Offshore wind energy

Marius de Mourgues
EPFL – EIFFAGE

Lausanne – 14/11/2022

École polytechnique fédérale de Lausanne

Marius de Mourgues– marius.demourgues@eiffage.com

Table of content

- Introduction
- Worldwide potential
- Offshore wind sectors
- Limitations
- Questions

Why ?

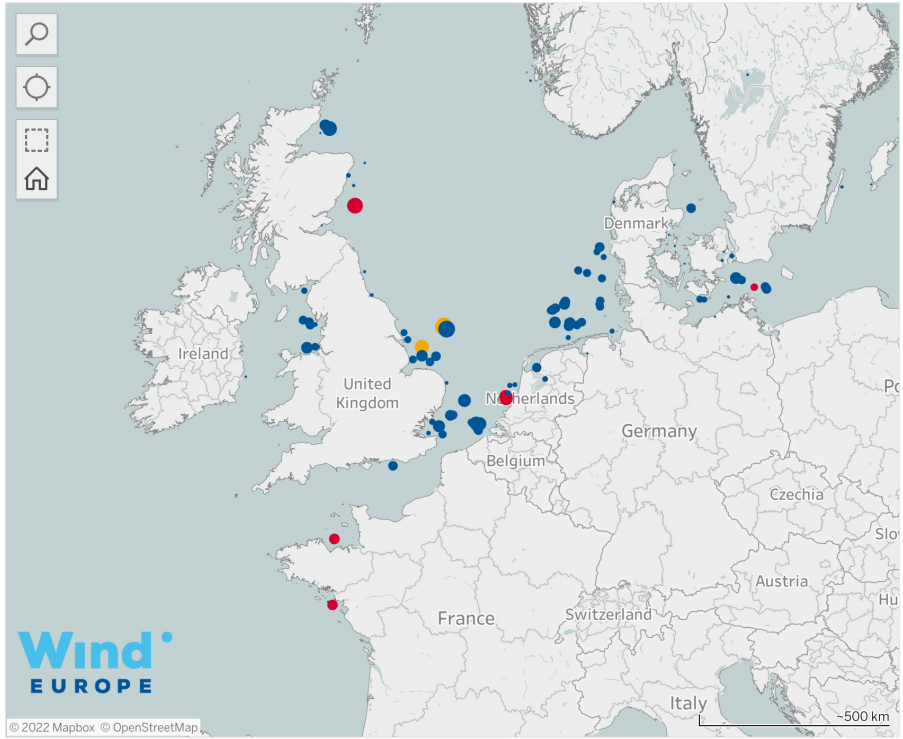
- Climate change and **renewable** energy
- Energy market **price** increasing
- Energy **independence**

But why offshore ?

- Limited onshore **potential**
- Higher **capacity factor** (40%)
- **Costs**

Marius de Mourgues – marius.demourgues@eiffage.com

Current offshore wind farms



Status

Online	
Partially online	
Under construction	

Technology

(All)

Country details

	MW connected	Turbines connected
UNITED KINGDOM	12,739	2,542
GERMANY	7,713	1,501
NETHERLANDS	2,986	599
DENMARK	2,308	631
BELGIUM	2,261	399
SWEDEN	192	80
FINLAND	71	19
IRELAND	25	7
PORTUGAL	25	3
NORWAY	6	2
SPAIN	5	1
FRANCE	2	1
ITALY	0	0

