Dr. Chris Golightly GO-ELS Ltd. - BSc. MSc. PhD CEng MICE
Geotechnical & Engineering Geology Consultant

Offshore Wind Energy – 2nd July 2022 UK2Zero/LI

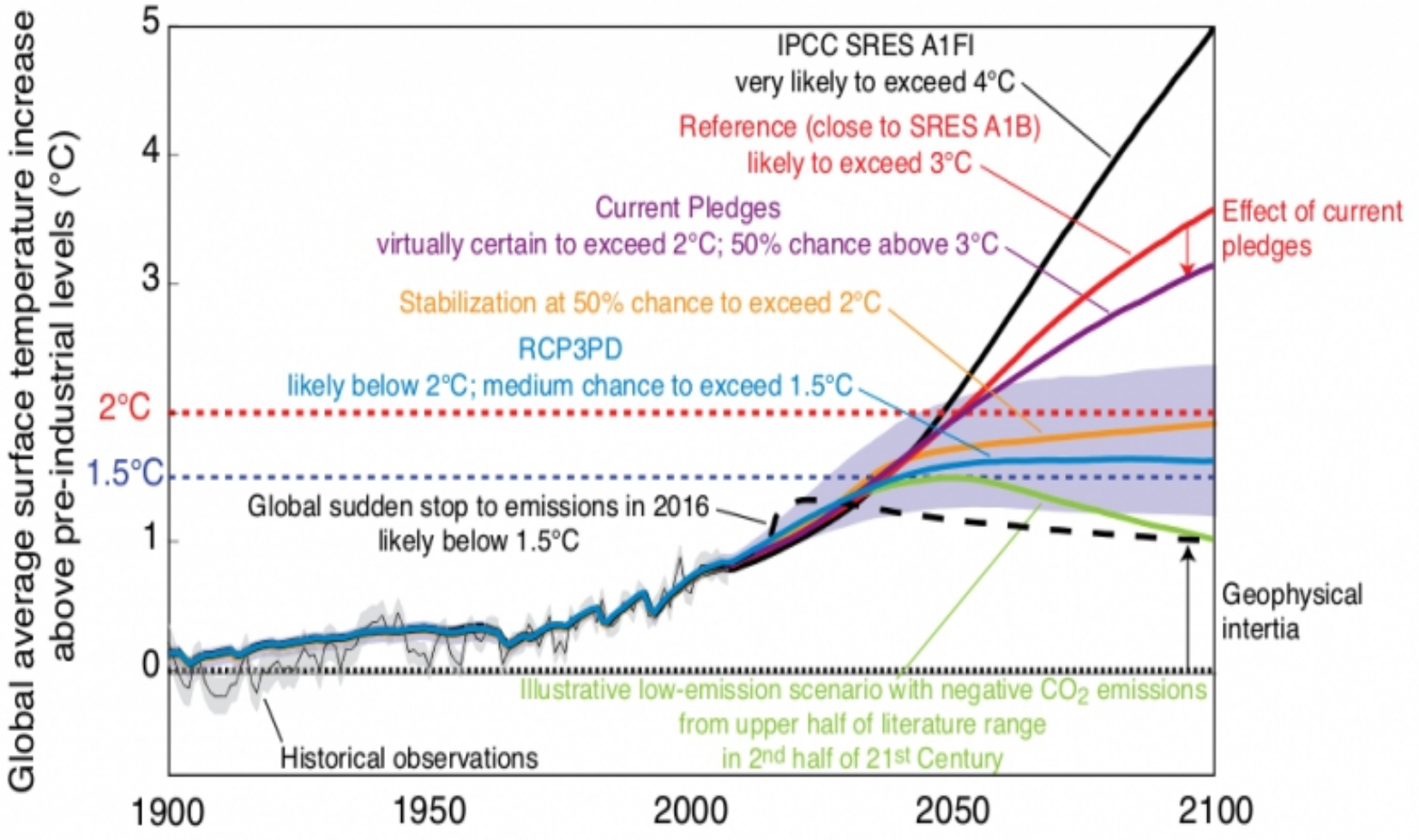
Education :	**University of Manchester**	**B.Sc.**	**1980 Civil Engineering**
	University of Durham	**M.Sc.**	**1982 Engineering Geology**
	University of Bradford	**PhD**	**1989 Soil Mechanics**

Professional **Chartered Civil Engineer (CEng MICE) UK Inst. of Civil Engineers (March 1997)**

