ENERGY

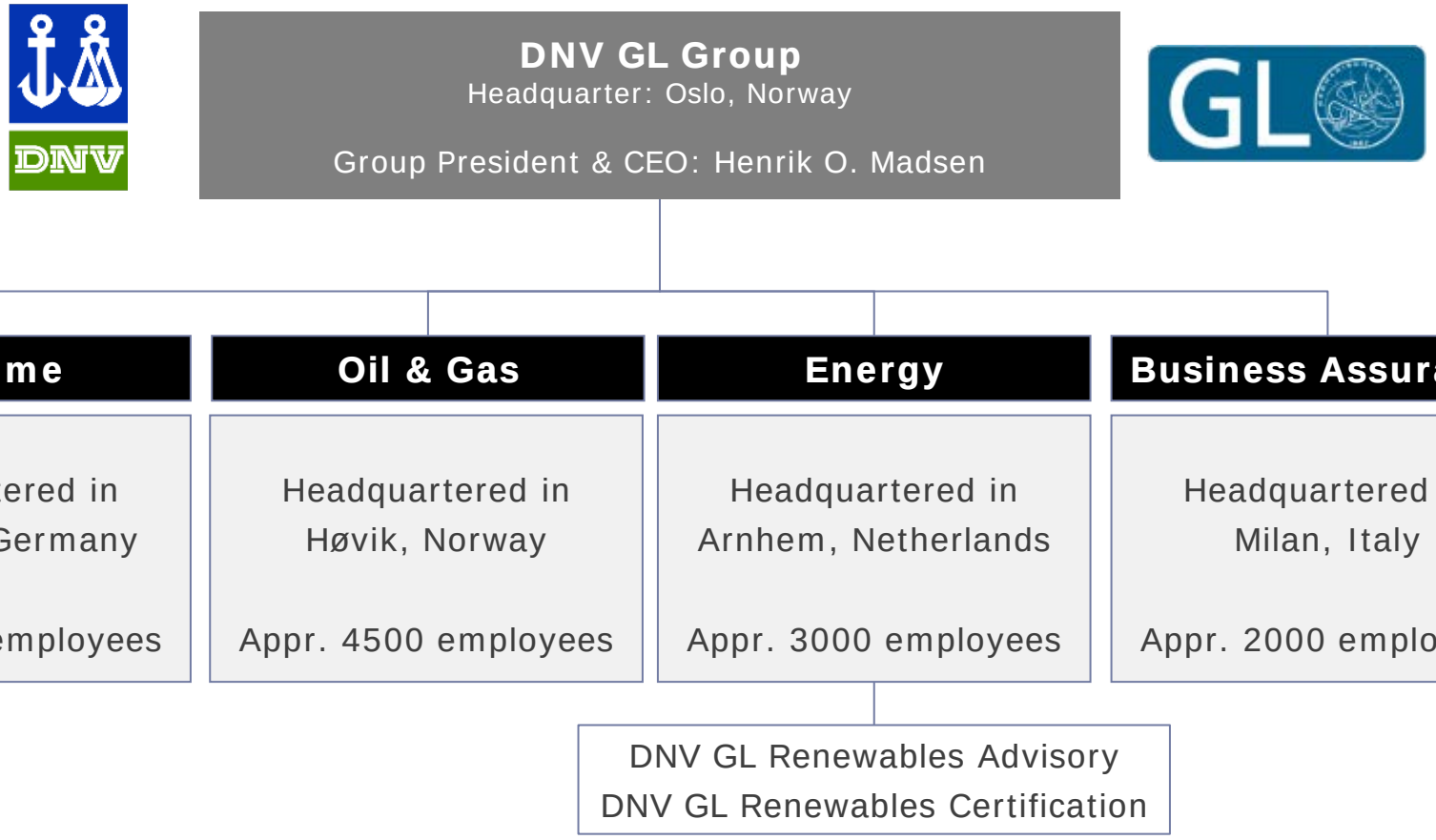
Floating wind technology

Future development

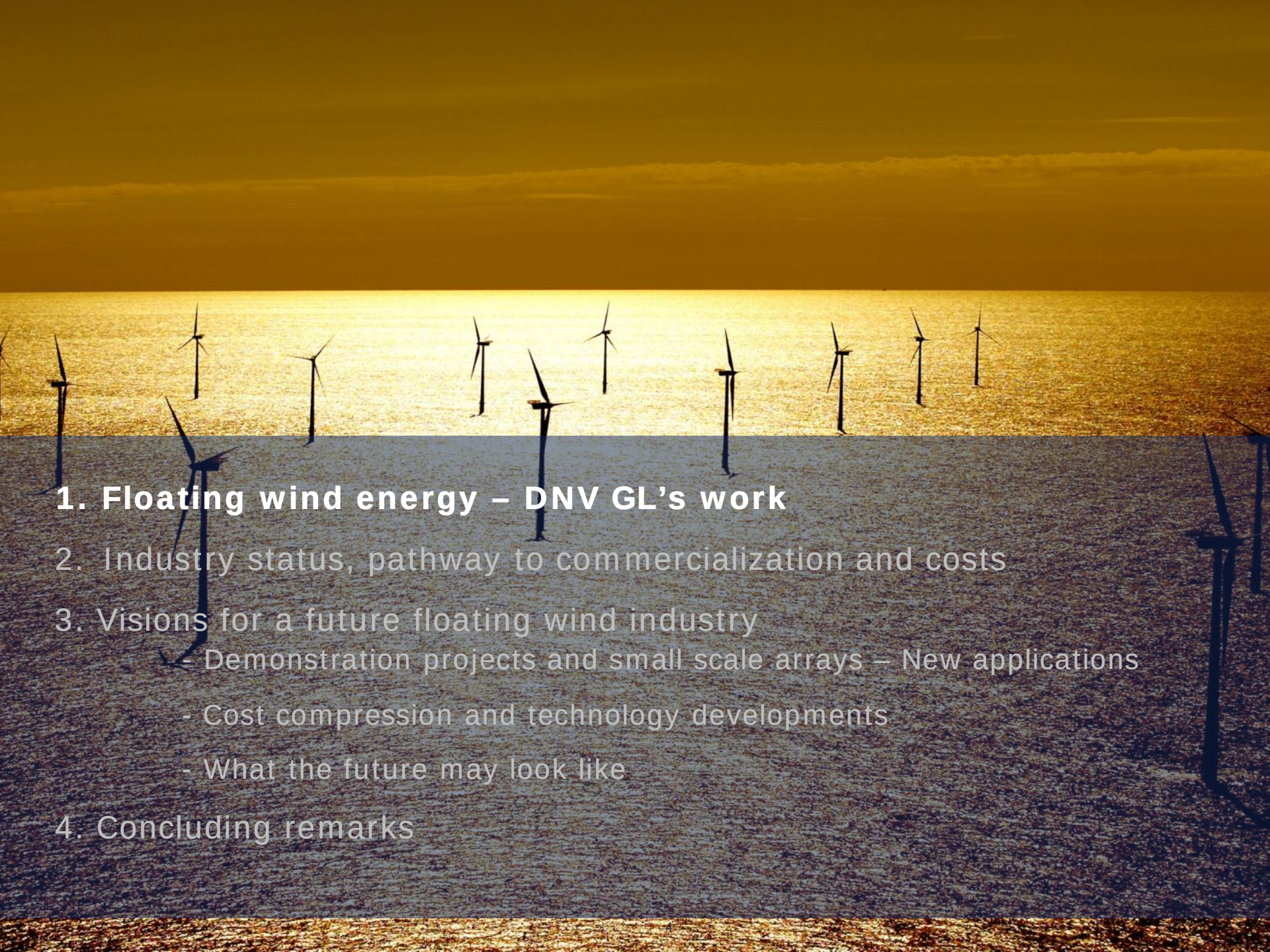
Johan Slätte

24 January 2014

DNV GL Group


DNV GL Group
Headquarter: Oslo, Norway
Group President & CEO: Henrik O. Madsen
Maritime
Oil & Gas
Energy
Business Assurance
Headquartered in Hamburg, Germany
Appr. 6000 employees
Headquartered in Høvik, Norway
Appr. 4500 employees
Headquartered in Arnhem, Netherlands
Appr. 3000 employees
Headquartered in Milan, Italy
Appr. 2000 employees
DNV GL Renewables Advisory
