


# GLOBAL WIND ENERGY SHIPPING AND LOGISTICS

## INSIGHTS FROM WORK PACKAGE 2
## STUDY ON PRIOR WORK DONE
## INNOVATIVE INSTALLATION LOGISTICS

DECEMBER 8, 2016, ESBJERG, DENMARK

*Prepared for the INNOlog conference at* ERHVERVS AKADEMI SYDVEST

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# Background & introduction

AALBORG UNIVERSITY DENMARK

Department of Mechanical and Manufacturing Engineering

Photo source: Colourbox

# Introduction – Thomas Poulsen

Aalborg University, Copenhagen Campus
Department of Mechanical and Manufacturing Engineering

**RESEARCH INTERESTS**

Global wind energy shipping and logistics

**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

# PhD Fellow with industry support

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

**PhD research project Reference Group**

FTI CONSULTING

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DHL GLOBAL FORWARDING

DANBOR

DONG energy

DANMARKS REDERIFORENING

AALBORG UNIVERSITET

DTU Wind Energy
Department of Wind Energy

DEN DANSKE MARITIME FOND

AARSLEFF

MÆRSK

J. Poulsen Shipping A/S

GIVE GOODWIND

ESBJERG HAVN Gateway Scandinavia

SIEMENS
Siemens Wind Power

HEAD ENERGY

AH Industries

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# Wind farm life-cycles and supply chains

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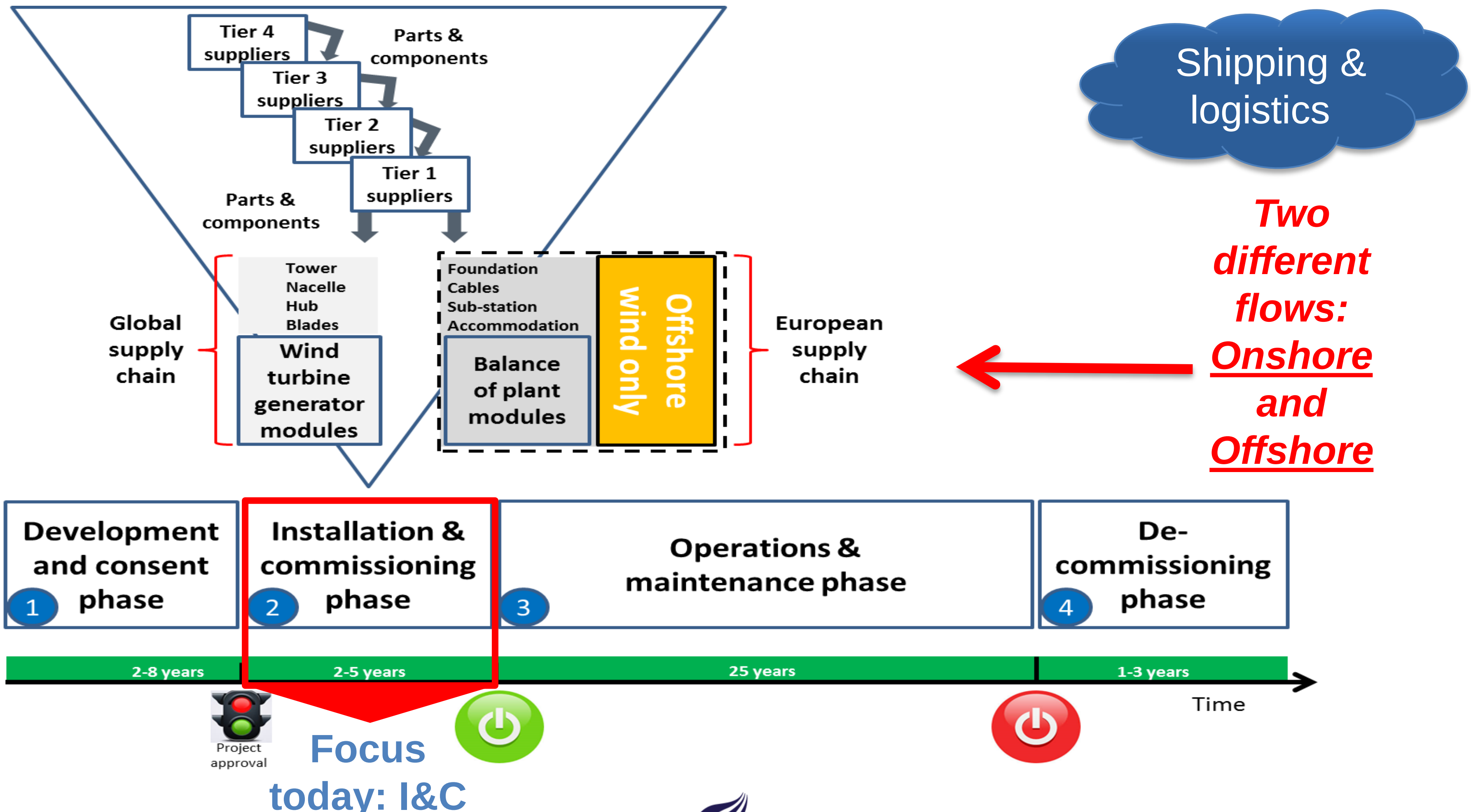
Photo source: Colourbox

# Context: Wind farm life-cycle phases




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

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# Project scoping and framework

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Photo source: Colourbox

# Cost Reduction & Innovation Forum

**August 25, 2014** — *Kick-off*

**December 2, 2014** — *Brainstorm*

**October 8, 2015** — *First review*, *Kick-off area 2*

**Cost Reduction & Innovation Forum**
*40% cost reduction compared to 2012 Offshore wind*

Test case: Anholt

| Area 1 | Area 2 | Area 3 | Area 4 | Area 5 |
|---|---|---|---|---|
| White book of the Danish tendering process | Alignment of incentives in contracts during installation | Logistics process redesign and concept development | Efficient offshore transport for maintenance | Efficient sub-sea maintenance |

