Marine Renewable Energy Testbed

1. Introduction

The global transition to sustainable energy is intrinsically linked with the Blue Economy — the sustainable use of ocean resources for economic growth, improved livelihoods, and marine ecosystem health. Central to this transition is the development and deployment of Marine Renewable Energy (MRE) technologies. Through the MED-Hubs project, co-financed by the European Union, we are establishing a new MRE Testbed in Spain hosted by the Universidad Politécnica de Cartagena (UPCT) and supported by the Centro Tecnológico Naval y del Mar (CTN), the Región de Murcia, and the Federación de Municipios de la Región de Murcia (FMRM).

The Marine Renewable Energy Testbed, centered on the specialized floating platform, is critically important for small and medium-sized enterprises (SMEs) and startups in the marine energy sector. It acts as an essential bridge, guiding innovative concepts from the drawing board to commercial viability, directly addressing the formidable challenges inherent in ocean technology development.

The testbed significantly lowers the cost and risk of technology development, which is typically prohibitive for early-stage companies:

- Technology Validation (TRLs): Startups face high barriers in moving beyond laboratory testing (TRL 4) to real-world demonstration (TRL 5-7). The floating platform provides a pre-permitted, instrumented site for Prototype Testing at mid-to-high TRLs (NON-MESS and REA-MESS stages). This includes:
    - Structural Validation and Durability Assessment in harsh marine conditions.
    - Energy Performance Testing under real-world currents and waves.
- Proof-of-Concept for Investors: By providing independent, verifiable data on energy output, efficiency, and survivability, the platform enables real-world demonstrations that attract private capital and secure funding. This de-risks the investment environment, making the startup more bankable.
- Shared Infrastructure: Startups can access expensive assets like the Acoustic Doppler Current Profiler (ADCP) and the Multi-Source Energy Generation system without the massive upfront capital investment, making R&D more affordable and efficient.

1.1 The testbed

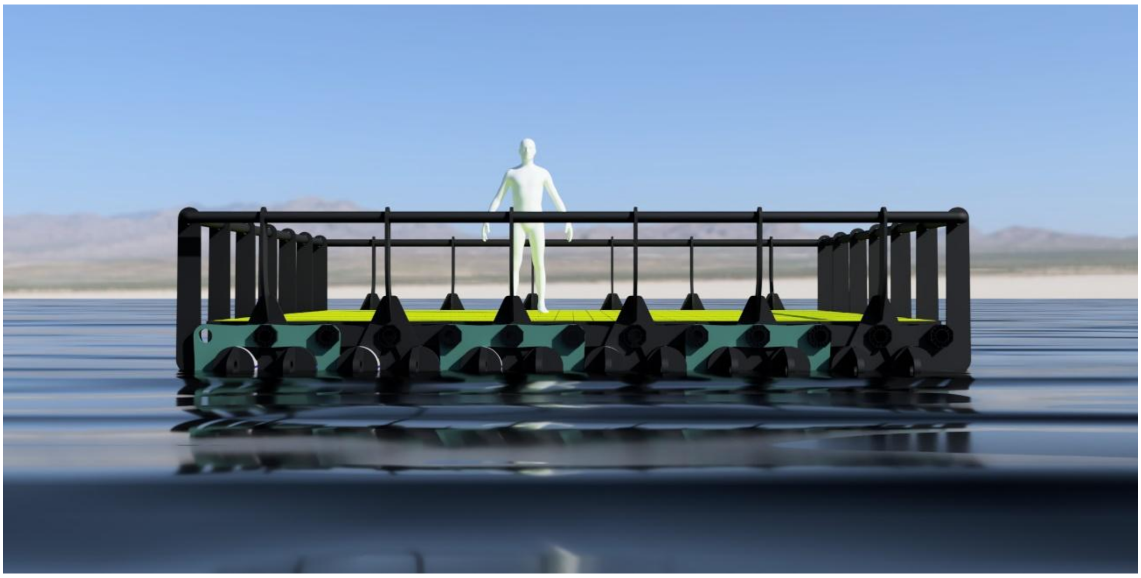
The proposed floating platform is conceived as a strategic component within the broader framework of the Marine Energy Hub, supporting the development, testing, and validation of small-scale marine renewable energy devices intended for use in harbors and by vessels. Its purpose aligns with the project's objectives of fostering innovation, technology validation, digitalization, and the long-term strengthening of testbeds that enable the progression of solutions “from the idea to the real world”.