DNV GL Renewables Certification

1. Floating wind energy – DNV GL's work
2. Industry status, pathway to commercialization and costs
3. Visions for a future floating wind industry
   - Demonstration projects and small scale arrays – New applications
   - Cost compression and technology developments
   - What the future may look like
4. Concluding remarks



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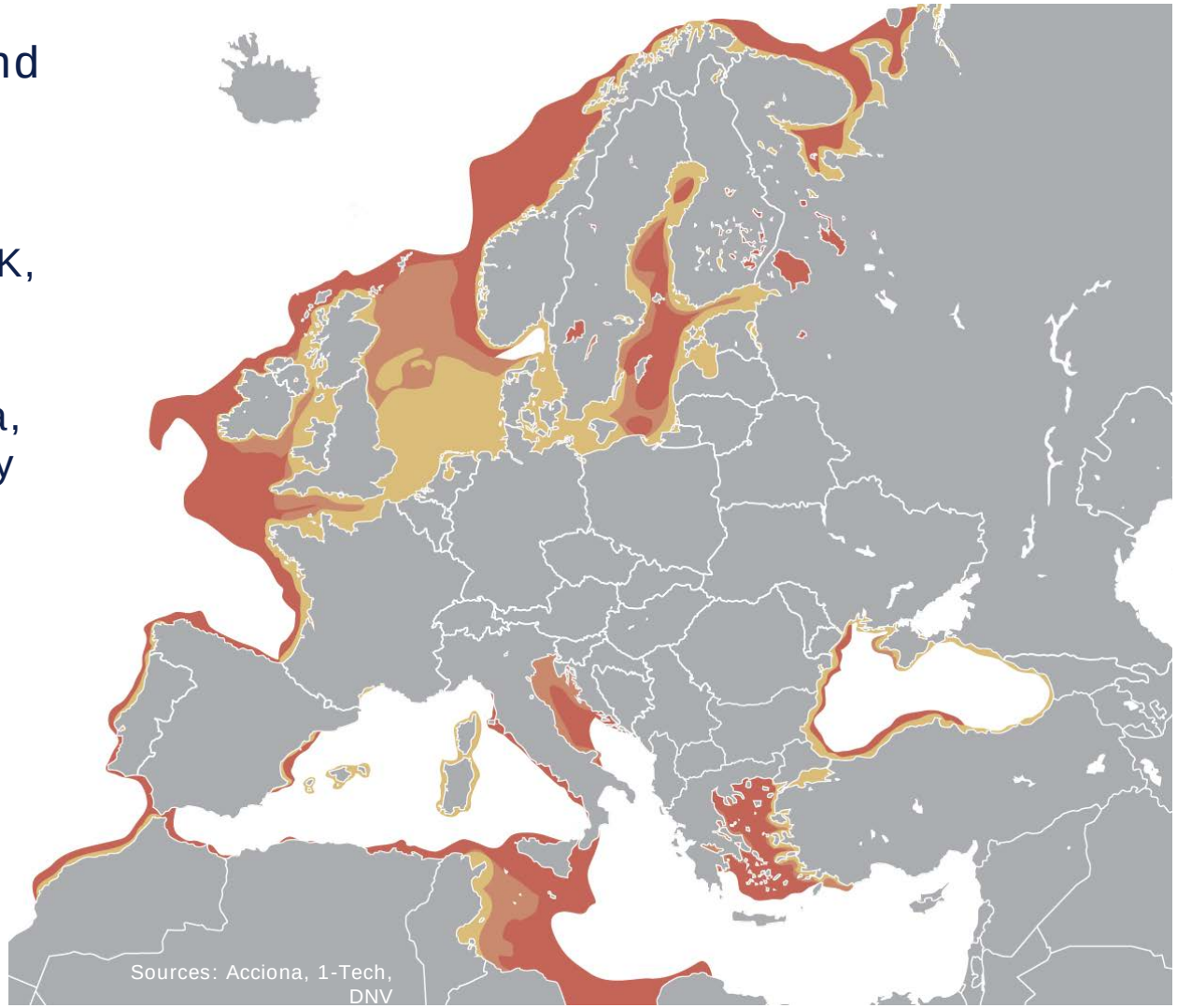
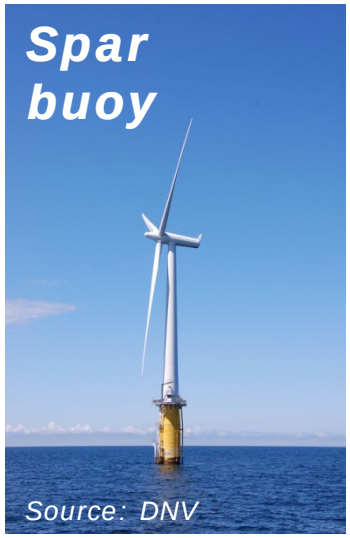
Vast resources – supreme energy yield sites

