



GLOBAL WIND ENERGY SHIPPING AND LOGISTICS

PHD RESEARCH PROJECT
8TH REFERENCE GROUP MEETING

MARCH 29, 2017, DHL, COPENHAGEN

Proprietary, private, and confidential



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DENMARK

Today's program

12:00-12:45 Working lunch

12:45-14:15 Meeting part I

14:15-15:50 Coffee and meeting (II)

15:50-16:00 Ready for “gå-hjem”

16:00-18:00 “Gå-hjem” meeting

Working lunch



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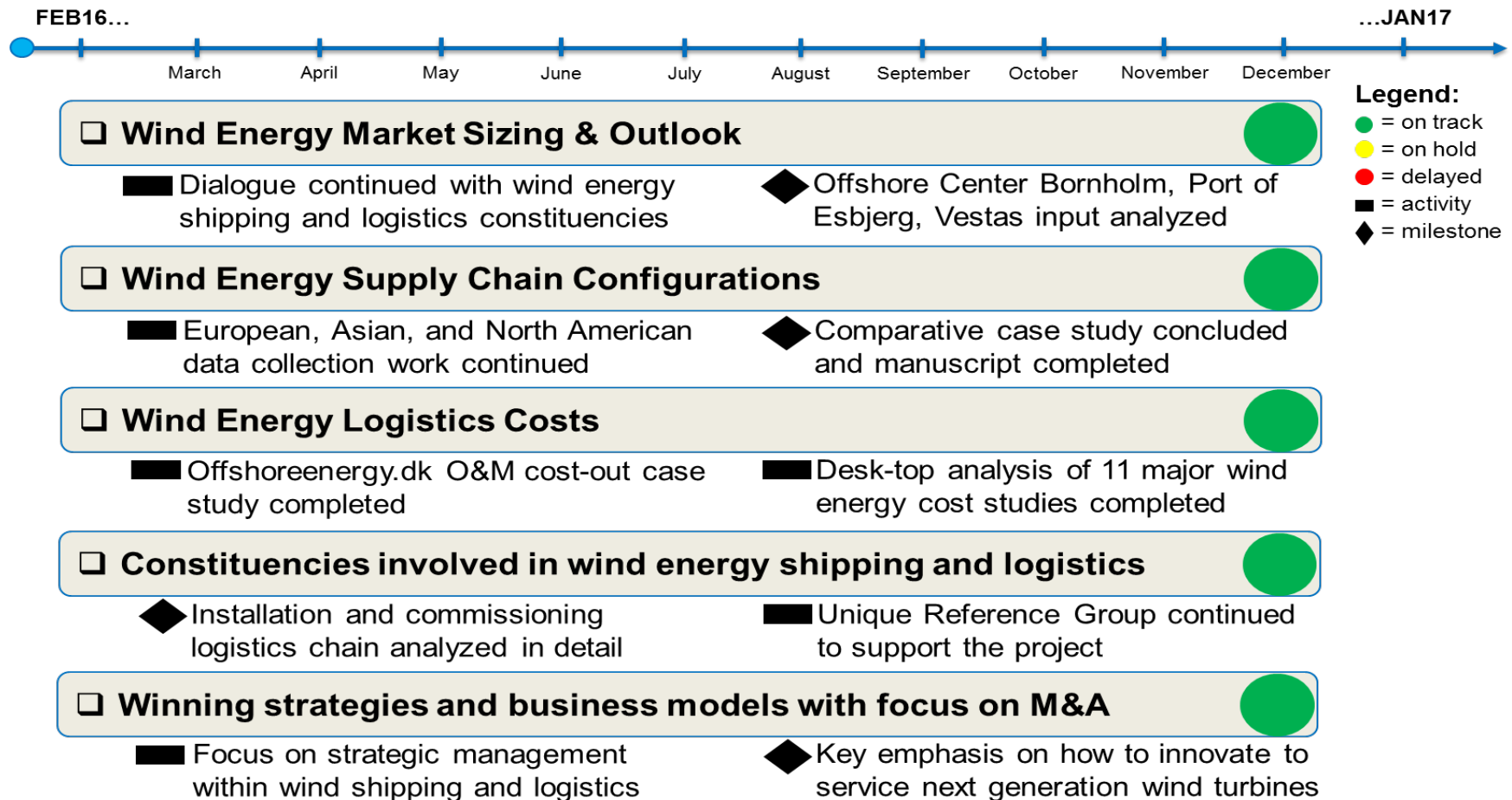


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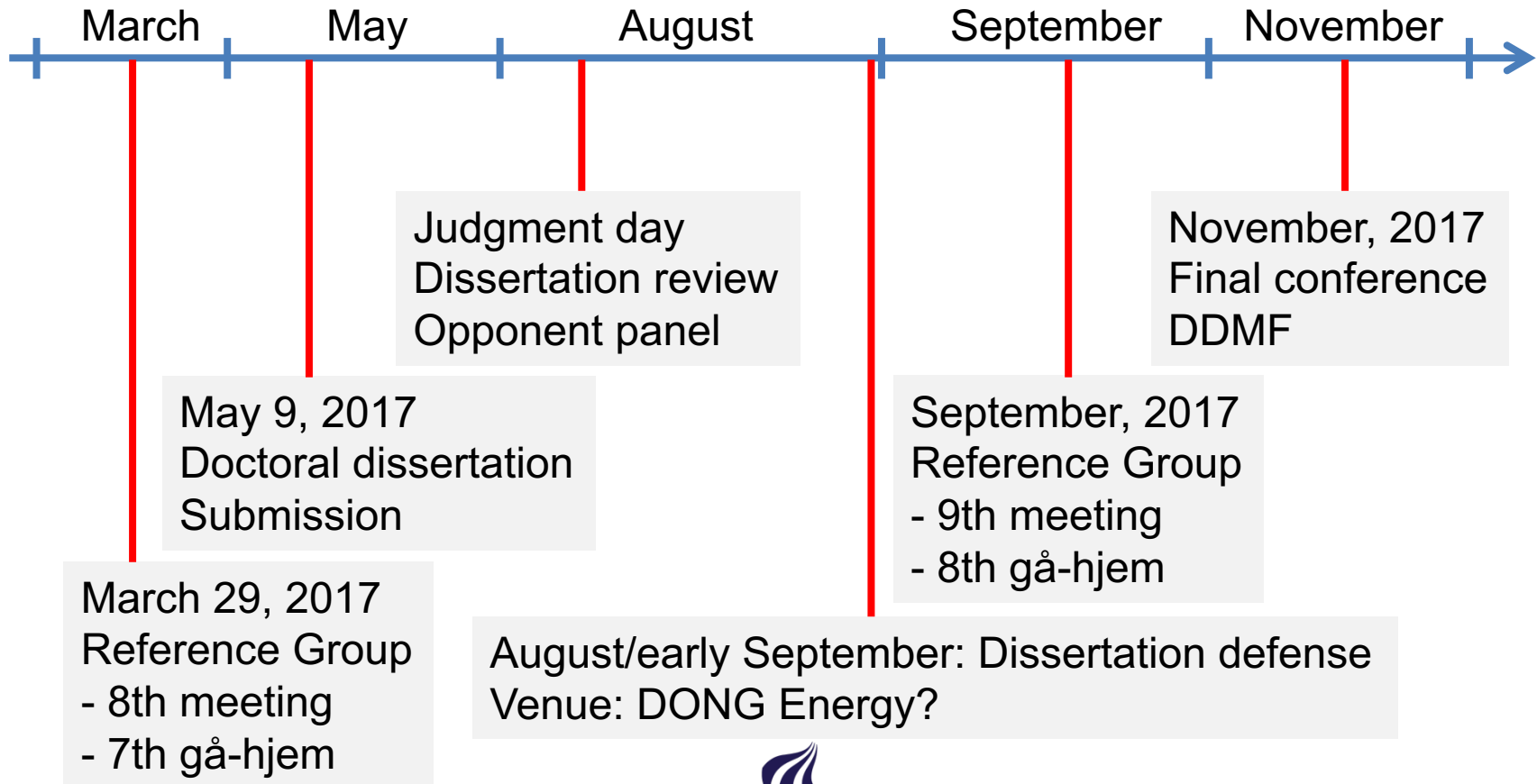
Agenda – Reference Group

1. Meeting opening, welcome, and agenda review during working lunch
2. New / changed Reference Group member organizations / changed participants – short introduction by new participants
3. Short review of scoping of PhD research project efforts from first meetings
4. Detailed review of the readiness of the global wind energy supply chain with a focus on shipping, logistics, and SCM
5. Key activities since last meeting. Focus on:
 1. The “speed boats” from the PhD “mother vessel”
 2. Government relations and tailor-made grants (Horizon 2020)
 3. Concurrent dissemination of research results and findings
6. Update on academic progress, 11-month plan, and plans to finalize the project
7. Wrap-up, preparation for after work / “gå-hjem” meeting, and date/venue for next meeting

From the Year 4 industry report



2017 project milestones



Brief introductions

(organizations, participants)



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Intro to new/changed Reference Group participants



- Quick personal background
- Brief overview of the activities of your organization
- Expectations from participation in the Reference Group and research project

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Recap of August, 2016 meeting

O&M part 2



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Last meeting: Paper on O&M

Practical action research case work:

