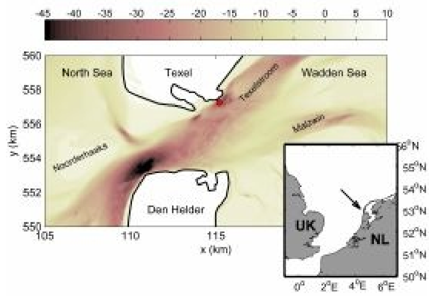
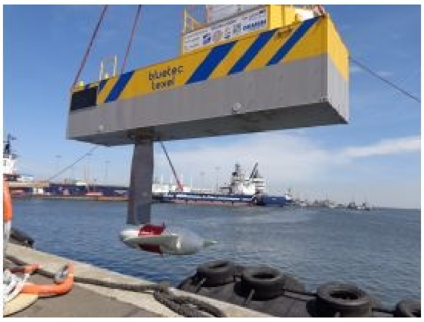
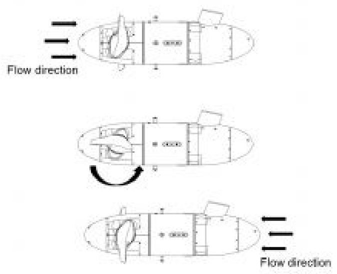
A FLOATING TIDAL ENERGY PLATFORM PROTOTYPE

BlueTEC Texel

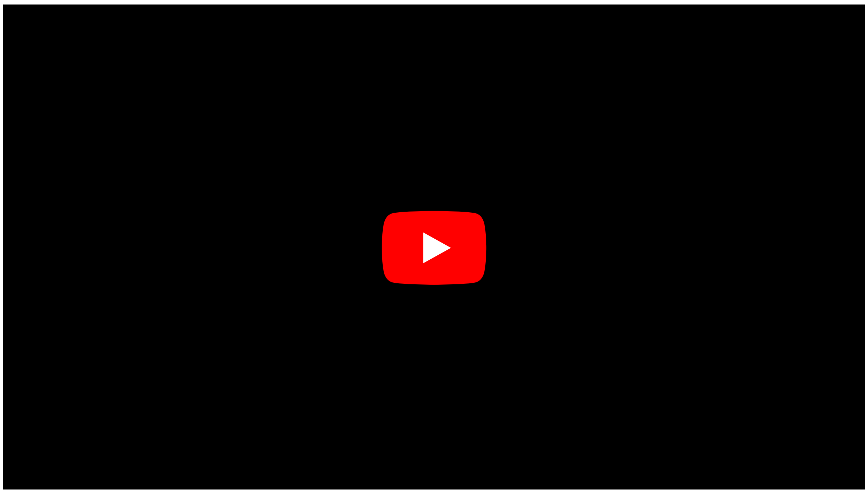






Traditional solutions for generating electricity from the tides, where tidal turbines are installed on the seabed, require high-end offshore installation vessels and do not allow for easy access for maintenance. The BlueTEC floating tidal energy platform has a different approach. It is a permanently moored platform which generates renewable electricity from tidal currents by holding a tidal turbine underneath. The BlueTEC Texel is the first prototype and serves as a demonstration platform and is being used for R&D testing purposes.

The project was realised through a partnership between companies active in the maritime and offshore industry; Bluewater, Damen Shipyards, Van Oord/Acta Marine, Tocardo, Schottel Hydro, TKF, Vryhof Anchors, NIOZ, Tidal Testing Centre, and the Port of Den Helder. The platform was installed off of the Dutch island of Texel in the Wadden Sea in the summer of 2015, initially equipped with a Tocardo T1 tidal turbine and in early 2016, re-installed with a larger T2 turbine.



