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BEHYOND

Bolstering the joint opEration of HYdrogen and Offshore wiND

Final dissemination event
Date 09.12.2021
Presenter: BEHYOND team

Operador do programa:
REPÚBLICA PORTUGUESA
Política do Mar

Promotor:
NEW by EDP & CTG

Parceiros:
edp
TechnipFMC
CEiiA
USN University of South-Eastern Norway
WavEC

Projeto:
BEHYOND

BEHYOND project overview

OBJECTIVE

Develop an engineering conceptual design of a **modular solution to produce hydrogen in large-scale from offshore wind energy.**

Partnership

NEW by EDP & CTG · edp · TechnipFMC · CEiiA · USN University of South-Eastern Norway · WavEC Offshore Renewables

Duration
1 year
Started at
26/10/2020

Budget
€665.663

%
Funding rate
67,19
(€465.964)

BEHYOND work flow: 1st phase

Market Analysis

Strategic Market Assessment → Identification and analysis of offshore wind-to-hydrogen concepts → Techno-economic assessment of the offshore wind-to-hydrogen concepts

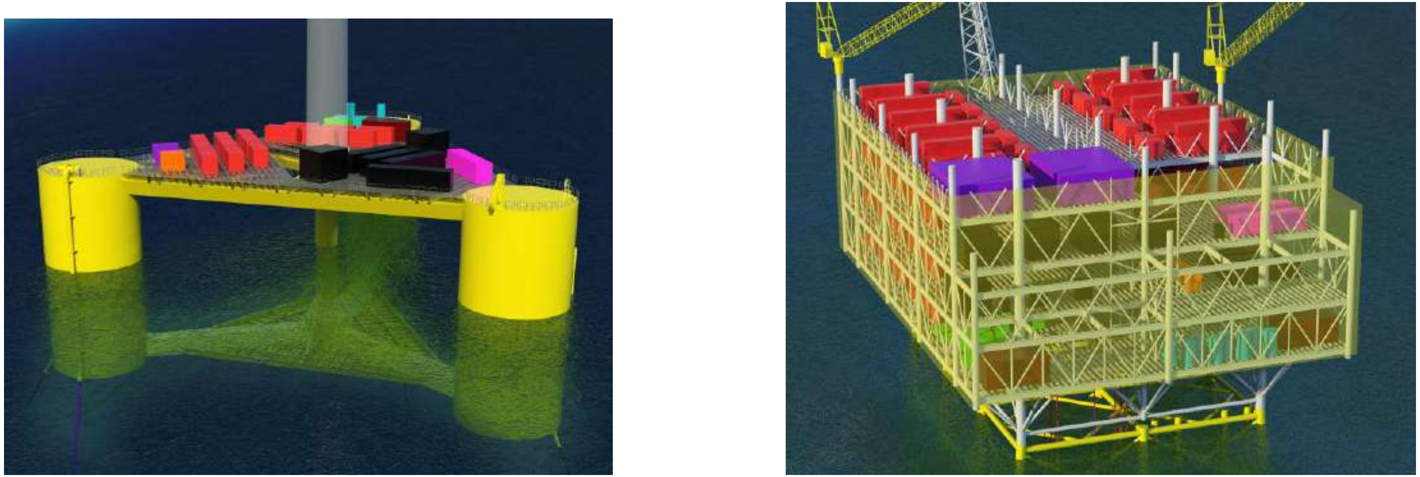
BEHYOND work flow: 2nd phase

Concept Engineering

System definition:
- Global system architecture
- Requirements identification
- Standards, guidelines, and materials

Hydrogen production module design:
- Definition of critical sub-systems
- Energy Management and advisory system definition

Infrastructure design:
- Bottom-fixed and Floating sub-structures design
- Offshore operations & economic impacts



BEHYOND work flow: 3rd phase

Commercialization Roadmap

- Industrial readiness assessment
- Risks identification and Management Strategy
- Bankable Hydrogen Business Model

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Operational Models, Business Cases and TEM

Filipe Arede - WavEC

Operador do programa: REPÚBLICA PORTUGUESA Política do Mar

Promotor: NEW by EDP & CTG

Parceiros: edp TechnipFMC CEiiA USN University of South-Eastern Norway WavEC

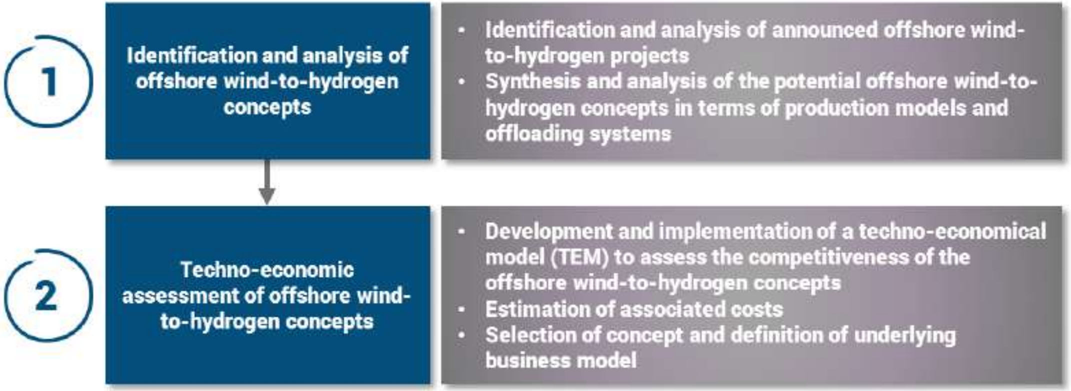
Projeto: BEHYOND

Operational Models and Business Cases

Research Questions.

- What is the underlying concept and business model of **today's offshore wind-powered hydrogen?**
- What are the **potential offshore wind-to-hydrogen concepts** that can be developed and deployed on a large-scale? What are the **associated constraints and benefits** (e.g. techno-economic, HSE, commercial readiness, social impacts and acceptance)?
- Is large-scale offshore production of hydrogen **economically viable** and what are the **key parameters to identify the viable concept(s)?**
- **What is the most viable/attractive concept(s) for producing hydrogen offshore?**

Methodology.



1 **Identification and analysis of offshore wind-to-hydrogen concepts**

- Identification and analysis of announced offshore wind-to-hydrogen projects
- Synthesis and analysis of the potential offshore wind-to-hydrogen concepts in terms of production models and offloading systems

2 **Techno-economic assessment of offshore wind-to-hydrogen concepts**

- Development and implementation of a techno-economical model (TEM) to assess the competitiveness of the offshore wind-to-hydrogen concepts
- Estimation of associated costs
- Selection of concept and definition of underlying business model

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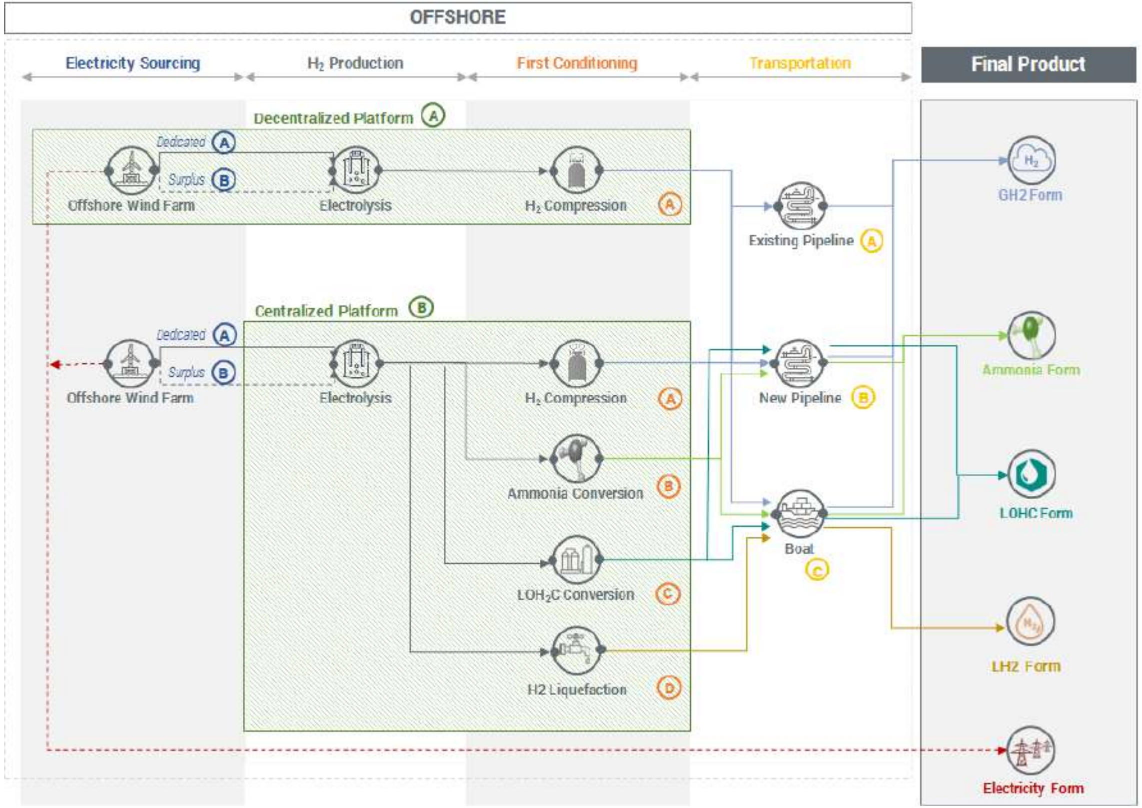
Operational Models and Business Cases