Hotspots for floating wind developments:

- In Europe:
  - Towards the Atlantic: UK, Ireland, Spain and Portugal
  - The Northern North Sea, off the coasts of Norway and the UK
- The US
- Japan

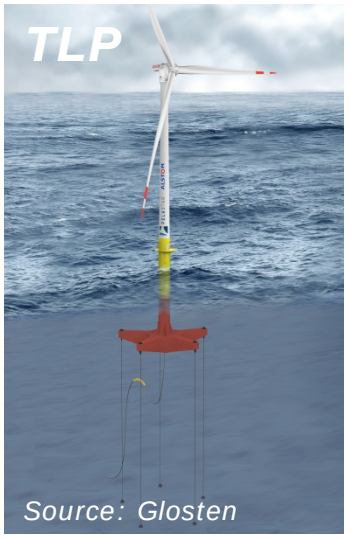


An emerging industry - An ocean of different concepts



Hywind

WindFloat



PelaStar

Kabashima

Tri-Floater

GICON

Time for innovation….and consolidation

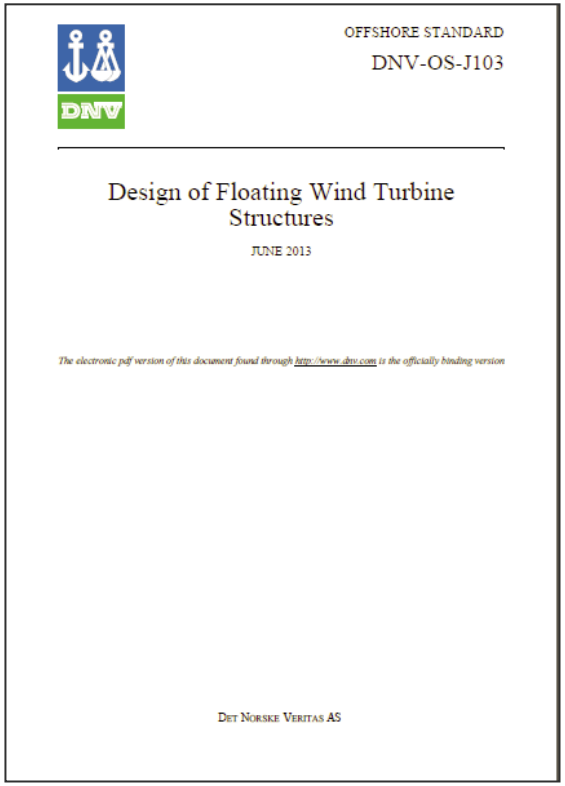
DNV GL have closely followed the development of the floating wind industry from its early days;

Core activities by DNV GL:

- Benchmarking studies
- Market analysis
- Technology evaluations
- Guideline and Standard development
- Conceptual design verification
- Prototype certification / Project certification

Standard development; DNV-OS-J103

- DNV-OS-J103 Design of Floating Wind Turbine Structures was published in June 2013
- Can be downloaded for free on **www.dnv.com**
- Developed through a Joint Industry Project (JIP) during 2011 – 2013
- Industry hearing April 2013
- Participants:
  - Statoil
  - Nippon Steel & Sumitomo Metal Corporation
  - Sasebo Heavy Industries
  - STX
  - Navantia
  - Gamesa
  - Iberdrola
  - Alstom
  - Glosten Associates
  - Principle Power


