


## Corporate Introduction



**TTCARDO**

**Power production driven by the moon; the clean energy that tidal stream and tidal range can harness is 100% predictable, years in advance.**





***“It is our **ambition** to make tidal energy ‘top of mind’; on par with solutions such as solar and wind power. Whenever production of clean energy is considered, tidal energy is among the possible solutions. Tocardo is the market and thought leader on tidal energy and systems.”***

# Index

1. Power production driven by the moon
2. Board of Directors
3. Partner organisations
4. Ambition and philosophy
5. Market intelligence
6. Our technology
7. Technology and market potential
8. Proven track record
9. Product certification & other tests performed
10. Contact Tocardo



# Power production driven by the moon

Tidal energy is literally powered by the universe. The gravitational forces of the moon and the rotation of the earth work together to create ebb and flood. The resulting differences in height create water flows that generate incredible amounts of kinetic energy. As long as the moon, the earth, the oceans and gravity exist, there will be tidal energy. It is universal and more predictable than other renewable sources of energy.

It is no coincidence Tocado was founded in The Netherlands. When you live in a country that owes its very existence to understanding and harnessing the enormous forces of water, you develop a uniquely strong bond with water. Throughout Dutch history, water has been a continuous source of inspiration and innovation. When you combine this historical expertise with the current need for renewable energy and smart solutions, you get a unique opportunity: tidal energy.

We are a young, dynamic company based in Wieringerwerf, North Holland, Cornish and Scottish owned. We develop, design and manufacture power generating solutions that provide a continuous and reliable flow of tidal energy. For our future clients we apply the learnings that we gain - tide after tide - from our showcase project at the Dutch icon the Eastern Scheldt storm barrier. We have seen the impact our technology and commitment can have, and we believe that what we have can and will change the world for the better.



***“There is a tide in the affairs of men, which taken at the flood, leads on to fortune...On such a full sea are we now afloat.”***

William Shakespeare



# Board of directors

## A multidisciplinary team

Success in the ocean energy sector requires a multidisciplinary team with significant experiences across the breadth of skills needed to fulfil the demands of our clients. Tocardo's board of directors' tackles this, and consists of the following persons:



**Andries van Unen**, Tocardo's CEO is a driven and analytical person who likes to work with other people and involved parties. He is perfectly capable of translating new concepts and ideas into an agile approach to validate the intended outcome of a business case as quickly as possible. In the past Andries has worked for RWE/innogy affiliates, the Energy research Centre of the Netherlands and the HVC group. He brings extensive knowledge of energy markets and the energy transition project development with him. Andries is convinced that use of ocean energy resources is necessary to create a balanced and predictable renewable energy mix in the near future.



**Richard Parkinson**, is a highly skilled Master Mariner and entrepreneur specializing in complex offshore and subsea operations. Richard's offshore career started in the oil and gas sector in 1984. In 2005 Richard applied his knowledge and experience to a then young offshore renewables sector growing a small company Mojo Maritime into an extremely successful marine project management company which he sold to James Fisher Marine Services in 2015. Richard founded Inyanga in 2017 growing rapidly it to a multimillion revenue in less than two years. In parallel Richard founded HydroWing Ltd developing novel tidal energy solutions with a focus on safe and cost-effective installation maintenance.



**Jeremy Smith**, has founded QED Naval in March 2008 and has raised nearly £2.0m to finance the Subhub project and manages business development. Jeremy is used to delivering large scale procurement projects in his previous role within the Structures' Delegated Design Authority (DDA) on the Queen Elizabeth class aircraft carrier project. Jeremy brings decades of involvement in marine structures, R&D within ship and submarine structures and leadership experience gained through MOD, QinetiQ and its forebears DERA and DRA.

## Leadership

As well as having the board support from Tocardo, QED Naval, Inyanga Marine and HydroWing, Tocardo benefits from an associated and much wider pool of resource made available and on tap from each organisation.

We have got the courage and can take responsibility to shape a better future by driving renewable tidal energy technology.



# Partner organisations

## Collaborative partnership

Tocado is fully owned by HydroWing Ltd. and QED Naval Ltd. This tripartite, collaborative partnership brings together decades of multi-sector expertise as well as a blend of well tested, complementary products. The joint venture provides a truly end to end service with a spectrum of turbines, foundation systems, marine operations, as well as design, support and service expertise.