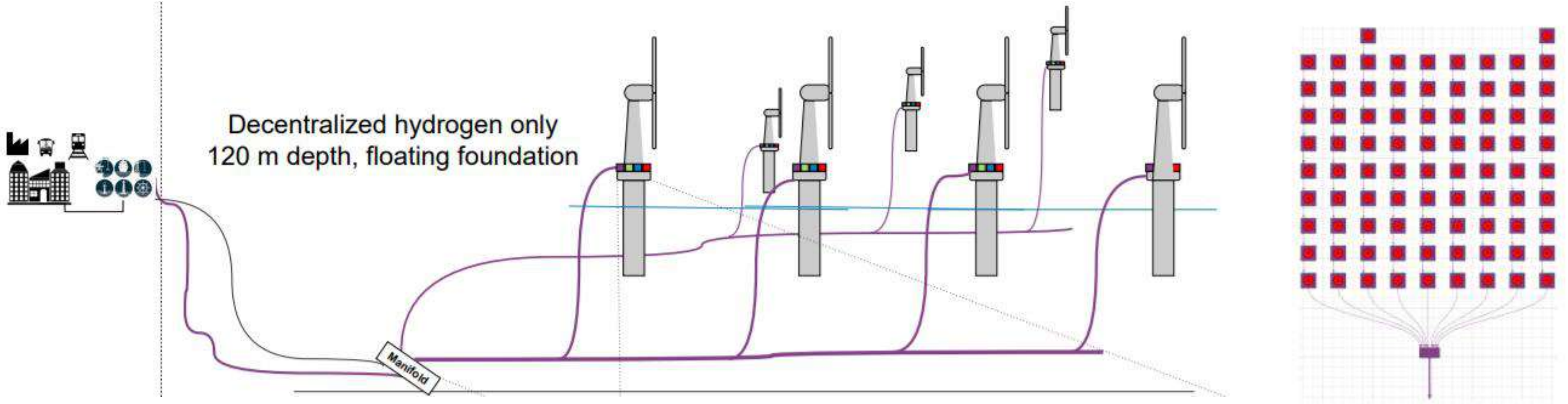


Research Questions.

- What is the most viable configuration for producing H2 offshore (technical, environmental, social, cost-competitive, etc.)?
- What is the cost of the H2 (EUR/kg) to be produced?

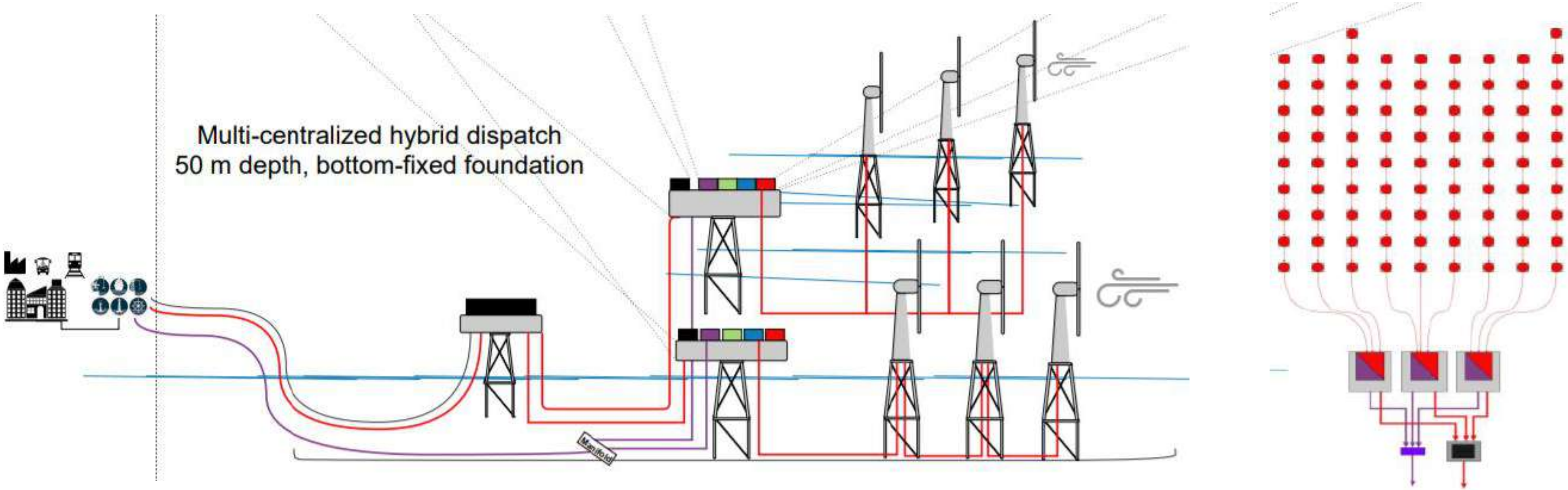
Offshore Wind-to-hydrogen concepts

Concept 1 – Decentralized Hydrogen only System



Offshore Wind-to-hydrogen concepts

Concept 2 – Multi-centralized Hybrid System



Techno Economic Model

INPUTS

- Site
- Wind Farm
- H2 platform
- Costs (CAPEX/OPEX)

PROCESSES

- Simulation of curtailment
- Modulation of power system
- Dispatching Strategies:

- H2 only
- Electricity only
- Hybrid dispatch based on H2 and electricity price ratio

OUTPUTS

- Combined revenue
- LCOE/LCOH/LCOHybrid
- NPV
- IRR

- **Market adjustable** (25-year hourly prices data)
- **Optimise hybrid system** (H2 only, electricity only or both) to maximise NPV/LCOH and hourly revenue
- **Automated modelling** (cable pipeline Requirements, HVDC/HVAC feedback, cable warning)
- **Optional system curtailment based on grid strength** (System Non-Synchronous Penetration Limit) and hourly market prices
- Assess the **economic viability of future system change**/repowering (new turbines /electrolysers)

Techno Economic Model - Results

Results

- As a function of wind farm rated power, NPV improved with increasing size from around 200MW to 1000MW capacity,
- Hybrid systems optimised through the solver saw the highest NPV
- hybrid systems that had equal electrolyser and wind farm capacity recording lowest NPV, due to under-utilization of electrolysers and electrical equipment such as cabling and grid connection costs.
- Increases from shore resulted in larger decreases in NPV for hybrid systems, with extra costs incurred for longer pipelines and export cables
- Pipeline costs per kilometer were lower than the cable costs, so hydrogen only systems with no export cables had smaller cost increases and were the most financially viable option at distances greater than 130km.
- For hybrid systems, NPV increases with higher electrolyser capacity up to around 60% of total wind farm size

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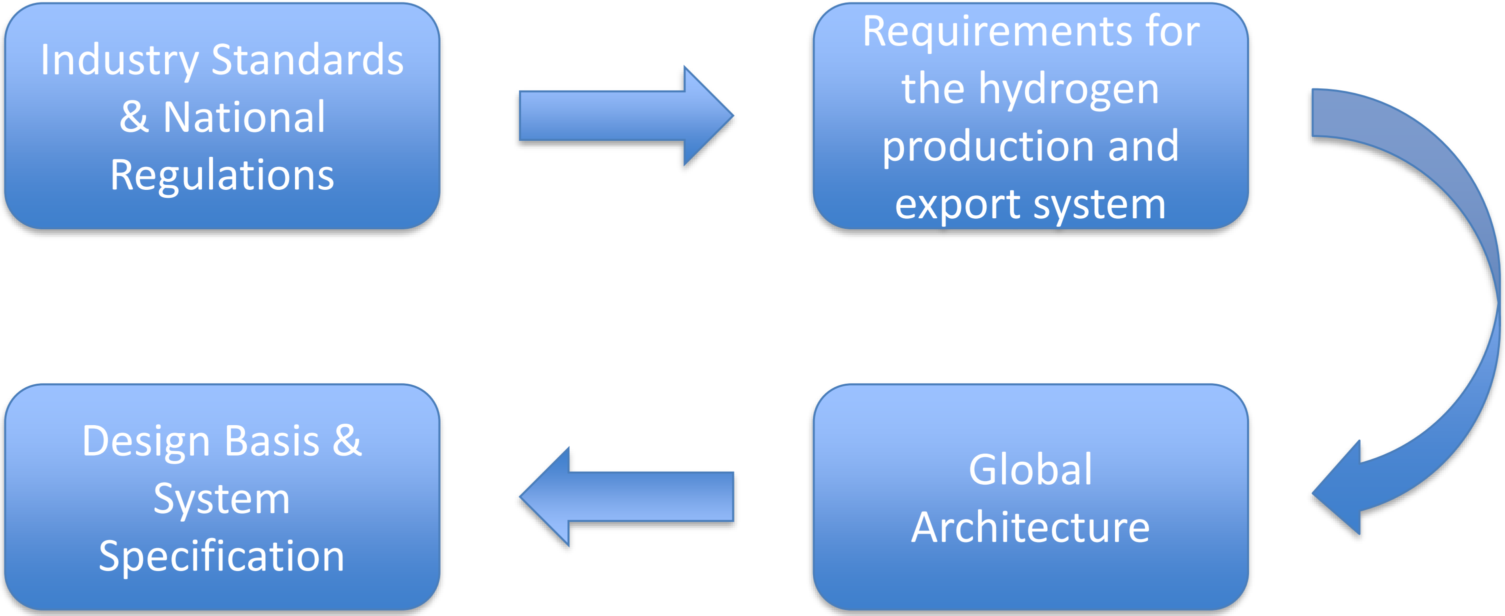
System Definition

