



Building the Hywind Windfarm Offshore Scotland

Oslo Project Symposium
Leif Delp, Project Director – Hywind Scotland Pilot Park project

Topics

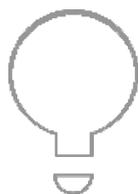
- Hywind concept - Introduction and Facts
- Project execution – a technology development and pilot project
 - Contract Strategy and Supply Chain
 - Overall execution and operational experiences
 - Key learnings during project execution
 - Substructures and Towers
 - WTG and towers assembly
 - Inshore heavy lift and mating
 - Marine Operations
- Experience and production figures
- UK and Scottish local content impact
- Next step for Hywind and Floating Offshore Wind



What is Hywind?

A standard offshore wind turbine placed on a ballasted substructure and anchored to the seabed

- Conventional technology used in a new way
- Simple substructure construction that enables mass production
- Inshore assembly reduces time and risk of offshore operations
- Beneficial motion characteristics and blade pitch control to dampen out motions



2001
The idea



2009
The demo

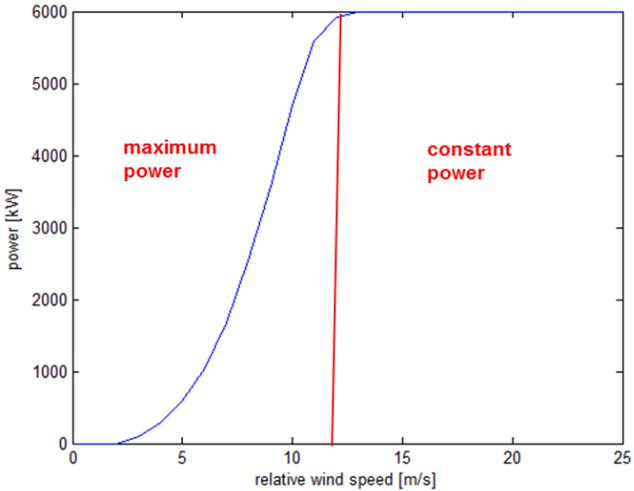


2017
The world's first
floating wind park



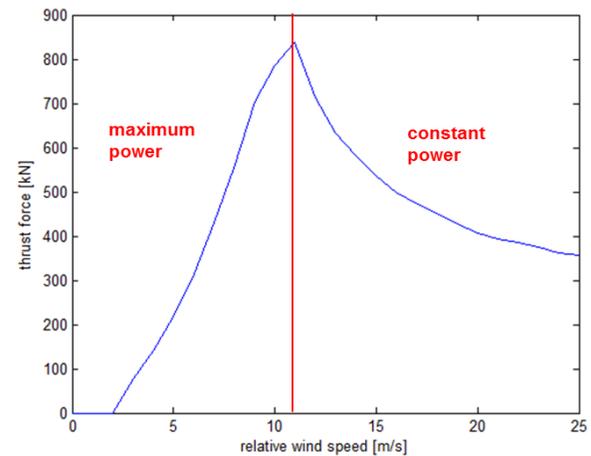
Active Damping Controller (ADC)

