


GLOBAL WIND ENERGY SHIPPING AND LOGISTICS

MARITIME LOGISTICS: POSSIBLE IMPACT ON LEVELIZED COST OF ENERGY REDUCTIONS FOR OFFSHORE WIND

AUGUST 24, 2016, COPENHAGEN, DENMARK

Prepared for gå-hjem meeting at Danmarks Rederiforening
Danish Shipowners' Association

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Background & introduction

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The expert panel here today

PhD objective is for the research to be useful to industry:

PhD research project Reference Group

Introduction – Thomas Poulsen

Aalborg University, Copenhagen Campus
Department of Mechanical and Manufacturing Engineering

RESEARCH PROJECT
Global wind energy shipping and logistics

RESEARCH INTERESTS
Strategy, business models, and M&A

BACKGROUND
- 25+ years of global shipping, logistics, and SCM experience
- Academic, practical, strategic, managerial, and consulting level experience
- Lived and worked in 8 different countries

PhD EXCHANGE
DTU Wind Energy, Risø

DEN DANSKE MARITIME FOND
DDMF grant 2012-097
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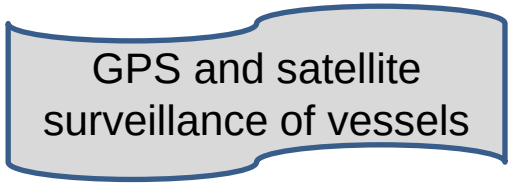
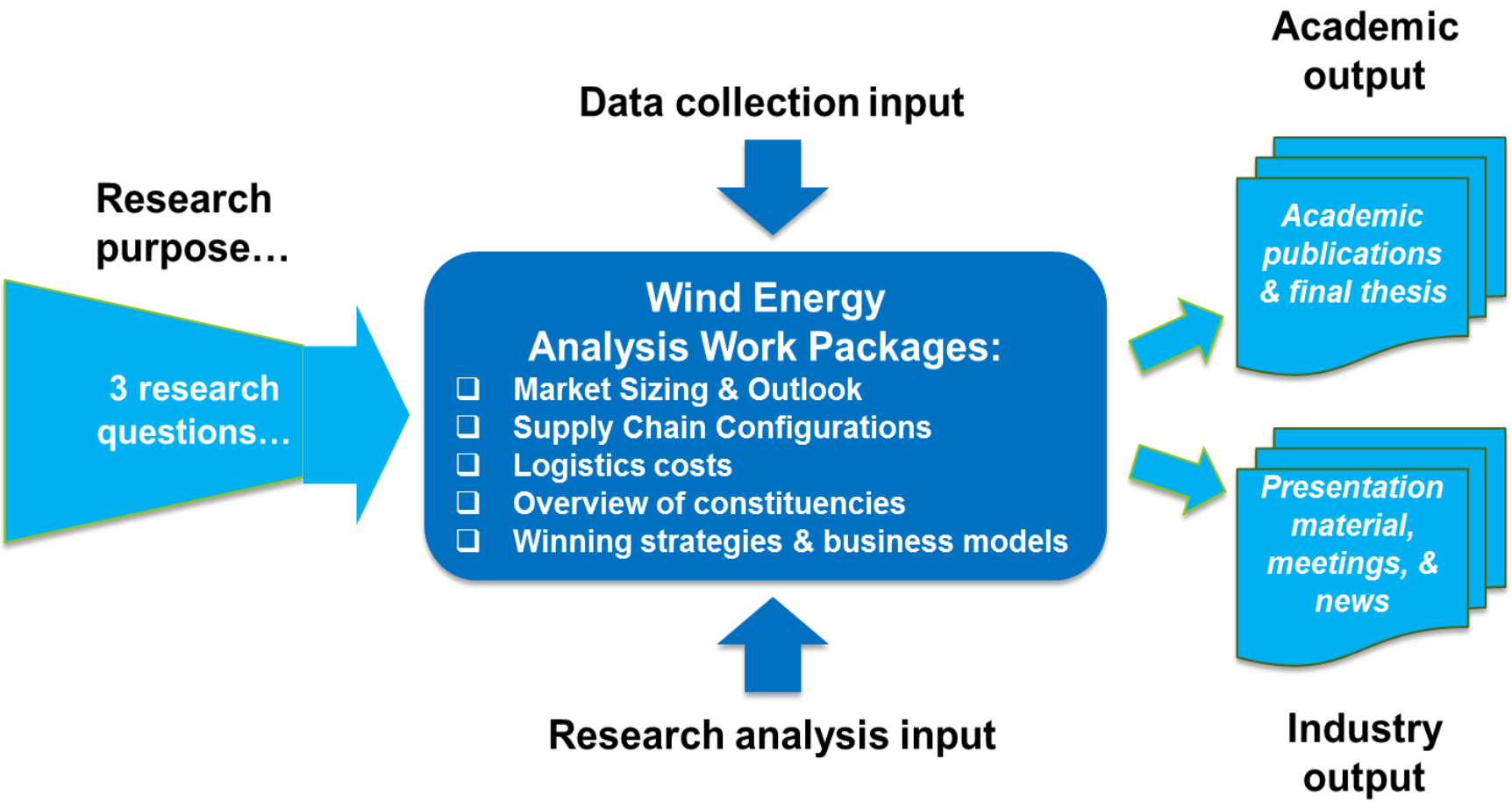
Aalborg University - logistics