Nuno Vaz - TechnipFMC

Operador do programa: República Portuguesa · Política do Mar
Promotor: NEW by EDP & CTG
Parceiros: edp · TechnipFMC · CEiiA · USN University of South-Eastern Norway · WavEC
Projeto: BEHYOND

System Definition Objectives



Industry Standards & National Regulations

Requirements for the hydrogen production and export system

Global Architecture

Design Basis & System Specification

Design Basis

The **Design Basis** guides the work performed in WP4 & WP5

DNV·GL

norsok
standard

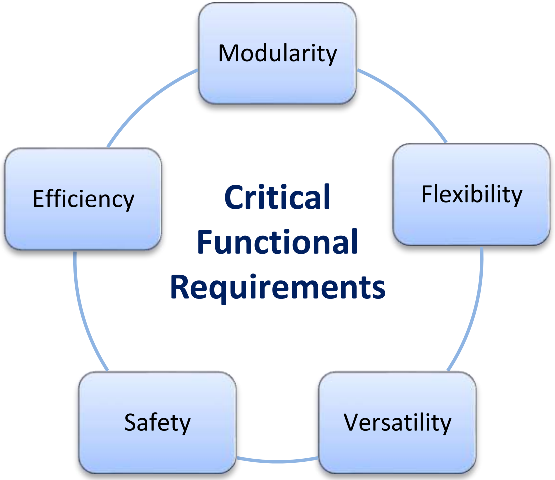
ISO
International
Organization for
Standardization

API
American
Petroleum
Institute

IEC®
International
Electrotechnical
Commission

cigré
INTERNATIONAL COUNCIL
ON LARGE ELECTRIC SYSTEMS

Design Basis



Critical Functional Requirements

Modularity

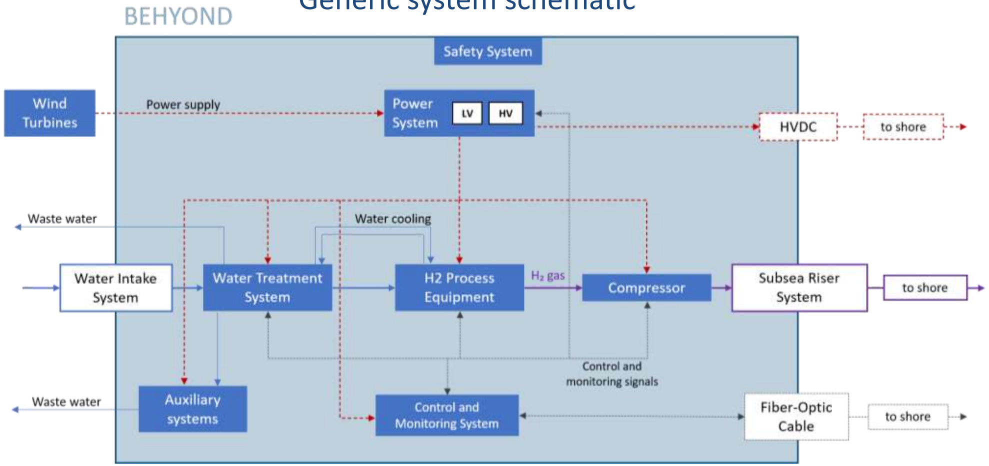
Flexibility

Versatility

Safety

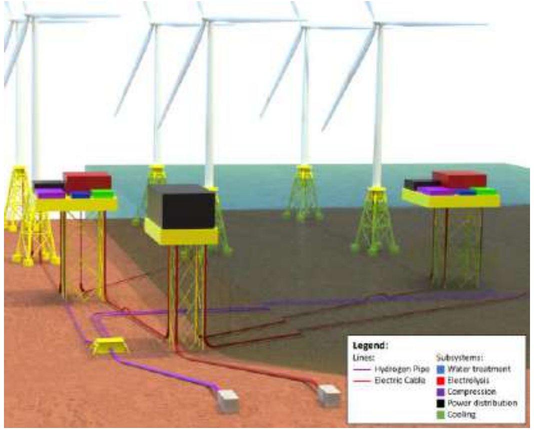
Efficiency

Generic system schematic



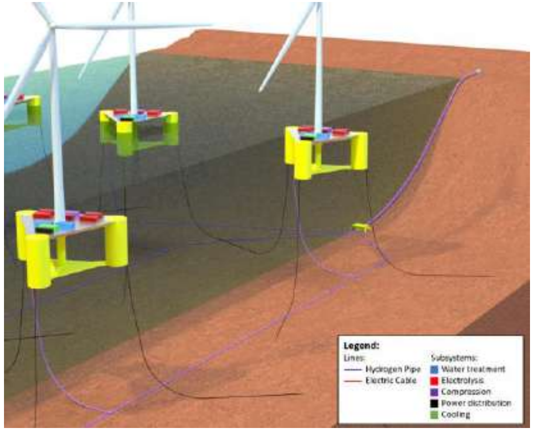
Design Basis

Multicentered system configuration



Parameter	Value	Per Hub
BEHYOND rated power	598 MW	200 MW
Electrical Export Capacity	94%	
Design pressure, H2 systems	300 bar 180 bar	
Electrolysers rating	600 MW	200 MW
Hydrogen production	10765 kg/hr	3588 kg/hr
Compressors input	239 MW	80 MW
Fresh water flow	96 ton/hr	32 ton/hr
Sea water input to reversed osmosis	240 ton/hr	80 ton/hr
Sea water treatment	400 kW	133 kW
Cooling system need	239 MW	80 MW

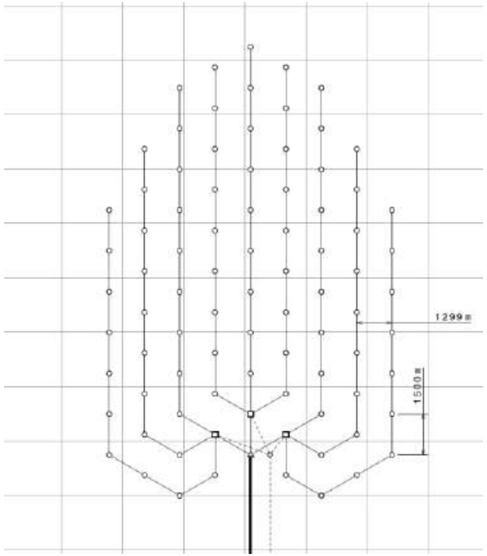
Decentralized system configuration



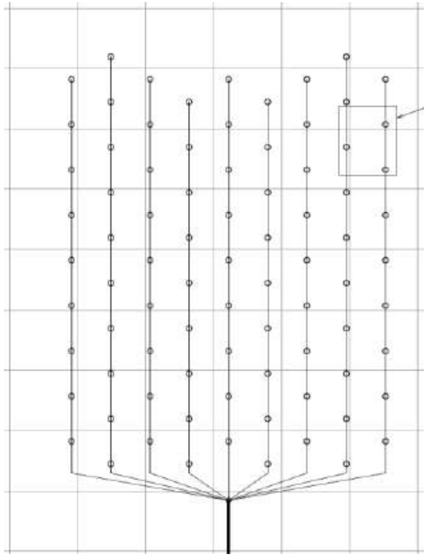
Parameter	Value	Per Turbine
BEHYOND rated power	876 MW	10.6 MW
Electrical Export Capacity	No electrical export	
Design pressure, H2 systems	300 bar 180 bar	
Electrolysers rating	10 MW	
Hydrogen production	15744 kg/hr	190 kg/hr
Compressors input	18.1 MW	0.2 MW
Fresh water flow	141 ton/hr	1.7 ton/hr
Sea water input to reversed osmosis	352 ton/hr	4.2 ton/hr
Sea water treatment	0.6 MW	7 kW
Cooling system need	350 MW	40.2 MW