By integrating measurement equipment, autonomous generation systems, and dedicated installation spaces, the platform contributes to addressing several identified needs within the sector, including the lack of adequate testing environments, the difficulty of obtaining proof-of-concept evidence for investors, and the barriers to market entry faced by innovation providers.

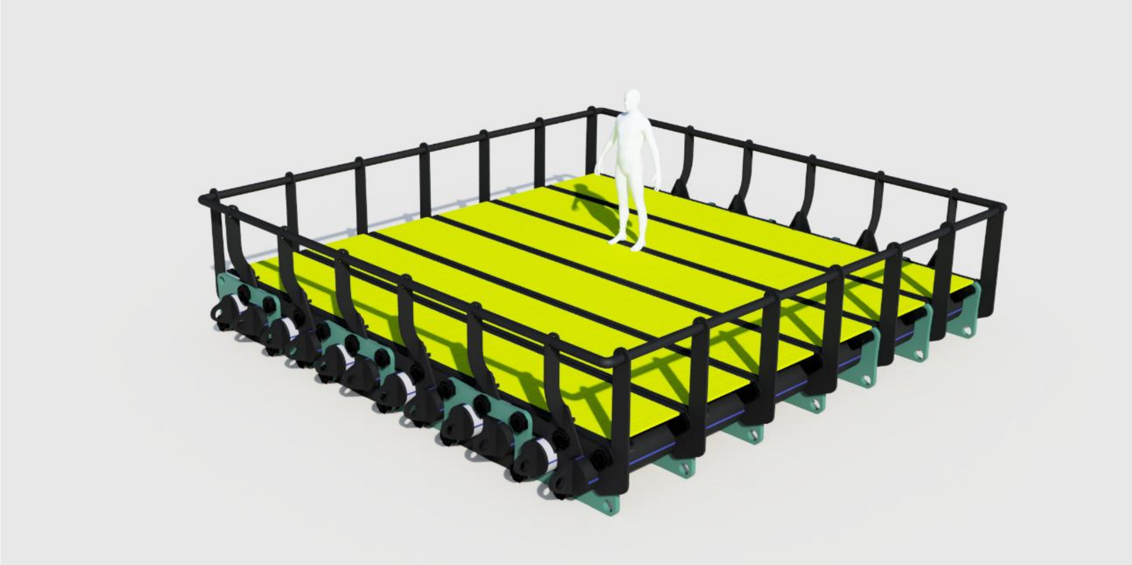
Within this context, the platform acts as an operational asset that supports controlled prototype evaluation, real-world deployment, and collaboration with academic, industrial, and governmental partners, reinforcing the sustainability and functionality of the regional innovation ecosystem.

The floating renewable energy platform offers a broad spectrum of technological, operational, educational, and commercial opportunities. Beyond being a self-sustaining hybrid energy system, it serves as a critical testbed for marine energy innovation, an accelerator for regional blue economy development, and a key tool for the ecological transition of port environments.

Draft of the platform at 1st iteration



Prototype courtesy of e- Tepsa



Prototype courtesy of e- Tepsa

The Marine Energy Hub Testbed will be physically located at the Port of Cartagena, one of the most strategically significant ports on the western Mediterranean coast. Cartagena's port offers exceptional accessibility — with deep-draft capacity, well-established maritime infrastructure, and direct connectivity to international shipping routes — making it an ideal environment for deploying, testing, and demonstrating marine renewable energy technologies under real operational conditions. Its central location within the Region of Murcia also ensures easy access for startups, researchers, and institutional partners from across the Mediterranean basin.

1.2 The laboratory

Our laboratory features the GUNT HM 162 experimental flume (cross-section 309 × 450 mm and length of 12.5 m) with a closed water circuit and a glass-walled test section that offers optical access for quantitative imaging. The inlet is shaped to deliver a low-turbulence approach flow, enabling studies from gradually varied flow to wave–structure interaction. All wetted parts are corrosion-resistant.

