


GLOBAL WIND ENERGY SHIPPING AND LOGISTICS

LOGISTICS AND SAFETY – NOW AND IN THE FUTURE

LOGISTICS IN THE OFFSHORE WIND VALUE CHAIN

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About knowing one's place

The tail does NOT wag the dog

We in transport know that we are basically considered coolies that just make things work safely...

PhD mechanics

Methodology: Case study efforts

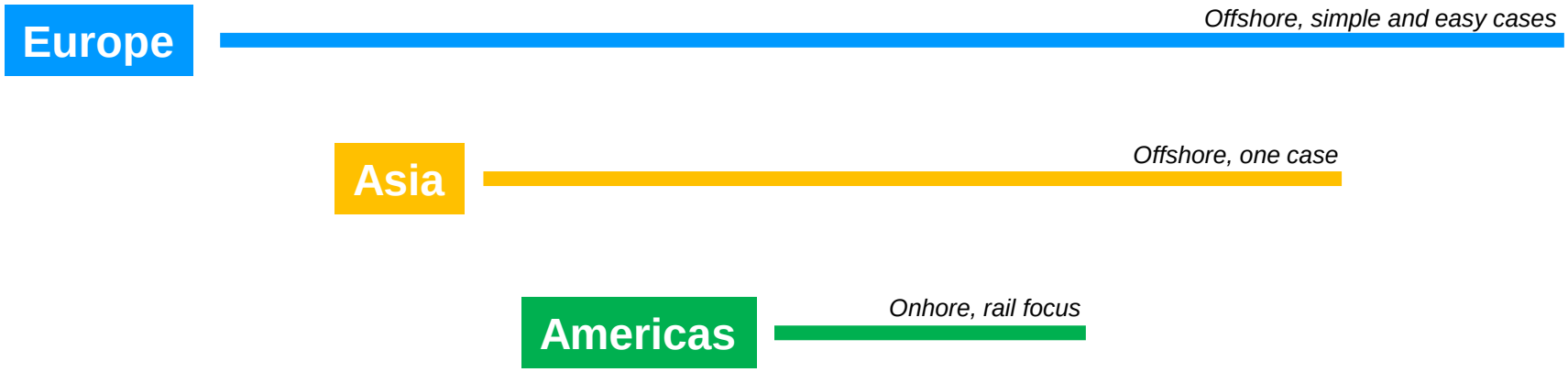
Number of companies

Time spent

Extent of case study scope

Depth

Width



Broad industry support

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

Reference Group

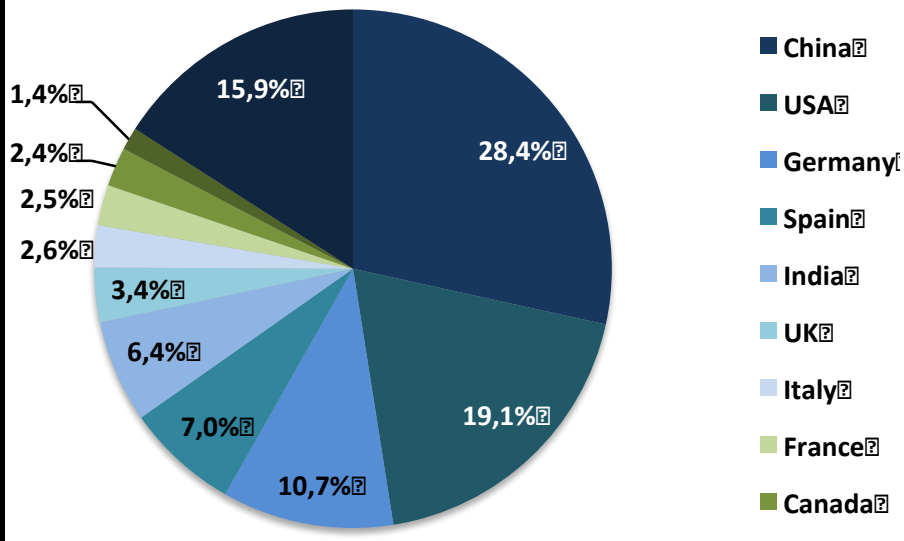
Market beyond 2020? How big and heavy will it get? By when?

1. TECHNOLOGY AND MARKET

10 largest onshore wind markets - up until 2013

Top 10 global onshore markets			
Ranking	**Country**	**Cumulative**	**2013 new**
1	China	91460	16052
2	USA	61292	1084
3	Germany	34468	2729
4	Spain	22637	175
5	India	20589	1987
6	UK	10946	1028
7	Italy	8448	450
8	France	8128	535
9	Canada	7813	1599
10	Portugal	4557	196
Rest-of-the-world		51221	10299
Grand total		321559	36134

Cumulative percentage distribution

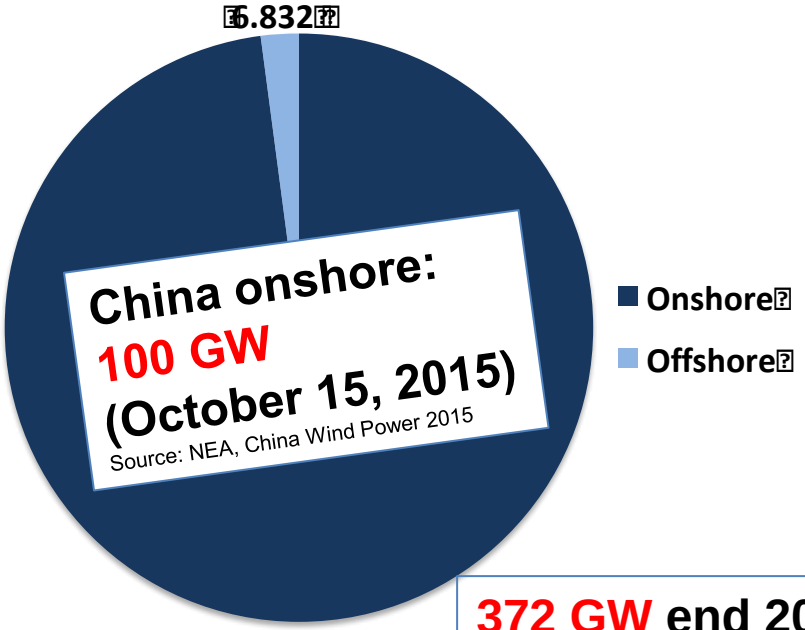


372 GW end 2014
51 GW added capacity 2014
Source: Navigant Research, 2015

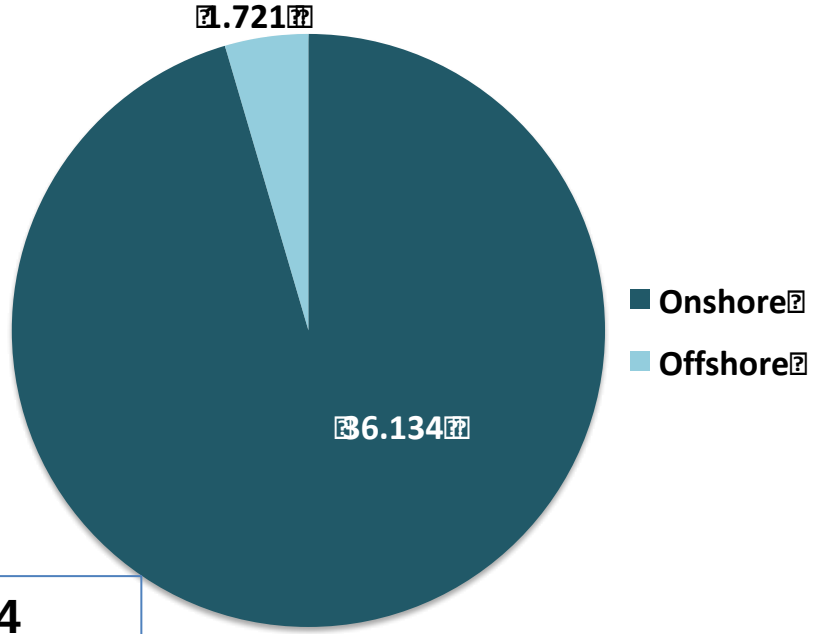
Source: BTM Consult part of Navigant (2014) and own construction

Onshore and offshore distribution

Cumulative distribution ultimo 2013 (MW)



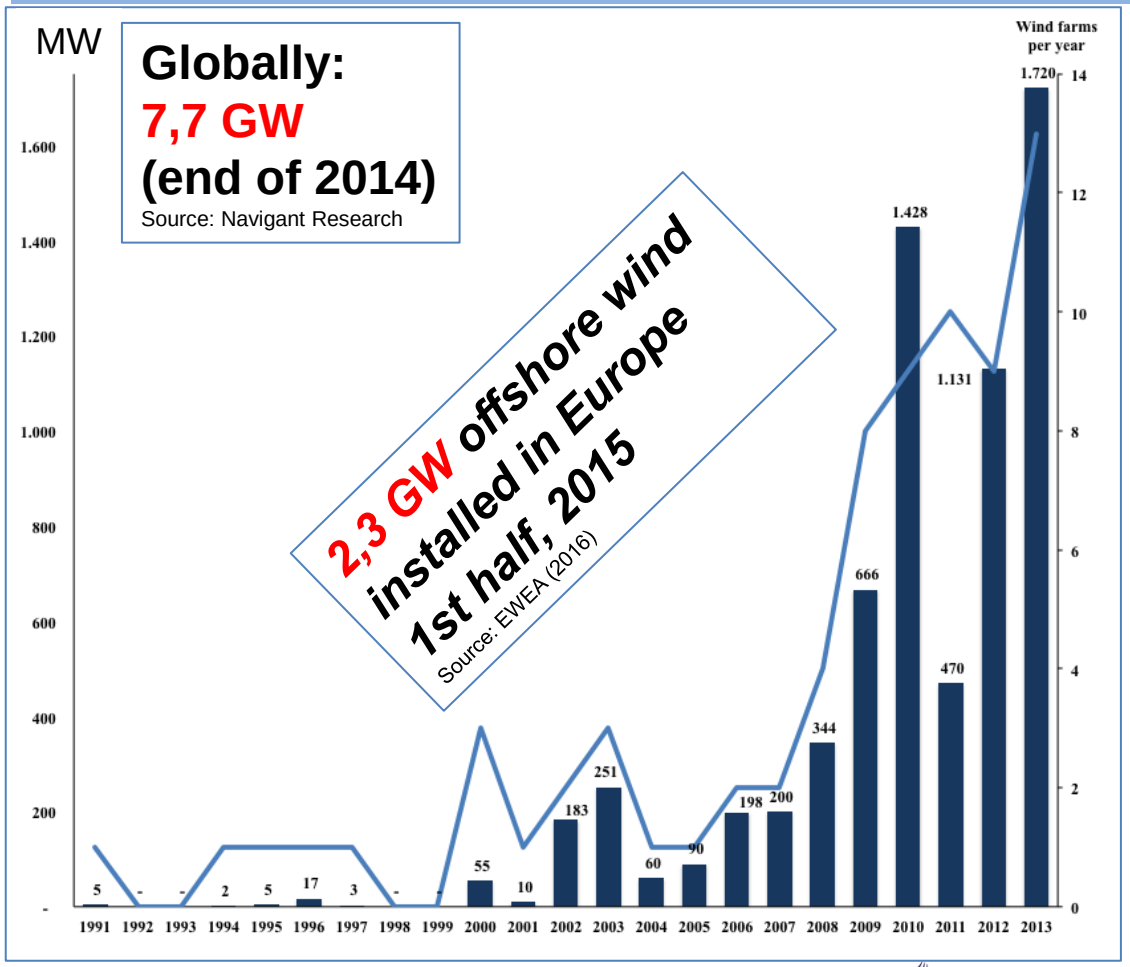
Installed distribution in 2013 (MW)



372 GW end 2014
7.7 GW offshore wind
Source: Navigant Research (2015)

Source: BTM Consult a part of Navigant (2014) and own construction

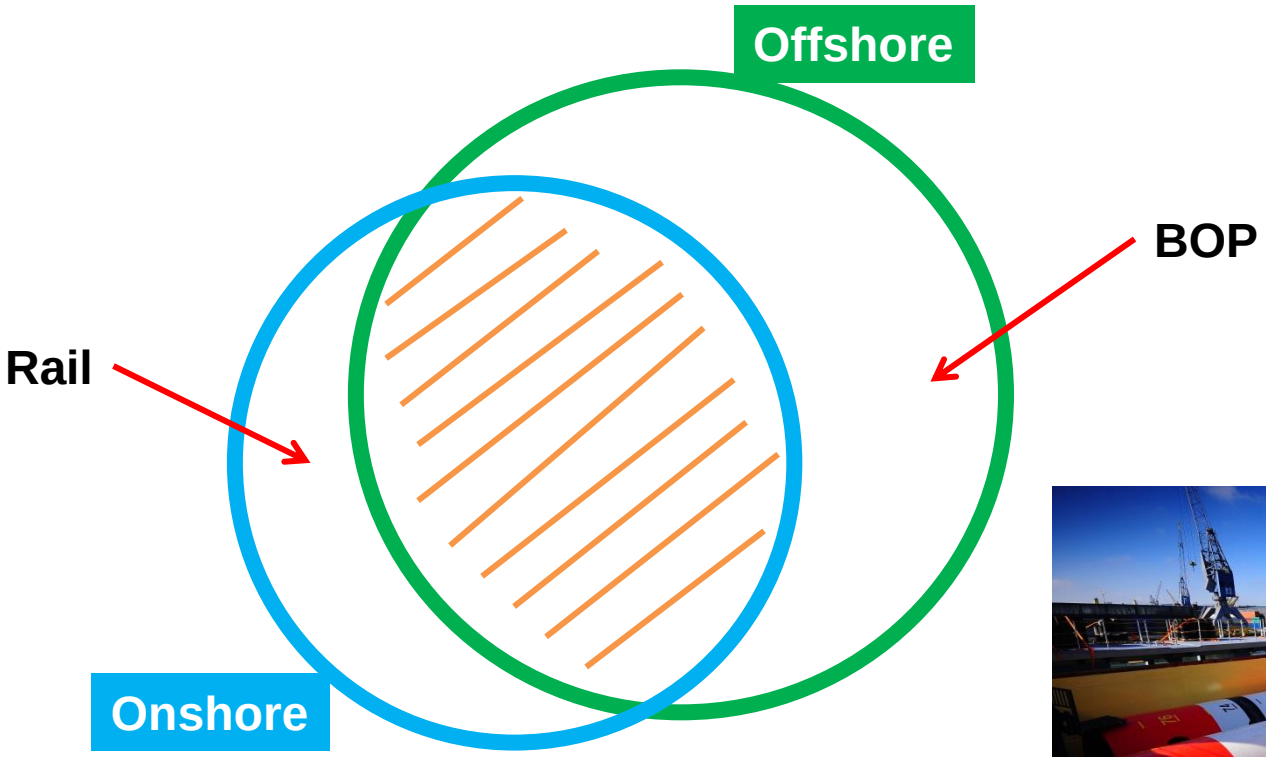
Number of offshore annual MW and wind farms installed up to and including 2013