Now: **INNOlog**
*Kick-off* on November 6, 2015

Source: CRIF Group 4
O&M Logistics, AAU

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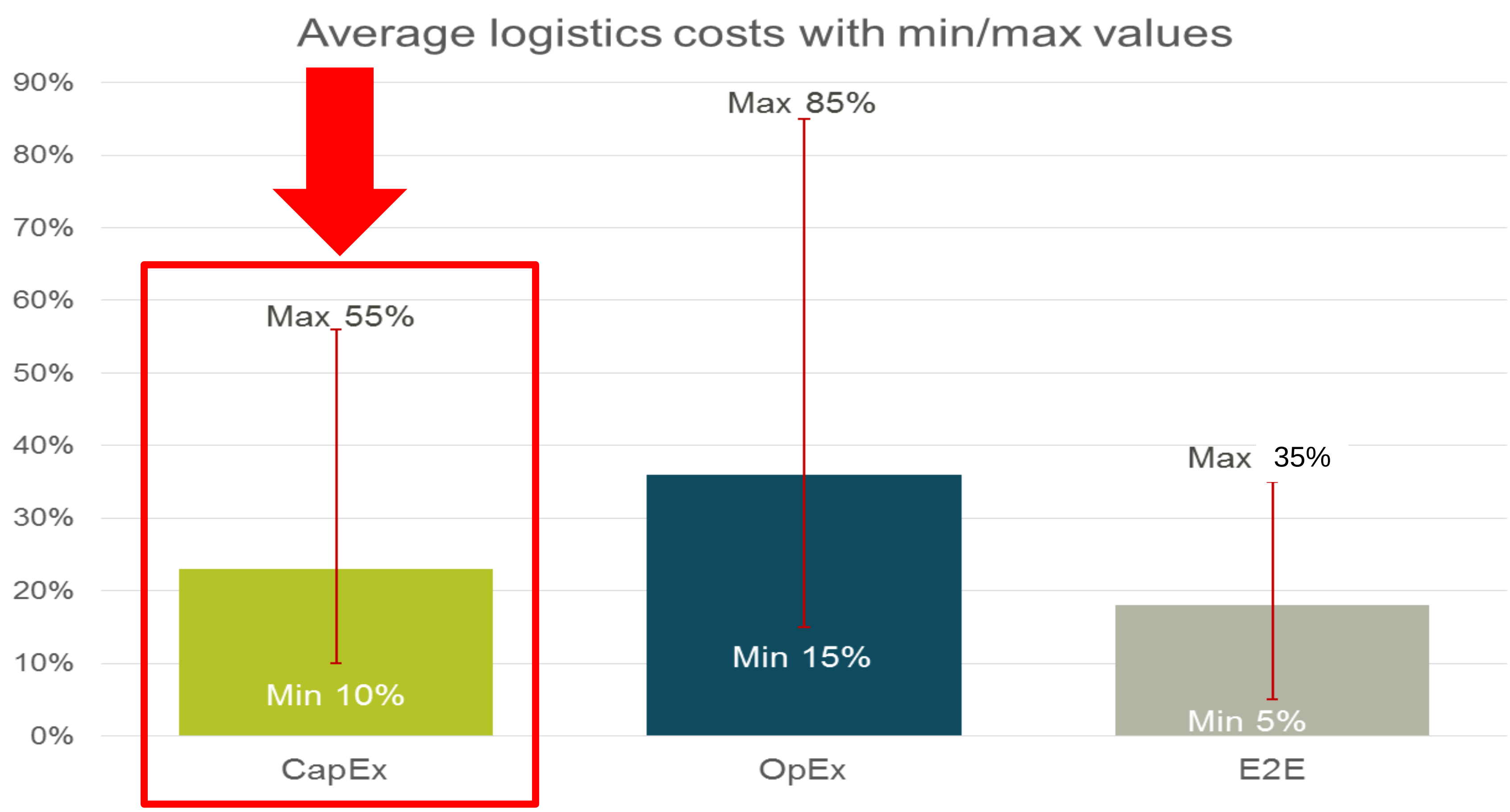
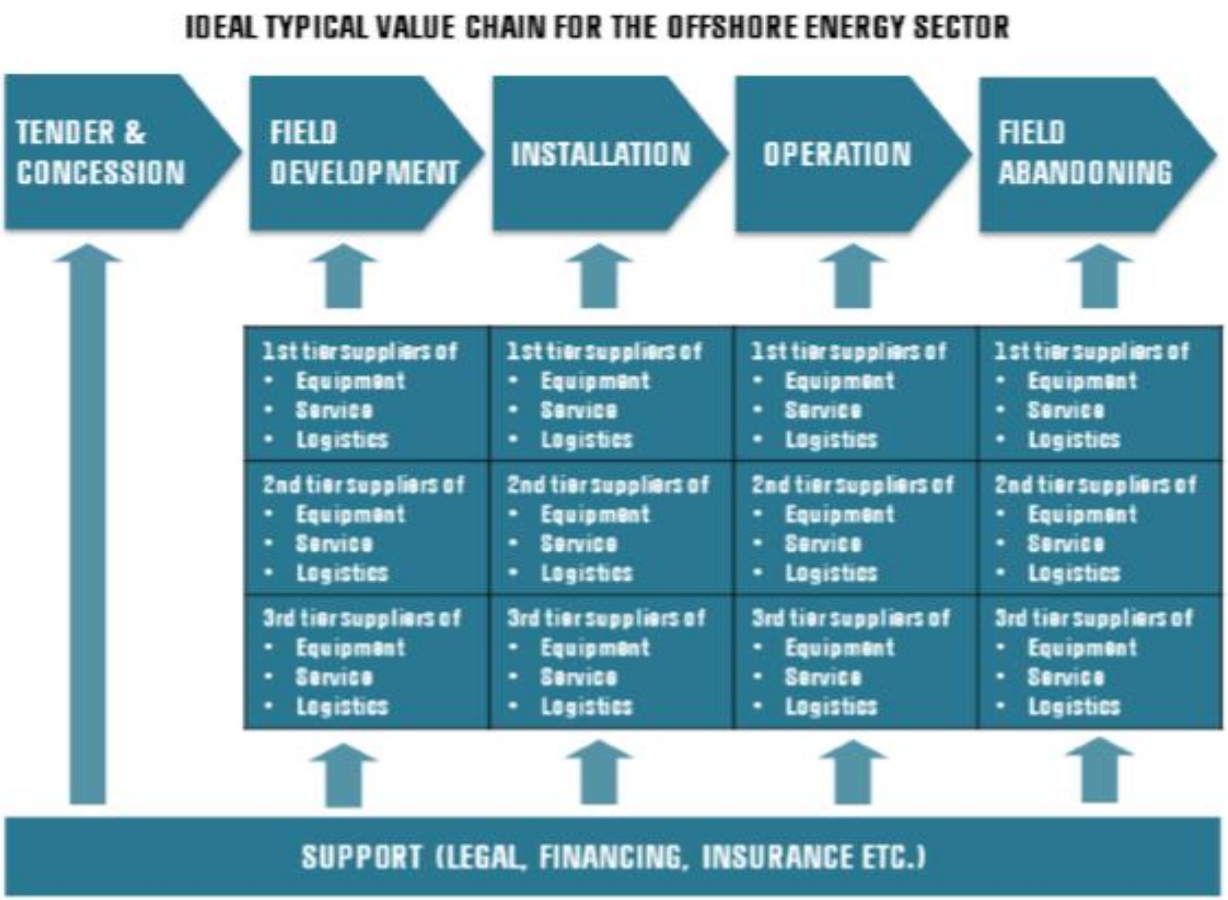
# The money: Recent case study






