



GLOBAL WIND ENERGY SHIPPING AND LOGISTICS

OFFSHORE WIND OPERATIONS, MAINTENANCE, & REPAIRS SHIPPING/LOGISTICS PERSPECTIVE

MARCH 9, 2016, ESBJERG, DENMARK

Prepared for gå-hjem meeting at PORT OF ESBJERG



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Background & introduction



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Department of
Mechanical and Manufacturing Engineering

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



DDMF grant
2012-097



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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

PhD mechanics

**Research
purpose...**

**3 research
questions...**



Case study efforts

Time spent

Number of companies

Extent of case study scope

Width

Depth

Europe

Offshore, a number of cases

Asia

Offshore, a few cases

**5 trips
2 months**

Americas

Onshore, rail focus

Broad industry support

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

Reference Group



AARSLEFF



J. Poulsen Shipping A/S



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Wind farm life-cycles and supply chains

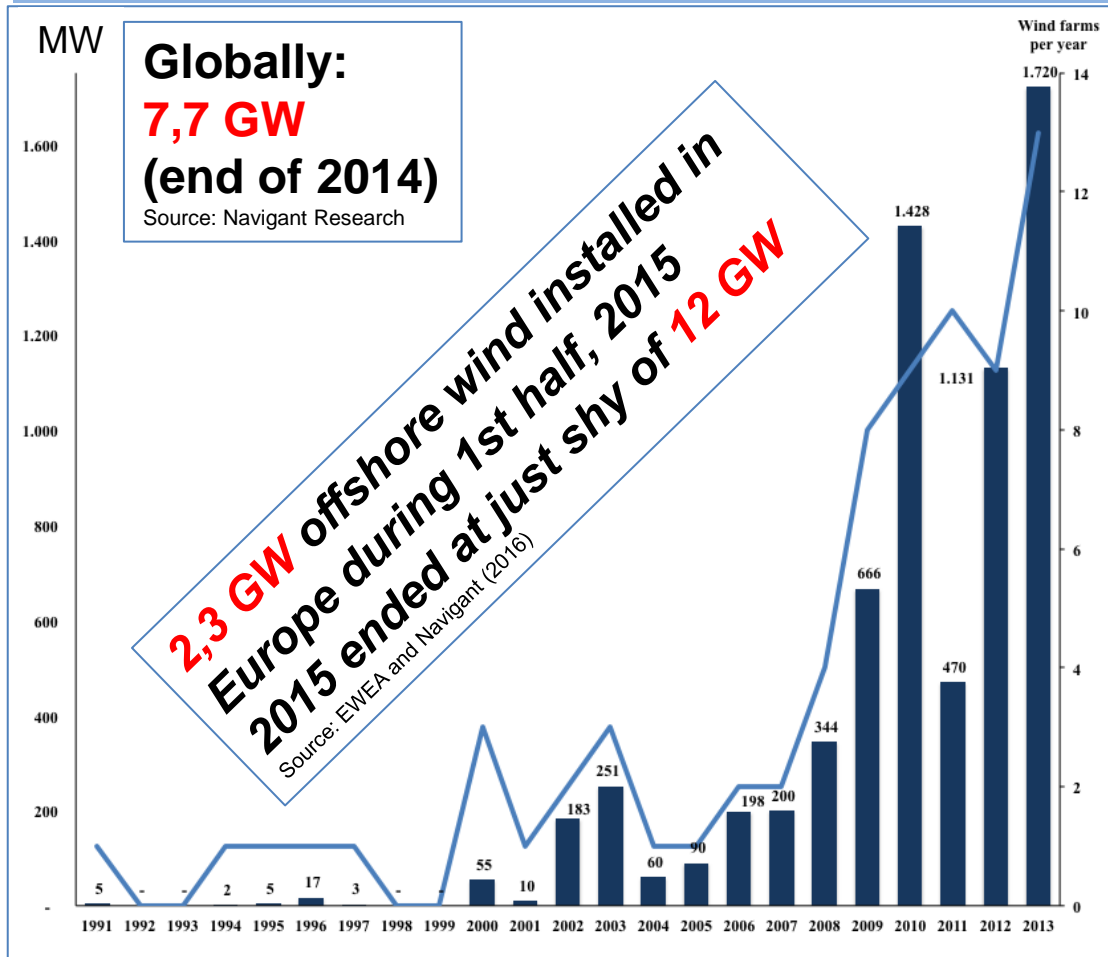


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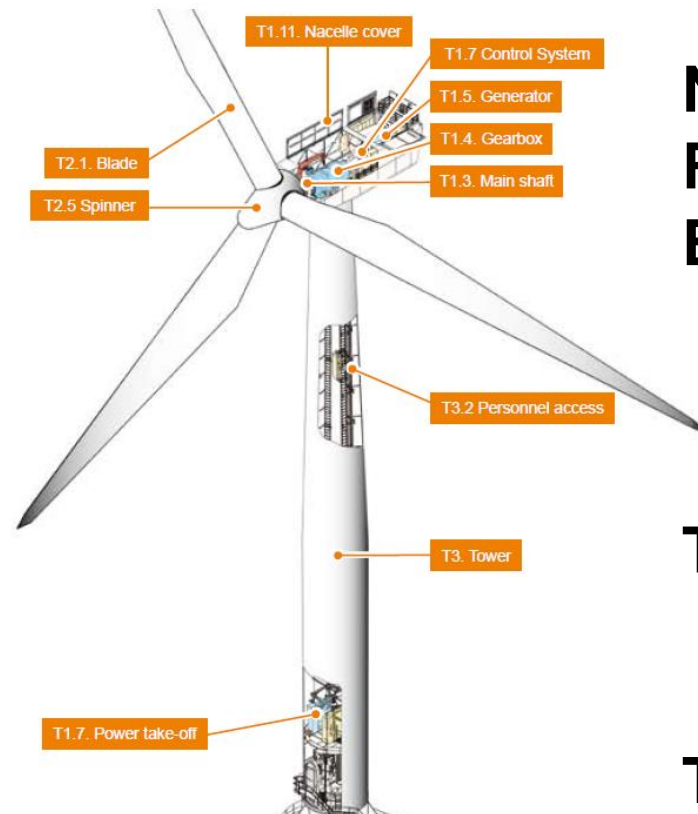
Offshore wind statistics until end 2013