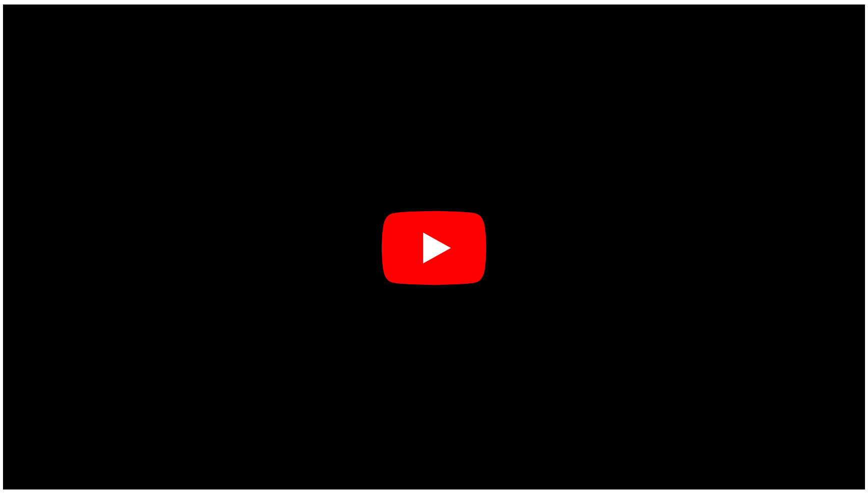
The BlueTEC Platform

The platform consists of three modules of standard 20” and 40” shipping container dimensions, allowing the system to be shipped at low cost to ports worldwide. The platform allows for easily assessed, dry storage of all critical electrical equipment. The strut holds the turbine underneath the platform, and a dynamic export power cable transports the generated electricity to shore. The platform is kept in place by four mooring lines, which are under tension with four drag anchors, allowing the platform to stay in place under all-weather circumstances, including storms (Figure 1).

Pre-operational Phase

Previous to the installation of BlueTEC, NIOZ conducted several oceanographic measurements to better understand the patterns of circulation near the Marsdiep inlet as well as to select an optimal deployment location. The results show that the region is mainly dominated by tidal currents. However, a wind-forced residual component in ebb direction was also identified. During ebb phase, i.e. during the period when the water flows from the Wadden Sea towards the North Sea, the circulation is marked by a strong current, which results in homogeneous vertical velocities. On the other hand, the flood phase is characterised by weaker and vertically sheared velocities, with the core of the tidal current found at subsurface, at approximately 15 metres depth. This peculiarity is particularly interesting, since the turbine is placed close to this depth of maximum velocities.

The transition from neap to spring tides is distinguished by increasing velocities during ebb, while the flood currents remain nearly constant. Spatially, the distribution of velocities depends on the interaction with the bathymetry, being stronger in the Texelstroom, the main tidal channel in the Marsdiep inlet. The BlueTEC location was selected (Figure 2) based on in-situ observations of the local currents, and also taking into account other factors such as, for instance, a safe distance from the navigation channel and proximity to the Royal NIOZ on Texel.



Offshore Installation

Prior to the first offshore installation, the turbine was fitted underneath the mid-module of the platform on the quayside. The module was then lifted into the water by crane and connected to the two end modules while in the water. Meanwhile, offshore, the drag anchors were embedded in the sand at the site using a multi-cat vessel. Hereafter, the platform was towed to the site and hooked up to the mooring lines and tensioned using the multi-cat vessel’s on-board winch. Next, the power cable was lifted through an opening in the platform and connected to the platform. The remainder of the cable was laid on the seabed with weights to hold it in place, and its end connected to the grid onshore (Figure 3).

The offshore vessel used was a 37-metre-long multi-cat with dynamic positioning class 1 (DP1). Compared to other ocean energy installations, this is a relatively simple vessel (Figure 4). The offshore installation work required attention to the times of the tides and their direction. The weather window adhered to for the offshore installation was three full days of waves with significant wave height (Hs) lower than 1.0 metre, and wind speeds of maximum 5 Beaufort.

During the turbine change-out, improvements to the platform were made to ease the offshore installation.

Monitoring Programme

The monitoring programme involves a suite of instruments mounted on and in the platform (Table 1), as well as on the turbine. The Royal NIOZ investigates the impact of the tidal energy extraction on the local flow and sediment balance using two downward looking ADCPs on either end of the platform. They measure the incoming flow and the flow just behind the turbine and can be used to observe local bathymetric changes. Moreover, also the efficiency of the turbine is examined under various hydrodynamic conditions, varying from neap to spring tide; high and low discharge conditions and thus strength of the stratification, and under various wave conditions as measured with the AWAC, which is moored on the seafloor next to the platform.