OEDK CR(I)F Group 4 O&M Logistics

Initiative name	Cost-out initiative description	Idea agreed
Lean in O&M logistics	Eliminate waste from quay side up to in within the offshore wind farm site	First series of meetings
Working 24/7	Adding a night shift to present daytime operations (12/7) during maintenance campaigns	First series of meetings (and the focus of this research)
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

Desktop study of 11 LCoE reports

Study Name	Year	Study Examines	O&M to OpEx	Currency	Simulated or Actual Cost Reduction	WTG Cap? [MW]	Farm Cap? [MW]	Life-cycle phases
Megawind	2015	OpEx	1	EUR		Open	Open	All
Douglas-Westwood	2015	OpEx	1	EUR	Simulated	N/A	N/A	All
BVG UK SC	2014	OpEx	1	GBP	Simulated	6	500	No de-comms
P + FG Germany cost reduction	2013	OpEx	1	EUR	Simulated			
Scottish Enterprises GL Garrad Hassan	2013	O&M	2	GBP		6	500	
TCE UK cost reduction	2012	OpEx	1	GBP	Simulated	4, 6	500	
Deloitte DK study	2011	N/A	N/A	N/A				Only CapEx
UK RAB 2010	2010	OpEx	1	GBP				
EWEA2009	2009	O&M++	1.5	EUR	Simulated	2	160-20	
KF Vattenfall	2008	O&M++	1.5	GBP	Actual	3	90	
ODE UK study	2007	O&M	1.5	GBP	Simulated	3,6	108	

Supply chain readiness

- shipping/logistics/SCM focus

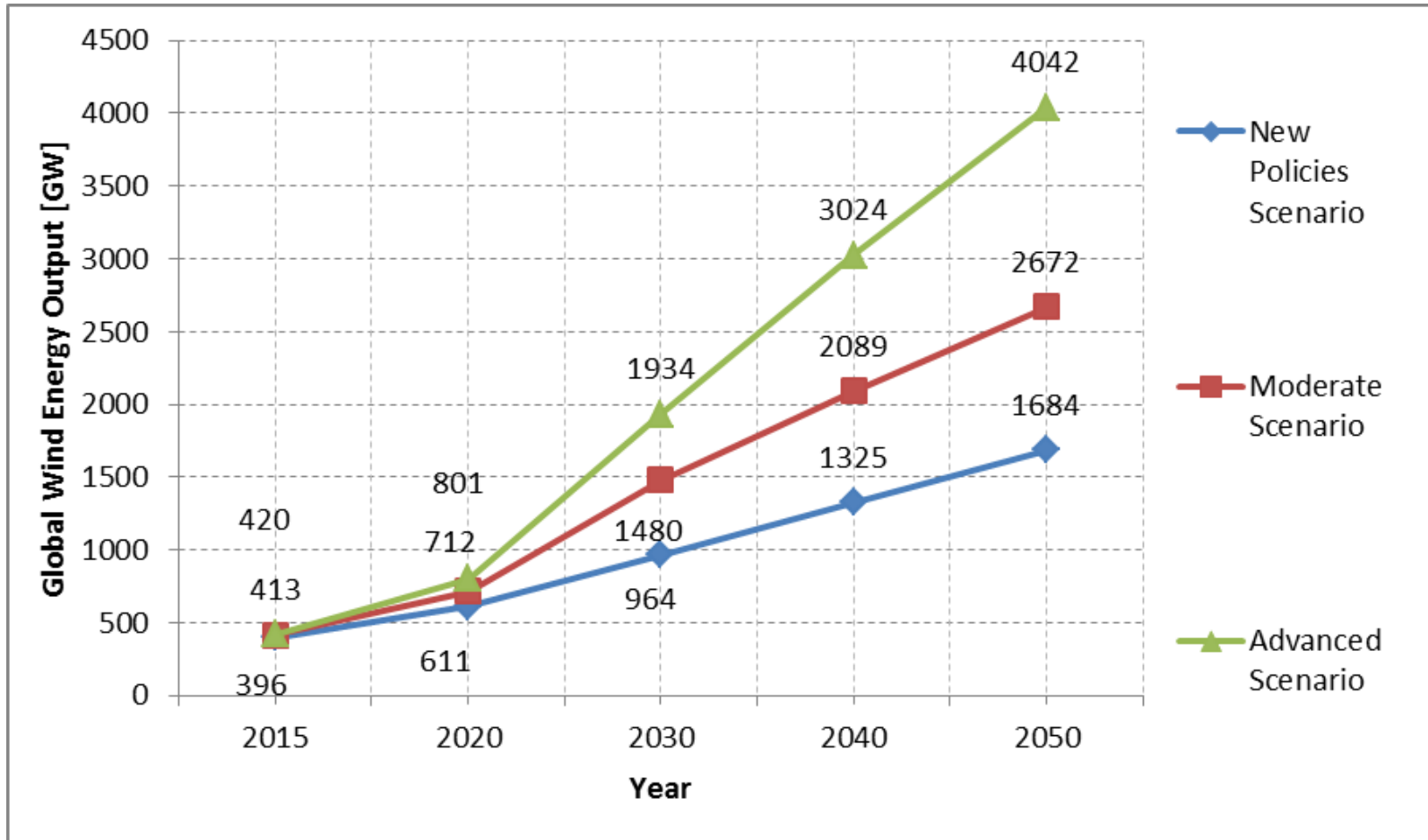


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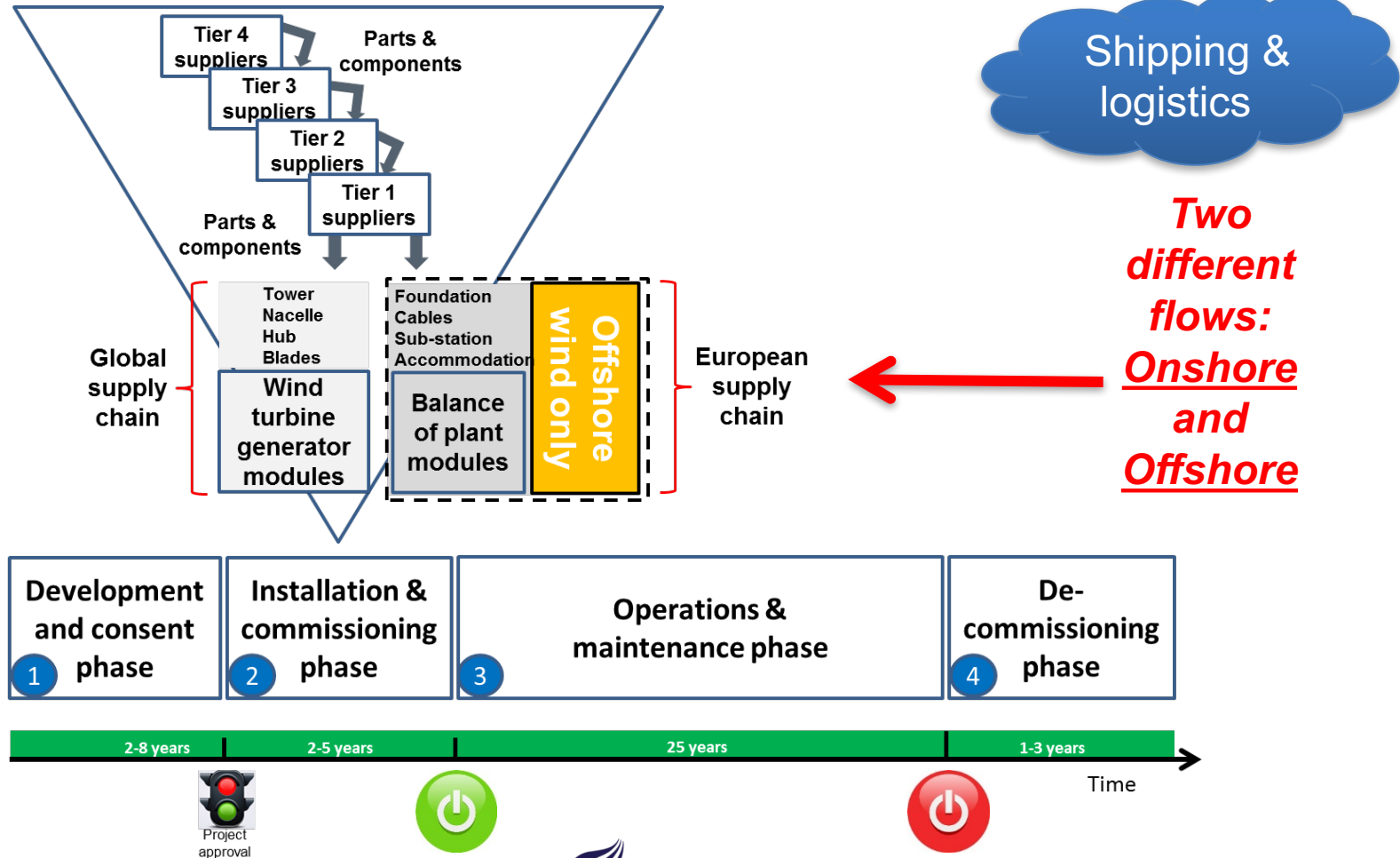