PhD mechanics



Case study efforts

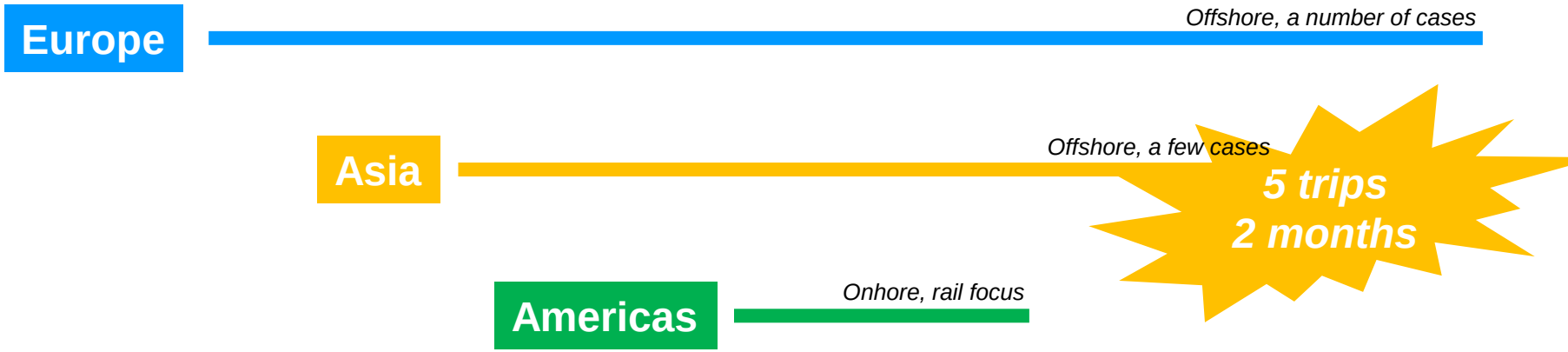
Time spent

Number of companies

Extent of case study scope

Width

Depth



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Levelized cost of energy

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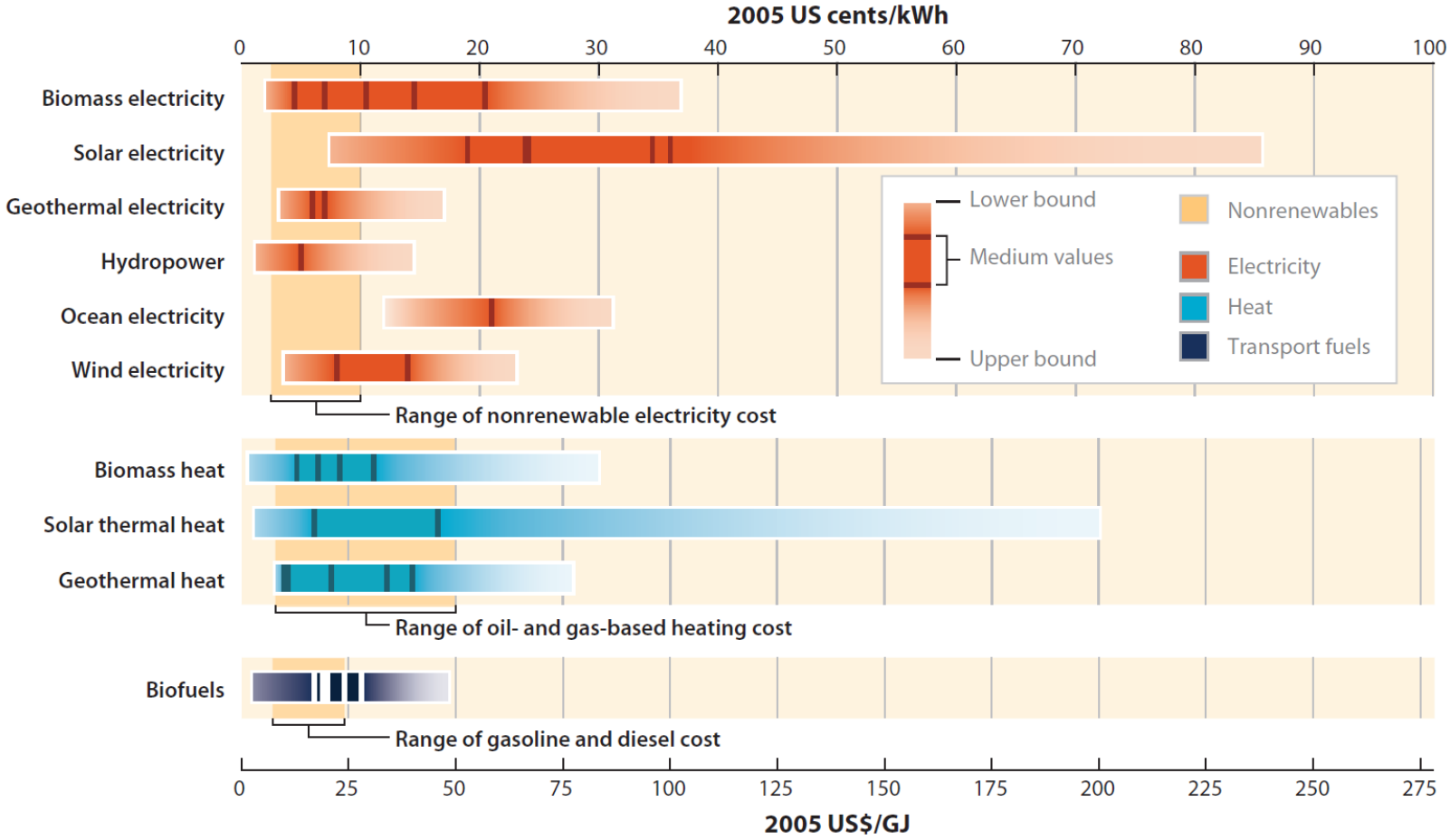
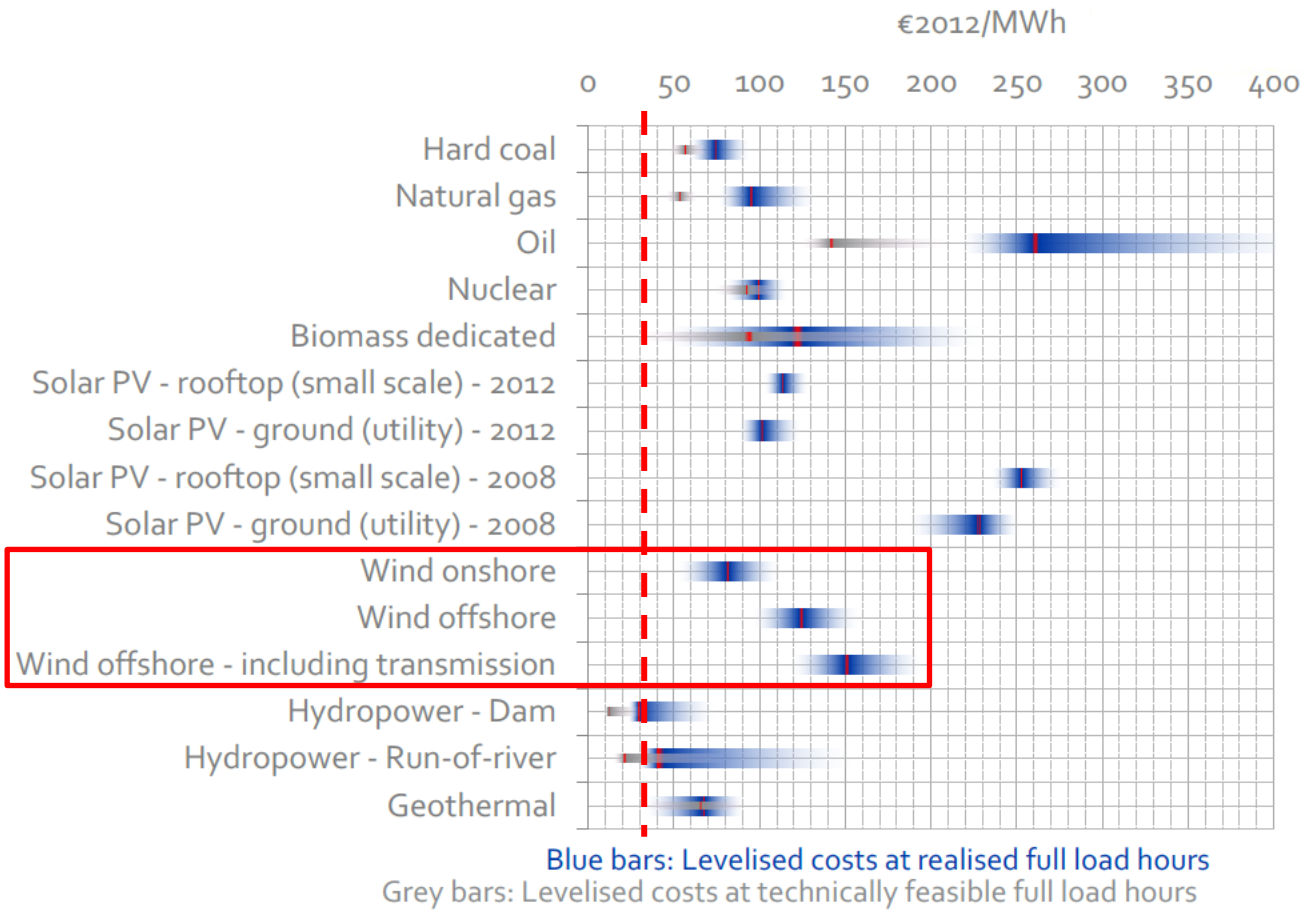
Renewables vs fossil fuels



Source: Edenhofer et al., 2013

Offshore wind is not competitive



Measure used to compare is ***levelized costs***

- What does it actually mean?
- How is it calculated?
- What is the target?

Source: Ecofys, 2014

Definition and ambition (2012)

What do we mean by the Levelised Cost of Energy (LCOE)?

In simple terms, LCOE can be seen as the lifetime cost of the project, per unit of energy generated.

It is defined as the sum of discounted lifetime generation costs (£) divided by the sum of discounted lifetime electricity output (MWh). Generation costs include all capital, operating, and decommissioning costs incurred by the generator/developer over the lifetime of the project, including transmission costs. It does not necessarily correspond to the level of revenue (or 'strike price') that
–it is an expression of cost rat
Weighted Average Cost of Cap
as determined by the capital s
calculated on a post-tax basis

Reducing the cost of offshore wind to £100/MWh by 2020 is achievable

Source: The Crown Estate, 2012

The formula (2013)…

The levelised cost of energy (LCOE) is the **finance mathematical average cost** over the lifetime of the generation plant. It is calculated as follows:

$$LCOE = \frac{I_0 + \sum_{t=1}^{n} \frac{A_t}{(1+i)^t}}{\sum_{t=1}^{n} \frac{M_{el}}{(1+i)^t}}$$

LCOE	Levelised cost of energy in $Euro_{2012}$/MWh
I_0	Capital expenditure in Euro
A_t	Annual operating costs in Euro in year t
M_{el}	Produced electricity in the corresponding year in MWh
i	Weighted average cost of capital in %
n	Operating lifetime (20 years)
t	Individual year of lifetime (1, 2, …n)

Source: Prognos & Fichtner Group, 2013

The calculation

Model input
Simple version High Level

3. LCOE model

MEGAVIND

General	
Base price input	Nominal
Base price out	Real 2014
FID Year	2012
WACC	8 %
Inflation	2 %

Park Design	
Park Capacity (MW)	400
Turbine model	4 MW offshore
Turbine number	100
Turbine capacity (MW)	4.00
Turbine Rotor meter (m)	120

Cost and earning	
Cost input method	Manual simple
Earnings input method	% of investment
Park earnings method	250 %

Tax	
Corporate tax rate	25 %
Tax depreciation method	Declining balance
Tax depreciation rate	25 %

Prod		Total Prod	2009	2010	2011	2012	2013	2014	2015..
Net AEP	GWh	39,424						756	1577

Cost		Total cost	2009	2010	2011	2012	2013	2014	2015..
DEVEX	€ M	20	6.7	6.7	6.7				
CAPEX	€ M	1520				304	532	684	
OPEX	€ M	1028							16,7
ABEX	€ M	127							