The HM 162 provides a self-contained tank–pump–flume–return loop so discharge can be set and repeated without external supply. The closed loop minimizes head losses and spillage and supports steady, uniform flow conditions for hydraulics experiments (controls, weirs, gates, drag around bodies). The closed water circuit specification and extendibility are defined in the HM 162 documentation.

For bed-load transport, the channel integrates a closed sediment circuit (HM 162.71), a sediment trap (HM 162.72), a sediment feed (HM 162.73), and the water pump-return line to recirculate the mixture between runs. Importantly, the sediment circuit is independent of the water circuit, preventing particles from entering the water-loop pump/flow meter. The HM 162.72 sediment trap provides a simpler arrangement (trap with manual return), and the HM 162.73 sediment feed uses a vibratory conveyor to deliver sand of 1–2 mm into the test section at controlled rates. Together, these modules allow experiments on bed-load transport thresholds, dune/ripple development, and incipient motion by observing first movement of grains and evaluating a critical Shields parameter under known depth, slope and discharge.

The HM 162.41 wave generator produces regular surface waves via a paddle driven by a motor with frequency converter and crank mechanism; the stroke is continuously adjustable. The drive mounts on the HM 162 test section, with the paddle fixed to the flume bottom. In combination with end treatments (e.g., a perforated passive absorber) and hydraulic structures, the module supports laboratory studies of dispersion, reflection, run-up and overtopping as well as wave–structure interaction at model scale.

With water and sediment recirculation plus wave generation in a single facility, the HM 162 platform supports integrated hydraulics, fluvial/coastal engineering curricula: steady and gradually varied flow, sediment transport and Shields-type incipient motion tests, movable-bed morphodynamics, and regular waves for calibration/validation and design recommendations at constant Froude. The glass walls and closed circuits favor high-quality measurements (e.g., point gauges or image-based time series) with efficient turnaround between groups.

Some Photos of flume lab.

1.3 The CTN

The CTN (Centro Tecnológico Naval y del Mar), member of MED-Hubs consortium, is a reference point in Europe for underwater acoustic measurements, distinguishing itself through its laboratories and high-precision infrastructure.

1.3.1. Hydrophone Calibration Services

The calibration of electro-acoustic transducers is one of CTN's core competencies. They operate a Hydroacoustic Metrology Laboratory, which ensures that their measurements are traceable and legally valid for international defence and industrial applications.

Key Services & Methodologies:

- Primary Calibration (Reciprocity Method): This is the gold standard for accuracy. CTN employs the reciprocity method (free-field) for the absolute calibration of hydrophones. This technique does not require a reference transducer and derives sensitivity directly from electrical and geometrical measurements.
- Comparison Method: For routine testing, they calibrate sensors by comparing them against a standard reference hydrophone with a known sensitivity curve.
- Frequency Range: Their capabilities cover a vast spectrum, typically ranging from very low frequencies (infrasound, starting around 1 Hz) up to high-frequency ultrasonic bands (up to 200 kHz or higher depending on the specific setup).
- Parameters Measured:

    - Receiving Voltage Sensitivity (RVS): Measured as a function of frequency (V/\μPa).
    - Transmitting Voltage Response (TVR): For projectors/emitters.
    - Directivity Patterns: They measure the beam pattern of transducers (horizontal and vertical planes) using automated rotators to determine the sensor's directionality and side-lobe levels.
- Standards: Strict adherence to IEC 60565 (Underwater acoustics - Hydrophones - Calibration in the frequency range 0.01 Hz to 1 MHz).

1.3.2. Acoustic Properties of Underwater Panels (Materials Testing)

This service is essential for the defence sector (stealth technology/submarines) and the offshore industry (noise mitigation). CTN characterizes how materials interact with sound waves underwater.

Measurement Capabilities:

- Acoustic Windows & Domes: Testing materials designed to be acoustically transparent to protect sonar arrays without degrading performance.
- Anechoic Coatings & Tiles: Testing materials designed to absorb sound (stealth) or reduce reflections.
- Baffles & Decouplers: Assessing materials used to isolate sensors from structural noise.

