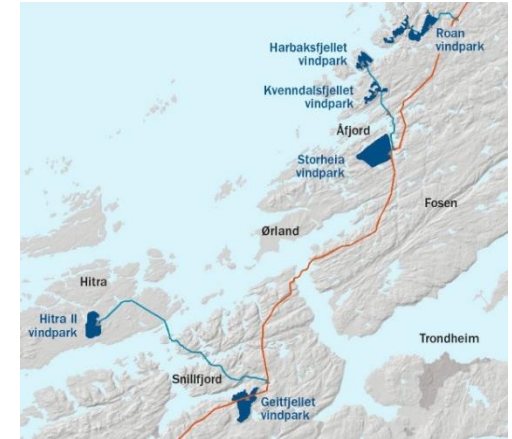
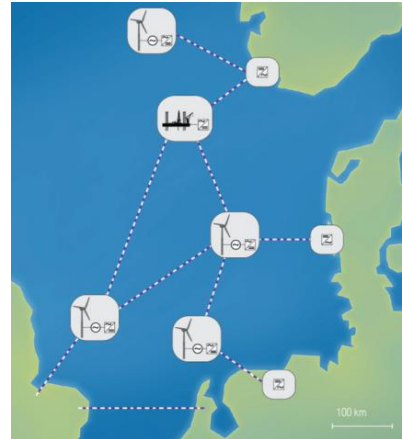


Workshop Trondheim 17/6-2016

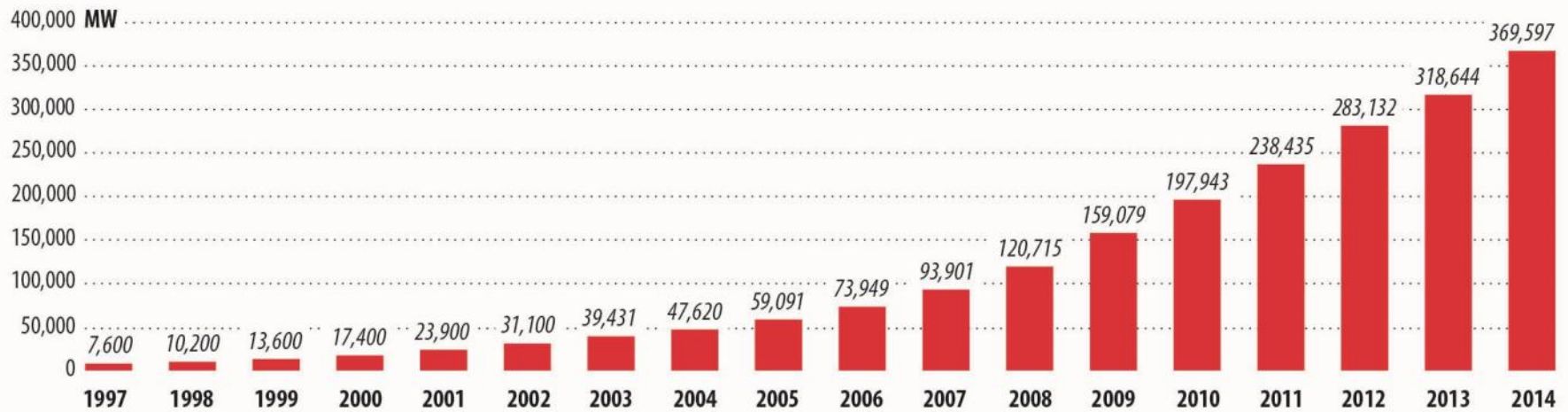
# Offshore wind

John Olav Giæver Tande  
Director NOWITECH  
Senior Scientist / Research Manager  
SINTEF Energy Research  
John.tande@sintef.no



