Optimised performance for two-way hydro turbines

TIDETEC

Optimising two-way hydropower

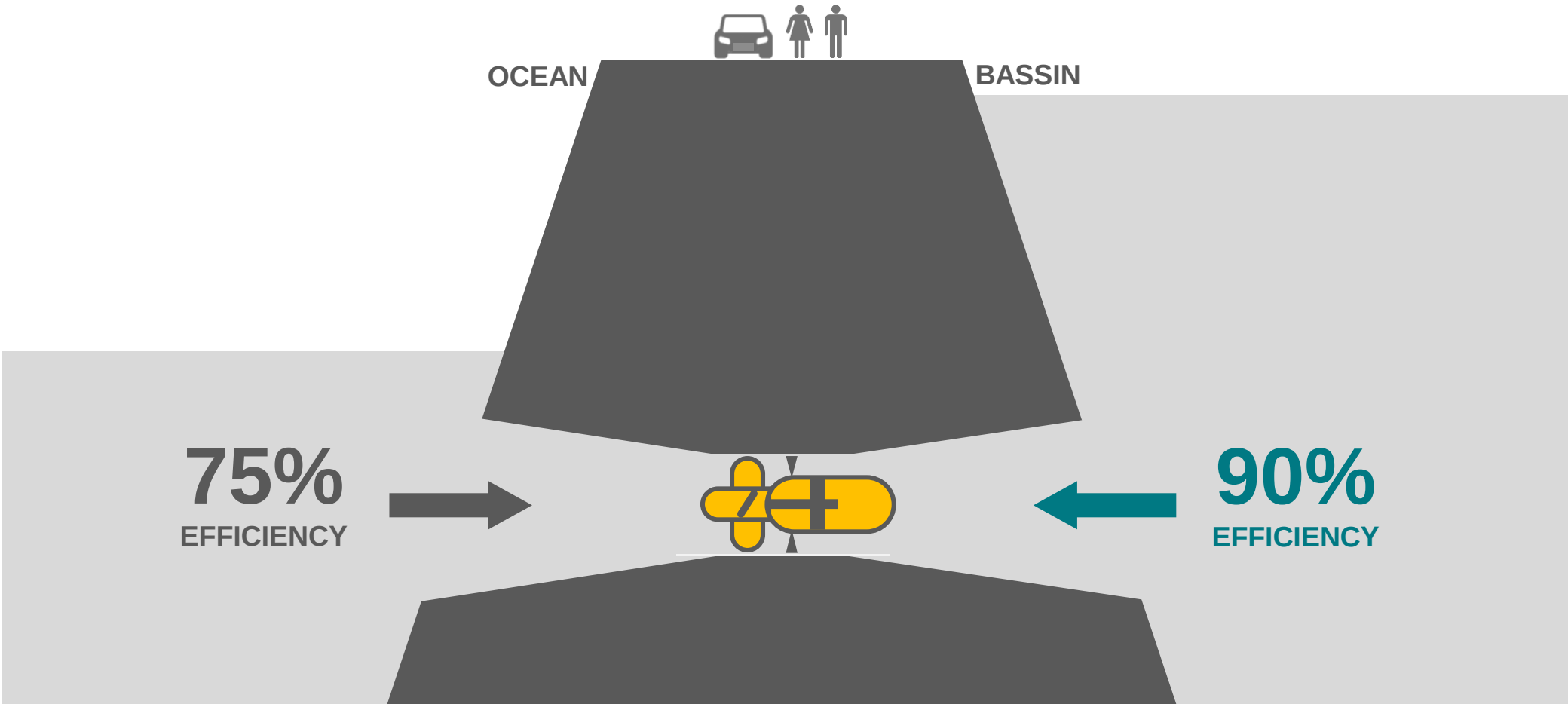
Projected tidal lagoons in UK can potentially deliver 12% of UK annual energy