Year	MW installed	Number of wind farms
1991	5	1
1992	-	0
1993	-	0
1994	2	1
1995	5	1
1996	17	1
1997	3	1
1998	-	0
1999	-	0
2000	55	3
2001	10	1
2002	183	2
2003	251	3
2004	60	1
2005	90	1
2006	198	2
2007	200	2
2008	344	4
2009	666	8
2010	1.428	9
2011	470	10
2012	1.131	9
2013	1.720	13

Source: BTM Consult a part of Navigant (2014a) and own construction

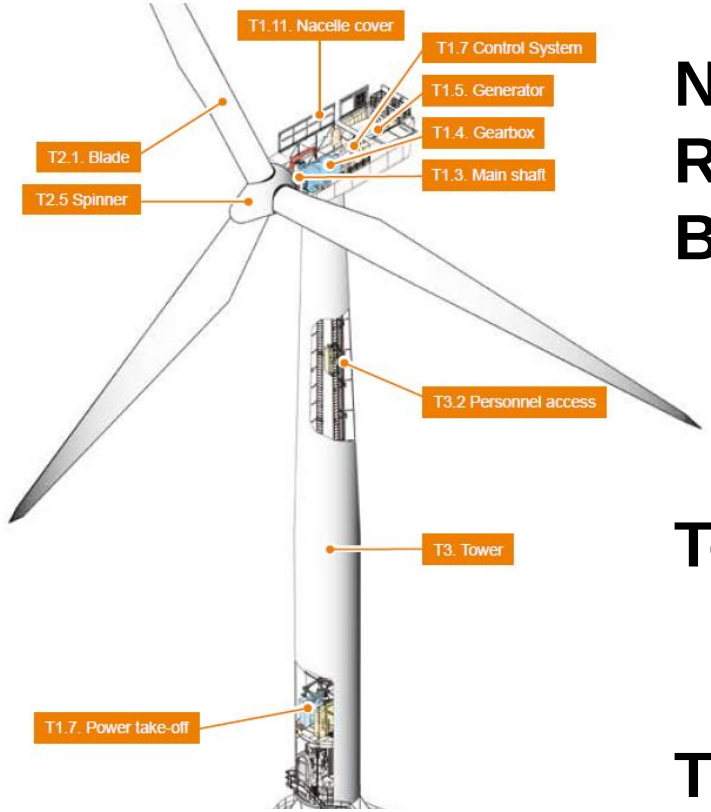
Onshore and offshore - logistics



Source: AAU research
Photo: Courtesy J Poulsen Shipping

Today's super star

- The offshore wind turbine
- SWP 3.6 MW power horse



Nacelle
Rotor Blades

Tower

Export and array cables

Transition Piece

Offshore sub-station

Foundation /Jacket

Accommodation platform/vessels

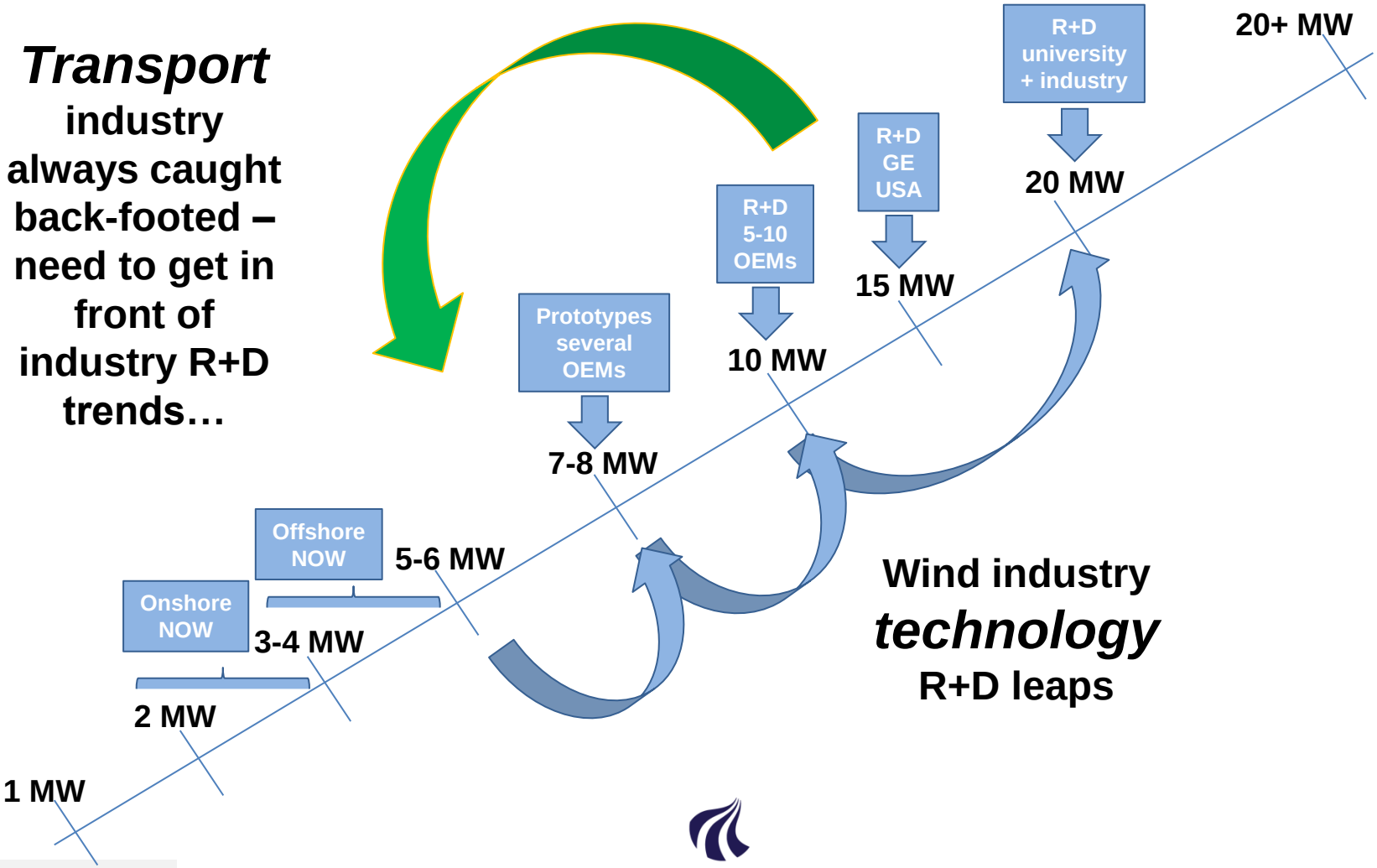
Monopile

Source: Siemens '

Onshore vs. offshore

Innovation – what comes first?

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



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R+D - logistics

Implications on:

- **Infrastructure (roads, bridges, tunnels, viaducts, storage facilities, ports)**
- **Logistics and shipping assets (trucks, trains, vessels, helicopters)**
- **Lifting equipment (land-based cranes, sea-borne cranes)**
- **Transport equipment (lifting equipment, transport frames, seafastening)**
- **Health, safety, security, environment, and quality (HSSEQ)**

Makers of wind turbines (OEMs):

The pioneers

N·E·G MICON Powerful Simplicity Vestas

BONUS Energy A/S SIEMENS

GE NASA

The "other" Europeans

ENERCON ENERGY FOR THE WORLD

NORDEX We've got the power.

ALSTOM

Gamesa

AREVA

Adwen AN AREVA GAMESA COMPANY

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Examples of the Asian "newcomers"

金风科技 GOLDWIND

SINOVEL 华锐风电

联合动力 United Power

HYUNDAI HEAVY INDUSTRIES CO.,LTD.

SAMSUNG

UNISON

SENVION wind energy solutions

SUZLON POWERING A GREENER TOMORROW

ENVISION

Source: AAU research, DHL Global Forwarding, Renewable Energy Solutions

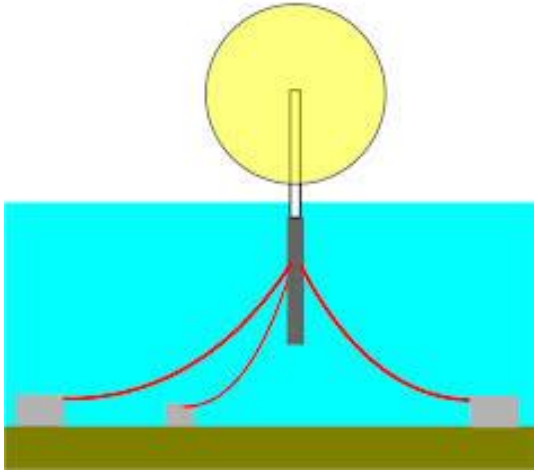
Dimensions – Logistics challenges

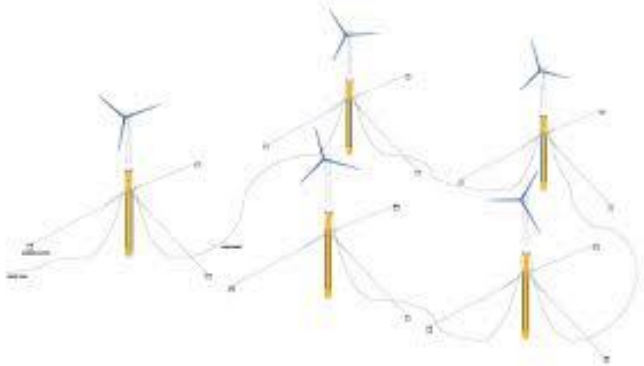
Source: Danish Shipowners' Association, courtesy Siemens Wind Power

And what about…?

Floating turbines…

- Installation?
- O&M?





How big is big enough?

Weight & Dimensions	Full nacelle weight (t)	Hub weight (t)	Total Hub Mass (t)	Blade Length (m)	Blade weight (t)	Tower weight (t)
Siemens 2.3 MW	82			45		
Repower 6.15 MW	325			61		
Siemens 6 (7) MW	364	96	360	75	27	
Samsung 7.5 MW				83		
Vestas 8 MW	390			80		
NREL/DTU 10 MW	446	106-180	700	86-100	42-57	628
NREL 15 MW		303	1000	125	100	1000
DTU 20 MW	1061	299		125	118	1985

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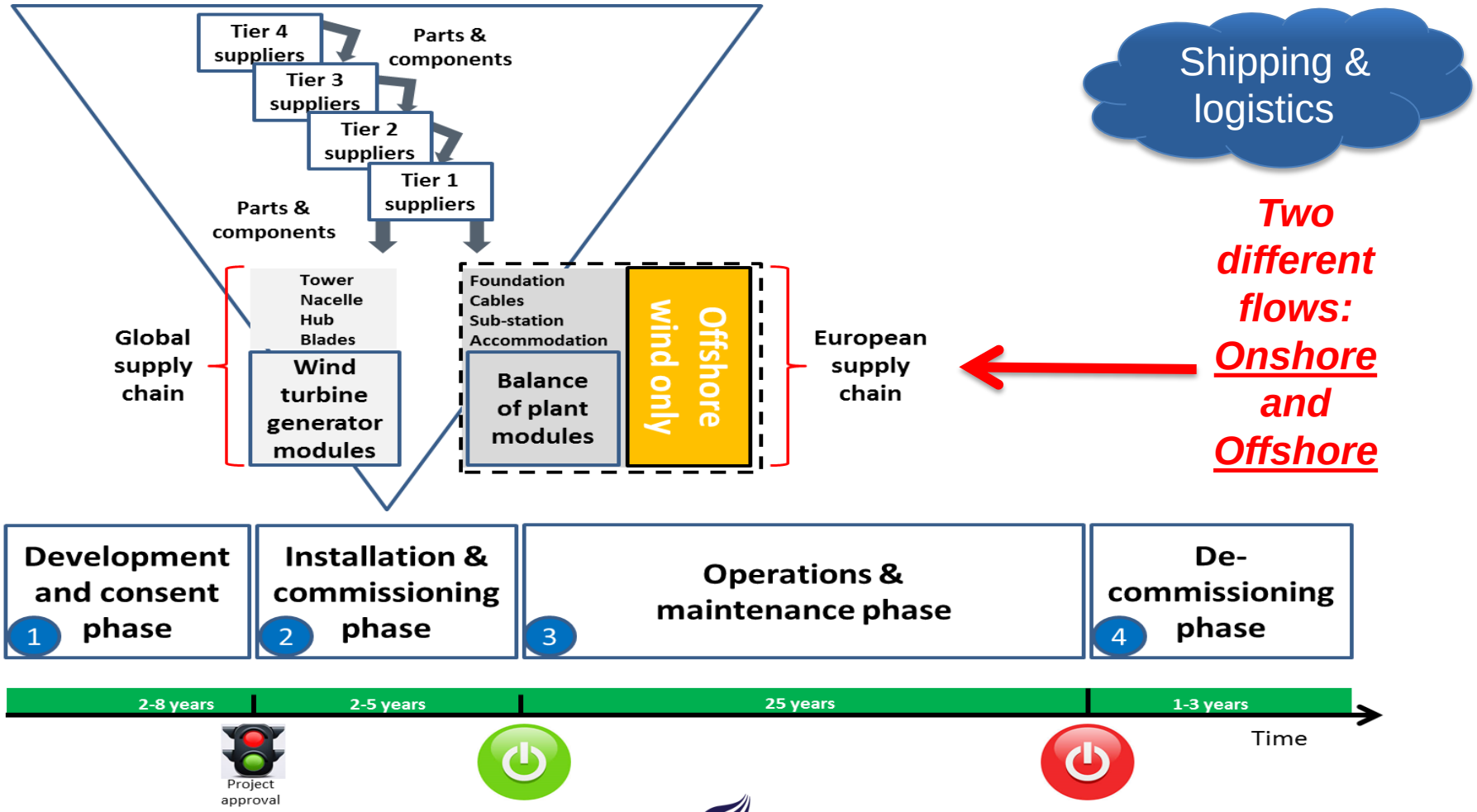
Source: AAU research, NREL, DTU Risø Wind, Siemens Wind Power, Renewable Enerergy Solutions

Are there more supply chains? Are they different or similar?