OFFSHORE STANDARD

DNV-OS-J103

Design of Floating Wind Turbine Structures

JUNE 2013

The electronic pdf version of this document found through http://www.dnv.com is the officially binding version

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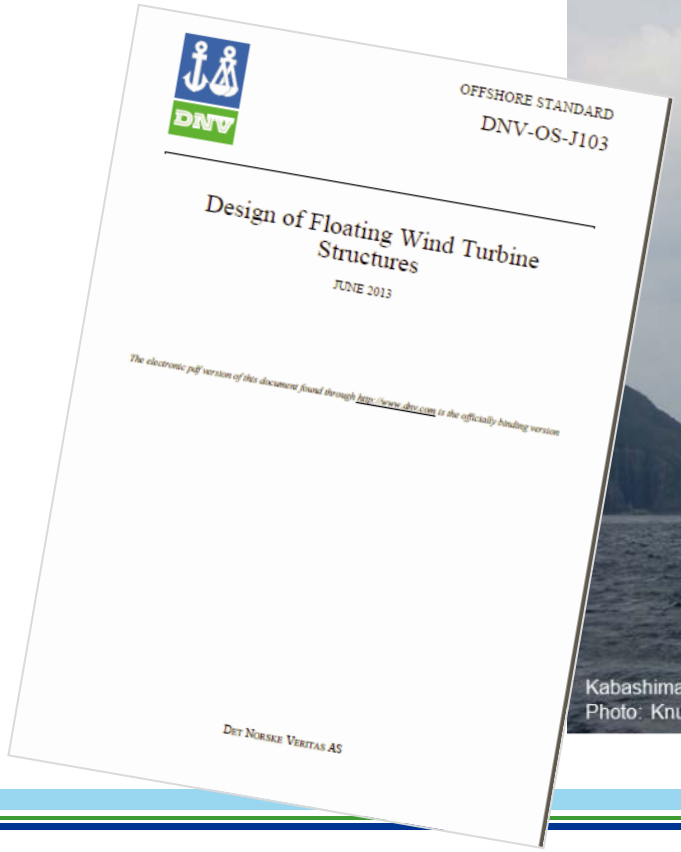
Contents of DNV-OS-J103 – Technical issues covered

- Safety philosophy and design principles
- Site conditions, loads and response
- Materials and corrosion protection
- Structural design
- Design of anchor foundations
- Floating stability
- Station keeping
- Control system
- Mechanical system
- Transport and installation
- In-service inspection, maintenance and monitoring
- Cable design (structural)
- Guidance for coupled analysis (appendix)

Mitsui

Why is a standard for floaters important?

- Expert / industry consensus on design principles
- Capturing industry experience
- Economically optimized designs through rules considering the unique aspects of floating wind turbines