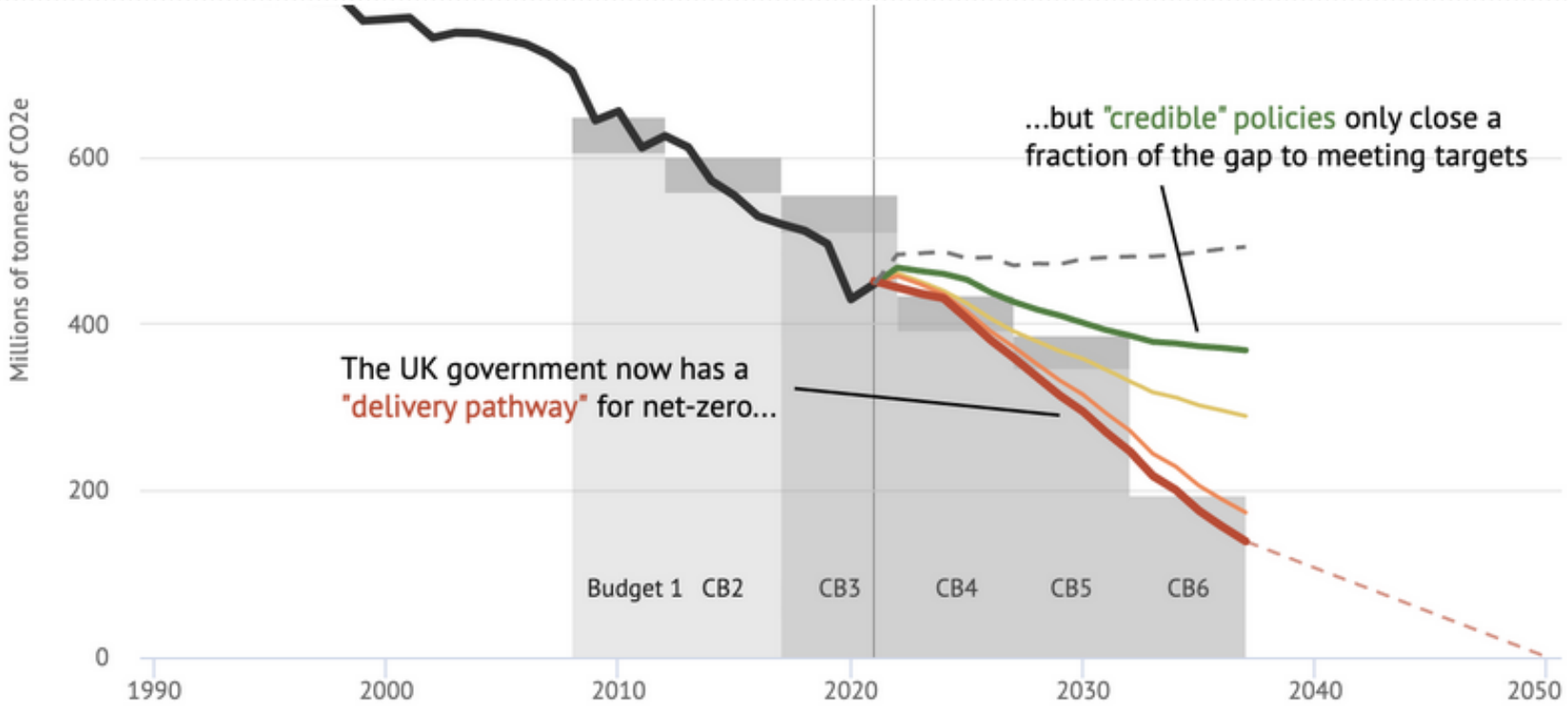
Fellow: British Geological Society

Oct. 05 – Present	**Independent Geotechnical and Engineering Geology Consultant, Brussels.**
Feb. 03 – Oct. 05	**Shell Global Solutions International (SGSI) BV, The Hague, The Netherlands.**
	Senior Geotechnical Engineer, Civil Storage and Marine Group
Sept. 99 – Feb. 03	**Thales Geosolutions SA/NV, Brussels, Belgium, Senior Geotechnical Engineer**
June 97 - July 99	**BP International, Research and Engineering Centre, Sunbury-on-Thames, UK.**
	Geotechnical Engineer, Shared Petrotechnical Resource, New Developments.
Feb. 92 – May 97	**Fugro-(McClelland) Engineers B.V., Leidschendam, The Netherlands.**
	Senior Engineer, Central Engineering Department.
July 90 – Feb. 92	**Arup, Gibb, A&L Consulting Engineers U.K.**
April 89 – July 90	**Institut Francais du Petrole, Paris, Research Fellow, Exploitation en Mer.**
Sept. 85 – April 89	**University of Bradford, Research Assistant, Department of Civil Engineering.**
Nov. 82 – Sept. 85	**Ove Arup and Partners, Cardiff UK: Geotechnical Engineer.**
Oct. 81 – Sept. 82	**University of Durham, U.K. Dept. of Geological Sciences, Research Student**

Global Temperature Predictions [World Bank 2012]



UK Path to Net Zero?



"Climate Change Committee (CCC) released their latest progress report to UK Parliament, detailing ways in which the UK is – or is not – on track to achieve its own climate goals". Carbon Brief 1st July 2022: bit.ly/3AfmfLc

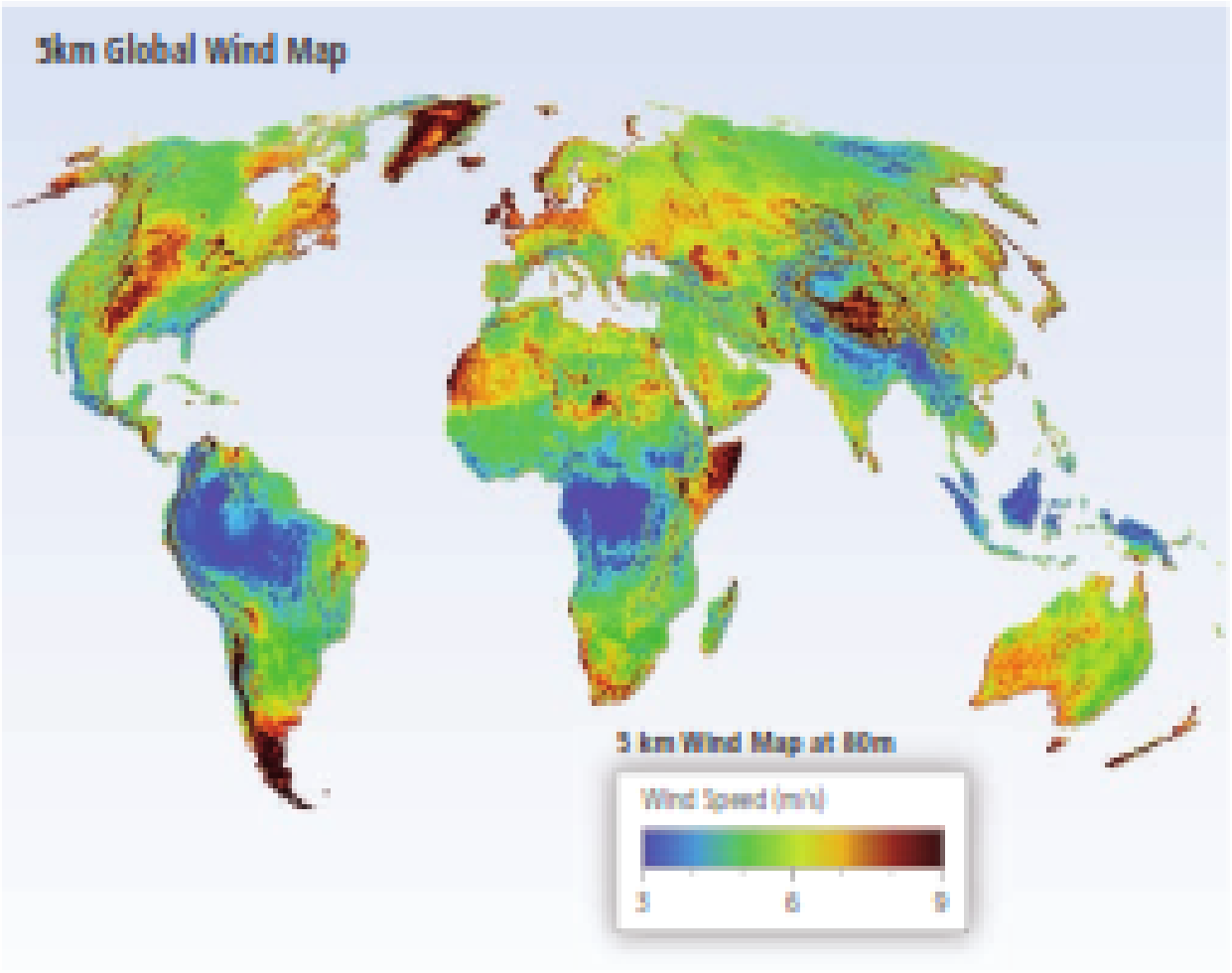
The Clean Energy Transition

Daily Telegraph (2020), "Australia Plans World's Biggest Solar Farm", 21st October 2020[Northern Territory 10 GW USD 20] Billion. www.telegraph.co.uk/business/2020/10/21/australia-plans-worlds-biggest-solar-farm/

Largest Single Axis Tracker Project in Asia 172MW- Arctech Solar PV

Introduction – Global Offshore Wind (OW) Energy

- Global clean & abundant energy to accelerate as fossil fuel costs rise.
- Economies of scale & innovation leads to “Energy Transition”
- 1st OW farm Denmark 1991. OW energy % in Europe increasing.
- OW industry still conservative & risk averse. Creative innovation replaces “proven technology”.
- Shift from 3 blade HAWT to carbon fibre VAWT?
- Focus: Germany, Denmark, Baltic, Belgium, UK & France. US W&E, China, Taiwan, Korea, Vietnam, Japan – Mediterranean, India, S. Africa in future.



