R&D AS INPUT TO COST OF ENERGY REDUCTION

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EERA DeepWind 2015

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Contents

- LCOE status
- Radical versus Incremental designs - LCOE reduction game– exemplified
- R&D and upscaling of turbines and foundations
- Example – R&D
- Conclusion

Offshore Wind in Statkraft - Status

- **Statkraft Strategy**
  - Long term player within offshore wind
  - Profitable lead operator in all phases

- **News**
  - Dudgeon contracted cost indicate significant cost of energy (COE) saving from Sheringham Shoal
    - Larger wind resource
    - Larger turbines (highest potential for cost reduction)

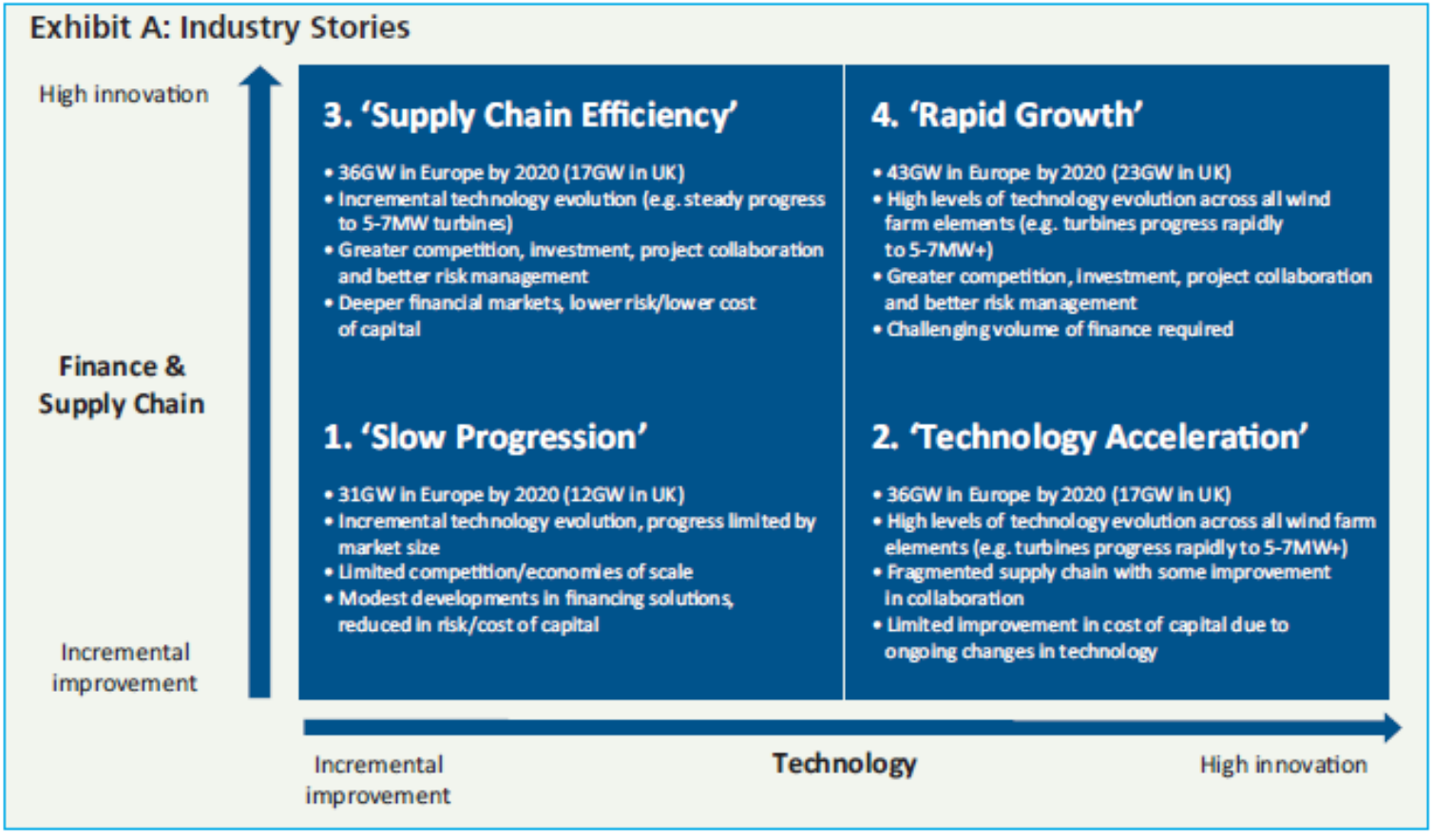
- **Optimized and integrated design – contribution to LCOE - still not fully utilized**

