UFRN UNIVERSIDADE FEDERAL DO RIO GRANDE DO NORTE

CREATION Innovation and Optimization of Products and Process Offshore Wind Energy

GREAT for PARTNERSHIP BRITAIN & NORTHERN IRELAND

OFFSHORE WIND: Market, technological development and competitiveness

Prof. Mario González

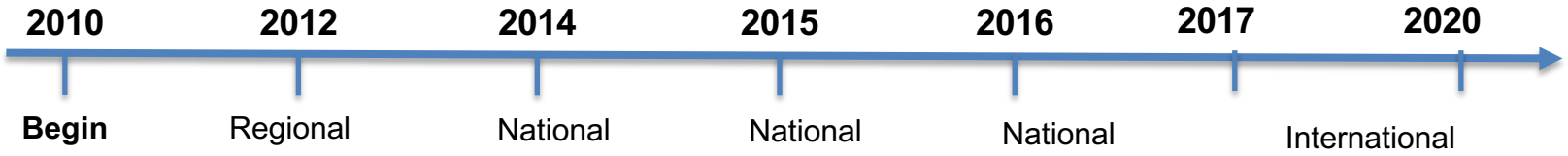
RN-Brazil, March 15, 2021

Topics

- Market
- Technological development
- Competitiveness

Timeline

CREATION – Innovation of Products and Processes for Offshore Wind Energy



UFRN Universidade Federal do Rio Grande do Norte

ABEEólica

IDGP Instituto de Inovação e Gestão de Desenvolvimento do Produto

DTU Technical University of Denmark

TU Delft Delft University of Technology

Engenharia de Produção UFRN

cerne Centro de Estratégias em Recursos Naturais & Energia

CTGAS-ER Centro de Tecnologias do Gás & Energias Renováveis

BR Petrobras CENPES

東京大学 The University of Tokyo

CNPq

ANEEL Agência Nacional de Energia Elétrica
Programa de Pesquisa e Desenvolvimento - P&D

University of Portsmouth

Ministério da Ciência, Tecnologia, Inovações e Comunicações

Pátria Amada Brasil Governo Federal

- **Case Research**:
  - Offshore wind in developed markets: Denmark; UK; Germany.
  - Offshore wind in new markets : Taiwan, Japan and USA.
- **Research in onshore wind energy,** since 2010.

- **Scientific missions**:
  - England (2012; 2014; 2018)
  - Japan (2016)
  - Norway (2016)
  - Denmark (2015, 2016, 2017, 2018 and 2019)
  - Sweden (2017 and 2018)
  - Germany (2018; 2019)
  - Holland (2019)
  - Belgium (2019)
  - Portugal (2019)
  - Spain (2019)

- **Technical visits**:
  - Offshore blade factory (Siemens-Gamesa, England - 2018);
  - Offshore nacelle factory (MHI Vestas, Denmark– 2017)
  - Port of Cuxhaven (Germany – 2018)
  - Port of Hull (England – 2018)
  - Port of Barrow (England – 2018)
  - Port of Esbjerg (Denmark – 2018; 2019)
  - Port of Eemshaven (Holland – 2019)
  - Port of Rotterdam (Holland – 2019)
  - Port of Oostende (Belgium – 2019)
  - Offshore wind farm of Middelgrunden (Denmark – 2015; 2018)
  - Offshore wind farm of Fukashiba (Japan – 2016)
  - Offshore wind farm of Lillgrund (Sweden – 2017)

Research Projects

2010 - 2012

- Performance Measurement in the Brazilian wind power supply chain

2012 - 2014

- Sustainable development of communities near of the Rio Grande do Norte wind farms

2013 - 2015

- Technological forecasting of wind turbines for wind energy (Onshore and Offshore)

2015 - 2017

- Open innovation practice for technological development of Brazilian wind energy

2016 - 2020

- Economic studies of infrastructure and the value chain of the offshore wind industry

2019 - Atual

- Economic studies and innovation for the development of offshore wind energy in Brazil