Source: Poulsen & Hasager, 2016

# Framework from CBS selected




- Shipyard background
- Offshore energy focus (oil & gas)
- Tiered structure also applicable for wind shipping and logistics

Source: *Offshore supply industry dynamics,* Thomas Roslyng Olesen, 2015

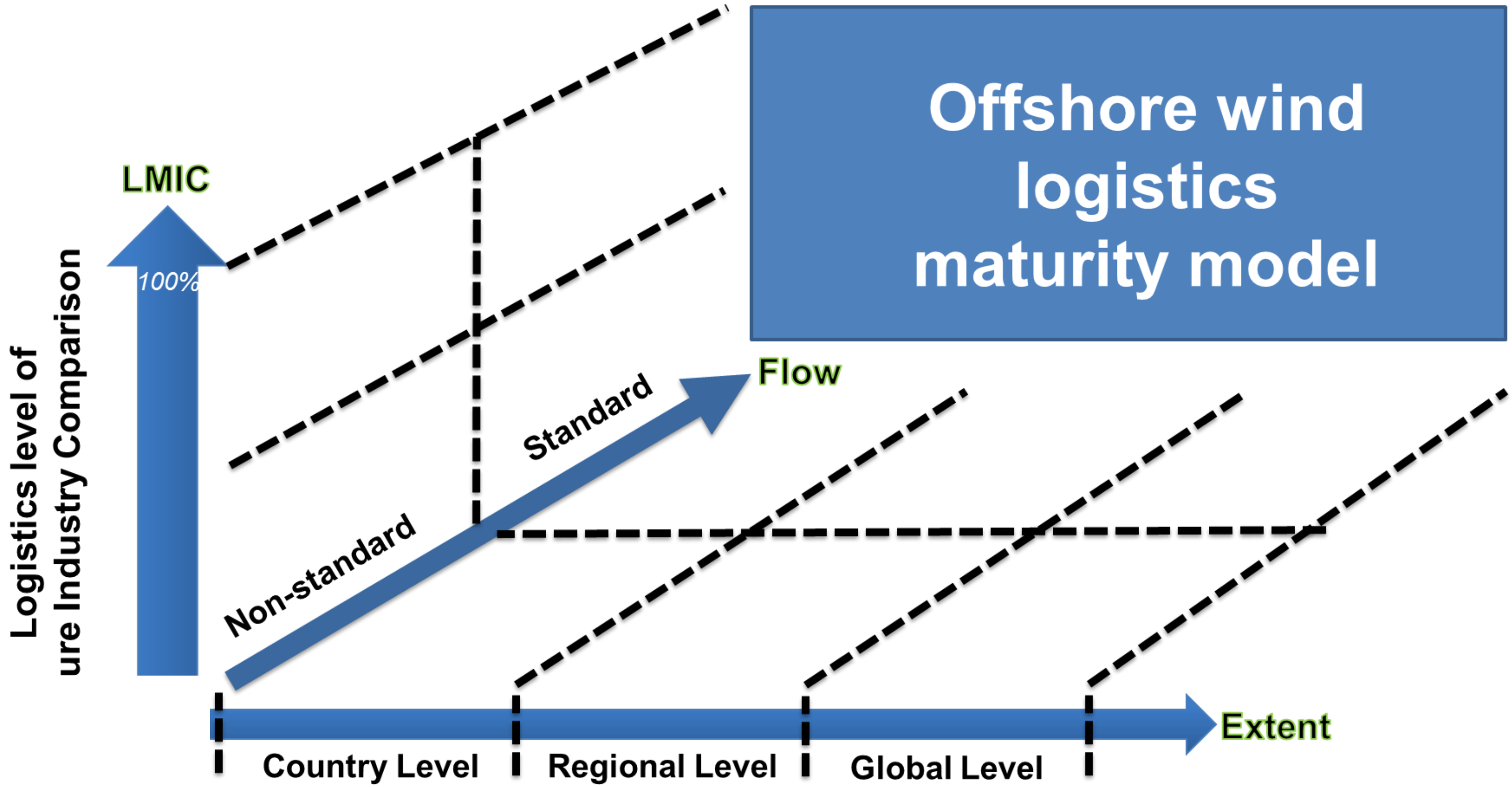
# Prior work framework: Wind

- Dimensions for consideration:
  - ✓Inbound vs. outbound
  - ✓Activities in the supply chain
  - ✓Tiers of supply chain constituencies
  - ✓Material (physical) flow vs. cost / documentation / information flows
  - ✓Buying terms, flow, extent, and degree of standardization
- Framework provided on May 31, 2016