## Partnerships

To realise tidal energy projects, we work together with expert partners in offshore installation, foundation systems, maintenance and project development. The Tocardo team is supported by an ever-expanding group of internationally recognized industries and institutes:

- Inyanga Tech SAS
- Dutch Energy Form Water Association (EWA)
- Dutch Marine Energy Centre (DMEC)
- European Marine Energy Centre (EMEC)
- Gems B.V.
- Huygens Engineers B.V.
- Maridea B.V.
- Ocean Energy Europe (OEE)
- Zelospark B.V.

## Recognitions

Since January 2020 Tocardo has received the following awards and labels:





# Ambition and philosophy

## Vision

It is our vision that clean, safe and reliable energy is a basic need for people and organisations to develop and evolve. Tidal energy offers a dependable power source that is a valid alternative or an addition to existing green energy solutions.

## The problem Tocado addresses

Although a 100% renewable energy mix on a global level is not foreseen in 2050 power generation forecasts, the rise of renewable power sources will severely impact the grid. The need for solutions like batteries, distributed energy resources, and smart grids to manage volatility is essential. The reliability and predictability of tidal stream gives it significant advantage over any other form of renewable power, and is easy to integrate into the energy system.

While tidal energy is well proven, the sector has been slow to industrialise due to the high costs of manufacturing, installation and O&M. Reliability and scalability have hindered commercialisation of the sector as a whole with many in the sector trying to develop their own 'complete' solutions; ie turbines as well as foundations, and as not being specialists in all areas, there has been a lack of focus and success resulting in struggle to attain political confidence and much needed revenue support schemes.



## Our answer

To claim our position in the market, Tocado is the first independent tidal turbine developer with a focus on pure turbine development. We develop and manufacture our turbines on a commercial basis, already in a more advanced stage of the tidal energy market. Tocado is focused on bringing down the Life Cycle Cost (LCC) of tidal turbines, further de-risking design (RAMS/FMEA) and increasing the power output at the same time. This will specifically bring down the LCOE and increase the market attractiveness of tidal power.

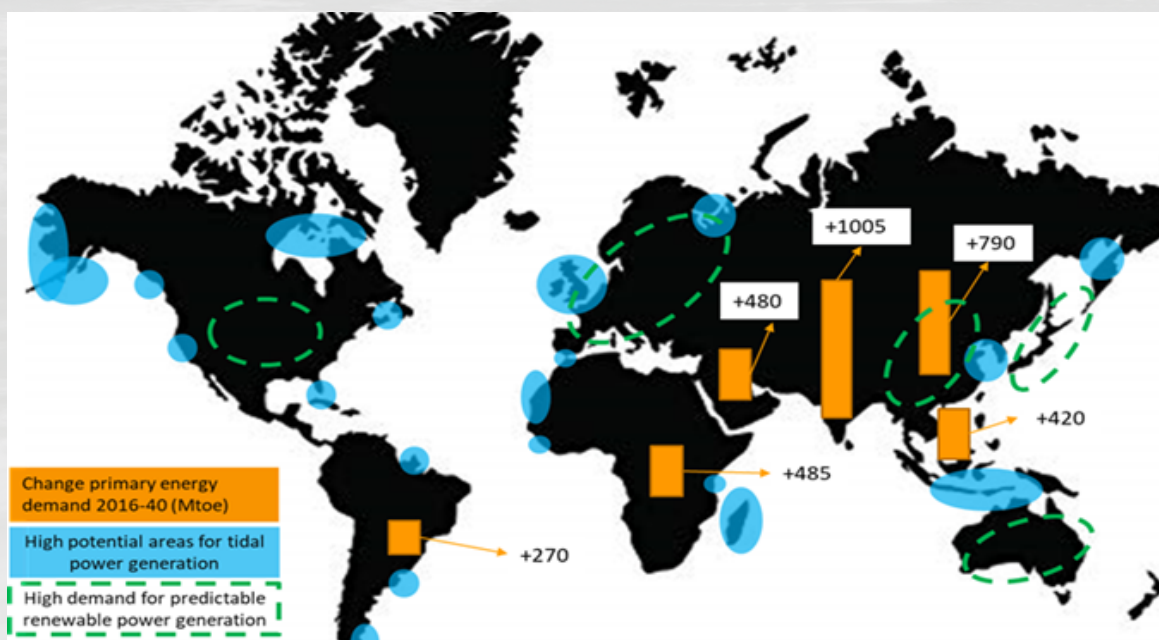


# Market intelligence

## Global potential

Renewables have grown rapidly in recent years, but in many cases intermittency of supply remains an issue. Ocean energy has been in development since the mid-20th century with the French La Range tidal barrier (1966) as a landmark project. The promise of unlimited clean ocean energy has never stopped. With the worldwide tidal market potential being **500 GW**, tidal power innovations such as our turbines hold huge environmental and economic potential.