Larger turbines and improved access system with highest impact on CoE

1+ 4	New foundation design (including without piling) optimized for fabrication, transport and installation *
5	Improved jacket design manufacturing
6	*Engineering tool for foundation concept evaluation and selection - not quantified*
14	*Reliability database for the offshore wind industry (like OREDA) - not quantified*
17	*New design. Integrated solutions (transport/ installations, pre-assembly), floating installation vessels/crane, improved feeder and other transport solutions – not quantified*
18	*Engineering tool for installation concept evaluation and selection – not quantified*
26	Safe Access/transfer system for DB conditions
27	Increase use and utilization of CMS
29	Development and validation of improved wake models * *
20	Higher voltage inter-array (66 kV)**
35	6 and 7 MW offshore wind turbines ***

**Reduction potential number from Offshore Wind Accelerator for concepts at 35 m water depth*
*** Reduction potential number from Offshore Wind AcceleratorProgram*
**** Average of a 6 and a 7 MW turbine*

Innovation as input to Cost Reduction



Offshore Wind Cost Reduction. Pathway Study: Crown Estate 2012

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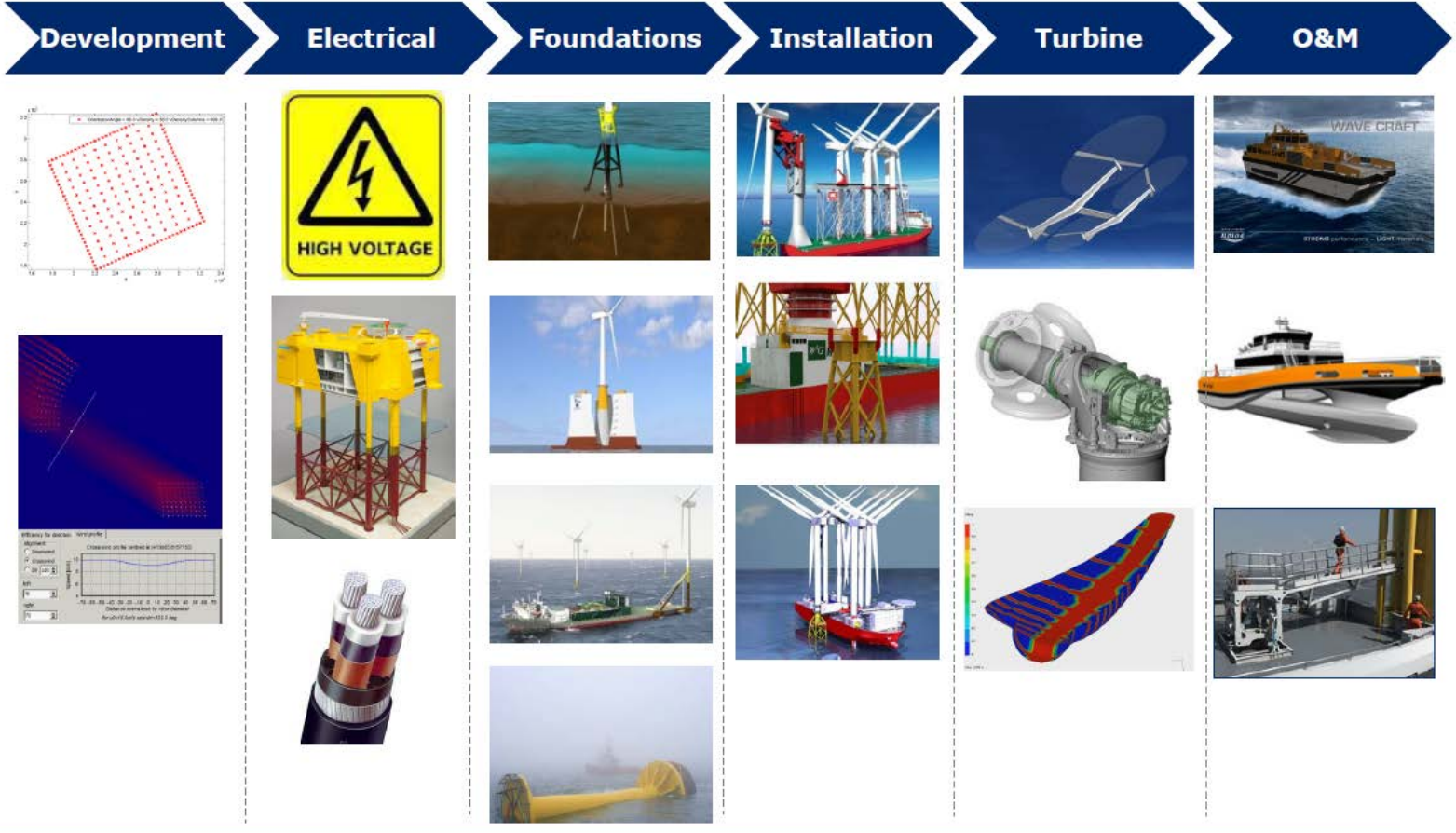
Opportunity for innovation to drive down costs across the supply chain



