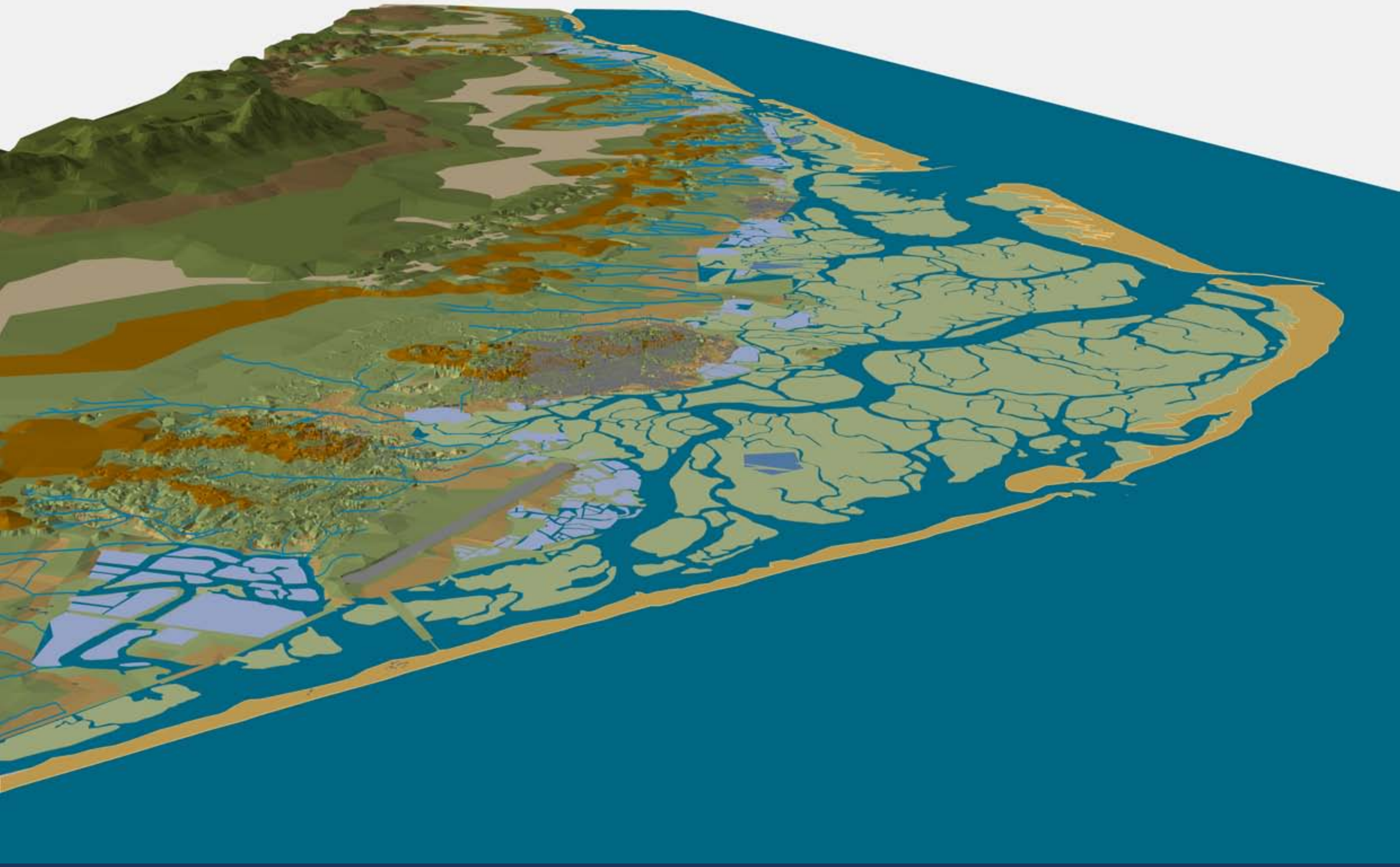

RIA FORMOSA

Challenges of a coastal lagoon in a changing environment

Edited by
Jaime Aníbal, Ana Gomes, Isabel Mendes & Delminda Moura

UAlg CIMA
UNIVERSIDADE DO ALGARVE
CENTRO DE INVESTIGAÇÃO MARINHA E AMBIENTAL

9. Marine energy prototype testing at Ria Formosa

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9.1. Renewable energy, a world urgent need

Economic growth and increasing human demands are among the most important factors for growing world energy consumption. Energy is present in everything around us: it is a property of all objects and is essential to life. We find various forms of energy in the world around us. When plants grow, for example, they are converting sunlight energy into chemical energy in the form of carbohydrates and other compounds stored in your body (e.g. sugars). The form of energy that man uses most today is the chemical energy contained in fossil fuels, such as oil, coal and natural gas. About 80% of the energy we use comes from these sources. However, these sources are very polluting, since their use releases substances harmful to the environment and to public health. An example of this is the increased concentration of greenhouse gases such as carbon dioxide (CO_2) in the atmosphere, which is a cause of climate change. In addition to pollutants, these sources of energy are non-renewable, which means that they are being consumed at a faster rate than is necessary for their production, so their availability is decreasing.

Due to the increasing oil and natural gas prices, reduced fuel reserves and the requirement for reduced CO_2 emissions to avert climate change, the use of alternative energy sources is both financially unavoidable and environmentally preferable (UN, 2015). Hence, generating renewable energy is nowadays one of the most relevant endeavours for research. Countries worldwide now recognise the need to incorporate renewable energy resources in their energy policy as an alternative to finite fossil fuel resources in order to achieve future energy security and to mitigate the effects of climate change induced by human activities. Today, renewable energy is now firmly entrenched as the world's fastest growing energy sector (IEA, 2017).

