

# Hywind roadmap, R&T and operations

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# Providing offshore wind to >1M homes



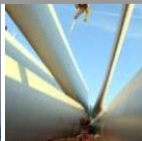
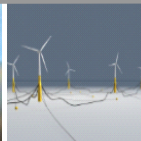
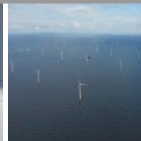




Playing to  
Statoil's  
strengths



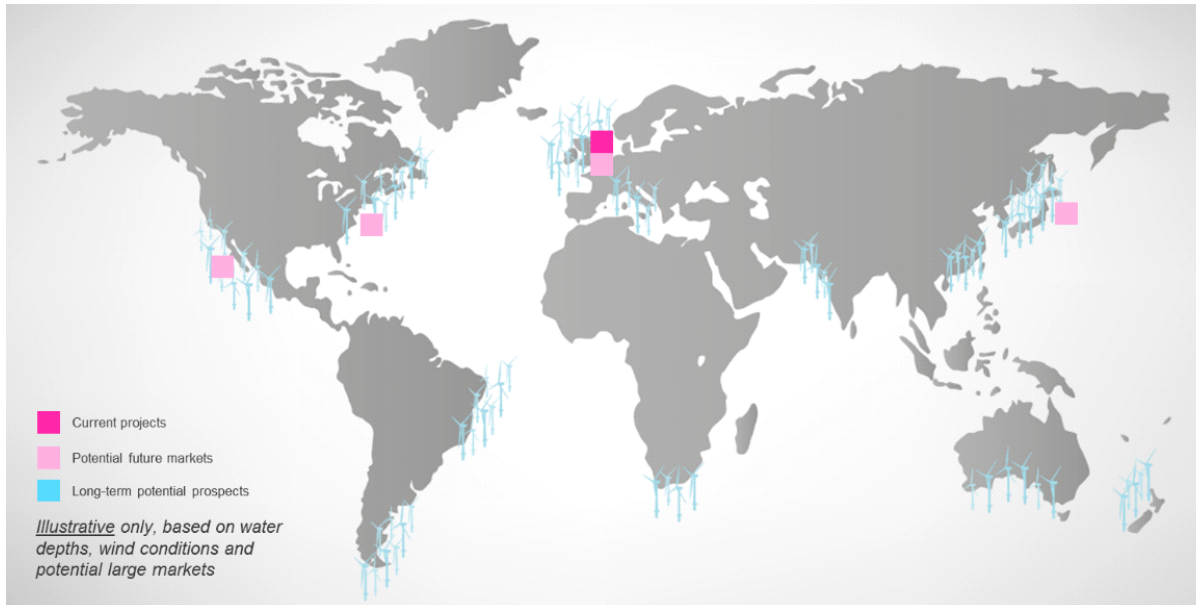
- Deeply **competitive** financing, development & operations
- Leveraging our global **presence** & supply chain
- Ability to apply **technology** to reduce energy costs

**Attractive**  
and growing  
market

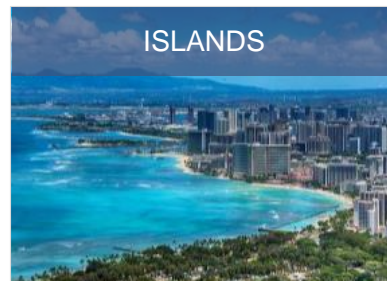


Hywind demo	Sheringham Shoal	Dudgeon	Hywind Scotland	Arkona	Dogger Bank	North / West Europe	Europe	United States East Coast
							Japan	
							US West Coast	
							Hywind large scale	New York
								
In operation	In operation	Commissioning	Commissioning	In construction	Consented	Auction won		
<b>2.3 MW</b>	<b>317 MW</b>	<b>402 MW</b>	<b>30 MW</b>	<b>385 MW</b>	<b>3 x 1.2 GW</b>	<b>1-2 GW</b>		
2009-	2012-	2017	2017	2019	2022-	2024-?		