Source: Renewable Energy Solutions (2016), INNOlog

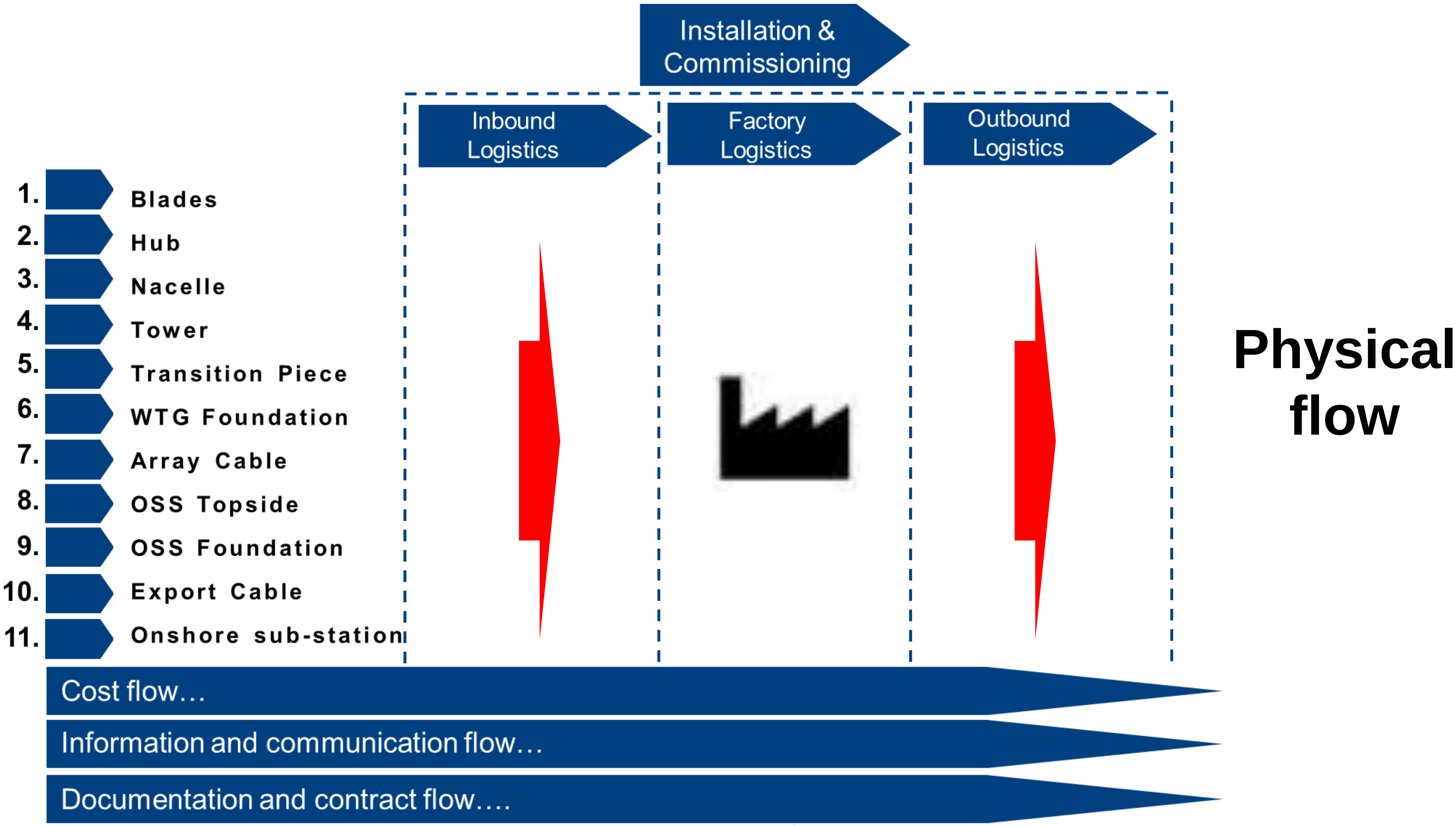
# Shipments and flows






Source: Renewable Energy Solutions, INNOlog

# Logistics cost reductions



# Industry comparison: Maturity

**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

# The final INNOlog framework

| | Inbound | Factory | Land Transport | Port Operations | Sea Transport | Installation | Commis-sioning |
|---|---|---|---|---|---|---|---|
| Blades | | | | | | | |
| Hub | | | | | | | |
| Nacelle | | | | | | | |
| Tower | | | | | | | |
| Transition piece | | Out of Scope | | | | | |
| WTG foundation | | | | | | | |
| Array cable | | | | | | | |
| Export cable | | | | | | | |
| OSS* topside | | ***Access deemed difficult*** | | | | | |
| OSS* foundation | | | | | | | |
| Onshore sub-station & related | | | | | | | |

***Hypothesis:***
Logistics cost savings potential

***Hypothesis:***
Logistics cost savings potential



Source: Renewable Energy Solutions (2016), INNOlog

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# Prior work efforts rendered

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Photo source: Colourbox

# The team behind the review

- WP 2 efforts performed by a team led by Lone R Thomsen, TINV
- Team members from EASV led by Lisbeth Brøde Jepsen, EASV

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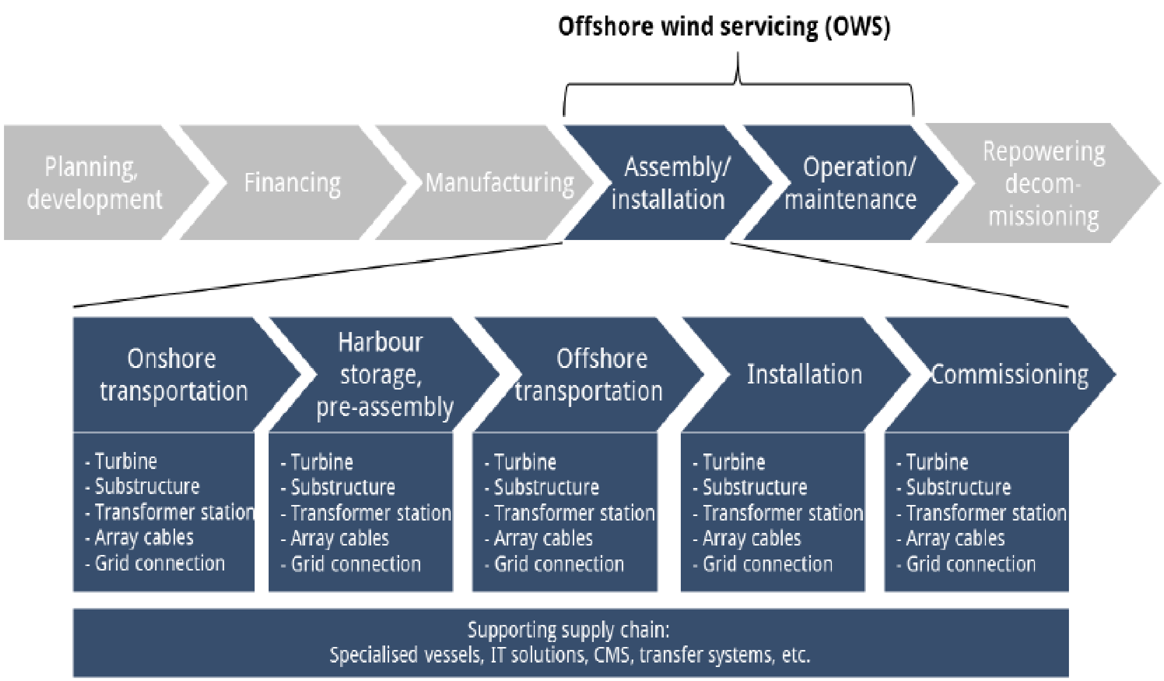
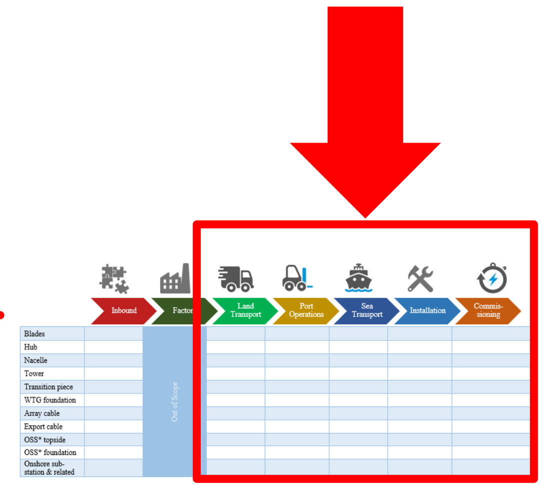
- Review of prior efforts based on relevant reports, books, news clippings, and academic journal articles