9.2. EU priority to become carbon neutral in 2050

The EU has set objectives to become a smart, sustainable and inclusive economy by 2020 (EREC, 2010; EC, 2011). The EU objective are to cut 20% of greenhouse emissions, 20% increase in energy efficiency and 20% of energy produced using renewable sources. To accomplish those objectives each of the EU countries had to establish individual targets and action plans; as well as collaborate with each other's on joint project in energy share. The challenges of transforming Europe's energy system remain urgent and daunting: the EU currently imports approximately 55% of its energy – and might reach 70% in the next 20 to 30 years. In 2030 the EU will be importing 84% of its gas, 59% of its coal and 94% of its oil. Only 8.5% of the energy market of the 28 European countries is from renewable energy sources (EREC, 2010). In these circumstances, it is obvious that the challenge to satisfy our energy needs is urgent and most European governments have introduced schemes to encourage the development and uptake of renewable energy, either through direct grants or by introducing favourable tariffs for electricity generated from renewable sources.

The European Commission is looking at cost-efficient ways to make the European economy more climate-friendly and less energy-consuming. The roadmap (European Commission COM12, 2011) suggests that, by 2050, the EU should cut its emissions to 80% below 1990 levels through domestic reductions alone (milestones to achieve this are 40% emissions cuts by 2030 and 60% by 2040). To reach this goal, the

EU must make continued progress towards a low-carbon society where clean technologies play an important role.

9.3. The huge untapped source for clean energy production, the sea

The oceans cover 70% of the planet Earth and are composed of huge masses of water of different characteristics in constant movement as result of the interaction Ocean-Atmosphere. This constant movement can produce virtually inexhaustible energies: marine renewable energies (MRE). The MRE' resources are categorized based on which properties of the ocean are used, such as motion, heat or salinity. There are 6 forms of MRE: offshore wind, tidal potential energy (e.g. tidal barrage/lagoons), tidal kinetic energy (e.g. ocean currents), wave energy, and energy produced by thermal or salinity gradients (Figure 9.1).

Tidal Barrage Energy (Potential) Wave Energy (Kinetic) Ocean / Tidal Energy (Kinetic)

Temperature Gradient Salinity Gradient Offshore Wind Energy (Kinetic)

Figure 9.1.
Different forms to extract energy from ocean processes: tidal barrages/lagoons, wave devices, tidal turbines, temperature/salinity power plants and offshore wind platforms (e.g. Windfloat Project, Portugal). These energy resources have the potential to be an alternative for global energy production, compared to oil resources and nuclear power plants. Despite the high potential for solving some of the world's energy requirements, technologies for marine energy extraction are at an early stage of development, so their use is not yet economically viable.

Marine renewable energy sector offers the opportunity for a balanced, consistent and sustainable social and economic development of the whole Europe. The existing estimates is that the harvestable energy from the World's Ocean is equal to twice the amount of electricity produced in the World today (World Energy Council, 2016). Currently, MRE has the potential to satisfy approximately 15% of the present European electricity demand and the EU is currently the market leader (Table 9.1). This huge potential as a clean green source of power could provide a substantial amount of the total electricity demand by 2050, as well as help to cut carbon emissions and support thousands of jobs reducing unemployment and encouraging social cohesion (European Commission COM12, 2011). Whilst the majority of work to date has focused on the wind and solar sectors, the generation of electricity from waves, tidal currents and tidal range has received renewed interest as some of the complexities of practically harnessing other forms of renewable energy become apparent.

Table 9.1.
European objectives for electric production using marine energy resources (Source: ***European Marine Board*** & ***International Energy Agency – Ocean Energy Systems***)

European Objectives	Offshore Wind	Tidal Energy	Wave Energy
Electric Production (TWh/year)	563(2030)	36(2040)	142(2040)

Despite the global financial crisis, the ocean renewable energy sectors in Europe have received €80m of European Commission (EC) funding and over €680m private investment in the last 7 years (European Ocean Energy 2013; SI Ocean, 2014; EWEA, 2014). The investment to date in offshore renewable energies has shown growth across the maritime sectors and throughout the supply chain (SI Ocean, 2014). Survey companies have expanded, professional services and design consultants have been commissioned, vessel operators have diversified, and offshore contractors have undertaken significant work (Figure 9.2).

Figure 9.2.
A new offshore wind prototype, Starfloat. Offshore wind is today the renewable energy sector with the fastest growth in Europe. By 30 June 2013 European waters contained 1,939 offshore wind turbines (capacity 6040 MW) in 58 wind farms across 10 countries (IEA, 2017) (source: OceanFlow Energy Ltd).

The European Commission is fully engaged in the development of offshore marine renewable energies. Under the Research Framework Programme, the cumulated EC contribution over the last fifteen years is above 20 million €. Meeting the EU's new binding targets for marine renewable energy would lead to a net increase of 410,000 jobs in the EU by 2020 (European Ocean Energy, 2013). However, progress towards cost-competitiveness will depend on creating the right market environment and investment decisions across Europe for the future. By addressing regulatory challenges, the sector can bridge the gap to commercialisation and make a significant contribution towards growth, employment and decarbonisation throughout the EU.

9.4. Portugal potential on the marine energy sector

At a European level, Portugal can be considered a pioneer in testing and connecting marine renewable energy to the grid. The natural potential of the Portuguese coast and the conditions arising from the proximity of technology infrastructure support, the fixed fee for electricity produced and the knowledge acquired in the area of utilisation of these energies are significant comparative advantages that the country can enjoy with great benefit, both in terms of production of renewable electricity, technology development, products and services exported to other regions of Europe and the world. Those factors has encouraged the first offshore wave projects to be sited in Portuguese waters. One of the first pilot wave station was set in Pico (Açores) and the first offshore wave project array was sighted in Portuguese waters (Pelamis, Aguçadoura). The marine renewables are a priority of the National Strategy for the Sea (DGPM, 2012), reinforced by the National Action Plan for Renewable Energy 2020 (PNAER, 2011). However, the capacity to attract marine renewable devices in Portuguese waters dropped considerable, despite the natural potential of the Portuguese coast and the conditions arising from the proximity of technology infrastructure support, the fixed fee for electricity and the knowledge acquired. Today, Portugal has solely one prototype in the water, an offshore wind device, the Windfloat (Figure 9.1). To invert this situation, the European Commission approved a new support scheme launched by the Portuguese Government so that Portugal would be able to support wave energy projects and wind offshore technologies. This state support translates into a guaranteed energy purchase tariff for 25 years in order to offset the higher costs of new technologies. The scheme will support demonstration projects for a total installed capacity of 50 MW, 25 MW of which have already been allocated to the Windfloat project. The remaining 25 MW capacity will be allocated to different promoters / projects (https://www.edp.com/en/windfloat).