# Vast potential for floating wind



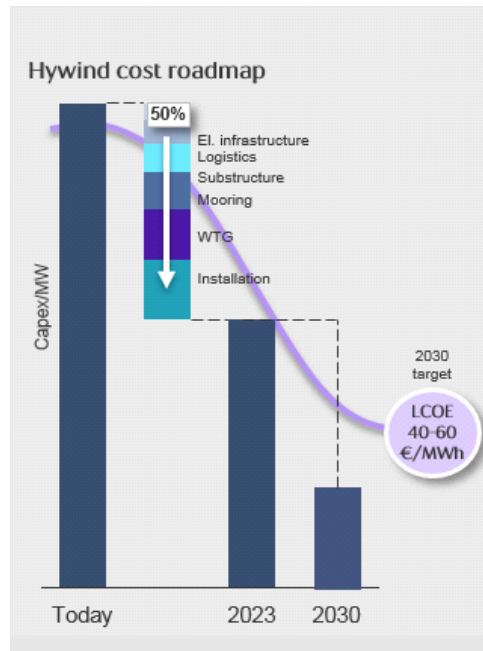
- Virtually unlimited resources
- Standardised foundations
- Site flexibility
- Environmental benefits



# Cost development for floating offshore wind

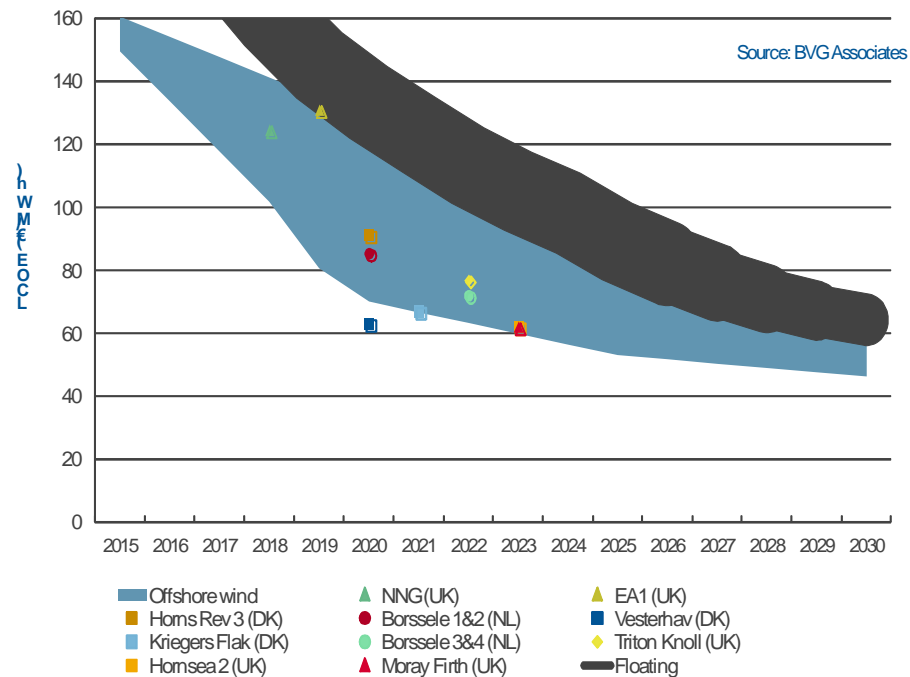
## Statoil's cost roadmap for Hywind

Capex/MW and 2030 LCOE target



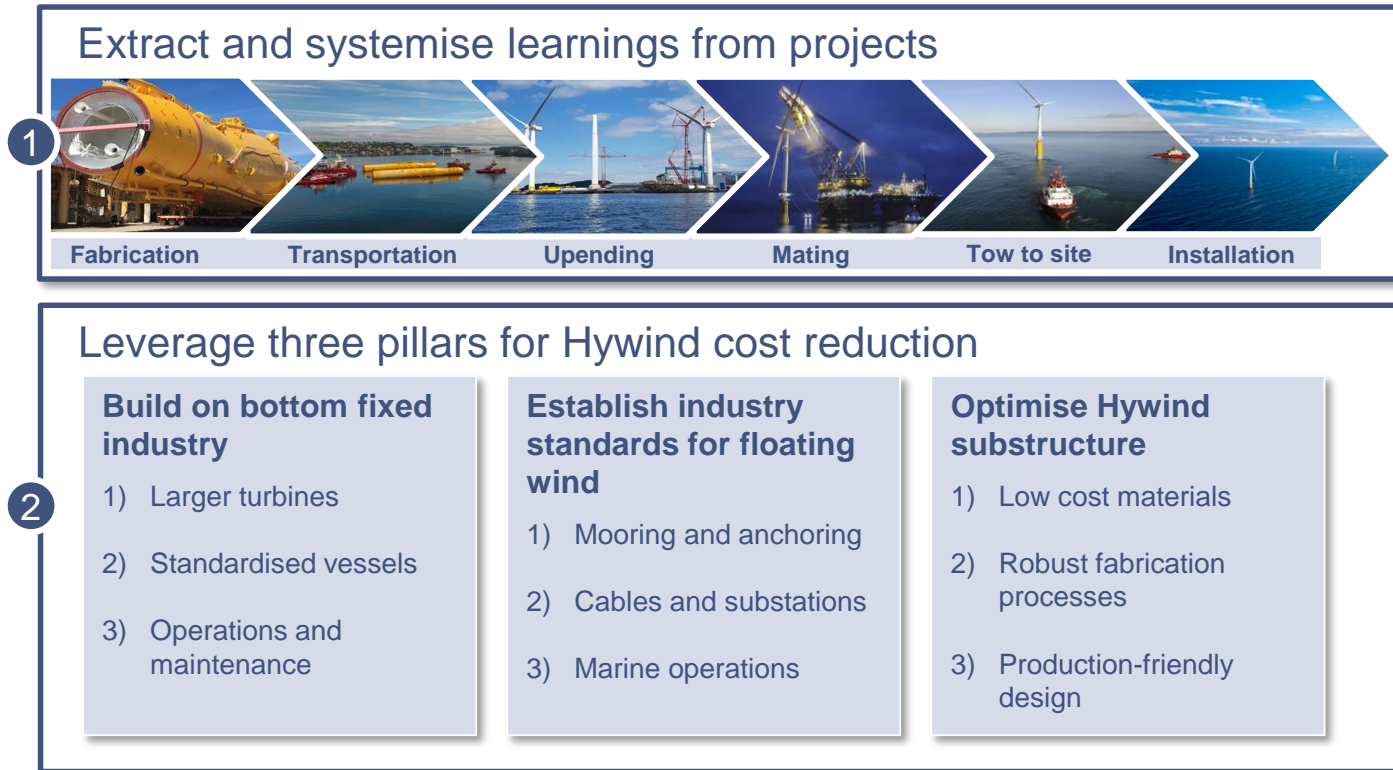
## BVG Associates LCOE trajectory for floating vs bottom fixed offshore wind

Levellised cost of energy (LCOE)



# Hywind Factory

- a systematic approach to Hywind industrialisation





# Full-scale measurement; closing the learning gap

- Full-scale wind measurements
  - Wind resource prediction method tested against full scale measurements.
  - Turbulence and wake models verified with full scale measurements from Hywind Scotland .