North Sea/Atlantic Offshore Wind Resource

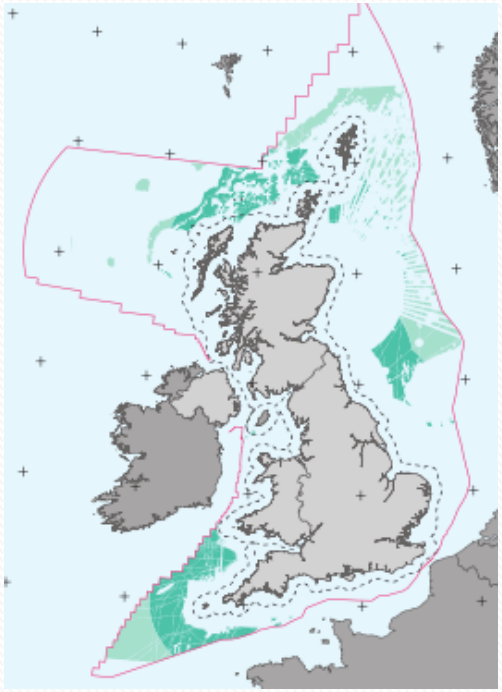
Source: www.openocean.fr 2017

"We find ourselves in a comparable position to that of the **nascent UK oil and gas companies in the 1970s**"

Source: UK Offshore Valuation Group (2010)

"Clean, green offshore wind is set to power more than 30% of British electricity by 2030", Energy and Clean Growth Minister Claire Perry (7th March 2018) with launch of new joint government-industry Offshore Wind Sector Deal

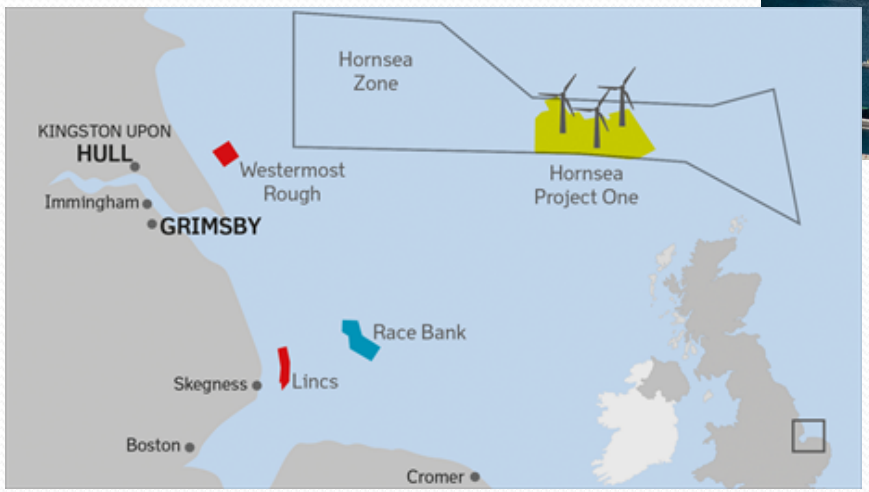
Source: UK BEIS: Offshore Wind Sector Deal.



Toaster 1KW – GE-Haliade WTG 14MW – Hornsea 1: 1200 MW

Average UK Household uses 3,700 to 4,000 kWhrs/year

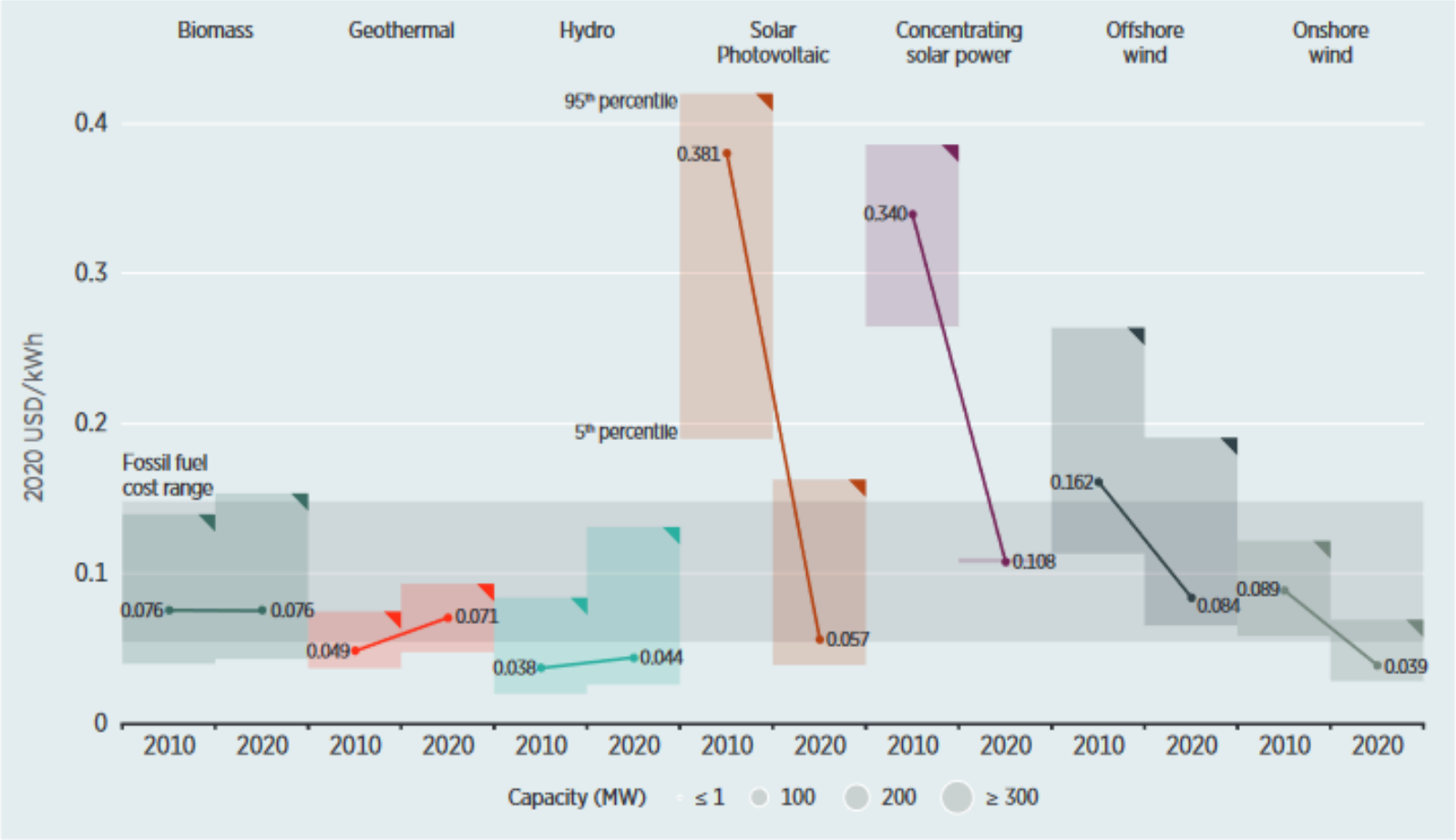
Hornsea 1 Project (Siemens 7 MW Turbines provides power to 1.3 Million households for 1 year.



GE Haliade X 14 MW Rotterdam: www.youtube.com/watch?v=XX2-DE0etcQ&t=69s

LCOE Ranges & Averages [IRENA, 2010 - 2020]