2. SUPPLY CHAIN COMPOSITION

Single project life-cycle E2E



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Source: LogMS conference paper, 2013, Singapore 2013, Poulsen et.al.

Scoping of the Ph.d. research

First Reference Group meeting scoping conclusion:

Wind energy supply chains						
Wind farm phase	***Development & Consent (D&C)***	***Installation & Commissioning (I&C)***		***Operations & Maintenance (O&M)***		***De-commissioning (De-comm)***
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 larger 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

The race is on for larger WTG output
- and importance of shipping/logistics/SCM

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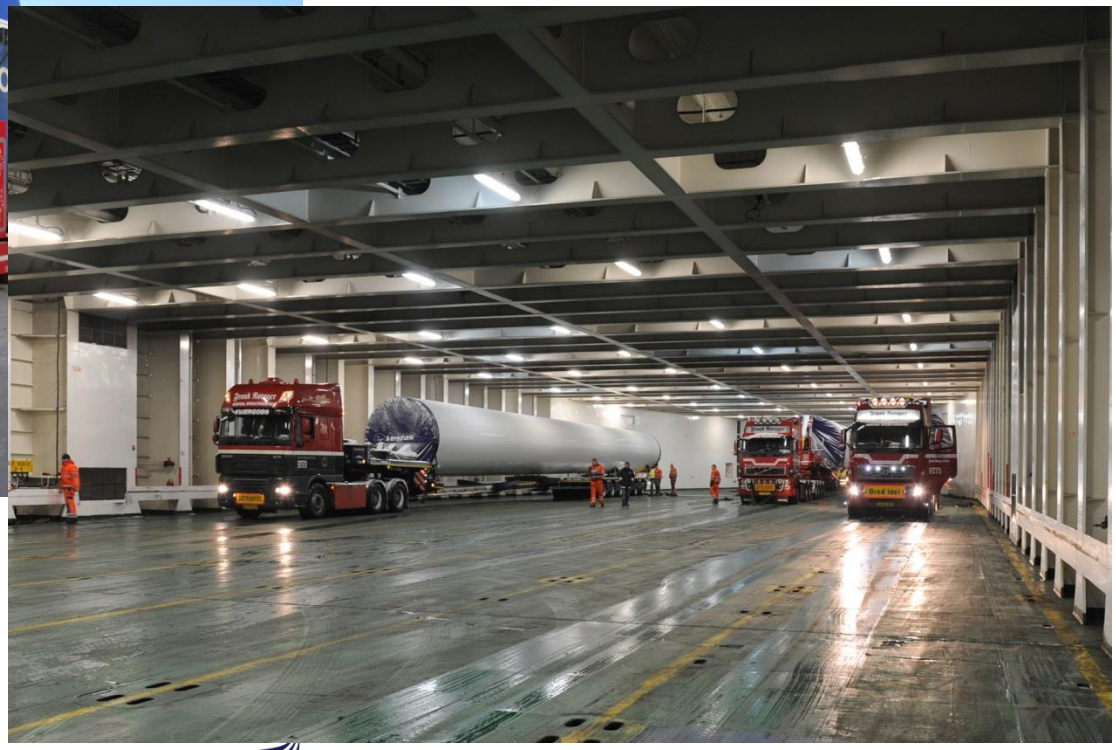
Source: Upwind Project (design limits and solutions for very large wind turbines) and Aalborg University Copenhagen photos

RO/RO safety

Source: Siemens Wind Power internal newsletter

RO/RO safety



Source: DFDS

But also D&C and O&M…

Latest in wind O&M
(SOV)

Surveys

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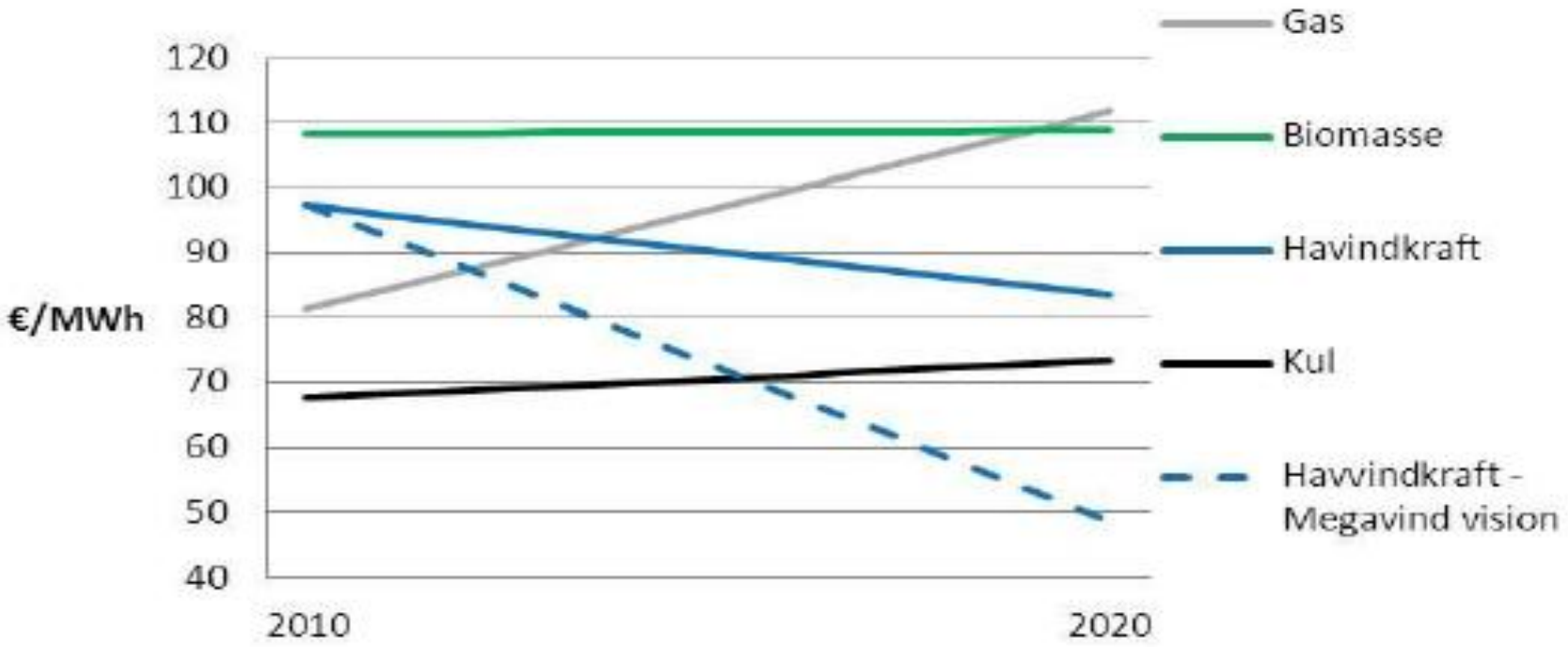
Source: CT Offshore

Does logistics matter? What is logistics as a percentage of LCoE?

3. THE COST OF LOGISTICS

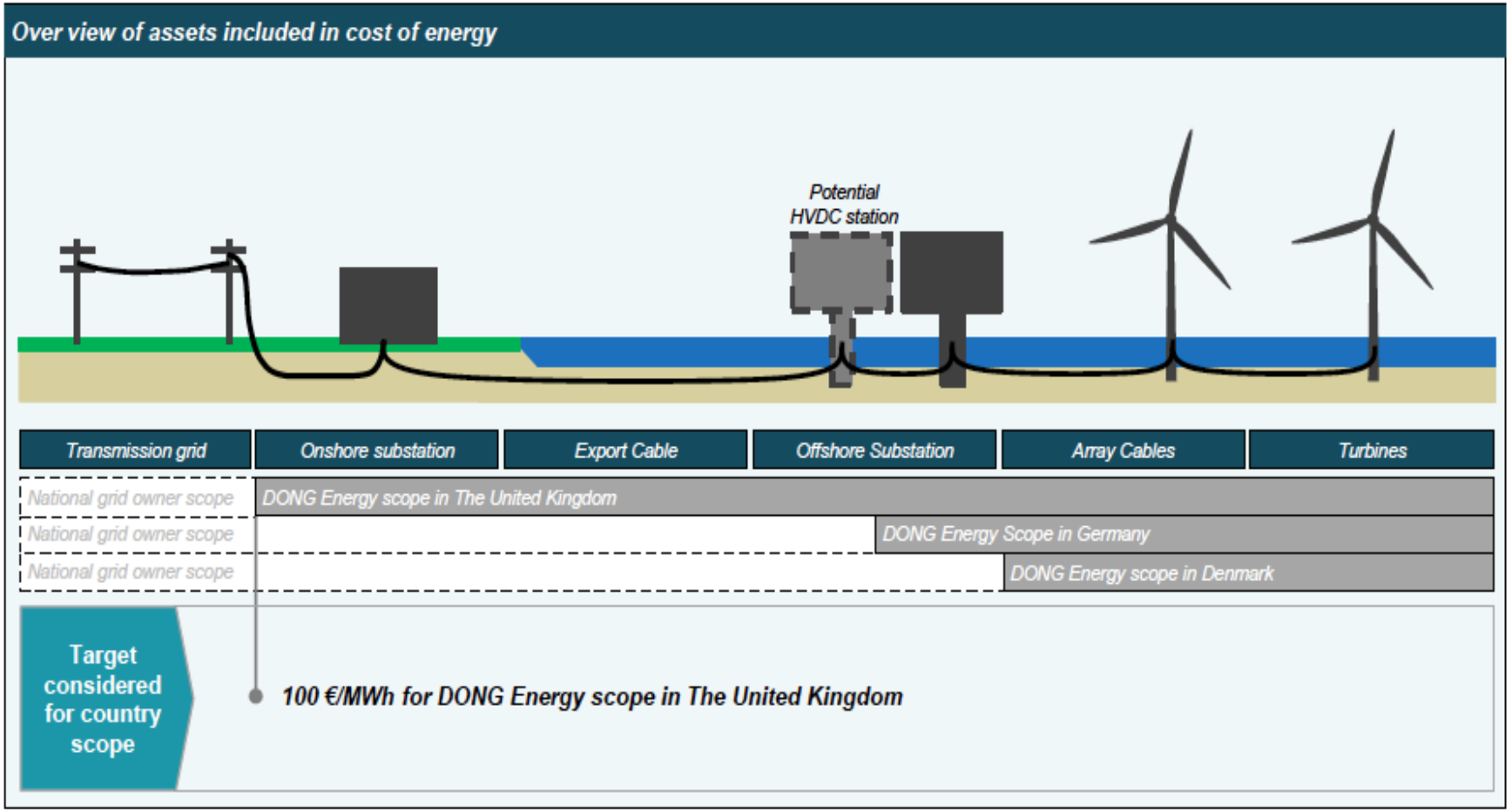
The Cost of Energy challenge

Forward Cost of Energy projections
(Danish Energy Administration vs DWIA)