  - Analysis tools for floating turbine and wakes verified with full scale measurements and updated
  - Coherence measurement at Norwegian cost



# Full-scale measurement; closing the learning gap

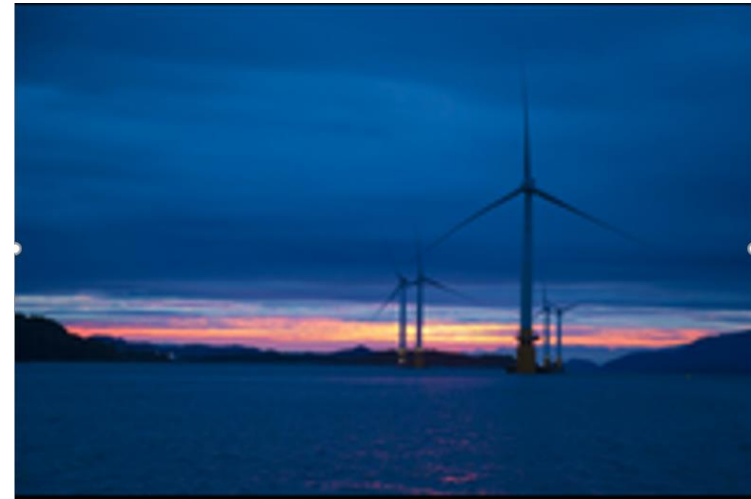
- Floating offshore wind
  - New floating wind turbine controllers tested and verified
  - Improved design methods and software tools, based on result from full scale measurements on Hywind Scotland, for hull, tower and mooring system



# Improved method for Assembly

- **Marine operation**

- Methods for heavy maintenance at various site conditions
- Assess and qualify industrialized Hywind installation methods
- Installation methods for Hywind concept assemble in different water depths.