# Wind energy in strong development

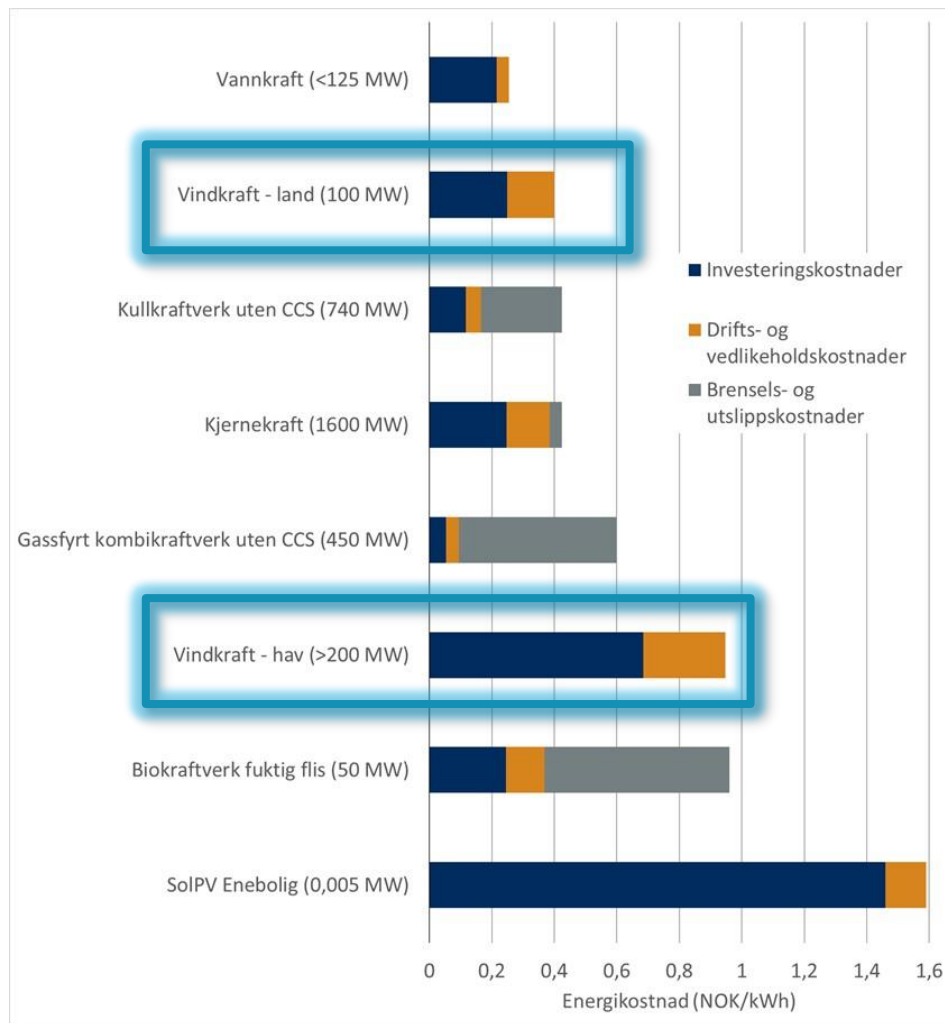
GLOBAL CUMULATIVE INSTALLED WIND CAPACITY 1997-2014



Source: GWEC

# Wind energy on land is cost competitive

## Offshore wind energy needs to be developed



# A great science and engineering challenge!



# See any similarities?

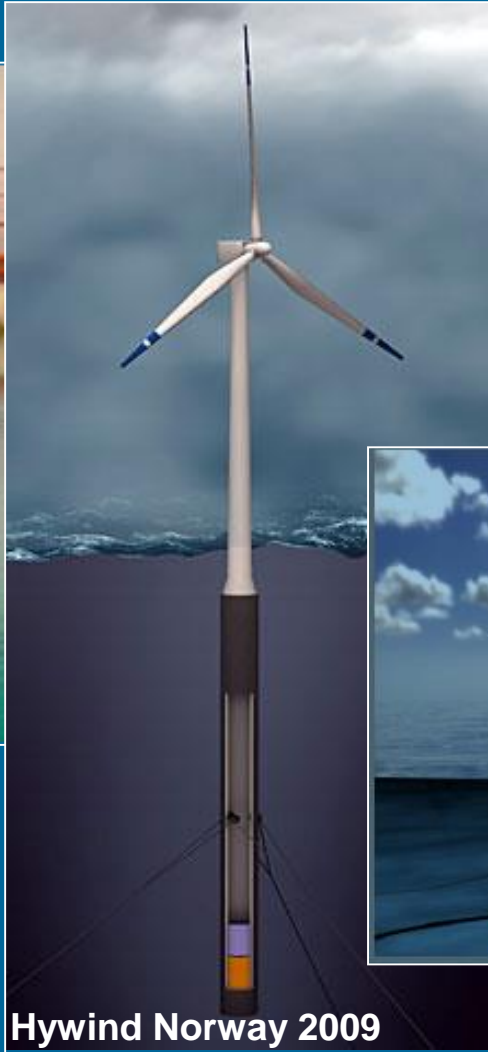


# Exciting development of floating wind

## Statoil is taking the next step



Hywind  
SINTEF/  
MARINTEK  
2005

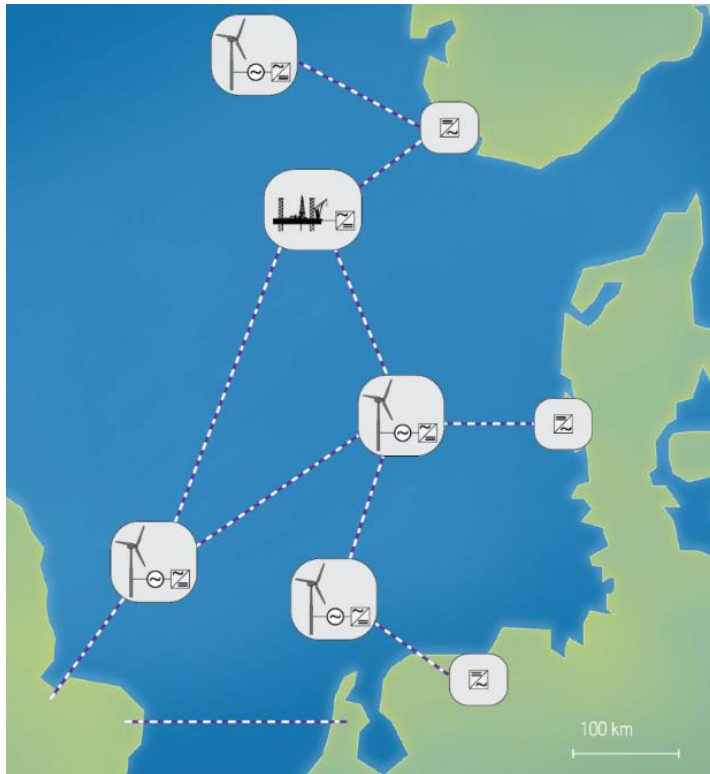


Hywind Norway 2009

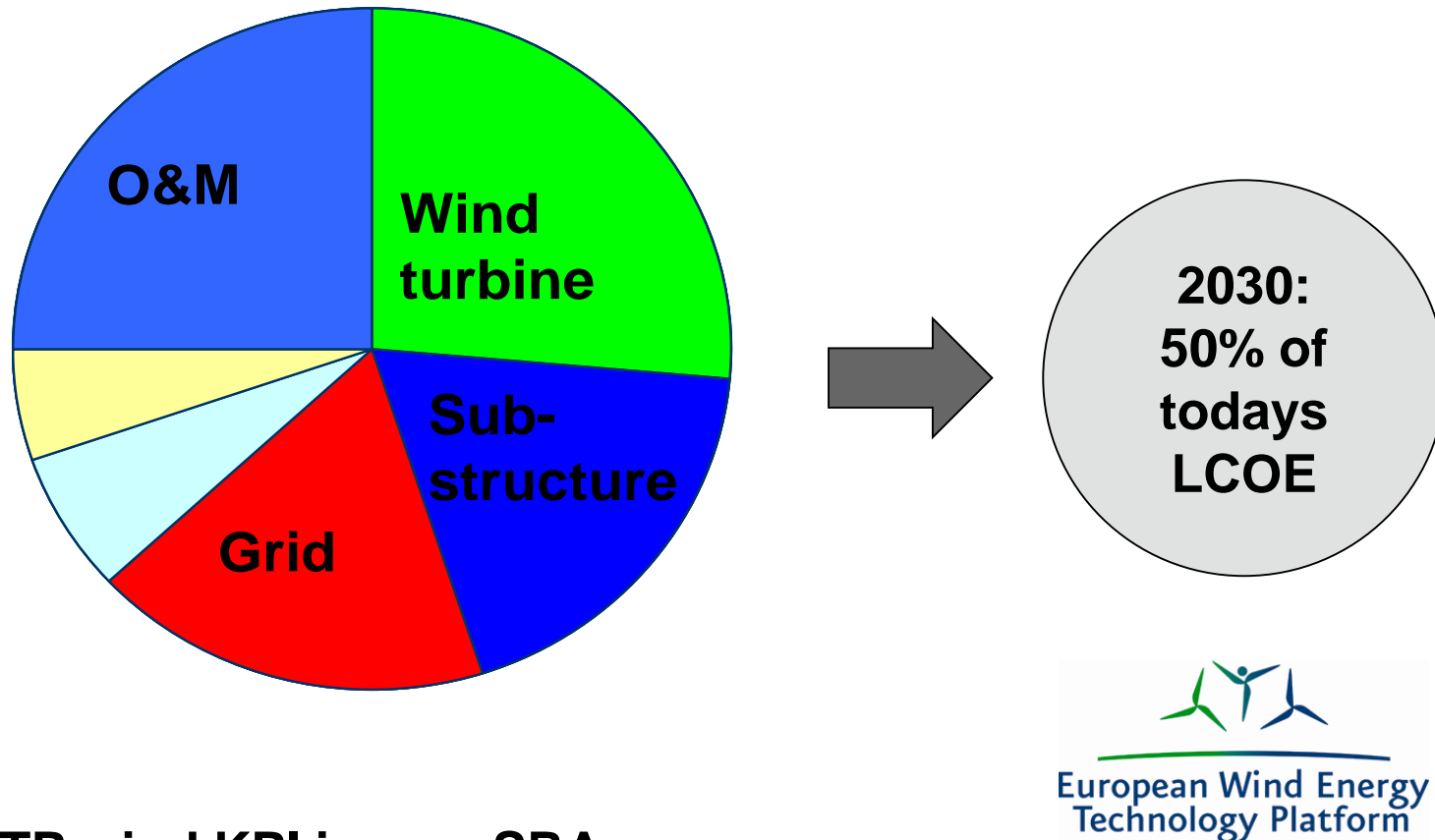


Hywind Scotland 2017

# Moving towards an North-Sea offshore grid



# Offshore wind main challenge: Reduce Levelized Cost of Energy (LCOE)



**EU TP wind KPI in new SRA:**

**Reduce LCOE by 50% from present levels for similar sites by 2030**



## Offshore wind LCOE

# Offshore wind has cost reduction opportunities in multiple areas including scale effects

### Turbines & plant



- Larger turbines and wind farms
- Increased reliability
- Scale effects and industrialisation

### Substructures



- Standardised and optimised offshore foundation design and design criteria
- Industrialised manufacturing

### Transmission



- eBoP optimisation of substation and transmission capex
- Innovative transmission solutions
- Improved grid access

### O&M



- Low OPEX drivetrains
- Turbine and component quality
- Condition monitoring, diagnostics, preventive maintenance

Source: Siemens, MHI-Vestas, MAKE

# NOWITECH in brief

- ▶ A joint pre-competitive research effort
- ▶ Focus on deep offshore wind technology (+30 m)
- ▶ Budget (2009-2017) EUR 40 millions
- ▶ Co-financed by the Research Council of Norway, industry and research partners
- ▶ 25 PhD/post doc grants
- ▶ **Key target: innovations reducing cost of energy from offshore wind**
- ▶ Vision:
  - large scale deployment
  - internationally leading