# Major projects reviewed

**LEANWIND (www.leanwind.eu)**

**ECOWINDS (www.ecowinds.eu)**




**GADOW (www.gadow-offshore.net/en/)**

**Logistics focus = O&M**



Ilustration sources: ECOWindS, INNOlog

# Major cost reduction studies

- Denmark study 2011 (Deloitte)
- UK study 2012 (The Crown Estate)
- Germany study 2013 (Prognos & Fichtner Group)

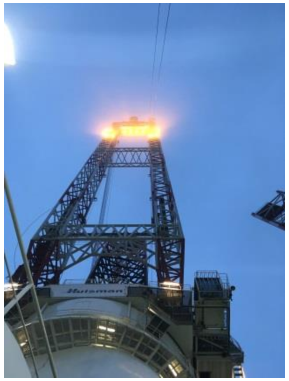


Photo sources: Colourbox and Thomas Poulsen courtesy SeaJacks

# High level process

- Partial review completed:
  - ✓ Entries provided originally by Thomas Poulsen June 3: 77
  - ✓ Total number of entries deemed relevant after search: 121
  - ✓ Review completed: 58
  - ✓ Deemed not relevant: 10
  - ✓ Net entries included in this review so far: 48
- Search conducted using the SDU database/library
- July 12 input to WP 3 interview structure based on findings thus far

# July meeting on interviews

- Categories serving as input to WP 3:
  - ✓Crane/lifting equipment
  - ✓Sea fastening
  - ✓Transportation frame
  - ✓Standardization
  - ✓Cables
  - ✓Communication/cooperation



Source: EASV (2016), INNOlog
Photo source: Colourbox

# Search process

- Goal:
  - ✓The identification of existing research and information about ***cost reduction*** in ***offshore wind logistics flow*** of ***components***
- Specific keywords used (examples):
  - ✓Array cable
  - ✓Nacelle
  - ✓Tower
- ”References of references” technique

# Cost reduction potential

- From academic literature:

| Topic | Findings | Sub-topics | Sources | Source count |
|---|---|---|---|---|
| Sea transport and installation | Particularly during installation and sea transportation of offshore wind components, studies have shown that great cost reduction opportunities can be realized | | (Crown Estate, 2012; Hoeksema, 2014; Estaban et al., 2015; Vis et al., 2016; Roddier, 2010; Lawson, 2012; Marsh, 2010; Blanco, 2009) | 8 |
| Sea transport and installation | | - Foundations | (Deloitte, 2011; Crown Estate, 2012; Prognos & Ficthner Group, 2013; Barlow et al., 2015; Junginger et al., 2004; Sun et al., 2012; Estaban et al., 2015; Vis et al., 2016) | 8 |
| Sea transport and installation | | - Nacelles | (Crown Estate, 2012; Prognos & Ficthner Group, 2013; Junginger et al., 2004; Sun et al., 2012; Vis et al., 2016) | 5 |
| Sea transport and installation | | - Array cables | (Crown Estate, 2012; Junginger et al., 2004; Barlow et al., 2015; Bauer et al., 2015) | 4 |
| Sea transport and installation | | - Blades | (Prognos & Ficthner Group, 2013; Barlow et al., 2015; Junginger et al., 2004; Vis et al., 2016), | 4 |
| Sea transport and installation | | - Towers | (Prognos & Ficthner Group, 2013; Junginger et al., 2004; Barlow et al., 2015; Vis et al., 2016) | 4 |
| Sea transport and installation | | - Transition pieces | (Prognos & Ficthner Group, 2013; Hoeksema, 2014; Vis et al., 2016) | 3 |
| Sea transport and installation | | - Substations | (Junginger et al., 2004; Barlow et al., 2015) | 2 |
| Sea transport and installation | | - Hubs | (Prognos & Ficthner Group, 2013; Vis et al., 2016). | 2 |
| Largest cost factor: Vessels | The single largest installation cost is rental for special ships for the installation of turbines, support structures, cables, and transformer platforms | | (Dalgic et al, 2015b). | 1 |
| Installation logistics costs | Larger, faster ships and adaption of installation processes are anticipated to result in a reduction in installation logistics costs. Additionally, installation costs are expected to decrease mainly due to improved logistics concepts and increased competition. | | (Crown Estate, 2012). | 1 |
| Vessels and process innovation | Improving the installation for [space?] frames also will be achieved through more efficient and optimized vessels, shortening the support structure installation process | | (Crown Estate, 2012) | 1 |
| | The sea transportation of specific components is identified as sources for cost reductions such as | | | |
| Sea transport | | - Foundations | (Prognos & Ficthner Group, 2013; Hoeksema, 2014; Estaban et al., 2015; Vis et al., 2016; Roddier, 2010; Lawson, 2012; Marsh, 2010) | 7 |
| Sea transport | | - Towers, nacelles, hubs, blades | (Vis et al., 2016; Lawson, 2012; Marsh, 2010) | 3 |
| Sea transport | | - Transition pieces | (Hoeksema, 2014; Vis et al., 2016). | 2 |
| Sea fastening | Poor or missing seafastening | | (Crown, 2012) | 1 |
| Sea fastening | Seafastening that can be modified to handle both turbine and support structures and variations in size and design can reduce costs as well. This can also maximize vessel utilization by allowing vessels to handle more than one kind of installation | | (Crown, 2012) | 1 |
| Sea fastening | New way of seafasting transition piece will eliminate use of bolts and nuts and improve operating time | | (Hoeksema 2014) | 1 |
| Sea transport innovation | "Roll-on/Roll-off" for rotor blades and nacelles and expects to save 15-20% of costs for transport solution. The new vessles can handle 8 nacelles or 12 blades | | (Siemens, 2015) | 1 |
| Port contracts | Increased contract period from 1 to 5-7 years will reduce costs by around 20% for port facilities. | | Crown Estate study (2012) | 1 |
| Contracts | Initial projects in the UK have mainly been contracted on a lump sum, fixed-price basis with poorly defined contract terms and inadequate incentives and penalties for performance and delays. Moving away from lump sum contracts, tightening terms and conditions, and the introduction of more appropriate incentive mechanisms may lead to cost reductions | | (Crown Estate, 2012). | 1 |
| Weather downtime | Additionally, sea state data can improve contracts for vessels. A significant cost driver is vessels being on standby during bad weather. Unknown weather risk often leads to significant pricing in the contractual framework, to ensure the full range of potential risks are covered. If it is possible to provide site-specific sea state data, contracts can include maximum wave heights and wind speeds for various lifting situations based on historical data | | (Crown Estate, 2012). | 1 |
| Economies of scale | Effect of economies of scale | | (Blanco, 2009, Green et al., 2011; BVG, 2015; Esteban et al., 2015; Sun et al, 2012; Poulsen et al, 2016 and Junginger et al., 2012) | 7 |
| Standardization | Effect of standardization | | (Esteban et al., 2015) | 1 |
| Maturity | Learning effects and curves | | (Wüstemeyer et al 2015; Sun et al, 2012, Deloitte, 2011 and Blanco 2009) | 4 |
| Collaboration | Cooperation between companies | | (MEGAVind, 2012). | 1 |
| Trust | Visibility and confidence | | (BVG, 2015). | 1 |
| FEED, procurement | Early involvement of suppliers, front-end engineering and design, better procurement | | (Crown Estate, 2012). | 1 |

