Blue Talk Cuba

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The Ocean: a huge **theoretical** resource – 275,500 TWh/y

Waves (44,000 TWh/y)

Ocean thermal energy conversion (OTEC): temperature differential between cold water from the deep ocean and warm surface water (50,000 TWh/y)

Tidal

Tidal stream: energy in fast flowing tidal currents (2,200 TWh/y)

Tidal range: energy from the difference between high and low tides (300 TWh/y)

Hydrothermal vents

Salinity gradient: pressure differential between salt and fresh water (osmotic energy) (20,000 TWh/y)

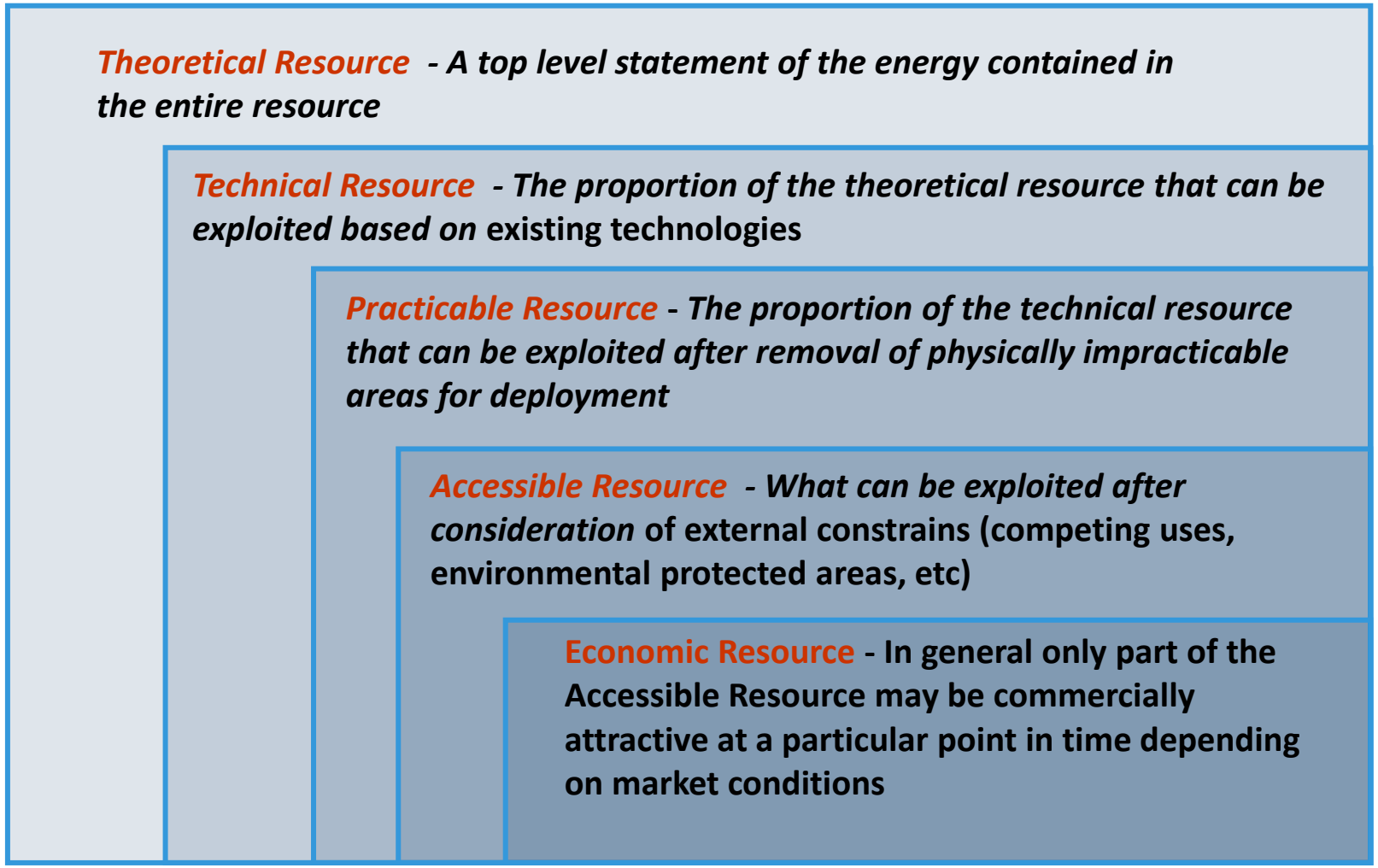
Marine Biomass: macroalgae cultures to produce bio-fuel