9.5. Tidal energy

Of all marine renewable energy sources, tidal energy is one of the greatest forces on Earth with vast potential as a major renewable source and can play a key role in global energy production in the near future. Tidal energy is the energy dissipated by tidal movements, which derives directly from the gravitational and centrifugal forces between the Earth, the Moon and the Sun (Figure 9.3). Tidal energy can be predicted for centuries, both from the point of view of time of occurrence and magnitude, is clean and does not run out, in contrast to the unpredictability of other renewable energies, such as wind, solar, waves, etc.

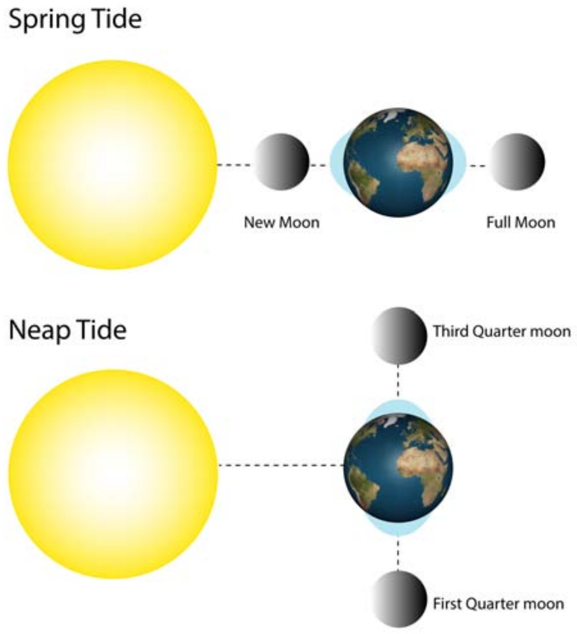

Figure 9.3.
The tides are changes in mean sea level: water rises when the tide is filling; and descends when the tide is dropping. This rise and fall of the water level occurs because the gravitational forces of the Moon (which has greater influence because of being so close to the Earth) and the Sun attract the water masses of the Oceans towards them, forming a tidal wave. As tides are caused by gravitational forces, the amplitude of the tides (i.e. varying height between low tide and high tide) depends on the relative position between the Earth, the Moon and the Sun. If all are aligned, for example, their gravitational forces add up and the amplitude of the tide is greater - it is at these times that we have Spring-tides! If they are misaligned, the amplitudes of the tides are smaller and we have the so-called Neap-tides.

The world tidal power resource (i.e. tidal potential and tidal kinetic energy) is estimated to be 3 TW, with 1 TW located in relatively shallow waters. However, due to geographical, technical and environmental constraints only a fraction of this could be captured in practical terms (World Energy Council, 2016). In practice, suitable locations need mean spring peak tidal currents that are faster than 2-2.5 ms^{-1} to offer an energy density that allows for an economically viable project. For example, at the European level 106 locations with a strong tidal stream potential were identified, together offering 48 TWh/yr of potential resource (World Energy Council, 2016).

Tidal energy provides excellent long-term potential for economic growth, energy security and job creation. According to European Ocean Energy (2013), by 2050, Europe could have up to 100 GW of wave and tidal energy installed capacity delivering 260 TWh of clean, affordable and reliable electricity, enough to power 66 million European homes. With up to 337 GW installed around the world, wave and tidal energy could be a multi-billion-euro international industry with significant exports to markets in Asia and across South and North America.

Tidal energy conversion systems can be grouped into 1st generation systems that convert potential energy into electrical energy due to the interaction of two bodies of water during the tide (e.g. tidal barrages, Figure 9.1); and 2nd generation systems that convert the kinetic energy from the movement of the water flow into electrical energy (e.g. tidal turbines, Figure 9.1). First-generation systems require locations with a tidal amplitude greater than 5 m and there are only about 40 sites in the world with such characteristics. Extraction of energy from 2nd generation systems is in an early stage of development, and there is currently no major technology in the market. More than 90 companies are registered in the EMEC European Marine Energy Centre, Orkney Islands in Scotland, with commercial patents in diverse variations of concepts. However, the most mature technology is the horizontal-axis turbine with fixed connexion to the bottom (Figure 9.4) because it resembles wind turbines, and therefore imports direct knowledge of this technology with more than 20 years of sustained commercial implementation in the market. The big difference between the two is the diameter of the blades. Because the water is eight hundred times denser then air, less rotation area is needed to generate the same amount of energy.

Figure 9.4.

(A) SeaGen of Marine Current Turbines (MCT, credit: Siemens AG) was the first commercial scale prototype installed in the world (2008), with a capacity of 1.2 MW (6000 MWh/year - equivalent to the supply of 1500 houses). The company was acquired by the Siemens Group and has planned projects in other UK locations (Kyle Rhea, Anglesey Skerries and Brough Ness, all in the UK) and Bay of Fundy (Canada). However, the first company to test a prototype in open sea condition was (B) OpenHydro (today DCNS group, credit: Mike Brookes-Roper/EMEC) with its 6 m diameter turbine and power generation capacity to supply 150 houses. A tidal turbine functions like a wind turbine under water. The ocean's currents turn the turbine blades. The nacelle has a gearbox inside that increases the speed of rotation and a generator of energy that converts the mechanical into electrical energy. The equipment also has an inverter to transform the produced energy into the voltage needed into the grid. Power estimates are determined by integrating along a Neap-Spring tidal cycle the cube of velocity times the swept area of the turbine, times the water density, times the efficiency factor of each turbine.

