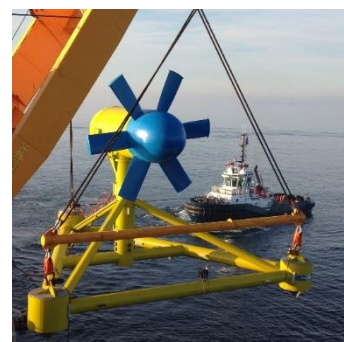
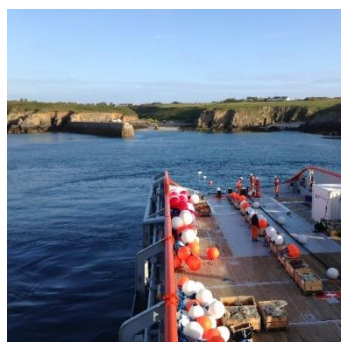
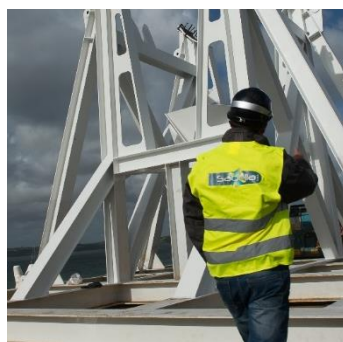




USHANT SHOWCASE OF TIDAL ENERGY WORLDWIDE

SABELLA SIMPLICITY TO RIDE THE TIDE



EDITORIAL

A word from the president



In the name of SABELLA, I must underline the strong-willed policy from France, the Brittany region and the European Union to develop a hexagonal field for marine renewable energy.

They deserve a wealth of thankfulness for their trust and support to innovative SME and more specifically for their continuous help in this project and in the integration of the company toward export markets.

Inside this international nascent industry, the D10 projects (and its following) in the Celtic sea has become a flagship for exploitation of marine currents and has allowed SABELLA to enter into a « big four » of actors which have already undergone real-conditions tests at sea and at this power output, with success. The Ushant application of D10 offers a true credibility, as a showcase for other isolated places worldwide. This model especially applies to ASEAN, where it could bring an appropriate and carbon free solution.

Strengthen by this technological success and by our local attachment and anchorage, SABELLA's ambition is now to represent France and our expertise so as to build a bright industrial and commercial future that will answer to the actual energy challenges, for economy, ecology and society.



SABELLA

Tidal power pioneer, driving for of the energetic transition

With the strong raising awareness of the repercussions of climate change on our planet and the political understanding of the need to take environmental responsibilities, the marine renewable energies have been lately called to the forefront of the energy mix of tomorrow.

Founded in 2008, SABELLA is an **innovative tidal and ocean in-streams turbines developer**, supplying reliable turnkey energy solutions worldwide.

After the successful immersion of the D03 prototype in 2008, SABELLA stands out with the completion of its demonstration project in Ushant, Sabella D10 being the **first tidal stream turbine immersed and grid-connected to the French national grid**.

ISO9001 certified, SABELLA offers a range of medium to high power tidal in-stream turbines, so as to fit the characteristics of each site.

With a differentiated and economically optimized range of technologies, protected by appropriated patents, SABELLA endeavors to promote a **new energetic model tailored for remote grids on islands and isolated shore communities**. Based on a clean and reliable resource, the model offered by SABELLA to these markets is a sustainable alternative to costly and polluting fuel-based power generation.

| | | |
|-----------------|-----------|----------------------|
| 2008 | 20 | 2 |
| Foundation date | Engineers | Field-tested devices |

Insular energetic model

DOM-TOM, ASEAN, Americas, subarctic, islands

Why tidal stream power?