## Research partners:

- ▶ SINTEF Energy (host)
- ▶ IFE
- ▶ NTNU
- ▶ MARINTEK
- ▶ SINTEF ICT
- ▶ SINTEF MC

## Industry partners:

- ▶ CD-adapco
- ▶ DNV GL
- ▶ DONG Energy
- ▶ Fedem Technology
- ▶ Fugro OCEANOR
- ▶ Kongsberg Maritime
- ▶ Norsk Automatisering
- ▶ Statkraft
- ▶ Statoil

## Associated research partners:

- ▶ DTU Wind Energy
- ▶ Michigan Tech Uni.
- ▶ MIT
- ▶ NREL
- ▶ Fraunhofer IWES
- ▶ Uni. Strathclyde
- ▶ TU Delft
- ▶ Nanyang TU

## Associated industry partners:

- ▶ Devold AMT AS
- ▶ Energy Norway
- ▶ Enova
- ▶ Innovation Norway
- ▶ NCEI
- ▶ NORWEA
- ▶ NVE
- ▶ Wind Cluster Norway

# NOWITECH achievements



Successful innovations



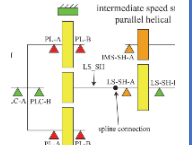

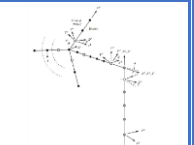
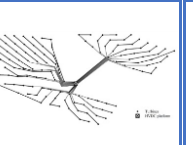


Excellence in research



Strong educational program

# NOWITECH has prepared 40 innovations

							
3DFloat integrated model TRL7	3DWind park wake model TRL6	INVALS general purpose optimization TRL8	Commercial grade rotor CFD TRL6	Simo-Riflex TRL7	WindOpt TRL4	Real time hybrid model test in ocean basin TRL3	Novel floater TRL2
							
Variational Multiscale Error Estimator TRL3	www.IFEM.no	www.ASHES.no	Seawatch Wind Lidar Buoy TRL8	CFD simulation TRL5	Droplet erosion resistant blade coatings TRL3	Droplet erosion testing TRL4	Fleet optimization TRL4
							
Gearbox fault detection TRL3	Gearbox vulnerability map TRL4	Dual layer corrosion protection coatings TRL3	NOWicob TRL4	Remote Presence TRL5	Routing and scheduling TRL2	Thermally sprayed SiC coatings TRL4	Buckling resistant blades TRL3
							
Fatigue damage simulation TRL4	PSST Power System Simulation TRL3	Net-Op network optimization TRL3	Viper Estimate Energy Output from Offshore Wind Farms TRL3	Smartgrid Lab HVDC grid TRL4	Control of multi-terminal HVDC grid TRL4	Wind Supply to Oil & Gas TRL3	Turbine control TRL3
							
