



# GLOBAL WIND ENERGY SHIPPING AND LOGISTICS

## WIND ENERGY SUPPLY CHAINS AND END-TO-END LOGISTICS

MARCH 29, 2017, COPENHAGEN, DENMARK

*Prepared for gå-hjem meeting hosted by*



AALBORG UNIVERSITY  
DENMARK



# Background & introduction



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DENMARK



*Department of*  
**Mechanical and Manufacturing Engineering**

# The expert panel here today

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

## PhD research project Reference Group



GLOBAL WIND ENERGY SHIPPING AND LOGISTICS  
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# Introduction – Thomas Poulsen

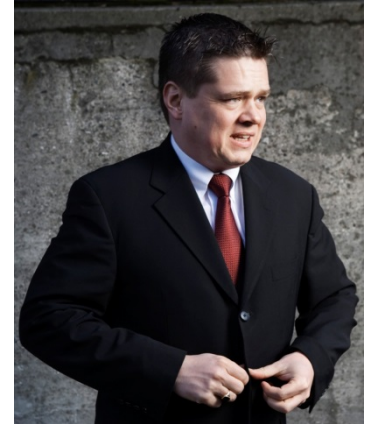
*Aalborg University*, Copenhagen Campus  
Department of Mechanical and Manufacturing Engineering