Offshore Wind: tipically a Wind Resource, but in fact it is also a Marine Energy Resource (176,000 TWh/y)

World Energy Consumption: 140,000 TWh/y

Scale of the resource assessment

- When discussing energy potential it is important to clearly define the limitations included



The Ocean: a relevant **market** resource

Waves (250 - 1500 TWhe/y)

Ocean thermal energy conversion (OTEC): temperature differential between cold water from the deep ocean and warm surface water **(small)**

Tidal

Tidal stream: **energy in fast flowing tidal currents** (50 - 150 TWhe/y)

Tidal range: **energy from the difference between high and low tides (small)**

Salinity gradient: **pressure differential between salt and fresh water (osmotic energy) (122 TWhe/y)**

Marine Biomass: macroalgae cultures to produce bio-fuel (NA)

Offshore Wind: tipically a Wind Resource, but in fact it is also a Marine Energy Resource **(1500 - 15000 TWhe/y)**

World Electrical Energy Consumption: 14,000 TWhe/y

SUMMARY

- ✓ SIZE OF THE OPPORTUNITY
- ✓ OFFSHORE WIND
- ✓ TIDAL STREAM
- ✓ WAVE

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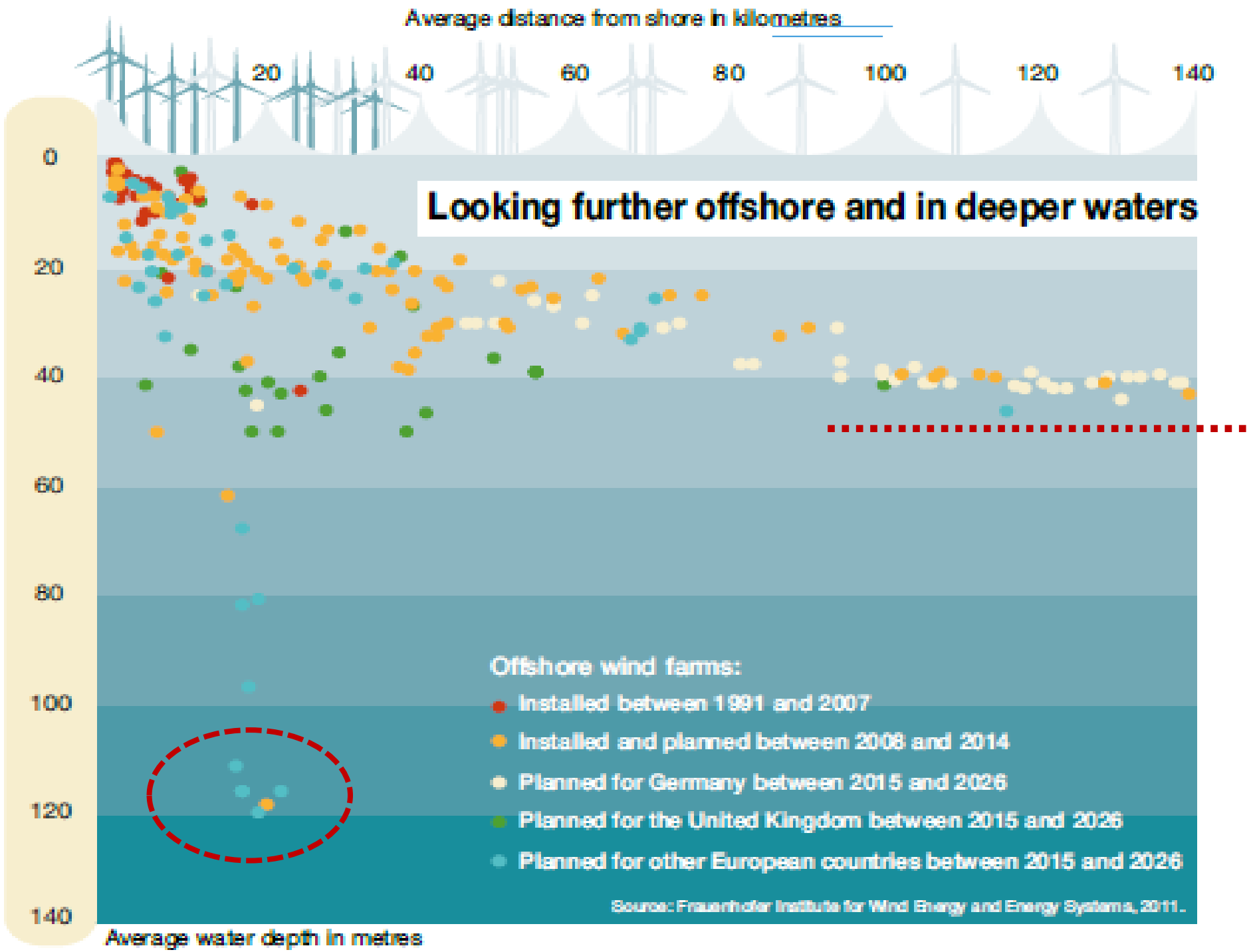
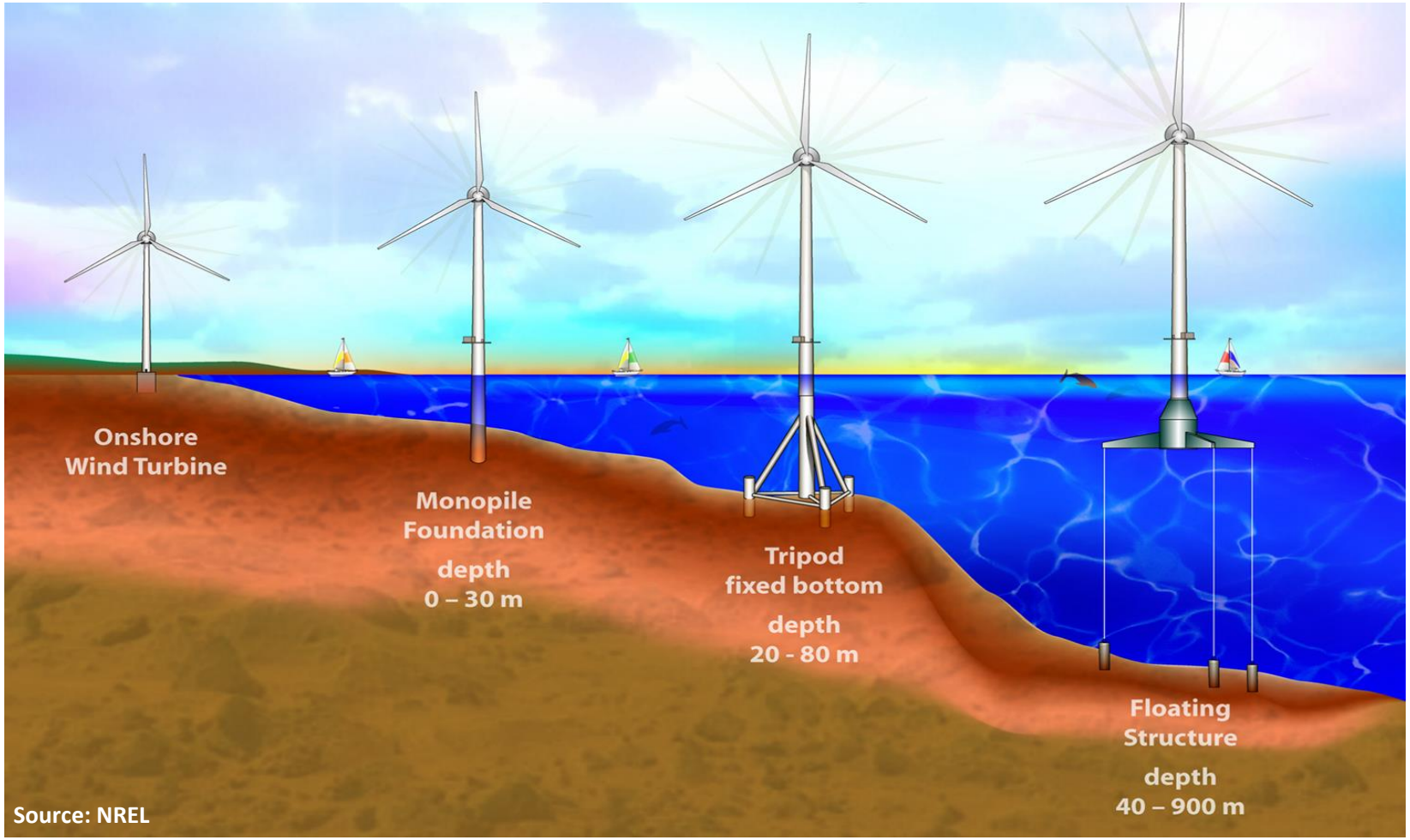
Offshore Renewables