Tidetec's patented solution can kick-start this £30bn market

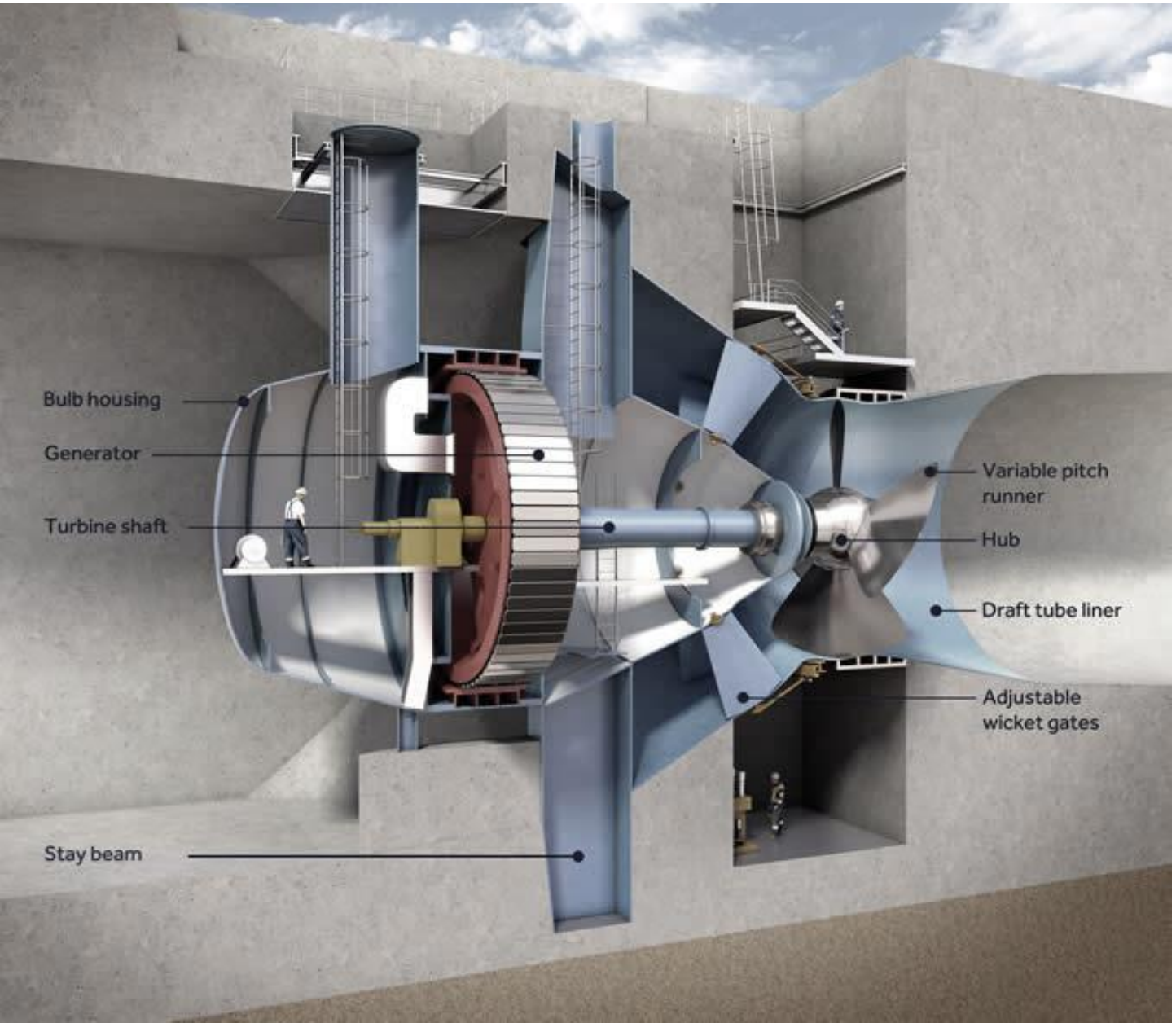
Tidal Lagoon and Tidal Barrier projects

TIDETEC
Revolutionary hydropower

Most tidal power plants today produce power in one direction. Projected tidal plants with two-way production have sub-optimal production