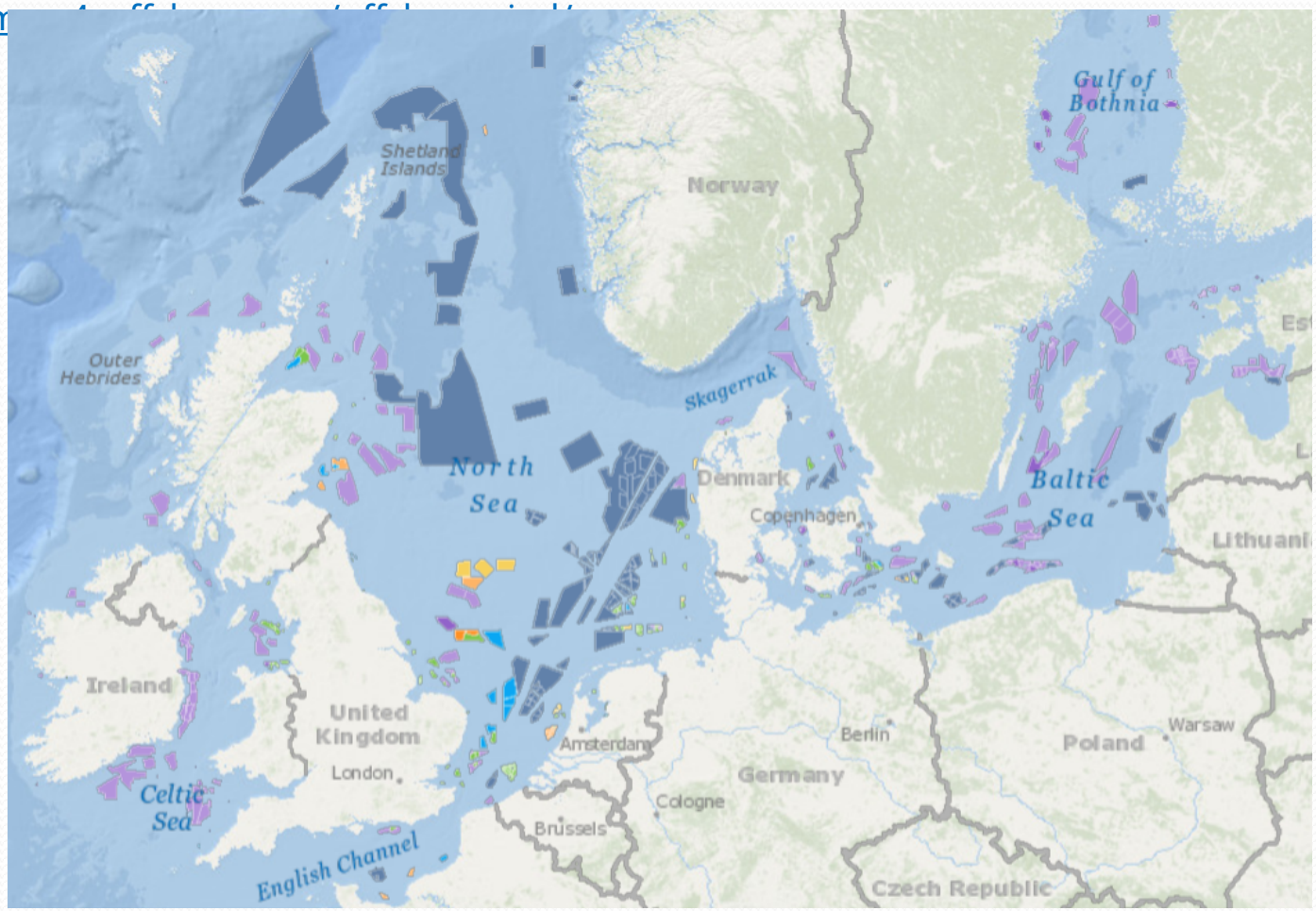
Figure ES.2 Global LCOEs from newly commissioned, utility-scale renewable power generation technologies, 2010-2020



Source: IRENA Renewable Cost Database

Offshore Wind – Potential Energy Resource

Most European projects in North & Baltic Seas, flat shallow water continental shelf.



Source: map.4coffshore.com/offshorewind/

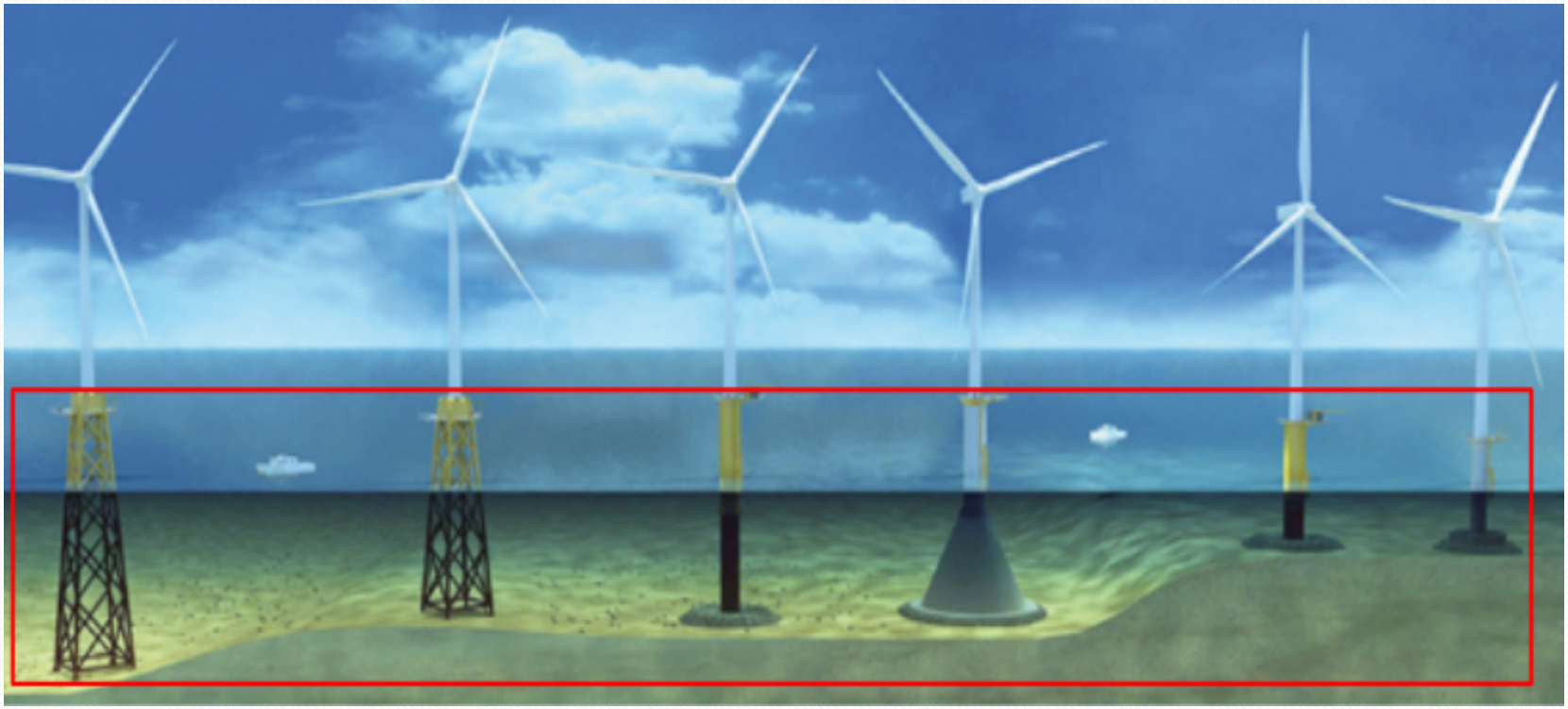
Installing an Offshore Wind Farm

Siemens Gamesa 2020: www.youtube.com/watch?v=mDvS7tizetg

Offshore Wind Turbine Fixed “Foundation” Definition

Civil Engineering - “Foundation” = Everything Below Ground/Seabed
- Sub-Structure = Supporting Structure

Offshore Wind - “Foundation” = Everything Below Tower Transition Level



Source: Norwegian Geotechnical Institute

Types of Foundation for Offshore Wind Turbines [OWT]

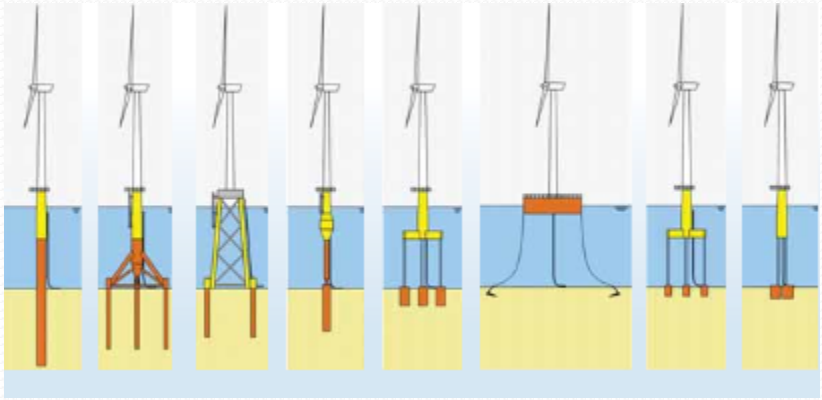
Choice of foundation solution influenced by:

- Water depth and seabed conditions, especially depth to rockhead
- Environmental loading (wind, wave, tidal)
- Onshore fabrication, storage and transportation requirements.
- Offshore vessel & equipment spread costs & availability
- Installation & Construction methodology.
- Developer CAPEX investment appetite and OPEX (Repairs & Maintenance) predictions

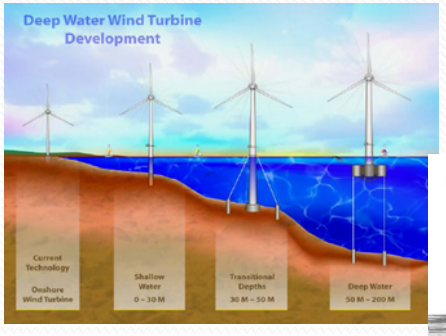
"Smarter" solutions available (suction caissons, GBS, lighter jackets/trusses, hybrids, seabed anchored templates)

Foundations 30 to 40% of overall CAPEX & rising. Cost reductions essential

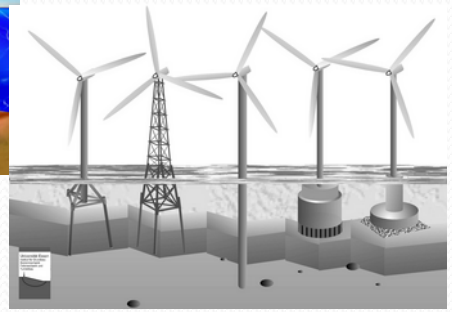
"Smarter" lighter hybrid foundations needed & move away from riskier costly conventional driven tubular steel piling.



Source: UPWIND Project Final Report 2011



Source: NREL

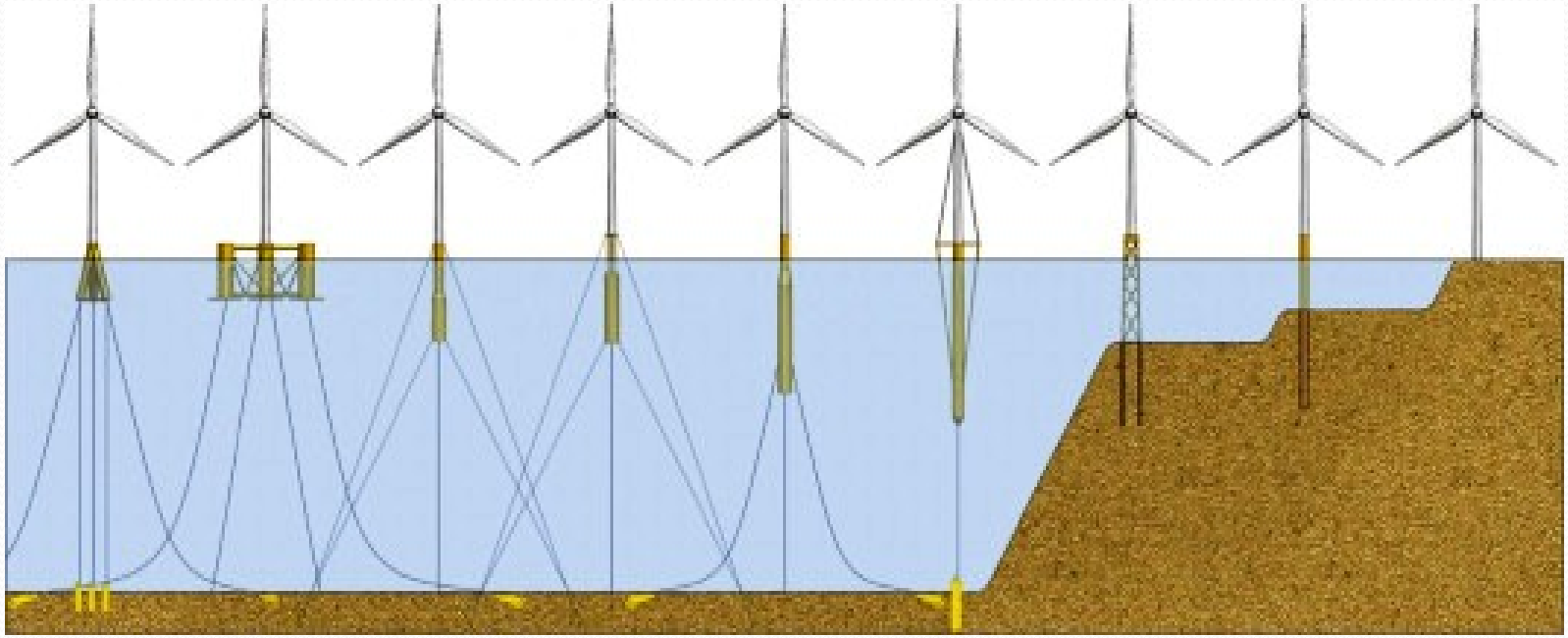


Examples of Floating Wind Structures

Approx. 30 floating wind concepts under development: see map of *Floating Wind Energy Projects of The World, Inducomm, 2017*

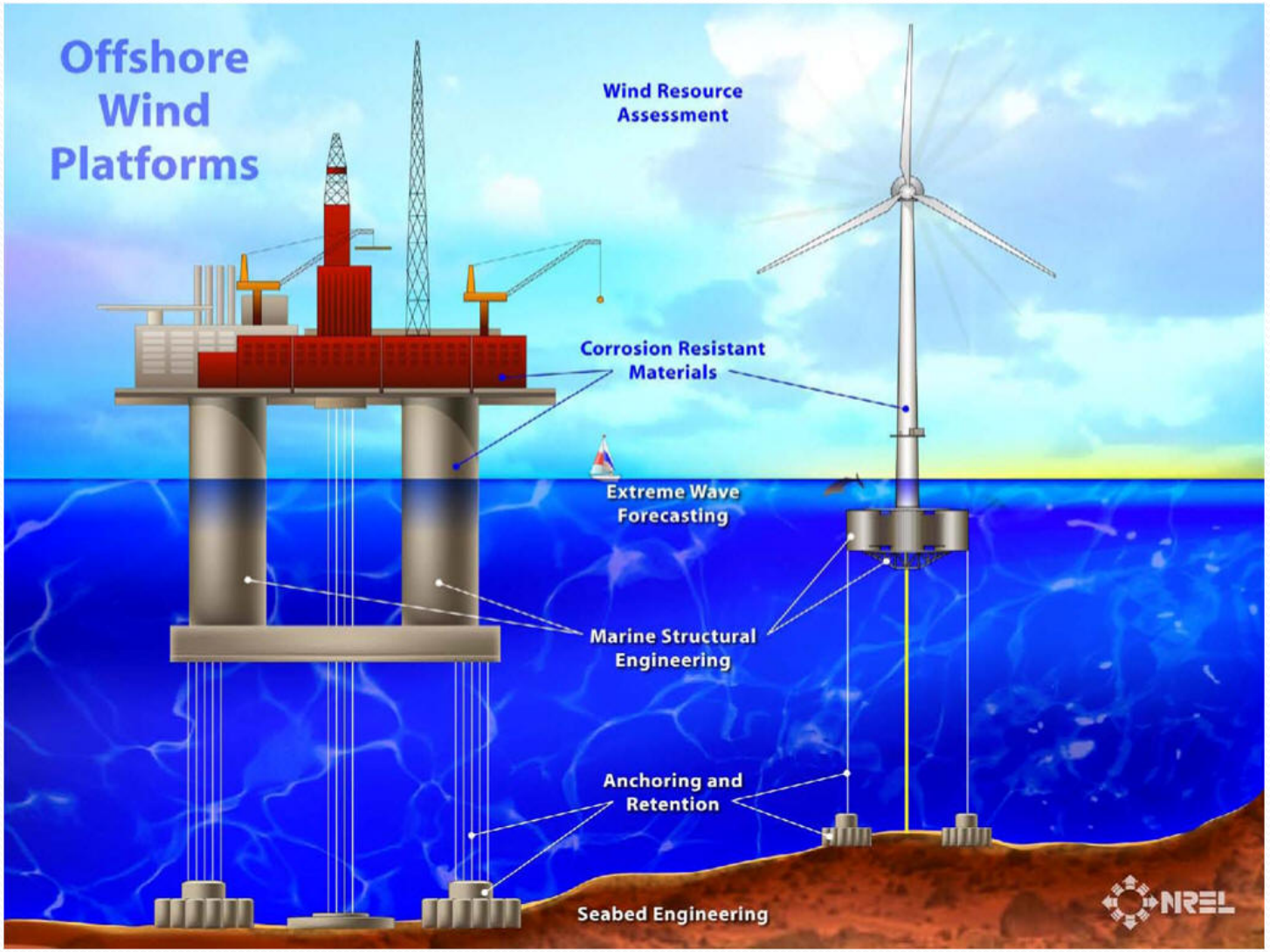
Offshore turbines mounted on seabed foundations limited to shallow waters < 50-55 m. Floating structures can be deployed in WDs > ~40-50 m.