Many investors, shareholders, regulators and the public are interested in the potential that the tides have for the production of renewable electricity. The site of the world with the greatest tidal amplitude is the Bay of Fundy in Canada (16 m wide), which means a movement of 160 billion tons of water. This site has enormous potential for tidal energy production, combining both 1st and 2nd generation systems, as there are locations in the bay where the current velocity exceeds 5 m/s. Studies at the University of Acadia in Nova Scotia (Canada) indicate an energy resource of 50 GW only at this location. As far as Europe is concerned, one of the first tide barrages in the World was installed at La Rance in Brittany (France) in 1966 and has a capacity of 240 MW. The tidal amplitude at this location is 8.5 m. Currently, there are several projects for the construction of coastal lagoons off the coast of Wales which aim to create artificial reservoirs in the open seas along the coast. The largest of these projects is Swansea Bay, which installed capacity will be of 240 MW. The largest commercial project planned for Europe is the MeyGen in Scotland at Pentland Firth, which will have an expected installed capacity of 86 MW and aim to reach 398 MW by 2020.

9.6. The environmental effects from exploitation

As above demonstrated, tidal energy can be exploited both by multi-megawatt tidal power farms and mini-power stations with turbines generating a few kilowatts. Such power stations can provide clean energy to small communities or even individual households located near continental shorelines, straits or on remote islands with strong tidal currents. However, despite its potential contribution to world energy demands, tidal energy technologies are currently not economically viable on large scale and are still at an early stage of development. Several devices and equipment have been tested but only a few have become real-scale prototypes, since commercial marine energy development depends largely on the ability of pilot projects to demonstrate the technical, economic and environmental readiness.

The deployment of tidal energy converters has been hindered by a lack of understanding of their environmental interactions, both in terms of the device impact on the environment (important for consenting and stakeholder bodies) and environmental impact on the device (fatigue, actual power output etc., which is vital to enhance investor confidence and increase financial support from the private sector). Most academic research has focussed on hypothetical numerical modelling which is perceived with fairly low confidence by regulatory bodies. In the few cases that devices have been deployed and monitored, the data is highly commercially sensitive and thus not in the public domain to further wider understanding. In order to assuage regulatory bodies' concerns about detrimental environmental impacts, access to freely available, transparently collected monitoring data from real deployments is paramount. Better understanding of device performance is required to draw investment and accelerate commercial scale deployments. Without further research to comprehend these environmental and performance concerns, these issues cannot be definitely resolved and will remain as challenges associated with commercial array deployment.

Extracting tidal energy at commercial scales can potentially have several impacts on the environment such as: to reduce tidal amplitude, to change flow patterns and thus to affect the transport and deposition of sediments, to affect population distribution and dynamic of marine organisms, to modify water quality and marine habitats, to increase ambient noise, and to increase mixing in systems where salinity/temperature gradients are well defined (Neil et al., 2009; Kadiri et al., 2014; Martin-Short et al., 2015). Up until now, no information exists for device arrays of tidal energy converters except some numerical modelling predictions without validation, which are perceived with fairly low confidence by regulatory bodies.

The future prospects for tidal energy converter technologies very much depend on the specific device concept and how those devices can be optimised to efficiently extract energy, minimising environmental impacts. Understanding potential environmental impacts is a key issue in gaining acceptance of new technologies. Primary concerns relating to tidal stream turbine installations are interference with the local ecosystem during installation activities, the potential of the rotating blades to injure fish, diving birds and sea mammals and the loss of amenity, fishing areas and navigation space for other users of the sea area.

9.7. The testing of a floatable tidal energy converter at Ria Formosa

The SCORE project – **S**ustainability of using Ria Formosa **C**urrents **O**n **R**enewable **E**nergy Production – is funded by the Portuguese Foundation for Science and Technology (FCT – PTDC/AAG-TEC/1710/2014) proposed to test for the first time a floatable tidal energy converter on Portuguese waters, the Evopod 1:10th scale prototype from OceanFlow Energy (OE, Figure 9.5). The project brings together a multidisciplinary team, including physicists, oceanographers, geologists, biologists, modellers, marine engineers and economists, and represents a unique opportunity to understand the performance of a floating tethered turbine in energetic tidal flow.