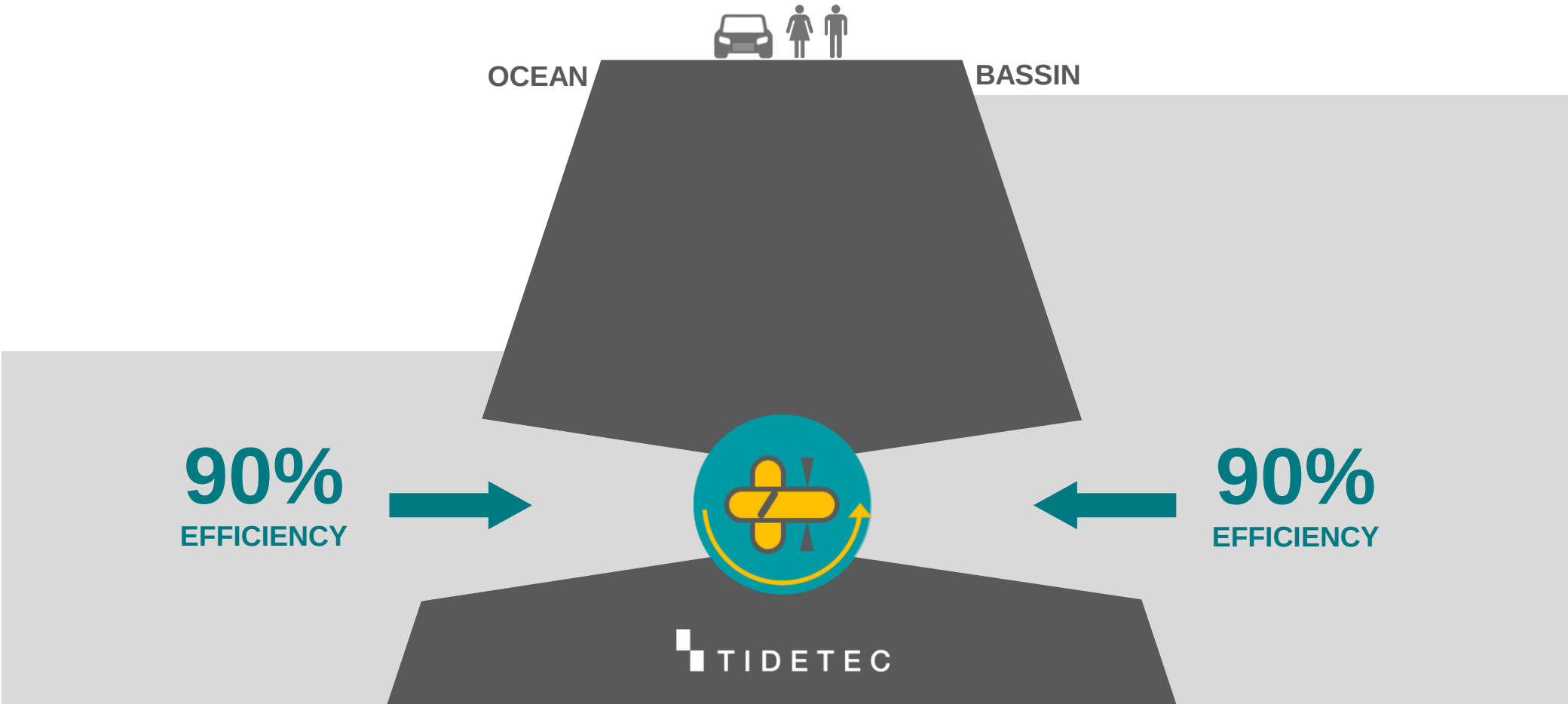
Traditional set-up - base case turbine

