IN ASSOCIATION WITH

CATAPULT
Offshore Renewable Energy

scottish renewables

OFFSHORE WIND CONFERENCE, EXHIBITION & DINNER

23 & 24 JANUARY 2017 **GLASGOW**

THE CROWN ESTATE
SCOTLAND PORTFOLIO

INVEST IN FIFE

NewWaves Solutions
Marine & Environmental Services

HIE
Highlands and Islands Enterprise
Iomairt na Gàidhealtachd 's nan Eilean

Planning and Consents

Patricia Hawthorn, Shepherd and Wedderburn

Gordon McCreath, Pinsent Masons
Adam Ezzamel, Aberdeen Offshore Wind Farm
Paolo Pizzolla, Royal HaskoningDHV
Helen Walker, ScottishPower Renewables

Gordon McCreath

Pinsent Masons

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CATAPULT Offshore Renewable Energy

THE CROWN ESTATE SCOTLAND PORTFOLIO

NewWaves Solutions Marine & Environmental Services

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Consenting offshore wind in Scotland and England – room for improvement?

Gordon McCreath

Partner

24 January 2016

Pinsent Masons

Scottish consenting report card

- In the UK class
- From pre-app to construction
- Too many detentions, compared to England
- Where can Scotland do better?

“Scotland excels at…”

- Access to decision makers
- Communication and collaboration
- Finding solutions: e.g. habitats issues
- Evolving, iterative regulatory approach
- Flexible procedure to allow that

“Both do well in different ways on…”

- Confidence of timescale for decision
- Fungibility
- Flexibility of project description

“Scotland would do well to take England’s example on…”

- **Guarantee** of timescales: but comes at a price…
- One stop shop: e.g. onshore planning, CA, temp possession, MLs, env permits, wildlife licences
- Considering in public e.g. Report on Implications for European Sites
- Conditions?
  - 38 in S36, 34/59 in OWF/OfTW MLs, 15 consent plans
  - When broken down into preconstruction, construction, post construction requirements = 210 conditions!

“Scotland would do well to take England’s example on…”

- Conditions:
  - Fewer? Only at first glance…
  - Clearer – drafted by developer…
  - Fewer consultees
    - fewer consultees means more information up front. SoCGs?!
  - Certainty of process for discharge
  - Better for developer, MS, funder, contractor
- PPAs and resources

In summary…

- Both work, in some areas with more difficulty than others
- Scotland certainly has room for improvement, but so does England and both will come with age
- But Scotland needs to be careful not to overcompensate and lose its advantages

Contact

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Helen Walker

ScottishPower Renewables

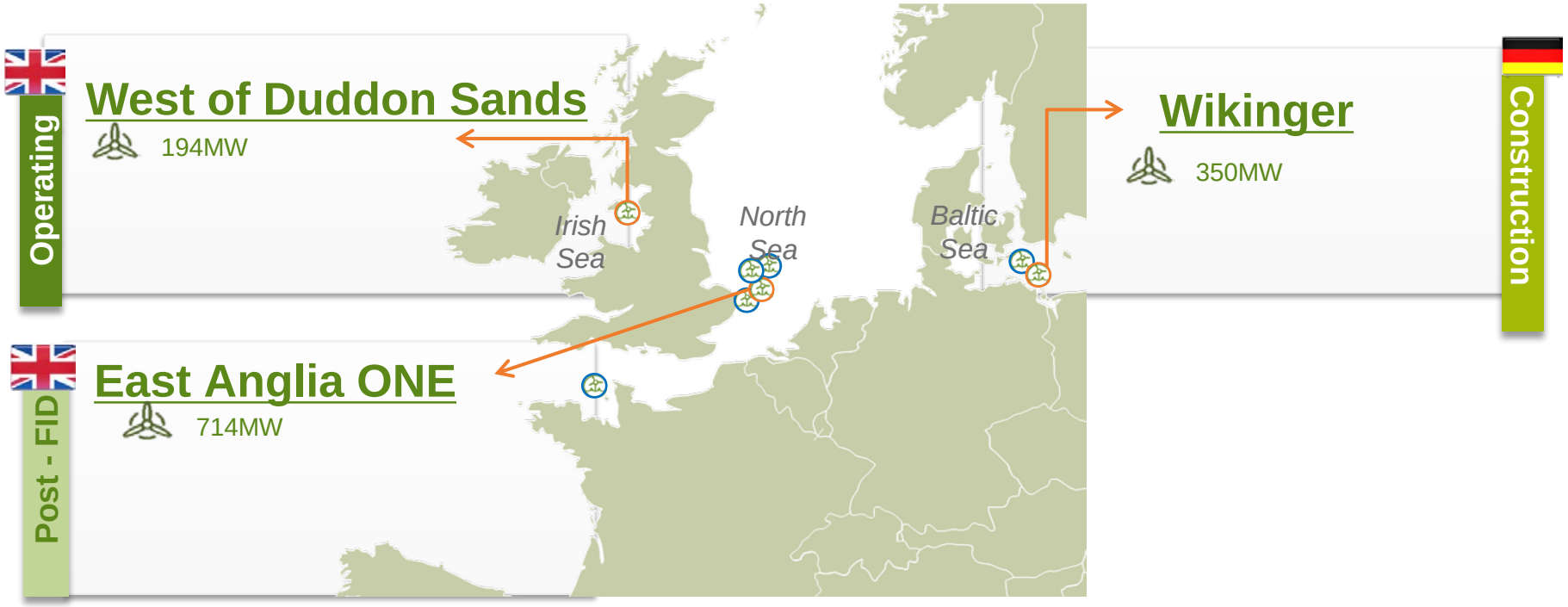
SCOTTISHPOWER RENEWABLES

Scottish Renewables Offshore Wind Conference

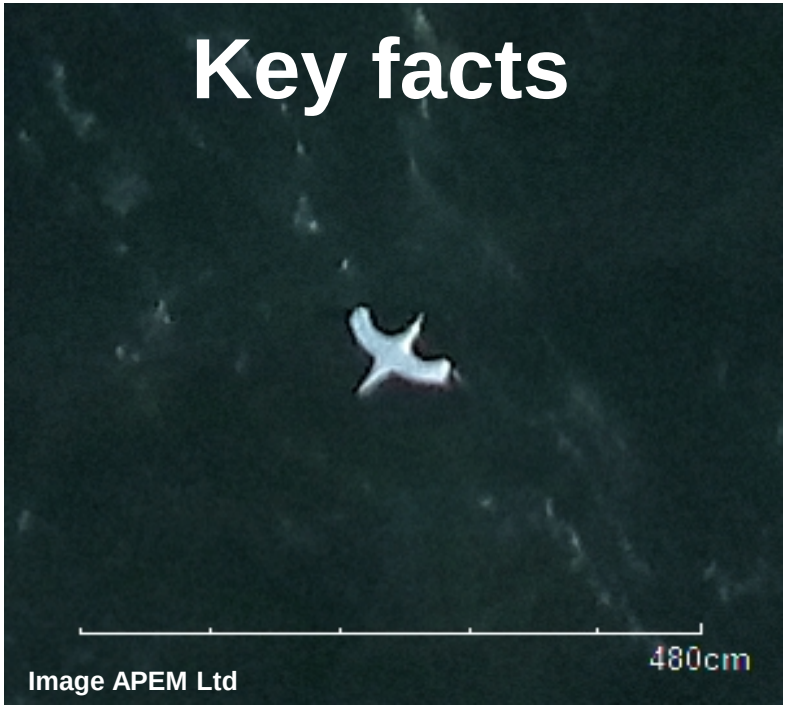
Helen Walker

European consenting regimes

Introduction to SPR – Offshore Projects Overview



Three offshore projects post FID (1.3GW) spread geographically and in time

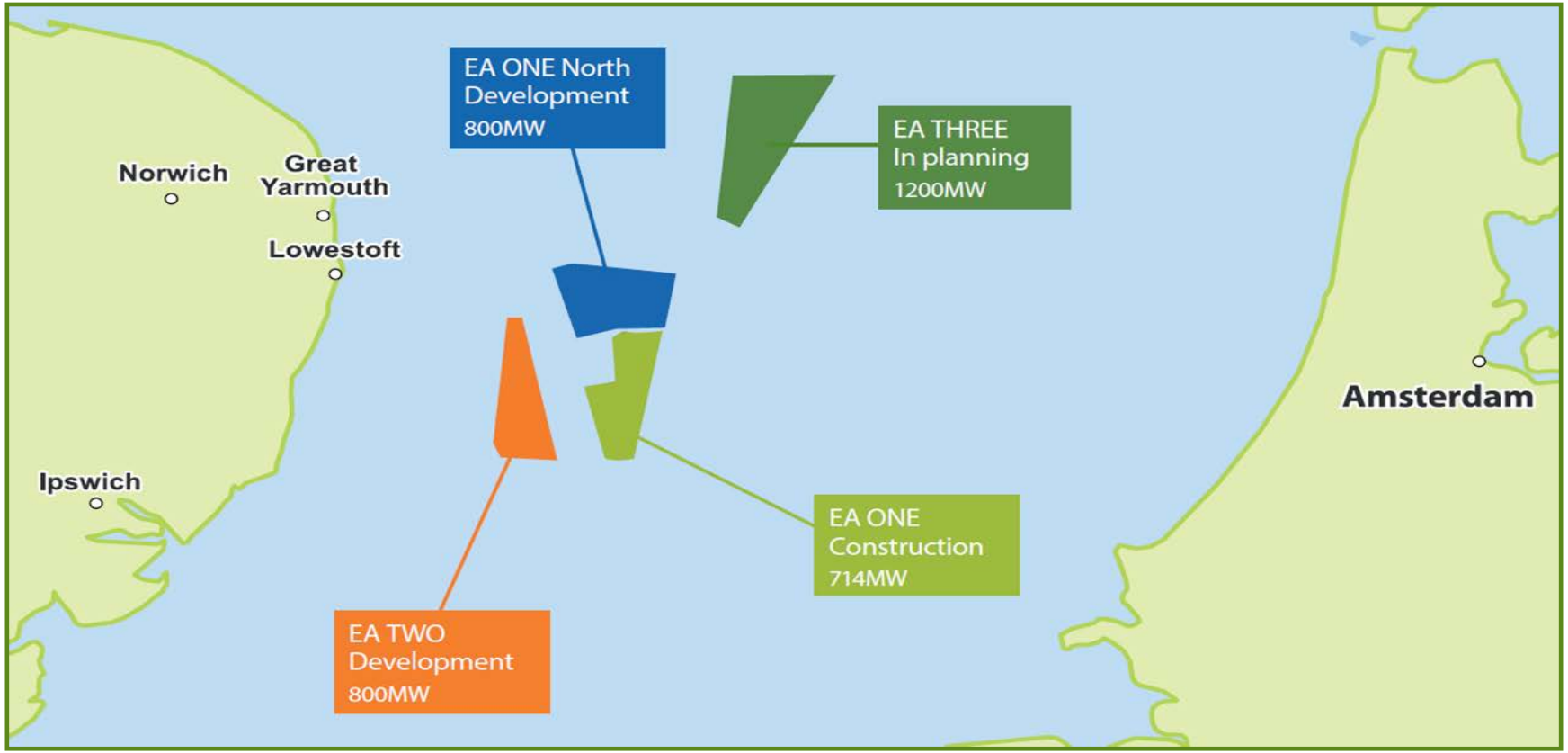


Marine Scotland competent authority for S36 consent and Marine License. Onshore works via S37 or Town and Country Planning.

Consultation is iterative throughout and up to 'Determination'.

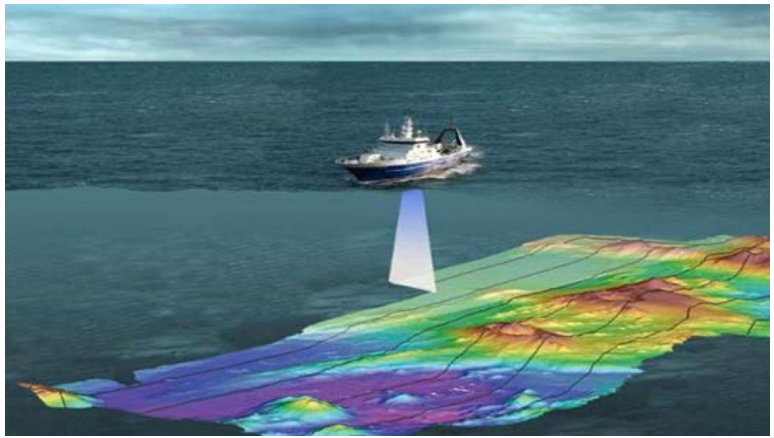
Timescales for determination are not defined. As consultation can continue up to determination, new information can be considered meaning a decision can take longer.

English and Welsh Consenting Process



What's the same?

- Shared environmental
- Shared supply chain and pool of consultants
- Rochdale Envelope



What's different?

- England and Wales extremely procedural process for development
  - Accurately plan when your decision will be made
  - Process front loaded pre application consultation
  - Pushed to resolve issues at examination under time pressure
  - all discussion must be publically available
  - DCO is as a cohesive consent, includes DML and associated development.
  - No right to roam – onshore survey access can be a significant issue
- Wales currently no associated development

- BSH
- No Rochdale envelope
- EIA and Design process clearly set out following process set out in StUK
- Onshore apsects consents and delivered separately
- 1st release: Design draft (requires geotechnical pre-investigation -10% of WTG positions-)
- Design draft: basis for EIA
- 2nd release: Basic design
- 3rd release: Implementation planning
- 4th release: Formal operation release

Industrial plan first. public debate, a series of submissions were made with regard to different aspects of the project, examination process actually started at planning application, in Oct. 2015.
A public inquiry took place in summer 2016.
Permit granting is expected in Q1 2017.

Concerns of fishermen about the inter array cables and navigational difficulties. No Rochdale envelope, grid connection supplied separately.

Summary

- Grid connection process very different
- Different approaches to Rochdale Envelope
- Same key EIA issues (and overarching directive)
- Consultation / public debate important in all regimes
- Some regimes more prescribed than others

Important for the future

- Certainty over timescales
- Over parameterisation of the consent
- Process for amending consent

Thank you!

Adam Ezzamel

Aberdeen Offshore Wind Farm

European Offshore Wind Deployment Centre

Consenting and Scientific Research

EOWDC Project Director: Adam Ezzamel

24/01/17

VATTENFALL

VATTENFALL UK WIND PORTFOLIO

EOWDC PROJECT FACTS

Turbines: Eleven V164-8.4MW

Foundation: Suction Bucket Jackets

Transformer Supply: 66Kv

Installed Capacity: 92.4MW

Annual Production: 309GWh

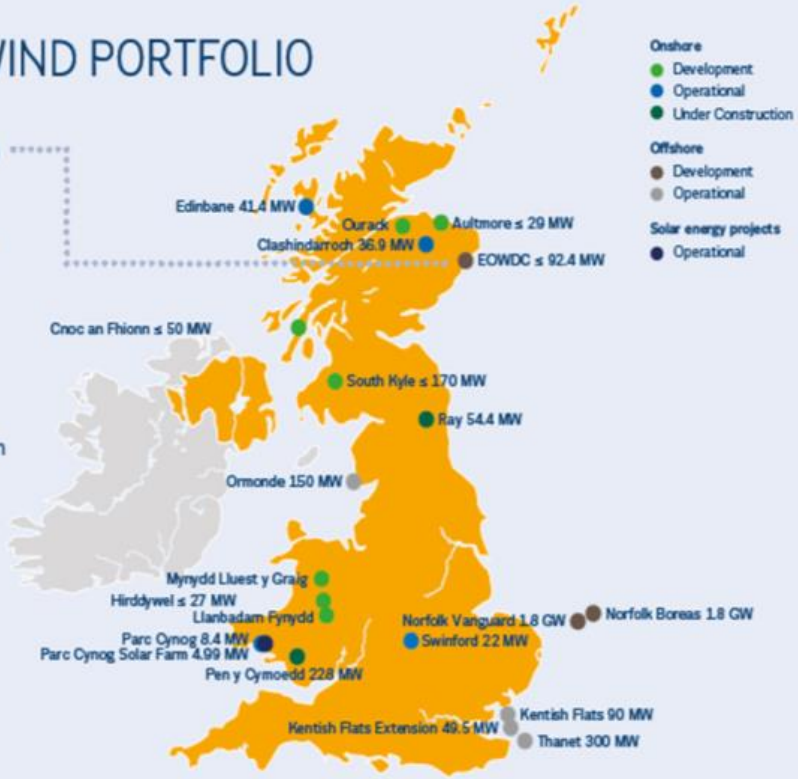
Displaced CO_2: 132,977

Grant Funding: Up to €40million from the European Union

Construction start date: Q4 2016

Commissioning: Q3 2018

Operational: 20 years



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EOWDC - ONSHORE CONSTRUCTION

Onshore construction began at Blackdog on the 17th October 2016

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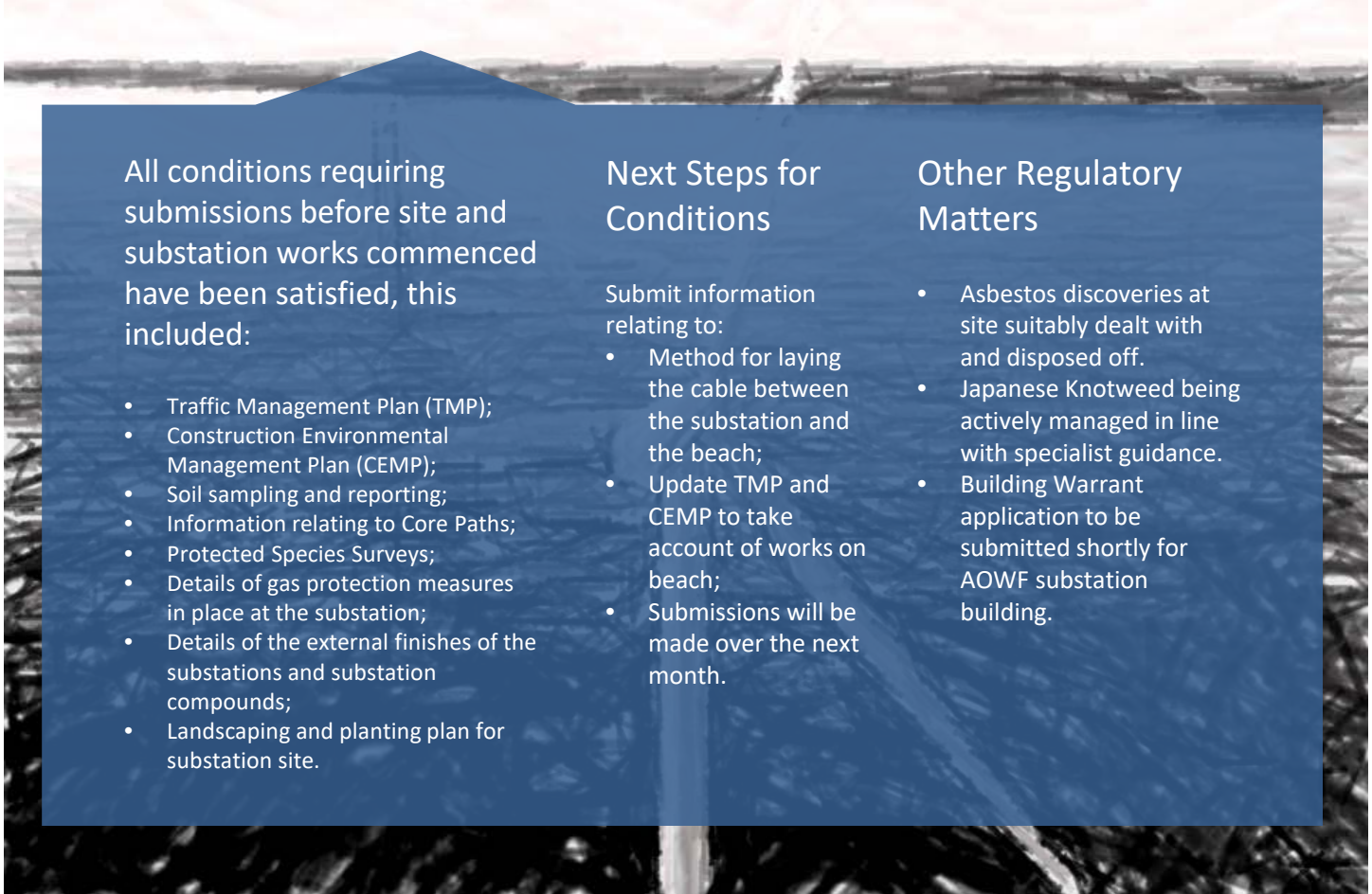
ONSHORE CONSENT UPDATE



All conditions requiring submissions before site and substation works commenced have been satisfied, this included:

- Traffic Management Plan (TMP);
- Construction Environmental Management Plan (CEMP);
- Soil sampling and reporting;
- Information relating to Core Paths;
- Protected Species Surveys;
- Details of gas protection measures in place at the substation;
- Details of the external finishes of the substations and substation compounds;
- Landscaping and planting plan for substation site.

Next Steps for Conditions

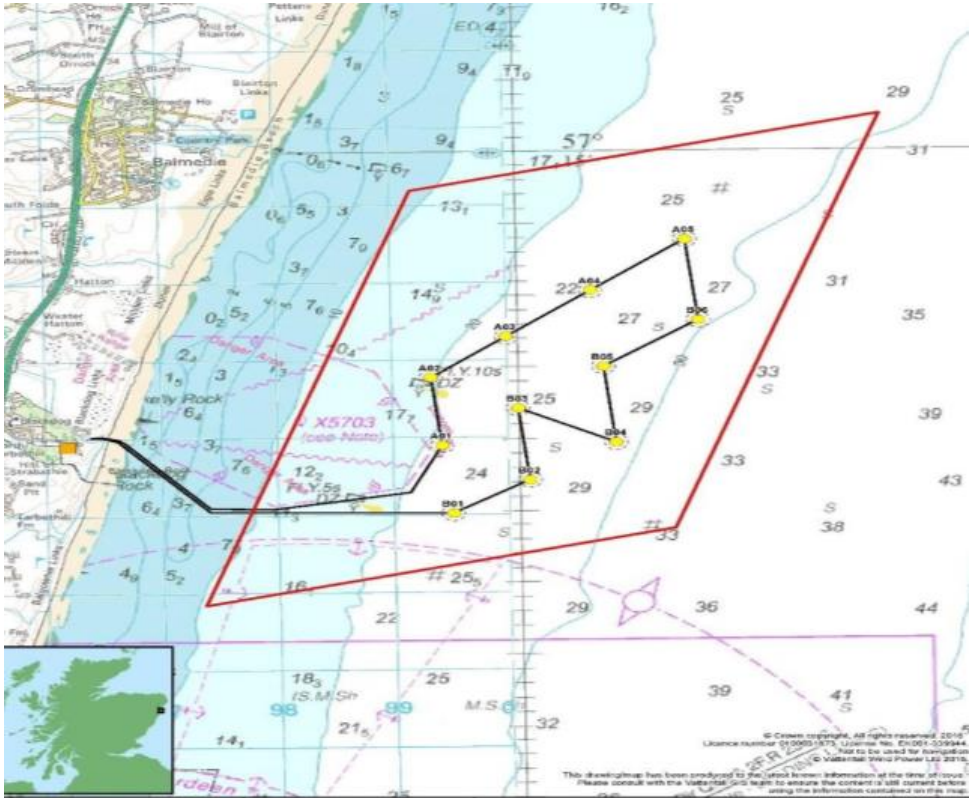
Submit information relating to:

- Method for laying the cable between the substation and the beach;
- Update TMP and CEMP to take account of works on beach;
- Submissions will be made over the next month.

Other Regulatory Matters

- Asbestos discoveries at site suitably dealt with and disposed off.
- Japanese Knotweed being actively managed in line with specialist guidance.
- Building Warrant application to be submitted shortly for AOWF substation building.

EOWDC - OFFSHORE DEVELOPMENT



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OFFSHORE CONSENT UPDATE

On 26 March 2013, AOWFL received consent from the Scottish Ministers under Section 36 of the Electricity Act 1989 for the construction and operation of the European Offshore Wind Deployment Centre.

On 15 August 2014 a marine licence was attained under section 25 of the Marine (Scotland) Act 2010. This Marine Licence was varied on 30 September 2016 to align with the duration of the Section 36 consent .

Where are we now?

- The S.36 Consent and Marine Licence contain a variety of conditions that must be discharged through approval by the Scottish Ministers/Licensing Authority (in consultation with the relevant stakeholders) prior to the commencement of any offshore construction works.
- These requirements include the approval of a series of plans and programmes (Cable Laying Strategy, Construction Method Statement, Design Statement,..).
- AOWFL is currently preparing these plans and programmes.

SCIENTIFIC RESEARCH

ENVIRONMENTAL
RESEARCH & MONITORING
LARGEST FUND OF ITS KIND

Areas of focus: Birds, Marine Mammals, Fish, Socio-economics, Coastal Processes, Water Quality, Benthos and Colonisation

Aug 16 Programme Launched

Sep 16 Calls for EoI (90+)

Nov 16 Shortlisted projects submitted detailed Proposal (16)

Nov-Jan Proposals under review

Mar17 Successful Projects Announced

SCIENTIFIC PANEL

marine scotland science
The Scottish Government
SEPA Scottish Environment Protection Agency
WDC Whale and Dolphin Conservation
VATTENFALL
rspb giving nature a home
Scottish Natural Heritage All of nature for all of Scotland
JNCC Joint Nature Conservation Committee
THE CROWN ESTATE
areg Aberdeen Renewable Energy Group

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SHORTLISTED PROJECTS

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Paolo Pizzolla

Royal HaskoningDHV

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Industry Evidence Programme (IEP)

Scottish Renewables

Paolo Pizzolla & Rufus Howard

24th January 2017

Welcome

- Introduction: State of EIA
- Industry Evidence Programme (IEP)
- Project Update
- Next Steps

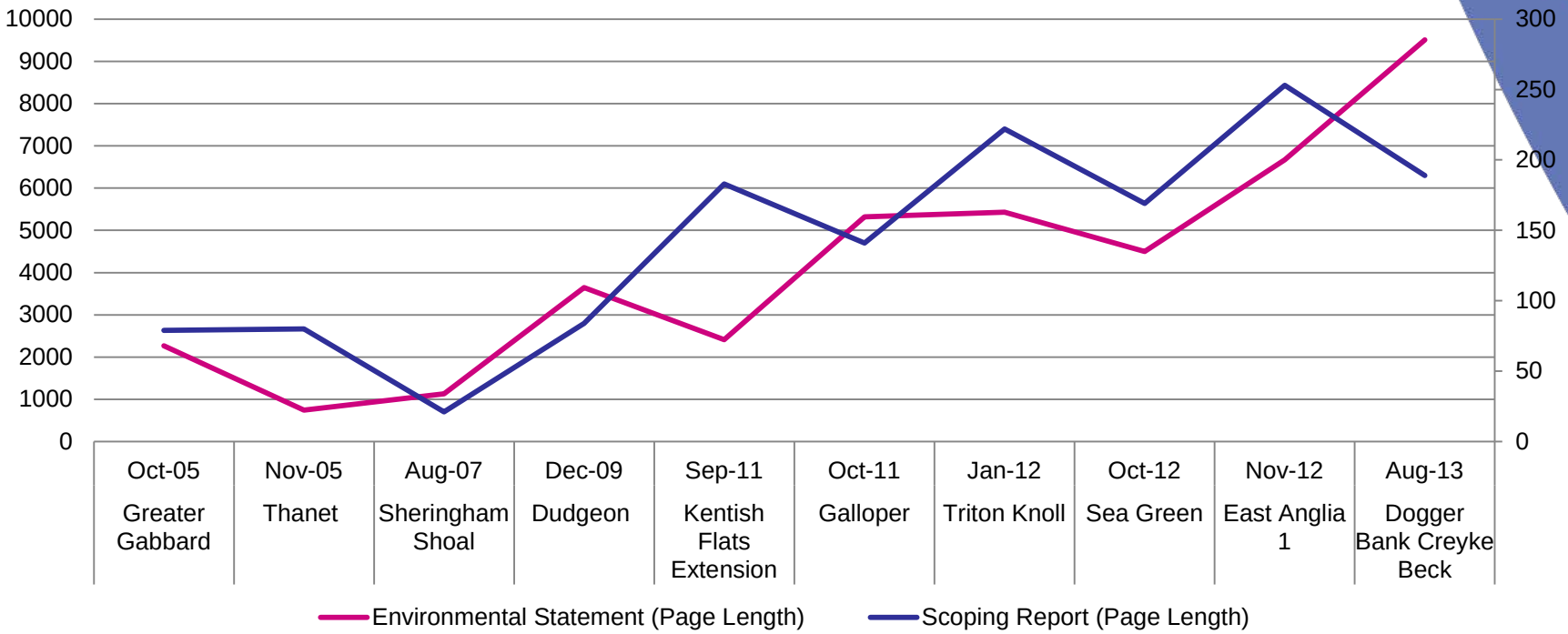
The State of EIA

IEMA Special Report June 2011

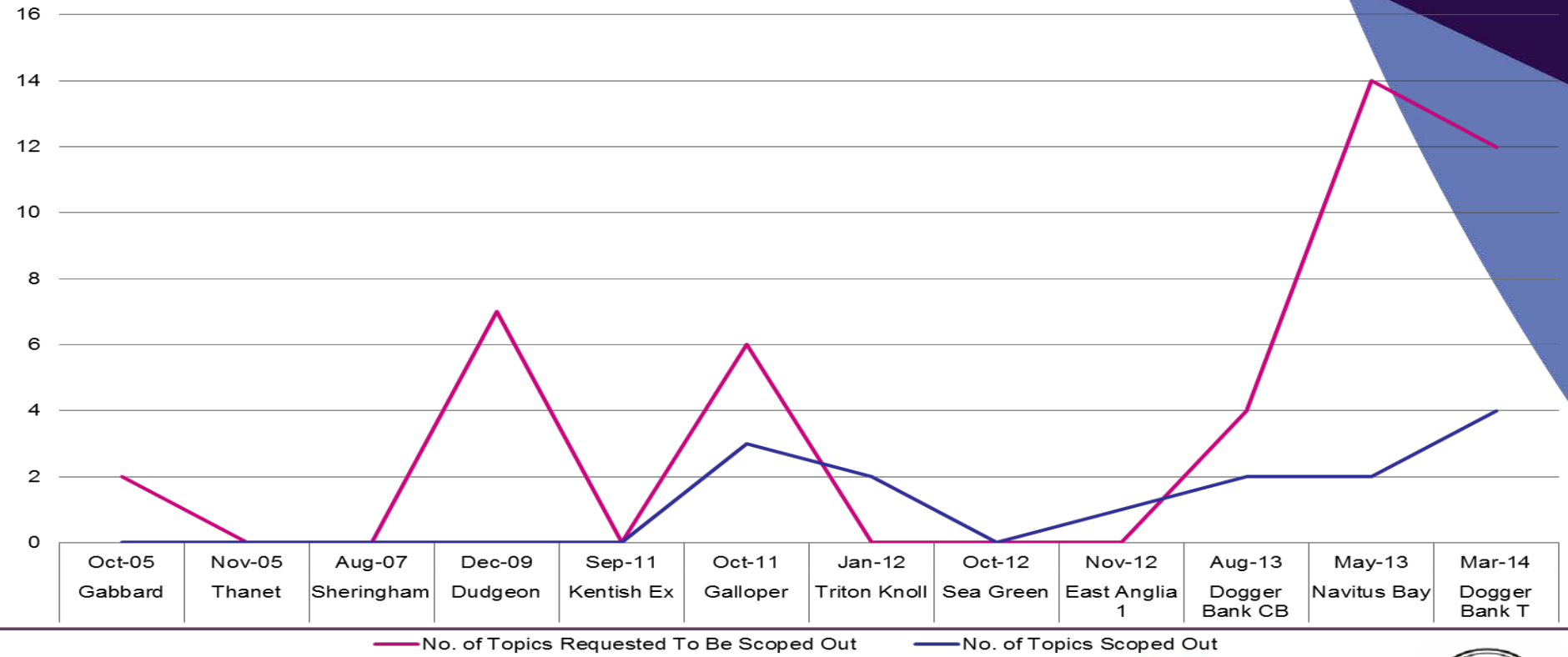
"Long Environmental Statements add burdens to all parties involved"

"Ineffective Scoping – risk aversion, poor planning, and commercial realities."

2005 to 2013 Trends Over Time



2005 to 2013 Scoping Decisions



How do we break the cycle?

- Lawyers & regulators are key.
- How do we encourage them to accept risk?
- Robust evidence on which to base risk decisions.
- Properly investigated, consulted upon and accepted by a consensus of stakeholders.
- Scoping is key to reduce size and cost of assessments by focusing on key risks and potentially significant impacts.
- Proportionate and effective assessment is the goal. Not a reduction in environmental safeguards.

Industry Evidence Programme

- Review of all ES, licences, EMPs etc. for a sector
- Catalogue all major adverse impacts by topic
- Look for trends
- Catalogue all moderate and minor impacts by topic
- Look for trends
- Catalogue all mitigations / management plans
- Look for trends
- Do the same for Monitoring (if there is any!)