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

Today's super star

- The offshore wind turbine
- SWP 3.6 MW power horse



**Nacelle
Rotor
Blades**

Tower

**Transition
Piece**

**Foundation
/Jacket**

Monopile

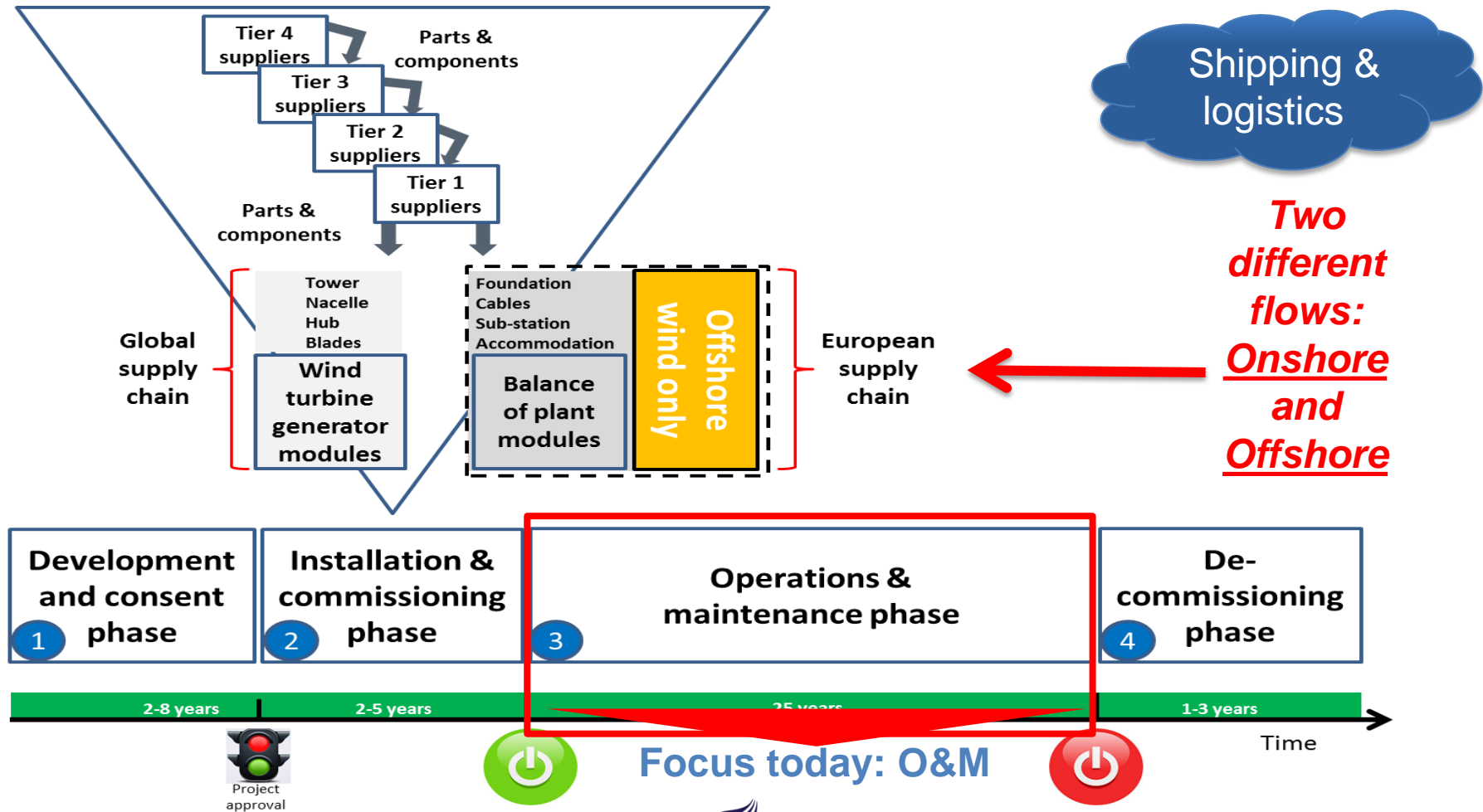
Export and array cables

Offshore sub-station

Accommodation platform/vessels



Single project life-cycle E2E



Case studies: Anholt



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

Key trends for offshore wind farms

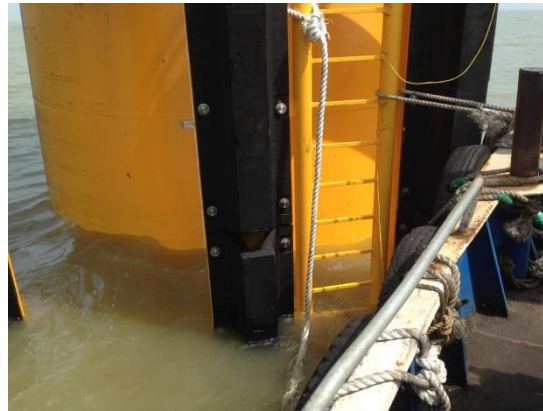
- Further away from shore
- Deeper waters
- Greater MW output of WTGs
- GW sized projects
- New foundation types (jackets)
- Construction innovation
- New O&M concepts