Innovation lies with the *Design & Installation of Support Structures*



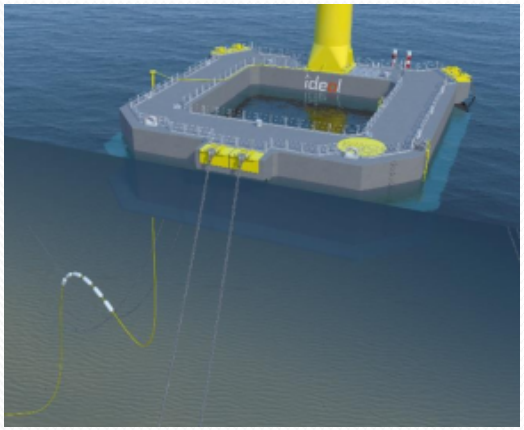
Source: Myhr et al, 2014. Ref. 17

Comparison Oil Drilling Semi-Sub Vs Offshore Wind Floater



Floating Offshore Wind – 3 Market Leaders +TLP

SEMI SUB IDEOL



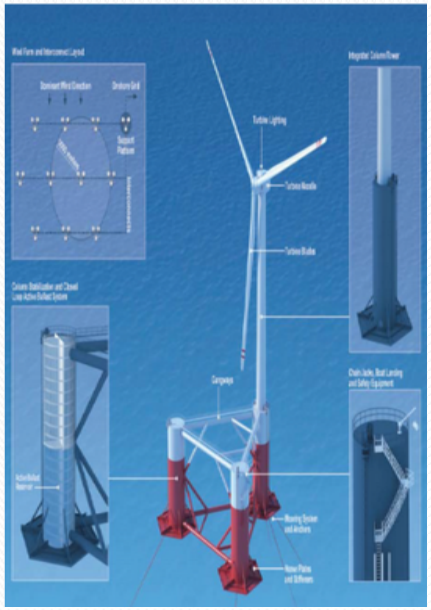
SPAR - HYWIND

Source: Statoil

TLP - PELASTAR

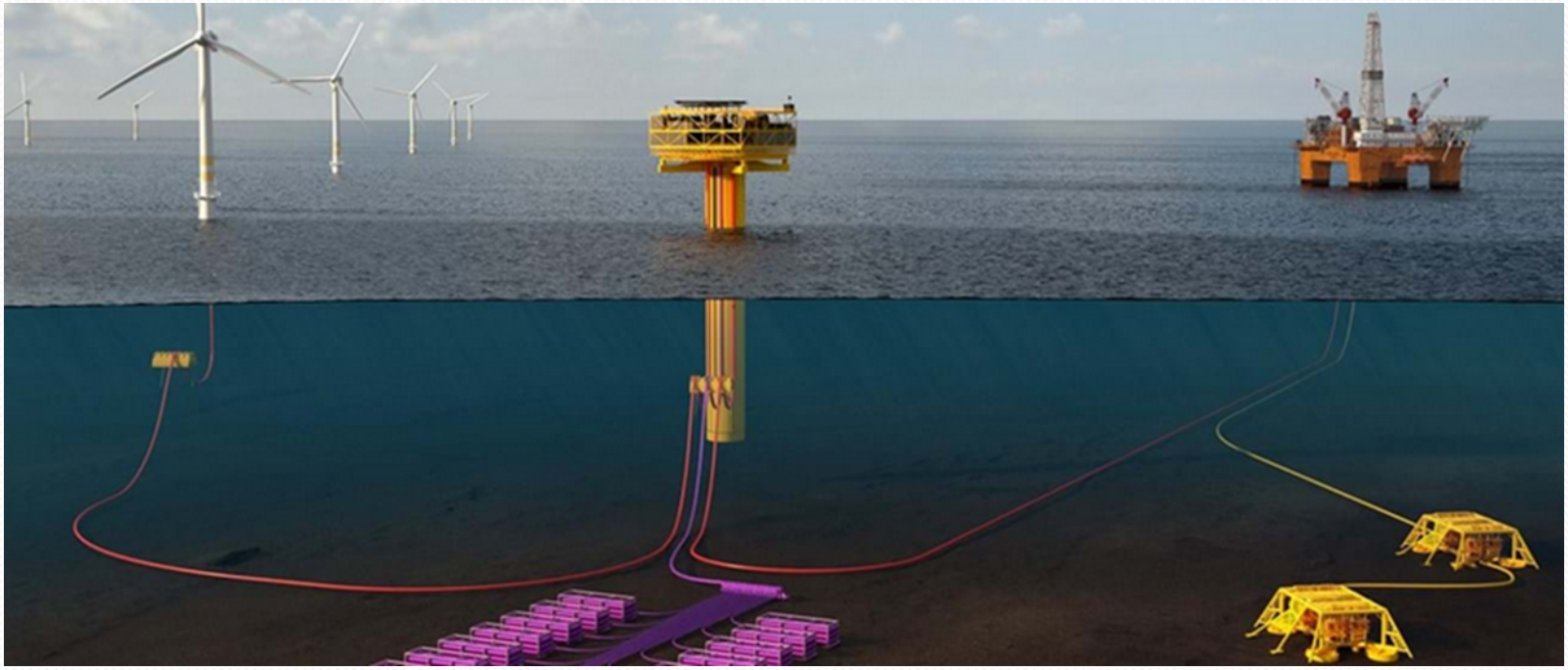
Source: Glosten Associates

SEMI SUB WINDFLOAT



Source: WINDFLOAT

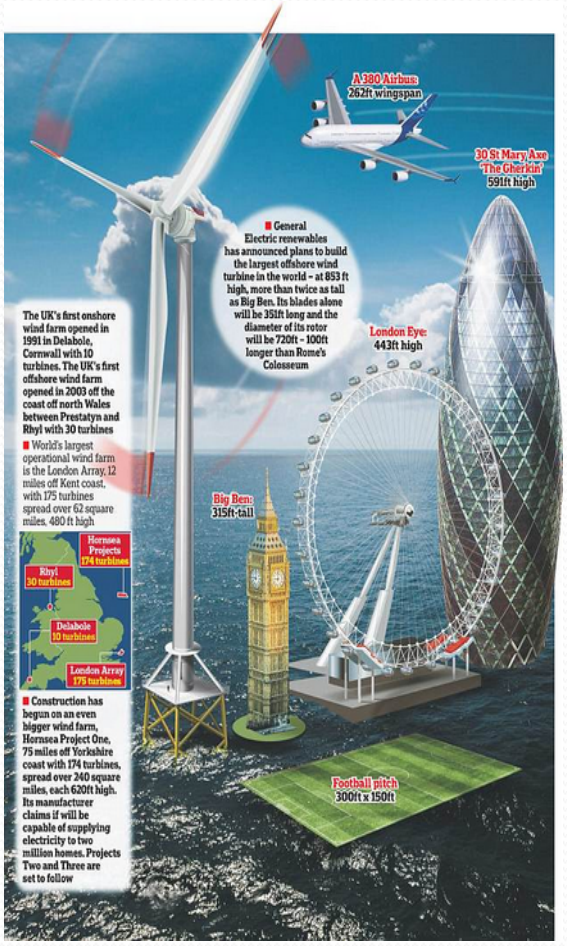
Offshore Energy Storage Wind to Hydrogen – Deep Purple



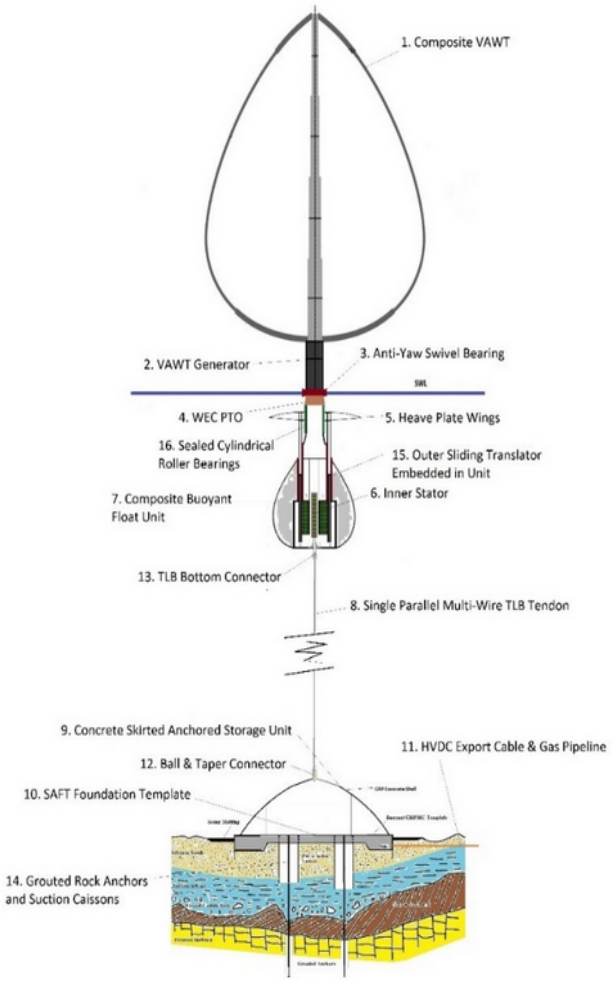
The Deep Purple offshore concept. Energy system management, electrolysers and fuel cells are located in the yellow floating spar unit in the centre of image. Hydrogen storage tanks are purple. Photo by TechnipFMC.
www.gceocean.no/news/posts/2020/july/deep-purple-project-collaboration
TechnipFMC, Ocean Hyway Cluster, Energy Valley and Sintef

Blackbird: Hybrid CAES Storage Base Mono TLP VAWT-WEC Buoy ENERMAR 9as Jornadas "El Mar y las Energías Renovables" - 28th June 2018 - Sevilla

Dr. Chris Golightly GO-ELS Ltd. Brussels
Geotechnical & Engineering Geology Consultant



- Offshore Wind – LCOE Comparisons