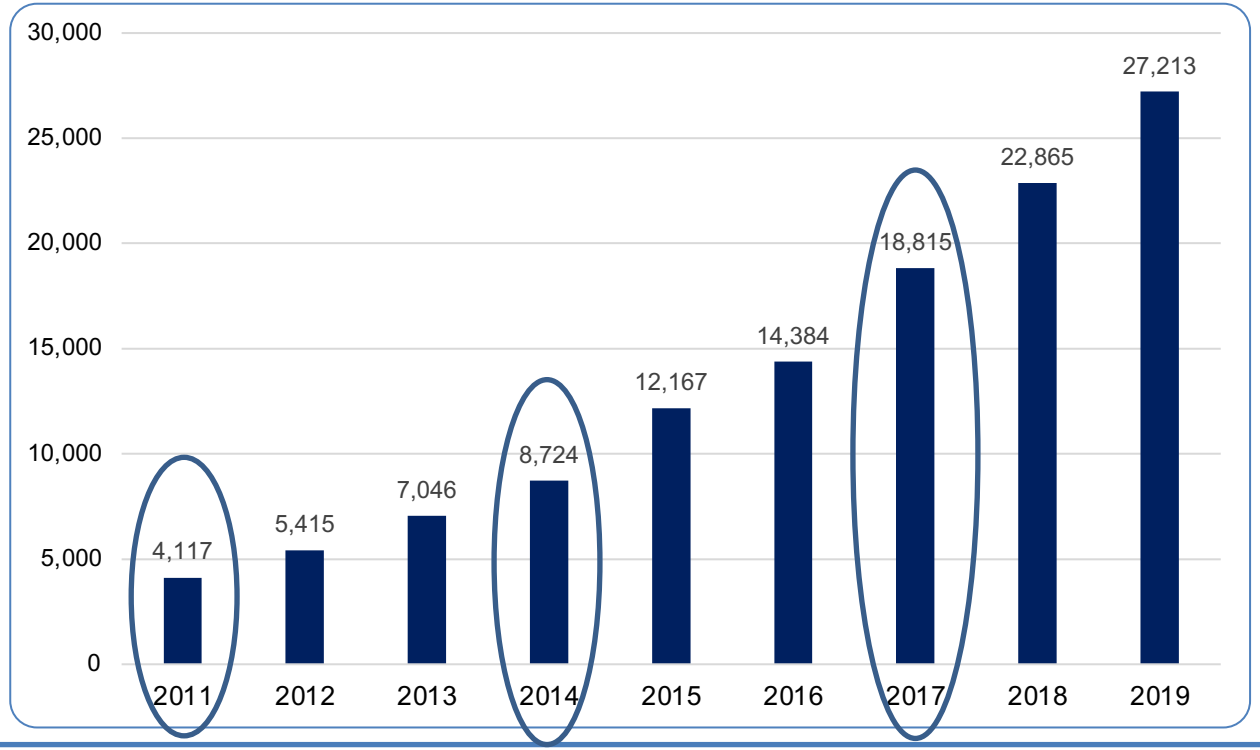
2019 - Atual

- Technical and economic and value chain studies of hybrid system: offshore wind and green hydrogen

Market

Offshore wind energy: market

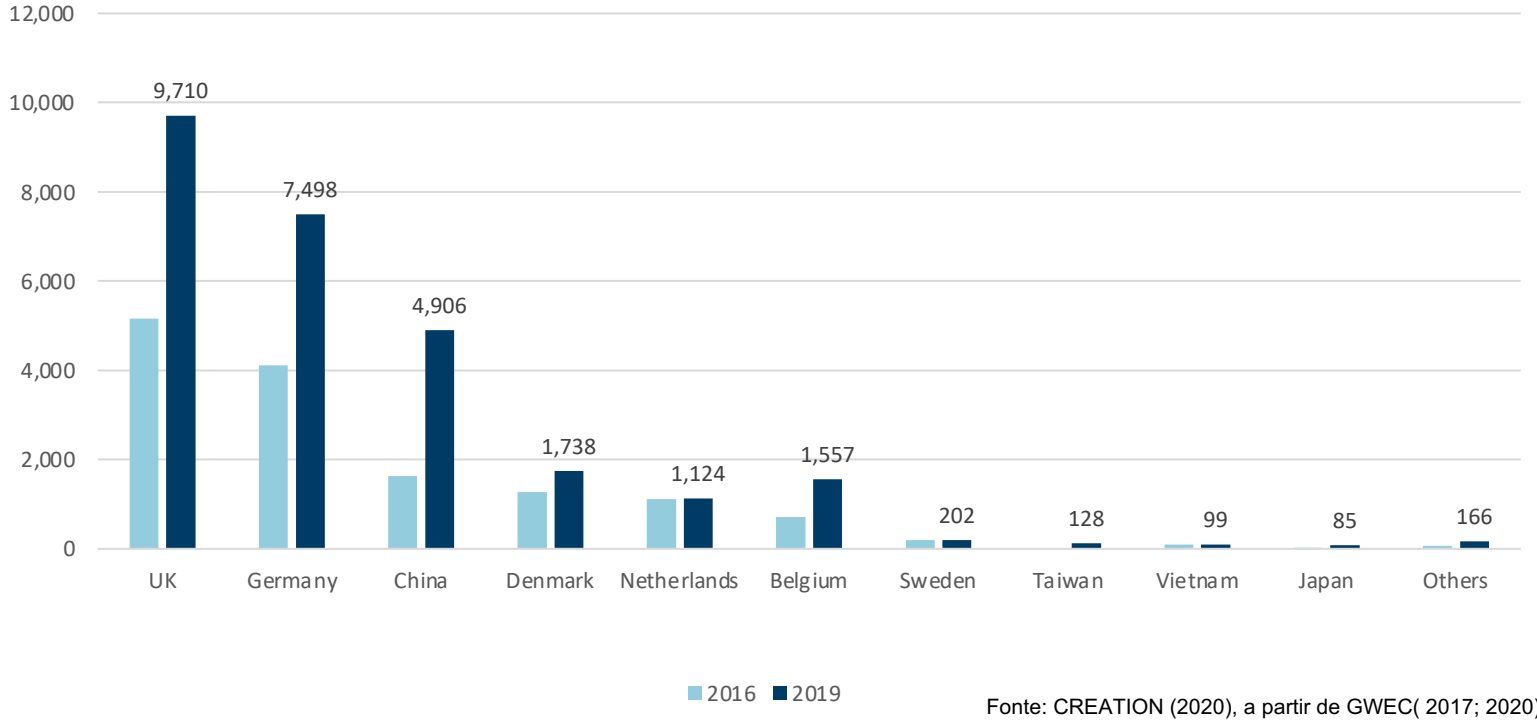
Accumulated installed capacity (MW)