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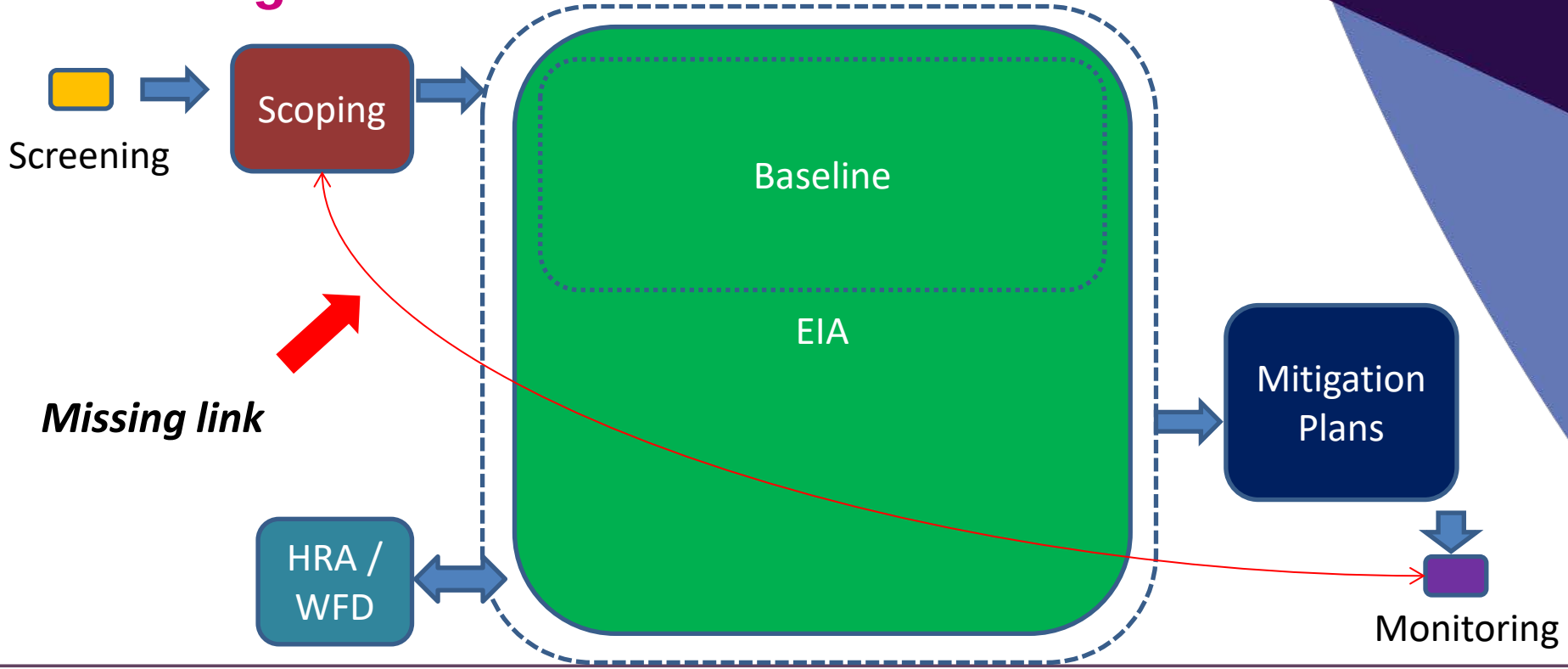
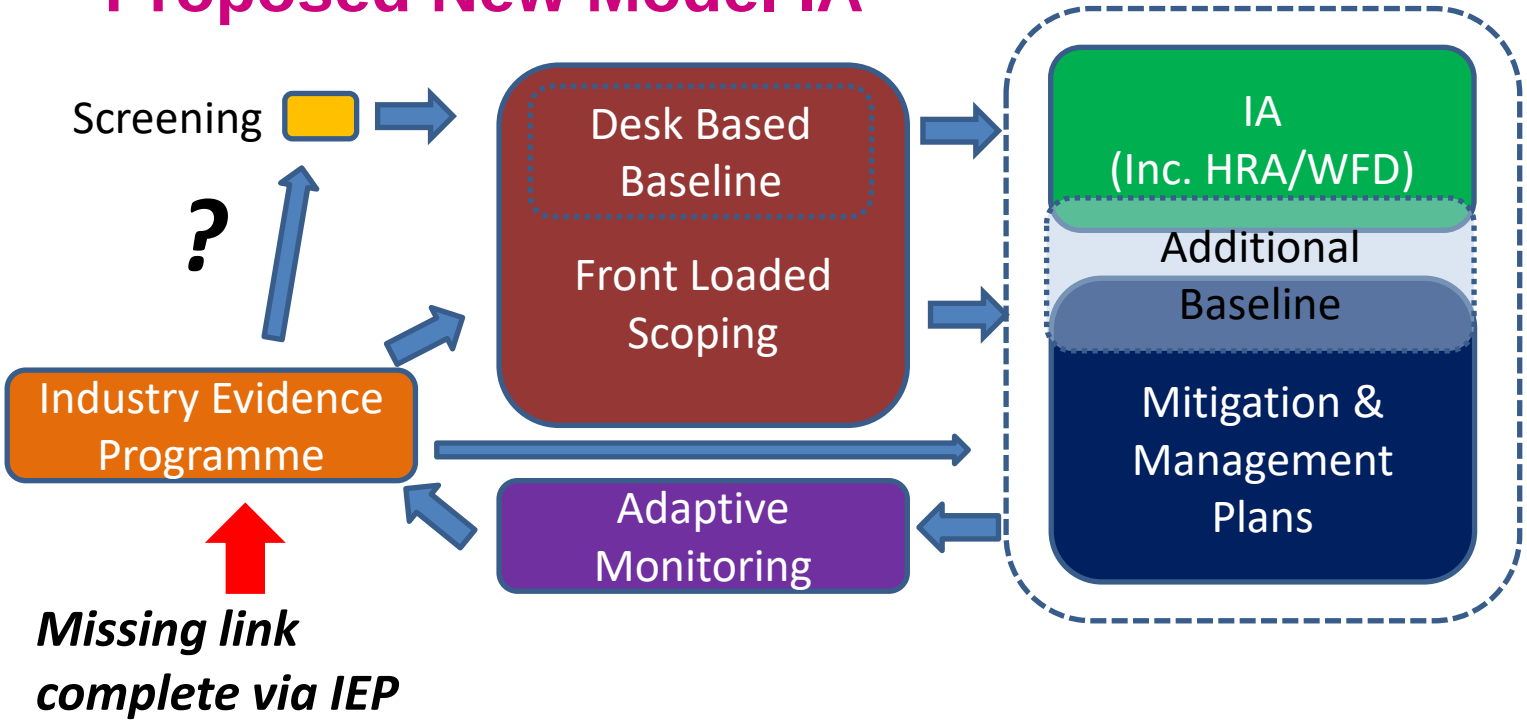
Existing Model EIA



Proposed New Model IA



Define Goals and Objectives

The Goals of the IEP are to:

- **Focus EIA on the significant environmental topics**
  - Identify topics of negligible concern
  - Identify topics with established mitigations that reliably reduce significance
  - Identify topics with likelihood of significant adverse effects
- **Provide a central hub for evidence, good practice and guidance**
  - Provide standardised and verified mitigation solutions
  - Provide standardised templates for conditions
  - Provide standardised monitoring for impacts during construction and operation
- **Provide evidence to support decisions that lead to a proportionate EIA**
  - Reduce costs and programme for developers, regulators and stakeholders
  - Provide greater legal and scientific certainty for all stakeholders
  - Establish knowledge gaps to direct further research

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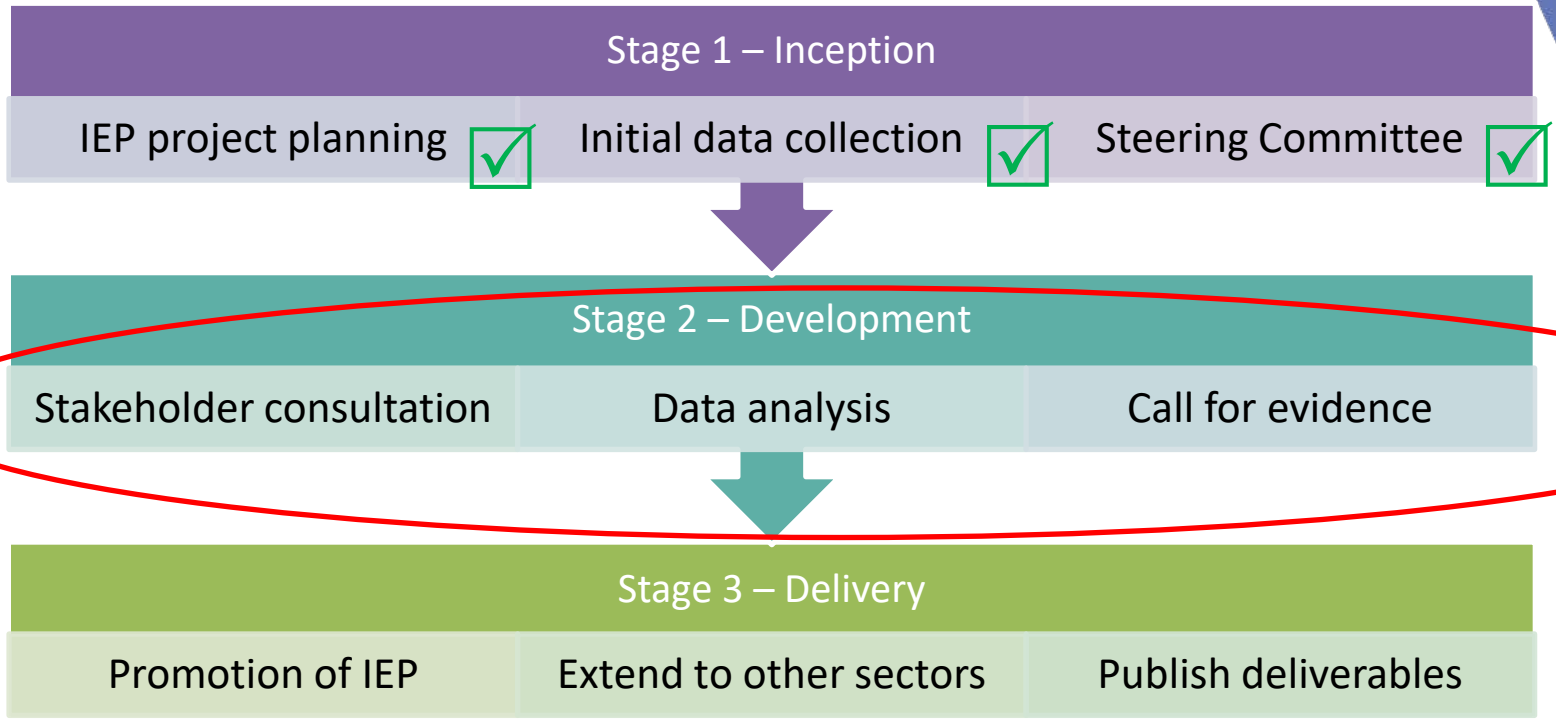
Project overview



Progress so far

- Data has been collated on all 50 UK offshore wind farms
- An initial review of the data underway
- Expert stakeholder workshops being organised
- Call for evidence is open

		Construction Phase					Operation Phase					Decommissioning Phase				
Environmental Topic	Impact	Pre-mitigation	+/-	Mitigation Actions	Post-mitigation	+/-	Pre-mitigation	+/-	Mitigation Action	Post-mitigations	+/-	Pre-mitigation	+/-	Mitigation Actions	Post-mitigation	+/-
Designated Sites	Internationally designated sites	3		None	3		3		None	3		3		None	3	
	Nationally designated sites	3		None	3		3		None	3		3		None	3	
	Locally designated or non-statutory designated sites and BAP priority habitats	3		None	3		3		None	3		3		None	3	
	BAP species and legally protected species	3		None	3		3		None	3		3		None	3	
Marine Physical Processes	Increase in suspended sediment concentrations and deposition	2		None	2											
	Fate of sediment not suspended by construction activities	2		None	2											
	Interruption of sediment transport by landfall construction activities	1		None	1											
	Increased turbidity due to landfall construction / decommissioning activities	2		None	2							2		None	2	
	Effects of foundations on tidal currents						2		None	2						
	Effects of structures on waves						2		None	2						
	Increase in suspended sediment concentrations as a result of foundations						2		None	2						
	Effect on nearshore sediment transport of seabed cable protection						2		None	2						
	Removal of cables and foundations											1			1	
Marine Water and Sediment Quality	Re-suspension of sediments - offshore	3		None	3							2		None	2	
	Re-suspension of sediments - nearshore	2		None	2							2		None	2	
	Re-supension of contaminants	2		None	2							2		None	2	
	Deterioration of bathing water quality (turbidity)	2		None	2							2		None	2	
	Landfall works	2		nstruction meth	2							2		nstruction meth	2	
	Accidental spillages and grey water discharge	4		EMMP	3		2		[MMP, MARPC	2		2		[MMP, MARPC	2	
	Suspension of solids due to scour						2		None	2		2		None	2	

Royal HaskoningDHV
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IEMA

Steering Committee

Next Steps

- **Volunteers** needed for **data analysis**
- Additional **funding** sought from potential **sponsors**
- Expressions of interest from **experts** to attend **workshops**
- Call for **evidence** to include in the **analysis**

- **Rufus Howard** will be presenting interim findings at the **International Association of Impact Assessment (IAIA)** annual international conference in Montreal the first week of April.
- Further information please contact:

Rufus.Howard@rhdhv.com

IAIA

Royal HaskoningDHV
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Q&A

Patricia Hawthorn, Shepherd and Wedderburn

Gordon McCreath, Pinsent Masons
Adam Ezzamel, Aberdeen Offshore Wind Farm
Paolo Pizzolla, Royal HaskoningDHV
Helen Walker, ScottishPower Renewables

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Infrastructure and Supply Chain

Peter Haughie, EDP Renewables

Andy Lewin, ORE Catapult
Alan Duncan, BVG Associates
Andrew Bellamy, 8.2 Aarufield
Stephen Thompson, Offshore Wind Industry Group
Brad Rabone, JDR Cables

Andy Lewin

ORE Catapult

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Offshore Wind Operations and Maintence Case Studies

24/01/2017 | Andy Lewin

CATAPULT Offshore Renewable Energy

The Purpose…

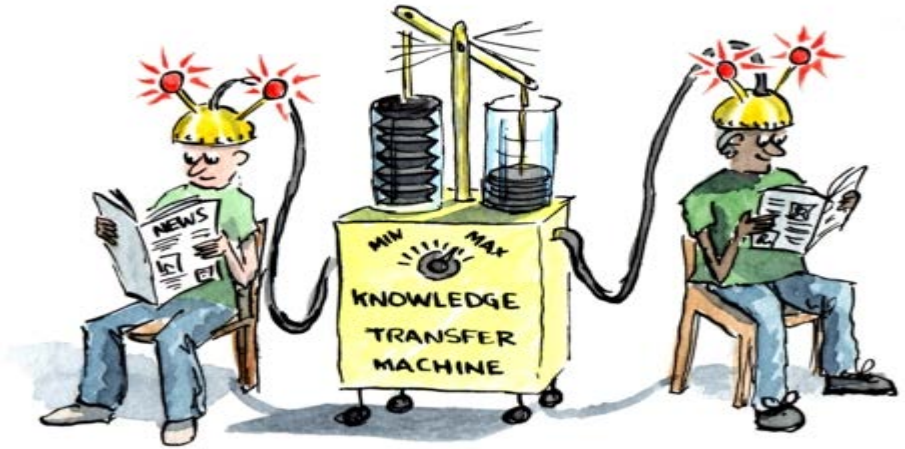
Share experience and knowledge

Identify common problems and share solu

Create a records and reference resource

Promote best practice

Ide



Case Study Portfolio

Case Study Name	Lead Company
Self Perform O&M at Robin Rigg	E.ON
An Evidence Based Appraisal of Crew Transfer Vessel Thresholds	RWE
Early Fault Detection Using SCADA Data	E.ON
End of Warranty O&M Contracting Strategy	centrica
Management of H_2S Gas in Wind Turbine Sub-Structures	EDF
Early O&M Experience of Jacket Foundations	VATTENFALL
Responding to an HSE Emergency	centrica
The Integration of Operational Data Using CORE	SCOTTISHPOWER
A Novel Offshore Wind Transfer Technique	REPSOL
Helicopter Strategy Appraisal at Westermost Rough	DONG energy

https://ore.catapult.org.uk/our-knowledge-areas/operations-maintenance/operations-maintenance-case-studies/

The Outcome…

10 Case Studies produced

2 Dissemination Workshops

April – London

June – Manchester

Published via the ORE Catapult website

Promoted via the TCE Operational Report

DEVELOPER 1

'The most useful industry event I've every attended'

DEVELOPER 2

'I thought the structure, enthusiasm, and honesty in the workshops made the event extremely useful'

DEVELOPER 3

'A great way to shared knowledge and best practice across the industry'

Management of Hydrogen Sulphide (H_2S) Gas in Wind Turbine Sub-Structures

The Product - CS#1 – Root Cause

All WTGs investigated and some found to be leaking from beneath the air tight platform via the cable hang off points.

Hydrogen sulphide (H_2S) is found in the foundation of the turbines, caused by a reaction between microbes and the cathodic protection system.

- The design assumption that the foundation moon pool was sealed was invalid due the to failure of the cable sealing system
- The cathodic protection design was changed during the 3rd Party Design Review with consideration of impacts
- The passive ventilation system in the foundations at Teesside wind farm was not fit for purpose

Gas emission identification

The Product - CS#1 – Lessons Learnt

H_2S was not considered as a residual risk

- Designer did not consider H_2S creation from CP system
- Ventilation system was never designed with consideration of H_2S.

Leaking airtight platform

- Post installation pressure test should have been conducted on airtight deck.

A better HAZOP study would have been beneficial

- Earlier feed in from operations
- Key hazards could have been identified and mitigation put in place at an earlier stage.

innogy

CTV Trials at Gwynt y Mor and Rhyl Flats Wind Farms

The Product - CS#2 - Challenge

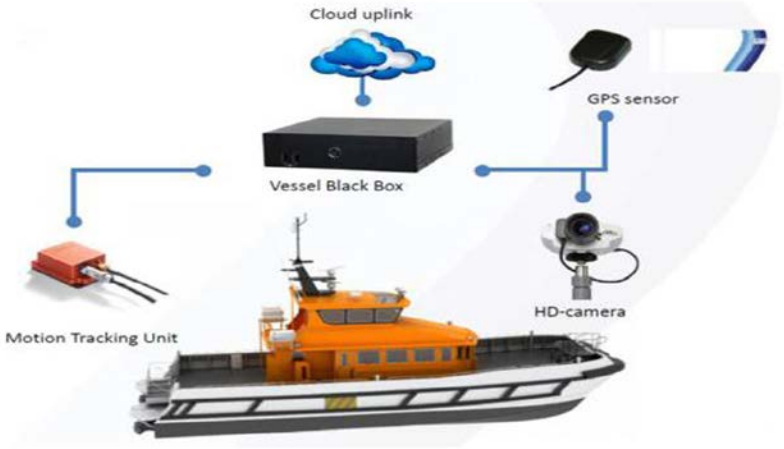
- Under the terms of the SWA for Gwynt y Mor there is provision for a number of hours of helicopter use to assist the OEM in their Service provision for the turbines.

- Innogy have challenged the requirement for a helicopter on the basis that larger, more capable, CTV's can achieve safe transit and transfer at 2m Hs on a regular basis. Thus narrowing the window where the helicopter would be of benefit.

- Innogy developed a project to produce an evidence base to support the revision of logistical support for the operational phase

The Product - CS#2 – What was done?

- Vessel Black Box' (VBB) system developed by BMO Measurement Solutions BV.
- Installed on the NSL Discovery and ICENI Victory.
- Vessel Trials undertaken on contractual weather days – exceeds limits but within expected performance
- Other Information available including live and historical wave rider readings



The Product - CS#2 – Results & Recommendations

- 1.5m Hs was achievable with all vessels used in trial.
- 1.8m Hs was achievable with 22m – 24m vessels.
- Improvements to crew transfer vessels can result in significant changes to an offshore windfarm logistics strategy and it is important to track these changes and understand their benefits.
- Contractual arrangements should be flexible to allow owners to take advantage of technology improvements, especially where long-term contracts are signed early in the development lifecycle.
- Commencing the collection of metocean data early in the development life cycle provides long time series datasets for use during the O&M phase.

The Product - CS#2 – CTV's v Helicopters

- Using the last 3 years Metocean data from GyM a CTV capable of operating at 1.8m Hs would have achieved 88% access.
- Of the remaining 12%, using the agreed helicopter operating limitations, a further 2.7% access would have been gained by utilising a helicopter. This equates to an additional 30 days access over 3 years.
- Assuming 2 WTG's repaired per day by helicopter team then revenue gain would be £740k over 3 years.
- Fixed costs for the helicopter under the SWA at Gwynt y Mor are greater than 7.5 times the possible revenue gain

2017 Onwards

Continue to promote the existing case studies

Develop new case studies (8-10 Case Studies)

- Topics
- Collaborators

Consider opportunities to extend to other phases of development, participants or specific topics

- Construction
- Development
- Supply Chain / Contractors
- Health and Safety*

QUESTIONS?

Alan Duncan

BVG Associates

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Scottish Renewables: OSW Conference (3A – Infrastructure & Supply Chain)

Alan Duncan, BVG Associates

Glasgow, 24 January 2017

BVGassociates

"Supporting change within renewables through business realism rather than eco-idealism…."

BVGassociates

Agenda

European deployment boom, the economic argument, diversification and the great O&M opportunity….

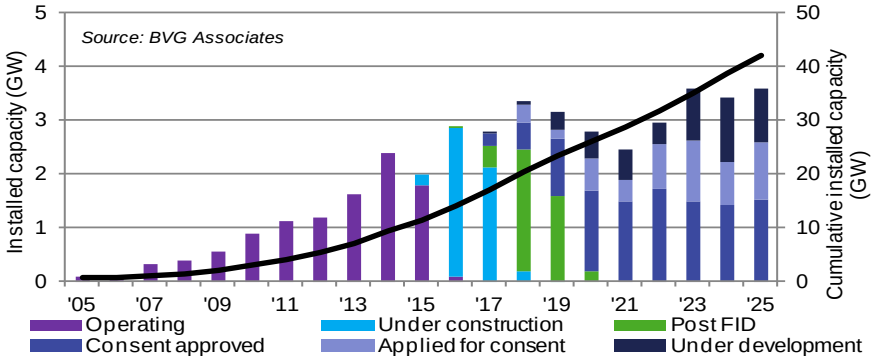
- Deployment forecast - *the offshore wind glory years*
- LCOE trajectory and where the money goes
- Diversification – the UK local content challenge & high potential areas of supply
- Areas of expected LCOE improvement to 2030
- Operations, Maintenance and Servicing - anticipated direction of travel and the expected innovation contribution to LCOE improvement

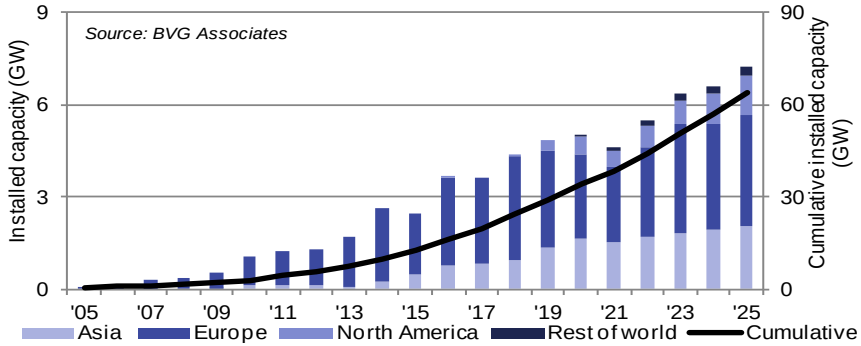
BVGassociates

Deployment forecast offshore wind

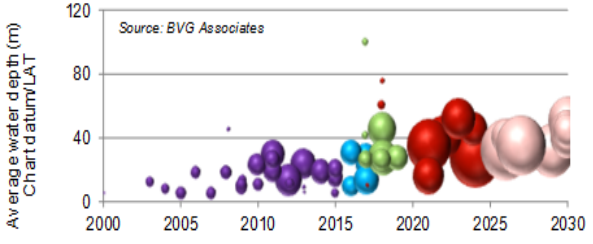
Deployment to ramp at pace for next decade and beyond : *deeper, further, 'blashier'*

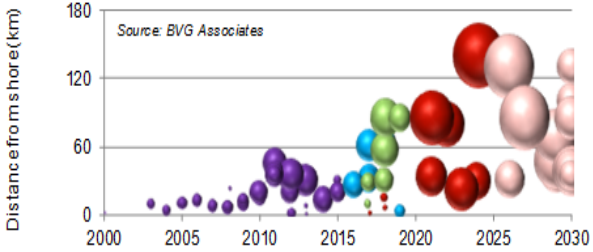
- Global deployment to 64GW by 2025

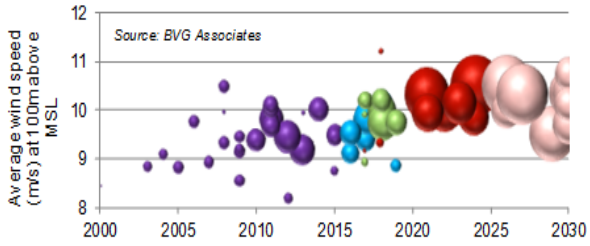




- European deployment to 40GW by 2025







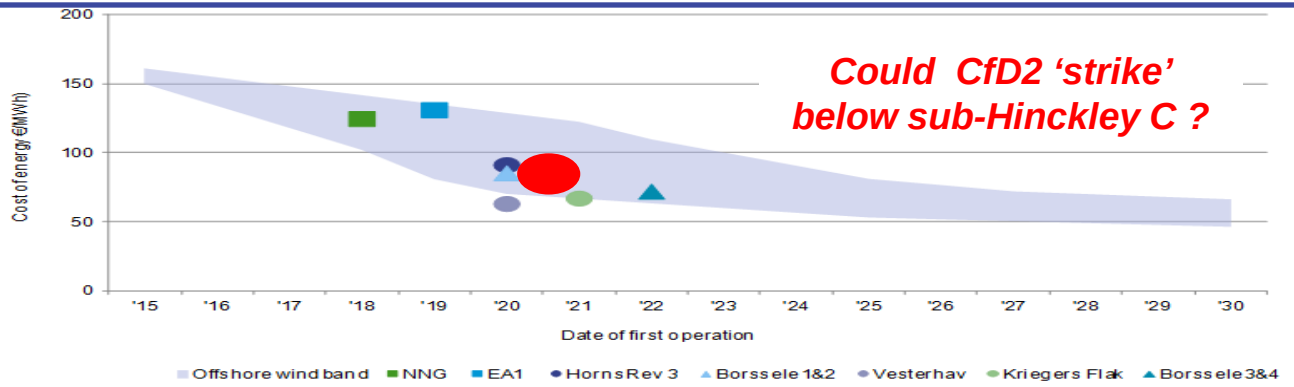
Year of first turbine installation

Operating | Under construction | Post-FID | Development near-term | Development long-term

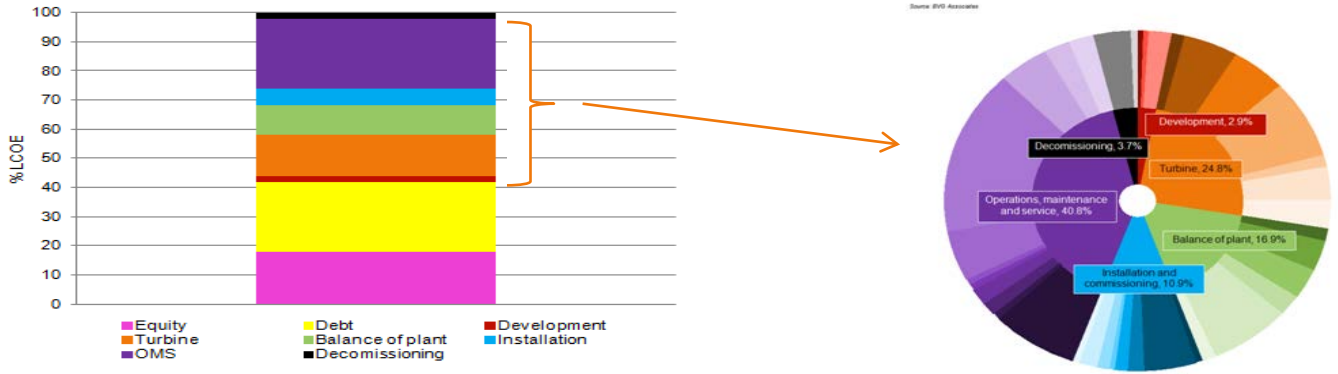
BVGassociates

LCOE trajectory and where the money goes

LCOE trajectory



Where the money goes

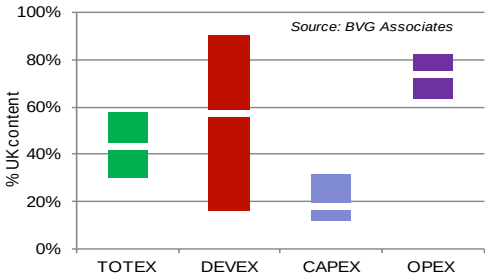


Diversifying and growing within the OSW supply chain

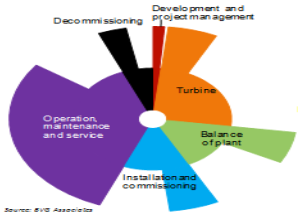
Political support for local content across Europe, competing with a supply chain birthed in Europe

UK content

- Average across 10 UK wind farms larger than 100MW

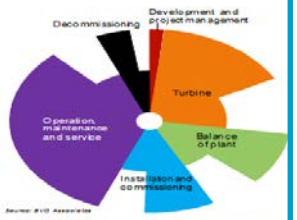


	UK content		
	Lower	Upper	Weighted average
TOTEX	30%	57%	43%
DEVEX	16%	90%	57%
CAPEX	12%	32%	18%
OPEX	64%	82%	73%



50% UK content – good target for current projects

- ***UK content but at any cost ?***



70% UK content – not in current environment

Diversification: think about the underlying supply logic

Considering the 35 supply chain sub-elements, logic of contracting decisions must be considered:

- track record in offshore wind
- sector synergies
- appetite from offshore wind
- potential for LCOE benefit from new involvement
- size and timing of investment (risk)
- size of the opportunity

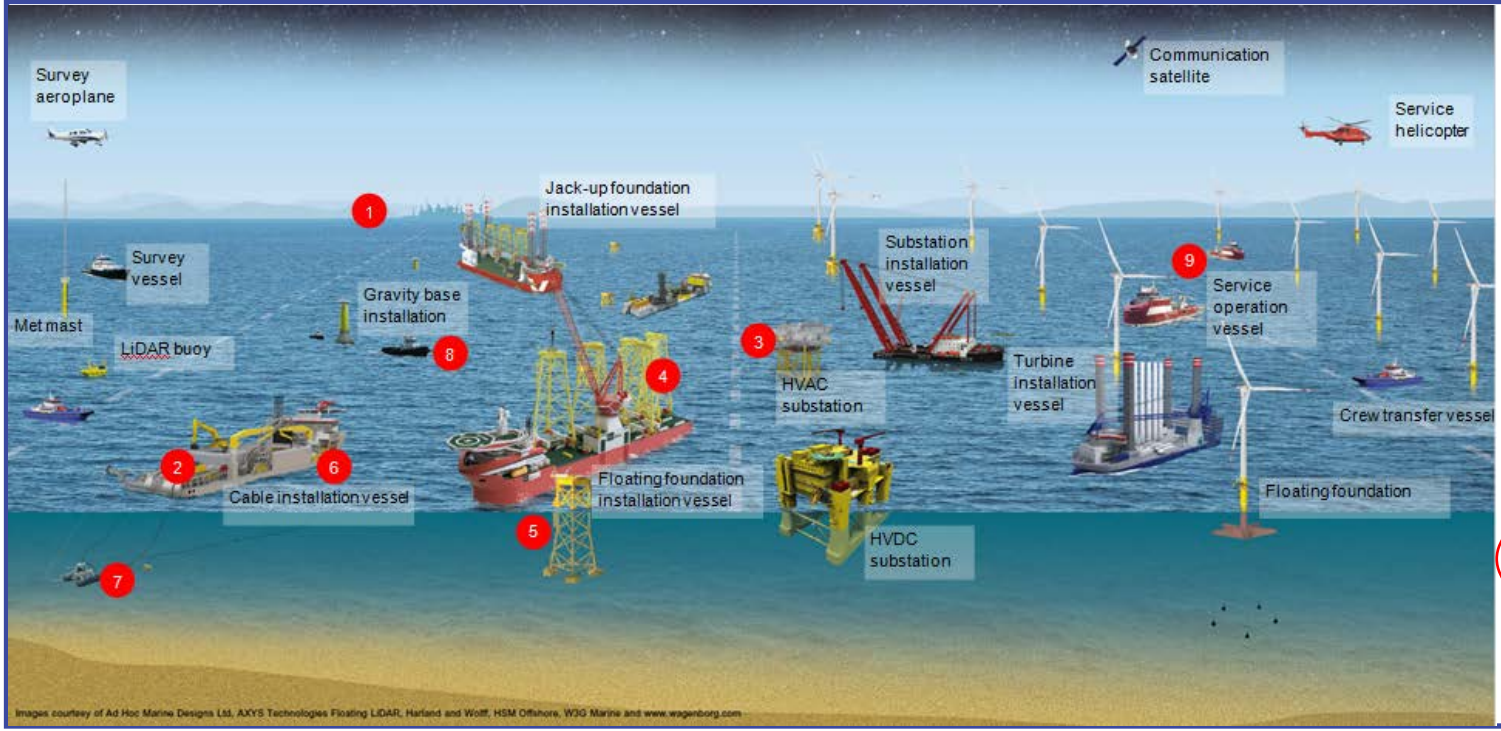
Two-way learning - processes and innovative thinking developed over decades in oil and gas can be transferred to offshore wind / rapid cost reduction, standardisation and faster deployment techniques in offshore wind can benefit oil and gas….