Wind turbine electrical interaction TRL2	Network Reduction TRL2	STAS linear State-Space Wind Power Plant Analysis TRL2	PM generator magnetic vibrations TRL4	PM generator integrated design TRL3	Wind farm collection grid optimization TRL1	Long distance AC transmission TRL1	Wideband model of wind farm collection grid TRL2

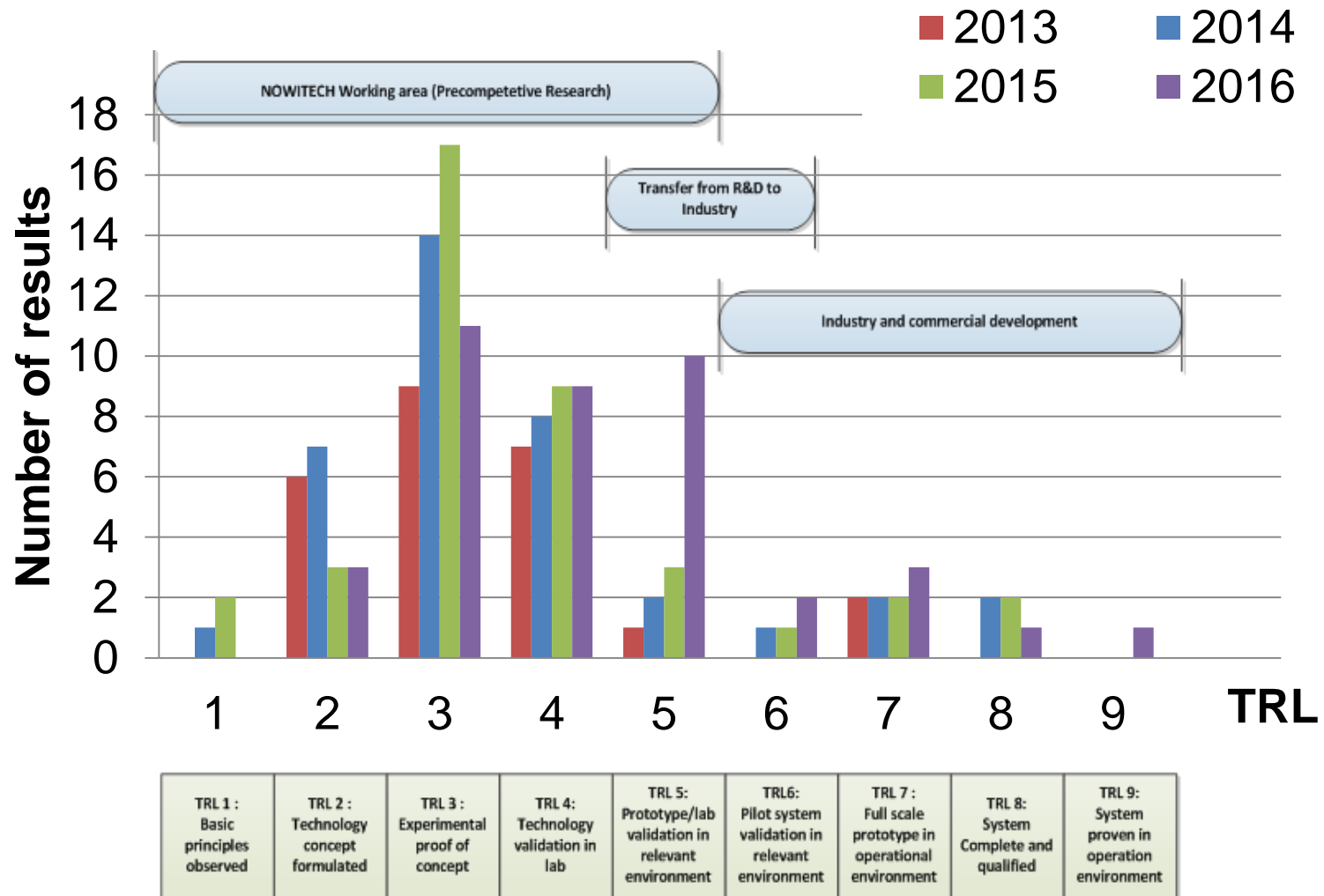
Technology/Process

Numerical model/method

Research Infrastructure

Software

# Results are migrating to commercial use

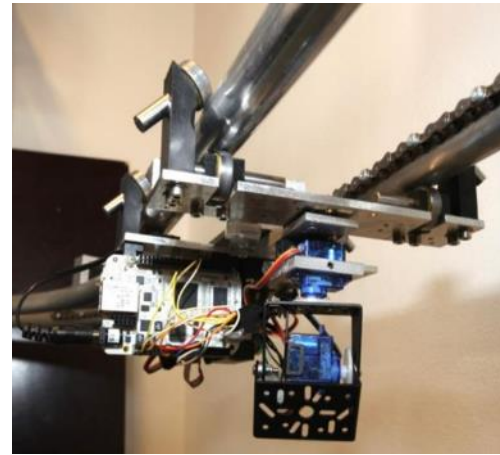
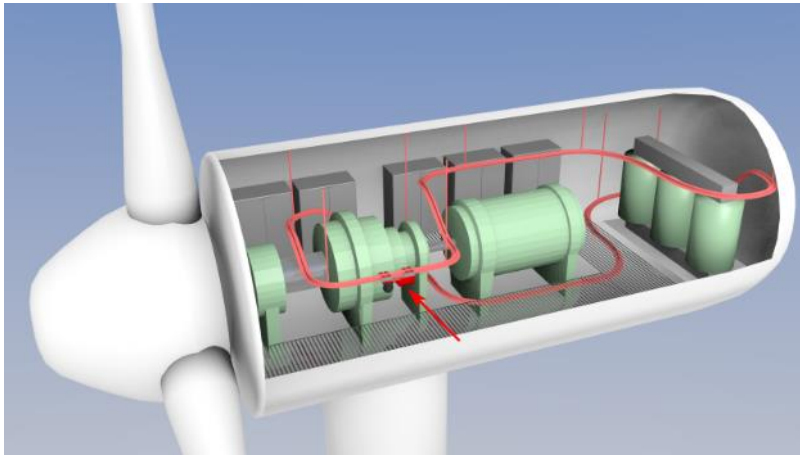