Fonte: CREATION (2020) a partir de GWEC (2017; 2020); WindEurope, 2020

Offshore wind energy: market

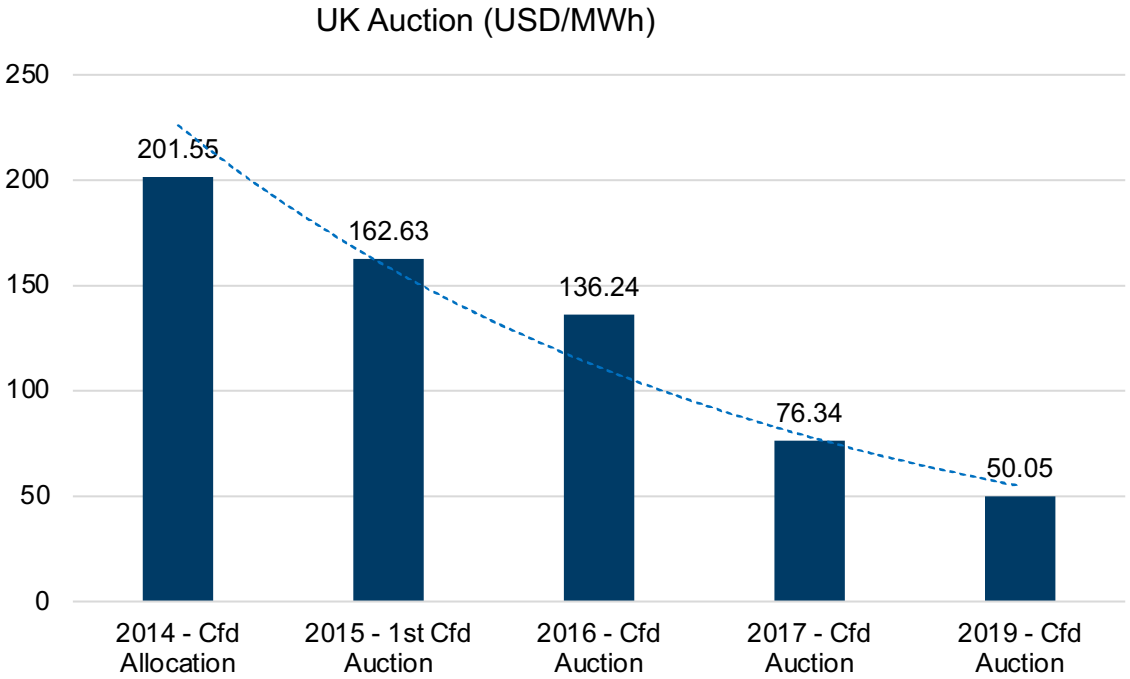
Accumulated installed capacity by country (MW)



Fonte: CREATION (2020), a partir de GWEC(2017; 2020); WindEurope (2020)

Offshore wind energy: market

Negotiated (lowest) price in the UK($/MWh)

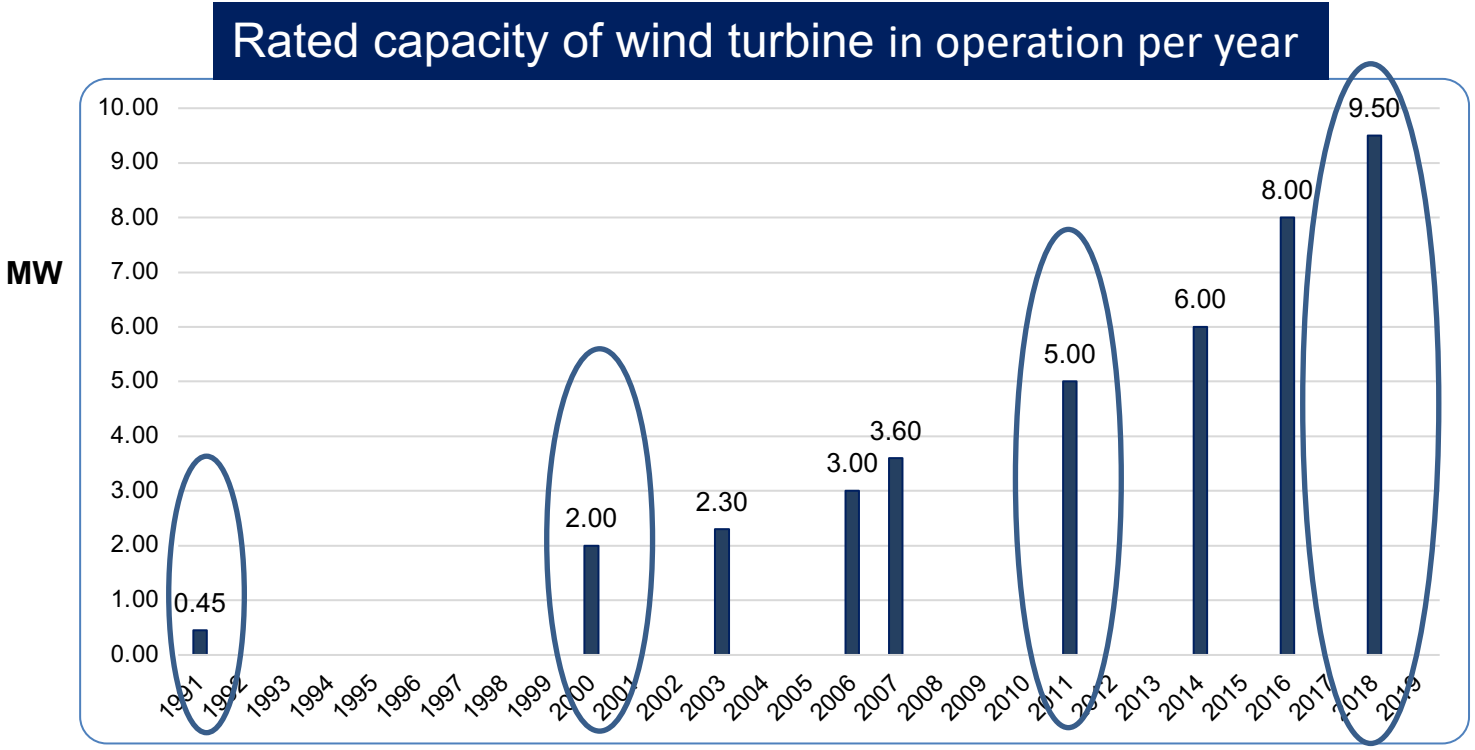


Fonte: CREATION (2020) a partir de TCE (2019); WindEurope (2020)