## **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, 18 years outside native Denmark



## **PhD EXCHANGE**

DTU Wind Energy, Risø

# Aalborg University - logistics

Port  
construction

GPS and satellite  
surveillance of vessels

Offshore  
oil & gas

Offshore  
wind

Carbon fiber  
vessels

Composite  
materials for  
vessels

Global wind  
energy  
shipping and  
logistics

Wave  
energy

Maritime  
cleantech

Logistics

Revenue  
management

# Funding partner: DDMF



# 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**

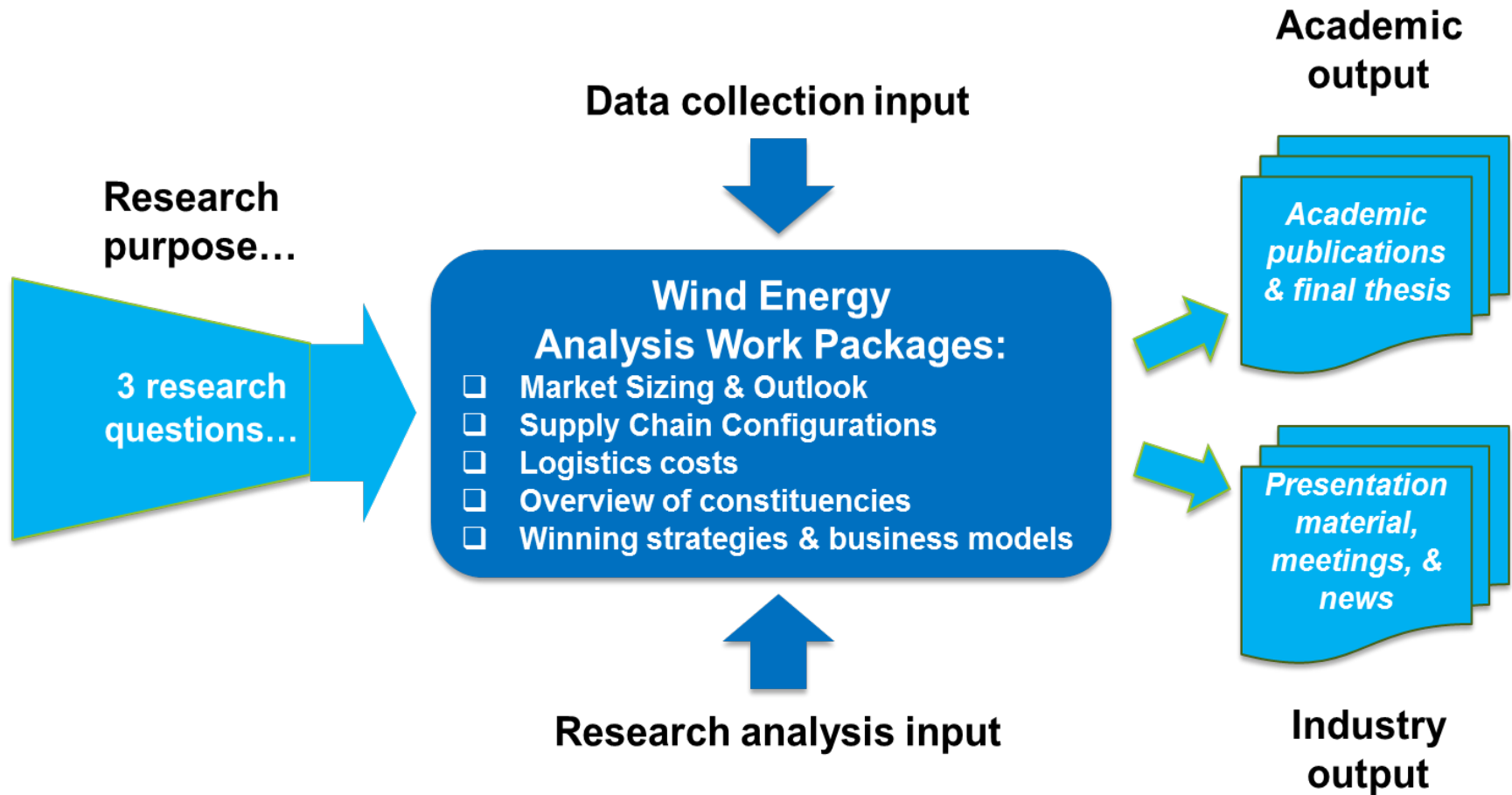