OWA has made real impact so far

Demonstrating innovations is critical to achieve cost reduction

Still to come

Reducing O&M cost

New vessels concepts

Fjellstrand

Prototype: 2013

NautiCraft

Prototype: 2014

WaveCraft

Prototype: 2015

Extreme Ocean

Prototype: 2015

- PDV vessel
- P-plots
- Divex
- Mothership

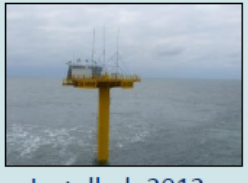
Radical

Reducing Foundation cost

New foundation concepts

Keystone

Installed: 2011



Universal

Installed: 2013

Suction Bucket Jacket

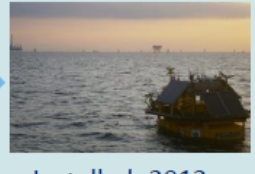
Installed: 2014

- UF demo
- Keystone demo
- GBF demo

Radical but monopile winning

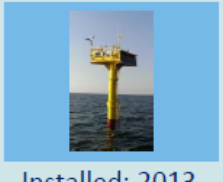
Reducing Financing cost

New wake models & LIDAR



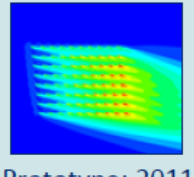
FLIDAR

Installed: 2012



Babcock

Installed: 2013



Fuga

Prototype: 2011

Wake Campaign

Installed: 2012

- Measured TI (LIDAR), modelled TI (Frandsen), scanning LIDAR

Incremental

Reducing Elec. System cost

Higher voltage arrays

66kV switchgear

Commercial: 2014

66kV