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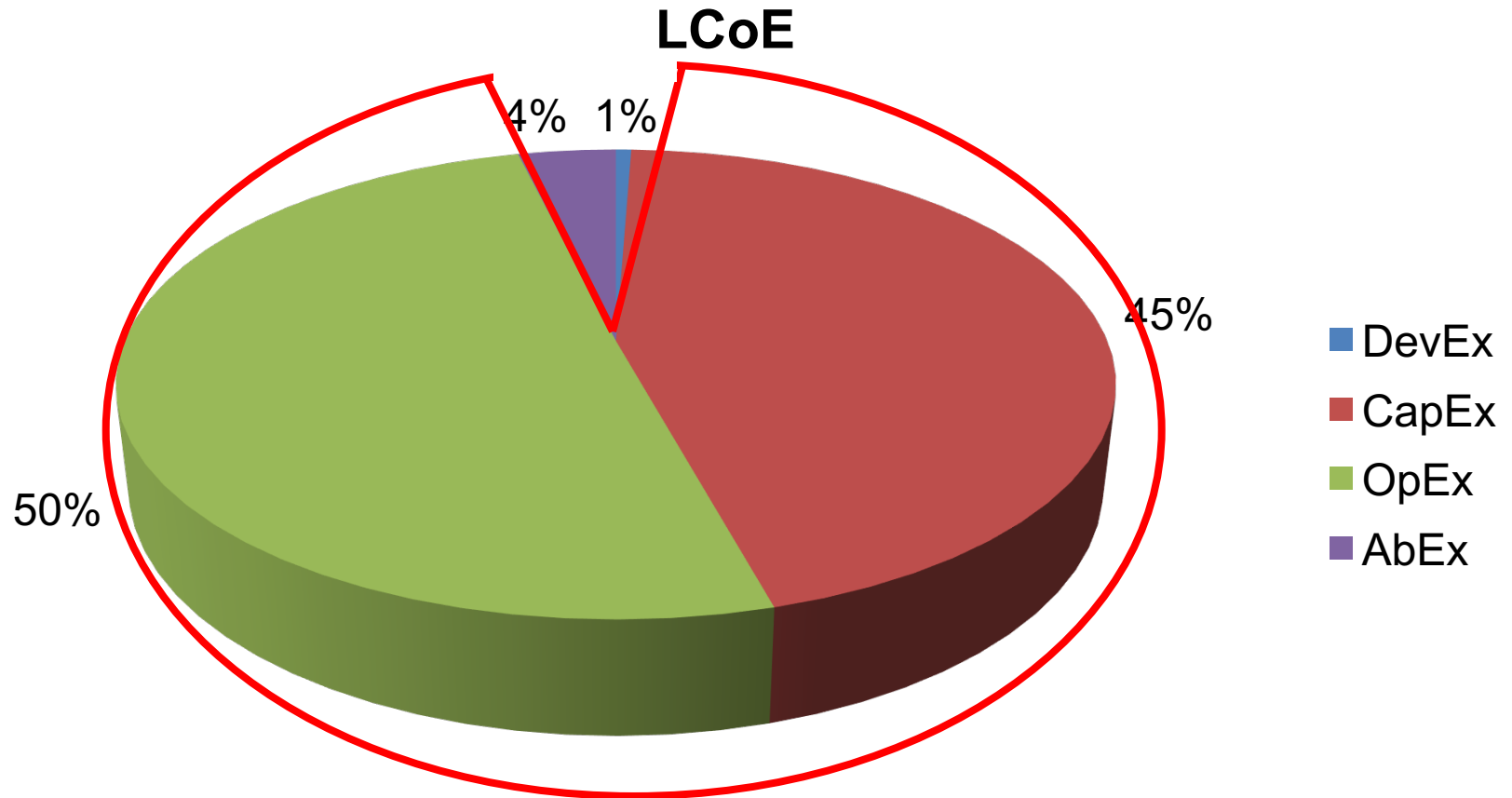
25-30% of 2050 electricity: Wind



Wind farm life-cycle



Life-cycle phases \$\$\$: LCoE



Life-cycles = logistical chains

Lead firms in the supply chain

Activity	Project management and financial planning
Sub activity	Wind farm design
Supply chain lead firm	Utilities
Lead firm examples	DONG Energy, RWE Innogy, Vattenfall, Iberdrola, Statoil, Statkraft, Guodian Longyuan, China Guangdong Nuclear, Daneng, KEPCO, Masdar

- Contract structure
- Task allocation
- Supply chain set-up
- Shipping/logistics scope
- Procurement structure
- Execution lead

Lead supply chain firm model

Offshore Wind Adaption

❑ Operator / Developer

❑ OEM



❑ EPC

❑ Contractor

Lead

Tier 1a: DONG Energy Wind Power

⬆ **Tier 1b:** Vattenfall, E.On, RWE, Longyuan

⬆ **Tier 2:** Statoil, EnBW, Iberdrola/SPR, Shell, CTG

⬆ **Tier 3:** CIP, WpD, Enbridge (*Investors*)

Tier 4: GCube, CODAN, AOn (*Insurers*)

**+BOP
OEMs**

WTG Leader:
SWP
(Now with Gamesa
and Adwen)

WTG Followers:
MHI Vestas,
Senvion
(used to be REpower)

WTG Emergents:
GE / Alstom
Asian players

Van Oord (Ballast Nedam/Bilfinger), DEME/GeoSea (Hochtief/COSCO),
Per Aarsleff, Fluor Corp., Bechtel, CCCC/ZPMC

Development: *Financing & Design*

Marine Support: *Ports & Logistics*

Misc. Support: *Various Services*

Financial investment decision

Development & consent (D&C chain)

Surveys

- Country scope (grid, sub-stations, cables)
- Before award / auction
- After award, before / after FID

Different kinds of vessels and logistical operations:

- Survey and maintenance vessels
- Geophysical survey vessels
- Hydrographic survey vessels
- Ornithological and mammal surveying vessels

...And equipment like remotely operated vehicles (ROVs)

$$\text{CapEx} = \text{I\&C}_{(1)}$$

Installation & commissioning (I&C chain)				
Inbound			Outbound	
WTG inbound		BOP inbound		
WTG	Foundations	Cables	Sub-station	Construction/installation /commissioning
Assembly	Assembly	Manufacturing	Assembly	Installation landside
Modules production	Modules production		Modules production	Installation BOP
				Installation WTG

+ *factory logistics*

$$\text{CapEx} = \text{I\&C}_{(2)}$$

Installation & commissioning (
Inbound			
WTG inbound		BOP inbound	
WTG	Foundations	Cables	Sub-station
Assembly	Assembly	Manufacturing	Assembly
Modules production	Modules production		Modules production

+ *factory logistics*

$$\text{CapEx} = \text{I\&C}_{(3)}$$

I&C chain)