Internal company models

VATTENFALL

SIEMENS

MHI VESTAS OFFSHORE WIND

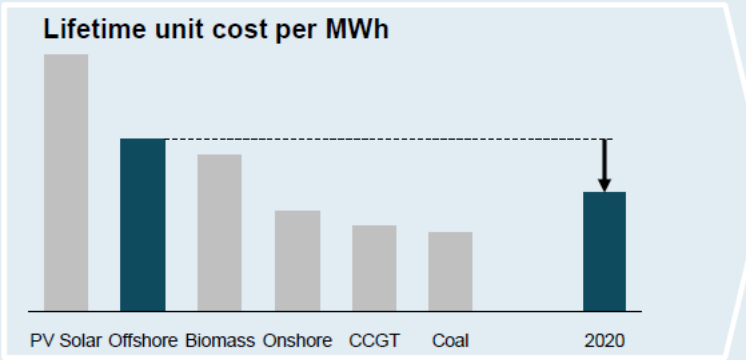
DONG energy

e·on

Source: Megavind, 2015

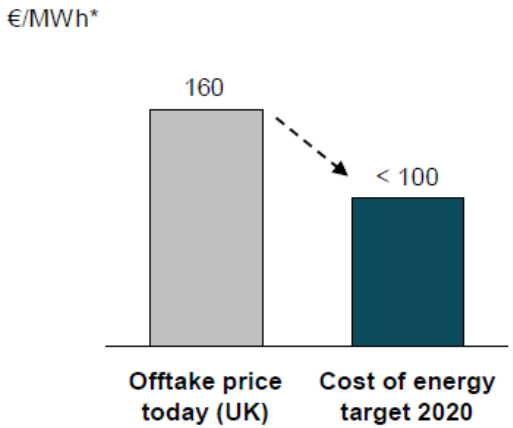
Industry: DONG Energy 2013

1 Offshore wind is not competitive with other energy technologies



- Offshore wind is more expensive than other commercial power generating technologies
- The cost of energy need to be reduced in order for offshore wind to become competitive and long-term sustainable

DONG Energy targets to reach a Cost-of-Energy below 100 €/MWh for investment decisions in 2020

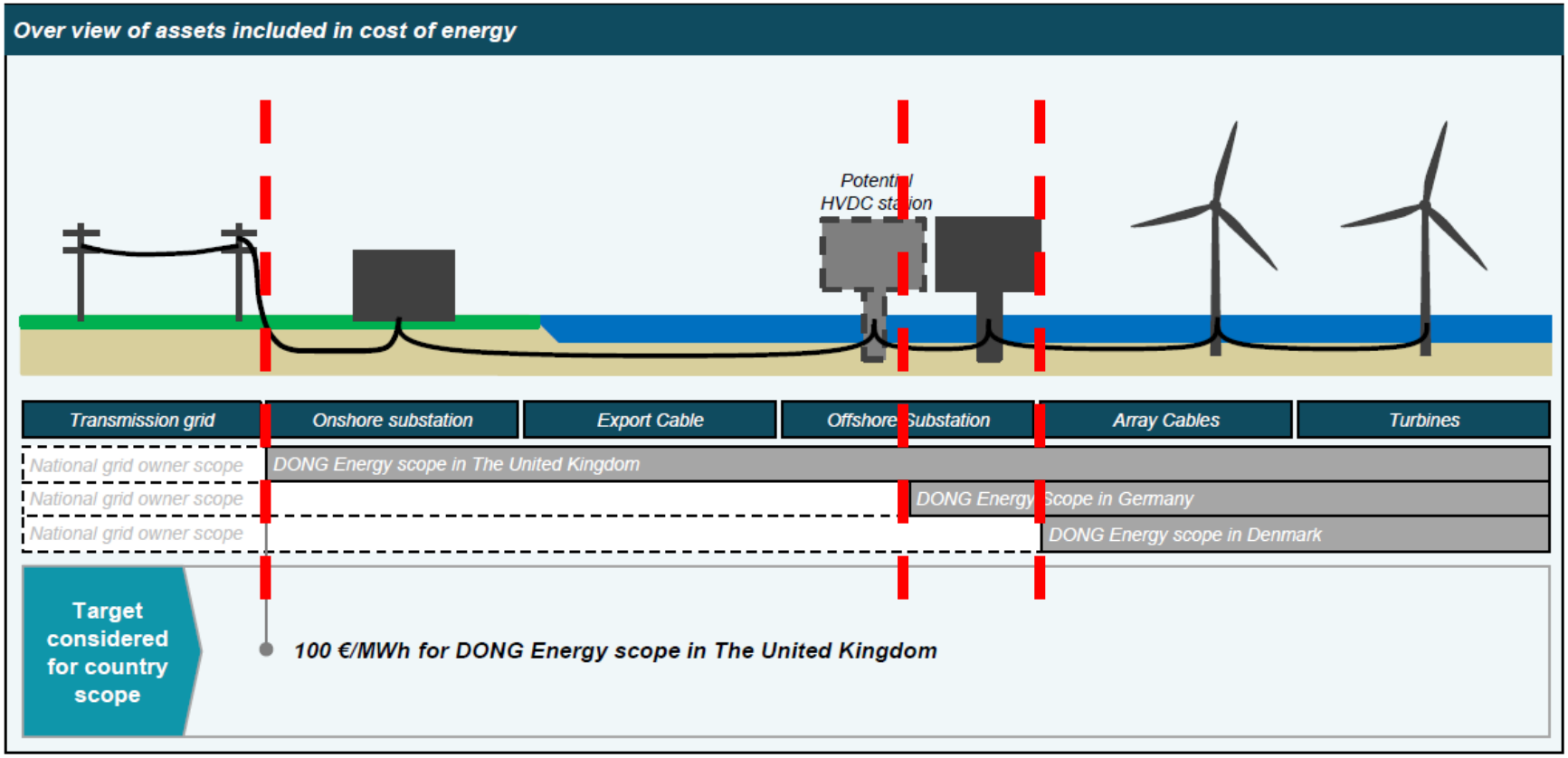


Cost-of-energy target is:

- *expected to be below 100 €/MWh for offshore wind projects with investment decision in 2020*
- *a present value measure of the average cost per MWh for the asset investment and the operations (see more on slide 4)*
- *based on a UK-round3 type-site including substations and offshore power cables (see more on slide 3)*
- *an ambitious, but realistic target which requires significant technical and supply chain development driven by both developers and governments*
- *requires continuous flow in asset investments towards 2020 to enable the reduction initiatives by having a transparent and efficient consenting process*

Source: DONG Energy Wind Power, 2013

Background: DONG Energy 2013

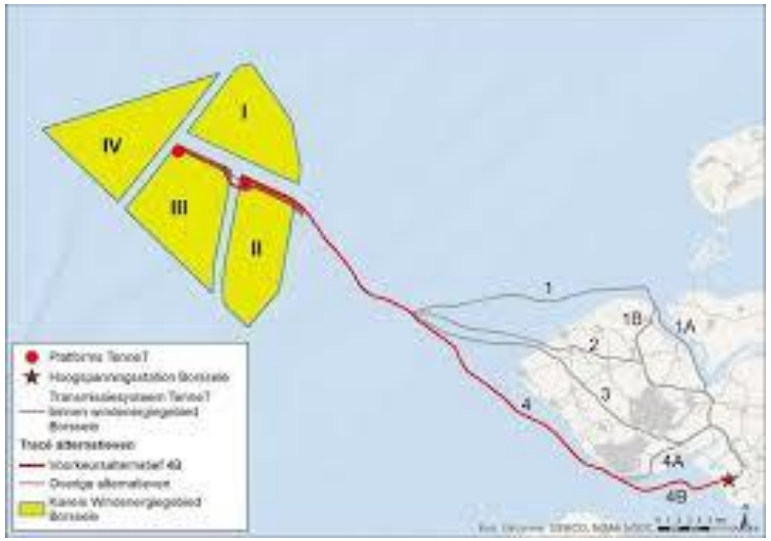


Different countries in the EU have different ways of calculating

Source: DONG Energy Wind Power, 2013

Borssele I and II, NL

- EUR 72.7 per MW/h was winning bid
- 2020 target achieved!



DONG energy

Fact box

- Borssele I = 95 WTG positions, 350 MW
- Borssele II = 95 WTG positions, 350 MW
- Approx. 30 km from shore
- 14-38m depth
- MP/TP
- Operational 4 (+1) years after award

- Offshore sub-station and export cables *excluded*; handled by TenneT TSO B.V.