AND...market is globalizing

Case studies: Rudong test farm



Operator: Guodian Longyuan
Capacity: 400 MW
Type: Intertidal, nearshore



OEMs: 7
WTG range: 2-6 MW
Foundations: 10
Vessel types: Many and varied

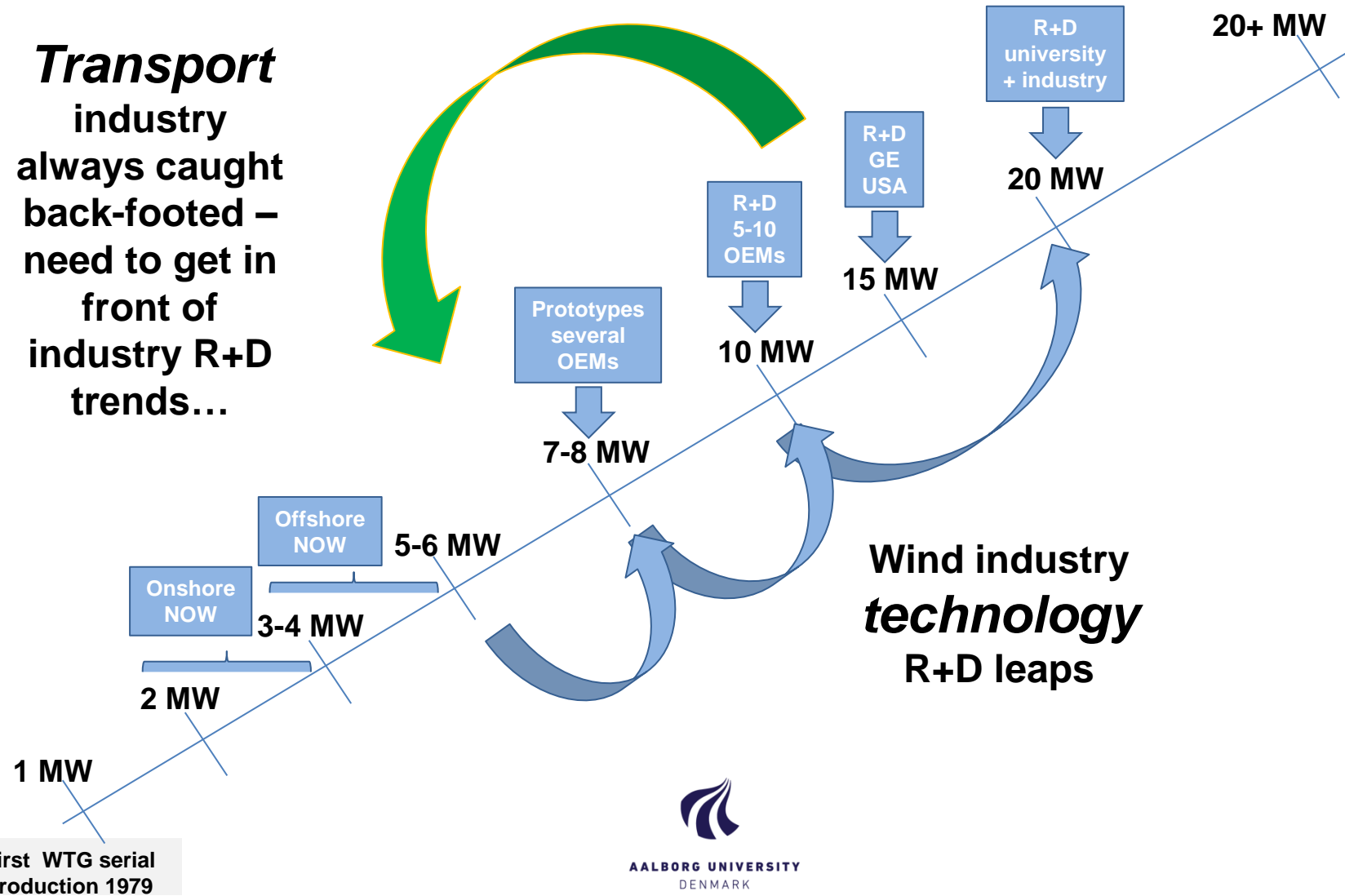


Step-change MW yield increase – profound impact on logistics

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

Innovation – what comes first?

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



Dimensions – Logistics challenges



Very different supply chains

Each life-cycle phase has very different characteristics

- Different supply chains
- Different logistics and shipping needs
- Different supply chain constituencies and contract set-up

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 larger vessels like MPV, tug&barge, WTIV	Project cargo/break-bulk

Focus today: O&M



Preventive O&M

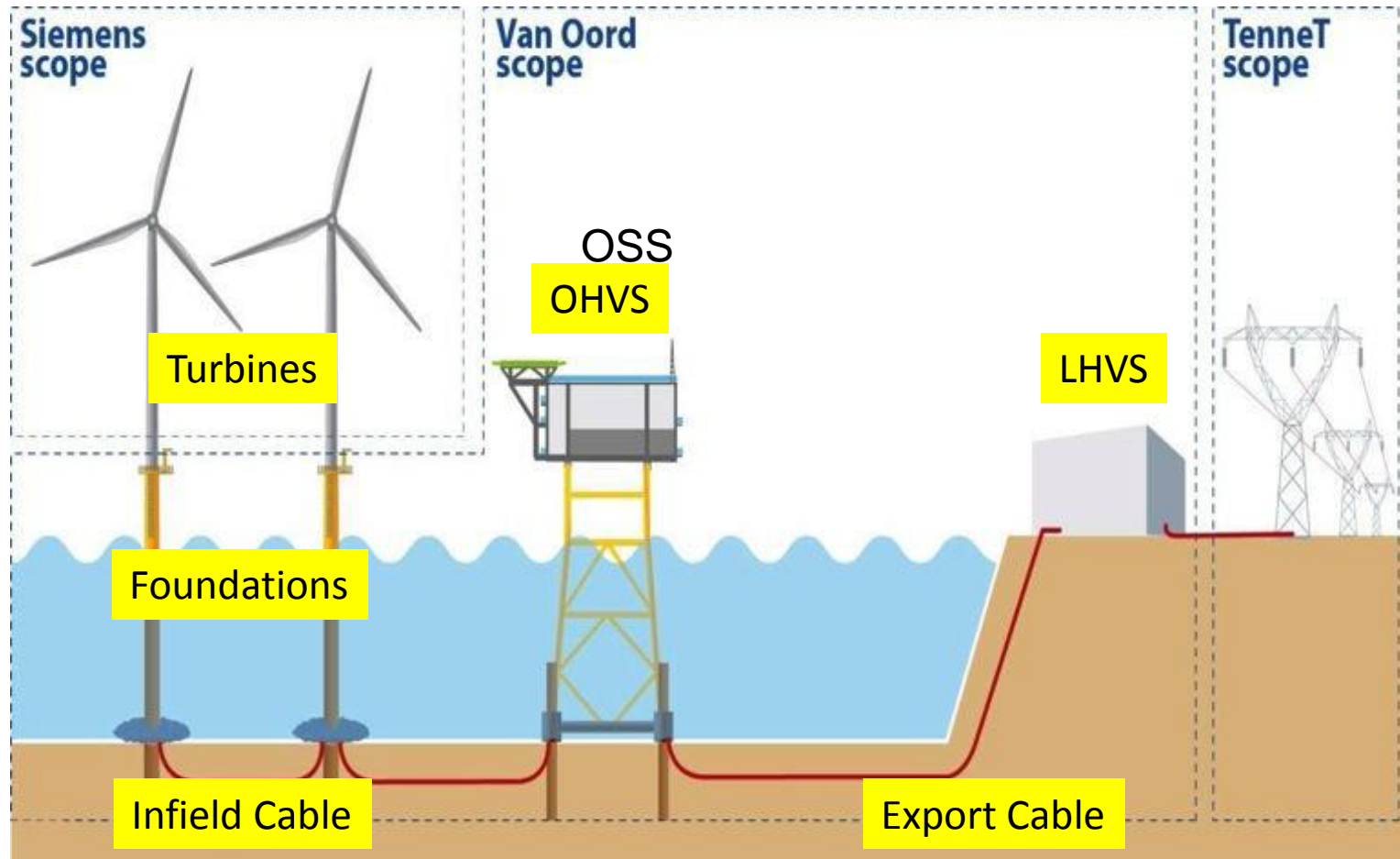
Usually organized for the entire wind farm:

- Technicians and tools
- Spare parts and major components
- Different types of conveyance / vessels
 - CTV
 - SOVs
 - Helicopters
 - Jack-up vessels
 - Heavylift vessels and barges
- WTGs and BOP treated differently
- Subsea more challenging than topside



Grout issues

Graphical view: Gemini in Holland



Array



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Safe transfer of crew

- Safety training
 - PPE
 - Tools
 - Potential survival in WTG
- Distance from shore
 - Steaming time
- Weather window
 - Height of waves



The floating village concept



Wind energy technicians can stay offshore similar to the oil & gas industry:

- Fixed structure as part of OSS (accommodation platform)
- Floating hotel / floatel vessel
- Special operations vessel (SOV)

The O&M ports - examples



- ❑ Focus is the Service Hub for the North Sea
- ❑ Considered Installation Back-up for Esbjerg
- ❑ Good Location & Access and relatively Cheap!
- ❑ *Project: SWP Crew Transfer Shore Base Butendiek*



- ❑ Focus is based on B2 crew transfer set-up
- ❑ Cheap and shortest distance to/from B2 site
- ❑ Very limited capabilities & space (scaling)
- ❑ *Project: SWP Crew Transfer Shore Base Baltic 2*



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

China

– status and what is needed?