Outbound

Construction/installation /commissioning

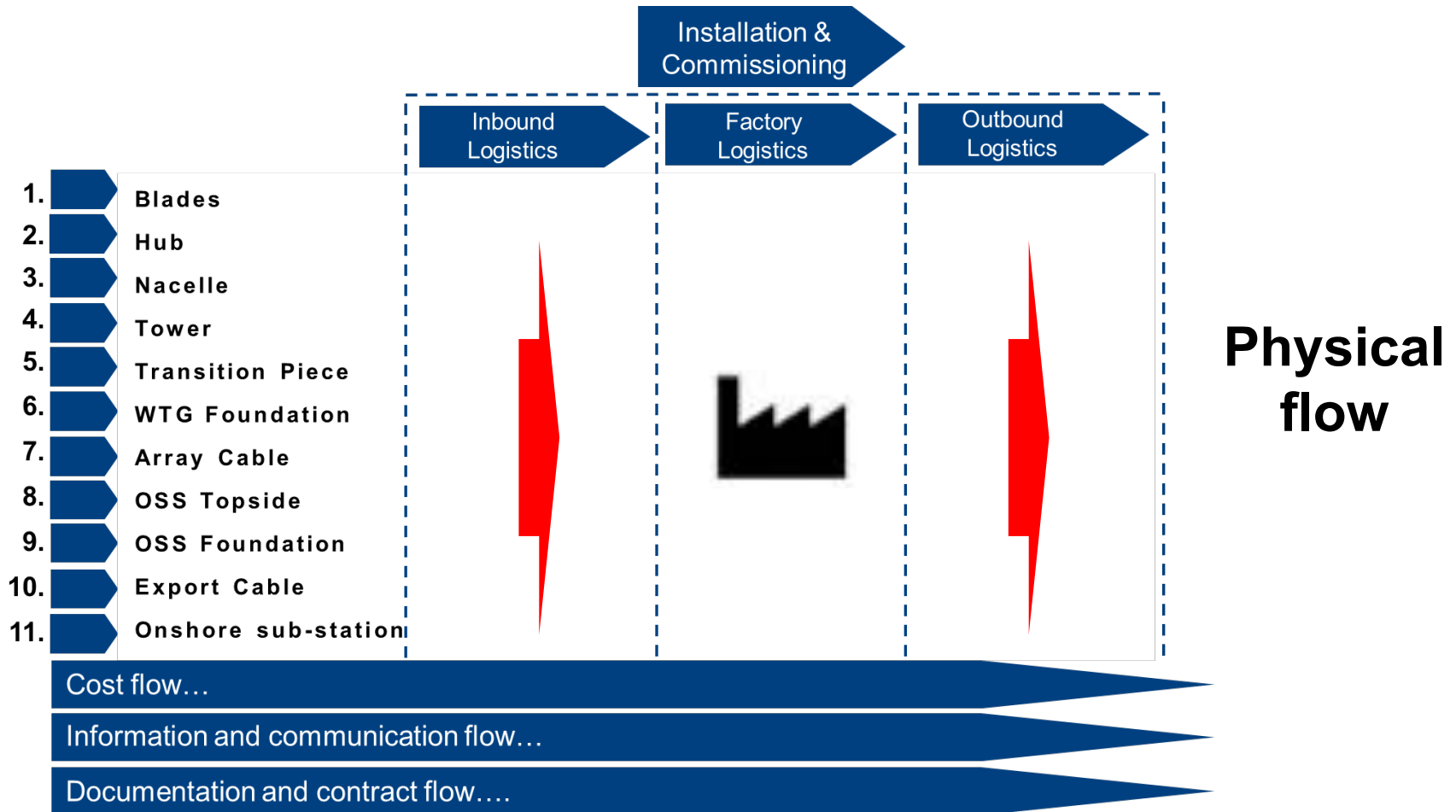
Installation landside

Installation BOP

Installation WTG

+ *factory logistics*

Engineer, build, and/or buy



O&M \neq OpEx

- O&M accounts for ~50% of OpEx
- OpEx can vary by a factor of 9,5x
- Correct up-front OpEx calculation can "make or break" overall offshore wind farm project profitability

Operations & Maintenance (O&M chain)

Preventive maintenance

Unscheduled maintenance

Contingency maintenance

Site abandonment

De-commissioning (De-comms chain)

WTG de-commissioning

BOP de-commissioning

Site restoration

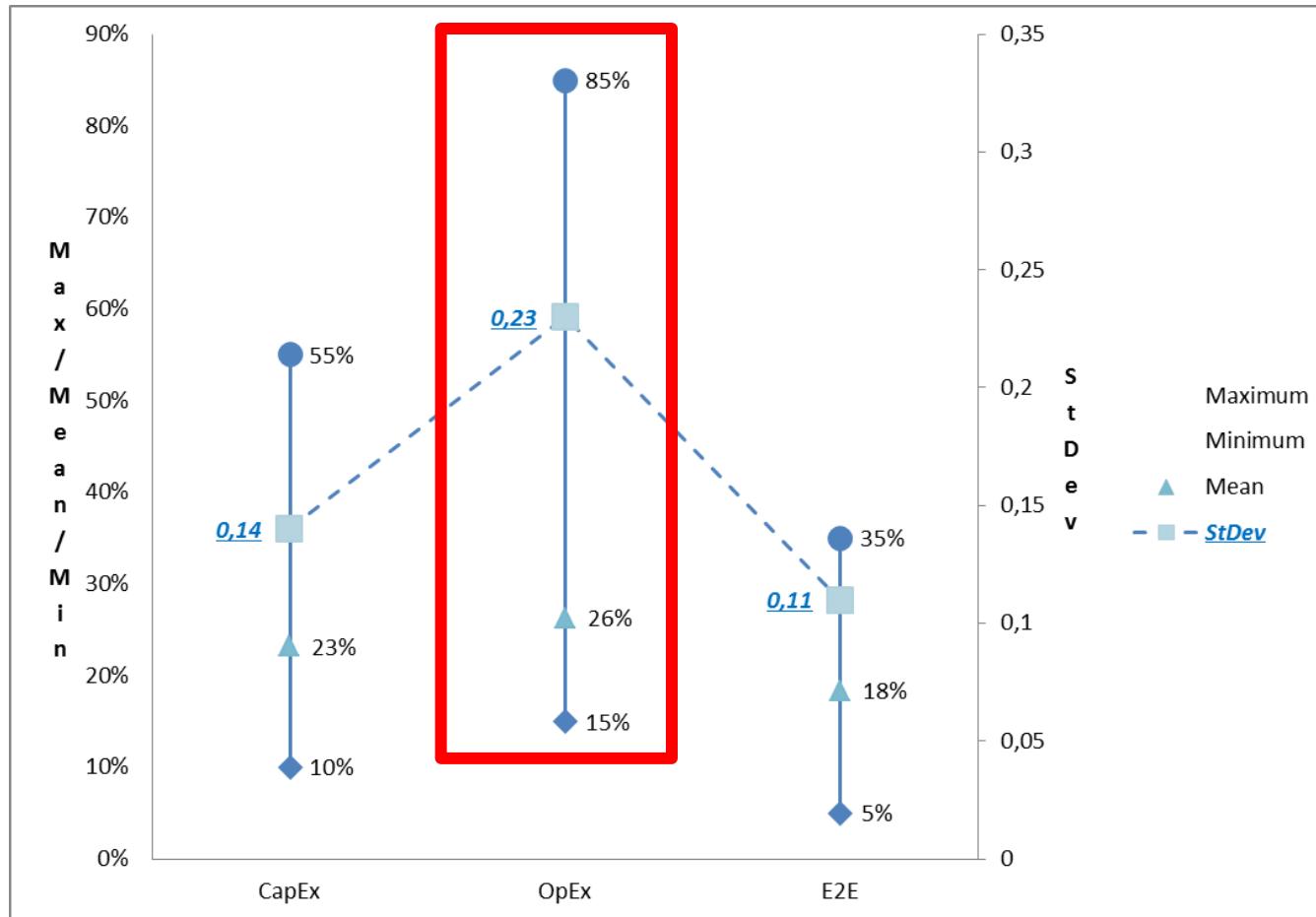
Not an easy task:

- Especially for offshore wind
- Global first for offshore wind: Vattenfall (Yttre Stengrund)
- World's first ever offshore wind farm: DONG Energy Wind Power (Vindeby)

Other issues:

- End-of-service-life extensions
- How to refurbish / reuse different parts and materials
- Supply chain sustainability

In reality, costs fluctuate

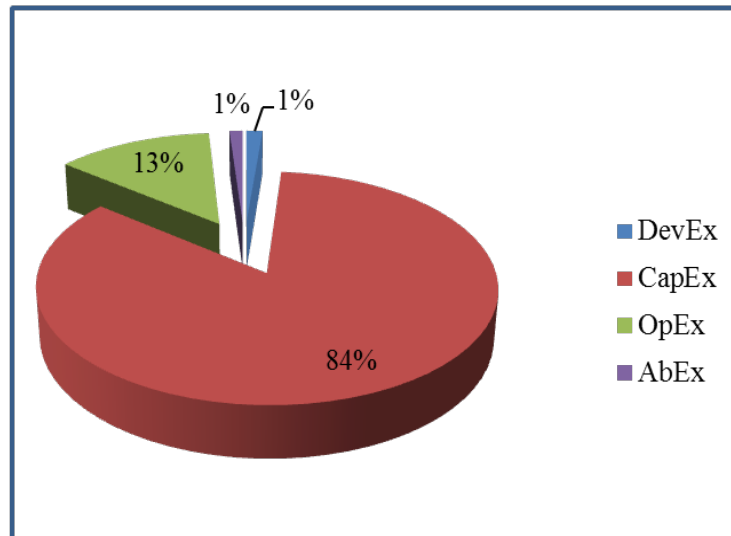


O&M had largest spread in answers provided

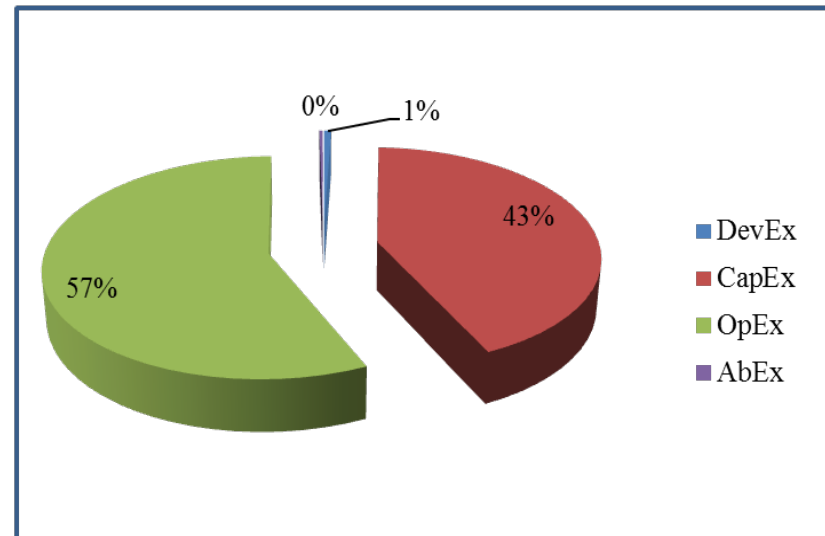
- *Logistics as a percentage of...*
- *OpEx!!!*
- *...O&M?*

Latest paper: OpEx share of LCoE

Lowest OpEx cost per MW per year and lowest CapEx cost per MW implying a near-shore offshore wind farm with a land-based O&M strategy. Discounted OpEx makes up 13.1% of the total costs



Highest OpEx cost per MW per year and highest CapEx cost per MW implying a far offshore wind farm with a sea-based O&M strategy. Discounted OpEx now makes up 56.5% of the total costs