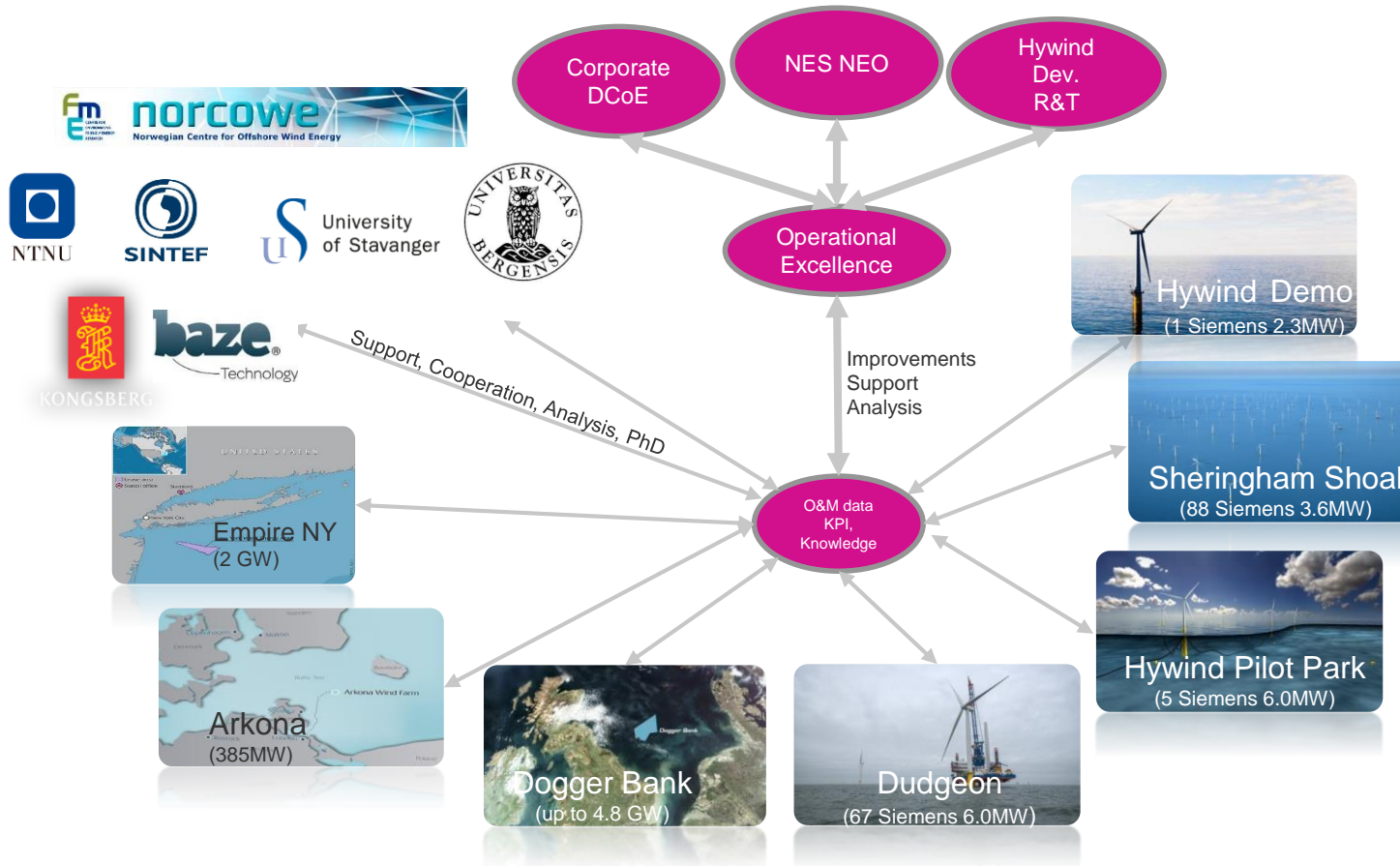


# Increased lifetime, reduced cost

- Wind turbine
  - Tools for advanced O&M data analysis and predictive/condition based maintenance for wind parks
  - Analysis model for drive train
  - Passive load reduction methods implemented in analysis software.