Status as of end, 2015:

- 2 projects have been completed and connected to the grid (Jiangsu Province)
- 8 projects are under construction (Jiangsu Province)
- 1 project is under construction (Fujian Province)
- 6 projects are in the preconstruction phase (Tianjin, Hebei, Jiangsu, and Zhejiang Provinces)
- 27 projects are in the early stage of development (Liaoning, Hebei, Jiangsu, Zhejiang, Fujian, Guangdong, and Hainan Provinces)

Gap analysis:

- BOP
- O&M
- Logistics
- Process
- Procedures

First OSS in China

Developer China Guangdong Nuclear

(September, 2015)

*"Power
booster
station"*



Break-down O&M

Focused on individual WTG or entire farm:

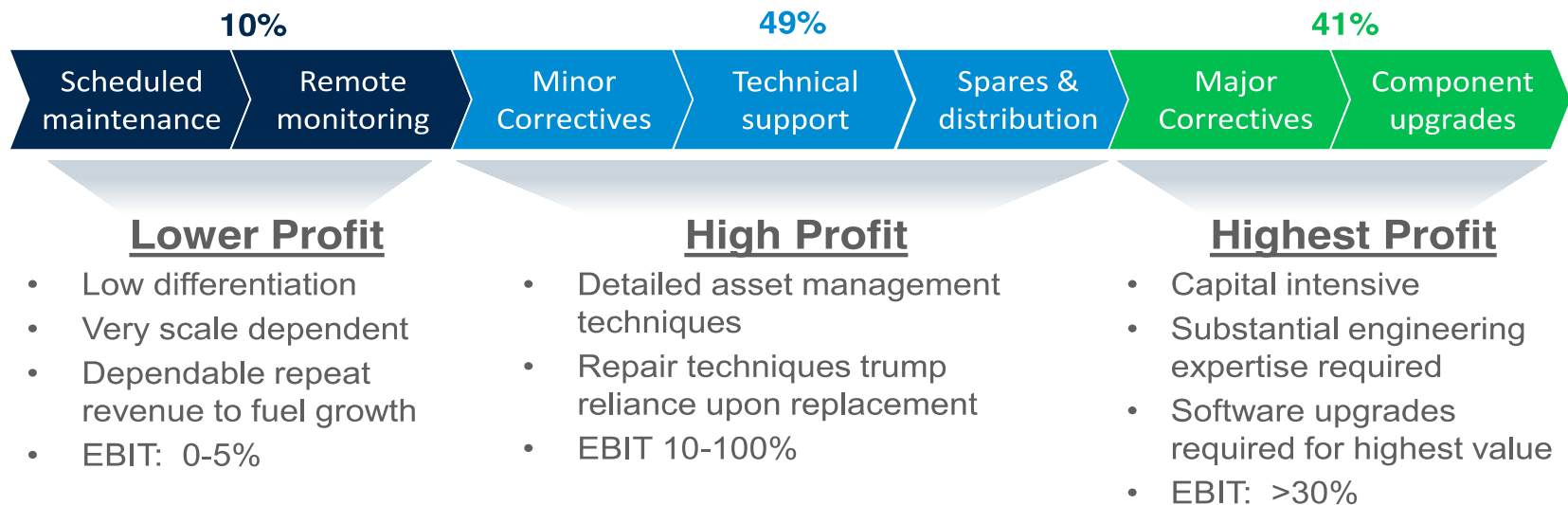
- Something has stopped functioning
- Diagnostics needed
- WTG:
 - Advanced diagnostics
 - Extensive experience
 - Some wind farms are old
- BOP:
 - Less remote sensors
 - More ad-hoc
 - Subsea inspections by divers/ROV

Cables amount to:
- 45% of claims
- 60% of claims value
- 45 construction phase cable claims
valued at EUR 75 million (2010-'14)
Source: Aon Risk Solutions

Attractive and growing market

- The O&M market is growing rapidly
- The contracts are long-term, often 5 years or more