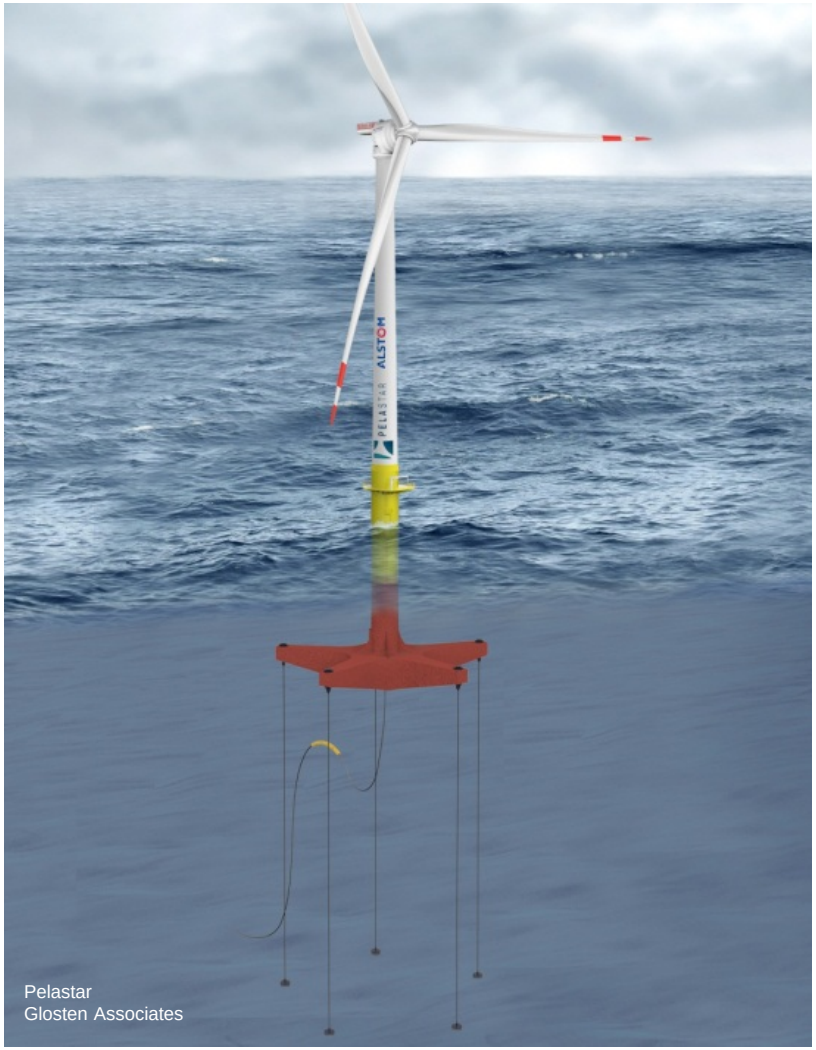



Kabashima demo FOWT, Goto Project, Japan
Photo: Knut Ronold, DNV

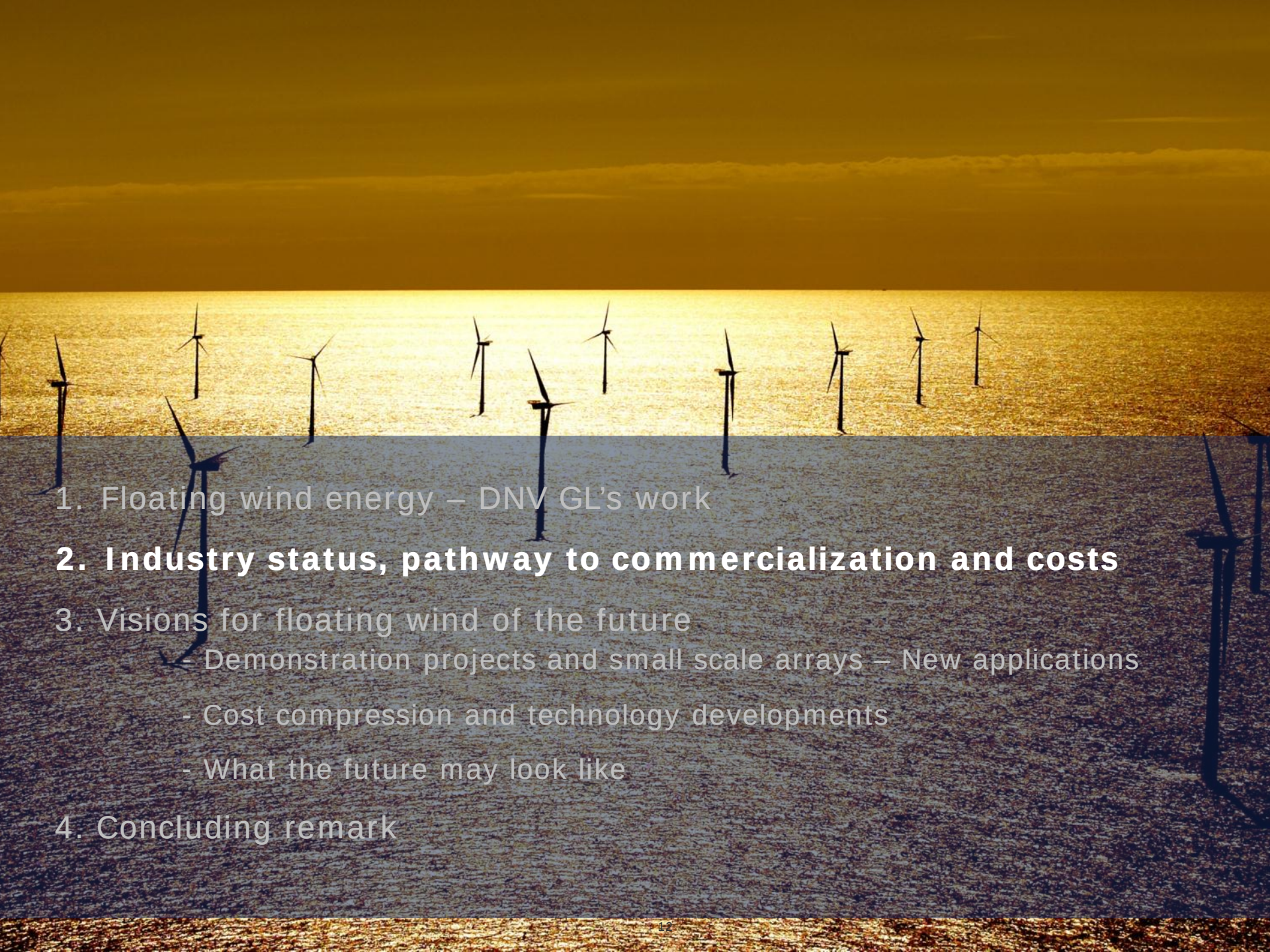
DNV-OS-J103 Design of Floating Wind Turbine Structures, published in June 2013

Application of the standard - Pelastar TLP demonstration project

- Floating wind turbine demonstration project in UK
- Funded by Energy Technology Institute (ETI)
- Glosten Associates' Pelastar TLP design has been selected
- The TLP will support Alstom's 6 MW Haliade turbine
- DNV performs certification of the design against the new standard, DNV-OS-J103
- The project is currently in Front End Engineering Design (FEED) phase
- Planned installation2015/2016