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Maritime logistics

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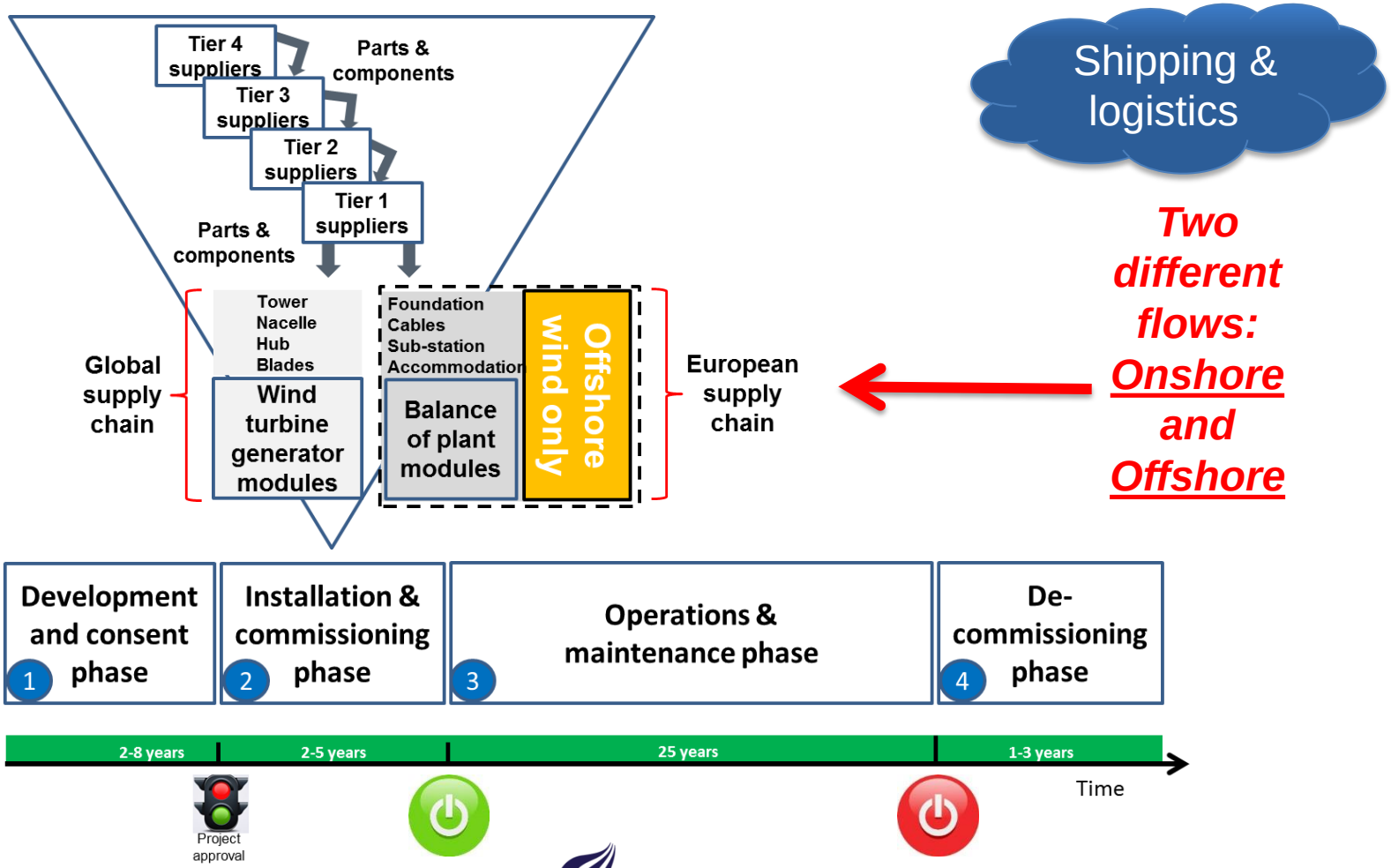
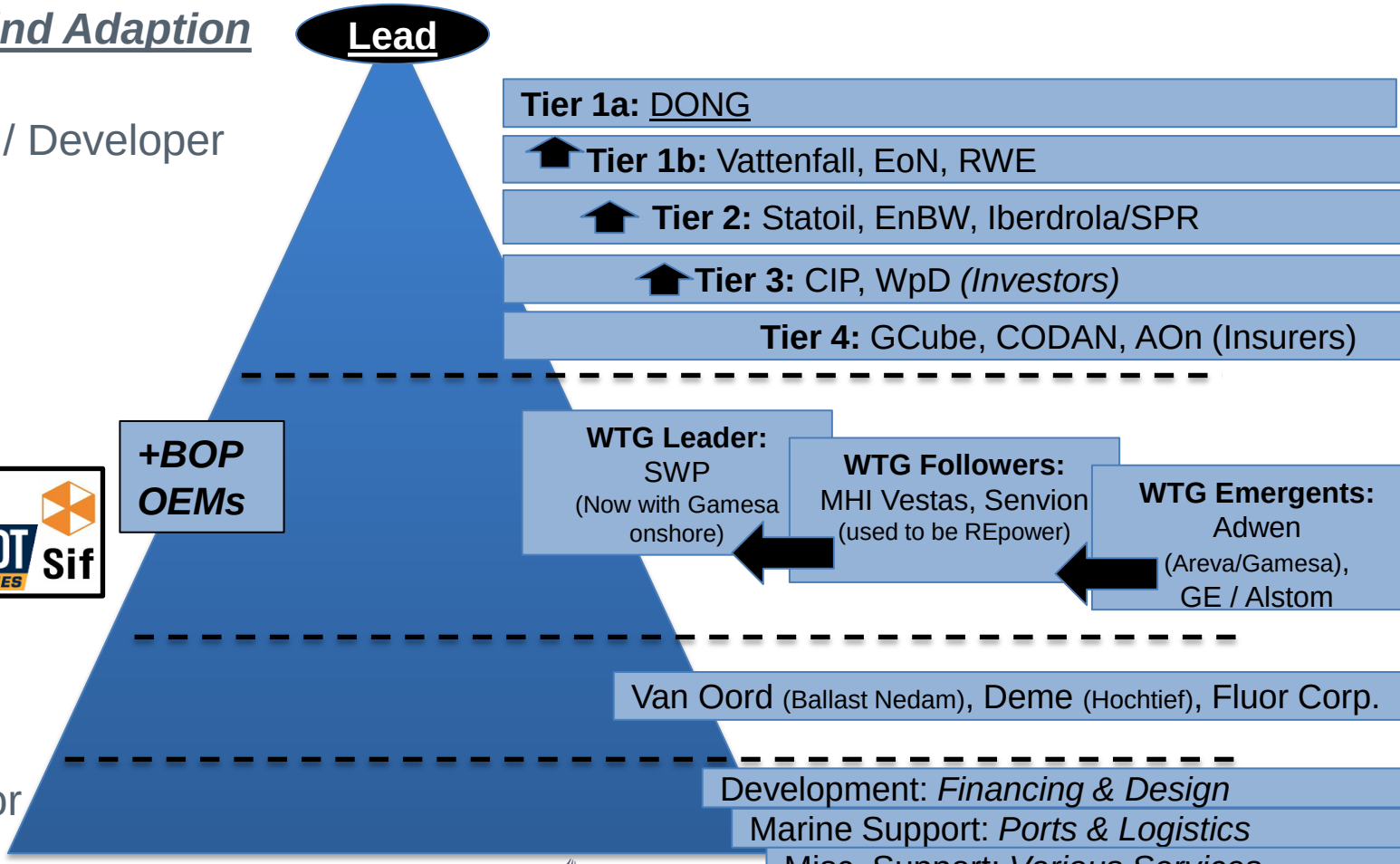
Wind farm life-cycle