BVGassociates

Offshore wind high potential diversification areas

Supply chain split into 35 sub-element areas of supply – 9 ‘hot spots’

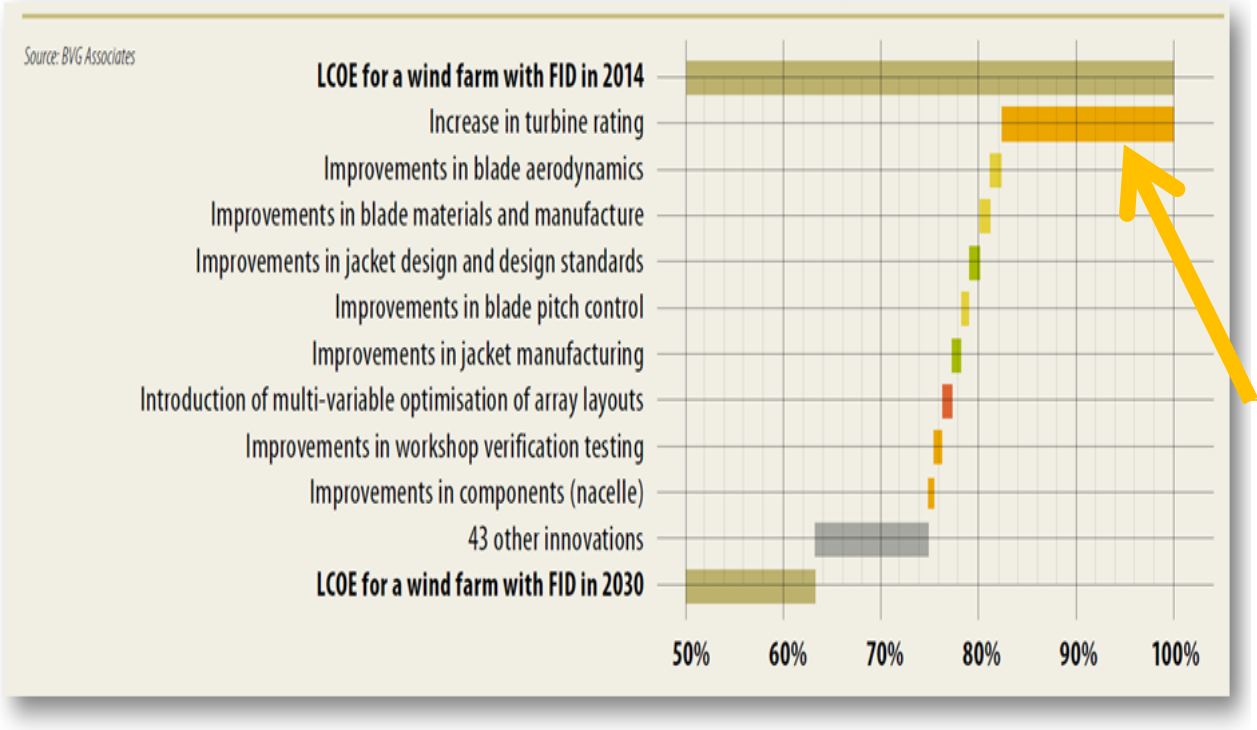
Scottish enablers supporting a number of diversification initiatives

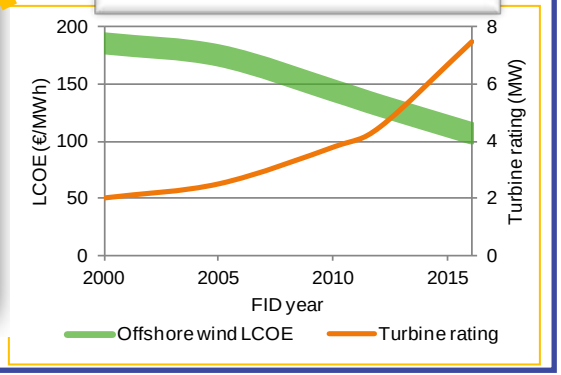


1. Project management
2. Array cables
3. Substation structures
4. Turbine foundations
5. Secondary steelwork
6. Cable installation
7. Installation equipment
8. Installation support services
9. Operations, maintenance & inspection services

LCOE reduction – expected innovations

LCOE expected to drop by 37% over the next decade





OMS – direction of travel

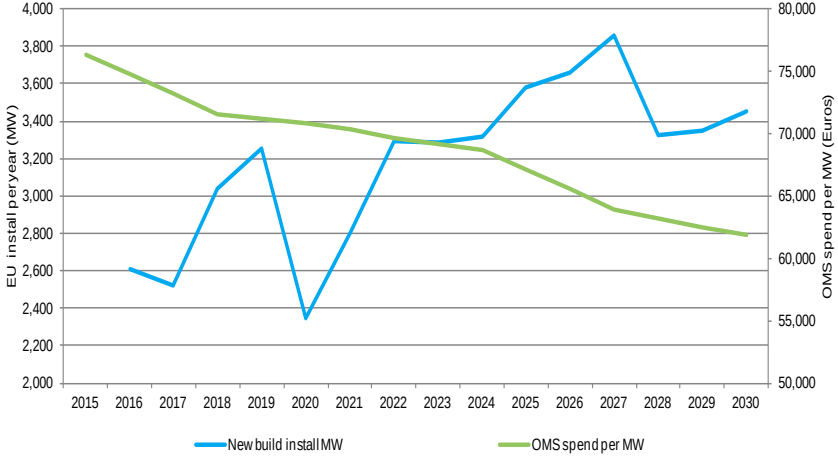
Average spend per MW will drop, gross spend to ramp dramatically to 2030

OMS spend per MW will continue to drop

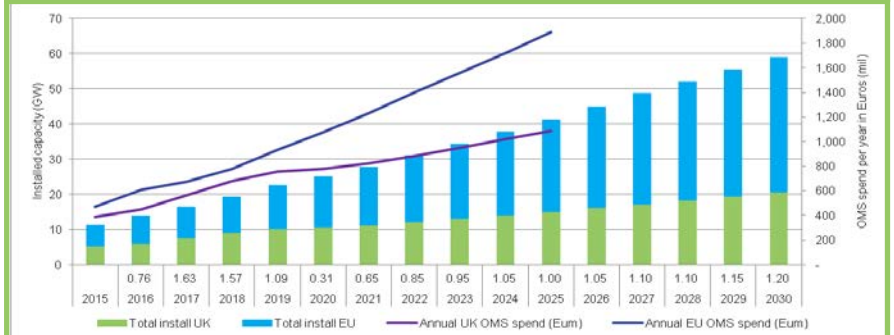
- Next generation sites will spend less on OMS per MW because:

  (i) larger turbines means a smaller number of numerical assets in each wind farm

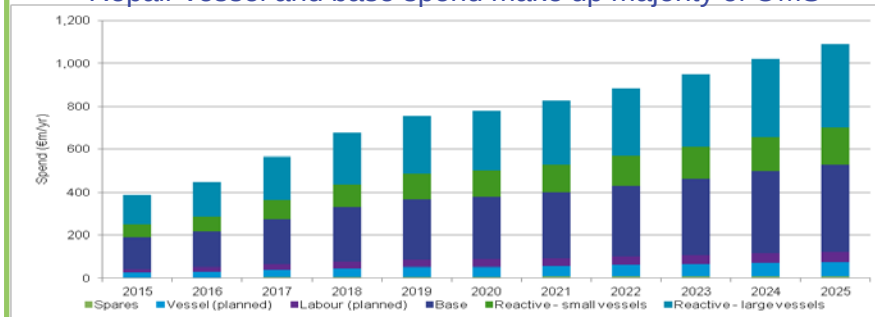
  (ii) OMS strategies will be more accurately refined and efficiency of components will increase



Total European OMS spend to top €3bn by 2025



- Repair vessel and base spend make up majority of OMS

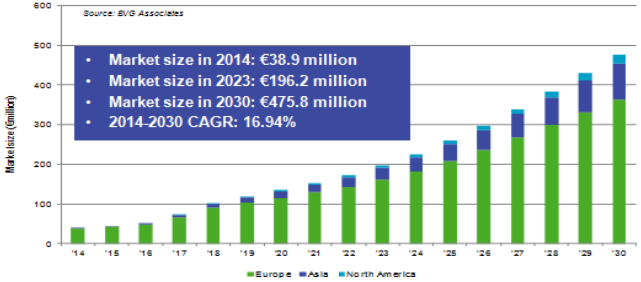


OMS – anticipated innovation contribution to LCOE

Average spend will drop, total spend to ramp dramatically to 2020

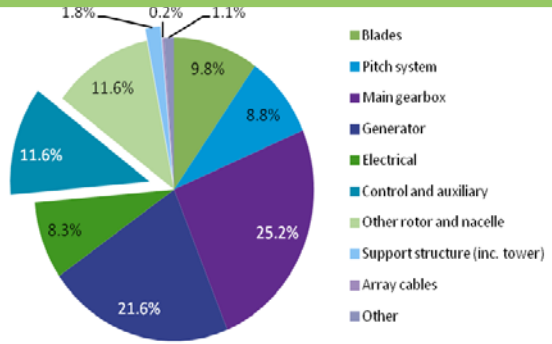
Nine industry innovations to deliver around 4% benefit

- Vessel strategy: Move from CTV to SOC servicing strategy (eg DONG, Siemens)

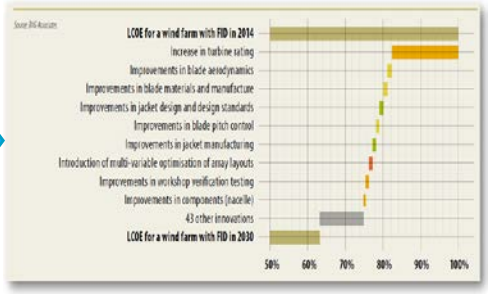


- Access systems: Improved personnel access via walkways, lifting pods and transfer vessels
- Condition-based maintenance: new methodologies to focus maintenance where it is of most benefit (eg decision-making tools and remote interventions)
- Component reliability and uptime – industry sharing
- Improved offshore logistics planning: increased remote intervention and planned maintenance campaigns (65% of OMS repair cost is unscheduled maintenance)
- Emergence of 3rd party OMS providers: 'one stop shop' competition for WTMs will increase competition (eg James Fisher and 3Sun)
- Standardisation: industry collaboration (eg boat landing systems)

Anticipated OMS by component



-4% OMS



Thank you for your attention

Please get in touch….. adu@bvgassociates.co.uk

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BVGassociates

Andrew Bellamy

8.2 Aarufield


8.2
8.2 Aarufield
Engineering Excellence
in Renewable Energy
Developing Specific Knowledge and Personnel for Offshore Blade Repair
SR Offshore 2017

8.2 Aarufield
Engineering Excellence
in Renewable Energy

5 Things about 8.2 Aarufield

- Part of the German 8.2 Group
- 180 industry-leading technical and engineering personnel
- Involved in almost every large continental onshore and offshore project to date
- Enormous experience of turbine defect analysis, inspection and quality assurance
- In the UK, based in London and Edinburgh

8.2 Aarufield
Engineering Excellence
in Renewable Energy

Rotorblades – What Could Possibly Go Wrong…?

- **The myth of blade maintenance**
- **The most extreme of engineering environments:**
  - High operating speed
  - Lightweight structures
  - Flexible design
  - Least possible maintenance
  - Almost 24/7/365 performance anticipated, for 20+ years

Difficult Access (offshore) + Difficult Access (Blades) + Weather = ☹

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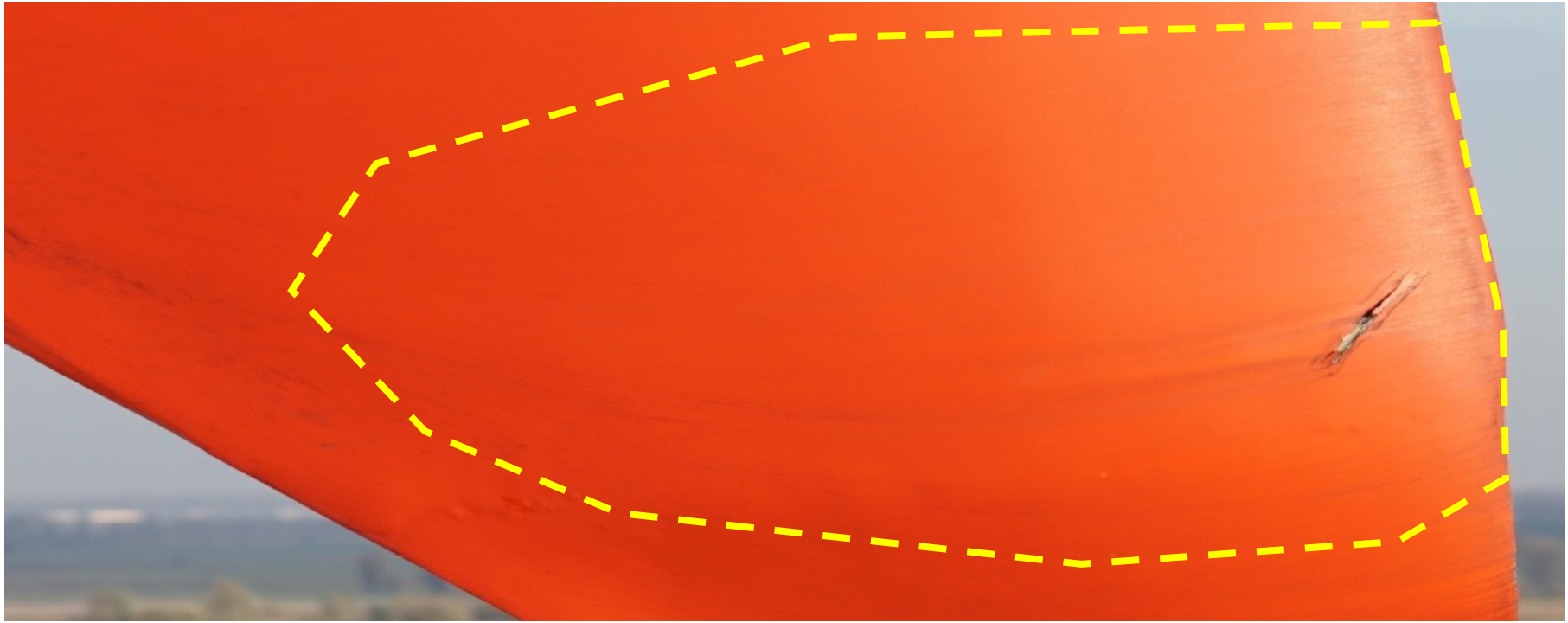
Engineering Excellence
in Renewable Energy

A few examples:

8.2 Aarufield
Engineering Excellence
in Renewable Energy

A few examples:



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in Renewable Energy

A few examples:

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Engineering Excellence
in Renewable Energy

The Offshore Difference

- **Remote Inspections and repair of rotorblades onshore is relatively straightforward**
  - Access
  - Weather
  - Stable Platform (terra firma)
- **Offshore there are many more challenges…**
- **Key Elements to Offshore Blade Fleet Management:**
  - Inspection – imaging (one shot per year!?)
  - Interpretation
  - Repair Planning
  - Offshore Works

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Engineering Excellence
in Renewable Energy

The Problem with Composites…

- There are many!
- The material isn't "taken to the repair" – its "made on the repair"
- Enormous emphasis on quality control to achieve high quality results
- Covered with filler and paint

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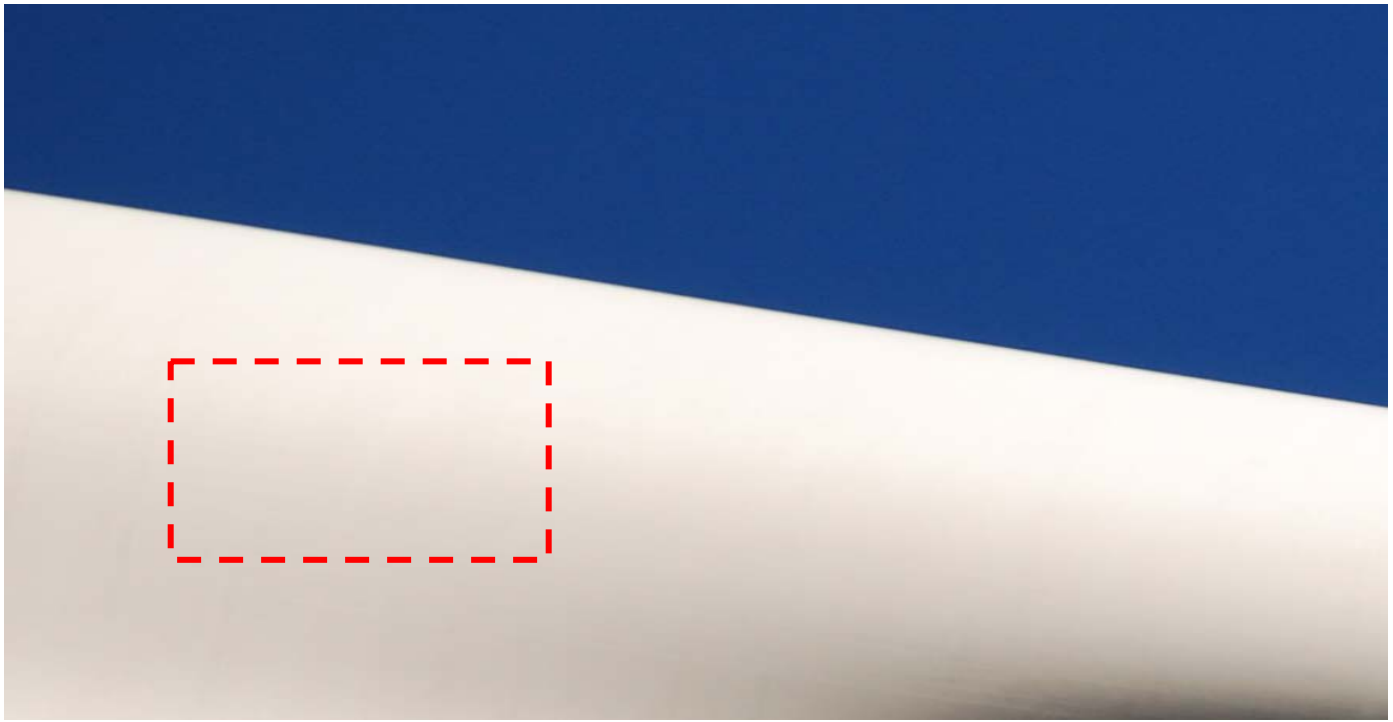
Engineering Excellence
in Renewable Energy

Good Repair, Bad Repair?



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in Renewable Energy

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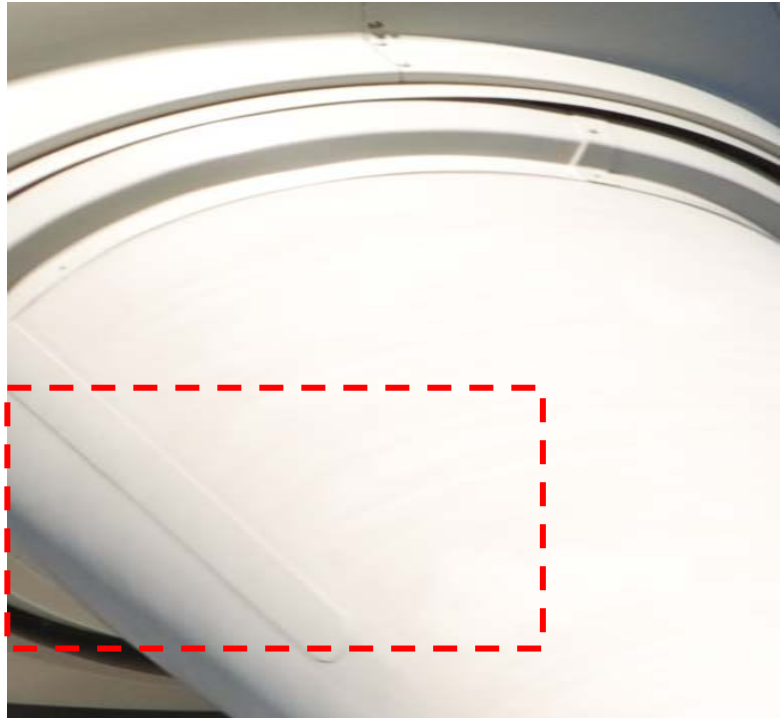

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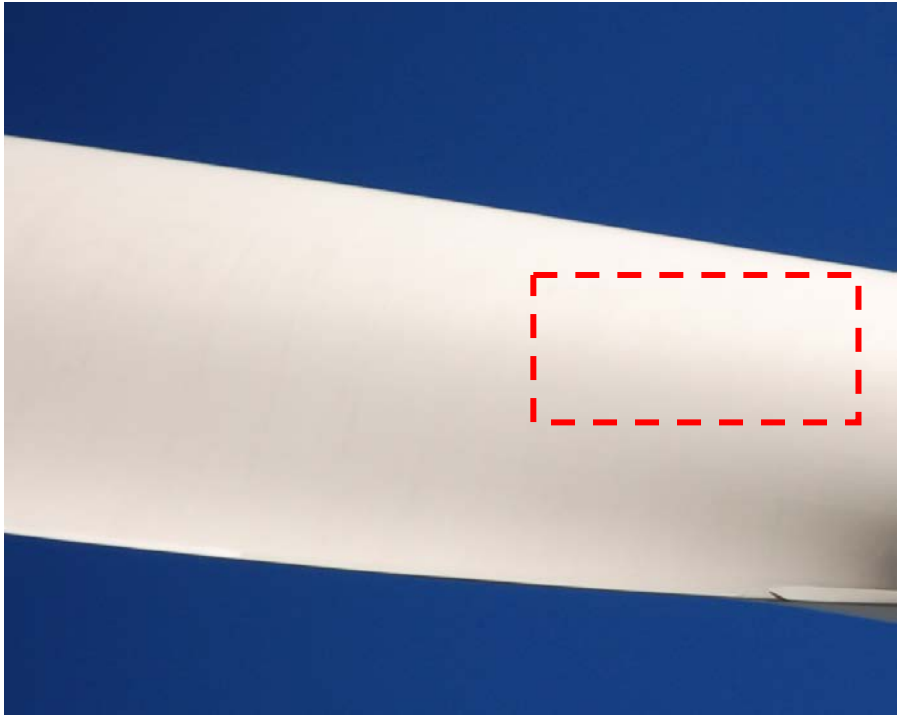

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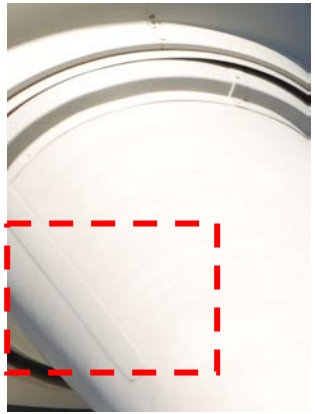
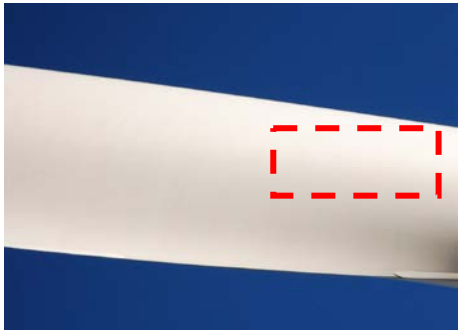
The Answers?





You just don’t know…

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Engineering Excellence
in Renewable Energy

Developing the UK Capability

- Qualified and competent repair technicians are essential to ensuring turbines keep running
- Training and Certification are essential for high quality repairs
- Maersk Training – a leader in independent training for offshore
- Competent blade technician course for the UK

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in Renewable Energy

Maersk Training - Newcastle

- Training in Composites, applied purely to wind turbine blades
- Working from platforms, ropes etc using composites
- Extremely popular with ex UK services and oil and gas personnel

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Engineering Excellence
in Renewable Energy

The Future

- 8.2 Aarufield are actively working with multiple oil and gas companies on their route to market in wind turbines, especially in blades
- Developing further specific skill and engineering knowledge areas for UK suppliers
- Providing information on potential for more courses to improve technical knowledge in other areas of turbine operations

Stephen Thompson

Offshore Wind Industry Group

- Supply Chain Subgroup

scottish renewables

CATAPULT Offshore Renewable Energy

THE CROWN ESTATE SCOTLAND PORTFOLIO

NewWaves Solutions Marine & Environmental Services

INVEST IN FIFE

HIE Highlands and Islands Enterprise Iomairt na Gàidhealtachd 's nan Eilean

SCOTTISH OFFSHORE RENEWABLES SUPPLY CHAIN GROUP

PRESENTATION AT SCOTTISH RENEWABLES OFFSHORE WIND CONFERENCE

GLASGOW 24TH JANUARY 2017

SCOTTISH OFFSHORE RENEWABLES SUPPLY CHAIN GROUP

MISSION STATEMENT:

‘TO BE A STRONG VOICE FOR THE SCOTTISH OFFSHORE RENEWABLES SUPPLY CHAIN.’

Scottish Offshore Renewables Supply Chain Group

SOME ISSUES THE SUPPLY CHAIN GROUP WILL TACKLE AND DISCUSS HOW TO DEAL WITH THEM!

- LOCAL CONTENTS
- COST REDUCTION
- PLANNING & CONSENTING
- DEVELOPMENT OF FLOATING WIND IN SCOTLAND
- NEXT CFD ROUND (E.G. NO MINIMA FOR TIDAL ENERGY)
- CONTACT OTHER UK OFFSHORE RENEWABLE SUPPLY CHAIN GROUPS
- CONTACTS WITH POLITICIANS & GOVERNMENT

OWIG SUPPLY CHAIN SUB GROUP

Terms of reference:

- A representative voice for the Scottish Supply Chain
- Assist the Scottish supply chain to increase their business
- Create a collective voice in the Scottish, UK and European marketplace
- Lead the drive for local content and identify how to accomplish this in reality
- Address industry issues head on (what and how?)
- Contact with the Scottish & UK Parliament for policies and practice that support the Scottish SC
- Encourage collaboration and innovation through extensive networking and tasks
- Completion of initiatives/actions set for members by the members

SCOTTISH OFFSHORE RENEWABLES SUPPLY CHAIN GROUP

- The Group sought to ensure that it was not replicating any other existing organisation that could deliver the same objective

- The following Groups were identified as part of a “mapping” exercise:

-Offshore Wind Industry Council (OWIC)
-Offshore Wind Program Board (OWPB)
-Renewables UK
-Scottish Renewables
- Aberdeen Renewable Energy Group (AREG)
-Carbon Trust
-Energy Technologies Institute (ETI)
-Offshore Renewable Energy (ORE) Catapult
-Energy Technology Partnership (ETP)
-East of England Energy Group
-Team Humber Marine Alliance
-Energi Coast
-Northern Ireland Renewables Industry Group
-Energy Wales Strategic Delivery Group
-Offshore Renewables Institute (ORI)
-AREG

SCOTTISH OFFSHORE RENEWABLES SUPPLY CHAIN GROUP

A complimentary group:

Discussion:

- No other organisation provided the focus on the Scottish prospective that the Group was seeking
- Many UK regional organisations were already promoting their own agenda, Scotland needed to catch up

SCOTTISH OFFSHORE RENEWABLES SUPPLY CHAIN GROUP

Where now?

- Appointed Tim Cornelius as Chairperson of the Group
- Appointed a “Steering Group” to meet periodically
- Write a “Constitution”
- Identify how to raise the voice of the Scottish Supply Chain!

SCOTTISH OFFSHORE RENEWABLES SUPPLY CHAIN GROUP

Membership

- Free. Each member covers their own costs
- Talk to us:
- Morag McCorkindale
  mmccorkindale@aberdeenrenewables.com
- Stephen Thompson
  stephen.thompson@gegroup.com

Brad Rabone

JDR Cables

scottish renewables

CATAPULT Offshore Renewable Energy

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Brad Rabone

Head of Sales Renewables – Europe

SR Offshore Wind Conference

Tuesday 24th January

PROVIDING THE VITAL CONNECTION

INFRASTRUCTURE AND SUPPLY CHAIN

- O&M innovations which are helping to lower the cost of offshore wind energy
- How the industry is working with the oil and gas sector to promote diversification
- The development of our supporting infrastructure.

JDR & OUR MARKETS

Oil & gas

Global offshore subsea intervention, production and control/processing installations.

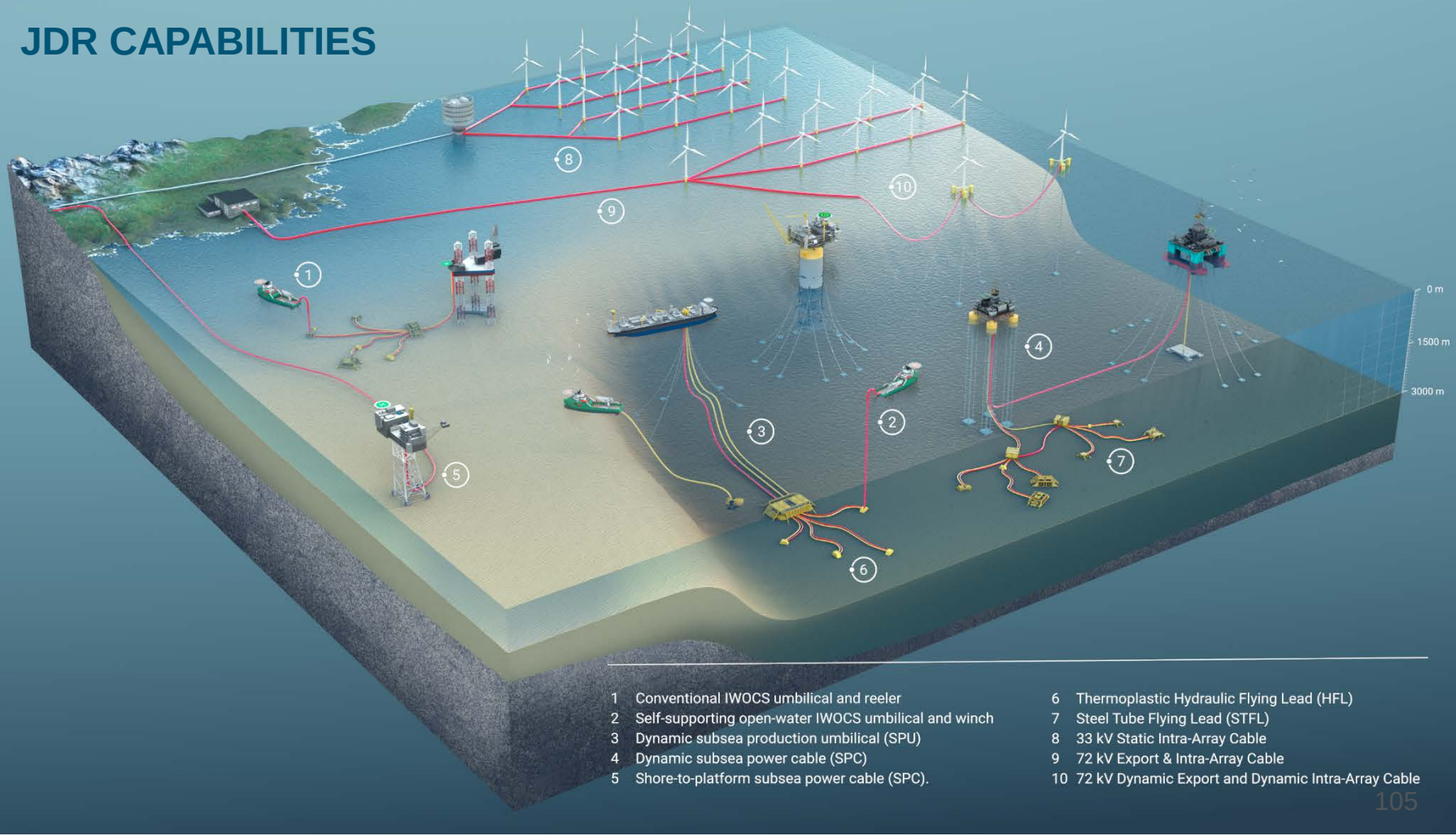
Renewables

Inter-array and export MV/HV power cables for offshore wind, wave and tidal energy projects.

Product and Installation Services

Offshore product services for the oil and gas and renewable markets. We support customers from project installation through commissioning and life of asset.

JDR CAPABILITIES



1 Conventional IWOCS umbilical and reeler
2 Self-supporting open-water IWOCS umbilical and winch
3 Dynamic subsea production umbilical (SPU)
4 Dynamic subsea power cable (SPC)
5 Shore-to-platform subsea power cable (SPC).
6 Thermoplastic Hydraulic Flying Lead (HFL)
7 Steel Tube Flying Lead (STFL)
8 33 kV Static Intra-Array Cable
9 72 kV Export & Intra-Array Cable
10 72 kV Dynamic Export and Dynamic Intra-Array Cable

GLOBAL OPERATIONS

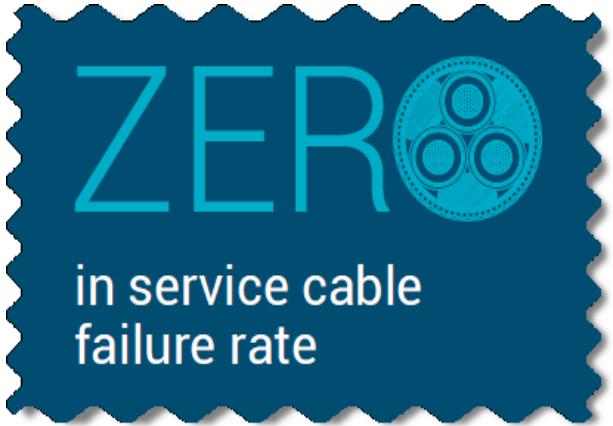
Over 500 employees around the globe.

We stand ready, 24/7, to innovate and assist your subsea projects

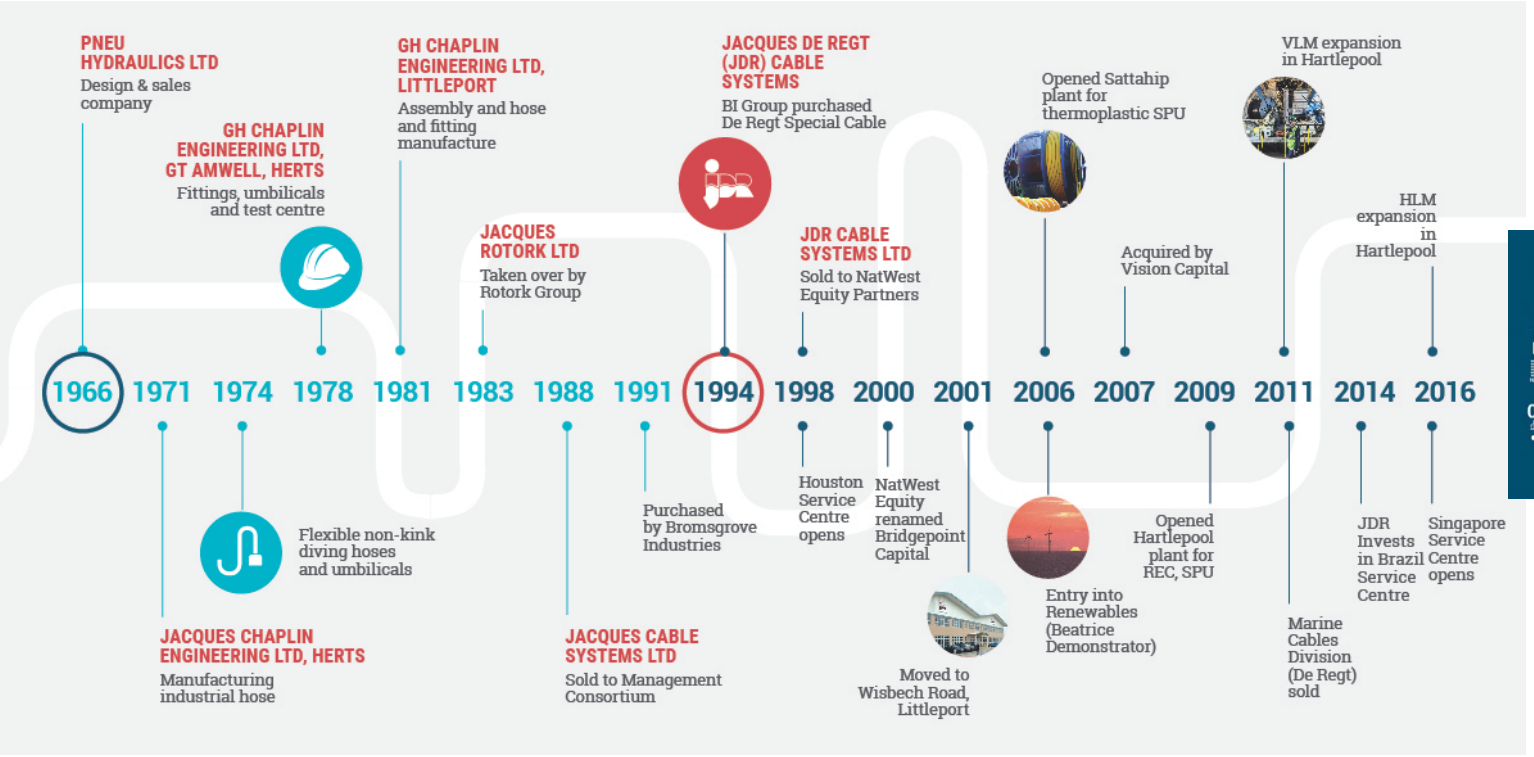
O&M

O&M innovations which are helping to lower the cost of offshore wind energy

- Cables should be maintenance free?
- Product Quality, Procedures
- Correct Installation
- Good spares strategy
  - Central spares Hub
  - Cable Joints
  - Emergency Response Capability

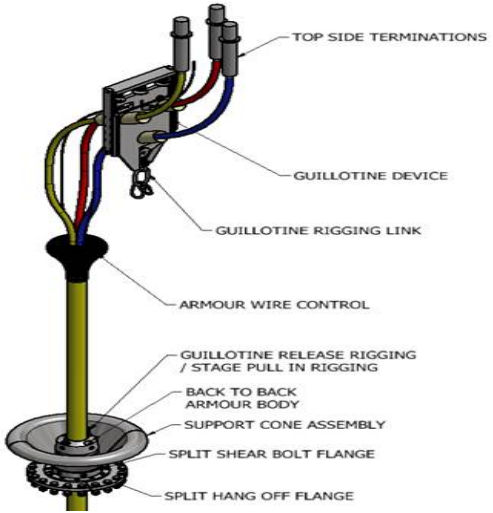


50 YEAR HERITAGE – 1966 TO 2016 OIL & GAS TO RENEWABLES



FLOATING OFFSHORE WIND

- Deeper water generation, further away from shore
- Power cables needs to suit high dynamic loadings for 25 years
- Dynamic, Fatigue Analysis & Testing all critical
- JDR’s Dynamic Oil and Gas cable experience valuable & hardware
- 72.5kv Power Umbilical's subsea villages



THE DEVELOPMENT OF OUR SUPPORTING INFRASTRUCTURE

DEVELOPER

SUPPLY CHAIN

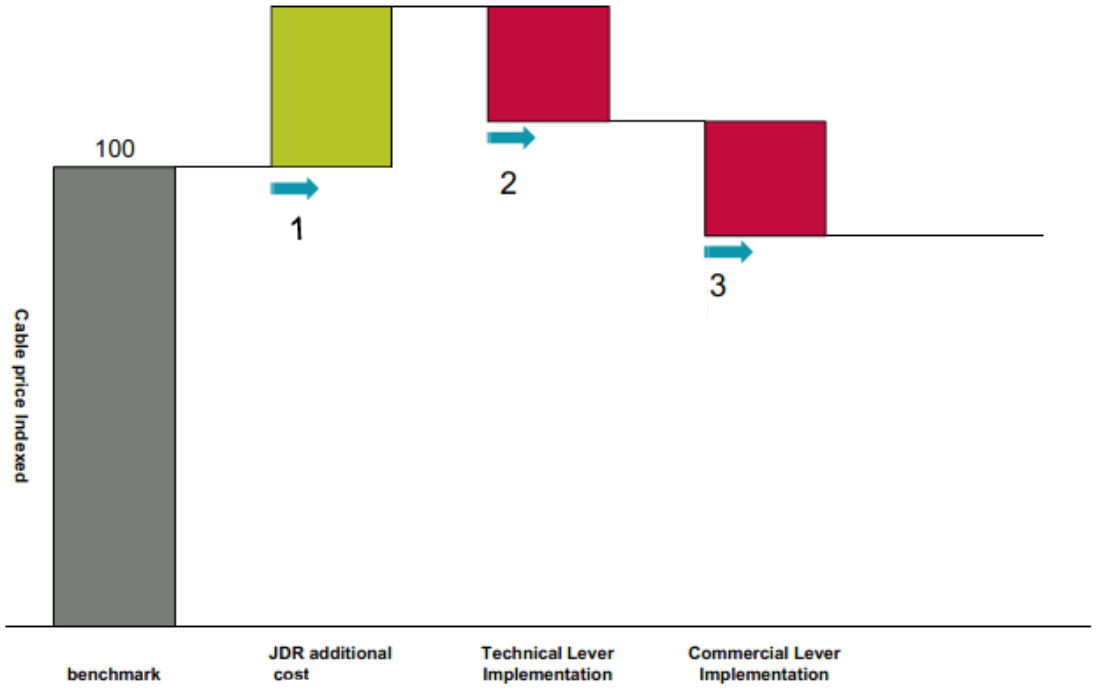
Benefits to JDR

- Exclusivity
- Advantage in relationship over competitors
- Opportunity to secure other projects
- Input into long production forecast

Benefits to Developer

- Reduce Lost Time Injury Frequency
- Secure reliable supply chain (help increase installed capacity)
- Reduce LCoE

WHY IMPLEMENT A COLLABORATION AGREEMENT?