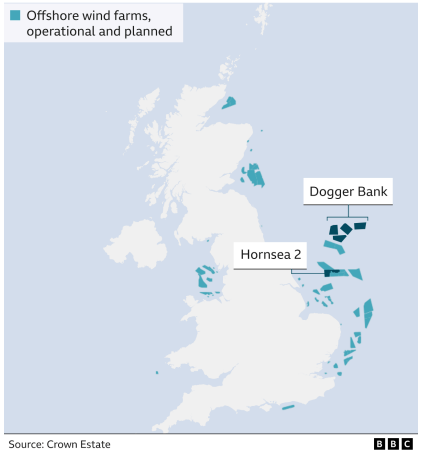
Status update 03/02/2022

Marius de Mourgues – marius.demourgues@eiffage.com

World largest wind farm

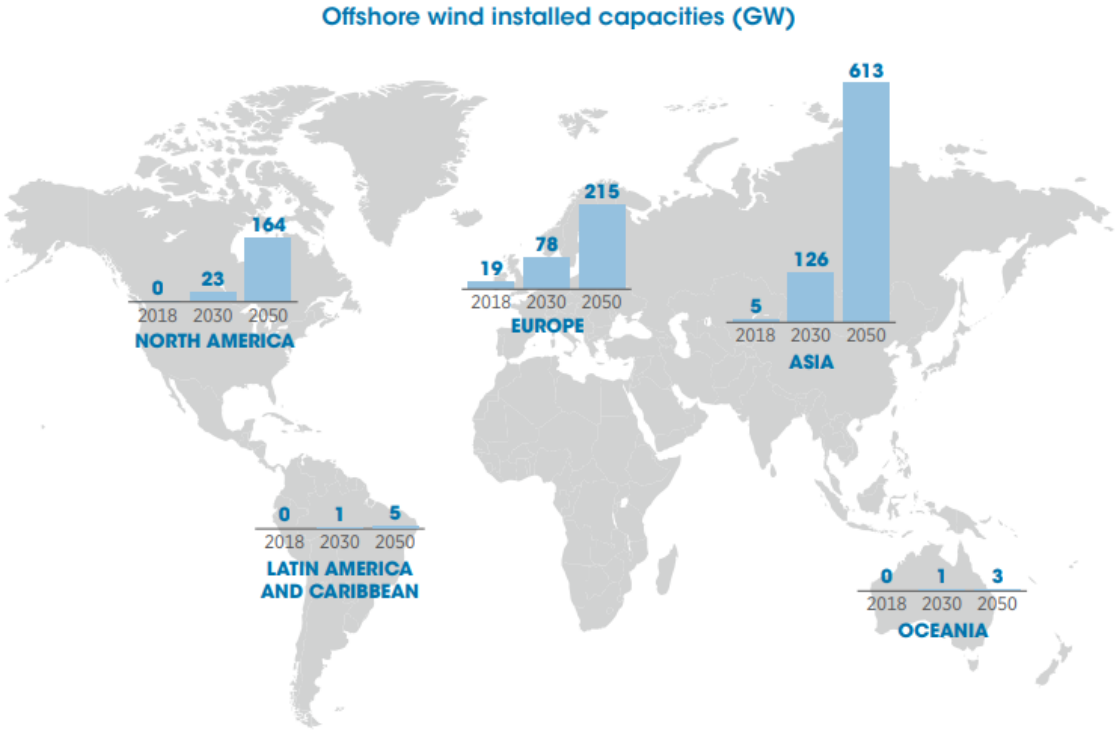
- Hornsea 2
  - Comissionned in August 2022
  - World largest wind farm
  - **1.32 GW** installed
  - Powering 1.3 million home
  - 165 turbines of 8MW