Technology

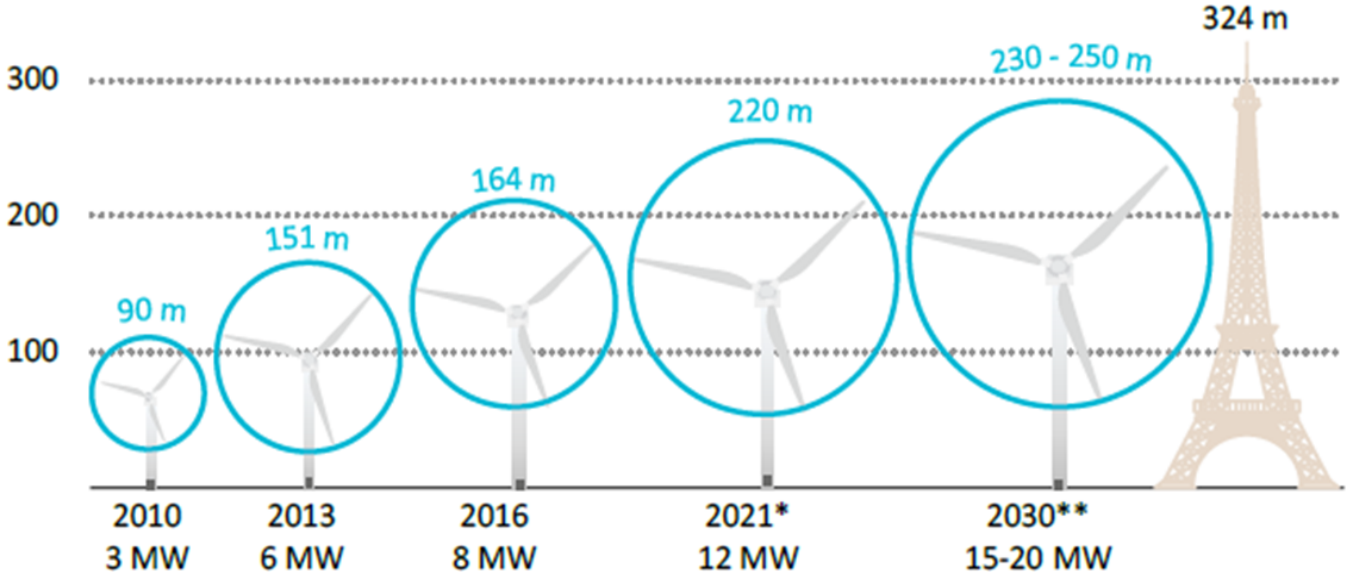
Technological development: wind turbine

- The technological development of offshore wind turbines is taking place at an accelerated rate.



Source: CREATION (2020); GWEC (2020); WindEurope (2020)

Technological development: offshore wind turbine



Source: IEA (2019)

Technological development: offshore wind turbine

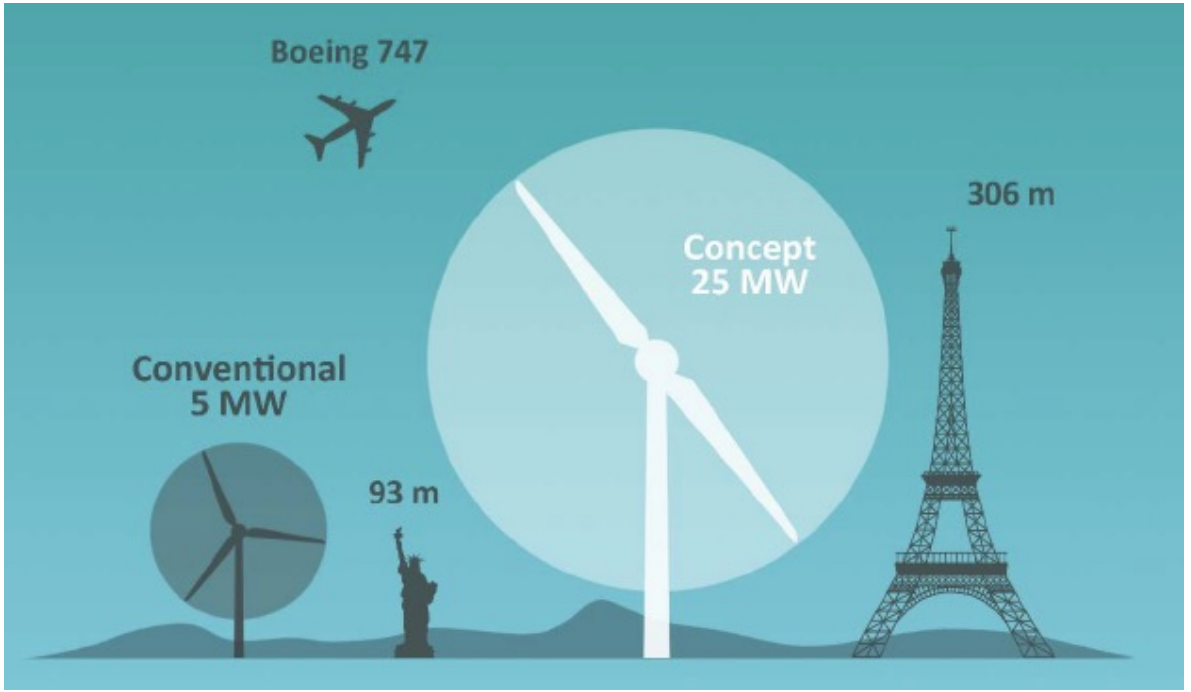
	Vestas V164	**GE** HALIADE X	**Siemens Gamesa** SG14	**Vestas** V236	**IEA** 15 MW	**Concept** 25 MW
Rated power (MW)	10	12	14	15	15	25
Available for Installation	2020	2021	2024	2024	--	--
Blade size (m)	80	107	108	115	120	160

Source: CREATION (2021)