Lead supply chain firm model

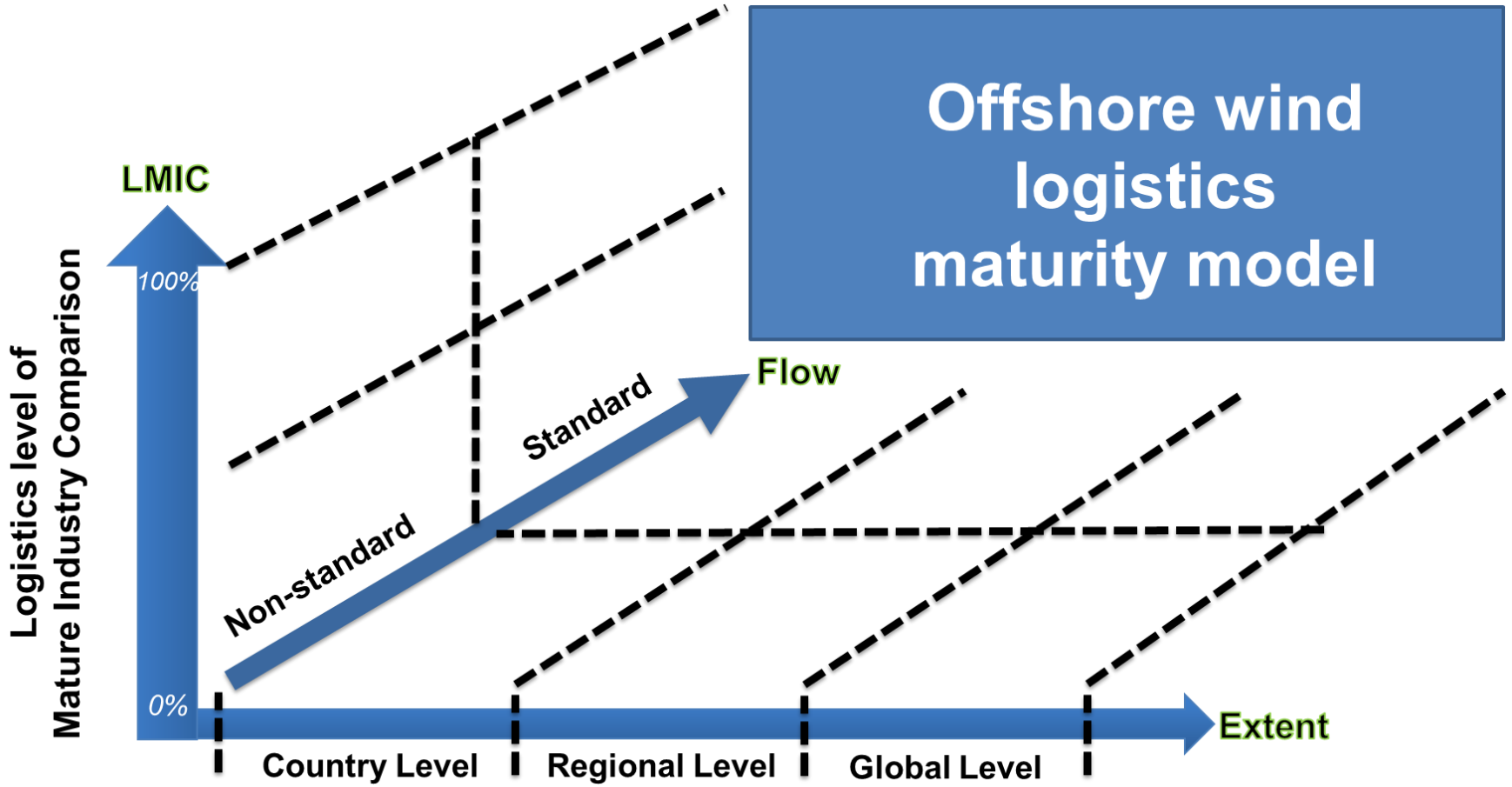
Offshore Wind Adaption

- Operator / Developer
- OEM
- EPC
- Contractor



Source: Renewable Energy Solutions, AAU

Shipments and flows



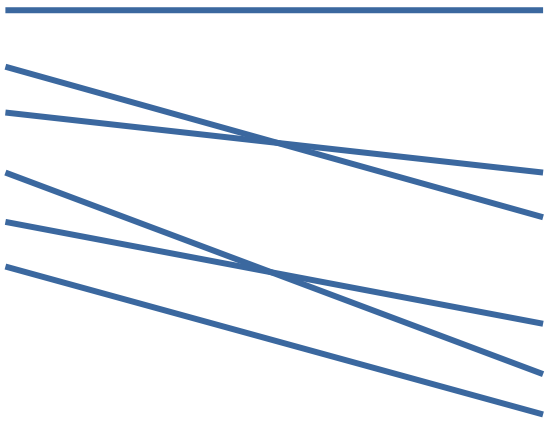
Source: Renewable Energy Solutions, INNOlog

Industry comparison

BVG Associates, 2014

Engagement with parallel sectors, in which discussions were held with industry analysts from the following sectors:

- Aerospace
- Automotive
- Composites
- Nuclear
- Oil and gas
- Rail



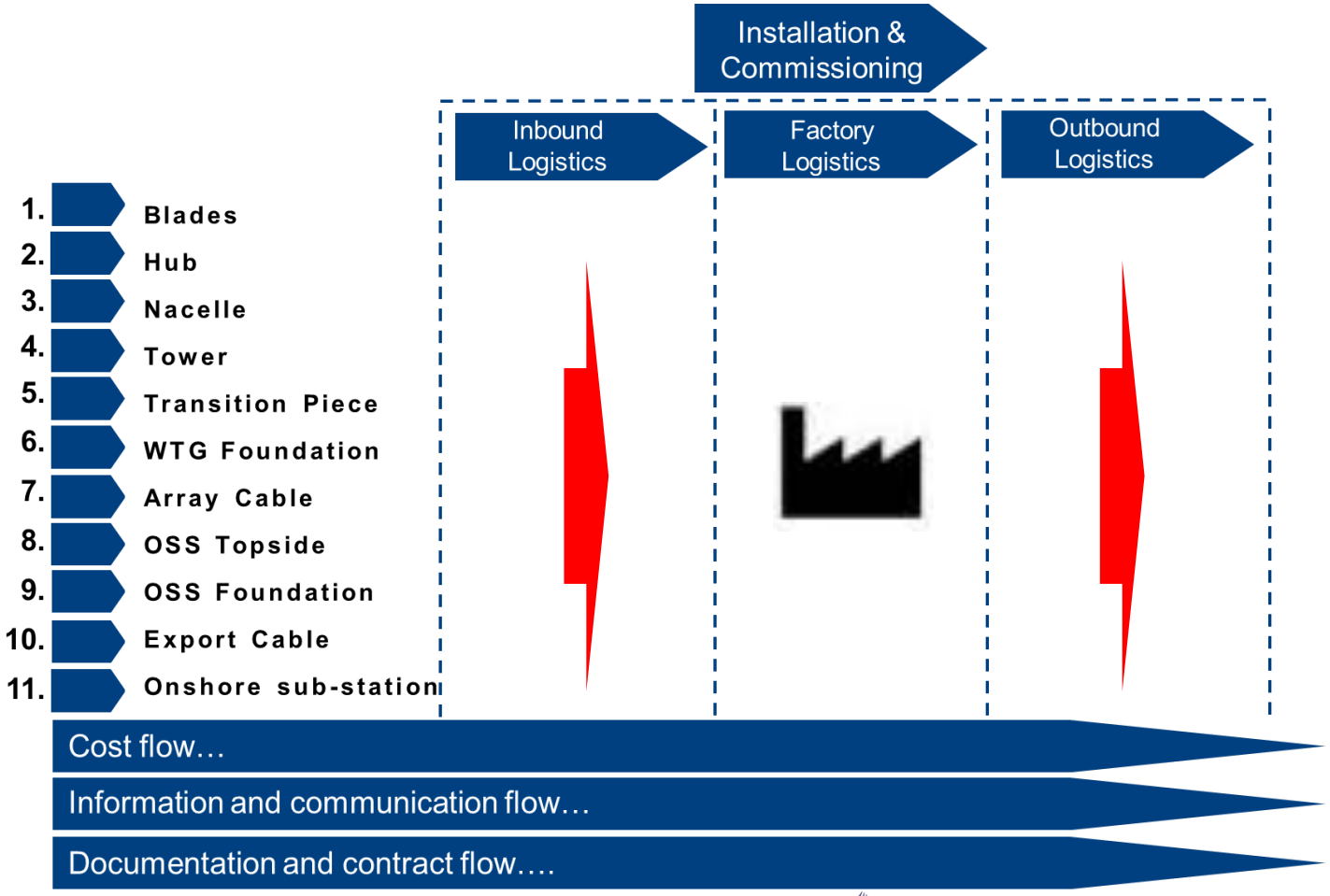
AAU Reference, 2015

Wind energy does not compare easily to other more traditional supply chains; a wind farm is a hybrid megaproject:

- Aerospace
- Shipyards
- Fiber optic cables
- Composites
- Automotive
- Truck assembly
- Oil & gas
- Nuclear
- Rail

Source: Poulsen & Hasager, 2016

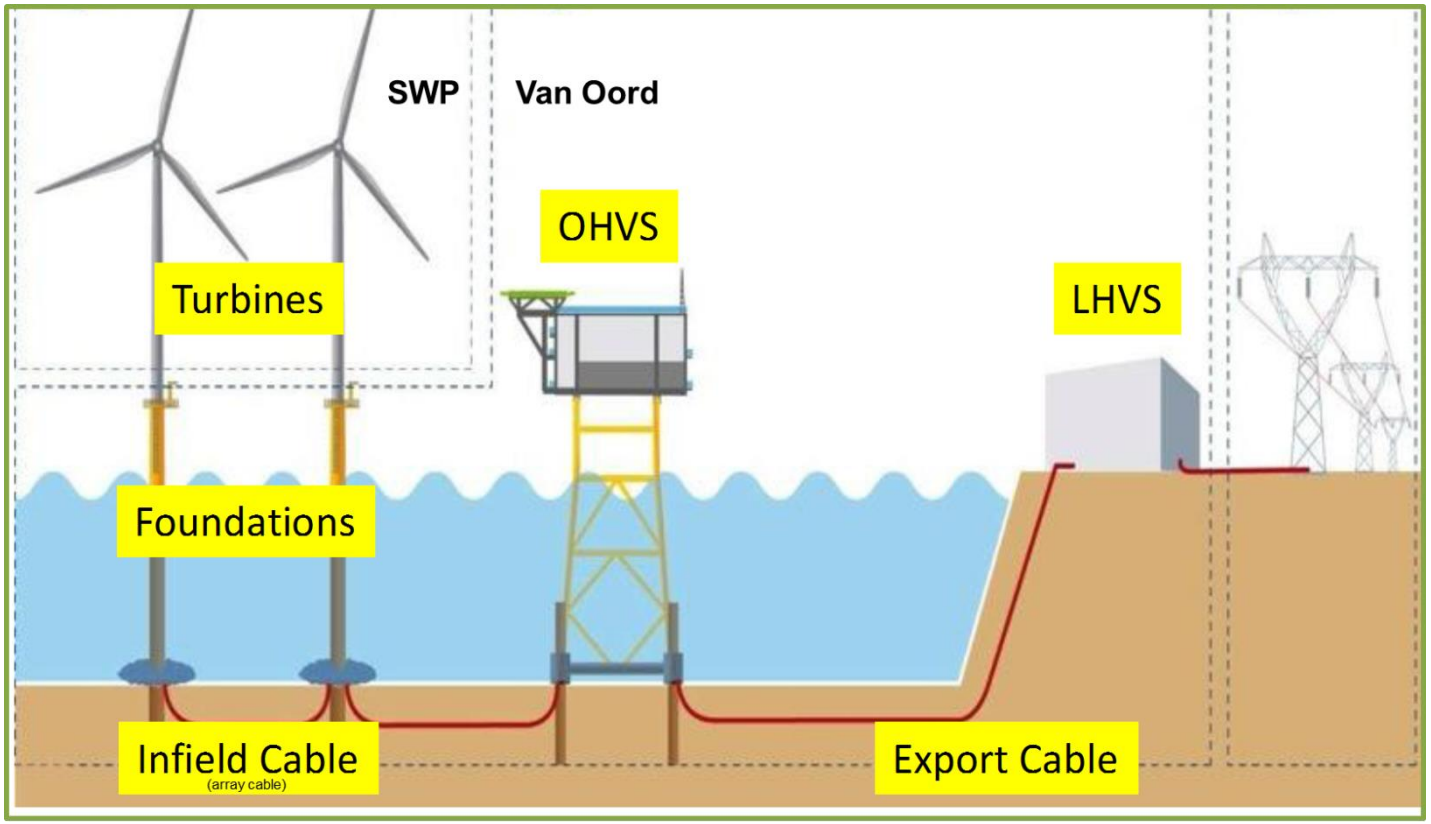
Engineer, build, and/or buy



Physical flow

Source: Renewable Energy Solutions, AAU

Single-contracting (construction example)