- Dogger Bank
  - **4.8 GW** planned by 2026



Marius de Mourgues – marius.demourgues@eiffage.com

Potential of offshore wind energy



Marius de Mourgues – marius.demourgues@eiffage.com

Projected prices of offshore wind energy

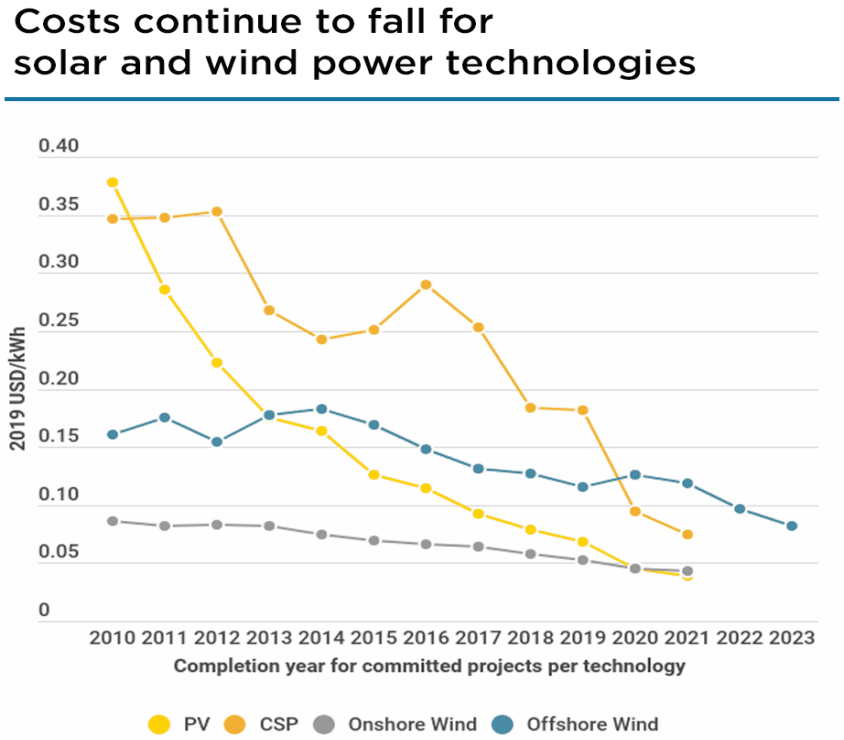
- Investment costs (CAPEX)
  - Onshore: 1355$/kw
  - Offshore: 3185$/kw

  x3

- Electricity prices
  - Onshore: 0.051$/kwh
  - Offshore: 0.099$/kwh

  x2
  - Today (mixed): 0.25$/kwh
  - 40% decrease by 2050 forecasted

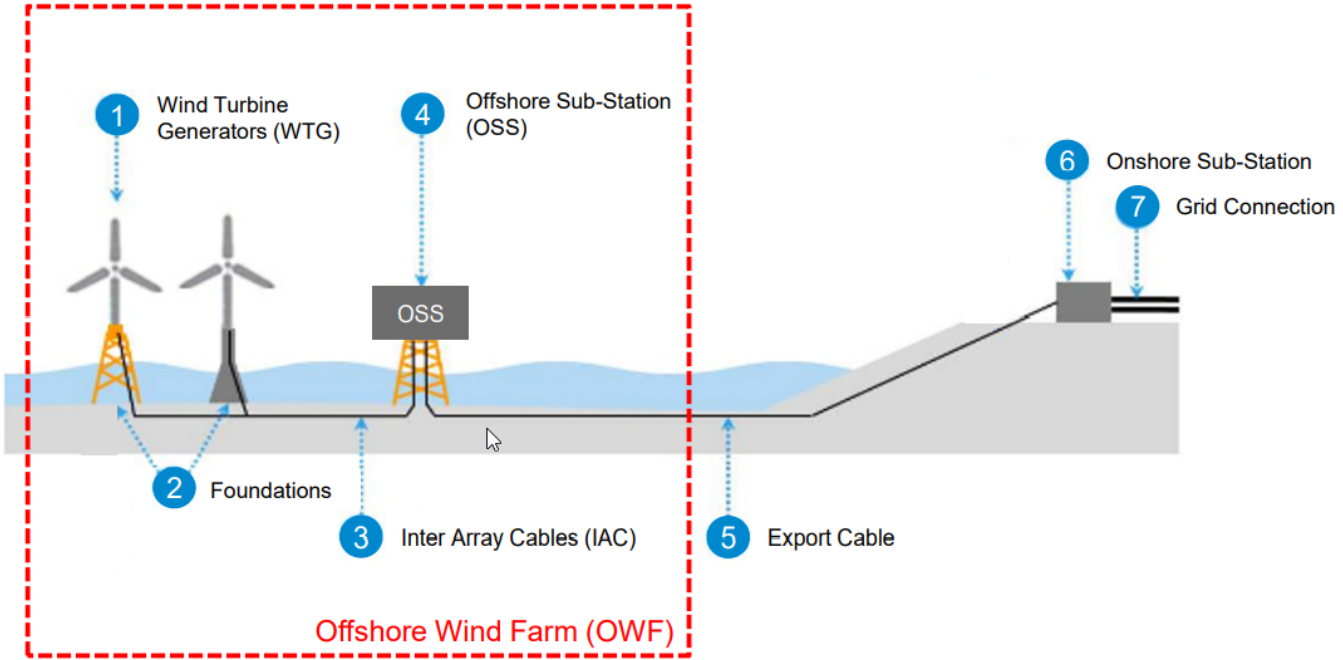
  - Higher **foundation** and **maintenance** costs for offshore energy