Design Basis

Farm Layout
Multicentered
Architecture



Farm Layout
Decentralized
Architecture



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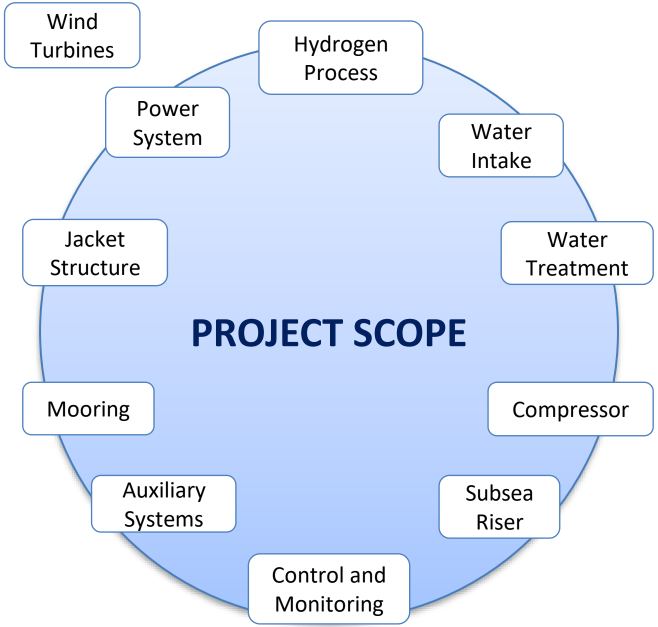
System Definition

Functional Requirements
- Safety
- Technical-economical optimization
- Optimal energy management
- System autonomy
- System availability and reliability

Design Requirements
- Environmental Conditions
- Structural Design
- Installation principles
- Piping Design
- Subsystem Requirements

Operational Principles
- Fabrication
- Packing, Storage and Preservation
- Transportation
- Validation

CRITICAL SUB-SYSTEMS



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Hydrogen Production Module Design

João Pedro Morais - CEiiA

Operador do programa: REPÚBLICA PORTUGUESA Política do Mar

Promotor: NEW by EDP & CTG

Parceiros: edp TechnipFMC CEiiA USN University of South-Eastern Norway WavEC

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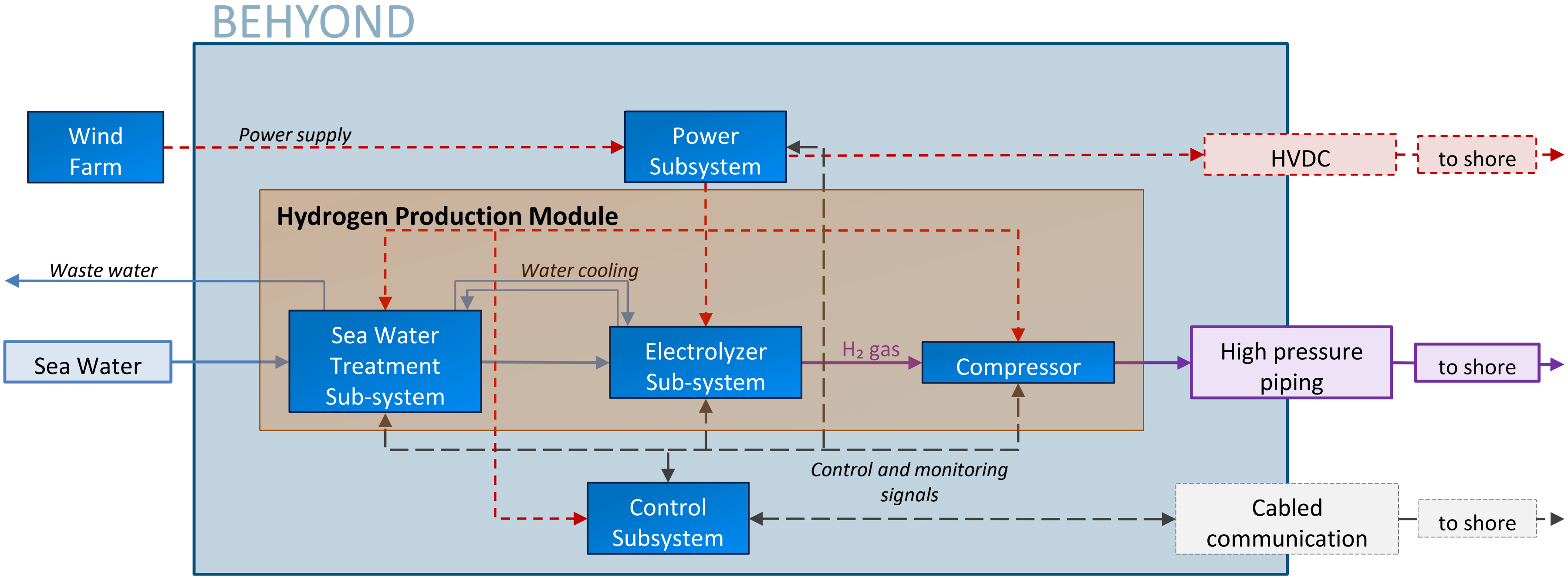
Hydrogen Production Module Design



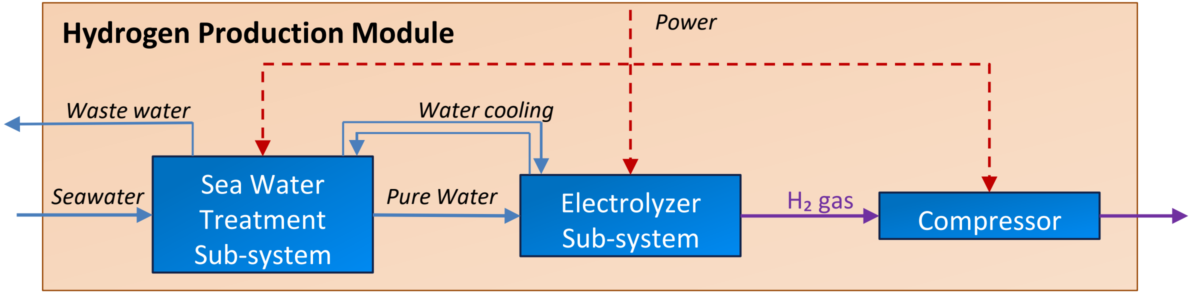
High Level PFD of BEHYOND

Hydrogen Production Module Design

Main Sub-systems

Critical subsystems studied:

- **Sea Water Treatment** Sub-system;
- **Electrolyzer** Sub-system;
- **Compressor** Sub-system.



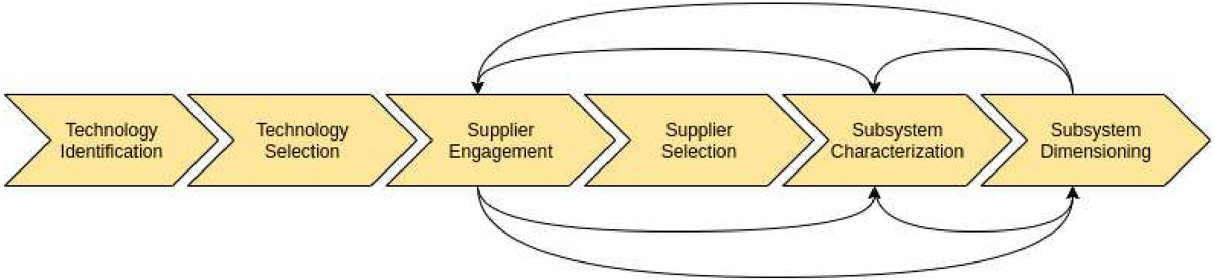
Hydrogen Production Module

Hydrogen Production Module Design

Approach

Approach to develop the relevant sub-systems:

1. Relevant technologies **identification** and study;
2. Technology **selection**;
3. Supplier **engagement**;
4. Supplier **selection;**
5. Sub-system **characterization** (based on supplier info);
6. Sub-system **dimensioning** (based on supplier info).



Sub-system Design Approach

Hydrogen Production Module Design

Operational Philosophy Elements

- **Modes of Operation:** related the BEHYOND state machine. Autonomous operation;
- **Efficiency:** optimizing production vs. lifetime;
- **Maintenance:** minimizing maintenance needs and maximizing equipment lifetime. Remote supervision;
- **Reliability:** feedbacks into redundancy and degradation mechanisms;
- **Availability:** aims at continuous, uninterrupted operation and feedbacks into redundancy and degradation mechanisms.

Operational Philosophy Elements

Hydrogen Production Module Design

Water Treatment Subsystem

Brief characterization:

- **Function:** treating sea water to obtain high purity water for electrolyzer operation;
- **Technology:** Seawater Reverse Osmosis (SWRO) and Electro De-Ionization (EDI);
- **Technological Maturity:** high;
- **Application Scenario Maturity:** medium;
- **Challenges:** autonomous operation/supervision, marine environment, maintenance and reliability.

SWRO Equipment (Courtesy of Pure Aqua)

Hydrogen Production Module Design

Electrolyzer Subsystem

Brief characterization:

- **Function:** converting high purity water into high purity H2 gas;
- **Technology:** Proton Exchange Membrane (PEM);
- **Technological Maturity:** medium;
- **Application Scenario Maturity:** low;
- **Challenges:** autonomous operation/supervision, optimal operation, marine environment, maintenance, availability and reliability.

PEM Electrolyzer (Courtesy of H-TEC)

Hydrogen Production Module Design

Compressor Subsystem

Brief characterization:

- **Function:** boosting low pressure H2 gas to high pressure gas for pipeline transportation;
- **Technology:** Reciprocating Piston or Diaphragm;
- **Technological Maturity:** high;
- **Application Scenario Maturity:** high;
- **Challenges:** autonomous operation/supervision, optimal operation, maintenance, availability and reliability.

