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OFFSHORE WIND CONFERENCE, EXHIBITION & DINNER

28 & 29 JANUARY 2019 **GLASGOW**

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Claire Mack

Chief Executive

Scottish Renewables

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Industrial strategy and Scotland's blue economy

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Matthew Taylor

Deputy Director – Carbon Capture and Renewables Sector

BEIS, UK Government

Scottish Renewables Offshore Wind Conference

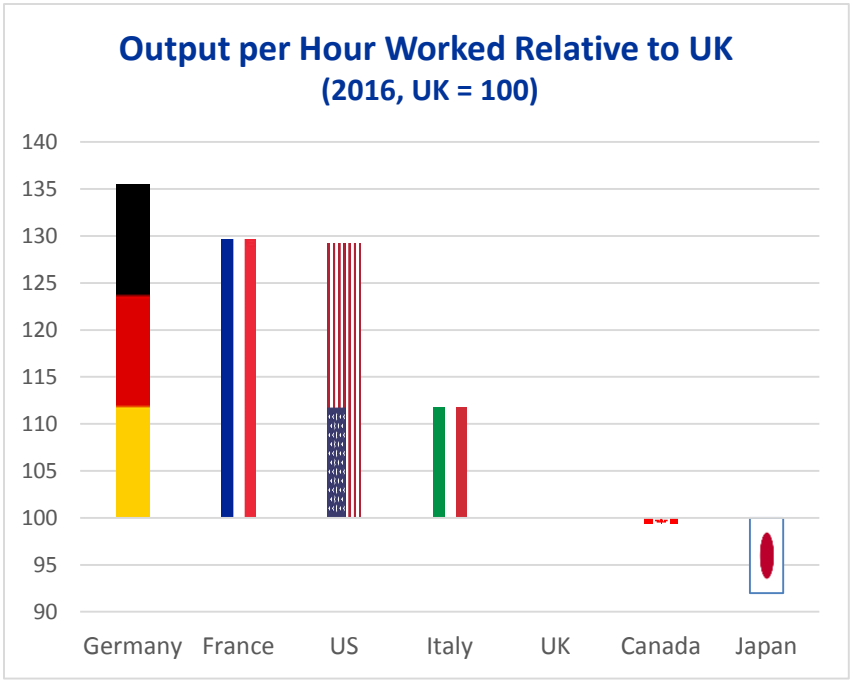
28 January 2019

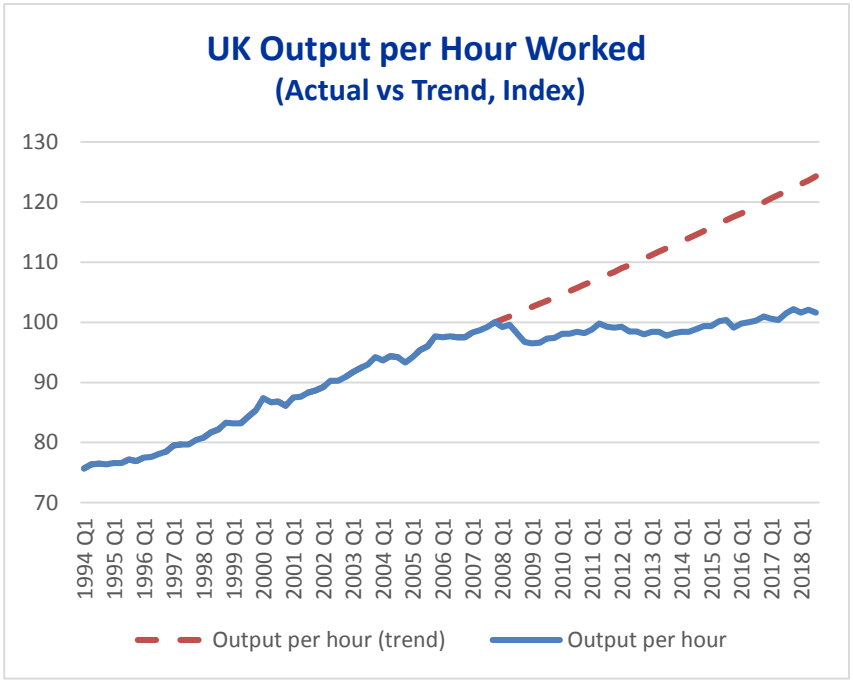
Department for Business, Energy & Industrial Strategy

A SEA OF OPPORTUNITY

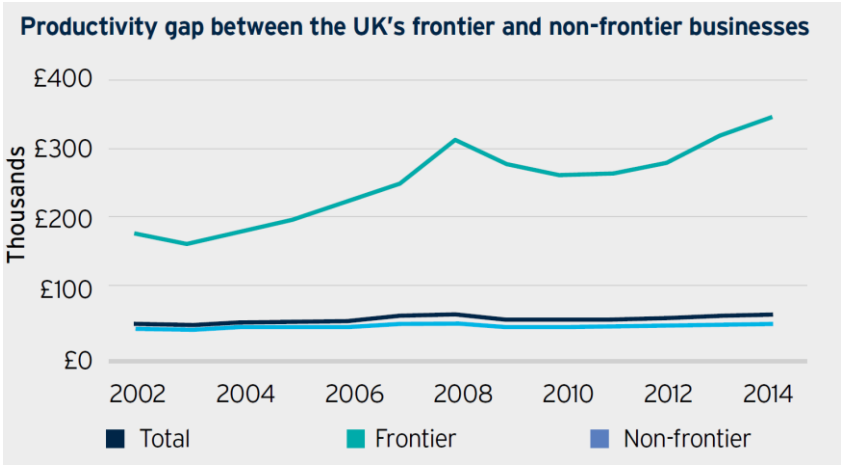
Offshore Wind Industry Council Proposal to Government for a Sector Deal.

Department for
Business, Energy
& Industrial Strategy

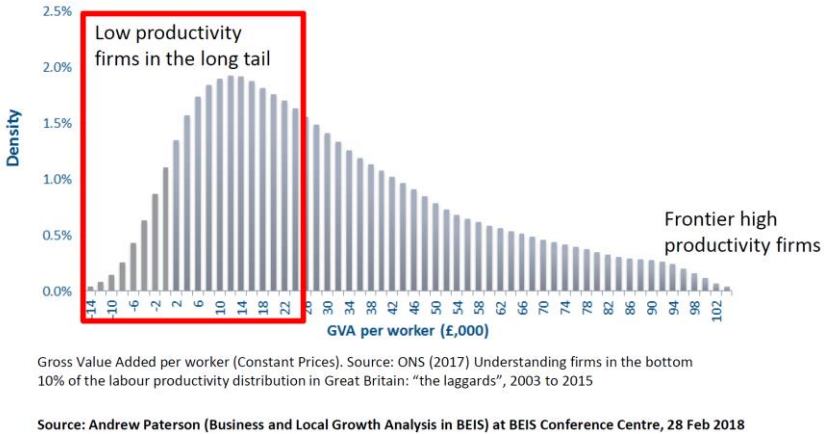




Source: ONS International Comparisons of Productivity, ONS Labour Productivity Introduction



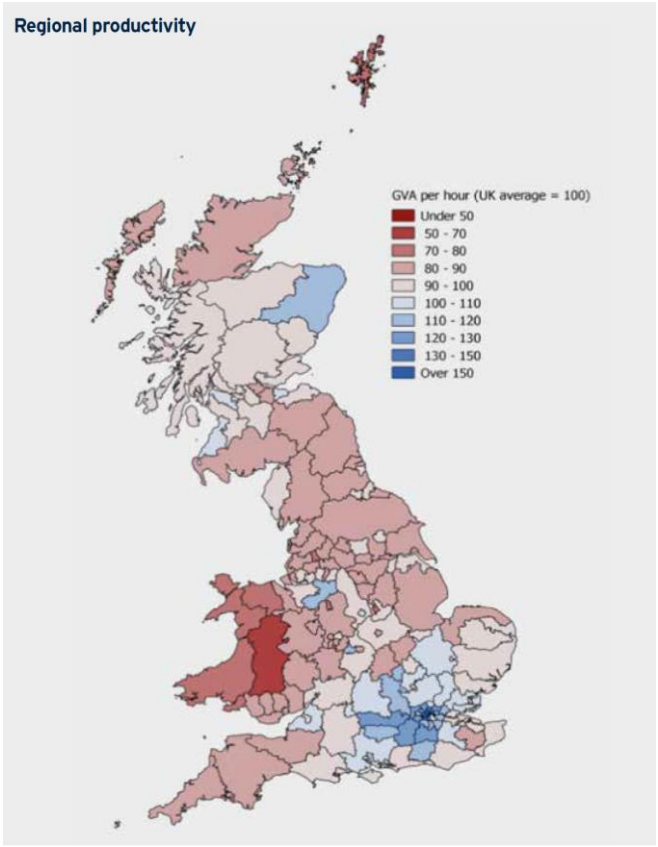
Source: The Industrial Strategy



Gross Value Added per worker (Constant Prices). Source: ONS (2017) Understanding firms in the bottom 10% of the labour productivity distribution in Great Britain: "the laggards", 2003 to 2015

Source: Andrew Paterson (Business and Local Growth Analysis in BEIS) at BEIS Conference Centre, 28 Feb 2018

Source: https://www.slideshare.net/statisticsONS/the-uk-management-and-expectations-survey-first-results?from_action=save



Source: ONS (2017) *"Subregional Productivity: Labour Productivity."*
Ordnance Survey Data © Crown Copyright 2017*NUTS3 statistical region classification

Source: The Industrial Strategy

Industrial Strategy differs seeks to break down policy silos and think about what it means for people, businesses and places

Artificial Intelligence and Data

Ageing Society

Clean Growth

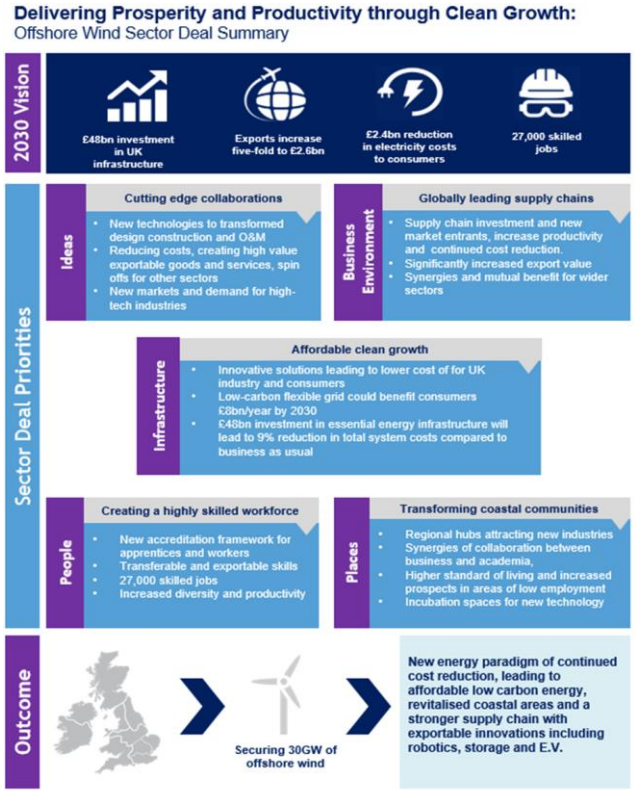
Future of Mobility

Sector Deals

Local Industrial Strategies

2030 vision for an offshore wind sector deal

- £48bn investment in UK infrastructure
- Five fold increase in exports
- £2.4bn reduction in electricity costs to consumers
- 27,000 skilled jobs



Turning vision into reality?

Inputs	Activities	Outcomes	Impacts
Private funding Government input Regulatory change Government collaboration Private sector collaboration	Spending on infrastructure Establish new funding arrangements Develop new programmes/technology /models Change in regulation etc	Sustainable funding models New facilities New Technology New legal/regulatory frameworks New skilled jobs Increase in R&D New collaboration	Increase in GVA/productivity Increased efficiency Clean growth, health benefits etc Increased FDI Increased exports Increase diversity Reduced regional inequalities

Kersti Berge

Director of Energy and Climate Change

Scottish Government

KERSTI BERGE

DIRECTOR FOR ENERGY AND CLIMATE CHANGE

Scottish Government
Riaghaltas na h-Alba
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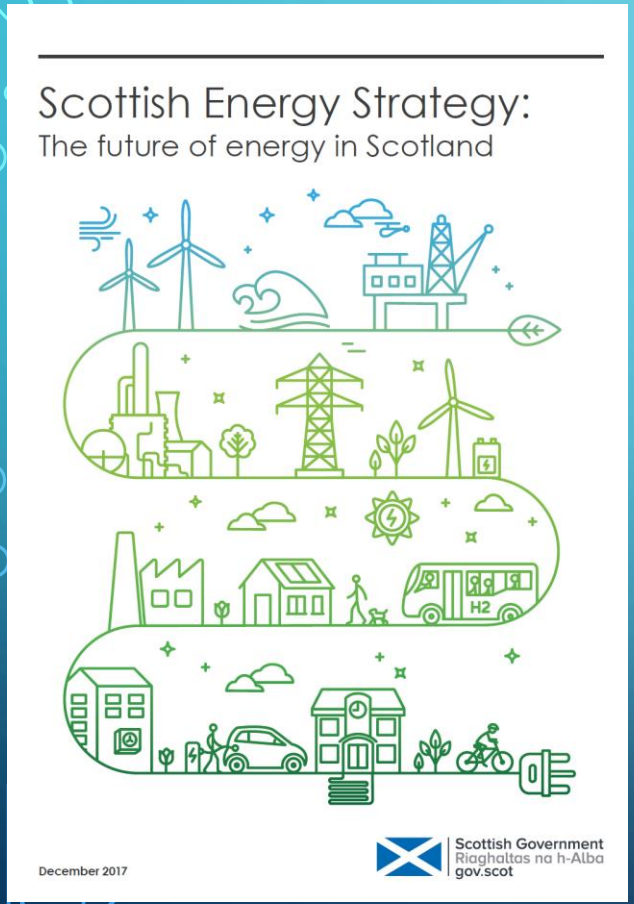
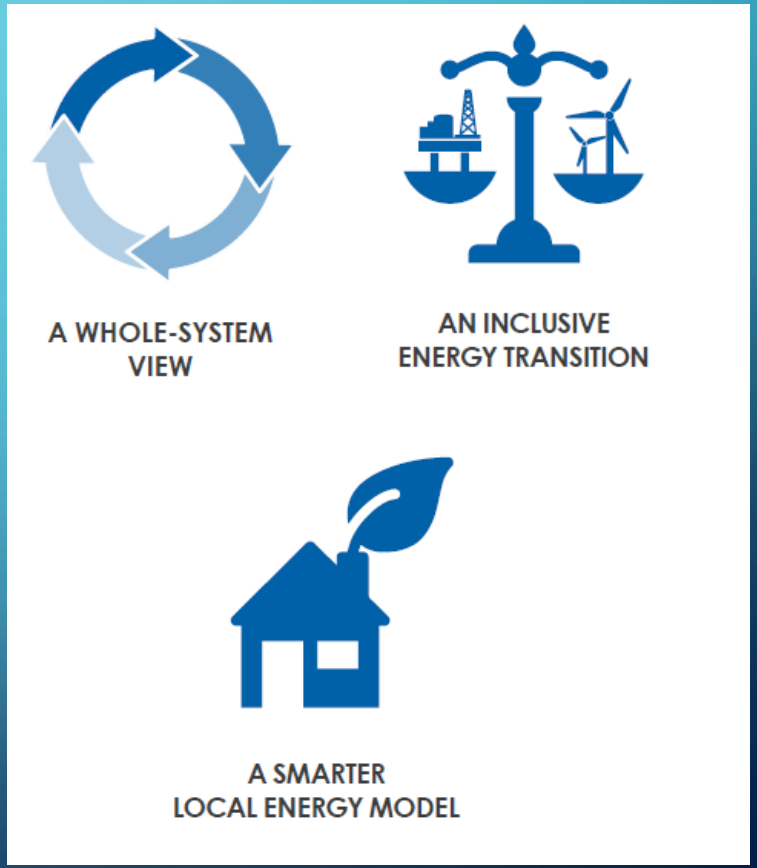
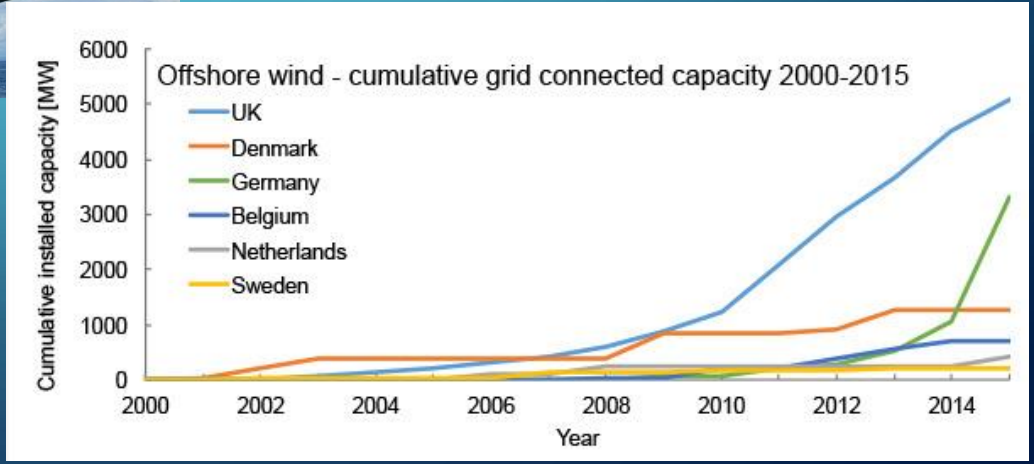
SCOTTISH GOVERNMENT SUPPORT

SCOTTISH ENERGY STRATEGY





DRIVING OFFSHORE WIND



SUPPLY CHAIN

Claire Mack
Chief Executive, Scottish Renewables

Matthew Taylor
Deputy Director – Carbon Capture and Renewables Sector, BEIS, UK Government

Kersti Berge
Director of Energy and Climate Change, Scottish Government

Guy Madgwick
Chief Executive Officer, Red Rock Power

David Walker
Offshore Development Director, ScottishPower Renewables

Dr Stephen Wyatt
Research and Disruptive Innovation Director, ORE Catapult

Steve Chisholm
Operations Director, Global Energy Group

Andrew McCallum
Managing Director, Aspect Reputation Management and Strategic Advisor, Global Underwater Hub

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Project speed-update: In development

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Colin Maciver

Development Manager

Crown Estate Scotland

Mark Timmons

Offshore Bid Manager

SSE - SeaGreen Phases 1 & 2

Mark Timmons

Offshore Bid Manager

SSE in Offshore Wind

Greater Gabbard

Ownership: 50%
504MW capacity
140 turbines

Walney

Ownership: 25.1%
367MW capacity
102 turbines

Arklow Bank

Ownership: 100%
Minimum 520MW

Beatrice

Ownership: 40%
588MW capacity
84 turbines

Dogger Bank

Ownership: 50%
3.6GW capacity

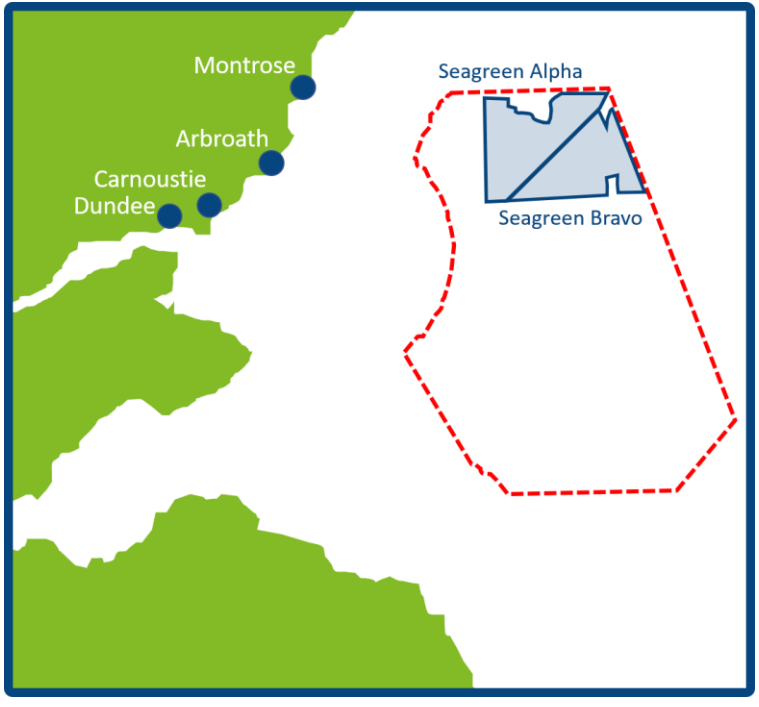
Seagreen

Ownership: 100%
3.8GW capacity

Operational | In construction | In development

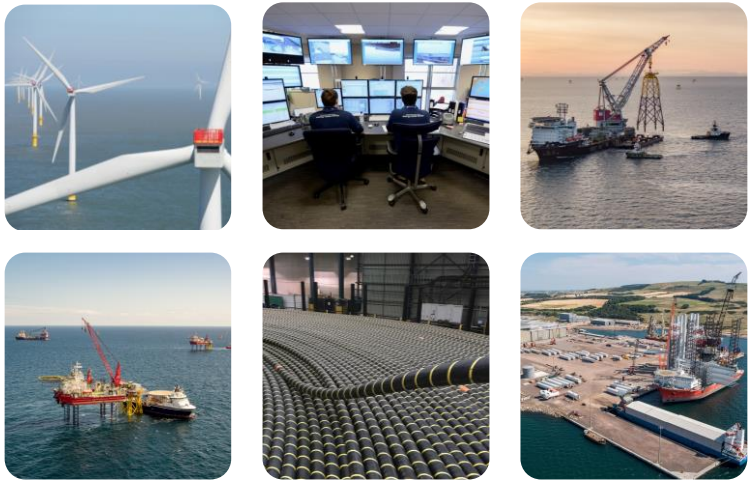
Firth of Forth : Seagreen Zone

- Round 3 Zone : jointly developed with Fluor now wholly owned by SSE
- Total area: 2,865km^2
- Distance offshore: 27km – 80km
- Water depth: 30 - 70m
- Development area (< 50m) ~ 1,000km^2
- Development capacity up to c4GW
  - Phase One – 1,500MW
  - Phase Two – ~1,400MW
  - Phase Three - ~900MW



Contract packages

- Wind Turbines
- Wind Turbines Transport & Installation
- Marine Installation
- Electrical Systems Infrastructure
- Operations and Maintenance
- Ports:
  - Operations & maintenance
  - Wind turbines staging
  - Foundations Staging

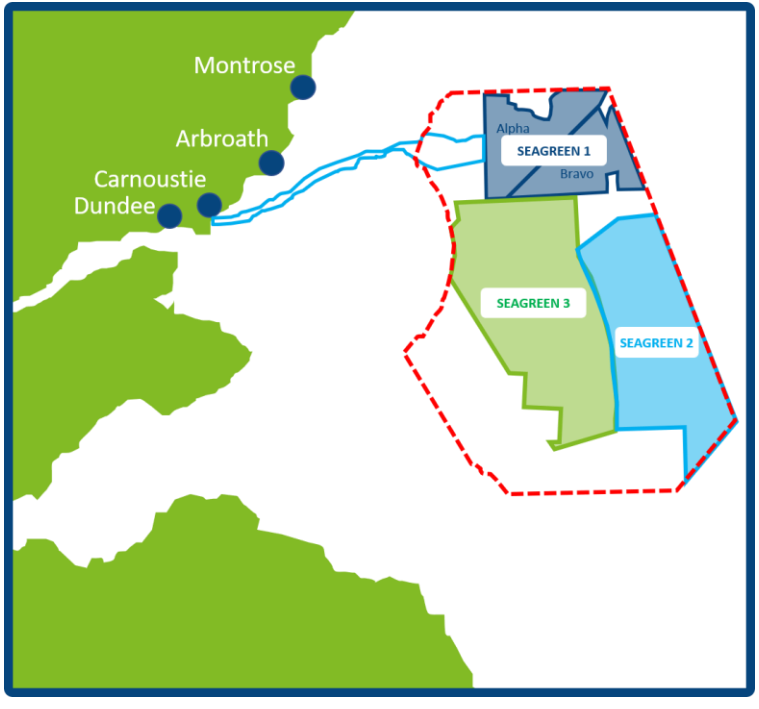


Indicative timeline

Seagreen 2 and Seagreen 3

- Indicative Capacity
  - **Seagreen 2 - 1400MW**
  - **Seagreen 3 - 900-1850MW**

- 2019 Scoping
- 2022 Consent
- 2025 Construction
- 2027 Operational



Keeping in touch

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0141 224 7192

Ian Johnson

Project Manager

Red Rock Power - Inch Cape

Inch Cape Offshore Limited

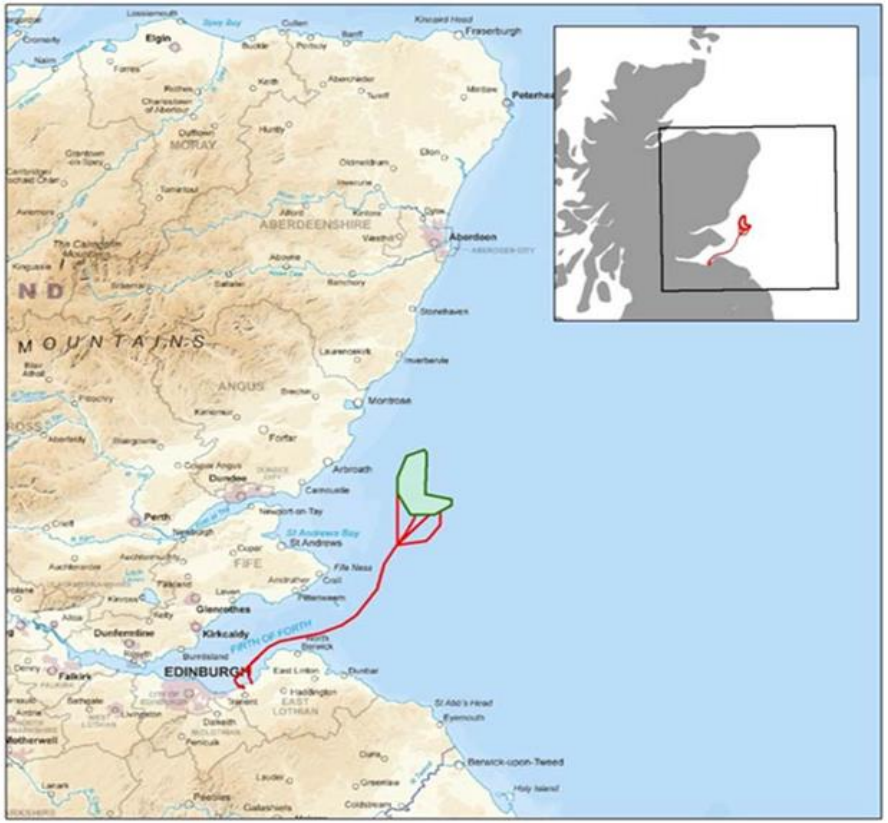
Ian Johnson – Inch Cape Project Manager

SDIC
Red Rock Power Limited

Introduction to Red Rock Power

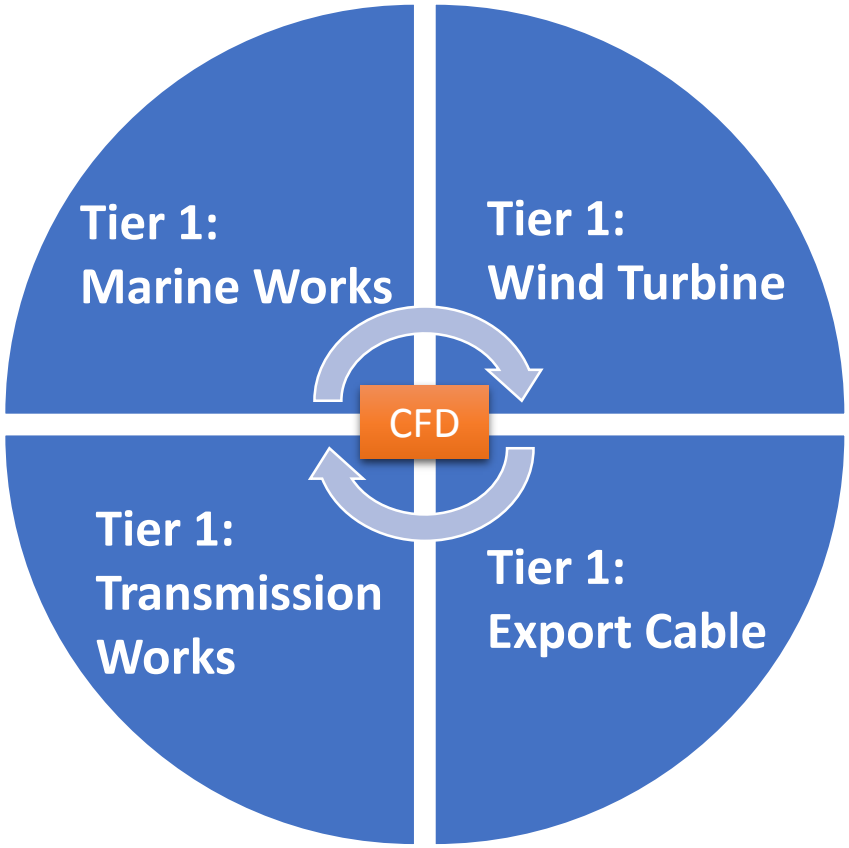
- In May 2016 SDIC Power acquired Repsol's New Energy UK business unit,
- Business renamed Red Rock Power and is SDIC investment vehicle for European Renewables,
- Headquartered in Edinburgh, Scotland,
- Approximately 50 staff with a focus to date on offshore project delivery (c.80 by mid 2019),
- Red Rock Power currently owns:
  - 25% stake in Beatrice offshore windfarm, in construction,
  - 100% of the Inch Cape offshore wind farm, in development,
  - 100% of Afton Onshore Wind Farm, operational since September 2018.