# Thermally sprayed silicon carbide coating



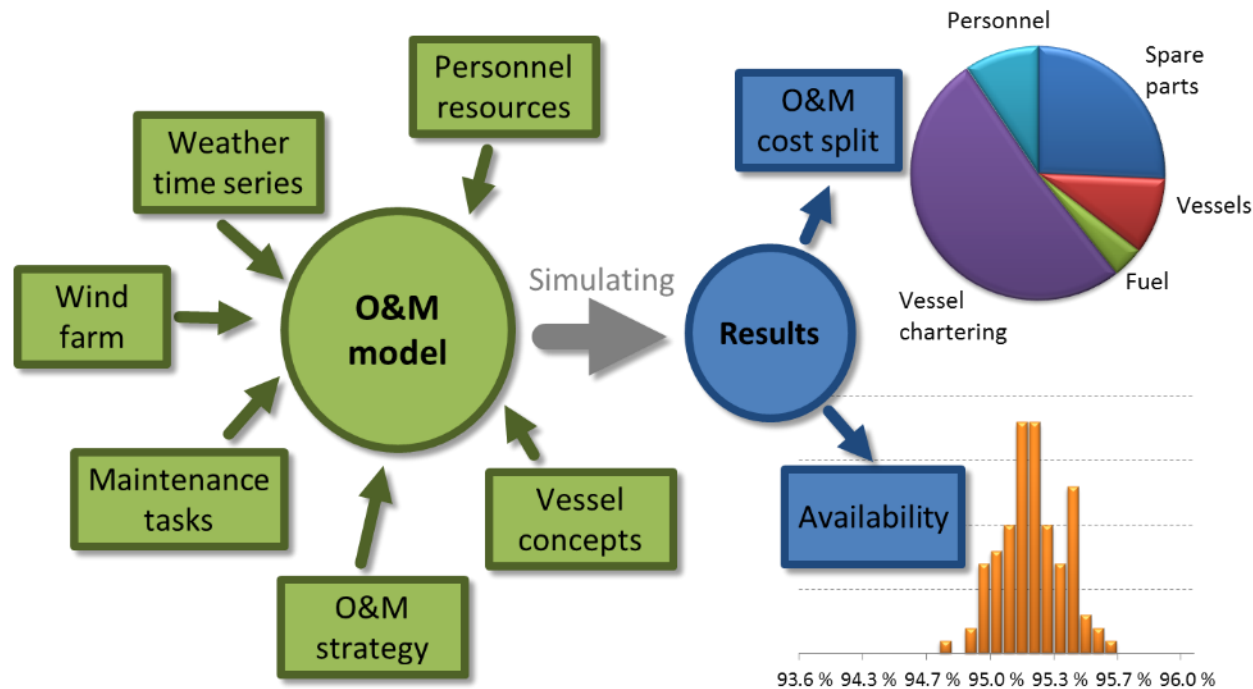
- ✓ Patented process result of NOWITECH PhD work.
- ✓ Being developed further by the spinout company Seram Coatings AS.
- ✓ The process provides for an extremely hard, wear-resistant, low friction ceramic coating that can be applied to rotating machinery like main bearings in large direct drive wind turbines; ultimately increasing lifetime and reducing cost for maintenance.
- ✓ In 2015 Seram Coatings AS won Startprisen and the Academic Enterprise Awards (ACES) in Barcelona and professor Nuria Espallargas won "Best Young Innovator".
- ✓ In recent media coverage the potential for the innovation is reported to be a billion kroner business with multiple application areas.

# Remote presence



- ✓ **Technology developed in part through NOWITECH PhD work**
- ✓ **Remote presence through a small robot on a track in the nacelle equipped with camera / heat sensitive, various probes, microphone etc. reducing offshore work by service personnel, downtime and costs**
- ✓ **Technology is commercialized by Norsk Automatisering AS through the new company EMIP**

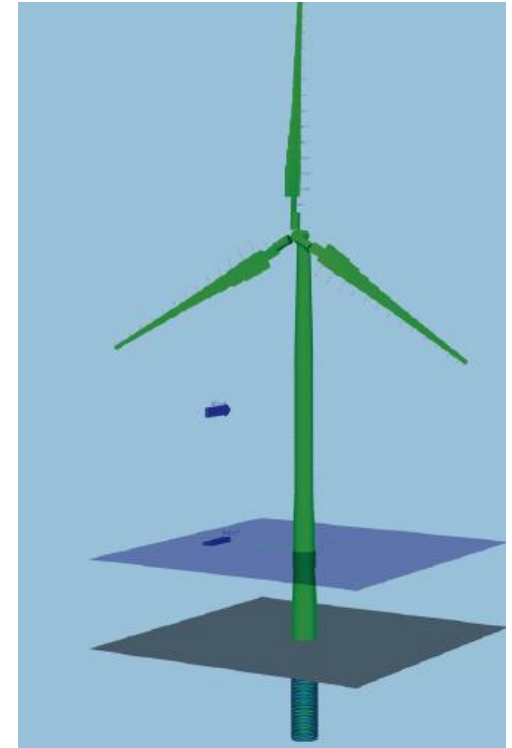
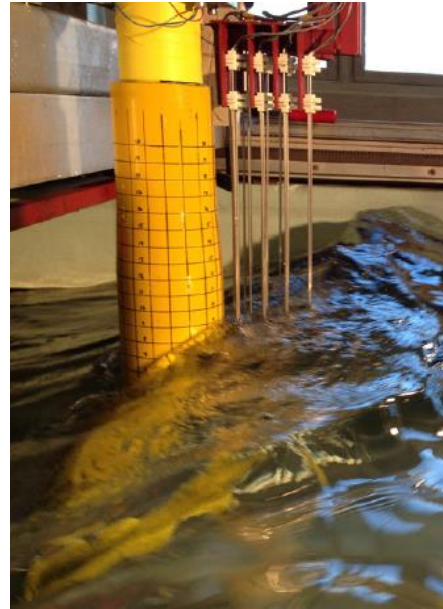
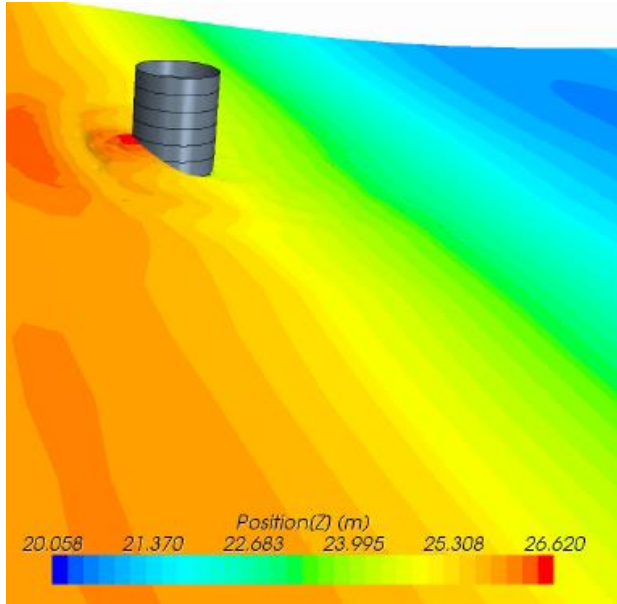
# NOWIcob – A operation and maintenance analysis tool for offshore wind farms