Tidal turbines harness the energy of marine currents, generated by the gravitational attraction of the Moon and the Sun, resulting in numerous advantages:

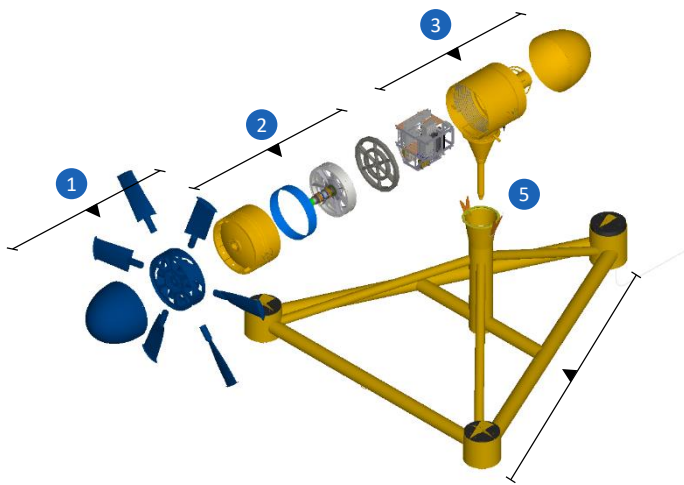
- ▶ **Unlimited** and **permanent** source of **clean** power
- ▶ **Reliable** and **predictable** energy, allowing a precise estimation of the power production and an optimal and easy sizing of energy storage
- ▶ A **worldwide distribution** of the resource
- ▶ **No impact on landscape**



THE TECHNOLOGY

Sabella D10 : leading edge of industrial series

Simplicity – Reliability - Ruggedness



Sabella D10 is based on technological concepts tested and validated during D03 demonstration project, which henceforth constitute the differentiating technological principles of SABELLA's design.

- 1 **Horizontal axis turbine with fixed symmetrical blades and no yaw drives**
→ No complex kinetics
- 2 **Direct drive synchronous generator with permanent magnets**
→ No wearing parts
- 3 **Inboard conversion and transformation**
→ Possibility to connect several devices to one export cable
- 4 **Gravity-based stabilization of the support structure**
→ No damaged to the site after decommissioning
- 5 **Modular architecture**
→ Dissociation of the dynamic stability and energy production function to simplify the maintenance operations

Deployed on the seabed and hold in position by its gravity-based foundation, the tidal device do not have any visual or acoustic impact at the surface.

Furthermore, neither the maritime traffic nor fishing activities will be disturbed by the device as it is deep underwater and where marine current are the strongest. There are no conflicts of interest for the marine environment.

A credo inherited from the Oil & Gas: **technological ruggedness** guaranteeing the **reliability of underwater equipment** for a **continuous power production** leading to:

- **An investment costs minimization**
- The **reduction of failure risks**, due to mechanical sophistication leading to a lower need for maintenance of the device in a hostile and difficult to access environment. **The time span of maintenance operation can reach 7 to 10 years** against 2 to 5 years for SABELLA's competitors. This is also a key point to decrease the costs of exploitation and maintenance

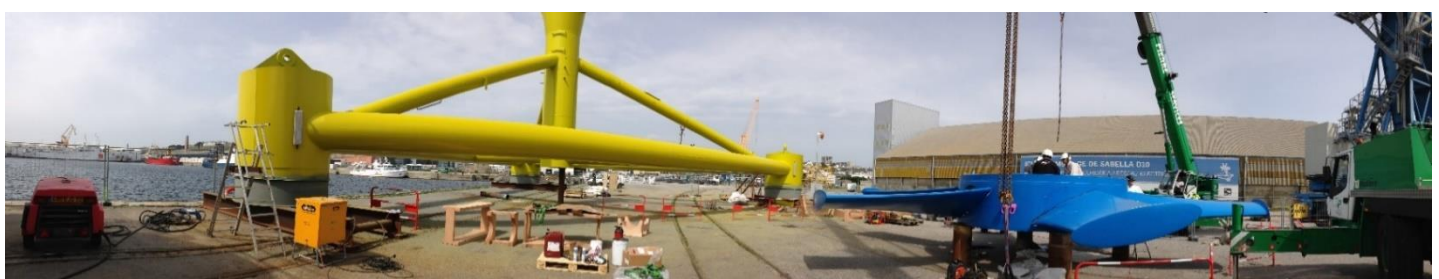
Proof of its reliability and economical competitiveness, SABELLA certify its client an optimal energy production with respect to the environment and to the sea users.

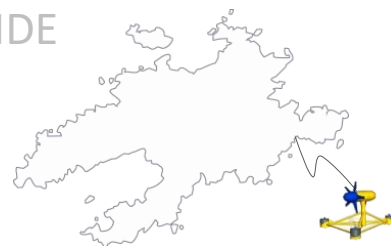


Technical specifications

Given its technical characteristics, Sabella D10 belongs to the closed circle of **full-scale high-power tidal turbines** tested and validated in **operating conditions**.