Commercial: 2015

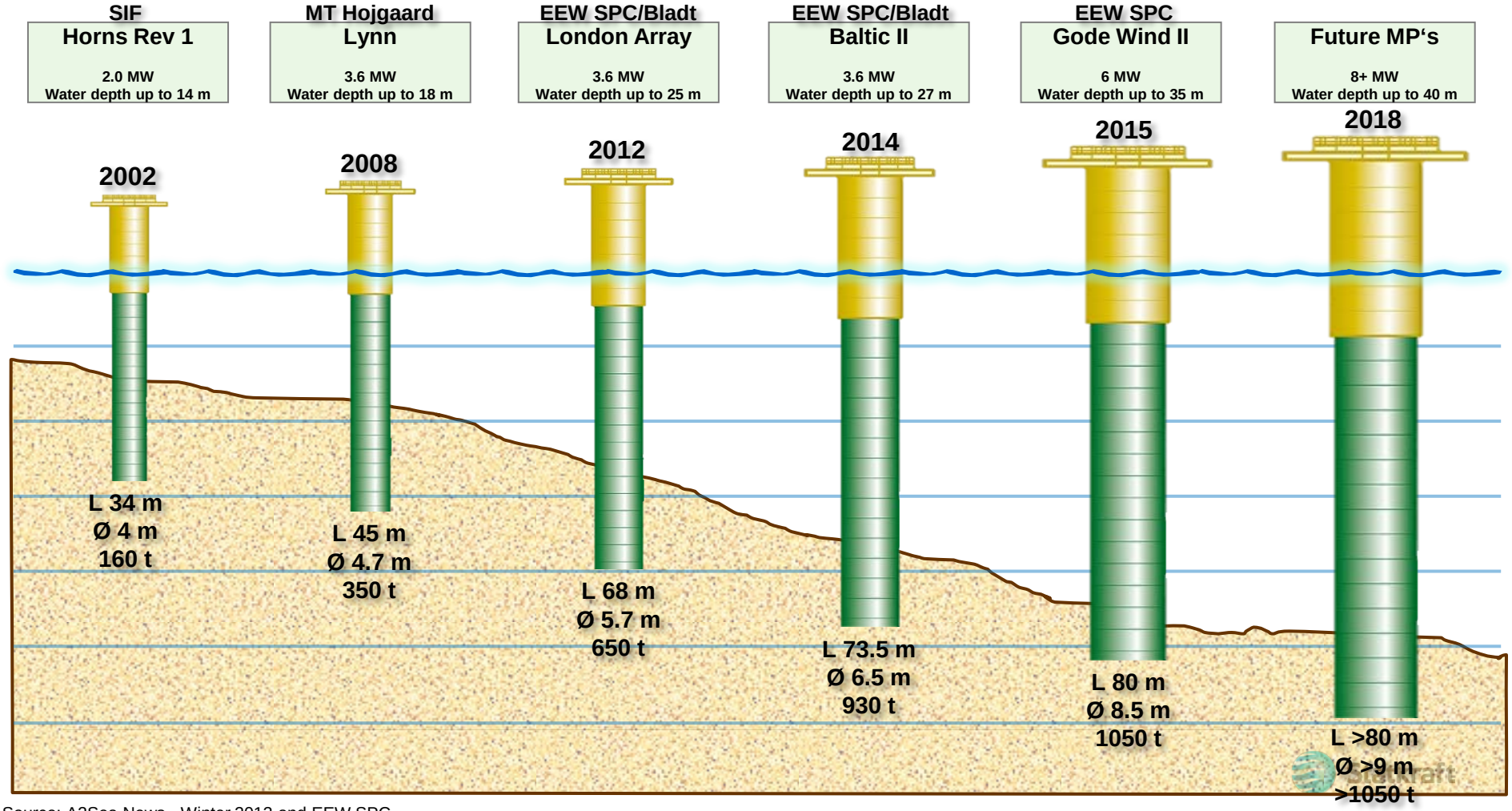
Cable qualification

Commercial: 2015

- 66kV demo
- Dynamic cable demo

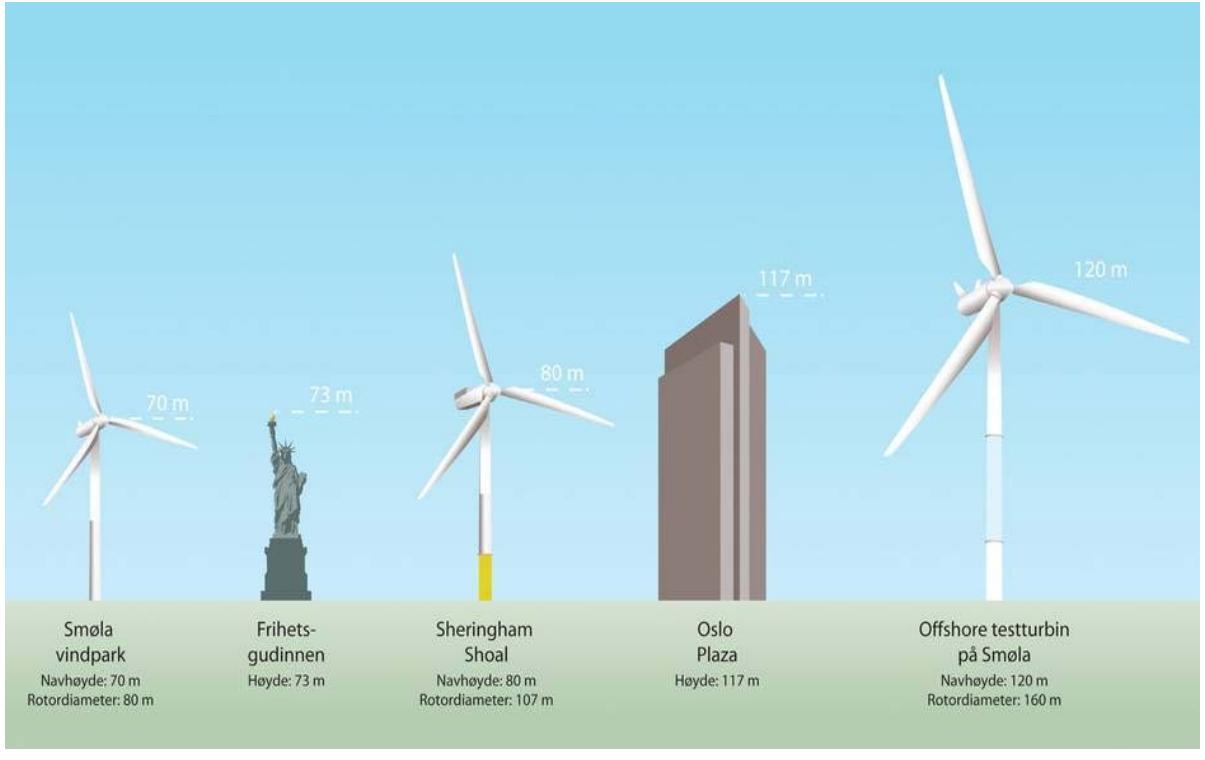
Incremental

Development of MP‘s – scaling up diameter and length



Source: A2Sea News - Winter 2013 and EEW SPC

Smøla test turbine – scaling up rotor diameter



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Example scaling - 6P interaction

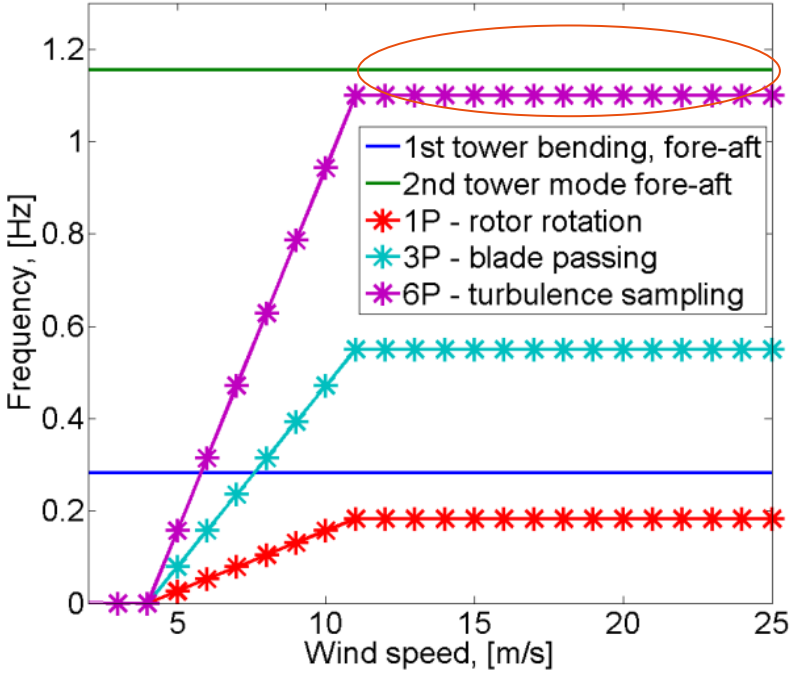
XL-diameter monopile
Large turbine - 154 meter diameter