The map below provides an overview of the locations with highest potential for tidal energy. This however does not mean that other locations are not interesting.



## Key facts

- A 60% growth in energy demand is forecasted for the next 30 years;
- Cost of fossil fuelled power generation will rise due to carbon-tax based schemes;
- Wind and solar energy alone cannot replace fossil fuel baseload due to their inherent intermittency;
- Oceans contain vast renewable energy potential – theoretically equivalent to more than double the world's current electricity demand;
- Tidal stream has the potential to generate 2.4% - 5.0% of global power consumption by 2050, for Europe only this percentage is 10.0%.



# Our value proposition

## Tidal stream power generation is a local business on a global scale

The driver for tidal stream power generation is combatting climate change by reducing the carbon emissions with a 100% renewable, 100% reliable and 100% predictable energy source. Because of the geographical limitations and specific local characteristics for successful tidal power (micro)plants the highest value can be generated on specific locations for specific type of customers. Tidal stream power is the missing renewable energy source to create a local balanced power generation mix.

## Coastal and island communities

The Tocardo turbines are the ideal solution for local community power generating demand at islands or to serve coastal communities located in regions with medium to high tidal flows. This also counts for a community that is close to a bay or lagoon that has a narrow entrance to the ocean. In general, narrow channels connecting larger bodies of water are those with significant tidal velocities.

## Climate resilient infrastructures

Globally, around 10% of world's population (a little under half a billion people) lives in the 2% of land that is below 10 meters elevation with much of this population living in Asia. Changing global climate is causing a range of consequences that pose significant threats for coastal zones. To protect these coastal zones significant efforts will be made in the years to come. Tocardo's OTP project installed in one of the gates the of the famous Dutch Delta Works is a leading example of a climate resilient infrastructure. Integrating power generating solutions with sea defences or flood protection can contribute positively to the cost-benefit analysis of this worldwide increasing demand for infrastructure investments.

## The 2030 Agenda for Sustainable Development

Our tidal power solutions contribute to six out of the seventeen Sustainable Development Goals (SDGs) adopted by all United Nations Member States in 2015.





# Tocado technology

## Background

Our turbines operate below the surface in marine and river environments. They have to deal with strong currents, extreme loads and floating debris and are generally quite hard to reach for maintenance. These challenges have determined the design principles of the Tocardo turbines.

1999, technology development started with a floating venturi system, after several technology changes the company moved towards the centre-based generator concept, with two blades. This is a concept showing a lot of similarities with the technology used in the wind turbine industry. With the on-going experience the company gathered from the first full scale turbines, we completely parameterised the design of the turbines and developed the current free flow turbine technology portfolio. Nowadays the company owns 20 patents worldwide.

## Direct drive generator

We have chosen for a direct drive generator which minimizes wear and tear and the need for maintenance.

## Rotor blades

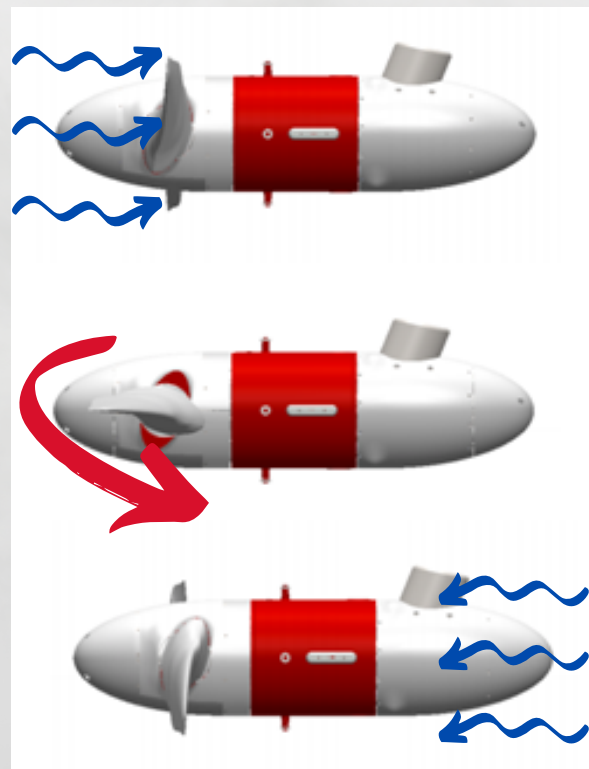
Our turbines are equipped with uniquely designed, fixed pitch rotor blades. Pitching mechanisms need maintenance and can fail, resulting in damaged rotor blades. In combination with a direct drive generator with variable speed our turbines are able to operate in a large bandwidth of water speeds.