CPS INTERFACE - Tekmar

- Demonstrate heat dissipation capability of the CPS
- Component level testing
- Variety of environments considered (including non-planned burial) – IEC calcs???/

THANK YOU


ZERO
cable failures
JDR's subsea power cables have been operating in harsh, offshore environments with zero cable failures since inception of this growing renewable industry.
JDR provides world-class subsea cables to some of the world's largest offshore wind farms. We continue to lead the market by engineering reliable products and by investing in people and technology that provide total lifecycle customer service.

Q&A

Peter Haughie, EDP Renewables

Andy Lewin, ORE Catapult
Alan Duncan, BVG Associates
Andrew Bellamy, 8.2 Aarufield
Stephen Thompson, Offshore Wind Industry Group
Brad Rabone, JDR Cables

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OFFSHORE WIND CONFERENCE, EXHIBITION & DINNER

23 & 24 JANUARY 2017 **GLASGOW**

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Innovation and Cost Reduction - Part 1

Session coordinated by

CATAPULT Offshore Renewable Energy

Maggie McGinlay, Energy, Scottish Enterprise

Tony Quinn, ORE Catapult
Dr Federico D'Amico, EDF Energy
Angus Cooper, Modus Seabed Intervention Ltd
Ray Thompson, Siemens Wind Power

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Tony Quinn

ORE Catapult

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Wind Turbine Design Validation:
Improving Reliability through Innovative Testing

24 January 2017 | **Tony Quinn, Operations Director**

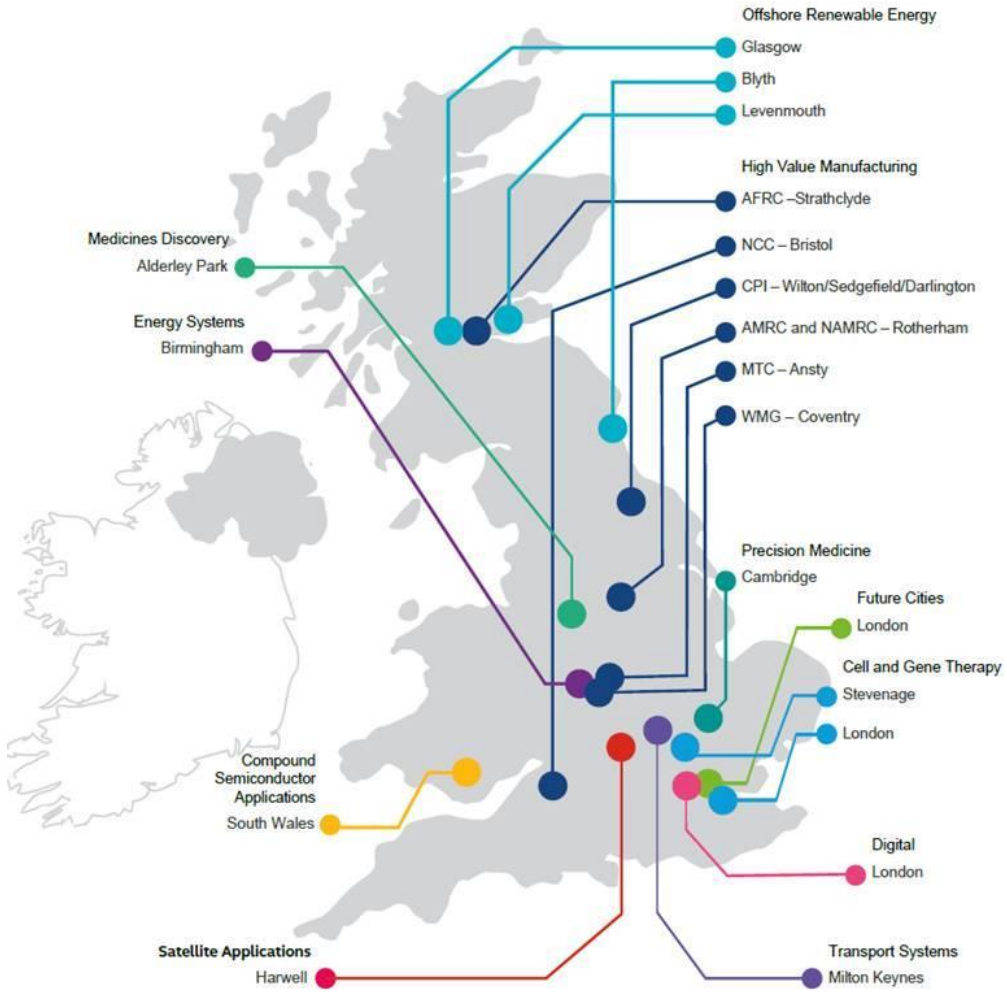
CATAPULT
Offshore Renewable Energy

The catapult network:
A long-term vision for innovation & growth

11

Catapults

- Established by InnovateUK
- Designed to transform the UK's capability for innovation
- Core grant leveraged with industry and other public funding



Our impact in 2015/16

50 Companies

151 SMEs

Operating **£1/4bn**

Global Reach

18 Countries

World Firsts

126 academic collaborations

53 industry collaborations

1:4:27

c.a. **£4.9m**

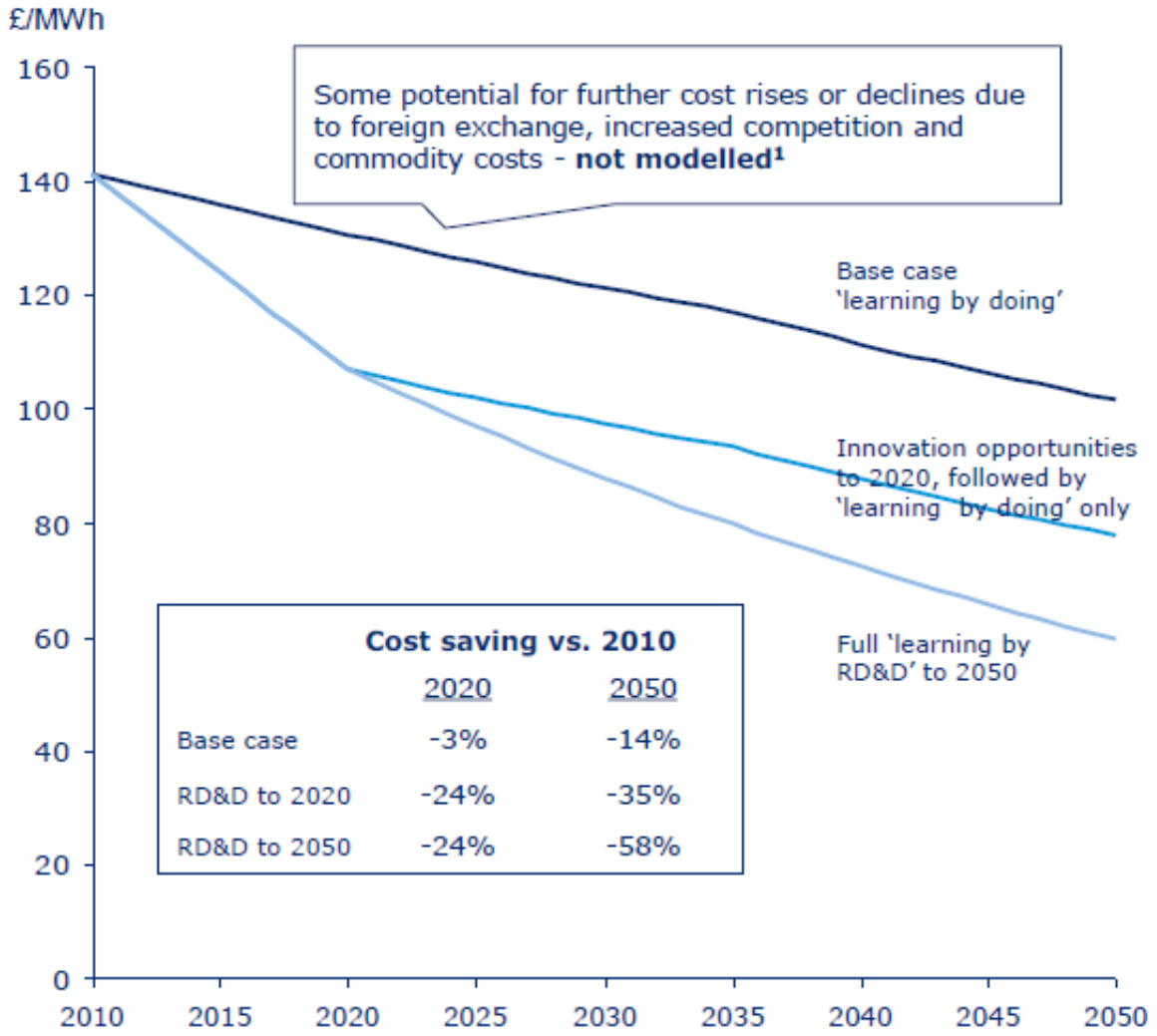
23

£6.2m

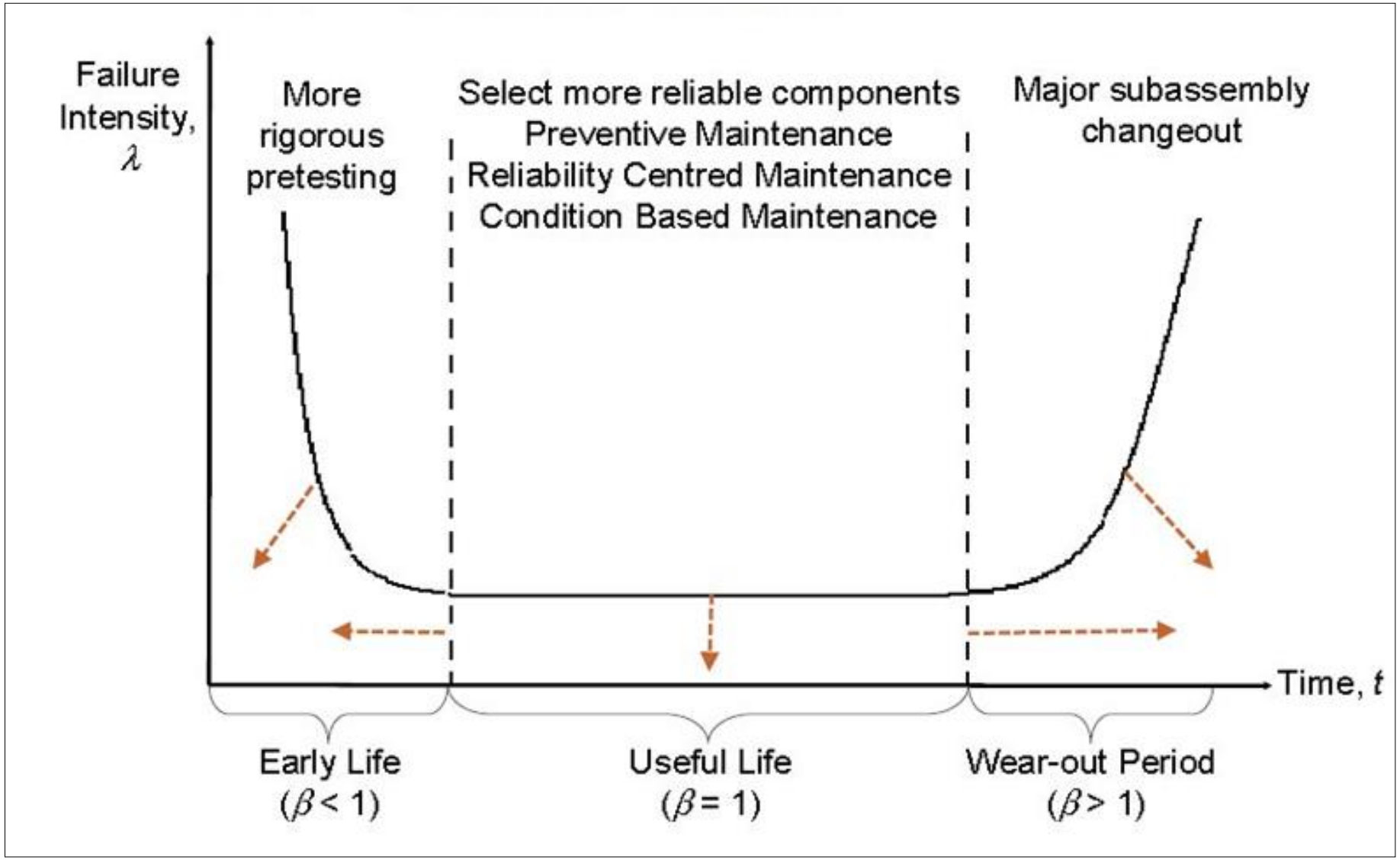
£5.7m

Technology Innovation Needs Assessment Report 2010

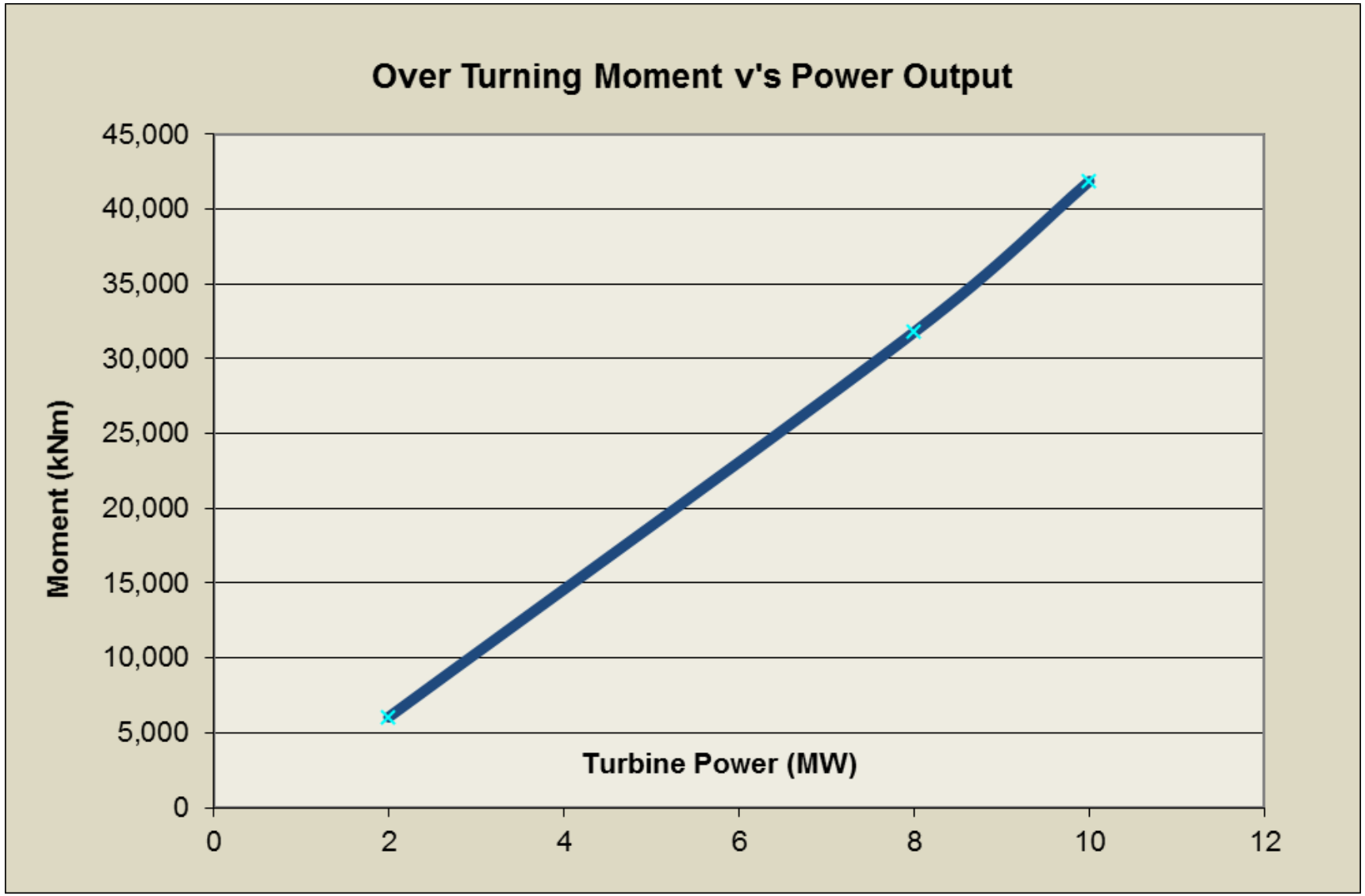
Chart 3 Potential impact of innovation on levelised costs of an example offshore wind site



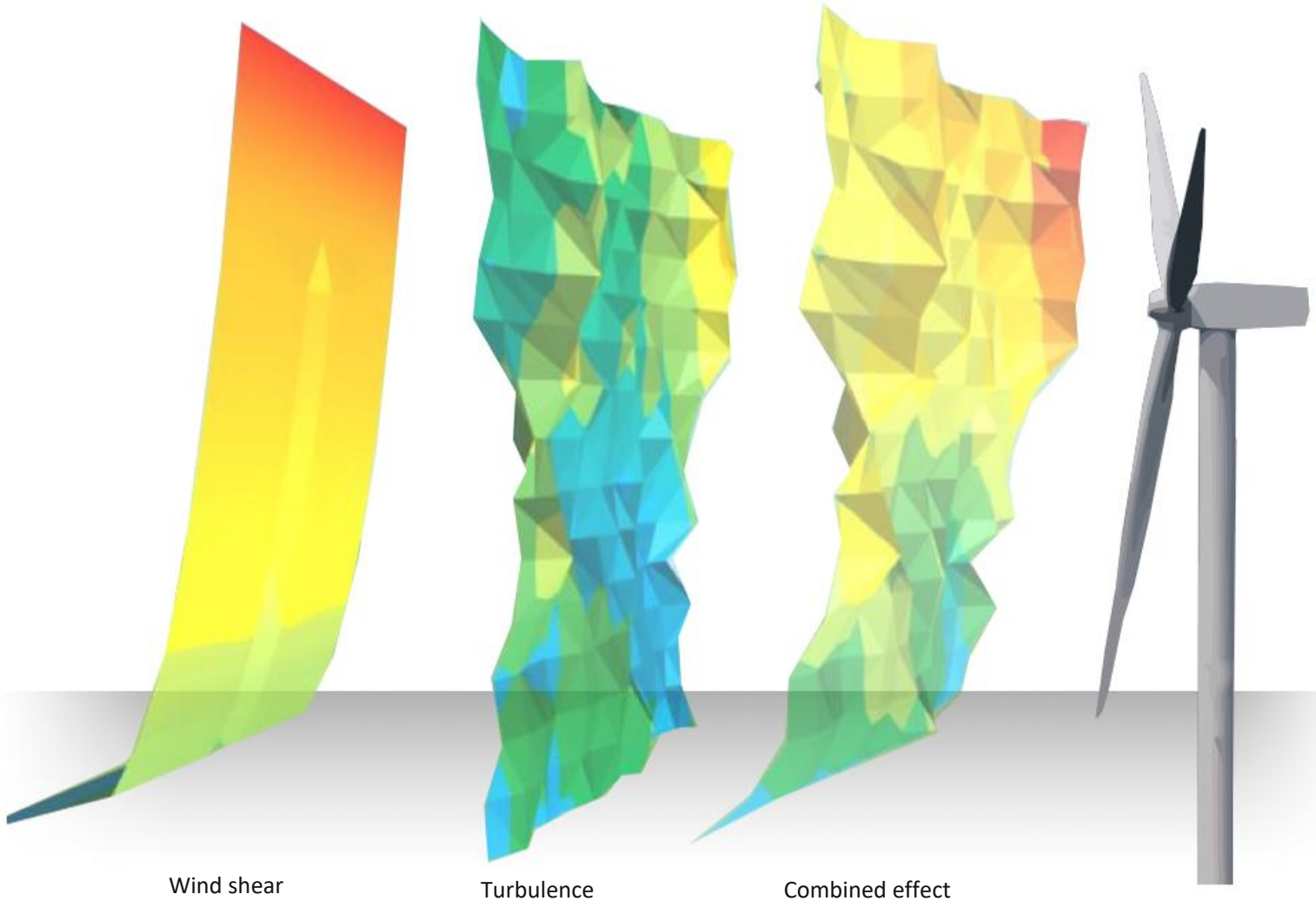
Accelerated Life Testing (ALT, HALT)



Bigger Turbines = Bigger Loads



Real World Load Generation



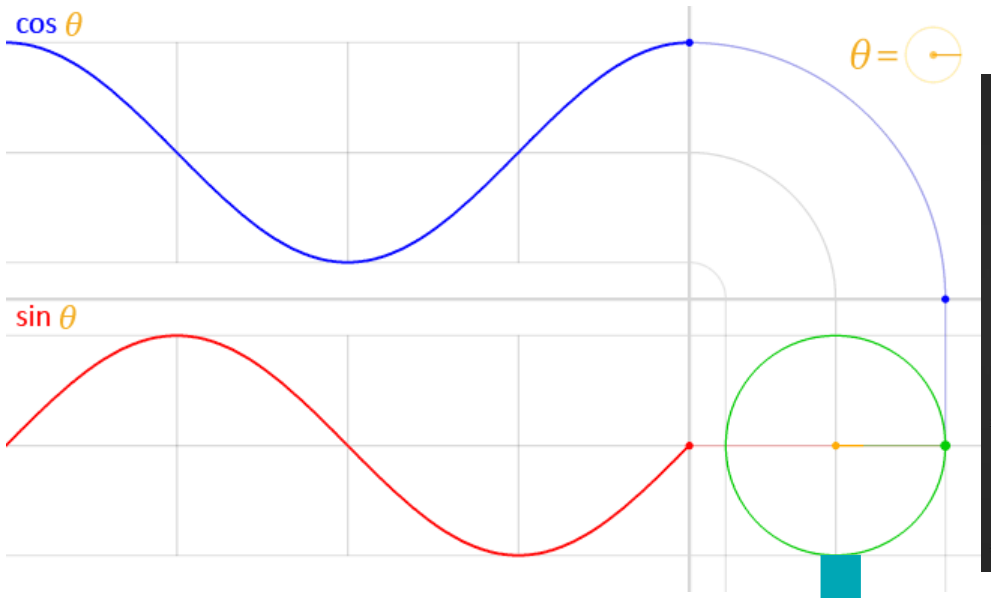
Wind shear
Tower shadow

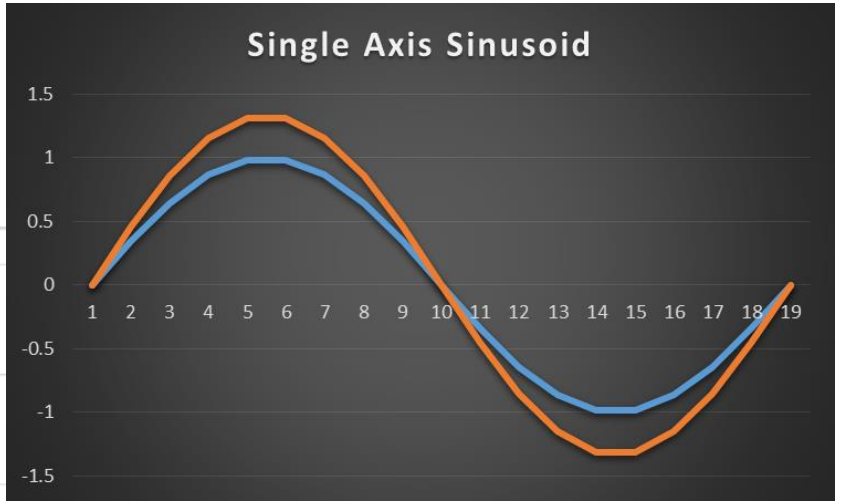
Turbulence

Combined effect

Representative Blade Testing

Challenging Conventional Wisdom

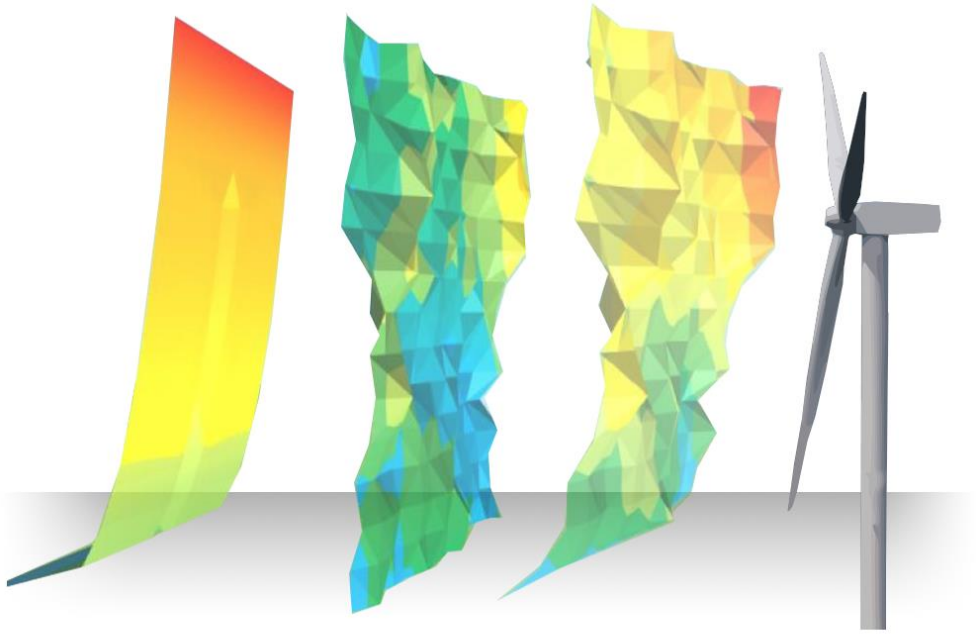




Force

R&D project - Wind turbine blade fatigue

- Flapwise loading
  - Mainly aerodynamic
    - Wind shear
    - Tower shadow
    - Turbulence
- Edgewise loading
  - Mainly due to gravity
- In service flapwise and edgewise loads occur together
- Single axis fatigue tests do not account for the combination of loads



Wind shear
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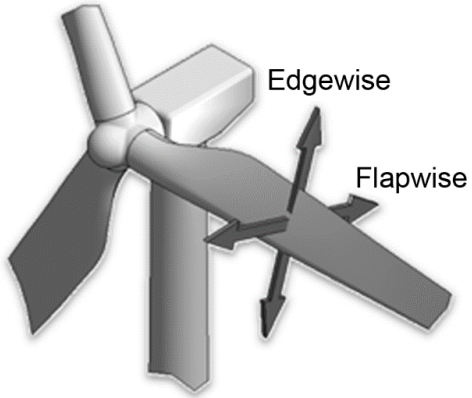
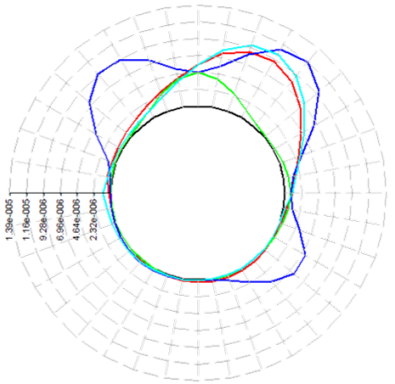
Combined effect

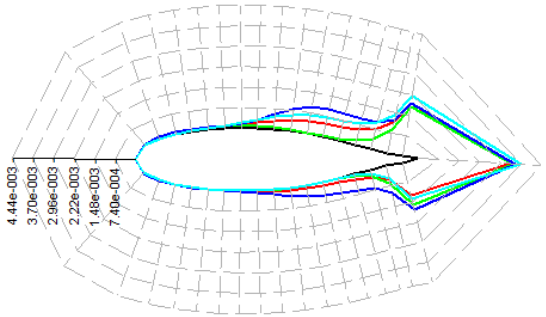


Resonant bi-axial fatigue testing

- Excite flapwise and edgewise natural frequencies simultaneously
- Optimise position and mass of test equipment so that the blade mode shape gives a good fit to target test loads
- Optimise flapwise and edgewise load levels so that test damage matches service life damage
- Faster tests
- More accurate representation of in-service damage



Damage comparison at 1.15m station



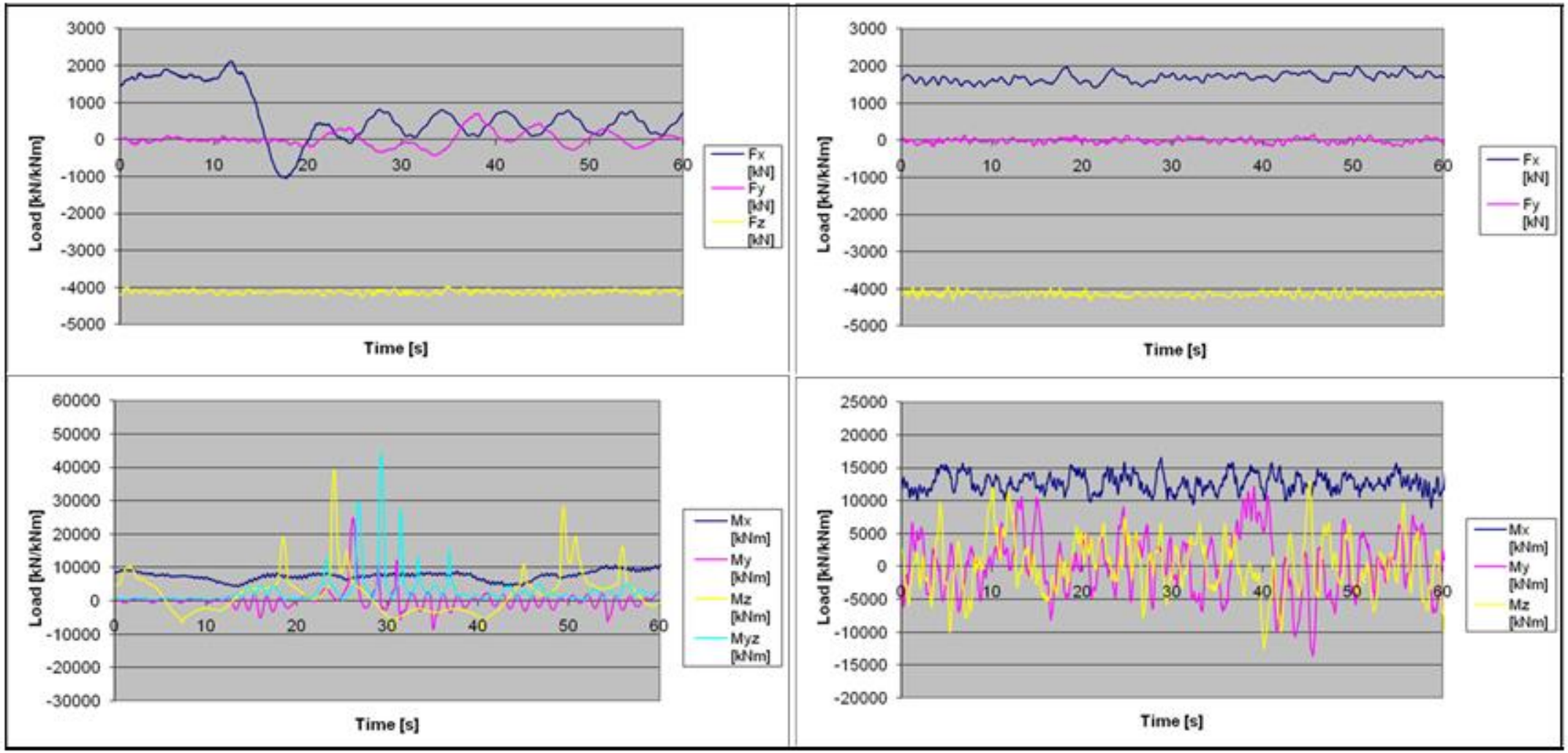
Damage comparison at 16.05m station

CATAPULT Offshore Renewable Energy

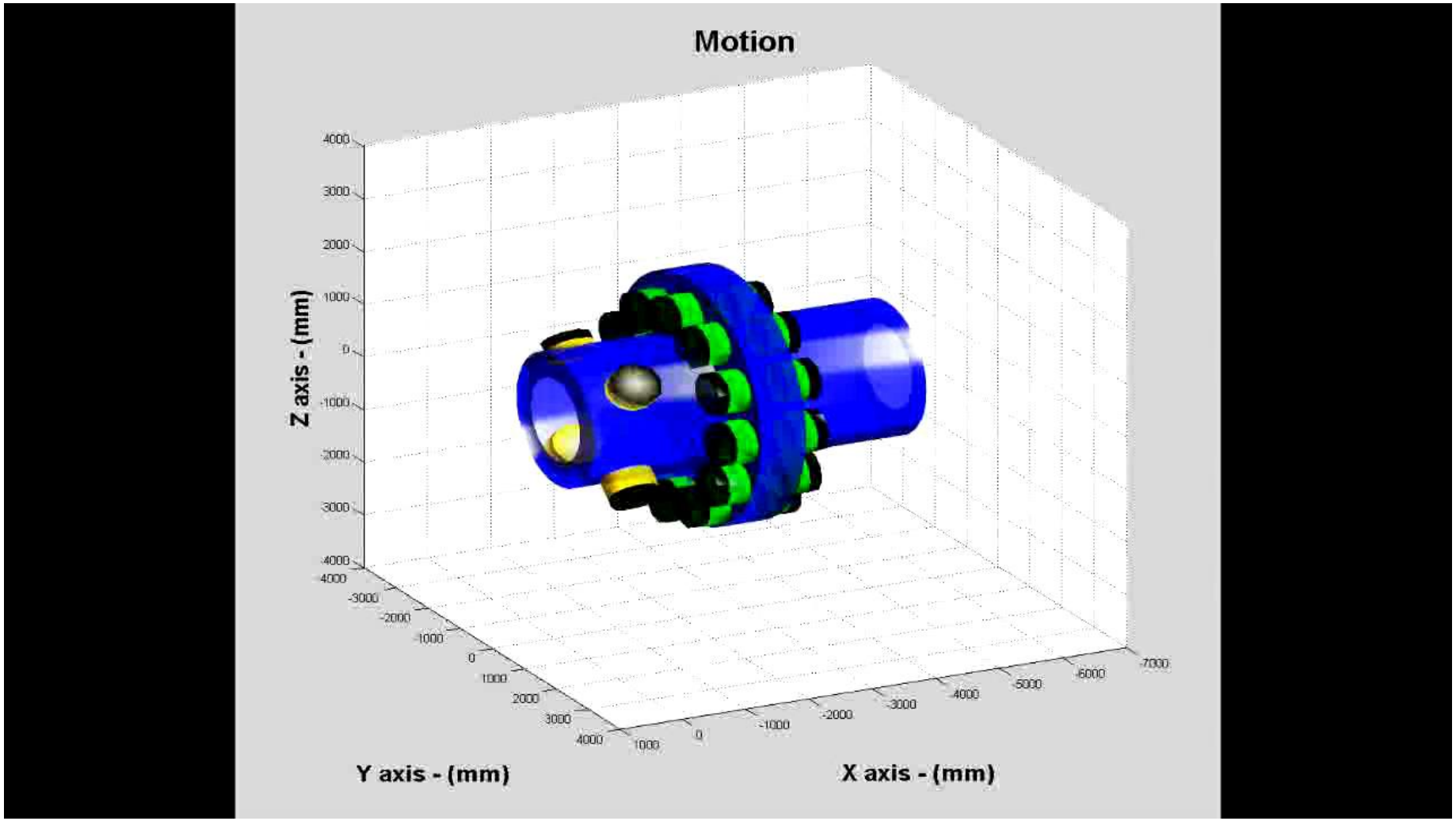
3MW tidal turbine nacelle testing facility

the Atlantis marine tidal turbine being tested in the 3MW Drive Train Facility.