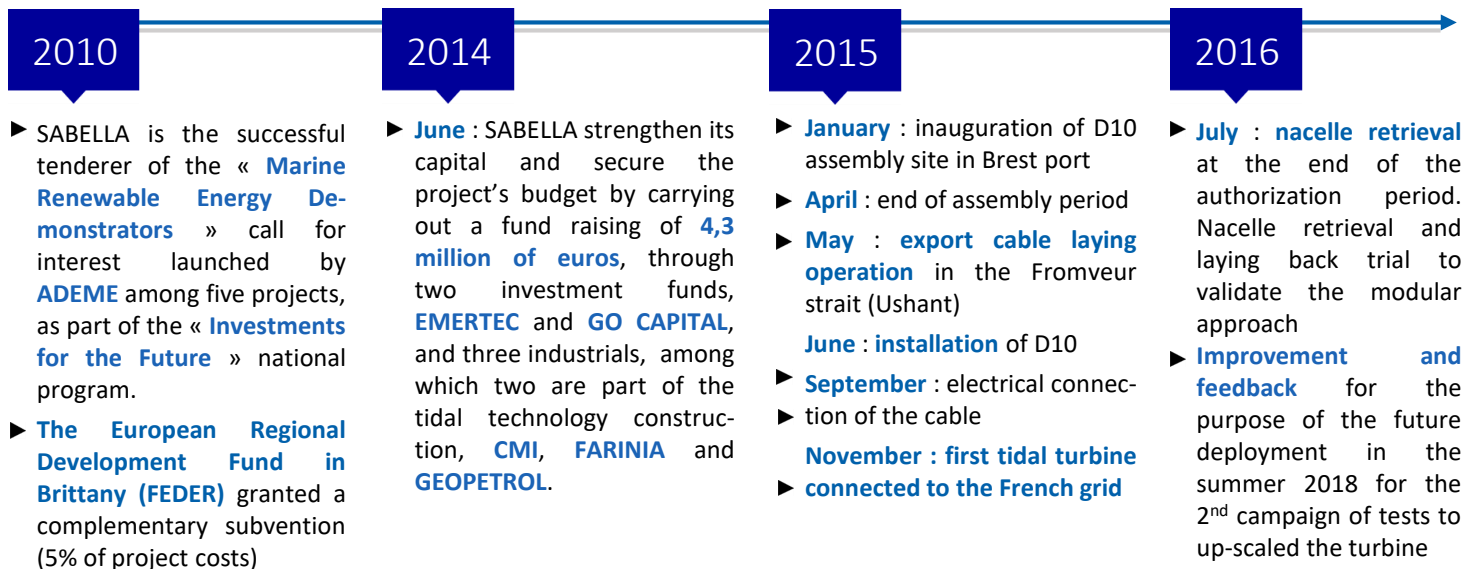
| | |
|-----------------------------|---------------------------|
| Rotor diameter | 10 meters |
| Maximum power output | 1 MW @ 4 m/s |
| Support structure | Gravity-based |
| Height | 17 meters |
| Mass | 450 tons |
| Footprint | 20 x 20 meters |
| Rotational speed | 5 to 20 rounds per minute |



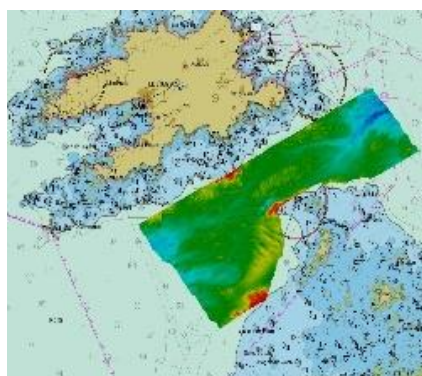


Sabella D10 – Ushant project

Six years of innovation to complete a flagship tidal energy project



The key steps of the project



Physics, environmental and social site characterization

- Localisation : Fromveur Strait
- Max current speed: 4,2 m/s
- Depth : 55 meters
- Distance to the coast: 2 km

Thanks to bathymetric measurements, a numerical model of the currents has been made. This study allows to define the future position of equipment both in the sea and onshore and to ensure an appropriate sizing.