Overview of Inch Cape Project



- Project located in North Sea, 15km off Angus coastline,
- Grid connection offer for 700MW connection at Cockenzie, East Lothian accepted in 2012,
- Offshore Consent for 110 turbines granted in October 2014,
- Onshore Consent application submitted lo Local Authority in March 2018 and ‘called in’ by Scottish Government in April 2018,
- New Offshore Consent for 72 larger turbines submitted in August 2018.

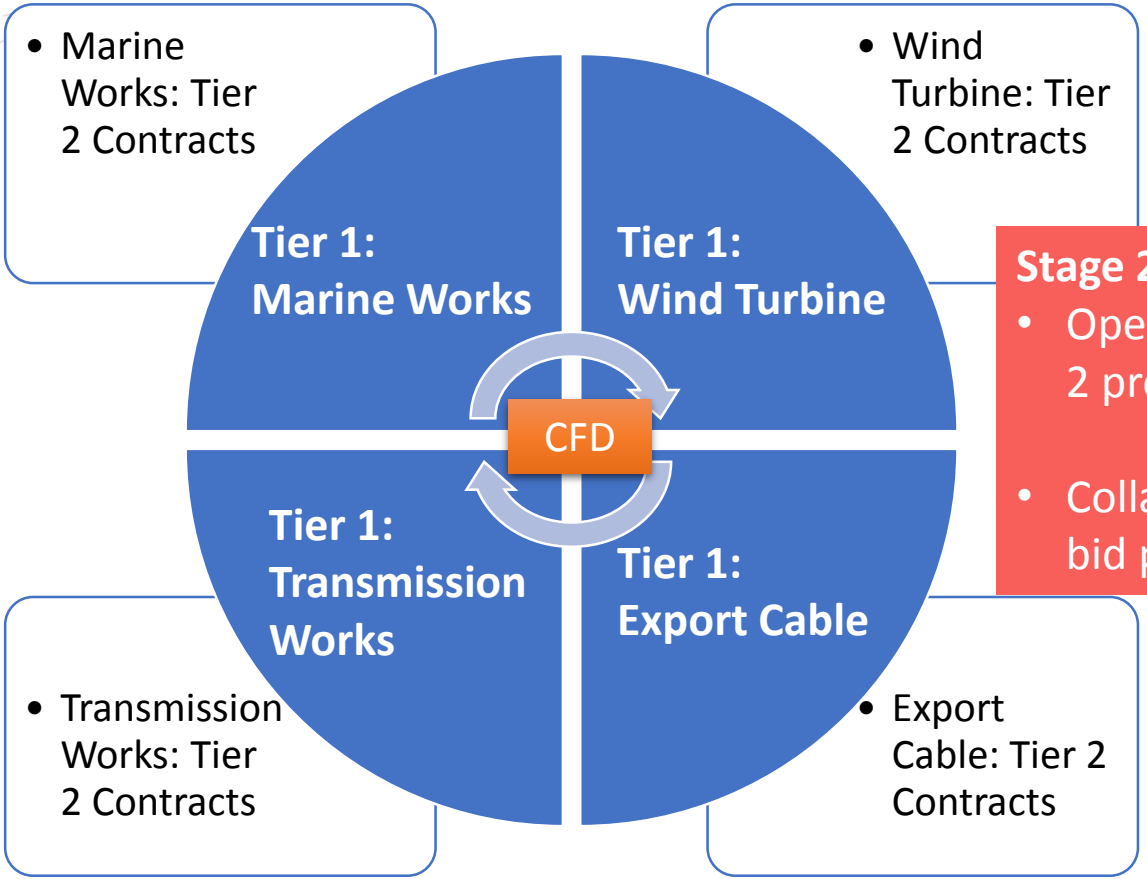
Inch Cape - 2 Stage Contract Strategy



Stage 1:

- Early selection of Tier 1 Contractors
- Collaborate to refine concepts and define Tier 2 scopes

Inch Cape - 2 Stage Contract Strategy



Stage 2:

- Open book review of Tier 2 proposals.
- Collaborate to agree CFD bid price.

Inch Cape Offshore Limited

SDIC
Red Rock Power Limited

Carlos Cerezo

Project Director

EDP Renewables - Moray West

MORAY WEST
OFFSHORE WINDFARM

Scottish Renewables – Offshore Wind Conference

Introduction to Moray West OWF – Carlos Cerezo, Project Director

28 January 2019

Moray West Offshore Wind Farm

- Introduction
- Current activity
- Milestones
- Challenges and Solutions
- Supply chain and North of Scotland Cluster

Moray West - Introduction

- Project company with sponsors – EDPR (majority) and ENGIE
- Headquartered in Edinburgh
- Over 100 staff in Edinburgh
- Moray West benefits from success of Moray East
- Moray West benefits from access to Moray East, EDPR and ENGIE expertise

Moray West – Current activity

Key Characteristics:

- Located over 22km from the coast.
- Water depth range: 35-54m
- Nominal capacity of 800MW
- Grid connection secured at Blackhillock in Moray, near Keith.
- Seeking consent for up to 85 turbines with max tip height 265m.
- WTG in the range of 164 – 230 m rotor diameter.

MORAY WEST
OFFSHORE WINDFARM

Moray West – Milestones

Key Milestones:

- EIA Scoping in 2016
- Offshore & Onshore consent applications submitted Summer 2018, Addendum in November.
- Targeting participation in the next UK CfD Round in 2019.

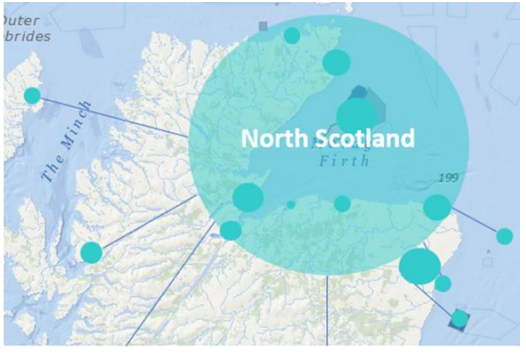
Moray West – Issues, Challenges & Solutions

- Multiple variables in building commercial model:
  - Procurement model
  - Utilising innovation
- CfD timetable
- Staff resourcing

By Andreas Trepte - Own work, CC BY-SA 2.5, https://commons.wikimedia.org/w/index.php?curid=4111831

Supply Chain Opportunities - North Scotland Offshore Wind Cluster

- Multi package or EPCI
- An ‘Established’ Cluster – Deep water offshore wind specialism
- Hub and spoke model across Highlands and Islands
- Operational projects; In-construction project, in development project; further pipeline
- Major supply chain facilities
- Start of wider engagement and awareness raising BUT need Sector Deal confirmed



Cluster ‘Champions’:

edp renewables

sse

MORAY WEST
OFFSHORE WINDFARM

MORAY WEST
OFFSHORE WINDFARM

THANK YOU

Allan MacAskill

Director

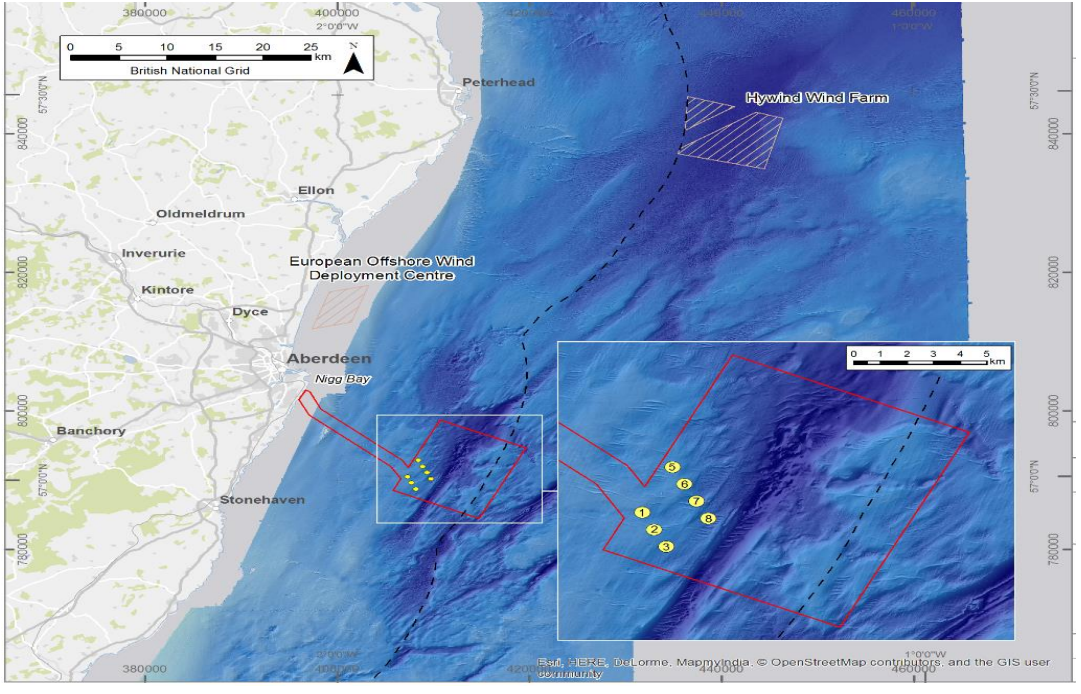
MacAskill Associates – Kincardine Offshore Wind

Kincardine Offshore Windfarm Limited

Project Update

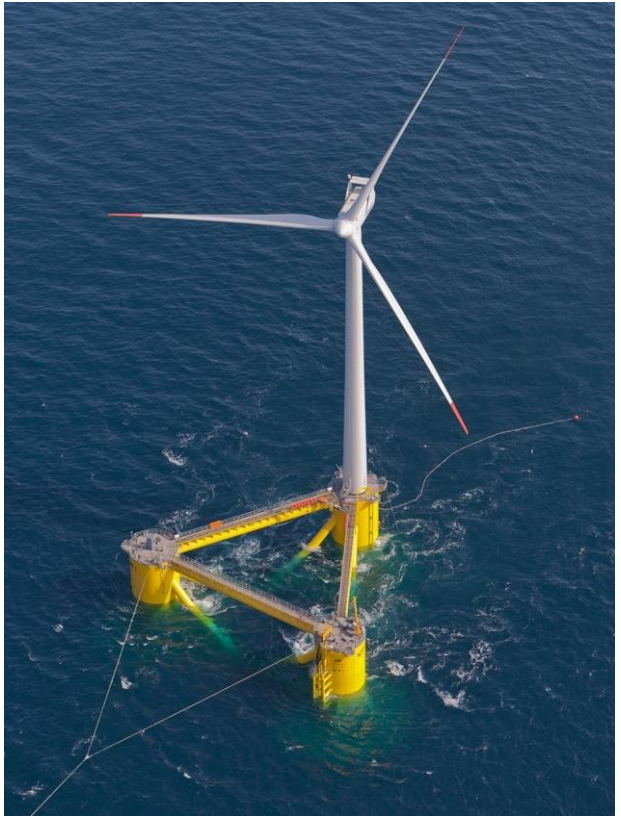
Kincardine Project

- Maximum Output 50 MW
- Location 15 km east of Aberdeen/shire coast
- Turbines
  - 5 x 9.5 MW Vestas V164
  - 1 x 2 MW Vestas V80
- Grid Connection
  - Grid connection at Redmoss
- Operational life
  - 25 years
- First Generation summer 2018
- Project Completion early 2020



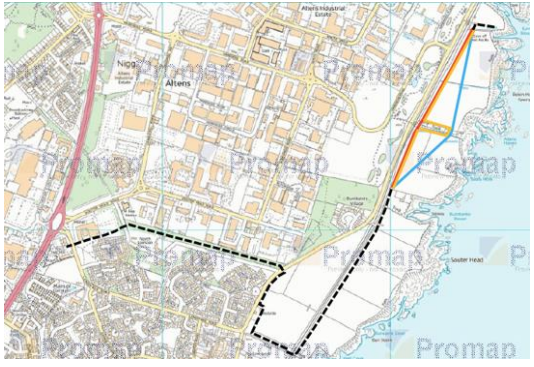
Semi-submersible Substructure

- Fabricated in Steel
- Triangular semi submersible structure
- Tower over one buoyancy chamber
- 3 mooring lines
- Installation of turbine at yard
- Tow and operation in semi-submersible mode
- Maximum dimensions :
  - Tip height up to 191 m
  - Rotor diameter 164 m

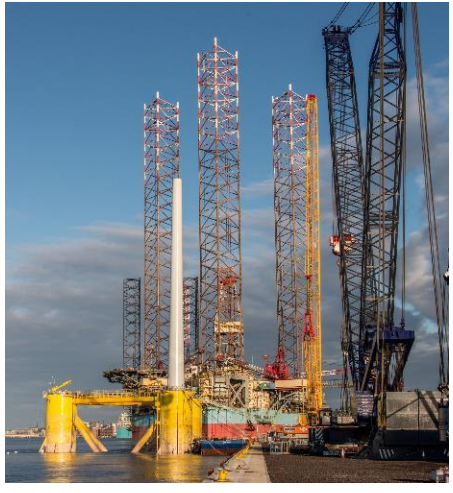


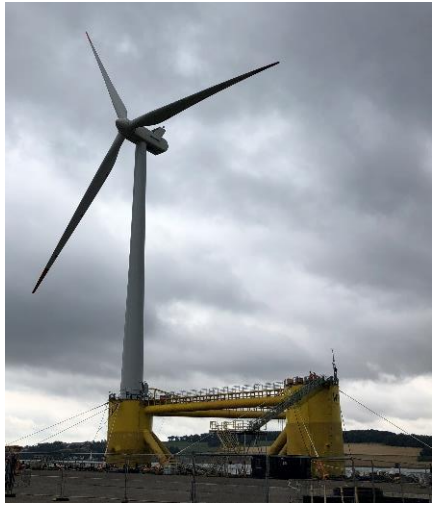
Onshore Facilities

- Constructed in 2018
- Substation at Redmoss adjacent to:
  - Grid connection
  - Hydrogen centre
- Substation dimensions
  - Compound 15 x 26 m
  - Building 13 x 4

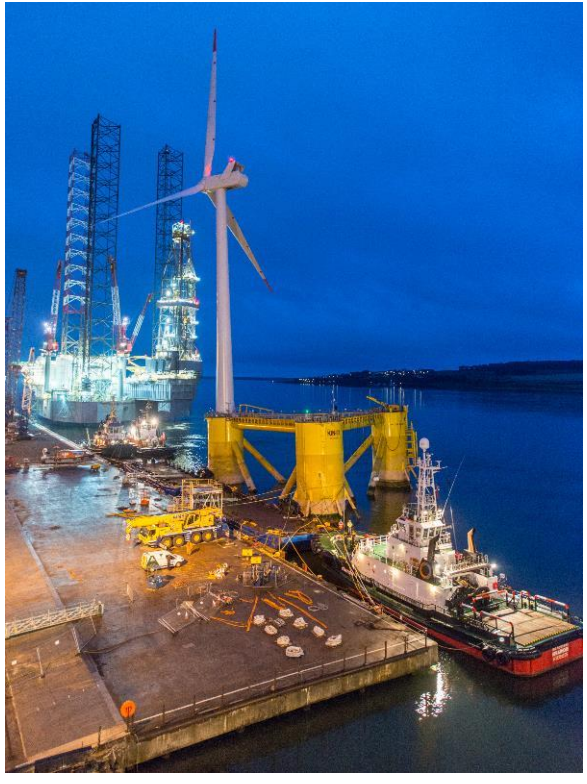


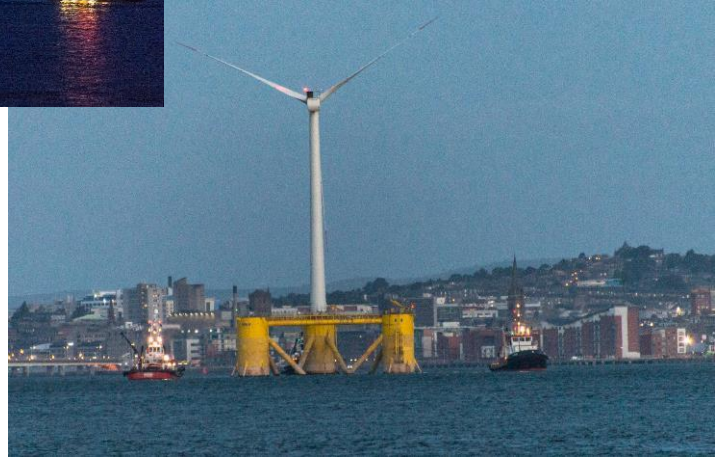
Turbine Assembly 2018



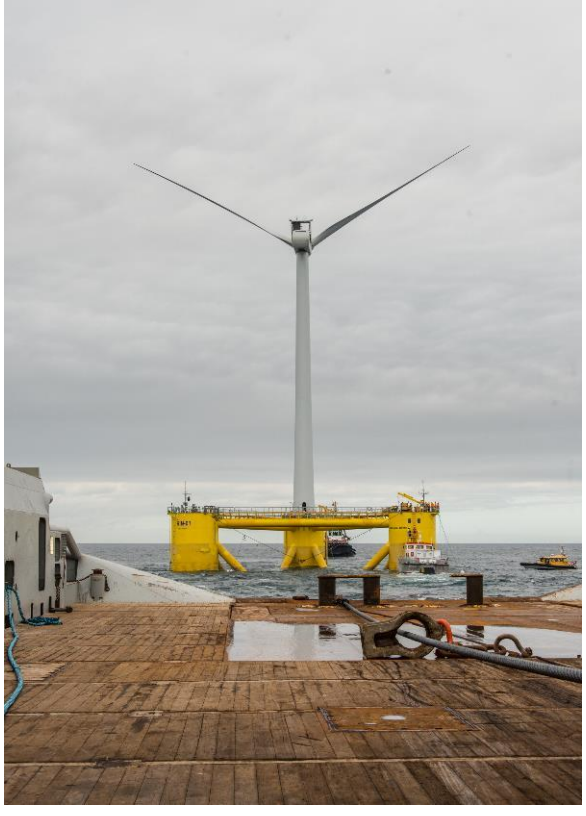


Leaving Dundee 2018



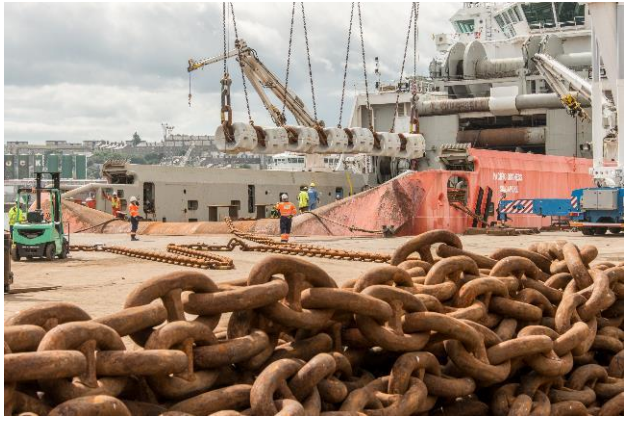


Preparing for Tow 2018



Under Tow 2018

Moorings Installation 2018



Cable Lay 2018

Cable Lay 2018

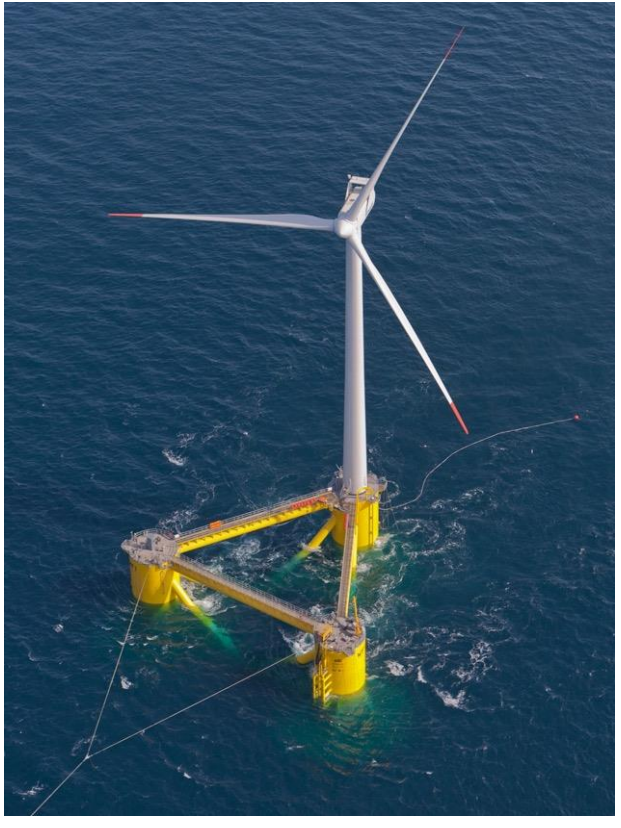
Next Steps

2019 activities

- Manufacture of turbines and substructures
- Preparatory offshore works

2020 activities

- Installation of moorings / second subsea cable
- Delivery of turbines and substructures
- Assembly and installation of turbines
- Completion of project



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Carlos Cerezo
Project Director, EDP Renewables

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Director, MacAskill Associates

The global outlook

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Jenny Hogan

Deputy Chief Executive

Scottish Renewables

Alastair Dutton

Managing Director, Advent.re &

Chair of GWEC Global Wind Task Force

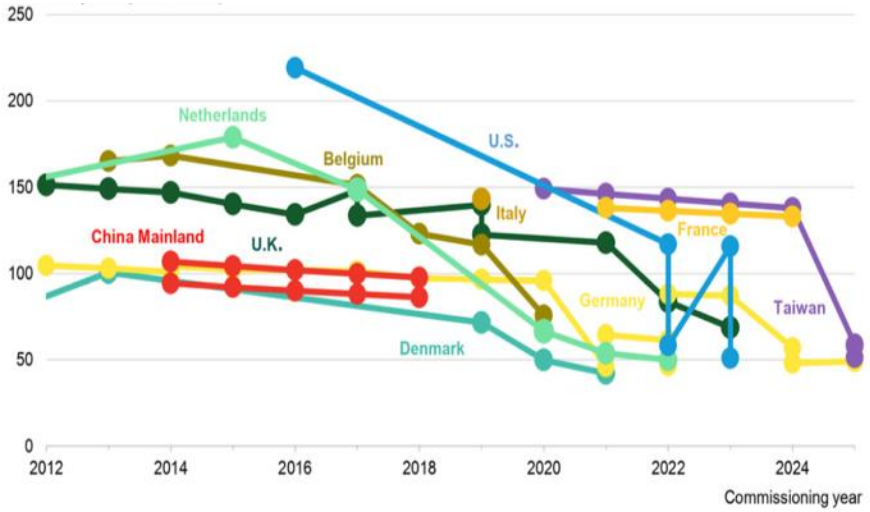
Taking Offshore Wind Global

28 Jan 2019

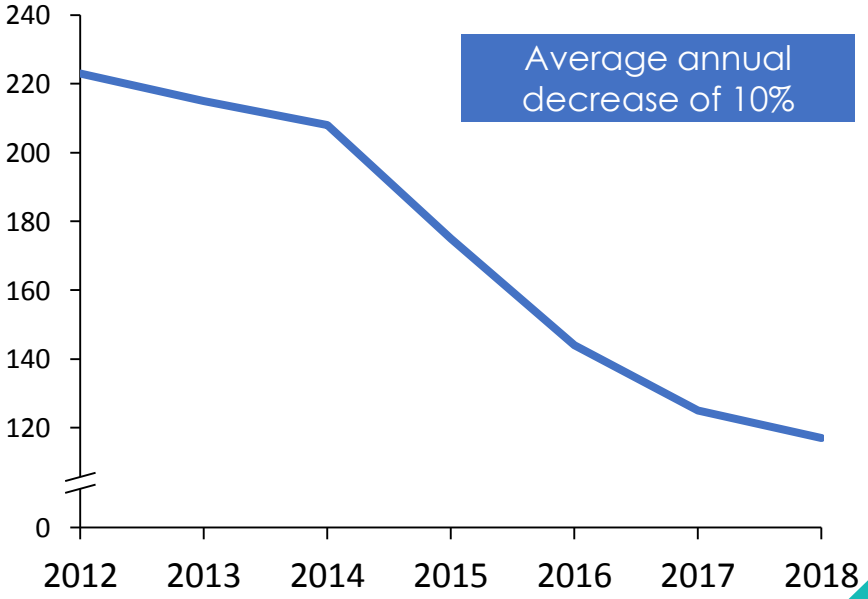
Alastair Dutton

Offshore wind – a maturing industry

Levelized offshore wind bids,
USD/MWh by year of commissioning

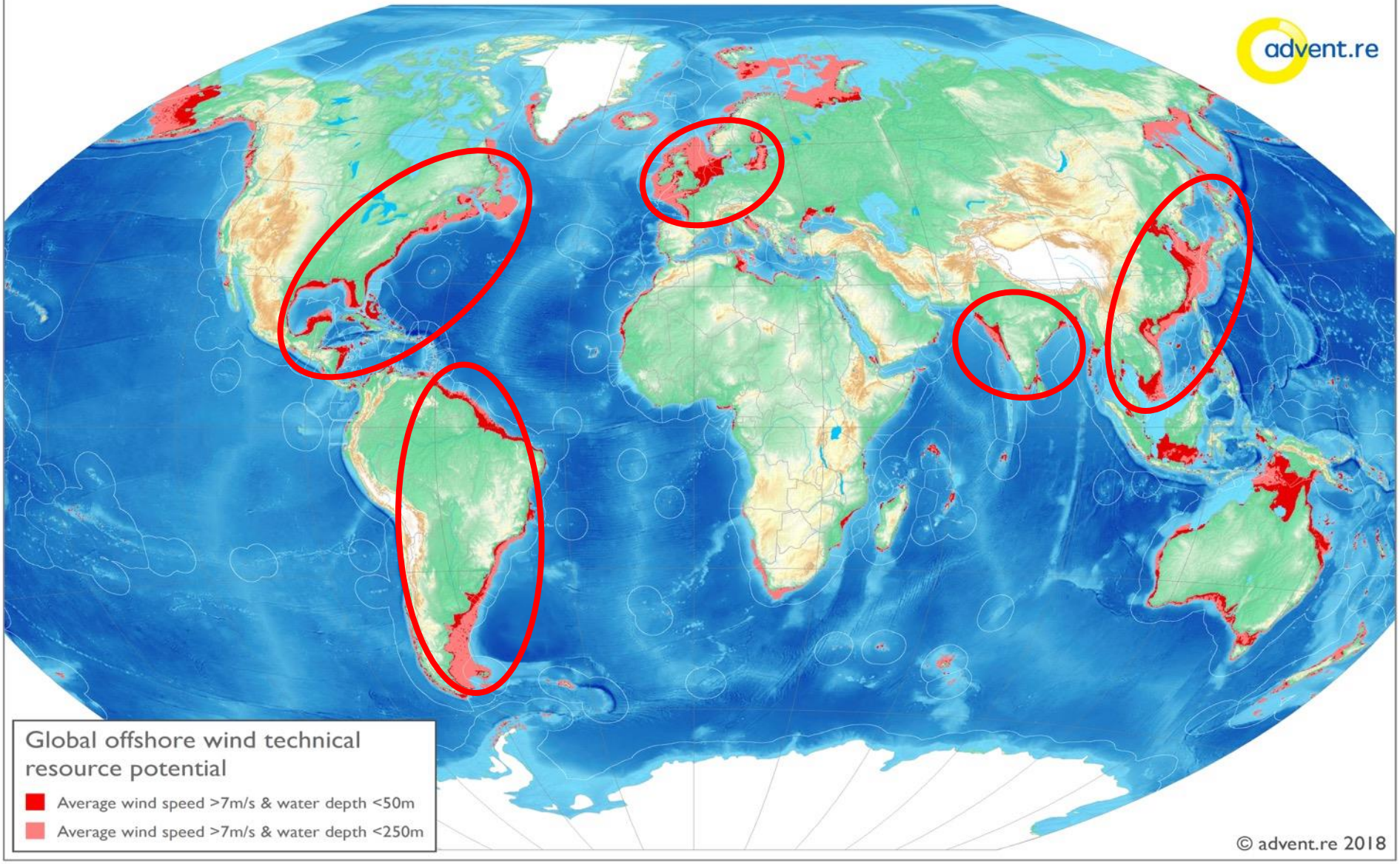


Levelized cost of electricity offshore wind
USD/MWh



Source: GWEC, BNEF H2 2018 Offshore Market Outlook, BNEF LCOE Database Jan 2019

GWEC
GLOBAL WIND ENERGY COUNCIL


advent.re
Global offshore wind technical resource potential
Average wind speed >7m/s & water depth <50m
Average wind speed >7m/s & water depth <250m
© advent.re 2018