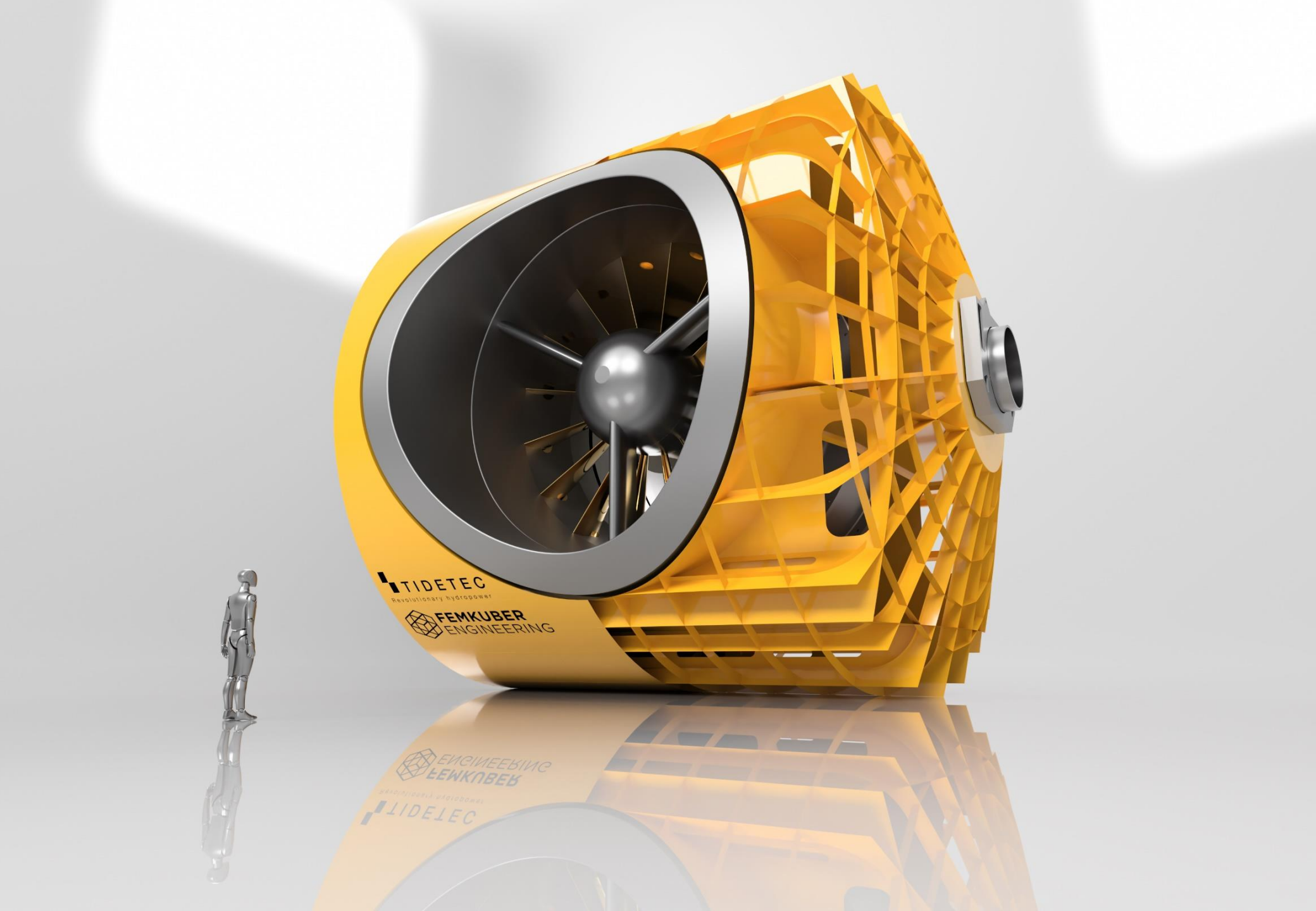


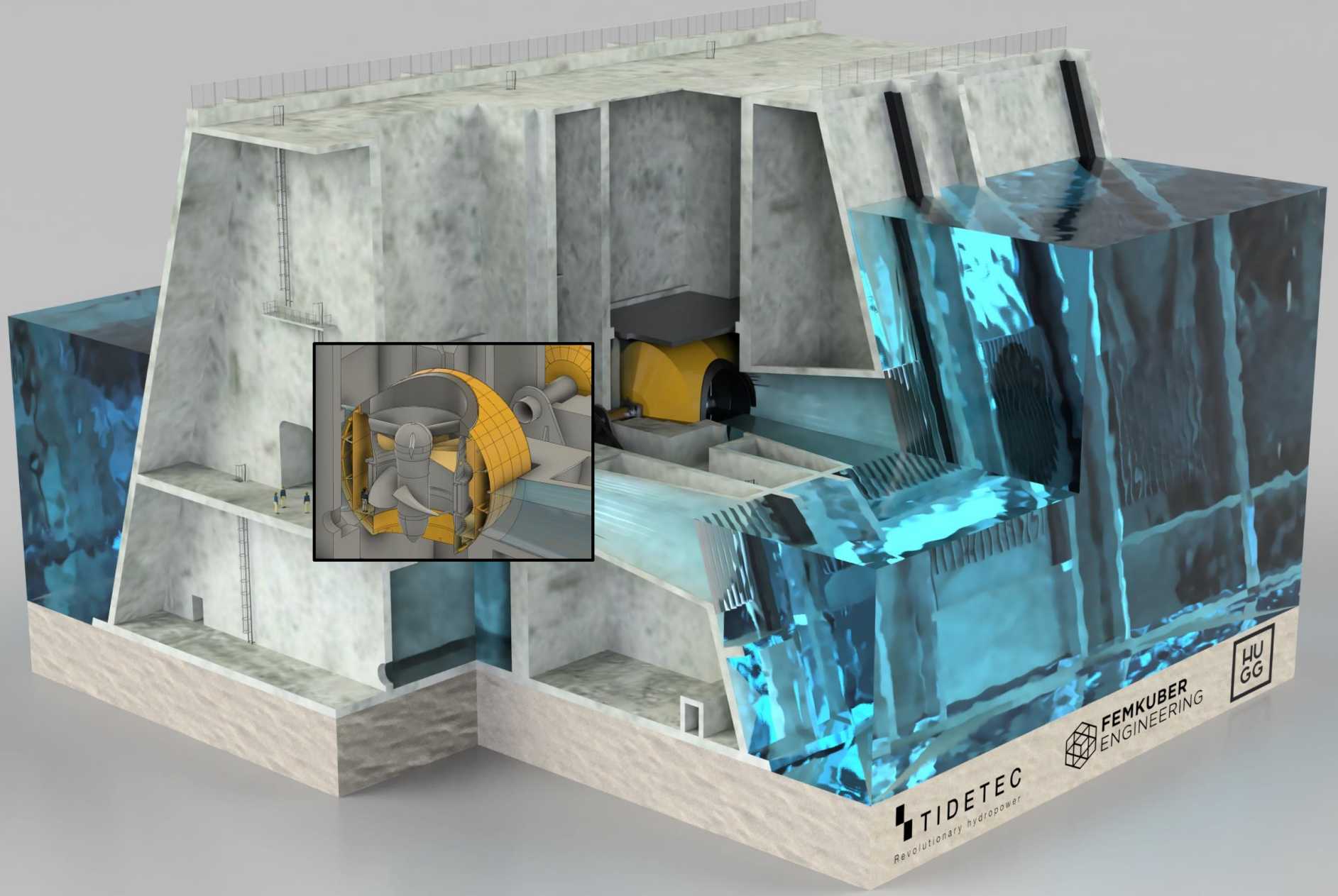
- Optimised one-way
- Less pumping efficiency and reverse mode
- Costly maintenance
- In-situ concrete section manufacturing