Output power vs relative wind speed

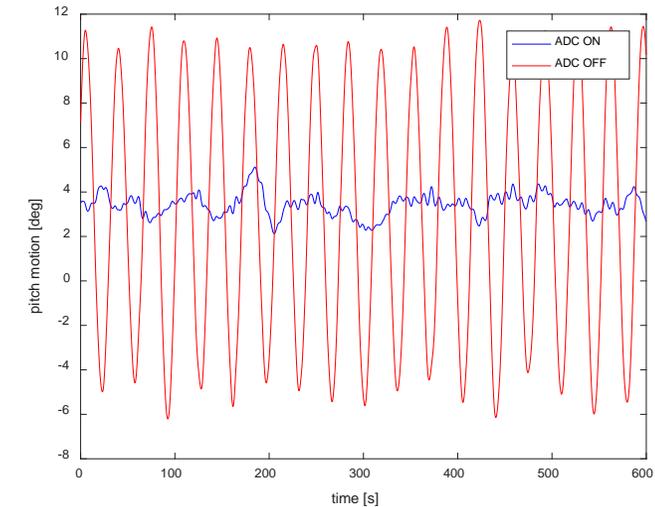


Equinor developed WTG-controller needed at wind speeds above rated power

Thrust force vs relative wind speed



Above ~12m/s
ADC needed



Graph shows 14 m/s condition with and without ADC