Pelastar
Glosten Associates



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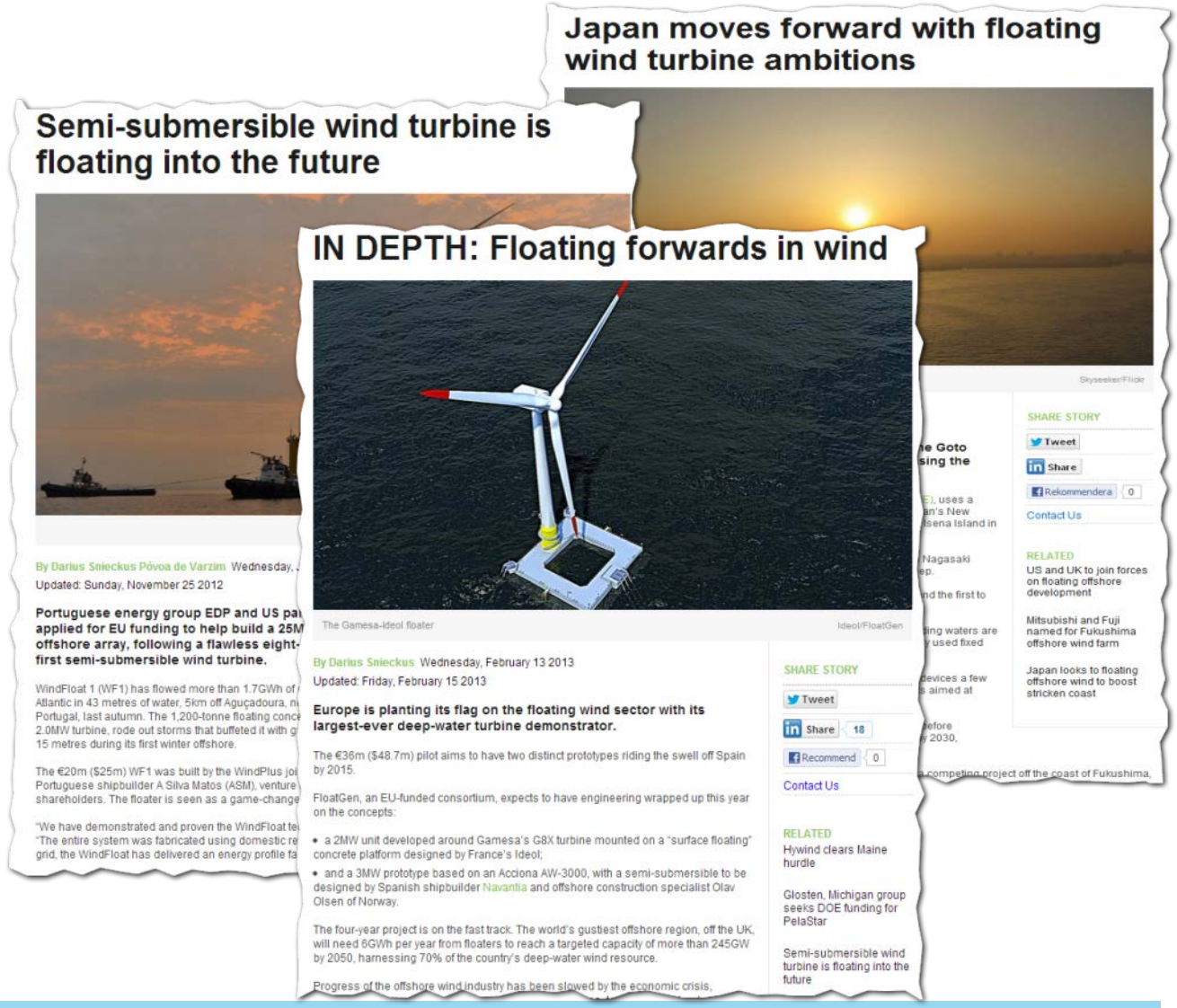
Floating wind technology – A rapid development

2009: The first full scale prototype deployed outside Karmøy, Norway

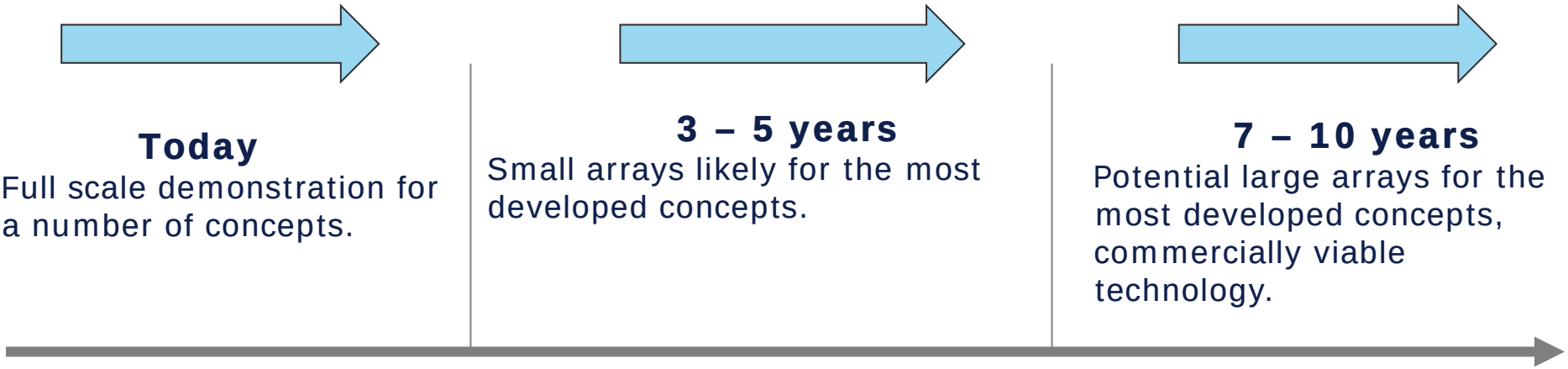


Typical development phases for new technologies

There are several natural steps in the development of a new technology:

1. **Proof of concept in the lab**
2. **Concept development and scale testing**
3. **Prototype demonstration**
4. **Commercial demonstration and system development**