Marius de Mourgues – marius.demourgues@eiffage.com

Offshore wind technology

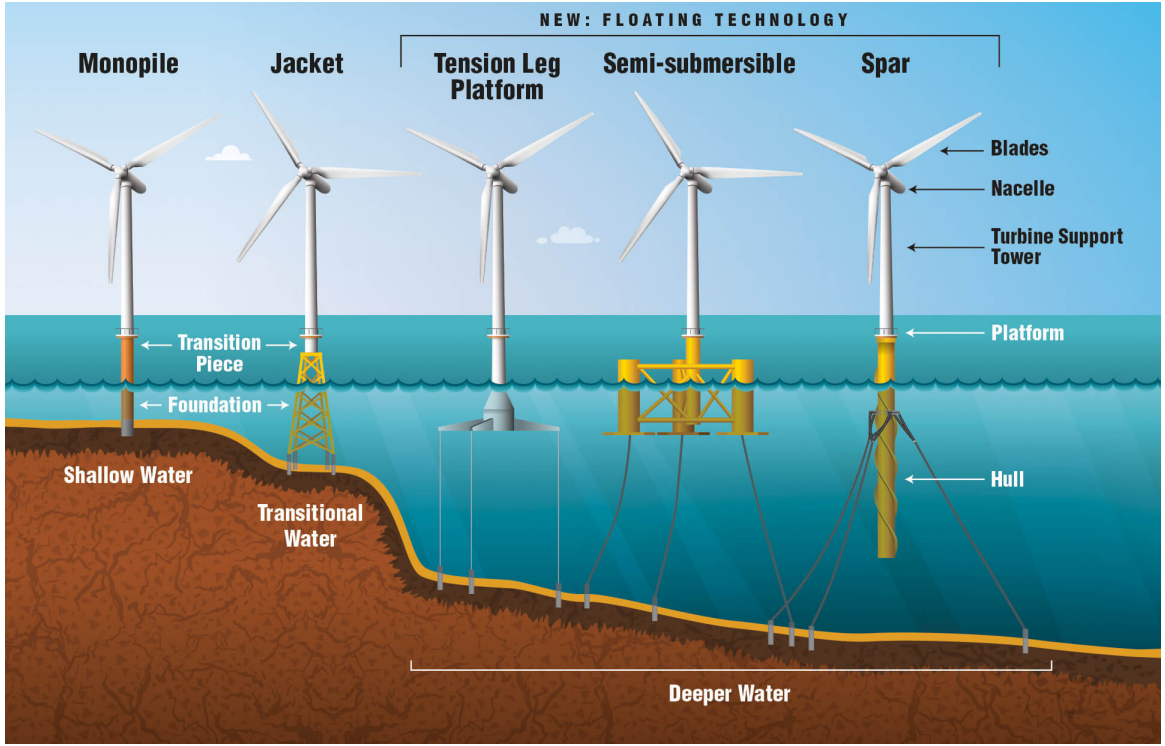
- The connection to the grid



Marius de Mourgues – marius.demourgues@eiffage.com

Offshore wind technology

- Fixed Foundations vs Floating foundations

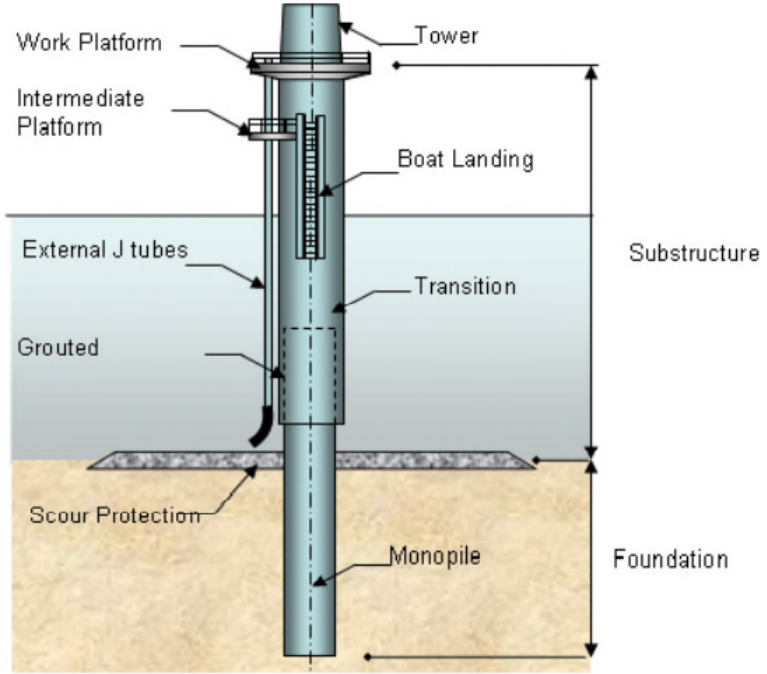


Marius de Mourgues – marius.demourgues@eiffage.com

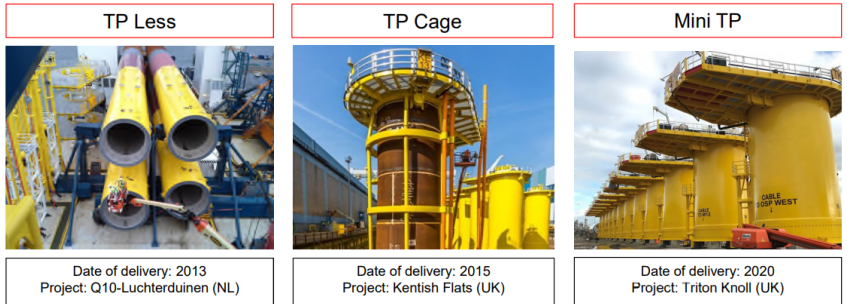
Fixed foundation technology

Marius de Mourgues – marius.demourgues@eiffage.com

- Monopiles