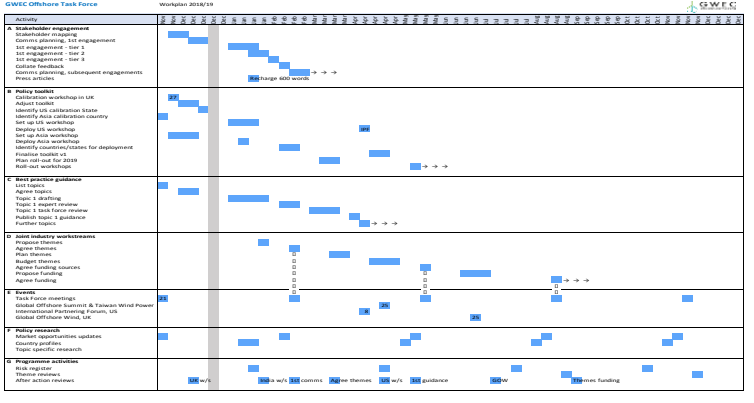
GWEC
OFFSHORE WIND TASK FORCE

Activities	
1	Market intelligence
2	Market readiness assessment
3	Market entry opportunities
4	Policy advocacy
5	In-country events
6	Knowledge transfer
7	Skills training
	and more to come…

Members

IBERDROLA RENEWABLES
Shell
SIEMENS Gamesa RENEWABLE ENERGY
DNV·GL
MHI VESTAS OFFSHORE WIND
MAINSTREAM RENEWABLE POWER
Ørsted

+ Wind Energy Associations, Carbon Trust, IFC



Thank you

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Deputy Chief Executive, Scottish Renewables

Alastair Dutton
Managing Director, Advent.re & Chair of GWEC Global Wind Task Force

Alan Duncan
Business Development Consultant, Windhoist

Dr Mark Leybourne
Associate Director, ITPEnergised

Jo de Montgros
Partner, Everoze

Paul O'Brien
Specialist - Energy & Low Carbon, Scottish Development International

Séamus McCabe
Vice President, Green Investment Group

Jenny Hogan

Deputy Chief Executive

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Paul Wheelhouse MSP

Minister for Energy, Connectivity and the Islands

Scottish Government

Jim Smith

Managing Director

SSE Renewables

Jason Fudge

Chief Operating Officer

DF Barnes

Offshore Renewables

Positioning Scotland's Supply Chain for Success

Overview

About JV Driver & DF Barnes

Why Scotland?

Moving Forward

Diversification

Strengthening the Supply Chain

Expansion & Investment

Working Together

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CANADA'S BEST MANAGED COMPANIES Platinum member

One of Canada's Largest Industrial Contractors

Operations throughout North America, the Caribbean, West Africa, and the UK

Comprised of 8 Business Units

Industry Leading Safety Systems, Culture, and Performance

About DF Barnes

Over 85 years of marine and offshore experience in Eastern Canada

Specialists in subsea fabrication and marine maintenance

Joined JV Driver Group in 2008

Leads the activities of its Marine Enterprise

Why Scotland?

Global Leader in Offshore Renewables

Strong Pipeline of Projects

Government Support for the Sector

Market Diversification

Synergies with Canadian Business

Motivated and Skilled Workforce

Alignment with Values and Work Practices

Export Potential to Emerging NA Market

Path Ahead for BiFab

Phase 1
Stabilize & Invest in Existing Markets

Phase 2
Sector Diversification

Phase 3
Geographic Expansion

Strengthening the Scottish Supply Chain

Leveraging O&G Expertise

Innovation and Investment

Continuity and Backlog

Appropriate Distribution of Risk

Challenge of Increasingly Tighter Margins

Maximum Opportunity for Local Supply:

Levers in the Sector Deal?
Developer Targets and Incentives?

Diversification

Energy markets can be highly cyclical and dependent on major project sanctioning

A strong well-diversified book of business helps to eliminate peaks and troughs

Renewables
Oil and Gas
Maintenance
Decommissioning
Export
Environmental

Expansion and Investment

Leveraging JV Driver Group clients and projects globally

North American and European Renewables

Capital Investment is required to improve competitiveness

Steady order book is critical to developing a highly trained and sustainable work force

Working Together

Scottish Government support has been First Class

A strong, progressive relationship has been established with union partners

Infrastructure Working Group

Scottish Enterprise and Highlands and Islands Enterprise

Fife Council

Stakeholder engagement efforts ongoing

Offshore Renewables

Positioning Scotland's Supply Chain for Success

Thank You

Claire Mack

Chief Executive, Scottish Renewables

Paul Wheelhouse MSP

Minister for Energy, Connectivity and the Islands, Scottish Government

Jim Smith

Managing Director, SSE Renewables

Jason Fudge

Chief Operating Officer, DF Barnes

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CATAPULT Offshore Renewable Energy

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From planning to deployment

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#SROFFSHORE19

Patricia Hawthorn

Partner

Shepherd + Wedderburn

Helena Gray

Deputy Director

Marine Scotland

John Robertson

Senior Manager

Crown Estate Scotland

Crown Estate Scotland
Oighreachd a' Chrùin Alba

SR Offshore Wind Conference

Parallel 4A: From planning to deployment

John Robertson

29 January 2019

Crown Estate Scotland

- Set up following the Scotland Act 2016
- Manage land and property owned by the Monarch in right of the Crown

Crown Estate Scotland
Oighreachd a' Chrùin Alba

From planning to deployment

- Seabed agreements
- Support development

Crown Estate Scotland
Oighreachd a' Chrùin Alba

ScotWind Leasing update

- Progress to date
- Current position
- Next steps

Crown Estate Scotland
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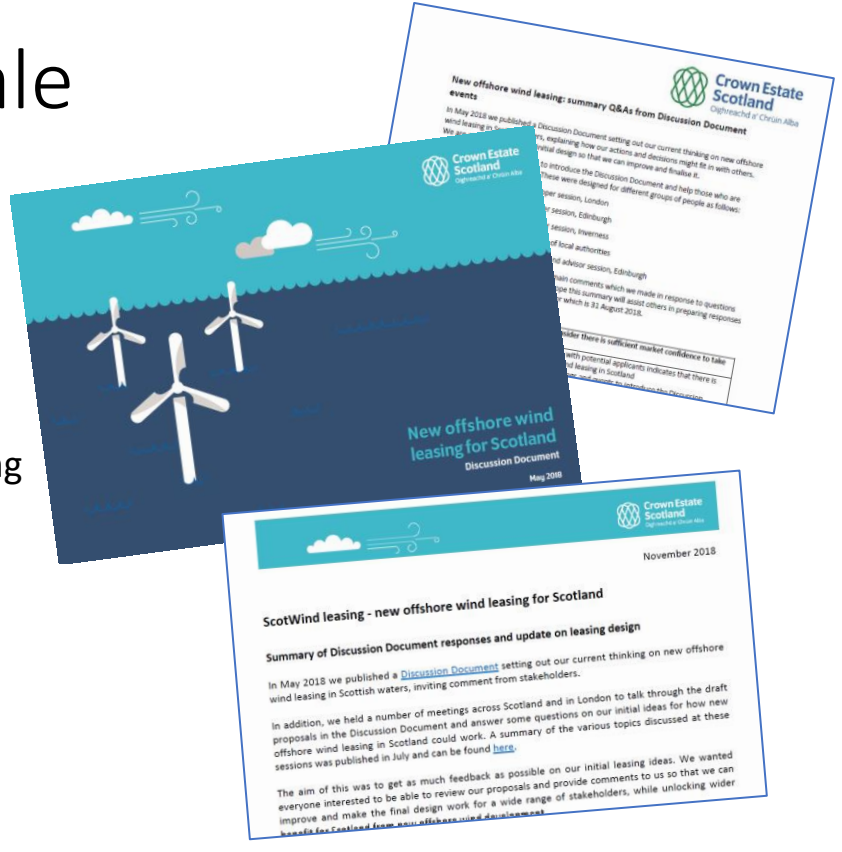
ScotWind Leasing timescale

- May 2018
  - Discussion Document - set out options
- November 2018
  - Timescales and Next Steps – firmed up sequencing
- January 2019
  - Update on intended timings



Crown Estate Scotland
Oighreachd a' Chrùin Alba

Wider considerations and conclusion

- Sector Deal development
  - Clusters
  - Vision
- Look ahead

Crown Estate Scotland
Oighreachd a' Chrùin Alba

Neil Douglas

Director

BVG Associates

Nancy McLean

Offshore Development Manager

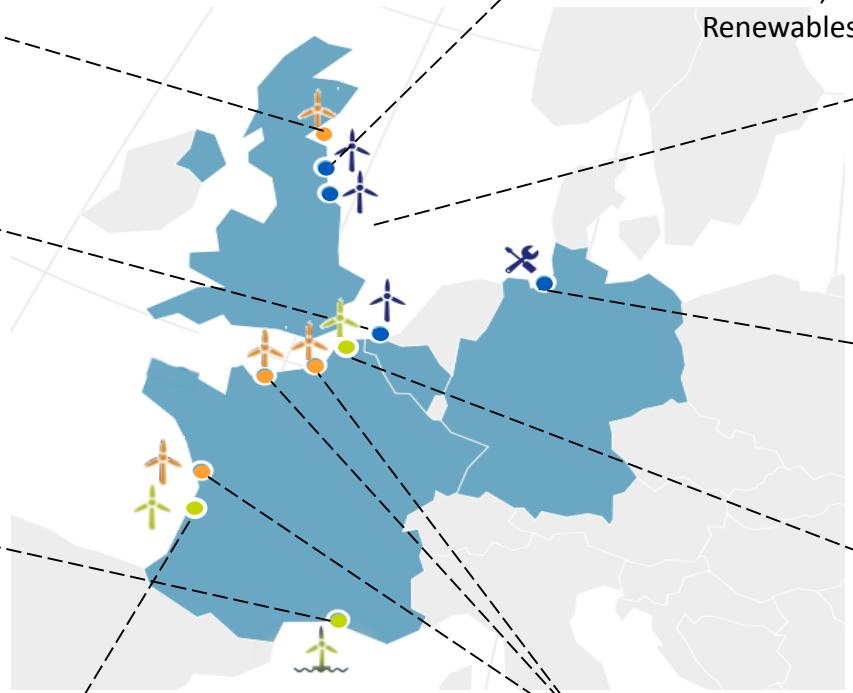
EDF Renewables

Scottish Renewables Offshore Wind

Nancy McLean

29//01/2019

EDF Renewables offshore wind projects in Europe



NNG (UK)

- Project fully authorized and acquired in May 2018
- 450 MW project
- 100% owned by EDF EN
- FID planned mid 2019

C-POWER (BE)

- 325 MW in operation since 2013
- EDF EN is one of the shareholders of C-Power since 2004

FLOATING WIND (FR)

- Provence Grand Large: 24 MW
- 8 MW turbines are supplied by Siemens and floating units by SBM

TEESSIDE (UK)

- 62 MW operating since summer 2013
- 2.3 MW turbines supplied by Siemens
- Owned, developed & operated by EDF Energy Renewables

BLYTH (UK)

- 5 turbines of 8.3 MW supplied by MHI-Vestas
- Commissioned in Q4 2017
- 100% owned by EDF EN

REETEC & OWS (Germany)

- Operation and maintenance of a 400 MW offshore wind farm since April 2015

ROUND 3 TENDER (FR)

- Dunkerque: ~600 MW
- With Innogy & Enbridge

ROUND 1 TENDER (FR)

- Fécamp: 498 MW – 35% EDF EN stake
- Saint-Nazaire: 480 MW – 50% EDF EN stake
- Courseulles: 450 MW – 42.5% EDF EN stake
- Other sponsors are Enbridge (CAN) and WPD

Further development (FR)

- Oléron: ~650 MW

In construction or in operation
In late development (fully consented)
In early development

Changes for project delivery processes since SWT and Round 3 leasing rounds

- Route to market from ROC to competitive allocation for CfD
  - Impact upon Regional Developer Groups
- Ground conditions and construction requirements are pivotal
- Development of technology and effect on design envelope
  - Speed v consequence of planning delays
- Just what is ‘worst case’ wrt EIA & HRA (most probable v worst case)?
  - Development of counterfactual population models for birds and marine mammals
  - Approach to HRA (beyond scientific reasonable doubt)
- Post consent monitoring needs to be able to answer specific questions

Initiatives to identify and fill knowledge gaps to reduce consenting risk

- COWIE, SOSS, NERC, MASTS…
- Scottish Offshore Renewables Research Framework (SpORRAn)
  - Receptor specific groups. Stakeholder, policy and industry representatives.
- → Scottish Marine Energy Research (ScotMER) programme
- TCE SEA Research & Seminars
- Offshore Renewables Joint Industry Programme (ORJIP)
  - ORJIP 2
- Post consent monitoring to reduce uncertainty around size of impact
  - Very hard to monitor consequence of impact at a population level

Further changes we should expect for ScotWind projects

- Market parity for CfD tenders in the 2020's
- Increased local spend delivered through the Scottish Government & Sector Deal commitments
- Technology to continue to develop – design envelope evolution
- Incorporation of new knowledge of impacts upon receptors, the consequences on the receiving population, and assessment methodology into EIA and HRA


240
MAMM

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Partner, Shepherd + Wedderburn

Helena Gray
Deputy Director, Marine Scotland

John Robertson
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ORE Catapult session 1: Disruptive Technologies

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@ ORECatapult
#SROFFSHORE19

Andy Macdonald

Senior Innovation Manager

ORE Catapult

Tweet @ScotRenew
@ ORECatapult

#SROFFSHORE19

Jo de Montgros

Partner

Everoze

everoze

Disruptive Innovation

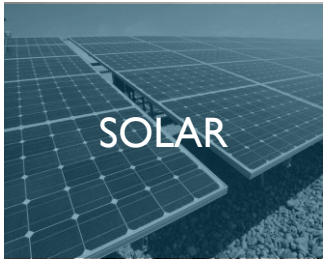
Jo de Montgros

29th January 2018

experts | evolving | energy

Everoze

Boutique consultancy with global reach – evolving our energy systems



Employee-owned consultancy, specialising in renewables, storage and wider energy flexibility.

Our unique strength is bridging the gap between the technical and the commercial. We exist to help our clients accelerate the transition to a decarbonised energy system.

Our locations:

- Fife
- Bristol
- London
- Paris
- Lyon
- Seville
- Madrid
- Freiburg

Key Markets:

- UK
- Ireland
- France
- Germany
- Scandinavia
- Spain
- Portugal
- Emerging markets

Trends – Resulting Business Models

Disruptive Innovation

Flexibility

everoze

Why (trends)

%

Increased renewables

Energy Mix

Renewables as part of baseload

Technical Innovation

Simulation

Controls

Power control

Digital twins

Business models

Driver:
Price optimisation for time, location, forecast accuracy, cannibalisation risk, etc.

Models:
New revenue stacks
Creative PPAs
Virtual power plants

Leading to:
Multi technology platforms and financing

Impact

Challenge:
Risk Allocation

Benefit:
Optimised and reliable integrated systems

Everoze

Source: Everoze, historical analysis based on OMIE day-ahead prices and REE production data, 2014-2017 period

2 Cost Reduction

everoze

Why (trends)

Subsidy Free

Auctions / Competition

Technical Innovation

Industrialisation

Scale up

Installation methods

Robotics / Big Data / AI

Life Extension

Business models

Driver:
Competitiveness focus

Models:
Engagement in advance of traditional milestones.

Leading to:
Wider partnerships
Novel fee structures and risk sharing approaches.

Impact

Challenge:
Barrier to new entrants

Benefits:
Reduced costs for consumers
Reduced safety risk exposure
Good grid citizens
Regional economic benefit

Everoze

3 Business Models

Flexibility requirements for future markets lead to new risks, that have previously been inherently mitigated in offtake structures.

Investors will need to find new ways to manage these risks through new:

Modelling tools
Ownership models
Contract structures
Insurance products

Cost reduction demands increased engagement and partnership across the value chain

Information sensitivity and cross project competition creates challenges

Partnership models align objectives

Leading to holistic management of stakeholder requirements.

Optimised, reliable, safe systems – happy stakeholders and happy investors

Thank You

Professor Helen Hastie

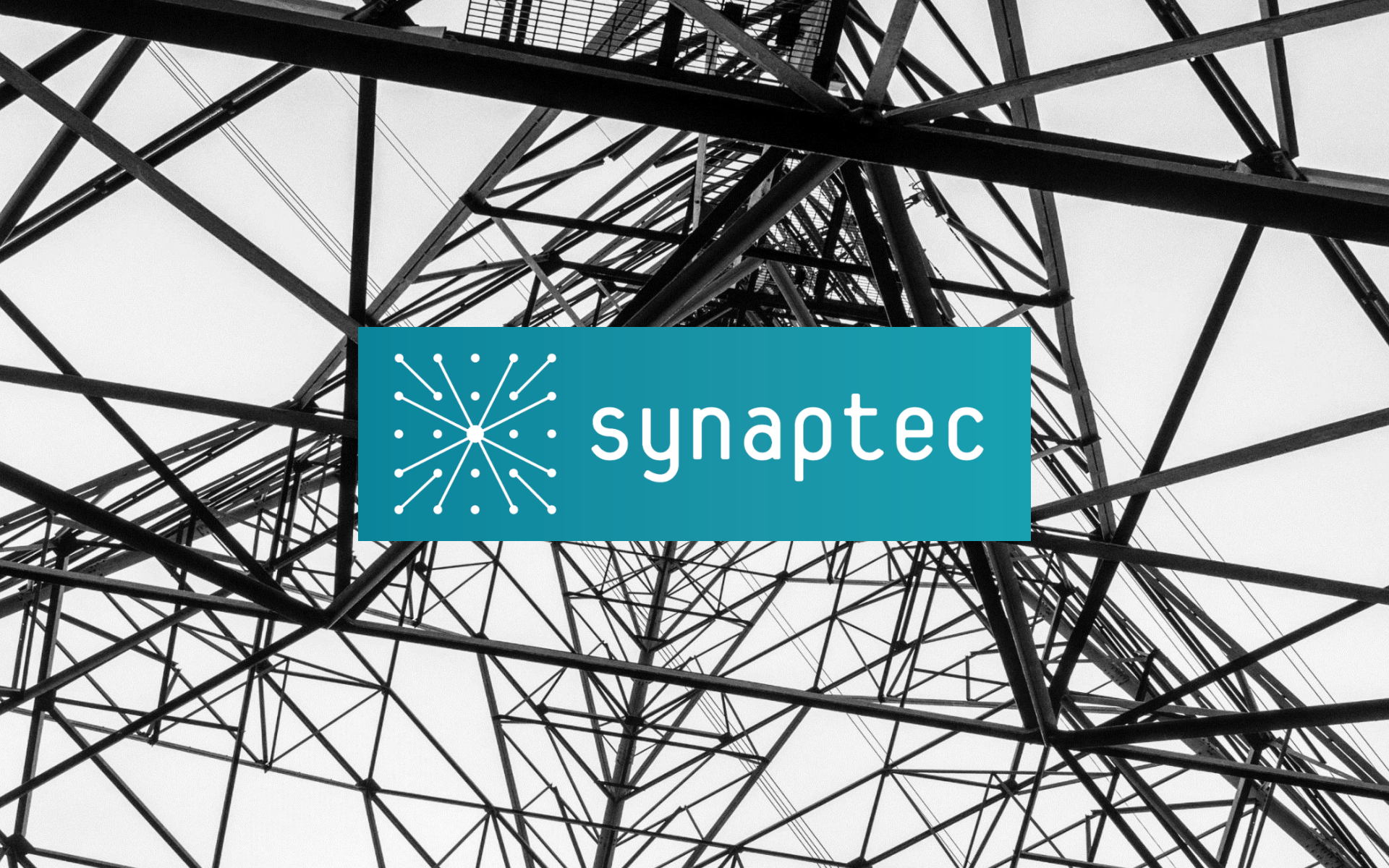
ORCA hub- Heriot Watt

View presentation here

Saul Matthews

Head of Business Development

Synaptec


synaptec

Agenda

- Synaptec does what?
- Core technology
- Applications offshore

Light-speed network awareness

- Next generation, hyper efficient, distributed instrumentation
- Focused on reducing network outage and operating costs
- Developed for transmission, deployed in UK **FITNESS** program
- First offshore wind deployment in 2019

SP ENERGY NETWORKS sse Statnett UK ENERGY INNOVATION AWARDS 2017 POWERED BY: ENERGY INNOVATION CENTRE scottish renewables

Technology platform

Leverages existing optical fiber,

for distributed and passive sensing,

with unprecedented efficiency & cost

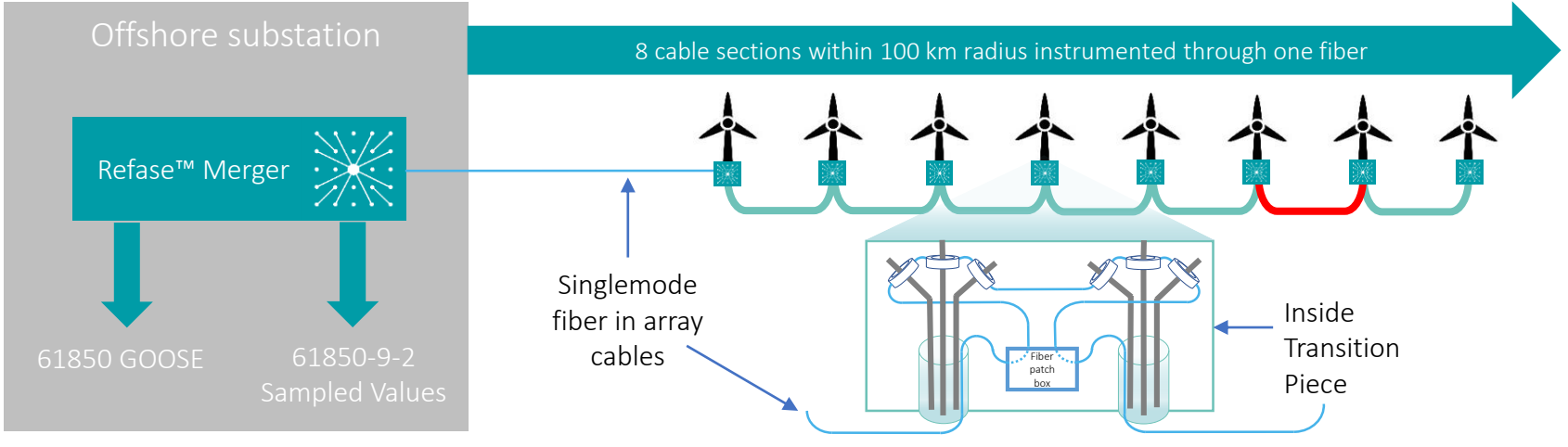
Completely unique and patent protected sensing solutions, easily integrated with existing fiber

Free from:
- Power supplies
- Copper wiring
- GPS
- Data networks
- Housings

Offshore Wind

- 1 fault per year for every 140km of array cable in UK, costing 1 month & £12m to fix*
- Needs human intervention and several days to locate which cable failed
- Refase™ finds it in 1ms and puts workable WTG back to production

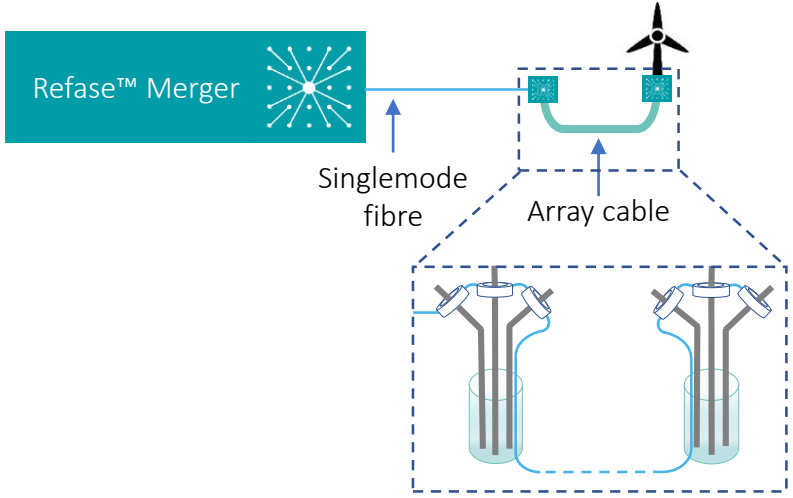
- Reduces outage by **~5 days**, saving £70K lost income per day
- eliminates damage to HV assets, and engineer H&S risk
- **$8M OpEx** saving + better availability over 25y array operating life