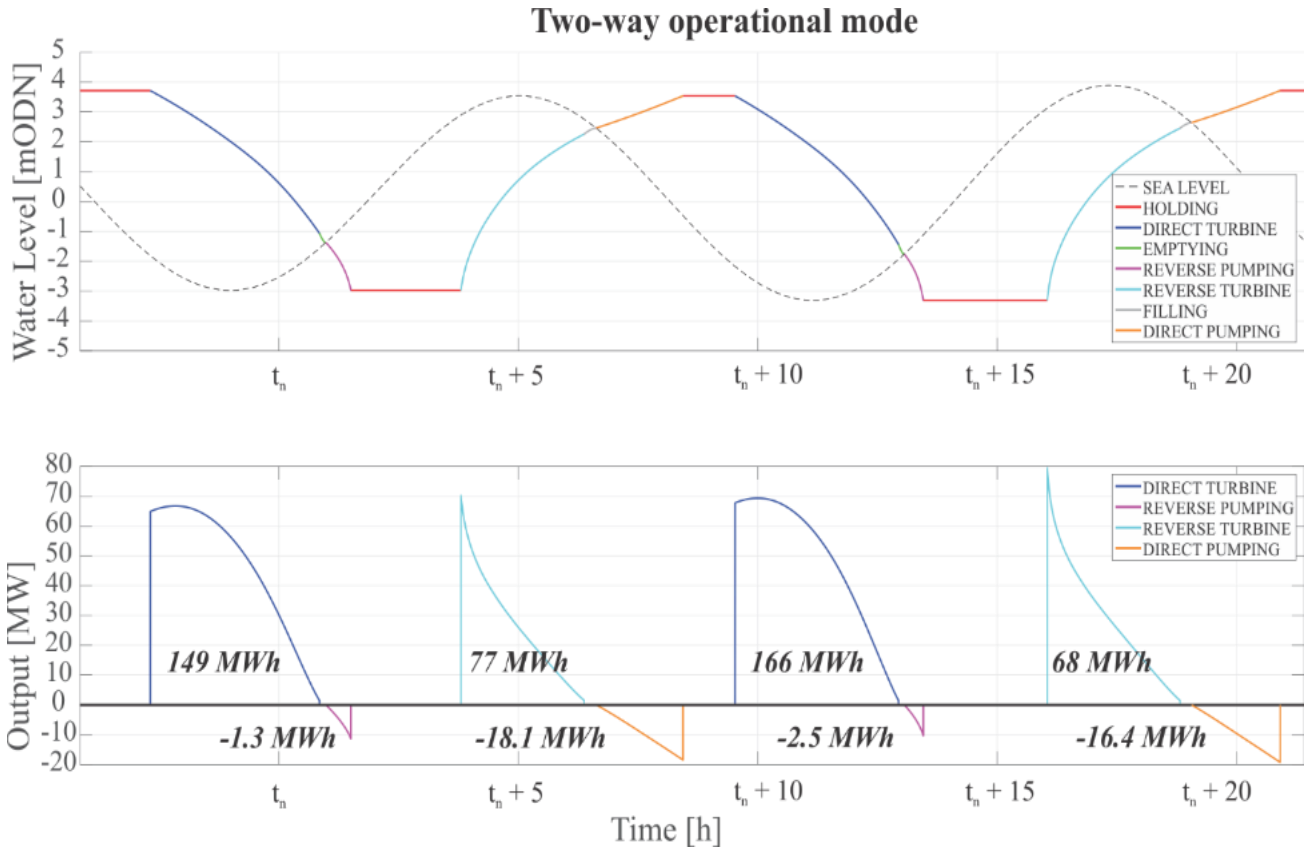
TIDETEC
Revolutionary hydropower

Tidetec improves the most effective tidal turbine technology by integrating the turbine into a rotating turret, enabling optimal efficiency both ways