  - 75% of fixed installed wind turbines
  - Water depth <35m
  - **Cost effective**
  - Requires strong soil properties

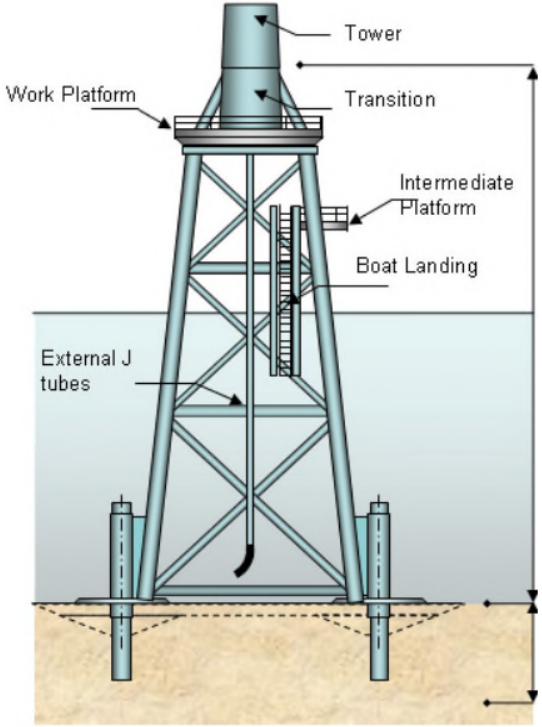


- Design evolution



Fixed foundation technology

- Jacket
  - 15% of fixed installed wind turbines
  - Water depth <50m
  - Based on oil and gas industry
  - Installation can be more **complicated**



- Design evolution

Thornton Bank (BL)	Moray East (UK)	Demain
		
Date of delivery: 2008 Number of units: 48	Date of delivery: 2020 Number of units: 103	2030