Coupled with the environmental impact study from which is established an environmental monitoring protocol, the relevant administrative and technical authorizations have been obtained.

In parallel, the information and consultation actions and process have been led with the public and several key stakeholders (islanders, representatives from the sea user, elected representatives...)



Engineering

- The design engineering of the Sabella D10 is launched in 2012, relying on trials on the pilot Sabella D03. Tests in basin undergone with the CNR-INSEAN (Italy), after being selected by the MARINET project have confirmed the performance and hydrodynamic loads of the device.

- IFREMER and BUREAU VERITAS have also shared their expertise with SABELLA's engineers one. One provides its collaboration for marine environment characterisation and the second for the publication of the first calculation guide for characterisation of tidal turbine. This is the first step toward a draft of a frame of reference for standardisation.



Construction & assembly

- Sabella D10 is 50% made in France and 50% locally made : blades and bulbs are made of composite, nacelle and support structure made of steel, cats-iron ballasts, generator electrical chain
- In January 2015, the assembly site in Brest port has been inaugurated, 5th East quay.

- Apart from the electrical chain that is pre-integrated to the nacelle before the delivery, most of the sub-subsystems are transported and then assembled on the site.
- The assembly phase ends up with the antifouling painting and the installation of the sacrificial anodes in April 2015.



Export cable laying

- The export cable links the turbine to the land at Pors Arlan, on the South coast of Ushant.
- The Argonaute, a ship equipped with a DP1 dynamic positioning system, is chartered for the laying, in May 2015. A ROV and a team of scuba-divers are watching and assisting the operations.
- After being stabilized and protected with 200m long cast-iron shells, the cable is pulled to the land by floating and then laid on the seabed.
- Once the laying ended, the cable is unwound along a specific scheduled route. Its extremity, equipped with a semi-conductor, is submerged into the water and put in place afterward until the final junction



Turbine installation

- During the neap tide in June 2015, the turbine installation on the seabed is done in one package, process allowing to decrease the time span for marine operations.
- To lead this delicate operation in difficult conditions, a « cargo heavy lift » has been mobilised plus three tugboat. Those three are able to keep the ship in position in addition to its own mooring system.
- A ROV is following the descent of the device and checking its position when its installed. A gyrocompass has measured a 0° pitch and 139° position. Those measurement prove the perfect orientation of the turbine on the seabed, the operation is accomplished.



Grid connection

- The connection between the export cable and the cable was supposed to happen right after the turbine installation, but the operation has been rescheduled in September 2015 because of the bad weather and sea conditions.
- A DP1 ship, the Argonaute is again chartered for this operation.
- Both extremities equipped with « dry-

mates » semi-conductors are recovered to the deck and installed on a guide plate to ease the junction. An arch is also used to guide the submersion and to stick to the bending radius of the cable. Once the connection is made, the entire cable can be deployed again. The communication system from the land with D10 is made, the brakes are opened: the turbine is now rotating and producing its firsts kWh.



Lifting

- In July 2016, after twelve months of tests and at the end of the authorisation period, SABELLA has retrieved its turbine (only the top part of the modular tidal device, dissociable of the gravity-based foundation).
- A ship with a D2 dynamic positioning system with redundancy, the Aker Wayfarer has been chartered, assisted by a watching ROV.

Following the turbine retrieval and the successful test of the second turbine layout on the foundation, the modular architecture of the system is validated.

The turbine is brought back to Brest port for a detailed technical check-up. Some land infrastructures of Ushant has also been brought back to Brest for the expertise. The foundation and export cable have stayed on site.

A full year of trials and environmental monitoring



After an entire year of tests, the D10 project has allowed SABELLA to gather a crucial feedback on this new kind of energy production. The knowledge acquire from the different aspects of the tidal turbine demonstration is, for sure, a competitive asset for SABELLA. The challenge has been completed for this high capacity turbine, and SABELLA is now part of the elite circle of 4 to 5 competitors on the planet.

Strengthen by this success, SABELLA aims to pursue its learning process with a second campaign of trials and production-injection with the retrieval of the turbine in the summer 2018.

Electricity production and injection to the grid

Production > 70 MWh

Sabella D10 has produced **more than 70 MWh between November 2015 and March 2016**, reaching maximal power output around 400kW during this period.