Diaphragm Compressor (Courtesy of PDC Machines)

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Infrastructure Designs

André Gonçalves - CEiiA

Operador do programa:
República Portuguesa
Política do Mar

Promotor:
NEW by EDP & CTG

Parceiros:
edp TechnipFMC CEiiA USN University of South-Eastern Norway WavEC

Projeto:
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Infrastructure Design

Main Systems

- **Critical systems studied:**
  - **Structures** (including bottom fixed and floating platforms);
  - **Mooring;**
  - **Cabling and Piping** (Rigid and Flexible).

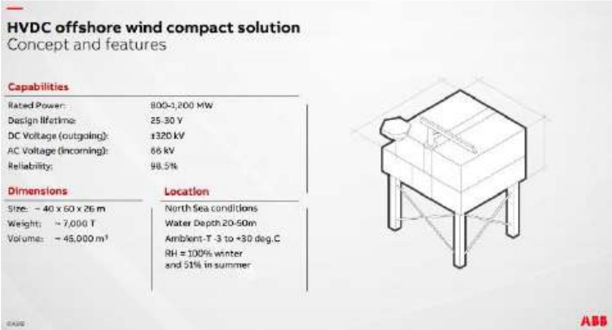
Infrastructure Design

References

large offshore O&G installation

Johan Sverdrup, The North-Sea Giant

- **4 platforms;**
- **Single lift installation** (lower costs and higher safety);
- **Topsides around 20.000t each;**
- **Jackets around 10.000t each.**



HVDC offshore wind compact solution
Concept and features

Capabilities

Rated Power:	800-1,200 MW
Design lifetime:	25-30 Y
DC Voltage (outgoing):	±320 kV
AC Voltage (incoming):	66 kV
Reliability:	98.5%

Dimensions

Size: ~ 40 x 60 x 26 m
Weight: ~ 7,000 T
Volume: ~ 45,000 m^3

Location

North Sea conditions
Water Depth 20-50m
Ambient-T -3 to +30 deg.C
RH = 100% winter
and 51% in summer

©ABB

ABB

large offshore HVDC station

HVDC Offshore Wind Station by ABB

- **Compact solution consistent with industry trend;**
- **Rated power and location compatible with study case.**

Infrastructure Design

References

reference wind turbine generator

GE Heliade-X 12MW

- Power rating consistent with industry trend;
- 713t Nacele & Hub;
- 55t Blades;
- 800t tower.

Infrastructure Design

References

floating offshore wind

Umaine VolturnUS-S Reference Platform

- 15MW power rating consistent with industry trend, but over design rating;
- Triple column semi-submersibles are one of the leading typologies in floating wind;
- Typical three-line chain catenary;
- 17.839t floating platform;
- 2.254t WTG.

floating offshore wind

WindFloat 8.4MW

- With high TRL, and larger projects being announced, the WindFloat is one of the leading technologies in floating wind;
- Cheap and safe installation;
- Compatible with project need for a production deck structure;
- Floating platform around 10.000t (most of the weight is the water ballast);
- WTG around 1.000t.

Infrastructure Design

Platforms Layout

Estimation of platforms footprint:

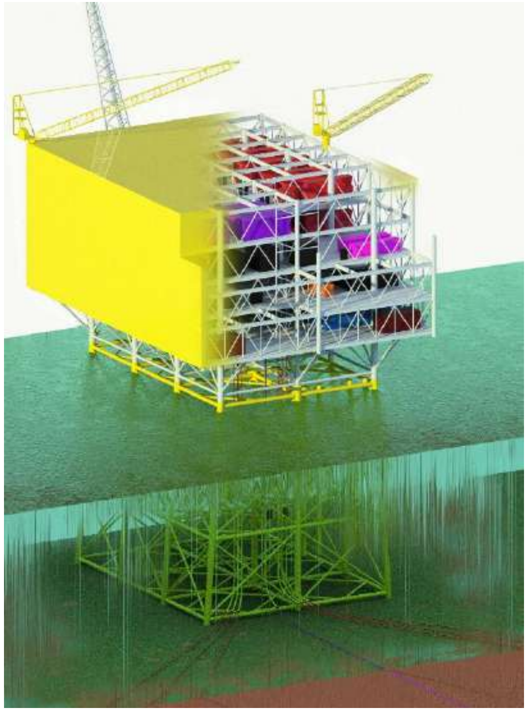
- **Assessment of primary and auxiliary equipment** (including fire system, winches and cranes)**;**
- **Evaluation of hydrogen safety requirements;**
- **Layout arrangement of equipment and interfaces.**

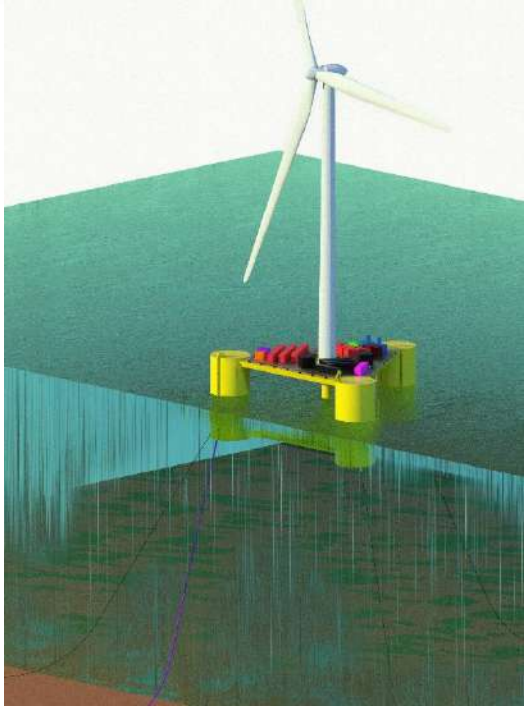
Infrastructure Design

Subsea Infrastructure

Approach to study the wind farm:

- Sensitivity analysis of wind farm arrangement;
- Structure type selection;
- Piping system:
  - Piping over-dimensioned to provide H2 storage
  - T-Junctions and Underwater Manifold
  - Dynamic analysis of floating platform umbilical
- Cabling definition.





Infrastructure Design

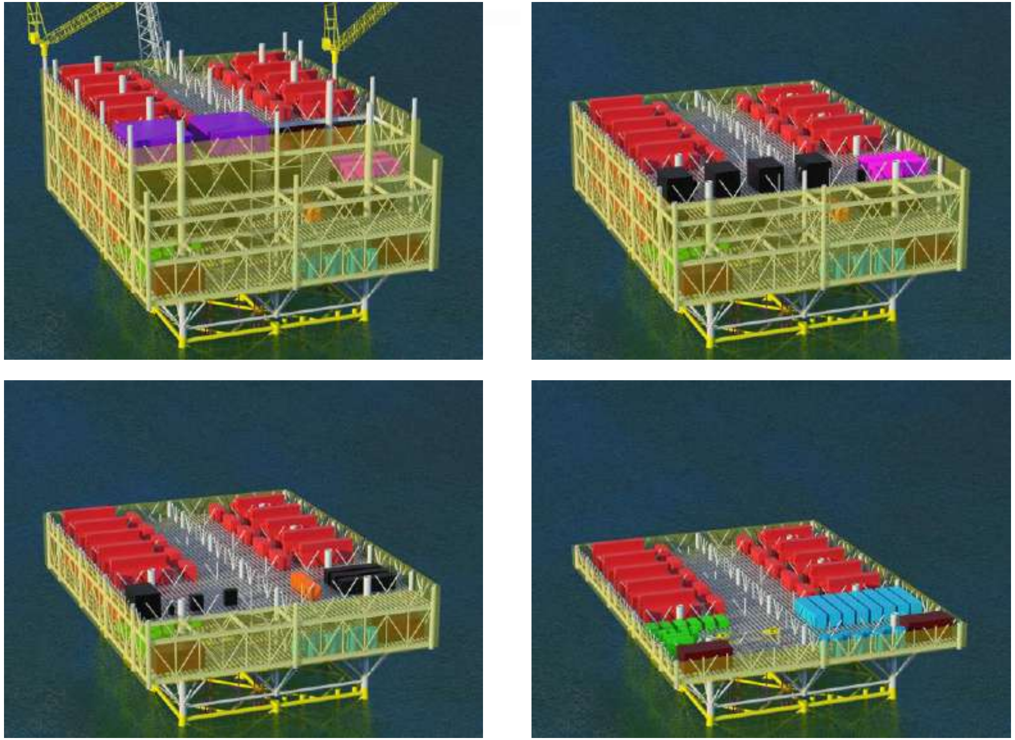
Multicentered Architecture

- Multicentered architecture study approach:
  - Estimation of platform size and weight;
  - Cost assessment.

