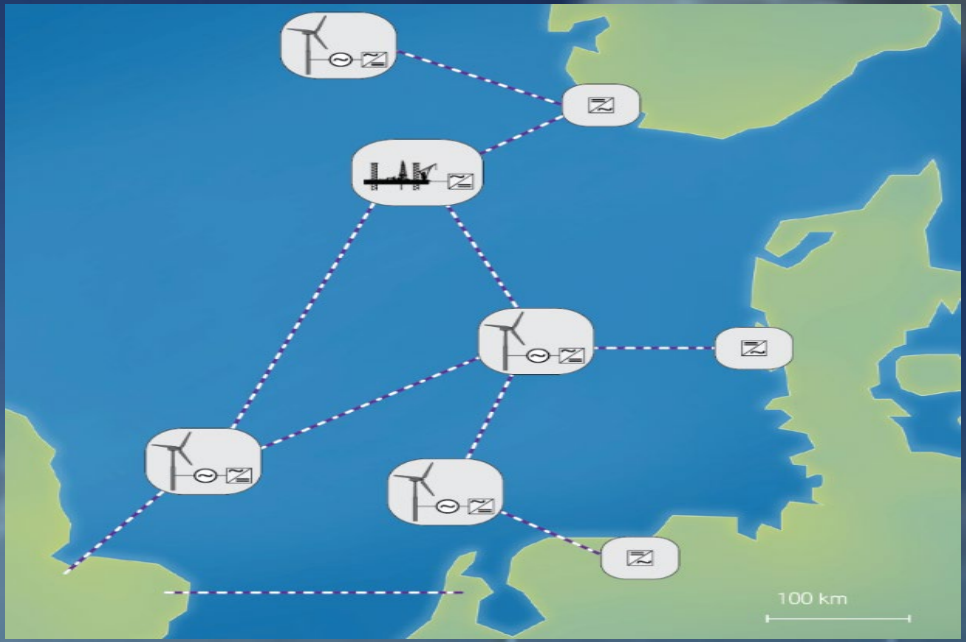


EERA DeepWind'2021

Making floating wind cost competitive

John Olav Giæver Tande, Chief Scientist, SINTEF Energi AS

John.tande@sintef.no

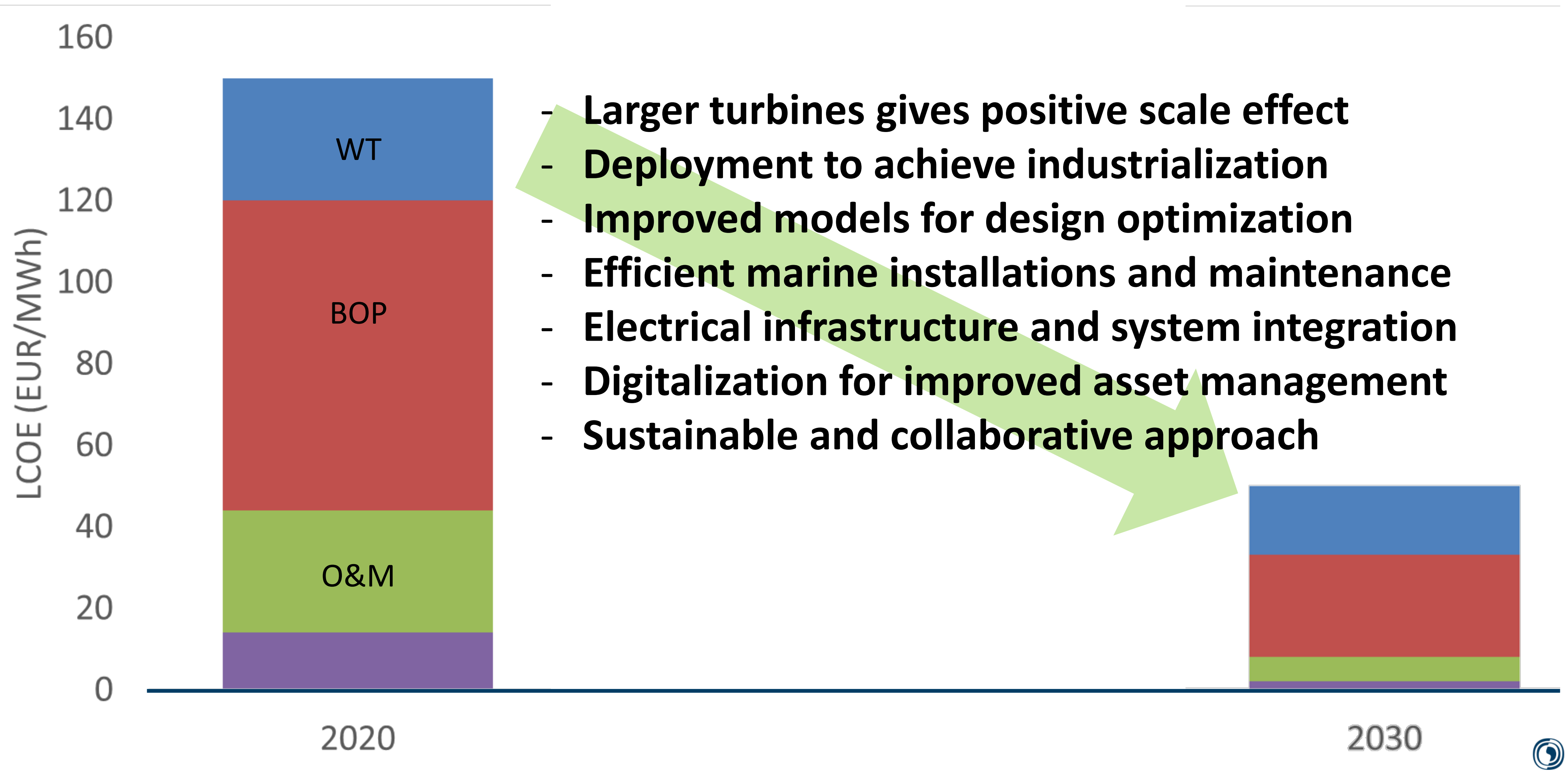
Graphic is courtesy of Equinor (main picture) and Aker Offshore Wind (insert lower right).
Grid illustration is by SINTEF.

Good reasons to develop floating wind farms

- Large scale clean energy supply
- Potential to supply the global electricity demand 14 times over
- Excellent wind conditions
- Development gives green jobs
- Vital to reach climate goals
- Proper execution gives minimal negative environmental impact

SINTEF

Goal: floating wind at 40-60 EUR/MWh by 2030



- Larger turbines gives positive scale effect
- Deployment to achieve industrialization
- Improved models for design optimization
- Efficient marine installations and maintenance
- Electrical infrastructure and system integration
- Digitalization for improved asset management
- Sustainable and collaborative approach

SINTEF

Cost reduction by design optimization (1 of 3)

Hywind development	Demo	Scotland	Tampen
Year	2009	2017	2022
Installed capacity (MW)	1x2,3	5x6,0	11x8,0
Rotor diameter (m)	85	154	167
Total displacement (ton)	5300	11400	22000
Floater construction	Steel	Steel	Concrete
Floater weight (ton)	1300	2300	9000
Floater weight (ton/MW)	565	383	1125
Floater cost (EUR/ton)*	3000	3000	500
Floater cost (MEUR/MW)*	1,7	1,2	0,6
Floater cost (EUR/MWh)*⁺	**30,1**	**20,4**	**10,0**

*For illustration only, actual cost of floater is not known by this study

⁺Assuming 4000 FLH, 25 years lifetime and 5 % discount rate

Drawings courtesy of Equinor

SINTEF

Cost reduction by design optimization (2 of 3)

Image courtesy WindFloat Atlantic / Principle Power with Aker Offshore Wind overlay