Value chain analysis of O&M market



Wind services revenue and profit opportunity, value chain perspective



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Research findings



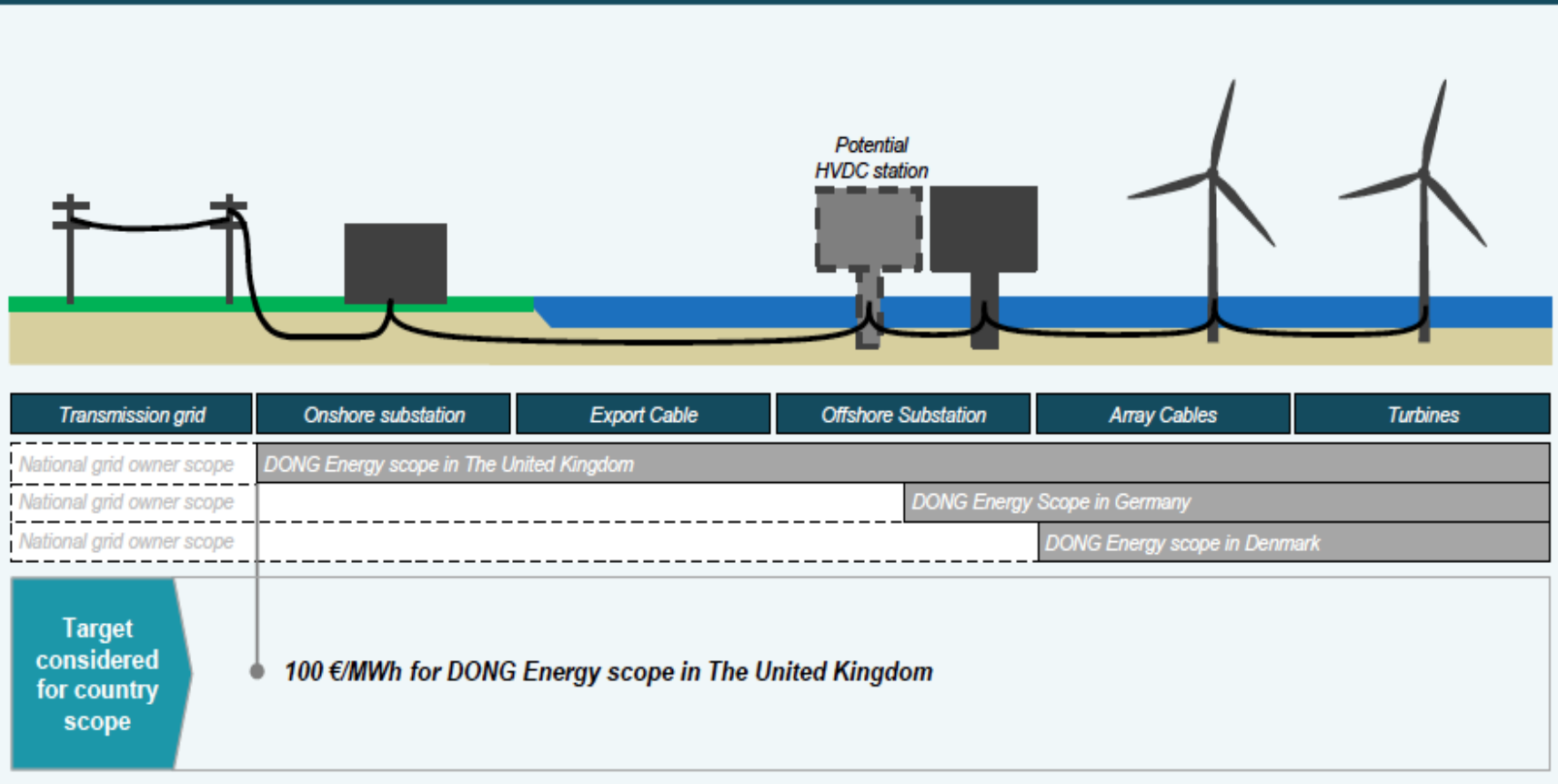
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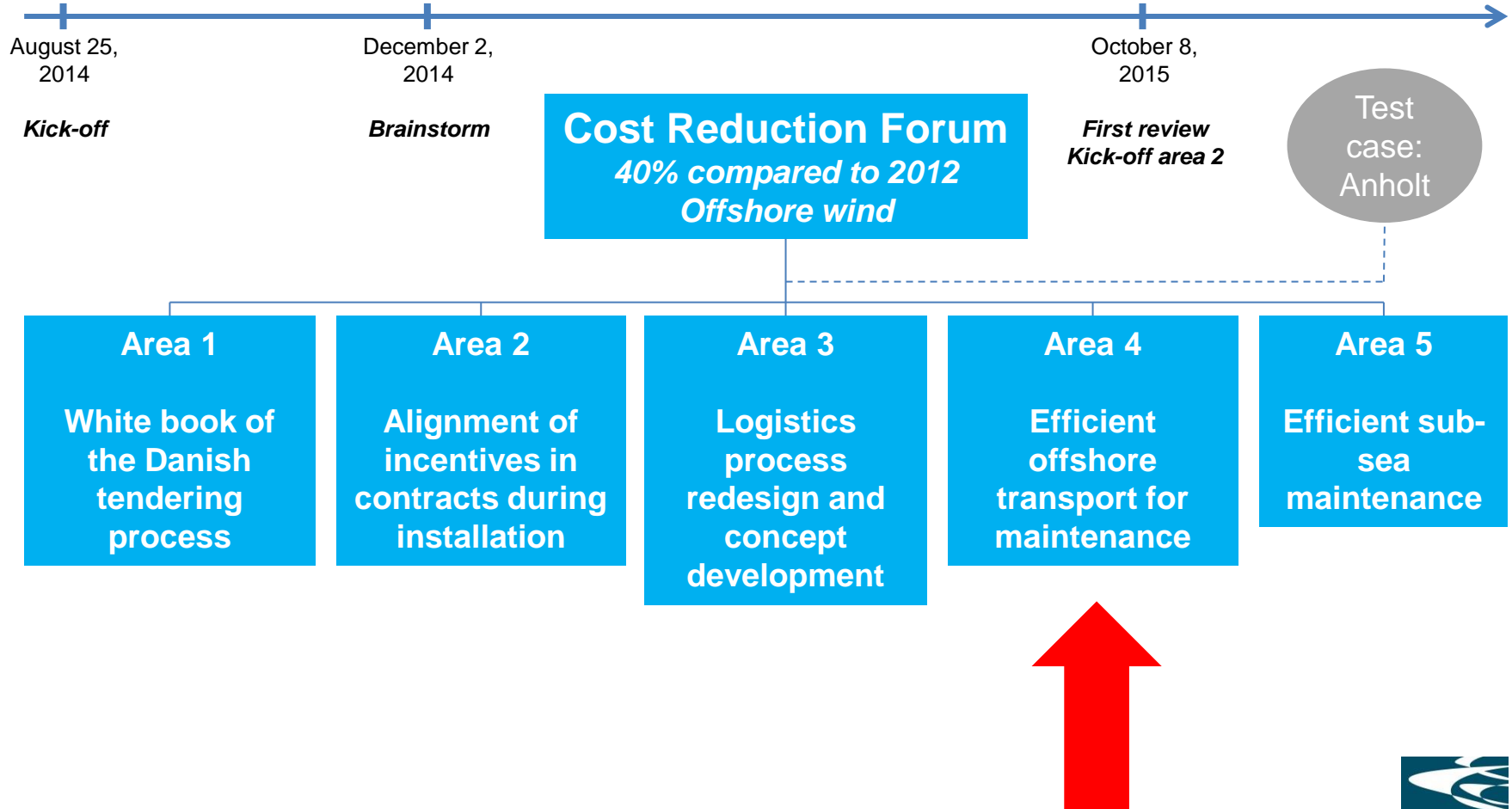
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Different ways to estimate LCoE