Infrastructure Design

Multicentered Architecture

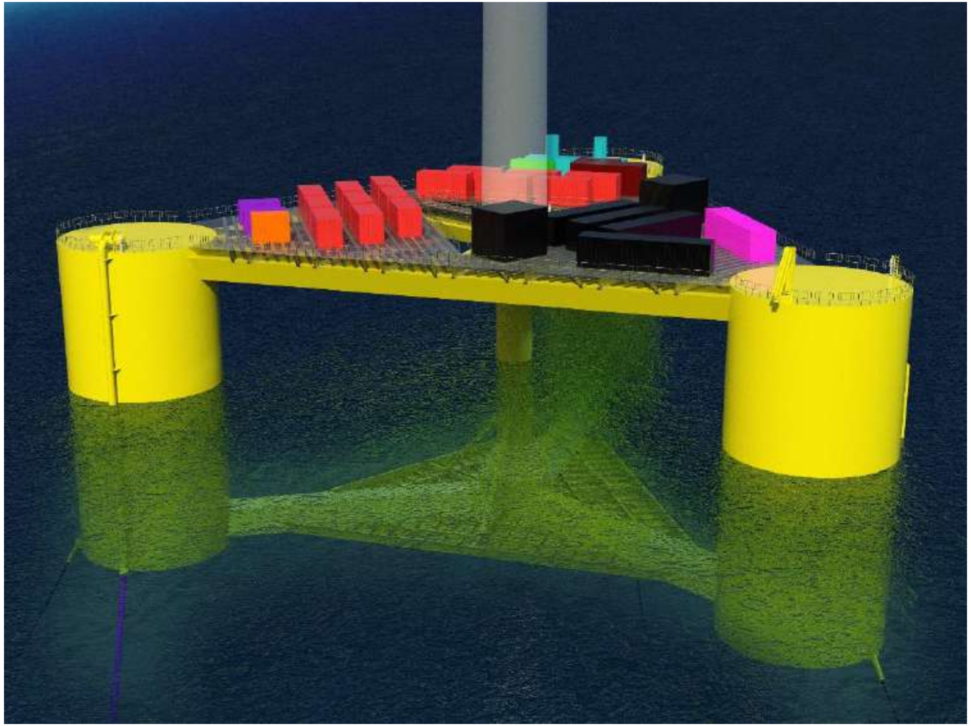
- Multicentered architecture study approach:
  - Estimation of platform size and weight;
  - Cost assessment.



Infrastructure Design

Decentralized Architecture

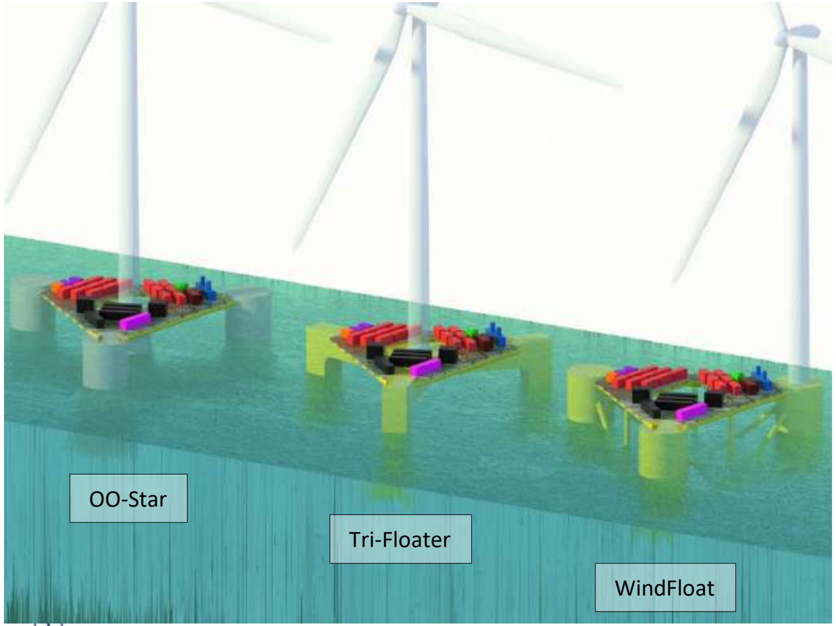
- Decentralized architecture study approach:
  - Estimation of dimensions and weight for a custom platform;
  - Preliminary design of process deck;
  - Design of mooring system;
  - Dynamic analyses;
  - Cost assessment.

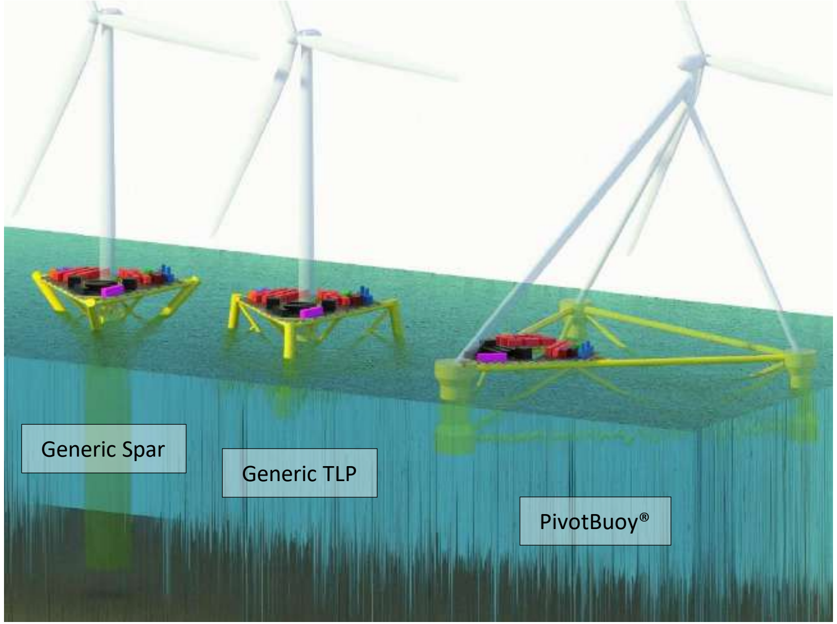


Infrastructure Design

Decentralized Architecture

An agnostic solution was designed to fit most floating platform concepts:





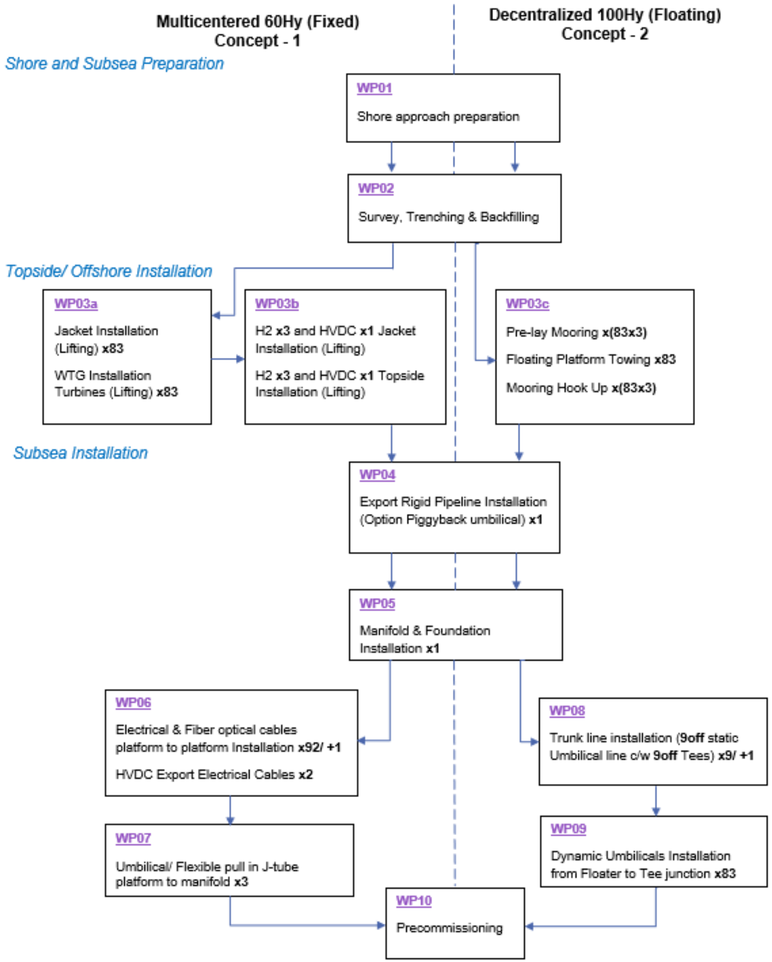
Offshore Installation

François Letournel – Luso TechnipFMC

Offshore Installation

Flowchart

Breakdown of marine operation activities for planning & cost assessment



Multicentered 60Hy (Fixed)
Concept - 1

Decentralized 100Hy (Floating)
Concept - 2

Shore and Subsea Preparation

WP01
Shore approach preparation

WP02
Survey, Trenching & Backfilling

Topside/ Offshore Installation

WP03a
Jacket Installation (Lifting) **x83**
WTG Installation Turbines (Lifting) **x83**

WP03b
H2 **x3** and HVDC **x1** Jacket Installation (Lifting)
H2 **x3** and HVDC **x1** Topside Installation (Lifting)

WP03c
Pre-lay Mooring **x(83x3)**
Floating Platform Towing **x83**
Mooring Hook Up **x(83x3)**

Subsea Installation

WP04
Export Rigid Pipeline Installation (Option Piggyback umbilical) **x1**

WP05
Manifold & Foundation Installation **x1**

WP06
Electrical & Fiber optical cables platform to platform Installation **x92/ +1**
HVDC Export Electrical Cables **x2**

WP07
Umbilical/ Flexible pull in J-tube platform to manifold **x3**

WP08
Trunk line installation (**9off** static Umbilical line c/w **9off** Tees) **x9/ +1**

WP09
Dynamic Umbilicals Installation from Floater to Tee junction **x83**

WP10
Precommissioning

Offshore Installation Feasibility

Multicentered 60Hy and Decentralized 100Hy

Immaturity/innovation needed on Hydrogen production for offshore operations

- Overall offshore installation plan is not pioneer since most of BEHYOND asset/equipments have been installed on various Oil & Gas and Offshore Wind projects
- Detailed engineering analysis will be required for specific hydrogen design (Rigid Pipeline, Umbilicals, Flexible)
- Requires further assessment for precommissioning requirements for hydrogen subsea pipelines
- Potential upgrade of Contractors Vessels to optimise installation (ex. large 12MW WTG, increase number jacket per trip,..)