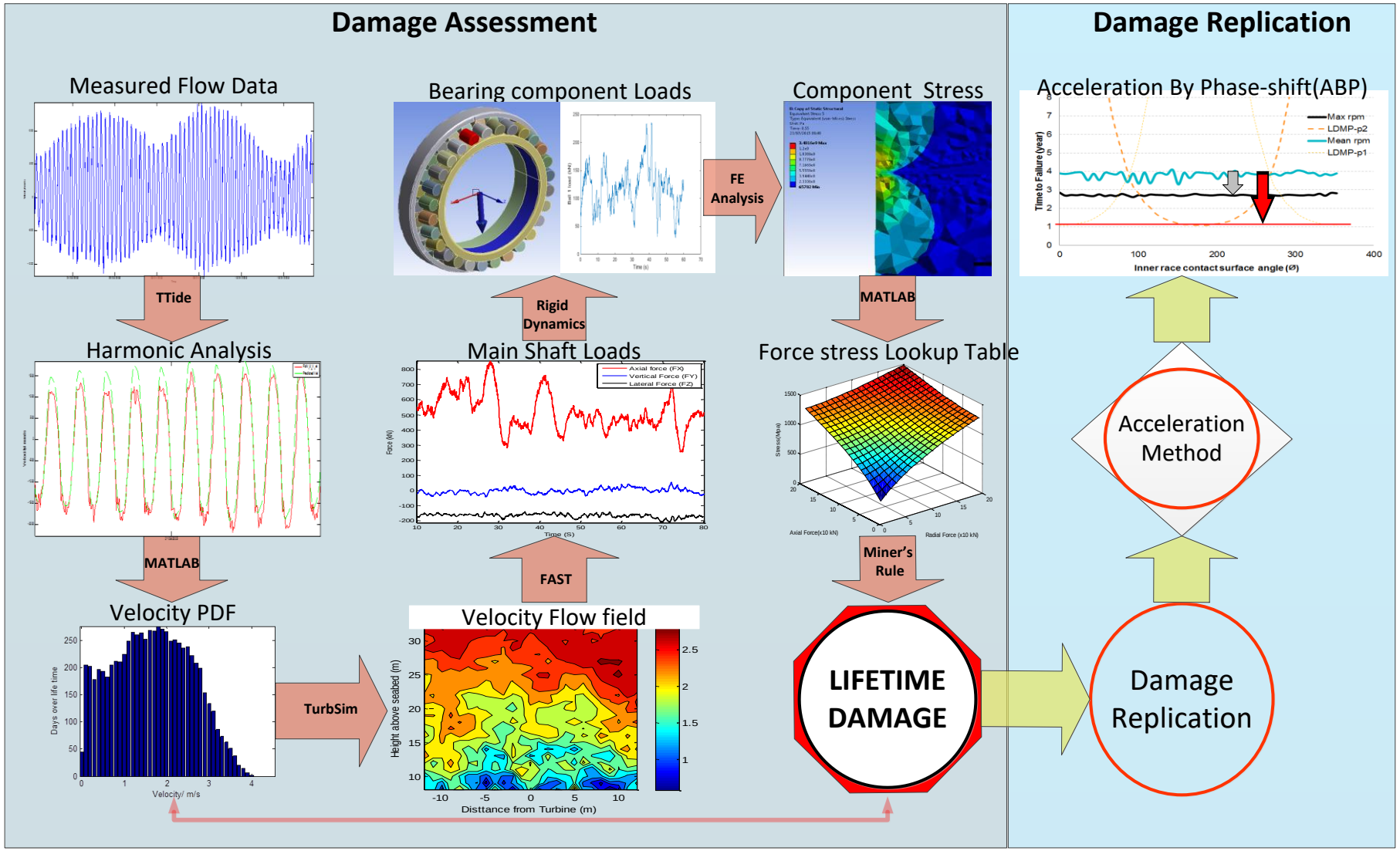
6 Degrees of Freedom – Dynamic Loads



Non torque loading concept



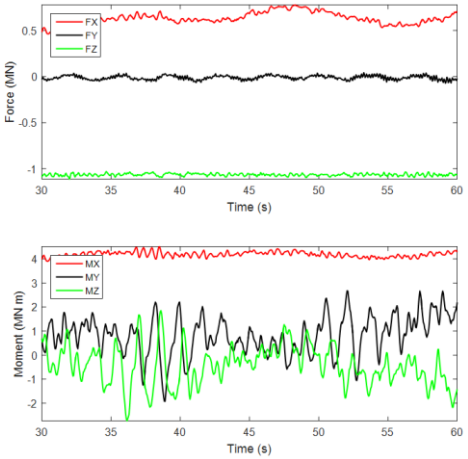
R&D Project:
Methodology for accelerated life test plan



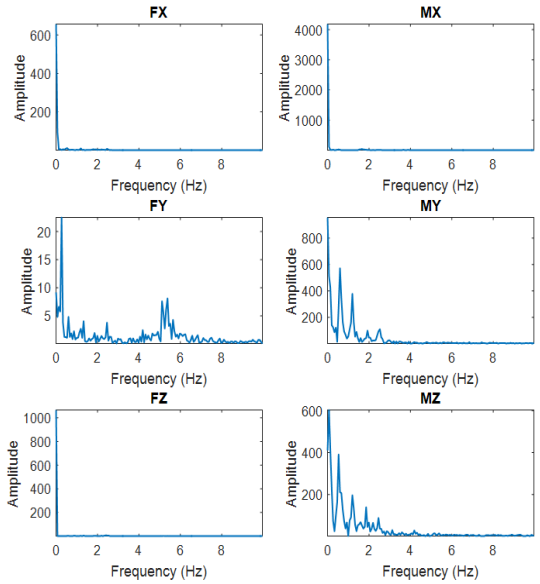
Focussing on Damaging Loads

- Wind turbine loading is far more complex than common industrial machines.
- Failure modes other than classical spalling (which is dependent on load magnitude and speed) can be excited.
- Main Bearing loads are highly dynamic and affect Failure modes such as Pitting, Scuffing and Abrasive wear

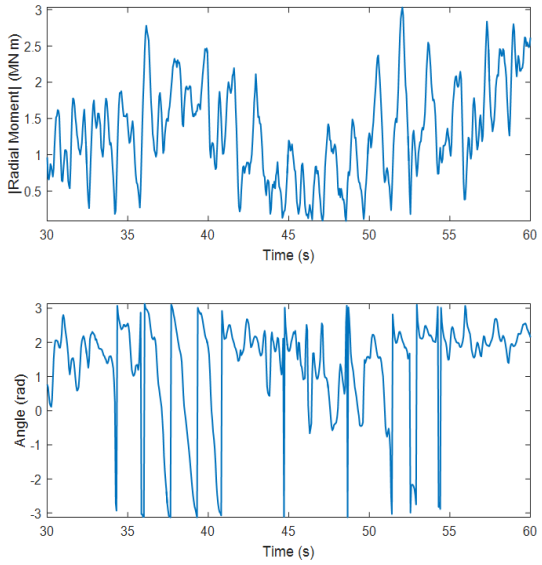
12m/s wind load on shaft



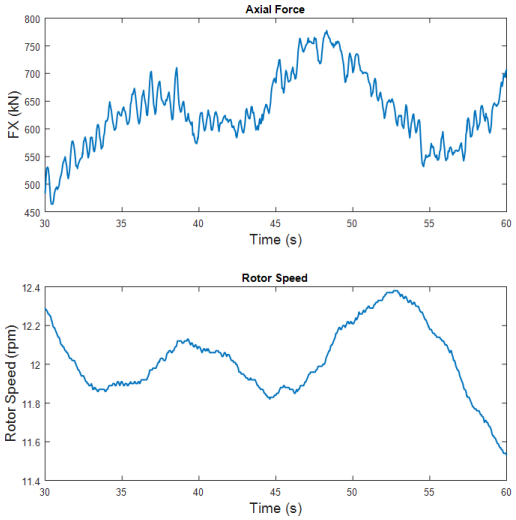
Frequency spectrum analysis



Extraction of the moment above (resultant)



Extraction of the axial forces above



CATAPULT Offshore Renewable Energy

Suggested Integrated Test profile

Spalling

- High Moments and forces (direction unimportant)
- High speed to accumulate load cycles quicker

Pitting

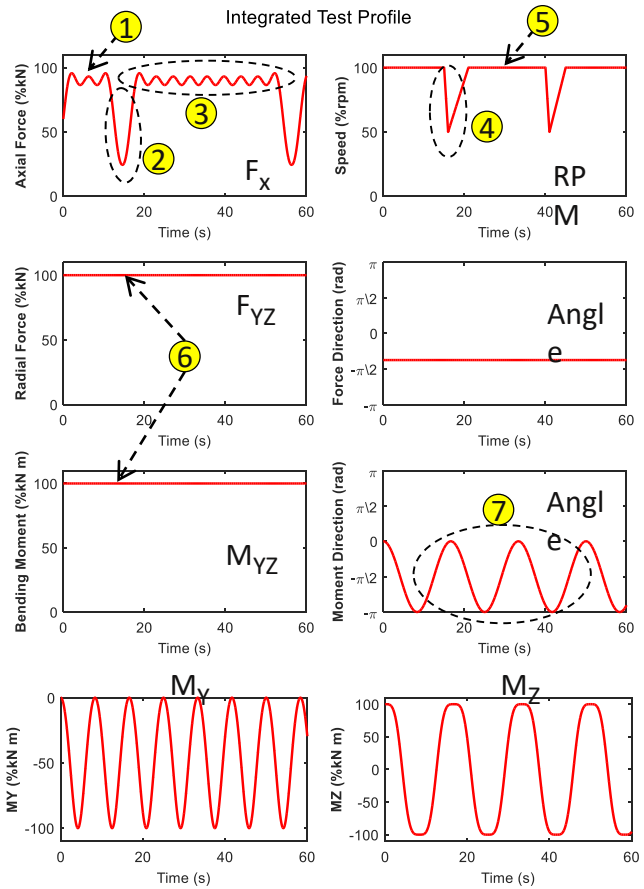
- Increased Surface shear stress while accelerating
- High loads for increased lubricant pressure, near surface shear stress.

Scuffing

- Reduced axial load leading to change roller load distribution
- Acceleration and deceleration in speed
- Dynamic bearing loaded zone due to changing angle of radial load

Abrasive wear

- High loads
- High acceleration/ deceleration
- Fluctuating axial load



Integrated Test Profile

CATAPULT Offshore Renewable Energy

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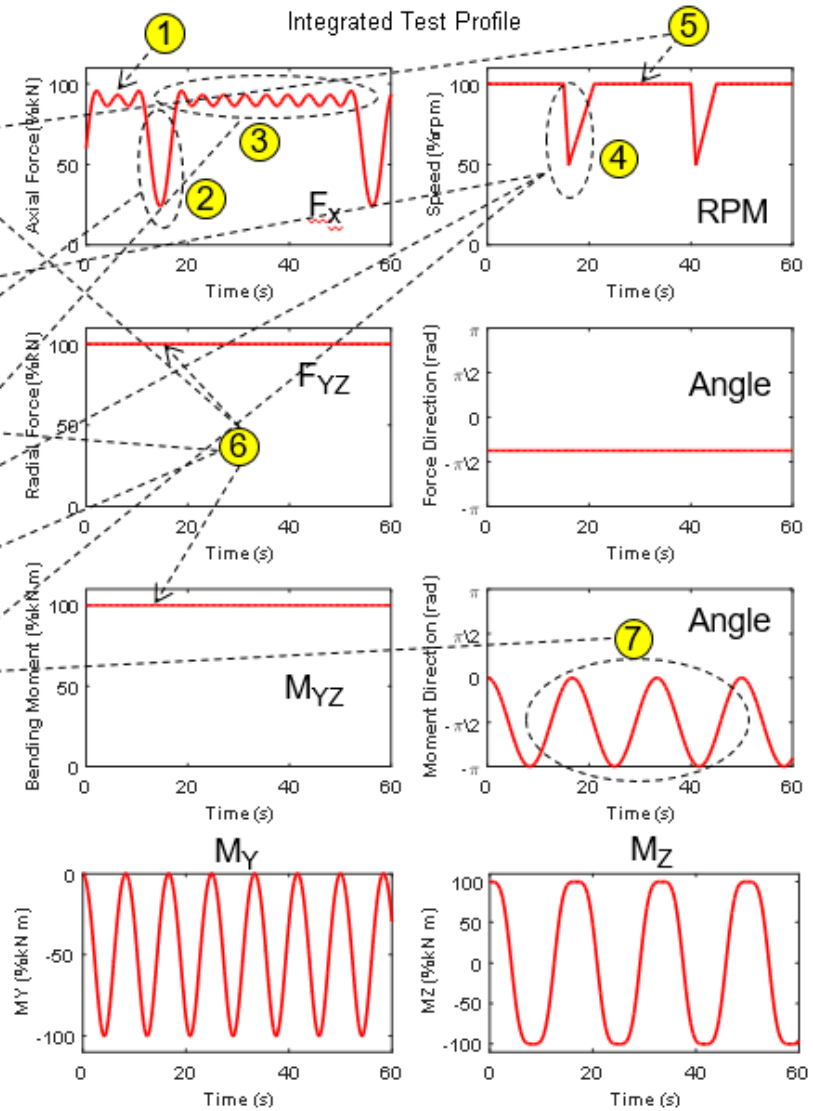
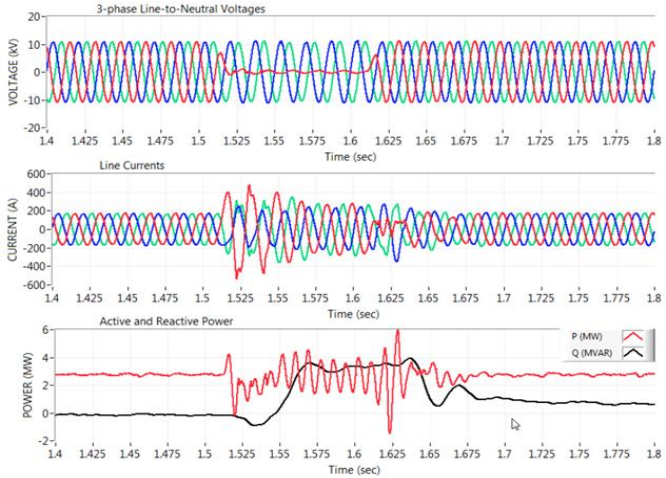
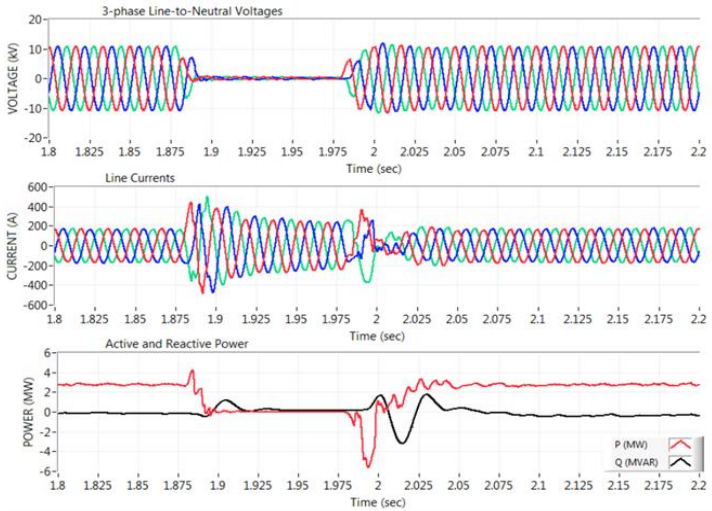


Combined Mechanical & Electrical Testing



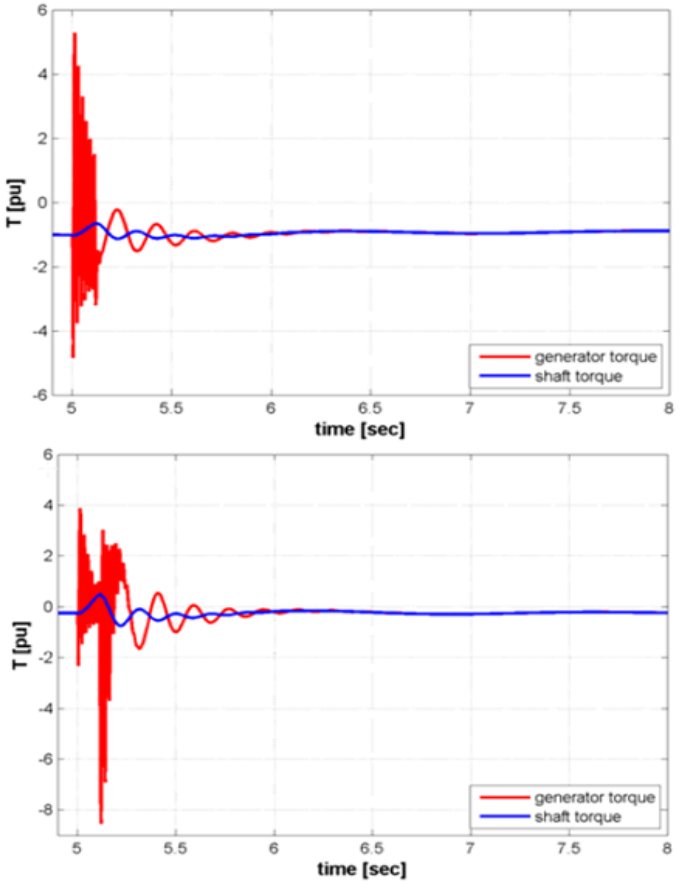
Single phase fault on 2.75MW PMG WT

(source: http://www.nrel.gov/docs/fy15osti/62998.pdf)



Three phase fault on 2.75MW PMG WT

(source: http://www.nrel.gov/docs/fy15osti/62998.pdf)



Powertrain torque during single phase (top) and three phase (bottom) grid fault

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CATAPULT Offshore Renewable Energy

THE CROWN ESTATE SCOTLAND PORTFOLIO

NewWaves Solutions Marine & Environmental Services

INVEST IN FIFE

HIE Highlands and Islands Enterprise Iomairt na Gàidhealtachd 's nan Eilean

Innovation & cost reduction in subsea survey & inspection

Angus Cooper – AUV Business Development, Modus

MODUS
Seabed Intervention

Offshore Wind Conference

Glasgow, 24th January 2017

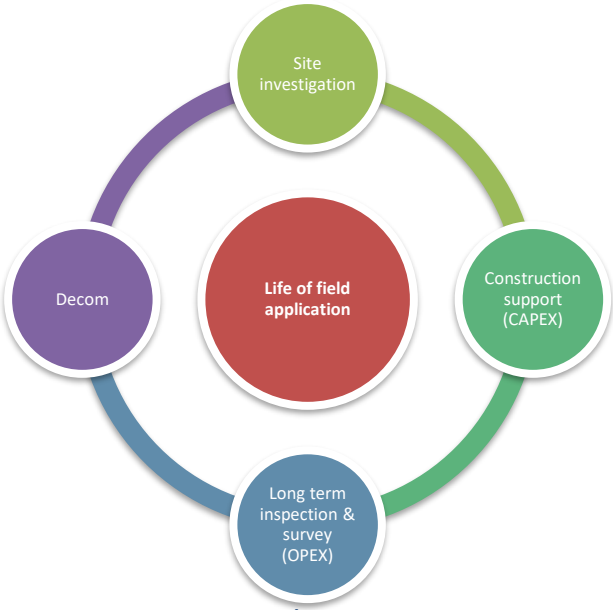
Company: Introduction

Established and experienced subsea and seabed intervention contractor

Exemplary safety record; +5 years and >1,000,000 man hours without LTI (Lost Time Incident)

ISO 9001+14001 REGISTERED
OHSAS 18001 REGISTERED
DNV
UKAS MANAGEMENT SYSTEMS
013
DNV Certification B.V.

FPAL
empowered by Achilles
Registered



Service lines:

1. **ROV services (ROV, AUV, Hybrid)**
   - Construction & drill support, intervention, maintenance, survey and inspection
2. **Seabed intervention**
   - Seabed earthmoving, infrastructure protection and stabilisation (trenching)
3. **Technical and managed services**
   - Fleet and operations technical support, engineering and management

THE SUNDAY TIMES SME EXPORT TRACK 100 2015 BT Business

MODUS Seabed Intervention

Service lines & track record (offshore wind)

ROV services (ROV, AUV, Hybrid)

Construction support, intervention, maintenance, survey and inspection

Fleet

8

1 No. CS-ROV 125hp WROV
3 No. CS-ROV 150hp WROV
1 No. CS-ROV 200hp WROV
1 No. E-ROV Panther Plus
1 No. AUV Remus 100
1 No. H-AUV Hybrid AUV

Offshore wind track record

- Entered OW market in 2010
- >30 OW projects completed
- >3,500 OW operational days
- Construction support, survey, UXO, trenching, inspection, maintenance

Trenching services

Seabed earthmoving, cable and pipeline protection and stabilisation

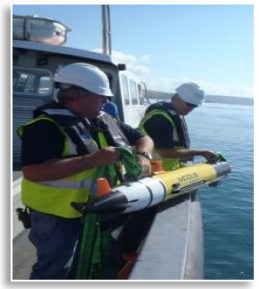
Fleet

4

1 No. 620hp tracked / free flying trenching class ROV
1 No. 400hp tracked / free flying trenching class ROV
1 No. 200hp free flying trenching / multi-role ROV
1 No. high pressure towed jetting sled

Technical services

- Engineering & project management
- 3rd party equipment (asset) management & operation
- Equipment maintenance & spares management
- Planned / preventive & reactive maintenance systems
- Equipment certification, procedures & documentation
- Procurement & logistics support
- Operational risk assessment & management



ISO 9001+14001 REGISTERED
OHSAS 18001 REGISTERED
DNV
UKAS MANAGEMENT SYSTEMS
DNV Certification B.V.

MODUS
Seabed Intervention

Why innovate and collaborate?

- **Operators are targeting cost reductions in the sector of 30-40% over the next 3-4 years**
- **Annual O&M costs average £2m p/a per OWF**
- **Survey & inspection of subsea assets is critical to reaching full life of field potential**

How to achieve cost reduction targets and maintain OWF Energy as a viable industry?

- Contractors reduce margins further
- Synergise the supply chain
- Lower the cost of financing
- Improve technology, efficiency and quality: INNOVATE

Innovation holds the only viable long term approach to achieving the targeted savings, and offers a realistic prospect of providing over 50% of the required savings

Innovation and collaboration between specialists will lead to longer term efficiencies and improved productivity while maintaining high levels of safety and quality

MODUS
Seabed Intervention

Steps for successful innovation and accelerating technology development

- **Innovation –** A continuous and collaborative process to develop and road map new technologies and techniques
- **Investment** – Collaboration can reduce exposure
- **Support** – Operator support required to adopt new technology and developments
- **Knowledge** – Utilising broad specialist knowledge and techniques from related fields can lead to synergistic benefits
- **Partnerships** – It is essential that a stakeholder community is established: operators, contractors, OEMs etc.
    - Partnerships lead to a broader understanding of the requirements and problems, and how to address the real issues
    - Partnerships with operators can provide access to trial sites, high quality feedback and early adoption of new technology

One such area where innovation and collaboration can be used is to reduce cost and improve quality in the survey and inspection of subsea assets and seabed…….

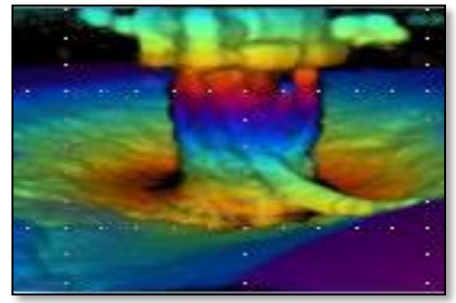
MODUS Seabed Intervention

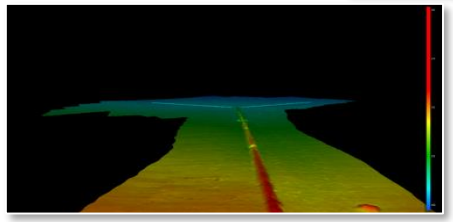
Cost reduction in subsea and inspection

Case study: Developing Hybrid subsea vehicles for survey & inspection during the pre-planning, construction and long term O&M phases:

Hybrid – offering the combined capability and characteristics of both ROV and AUV technologies; providing unrivalled flexibility for high resolution survey and inspection of seabed and assets

- Advantages of both ROV and AUV capabilities with additional emergent benefits
- Autonomous (hovering) structure inspection
- Autonomous pipe and cable tracking
- Adaptive mission behavior
- Independent movement in all 3 axis for difficult access areas
- Rotate in all axis to provide optimal positioning of sensors
- Simple and rapid onsite reconfiguration to suit survey requirements
- Integrated tried and tested payload





Multiple operational modes (rapidly changeable on site):

- Intelligent ROV;
- Thin tether ROV or AUV;
- Free flying AUV

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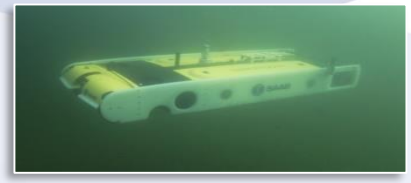
Seabed Intervention

Hybrid AUV capability



Long range autonomous endurance

Autonomous hovering capability

Multiple applications; rapid changeover between ROV and AUV mode

Mission planning & diagnostics carried out remotely

Subsea and surface docking

Reduction in offshore manning (compared to an ROV)

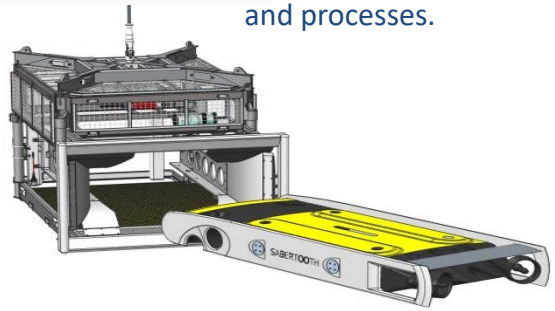
High speed survey

High quality data; more stable platform than hull mounted or towed units

Low logistic; lighter & smaller.

Advanced variable payload, superior quality data acquired close to seabed

In exclusive collaboration with Saab Dynamics AB, Modus have launched the offshore wind industry's most advanced and first commercially available Hybrid AUV. This is an innovative and differentiated approach to autonomous and remotely managed subsea survey and inspection; based upon disruptive technology and processes.



Game changing techno-economics

Collaboration:
Trialling & demonstration

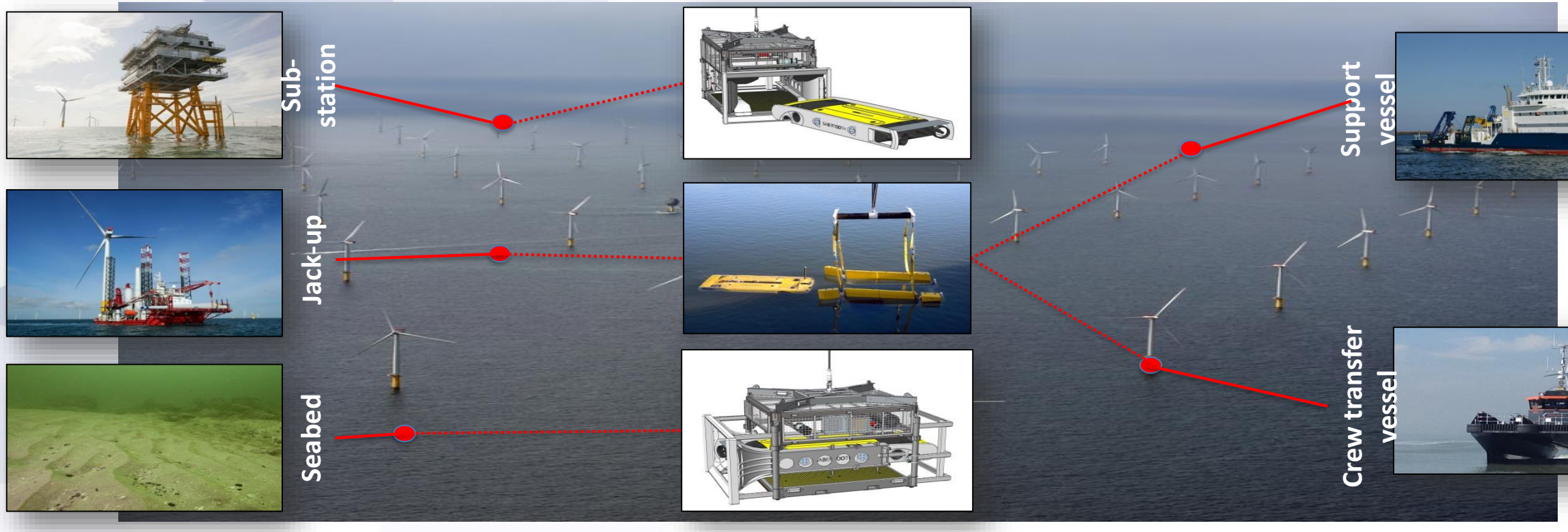
CATAPULT Offshore Renewable Energy

Collaboration:
Subsea and surface docking

SBIT

MODUS Seabed Intervention

Cost reduction through operational synergy & deployment flexibility



Remove incremental vessel costs (through SIMOPS)

Reduce manning levels

Mission planning and diagnostics performed remotely

Deploy from fixed structures (sub-stations)

ROV & AUV survey and inspection capability form one platform

Advanced sensor payload on one platform

Cost reduction

MODUS Seabed Intervention

Performance & operational cost reduction

- Hold position on any heading up to 1.5 knots, and up to 4.5 knots in forward direction
- Inspection can be run fully autonomously, with the AUV tracking and maneuvering around a structure with or without a tether.
- Multiple survey targets covered in a single mission without the need to reposition the support vessel
- Active pipe tracking using onboard sonar imaging or subsurface tracker can track at up to 4.5 knots
- Intelligent target tracking behavior and reacquisition
- Precise inertial positioning results in high resolution optical, acoustic and LIDAR images of cables and pipes
- Adaptive mission behavior can trigger additional actions if anomalies are found
- High quality data acquired close to seabed with advanced multiple sensor payload

Typical survey and Inspection payload:

Navigation /Comms	
Surface Comms	WiLAN/Radio/Iridium
INS	IXBlue Phins 3
DVL	Teledyne RDI Workhorse 600
Surface Nav	Novotel 638 DGNSS with SBAS
Acoustic Nav	USBL /LBL Aiding /DGNSS
OAS	Imaginex 881L -675 kHz
Cameras	Colour Video, Still HD , low light
Acoustic Comms	Sonardyne Avtrac 6

Sensor Payload	
Bathymetry – Option 1	Co-located Parametric Bathy Edgetech 2205 - 540kHz
Bathymetry – Option 2	R2 Sonic 2024 MBES With UHR
Sidescan Sonar	Edgetech 2205 230/540/1600 Khz
Sub Bottom Profiler	Edgetech 2205 - 2-16khz
Depth & SVP	Digiquartz /Valeport
HF/HD imaging sonar	Norbit /Aris/Echoscope
Planning, Acquisition & processing Software	QPS Qinsy & Qimera

Subsea inspection, survey, engineering and intervention

MODUS Seabed Intervention

Thank you!

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OHSAS 18001 REGISTERED
DNV Certification B.V.

FPAL empowered by Achilles Registered

IMCA

Corporate Member SUT Society for Underwater Technology

The Hydrographic Society UK

SUBSEA UK™ SUBSEA NE

Committee member

Member of nof energy

norstec

Regional Excellence Global Capabilities ENERGI COAST North East England's Renewables Group

Committee member

MODUS Seabed Intervention

Ray Thompson

Siemens Wind Power

scottish renewables

CATAPULT Offshore Renewable Energy

THE CROWN ESTATE SCOTLAND PORTFOLIO

NewWaves Solutions Marine & Environmental Services

INVEST IN FIFE

HIE Highlands and Islands Enterprise Iomairt na Gàidhealtachd 's nan Eilean

SIEMENS

Offshore Wind Cost Reduction

Cost reduction in practice – an operational perspective

Cost Reduction Equation has three elements

Capital Expenditure

- Installed cost of turbine
- Installed cost of Balance of Plant
- Electrical Infrastructure costs

Operational Expenditure

- Cost to Service all equipment
- Unplanned failures
- Service strategies to maximise energy production

Energy Production

- Energy Output from turbines
- Availability and reliability
- Minimisation of losses

Price Reductions in Offshore wind

Cost of Offshore wind is reducing quickly.