DGPS	The Differential Global Positioning System measures the platform’s geographical location and its heading with high accuracy.
Downward-looking ADCPs (x2)	Acoustic Doppler Current Profiles measure the velocity profile throughout the water column in Eastward, Northward and Upward direction using pings.
Horizontally-looking ADCPs (x2)	Acoustic Doppler Current Profilers measure the water velocity at the front and the back of the turbine.
AWAC wave profiler	Uses the same technology as ADCPs to measure wave height, speed and direction
Weather monitor	The weather monitor records the meteorological data at the site, such as wind speed, wind direction, rain fall and temperature.
	The motion sensor measures the

Motion sensor	movements of the platform such as the roll, pitch and heave.
Strut strain gauges	Strain gauges were mounted onto the strut to measure the forces from the turbine.
Module coupling strain gauges	The platform consists of three modules inter-connected by six rods. Strain gauges were mounted onto the rods to measure the forces exerted on these rods.
Mooring line load shackles	The mooring lines include a shackle near the platform which measures the forces (loads) on the mooring lines.
Water sensor (x2)	Two water sensors inside the local equipment room detect if there is water within the module.

Table 1: *Monitoring equipment installed on BlueTEC Texel.*

Turbines and Performance

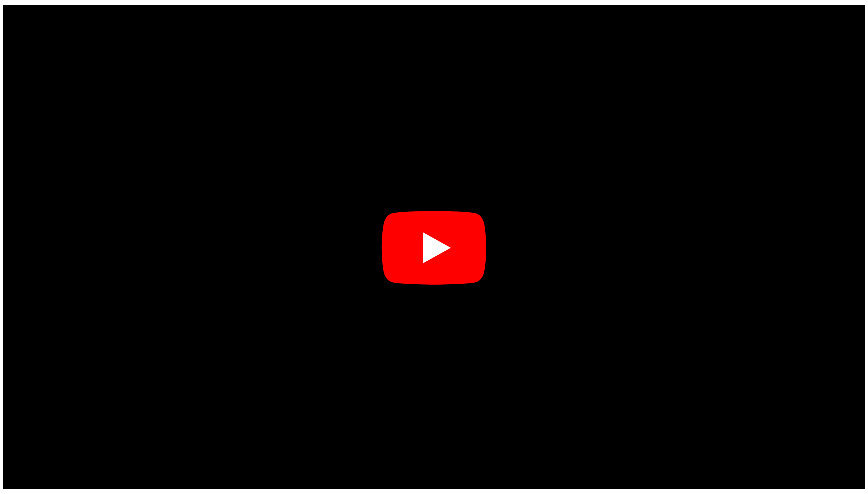
To achieve very high availability, Tocardo's turbines are kept as simple and robust as possible. It implies no yawing and no pitching system. Because tidal turbines are intended to work with flow coming from both directions (front to tail and reverse), the blades need to be orientated according to the direction of the flow. The bidirectional rotor design makes it possible to turn the two blades 180 degrees simultaneously for reverse flow operation (Figure 5).

To evaluate the performances of the T2 turbine, two horizontally-looking ADCPs were installed to measure the water velocity at the front and the back of the turbine. The ADCPs only use the central (forward looking) beam and measure the velocity at 16Hz. Each cell is 50cm long and the last cell centre is 25m ahead of the ADCP. One ADCP is mounted on the strut behind the rotor blades; observations at instances when the blades are in the path of the acoustic beam are discarded.

To measure the undisturbed water velocity, it is necessary to measure it at least two rotor diameters ahead of the 9 metres diameter rotor plane, explaining the need to have a 25 metres measurement range. Preliminary results show that the turbine efficiency is in line with the expectation.

Marine Growth

The platform was coated with anti-fouling on all subsea surfaces, which was provided through the Seafront project. Although these coatings notably prevented marine growth on the platform, significant marine growth in the form of mussels was found on the mooring lines and subsea power cable auxiliary equipment. Marine growth on these systems can significantly impact the system's dynamic behaviour and potentially the lifespan of the equipment. This experience revealed that marine growth in the local area should be well researched or tested far in advance of a project such that it can be properly accounted for in designs, anti-fouling plans, and operation and maintenance regimes.



Acknowledgements

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More information

- **Ponsoni**, L., Nauw, J.J. et al. (2016). Tidal energy extraction in the Marsdiep inlet: oceanographic measurements and site selection for deployment of a floating energy plant (*in preparation).*
- **De Vries**, J.J. (2015. On the local Dynamics of Currents and the estuarine Marsdiep Basin, PhD thesis, Utrecht University (http://dspace.library.uu.nl/handle/1874/317821)
- **Website** BlueTEC: http://www.bluewater.com/new-energy/bluetec-phil/