Technological development: offshore wind turbine

Turbine of 25 MW

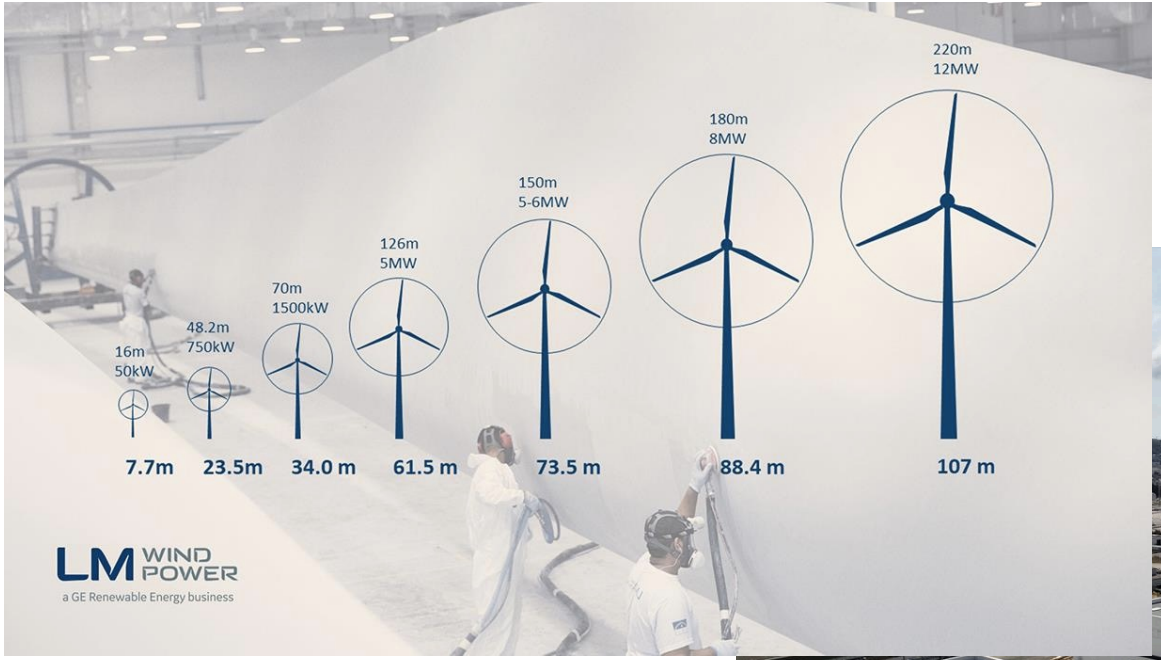
- Conceptual turbine
- 2 blades
- Blade length:160 m



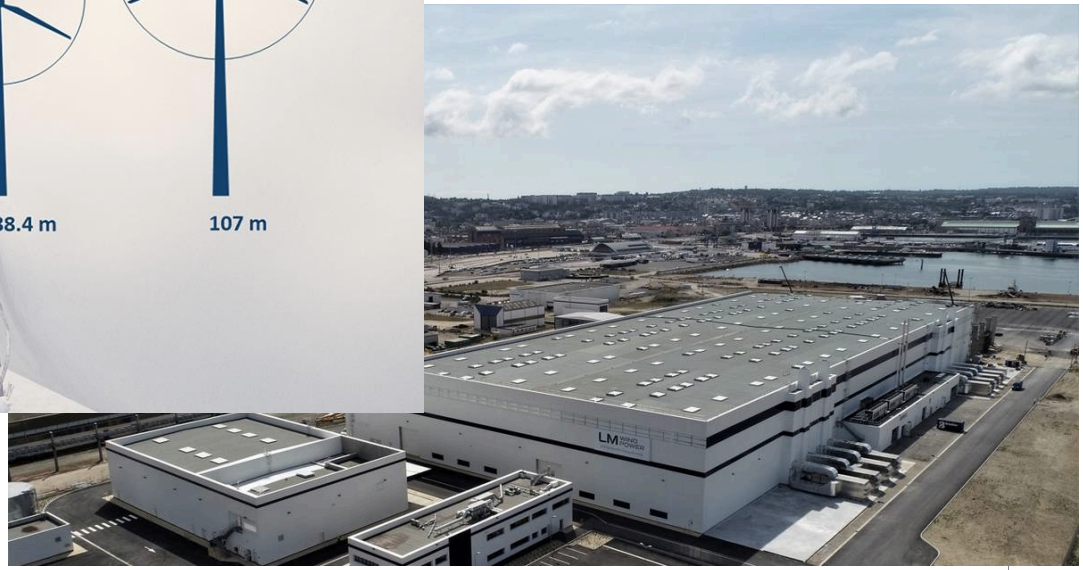
Fonte: Qin et al. (2020)

Technological development: offshore wind turbine

Blade case



Blade Factory “LM Wind Power” localized in port of Cherbourg (France). 2018.



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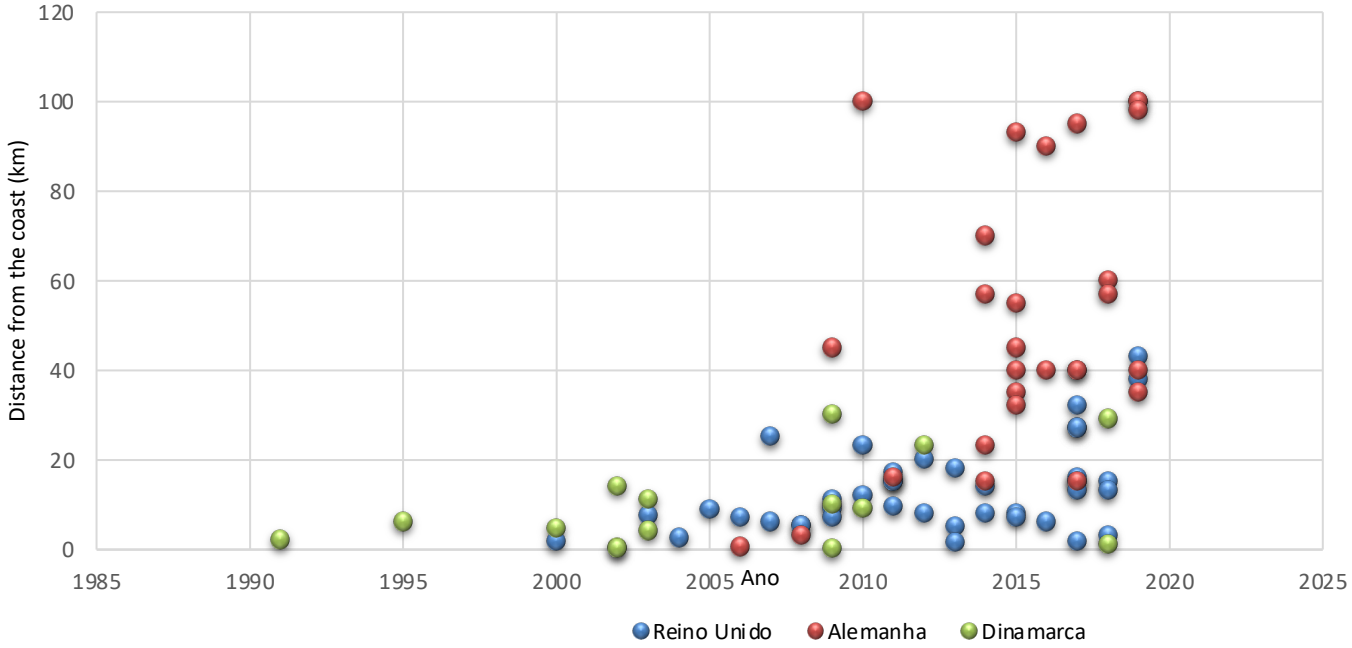
Technological development: wind farm