Example 15 MW WT

Vestas V164-8.4 MW

SINTEF

Cost reduction by design optimization (3 of 3)

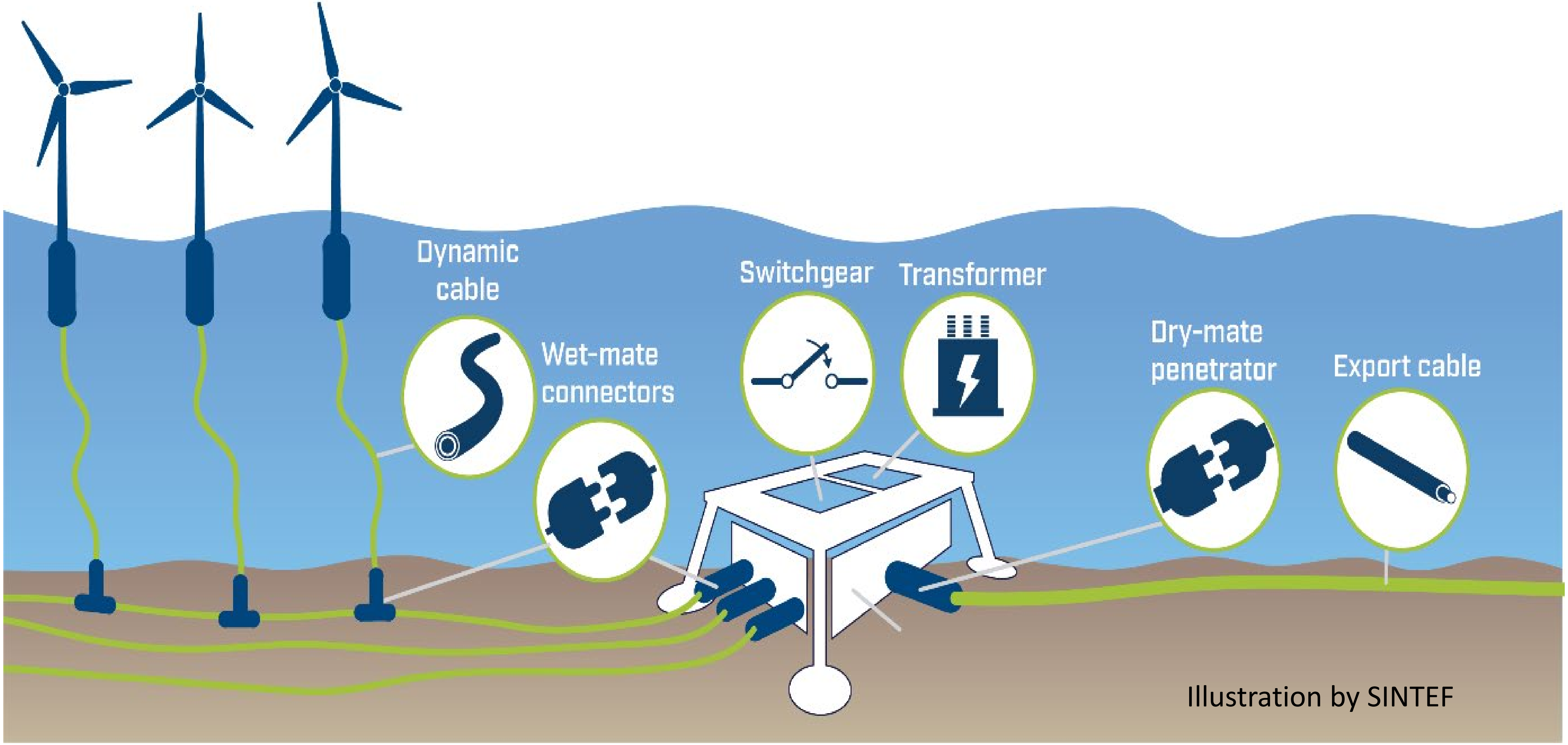
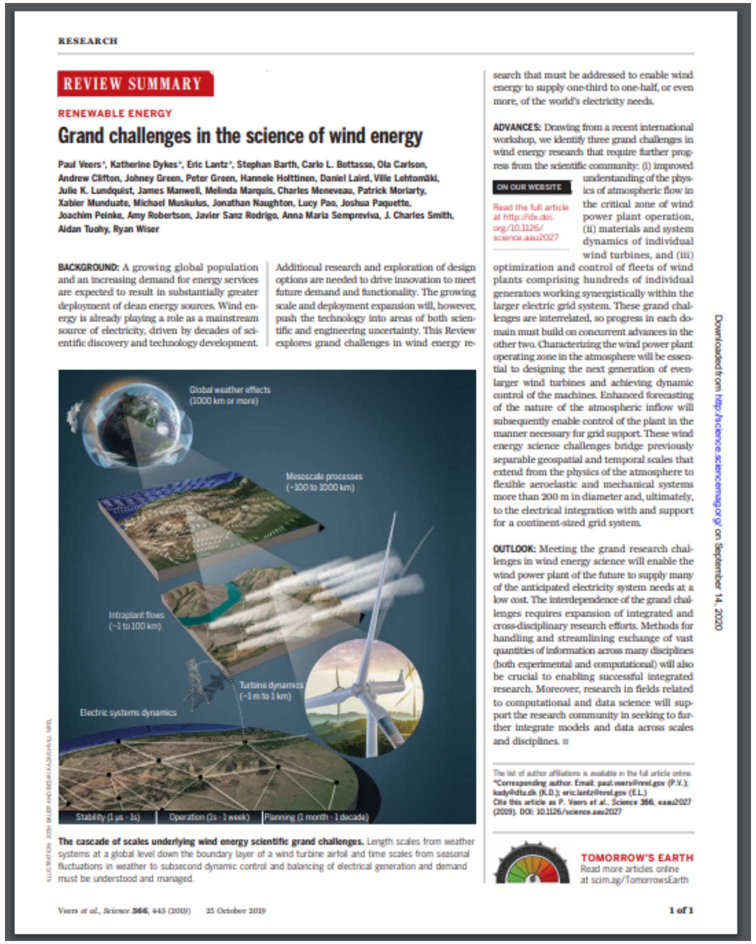