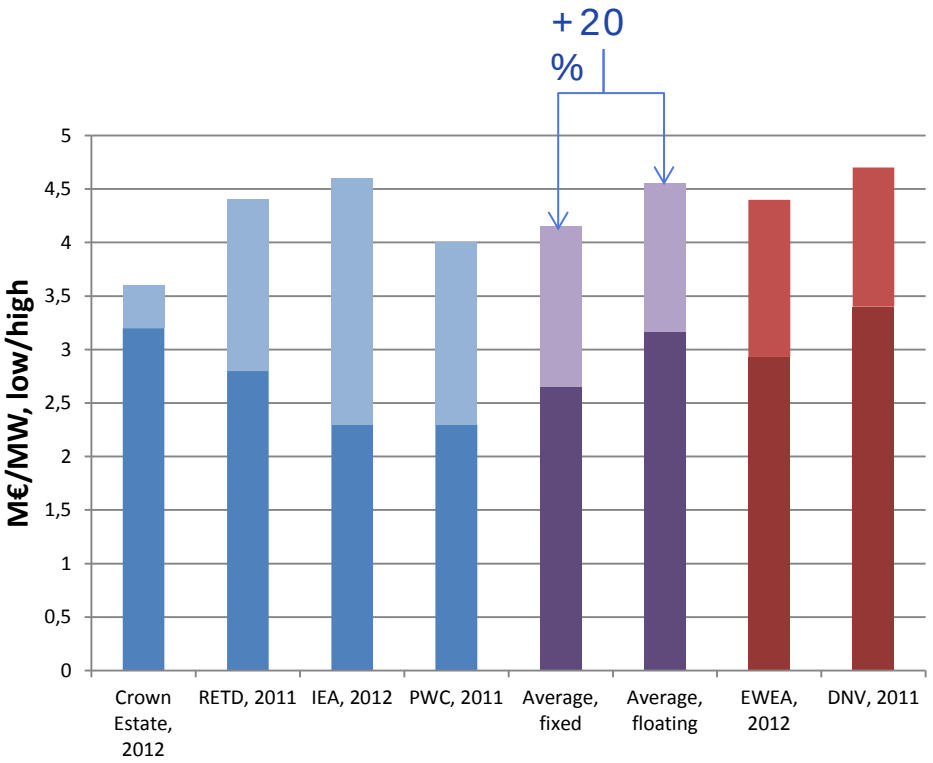
TRL (Technology readiness level) scale can be used to describe the development process.



CAPEX estimations – floating vs. bottom fixed turbines

Floating wind turbine CAPEX is estimated to be ***approximately 20 % higher for than bottom-fixed wind energy.***

DNV (2012) The Crown Estate – UK Market Potential and Technology Assessment for floating offshore wind power



Considering potential for a higher energy yield as well as an OPEX at least equal with bottom fixed wind turbines, the cost of energy gap could be considered even smaller

Higher energy yield and an efficient supply chain

- Mass production
- No specialized vessels
- Minimum offshore operations

Image: Renewable Energy Magazine

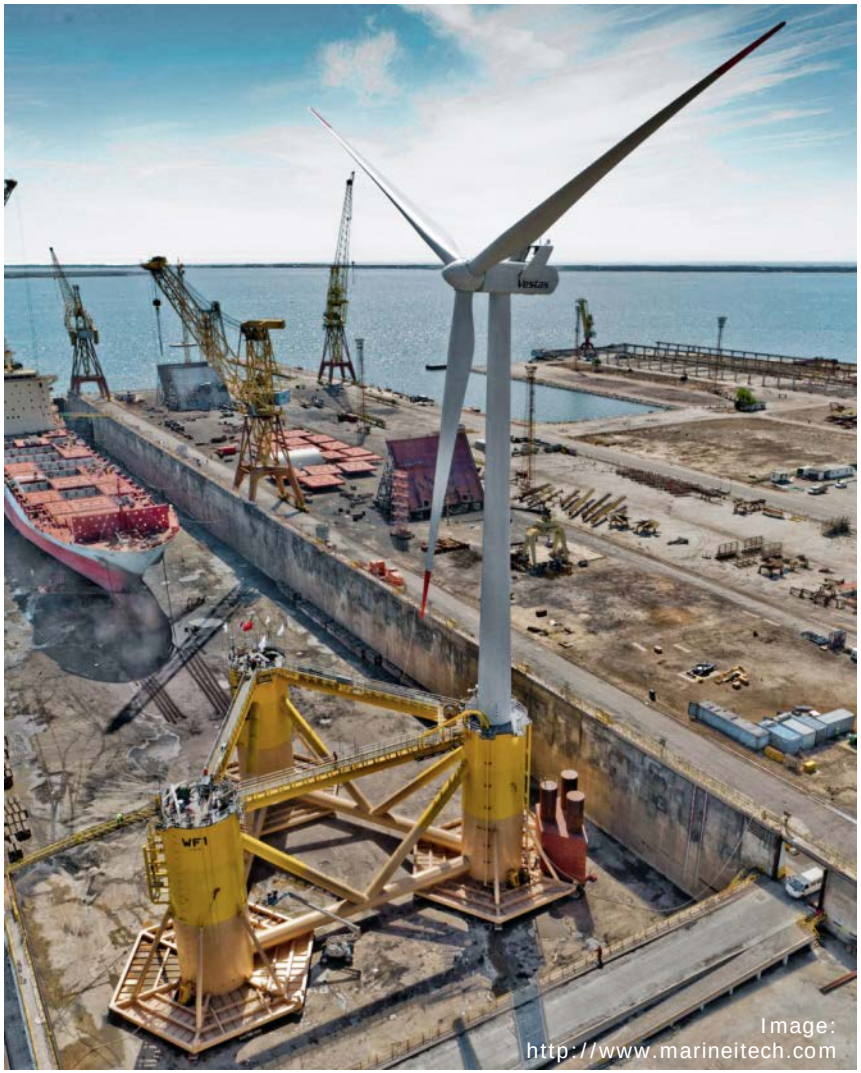


Image: http://www.marineitech.com

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Era of demonstration projects and small scale arrays

Demonstration projects/small arrays

- **Hywind**
- **WindFloat**
- **Fukushima project**
  Phase 1, 2013:
  - Floating substation
  - 2 MW semi-submersible substructure

  Phase 2, 2015:
  - Two 7 MW turbines on semi-sub and spar solution respectively
- **Kabashima project**: 2 MW spar buoy installed fall 2013
- PelaStar (2016), IDEOL, GICON, Tri-Floater, VertiWind……more to come

- Hywind Scotland (30 MW)

- WindFloat (27 MW)

- Japan initiatives, UK initiatives, US initiatives

Are there situations where power from floating wind turbines could be a cost effective solution already today?