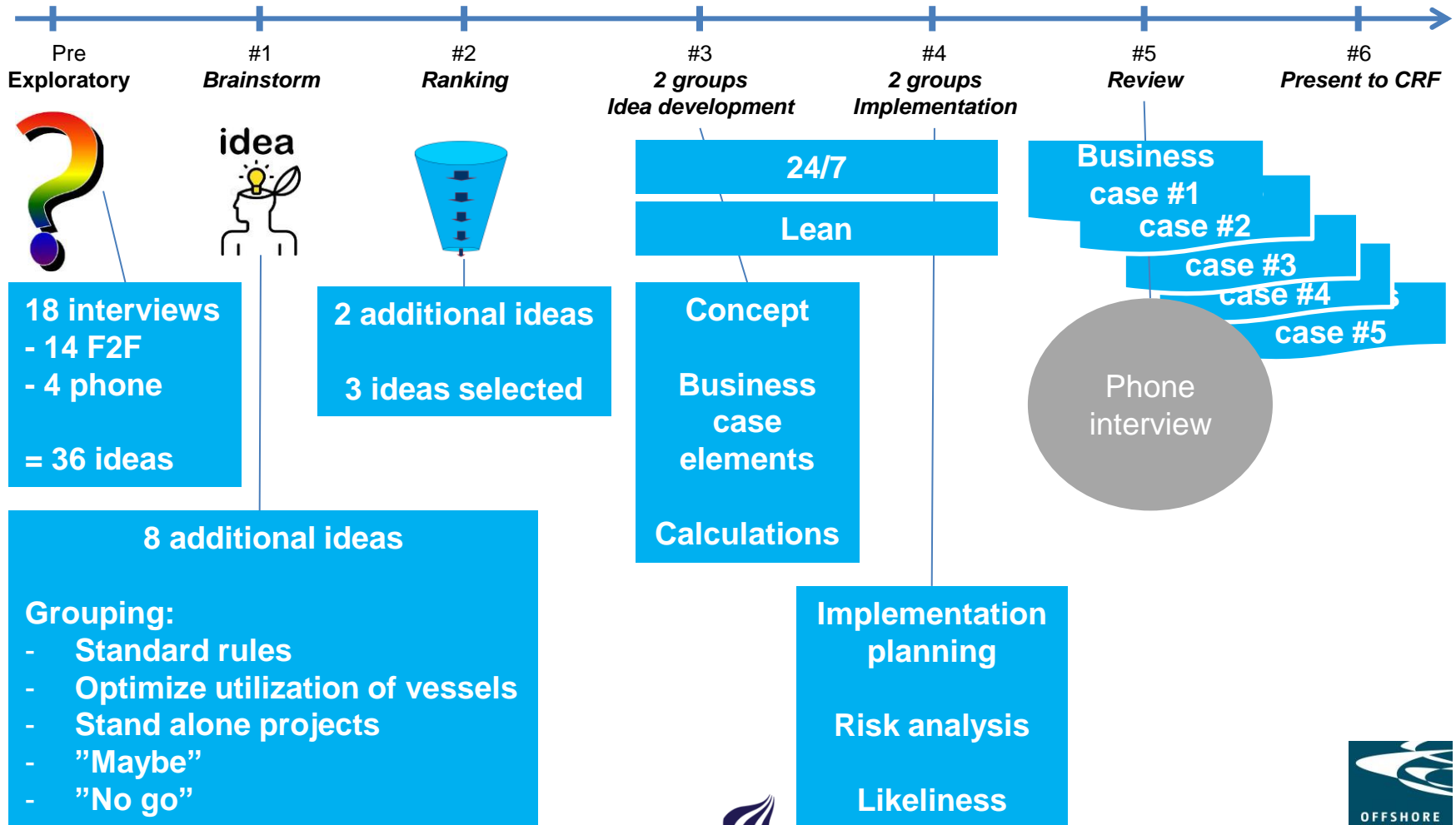
Over view of assets included in cost of energy