# New Energy Operations - Operational Excellence



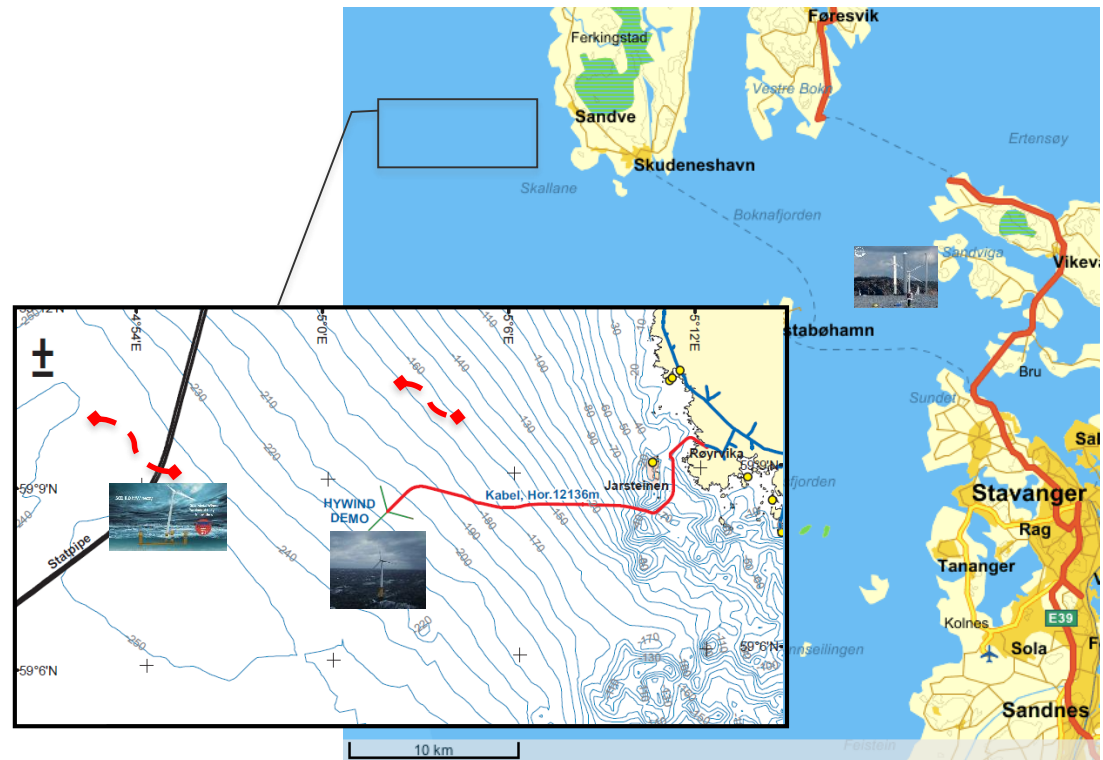
# Hywind Demo experience...

- In operation from September 2009, concession to 2020 Excellent HSE record- no serious incidents!
- Hywind controllers tested and verified, further demonstrated by Hywind Scotland
- Production 10,1 GWh in 2011 → Capacity factor 50,1% in 2011. Average Cap. Factor 41%
- Production: close to 65 GWh since start-up
- Production as good as or better than other 2.3 MW Siemens wind power turbines. NORWEA prize for the best producing wind turbine in Norway in 2011, 3rd best in 2012, 2<sup>nd</sup> best in 2014
- Experienced wind speed over 40 m/s and maximum wave height of 19 m. Floater motions have no negative impact on operations- in contrary
- No major issues. Same O&M as for the conventional bottom-fixed. All technical systems are working well – concept verified
- Valuable experience/learning still to be gathered and used in future floating development! Digitalization opens new possibilities! New technologies can be tried and tested!