Wind farm installation

Offshore wind farms: Timeline and competitiveness

Offshore wind farms: timelines (UK, Germany, Denmark)

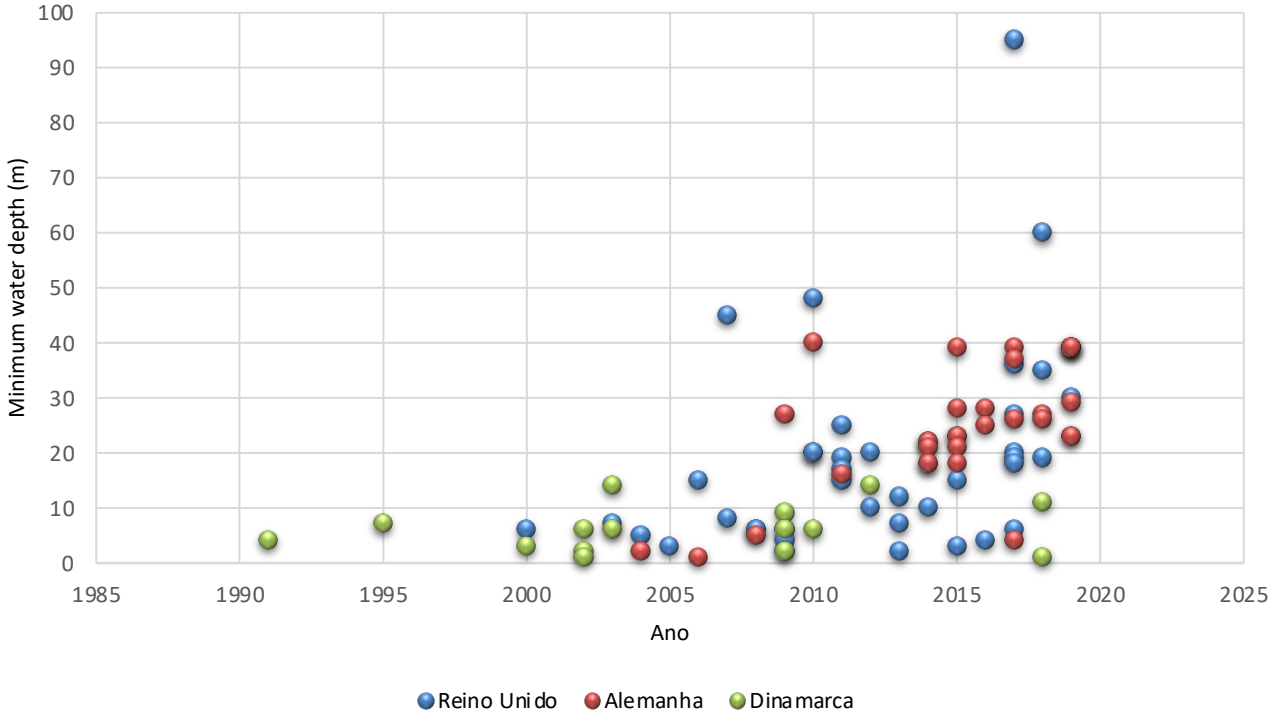
Minimum distance from the coast (Km)



Source: CRIACAO (2020)

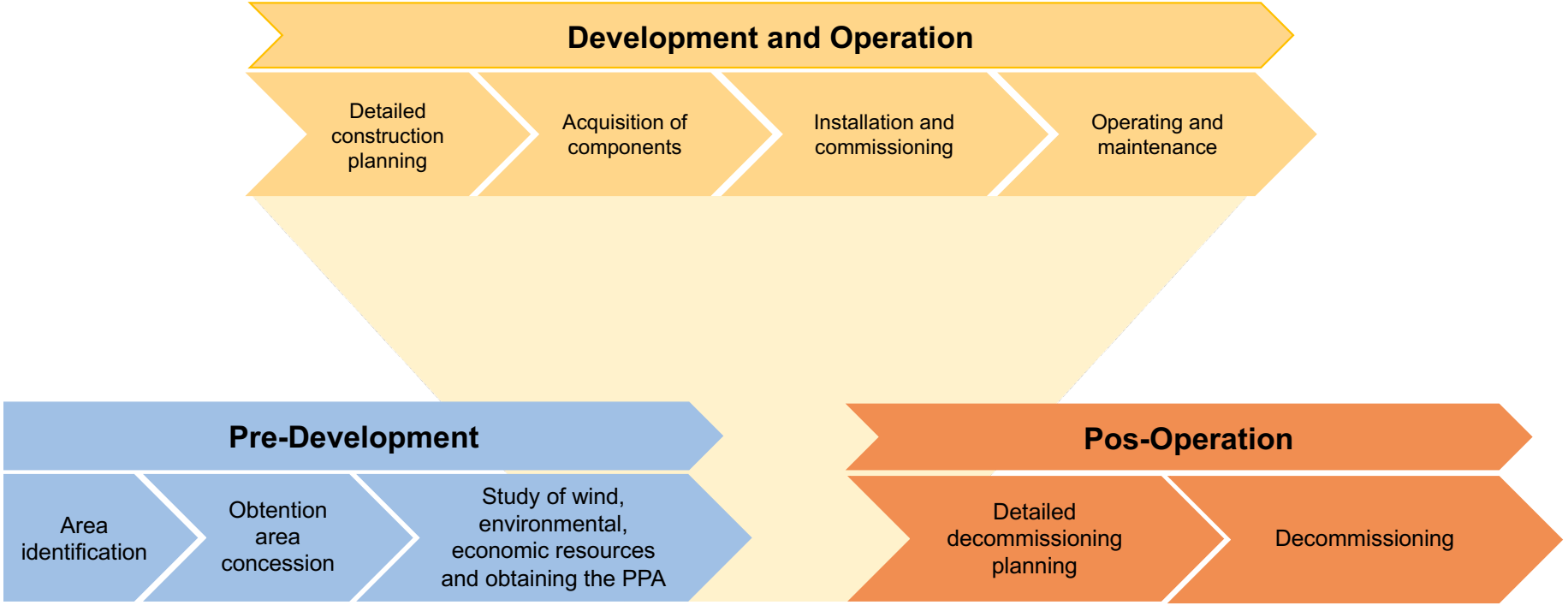
Offshore wind farms: timelines (UK, Germany, Denmark)