Source: Data provided by EASV (2016), own analysis

# Overall findings: In/outbound

| | Inbound | Factory | Land Transport | Port Operations | Sea Transport | Installation | Commis-sioning |
|---|---|---|---|---|---|---|---|
| Blades | | Out of Scope | | | | | |
| Hub | | | | | | | |
| Nacelle | | | | | | | |
| Tower | | | | | | | |
| Transition piece | | | | | | | |
| WTG foundation | | | | | | | |
| Array cable | | | | | | | |
| Export cable | | | | | | | |
| OSS* topside | | | | | | | |
| OSS* foundation | | | | | | | |
| Onshore sub-station & related | | | | | | | |

All 48 entries concentrated here

0 entries identified; major gap in prior efforts!

Source: Data provided by EASV (2016), own analysis

# Outbound entries: Components

Of 48 in total




Source: Data provided by EASV (2016), own analysis

# Outbound entries: Activities

Of 48 in total






Source: Data provided by EASV (2016), own analysis

# Outbound entries - ranking

- For the 48 entries, a maximum score of 3 can be obtained (144)
- Score based on levels of focus on cost reduction:

  3 - Extensive focus.

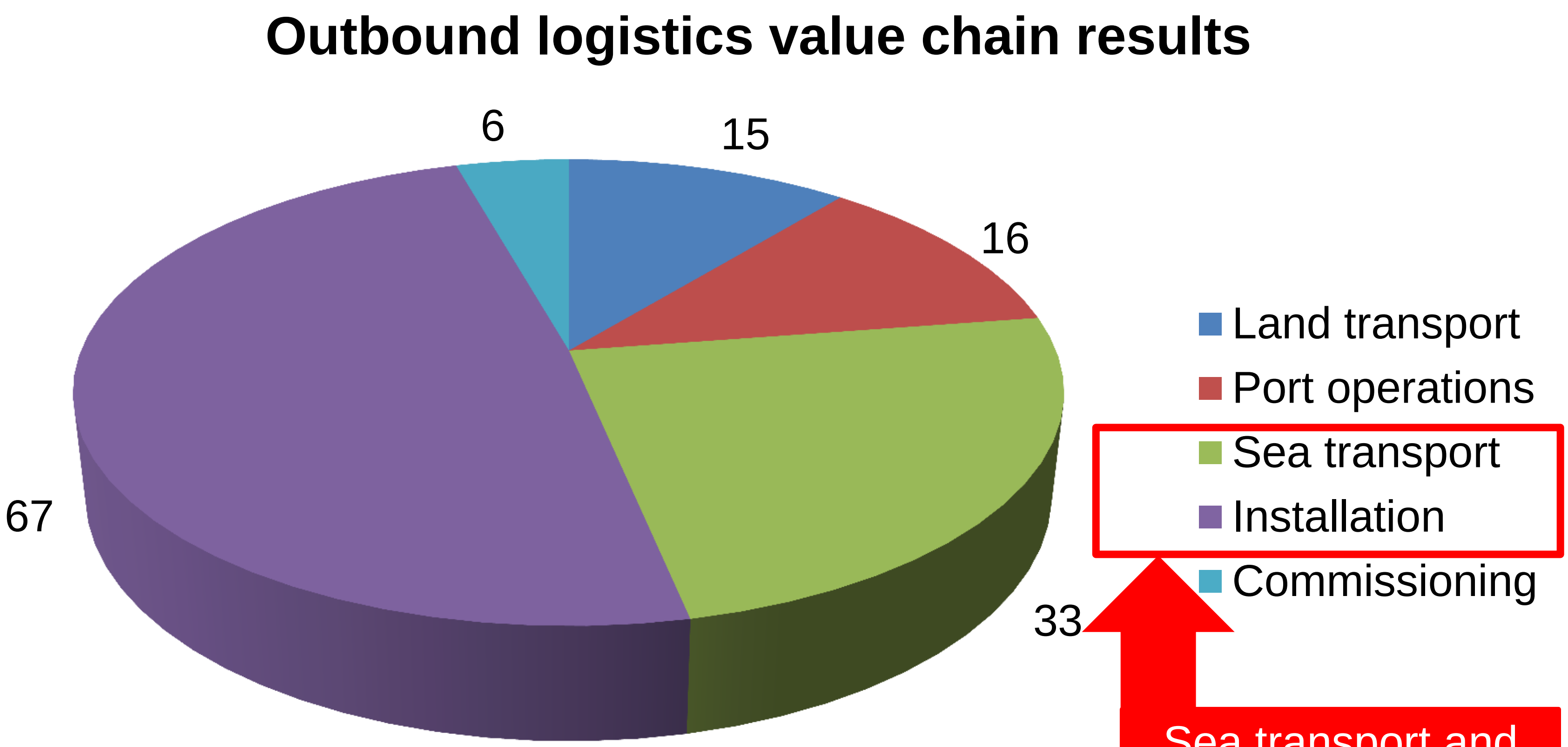
  2 - Moderate focus.