...success to be continued

# Marine Energy Test Centre Karmøy

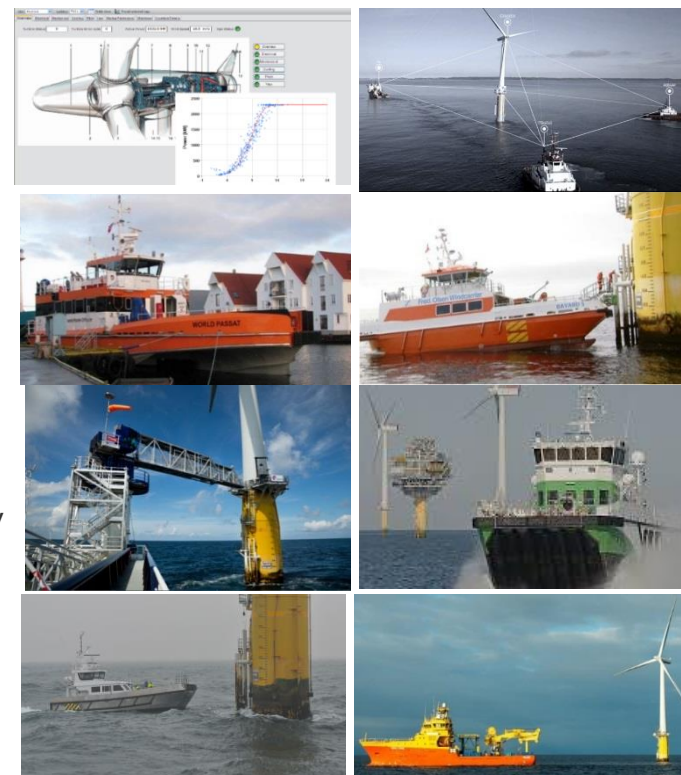
- Established around Hywind Demo as the first demo turbine with aim to be a “national test centre”
- All infrastructure in place, 40MW concessions
- 6 concessions for shallow 20-50 meter and 2 for deep water 200 meters
- 15MW 22kV cable (Hywind Demo 2,3 MW)
- Well functioning O&M base at Skudeneshavn
- Using local vendors → “knock-on” effect on the Norwegian supply chain
- Hywind “Living laboratory”, good cooperation with Norwegian and international Universities and R&D institutions





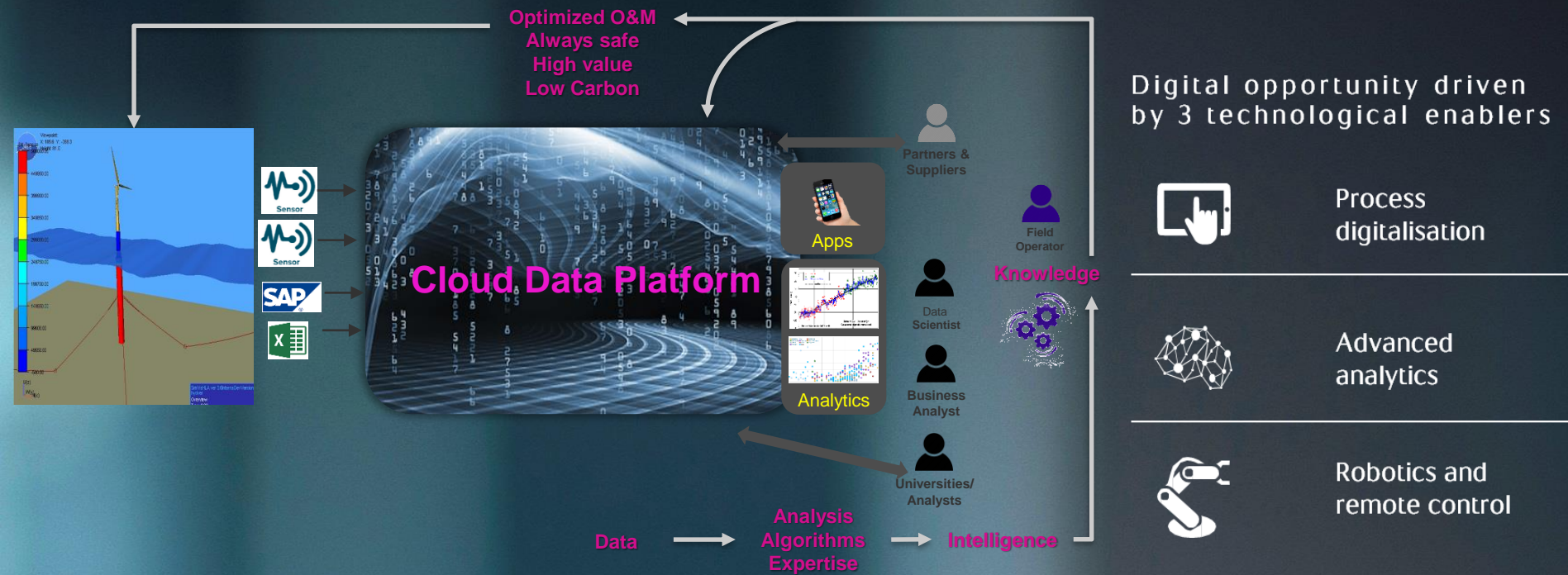
# High activity- test and use of new efficient O&M solutions