The injection to the grid has been **supervised by EDF SEI and ENEDIS**, producer and administrator of the Ushant grid.

On the other hand, the **signal quality produce by D10 has been controlled and validated** by EDF SEI and ENEDIS, regarding its voltage, frequency and harmonic.

The optimistic results of D10 offered a new perspective of a 1 MW maximal power output possibility for the second campaign of trials.

Sizing and structural behaviour

Mechanical integrity

During this full year of experimentation, D10 has been dealing with diverse environmental conditions, including high tidal coefficient and several winter storms. Thanks to all the embedded sensors and *in situ* scuba-diving observation operations, the mechanical integrity of the device has been insured. The following conclusions have been drawn:

- ▶ **Excellent structural holding of the rotor**
- ▶ **Efficient stabilisation on the seabed and no movement of the structure**
- ▶ **No vibration modes with damages to the device**
- ▶ **Good thermal dissipation**

These conclusions have been substantiate by further analysis with the deeper technical assessment of the nacelle, back in Brest port.

Installation means and process

Modular installation

SABELLA has made the choice to submerge its device in one unique package. This choice has highlighted the rarity of ship with dynamic positioning with lifting gears strong enough for such a heavy load.

Moreover, during the deployment, significant weaknesses have been observed regarding the ship capacity to hold a steady position, despite the presence of three tug ship to assist. Those weaknesses have led to partial damage to the cable.

This failure has motivated the choice of a new installation philosophy which will be modular and pluggable and would allow the use of strong dynamic positioning ship but with standard means of lifting, often used in oil and gas industry.

The lifting and laying back operation of the nacelle has been done in July 2016 and has already approved **the suitability of the modular architecture**.



Control/Command and driving

Driving validation



The damaged export cable has generated functional losses and driving issues, but it has allowed to test different ways of driving and the control/command of the device has been improved with new electronic redundancies. The initial redundancies have already allowed to check the **exploitation flexibility** of the device, even in a deteriorated running.

Environmental monitoring

Environmental innocuousness



The improper laying and the partial damaged to the export cable have disturbed the environmental data acquisition for some sensors. However, the registered data by the autonomous sensors have clearly confirmed the **innocuousness of the device toward the submarine fauna and flora** as well as the acoustic emergence.

Social acceptance

Appropriation of the project



Thanks to the amount of **public meeting**, the **continuous communication** and **regular information on social medias**, the D10 project is followed and appropriated since the beginning by the Ushant inhabitants. This technological blue adventure is raising a real craze by the population. In addition, being the first French grid-connected tidal turbine, D10 generates a **rising interest from national public decision-makers**.



Strategies & perspectives

SABELLA, actor of the energy transition



An energy model for islands

Energy distribution is a major question for non-connected communities such as islands and far-flung places, energetically isolated. With a price of electricity to the roof compared to the continental interconnected grid and a strong dependency to fossil pollutant energies, these areas are a key stake for the energy transition. SABELLA has understood this problematic and has focused its development toward these isolated regions, away from the grid, economically receptive to the deployment of tidal solutions even still industrially immature. Current electric production of such isolated communities based on polluting and costly diesel power generators whereas marine current is cost-competitive, predictable, clean, silent and invisible. Several initiatives have emerged to start the energy transition for islands and far-lung areas, to commercialised low carbon emission integrated solutions that fit the needs of the population.

Thanks to its experience with D10, SABELLA is from now on a key partner for the developers of such projects. The company is an active participant to programs for the development of renewable energy on islands, providing its expertise to develop **hybrid production** and the **use of fuel free electricity**.

SMILE

Joint project with a collaboration between diverse developers including SABELLA, different academic partners as well as Brittany communities, the SMILE project focuses on the development of **new smart energetic project that will coupled storage, renewable energies and smart grids** to be used on the islands of Ponant, Yeu and Ushant.

As Ushant as already started its energy mutation with D10 pilot, its goals is now to substitute the entire electricity

production by a mix system including marine energy here from 2030.

Intelligent Community Energy (ICE)

The **INTERREG « ICE »** (Intelligent Community Energy), part of the **SMILE program** and supported by **BDI** (Brittany Innovation Development) is following the **MERIFIC** project. SABELLA has been asked to develop a tidal infrastructure at a bigger scale and to maximize the injection of its production to the Ushant grid.