- Why Floating Wind? Will it Become Subsidy Free?
- North Sea Vs Global Bathymetry and Seabed Geology
- European OW Fixed Bottom Structure Costs
- Comparison Oil Drilling Semi-Sub Vs Offshore Wind Floater
- Offshore Floating HAWT – Market Leaders
- Global Wave Power
- Floating VAWT [FVAWT] – Sandia Labs
- BLACKBIRD: Storage Base Mono TLP VAWT-WEC Buoy
- Seabed Anchored Foundation Template [SAFT]
- Conclusions, References, Links, Contact Details.



Future of Offshore Wind Energy?

Floating VAWT platform design may allow access to vast deep-water wind resources.

- TLP mooring with short mooring cables & lower installation costs offers performance benefits due to reduced platform motions, small anchor footprint.
- Challenges trends in commercial floating HAWT platforms, which to date favour semisubmersible and spar floaters.

Objective: The Most Efficient Abstraction of Kinetic Energy From Moving Turbulent Air

- How Would That Be Done in 21st Century From A Standing Start? Fixed Structure Top Heavy 3 Bladed Onshore HAWT on Fixed Steel Towers?

  >> No!! Floating HAWTs Too Expensive and Subsidy Dependent

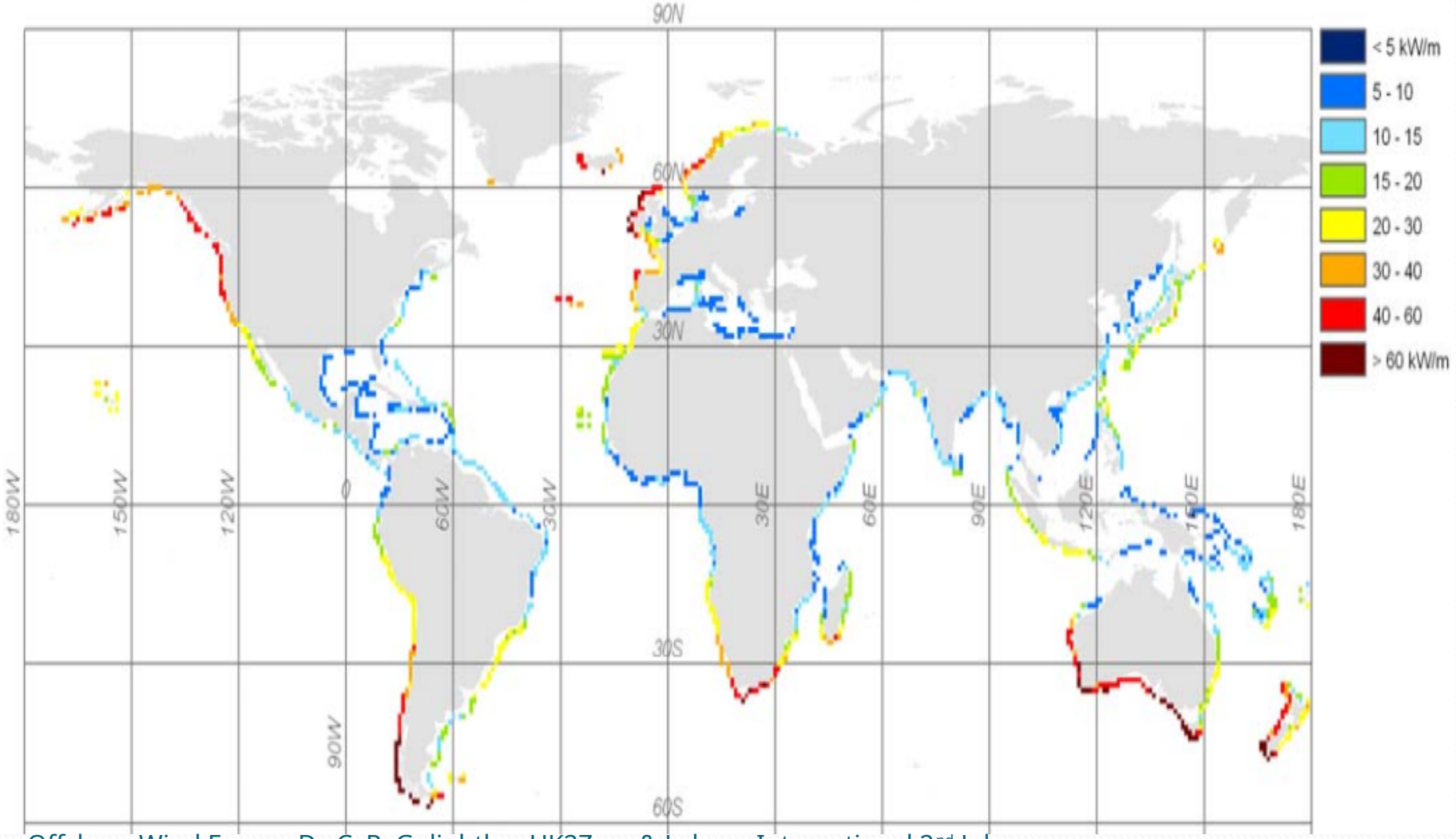
- What Will The Global Mix Be Between Fixed Vs Floating?