**OEM's**

**EPC companies**

**SWF**

← Extent of services →

# PhD structure





# The mechanics of a PhD

**Activities**  
**Work streams**  
**Case studies**



- Teaching
- Supervision
- Learning

**Findings**



**Research questions**





# Wind energy supply chains

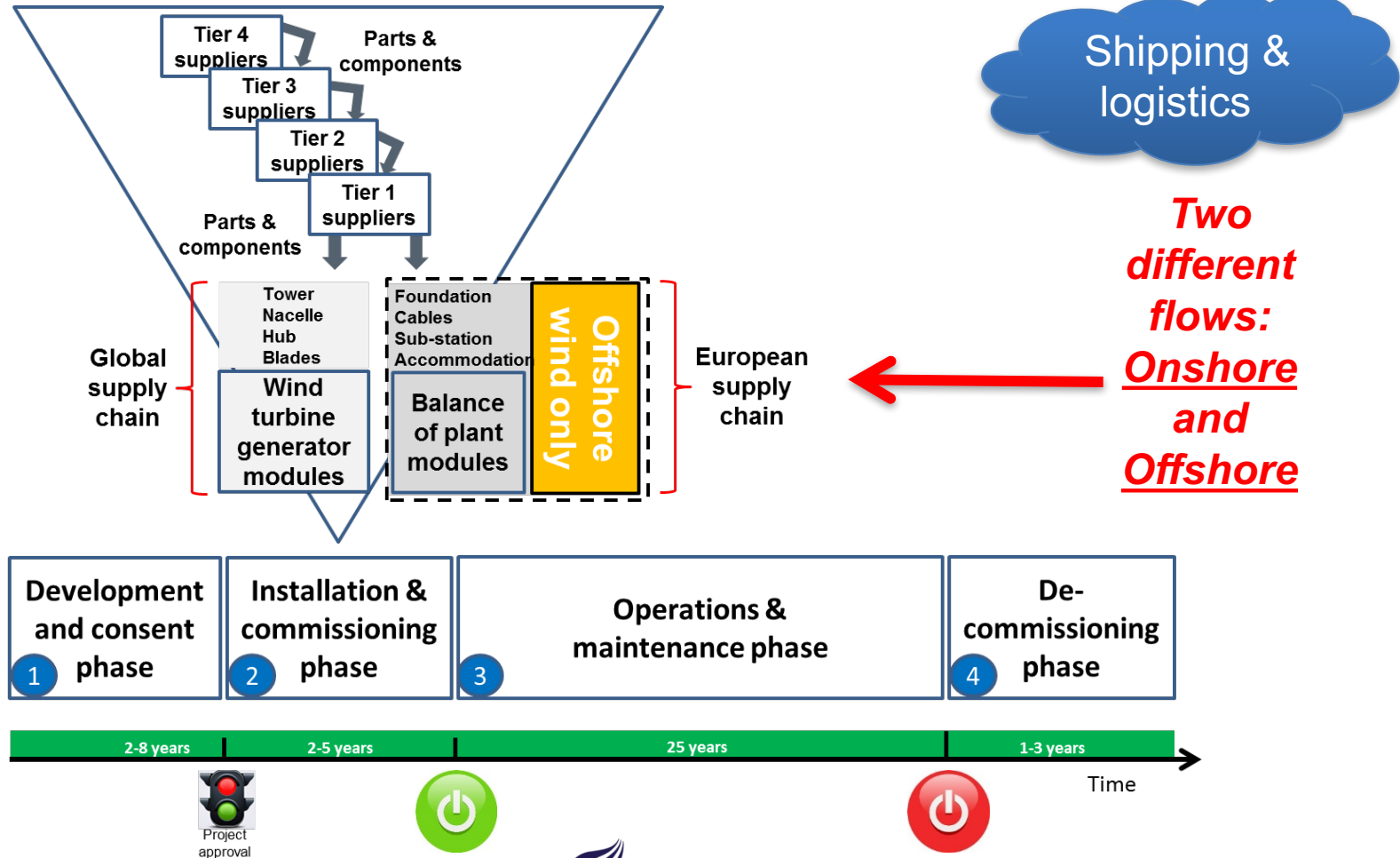


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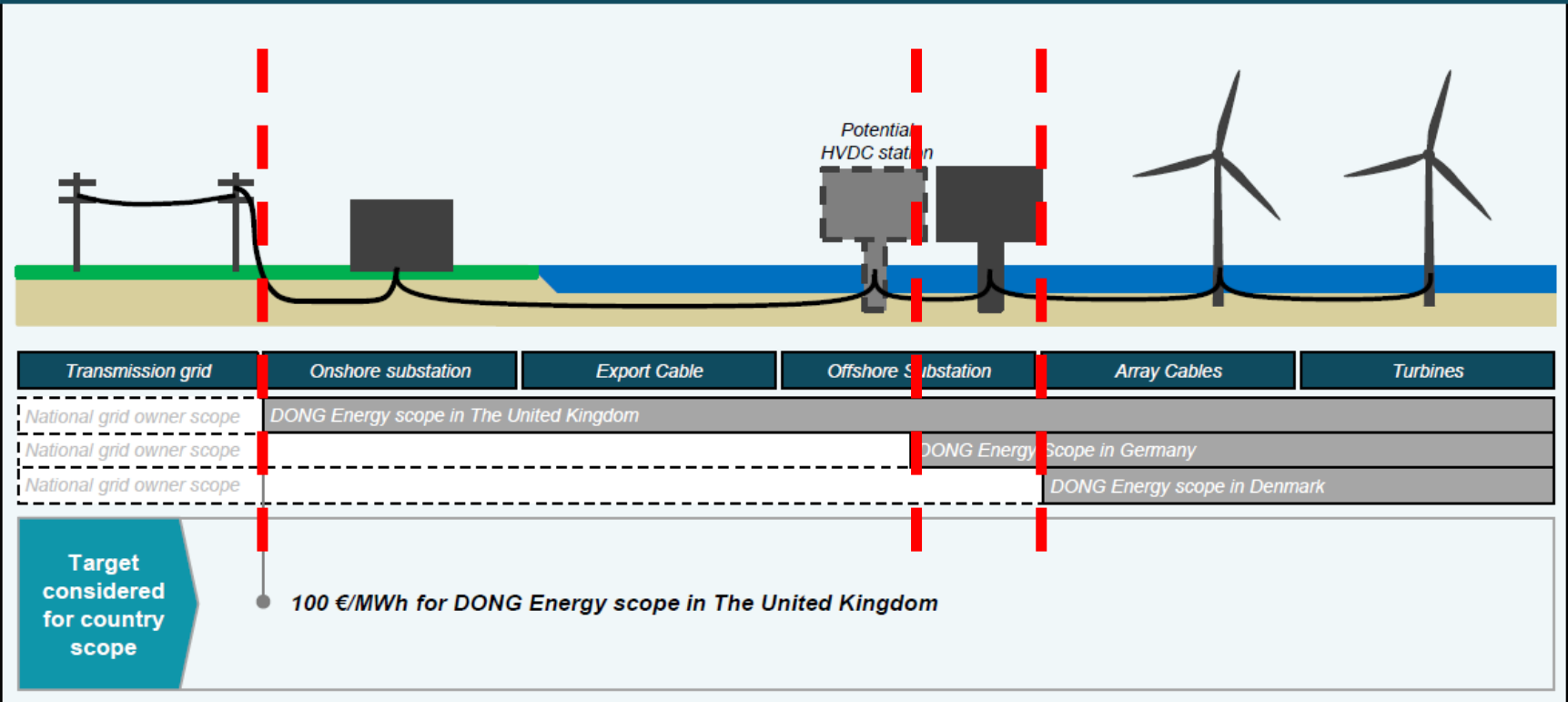
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# Wind farm E2E life-cycle