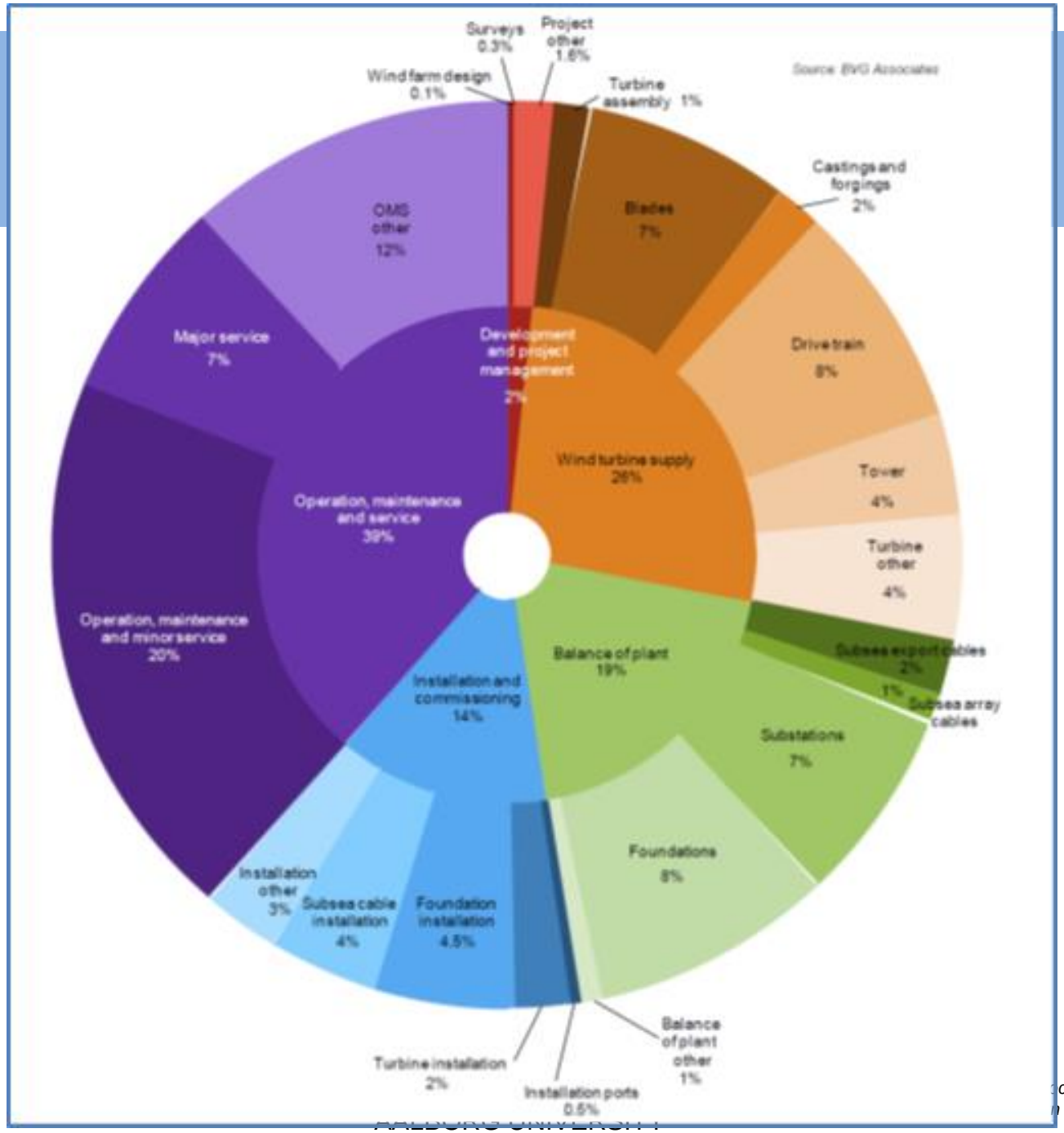


Source: Megawatt Baggrund – Det nye offshore (DWIA)

Different ways to estimate LCoE



Source: DONG Energy



ciates for the Estate, 2014

Who? What? How?