  >> Deeper Waters/Sloping Seabeds >> FLOATING VAWT

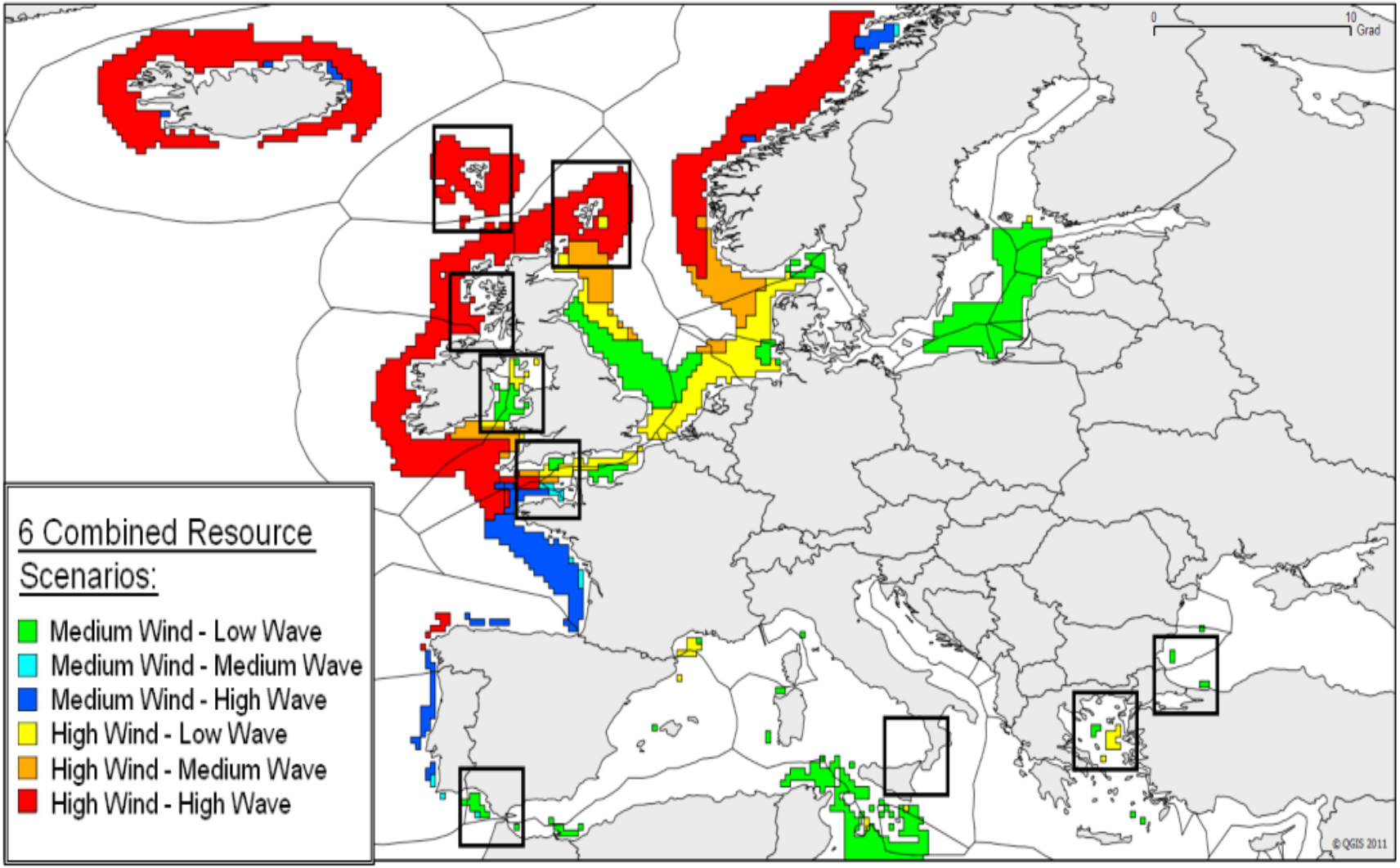
- A Real Offshore Wind "Gamechanger"- or not? Yes there must be soon.

  >> Because of: $$$ ECONOMICS $$$

Global Wave Energy Potential – Fugro OMAE 2010



European Wind-Wave Combined Potential – ORECCA 2011



Offshore Wind Links

- Wind Europe Statistics 2020: windeurope.org/data-and-analysis/statistics/
- European Marine Observation and Data Network [EMODnet]: emodnet.ec.europa.eu/en
- Global Wind Energy Council: gwec.net/greenrecovery/
- IRENA Costs Database: irena.org/wind
- UK Govt. Offshore Wind Industrial Sector Deal March 2020: www.gov.uk/government/publications/offshore-wind-sector-deal/offshore-wind-sector-deal
- US NREL: www.nrel.gov/wind/offshore-wind.html
- 4C Offshore Wind Database & Global Interactive Map: www.4coffshore.com/offshorewind/
- Innovative Wind Conversion Systems (10-20MW) Offshore Applications: innwind.eu
- UK Crown Estate: www.thecrownestate.co.uk/en-gb/resources/downloads/
- Renewable UK Wind Energy: www.renewableuk.com/page/WindEnergy
- ARPA-E Atlantis ARCUS-Vertical Axis Wind Turbine: arpa-e.energy.gov/technologies/projects/arcus-vertical-axis-wind-

Contact Details

Dr. C.R. Golightly, BSc, MSc, PhD, MICE, FGS.

Geotechnical and Engineering Geology Consultant

Rue Marc Brison 10G, 1300 Limal, Belgium

Mobile: +32 478 086394

Email: chris.golightly@hotmail.com

skype: chrisgolightly

Linked in: www.linkedin.com/in/chrisgolightly

Twitter: @Gallowglaich

Academia.edu: independent.academia.edu/ChristopherGolightly

Researchgate: www.researchgate.net/profile/Chris_Golightly

"...and we can save 770 lira by not taking soil tests"

"You Pay for a Site Investigation - Whether You do One or Not" – Cole et al, 1991.

"Ignore The Geology at Your Peril" – Prof. John Burland, Imperial College.

All my students know how to respond to the question "What happens when you use land-based technology in the ocean?" They learn from day one to answer in unison: "You die."

'The Silent War' – John Craven