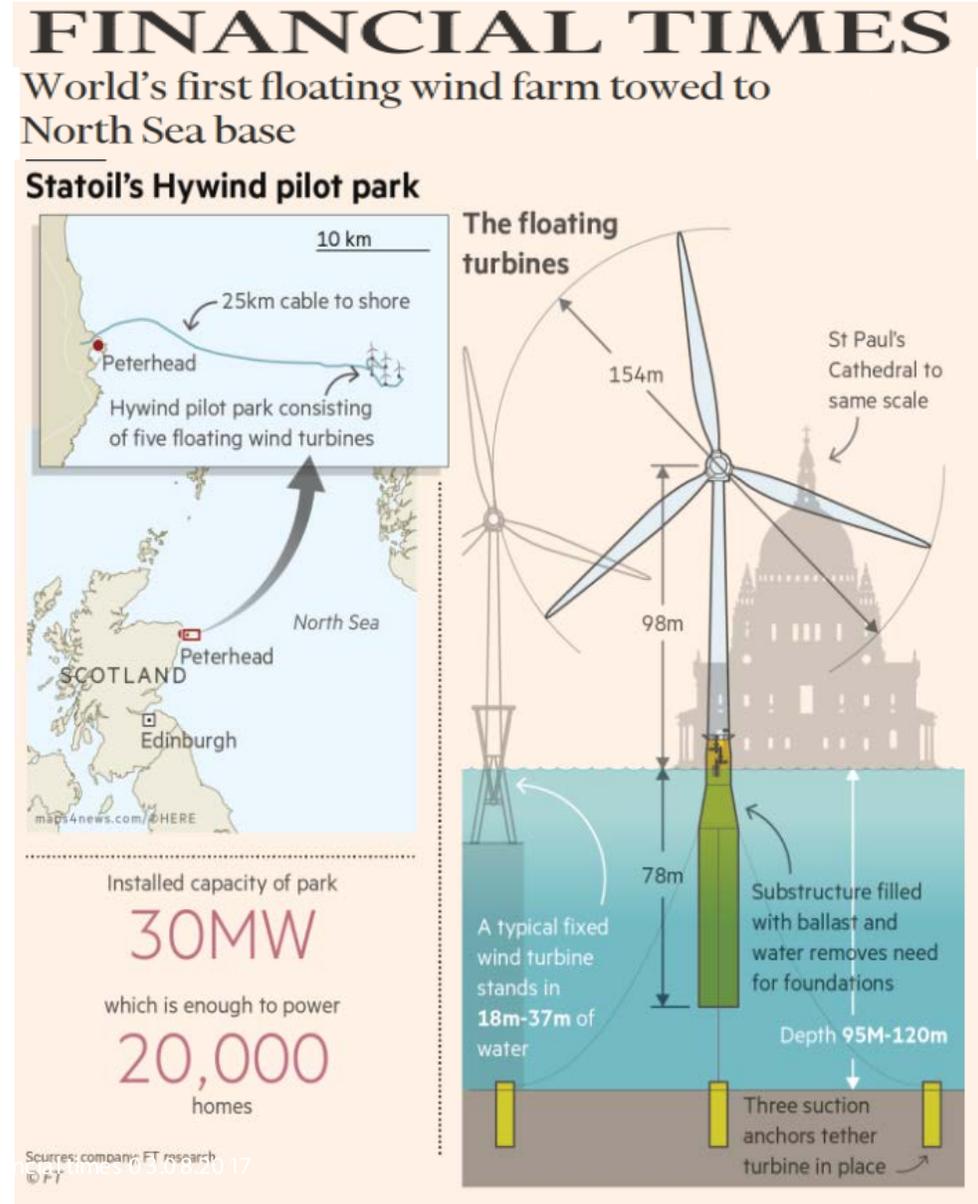
Hywind Scotland

The **world's first** floating offshore wind park



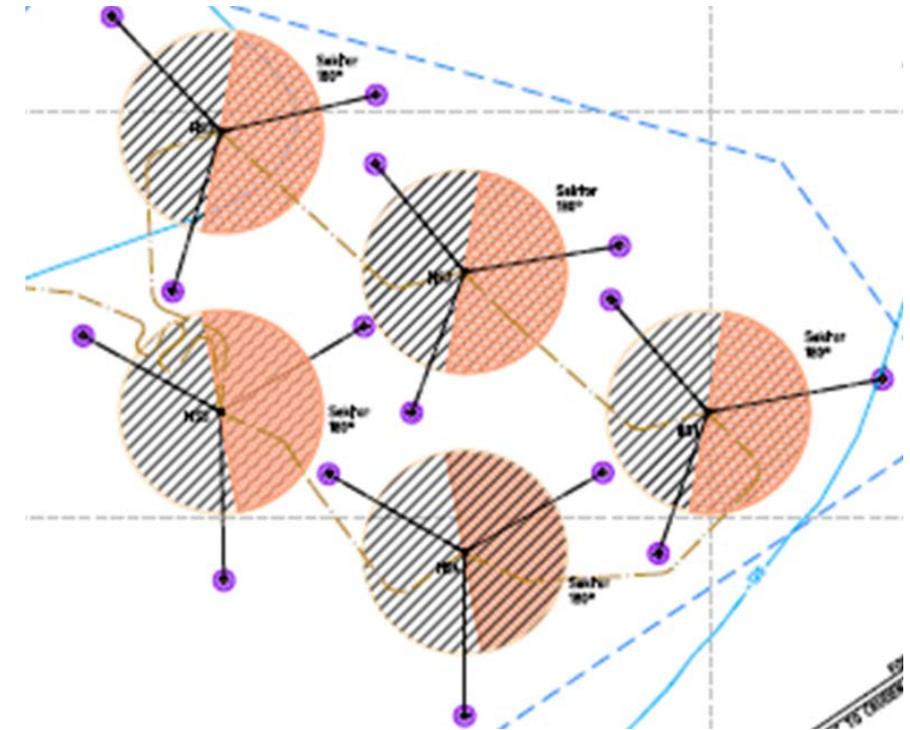
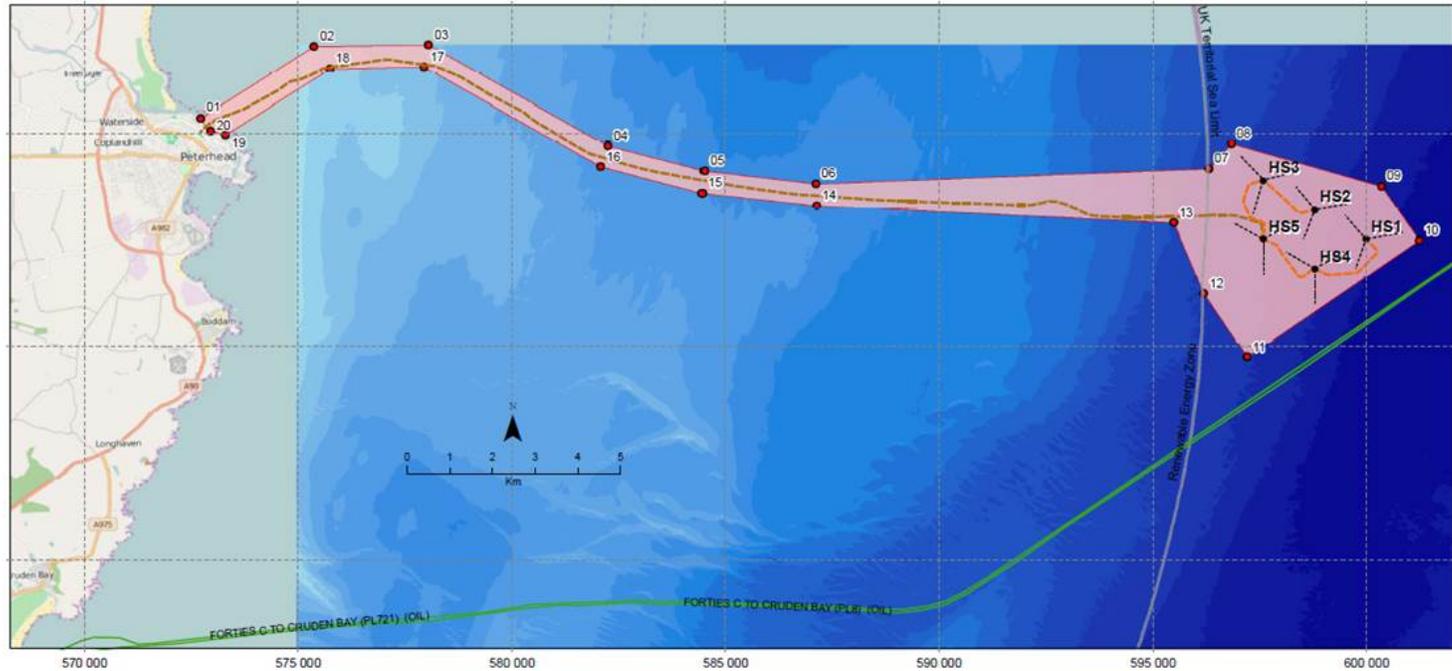
65% capacity factor Nov'17- Jan'18