- ✓ Strategic discrete-event simulation tool for analysis of different offshore wind farm maintenance and logistics strategies
- ✓ Developed by SINTEF Energy in NOWITECH
- ✓ In use by wind farm developers for O&M planning

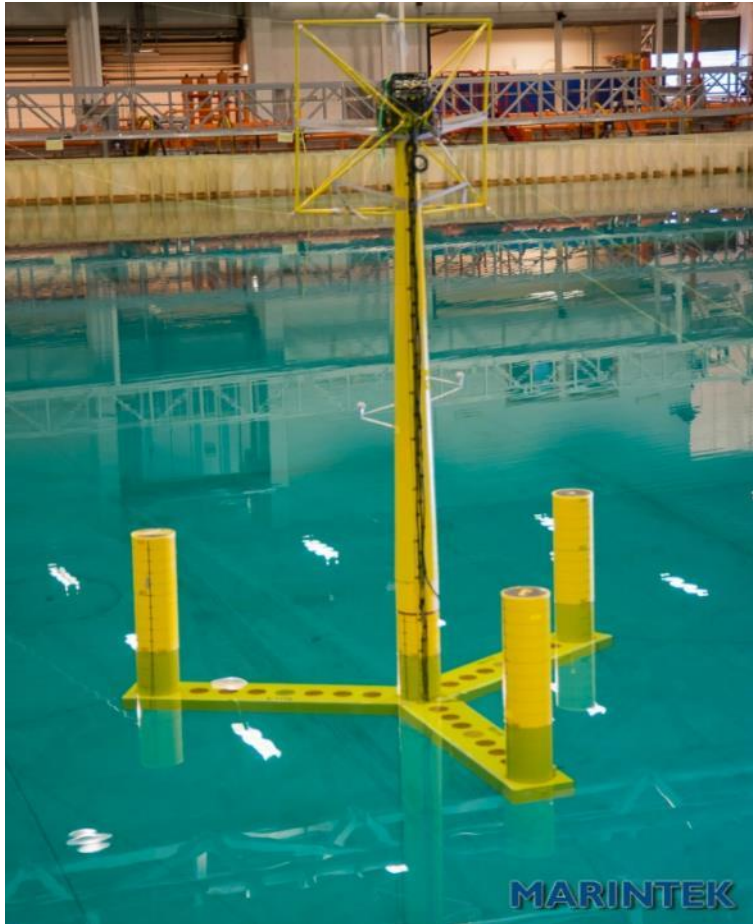


# Savings costs with knowledge, models and labs



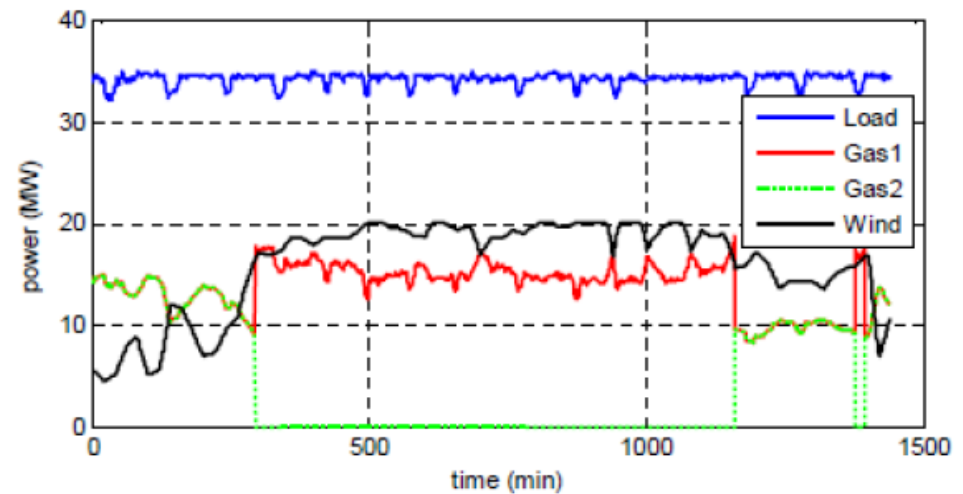
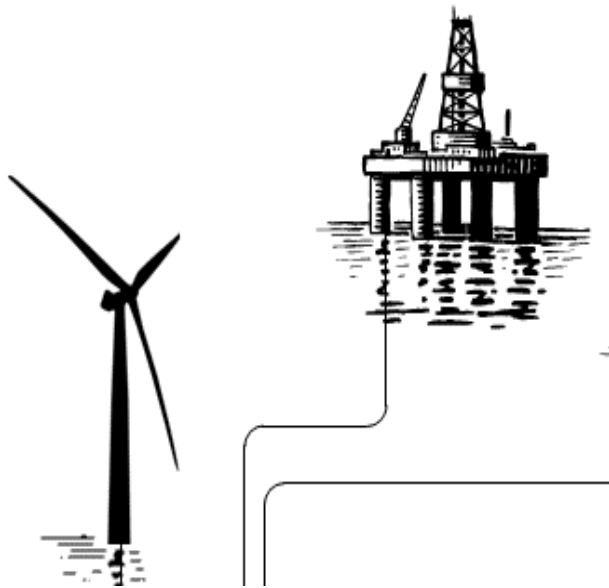
**De-risking monopole for Dudgeon 402 MW Offshore Wind Farm**  
MARINTEK using CFD, lab experiments and FE SIMA analysis