Average distance from shore in kilometres
20
40
60
80
100
120
140
0
20
40
60
80
100
120
140
Looking further offshore and in deeper waters
Offshore wind farms:
Installed between 1991 and 2007
Installed and planned between 2008 and 2014
Planned for Germany between 2015 and 2026
Planned for the United Kingdom between 2015 and 2026
Planned for other European countries between 2015 and 2026
Source: Fraunhofer Institute for Wind Energy and Energy Systems, 2011.
Average water depth in metres

Progressing to deeper waters: Floating!

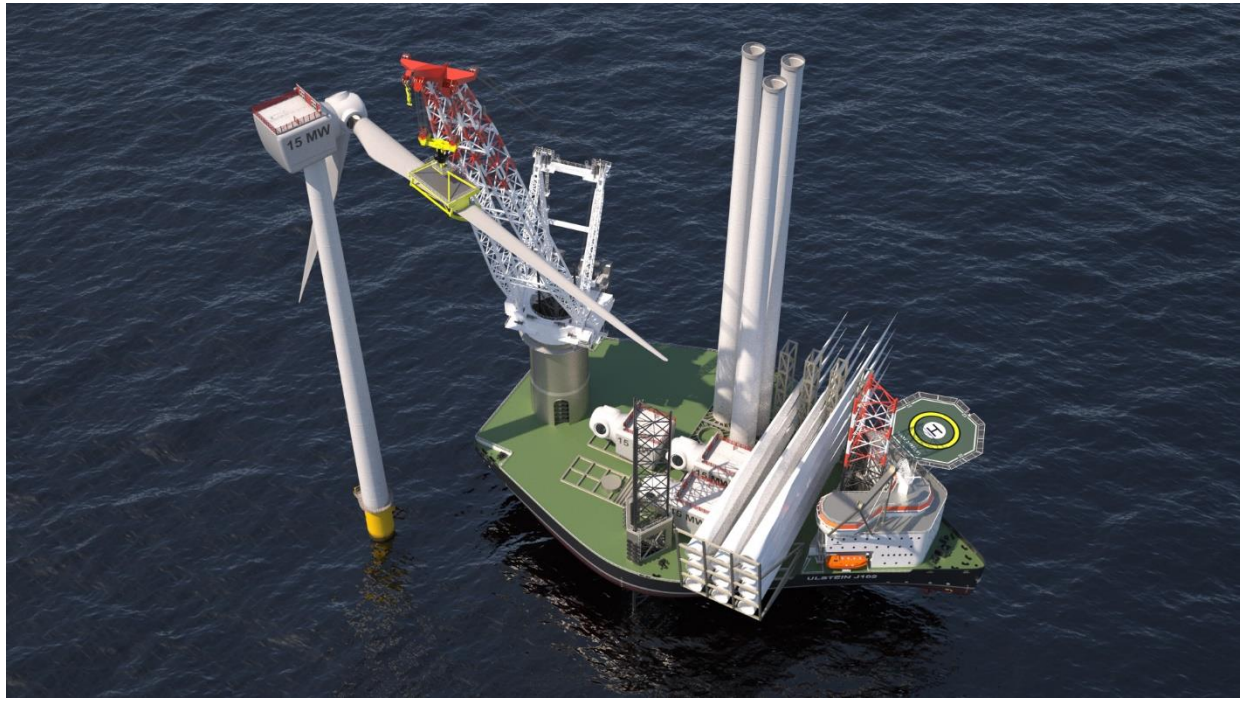


Targets for offshore wind

- **IRENA 2021 (World)**
  - 2020 – 34 GW deployed (fixed foundation)
  - 2030 – 380 GW
  - 2050 – 2000 GW
- **Wind Europe 2021 (Europe)**
  - 2050 – 450 GW
    – 150 GW floating
- **KIC InnoEnergy 2021 (foating)**
  - 2050 – 13 GW Spain
  - 2050 – 9 GW Portugal