[Hywind Scotland video:](#)



The Hywind Scotland pilot park

The world's first floating offshore wind park



- Investing around NOK2 billion
- 60-70% cost reduction from the Hywind Demo project in Norway
- Installed capacity: 30 MW
- Powering ~20,000 UK homes
- Water depth: 95 - 120 m
- Avg. wind speed: 10.1 m/s
- Area: ~4 km²
- Average wave height: 1.8 m
- Export cable length: ≈30 km
- Operational base: Peterhead
- Start power production: September 2017

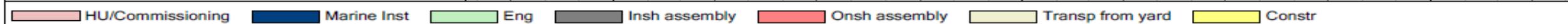
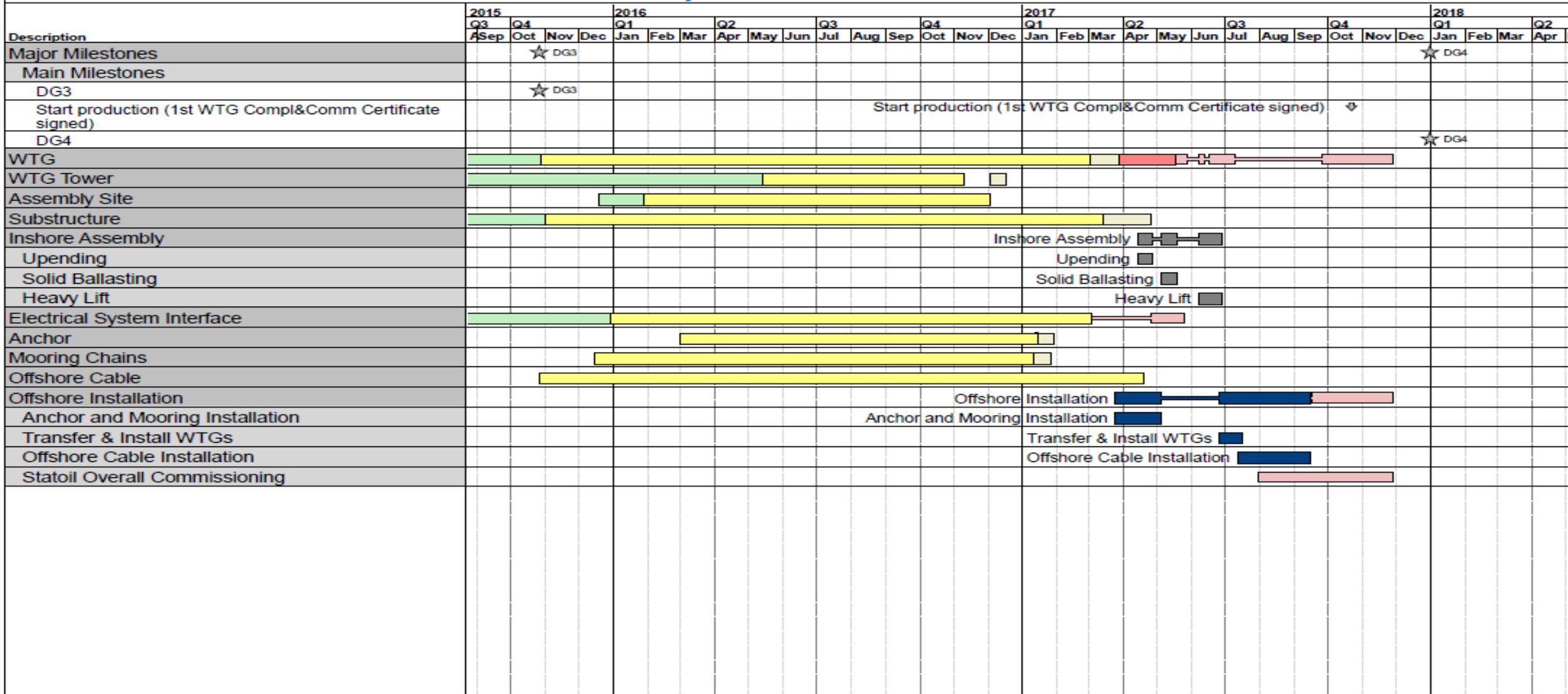
Procurement and supply chain at Hywind Scotland