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H2 Maintenance and Repair System Definition

Francisco Fonseca - WavEC

Operador do programa:
República Portuguesa
Política do Mar

Promotor:
NEW by EDP & CTG

Parceiros:
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H2 Maintenance and Repair System Definition

O&M COMPATIBILITY	▪ The high maintenance frequency of the H2 subsystem is compatible with the observed large number of monthly visits per turbine in a typical offshore wind farm ▪ The H2 production subsystem may significantly increase the total preventive maintenance hours for the decentralized configurations - when compared to the reference offshore wind
O&M IMPROVEMENT	▪ Water treatment units and the membrane compressors are major contributors to the total annual farm maintenance effort ▪ Developing technological solutions to achieve a minimum 6-months maintenance periodicity for the water treatment unit and membrane compressors should be prioritized

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Commercialization Roadmap

Alex Coronati – EDP NEW

Commercialization Roadmap

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Commercialization Roadmap

The bankability and industrialization of a technology depend not only on the correct identification and assessment of the associated risks in terms of manageability, severity, and probability but also on the reliability of the risk mitigation measures to implement.

OBJECTIVES

- **Assess the industrial readiness level** across the supply chain.
- **Implement a risk management strategy** able to identify, quantify and mitigate the risks inherent to all the development phases.
- **Identify innovation needs** and future developments and link them to fund raising opportunities whenever possible.
- **Develop the Bankable Hydrogen Business Model.** A bankability study will be performed to identify the targeted investors, explore risk dilution strategies and propose financing mechanisms to support future larger-scale implementation of this technology.

Industrial readiness level assessment

Since all the technologies included in BEHYOND are commercially available, qualification has been based on an assessment of previous use and suitability for offshore application.

System	Sub-systems / Equipment	TRL
Wind turbines, offshore		9
Subsea cables, HV		9
Power systems, High and low voltage	Transformers, converters, switchgear etc.	7
	Li-ion battery energy storage	7
Process systems	Water treatment system	5
	De-ionization system	5
	H2 PEM Electrolyzers	5
	Compressors	5
	H2 pressure vessels- topside	7

System	Sub-systems / Equipment	TRL
Control Systems	Process control system	5
	Advisory control system	5
	Safety system	5
Auxiliary Systems	HVAC system	7
	N2 purging system	7

TRL 5 – technology validated in relevant environment
TRL 6 – technology demonstrated in relevant environment
TRL 7 – system prototype demonstration in operational env.
TRL 8 – system complete and qualified
TRL 9 – actual system proven in operational environment

Risks assessment and management strategy

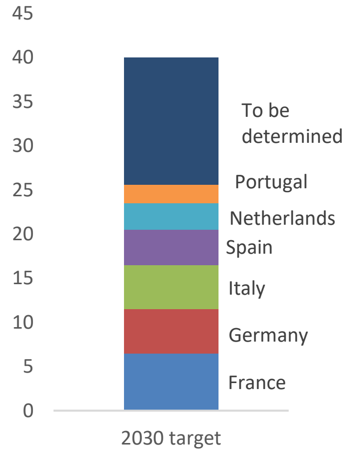
Category	Main Risks	Cause	Effect	Mitigation Measures
Development Engineering Fabrication	Requirements unfulfilled (regulatory)	Lack of regulatory maturity	Lack of certification; Non-conformity	Surveys; compliance with certification guidelines; partnering with certification bodies; one-stop shops
	Marine environment impact	Impact underestimated	Operational problems; Shutdowns;	Accurate structural analysis and validation; eliminate conceptual and development shortcomings; avoid fast prototype construction; thorough system validation prior to full-scale installation
	Lengthy/Complex qualification process	Technology immaturity	Non-conformity	Technology validation prior to deployment; exhaustive bench-testing of individual components and sub-systems; where possible resort to off-the-shelf components/equipment
Installation	Riser Hydrogen Umbilical (pull-in)	Quick changes in Metocean conditions; Faulty lock system		Operational window must be evaluated upfront. Real Time monitoring systems can be deployed to aid safer installation. Lock system shall be designed in a way that allows testing of the locking condition. Eventually water pressure testing shall be applicable.
Operation & Maintenance	Absence of qualified personnel	Low maturity of the sector	Cost increase Longer time to execute	Recruit expert personnel from outside local area or from other suitable industries (O&G), rigorous training.
De-commissioning	Inexistent subsea Hydrogen valve	valve failure	Leak, explosion, hazard for marine life / users	Ensure valves pass strict qualification tests (hyperbaric, endurance, pressure and temperature).

Bankable Hydrogen Business Model:

Market outlook

EU's strategic objective is to install >40GW renewable electrolysers by 2030

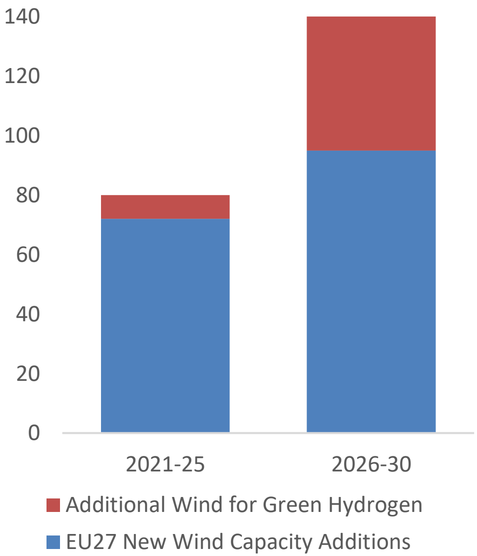
Committed hydrogen capacity by EU state, GW



Source: EU Hydrogen Strategy (2020)

Which would result in >60GW additional wind installed

GW cumulative new installed wind capacity forecast 2021-30, GW



Source: Bloomberg New Energy Finance

With huge implications on the required investment in renewables

- The EU hydrogen objectives hugely benefits renewables with c. **2/3 of the required investment likely to be in renewable electricity production**
- EU assumes **80-120GW of renewables capacity** will be required **to meet green hydrogen targets** (depending on mix of electricity generation technologies)
- The leading technology varies by region:
  - Wind(on/offshore): Northern Europe incl. France, Germany, Netherlands
  - Solar: Southern Europe incl. Italy, Spain, Portugal
- Whilst solar has a lower LCOE/H **a hybrid system will be advantageous to the grid in balancing and storing energy**

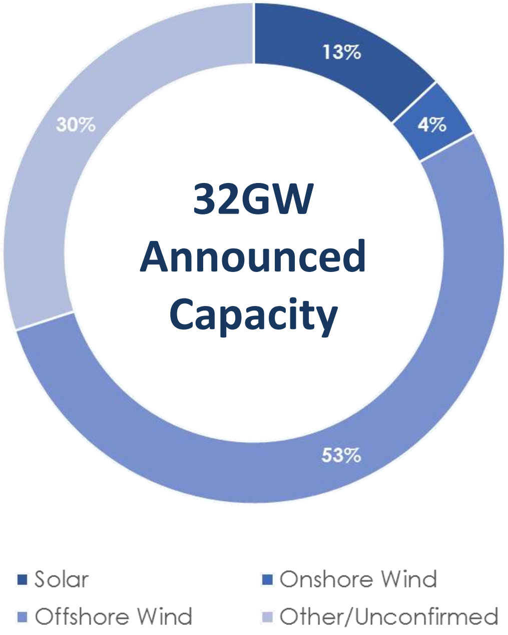
Bankable Hydrogen Business Model:

Offshore wind prevalent among the generation options for green hydrogen

Confirmed green hydrogen projects span the dominant renewable generation options.

- **Offshore wind is the dominant proportion of confirmed green hydrogen projects**.
- **The** size of the potential resource and **location of leading research countries (Northern Europe) is driving this trend**.
- While market forecasts place **PV supplied green hydrogen** at the lower end of the LCOH spectrum, these options are **constrained by**:
  1. **Poor solar resource in the countries leading** green hydrogen development.
  2. The **absence of a centralized market** for green hydrogen to allow trading.
  3. A **lack of transport/transmission infrastructure to allow regions with better solar resource to export**.