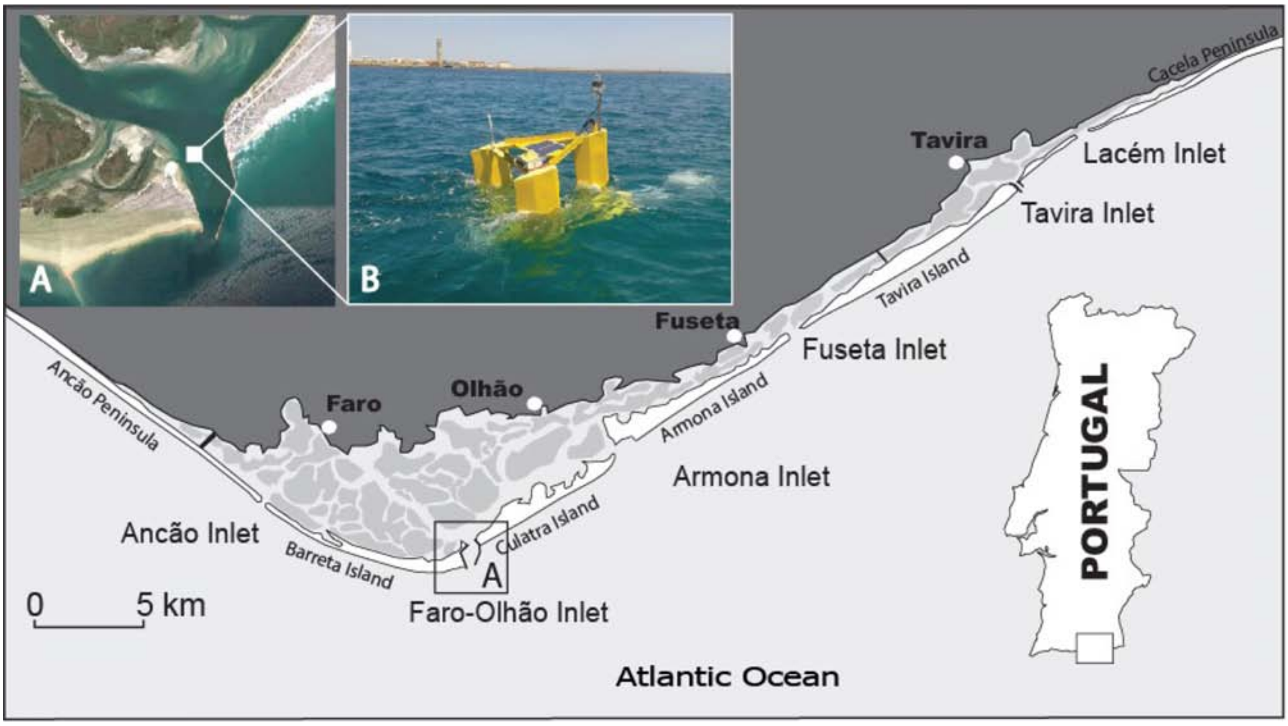

Figure 9.5.
The Ria Formosa system is an ideal place for testing floatable tidal energy converter' prototypes and can be used as representative of the vast majority of coastal areas where these devices can be used in the future to extract energy to power small communities on estuaries and coastal areas. In particular, the Faro-Olhão Inlet, the main inlet of the system, traps 60% of the total spring-tidal prism of the RF system. The inlet is characterised by strong currents and therefore has potential for energy extraction (adapted from Pacheco et al., 2018).

Evopod device is at the technology readiness level (TRL) 7 and a 1:4th scale prototype was tested on Scottish waters on combined ocean-current environment, the requisite required for reaching TRL 8 (i.e. pre-commercial stage) (see Box 9.1). The innovative aspect of testing in Portugal lies with the unique morphological characteristics associated with the device deployment site at Ria Formosa, a coastal lagoon protected by a multi-inlet barrier system located in southern Portugal (Algarve Region). Ria Formosa can be used as representative of the vast majority of shallow coastal areas where tidal energy converters can be used in the future. It is therefore ideal to analyse both the energy extraction efficiency and eventual impacts that extracting energy from the flowing currents will have on the ecological communities and physical settings (Figure 9.5).

Box 9.1. What is a technology readiness level (TRL)?

The TRL was developed by the North American Space Agency (NASA) and is a type of measurement system used to assess the maturity level of a particular technology. Each technology project is evaluated against the parameters for each technology level and is then assigned a TRL rating based on the projects progress. There are nine technology readiness levels. TRL 1 is the lowest and TRL 9 is the highest (Figure 9.6).