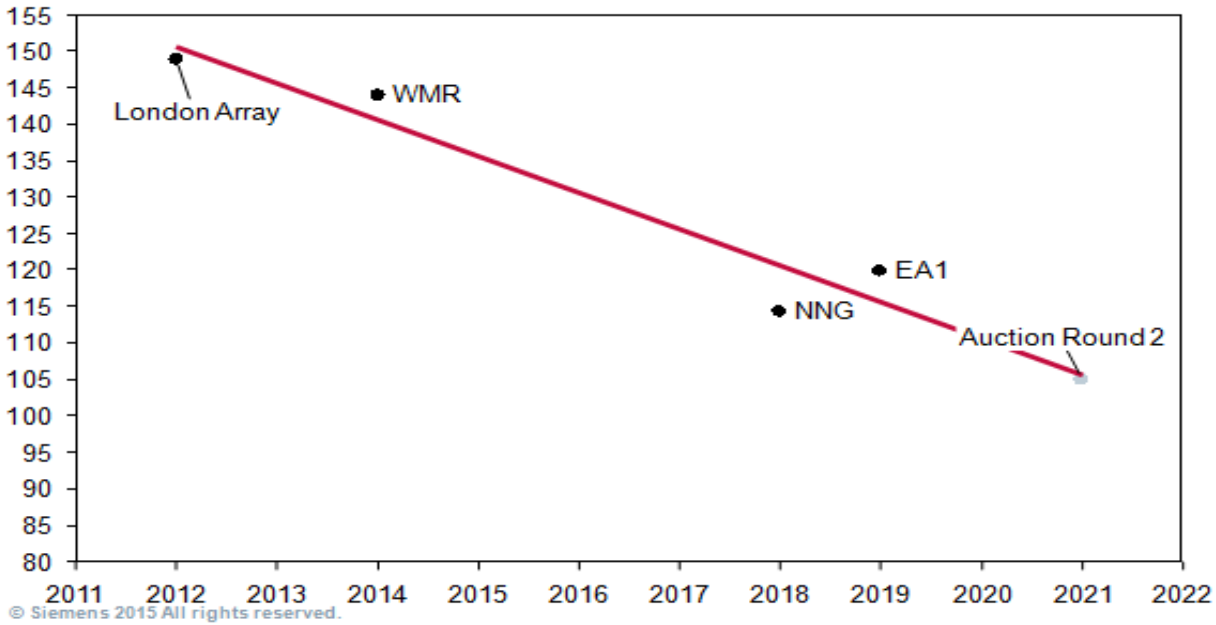
Last UK auction – Lowest price was NNG at £114/MWH

Next UK auction ‘capped’ at £105/MWH so prices will be below this

Recent Dutch auction won by Dong Energy at €72.20/MWH (About £80/MWH)

Customers face massive cost pressure to stay in the industry

Strike Prices (£/MWH)against time



Better Turbines

Better Vessels

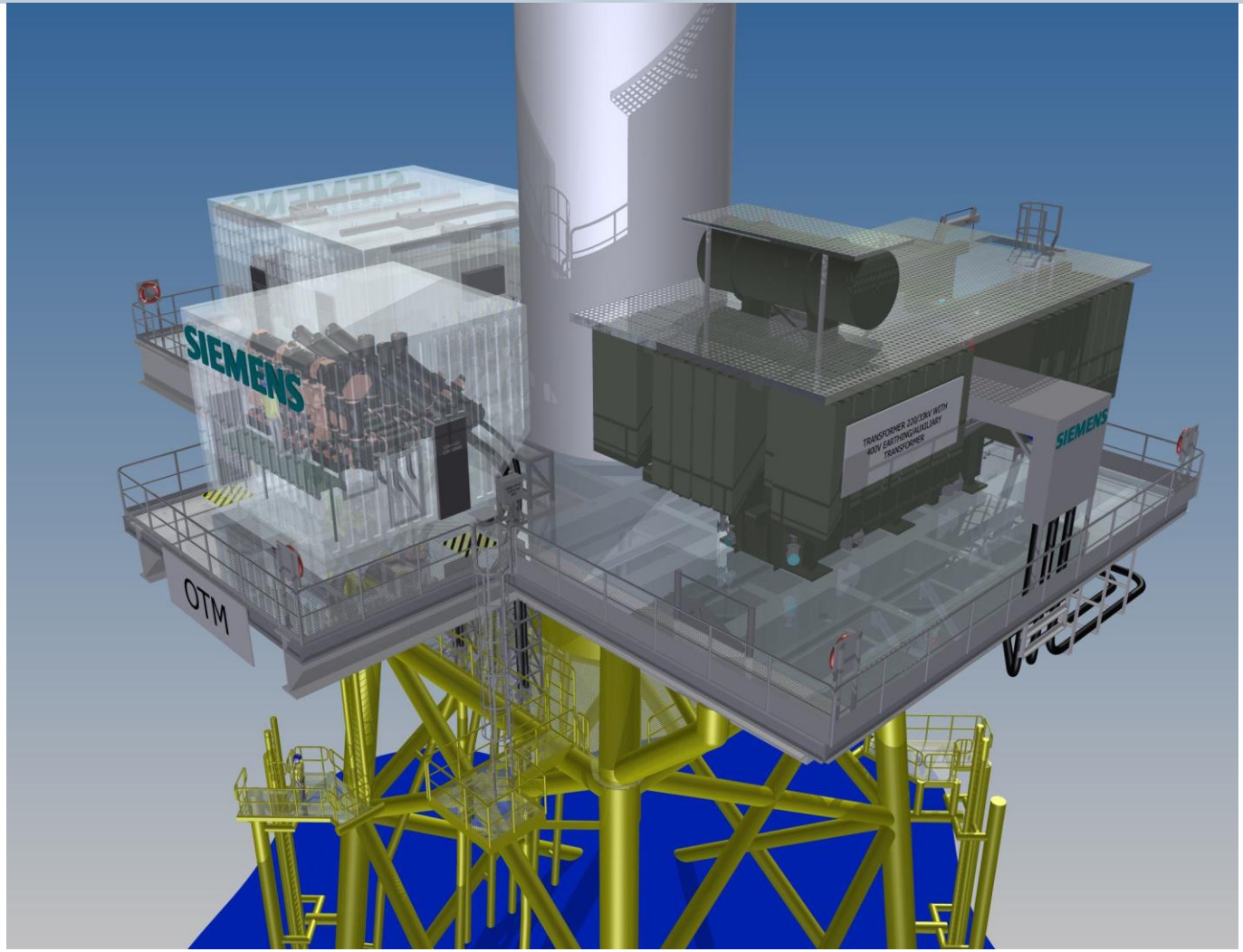
Better port side facilities

Better people and skills

Better Logistics Solutions

Better O&M strategies and operations

Lower cost Grid solutions



Lower cost of capital

So what does all this mean?

- All evidence suggests that costs have fallen much faster than expected
- Parity with lowest cost generation forecast to be early 2020’s
- The drive to reduce costs continues
- The industry is in a strong position to deliver more of our clean energy requirements at lower costs to consumers

Contact Details

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Innovation and Cost Reduction - Part 1 Q&A

Session coordinated by

CATAPULT Offshore Renewable Energy

Maggie McGinlay, Energy, Scottish Enterprise

Tony Quinn, ORE Catapult
Dr Federico D'Amico, EDF Energy
Angus Cooper, Modus Seabed Intervention Ltd
Ray Thompson, Siemens Wind Power

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CATAPULT Offshore Renewable Energy

OFFSHORE WIND CONFERENCE, EXHIBITION & DINNER

23 & 24 JANUARY 2017 **GLASGOW**

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Innovation and Cost Reduction - Part 2

Session coordinated by

CATAPULT Offshore Renewable Energy

Zoe Barnes, Everoze

Professor Simon Hogg, DONG & Durham University
Sebastian Bringsværd, Statoil ASA
Mikael Jakobsson, 2-B Energy
Una Brosnan, Atkins

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Innovation and Cost Reduction - Part 2

Shaping the Future of Offshore Wind

- Úna Brosnan
- Growth Manager - Atkins

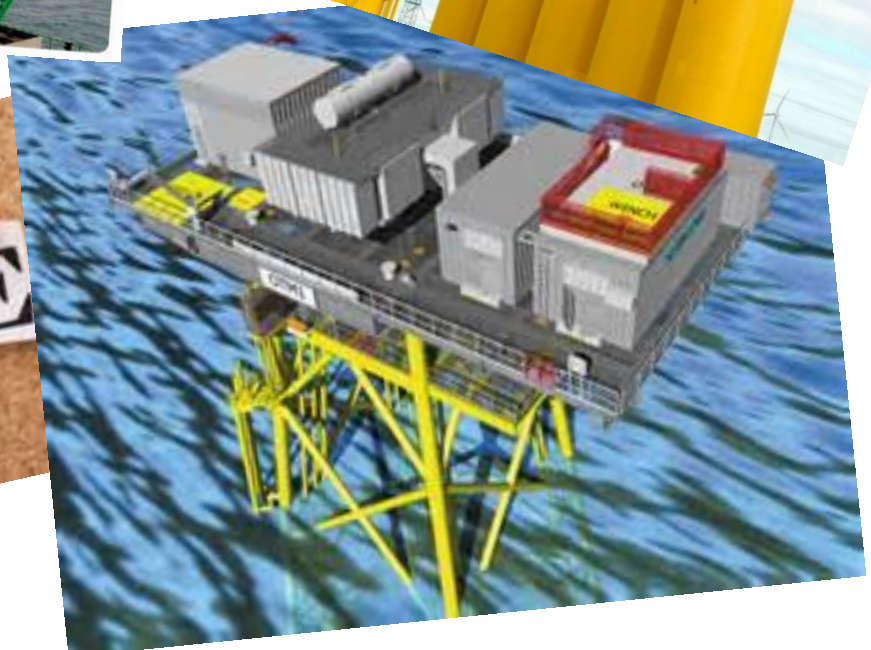
Innovation and Cost Reduction

- The OSW Journey to date
- Future developments and global markets
- A Future Disrupter – Floating Wind

The Present

- The Journey since the release of Round 3 (2010)
- On Target for £100/MWh by 2020
- Cost competiveness for the CDF Rounds
- Impact of our success & commitment to cost reduction

Innovation - the current disrupters



The “Stretch Targets” for Fixed Structures

- Our cost Challenges in Europe
- Even Larger Turbines
- Further optimised structures - built on strength of knowledge and experience on the cost reduction successes to date

Project	Country	Lead Developer	Est. Total Capacity	Bidded Energy Cost
Borselle 1 & 2	Netherlands	Dong	700 MW	72.70 €/MWh
Borselle 3 & 4	Netherlands	Shell	700 MW	54.50 €/MWh
Krieger Flak	Denmark	Vattenfall	600 MW	49.90 €/MWh

BEWARE of the comparison !

Longer term potential disrupters…

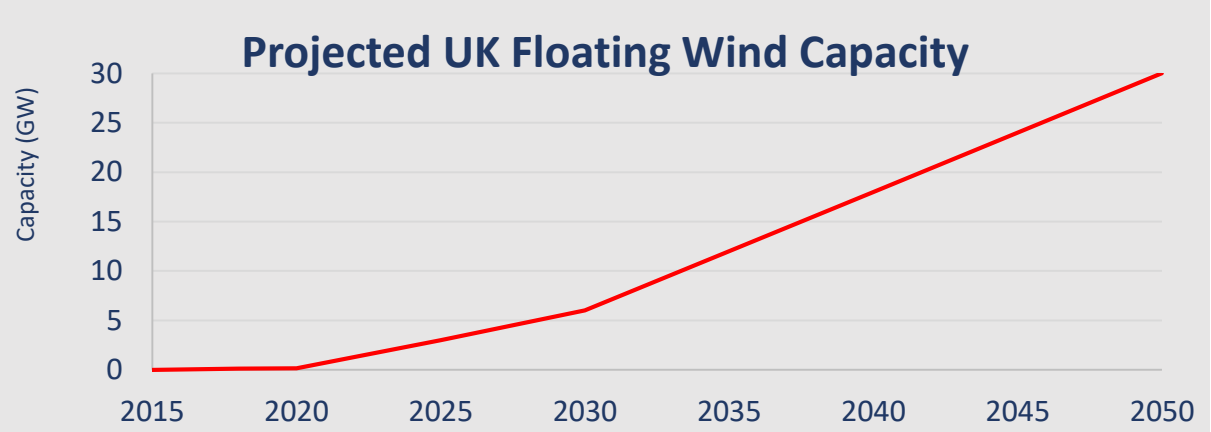
- Floating technology
- One / two bladed Turbines
- Horizontal v Vertical Axis
- Automated O&M
- Big data
- Low frequency AC transmission
- Ever larger turbine capacity
- Hybrid solutions
  - Wind – Wave Technology e.g. FPP
  - Integrated energy storage e.g. Batwind

A Future Disrupter – Floating Wind

- **Why Floating wind…**
- Increased wind exploitation
- Larger resource base
- Significantly reduced ground risk
- Adv. for major repairs/upgrades
- Deployment further offshore
- Anchored moorings
- Safety

Country / Region	% of OW Resource in deep water (>60m)	Potential floating wind capacity
Europe	80%	4,000GW
USA	60%	2,450GW
Japan	80%	500GW

(US NREL, 2012 EWEA; Marine International consulting, 2013



Sources: *Carbon Trust "Floating Offshore Wind: Market and Technology Review", June 2015*
Pelastar Cost of Energy Study, 21 January 2014

Innovation – Floating Wind

- Currently over 30 floating wind concepts under development
- For the most part, concept designed to date the innovation for Floating Wind lies within the *Design and Installation* of the support structures.
- Classification of Substructures fall into:
  - Spars
  - Semi – Submersibles
  - Tension Leg Platforms (TLP's)
  - Multi- Turbine
  - Hybrid Wind/Wave devices

Challenges & Innovative approaches

- Technology Status/Challenges
- Confidentiality - IP based technologies
- De-Risking Projects
  - Consent
  - Securing grid connection
  - Market/Subsidies
- Early Supply Chain Engagement
- Financing

Conclusion

- Market disrupter advancement to set to continue
  - Global appetite for offshore wind
  - Recognition of our industry contribution to energy market
  - Innovation support - it MUST continue if we are to stay as leaders

- The Future for Offshore Wind is bright !

Thank you

- If you'd like to find out more visit: www.atkinsglobal.com

Sebastian Bringsværd

Statoil ASA

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Hywind

Scottish Renewables Offshore Wind conference on 24th January 2017

NES Strategy

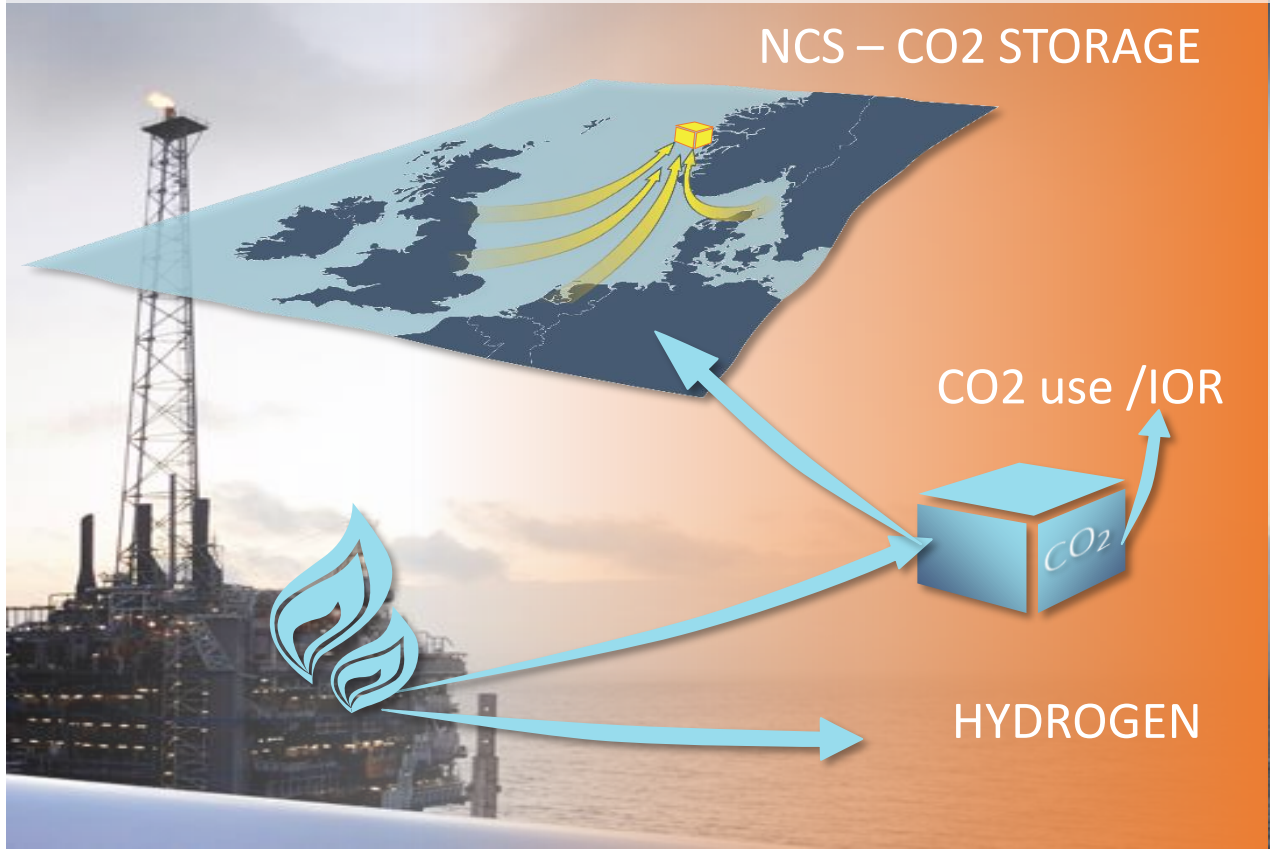
Build a profitable renewables business

OFFSHORE WIND

SOLAR

ENERGY STORAGE

Develop new lower-carbon business opportunities for Statoil's core products



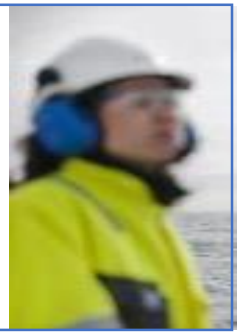
Statoil and offshore wind

Playing to our strengths

- Complex projects
- Marine operations
- O&M & HSE ability
- Leading floating tech.

Attractive market

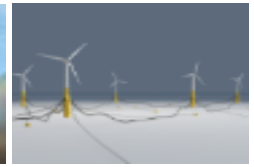
- Attractive risk/return
- Predictable revenue
- OECD countries
- High entry barriers



Offshore wind projects currently in progress delivering >1100 MW

Additional 4800 MW consented / ~5 mill. homes

North West Europe | Japan | United States

Hywind demo	Sheringham Shoal	Dudgeon	Hywind pilot	Arkona	Dogger Bank	Hywind large scale
						
In operation	In operation	In development	In development		Consented	
2.3 MW	**317 MW**	**402 MW**	**30 MW**	**385 MW**	**4 x 1200 MW**	
2009-	2012-	2017	2017	2019	2020-	

** All capacity figures on 100% basis*

Masdar 25% share

New York Licens

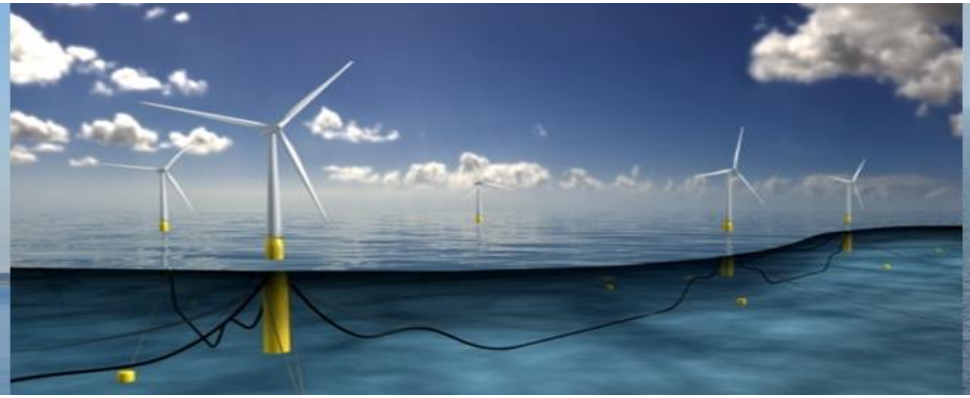
Expanding the potential floating wind market

Illustrative only, based on water depths, wind conditions and potential large markets

The Hywind Concept

Proven technology in a new setting

- Simple spar-type substructure
- Standard offshore wind turbine
- Conventional 3-line mooring system
- Blade pitch control system for motion damping
- Suitable for harsh conditions



Demo → Pilot Park → Large parks

Hywind Demo Experience

- Excellent HSE record - No serious incidents
- Produced 55 GWh since start-up in 2009
- Production as good as or better than other 2.3 MW Siemens wind power turbines
- Experienced storms with wind speed over 44 m/s and maximum wave height of 19 m
- Verification of system integrity in operational mode

Realising the Hywind Scotland pilot park

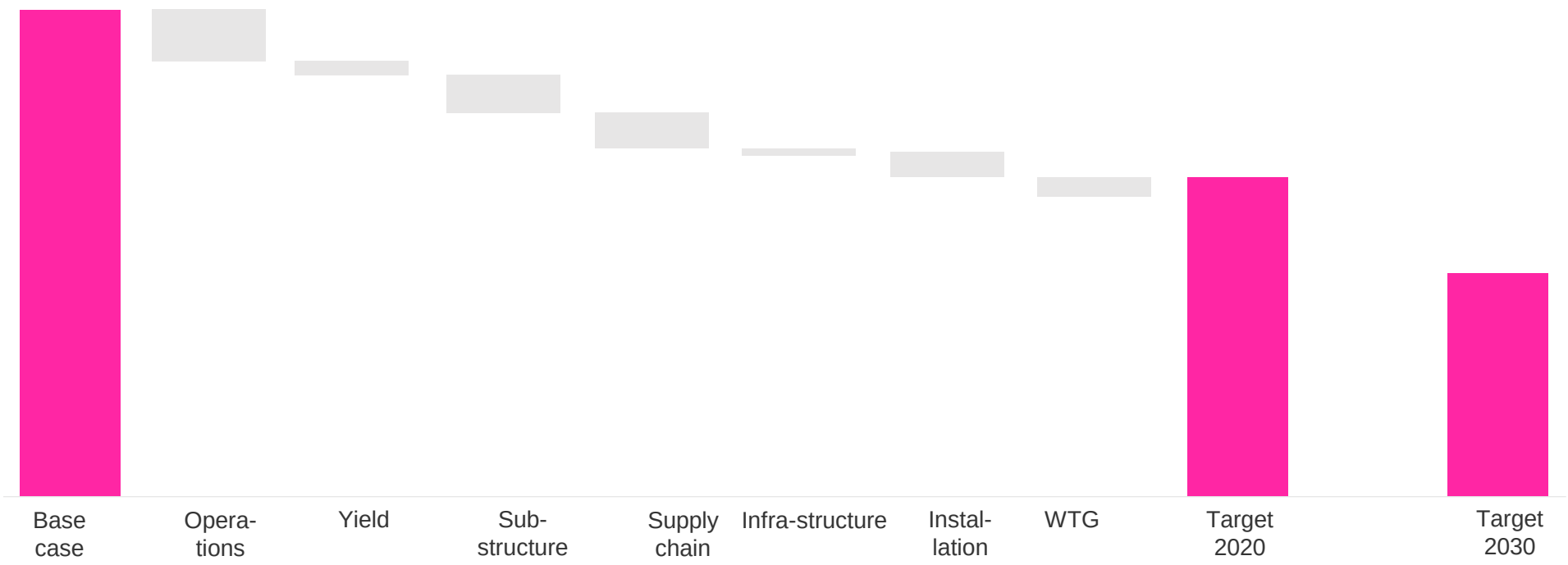
- **Investing around NOK 2 billion**
- **Partner:** Masdar 25%
- **60-70% cost reduction** from the Hywind Demo project in Norway
- **Powering ~20,000 UK homes**

- **Installed capacity**: 30 MW
- **Water depth**: 95-120 m
- **Avg. wind speed**: 10.1 m/s
- **Area**: ~4 km^2

- **Average wave height**: 1.8 m
- **Export cable length**: ~30 km
- **Operational base**: Peterhead
- **Start power production**: 2017

Challenges - Bringing down the cost

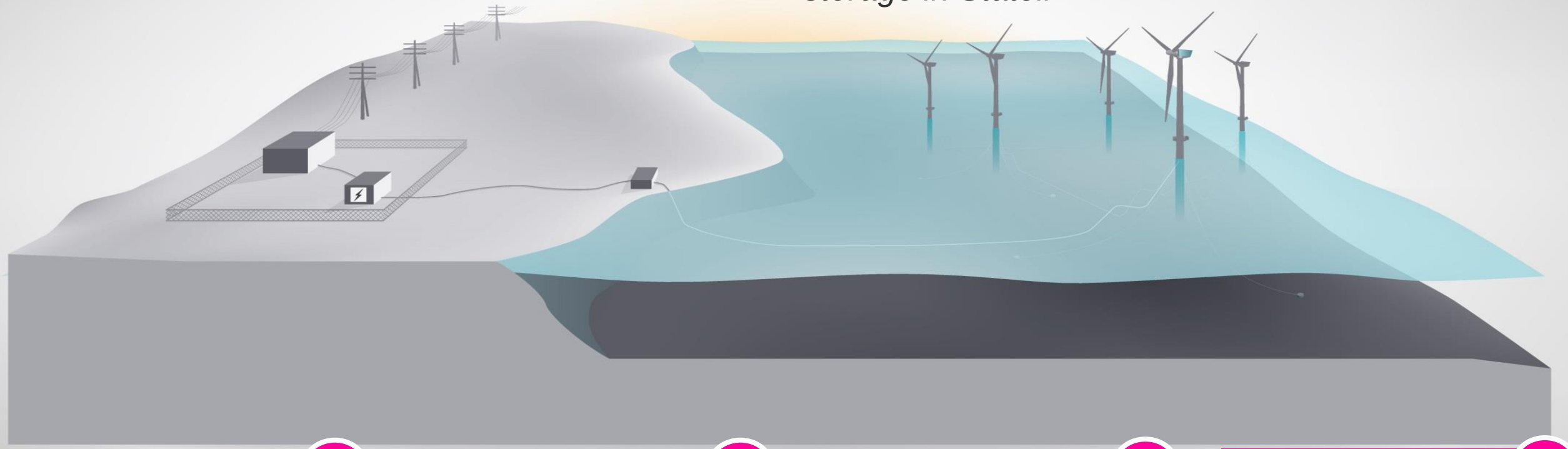
Cost reduction of 40-50% by 2030 a realistic target



Piloting Batwind concept for Hywind

Floating Wind + Storage + Grid

- ✓ *Increase the value of floating wind*
- ✓ *Start developing new business models around storage in Statoil*



1 Capture wind overshoots
Ability to store excess electricity for sale when capacity is free

2 Reduce balancing co
Counter impact of wind forecasting errors

3 Increase power mark value
Capture price peaks through arbitrage

4 Deliver power system services
Provide frequency reserve response and other ancillary services

The future for Hywind

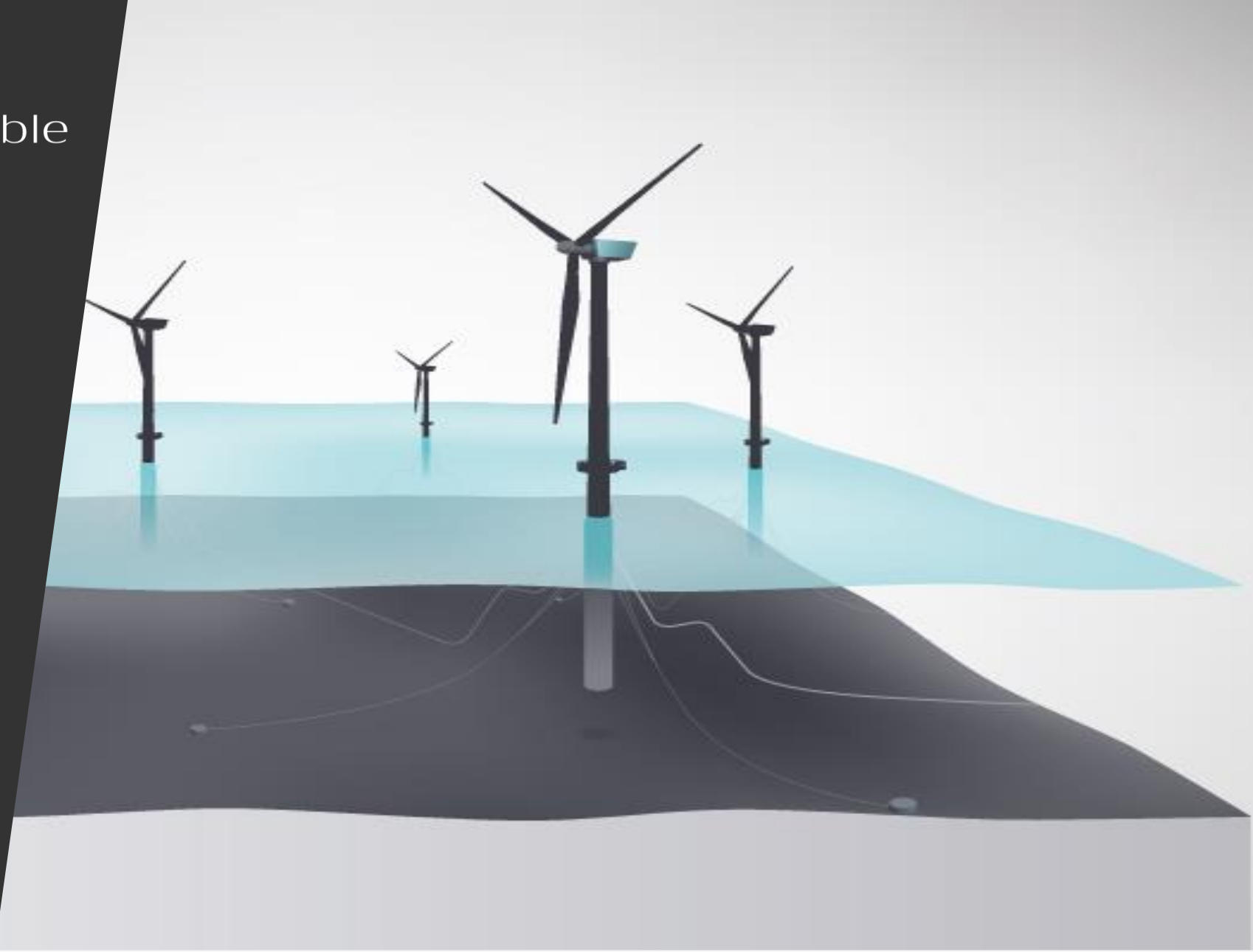
Large resource potential

Hywind is the most mature concept

Statoil is an experienced developer with a strong financial position

Target markets for the next step

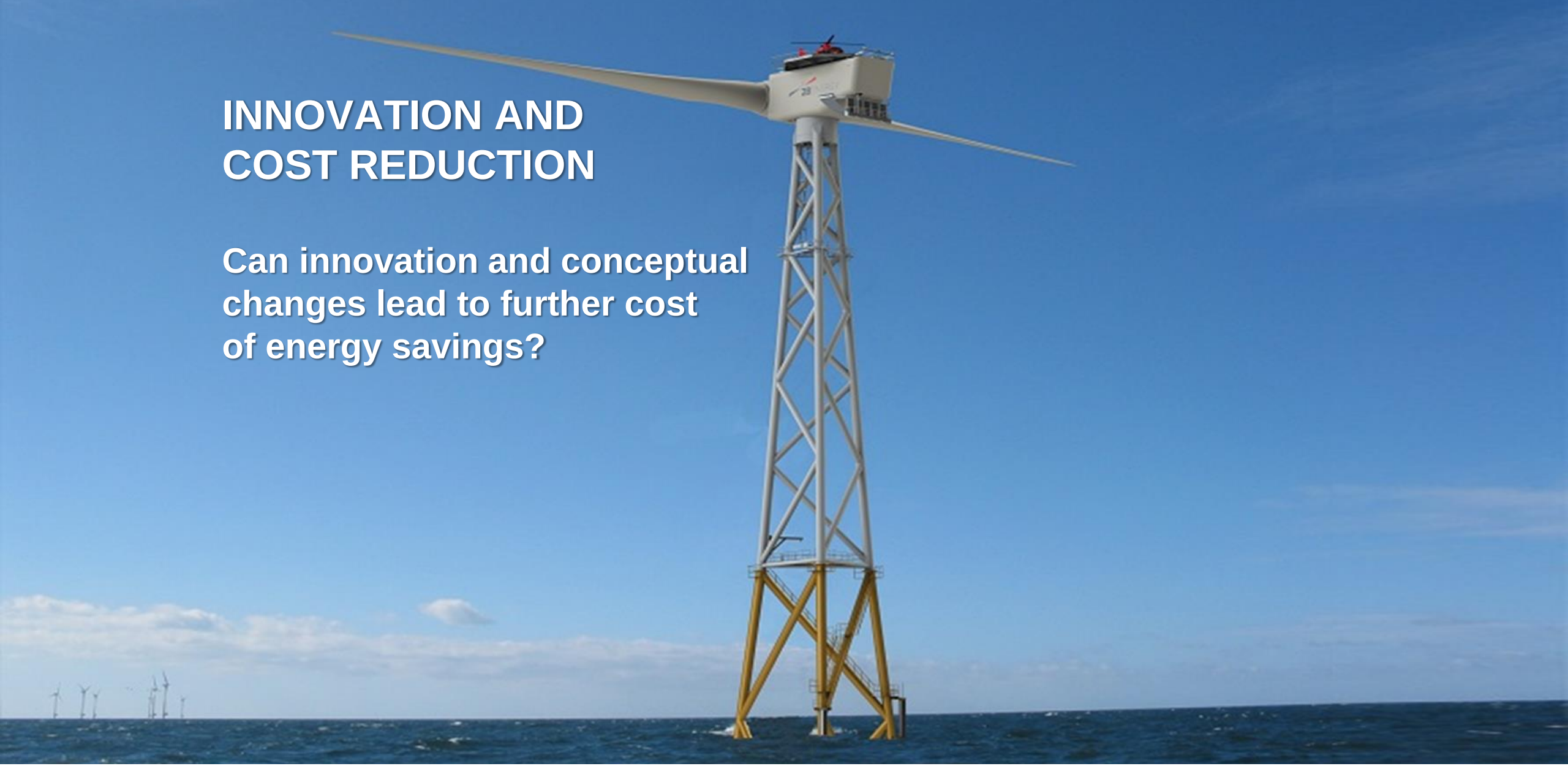
Statoil. The Power of Possible



www.statoil.com

Mikael Jakobsson

2-B Energy



INNOVATION AND COST REDUCTION

Can innovation and conceptual changes lead to further cost of energy savings?