6P = 1.1 Hz

2nd tower mode = 1.15 Hz

Critical design drivers - Significant influence on COE

- Avoidance of 1P, 3P interaction with 1st tower bending mode (All turbines)
- Avoidance of 6P interaction with 2nd tower bending mode (Large turbines)



ref Lene Eliassen post.doc - NTNU

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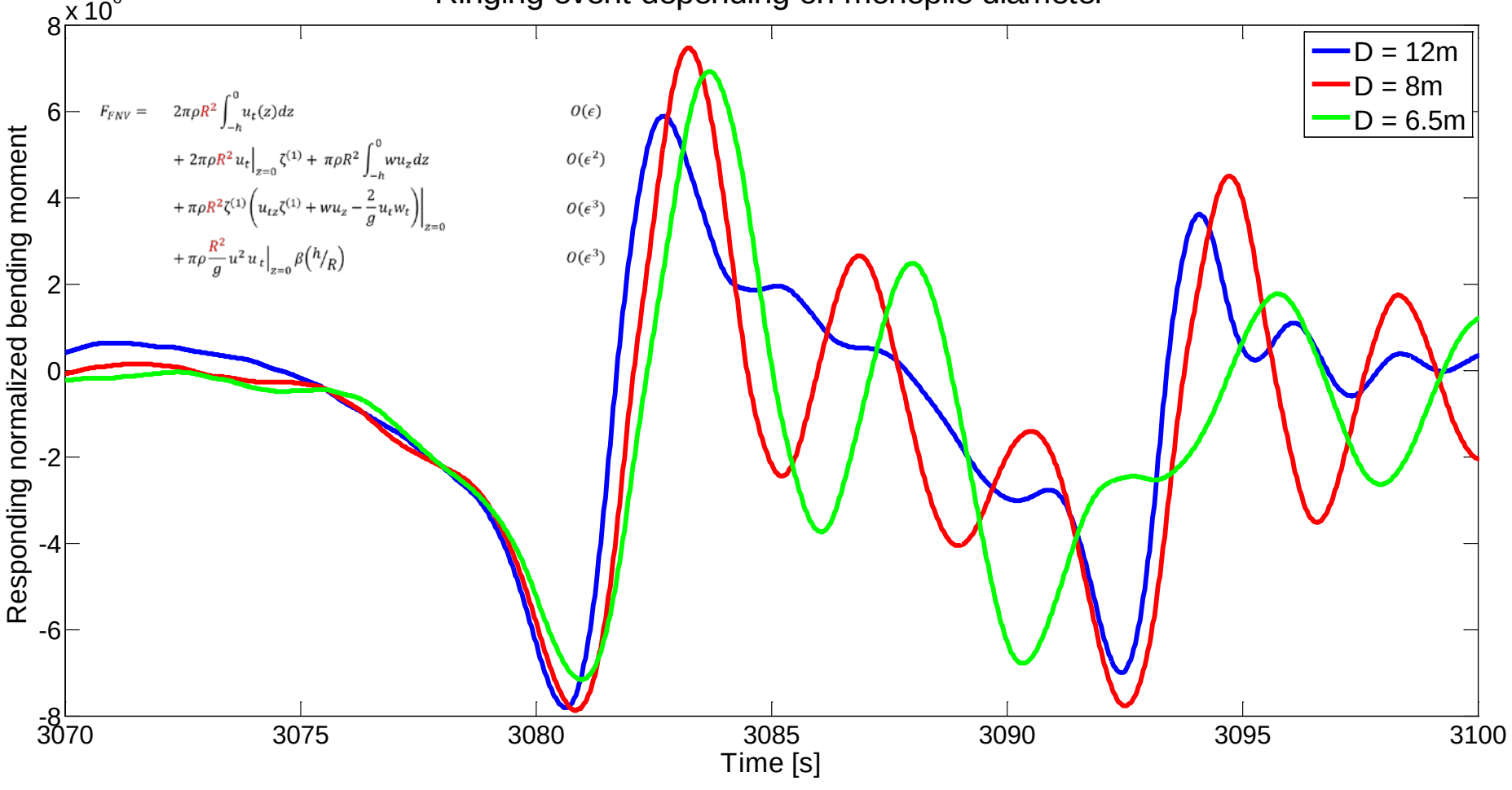
Example scaling