Gemini OWF ***600 MW***

SWP responsible for WTG installation scope, Van Oord responsible for the rest of the installation scope

60% ownership

NORTHLAND POWER

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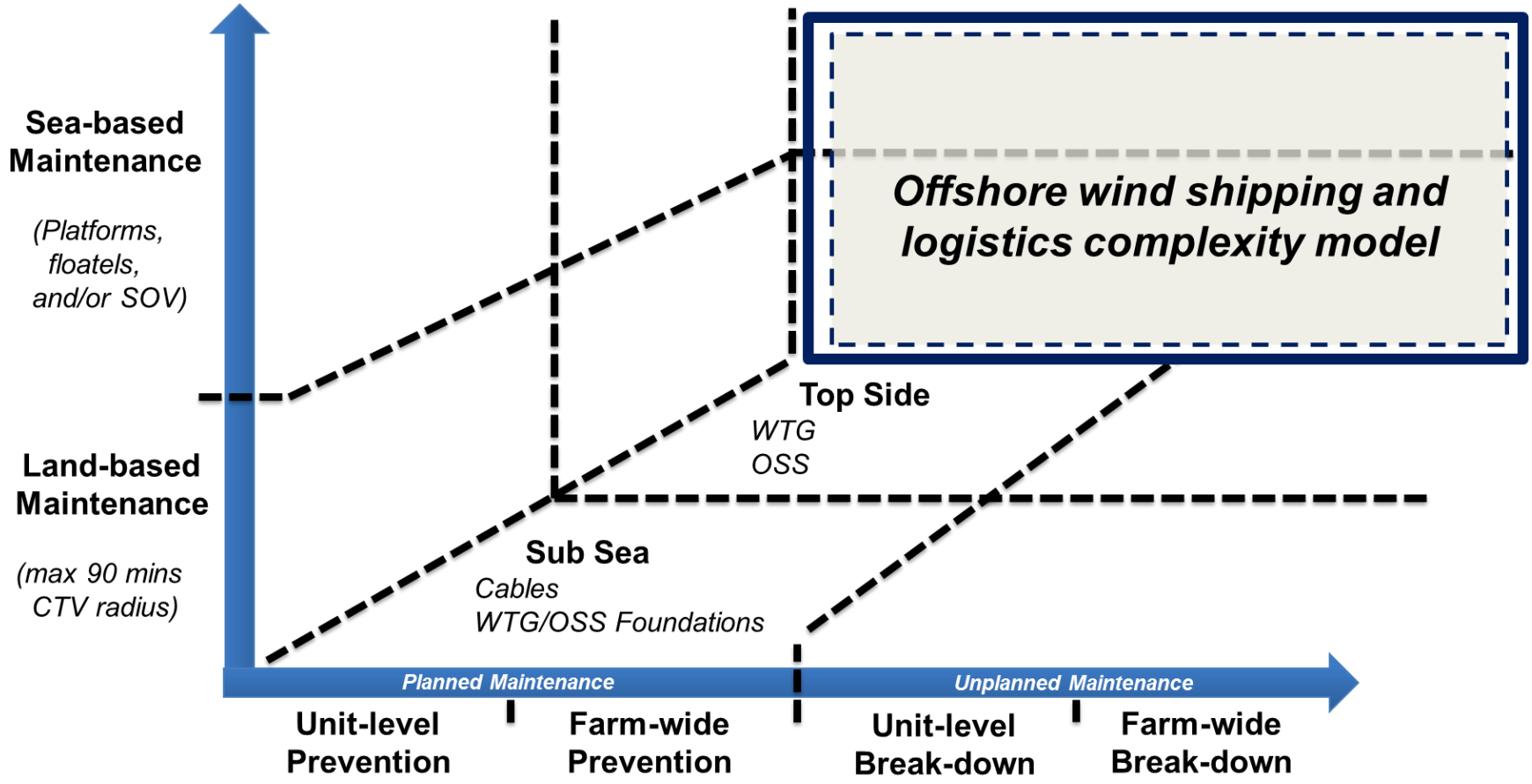
O&M logistics strategy



Source: Renewable Energy Solutions, AAU

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Cost reductions

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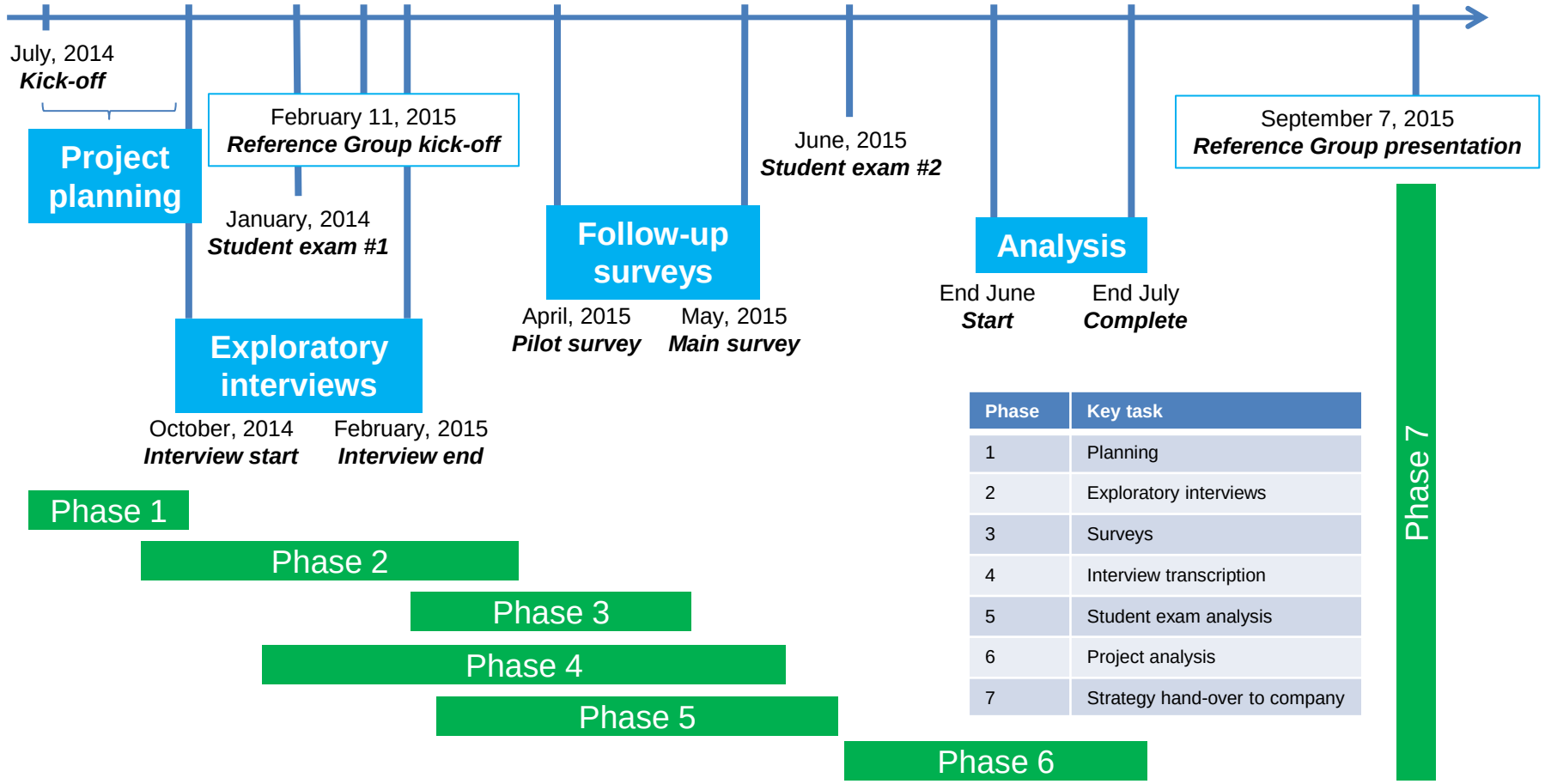
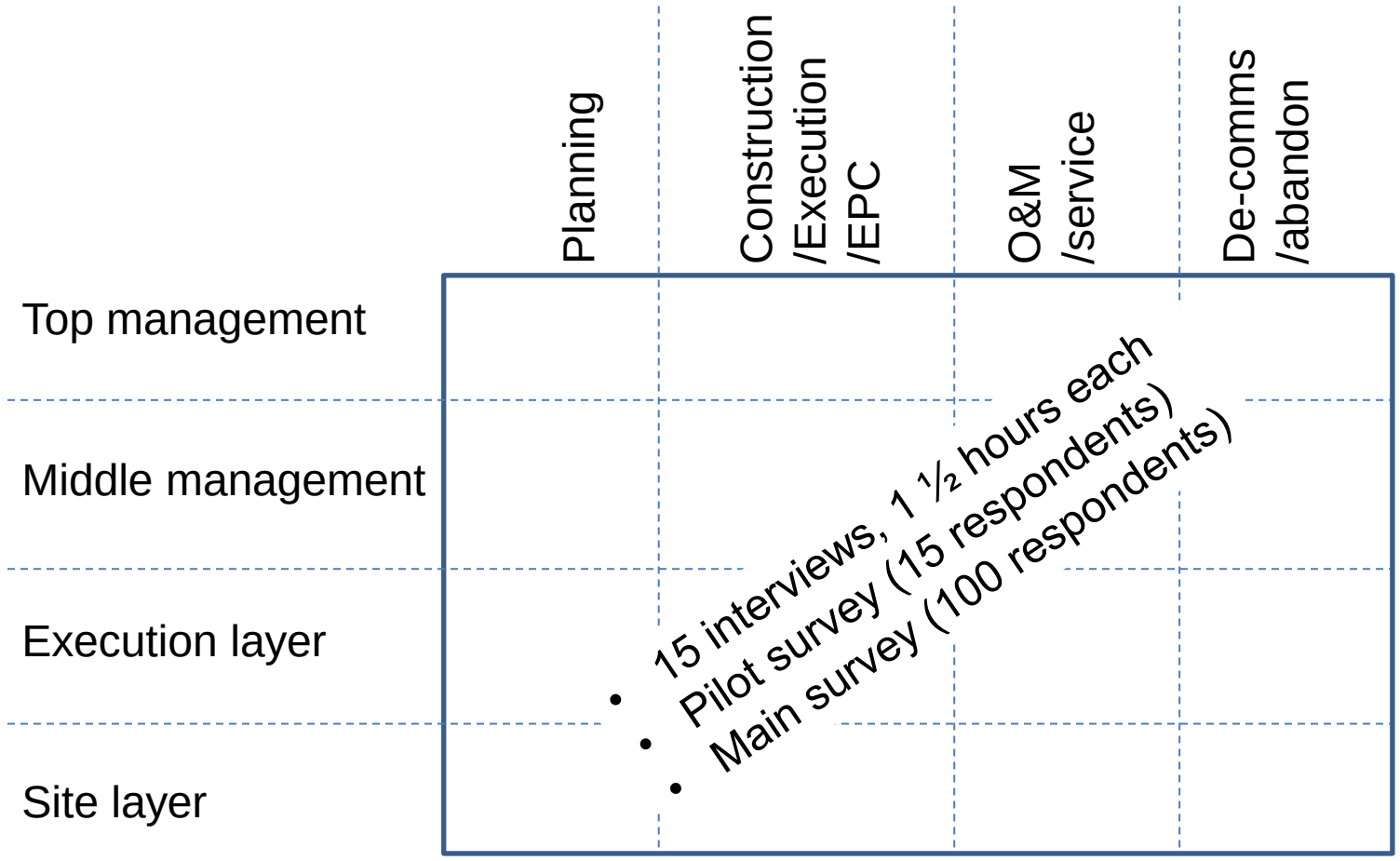
Case: Logistics innovation