Hywind Scotland Project Execution - Overview



Hywind Scotland Pilot Project Master Schedule



Key learnings from project execution

- Key message - Understand and handling of project risks
- Multi-contracting execution strategy
 - handling of interfaces between contracts
- Secure sufficient schedule float towards critical inshore heavy lifts
 - Substructure and Towers fabrication in Spain
- Scope of Towers and WTG onshore assembly and completion
- Successful heavy lift and mating operations
- Contractors new to Equinor with limited offshore wind experience
- Site manning and completion support (Equinor and Aibel)
- Early design freeze – avoid late changes (mainly marine operations requirements)
- Inshore and offshore completion strategy
 - Scope, schedule and manning



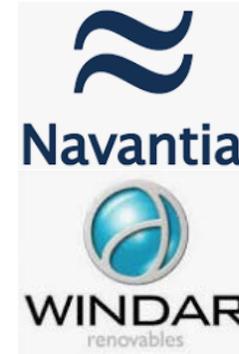
Key learnings - Substructures and Towers fabrication

Characteristics:

- Substructures: 2.300 tonnes + 1.000 tonnes of concrete ballast
 - steel structures with heavy ring stiffeners, plt.th 35 - 80 mm
- Towers: 700 tonnes
 - non-standard design due to floater motions
 - Not part of WTG supplier delivery

Key learnings:

- Yard space and capacity
 - workshops, paint shops, assembly area
- Rolling and welding competence & experience
- Robust execution method – sufficient float
- Proper planning and progress reporting



Fene, Spain



Bilbao, Spain



Key learnings - Turbine and towers onshore assembly

- Tower and Turbine assembly at deepwater quayside, Stord
- Positive learnings:
 - Successful WTG delivery (SiemensGamesa)
 - Efficient assembly of tower sections and WTG's (SiemensGamesa)
 - Efficient pre-commissioning (SiemensGamesa)
- Improvement areas:
 - Secure timely tower deliveries with minimum carry-over scope
 - Secure proper planning and progress reporting to optimize manning of onshore and inshore completion works

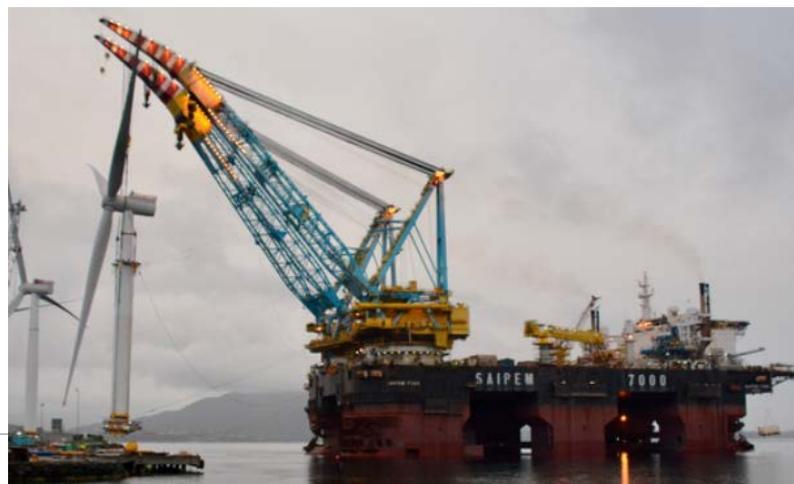


Stord Base, Norway



Key learnings – inshore heavy lift and mating

- Successful and efficient heavy lift / mating operations (Saipem 7000)
- Requires high quality dynamic analysis
- Strict guiding system/tolerances
 - hydraulic soft landing and flange clamping tool system
 - flange and bolt alignment
- Substructure draught increases ~11m during mating
 - Personnel access pre and post mating
- Secure heavy lift vessels availability and avoid standby time



Key learnings - Marine Operations

- All operations performed with no serious incidents
 - Proper risk understanding and planning
- Successful performance of all marine operations:
 - Transport of substructures and towers
 - Inshore marine operations (upending, ballasting)
 - Mooring system installation (suction anchors & chains)
 - FWT tow-out and hook-up
 - Offshore cables installation
 - BP Forties pipeline rock protection