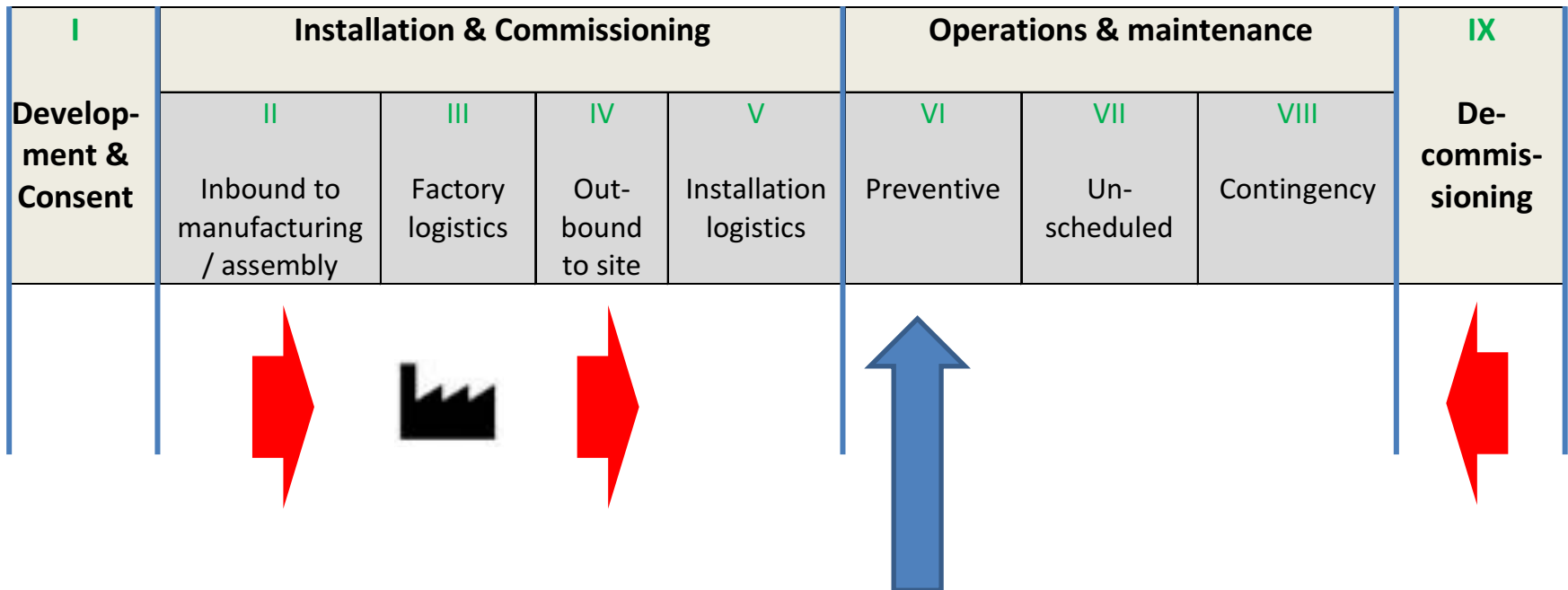
# Scope: DONG Energy Wind Power

## Over view of assets included in cost of energy



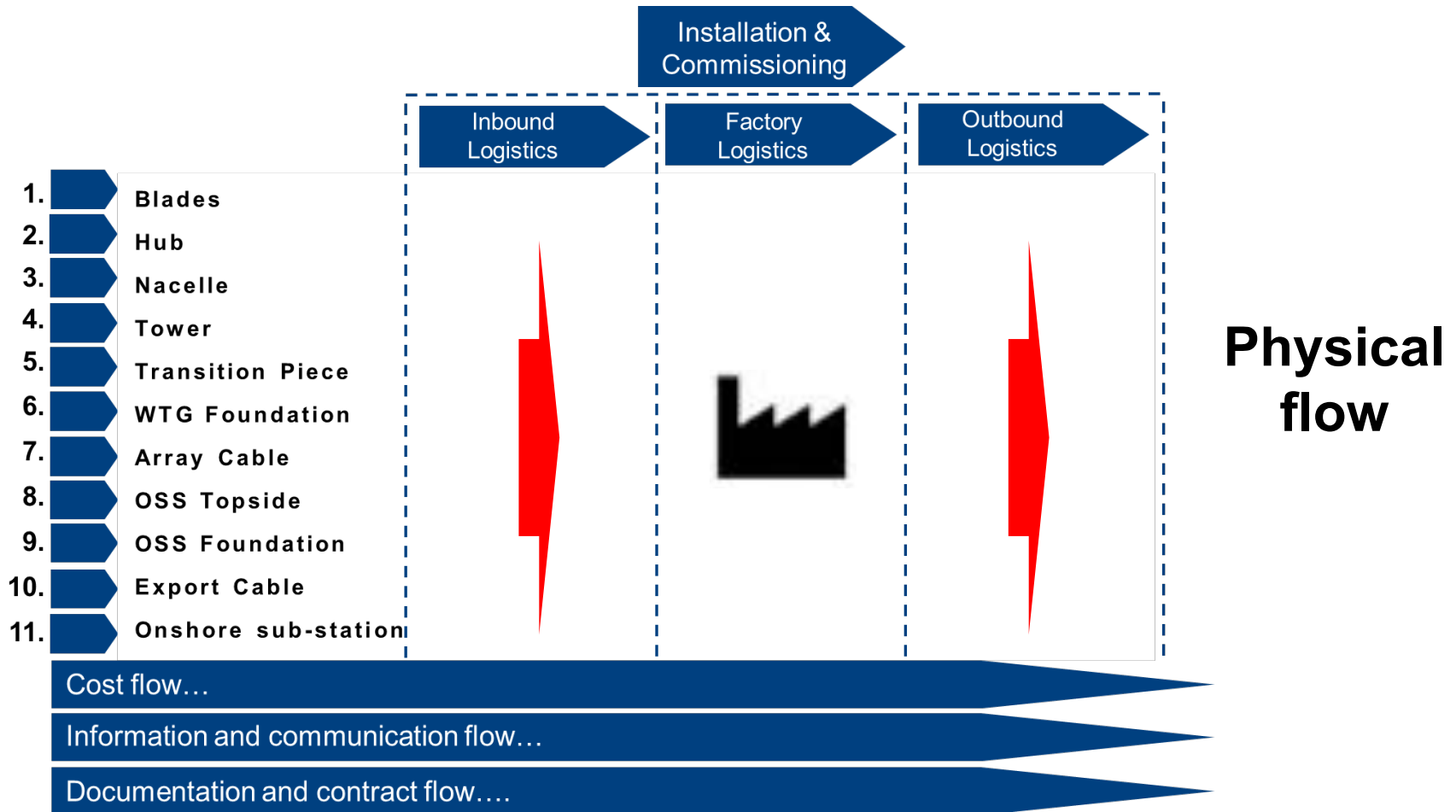
Different countries in the EU have different ways of calculating and scoping

# 9 unique logistics chains



Possible to plan  
- and optimize!!!

# I&C example



# O&M: Logistics sub-chains

Operations & maintenance		
Preventive	Unscheduled	Contingency
Land-based O&M		Sea-based O&M
Topside		Subsea
-WTG -Offshore sub-station		-Export cables -Array cables -WTG foundations -Offshore sub-station foundations
4		8
12	12	4
28		