Key Acoustic Metrics:

- Echo Reduction (ER): Measures how much sound energy is reflected by the panel. Essential for stealth (reducing Target Echo Strength).
- Transmission Loss (TL) / Insertion Loss (IL): Measures how much sound energy passes through the panel.
- Sound Absorption Coefficient: The ratio of absorbed energy to incident energy.

Infrastructure for Materials:

- Large Acoustic Tank: A controlled environment ($10m \times 5m \times 5m$ approx.) equipped with precision positioning systems to perform free-field measurements on large panels (e.g., $1m \times 1m$).
- Parametric Arrays: Use of highly directional sound sources to isolate the sample and avoid wall reflections in the tank.

1.3.3. Offshore Sensor Testing & Validation

Beyond acoustics, CTN offers comprehensive validation for sensors deployed in harsh marine environments (Oil & Gas, Floating Wind, Oceanography). This ensures sensors survive the physical rigors of the deep ocean.

Testing Services:

- Hyperbaric Testing (Pressure):
    - They utilize hyperbaric chambers to simulate deep-sea pressure.
    - capabilities: Tests can go up to high pressures (e.g., 600 bar, simulating 6,000 meters depth) to check for housing integrity, connector leaks, and sensor drift under pressure.
    - Functionality under Pressure: Unlike simple crush tests, CTN can power and monitor the sensor *while* it is pressurized to ensure it captures data correctly at depth.
- Accelerated Aging & Corrosion:
    - Saline mist chambers and climatic chambers to test the long-term resistance of sensor housings and cabling to the marine atmosphere.
- Vibration and Shock:
    - Simulating the impact of deployment (splashing zone) and operation on vibrating machinery (pumps, drilling risers).

1.3.4. Specialized Infrastructure

To perform these "precise and prolonged" tests, CTN utilizes specific assets:

- The Acoustic Tank: Two large freshwater volume with precise temperature control (on inside and other outside the CTN facilities). It features an automated positioning bridge (X, Y, Z, and rotation) to place hydrophones and panels with millimeter accuracy.
- Open Sea Lab: For tests that cannot be simulated in a tank (e.g., low-frequency propagation over long distances), CTN has access to an offshore test site off the coast of Cartagena. This allows for realistic "in-situ" validation of sensor networks and buoys.

Testing lab at CTN

1.4 The Ports

The ports of Águilas, Mazarrón, Cartagena, Cabo de Palos, and San Pedro del Pinatar are more than gateways for fishing, tourism, and trade. They are strategic hubs for the Blue Economy, fostering sustainable growth and technological advancement in marine sectors. Their infrastructure supports:

- Marine Research & Innovation: Proximity to rich ecosystems and marine reserves enables collaboration with universities and research centers for biodiversity monitoring, renewable energy (offshore wind, wave), and sustainable aquaculture.
- Smart Port Development: Digitalization of operations, energy-efficient facilities, and integration of IoT for vessel traffic and resource management enhance competitiveness and reduce environmental impact.
- Eco-Tourism & Nautical Activities: Modern marinas and services attract sustainable tourism, promoting low-carbon recreational boating and diving in protected areas.
- Circular Economy Practices: Opportunities for waste-to-energy projects, water treatment, and recycling within port operations align with EU Green Deal objectives.

By leveraging these assets, the ports can become innovative platforms, connecting local businesses, technology providers, and research institutions to create value while preserving marine ecosystems.

Port	**Type**	**Berths**	**Draft**	**Key Services**
Águilas	Fishing & Marina	~180	~3 m	Water, electricity, fuel, crane
Mazarrón	Marina & Fishing	>330	Up to 30 m vessels	Water, electricity, boatyard, crane
Cartagena	Commercial, Naval, Cruise, Marina	Large capacity	Deep (large ships)	Cargo docks, cruise terminal, naval base
Cabo de Palos	Fishing & Marina	~185	2–2.5 m	Water, electricity, basic leisure services
San Pedro del Pinatar	Fishing & Marina	Multiple berths	Moderate	Fish market, water, electricity, fuel