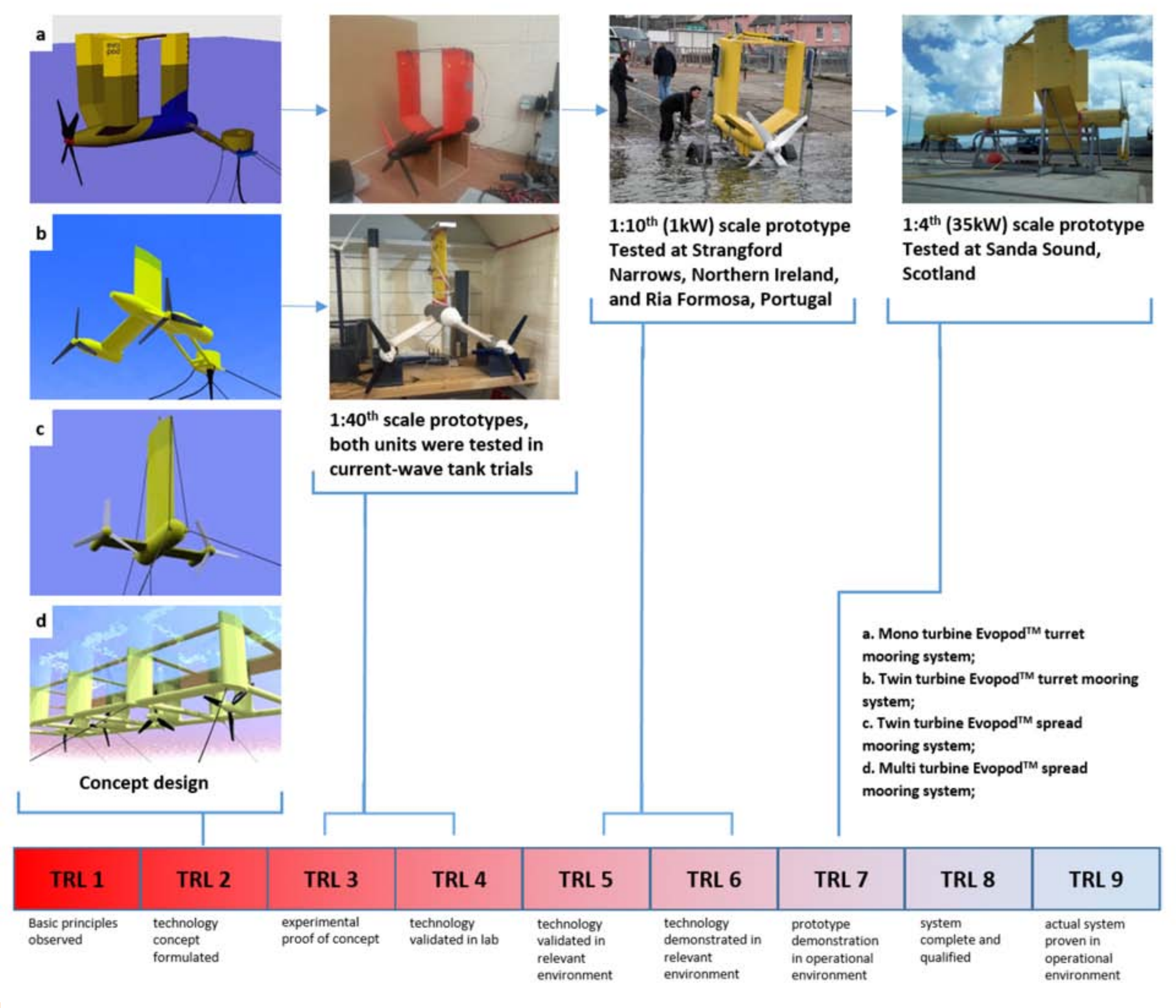

Figure 9.6.
Example of the Evopod™ development path on the Technology Readiness Level (TRL) scale.

Evopod™ is a device for generating electricity from coastal tidal streams, tidal estuaries, rivers and ocean currents (Figure 9.7). It is a unique floating solution drawing upon proven technologies used in the offshore oil / gas and marine industries (Mackie et al., 2008). The 1:10th scale E1 consists of a positively buoyant horizontal cylindrical body of 2 m length and 0.4 m diameter to which are attached three stabilising fins set in a triangle, tethered to the midwater buoy. Each fin is approximately 1.2 m long by 0.1 m and 0.4 m wide. The main body and fins are constructed of steel and painted yellow.

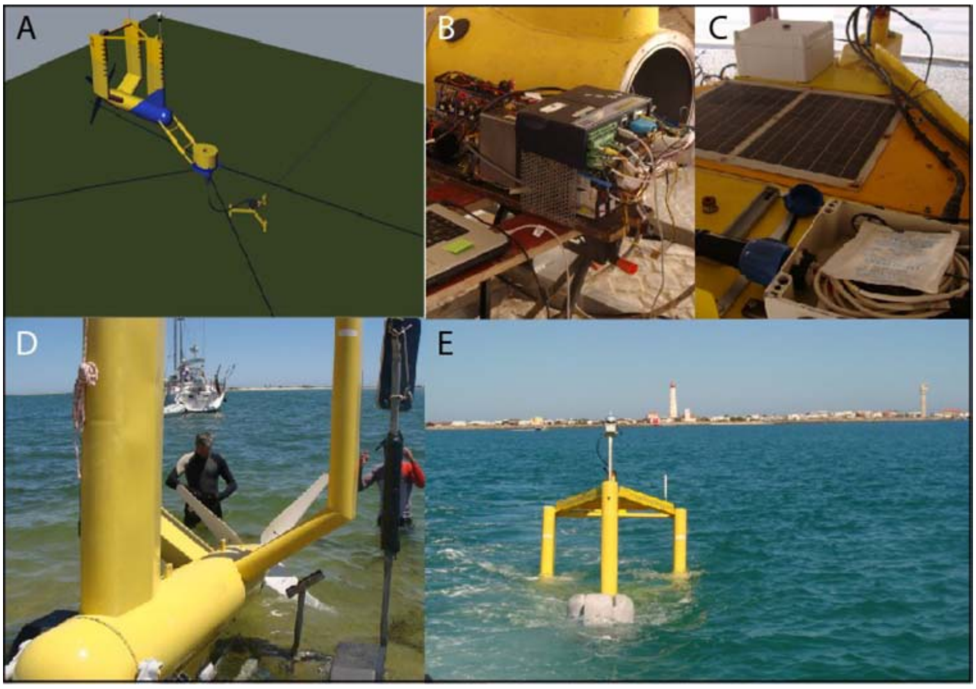

Figure 9.7.
(A) Scheme of Evopod™ with the mooring lines spreading from the mid-water buoy; (B) inside components connect to the logger; (C) detail of the deck with the solar panels and control box; (D) E1 launch on the water and (E) it trawl to the deployment site (adapted from Pacheco et al., 2018).

When deployed, approximately 0.4 m of the three yellow fins are visible above the water surface. A four-bladed 1.5 m diameter turbine made of composite is attached at the rear of the body and is designed to rotate between 20-55 rpm giving a maximum blade tip speed of 4.3 ms^{-1}, driving a 1kW permanent magnet generator. The width of the blade is approximately 0.1 m and the depth between the sea surface and the highest point of the rotor is 0.45 m. The power from the generator feeds the navigation light plus an extensive suite of instrumentation i.e. flow speed, voltage, current, torque, revs, temperature, resistor settings, yaw angle and mooring tension; which are logged and transmitted back to shore over a mobile phone data link. Table 9.2 summarises Evopod key discriminators at different scales.

Table 9.2.
Evopod key parameters (adapted from Pacheco et al., 2018)

	Full scale (Pentland Firth, UK)	**1:10th scale (Stranford Narrow IRL / Ria Formosa, PT)**	**1:40th scale (Newcastle University test tank, UK)**
Length overall (m)	21.5	2.15	0.538
Breadth across struts (m)	13.7	1.37	0.343
Displacement (t)	375,000	375	5.86
Turbine diameter (m)	15	1.5	0.375
Rated output (kW)	1800	0.57	0.004
Rated flow speed (ms^{-1})	4.0	1.26	0.63
Average operating sea state	$H_S = 3$ $mT_Z = 8$ s	$H_S = 0.3$ m $T_Z = 2.5$ s	$H_S = 0.0075$ m $T_Z = 1.26$ s
Survival sea state	$H_S = 14$ m $T_Z = 14$ s	$H_S = 1.4$ m $T_Z = 4.43$ s	$H_S = 0.35$ m $T_Z = 2.21$ s

where H_S is significant wave height and T_Z is the mean zero up-crossing period.