Key modelling assumptions include WACC of 10% (The Crown Estate 2012), OpEx and AbEx numbers have been discounted according to the project operating life assumptions, lowest OpEx example includes a "normal" O&M life-cycle phase of 20 years' operating life whereas highest OpEx example includes a "prolonged" O&M life-cycle phase of 25 years' operating life, and AEP/DevEx/AbEx numbers for the model simulated based on Megavind (2015). Eight (all from 2010 or later) of eleven studies (Megavind 2015; Douglas-Westwood 2015; BVG Associates 2014; Prognos and Fichtner Group 2013; GL Garrad Hassan 2013; The Crown Estate 2012; Deloitte 2011; BVG Associates 2010) in our analysis are included in these numbers

Geographical scope: Expansion

OWF site visits

Name of offshore wind farm visited	Country	Life-cycle focus	Timing of offshore visits
Anholt OWF	Denmark	Installation & Commissioning	April, 2013 and September, 2015
Middelgrunden OWF	Denmark	Operations & Maintenance	March, 2015
Horns Reef I OWF	Denmark	Operations & Maintenance	June, 2015
Longyuan Rudong Intertidal Trial OWF	China	I&C and O&M	July and October, 2016

PhD project travels:

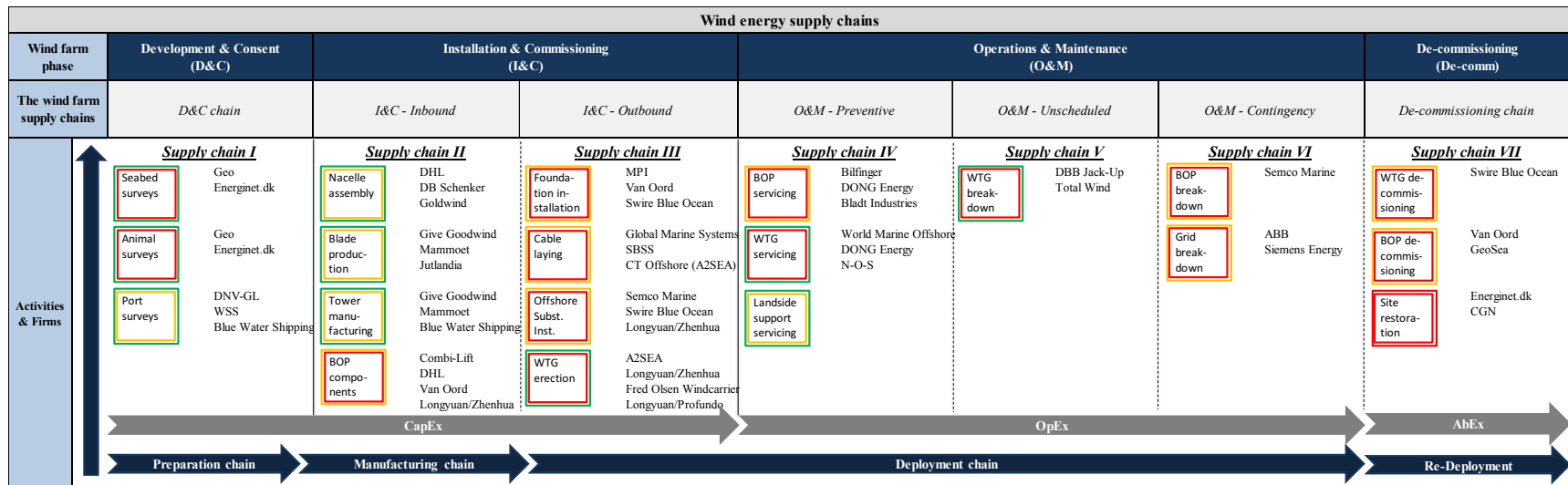
- China: 5 visits, 2 months in-country
- Associate researcher China stay: 2 months
- South Korea: 2 visits
- Singapore: 3 visits
- North America: 6 visits

The market in China

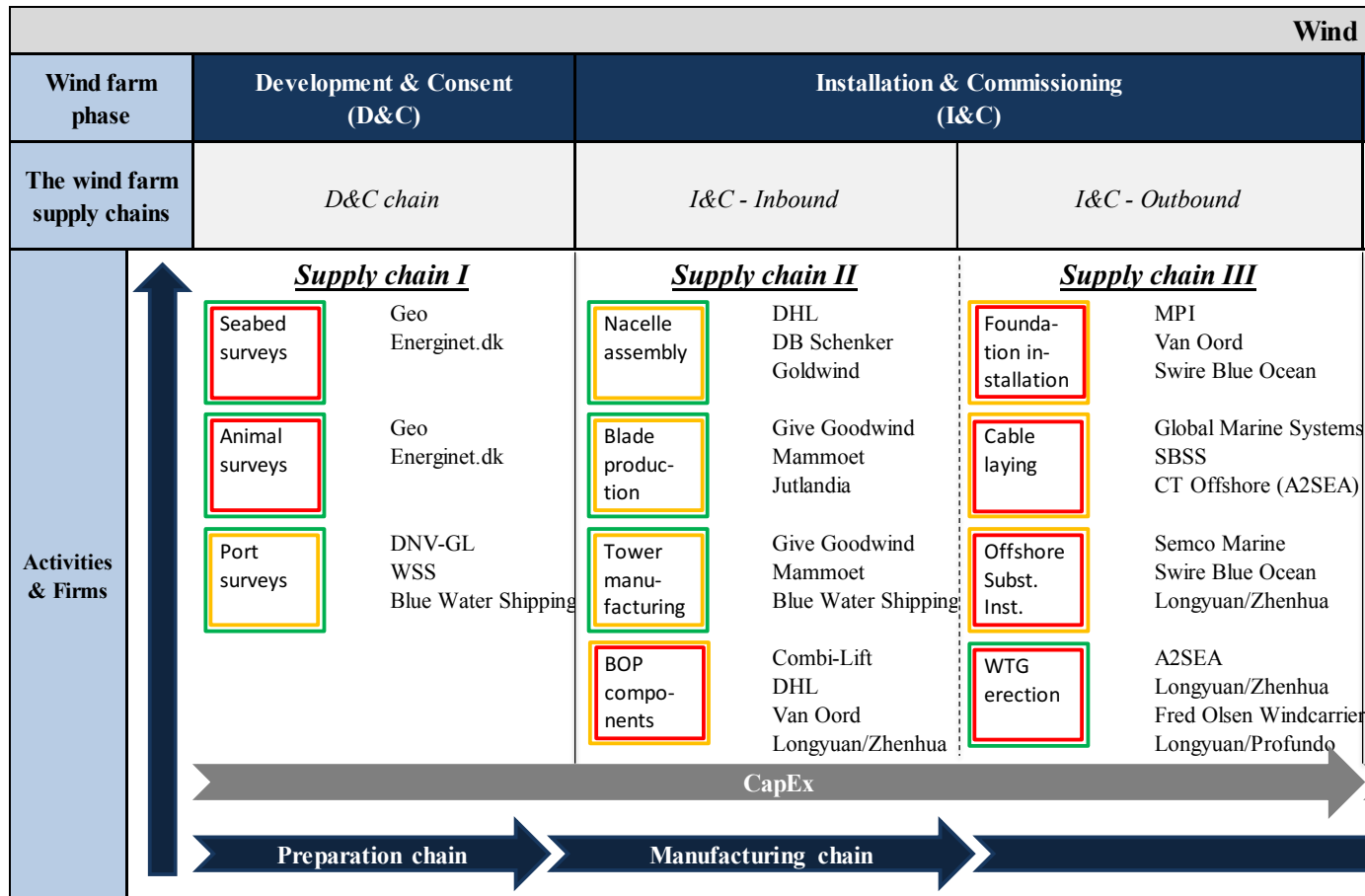
The national Offshore Wind Power Development and Construction Program (2014-2016):

Province	Number of projects	Capacity (MW)
Tianjin	1	90
Hebei	5	1.300
Liaoning	2	600
Jiangsu	18	3.490
Zhejiang	5	900
Fujian	7	2.100
Guangdong	5	1.700
Hainan	1	350
Total	44	10.530

Logistical chains: Readiness?