# Scaled HIL optimized floating wind turbine model test



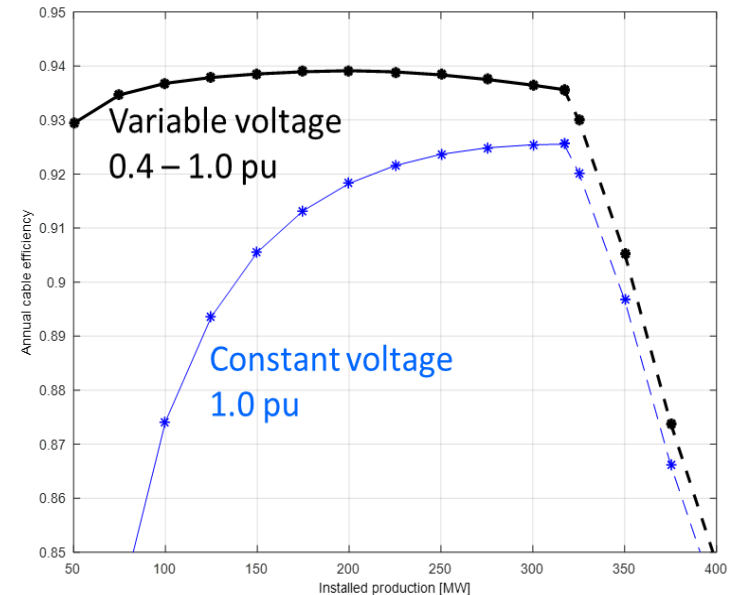
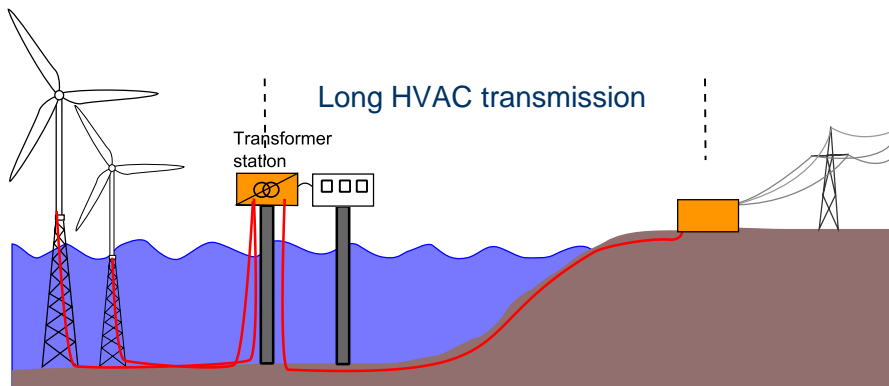
- ✓ A world's first of a kind test
- ✓ Uses new hardware-in-the-loop (HIL) technique for lab-scale test of a floating wind turbine.
- ✓ <https://youtu.be/slywrZFKd84>
- ✓ The results is used in LIFES50+ (EU H2020) coordinated by MARINTEK. The project shall bring forward innovative technology for floating substructures for very large wind turbines (10 MW) at water depths greater than 50 m.

# Offshore wind energy supply to oil & gas platforms



- ✓ Concept developed in NOWITECH by SINTEF & NTNU
- ✓ Further development through IPN (RCN) coordinated by Statoil

# Long distance HVAC transmission

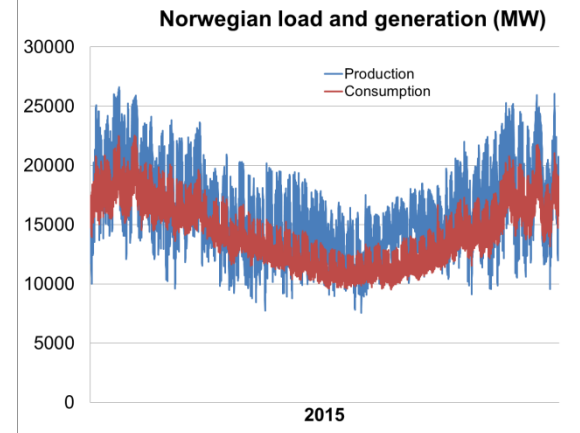
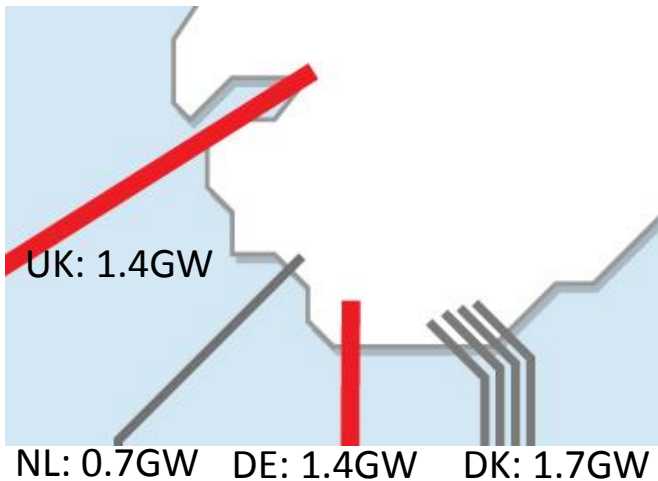
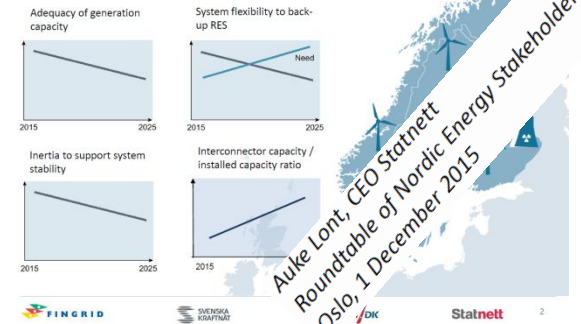