## Bi-directionality

Another unique and patented feature is the smart reverse system which enables the turbine to operate in opposite tidal flows. Instead of using maintenance sensitive yawing systems which turns the entire turbine, we only let the rotor blades flip. The whole system is powered only by the force of the water (passive pitch).

## Lifetime

We believe in simplicity and a robust design approach. The turbines are made to last with very minimal maintenance. The design lifetime of our tidal turbines is at least 20 years.





# The market for Tocado turbines

## Deployment

Our turbines can be deployed in tidal sites and river sites. The core technology is the same for all turbines. The turbines can be deployed in water as shallow as 4.5 meters and in seas over 50 meters deep. Each tidal energy project has to be very specific in its design due to all local variables: customer type, project finance, remoteness, seabed, protected species, local fisheries, legislation, subsidies and height of the waves. Local criteria are the most important factor in deciding how big (large a diameter) and how much capacity the turbines need to have for a cost-effective and environmentally friendly energy solution. For every project Tocado will look for the best solution when it comes to turbine configuration, foundation and park design.

## The best solution for your projects

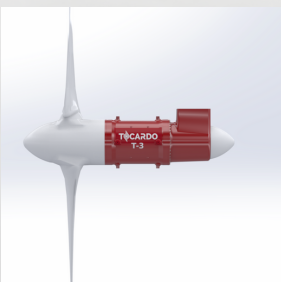
We can scale the size of the generator and the size of the rotor blade in order to make it fit for a project site or to meet your needs. Tocado's range includes the following turbines:



**T-1 Series** - Tocado brings innovative Dutch water technology to a whole new level with the T-1 turbine. The T-1 is our most proven turbine. By generating energy in a predictable and cost-effective way the T-1 is the best tidal turbine in its market segment with power outputs ranging from 40 to **100 kW**. Due to its relatively small size, it can be installed in shallow waters (4.5 meters and deeper). The T-1 turbine power generation commences at flow speeds of 0.4 m/s and peaks at 4.5 m/s producing 100 kW.



**T-2 Series** - The T-2 turbine series comes next in line as a scaled-up version of the T-1 series. Tocado T-2 tidal turbines offer a step up in power generation capabilities on a commercial basis which benefit more industrial applications or deployed as an array. The T-2 is a medium sized tidal turbine suitable for various locations, with power outputs ranging from 100 kW to **250 kW**. The T-2 turbine power generation commences at flow speeds of 0.4 m/s and peaks at 4.5 m/s producing 250 kW.



**T-3 Series** - Cost-effectiveness is critical to making the business case viable and to convince decision makers that tidal energy solutions are a good investment. This goal will be achieved by the commercial launch of the Tocado T-3 turbine series with power outputs ranging from 100 kW to **450 kW**. The improved control strategy and improved transition piece allow the turbine to be installed in combination with a variety of foundation systems and in various conditions. The T-3 is the only commercially available tidal stream turbine in the mid-sized turbine segment.



# Proven track record

## The global leader in tidal energy solutions

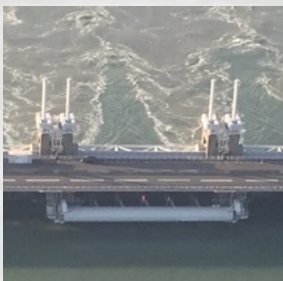
Tocado is one of the most experienced tidal energy companies in the sector. The first tidal turbine was deployed in 2005. Since then, the company has scaled up and tested the current turbines technology both in the Netherlands and abroad.



**Project Den Oever, operational 2008 – 2019** - In 2008 Tocardo installed a single 100 kW T-1 tidal turbine at the test site at the Afsluitdijk in the north of the Netherlands. The purpose of this turbine was to demonstrate the technology and its operational capabilities during a longer period. The patented bi-blade system was also tested on this turbine. In April 2019 this site was decommissioned as a result of the multi-year project to raise the Afsluitdijk in connection with the expected sea level rise.