By: Mikael Jakobsson
Chief Business Development Officer
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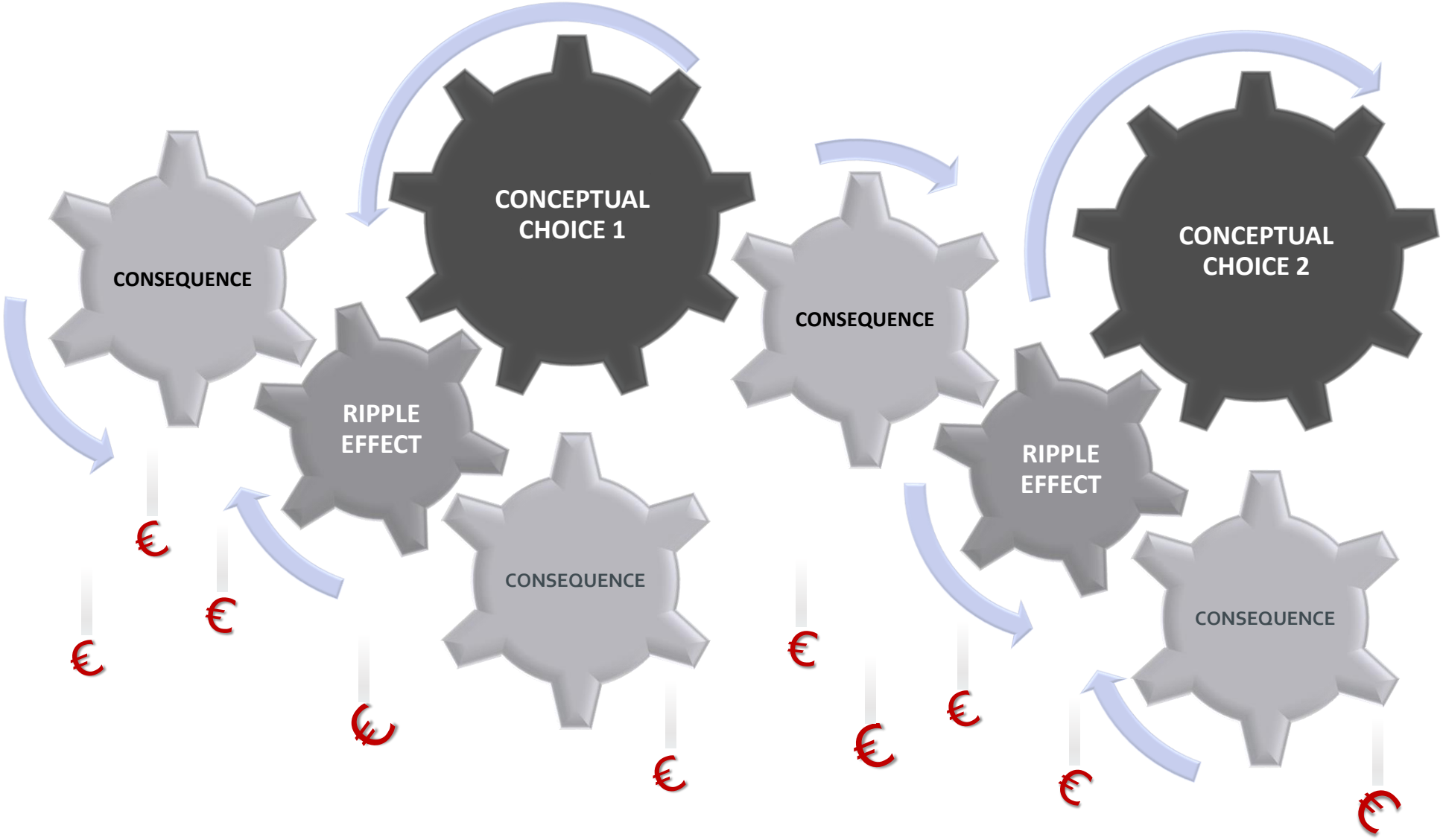
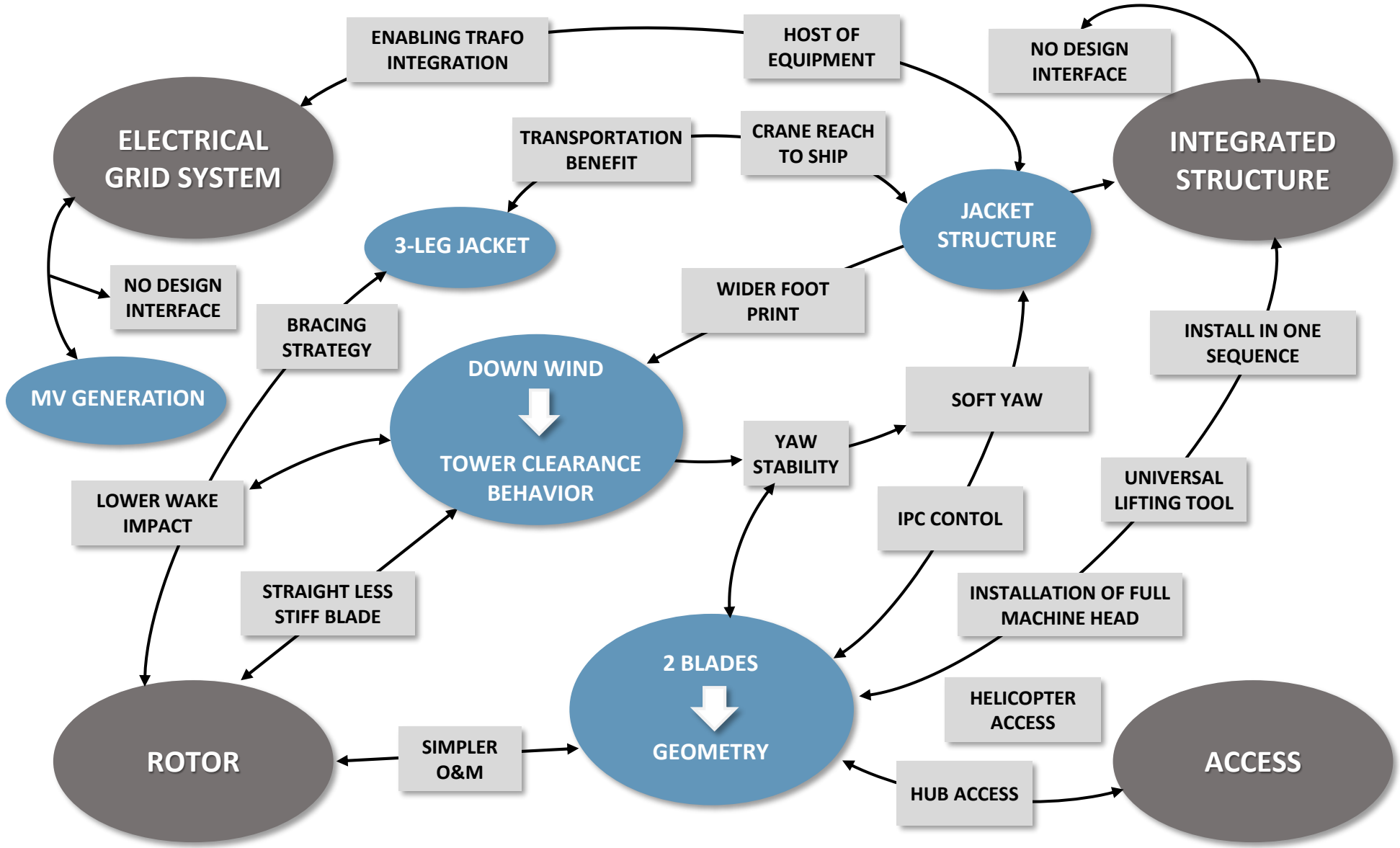
2017-01-24

There is no holy grail for reaching new levels of COE..

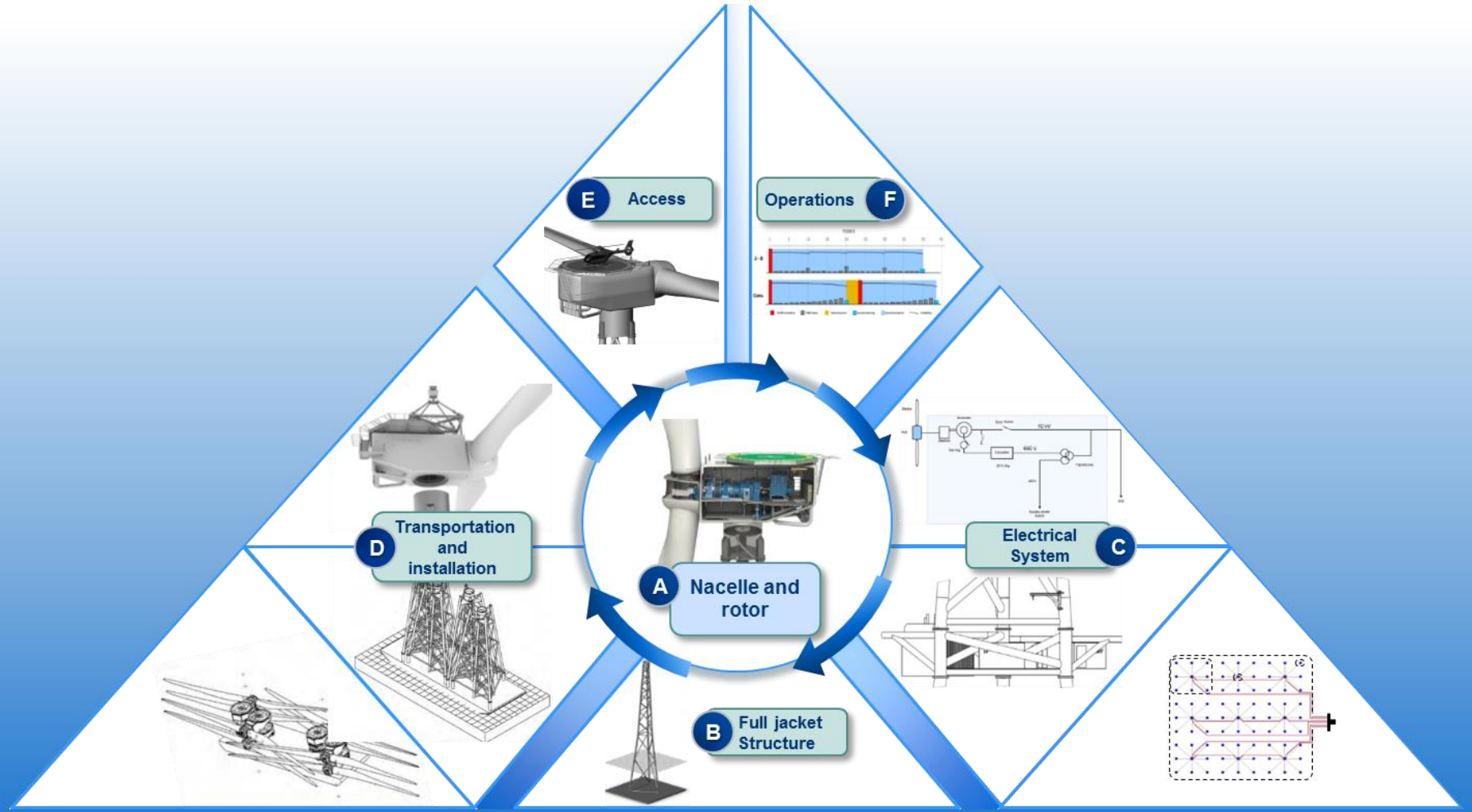


....but new concepts can create new paths to lower COE !

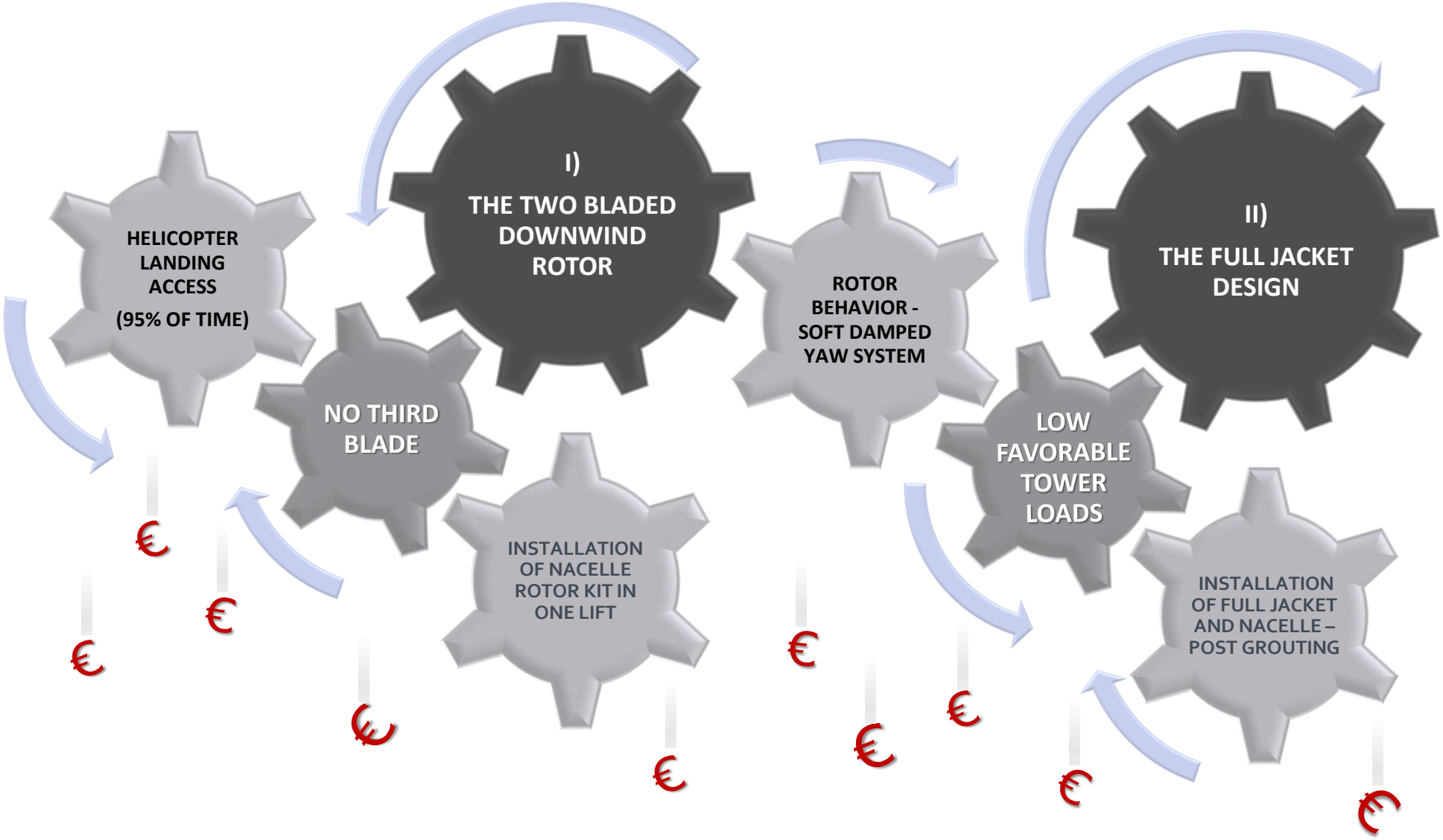
Understand your Relationships and its Consequences



How to make order out of chaos
– The integrated power plant design



An example of effects from two-bladed rotor / full jacket



....but requires new conceptual choices !

What can the potential be for evolving technology

LCOE REDUCTION OF OVER 25% BY NEW DESIGNS ON A SIDE-BY-SIDE BASIS:

- **2 bladed rotor**
- **Full jacket structure**
- **Electrical system**
- **Fewer components**
- **Installation process**
- **Helicopter landing access**
- **40 year project design life**

✓ Lower CAPEX

✓ Lower OPEX

✓ Availability

✓ Project risk (WACC)

Two bladed downwind rotor in rated production

CONCLUSION:

1) There are proven conceptual designs for offshore wind that leads to further cost efficiency

2) Several areas of both risk and cost efficiency can only be achieved by introduction of new technology paths

Scaling benefits is available to all, but conceptual innovation can create considerable gap in cost and risk to the conventional design of today

Thank you.

2-B Energy 2017

Professor Simon Hogg

DONG & Durham University

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…..‘decarbonising energy, through focussing on the central role of society on energy technologies, renewables, and the continued but cleaner use of fossil fuels’….

SCIENCE AND SOCIETY

Innovations for Improving Wind Energy O&M Performance - Some examples of Current University Development Projects.

Professor Simon Hogg
DONG Chair in Renewable Energy

SR Offshore Wind Conference
Glasgow
24th January 2017

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Selected Research Topics

Blade Fatigue Testing

– Dual Axis test methodology.
– More accurate than single axis testing.
– Essentially halves test times – cheaper.

Data Mining

– SCADA and service life data
– Performance assessment
– Earlier detection of emerging faults

Condition Monitoring

– Both conventional and novel methods
– Maximising use of available data
– Use of coarse SCADA data

Dynamic Coordinated Control

– Wake flow simulation
– Optimising energy yield
– Decreasing fatigue loads

(Burbo Bank Offshore Wind Farm)

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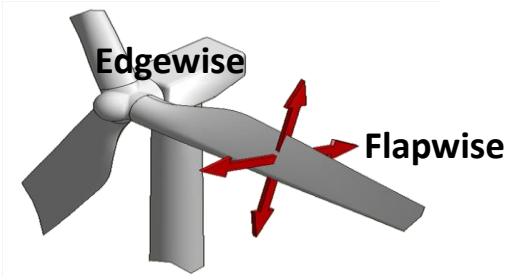
Turbine Blade Fatigue Life Testing.

Single Axis Blade Testing.



New: Dual Axis Testing.

- Simulates actual cyclic loading
  - edgewise = gravitational
  - flapwise = aerodynamic
- 70m + blade length
- Advantages
  - **More accurate** fatigue tests.
  - **Cheaper** – essentially halves test times.
- Collaboration with UK's Offshore Renewable Energy Catapult (OREC)
- PhD completed 2013, researcher did KTP, now OREC employee.
- New Standard for wind turbine blade fatigue testing.

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Data Mining

- Aim to use very simple (coarse) SCADA data to monitor the health of turbines in a wind farm
- Research question:
  - How much can we infer about WT condition from looking at just power production?
  - If we can infer condition, how much warning do we get that WT is degrading?
- Methodology is stochastically informed: we will consider the probability that a turbine produces a certain power
- Ultimately: we would like to have sufficient prognostic warning that we can organise maintenance before turbine fails!

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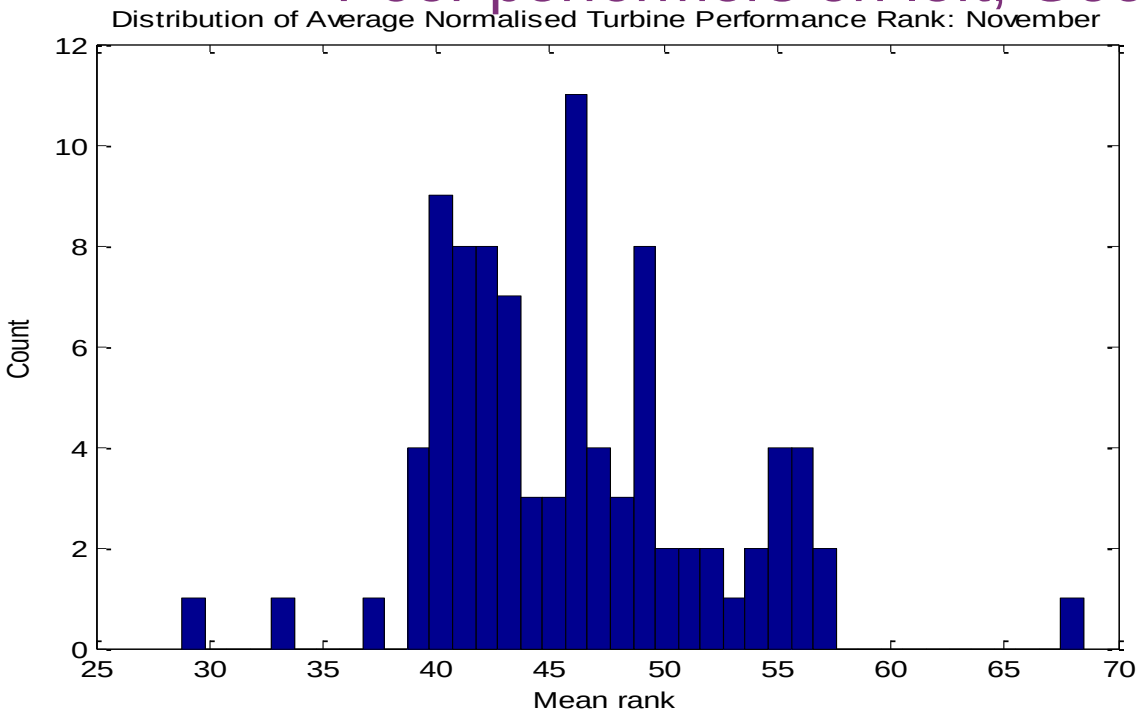
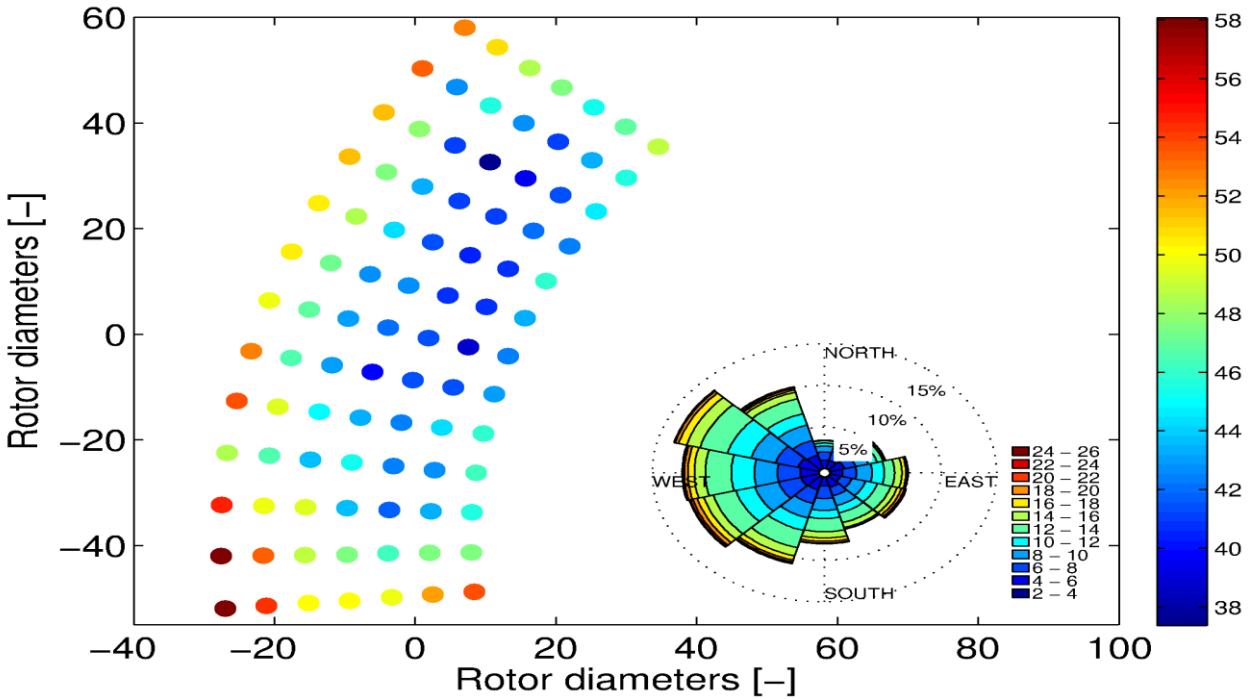
Turbine Rank Analysis

Monthly breakdown (*selected result from November 2013*)

- Where production is similar, rank discriminates well
- E.g., can see clusters of WTs
  - Poor performers on left, Good performers on right





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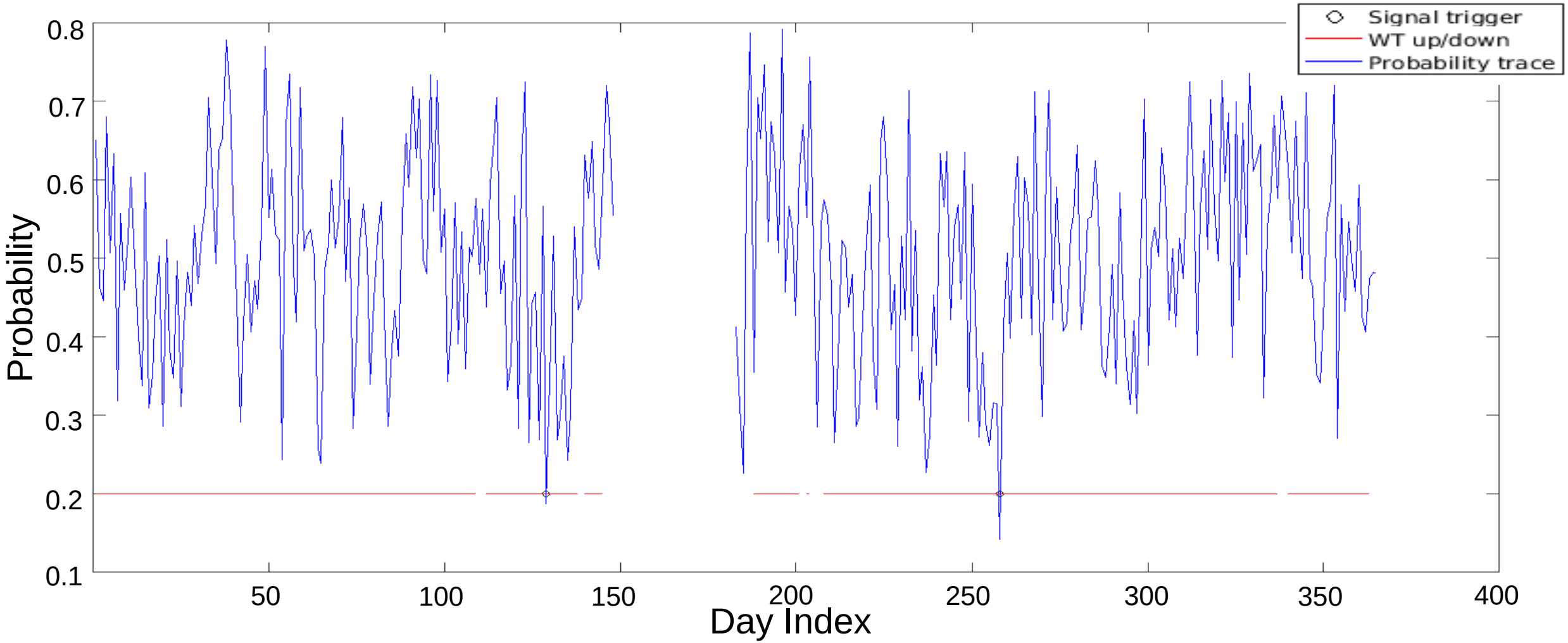
Example of Probability Based Warning Signal

Probability = probability of turbine producing up to the measured power output.



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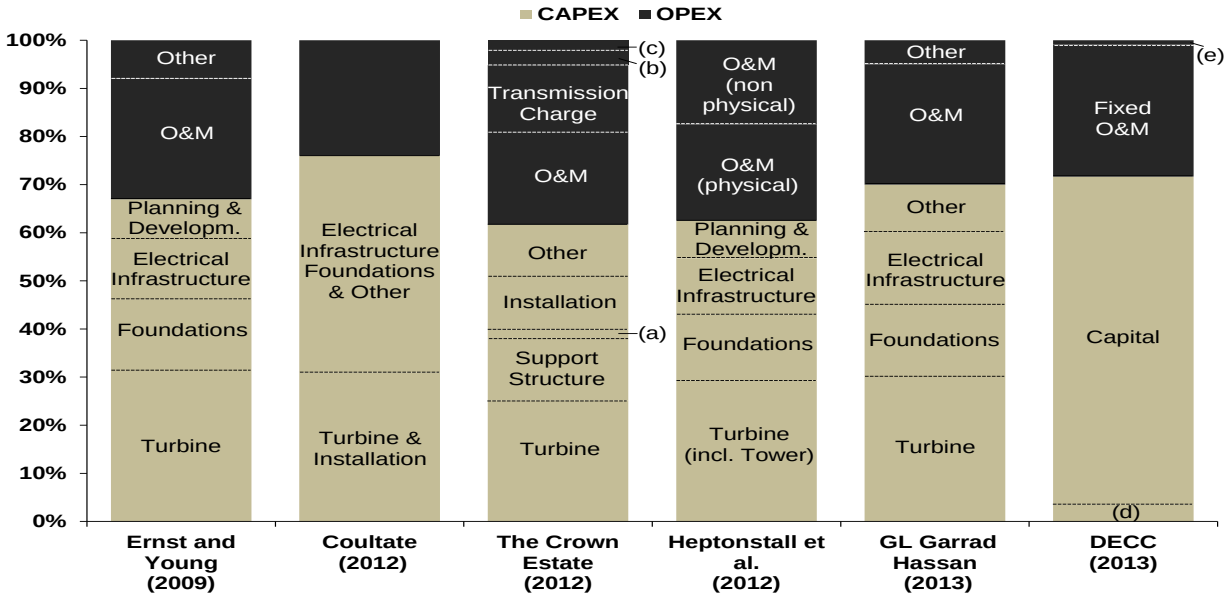
SCADA Analysis Comments

- SCADA results are promising, benefit is low (zero) additional cost
- There is growing interest in SCADA analysis
  - Durham has been active in this area since 2010
- Challenge for development is ‘knowing’ good operation from faulty
  - Durham is leading with DONG Energy by merging maintenance and SCADA databases

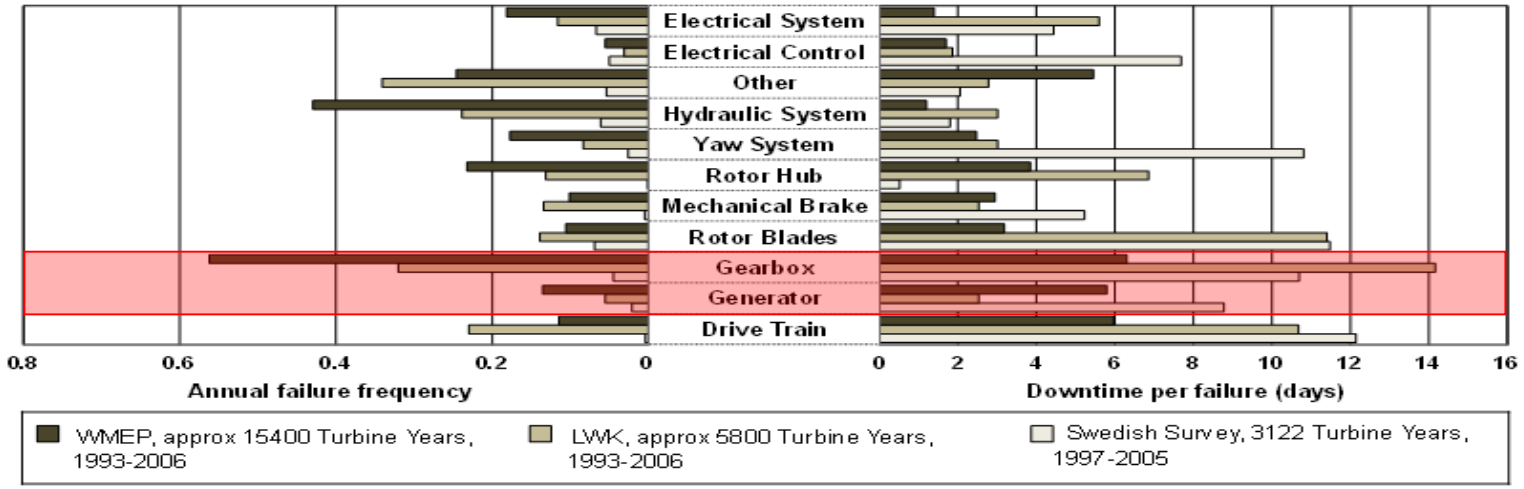
Condition Monitoring



(a) Array Cables; (b) Decommissioning; (c) Seabed Rent: (d) Pre-development; (e) Variable O&M

Minimise wind turbine O&M costs through the adoption of reliable and cost effective condition monitoring systems (CMS)

Which wind turbine components are the most critical for monitoring?