*OWA Catapult database

REACTION

- Renewable Energy Array Cable and Termination Instrumentation using Optical sensor Networks
- Trial of Synaptec's Refase system on OREC's 7MW Levenmouth Demonstration Turbine in 2019-20



- Enabling differential current protection as before, but also
- Exploring scope for better analytics;
  - electrical, structural and mechanical monitoring in WTG & cables
  - power quality monitoring
  - cable failure prognostics and predictive maintenance

Key points

- Light speed awareness of decentralized power networks
- 50:1 more efficient measurement for better management
- Reduced size, complexity and cost of instrumentation
- Saves $millions in CapEx & in OpEx

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Glasgow G1 1XW, UK

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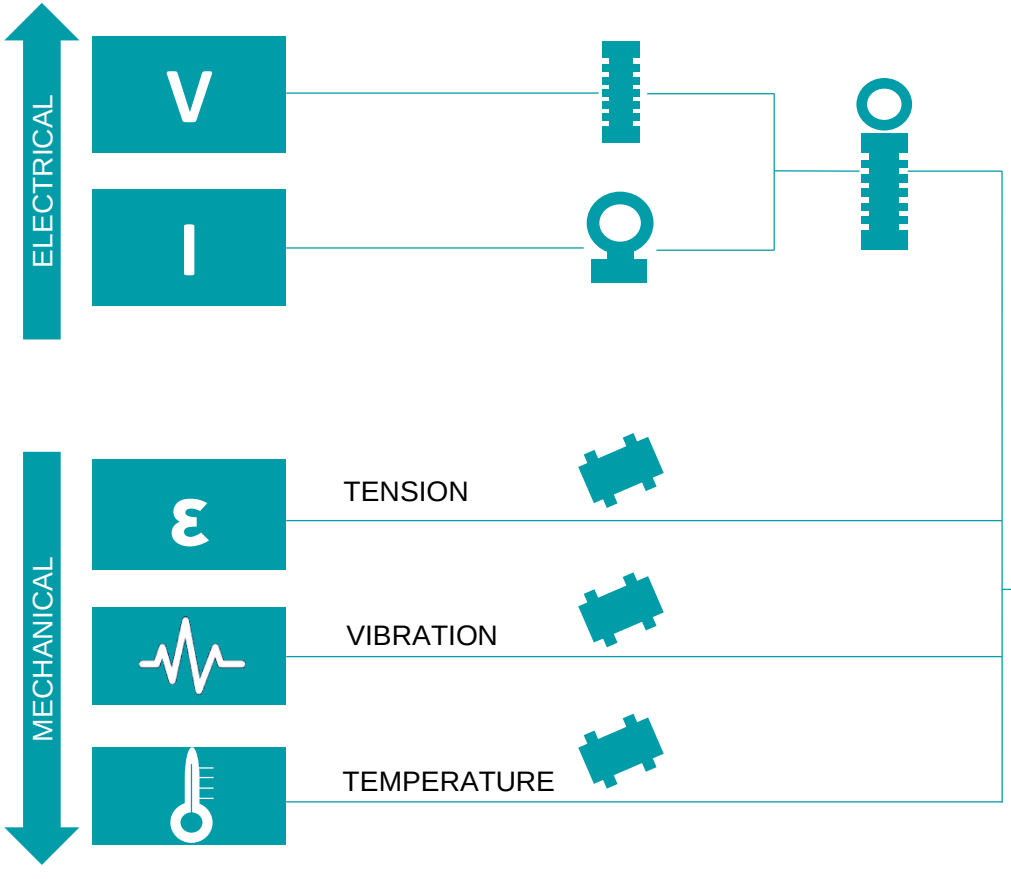
w: synapt.ec

Back up slides

Distributed electrical and mechanical sensing



- Passive — no power supply
- Safer — no copper wiring
- Secure — no data outside substation
- Time stamped — no GPS access needed
- Compliant — IEC 60044/61850/61869
- Robust — to temperature change & installation issues

Bespoke electromechanical solutions

One system for combined electromechanical monitoring

Protection & termination temperature monitoring

Fault location, power flow & power quality

Line sag, galloping, fault characterisation

Better informed maintenance decisions

Gunnar Prytz

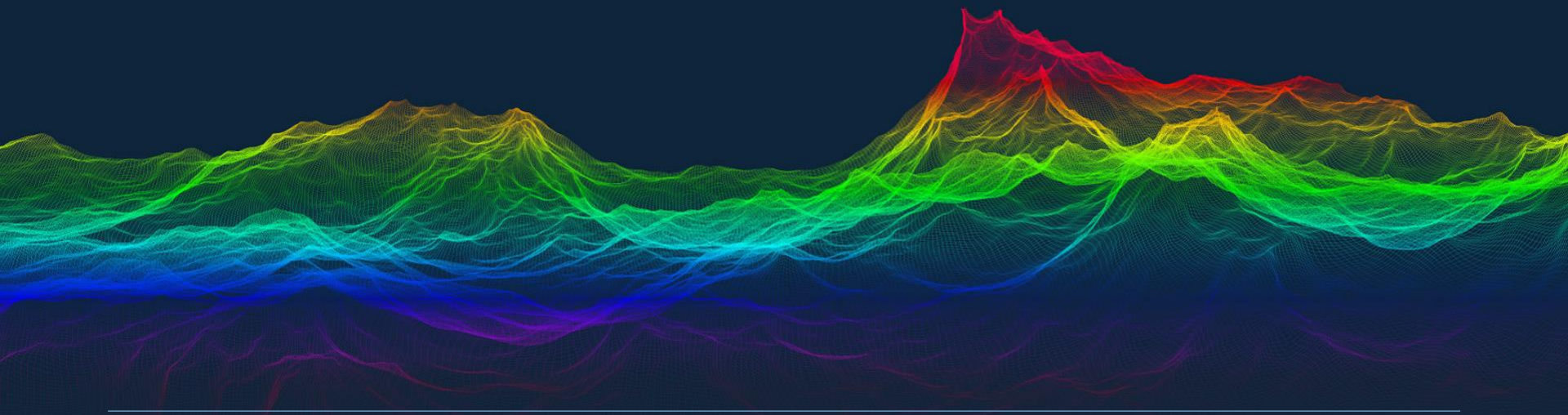
Chief Technology Officer

Miros Group

Gunnar Prytz, Ph.D.
Chief Technology Officer
Miros AS
Solbraaveien 20
NO-1383 Asker, Norway

MIROS

METOCEAN MEASUREMENTS AS-A-SERVICE



SHORT OVERVIEW OF MIROS

- Miros was founded in 1984 and the first Wave Radar was installed in the North Sea that year.
- Miros makes instruments and systems for monitoring of ocean waves and surface currents, water level, oil spill, speed-through-water and many other environmental parameters.
- Miros provides situational awareness to customers all over the globe in applications within offshore oil & gas, offshore wind, shipping and monitoring of coasts, ports, rivers, fjords and lakes.
- We are close to 50 people located in Asker, Norway and Aberdeen, Scotland with app. 25% working on R&D. Revenues were close to 10 MUSD in 2017.

WHAT?	Metocean measurements as-a-Service
WHERE?	Offshore wind farms, SOVs
WHO?	Owners and operators, personnel onshore and offshore
WHY?	Situational awareness, safety, data science, digitalization
HOW?	Metocean information easily accessible in real time anywhere

Traditionally, Metocean systems have been complex to install, integrate and use. This is an obstacle preventing efficient usage of this type of information for digitalization.

With new technologies from the Internet-of-things domain this is no longer an issue.

KEY APPLICATIONS FOR METOCEAN MEASUREMENTS

- Situational awareness beyond forecasts
- Analysis of structural stress on the windfarm constructions
- Trip planning
- Crew transfer safety
- SOV (compensated) gangway operation
- Crane operations
- Maintenance activities close to the water
- Vessel activities close to constructions
- Optimization of bidding for operational contracts
- Post operation and incident analysis
- Helicopter operations

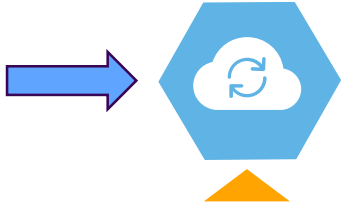
A PORTFOLIO OF MODERN IOT SENSORS & SYSTEMS

Cloud applications have to be delivered **as-a-Service**

The complete Metocean solution can thus be delivered in two ways:

1) A hybrid sale/aaS delivery
2) A pure aaS delivery

Where is the offshore wind business going with respect to service based business models?



Cloud applications for collection, storage, processing, presentation and distribution

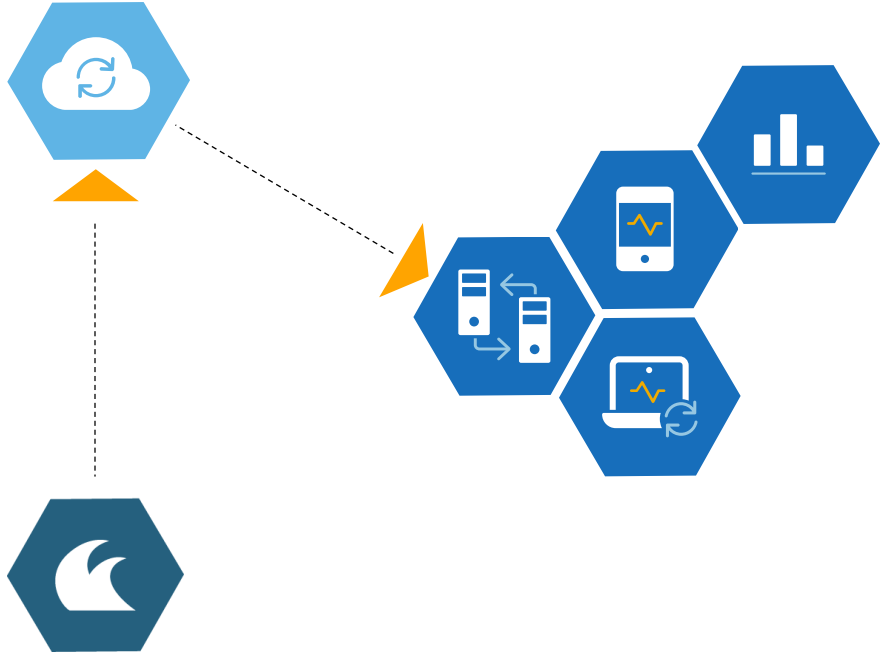
A new way of collecting and sharing real-time and historical Metocean data to any user, anytime, anywhere.

High reliability and low operating costs.

Radar based IoT sensors

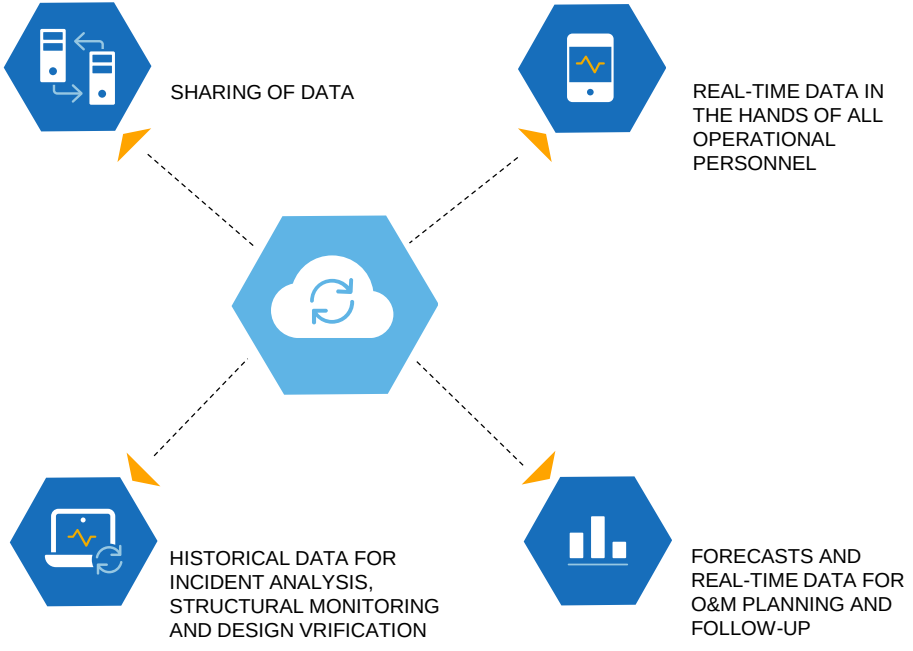
INTEGRATION FROM SENSOR TO CLOUD

- Miros Cloud is a set of services that adds value to Miros sensors and systems
  - Data collection from Miros sensors
  - Data collection from 3rd party sensors
  - Data storage
  - Data visualization in real-time UIs
  - Data download/data push/data API
  - Integration of 3rd party data and services (weather forecasts, tidal, AIS etc.)
  - Device management and access control



IOT TAKES METOCEAN TO THE NEXT LEVEL

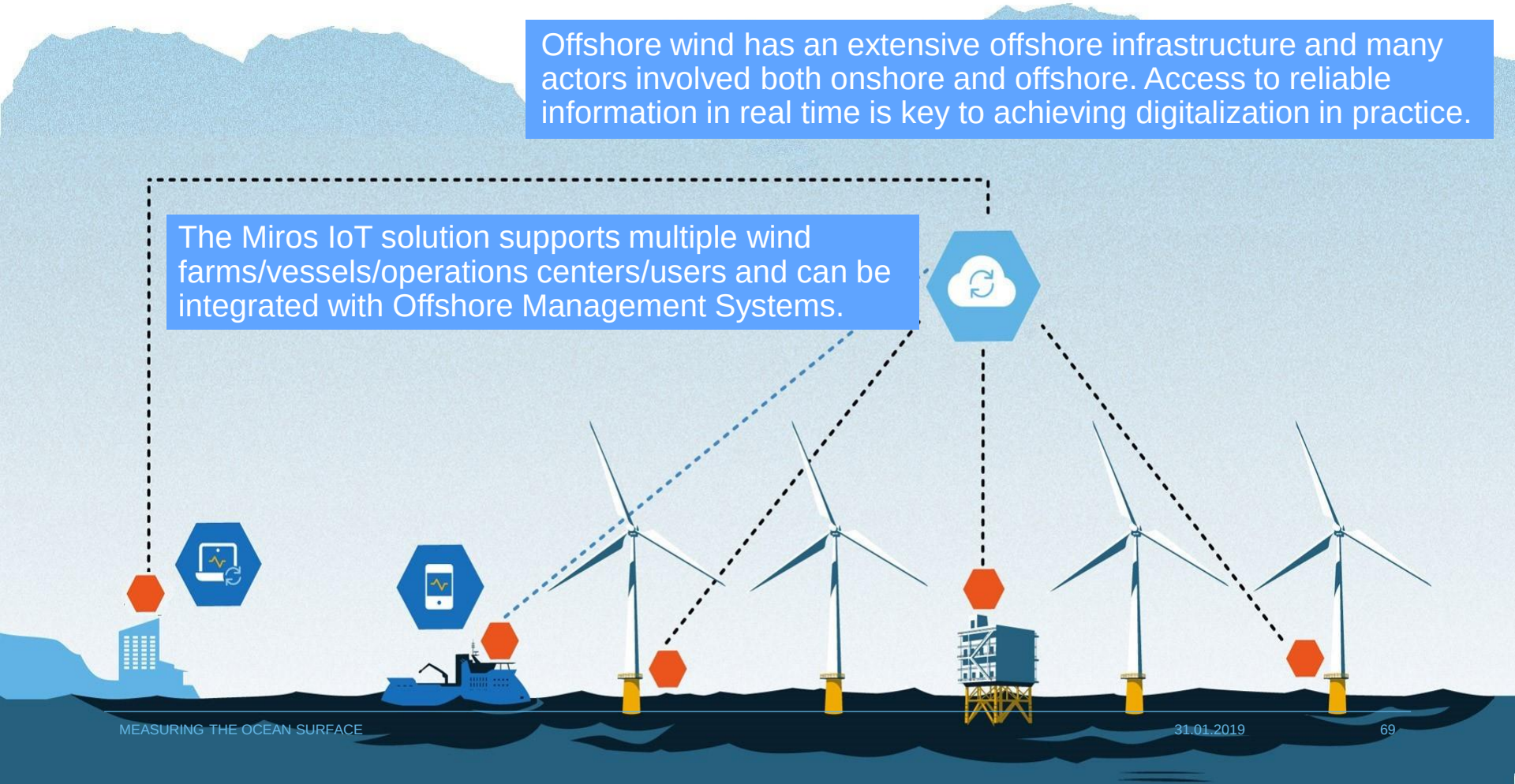
Collecting Metocean data directly to the cloud; making real-time and historical data available for all uses and users, anytime, anywhere.



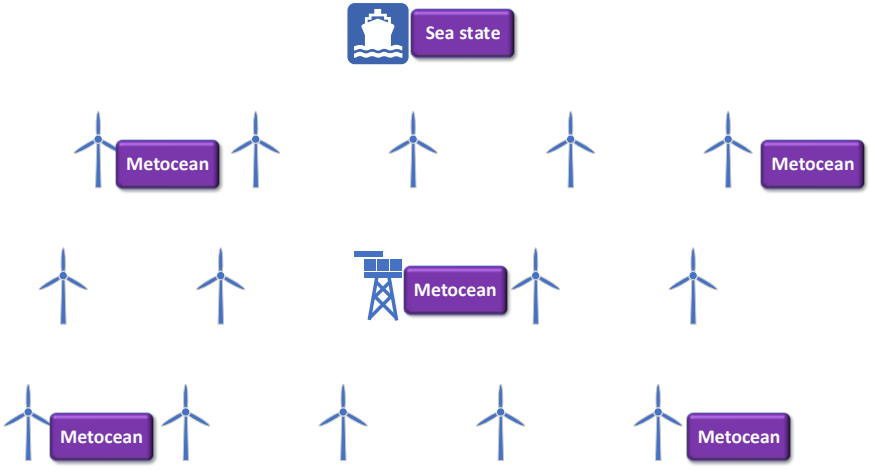
METOCEAN FOR OFFSHORE WIND – THE BIG PICTURE

Offshore wind has an extensive offshore infrastructure and many actors involved both onshore and offshore. Access to reliable information in real time is key to achieving digitalization in practice.

The Miros IoT solution supports multiple wind farms/vessels/operations centers/users and can be integrated with Offshore Management Systems.

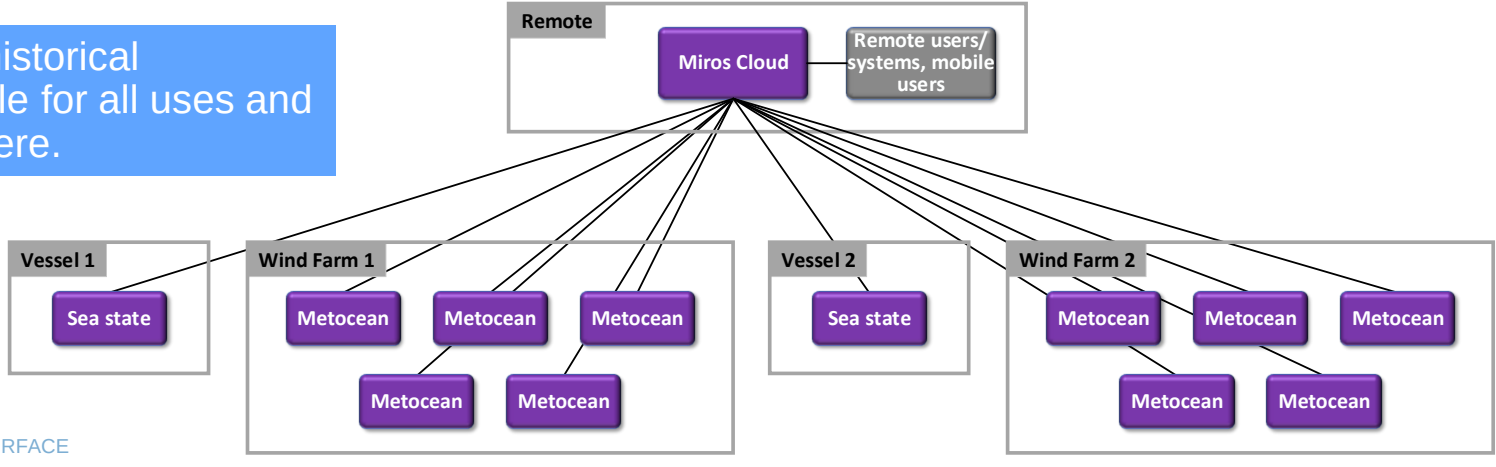


MIROS SOLUTION FOR OFFSHORE WIND



Miros Cloud UI

Making real-time and historical Metocean data available for all uses and users, anytime, anywhere.



SUMMARY – MIROS METOCEAN AS-A-SERVICE

- **COST REDUCTION** - Modern, dry IoT sensors with high reliability and low operating cost. Installation & Maintenance via local personnel. Reduced CAPEX through as-a-Service Model. Reduced OPEX through optimization of operations.
- **RISK REDUCTION** - Real-time situational awareness for all operational purposes – increased weather windows and enhanced safety at sea.
- **DATA AVAILABILITY** – Holistic environmetal overview across entire organization and teams for planning and analysis.
- **SCALABILITY** across multiple assets, systems and users.

Andy Macdonald
Senior Innovation Manager, ORE Catapult

Jo de Montgros
Partner, Everoze

Professor Helen Hastie
ORCA hub – Heriot Watt University

Saul Matthews
Head of Business Development, Synaptec

Gunnar Prytz
Chief Technology Officer, Miros Group

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Scotland plc: a globally competitive supply chain

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David Stevenson

Head of Energy Supply Chain

Scottish Government

David Stevenson
Head of Energy Supply Chain, Scottish Government

Claire Canning
Project Development Manager, ORE Catapult

Lesley Black
Sales and Marketing Function Leader, CS Wind

Robin Presswood
Executive Director - City Development, Dundee City Council and Spokesperson Forth & Tay Offshore

Philip Taylor
Director, Limpet Technology

Simon Miller
Business Development Manager, Renewables and Subsea Projects, Oceaneering

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ORE Catapult session 2:

O&M for Scotland - maximising the opportunity

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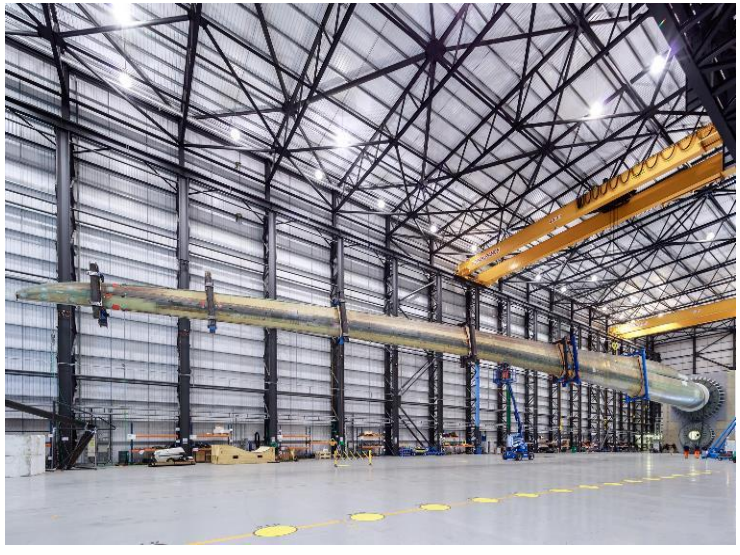
Hazel Gulliver

Director of Policy & Regulation
ScottishPower Renewables

Andy Kay

Head of Project Development

ORE Catapult



O&M for Scottish Offshore Wind
Overview of the Opportunity

29/01/2019 | Andy Kay – Head of Project Development

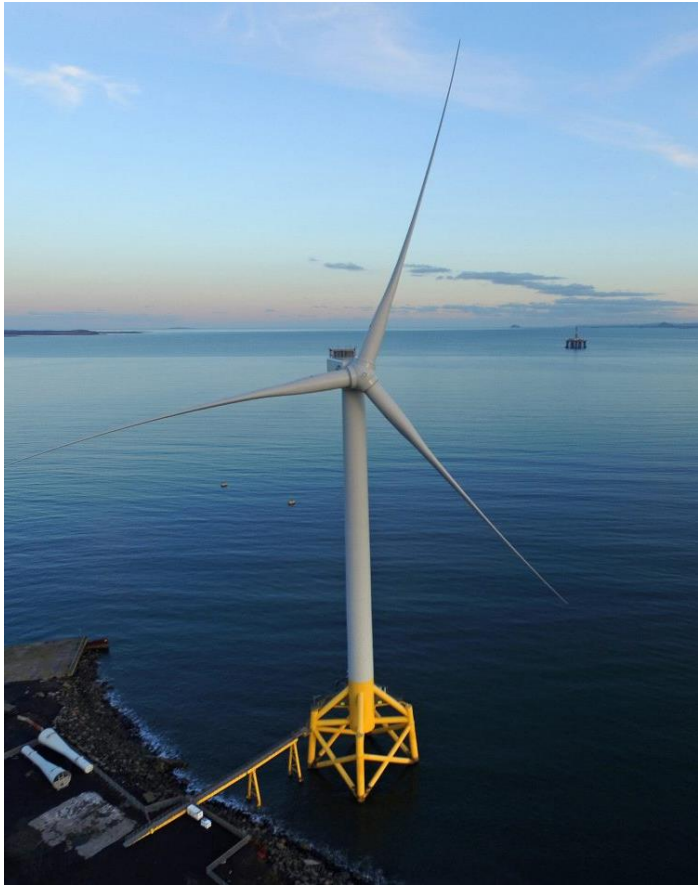
CATAPULT
Offshore Renewable Energy

ORE Catapult & O&M

- Operational Performance Directorate

- Engineering & Project Management
  - Technology Innovation & Demonstration
  - Academic & Supply Chain Support
  - Collaboration Agreements

- Focus areas:
  - O&M Excellence
  - Data and Digital
  - Robotics and Autonomous Systems
  - Balance of Plant (BoP)



Levenmouth 7MW Turbine

Scotland's Offshore Wind O&M Market

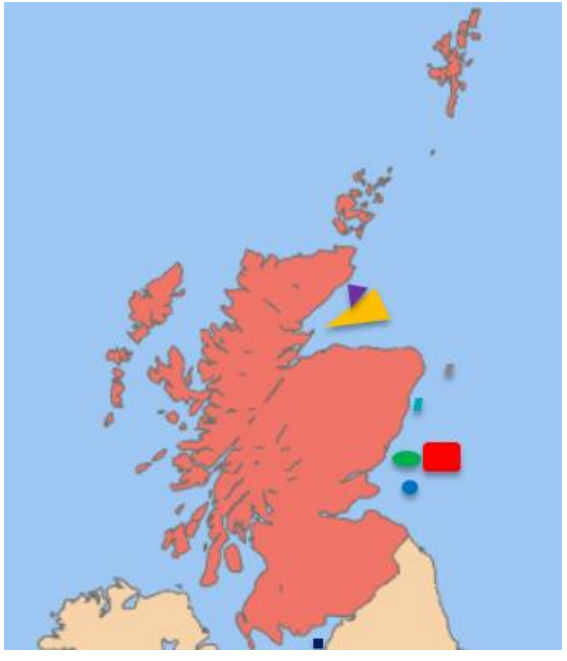
- Operational installed capacity in 2019 (0.3 GW)
- Potential installed capacity in 2030 (5.3 GW)

OPEX (2019) – £65,000/MW/year (avg.)