**TTC Den Oever, operational 2015 – 2019** - In 2015 Tocardo installed three T-1 turbines in the Afsluitdijk tidal barrage, a 32 km long primary sea defence, next to the existing installation with the single T-1 (project Den Oever). All electricity produced was fed into the grid. The turbines provided vital data and experience in turbine arrays. The array had a capacity of more than 300 kW, producing electricity for approximately one hundred local households. In 2019 this site was also decommissioned.



**Tocado OTP, operational since 2015** - In September 2015 Tocardo has installed, together with Huisman Equipment B.V., a tidal power plant in one of the gates in the Oosterschelde barrier. The entire Oosterschelde system consists of five T-2 tidal turbines supplied and designed by Tocardo which are all installed on a single hydraulic lift frame designed, constructed and supplied by Huisman Equipment. The turbines can be lifted for maintenance or safety reasons. The peak power capacity of the tidal plant is approximately 1.2 MW at 4.0 m/s water speed. This project brings the technology readiness level (TRL) of the T-2 turbine series to TRL-8. Tocardo is responsible for the operations and maintenance of the entire plant, that is currently still in operation and injecting electricity to the grid.



**TFS, operational 2016 - 2017** - Offshore operator Bluewater as project leader has partnered with a group of leading companies such as Damen, Vryhof, TKF and Van Oord to realise a floating tidal energy platform, named TFS. The platform was installed and commissioned in the summer of 2015 in combination with a single T-1 turbine. In early 2016, the platform was commissioned with the T-2 turbine. The platform generated clean electricity from the tides in the Wadden Sea in the north of the Netherlands. In March 2017 the TFS platform has been operated at the Fall of Warness, the tidal test site of EMEC.



# Product certification & other tests performed

## DHV-GL Statement of Feasibility

Tocado's T-2s turbine series has received a Statement of Feasibility by DNV-GL in 2016. This marks an important step towards a full type certification of the technology. Royal Haskoning DHV, the Dutch certification body with offices in 30 countries, has performed a technology due diligence into the T-2 turbine as well. It has concluded that Tocardo generally covered the majority of risks associated with deploying turbines and has endeavoured its best to minimise technical risk at affordable cost seeking robust and practical solutions for risk mitigation, using best and relevant engineering practice.

## Blades tests at Knowledge Centre WMC

The design life time of the blades is 20 years, in principle our blades should be 20 years maintenance free. The T-2 blade design is a scaled version of the Tocardo T-1 blade design. A fatigue test of the T-1 blades has been performed at the facility of Knowledge Centre WMC (part of LM Wind Power) in accordance with DNVGL-ST-0164 18.2.

## Powertrain tests at ORE Catapult

In 2017, Tocardo has performed a powertrain test the at the ORE Catapult facilities, using the powertrain from the floating tidal energy platform demonstrator used at EMEC (TFS). ORE Catapult is a renowned technology innovation and research centre for offshore renewable energy based in Blyth in the UK. Testing is an important step in our engineering process and the data collected will play a role in our future turbine designs



## Environmental impact studies

During the years 2015 – 2016 no correlation with the number of grey seals and normal seals counted (increase / decrease of numbers) in the Eastern Scheldt and the presence of tidal turbines was identified. Tocardo strives to produce fish friendly, innovative turbine solutions. In April 2019 a fish mortality was executed at the Afsluitdijk during the operations of three (3) T-1 Turbines, in front of the turbine the current velocity was 2.5 m/s. The results of the tests with smolts and silver eel are in accordance with the outcome of the model calculations, as for both species the immediate mortality is 0.00%. No turbine related injuries of fish were observed, although fish clearly interacted with the turbine blades.



# Contact Tocardo

## **Powering the next level in tidal energy**

If you want to be part of the successful transition towards renewable energy, your first thought should be of Tocardo. We are setting the benchmark in power generating solutions. Feel free to contact us!

## **Office / workshop facilities**

*Address:*

Nieuwzandweg 1  
1771 MZ Wieringerwerf  
the Netherlands

*Phone:* +31 853 036 799

## **Online presence**

For latest news about our business and/or background information about ocean energy please visit [www.tocardo.com](http://www.tocardo.com) Our social media accounts can be found here: [LinkedIn](#), [Twitter](#), [Facebook](#) and [Instagram](#)