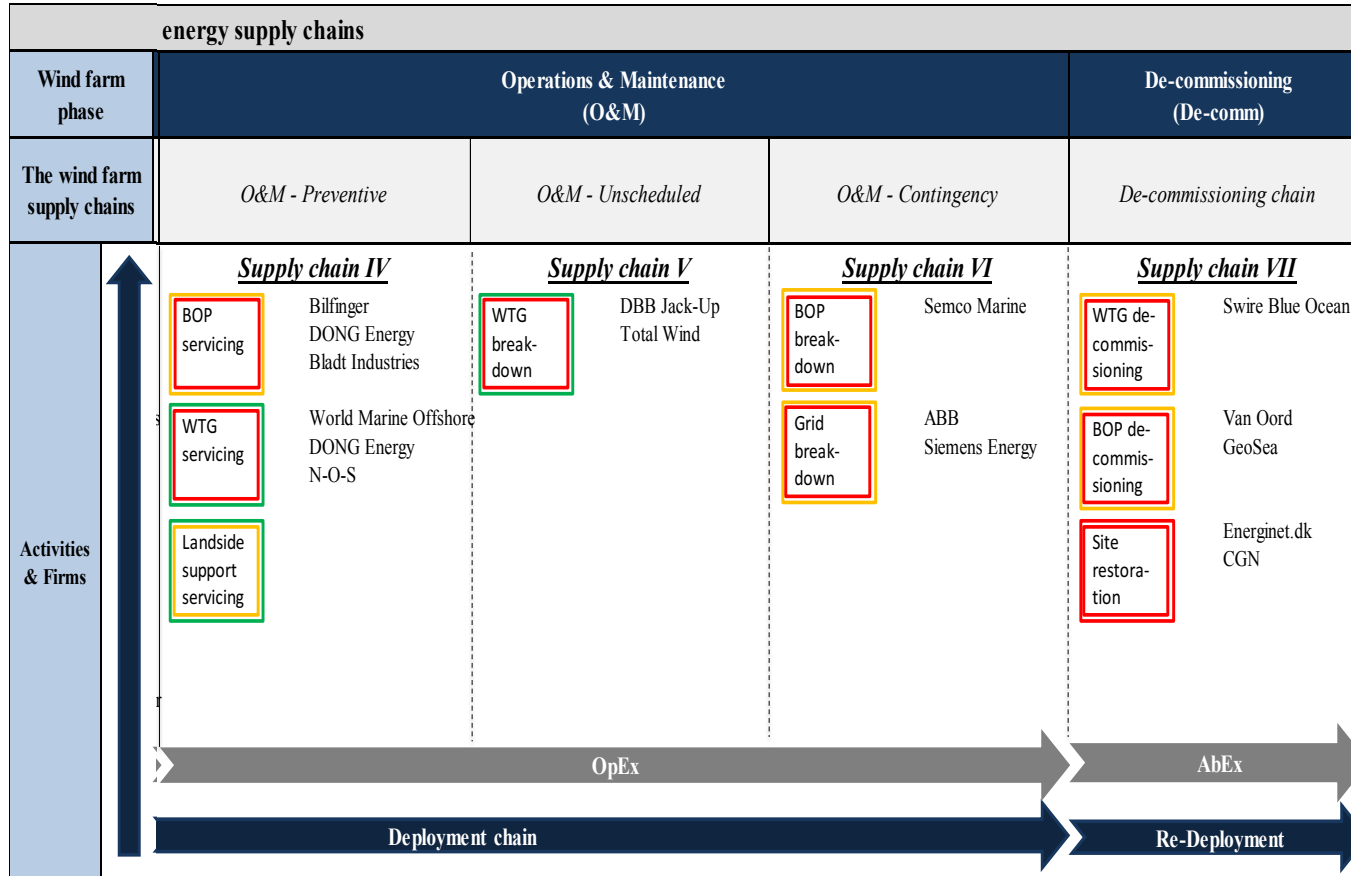


D&C, I&C view



- Europe
- Asia

O&M, De-comms



- Europe
- Asia

Readiness traffic light: I&C

	0	1	2	3
Supply chain #II - Inbound to manufacturing				
Nacelle				EU, PRC
Tower				EU, PRC
Blades/hub				EU, PRC
Wind turbine foundation monopile/transition piece		PRC	EU	
Wind turbine foundation jacket	PRC	EU		
Onshore sub-station/booster station			PRC	EU
Offshore sub-station/booster station		PRC	EU	
Offshore sub-station foundation		PRC		EU
Export cables	PRC			EU
Array/infield cables		PRC		EU
Supply chain #III – Installation and commissioning				
Onshore sub-station/booster station			PRC	EU
Offshore sub-station/booster station	PRC	EU		
Export cables	PRC	EU		
Array/infield cables		PRC	EU	
Wind turbine/offshore sub-station foundations		PRC	EU	
Wind turbine generator		PRC	EU	

Logistics readiness: O&M

	0	1	2	3
Supply chain #IV – Preventive operations & maintenance				
Preventive/planned (wind turbine generator)		PRC	EU	
Return flow (reverse supply chain)		PRC	EU	
Supply chain #V - Unscheduled maintenance				
Unscheduled/Break-down (wind turbine generator)	PRC	EU		
Supply chain #VI – Contingency maintenance				
Contingency (entire offshore wind farm)	PRC	EU		

Supply chain readiness views - shipping and logistics focus

Group #1

Geographies

Shipping and logistics in Europe/Asia/Americas

Group #2

Life-cycles

Shipping and logistics D&C/I&C/O&M/De-comms

Group #3

Wind energy components

WTGs, foundations, sub-stations, cables

Group #4

Supply and demand

Competitive situation shipping and logistics firms

4 groups

Please nominate:

- Captain
- Time-keeper
- White board note taker
- Presenter

Please be ready to:

- Recap the question
- Provide your answer
- Explain your discussions
- Review your findings on the flip-chart
- Answer questions from the group

The groups

#1 Christina, Mads, Per, Hans

Geographies

#2 David, Johan, Barry, Helle, Anders

Life-cycles

#3 Jesper, Henrik, Preben, Christian, Jens

Components

#4 Lars, Thomas (DSA), Hans Ove,
Morten, Sebastian

Supply/demand

Please be back at...

14:50 PM

With a coffee!

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Presentation of group results



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Presentations

***Flip-chart presentations
from the 4 groups***

Scoping from first meetings



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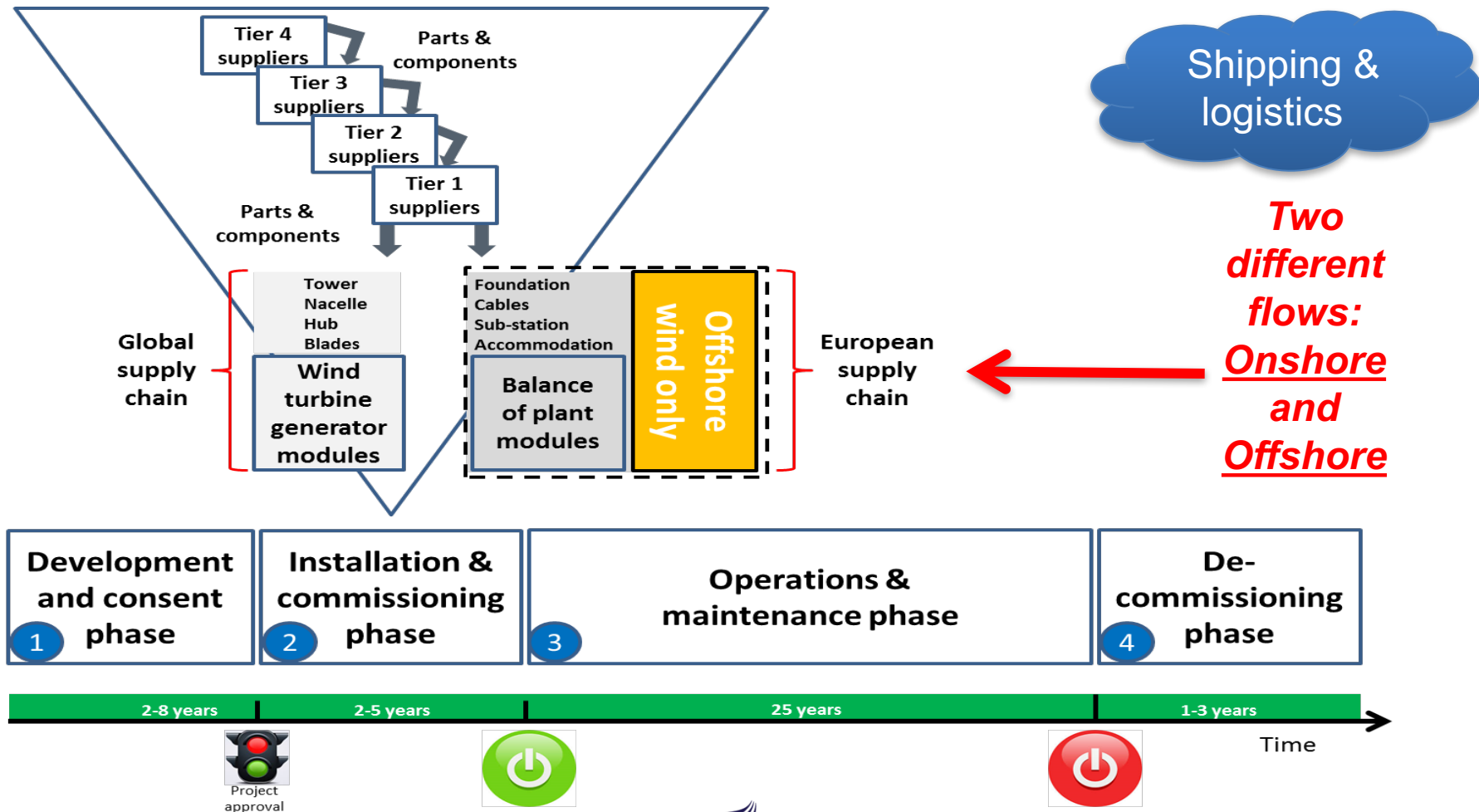
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Charter

The Reference Group will:

- Remain in *active existence* throughout the life-span of the research project
- Convene *twice per year*
- Meetings *at member organization* venues
- *Actively partake* in the research project
- Facilitate the *research project* internally in member organizations, and externally
- Support the on-going *research efforts*

End-to-end life-cycle focus



Shipping, logistics, SCM, end-to-end: *What does it really mean?*

Conclusion:

“The inbound to manufacturing assembly supply chain consists of “standard transportation” mainly by ocean and some air. This part of the end-to-end supply chain was therefore considered less interesting for the project to review than installation & commissioning, operations & maintenance, and decommissioning”

Theory / Practice linkage	Support / Lobby	Challenges /Solutions
Learn biz	Convey info	Practical and relevant / correct
Chinese market network sharing	Investments going forward (vessels, financing, etc.)	Practical background → tools
Reducing LCoE	Project timelines	Academia vs. consulting
Applied research	Offshore wind knowledge	Capture change
Good quality research	Case studies	Look at change in future
Scope: Narrow, realistic, big, complex, crystalize, etc.	Continuous “smart” goals: Concrete, specific, look ahead, value	Moving research target (in time)
On-time project	E2E wind supply chain	Bridge more industries

Case study efforts

Number of companies

Time spent

Extent of case study scope

Depth

Width

Europe

Offshore, simple and easy cases

Asia

Offshore, one case

Americas

Onshore, rail focus

Wind energy shipping and logistics: Involved parties...