Illustration by SINTEF

Grand Scientific Challenges


RESEARCH

REVIEW SUMMARY

RENEWABLE ENERGY

Grand challenges in the science of wind energy

Paul Veers*, Katherine Dykes*, Eric Lantz*, Stephan Barth, Carlo L. Bottasso, Ola Carlson, Andrew Clifton, Johney Green, Peter Green, Hannele Holttinen, Daniel Laird, Ville Lehtomäki, Julie K. Lundquist, James Manwell, Melinda Marquis, Charles Meneveau, Patrick Moriarty, Xabier Munduate, Michael Muskulus, Jonathan Naughton, Lucy Pao, Joshua Paquette, Joachim Peinke, Amy Robertson, Javier Sanz Rodrigo, Anna Maria Sempreviva, J. Charles Smith, Aidan Tuohy, Ryan Wiser

BACKGROUND: A growing global population and an increasing demand for energy services are expected to result in substantially greater deployment of clean energy sources. Wind energy is already playing a role as a mainstream source of electricity, driven by decades of scientific discovery and technology development. Additional research and exploration of design options are needed to drive innovation to meet future demand and functionality. The growing scale and deployment expansion will, however, push the technology into areas of both scientific and engineering uncertainty. This Review explores grand challenges in wind energy research that must be addressed to enable wind energy to supply one-third to one-half, or even more, of the world's electricity needs.