- R&D and testing of new turbine controller for Hywind Scotland,
  - HSE courses, drills,
  - Weather buoys, marine and production forecasting,
  - Demo and testing of new technologies and O&M systems
  - Validate test of autonomous drones/robotics
  - Huge media interest, investor visits
- Testing of innovative vessels, equipment and access solutions ie:
    - Buksér & Berging “Buddy”
    - Windcarrier “Bayard3” w/ MaXccess
    - “Island Crown” w/ Uptime
    - Fjellstrand / WMO “World Passat”
    - A+D Vessel Motion Measurement System
    - Deepocean / “Edda Fonn” w/ ROV
    - Stinger Micro- and Mini ROVs
    - Umoe Mandal «Umoe Firmus»
    - Rødne «Rygerkongen»
    - Karmsund Shipping «Steven»
    - MCS «MCS SWATH1»





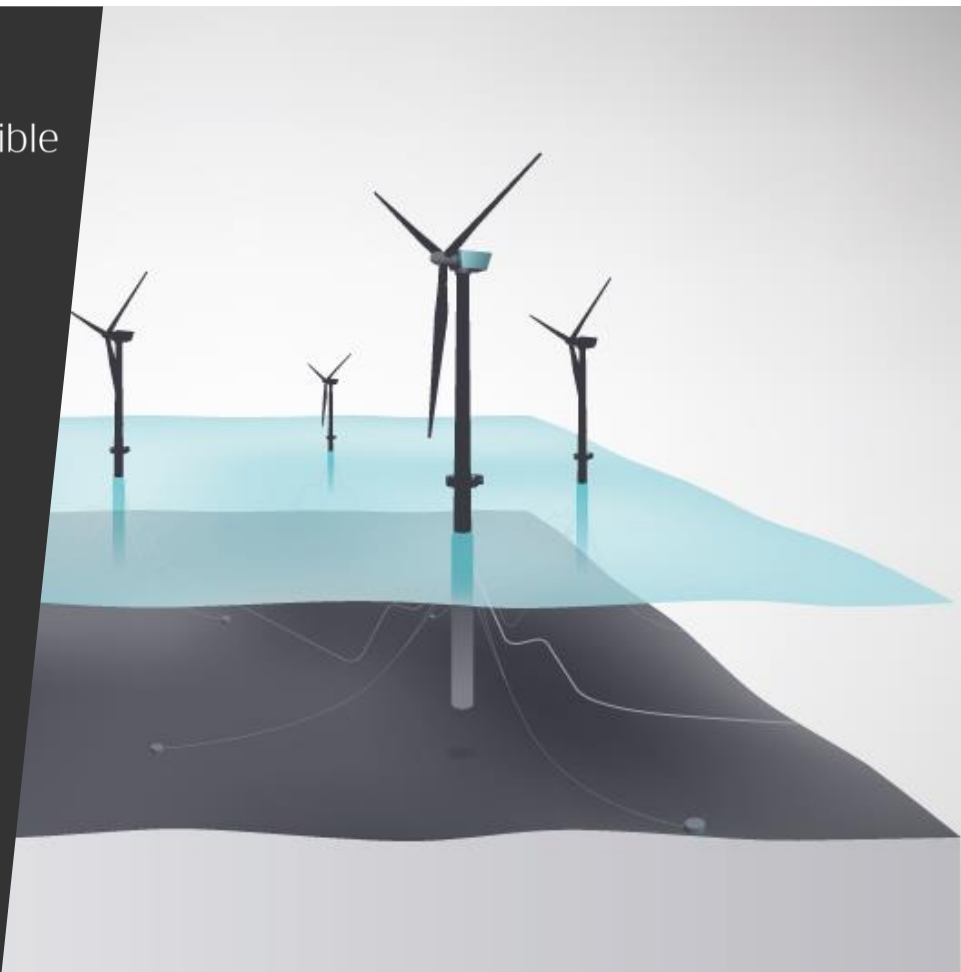
# Digitalization-new possibilities for collaboration driving innovation and continuous improvement



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