2. Operational Capabilities of the Marine Energy Hub

2.1. Multi-Source Energy Generation

The combination of hydrogenerators, wind generators, and solar panels allows the platform to operate as a fully self-sustaining hybrid energy system, providing distributed and continuous renewable power:

a) Solar Photovoltaic Generation

- Powering charging stations for small boats, buoys, or scientific instruments.
- Supplying port lighting and coastal signaling systems.
- Serving as a test environment for innovative PV panels designed for marine conditions.

b) Hydrogenerators (current and wave energy)

- Assessment of prototypes capturing energy from currents or wave-induced motion.
- Performance testing in real marine conditions, analyzing efficiency, durability, and structural response.
- Evaluation of the impact of waves, fouling, and long-term immersion on moving or oscillating systems.

c) Small-Scale Wind Generator

- Ensuring continuous power generation during low-sunlight periods.
- Testing compact turbines are designed for port or maritime applications.
- Integration into a hybrid wind–solar–current energy management system for improved reliability.

2.2. Oceanographic Monitoring and Data Collection

With the meteorological station and acoustic doppler current profiler, the platform can act as an advanced environmental monitoring node:

a) Acquisition of key environmental variables

- Wind speed and direction
- Solar radiation
- Air and sea temperature
- Current profiles and wave characteristics

b) Calibration and validation of sensors

The platform provides a stable real-world environment ideal for:

- Research centers
- Blue economy companies developing marine sensor technologies
- Startups
- Universities

2.3. Technology Testbed

The Marine Energy Hub integrates seamlessly "From the Idea to the Real World" methodology and supports innovation at multiple readiness levels:

a) Prototype testing at mid-to-high TRLs

- Structural validation
- Energy performance testing
- Durability and corrosion assessment in a marine environment

b) Demonstration platform for investors and clients

- Enables real-world demonstrations
- Reduces market-entry barriers for startups and innovators

c) Educational participation

Students from universities and research centers gain hands-on experience in:

- Installation of devices
- Maintenance and operation
- Environmental data analysis

This contributes significantly to developing skills demanded in the blue economy sector.

2.4. Energy Supply for Port and Coastal Operations

The floating platform can provide practical energy services in ports such as Águilas, Mazarrón, Cartagena, Cabo de Palos and San Pedro del Pinatar.

- Charging electric small craft
- Powering smart buoys
- Supporting maritime signalling infrastructure
- Providing auxiliary energy to tourism-related facilities
- Reducing reliance on diesel generators in port operations

2.5. Floating Laboratory and R&D Space

With its equipment housing and fiber-optic reel, the platform can be used as a floating applied research laboratory:

- Testing underwater communication and telemetry systems
- Developing automation and digitalization solutions for marine devices
- Evaluating control algorithms for hybrid power systems
- Integrating with smart-port electrical grids.

- Mooring System provides secure installation in port environments and restricted navigation zones suitable for NON-MESS testing.

3. What Startups Can Expect from the MED-Hubs Program

- Access to the floating platform and laboratory facilities, including the GUNT HM 162 experimental flume and the CTN acoustic tank, for prototype testing at mid-to-high TRLs (NON-MESS and REA-MESS stages).
- Access to the Marine Renewable Energy floating platform located at the Port of Cartagena to test and demonstrate their devices under real sea conditions in an operational port environment.
- Access to the following ports for real-world demonstration and validation (REA-MESS): Águilas, Mazarrón, Cartagena, Cabo de Palos, and San Pedro del Pinatar.
- Support to connect with local stakeholders (port authorities, municipalities, industry partners) and assistance obtaining the necessary permits and clearances to begin experimentation in port environments.
- Mentoring and business development support from UPCT researchers and industry experts, including guidance on technology readiness, investor preparation, and market entry strategy.
- Co-working space at UPCT (Cartagena), including access to innovation and entrepreneurship facilities, meeting rooms, and high-speed connectivity.
- Visibility and networking opportunities within the MED-Hubs international network, including participation in demonstration events and access to potential investors and blue economy stakeholders.

For more information, please contact the UPCT representative, Jose Gutierrez at jose.gutierrez@ucpt.es