Hywind Scotland – Immediate Success

- Project delivered on time and without serious incidents
- Successful commissioning and start-up
- First power to grid 15.09.2017
- Opening Ceremony 18.10.2017
- Handover to operations 15.11.2017 (6 weeks ahead of schedule)
- Production and performance exceeding expectations

Month	Generation vs. Budget	Wind Speed vs. Expected	Availability vs. Budget
Nov-2017	111%	117%	97%
Dec-2017	102%	102%	101%
Jan-2018	108%	97%	108%
Feb-2018	113%	104%	109%

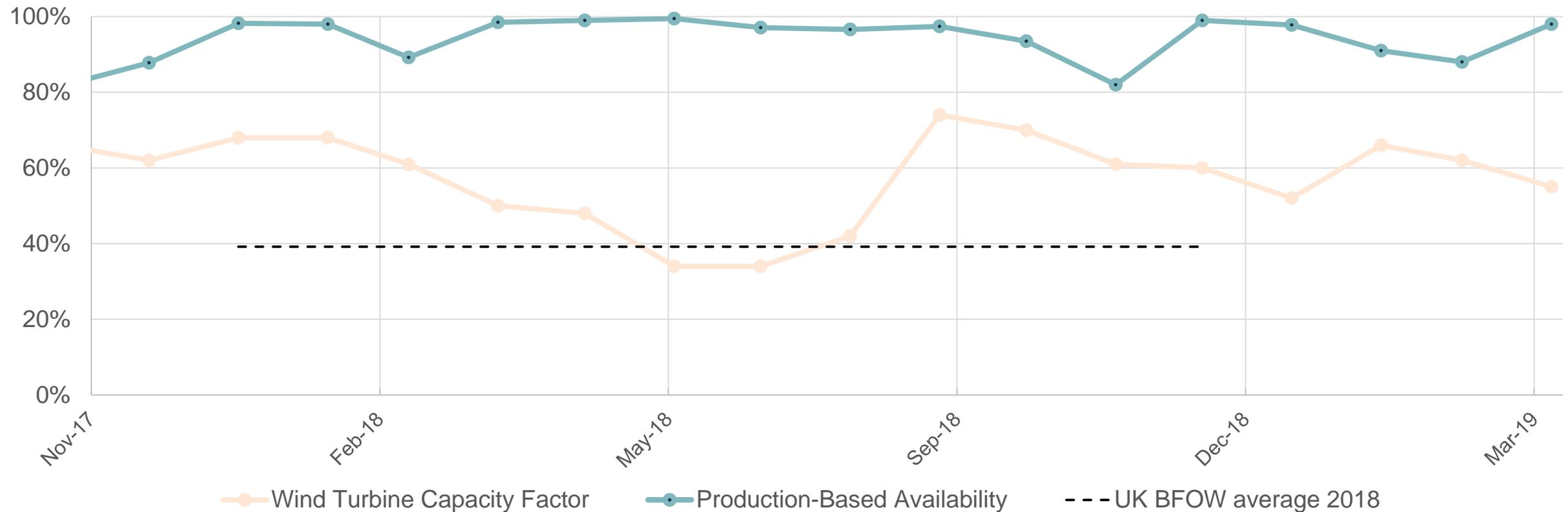
Extreme weather

- Recorded 80 mph (125 km/hr) gusts of wind during Storm Ophelia
- These wind speeds were surpassed during Storm Caroline in early December: gusts in excess of 100 mph (160 km/hr) and waves in excess of 8m.

Hywind Scotland performance

Since start of operations in November 2017:

- Average Capacity factor **57%**
- Average Production-Based Availability **94%**



Hywind Scotland – UK & Local Scottish in Execution Phase

Main Contracts:

Global Energy – Isleburn:

- Suction Anchors fabrication



Balfour Beatty - EPC contract:

- Onshore Substation
- Onshore cable
- HDD at landfall



Total contract values: 100 - 150 MNOK

Hywind Scotland – Local Scottish Content in O&M Phase

Scottish content: Appox 35 FTE, where 40% Scottish Content

Onshore

- 3 year substation and export cable maintenance and support contract awarded to local company MES Power Engineering:



- Use of further local subcontractors to support this contract:



Supply Chain

- Spare, consumables and general procurement



- Warehousing, logistics and onshore base in Peterhead



Offshore

- Contract recently awarded to Maritime Craft Services



- Turbines serviced by Siemens Gamesa Renewable Energy

- Scottish technicians

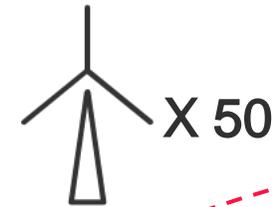
- Berth for vessel with local port



Path to commercialization of floating offshore wind

Industrialisation

- Mobilise Supply Chain
- Industrialise and Scale Up
- Competitive auctions / New Business Models



**US
France
East Asia
North Sea**
(12-15 GW market by 2030)

Cost of energy
40-60 €/MWh
by 2030

Large scale
2025-26
300-500 MW
Commercialise

**France
Scotland
Spain**

Technology-agnostic developer:

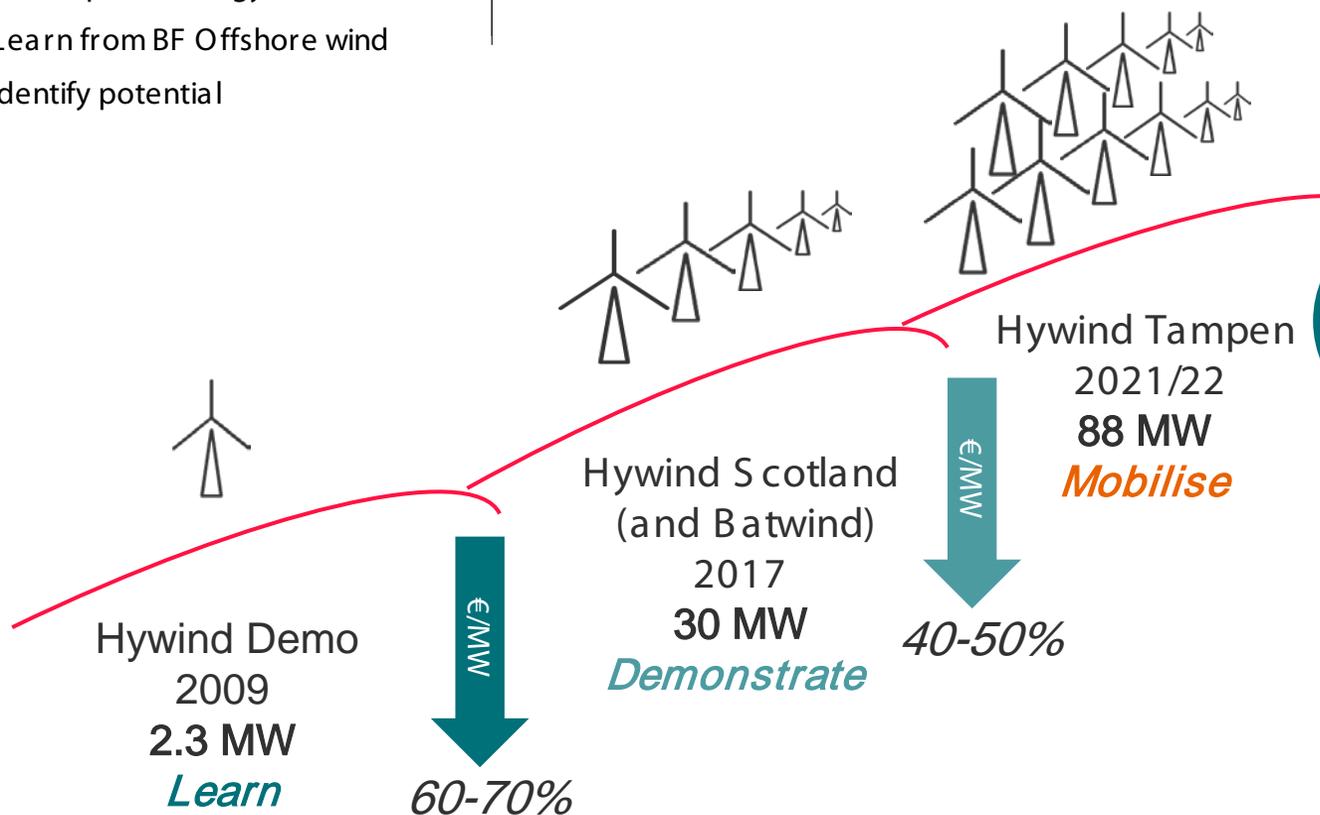
- Spar
- Semi-submersible
- Barge
- TLP

Cost Reduction

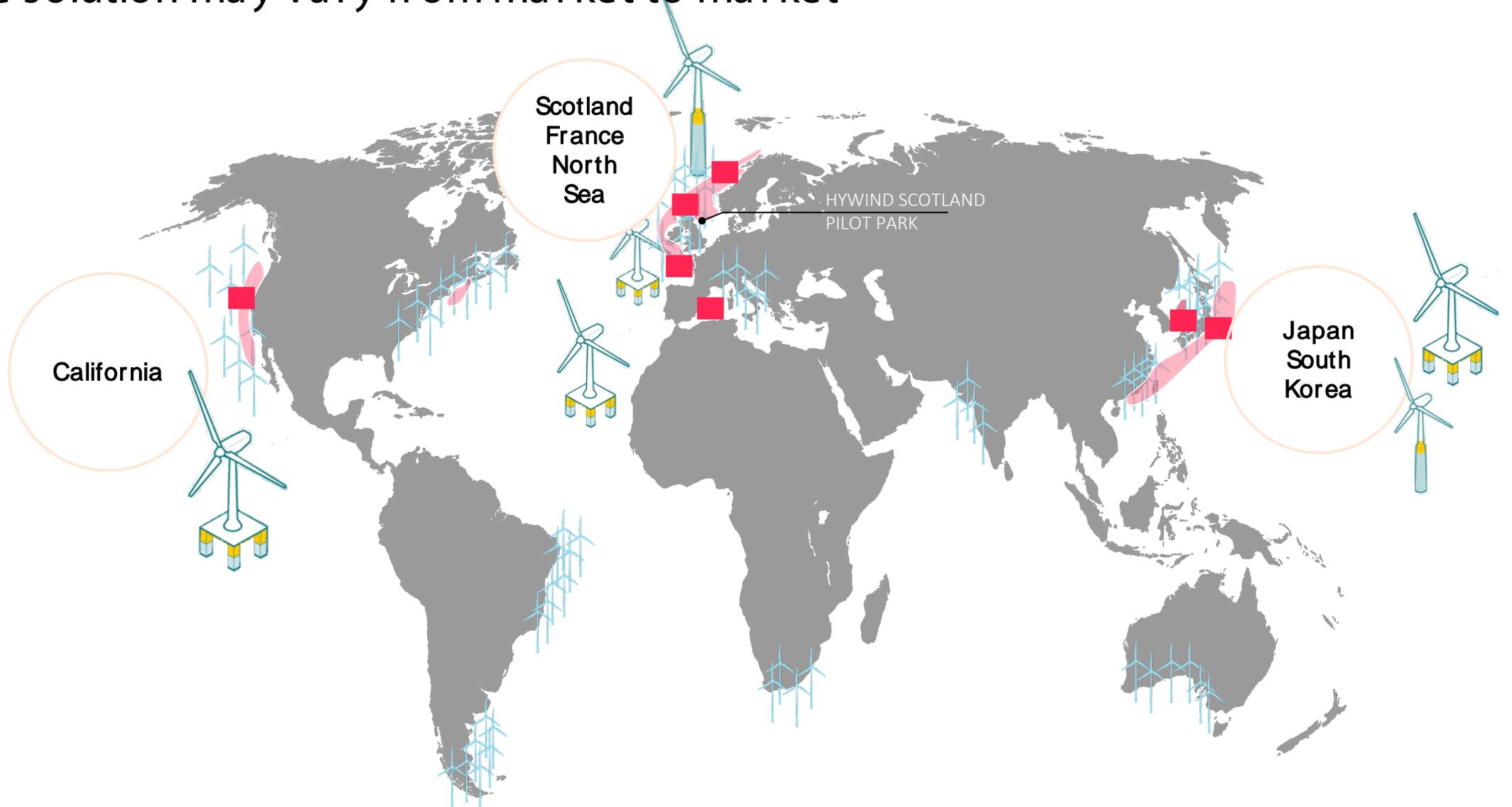
- Consolidate technologies
- Reduce cost
- Open markets

Technology Game

- Develop technology
- Learn from BF Offshore wind
- Identify potential



Where to play and how to choose substructure type - the solution may vary from market to market



Thank you for your attention!!