Local Energy loop (BEL)

Under the aegis of the Brittany region, an energy transition convention has been signed between the three islands of Ponant (Sein, Molène, Ushant) in order to **develop a local energy loop** (BEL) on this three islands. They have been labeled as positive energy territories for the green growth.

Second trials campaign

In this context and after the complete technical audit, the D10 turbine will be reinstall on its foundation. This second campaign will allow **to strengthen the previous acquire feedback and to increase the maximum power output**, but also to **secure the energy supply to Ushant**, in the expectation of the future pilot farm deployment.

« PHARES » project

Convinced by the adequacy of the technical solution of SABELLA and of the renewable energy supply of Ushant project, **AKUO ENERGY**, first French independent energy renewable producer, has decided to associate with SABELLA for the development of a tidal pilot farm. **The farm will be composed by two tidal D12 turbines with a maximum power output of 1,2 MW and a diameter of 12 meters.**

The raising project from this cooperation, **PHARES** (Advanced Hybrid Program to Renew the Energy in Insular Systems) propose a hybrid insular energy model, coupling different means of electricity production from renewable sources (tidal turbine, wind turbines and photovoltaic panels) for a maximized substitution of fuel power generators. A powerful storage solution will secure the equilibrium between offer and demand of energy, ensuring an optimal exploitation of the renewable production sources and a minimal action for the fuel power generators.

The commissioning of these different components of this energy system are scheduled for 2019, for an exploitation that would last around 20 years.

Further to the electricity supplying security, the penetration ratio of renewable energy in the energy mix of Ushant is estimated to be 70%, leading to a reduction of the same level of carbon emission.

Commercial deployment of the Fromveur

The pilot farm foreshadows a wide deployment in the Fromveur Strait, allowing the acquisition of **multiple feedback (production, stability, social acceptance, environment)**. An exploitable potential of 500 MW of tidal energy power output would match the energy needs of the residential sector of the Finistère region, mainly powered by Flamanville and Cordemais nuclear power plants.

Brest polder

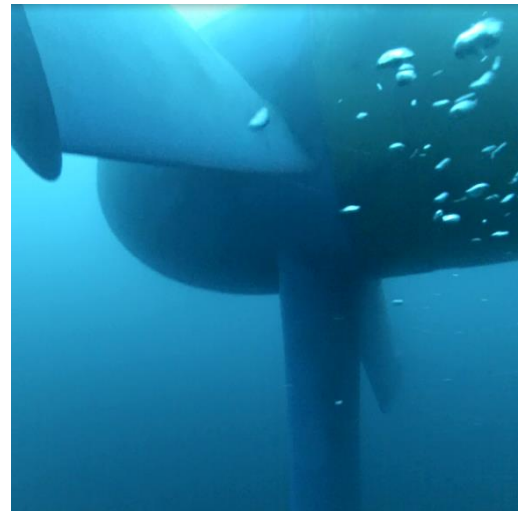
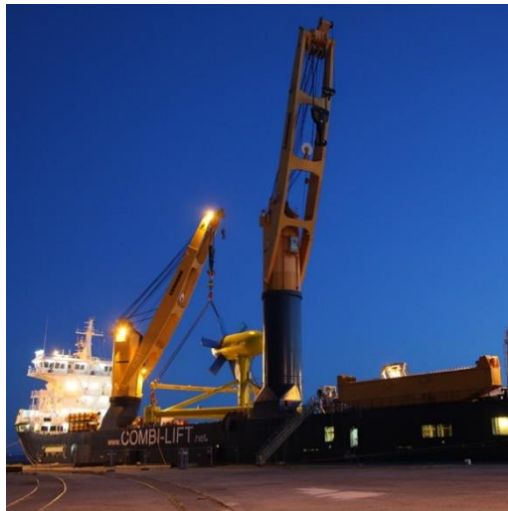
The pilot farm is also the prelude to the development of a new industrial field that will enhance Brest port with the transformation of the space into an industrial site dedicated to Marine Renewable Energy. This project is part of the expansion of the port project.

International development

In parallel, SABELLA keeps going with its development worldwide, targeting countries that are combining an attractive potential in tidal resources and a need for self-sufficiency and security of the electricity supply. In this way, SABELLA keeps making new relations and collaborations.