The SCORE team installed the prototype on 8th June 2017 in collaboration with a local company, which was subcontracted to provide a barge boat equipped with a winch (Figure 9.8A), essential to lower the anchoring weights at the exact planned position (Figure 9.8B). The device was tethered to the seabed using a four-line catenary spread mooring system attached to the above mentioned anchoring weights (Figure 9.8C), such that it is free to yaw (weathervane) into the predominant current direction. On each mooring line is placed a load cell (Figure 9.8D) that are measuring the tension while E1 is extracting energy.

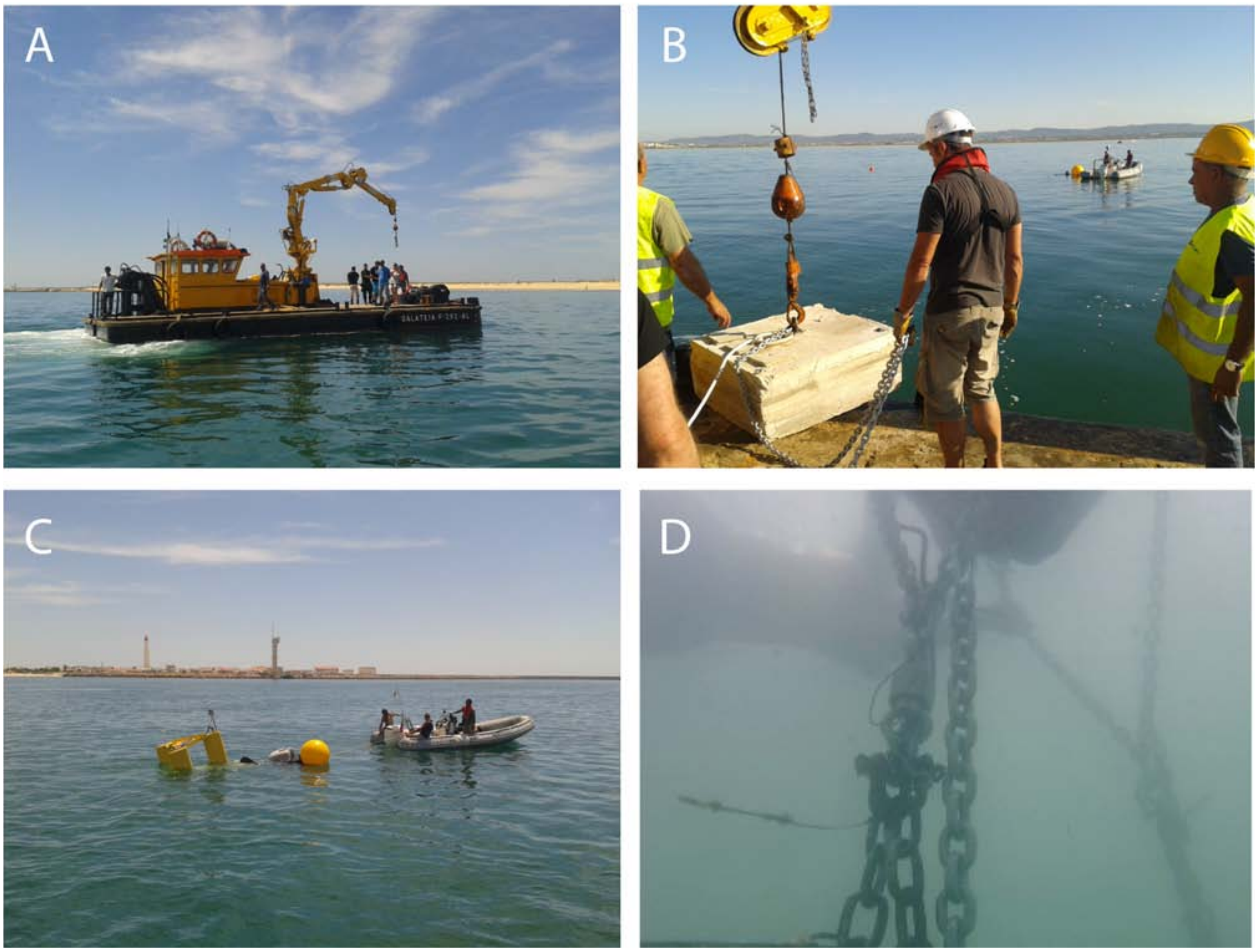

Figure 9.8.

(A) Barge boat equipped with a winch used on the deployment day; (B) mooring operation to lower the anchor weights at the exact plan position; (C) Evopod™ deployed by the divers on 8th June 2017; (D) Load cells on the mooring lines to measure the drag while the device is extracting energy. The entire deployment operation was performed at slack tide and evolved a staff of ten people, including skippers, researchers, divers and technical operators, supervised by the maritime authorities (adapted from Pacheco et al., 2018).

The anticipated flow speeds, wave and wind characteristics at the deployment site used for the design of the mooring system are presented on Table 9.3. The prototype operated at site until the 21st November 2017, when it was towed back to the harbour and removed from the water. All the anchoring system was removed except the anchoring weights that remained on site. In between i.e. period while the prototype was operating, the device had to be removed for maintenance three times, which evolved it subsequent re-installation.

Table 9.3.
Tidal stream, wind and wave characteristics used in mooring design (adapted from Pacheco et al., 2018).