Phase	Key task
1	Planning
2	Exploratory interviews
3	Surveys
4	Interview transcription
5	Student exam analysis
6	Project analysis
7	Strategy hand-over to company

Complex organization to cover

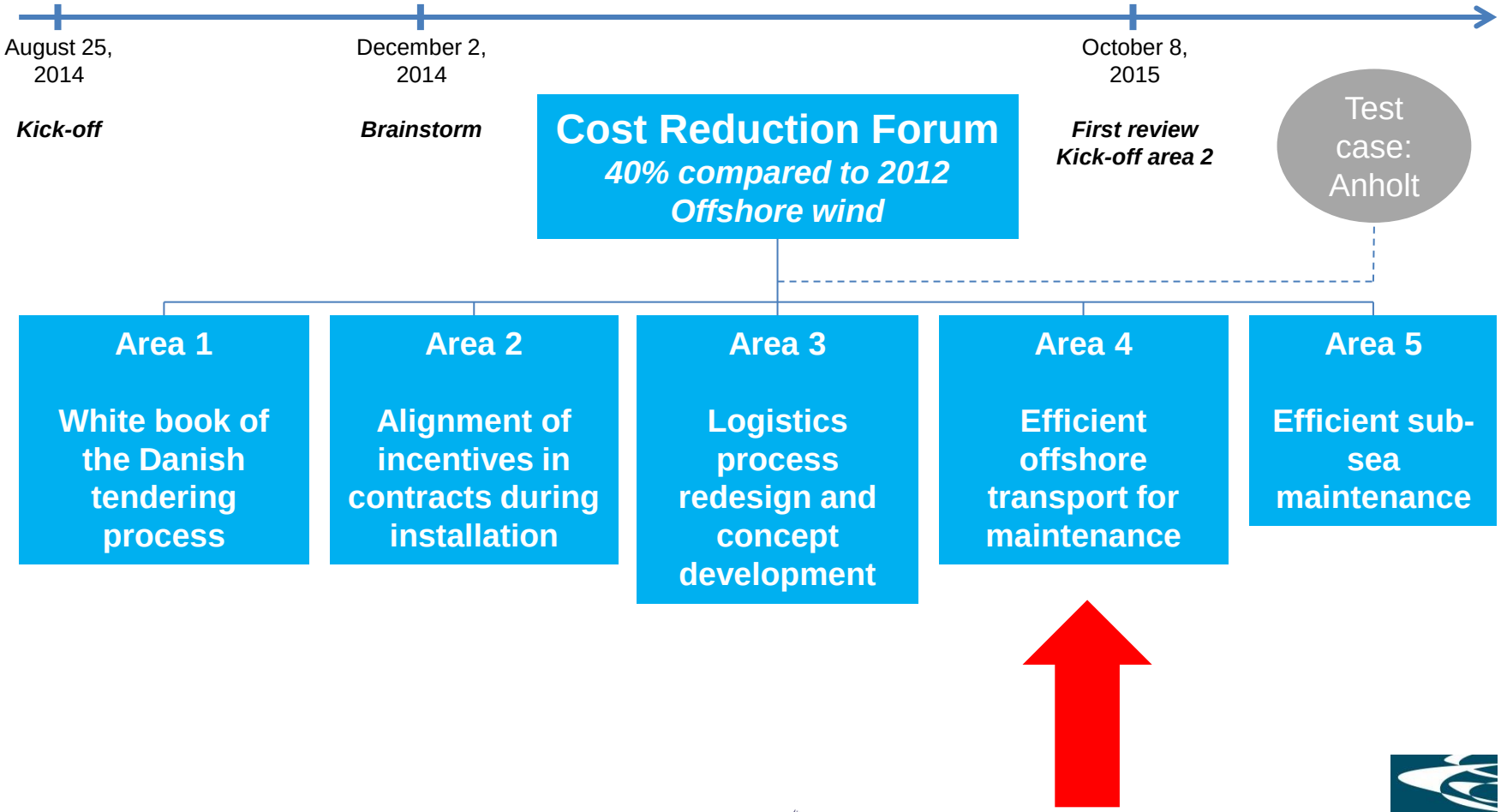


Innovation to reduce costs

	Innovation description	CSF
1.	Establish preventive maintenance process for BOP components, incl. foundations/cables/OSS	LCoE
2.	Market analysis of future offshore accommodation options as OWFs move further away from shore into deeper waters	LCoE
3.	Improve present and future crew transfer process to / from any offshore structure to reduce risk of accidents	HSSEQ
4.	Proactively support WTG MW yield stepchange in terms of logistics to cater for heavier and larger WTG and BOP components	LCoE
5.	Determine if pressent and future vessels can be used for multiple purposes (e.g. WTIVs for foundations, WTG's, cables, and OSS; CTVs for surveys)	LCoE

Source: Poulsen & Hasager, 2016

Case: Cost Reduction Forum



Group 4: First series of meetings

Pre
Exploratory

#1
Brainstorm

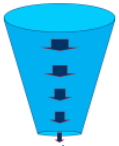
#2
Ranking

#3
2 groups
Idea development

#4
2 groups
Implementation

#5
Review

#6
Present to CRF



18 interviews
- 14 F2F
- 4 phone

= 36 ideas

8 additional ideas

Grouping:
- **Standard rules**
- **Optimize utilization of vessels**
- **Stand alone projects**
- **”Maybe”**
- **”No go”**