- *£20 million p.a. addressable market*

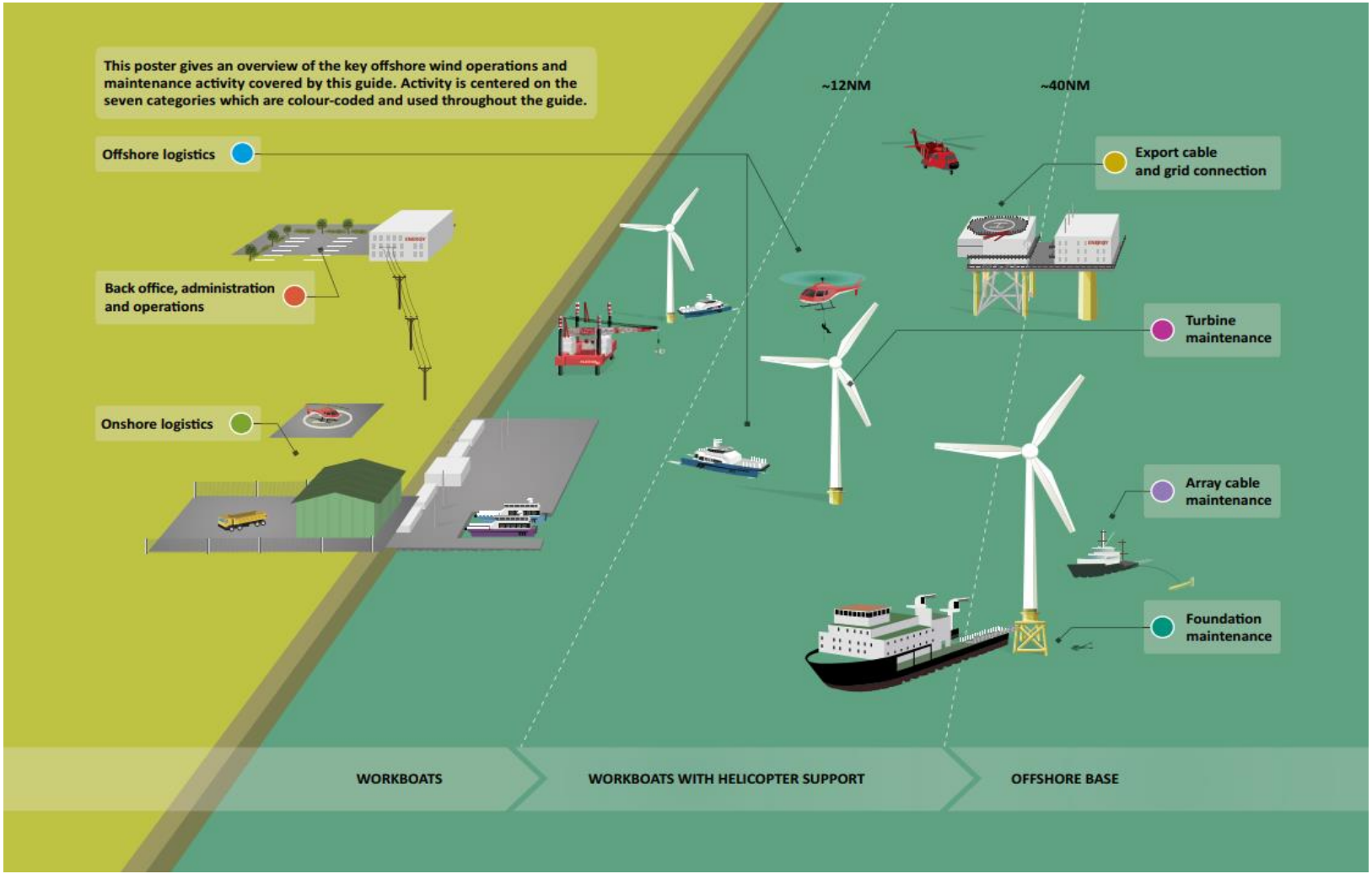
OPEX (2030) – £35,000/MW/year (est.)

- *£186 million p.a. addressable market*



- Robin Rigg – 180 MW
- Aberdeen Bay – 93.2 MW
- Hywind – 30 MW
- Beatrice – 588 MW
- Inch Cape – 784 MW
- Neart na Gaoithe – 448 MW
- Seagreen – 1500 MW
- Moray Firth – 1700 MW

Opportunities for the Scottish Supply Chain



Ref: A Guide to UK Offshore Wind Operations and Maintenance (Crown Estate)

Turbine O&M

Opportunity for Scottish Supply Chain - Low to Medium

- Blades
  - Access
  - External/internal inspection (automation)
  - Maintenance & repair (automation)
- Nacelle
  - Remote monitoring (e.g. novel sensors)
  - Advanced data analytics (e.g. machine learning)
- Technicians
  - Supply for turbine and H&S inspections
  - Remote supervision (e.g. augmented reality)
  - Health monitoring

Blade leading edge erosion

BoP O&M

Opportunity for Scottish Supply Chain - High

- Seabed
  - Scour surveys (automation)
  - Sensing & data analytics
- Foundations
  - Structural health monitoring
  - Data analytics and predictive modelling
  - External/internal inspection (automation)
  - Protection (corrosion & biofouling)
- Cables
  - Online monitoring
  - Inspection (automation)
  - Repair (e.g. jointing)

Ref: Oil & Gas people

Ref: 4C

Ref: CIP

Logistics (onshore & offshore)

Opportunity for Scottish Supply Chain - Medium to High

- Onshore Logistics
  - Port facilities, equipment & staff
  - Inventory management tools
- Offshore Logistics
  - Advanced planning tools
    - Vessels (CTV and SOV scenarios)
    - Weather (turbine access forecasting)
    - Tasks (increase time between visits)
  - Weather and Seastate measurement/forecasting
  - Robust communication equipment & infrastructure

Ref: Power-Technology

Challenges facing the Scottish Supply Chain

- ***Competition*** – need to add value (reduce OPEX, reduce downtime, increase H&S)
- ***Commercial viability*** – will a solution/service provide value for money?
- ***Technical validation*** – is a solution/service fit for purpose?
- ***Demonstration*** – de-risk technologies, attract investment and add credibility

Summary

- Offshore wind O&M in Scotland
  - £186 million p.a. potential market size by 2030
- Largest opportunities for the Scottish Supply Chain
  - Supply of human personnel and port facilities
  - Offshore logistics planning tools
  - Advanced data analytics tools & services
  - Automation of O&M tasks (equipment & services)
  - BoP O&M
- Challenges can be addressed through collaboration with ORE Catapult

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Leven
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Cian Conroy

Senior Manager

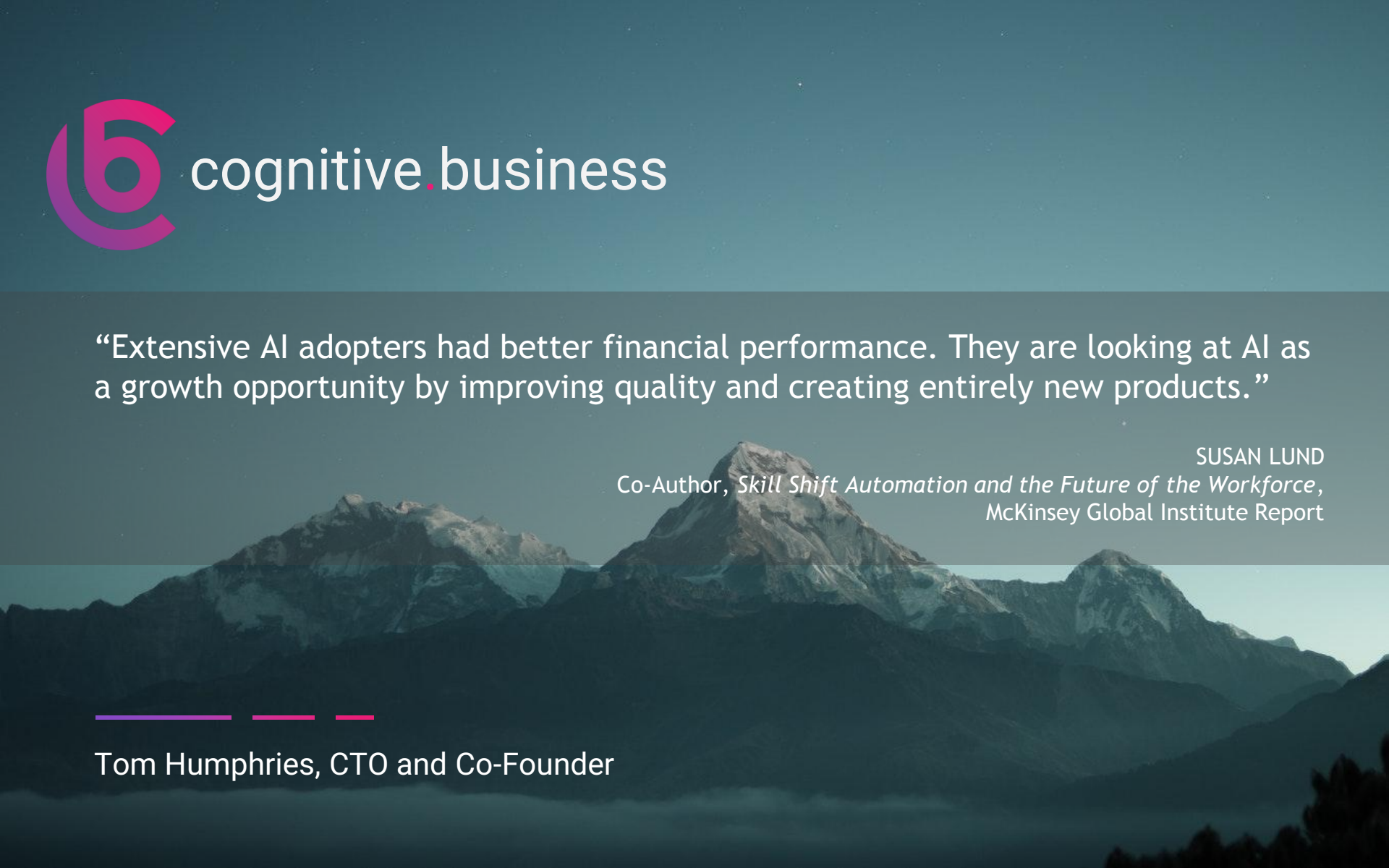
Principle Power

View presentation here

Thomas Humphries

Co-Founder

Cognitive.Business


cognitive.business
“Extensive AI adopters had better financial performance. They are looking at AI as a growth opportunity by improving quality and creating entirely new products.”
SUSAN LUND
Co-Author, *Skill Shift Automation and the Future of the Workforce*,
McKinsey Global Institute Report
Tom Humphries, CTO and Co-Founder

2.4B

Machine Learning calculations every 10 minutes

Google

who's the actor with the eyebrows?

All Images News Shopping Videos More Settings Tools

About 30,400,000 results (0.46 seconds)

William Jack Poulter

William Jack Poulter (born 28 January 1993) is an English actor known for his work in the films Son of Rambow (2007), The Chronicles of Narnia: The Voyage of the Dawn Treader (2010), **We're the Millers** (2013), The Maze Runner (2014), The Revenant (2015), Detroit (2017), Maze Runner: The Death Cure (2018), and Black ...

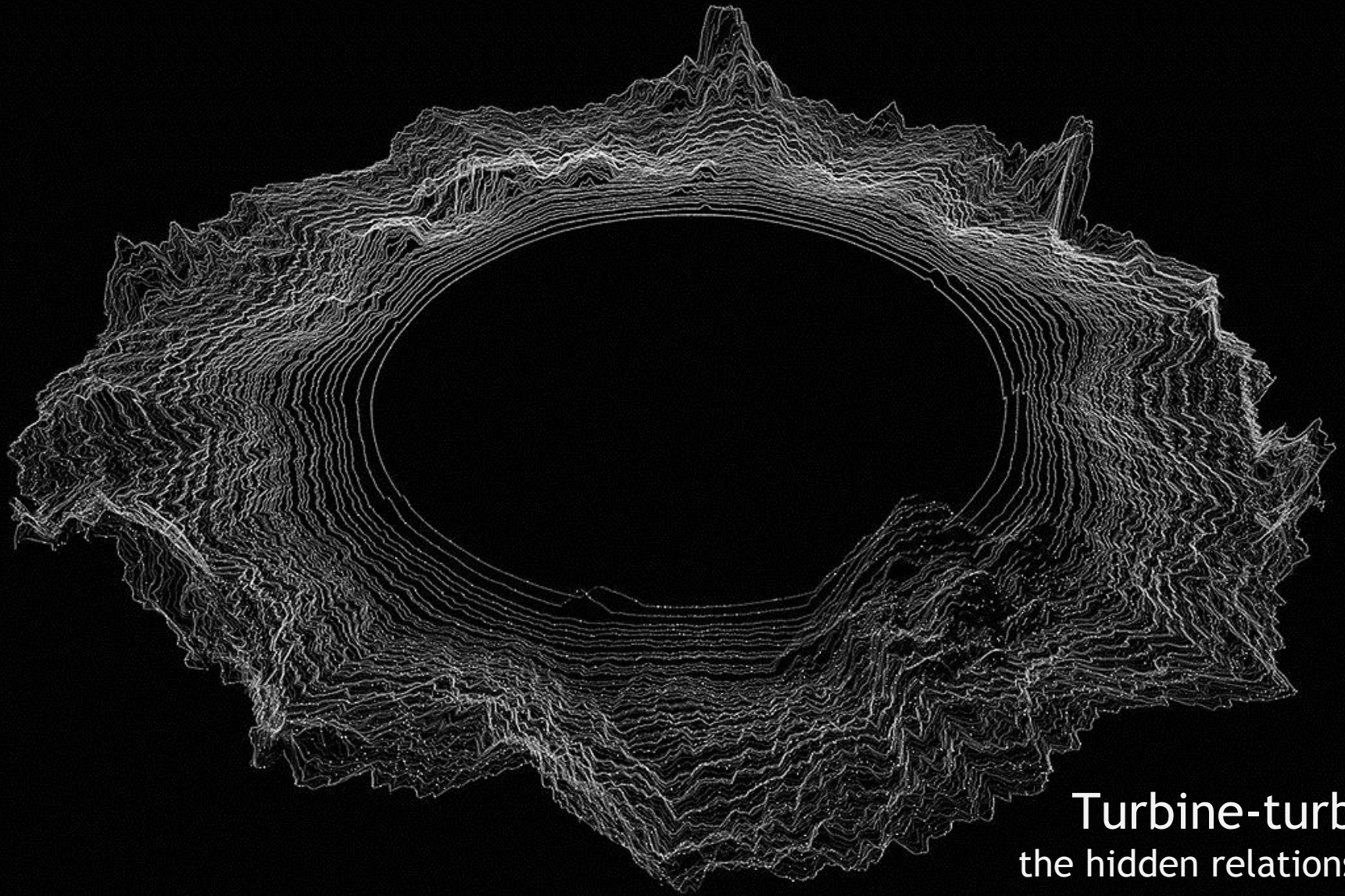
Will Poulter - Wikipedia
https://en.wikipedia.org/wiki/Will_Poulter

About this result Feedback


“Humble” A.I.

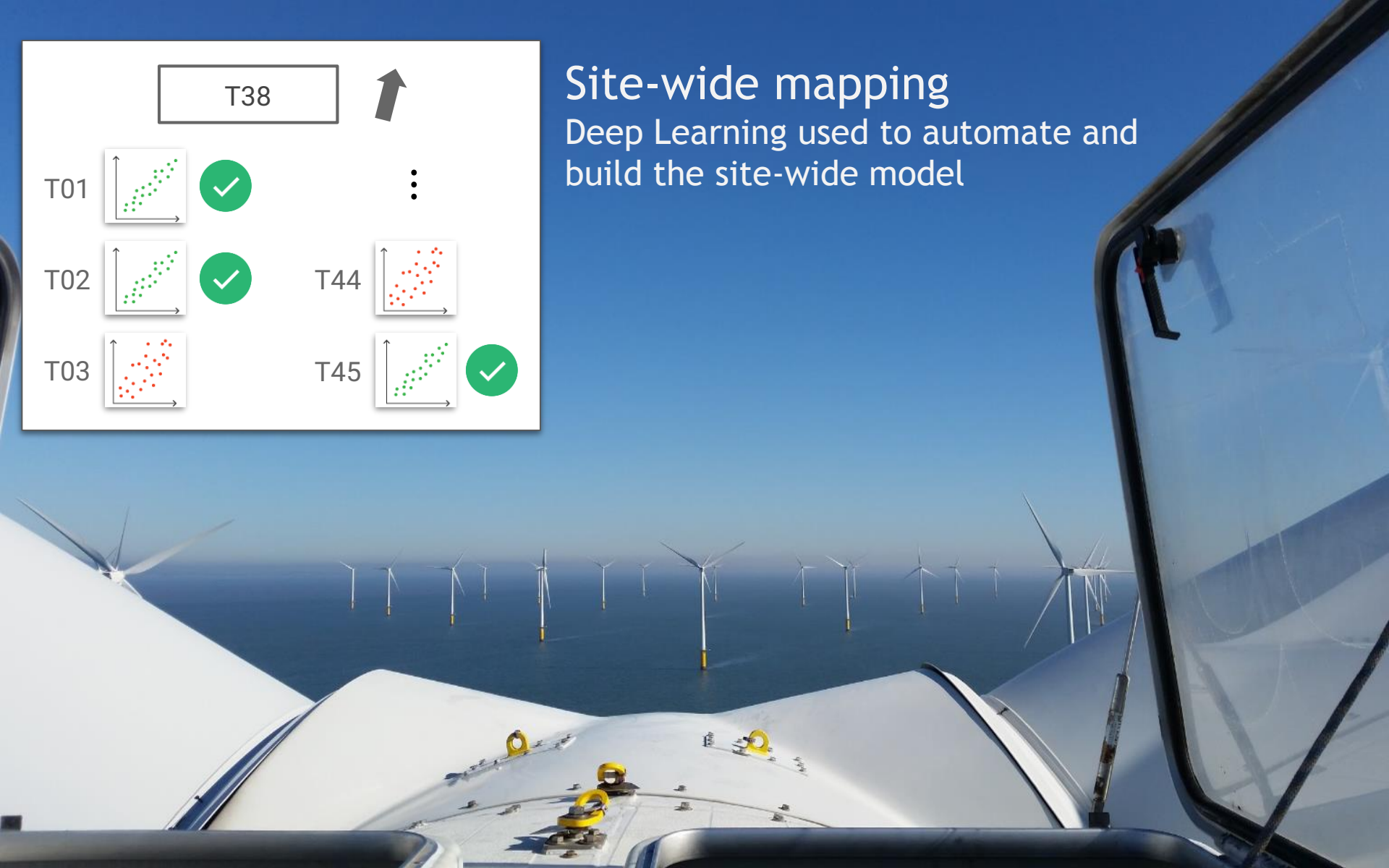

Where to begin?

Performance monitoring



Turbine-turbine

the hidden relationships



Site-wide mapping

Deep Learning used to automate and build the site-wide model

Outcomes

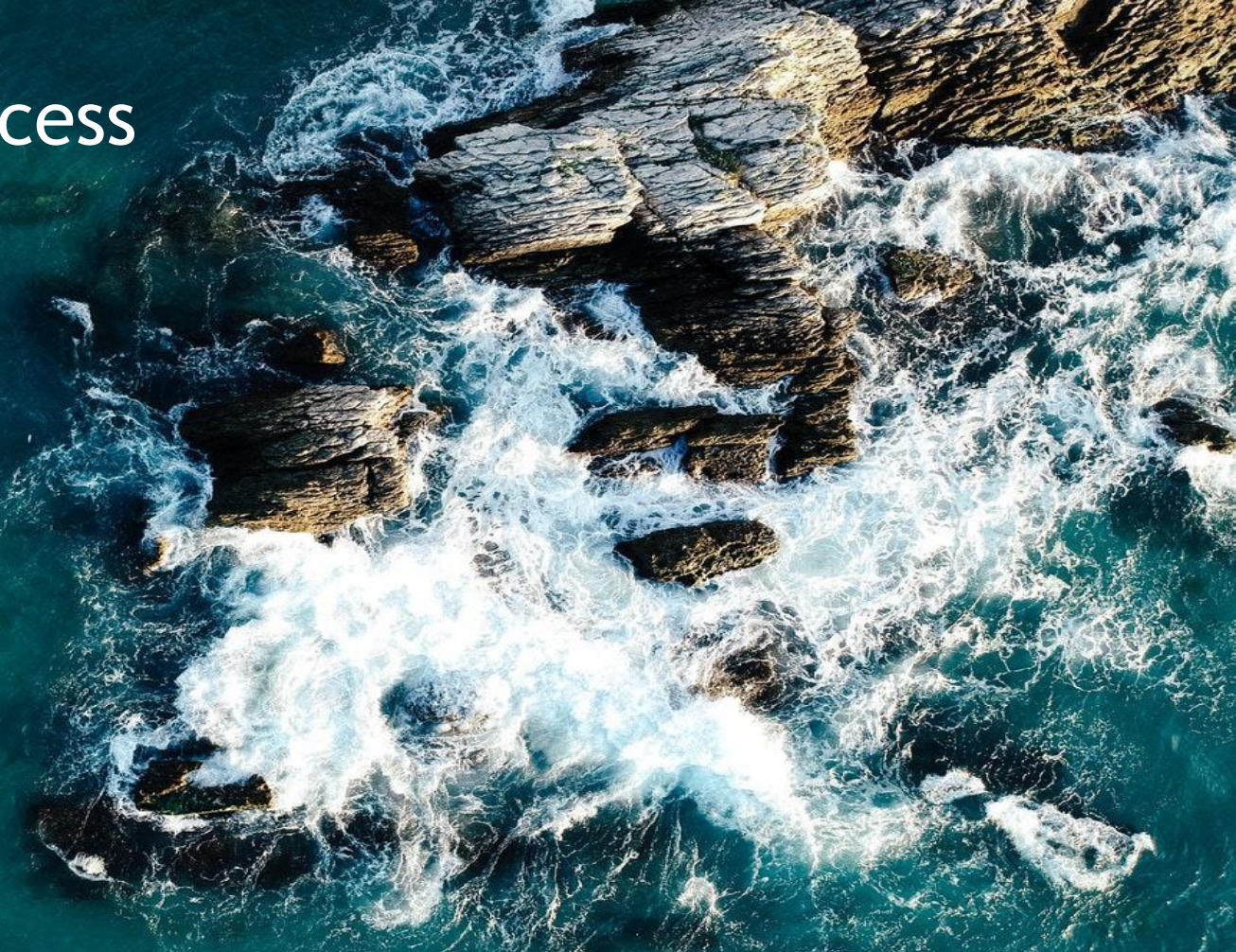
Automated | 3% resolution | Gained more value from existing data | Digitalising knowledge | Scalable and repeatable process | Live and Online

Key to A.I. Success

Insight is worthless without action

Intrinsically linked to transparency of the system, need to believe the output to action it

Humble AI - keep the human in the loop for maximum value



“Continuous improvement is better than delayed perfection”
MARK TWAIN

Phil Buchan

Commercial Director

Cyberhawk

CYBERHAWK

Aerial Inspection and Surveying Specialists

Using Drone Collected Inspection Data to Significantly Improve Offshore O&M

Presented by

Phil Buchan - Director

Contents

About CYBERHAWK


CYBERHAWK Team
>60 Members of Staff
Pilots
Inspection Engineers
Surveyors
Software Developers

Selected Clients

Our Experience

Offshore Wind Farms

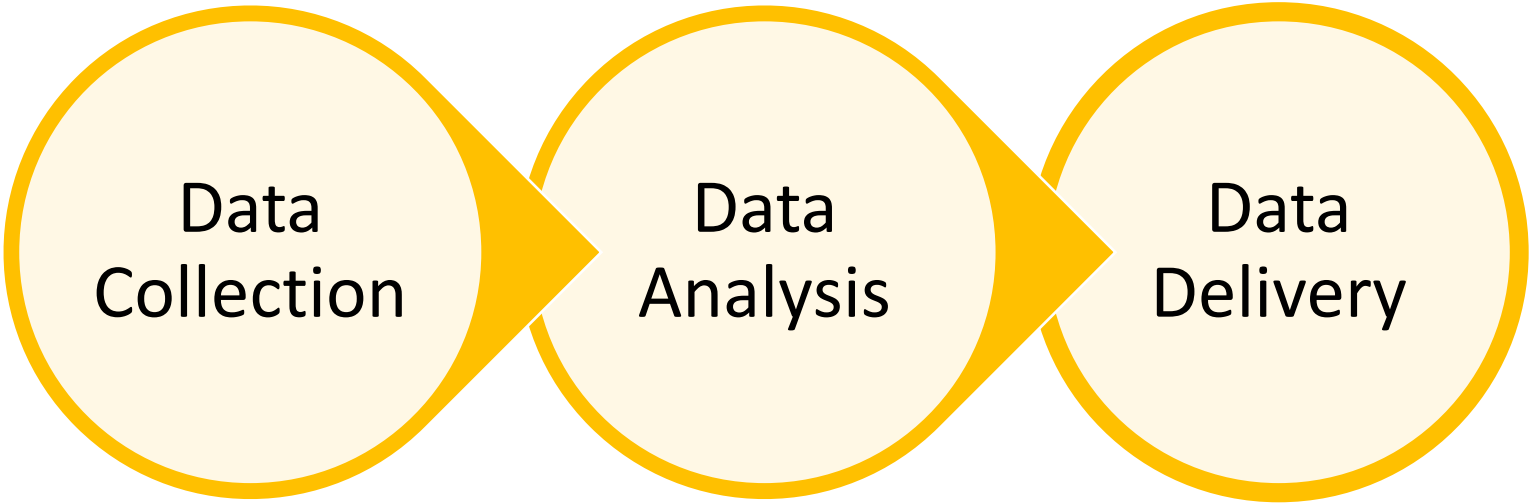
- Anholt
- BorWin
- Docking Shoal
- Dogger Bank
- Greater Gabbard
- HelWin
- Lincs
- Moray
- Race Bank
- Rhyl Flats
- Robin Rigg
- SylWin
- Teesside
- Trianel
- West of Duddon Sands

Onshore Wind Farms

- Scotland
- Republic of Ireland
- Northern Ireland
- England
- Denmark
- Germany
- Croatia
- Turkey