- ✓ Operation of long distance HVAC transmission cable at variable voltage can give significant efficiency improvements.
- ✓ The figure is for a 200 km, 220 kV, 1000 mm<sup>2</sup> cable.
- ✓ Development in NOWITECH by SINTEF Energy Research

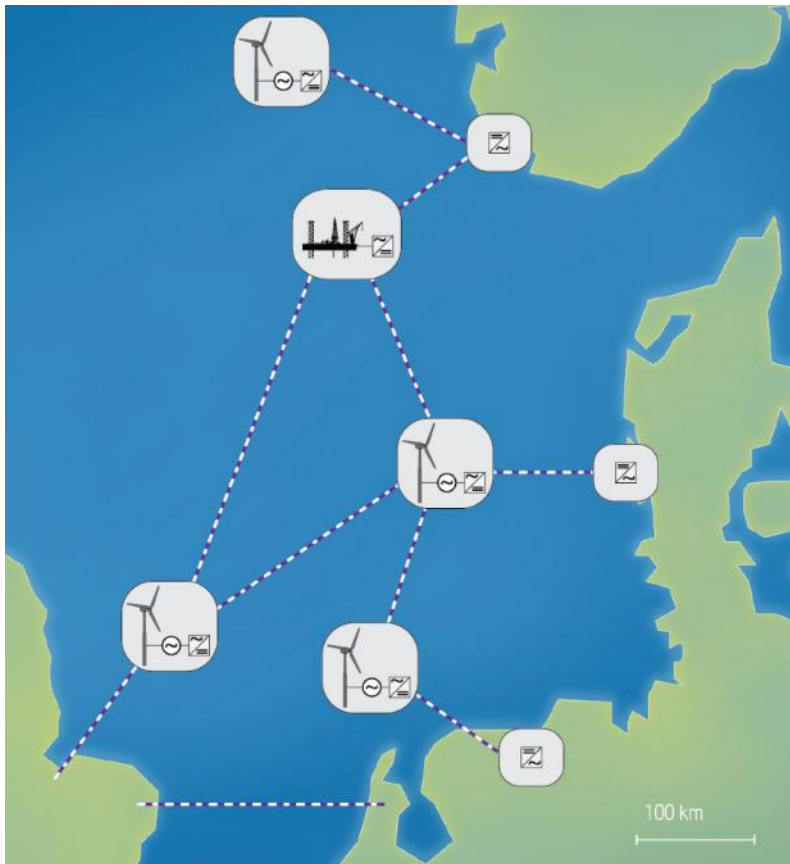
# Near future Norwegian power system

- ✓ More transmission between Norway and other countries
- ✓ More wind power and other variable energy supply
- ✓ Increased use of power electronic converters
- ✓ Changes in load patterns & consumer behavior
- ✓ Higher demand for reserves and balancing resources
- ✓ **Periods of extremely low inertia and reduced stability margins**

## Trends that challenge the security of the power system



# Laboratory demo of the future North-Sea grid



- ▶ Operation and control
- ▶ Converter interoperability
- ▶ System stability
- ▶ Fault handling
- ▶ System services
- ▶ Security of supply
- ▶ New market solutions



**SmartGrid lab (NTNU/SINTEF) is further developed with RI funding from RCN  
Lab is applied for validating new HVDC technology in BestPaths (EU FP7)**



# SET-plan initiative: Global Leadership in Offshore Wind



- ✓ **Offshore wind costs must be reduced** and performance and reliability increased to meet its full contribution to the European energy mix.
- ✓ There is a need to **develop (floating) substructures or integrated floating wind energy systems for deeper waters** and for use in other climate conditions, to increase the deployment possibilities and to improve the European position in the global market.

Brussels 20 January 2016

## Agreed strategic targets for offshore wind energy

1.Reduce the levelised cost of energy (LCoE) at final investment decision (FID) for fixed offshore wind\* by improvement of the performances of the entire value chain to

- less than 10 ct€/kWh by 2020 and to
- less than 7ct€/kWh by 2030;

2.Develop cost competitive integrated wind energy systems including substructures which can be used in deeper waters (>50m) at a maximum distance of 50 km from shore with a LCoE\* of

- less than 12 ct€/kWh by 2025 and to
- less than 9 ct€/kWh by 2030

*\* the costs for delivering the electricity to onshore substations are taken into account within the LCoE*

Copy from [https://setis.ec.europa.eu/system/files/declaration\\_of\\_intent\\_offshore\\_wind.pdf](https://setis.ec.europa.eu/system/files/declaration_of_intent_offshore_wind.pdf)

# Norwegian export of goods and services within renewable energy

I følge Multiconsult utgjorde eksport 5 mrd. kroner eller 24 prosent av omsetningen innen leverandørindustrien i fornybarnæringen. Omsetningen (2013) fordeler seg som følger:

- ✓ 0,8 mrd. kroner vannkraft
- ✓ 0,7 mrd. kroner landbasert vindkraft
- ✓ 1,9 mrd. kroner havbasert vindkraft
- ✓ 0,5 mrd. kroner solenergi
- ✓ 1 mrd. kroner kraftnett

03.02.2016, Ivar Slengesol, Eksportkreditt Norge: Målet må være å ta et større stykke av den voksende offshore vindkaken. Jeg tror «2020-10» er innen rekkevidde: i 2020 skal norske selskaper stå for 10 prosent av leveransene til europeiske offshore vindparker!



# Interesting developments 😊

## **New agreement to bolster offshore wind energy projects:**

"Ireland is to sign the declaration on the fringes of a European Council energy meeting. Other signatories are Belgium, Denmark, France, Germany, the Netherlands, Luxembourg, Sweden, the UK and Norway.

The declaration calls for “further cost-effective deployment of offshore renewable energy, in particular wind, through voluntary cooperation”. "

<http://www.irishtimes.com/business/energy-and-resources/new-agreement-to-bolster-offshore-wind-energy-projects-1.2673689>

# We make it possible!

[www.NOWITECH.no](http://www.NOWITECH.no)



**EERA DeepWind'2017**  
**14th Deep Sea Offshore Wind R&D Conference**  
**Trondheim 18-20 January, Norway**



**NOWITECH**

Norwegian Research Centre for Offshore Wind Technology