Marius de Mourgues – marius.demourgues@eiffage.com

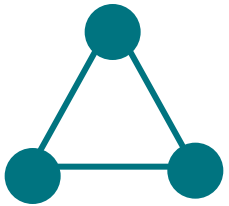
Installation of fixed foundations

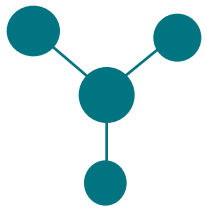
- Depends on soil characteristics
- Installation of monopiles using the « hammer » technique
- Drilling technique
- **Costly** operation

Marius de Mourgues – marius.demourgues@eiffage.com

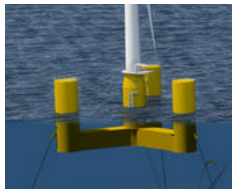
Floating technology

- Semi-submersible floater
  - Triangular design
  - Maximum **buoyancy** concept
  - Most versatile concept
  - Limited by weight
  - Restoring momentum comes from the buoyancy of the **external columns**





- Current development
  - Pilot farms in Europe (EFGL, PGL)
  - Tender phase



Hydrostatic stiffness:

$$K_H = \rho V g(KB - KG + \frac{I}{V})$$

Marius de Mourgues – marius.demourgues@eiffage.com

Floating technology

- Spar technology
  - 80m long cylinders to **lower the COG**
  - Particularly adapted for **deep waters** but requires high water depth at quay
  - Restoring momentum comes from the low COG

- Tension-Leg-Platform
  - Lower weight and size to **reduce manufacturing costs** but technically challenging to install
  - Stability is provided by the **buoyancy** force against the **tension in the mooring line**

Marius de Mourgues – marius.demourgues@eiffage.com

Procurement, Construction and Installation (PCI)

- Procurement of **steel** all over Europe
- Pre-assemby construction in several european facilities
- Final assembly of sub elements on yards

Marius de Mourgues – marius.demourgues@eiffage.com

Procurement, Construction and Installation (PCI)

- Turbine integration on yards
  - Floaters next to the quay
  - Large **cranes** lifting the mast, the nacelle and finally the blades
  - Supervised by turbine manufacturer

Marius de Mourgues – marius.demourgues@eiffage.com

Procurement, Construction and Installation (PCI)

- Installation by regular boat transport
- Mooring connections pre-layed before the installation with anchoring system depending on seabed properties
  - Flexible chains
  - Synthetic fibres
  - Steel cables
- Connection from the I tube to the Inter array cable
- **Less costly** operation

Marius de Mourgues – marius.demourgues@eiffage.com

Limitations

- Weight: *A floating unit is 4000t*
- Technical manufacturing of large steel structures
- **Industrialization** of the supply chain interacts with evergrowing **design evolution**
- **Yard** size
- **Public** opposition
- **COSTS**

Marius de Mourgues – marius.demourgues@eiffage.com

EPFL

EIFFAGE MÉTAL

Questions?