4. THE CONSTITUENCIES

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

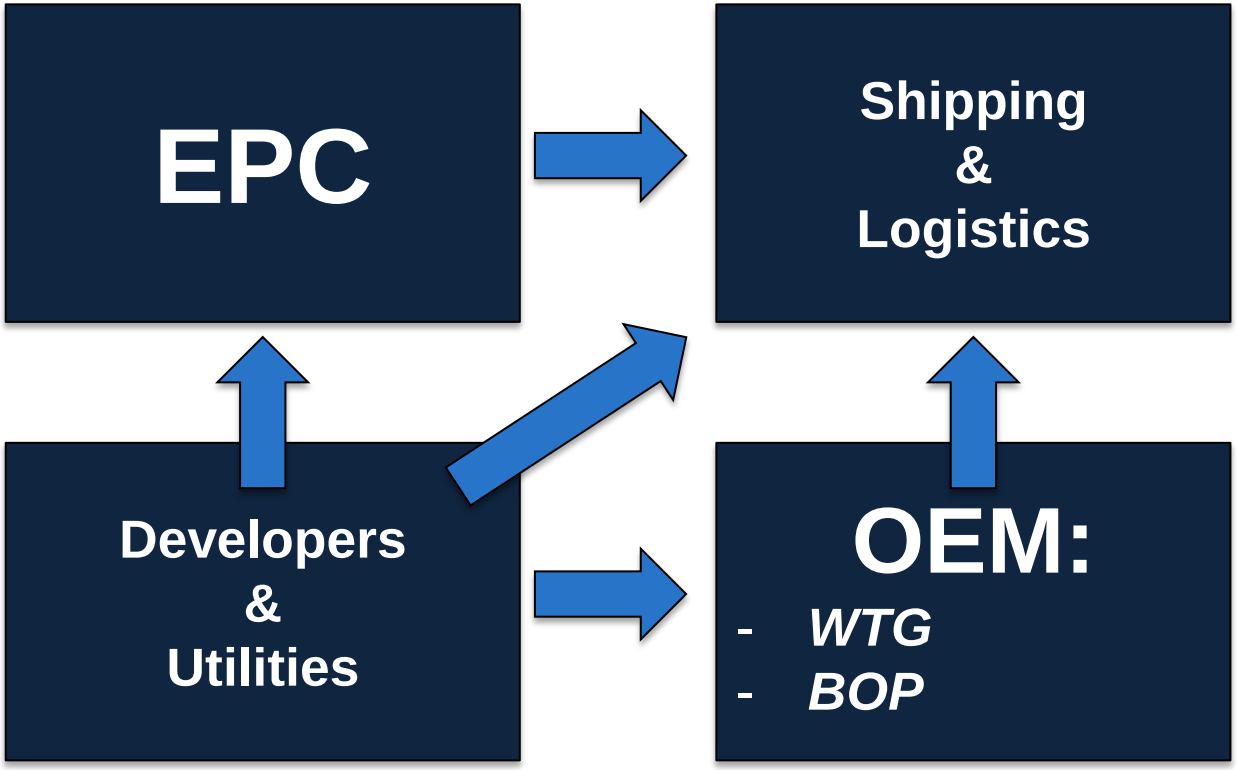
Land based cranes

Utilities | **Operators** | **OEM's** | **EPC companies** | **SWF**

Extent of services

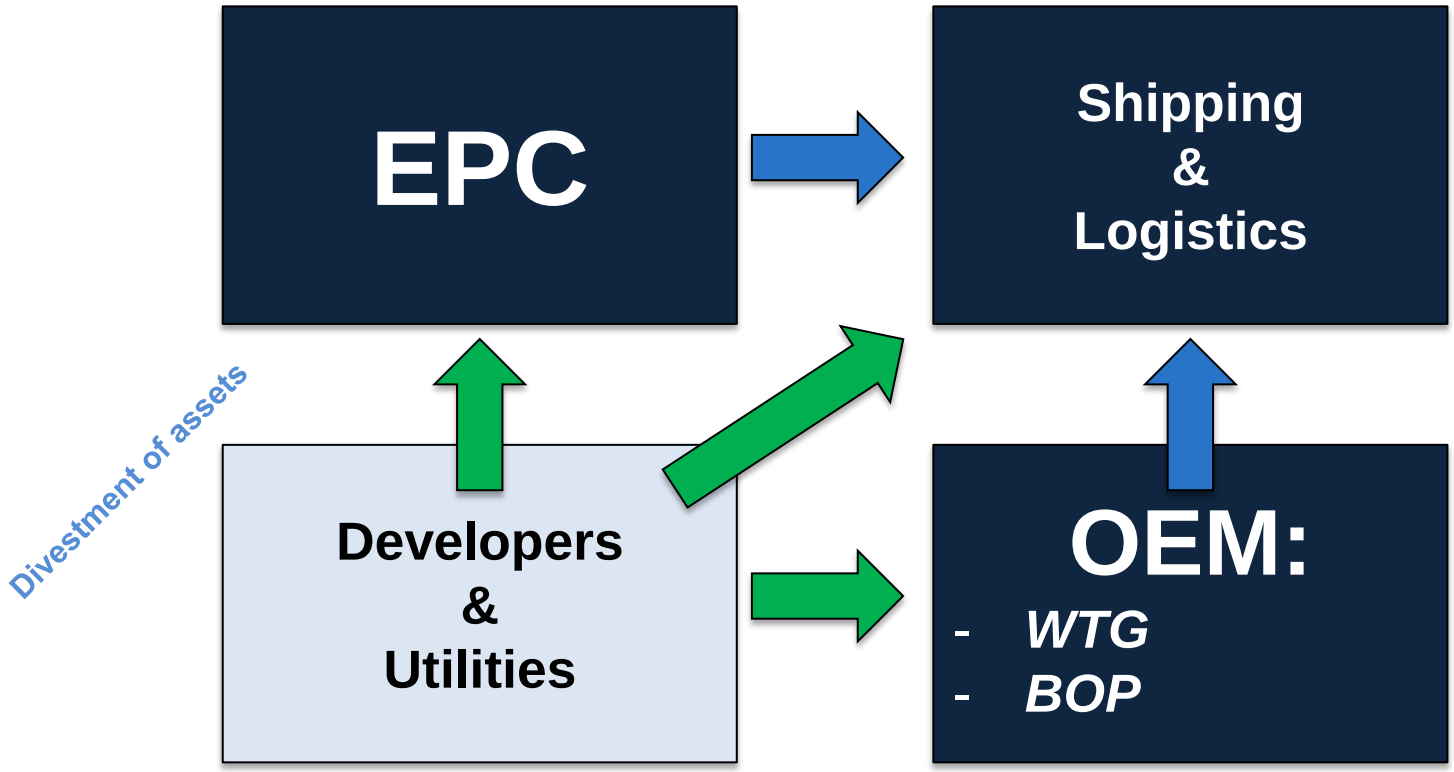
Shipping/logistics order flow 2015

Hypothesis: Europe



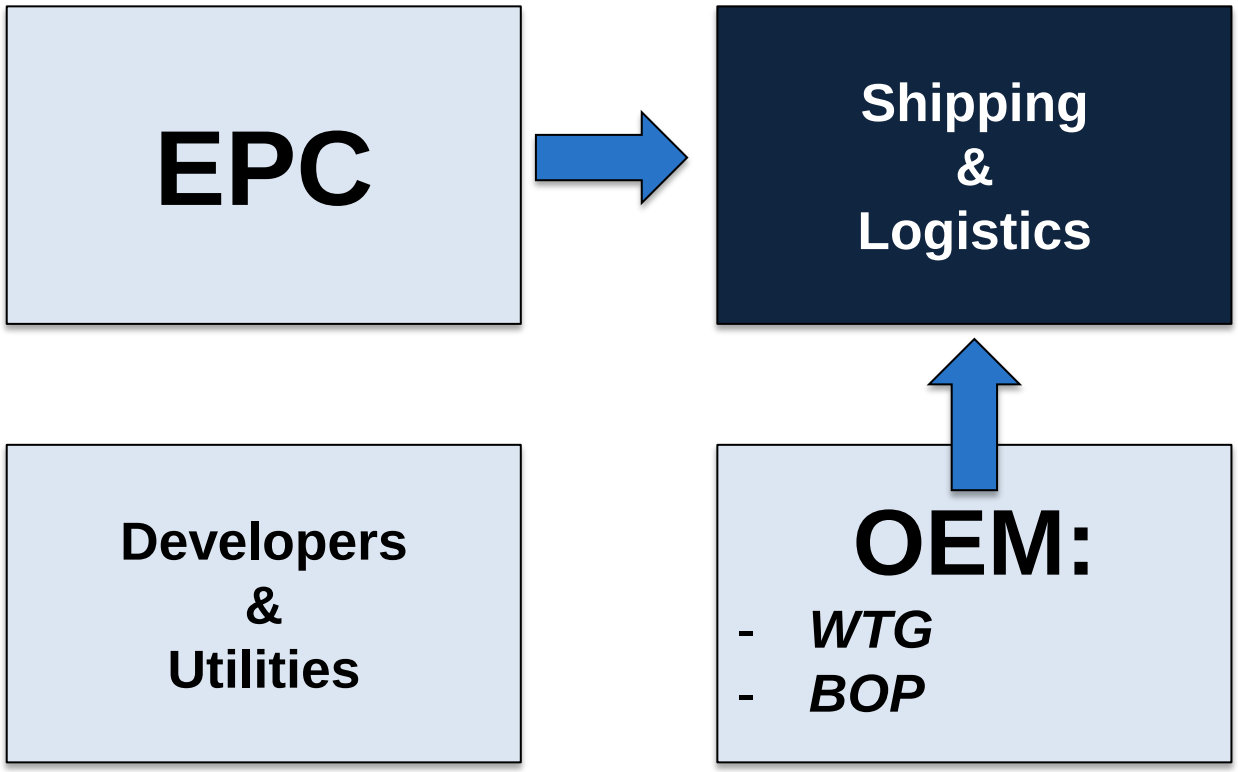
Shipping/logistics assets 2020

Hypothesis: Europe



Continued divestment 2030

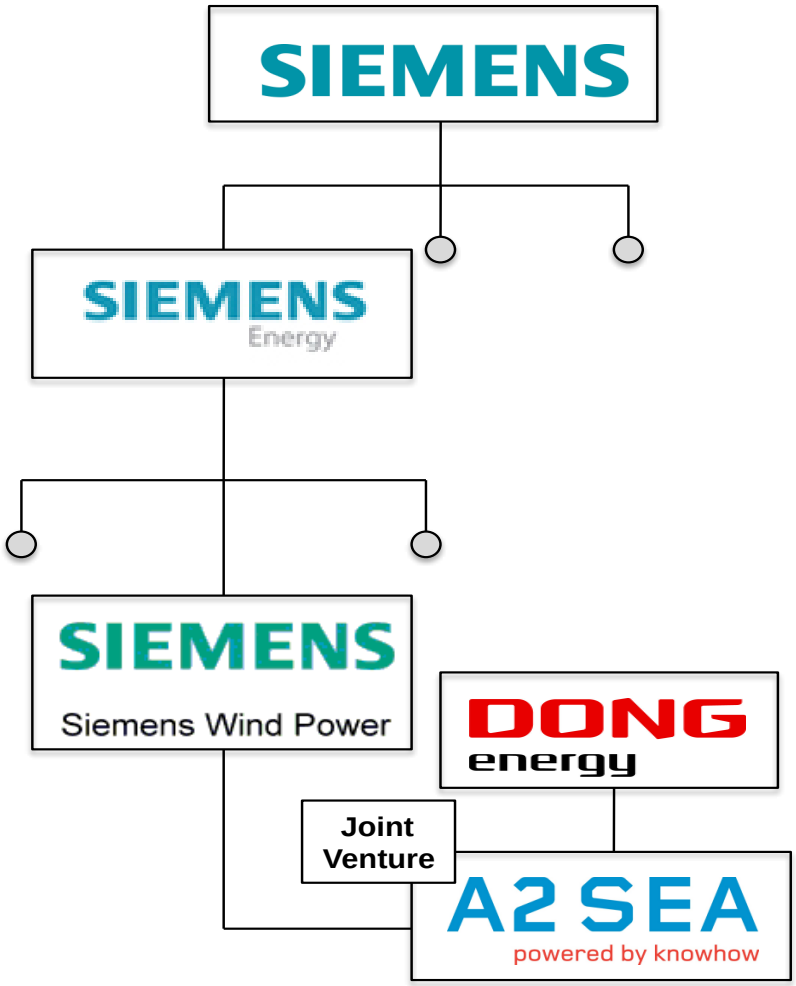
Hypothesis: Europe



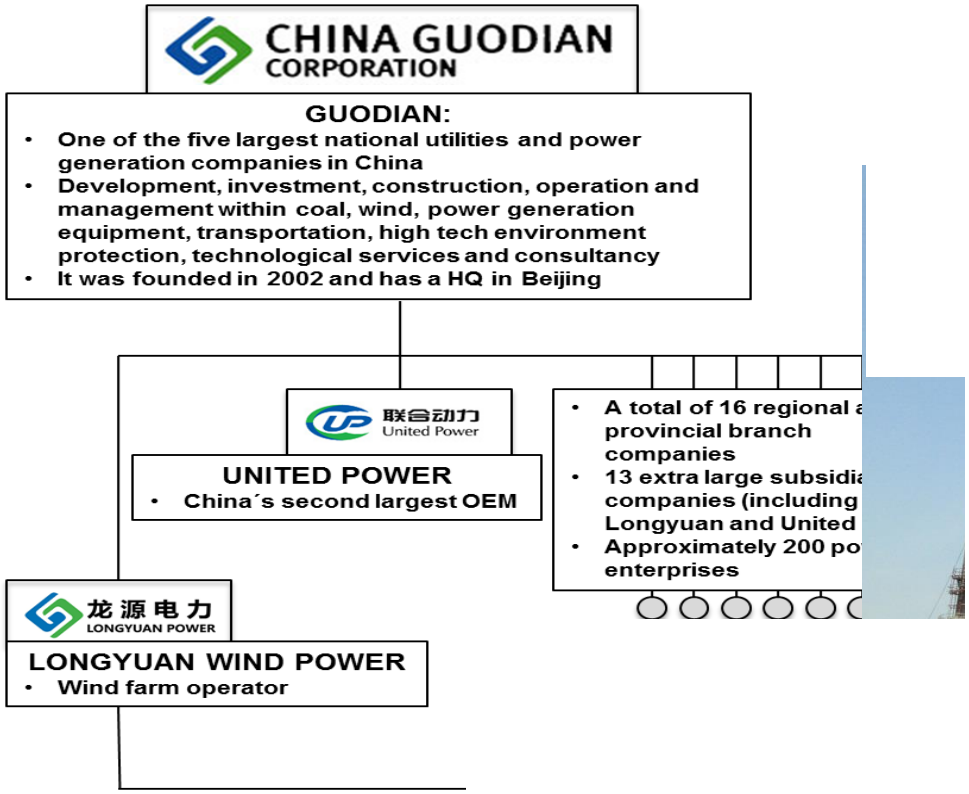
How to win? Locally/regionally/globally? O&G experience or not?

5. STRATEGIES & BUSINESS MODELS

Business Model in Denmark

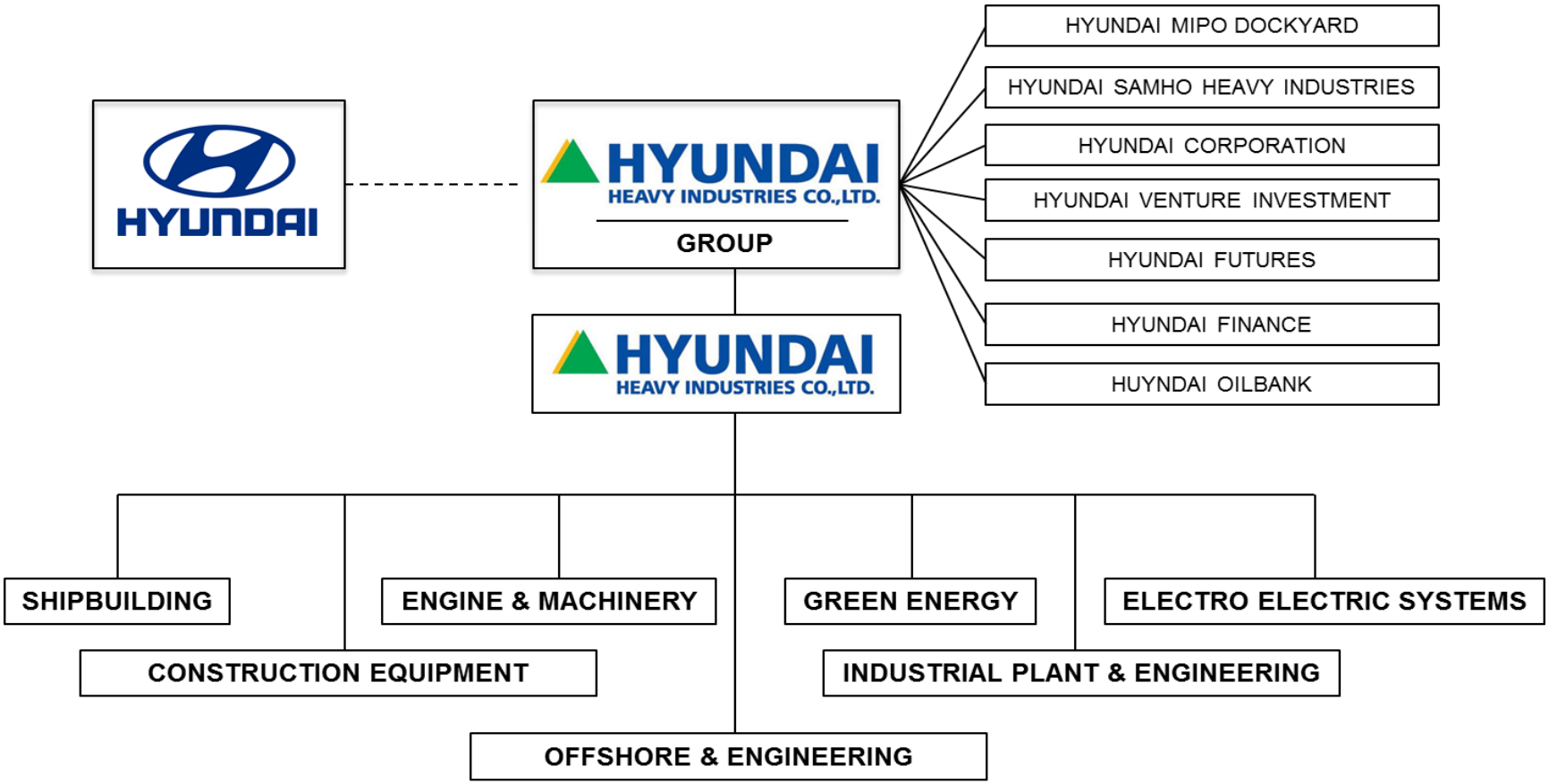


Vertically and horizontal integrated business model China



Top South Korean Chaebol….