Freight forwarders:

- Global
- Regional
- Local

Ocean transportation and related:

- RO/RO (“Roll-on/Roll-off”)
- LoLo (“Lift-on/Lift-off”)
- Short-sea/regional operators
- Tug/barges and landing crafts (“LCTs”)
- Multi-purpose vessels (“MPV”)/Floating cranes
- Container vessel operators
- Safety vessels, work boats, and crew/hotel vessels
- Special vessels like offshore wind turbine installation and cable laying vessels

Ports

Storage:

- Warehouses
- Yards
- Storage areas

Rail

Specialty trucks

Land based cranes

Utilities

Operators

OEM's

EPC companies

SWF

← Extent of services →

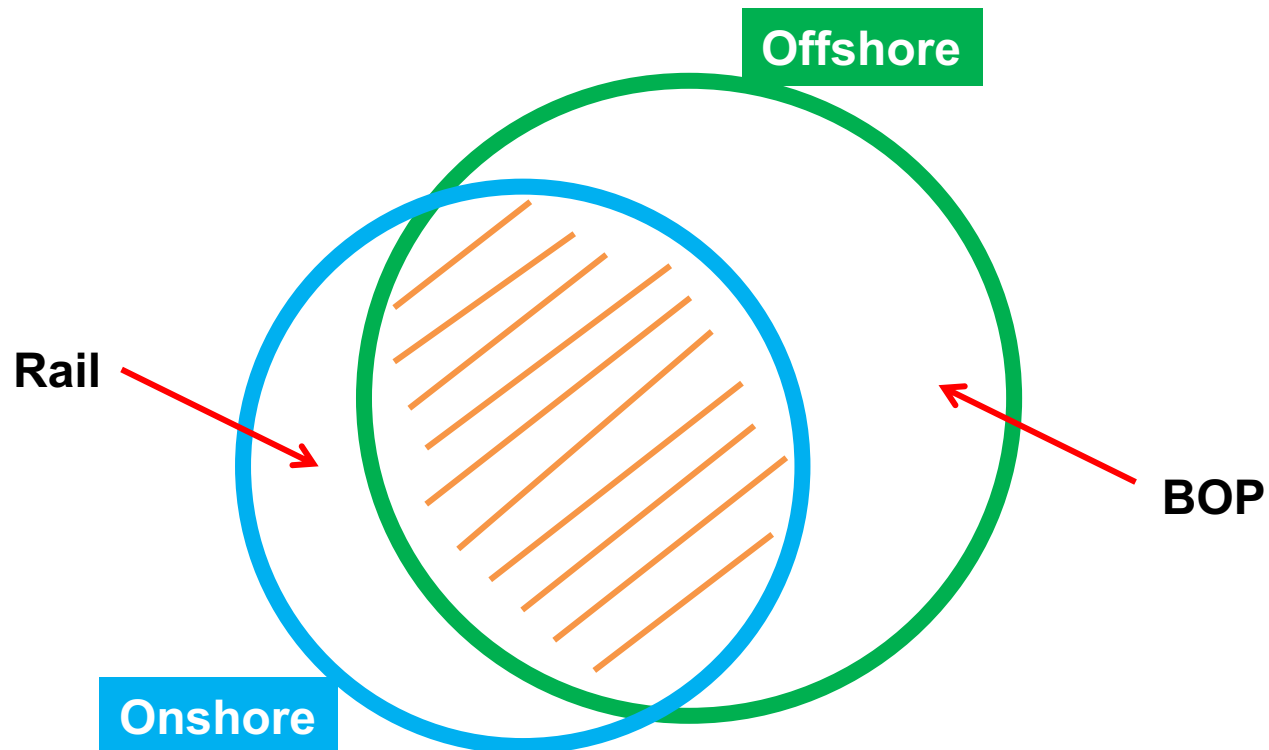
Definition of “The blue Denmark”



Conclusion:

“Definition should be rather broad for this project and not just include for example the shipping companies/DSA members”

Onshore and offshore SCM



Onshore and offshore wind – Differences and similarities

Conclusion:

“Whereas both similarities and differences exist between the onshore and offshore wind farm supply chains, the offshore wind supply chain is more complex in terms of shipping and logistics”

Similarities	Differences
Inland: <ul style="list-style-type: none">- Same trucks / Equipment- Daytime- Infrastructure	Sea carriage: <ul style="list-style-type: none">- Assembly to site (outbound)
Port storage: <ul style="list-style-type: none">- Temp. storage	Infrastructure: <ul style="list-style-type: none">- Quayside loading / logistics- Diff. equipment (vertical)- Area / space (buffer)- Seamen education (outbound)- BOP- Installation / equipment / skills
Actual maintenance	Maintenance <ul style="list-style-type: none">- Certificates- Transportation- Equipment

Scoping of the Ph.d. research

First Reference Group meeting scoping conclusion:

Wind energy supply chains						
Wind farm phase	<i>Development & Consent (D&C)</i>	<i>Installation & Commissioning (I&C)</i>		<i>Operations & Maintenance (O&M)</i>		<i>De-commissioning (De-comm)</i>
Supply chains	D&C chain	I&C chain - Inbound	I&C chain - Outbound	O&M - Preventive	O&M - Breakdown	De-comm chain
Description	Site surveys, birds, wildlife, sea, seabed	Inbound assembly parts and components	Outbound wind modules for wind farm site	Personnel, parts, and components	Personnel, parts, components, and modules	Restoration of site for new wind farm or to original condition
Characteristics	Specialized vehicles (onshore) and vessels (offshore)	Mainly a homogenous flow using ocean containers and air; some project cargo	Project cargo/break-bulk	Mainly service boats, crew transfer vessels and some larger vessels	Service boats and helicopters, some large vessels like MPV, tug&barge, WTIV	Project cargo/break-bulk

Assumed to have the largest possible impact on potential reductions of levelized cost of energy



Achievements since last meeting



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Speed boats – USA onshore

Rail logistics focus:

- Continuation of execution of plan to conduct study visits
- Site visits to Canada and the US
- Rail focus in Dallas and Corpus Christi
- Large-scale onshore wind farm visits conducted
- Project partners include BNSF, Algoma, and Vestas

Speed boats – INNOlog

OEDK CRIF Group 3 I&C logistics:

- Innovative logistics solutions
- Project now advanced to WP5 of 7
- December 8, 2016 Esbjerg WP4 conference
- Literature review analysis presentation
- Project lead for “installation vessel cost drivers” work group on behalf of OEDK

Speed boats: Logistics test center

Bornholm nearshore wind farm:

- EIA completed
- Site not selected for auction
- Possible attempt to find local funding
- Offshore logistics test centre concept part of Megavind test center project
- Collaboration Rønne Havn and Offshore Center Bornholm offshore wind cluster

Government relations - and tailormade grants



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EU Commission lobbying

March 2015 Reference Group success:

- H2020 grant LCE 13 and LCE 14 meetings with EU Commission officials during March, 2015 in Brussels and CPH



- 2018-2020 program of H2020 also includes very relevant grants (RES9 and RES10), lobbying on-going now

EU future research agenda

- Former EU research umbrella TPwind now replaced by ETIP Wind:
 - European Technology and Innovation Platform on Wind Energy
 - Only AAU representative for expert interviews in April – June time frame
 - Strategic Research and Innovation Agenda 2016 report was published on September 27, 2016

Papers – policy level impact?