  1 - Benign focus.

  No mark = No focus.

Source: Data provided by EASV (2016), own analysis

# Scores based on (48x3) 144 max




Sea transport and installation are most extensively covered

Source: Data provided by EASV (2016), own analysis

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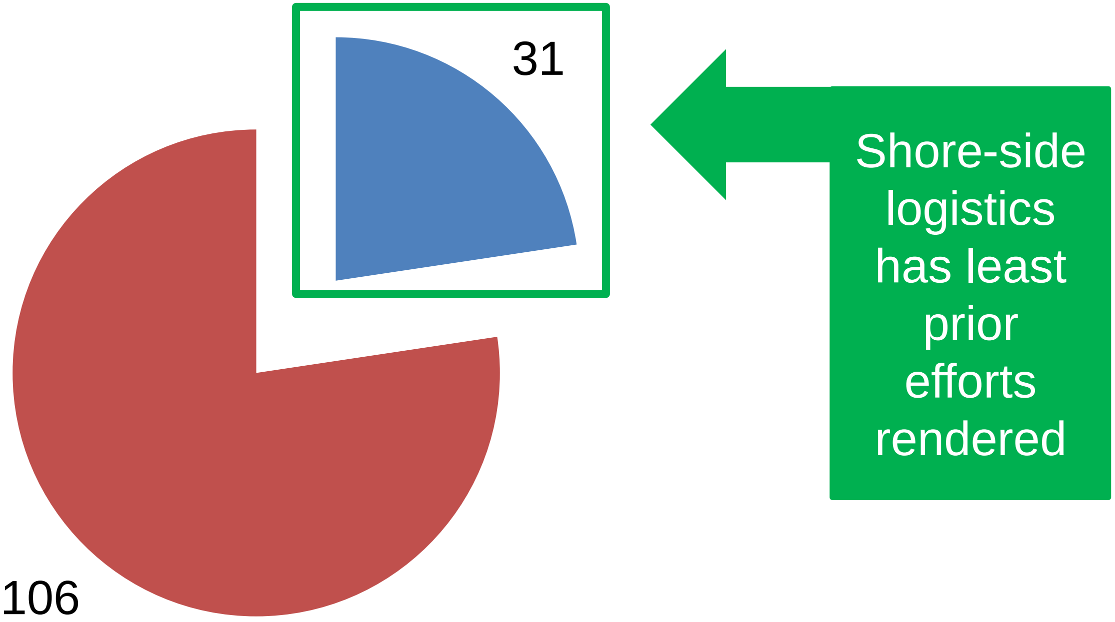
# Only 23% shore-side prior work

31 of 288 max
106 of 432 max




■ Shore-side (land transport and port operations)
■ Ocean (sea transport, installation, and commissioning)

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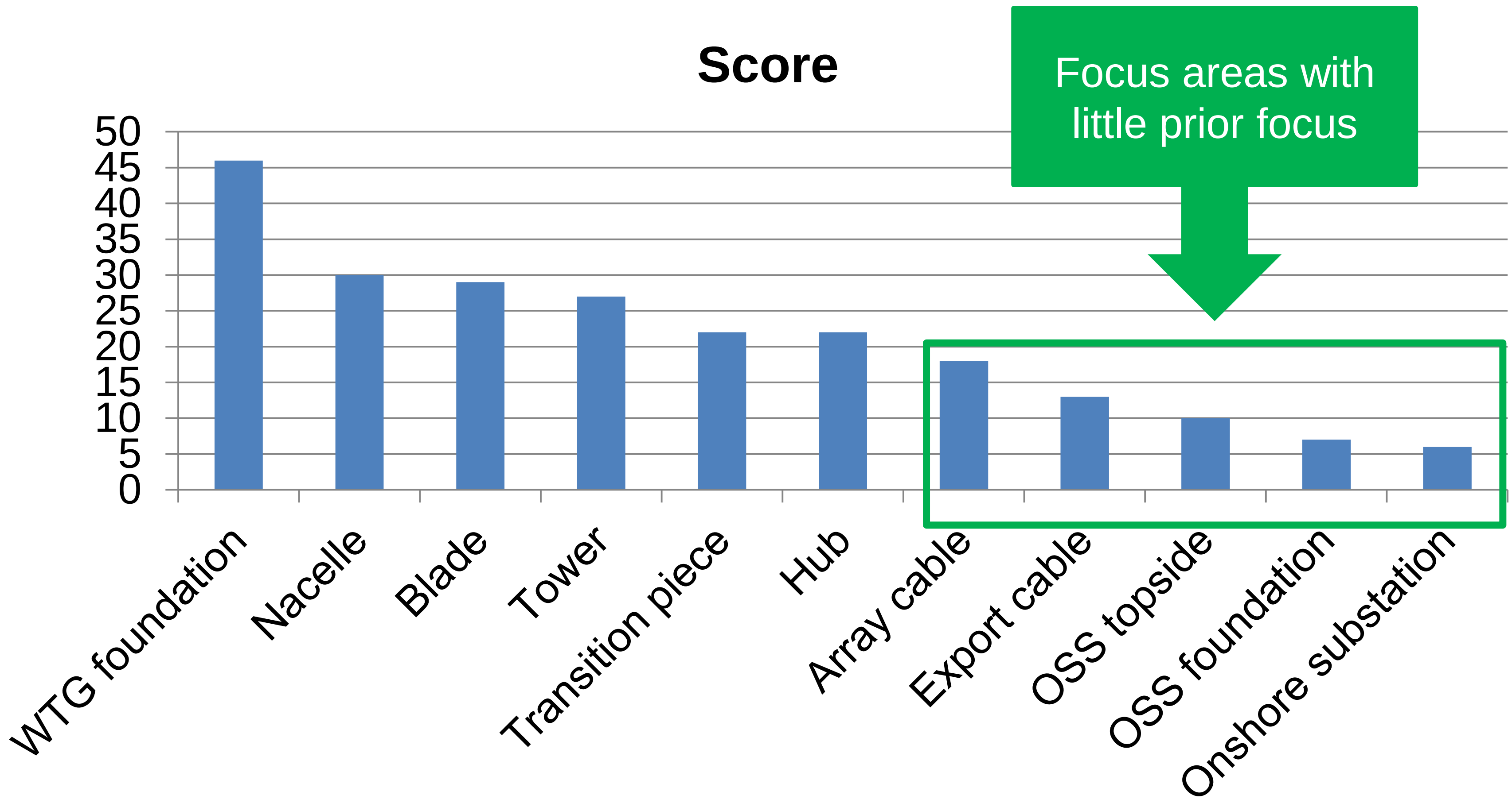
Source: Data provided by EASV (2016), own analysis