Minimum water depth (m)



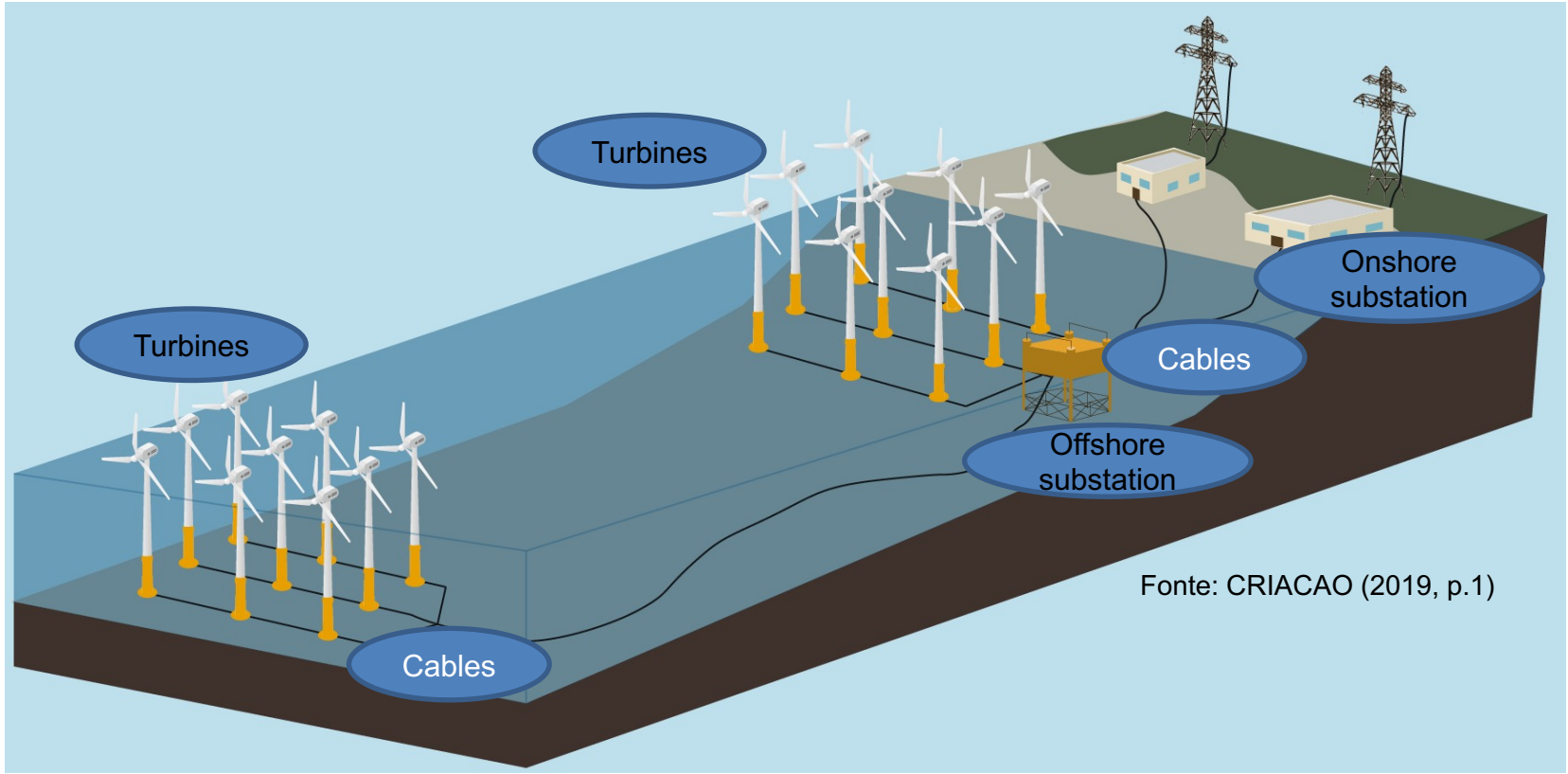
Fonte: CRIACAO (2020)

Competitiveness: Life cycle of offshore wind project



Source: CREATION (2020)