Offshore Turbine Inspection

Cyberhawk Inspection Process



- Drone
- AI & Inspection Engineers
- Cloud Based Software

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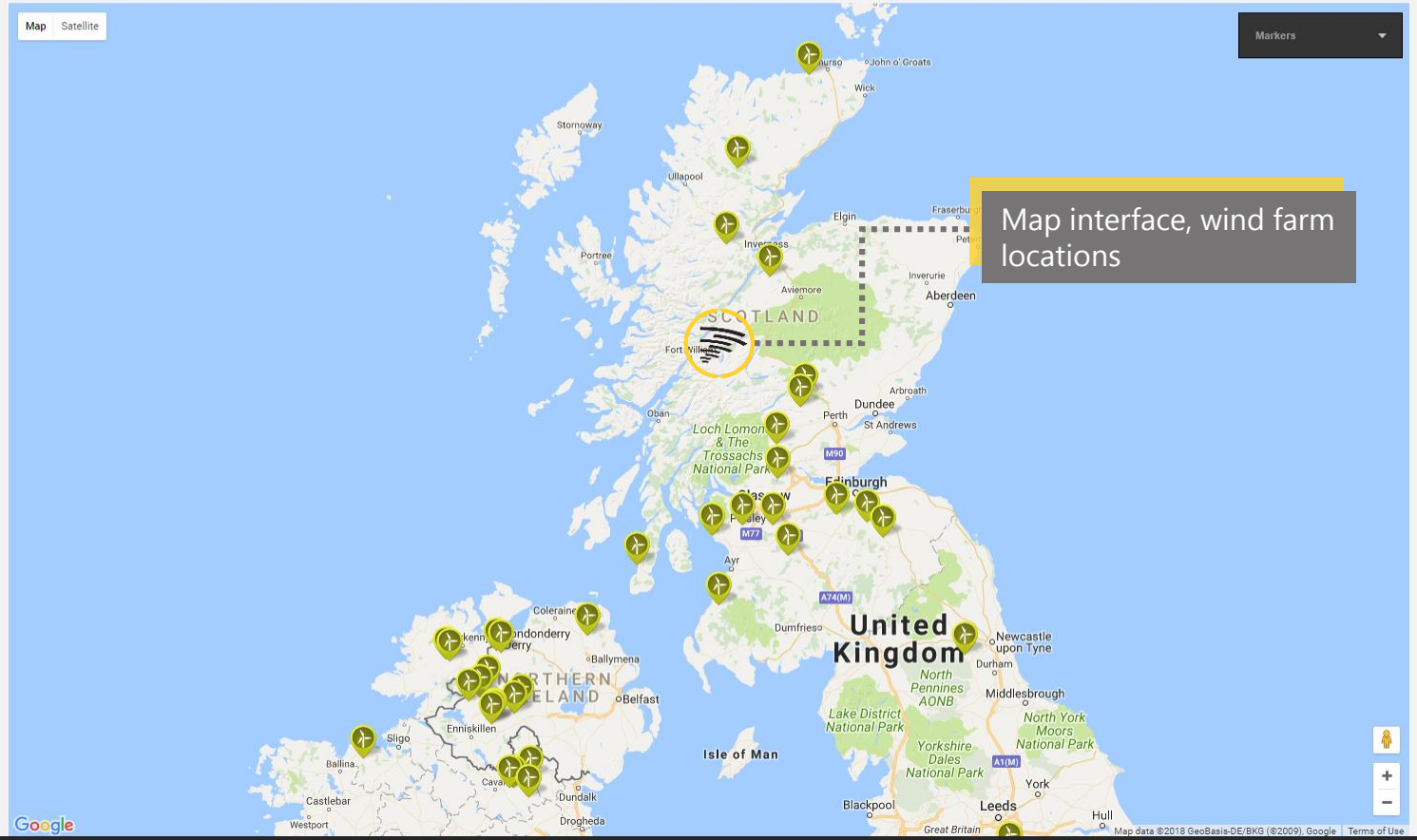
BY CYBERHAWK

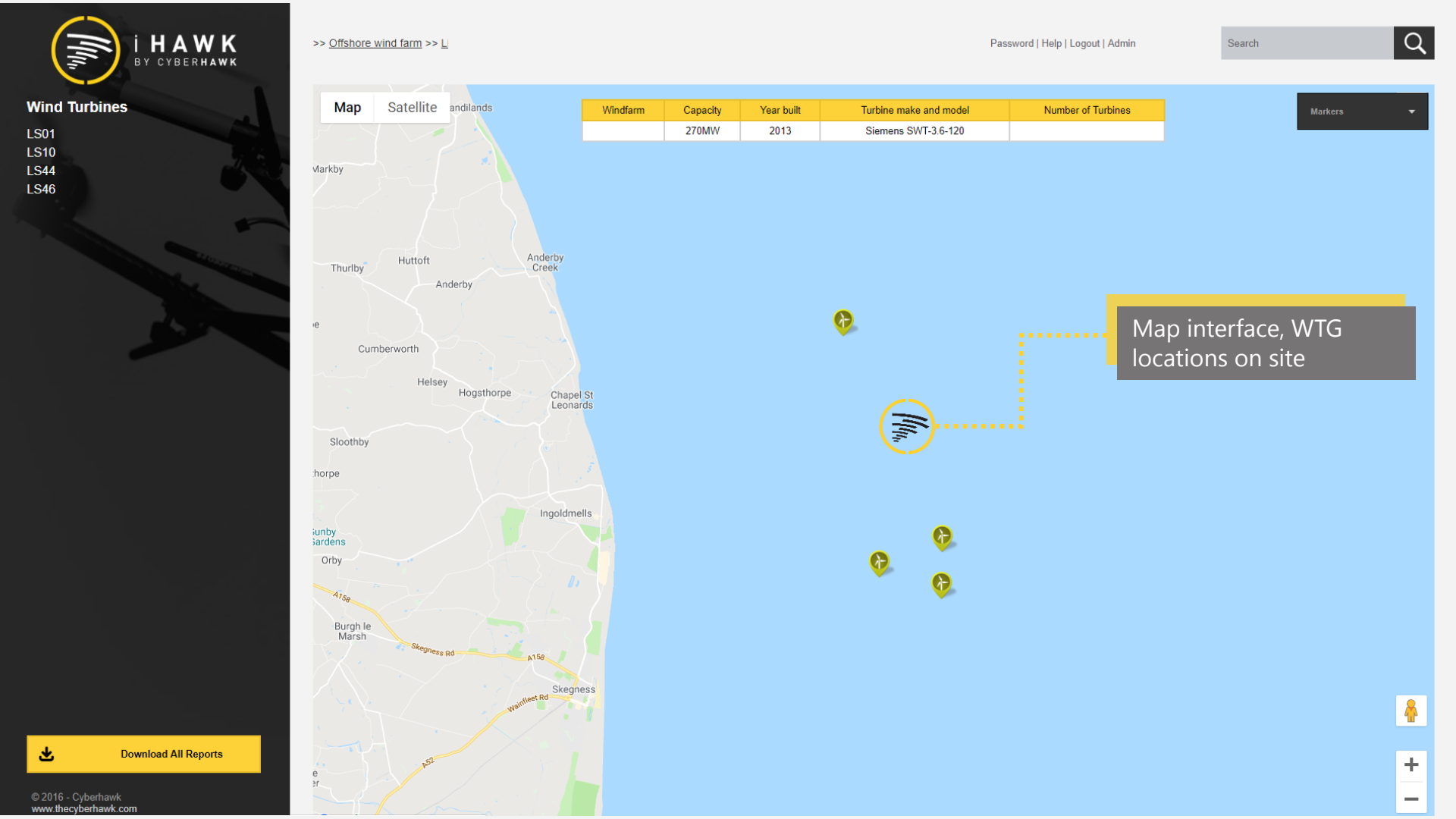
Wind Farms

>> Onshore wind farm

Password | Help | Logout | Admin

Search




i HAWK
BY CYBERHAWK
Wind Turbines
LS01
LS10
LS44
LS46
>> Offshore wind farm >> L
Password | Help | Logout | Admin
Search
Map
Satellite
Windfarm
Capacity
Year built
Turbine make and model
Number of Turbines
270MW
2013
Siemens SWT-3.6-120
Markers
Map interface, WTG locations on site
Markby
Thurlby
Huttoft
Anderby Creek
Anderby
Cumberworth
Helsey
Hogsthorpe
Chapel St Leonards
Sloothby
Ingoldmells
Orby
Burgh le Marsh
Skegness Rd
A158
Skegness
Wainfleet Rd
A52
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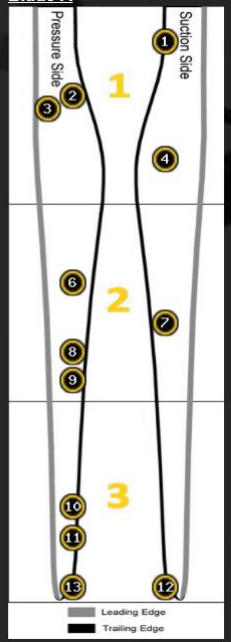
WTG Data			Rotor Blades											
			Blade - SGL-0538				Blade - SGL-0540				Blade - SGL-0541			
WTG No	Inspection Date	WGS 84- Lat/Long	Pressure Side	Suction Side	Leading Edge	Trailing Edge	Pressure Side	Suction Side	Leading Edge	Trailing Edge	Pressure Side	Suction Side	Leading Edge	Trailing Edge
WTG 1	28-06-2016	57.5395 -4.66326	3	3	3	2	3	3	3	1	3	2	3	3
WTG 2	28-06-2016	57.5362 -4.66247	2	1	4	2	2	2	3	2	2	1	3	2
WTG 3	29-06-2016	57.5342 -4.65952	2	2	4	1	2	2	3	2	3	3	3	2
WTG 4	06-09-2017	57.5311 -4.65498	3	2	4	2	2	3	3	3	1	3	4	2
WTG 5	06-09-2017	57.53 -4.65135	1	3	4	2	4	2	4	2	1	2	4	3
WTG 6	05-09-2017	57.5289 -4.64758	3	1	3	4	3	2	4	1	4	1	4	2
WTG 7	05-09-2017	57.528 -4.64382	1	2	4	3	4	2	4	1	1	2	4	1
WTG 8	05-09-2017	57.5268 -4.63927	4	2	4	2	1	3	4	2	2	2	4	2
WTG 9	06-09-2017	57.5399 -4.65697	3	3	4	2	2	3	4	1	3	2	4	2
WTG 10	29-06-2016	57.5378 -4.65586	3	3	3	1	3	3	3	2	3	3	3	1
WTG 11	06-09-2017	57.5353 -4.65482	2	2	3	2	3	3	4	2	2	2	3	2
WTG 12	06-09-2017	57.5332 -4.65314	4	1	4	3	1	2	4	2	2	1	4	3
WTG 13	24-08-2017	57.532 -4.64968	3	2	3	3	3	2	3	2	3	2	3	3
WTG 14	29-06-2016	57.5321 -4.64478	2	2	3	2	2	2	4	2	2	2	4	2
WTG 15	29-06-2016	57.5302 -4.6419	3	3	4	2	3	3	3	2	3	2	3	2
WTG 16	30-06-2016	57.5316 -4.63794	3	3	3	2	3	3	3	2	2	3	3	1
WTG 17	24-08-2017	57.5289 -4.63661	4	2	4	2	3	1	3	2	4	2	4	2
WTG 18	30-06-2016	57.5268 -4.63396	3	3	3	3	3	3	4	1	3	3	4	3
WTG 19	30-06-2016	57.5288 -4.63027	3	3	3	2	3	2	4	1	3	3	3	3
WTG 20	01-07-2016	57.5308 -4.62638	3	3	3	1	3	3	4	1	3	3	3	1

5	Substantial Structural Damage
4	Structural Damage
3	Functional Damage
2	Superficial Damage
1	Good working condition

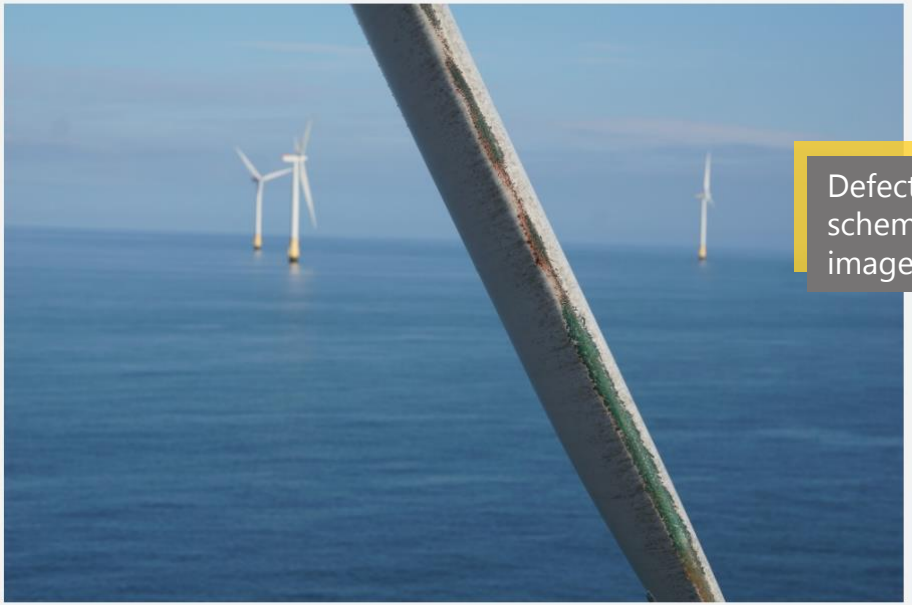
Wind farm summary reporting matrix

iHAWK BY CYBERHAWK

Turbine: LS10
Inspection Date: 20-09-2016
Blade A



LE
TE
PS
SS
LE
TE
PS
SS
LE
TE
PS
SS



Defects on blade schematic & access to all images

Previous Finding

Image 7 of 8

Next Finding

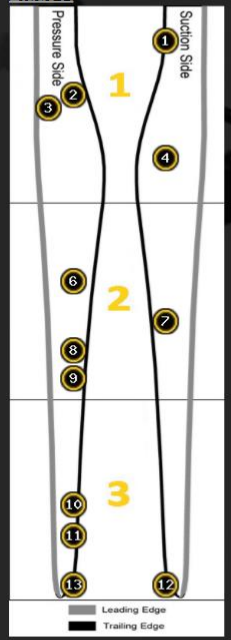
Finding no	11	Distance from root (m)	58	Defect Class	3
Finding Type	Coating Damage	Distance from LE (cm)		Condition	Functional Damage
Comment	LE erosion				

Gallery

All images sorted by *Distance from Root*

iHAWK BY CYBERHAWK

Turbine: LS10
Inspection Date: 20-09-2016
Blade A



LE
TE
PS
SS
LE
TE
PS
SS
LE
TE
PS
SS

Zoom into detail

Previous Finding

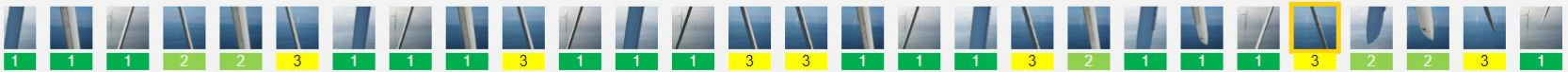
Image 7 of 8

Next Finding

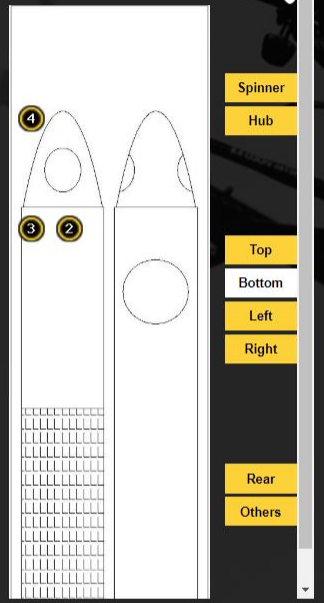
Finding no	11	Distance from root (m)	58	Defect Class	3
Finding Type	Coating Damage	Distance from LE (cm)		Condition	Functional Damage
Comment	LE erosion				

Gallery

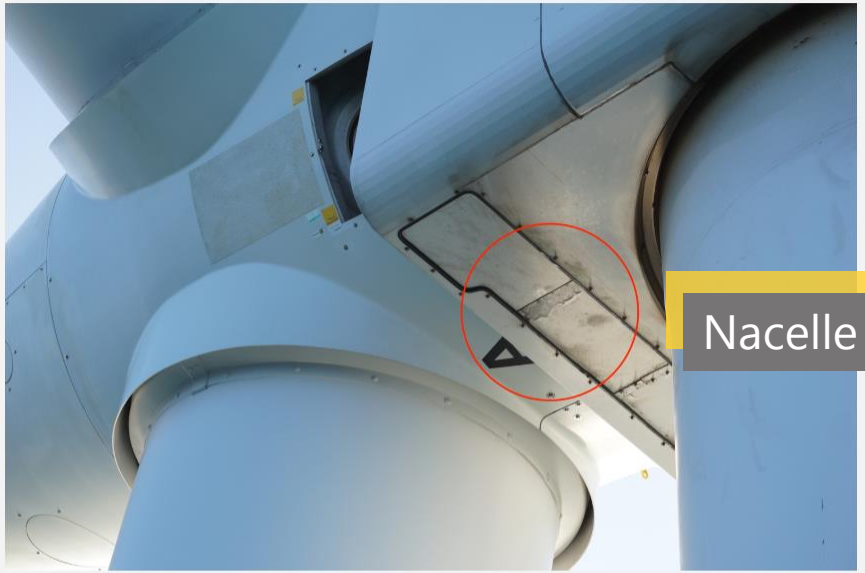
All images sorted by *Distance from Root*



Turbine: LS10



Spinner
Hub
Top
Bottom
Left
Right
Rear
Others



Nacelle Inspection

Previous Finding

Image 3 of 3

Next Finding

Finding no	3	Distance from Platform		Defect Class	2
Finding Type	Coating Condition	Distance from LE (m)	0	Condition	Superficial (Slight) Damage
Comment	Coating damage				

Gallery

All Images

All Findings

All Images

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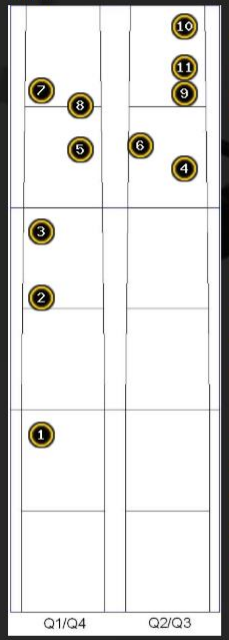
Turbine: 1
Inspection date: 2015-01-01



1 2 3 4

1 2 3 4

1 2 3 4

Tower Inspection

Previous Finding Image 1 of 4 Next Finding

Finding no	10	Distance from Platform	62.1	Defect Class	2
Finding Type	Coating Condition	Distance from LE (m)	0	Condition	Superficial (Slight) Damage
Comment	Grease Contamination				

Gallery

All images from section 1, Quadrant 1 - sorted by *Distance to Platform*

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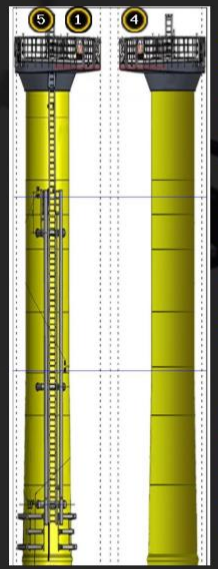
Turbine: LS10



1 2 3 4 1 2 3 4 1 2 3 4

Transition Piece Inspection

Previous Finding

Image 1 of 1

Next Finding

Finding no	4	Distance from Platform		Defect Class	2
Finding Type	Coating Condition	Distance from LE (m)	0	Condition	Superficial (Slight) Damage
Comment	possible corrosion on platform and supports				

All Images - sorted by *Distance to Platform*

All Findings

All Images

Offshore Substation Inspection

Siemens - TenneT Converter Station

- Inspection of 3 offshore converter stations
- Completed in 7 days
- Harsh winter conditions
- Increased safety vs traditional rope access
- Savings in time and cost

• North Elevation

View Looking South

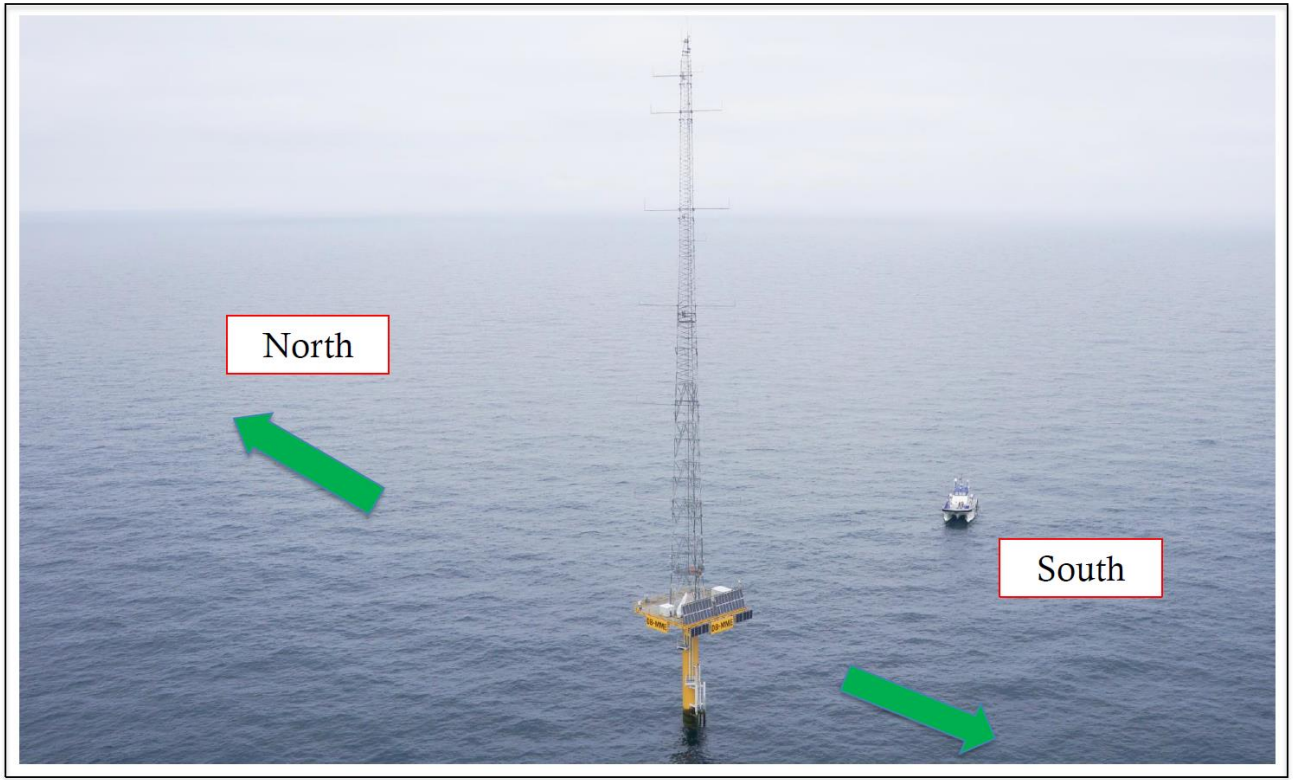
Superstructure underside in good condition with no obvious signs of defects.

Photo: DSC00452.jpg

Offshore Met Mast Inspection

CYBERHAWK
Aerial Inspection and Surveying Specialists

Metrological Mast XX MME (East)



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Tel: +44 (0) 1506 592187 info@thecyberhawk.com

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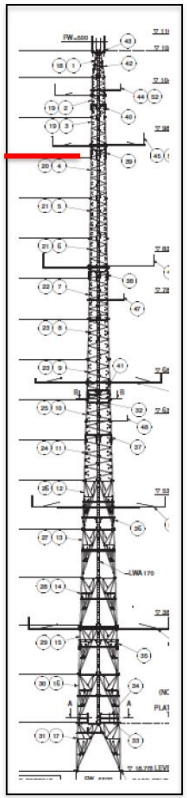
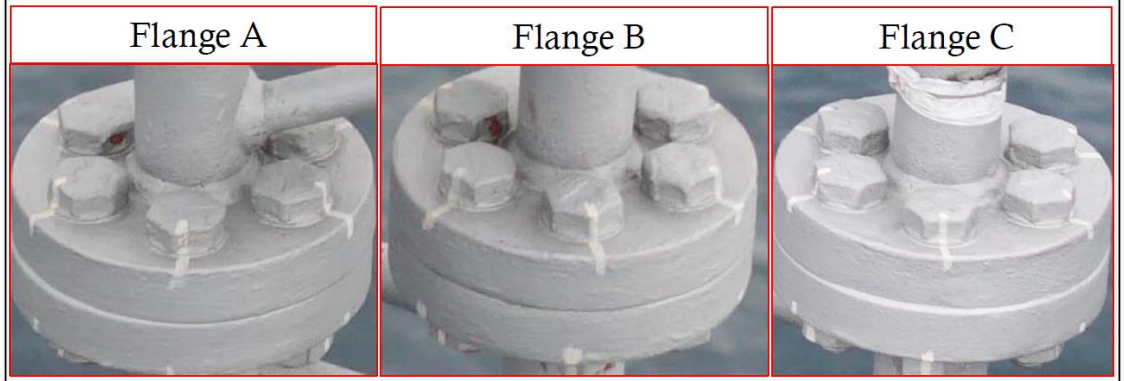
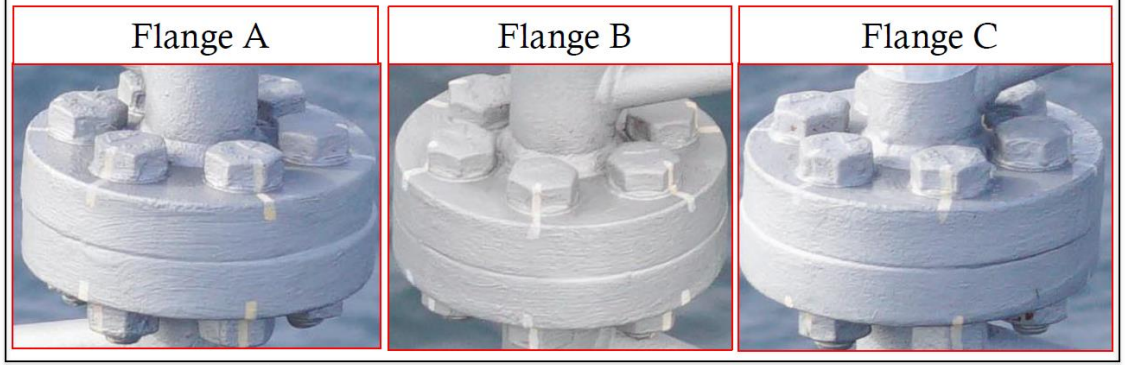
Module 10 – Flanges at 76m top







Refer to page 7 for individual flange assessment and sketch on page 26 which explains the identification of each individual nut above

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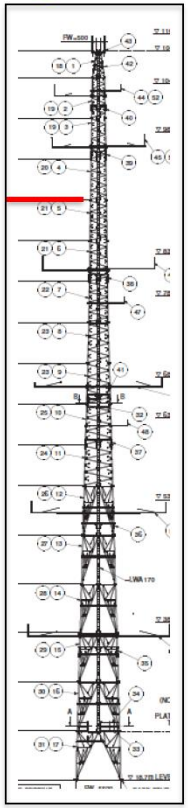
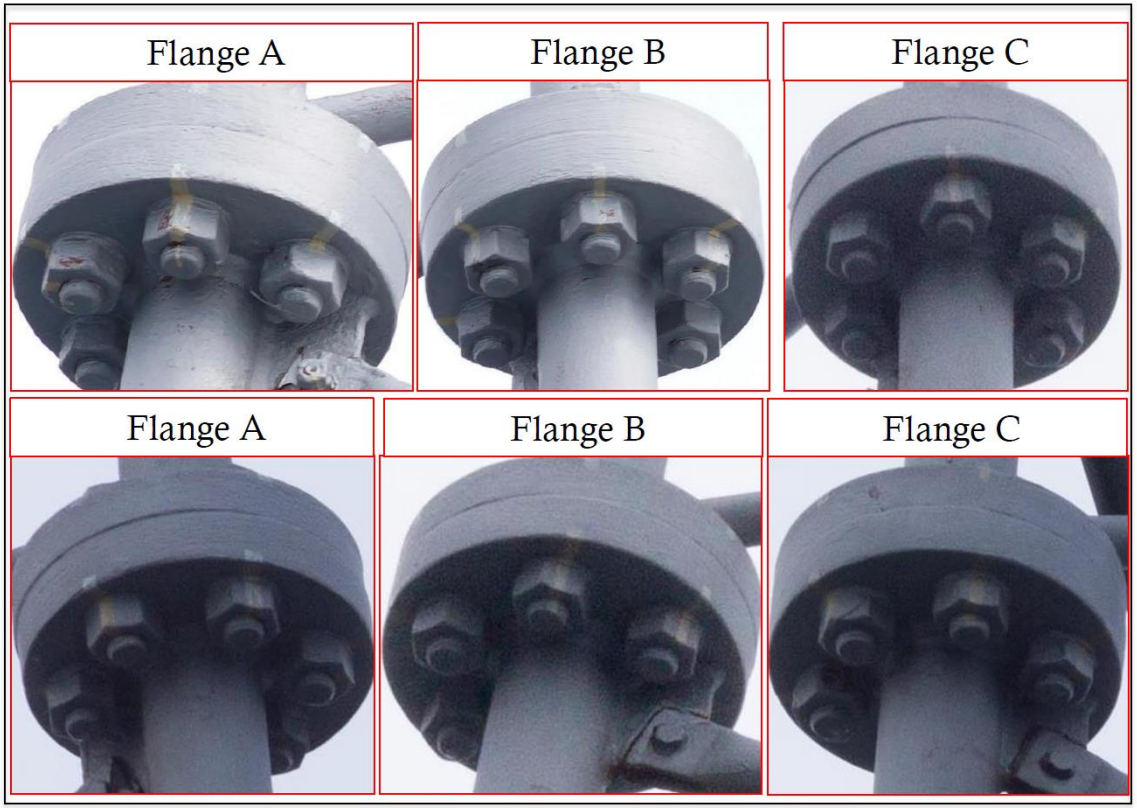
Module 11 – Flanges at 71m bottom