Marius de Mourgues

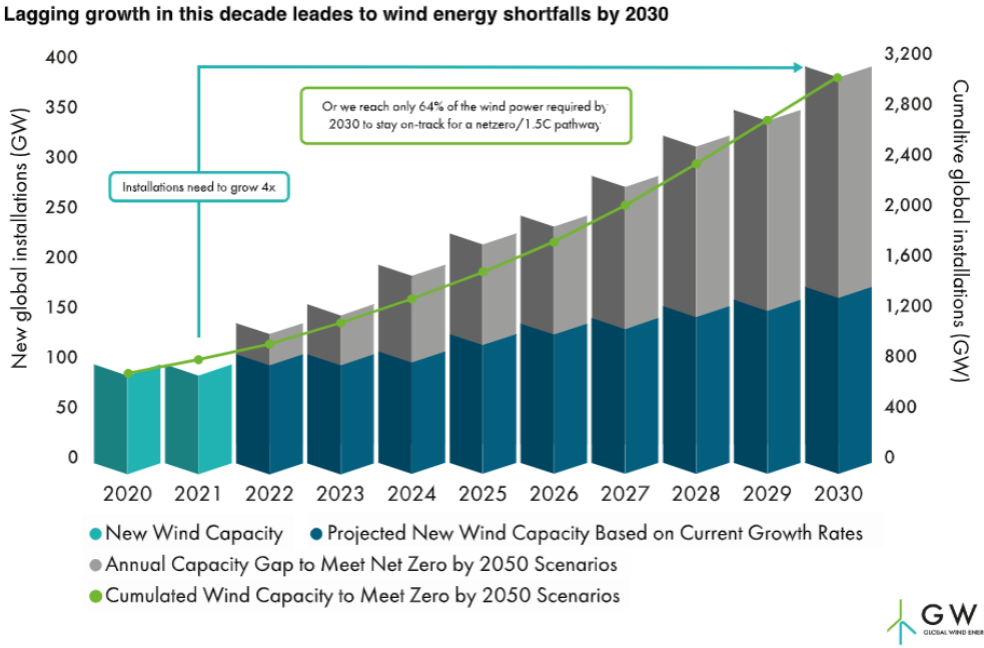
Interesting links

Marius de Mourgues – marius.demourgues@eiffage.com

- Videos to watch
  - https://www.youtube.com/watch?v=wr7QZ364jPY&t=632s
  - https://www.youtube.com/watch?v=xbdUlfYCRwc&t=9s

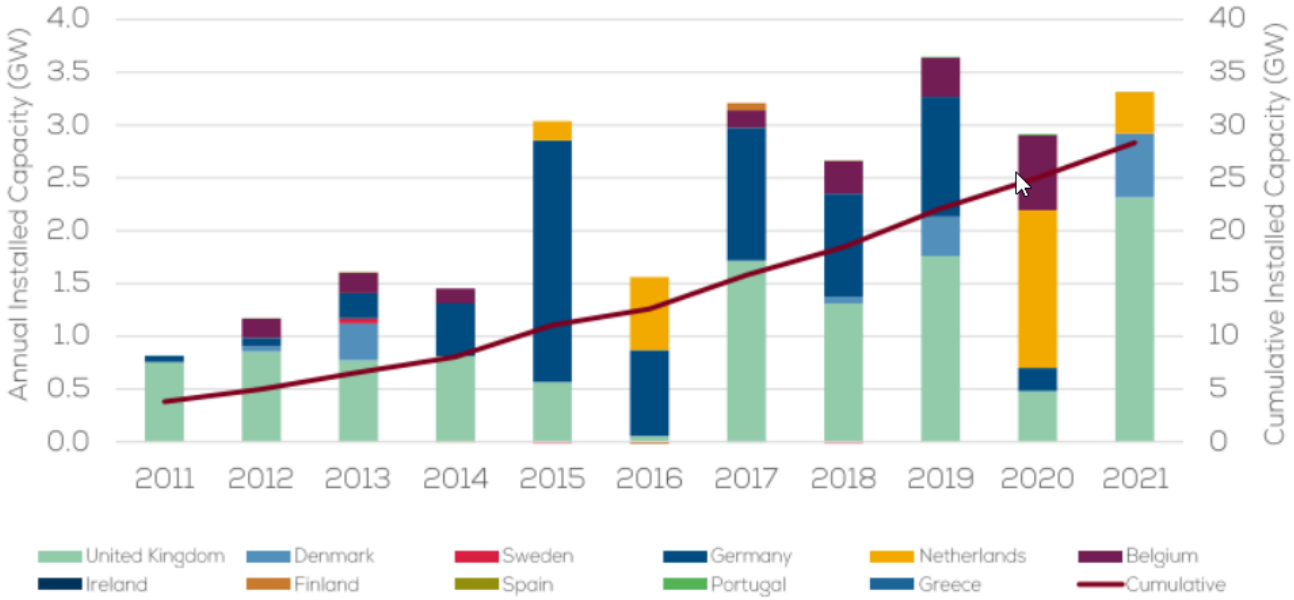
- Websites
  - https://globalwindatlas.info/fr
  - https://www.iea.org/reports/offshore-wind-outlook-2019
  - https://gwec.net/gwecs-global-offshore-wind-report/

Global Wind Report 2022 - Global Wind Energy Council



Marius de Mourgues– marius.demourgues@eiffage.com

Cummulative installed capacity in Europe



Marius de Mourgues – marius.demourgues@eiffage.com