# Different components: Logistics




Source: Data provided by EASV (2016), own analysis

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# Guide to Excel sheet with entries

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Photo source:
Thomas Poulsen
courtesy SeaJacks

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# First tab – Reference list

MS Word guide also available

...is a list of references to literature related to Offsh[illegible] turbines. The list is not complete and can be exp[illegible].

| | A | B | |
|---|---|---|---|
| 1 | ID | Reference | Remar |
| 2 | A.01 | Council of Supply Chain Management Professionals. *CSCMP's Annual State of* [illegible] *oves the Economy in 2014* ; National Press Club: Washington, DC, USA, 2015. | |
| 3 | A.02 | FTI Intelligence. Global wind supply chain update 2015. FTI CL Ene[illegible] | |
| | A.03 | European Wind Energy Association. The European offshore [illegible] statistics 2015. http://www.ewea.org/fileadmin/files/library/publicat[illegible]an-Offshore-Statistics-2015.pdf; 2016. [accessed 08.02.16] | |

- **Column A** contai[illegible] umber which each entry has been assigned
- **Column B** [illegible] reference to the given literature
- **Colum**[illegible] **orward** is used internal by the project ow[illegible] ntrol the process

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Source: EASV (2016), INNOlog

# Second tab - Categorization

…is a matrix. The matrix was used during the literature review to categorize the content of each source.

| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z | AA | AB | A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | WTG foundation (jacket) | | | | | | OSS foundation | | | | | | Array cable | | | | | | Export cable | | | | | | Onshore s | | |
| 2 | ID | Source | No specific focus | Land Transport | Port Operations | Sea transport | Installation | Commissioning | No specific focus | Land Transport | Port Operations | Sea transport | Installation | Commissioning | No specific focus | Land Transport | Port Operations | Sea transport | Installation | Commissioning | No specific focus | Land Transport | Port Operations | Sea transport | Installation | Commissioning | No specific focus | Land Transport | Port Operatio |
| 3 | A.10 | Deloitte, 2011 | 1 | | | | 1 | | | | | | | | 1 | | | | | | 1 | | | | | | | | |
| 4 | A.11 | Crown Estate, 2012 | 1 | 1 | 1 | | 1 | | 1 | | | | | | 1 | | | | 1 | | 1 | | | | 1 | | 1 | | |
| | A.12 | Prognos & Ficthner Group, 2013 | 1 | | | 1 | 1 | | 1 | | | | | | 1 | | | | | | 1 | | | | | | 1 | | |

- **Column A is ID of source**
- **Column B** is short source name – the full reference to the source can be found in the "Reference list" (tab 1)

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Source: EASV (2016), INNOlog

# Third tab – Summary of research

…is a summary of the research and gives in general a summary of the literature

| ID | Crane/lifting equipment | Cables | Sea Fastening | Communication & Cooperation | Transportation Frame | Standardizing | Not in focus | Source | Summary | Focus |
|---|---|---|---|---|---|---|---|---|---|---|
| A.10 | | | | | | | | Deloitte (2011) | In their report for the Danish Ministry of Climate and Energy, Deloitte (2011) breaks down key cost drivers of OWFs. The report points out that a key cost driver for capital expenditure is installation vessels, and the Germanischer Lloyd Garrad cost underlying wind turbine installation vessel (WTIV) database is used to document the role of the WTIVs. The report argue that both water depth and distance from shore result increasing costs for all major project elements: wind turbines, foundations, electrical plant and installation. | One of the ma… with the lease … turbine erectio… |
| A.11 | | | | | | | | The Crown Estate (2012) | Supply chain bottlenecks and the maturity of the supply chains serving offshore wind developers can drive operating costs up. This study from 2012 identifies many, diverse ways in which offshore wind cost can be driven down | According to th… increased cont… years will redu… |

- Scoring scale from 0 to 3 for the 6 July focus areas in the process of being added to this tab as a filter function
- The filter function can be used to find related literature and summaries that handle a specific topic

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Source: EASV (2016), INNOlog

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# Conclusion

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Photo source:
Thomas Poulsen
courtesy SeaJacks

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# Summary of least prior attention

| **Inbound** | | | |
|---|---|---|---|
| **Outbound** | | **Entry count** | **Score** |
| Activities | Commissioning | ✓ | ✓ |
| | Land transport | ✓ | ✓ |
| | Port operations | ✓ | ✓ |
| Components | Onshore substation & related construction | ✓ | ✓ |
| | OSS foundation and topside | ✓ | ✓ |
| | Transition piece | ✓ | |
| | Hub | ✓ | |
| | Cables (export and array) | | ✓ |

Source: Data provided by EASV (2016), own analysis

# Questions & answers?


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