Refer to page 7 for individual flange assessment and sketch on page 32 which explains the identification of each individual nut above

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A: Innovation Centre | Alba Campus | Livingston | EH54 7GA | UK

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Director of Policy & Regulation,
ScottishPower Renewables

Andy Kay
Head of Project Development, ORE Catapult

Cian Conroy
Senior Manager, Principle Power

Thomas Humphries
Co-Founder, Cognitive.Business

Phil Buchan
Commercial Director, Cyberhawk

ORGANISED BY

scottish renewables

IN ASSOCIATION WITH

CATAPULT Offshore Renewable Energy

OFFSHORE WIND CONFERENCE, EXHIBITION & DINNER

28 & 29 JANUARY 2019 **GLASGOW**

areg Aberdeen Renewable Energy Group

Crown Estate Scotland Oighreachd a' Chrùin Alba

DEME Dredging, Environmental & Marine Engineering

FORTH & TAY OFFSHORE

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

OCEANEERING®

Offshore Wind Journal

reNEWS

Project speed-updates: later-stage projects

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#SROFFSHORE19

Steve Wilson

Project Director

SSE – Beatrice Offshore Wind Farm


Beatrice
Offshore Windfarm Ltd
PACIFIC ORCA
Steven Wilson
Project Director


PACIFIC ORCA
Beatrice
Offshore Windfarm Ltd

TURBINE INSTALLATION

54
INSTALLED

- >60% turbines installed
- Completion May 2019
- Handover June 2019

Beatrice
Offshore Windfarm Ltd


Beatrice
Offshore Windfarm Ltd


O&M BASE
MARINE FACILITIES
Beatrice
Offshore Windfarm Ltd

WICK HARBOUR

- £20m investment
- Historic building restoration
- Harbour repurposing
- Pontoon installation
- Completion April 2019

Beatrice
Offshore Windfarm Ltd


Beatrice
Offshore Windfarm Ltd

POWER EXPORT

- First export on 19 July 2018
- Over 400GWh generated to date
- Output can power 450,000 homes

Beatrice
Offshore Windfarm Ltd


Beatrice
Offshore Windfarm Ltd

BLACKHILLOCK

- Energised May 2018
- Commissioned June 2018
- OFTO Process Ongoing

Beatrice
Offshore Windfarm Ltd

Beatrice
Offshore Windfarm Ltd

beatricewind.com

@beatricewind

Crown Estate Scotland
Oighreachd a' Chrùin Alba

David Sweenie

Development Manager

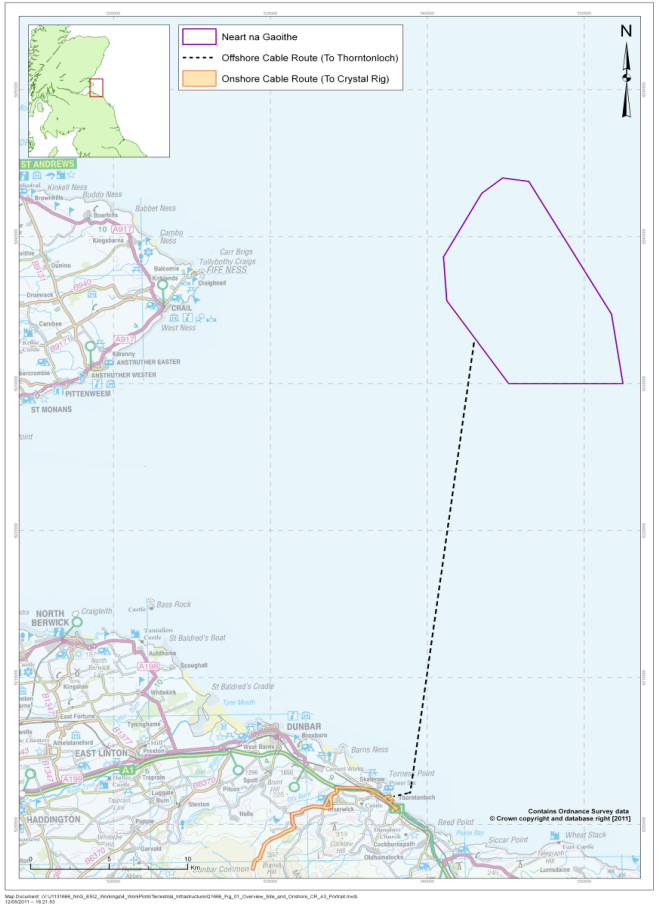
EDF Renewables - Neart Na Gaoithe Offshore Wind Farm

Neart na Gaoithe

Scottish Renewables

29th January 2019

Project Overview



Project Capacity

- Consented 450MW
- CfD 448MW

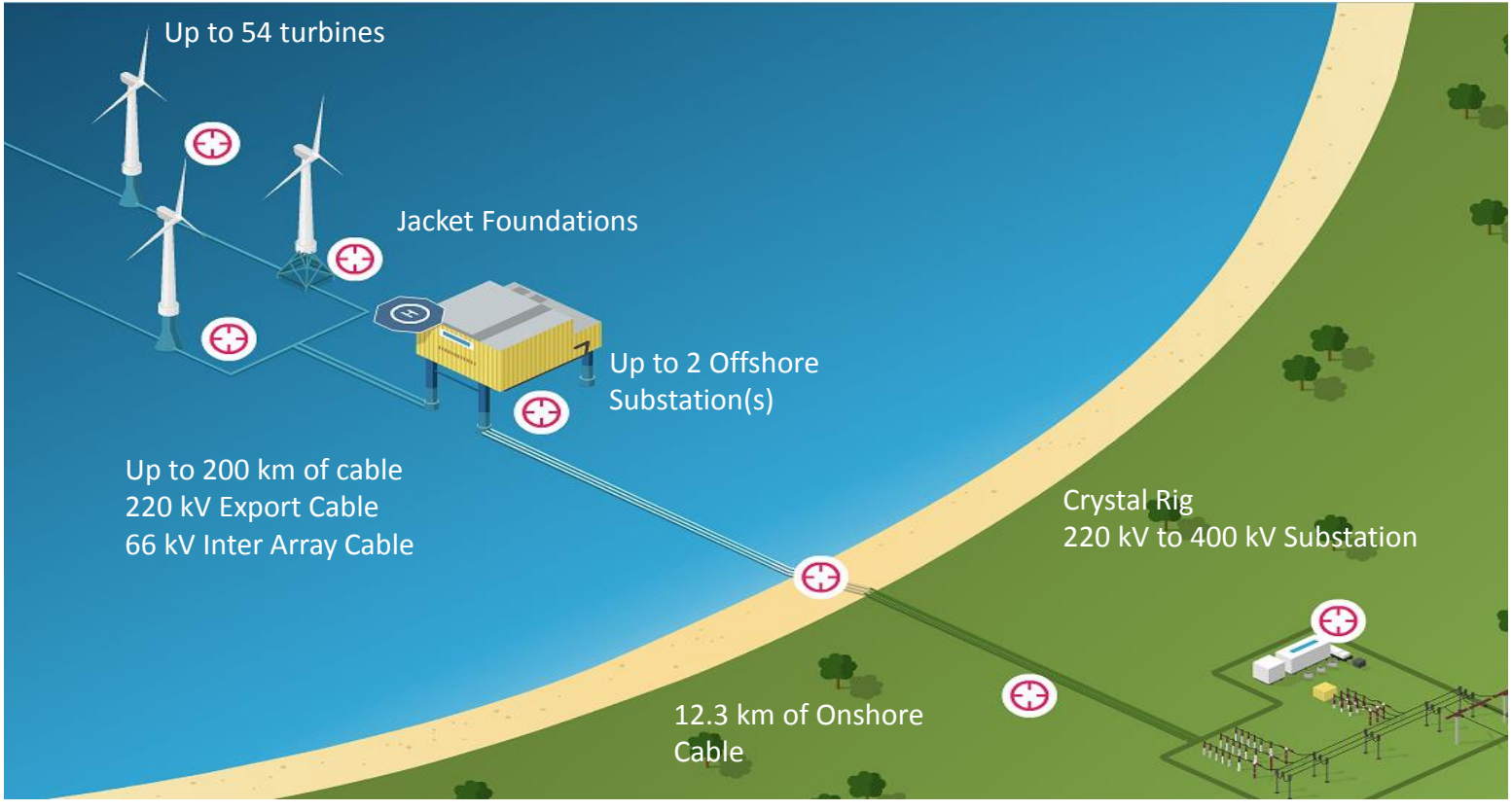
Information

- Located in the Outer Firth of Forth
- 15km East of Fife Ness
- Grid connection at Crystal Rig (Lammermuir Hills)
- Water depths of between 45 – 55m

Key Dates

- February 2009: Exclusivity awarded by The Crown Estate
- February 2010: Grid connection secured
- June 2013: Onshore consent awarded
- October 2014: Consent awarded
- March 2015: Signed CfD Contract (£114.39)
- November 2017: End of Judicial Review
- March 2018: Submitted new consent
- May 2018: NnG acquired by EDF Renewables
- December 2018: New consent awarded

Technical Overview



Original and New Consent Comparison

Parameter	Originally Consented Project	New Application
Maximum number of turbines	75 (Original application was 125)	54
Maximum rotor tip height (mLAT)	197	208
Maximum hub height (mLAT)	115	126
Maximum rotor diameter (m)	154	167
Minimum spacing between turbines (m)	450	800
Blade clearance (mLAT)	30.5	36

Project Schedule

The schedule is currently being finalised.

Key Milestones - Draft	Year
Financial Close	2019
Onshore Construction Start	2019
Offshore Pile Installation Start	2020
Offshore Jacket Installation	2021
Grid Connection	2021
Offshore Cable Installation	2021
Offshore Substation Installation	2021
Offshore Turbine Installation	2022

Potential Contracting Structure

The contracting structure is currently being finalised.

Foundations	Wind Turbine Generators		Electrical Balance of Plant (BoP)		
Design, Fabricate and Installation Piles Jackets	Turbine Supply Turbine O&M	Installation Vessel	Export Cable Offshore Onshore	High Voltage Stations Offshore Onshore	Inter Array Cables


Thank You

Oscar Diaz

Project Director

EDP Renewables – Moray East Wind Farm

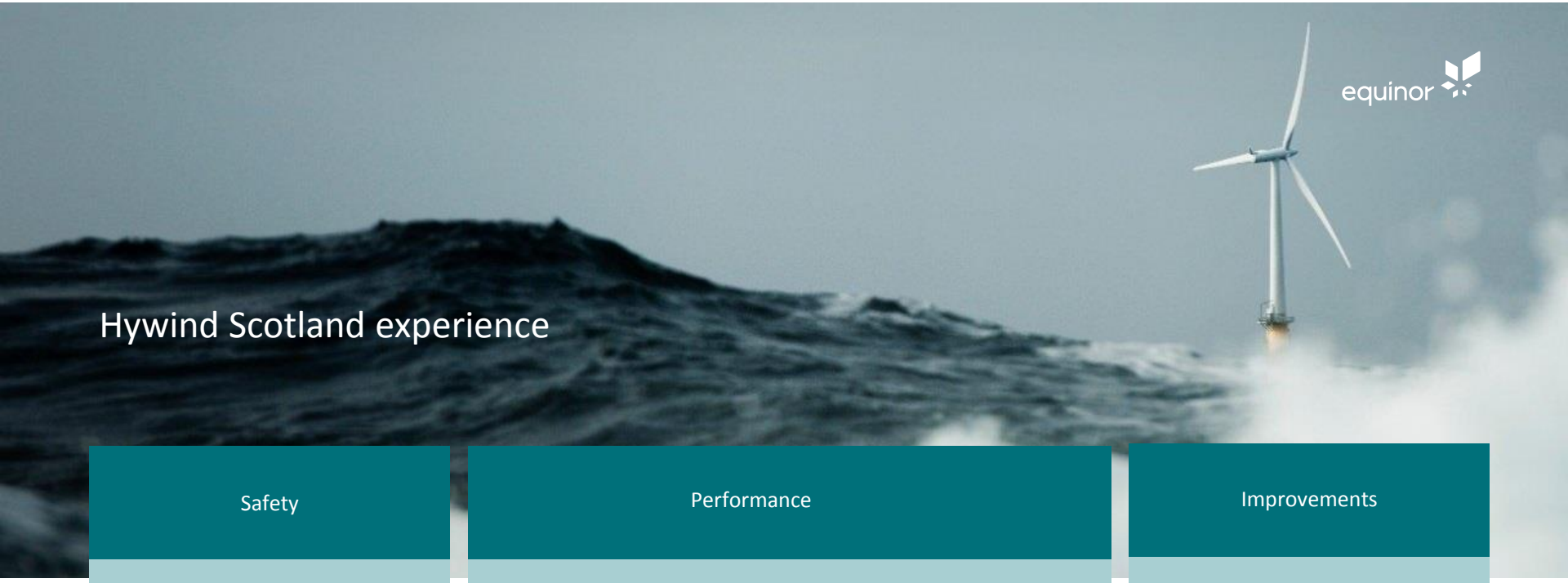
Bjørn Johansen

Project Manager for Scotland

Equinor - Hywind

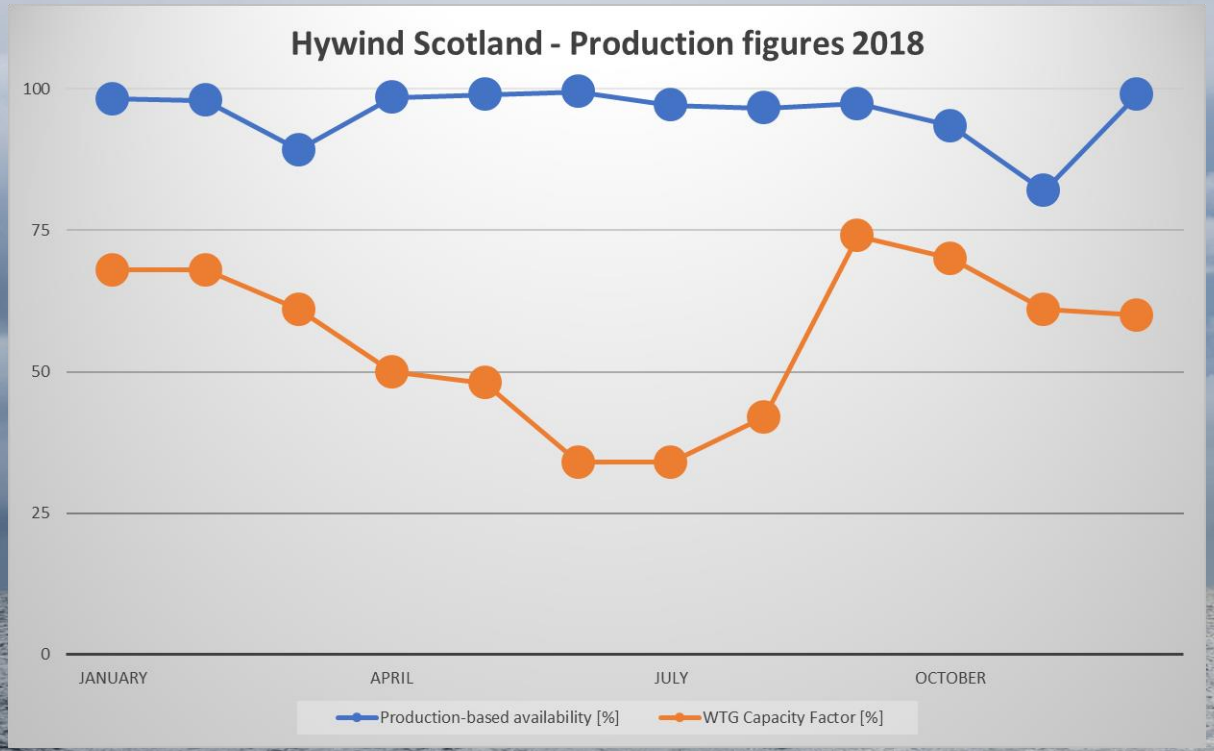
Hywind Scotland

Project speed-update



Hywind Scotland experience

Safety	Performance	Improvements
Zero HSE incidents	Dynamic performance – within design parameters Capacity factor - above industry average Performance availability - above budget and industry average	Testing of advanced motion controllers


Hywind Scotland - Production figures 2018
100
75
50
25
0
JANUARY
APRIL
JULY
OCTOBER
Production-based availability [%]
WTG Capacity Factor [%]

Floating Offshore Wind Centre of Excellence

- Promote floating offshore wind
- Engage with supply chain
- Capture and disseminate experience from ongoing projects
- Establish a point of contact for research and development activities

Thank you for your attention.

Kevin Metcalfe

Project Director

Vattenfall – European Offshore Wind Deployment Centre

European Offshore Wind Deployment Centre

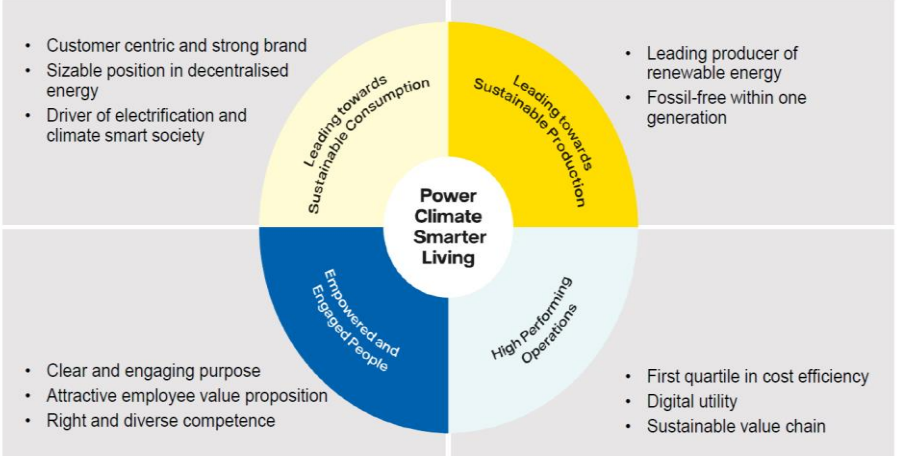
Kevin Metcalfe

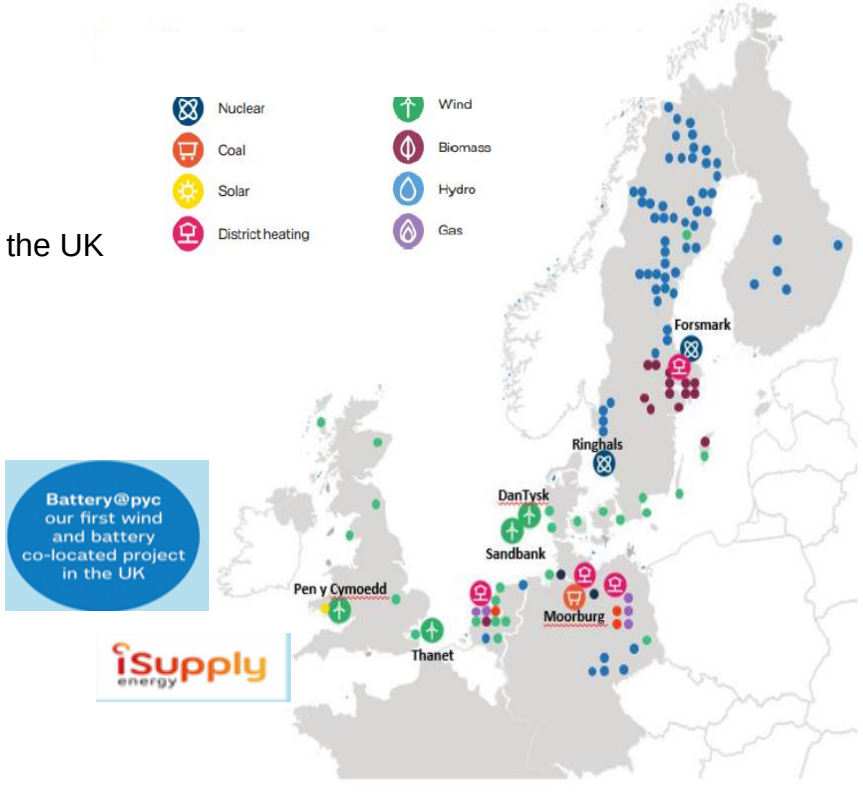
EOWDC Project Director

This is Vattenfall

Basic Facts

- One of Europe's largest producers of electricity and heat
- 100% owned by the Swedish State
- Main products: electricity, heat, gas and energy services
- Main Markets: Sweden, Germany, Netherlands, Denmark and the UK
- About 20,000 employees





Fossil-fuel free in one generation

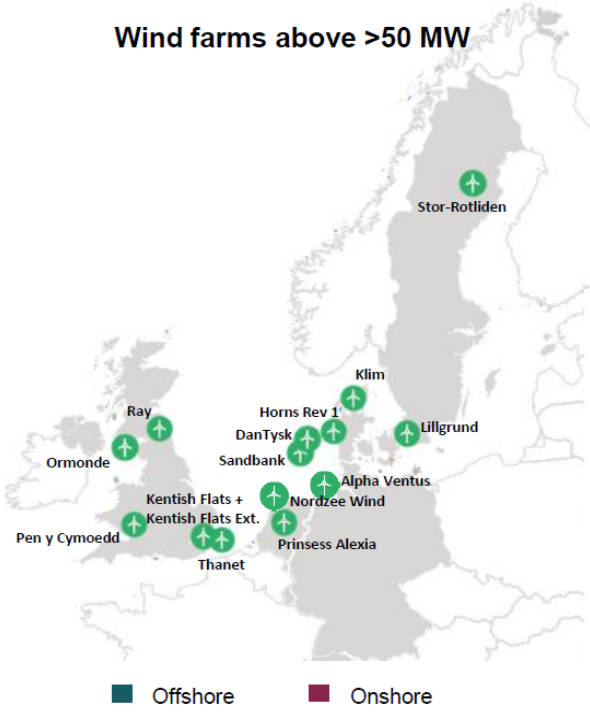
Operating wind farms, construction and pipeline

In operation

Name	Capacity (MW)	Country
Thanet	300	UK
Ormonde (51%)	150	UK
Kentish Flats	90	UK
Kentish Flats extension	50	UK
Pen y Cymoedd	228	UK
Ray	54	UK
Lillgrund	111	SE
Stor-Rotliden	78	SE
Horns Rev 1 (60%)	158	DK
Klim (98%)	67	DK
DanTysk (51%)	288	DE
Sandbank (51%)	288	DE
Alpha ventus (26%)	60	DE
Nordzee Wind (50%)	108	NL
Prinsess Alexia	122	NL
Other offshore	10	
Other onshore	669	

Total 2,764 MW

Wind farms above >50 MW



In construction

Name	Capacity (MW)	Commissioning	Country
Aberdeen	92	2018	UK
Horns Rev 3	406	2019	DK
Slufterdam	29	2019	NL
Wieringermeer	180	2020	NL

Total 707 MW

Pipeline

Name	Capacity (MW)	Commissioning	Country
Wieringermeer ext.	~118	2019	NL
Blakliden + Fäbodberget	~354	2022	SE
South Kyle	~200	2021	UK
NK II	~120	2021	DK
Danish Near Shore	344	2021	DK
Danish Kriegers Flak	602	2021	DK
Hollandse Kust	700-750	2023	NL
Sandbank Plus	<250	2024	DE
Thanet Extension	272	2024	UK
Norfolk Vanguard	1,800	2027	UK
Norfolk Boreas	1,800	2028	UK

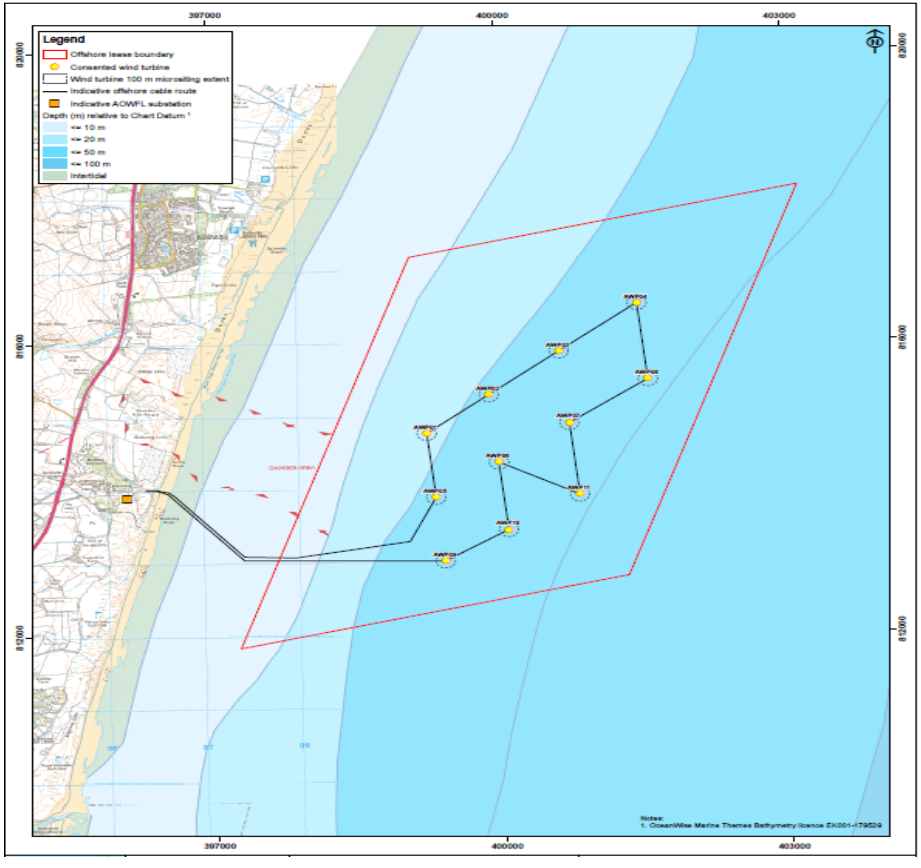
Total ~6.5 GW

EOWDC in numbers

11 wind turbines
11 three-legged suction bucket jacket foundations
Transformer Supply - 66kV
Installed Capacity-up to ~93.2MW
Annual Production-up to 312GWh
Annual CO_2 displacement - over 130,000 tonnes
Removing the equivalent emissions of over 730,000 cars from UK roads throughout its lifetime.
Annually powering approx. 80,000 homes

Inaugurated on Friday 7th September 2018 by Scotland's First Minister Nicola Sturgeon.