Ringing event depending on monopile diameter



NTNU – Trondheim
Norwegian University of Science and Technology

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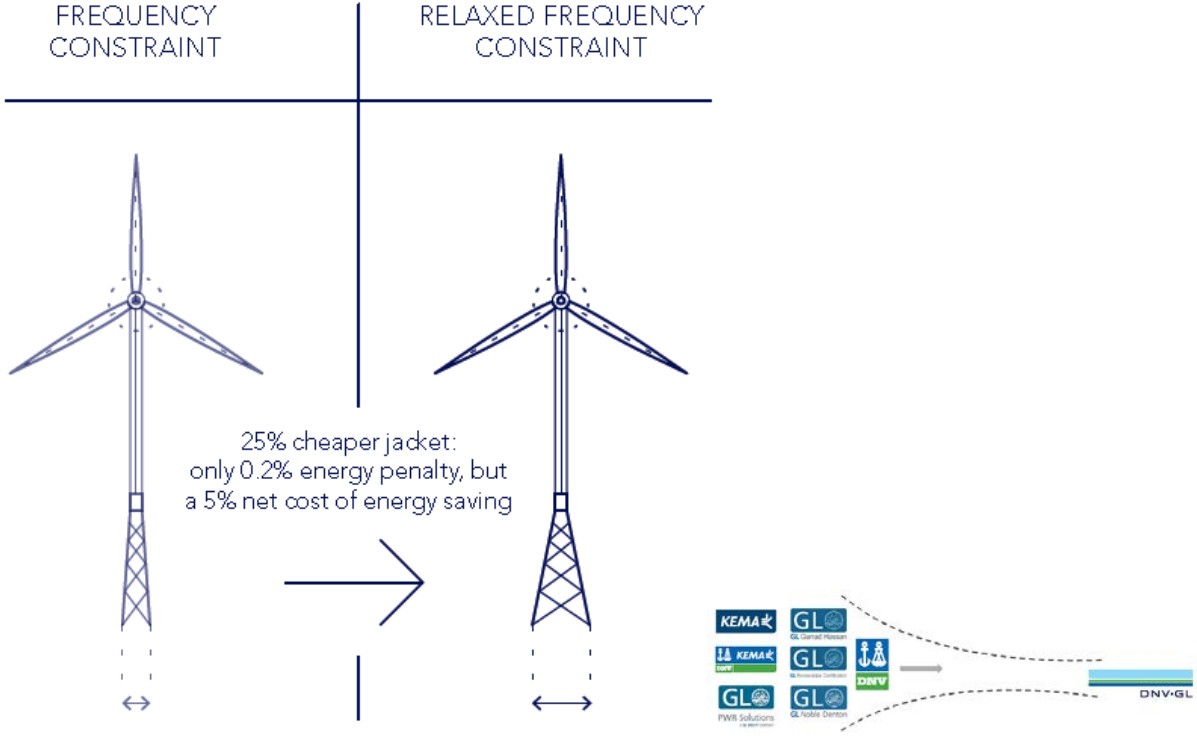
Large turbines – highly integrated with tower and foundation design – cost implications

- OWA (Offshore Wind Accelerator) studies show cost estimates for foundations (Capex) sensitive to large rotors (above 150 meter diameter) due to interaction
- Comparisons between foundations with 5 MW turbine and updated foundations with 8 MW turbine **-> relative cost picture has been changed**
- In particular for jacket designs and some mono-type foundations

Cost targeted R&D needed - incremental



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Summary and reflections

- Incremental technology development and upscaling choosen as a mean to reduce LCOE – the industry do not risk to many radical concepts due to unacceptable risk
- R&D LCOE reduction:
  - Integrated methods
  - helping out with integrated foundation and turbine design
  - park layout
  - yield estimates and more optimal O&M
- Incremental technology development will require targeted method contributions from R&D – FAST IMPLMENTATION

THANK YOU

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