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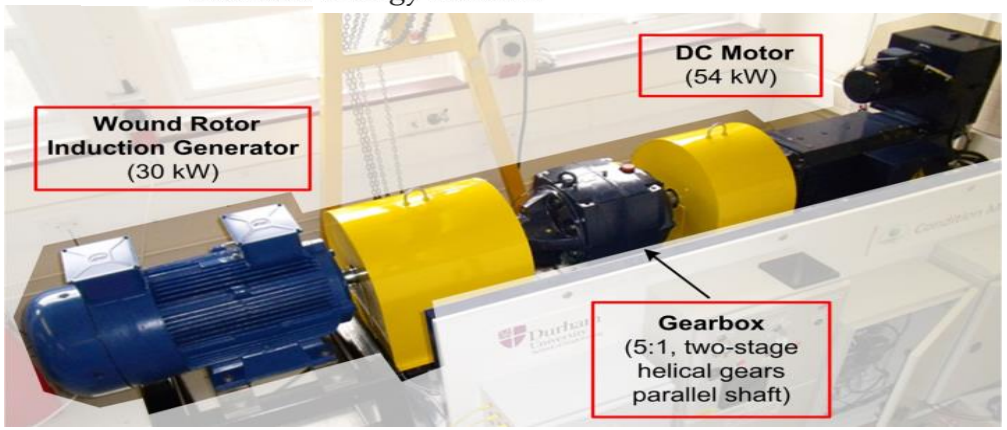
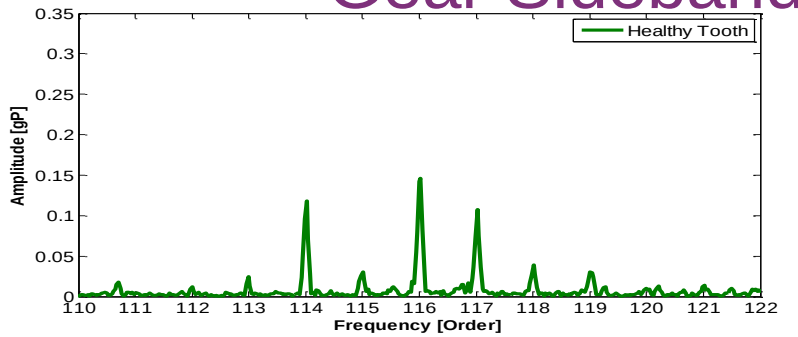
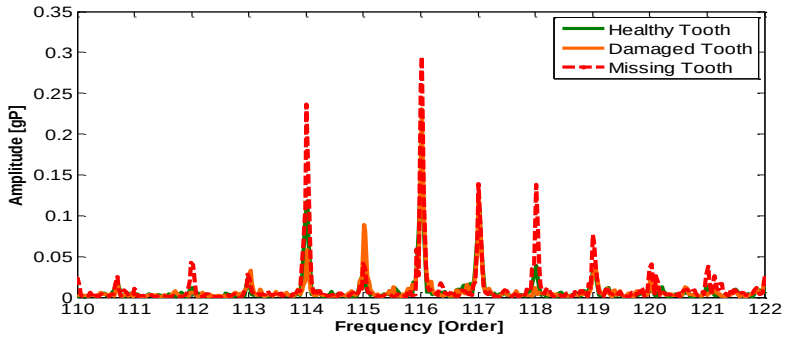
Gearbox Pinion Tooth Damage

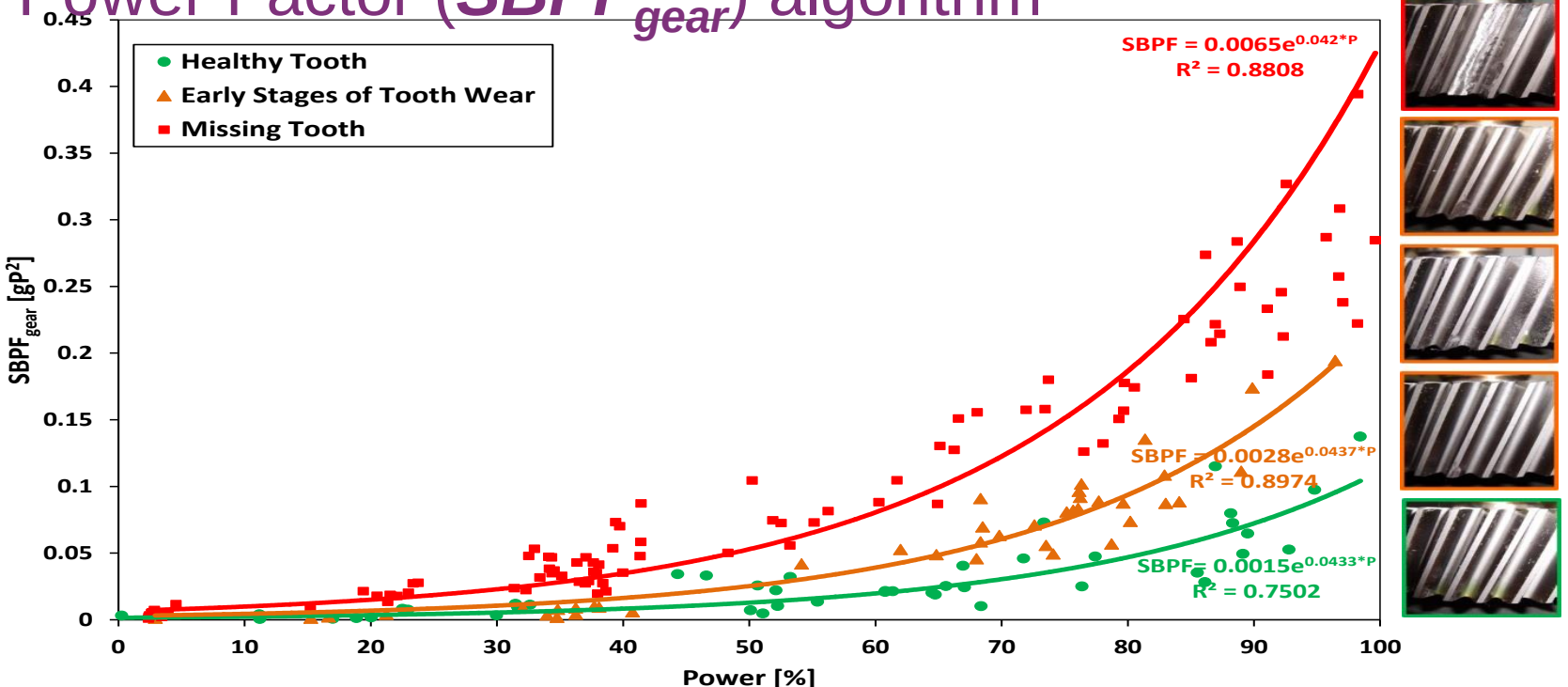


- Durham Wind Turbine CM Test Rig
- 30 kW induction-machine
- SKF WindCon CMS

Gear Sideband Power Factor ($SBPF_{gear}$) algorithm







Field Data Analysis

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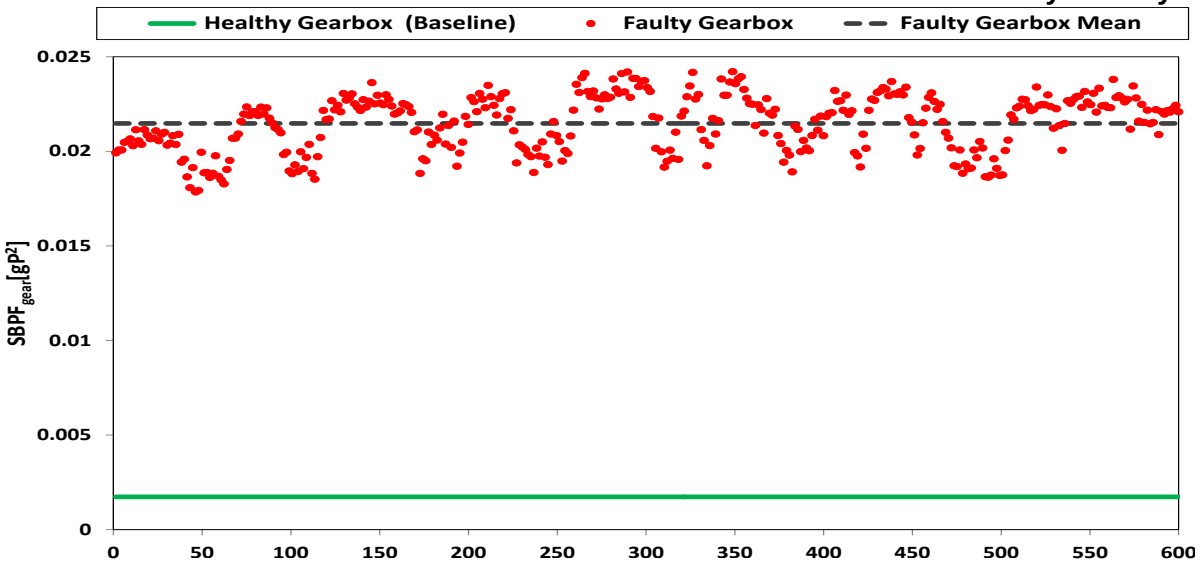
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

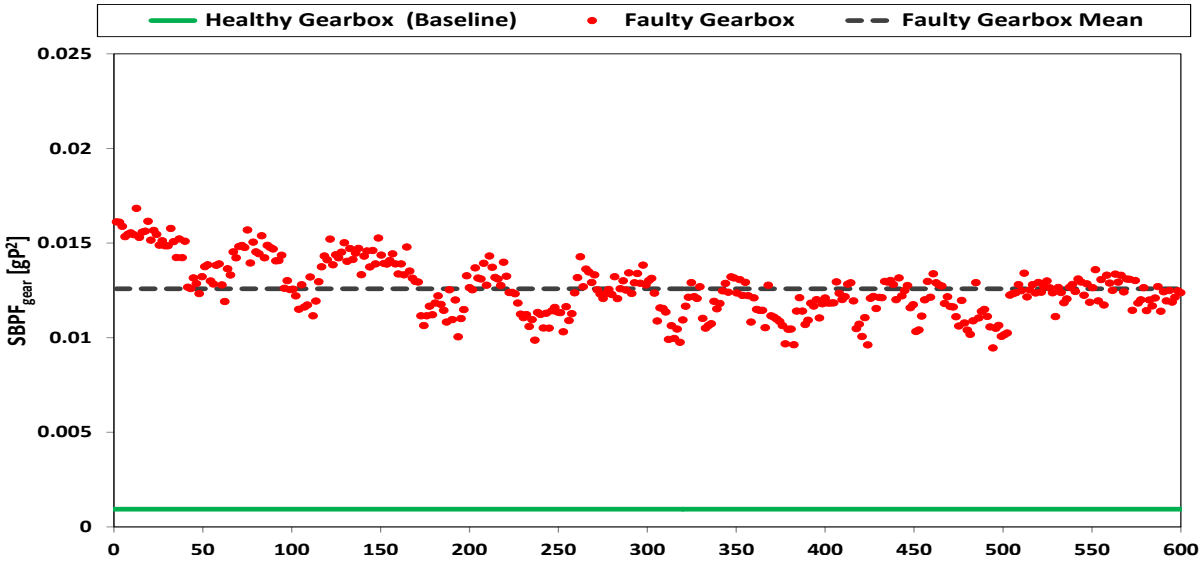
Data source: Wind Turbine Gearbox Condition Monitoring Round Robin project

Photo by Lee Jay Fingersh / NREL 16913

Photo by GEARTECH, NREL / 19743



Accelerometer AN6 ISS Radial



Accelerometer AN7 HSS Radial

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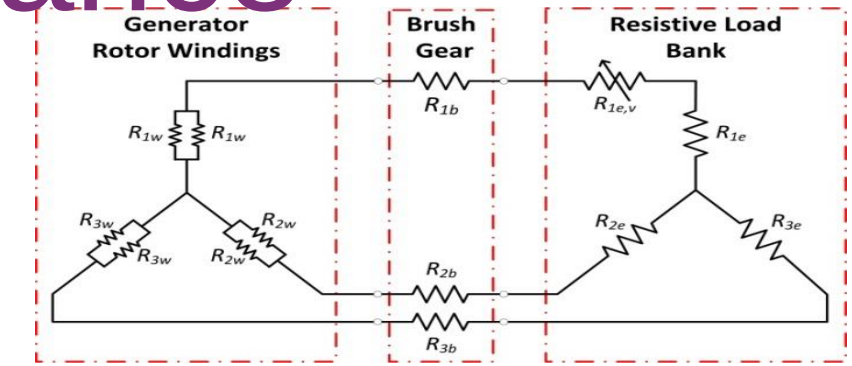
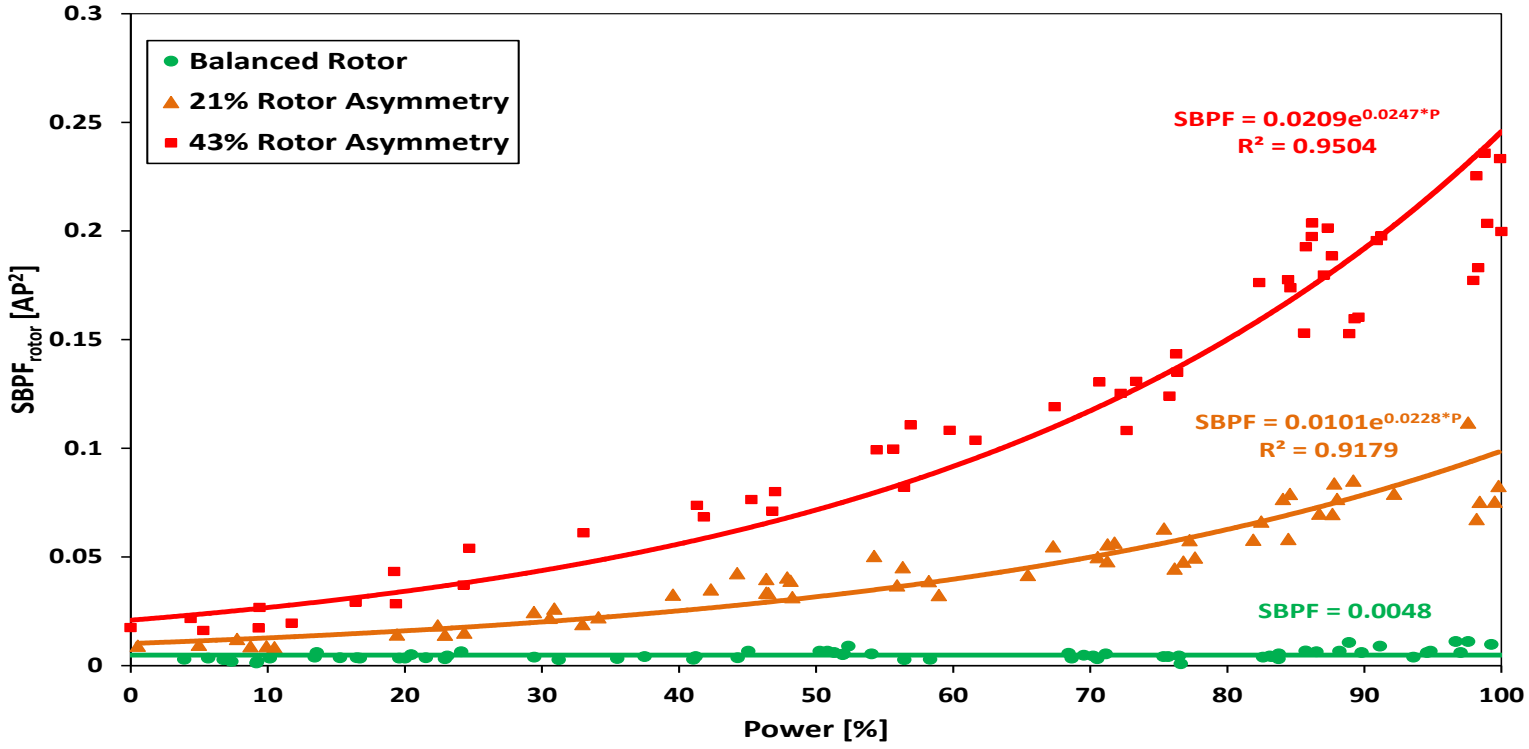
Generator Rotor Electrical Unbalance



Rotor Sideband Power Factor (***SBPF$_{rotor}$***) algorithm



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Wind Farm Coordinated Control

SCIENCE AND SOCIETY

- Wake effects can decrease farm power by up to 60%[1]
- Wind turbines can help each other by reducing wake effects (Coordinated control)
- Computationally efficient and accurate
- Suitable for real-time application

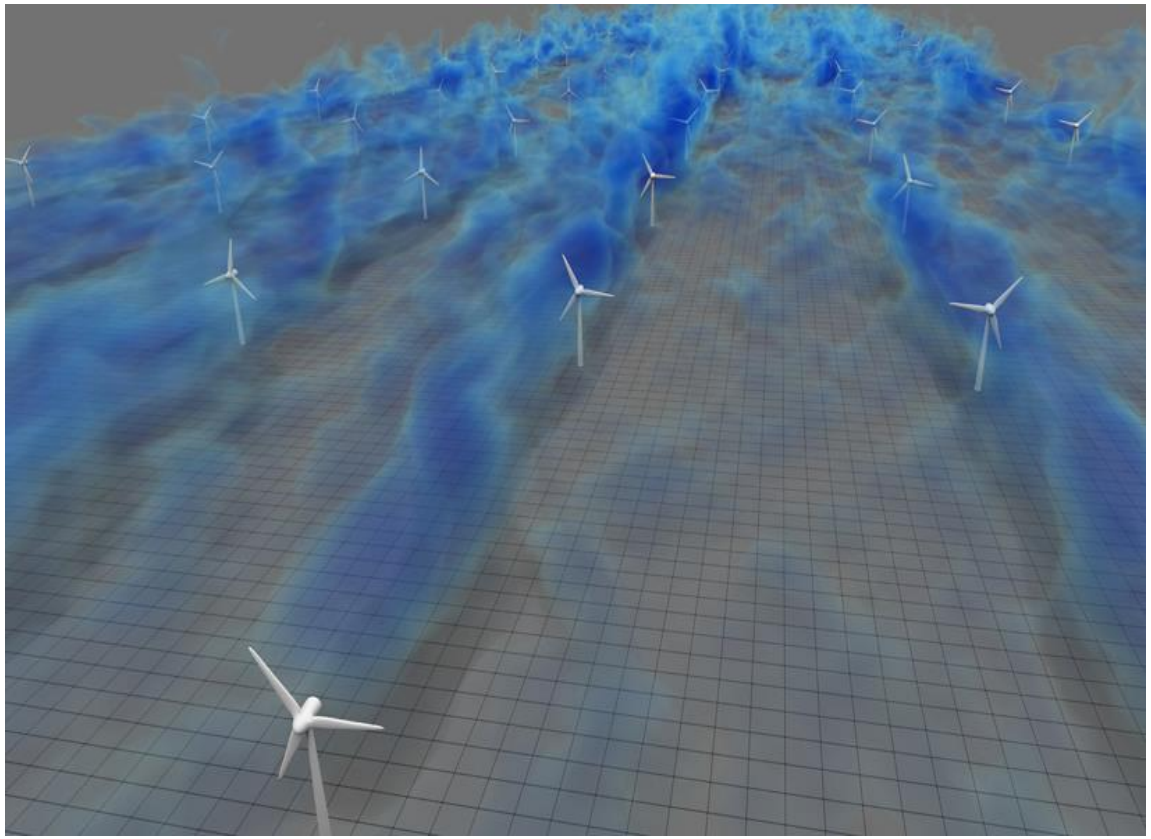

Image by Bock (NCSA and XSEDE)

[1]Rodrigo, Gankarski: Windbench – Benchmarking of flow models for wind applications (2014)

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Power Rose

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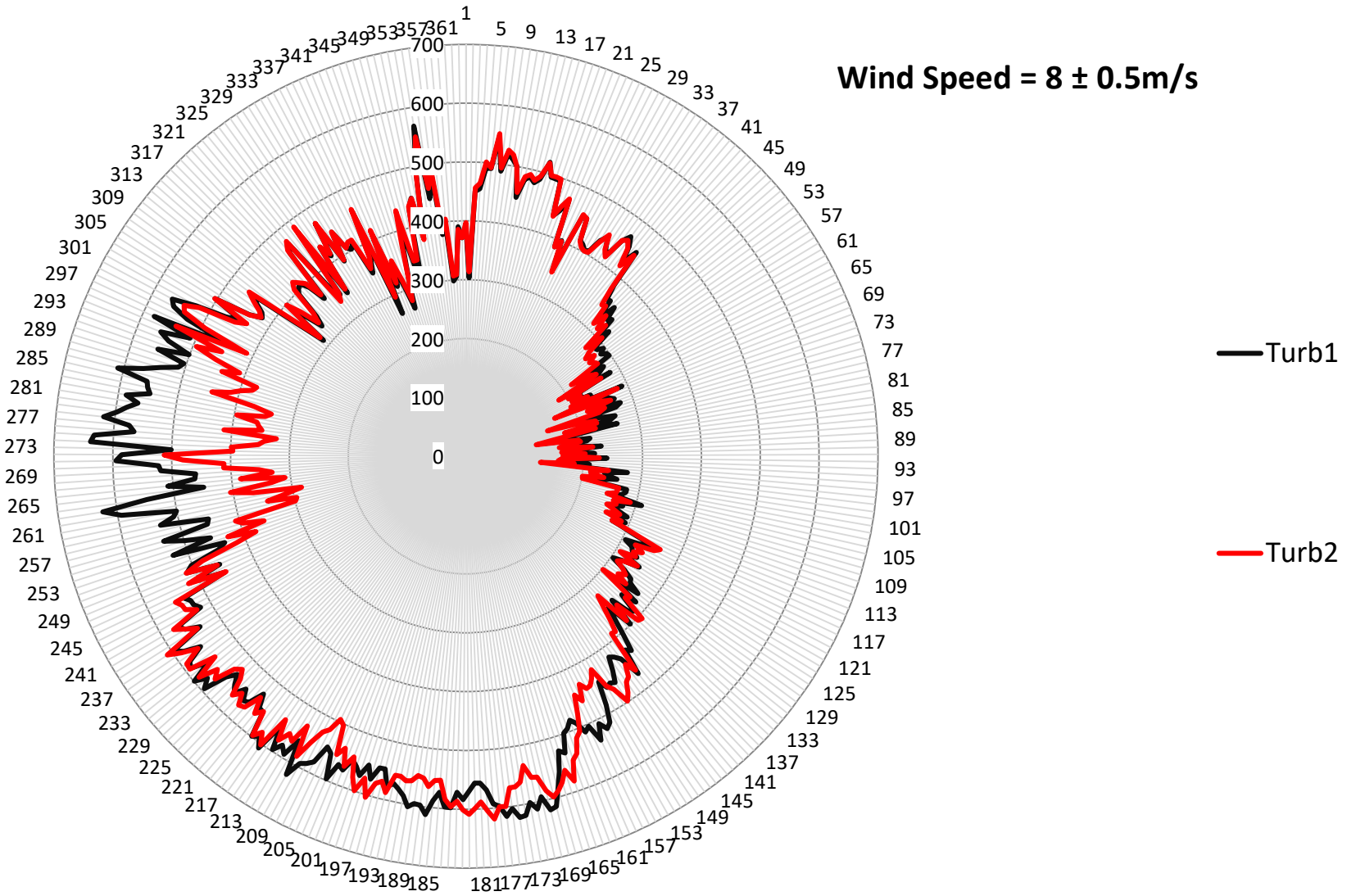

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Methodological Approach

- Fast processing and accurate wind deficit model
- Heuristic Particle Swarm
- Optimisation for developing a real-time farm controller

These strategies were implemented in Le Sole de Moulin Vieux (SMV) wind farm, France.

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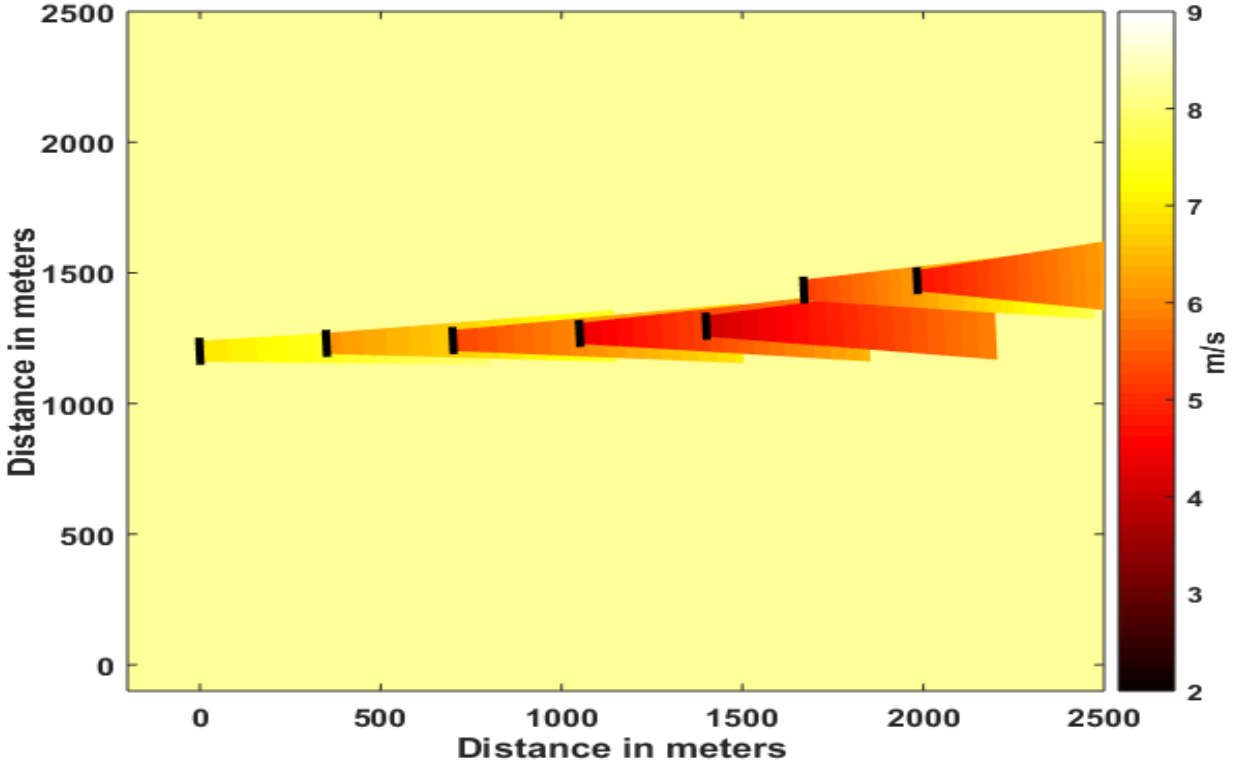
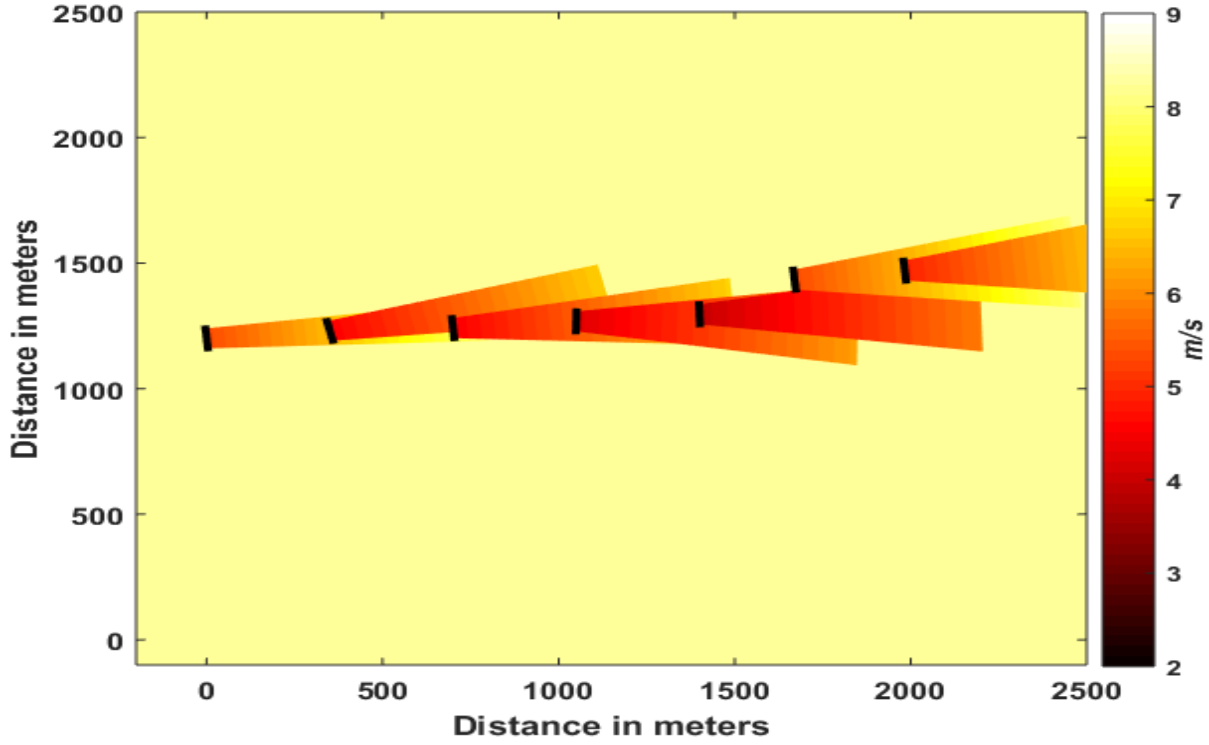
SMV Wind Farm

CP-based optimisation



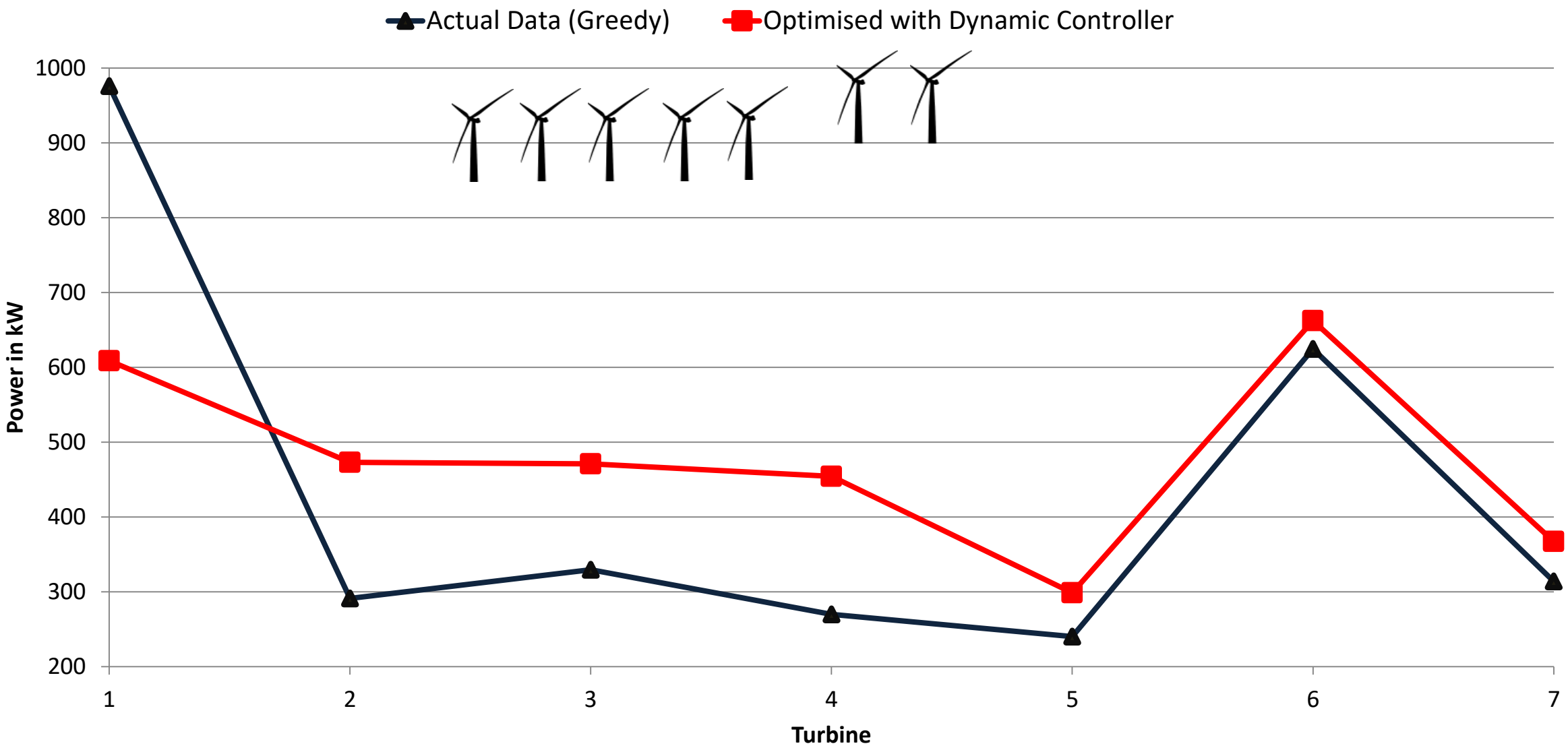
Yaw-based optimisation



Durham University
Durham Energy Institute

Dynamic Control

SCIENCE AND SOCIETY



Durham University
Durham Energy Institute

SCIENCE AND SOCIETY

Summary

- Examples of current Durham University development projects aimed at improving wind energy O&M performance
- Improved blade testing methodology
- Application of data mining techniques for earlier detection of emerging faults
- New fault detection algorithms for condition monitoring systems
- Improving energy yield from wind farms through dynamic system control

Innovation and Cost Reduction - Part 2 Q&A

Session coordinated by

CATAPULT Offshore Renewable Energy

Zoe Barnes, Everoze

Professor Simon Hogg, DONG & Durham University
Sebastian Bringsværd, Statoil ASA
Mikael Jakobsson, 2-B Energy
Una Brosnan, Atkins

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Plenary 1

Niall Stuart, Scottish Renewables

Paul Wheelhouse MSP, Minister for Business, Innovation and Energy
Dame Anne Glover DBE, FRS, FRSE, FASM, ORE Catapult
Jonathan Cole, ScottishPower Renewables & Offshore Wind Programme Board

Paul Wheelhouse MSP

Minister for Business, Innovation and Energy

Dame Anne Glover DBE, FRS, FRSE, FASM

Vice-Principal External Affairs &

Dean for Europe at the University of Aberdeen,

& Non-Executive Director, ORE Catapult

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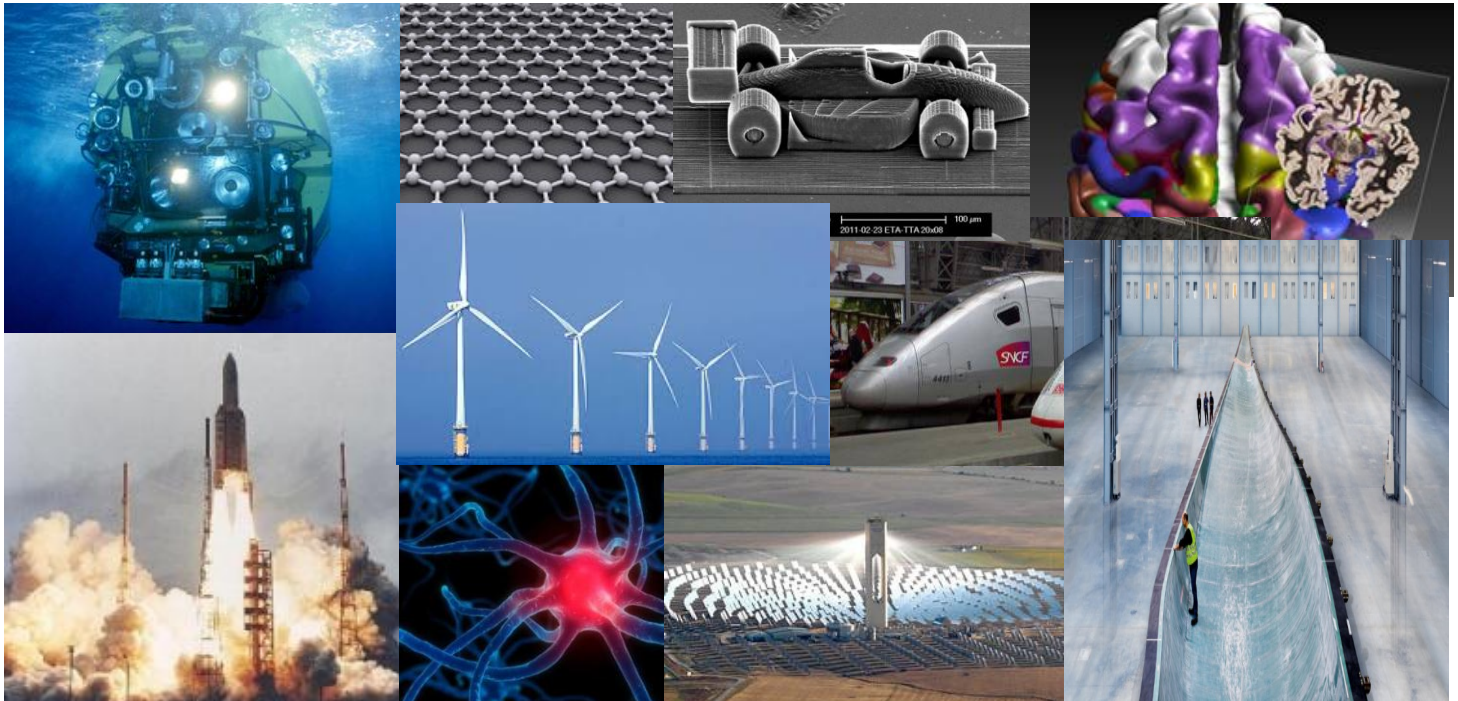
“We need to talk about ……”

Professor Dame Anne Glover FRS FRSE
Vice Principal External Affairs, University of Aberdeen

Europe is no. 1 in science, engineering and technology



Innovation requires imagination

kPad

pPad

jPad

iPad

Science Fiction 1966 – Reality 2017

Science Fiction 1966 – Reality 2017

Effective communication is essential

Where innovation fits in

- Have an innovative idea but can't afford the R&D?
- Need for cultural change – scientists need to think entrepreneurial and business needs to think science – new people = new solutions
- Turning small companies into medium then large
- Regulation needs to support SMEs – empower Government

Look to other sectors for innovation

Restaurant meets airport

©crossindustryinnovation

Baby buggy meets aircraft landing gear

Lego meets telecom

©crossindustryinnovation

Oil and gas technology applied to floating wind platforms

Think ahead

1993 – mission planning
2004 – mission launch
2014 – rendezvous with comet
2014 – 12th Nov Philae lander on comet 67P

30 year old technology doing 21st century science

Some challenges to consider

- Who do you work with?
- What did you do last week that was innovative?
- Who's role is innovation?
- Where is the creativity in your industry?

How to improve the pathway from knowledge generation to innovation

- Communicate often and well
- Be transparent
- Find the right partner/s

Thank you

SCIENTISTS FOR EU

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Jonathan Cole

Offshore Managing Director, ScottishPower Renewables and Chairman, Offshore Wind Programme Board

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Q&A

Niall Stuart, Scottish Renewables

Dame Anne Glover DBE, FRS, FRSE, FASM, Offshore Renewable Energy Catapult
Jonathan Cole, ScottishPower Renewables & Offshore Wind Programme Board

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Plenary 4

Industry Leaders Debate

Lindsay Roberts, Scottish Renewables

Andrew Jamieson, ORE Catapult
Sarah Pirie, EDP Renewables
Ronnie Quinn, The Crown Estate Scotland Portfolio
Brian McFarlane, SSE
David Stevenson, Scottish Government

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