ADVANCES: Drawing from a recent international workshop, we identify three grand challenges in wind energy research that require further progress from the scientific community: (i) improved understanding of the physics of atmospheric flow in the critical zone of wind power plant operation, (ii) materials and system dynamics of individual wind turbines, and (iii) optimization and control of fleets of wind plants comprising hundreds of individual generators working synergistically within the larger electric grid system. These grand challenges are interrelated, so progress in each domain must build on concurrent advances in the other two. Characterizing the wind power plant operating zone in the atmosphere will be essential to designing the next generation of even-larger wind turbines and achieving dynamic control of the machines. Enhanced forecasting of the nature of the atmospheric inflow will subsequently enable control of the plant in the manner necessary for grid support. These wind energy science challenges bridge previously separable geospatial and temporal scales that extend from the physics of the atmosphere to flexible aeroelastic and mechanical systems more than 200 m in diameter and, ultimately, to the electrical integration with and support for a continent-sized grid system.

OUTLOOK: Meeting the grand research challenges in wind energy science will enable the wind power plant of the future to supply many of the anticipated electricity system needs at a low cost. The interdependence of the grand challenges requires expansion of integrated and cross-disciplinary research efforts. Methods for handling and streamlining exchange of vast quantities of information across many disciplines (both experimental and computational) will also be crucial to enabling successful integrated research. Moreover, research in fields related to computational and data science will support the research community in seeking to further integrate models and data across scales and disciplines. ■

ON OUR WEBSITE

Read the full article at http://dx.doi.org/10.1126/science.aau2027

The cascade of scales underlying wind energy scientific grand challenges. Length scales from weather systems at a global level down the boundary layer of a wind turbine airfoil and time scales from seasonal fluctuations in weather to subsecond dynamic control and balancing of electrical generation and demand must be understood and managed.

The list of author affiliations is available in the full article online.
*Corresponding author. Email: paul.veers@nrel.gov (P.V.); kady@dtu.dk (K.D.); eric.lantz@nrel.gov (E.L.)
Cite this article as P. Veers et al., Science 366, eaau2027 (2019). DOI: 10.1126/science.aau2027

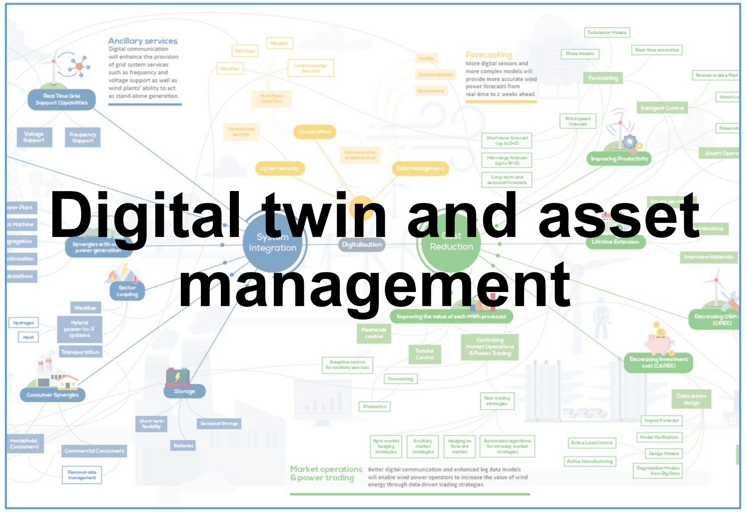
TOMORROW'S EARTH
Read more articles online at scim.ag/TomorrowsEarth

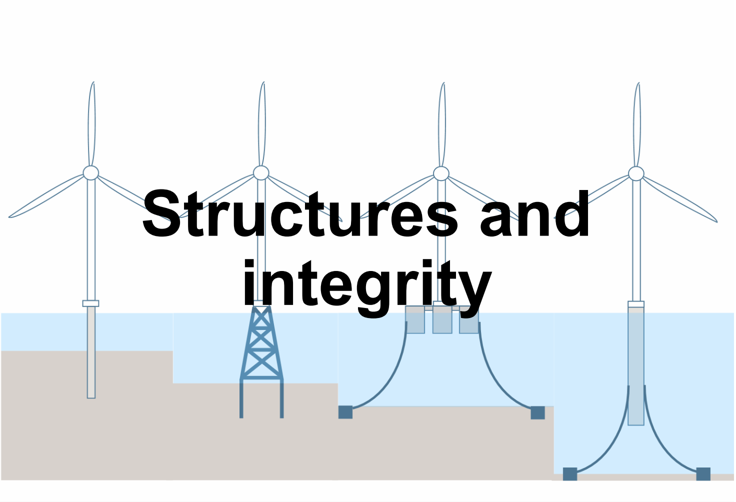
- Improved understanding of atmospheric and wind power plant flow physics
- Aero-, structural-, electrical- and offshore wind hydrodynamics of enlarged wind power plants
- Systems science for integration of wind power plants into the future electricity grid