# Money matters

## - hard to fully comprehend

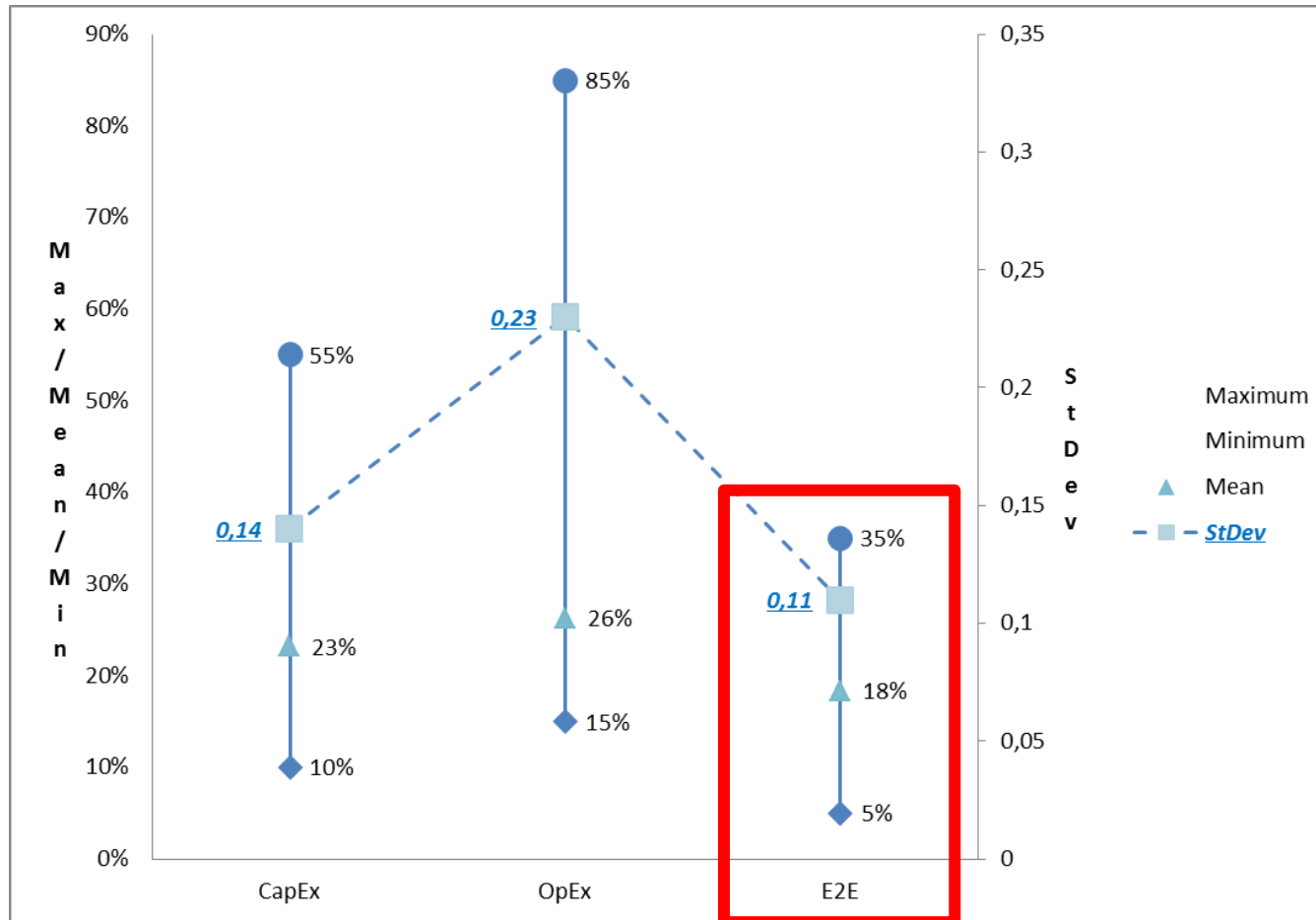
***LCoE: Detailed analysis performed – 11 studies issued over 10 years***

Year	Study
2015	Megavind 2015 LCoE calculator
2015	Douglas-Westwood offshore wind global forecast 2025
2014	BVG Associates UK Supply Chain Assessment
2013	Prognos and Fichtner Group Germany cost reduction
2013	GL Garrad Hassan offshore wind O&M spend guide for Scottish Enterprise and The Crown Estate
2012	The Crown Estate UK cost reduction pathways study including sub-studies in work streams
2011	Deloitte study on offshore wind competitiveness for Denmark
2010	BVG Associates UK Renewables Advisory Board offshore wind sector value break-down report
2009	European Wind Energy Association report on the economics of wind energy
2009	Vattenfall VindKraft third annual technical report for Kentish Flats OWF
2007	Offshore Design Engineering OW cost study for UK Department of Trade and Investment



# The money:

- logistics is 18% of LCoE



**O&M had largest spread in answers provided**

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



# End-to-end (E2E) logistics



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# Logistics defined by industry

## The leading industry practitioner definition:

- The US has the largest independent network of industry practitioners in Council of Supply Chain Management Practitioners (CSCMP)
- CSCMP defines logistics as:

***“That part of supply chain management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements”***

# Wind: Onshore vs. offshore



# Technology R&D

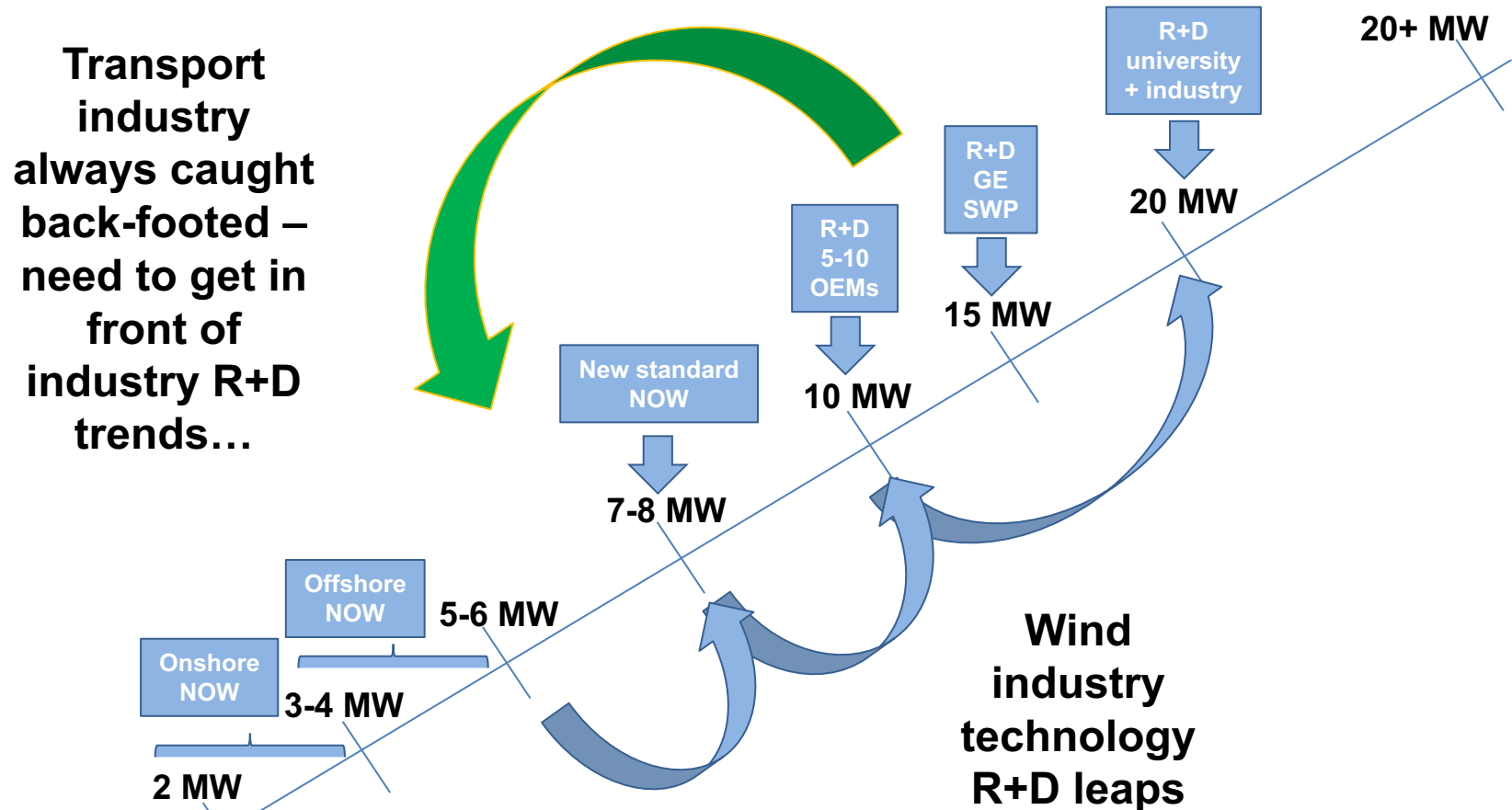
## - logistics must accommodate

- Rapid technological development
- Support industries must follow suit
- Significant shipping / logistics impact

Weight & Dimensions	Full Nacelle Weight (t)	Nacelle dimensions (m)	Hub Weight (t)	Total Hub Mass (t)	Hub Height (m)	Blade Length (m)	Blade Weight (t)	Tower Weight (t)
Siemens 2.3 MW	82			142	80	45		162
Siemens 3.6 MW	140				80	58.5	18	
Repower 6.15 MW	325					61		
Siemens 6 (7) (8) MW	364		96	360	135	75	27	
Samsung 7.5 MW						83		
Vestas 8 (8.3) MW	390	20 x 8 x 8			105-140	80	35	
NREL/DTU 10 MW	446		106-180	700		86-100	42-57	628
NREL/SWP 15 MW			303	1000		125	100	1000
DTU 20 MW	1061		299			125	118	1985

# Research and development (R+D)

**Transport industry  
always caught  
back-footed –  
need to get in  
front of  
industry R+D  
trends...**



First WTG serial  
production 1979

# Installation & commissioning

## WTG & BOP modules

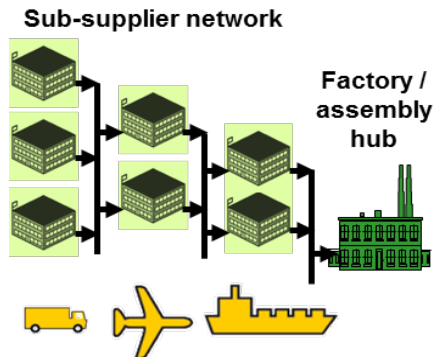
### Parts & components

#### WTG:

- Nacelle
- Blades
- Hub
- Tower

#### BOP:

- Foundations (MP/TP's or jackets)
- Array/export cables
- Substation foundations/topside
- Hotel/accommodation platform