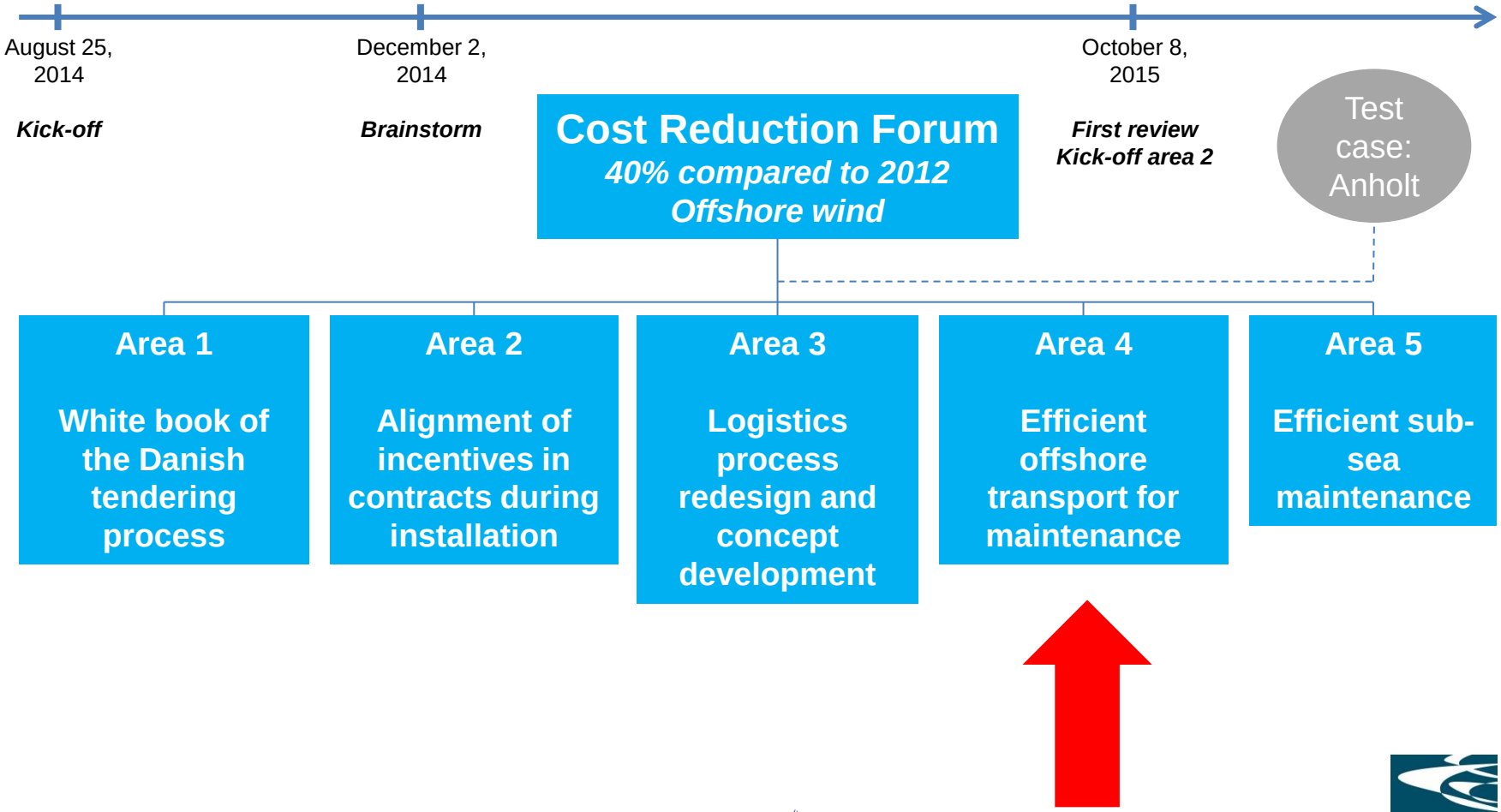
Horizontal and vertical integration



The research so far

THE CASE STUDY RESULTS

Case: Cost Reduction Forum



Area 4: O&M Transport, 7 steps

Pre
Exploratory

#1
Brainstorm

#2
Ranking

#3
2 groups
Idea development

#4
2 groups
Implementation

#5
Review

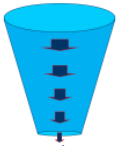
#6
Present to CRF

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

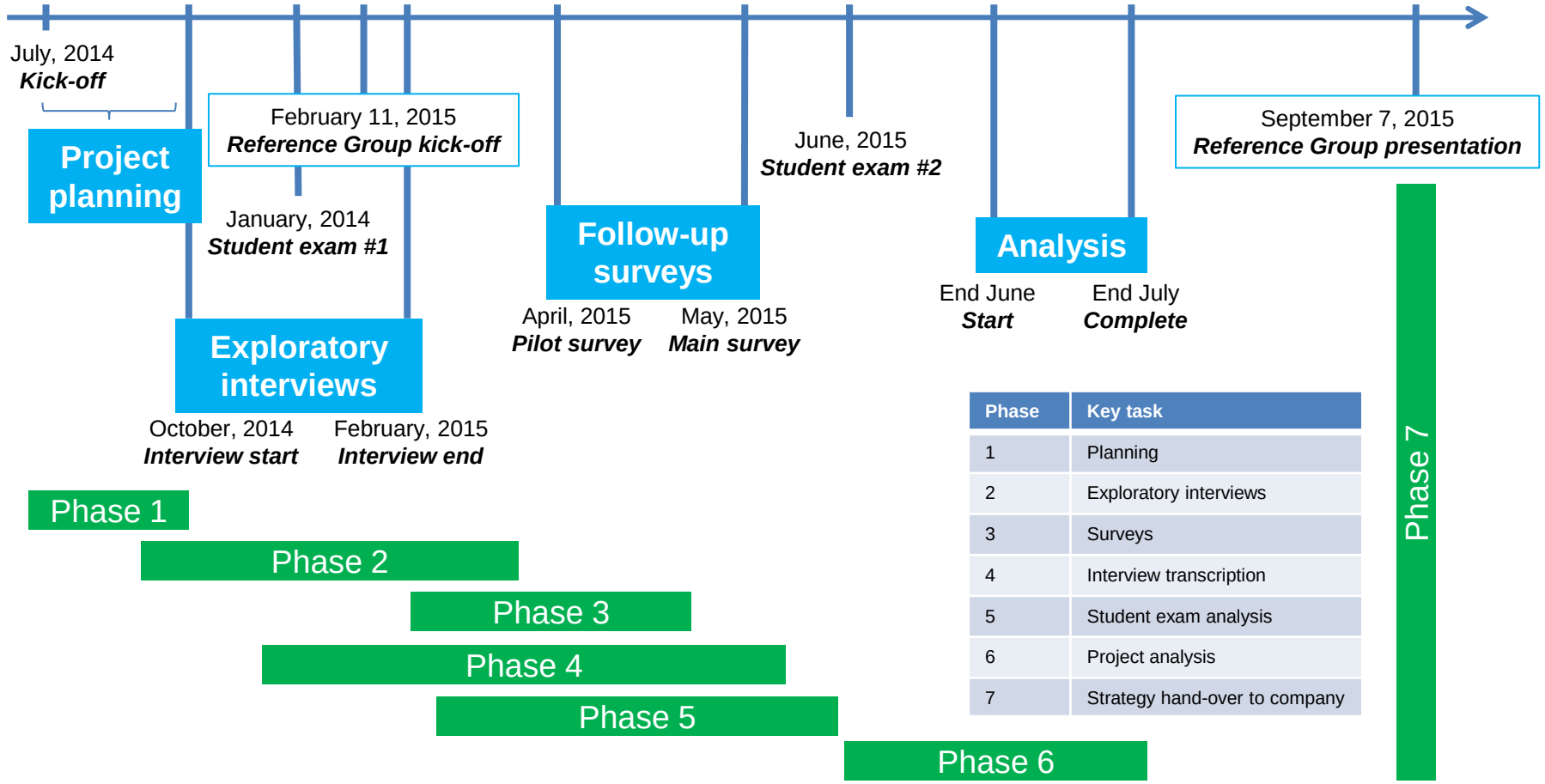
Likeliness

Business case #1

Business case #2

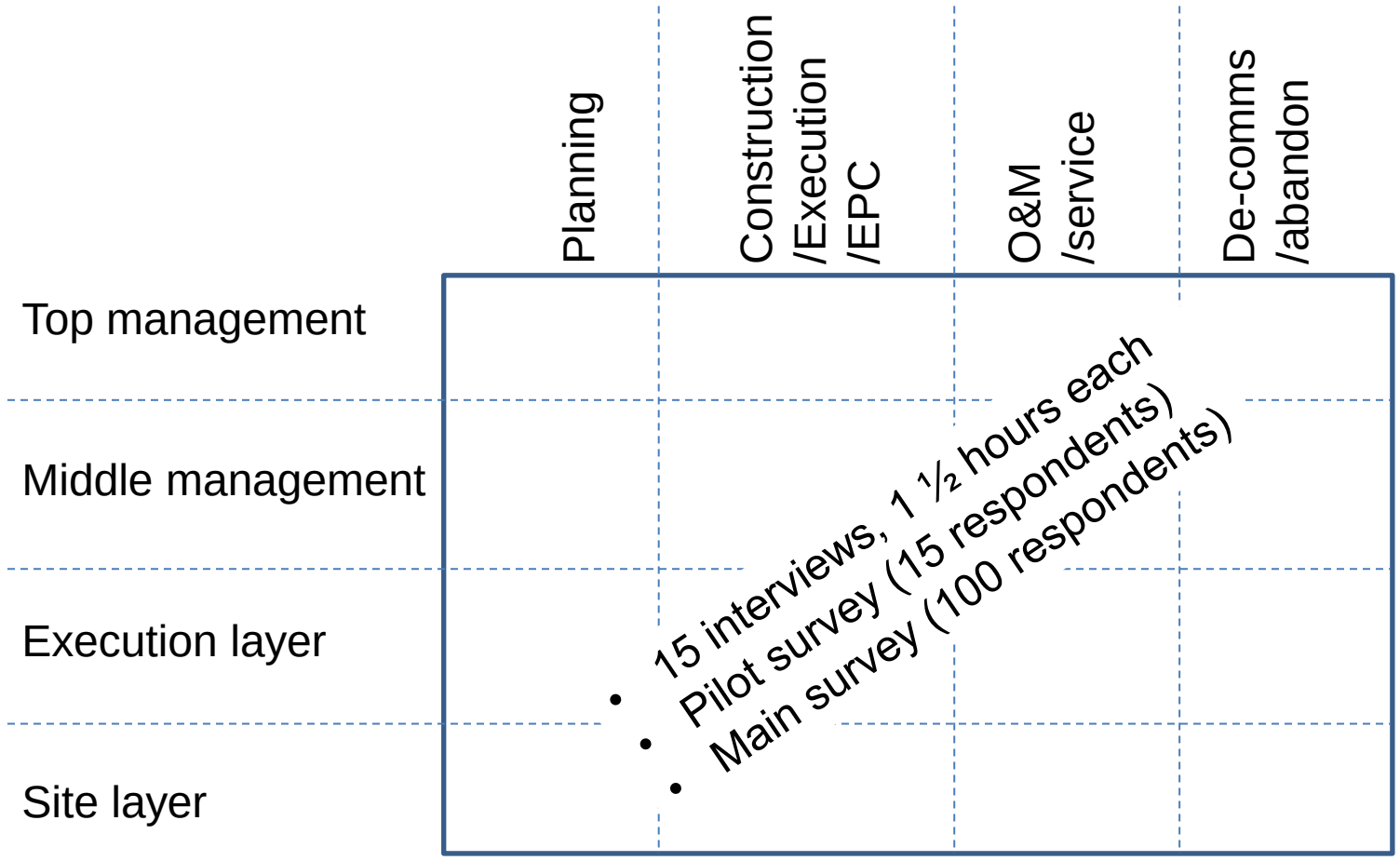
Phone interview

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



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"

Source: CSCMP

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

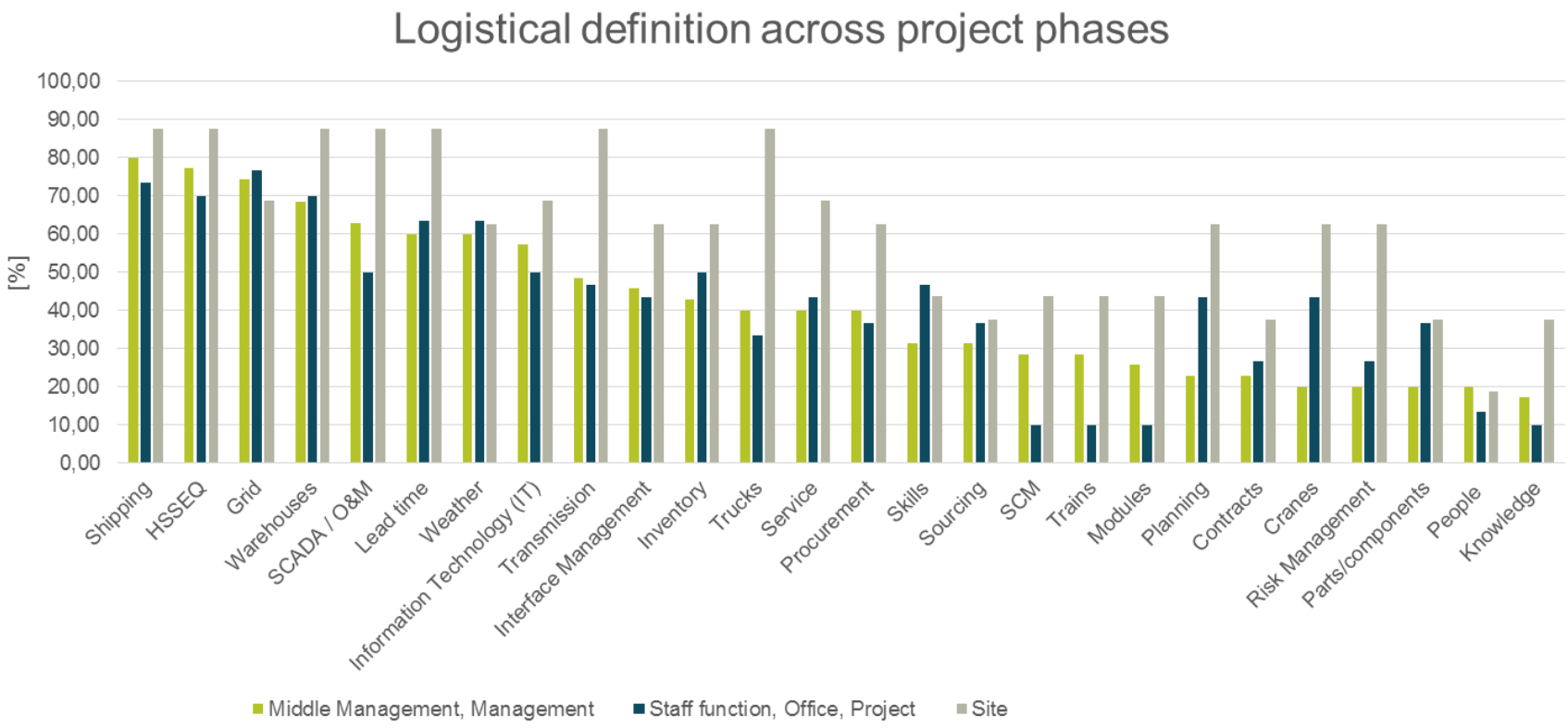
Conclusion:

"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

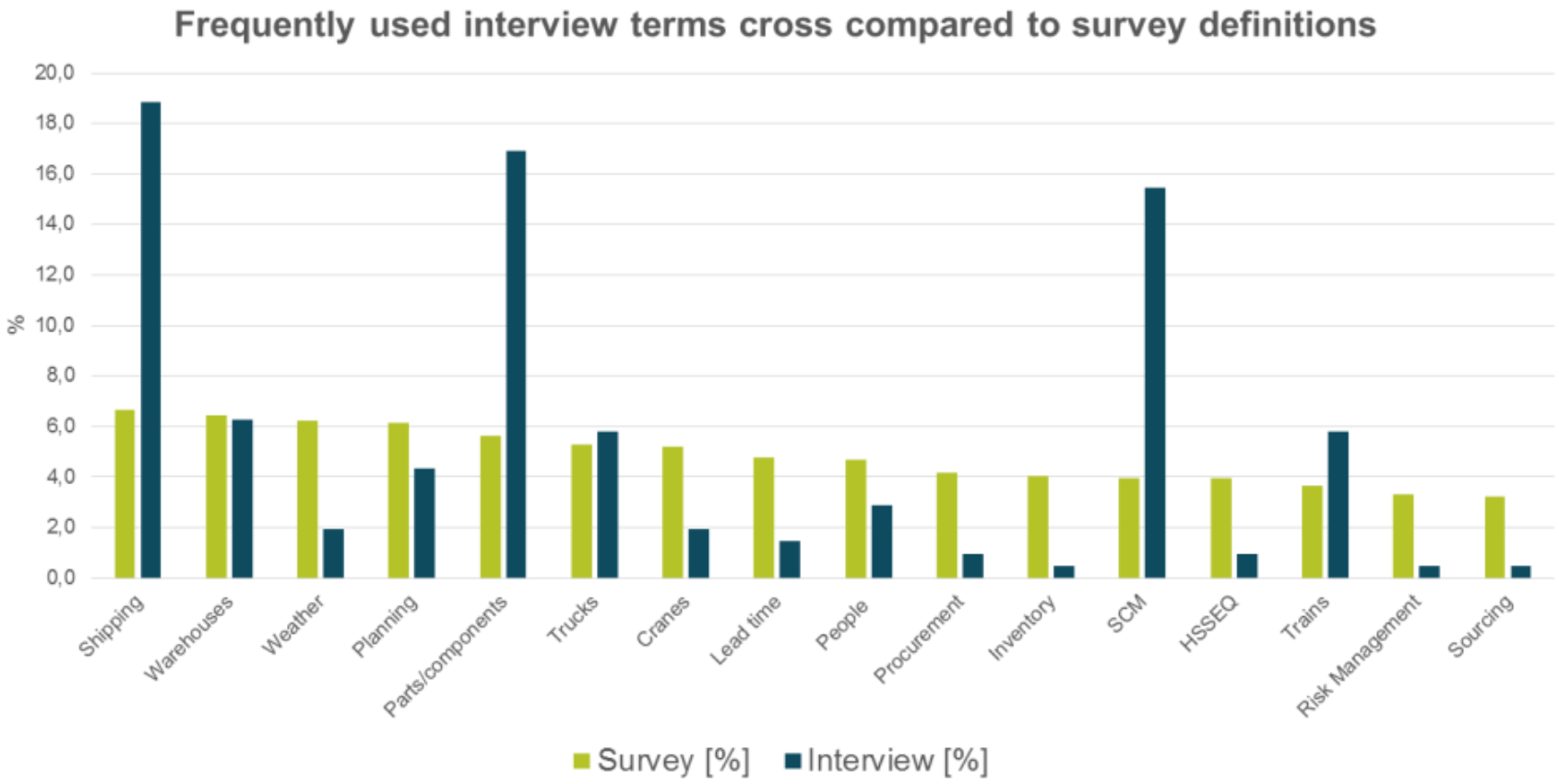
Source: First Reference Group meeting

One of our recent case studies



Source: AAU research, survey results 2015

Firm vs industry language



Source: AAU research, survey and interview results 2015

Case study deep-dive: Firm lingo

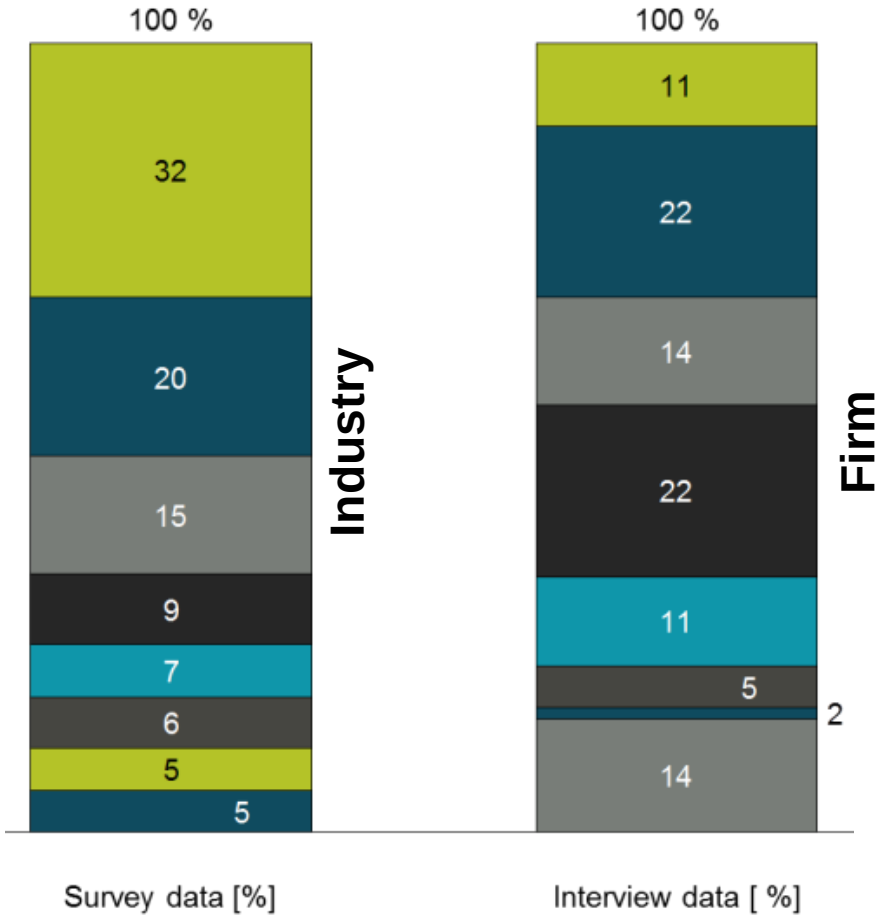
Shipping
Transport
Vessel
Crew transfer vessel
Helicopters
Transportation as part of installation
Accomodation vessels
Survey vessels
Other vessels
Offshore
Transportation with installation vessel
Personel logistics
Execution
Installation vessel
Unloading
Prepare for shipping
Sailing