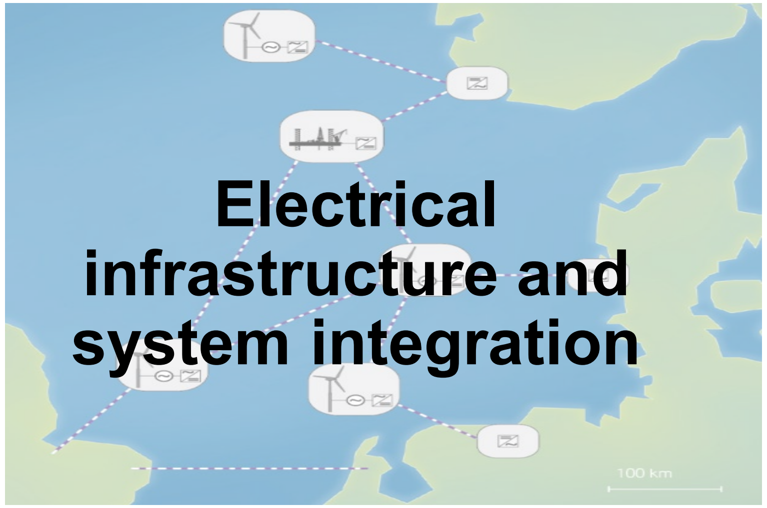
FME NorthWind is in the making

- Offshore technology for the international market
- Cost competitive floating wind
- Wind energy respecting nature
- Opportunity for collaboration
- Starting summer 2021
- 8 year programme

NorthWind Research Programme







FME NorthWind partners

Research

- SINTEF
- NTNU
- NGI
- UiO University of Oslo
- NINA

Industry

- Hafslund ECO
- AKER OFFSHORE WIND
- DNV·GL
- Sval
- Fred. Olsen Renewables
- aibel
- equinor
- IMPELLO
- Lundin Energy Norway
- SAP
- Nexans
- FORCE TECHNOLOGY
- Norwegian Energy Partners
- Energi Norge
- Statkraft
- HAVYARD
- Cognite
- Baker Hughes
- HITACHI ABB
- Norconsult
- RENERGY
- TrønderEnergi
- ABB
- SFE
- NKT
- FUGRO
- DR. TECHN. OLAV OLSEN
- OFFSHOREWIND
- Store Norske
- KONGSBERG
- Amon As
- ENERGY INNOVATION
- Finnmark Kraft
- EDR MEDESO
- Lloyd's Register
- 4subsea
- windcluster NORWAY
- NorSeaGroup
- NOV
- ESVAGT
- DOF Subsea
- VARD a Fincantieri company
- GFMS AS
- NORWEA

Associates

- DTU
- Fraunhofer
- TNO
- University of Strathclyde Glasgow
- NREL NATIONAL RENEWABLE ENERGY LABORATORY
- North China Electric Power University

Summing up

- Floating wind represent great opportunities for large scale clean energy supply, green jobs and a billion-euro export industry
- A target LCOE of 40-60 EUR/MWh can be reached by 2030 through Deployment incentives so that large floating wind farms can be built, and the production can be industrialized, and through Research and Innovation so that design, manufacturing, installation and operation can be optimized.

Technology for a better society