Offshore Construction

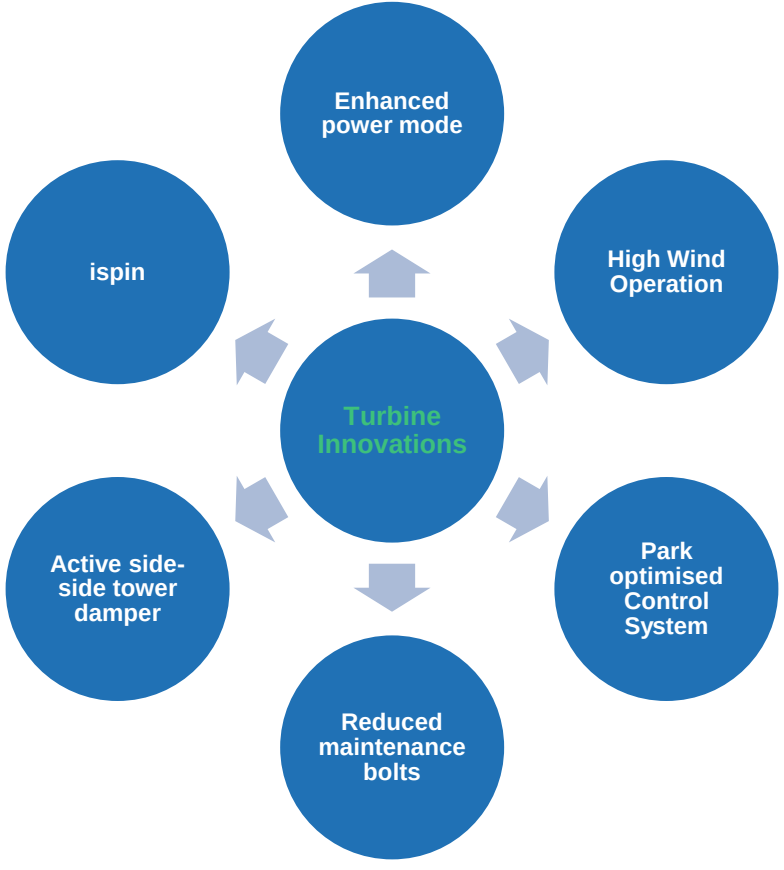



PACIFIC ORCA

V164 Wind Turbines at EOWDC

MHI Vestas V164 (Aberdeen Specifics)

Rotor Diameter – 164m
Tip height (AOWF) – 191mLAT
Hub height (AOWF) – 109mLAT
Nacelle weight - 390t
Tower weight - 366t
66kV electrical transformer and switchge



Suction Bucket Jacket Foundation

Height: 60 – 77m

Heaviest Foundation: Approx. 1800t

Suction Bucket Diameter: 9.5m / 10.5m

Suction Bucket Length: 9 - 13m

66kV Subsea Cabling

Onshore Construction

Operations and Maintenance

Capturing our natural resource, empowering communities

£3m community
benefit scheme that will run for the lifetime of the project.

£150,000 will be invested
annually throughout Aberdeen City and Aberdeenshire

Jenny Hogan
Deputy Chief Executive, Scottish Renewables

Steve Wilson
Project Director, SSE – Beatrice Offshore Wind Farm

David Sweenie
Development Manager, EDF Renewables - Neart Na Gaoithe Offshore Wind Farm

Oscar Diaz
Project Director, EDP Renewables – Moray East Wind Farm

Bjørn Johansen
Project Manager for Scotland, Equinor – Hywind

Kevin Metcalfe
Project Director, Vattenfall – European Offshore Wind Deployment Centre

Andrew Jamieson

Chief Executive

ORE Catapult

ORGANISED BY

scottish renewables

IN ASSOCIATION WITH

CATAPULT Offshore Renewable Energy

OFFSHORE WIND CONFERENCE, EXHIBITION & DINNER

28 & 29 JANUARY 2019 **GLASGOW**

areg Aberdeen Renewable Energy Group

Crown Estate Scotland Oighreachd a' Chrùin Alba

DEME Dredging, Environmental & Marine Engineering

FORTH & TAY OFFSHORE

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

OCEANEERING®

Offshore Wind Journal

reNEWS

THE ORCA HUB: Developing Robotics, Artificial Intelligence and Autonomous Systems for the Offshore Sector

Scottish Renewables' Offshore Wind Conference
Glasgow, January 29th 2019

Prof. Helen Hastie,
Heriot-Watt University, Edinburgh
h.hastie@hw.ac.uk

https://orcahub.org

HERIOT WATT UNIVERSITY · THE UNIVERSITY of EDINBURGH · UNIVERSITY OF LIVERPOOL · Imperial College London · UNIVERSITY OF OXFORD · INDUSTRIAL STRATEGY · UK Research and Innovation · EDINBURGH CENTRE FOR ROBOTICS

The ORCA Hub Vision and Mission

VISION:

- To support a long-term industry vision for a semi-autonomous offshore energy field; operated, inspected and maintained from shore.

MISSION:

1. To translate the ORCA Hub world-leading science into commercial products and services.

2. To support making the UK Supply Chain the most productive in the world.

ORCA HUB
Offshore Robotics for Certification of Assets
Remote Safety and Integrity

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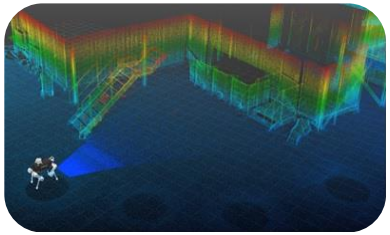
THE UNIVERSITY of EDINBURGH
UNIVERSITY OF LIVERPOOL
Imperial College London
UNIVERSITY OF OXFORD
INDUSTRIAL STRATEGY
UK Research and Innovation
EDINBURGH CENTRE FOR ROBOTICS

Offshore Robotics for the Certification of Assets

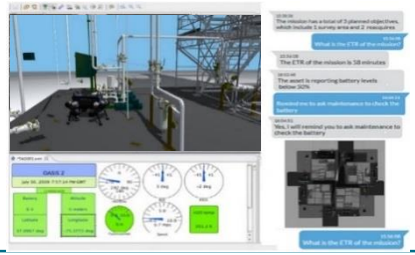
ORCA HUB
Offshore Robotics for Certification of Assets
Remote Safety and Integrity

1. Mapping, Surveying and Inspection



2. Planning, Control and Manipulation

3. Intelligent Human-Robot Interaction/XAI



4. Robot and Asset Self-Certification

ORCA HUB
Offshore Robotics for Certification of Assets
Remote Safety and Integrity

Human and Robots Working Together

Image from (modified)
http://www.renewableenergyfocus.com

- Operators need to feel confident and *trust* autonomous systems enough to deploy them in remote, high stakes, hazardous environments
- A human operator needs to have *high situation-awareness* of where the robots are, what they are doing and why
- Humans and robots need to work *seamlessly in teams* and have similar mental models of the world/tasks

The ORCA Solution

Build interfaces that support joint human-machine decision-making and that increase transparency through:

- Increasing Situation Awareness *"what are you doing/where are you?"*
- Explaining AI and Autonomy *"why did you do that?"*
- Explaining the Environment *"what do you see/sense?"*
- Modelling Causality and Explaining Plans *"I did this because the wind changed"*
- Controlling Vehicles and Goal Setting *"Inspect closer and send back photos and thermal imaging"*
- Accessing Prior Knowledge *"When was the last time damage was reported here?"*

Goal: to increase understanding, trust and situation awareness

MIRIAM: Multimodal Intelligent Interaction for Autonomous Systems

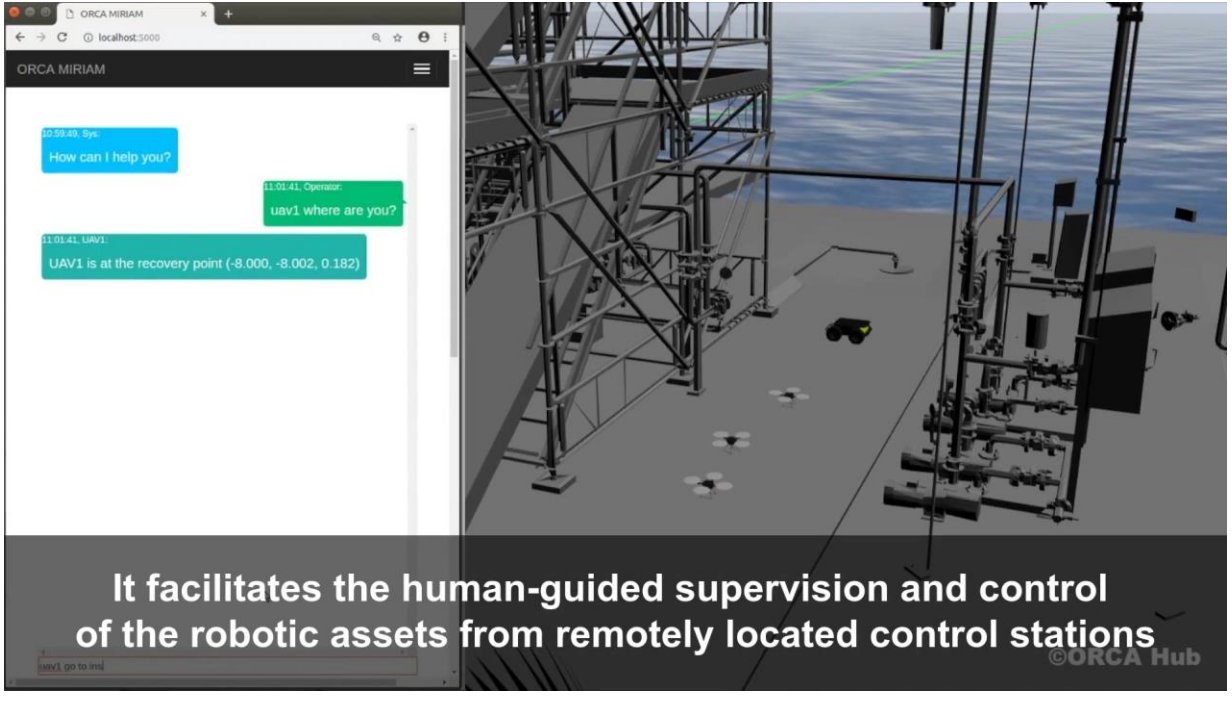
- In-mission interaction for autonomous underwater vehicles (AUV)
  - mission plan, mission and vehicle status, fault warnings, behaviour explanations and reminder setting
- Multimodal: voice, text and visual for hands-free as needed
- Post-mission reporting
- Evaluation of MIRIAM with real operators:
  - increases situation awareness [1]
  - improves the user's mental model of the AUV [2]

[1] D. A. Robb et al. *Keep Me in the Loop: Increasing Operator Situation Awareness through a Conversational Multimodal Interface.* In Proc of ICMI 2018

[2] F.J.C. Garcia, et al. *Explainable autonomy: a study of explanation styles for building clear mental models*. In Proc. of INLG 2018

Offshore Inspection and Emergency Response

- Prototype: send commands in natural language
- e.g. *"Perform an external visual inspection"*
- *"Take a photo and send it back"*
- Get alerts, warnings and status updates
- Digital twin in gazebo simulation



Future of Renewable Offshore Inspection and Maintenance

- *Greater* adoption of robotics and autonomous systems to do the hard dangerous work
- *Fewer* personnel in the field in extreme conditions
- *Intelligent interfaces* onshore that monitor for cognitive overload and provide decision support
- *Fewer* operators managing *more* robots doing *more* inspections, resulting in cost savings
- *Less* time writing and accessing reports

Interaction with End-users

We need:

1) **Case studies** relevant to offshore renewable energy

2) Understanding who the **stakeholders** and **end-users** are and their needs

3) Understanding the **tasks** that they do and ones that could be done by robotic and autonomous systems

4) **Training facilities,** where we can integrate a robotics component

5) Understanding of what the **barriers to adoption** are

If interested in becoming an ORCA project partner, email David Wavell d.wavell@hw.ac.uk

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@EDINrobotics

WindFloat: Delivering Innovative O&M solutions

January 2019

PRINCIPLE POWER

Introduction to Principle Power

Global Presence

Founded in 2007

> 100 employees - Offices in USA, France, and Portugal

Strong Backing

Shareholders

AkerSolutions, edp, REPSOL, PORTUGAL VENTURES, A.SILVA MATOS

Partners

eit KIC InnoEnergy, Shell

A Proven Technology

Successful 5-year Full Life-Cycle Demonstration

2MW Vestas, Identical Performance to Fixed Foundation

17GWh, Produced in 12m waves; Survived 17m waves

Project Pipeline

3 Precommercial Projects in Progress (99MW of installed floating capacity by 2021 in Europe)

Commercial Developments in Europe, USA, Asia

Our Vision: Be the global leader in deep water wind technology

Our Mission: To make the WindFloat the most competitive, safe, reliable and environmentally friendly floating technology and unlock GWs of global renewable energy potential

Already executing on projects in different geographies, which fully prove low risk and cost competitiveness

PRINCIPLE POWER

WindFloat Atlantic

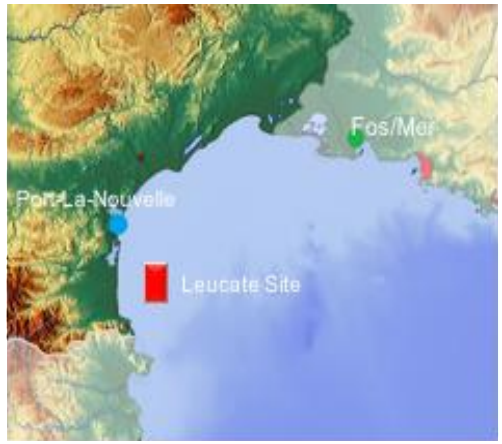
25 MW, Portugal, Operational 2019

- 3x 8.3 MW MHI Vestas
- 20 km out; 100 m deep
- Local Shipyard Construction
- Certified by ABS
- Feed-In Tariff
- Equity Financing complete w/ strong international sponsors
- First non-Recourse Project Finance of a Floating Wind Farm (Financial Investment decision in Q1 2018)

Golfe du Lion

24 MW, France, Operational 2020

- 4x 6 MW GE
- 18 km out; 70-100 m deep
- Local Shipyard Construction
- Certified by BV
- Feed-In Tariff (through competitive process)
- Very strong consortium with major energy companies and industrials
- Major innovations to advance technology to the next level of competitiveness



WindFloat Atlantic under construction: fabricating columns for 8MW+ turbine foundation

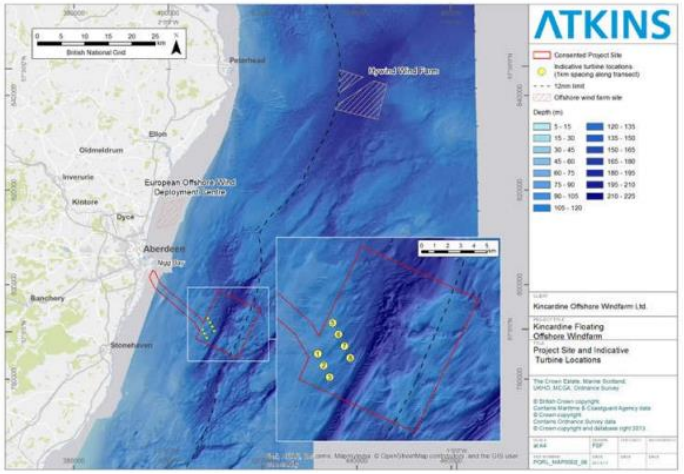
PRINCIPLE POWER

Kincardine Offshore Wind Project: first retrofit of a floating wind turbine

PRINCIPLE POWER

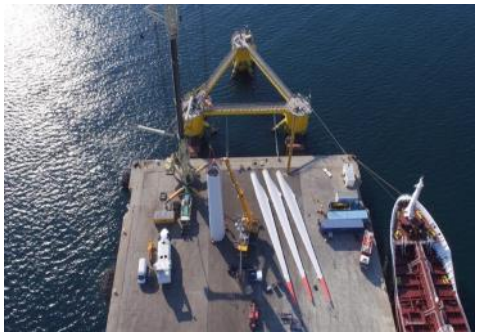
Project Overview

- **Total capacity:** 50MW capacity (1 x 2 + 5 X ~10 MW)
- **Location: 15 km off Aberdeen;** water depth = ~60m
- **Fabrication:** TBD
- **Status:**
  - Phase 1: Installation Summer 2018
  - Phase 2: Adv. Engineering and Procurement
    Installation 2020



WindFloat 1 Project – Prototype Objectives

- ✓ **Minimum offshore operations**:
  - ✓ Fabrication, Assembly and commissioning ONSHORE
- ✓ **Design Validation**:
  - ✓ Calibrate & validate all numerical models
  - ✓ Withstand wave- and wind-induced fatigue
- ✓ **Unparalleled Seakeeping Performances**:
  - ✓ Meets industry's availability benchmarks
  - ✓ Produces up to the 1-year storm
  - ✓ WTG performs as if on fixed foundation
  - ✓ Survives large winter storms with no damage
- ✓ **Return to shore for Decommissioning/ Large Correctives:**
  - ✓ Disconnect offshore
  - ✓ Towing with local vessels
  - ✓ All crane operations at quayside
  - ✓ Minimal Budget
  - ✓ Minimal Environmental Impact



Principle Power Inc. (PPI) – WindFloat 1, Portugal, 2011-2016

Low cost/risk large correctives are a key component of the WindFloat value proposition

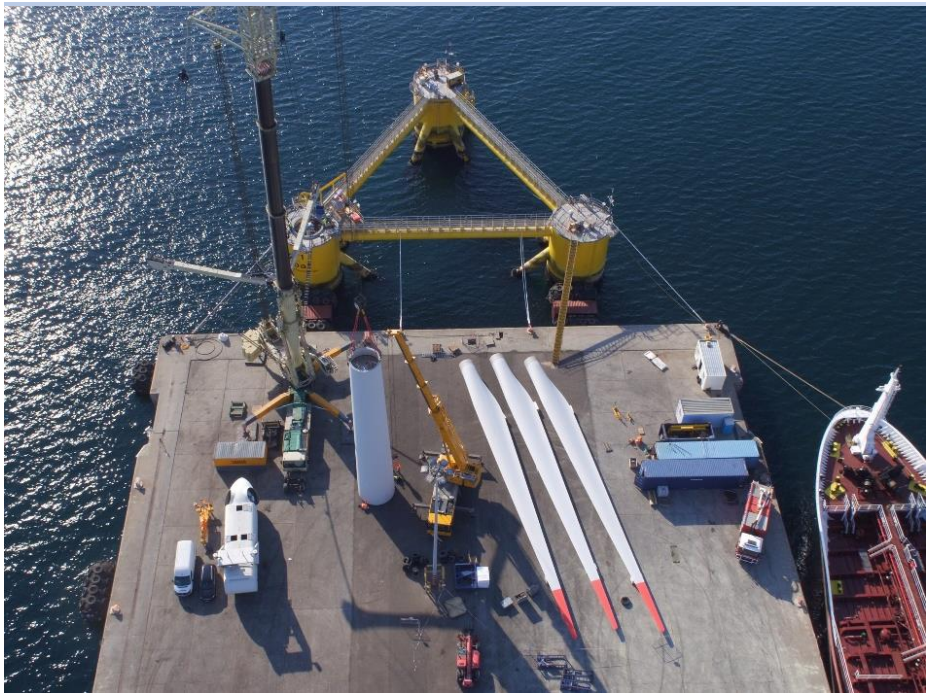
PPI aims to minimize Offshore Activities

- Offshore lifting operations are a key source of cost/risk for fixed projects
- The WindFloat eliminates the need for specialized vessels by shifting crane operations to quayside
  → Install, O&M, and Decom.
- Eliminating offshore lifts can reduce cost and increase predictability for offshore wind projects

PPI decommissioned WindFloat 1 safely and efficiently using only local vessels

Decommissioning Procedure

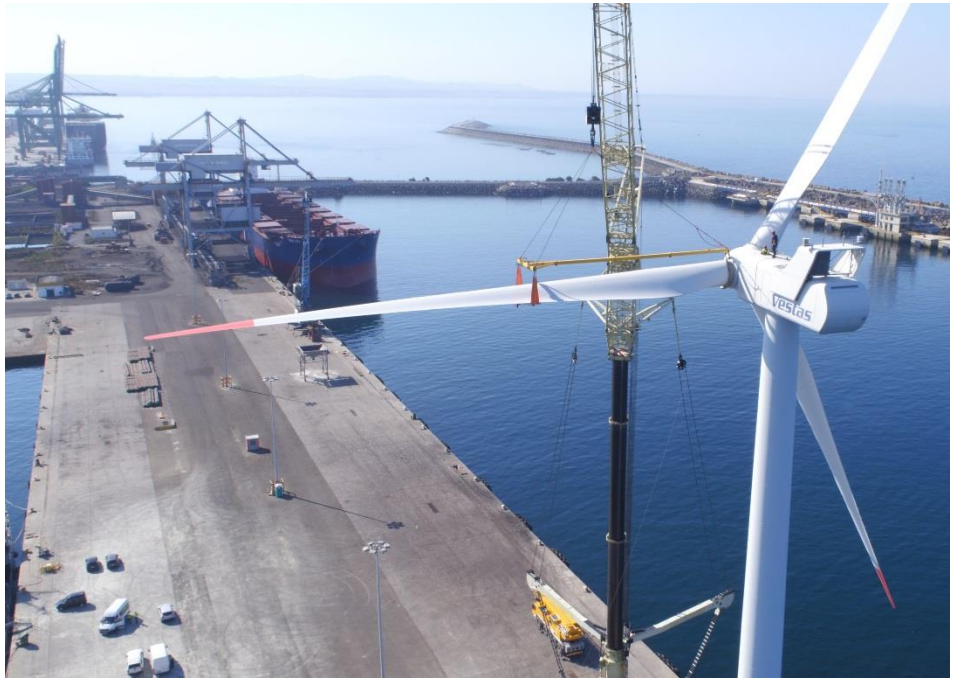
- Disconnection from SKS and IAC
- 400km Tow with local tug (75 bp)
- Moored at quayside (floating)
- Day 1: Blades Removal
- Day 2: Nacelle and Tower Removal



The decommissioning operation simulates large corrective operation, with fully reversible steps

Lessons Learned

- Removal of turbine from a floating platform demonstrated!
- Good Collaboration PPI-MHI Vestas on crane operations (WTG removal)
- Platform can be retrieved and moored at quayside during crane mobilization (operations in parallel)
- Operation complete in 8 days of working time (including 400 km tow); with significant potential to speed up



Decommissioning experience feeds back into design philosophy for next projects

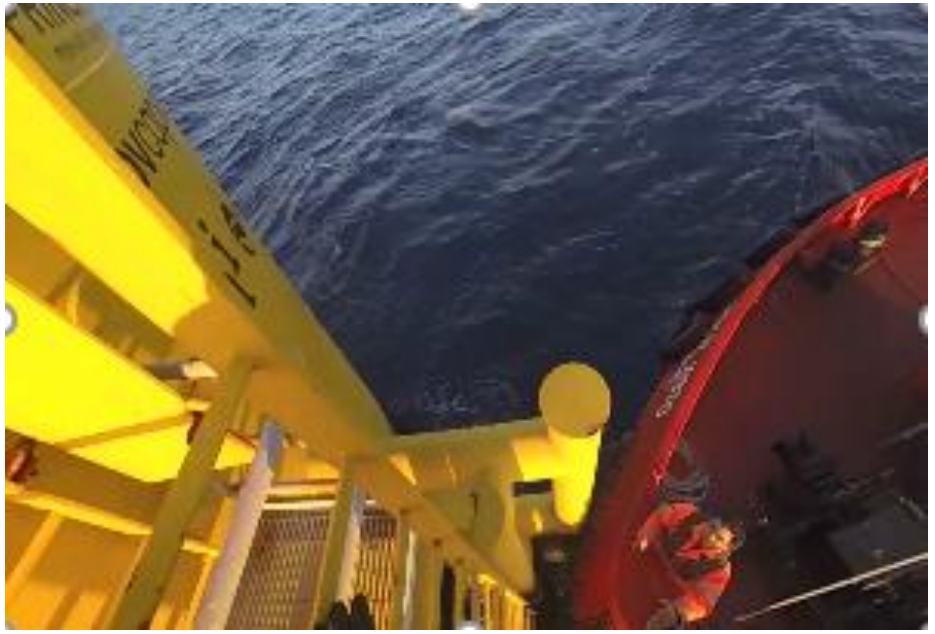
Return on Experience

- Diver-less approach (ROV) will limit time and weather sensitivity of dis/reconnection process
- Components must be designed with quick disconnect/reconnect in mind
  - Gen 2: PPI IP for Cable Interface
  - Gen 2: Proven Mooring Connections
- All operations can be completed with non-specialized offshore tugs supported by a CTV

Platform O&M experience feeds back into design for next projects → objective to maximize availability

WindFloat O&M Philosophy

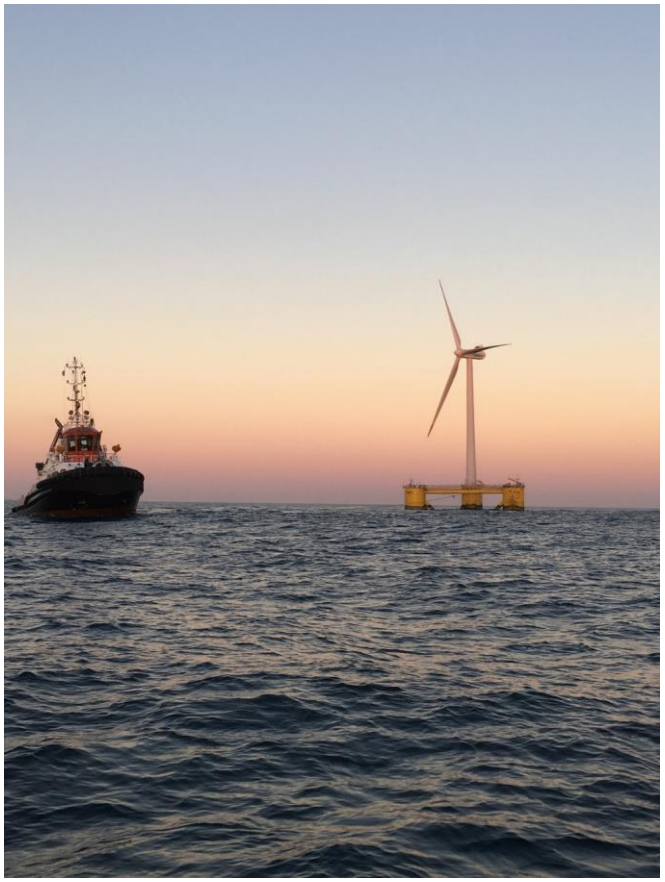
- Full redundancy on all active components: no impact of platform on availability
- Plug & Play maintenance approach (Replace Offshore & Fix Onshore)
- Platform inspections coordinated and mapped onto WTG scheduled maintenance
- No accessibility challenges (select vessel for metocean conditions)



Moving from demonstration to commercial projects imposes stringent requirements for O&M

Commercial Requirements

- Large corrective intervention costs must be predictable
  - There is no substitute for experience
  - Detailed method statements
  - Option contracts with negotiated rates and lead times
- High availability is key
  - Platform must enable turbines to perform as if fixed
  - Customers will require platform availability KPIs in O&M contracts for bankability



Cost ↓ Production ↑

These lessons learned are being implemented at WindFloat Atlantic (25 MW)

PRINCIPLE POWER

2 Towing Conducted by local tugs (identified and options for short term lease)

Transport time 1-2 days

1 Mooring and inter-array cables designed for simple release and hook-up

3 Large uptower correctives conducted quayside with standard onshore cranes.

Port of Vigo has confirmed availability for these activities; options for cranage

Total downtime less than 2 weeks from failure; total cost <€500k

Key take-aways

1. Decommissioning was the last step in the WindFloat lifecycle and proves the technical feasibility of a tow-to-shore strategy for large correctives

2. Lessons learned are incorporated into pre-commercial project design basis and support 25 year business case

3. Tow-to-shore large correctives strategies utilizing local vessel capabilities, can offer a considerable reduction in cost and risk relative to in-situ repair strategies

4. Value is enhanced in 1) new markets where specialized infrastructure does not exist and 2) with increasing turbine rating

Thank you!

PRINCIPLE POWER

www.principlepowerinc.com