#### Land/port storage



- Consolidation
- Storage
- Marshalling

#### Quay side



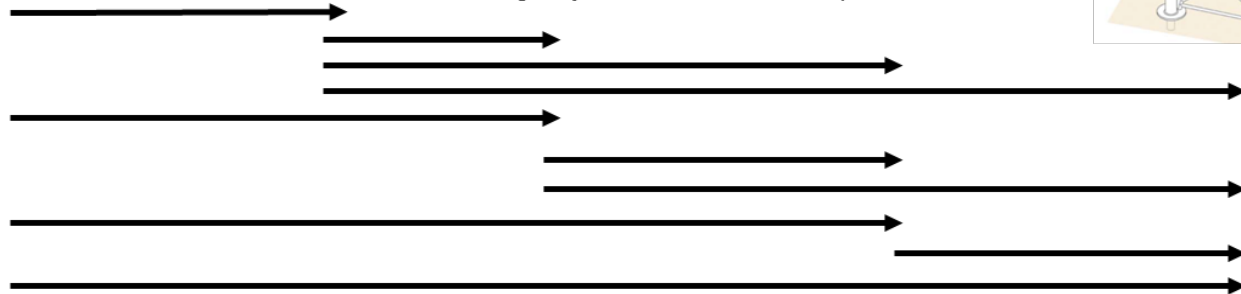
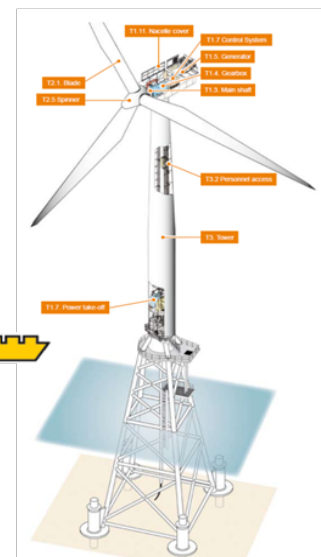
- Stevedoring
- Clearance
- Cranage
- Agency

#### Supply base












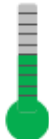
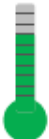




- Sub-assembly
- Vessel/tug&barge
- Maintenance & repair
- Inspections

#### Site



# Offshore Wind

## - E2E shipping / logistics challenges





<b>Turbines</b> <i>Improve production per position at reduced cost</i>	 <p>3-4 MW turbines</p>	 <p>&gt;5 MW turbines with higher reliability</p>	 <p>8-10 MW turbine to be developed aimed for high reliability and efficiency</p>
<b>Foundation</b> <i>Enable installation of larger turbines in deeper waters without increasing cost of energy</i>	 <p>Monopile design 15-30 m. water depth</p>	 <p>Industrialized jacket foundation 20-40 m. water depth</p>	 <p>Next generation foundation for deep water sites and large turbines +40 m. water depth</p>
<b>Offshore Transmission</b> <i>Reduce transmission costs and grid losses</i>	 <p>Traditional high voltage AC transmission to shore</p>	 <p>Long-distance transmission through high voltage DC</p>	 <p>AC/DC transmission solution with integrated/limited offshore platforms</p>
<b>Offshore Logistics</b> <i>Faster installation and less weather dependency</i>	 <p>Applied vessels from other industries (such as E&amp;P) for installation and operations <i>Asset accessibility</i></p>	 <p>Purpose-build vessels for installation and operations <i>Asset accessibility</i></p>	 <p>Multipurpose vessels to minimize and combine offshore activities <i>Asset accessibility</i></p>
<b>Operations &amp; Maintenance</b> <i>Minimize breakdowns and response time</i>	 <p>Traditional service with crew vessels</p>	 <p>Service performed by combining vessels and helicopters usage</p>	 <p>Limited service requirements due to high asset reliability and remote condition monitoring</p>