Parts/components
Foundations
Turbines
Cable
Goods/components
Towers
Building materials
Spare parts
Equipment
Suppliers
Survey equipment
Fixed platform
Life vests
Tools
Installation vessel
Onshore activity
Transition assets
Return of faulty component
Distribution
Unloading
Logistics concepts
Traffic

SCM
Delivery
Reduce delivery time
Setup around transportation
Preparation prior to execution
Coordinate logistics activities
Aligned flow of components
Installation
Logistics in O&M
Transport
Starts at production
End-to-end
Between different countries
Tier one customer
Idea to project handower
Quay site
Build a wind park
Supply
Onshore projects
Knowledge re transportation process quality

Source: AAU research, interview results 2015

Case study: Categories



Source: AAU research, survey and interview results 2015

OW innovation: Siting is crucial

1. Distance to shore
2. Water depth
3. Number of wind farm turbine positions
4. Weight and dimensions of WTG, foundation, and other BOP
5. Seabed conditions

- ✓ Near shore
- ✓ Offshore
- ✓ Far offshore

Source: AAU research

In Europe…

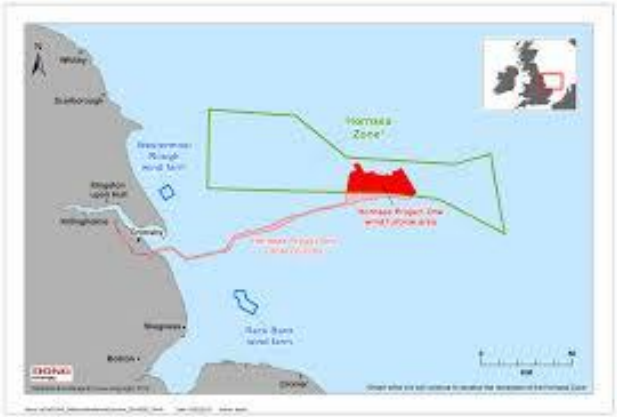
- Similar wind conditions:

➢Horns Reef III

VATTENFALL

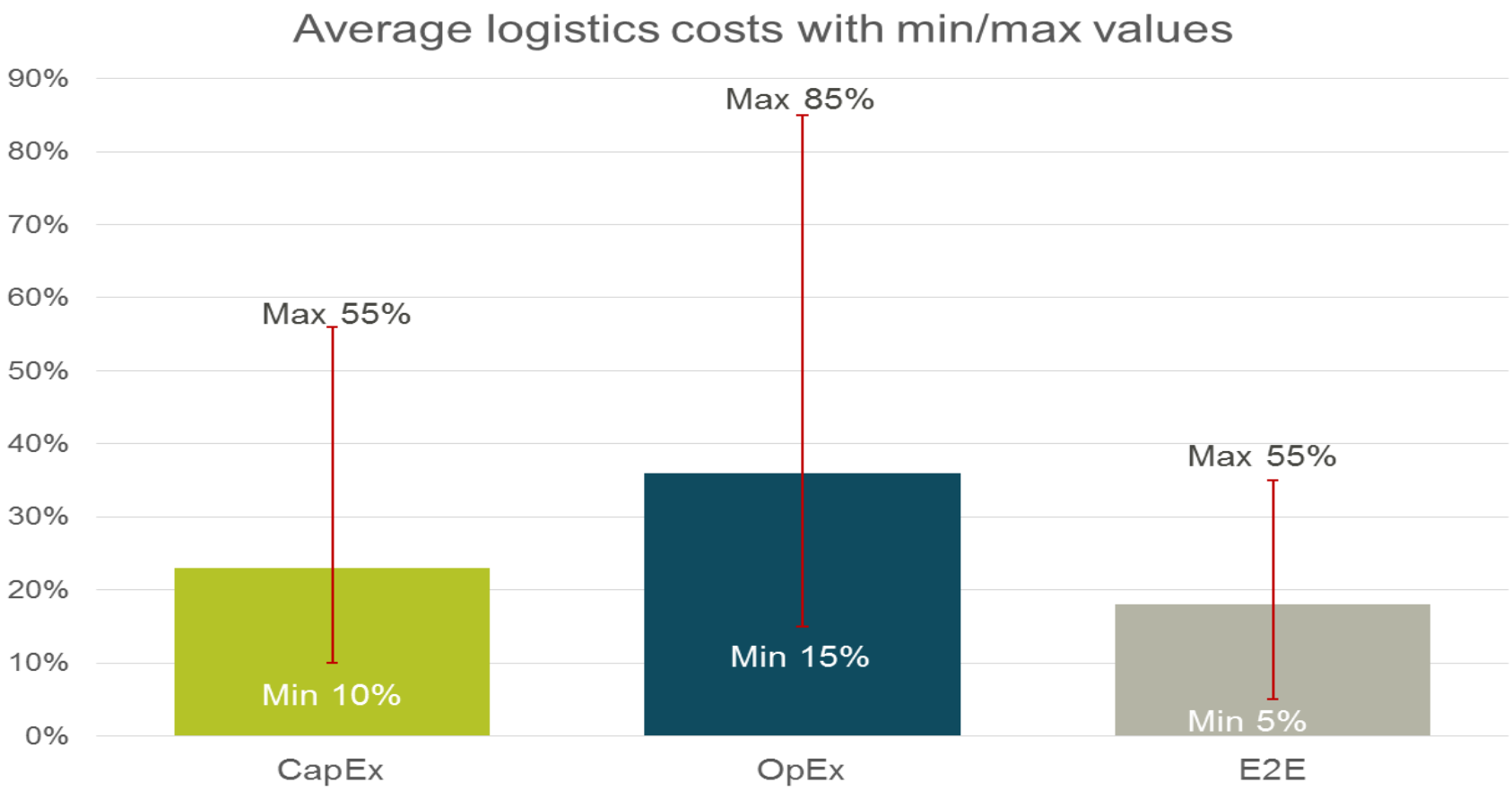
➢Hornsea

DONG energy



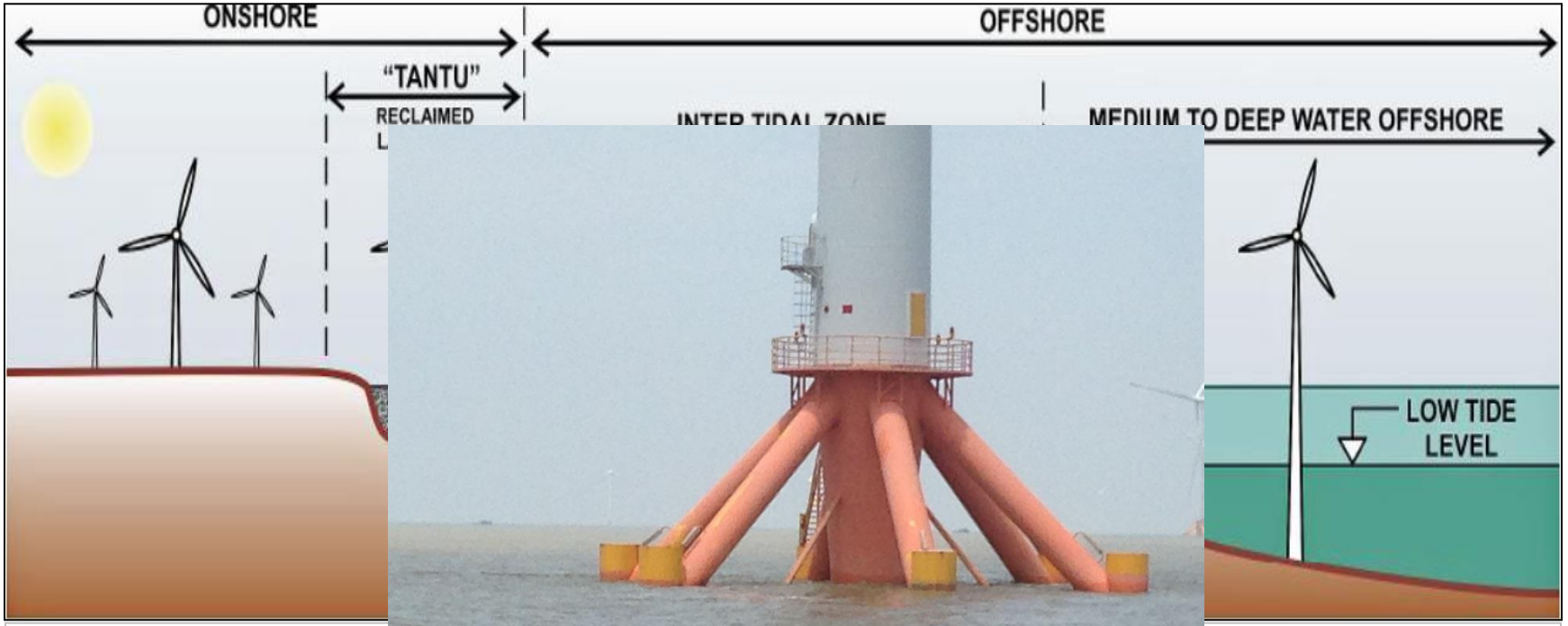
Source: AAU research and case study interview findings, 2015

The money: Recent case study



Source: AAU research, survey and interview results 2015

3rd PAPER: Industry, global, M&A



Example Jiangs Zhenhua JV):

- 30 km from shore, during low tide
- Eastern part of farm will need WTIV's to be permanently jacked up out of the water
- Requires different kinds of vessels than in Europe

Source: NEA & World Bank (2010), BTM Consult part of Navigant & Poulsen (2012), and AAU research

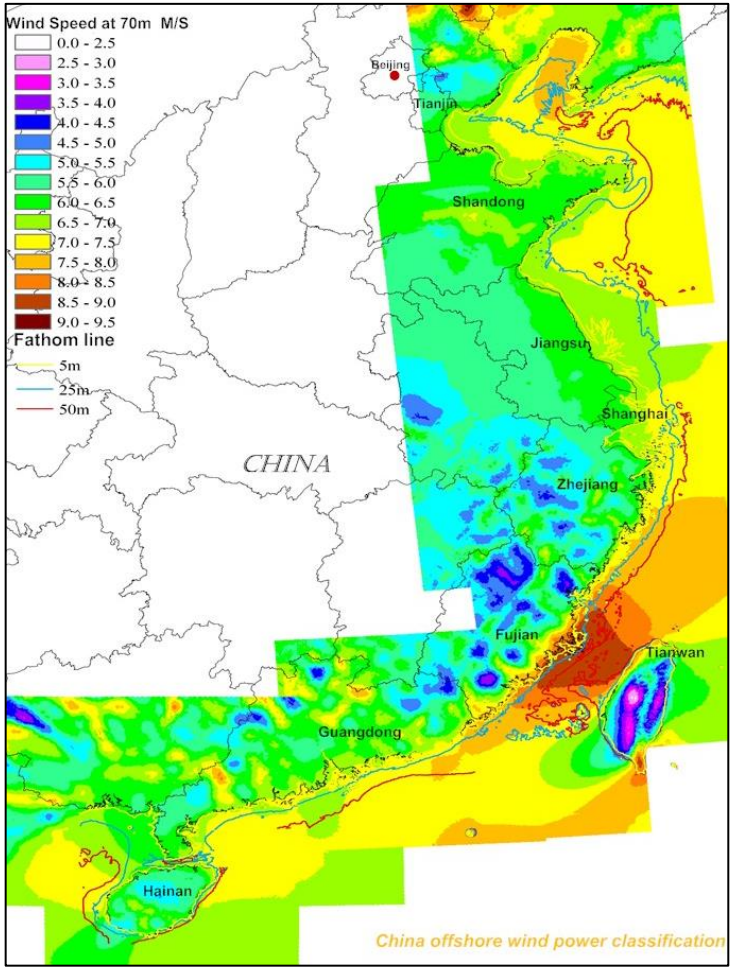
Wind resource map of China

- **18.000 km long coastline**
- **From shoreline to water depth of 20m = 157.000 km²**
- **Assuming only 10%-20% is suitable for offshore wind and the use of an average 5 MW WTG´s**