A potential future demonstration project?
Integration of offshore wind and Oil & Gas activities on the NCS

- High-level assessment of using floating wind turbines to power subsea water injection pumps, replacing gas turbines on the host platform.

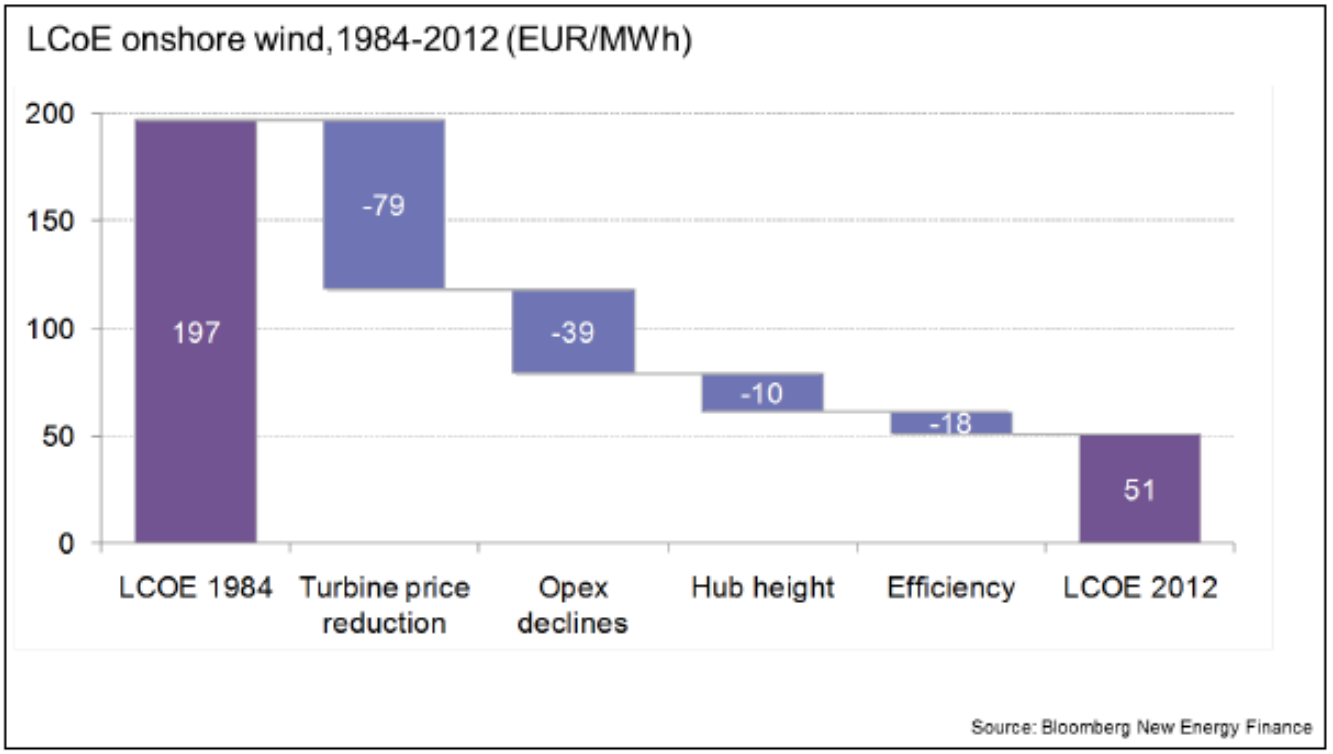
- Cost drivers: Long step-out distances between host platform & injection well, platform conversion costs, fuel costs for running gas turbines, emission costs on the NCS

- Recent successes with raw-seawater injection (Tyrihans) and new subsea water treatment systems under development

- *High-level indicators of economic and technical performance show an interesting window of opportunity for applications that can tolerate unprocessed seawater for injection in oil fields and also other configurations are possible*

The onshore experience

- Total cost compressions of close to 75% are indicated during a 28 year period.
- Onshore wind is a mature industry compared to offshore wind, however, IEA have estimated that the cost of generating energy will continue to decrease with another 26% up until 2050 and their corresponding assessment for offshore wind implies a reduction in the cost of generating energy of 52 %. Both analyses accounting for increasing capacity factors.



Historical developments in LCoE for onshore wind. Source: Bloomberg New Energy Finance

Concluding remarks

Demonstration projects:

- Design optimization and R&D efforts are obvious focus areas
- Technologies are being proven, the first small arrays on the way and commercialisation can be within the next few years

- Need not only to show the technical feasibility but also the ability to reduce costs – large potential for cost reductions

- New applications are possible – Integration with other offshore interests

- Stable, long-term policies are needed to create investor confidence

- DNV GL have strong belief in the floating wind industry focuses on its further development, assisting the industry through verification, certification, technology assessment and market studies!

Thank you

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