Marine Renewable Energy Technological Challenges

- **Floating offshore wind**
  - 15 -> 20 MW turbines
  - Metal -> Concrete floating platforms
  - Dynamic electrical cables
  - Underwater modular electric substations
  - O&M cost reductions



SUMMARY

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- ✓ TIDAL STREAM
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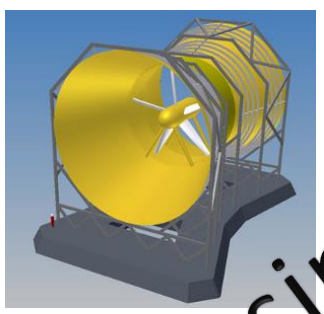
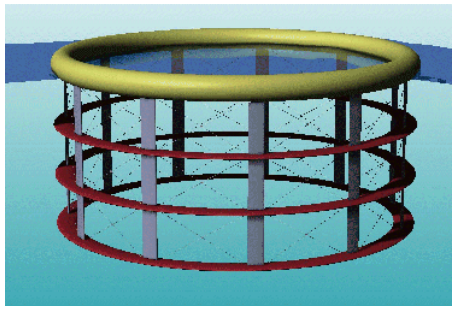
Tidal Stream Energy (TRL 6-8)

Horizontal Axis Turbines

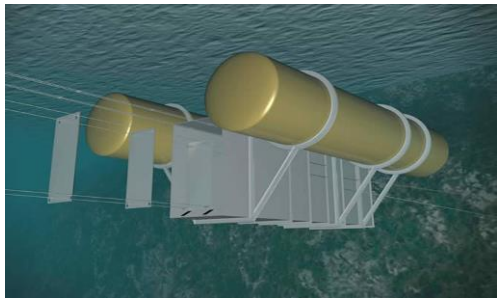



Vertical Axis Turbines





Hydrofoils


Prototype testing since 2004

3+ of continuous operation

- 27.7 MW installed in Europe since 2010 – 10.4 MW in operation in 2019 produced 15 GWh (oceanenergy-europe.eu)

TIDAL TECHNOLOGY EVOLUTION

RELEVANT ASPECTS

- Tidal energy production is proportional to the **blade swept area** and the **cube** of water velocity
- Tidal energy is variable but is **fully predictable**

TRENDS:

- **Higher turbines**: 1 MW at present / 5 MW in the future (?)
- **Improved deployment methods**: very strong currents (up to 5 knots) turn operations expensive and risky
- **Preventive maintenance**

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SUMMARY

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- ✓ **WAVE**

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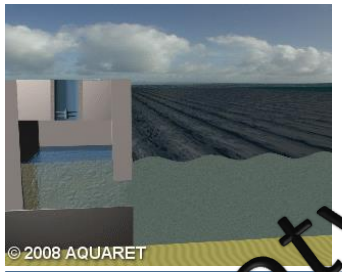
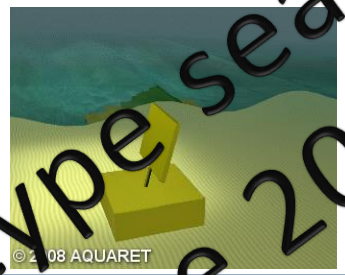
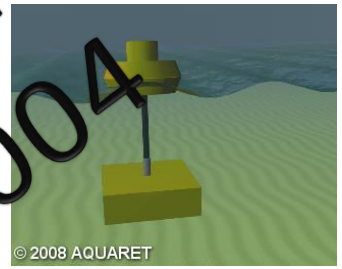
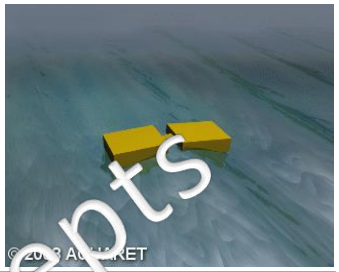
Wave Energy (TRL 6-7)