Predicted spring tide peak flow	1.5 ms^{-1}
Percentage time flow exceeds 0.7 ms^{-1}	20 %
Percentage time flow exceeds 1.75 ms^{-1}	0 %
Estimated wind induced surface current	0.2 ms^{-1}
Extreme current speed for mooring design	1.7 ms^{-1}
Wind Direction	NE or NW
Wind Speed	35 kmhr^{-1} (9.7 ms^{-1}or 18.8 knots)
Fetch	4 km (2.2 nautical miles)
Significant wave height H_S	0.45 m
Significant wave period $T_{1/3}$	2.6 s
Mean zero up-crossing period T_Z	2.4 s

The access to freely available, transparently collected monitoring data from real deployments is paramount. The existence of data on environmental conditions prior to extraction of energy on any location will be essential for cataloguing potential impacts of any marine renewable installation. The SCORE data (Pacheco et al., 2018) is now available to the scientific community and to industry developers, enhancing the operational knowledge of tidal technology concerning efficiency, environmental effects, and interactions (i.e. device/environment). An integrated "whole-system" impact monitoring program was implemented while operating the prototype in order to understand environment-device interactions (Figure 9.9). The tidal turbine is also instrumented to continuously monitor and record various parameters. The parameters captured during the Ria Formosa deployment were: flow speed (ms^{-1}), shaft speed of rotation (RPM), generator output voltage and current (Volts), device compass heading (º degree) and mooring tension (kN).

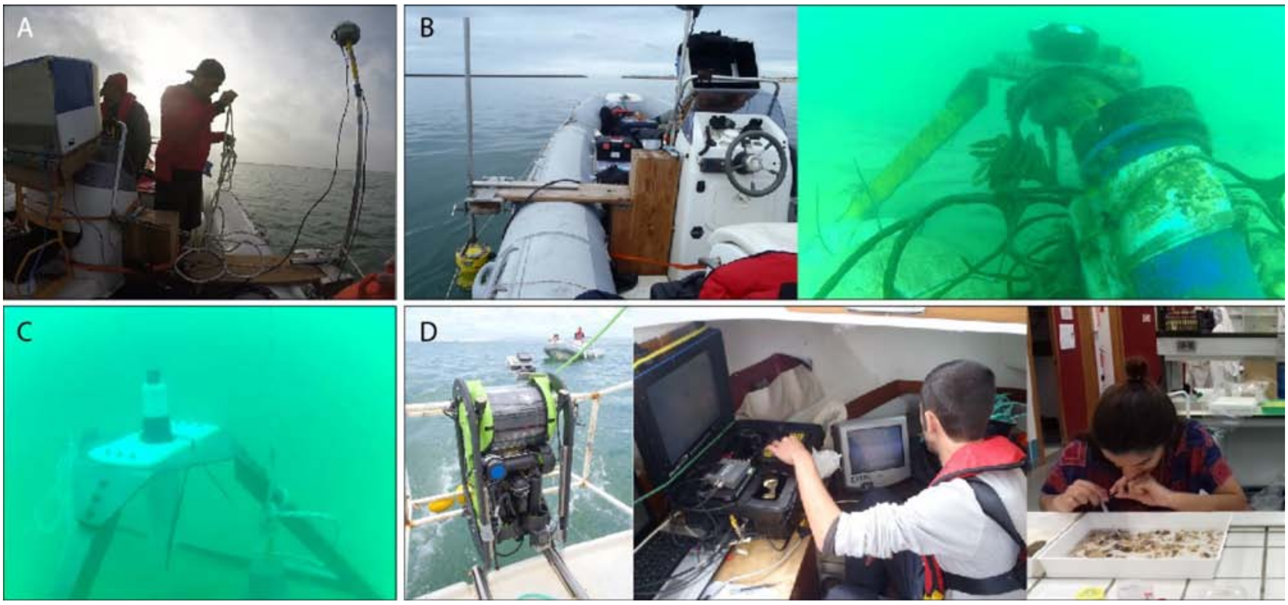

Figure 9.9.
(A) Bathymetric survey using a RTK-DGPS synchronized with the single beam echo-sounder; (B) Characterization of the 3D flow pattern using boat mounted (with bottom tracking) and bottom mounted ADCPs; (C) Acoustic measurements with a hydrophone bottom mounted; and (D) ROV videos and bottom trawling for habitat characterization (adapted from Pacheco et al., 2018).

The SCORE results will assist on validating a model to optimise power extraction having in consideration both the impact and the available resource. A conceptual tidal energy farm will be designed for the pilot site defining the number and appropriate distances between devices of different dimensions. Power generation capacity, energy capture area and proportion of energy flux for the site are the considerations that will be taken into account for the final tidal power plant design. The results can also be used by developers on the licensing process, on overcoming the commercial deployment barriers, on offering extra assurance and confidence to investors, who traditionally have seen environmental concerns as a barrier, and on providing the foundations whereupon similar deployment areas can be considered around the world for marine tidal energy extraction.

Since the project relates to the sustainability of producing electric energy using the Ria Formosa currents, team members are now focused on the cost benefit analysis using as case study the Culatra Island energy demands. This task aims to propose instruments, measures and guidelines that will support the future installation of TEC devices enhancing high levels of environment protection, adapted to real socio-economic scenarios, enabling to define optimum approaches to future tidal energy extraction on coastal estuaries.

A techno-economic assessment will be produced offering: (1) guidelines for device implementation projects on similar coastal lagoons and estuarine systems worldwide analysing scenarios based on energy extraction schemes; (2) a cost benefit analysis on extracting tidal energy from Ria Formosa and adjacent waters. Energy consumptions rates were asked to EDP and different scenarios were established to evaluate project break-even and investment. Installation, operation and maintenance costs are being estimated as well as the possible socio-economic impacts (e.g., job creation, increase of scientific activities related to industry. The work will also quantify the direct and indirect benefits of establishing Ria Formosa as a test case site for testing devices (e.g. local economy, employment), incorporating existing marine renewable energy networks. The tidal energy resource and the evaluation of impacts from extraction at shallow coastal areas proposed on SCORE project can guide energy policy, and position Algarve (and Portugal) on the forefront as test sites for new and/or existing TEC energy developers.

Acknowledgements

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