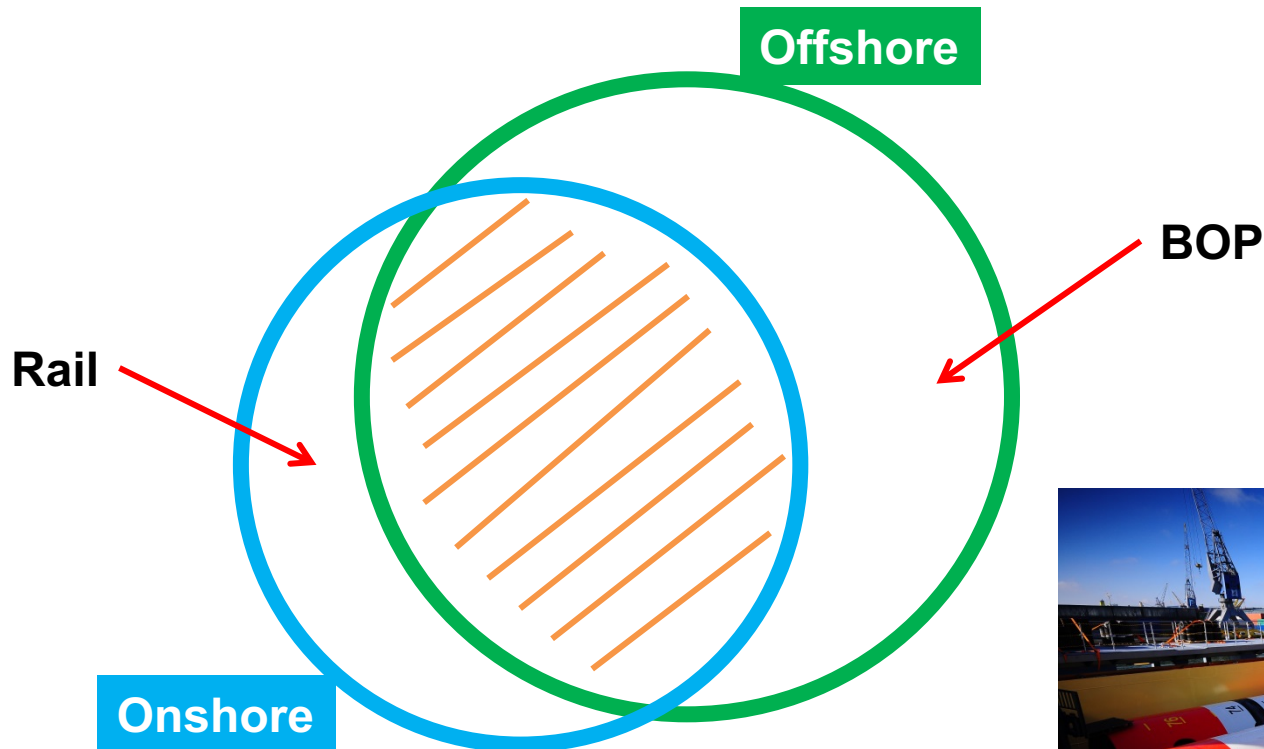
# Dimensions: Logistics Challenges



# Bottlenecks for the offshore wind industry

area	Description	Supply chain risk
<b>Subsea export cables</b>	<ul style="list-style-type: none"> <li>▪ Few players</li> <li>▪ Timescales to increase capacity are tight</li> <li>▪ A few new entrants foreseen</li> </ul>	
<b>DC substation electrical systems</b>	<ul style="list-style-type: none"> <li>▪ New technology</li> <li>▪ Few suppliers</li> <li>▪ Limited potential for new entrants</li> </ul>	
<b>Offshore wind turbines</b>	<ul style="list-style-type: none"> <li>▪ Sufficient capacity of &lt; 6MW WTGs, but little competition.</li> <li>▪ Many 6MW+ WTGs in development</li> <li>▪ Investment is required in manufacturing facilities for the larger WTGs.</li> </ul>	
<b>Foundation installation</b>	<ul style="list-style-type: none"> <li>▪ Sufficient number of vessels, but many are not efficient for installing jacket foundations</li> <li>▪ Few next generation concepts in development, - little consensus on optimal solution</li> </ul>	

# Onshore and offshore - logistics



# Offshore wind logistics:

## Our definition from the research

Parts, modules, components, people, consumables, and tools are responsibly stored and moved safely, weather permitting, onshore, as well as offshore by air/ocean/land using various transportation assets and transport equipment with a focus on an individual wind turbine generator, an offshore wind farm asset project, or across a portfolio of projects by means of different in-house and outsourced logistics skills/capabilities/IT systems used across multiple supply chains spanning different starting and ending points

- ➔ What?
- ➔ HSSEQ
- ➔ Weather
- ➔ On-/Offshore
- ➔ Transport mode
- ➔ Assets/TEQ
- ➔ Focus
- ➔ Staff
- ➔ Competencies
- ➔ Multiple SCs



# Conclusion



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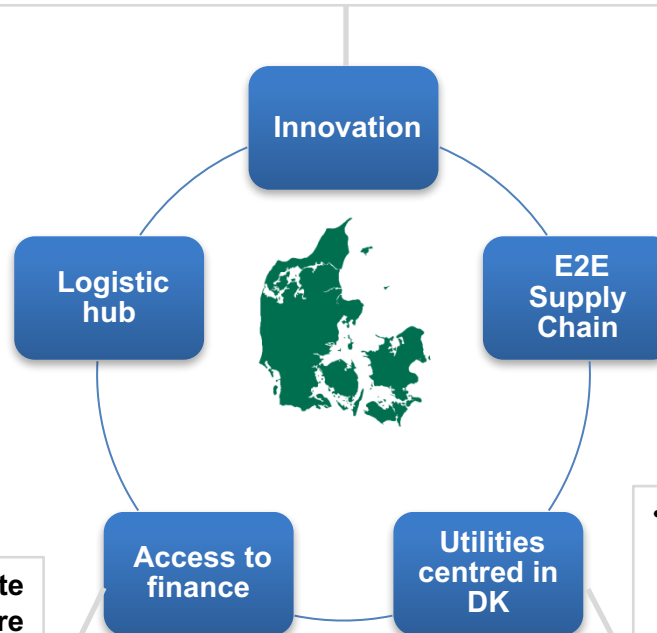
# Denmark is...

## - strategically well positioned

- Denmark was the first country in the world to install and utilize offshore wind farms with Vindeby in 1991
- Large test facilities in both Østerild (testing of large wind turbines) and Lindø (Europe's largest test bench for wind machine booths)

- Key hubs like Port of Esbjerg being the leading offshore wind hub in Denmark with 75% of all Danish wind turbine export shipped from the port
- Flexible logistical access to the sea from Danish Production facilities

- Danish institutional and private investors are active within offshore wind
- DONG Energy and Vattenfall have co-financed offshore wind projects with different institutional investors



- Offshore wind value chain with leading wind turbine manufacturers and heavy industry players is present in Denmark
- First-mover track record with largest global OEMs, Vestas and Siemens

- DONG Energy is a Danish based utility and a leading utility provider in Northern Europe, operating 21 offshore wind farms from their offshore base at Port of Esbjerg
- Vattenfall has its surveillance centre for offshore wind farms at Port of Esbjerg

# Key take-aways from today

- A wind farm life-span lasts 30-40 years
- Offshore wind logistics is more complex than onshore
- At least 9 different logistics chains exist
- Logistics sub-chains exist with unique requirements
- For offshore wind, logistics costs amount to at least 18% of LCoE



# Questions & answers?

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