Competitiveness: Offshore wind power



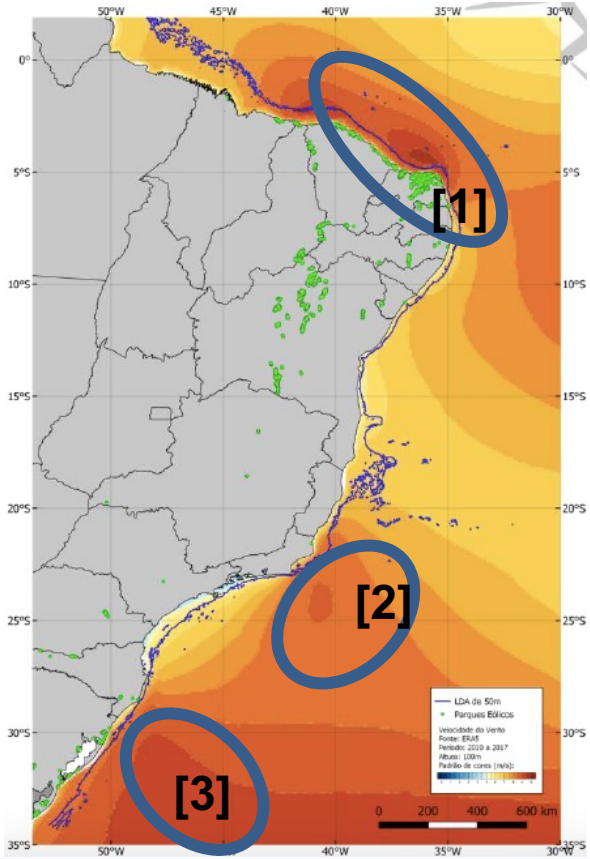
Fonte: CRIACAO (2019, p.1)

Offshore wind power in Brazil

Offshore wind potential:
- 697 GW (EPE, 2019)
- 1,200 GW (WORLD BANK, 2020)

[1] Northeast: States (RN and CE):
High potential near the coast
- Distance from the coast [20 km]
- Depth of water [12 - 15 m]
- Average Capacity factor some projects = 61%

[2] Southeast and [3] South:
Great potential near load.
- Distance from the coast [40 km]
- Depth water [> 40 m]



Source: Malateaux et al.(2018)

Factors that influence the competitiveness

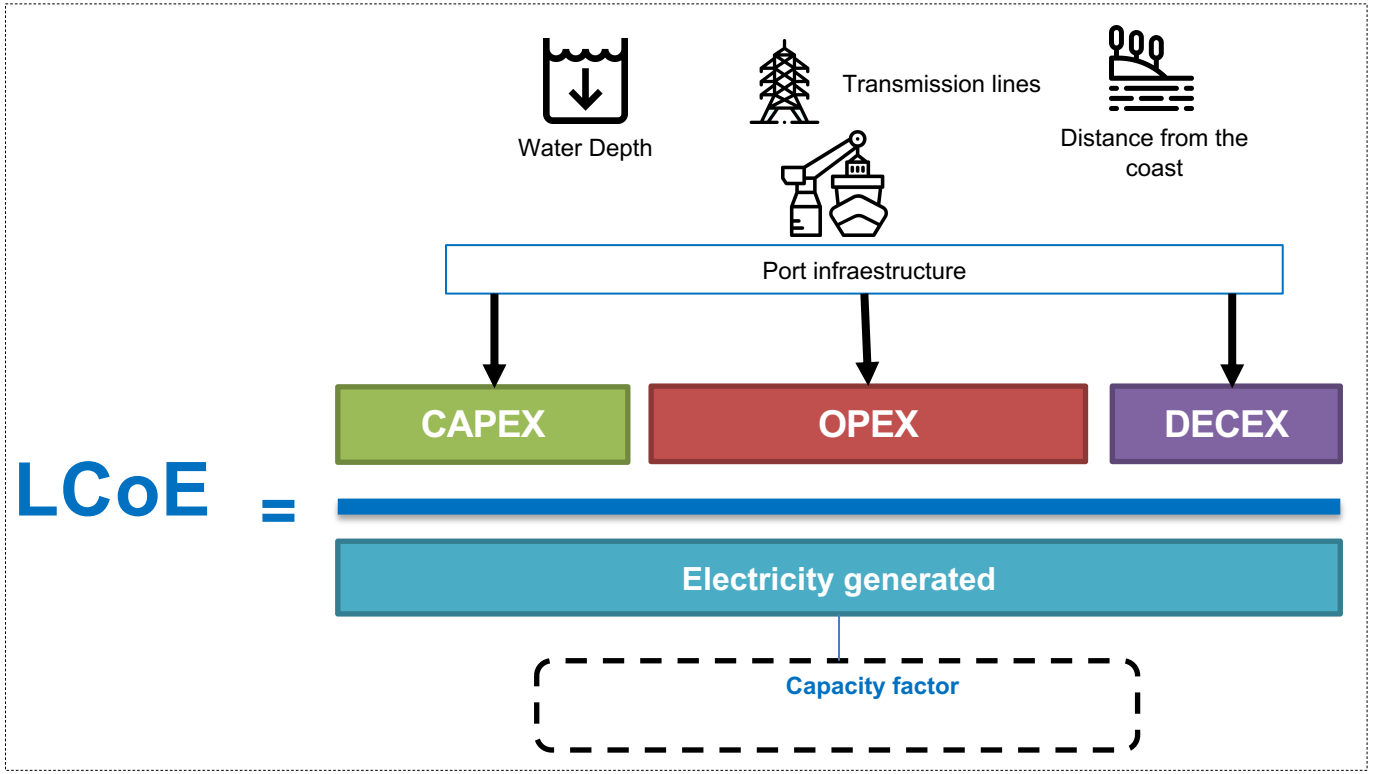
Project feasibility

NPV
Net Present Value

IRR
Internal Rate of Return

Payback

LCoE
Levelized cost of energy



Final remarks

- Offshore wind farms have a higher **Capacity Factor**
- What is accelerating the **cost reduction of offshore wind**?
  - Increase in the rated power of the turbine;
  - Innovations in transport and installation of turbines;
  - Innovation in the O&M process;
  - Better coordination of the value chain.
- **New markets** (USA, Japan, South Corea, Taiwan, Portugal....)
- Offshore wind, **opportunities for Brazil**, due to
  1) High potential and wind quality,
  2) Existence of supply chain with synergies (onshore wind and Oil & gas offshore).

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