OWC

Oscillating bodies

Overtopping

Deformable bodies

Prototype sea trials since 2004

Diversity of concepts

Inconsistent energy production

WAVE TECHNOLOGY EVOLUTION

RELEVANT ASPECTS

- ❑ Wave energy flux is proportional to the square of the wave height and the wave period
- ❑ Waves can be predicted five days in advance
- ❑ Production efficiency depends on the energy flux (30 times higher in storms as compared to average) and wave period

TRENDS:

- ❑ Unclear what is the best working principle
- ❑ Unclear what is the best power equipment (turbine, hydraulic generator, direct electric drive, etc.): **air turbines and direct drive maybe better options**
- ❑ Unclear how to scale to industrial size

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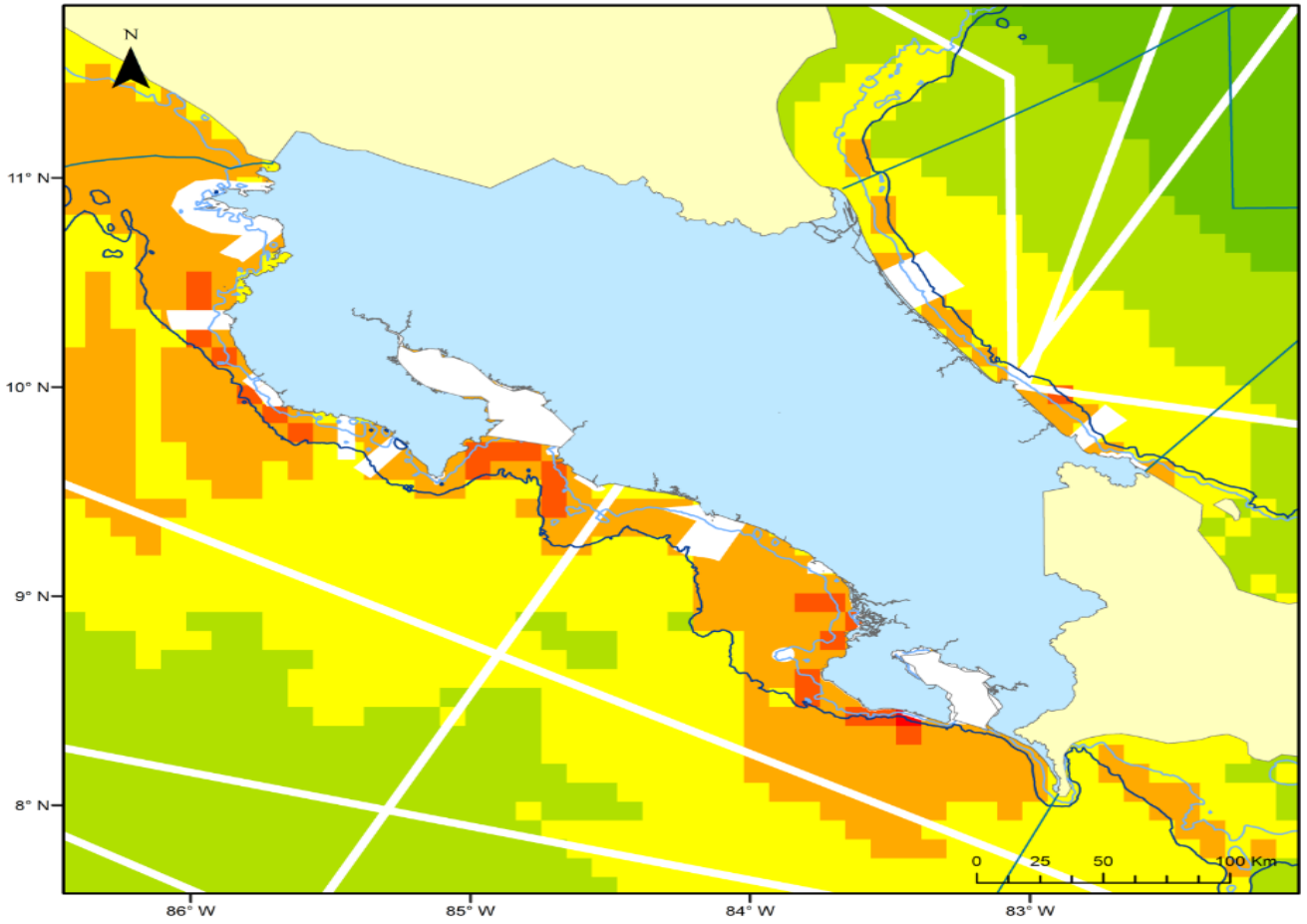