Three latest papers:

- DEWP case study
 - Logistics costs to be included and considered
- O&M paper
 - Standardize LCoE calculation methods or use another tool
- Comparative cross-case study
 - China/EU policy level recommendations: EU needs 2030 goals and China needs collaboration with EU firms

Dissemination of research results and findings



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Concurrent dissemination

Academic

- Journal papers:
 - Paper on supply chain readiness ***published***
 - Paper on O&M logistics ***published***
- Press clippings
 - Last gå-hjem meeting at DSA
 - Innovation dialogue facilitated by DEWP

Industry

- Gå-hjem meeting on August 24, 2016 in Copenhagen
 - Almost 60 people attended
- INNOlog conference on December 8, 2016
 - Almost 80 people attended

Academic update

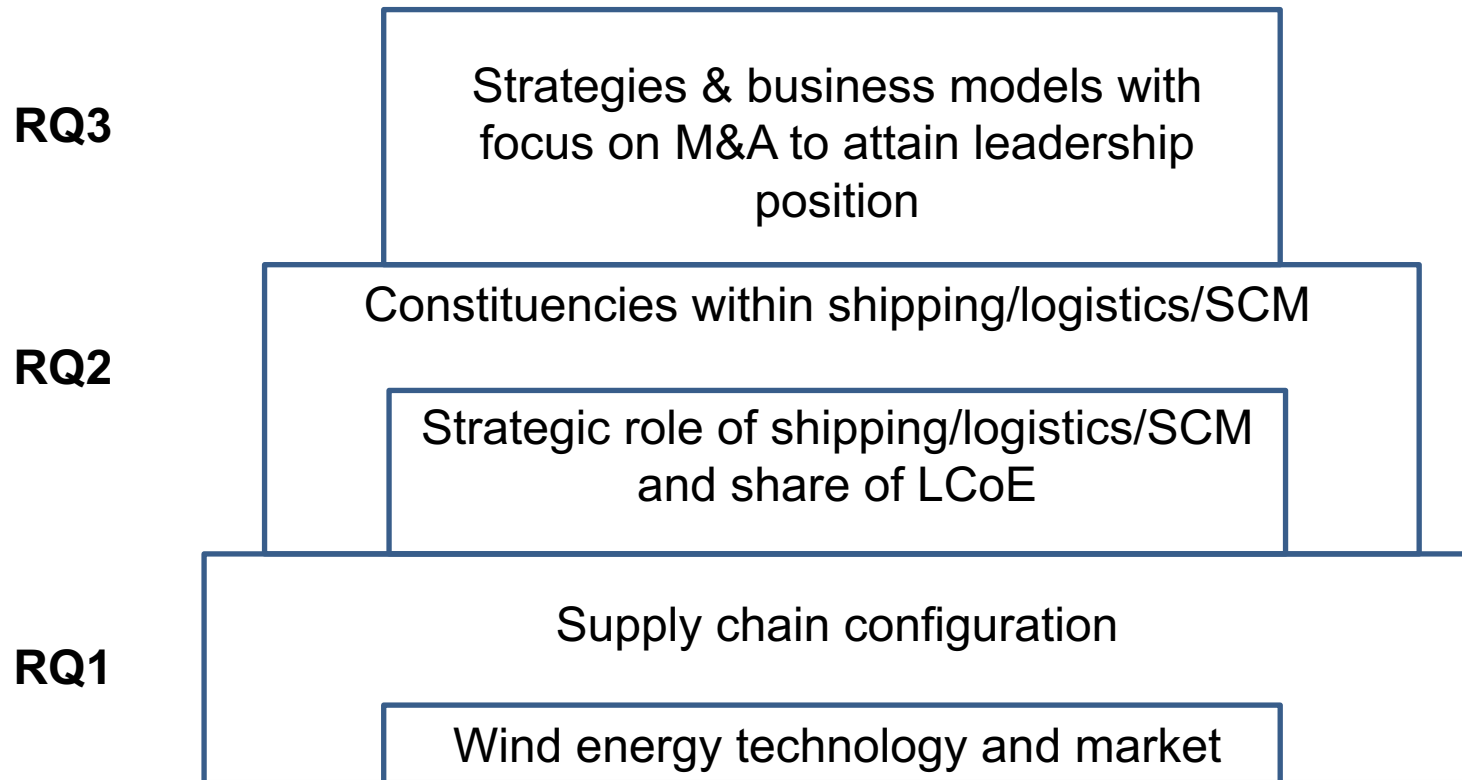


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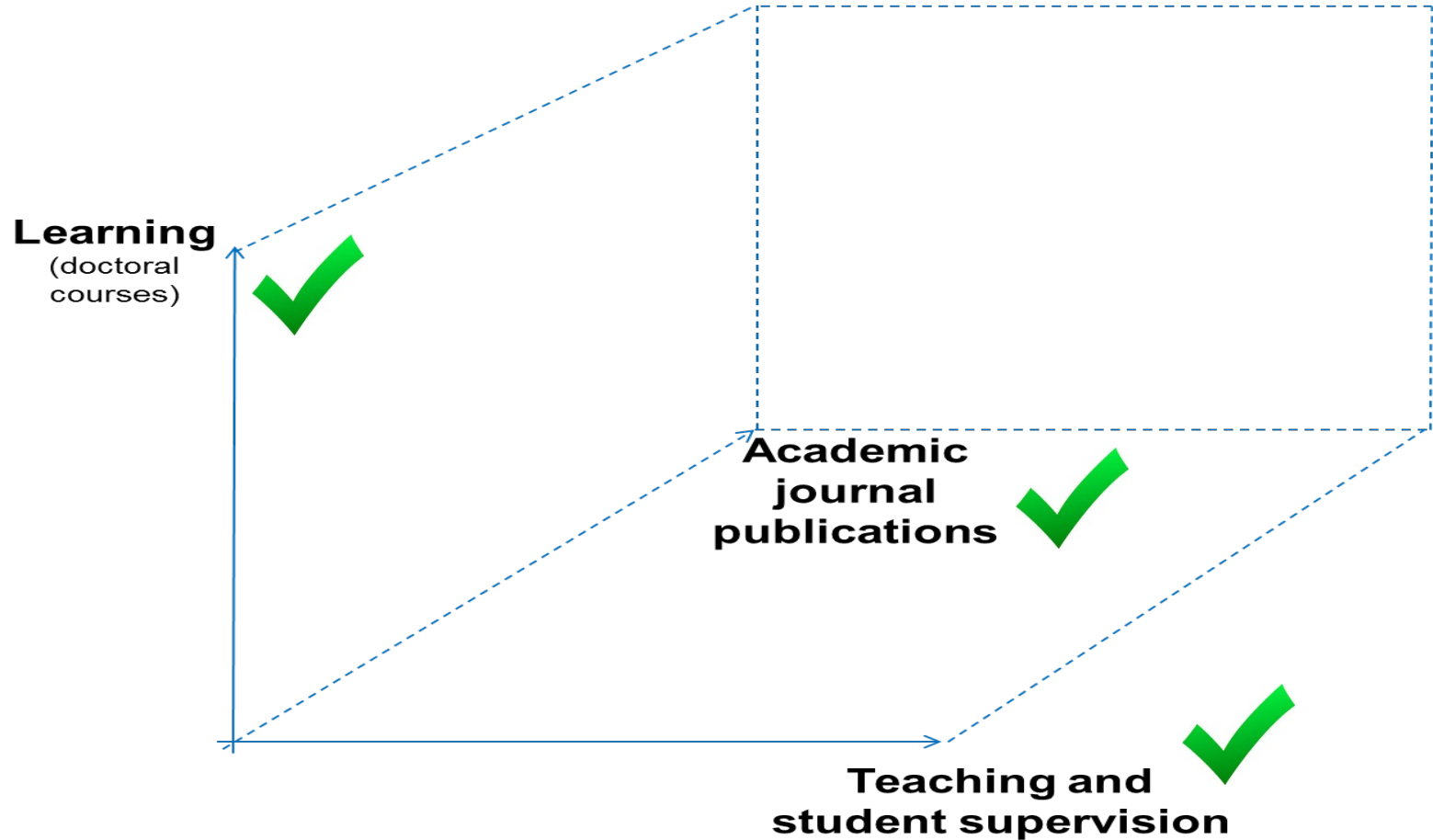


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Tiered research questions



Academic project KPIs



The academic currency: Papers

Subsidized market, government created, derived market of logistics, M&A
Peer reviewed book chapter published by Pearson, 2015

Cross-case study and supply chain readiness comparison Asia / Europe
Published, Renewable & Sustainable Energy Reviews, 2017

Case #1:
DONG Energy Wind Power
offshore wind logistics
innovation, LCoE, and
organization
Published, Energies, 2016

Case #2:
Offshoreenergy.dk
"Cost Reduction Forum"
Manuscript on Group 4 O&M
logistics and LCoE calculations
Published, Energies, 2017

Case #3:
China offshore wind
Gap analysis as of end 2015
Focus on shipping/logistics
Manuscript drafting
work-in-progress

Life-cycle case study "test" – Anholt OWF
Second peer reviewed conference paper/presentation EAWE, 2013

Life-cycles, exploratory, and industry practitioner challenges
Initial peer reviewed conference paper/presentation LogMS, 2013

The theoretical contribution! (Section 5.7)
"Wheel of SCM" Offshore Wind LCoE
Published International Journal of Energy Sector Management, 2016:

Doctoral dissertation

- Work in progress
 - ✓ Method applied
 - ✓ Case studies utilized
 - ✓ Summary of analysis
 - ✓ Discussion across papers
 - ✓ Conclusion

Wrap-up and close



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Closing of today

- Date for next meeting
- Hosting company
- City

✓Wrap-up

Next Reference Group meeting

Date suggestion: September 27, 2017

***DTU Department of Wind Energy
Risø, Roskilde***

Final conference: November 16, 2017

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Transfer to gå-hjem

***Now let us get ready for the
gå-hjem meeting / "go-home"
after work meeting***

HERE AND NEXT DOOR