2 additional ideas

3 ideas selected

24/7

Lean

Concept

Business case elements

Calculations

Implementation planning

Risk analysis

Likeliness

Business case #1

Business case #2

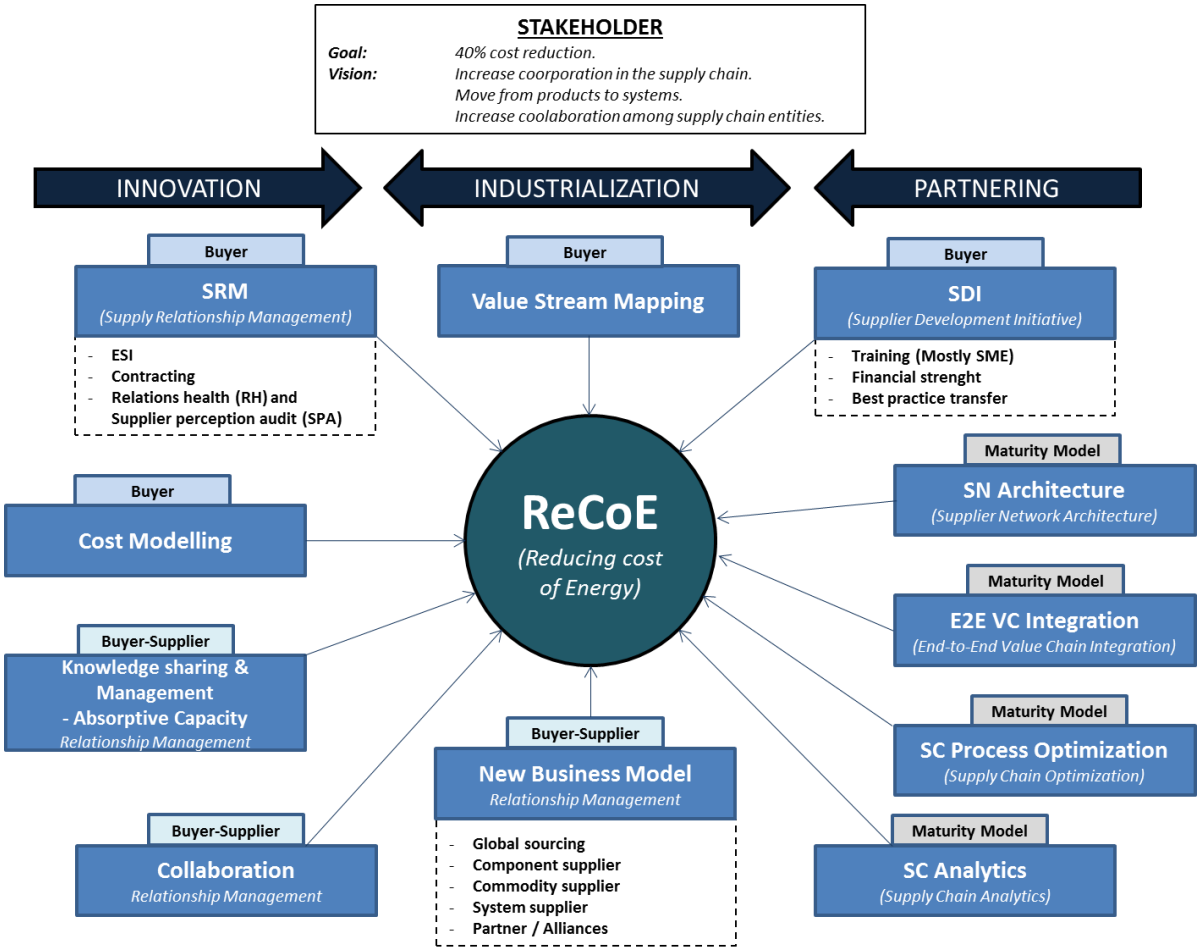
Phone interview

O&M logistics cost-out

Initiative name	Cost-out initiative description	Idea agreed
Lean in O&M logistics	Eliminate waste from quay side to offshore site	First series of meetings
Working 24/7	Adding a night shift to present day operations	First series of meetings
Asset sharing	The sharing of vessels and helicopters between different offshore wind projects	Second series of meetings
Parts, tools, and consumables pre-planning	Optimization of advance packing of parts and tools including location of tools	Second series of meetings
O&M logistics vision 2025	Vision for the future of O&M logistics in both near shore and far shore context	Second series of meetings

Source: Poulsen, Hasager, and Jensen, forthcoming

Conceptual - academia



Legend for academic terms

ReCoE:	Reducing cost of energy
SRM:	Supply Relationship Management
VSM:	Value Stream Management
SDI:	Supplier Development Initiative
ESI:	Early Supplier Involvement
RH:	Relations Health
SPA:	Supplier Perception Audit
SME:	Small to Medium sized Enterprise
SNA:	Supplier Network Architecture
E2EVCI:	End-to-End Value Chain Integration
SCPO:	Supply Chain Process Optimization
SCA:	Supply Chain Analytics

Source: Stentoft, Narasimhan, and Poulsen, 2016

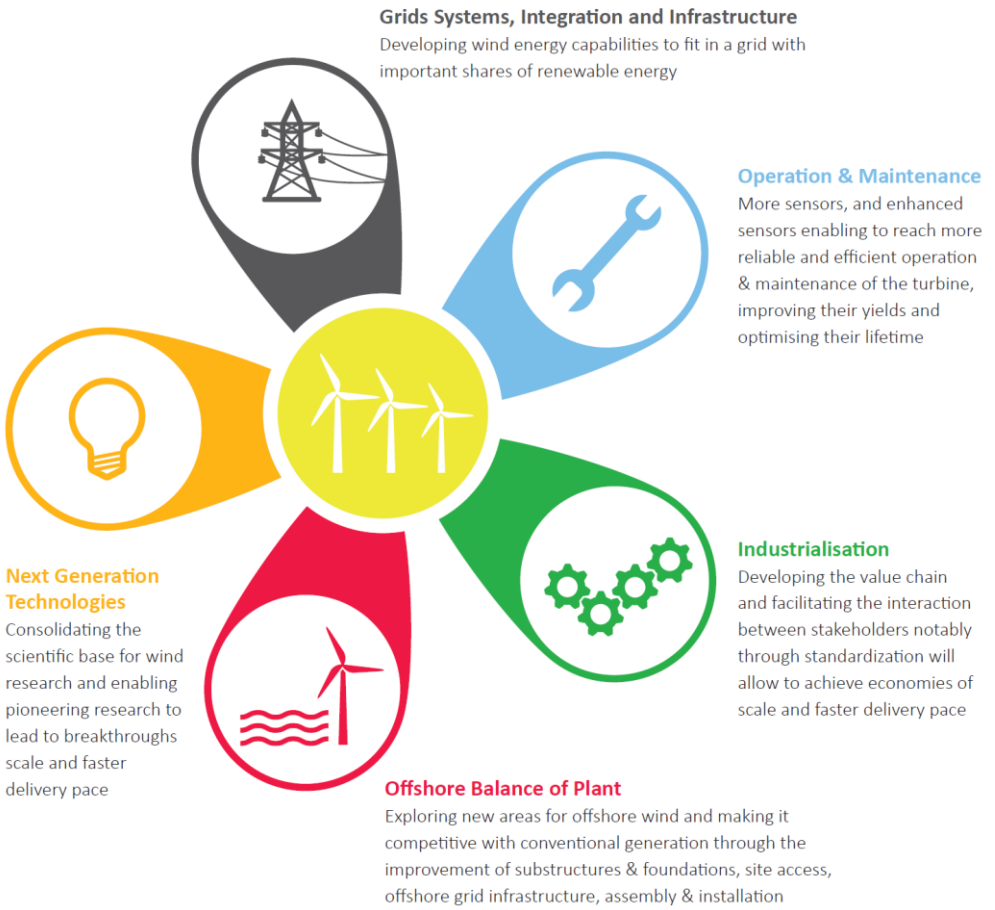
Input: Specific EU funding calls

EU Commission H2020 WP Energy 2016-2017 lobbying status:

- Logistics, shipping, and port related texts successfully inserted
- 2 separate low carbon energy calls about wind energy
  - ✓ **LCE 13 – 2016**: Solutions for reduced maintenance, increased reliability and extended life-time of wind turbines/farms (grant size ***EUR 7-10 million***)
  - ✓ **LCE 14 – 2017**: Demonstration of large >10MW wind turbine (grant size ***EUR 20-25 million***)

Huge success!

Input: EU future research agenda



1. **Grid systems, integration, and infrastructure**
2. **Operations & maintenance**
3. **Industrialization**
4. **Offshore balance of plant**
5. **Next generation technologies**

Source: European Technology and Innovation Platform on Wind Energy Strategic Research and Innovation Agenda, forthcoming September 27, 2016

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Conclusion

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Key take-aways from today

- Wind is not competitive with other energy forms
- Especially for offshore wind, LCoE has to be reduced
- LCoE is calculated in different ways for offshore wind
- A 40% cost reduction for offshore wind was targeted for 2020 based on 2012 prices
- Cost savings either as direct cost-out or innovations
- Takes time and requires cultural savvy to implement

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Questions & answers?

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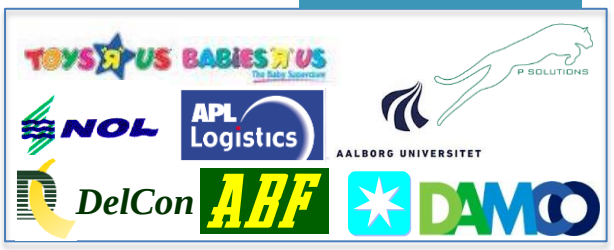
Past employers



Select consulting clients

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