→ 100-200 GW offshore capacity

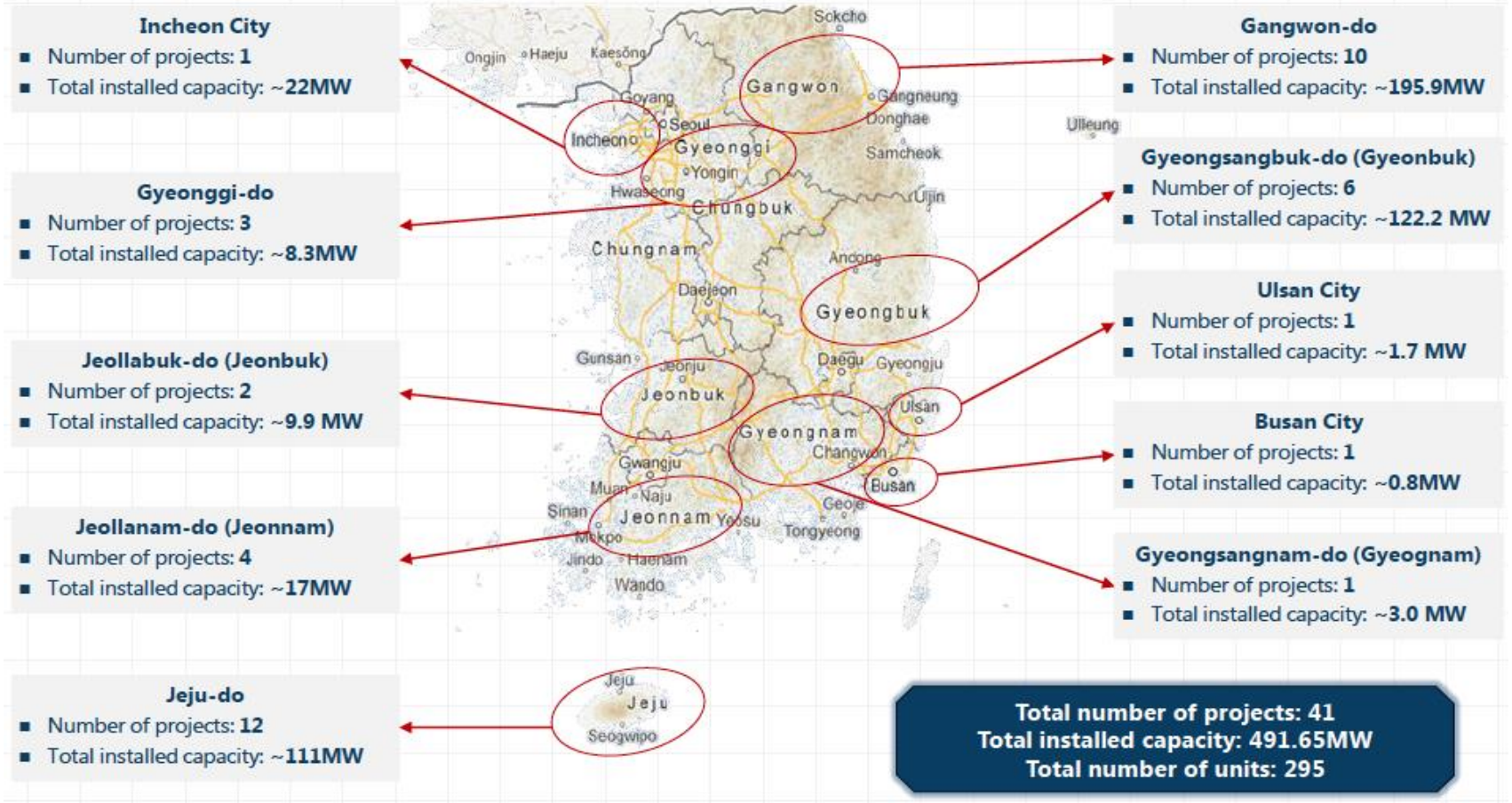
Offshore resources in China are spread across:

- **Jiangsu**
- **Zhejiang**
- **Fujian**
- **Shandong**
- **Guangdong**
- **Shanghai**



Source: Renewable Energy Solutions, BTM and data from National Climate Center of the China Meteorological Administration, June 2010

South Korea – more realistic?



7.5 GW home market offshore wind target by 2030

Source: Korea Wind Energy Association (2013)

Example from paper

Strategies and business models compared with the derived SCM industry example

Strategies and business models of select wind energy market constituencies					
Company name	**Origin country**	**Company type**	**Dimension 1: Business focus**	**Dimension 2: Integration of support industries**	**Shipping/logistics subsidiary or JV company name**
DONG Energy	Denmark	Semi-government owned	Conglomerate, utilities	Wind energy shipping JV with Siemens Wind Power	A2SEA
Vattenfall	Sweden	Semi-government owned	Conglomerate, utilities	No owned wind shipping activities	
RWE Innogy	Germany	Semi-government owned	Conglomerate, utilities	Wind energy shipping subsidiary	Offshore Logistics Company GmbH
Siemens Wind Power	Germany	Publicly listed	Conglomerate	Wind energy shipping JV with DONG Energy	A2SEA
Vestas	Denmark	Publicly listed	Exclusive wind focus	No owned wind shipping activities	
Hyuandai Heavy Industries	South Korea	Publicly listed	Conglomerate, chaebol	Own shipping activities like Hyundai Merchant Marine	
Suzlon	India	Private	Exclusive wind focus	No owned wind shipping activities	
Goldwind	China	Publicly listed	Exclusive wind focus	No owned wind shipping activities	
Guodian	China	SOE	Conglomerate, utilities	Wind energy shipping JV with CCCC	Jiangsu Longyuan Zhenhua Marine Engineering

Source: Own construction

Example from paper

M&A changes the landscape

- **Hochtief** – Beluga joint venture with Hochtief dismantled and Belgian firm GeoSea took over Beluga's shares and formed new company with Hochtief called HGO IntraSea Solutions:

- **A2Sea** – Acquired by DONG Energy who subsequently sold 49% to Siemens Wind Power

- **Swire** – Acquired Danish Blue Ocean and formed Swire Blue Ocean

- **Aarsleff** – Joint venture with German shipping company Bilfinger Berger called AB-JV:

M&A activity is picking up

- **DSV** - Acquired Baltship / Seatainers:
- **Mammoet** - Acquired KR Wind (cranes) and subsequently Brande Maskintransport (trucking):
- **Marubeni** - Acquired Sea Jacks:
- **Beluga** - Company was restructured by private equity Oak Tree (US) into Hansa Heavy Lift, many Beluga vessels taken over by banks and given to Döhle and Oldendorff to manage on behalf of the banks
- **NSG** - Acquired Danbor and later Øer

Latest M&A activity

- **Shipping.dk** – acquired Maersk Broker Agency from the Danish/Swedish Mærsk family

- **Deme** - acuired Hochtief Offshore via GeoSea subsidiary

- **Van Oord** - acquired Ballast Nedam Offshore

Pending deals

- **Mærsk**
  - Danish based A. P. Møller-Mærsk wants to sell their 75% stake in Esvagt subsidiary

Sold!!!

- **DONG Energy**
  - Danish based DONG Energy wants to sell their 51% stake in A2SEA subsidiary including tag-on acquisition CT Offshore

- **Bilfinger**
  - German based Bilfinger wants to sell their Bilfinger Offshore division

- **RWE Innogy**
  - German based RWE Innogy subsidiary of RWE wants to sell their OLC assets

Sold!!!

Pure play Danish constituencies

PORTS	SHIPPING	CRANE	TRUCKING	FREIGHT FORWAR-DERS	EPC
LORC	A2SEA powered by knowhow	FANØ KRAN-SERVICE A/S	GIVE GOODWIND	DSV BALTSHIP	AARSLEFF
ESBJERG HAVN Gateway Scandinavia	NT Offshore Marine & Offshore services	BMS	TORBEN RAFN & CO. A/S INTERNATIONALE SPECIALTRANSPORTER	BLUE WATER SHIPPING	RAMBØLL
Aalborg Havn Port of Aalborg	ESVAGT		VST VAMDRUP SPECIALTRANSPORT A/S	cargo service	MTHøjgaard
Grenaa Havn A/S	MAERSK LINE			MARTIN BENCHER	
AARHUS HAVN PORT OF AARHUS	THORCO			NIELSWINTHER in shipping since 1931	
	Combi Lift DEFINES HEAVY LIFT				

Acquired Danish companies

Mergers & Acquisitions

J. Poulsen Shipping A/S

Combi Lift Defines Heavy Lift → HARREN & PARTNER

BLUE OCEAN → SWIRE

KR Wind

BRANDE MASKINTRANSPORT → MAMMOET

Joint Ventures

A2SEA powered by knowhow → *(49%)* SIEMENS

J. Poulsen Shipping A/S → *(50%)* Combi Lift DEFINES HEAVY LIFT

abjv (Aarsleff Bilfinger Berger Joint Venture) → *(50%)* BILFINGER BERGER

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Foreign operators in Denmark

DHL GLOBAL FORWARDING

DB SCHENKER

GEODIS

KÜHNE+NAGEL

Agility
A New Logistics Leader

2nd PAPER: Anholt OWF

Fact box

- Operator: DONG Energy
- Ownership: DONG Energy, PKA, and PensionDanmark in JV
- Construction cost: DKK 11.5B
- Number of positions: 111 WTG's
- WTG type: 3.6 MW geared Siemens Wind Power
- Foundation type: MP/TP
- Total windfarm output: 400 MW
- Area covered: 88 km2
- Distance from installation / service port (Grenå): 15 km
- Water depth 15.5 – 18 meters

Source: DONG Energy, MTH, AAU research (meetings and site visits), EAWE conference paper, 2013 (Poulsen et.al.)

Example from paper

Main supply chain constituencies

Phase	Contract party	Product/service	Country
Development & consent	Geo	Geotechnical and geophysical investigations	Denmark
Installation & commissioning	Siemens Wind Power	Nacelles/hubs	Denmark
Installation & commissioning	Siemens Wind Power	Towers	Denmark
Installation & commissioning	Siemens Wind Power	Blades	Denmark
Installation & commissioning	Siemens	Substation control systems	Denmark
Installation & commissioning	Siemens	Offshore substation electrical equipment	Denmark
Installation & commissioning	Nexus	Array cables	Germany
Installation & commissioning	MTH/Bladt Industries	MP and TP	Denmark
Installation & commissioning	MTH/Ballast Nedam	MP installation - HLV "Svanen"	Holland
Installation & commissioning	MTH/Jumbo Shipping	TP installation - HLV "Jumbo Javelin"	Holland
Installation & commissioning	Visser & Smit Marine	Array cable installation	Holland
Installation & commissioning	A2SEA	Wind turbine installation	Denmark
Operations & maintenance	Hvide Sande Skibs- & Baadebyggeri	Service vessels	Denmark
Operations & maintenance	Port of Grenaa and misc. companies	35-50 jobs over coming 25 years	Denmark

Source: DONG Energy, MTH, AAU research (meetings and site visits), EAWE conference paper, 2013 (Poulsen et.al.)

1st PAPER: Review of the interviewees

Interviewees							
Total number of interviewees							400
	CxO	VP	Professor	Manager	Analyst	Student	
Positions of interviewees	69	110	23	145	31	22	
	17,3%	27,5%	5,8%	36,3%	7,8%	5,5%	
	Utilities	Operators	EPC	OEM's	Suppliers		
Interviewee by supply chain constituency type	18	0	1	36	13		
	4,5%	0,0%	0,3%	9,0%	3,3%		
	Politicians	Education	Shipping companies	Freight forwarders	Ports		
	25	45	98	71	23		
	6,3%	11,3%	24,5%	17,8%	5,8%		
	Warehouse /storage	Rail operators	Truckers	Crane providers	Market research	Others	
	3	2	3	0	25	37	
	0,8%	0,5%	0,8%	0,0%	6,3%	9,3%	

Wide variety of people part of the exploratory study

Example from paper

Industry challenges - macro

Seq.	What	Comments	Utilities	Operators	Shipping & Logistics comp.	OEMs	Ports	Regions & Countries
		Macro economy and policy						
1	2050 forecasting models	Present models only up to 2030-2040	✔	✔	✔			
2	Regional policy updates	Only European Union (EU) and People's Republic of China (PRC) have goals by law	✔	✔				
3	Country forecasts	Each country has own approach	✔	✔	✔			
4	Shipping/logistics contribution to Cost of Energy (CoE) reduction targets	Total CoE reduction targets and total shipping costs unclear	✔	✔	✔	✔	✔	
5	Development plans of sovereign wealth (SWFs) funds, utilities, and operators	SWFs from Norway/UAE/China and utilities from EU/China lead, operators depend on policies	✔	✔	✔	✔	✔	
6	OEM forecasts	OEMs compete by market and R+D is critical			✔		✔	
7	Government dependencies and subsidies makes shipping/logistics less desirable	Perception making "usual shipping and logistics company suspects" reluctant to invest			✔		✔	
8	Wind energy sector is immature	Supporting shipping and logistics business equally immature			✔		✔	

Source: LogMS conference paper, 2013 Poulsen et.al.

Key points of today

- Logistics and shipping innovation is key for the wind industry
  - Especially offshore wind is on the rise and very challenging
- Safety is critical
  - Use of RO/RO vessels
- The supply chain is complex
  - Different chains, different needs
- Relevant research is needed
  - Industry should be kept abreast
- The money
  - Logistics is a big part of LCoE

Should the tail wag the dog?

Thank you – Thomas Poulsen

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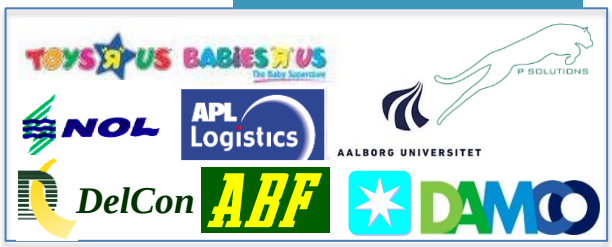
Employment history



Select consulting clients

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