- ▶ **Philippines:** an exclusive partnership have been signed in 2015 with the local project developer, H&WB, for the development of a pilot farm in the San Bernardino Strait, where the potential for tidal energy is estimated at 500 MW.
- ▶ **Indonesia:** a significative industrial agreement signature and the creation of the MPS consortium with PT. Meindo Elang Indah and PT. Prima Langkah Pratama pave the way to a major tidal energy development in this archipelago of more than 17,000 islands.
- ▶ **North and South America:** projects at different stages are raising, particularly in the Canada's High North
- ▶ In the **DOM-TOM** and in **the islands across the globe:** SABELLA is pursuing its prospection and the identification of potential areas of development.



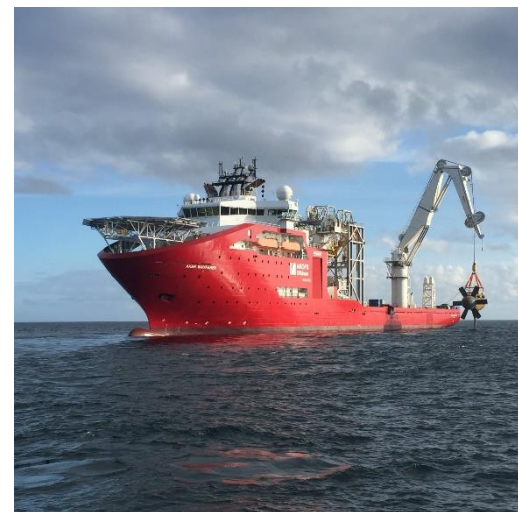
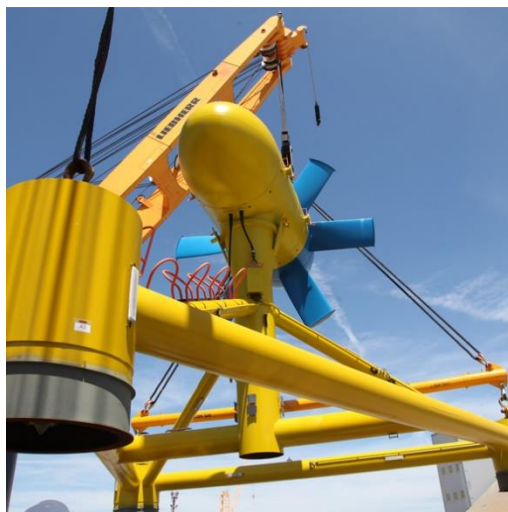
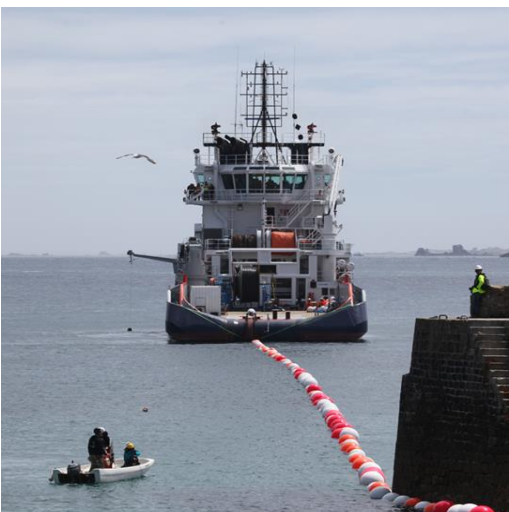
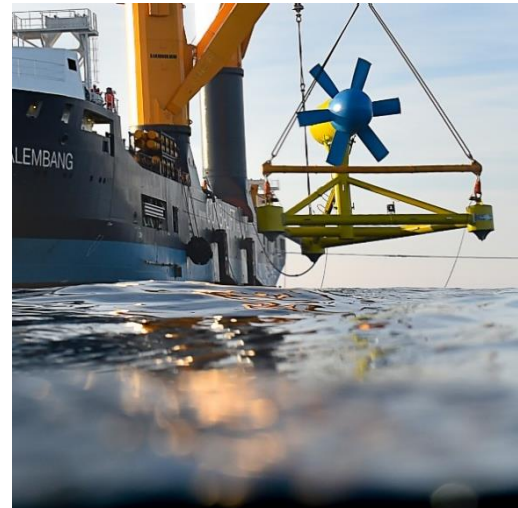


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