementary:

- Very time-consuming to optimise a scenario with simulation models & not humanly possible to consider all possible solutions.
- The optimisation models determine the key supply-chain configurations and the financial models examine the top ranking options in further detail.
- Simulation models can assess a scenario in detail and the Monte Carlo method considers the uncertainty of key risk factors e.g. failures and weather.
- Combined they can obtain the most economically viable and time efficient solutions to a wide range of logistical and strategic issues.

Potential end-users



Conclusion

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1. Comprehensive and complementary set of logistics and financial models
2. Can foster significant cost-savings in the industry through effective decision-support.
3. Fill a significant gap in the current models available.
4. They can be used individually or together to optimise and simulate the full supply-chain and lifecycle of an OWF project.
5. Combined use can save considerable computational time.
6. Designed primarily for the project planning and design phase but also useful during operational period.
7. They can address current and future challenges faced by a wide range of stakeholders.


See you in Cork!
- WESC 2019 -
June 17th – 20th
Cork, Ireland

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Thank you very much
for your attention