Evaluacíon Final del recurso de energia de las ondas con las zonas de exclusion

- 10
- 20
- 30
- 40
- 50
- 60
- 70
- Zona Económica Exclusiva de Costa Rica

Batimetria entre los 50 y 200m de profundidad

- -200
- -50

WAVEC KEY ACTIVITIES

- Costa Rica Marine Renewable Energy assessment and site selection (ICE, Costa Rica).

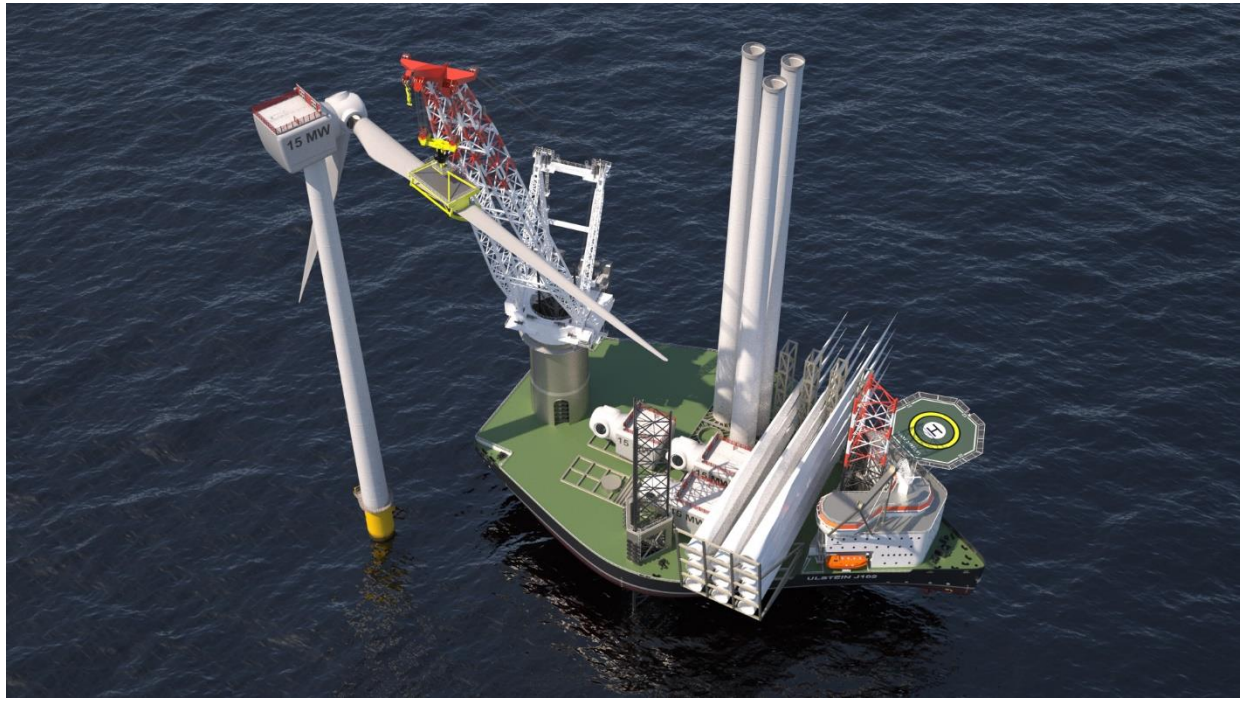
IMPACT:

- mapping of the resource and best areas for marine renewable energy.

"Making Things Happen"

Opportunities related to Marine Renewable Energy

- Cheap energy in the medium term.
- Socio-economic development due to the supply chain development.
- Energy independency and reduction of fuel imports.
- Reduction of environmental impacts.
- Opportunity to develop technology and supply chain for sustainable ocean exploitation (e.g., offshore aquaculture and multiuse of the maritime space).



THANK YOU

www.wavec.org

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