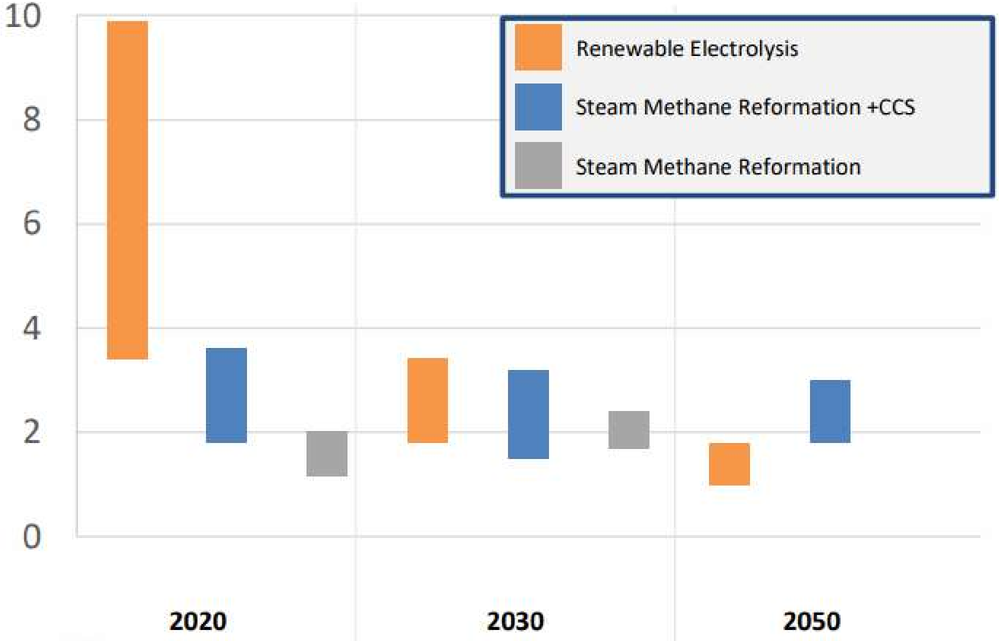
Green Hydrogen Project Pipeline



Bankable Hydrogen Business Model:

Costs of green Hydrogen are excepted to fall dramatically displacing grey and blue out of the market.

Forecasted Levelized Cost of Hydrogen by production method, $/kg



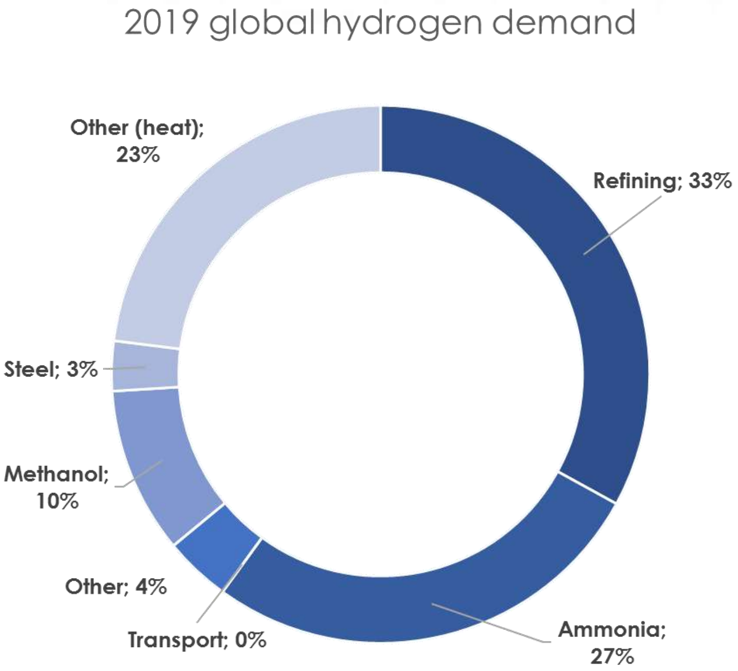
- **Grey hydrogen is currently the cheapest** production method, however carbon tax (direct or indirect) will add additional costs
- Costs of green hydrogen have a **wide range** due to projects being deployed at a demonstration scale and renewable electricity costs varying by market
- The development and widespread use of **Chinese electrolysers** (estimated c.80% lower cost) will drive green hydrogen costs down
- Blue hydrogen is expected to be cheaper than green in the medium term but announced projects and R&D appears limited and still has CO2 emissions in upstream extraction
- Economics and regulation are expected to drive grey hydrogen out **of the market by 2050**

Numbers Real 2020; Source: Team analysis of industry reports and forecasts

Bankable Hydrogen Business Model:

BEHYOND Financial gaps as today

- Current associated LCOH, is **uneconomic versus conventional production**.
- Consequently, highly **unlikely to see widespread demand** if produced today.
- We need to consider **discrete sources of demand that has self-interes**t in making an offtake agreement **for green hydrogen**.
- Without this certainty of cashflow, the economics of even pilot projects are difficult to reconcile with any commercial forms of financing.
- The **alternative is government incentives, or regulatory requirements to purchase carbon-neutral hydrogen for industry**.



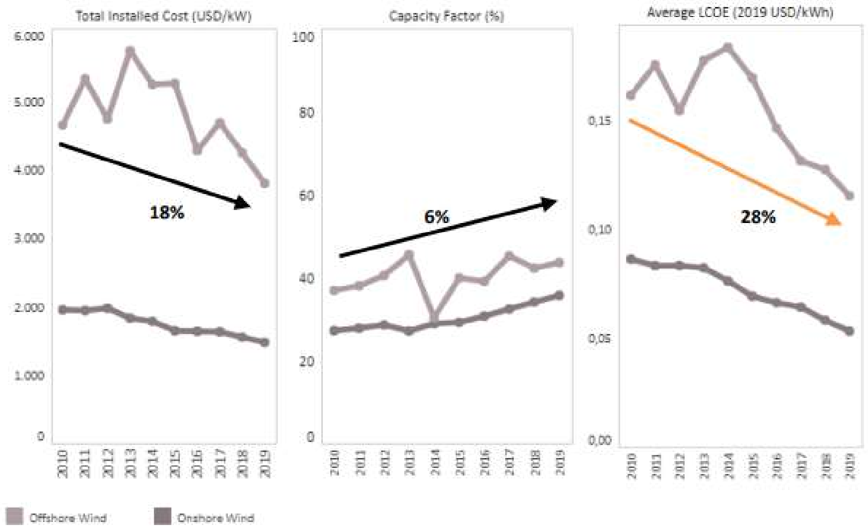
Bankable Hydrogen Business Model:

IRENA’s stages of policy support

	Technology Readiness ❶	Market Penetration ❷	Market Growth ❸
State of Market	• Use in demonstration projects only. • Limited infrastructure development. • Largest barrier to greater use is cost. • Government remains a significant player.	• Some applications operational. • Proof points of cost & operability. • Learning-by-doing reduces opex & capex. • Synergies (e.g. industrial clusters) are tested.	• Green hydrogen is well-known and widely used energy carrier. • Competitive on supply side and in end uses. • Direct incentives no longer needed.
Actions required	• Long-term climate policy commitments, net zero. • Short-term policy to close the gap between investment & operational cost. • R&D funding, co-funding of prototypes. • Demonstration projects lower cost of capital.	• Industrial users need to drive repurposing of gas infrastructure to provide distribution mechanisms. • Global markets begin to develop. • Displacement of electricity generation is managed.	• Gas infrastructure is entirely repurposed. • Demand infrastructure away from industrial uses is developed. • New sources of demand continue to develop.

Bankable Hydrogen Business Model:

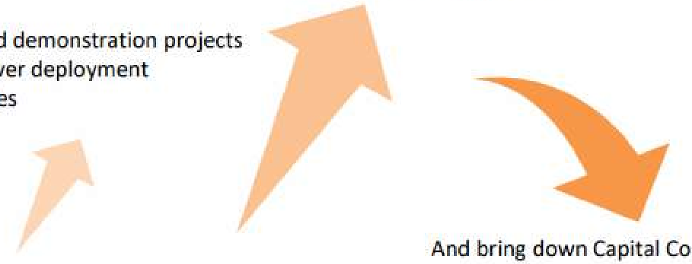
Phased deployment allows for harnessing cost reductions and load factors increases untimely benefiting LCOEs



Source: IRENA (2020)

LCOH based on deployment of 880 MWe and offshore farm with 1 GW capacity equals **€3.84 per kg of H2 (dedicated H2 production)**

Potential to bring this down if taking advantage of technological improvements and cost reduction



Pilot and demonstration projects with lower deployment capacities

Provide the Know-how and experience to scale up operations

And bring down Capital Costs

Critical to support Market Growth

Thank you

Working together for a green competitive and inclusive Europe!

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Operador do programa:
REPÚBLICA PORTUGUESA
Política do Mar

Promotor:
NEW by EDP & CTG

Parceiros:
edp TechnipFMC CEiiA USN University of South-Eastern Norway WavEC

Projeto:
BEHYOND