Case: Cost Reduction Forum

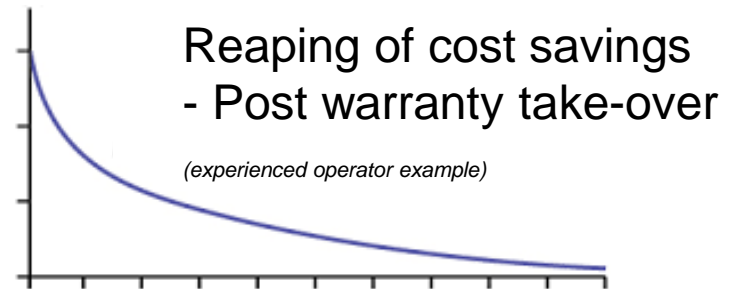


Case: O&M logistics cost reduction

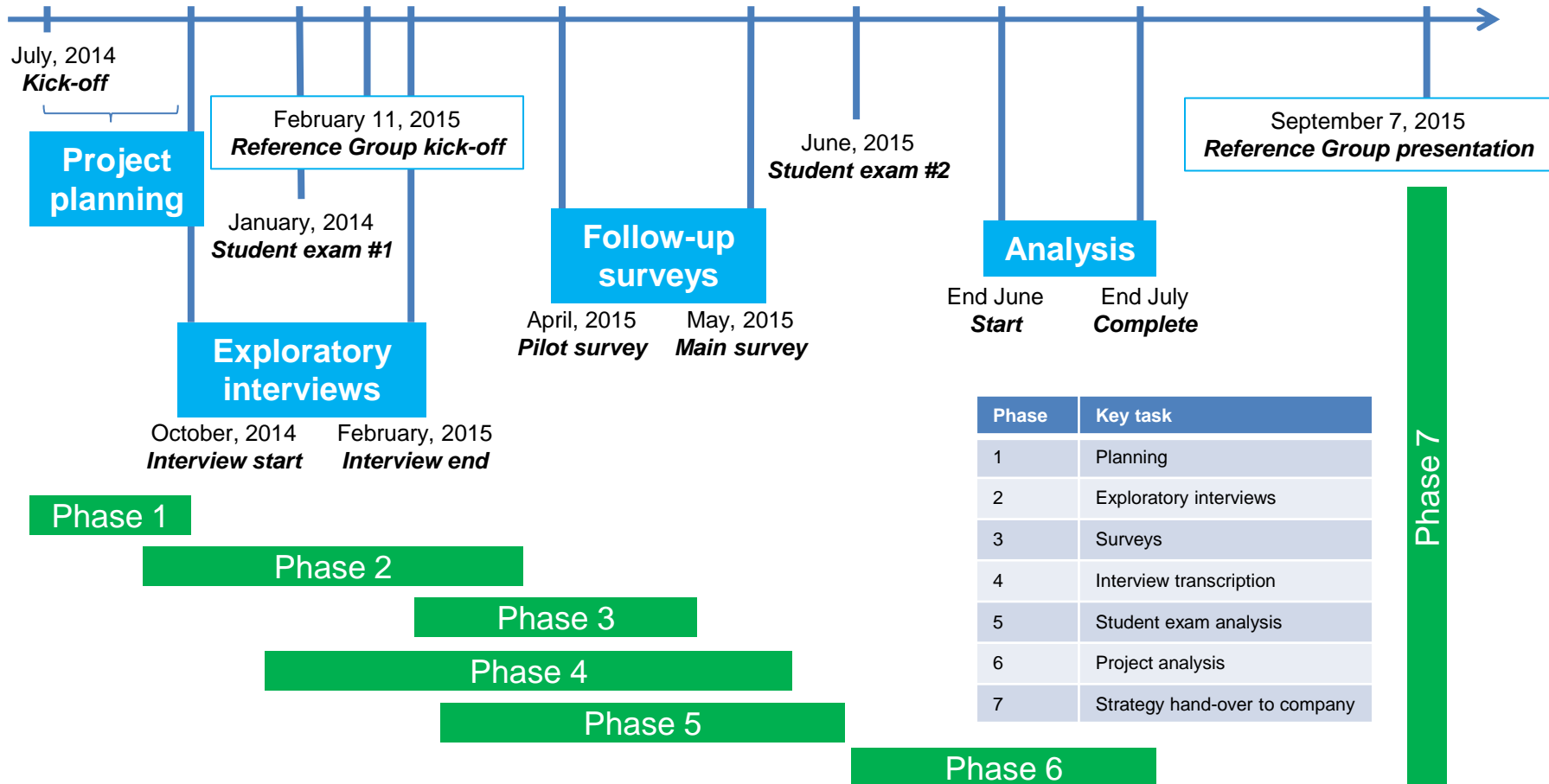


CRF findings

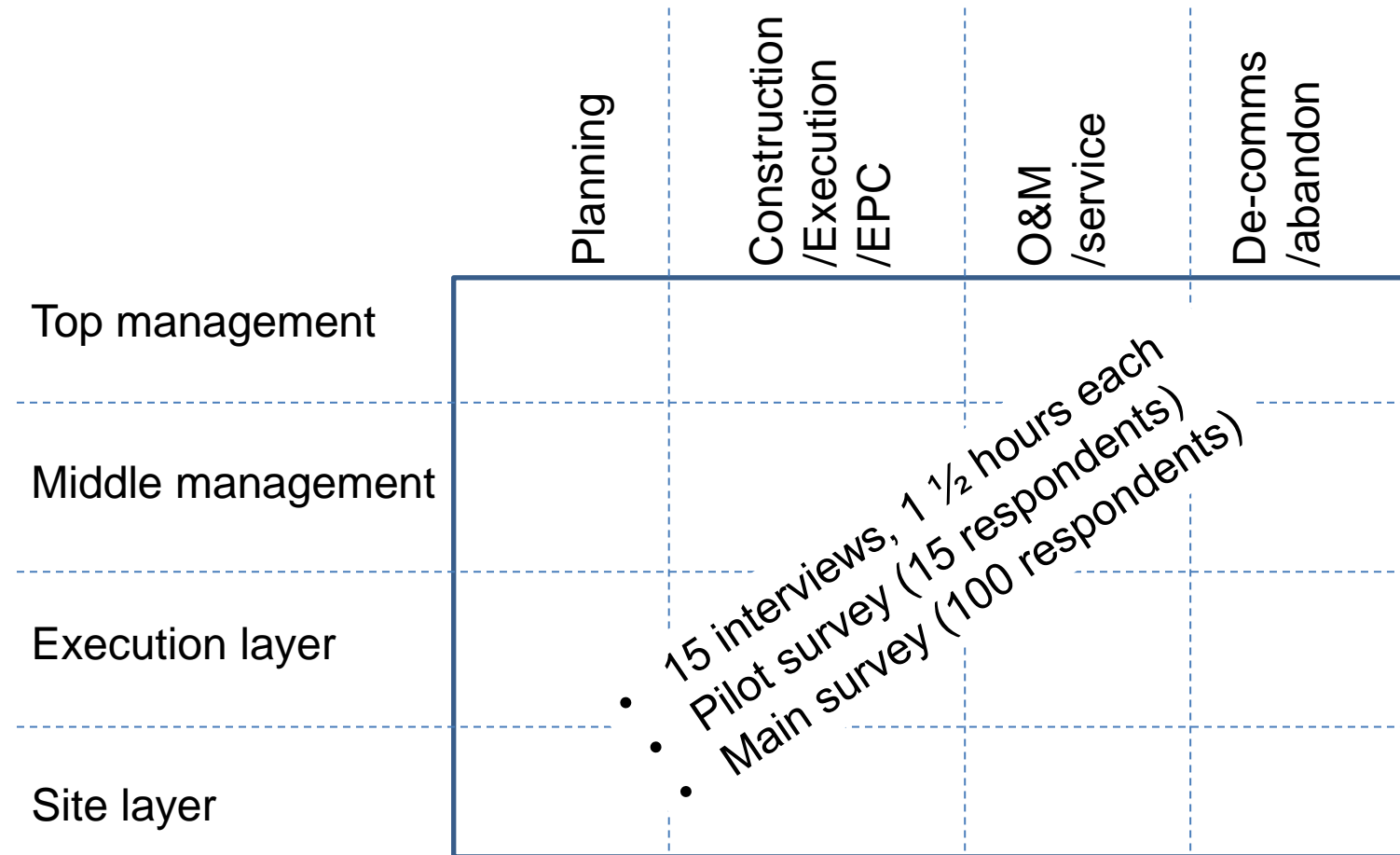
- Point of departure:
 - Key country LCoE reports (UK 2012, Germany 2013)
- How to get actual cost out – not just identify “potential levers”
- Warranty period expiry is a key milestone
 - Pre/post/hand-over



Case: Logistics innovation



Complex organization to cover



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



In Europe...

- Similar wind conditions:

➤ Horns Reef III
VATTENFALL 








➤ Hornsea
DONG
energy



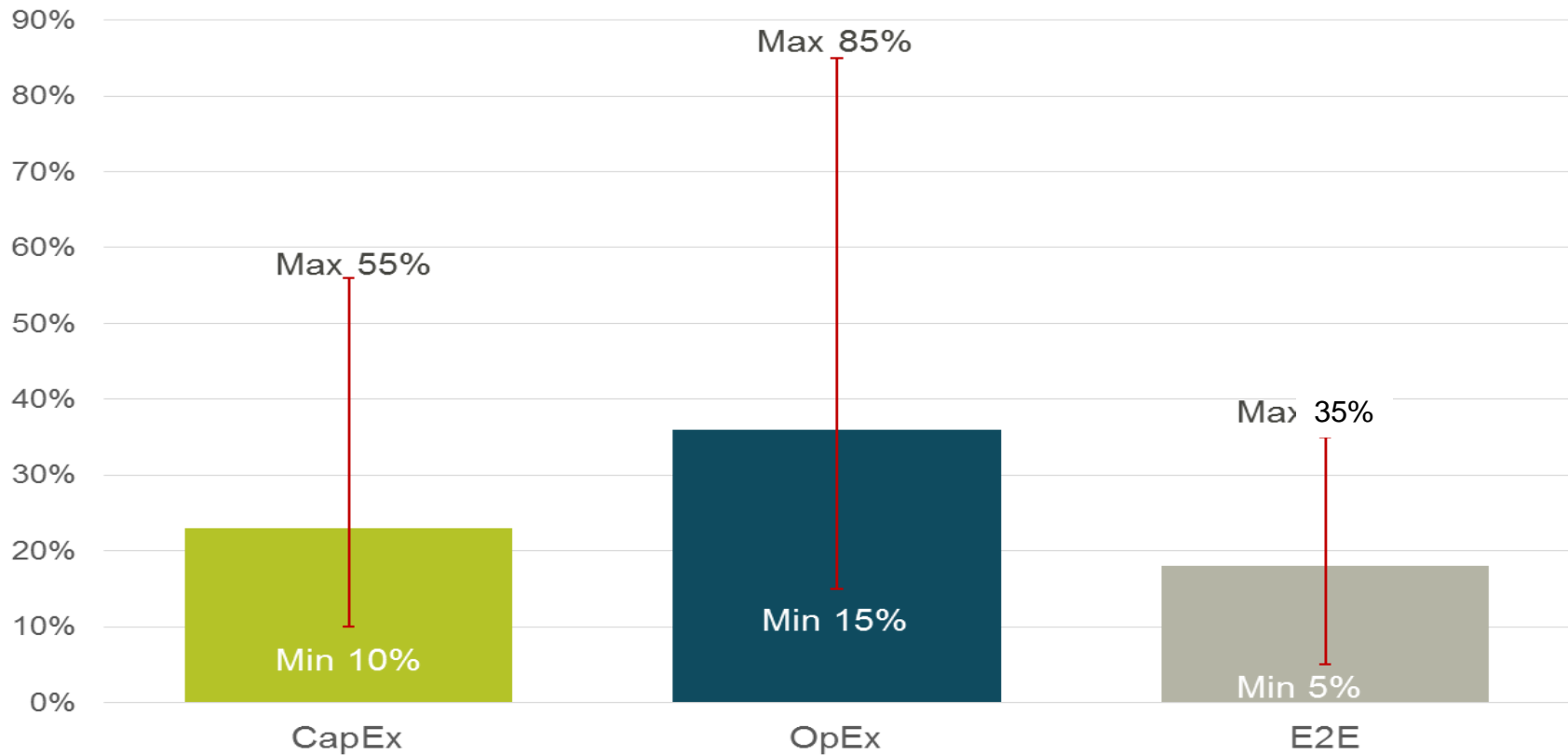
Case: Logistics innovation

Top innovation ideas from process – O&M relevance

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

The money: Recent case study

Average logistics costs with min/max values



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Conclusion

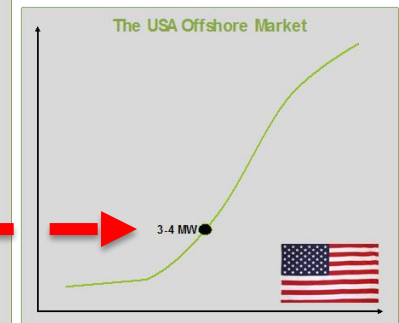
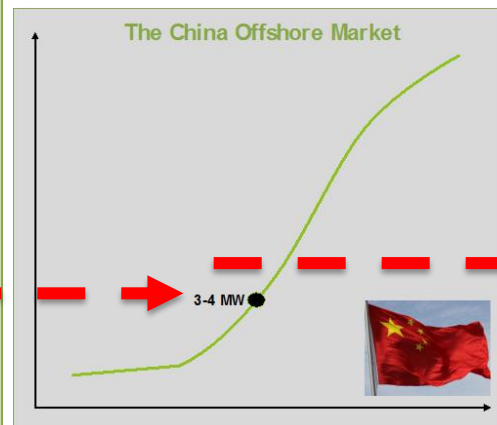
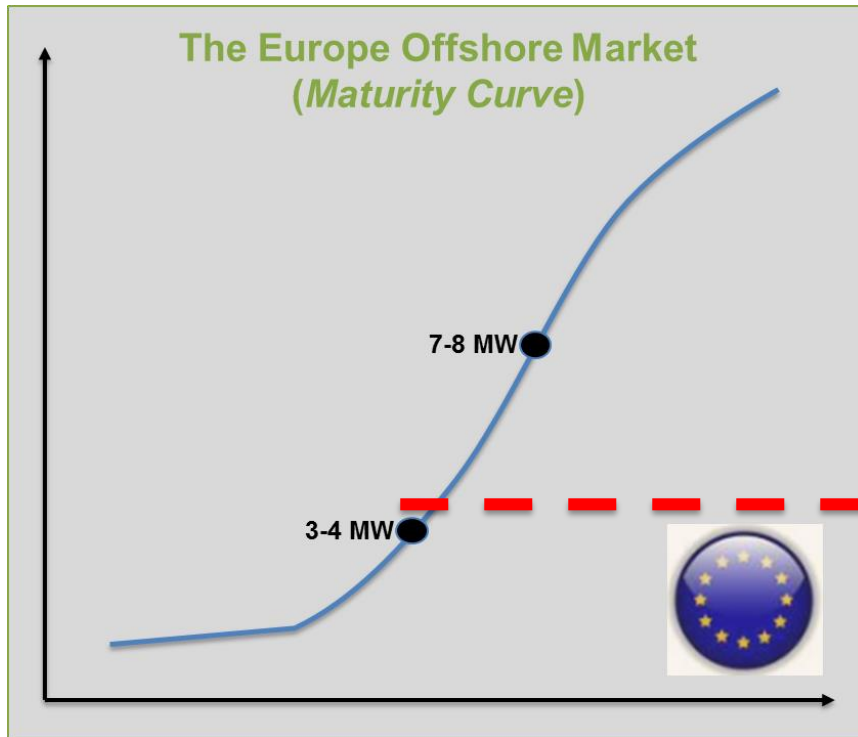


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Maturity and globalization



**Different
Business Model !!**

**Deferred
timing !!!**

China: Run to fail

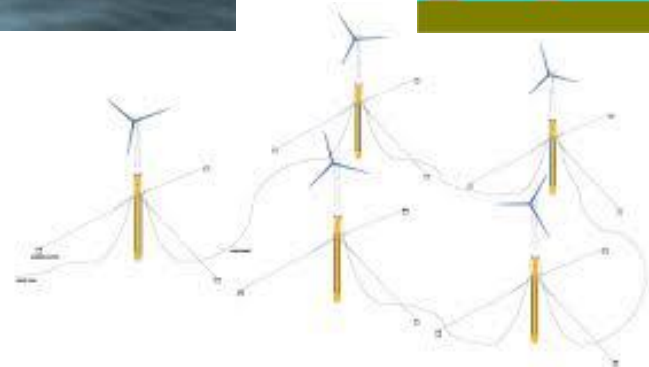
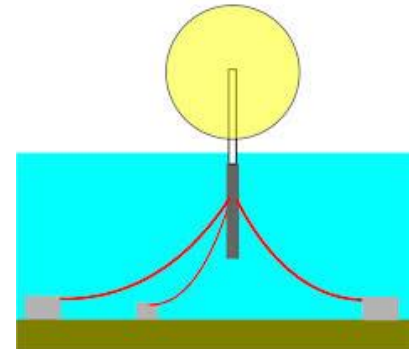


Onshore issues: Quality, materials, and grid curtailment

And what about...?

Floating turbines...

- Installation is tough
- O&M?



Key take-aways from today

- Offshore wind market is growing rapidly
- Many projects in the pipeline, under construction, and already in operation
- Number of operating wind farms increasing dramatically
- New O&M concepts are needed as wind farms move further from shore into deeper waters
- Globalizing market offers scalable business model

Questions & answers?

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