TIDETEC
Revolutionary hydropower
FEMKUBER
ENGINEERING

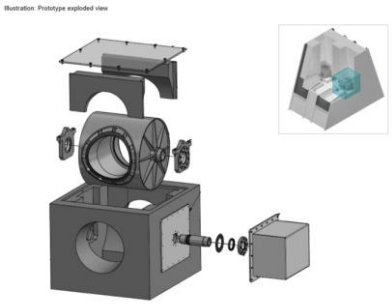

TIDETEC
Revolutionary hydropower
FEMKUBER
ENGINEERING
HUGG



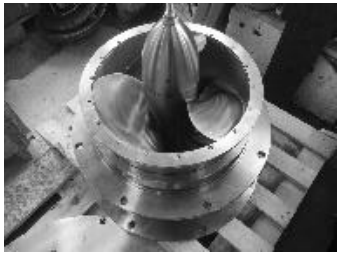
1. Rising tide and basin water level
2. Highest tide, barrage gates closed
3. Basin water held until an optimized head is achieved and direct/forward generation begins
4. Generation stops when the minimum head is reached and emptying/sluicing of the basin starts
5. Emptying/sluicing of the basin stops when the same level between the basin and the sea is reached and then reverse/backward pumping begins
6. Reverse/backward pumping stops when the maximum water lifting head is achieved or the lowest tide level is reached
7. Basin water held until an optimized head is achieved and reverse/backward generation begins
8. Generation stops when the minimum head is reached and filling/sluicing of the basin starts
9. Filling/sluicing of the basin stops when the same level between the basin and the sea is reached and then direct/forward pumping begins
10. Direct/forward pumping stops when the maximum water lifting head is achieved or the highest tide level is reached
11. Basin water held until an optimized head is reached and steps 3 to 12 are repeated.

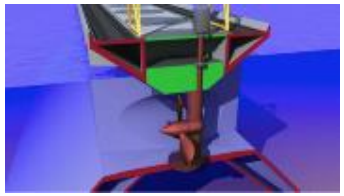
From patents to commercialisation

Turning mechanism and turret prototype

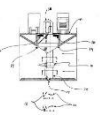


Turbine prototype





2003
Tidetec founded
by Per Kollandsrud



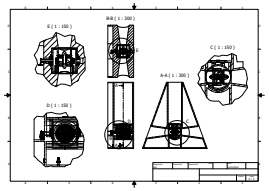
Per Kollandsrud
ounder files 3 patents

2013
Arne Kollandsrud
hired as MD

2014-2017
MEUR 1.9 Eurostars project
3 employees

2015
Nomination at
Tidal Energy Summit 2015

2016
New patent Rolling turret filed



2016
Functional scale model turning
mechanism tested in sea water

2017
Tidetec featured as promising
technology in Hendry review
All-Energy prize
Model turbine tested

2017/18
MoU Atlantis Wyre
Patent granted

2019
Collaboration Mersey Tidal
Project
Europe patent granted
Pumped hydro storage
application H2020

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Case study of impoundment that combines 0,7m reduction of flooding level in London with 300 GWh yearly power production and transport infrastructure

SITUATION AND CRITICAL ISSUE

*Safe*Coast*

London is in urgent need of enhancing/upgrading their flood protection system. This can be conducted by upgrading the Thames barriers significantly or by making addition pool/lagoon at the entrance of the Thames river. The Safe*Coast project will explore how flood defence and tidal power plants can be integrated. Integration will significantly reduce of the total societal cost for power production and flood protection.

TideTec SOLUTION

- **Concept:** TideTec proposes to build a tidal lagoon (27km$^{2)}$ that will act as flood protection, in addition to generating electricity
- **Flood:** Turbines (in pumping mode) in combination with sluices are able move/drain significant amounts of water away from areas prone to flooding, into a storage pool. The simulated reduction of sea level during a flooding situation is 60 – 70 cm*.
- **Electricity generation:** During normal tide cycles the pool will generate energy when water flows into the pool, and when it flows out. Total electricity production is simulated (by HR Wallingford) to be approximately 300 GWh*

Key numbers:

- Electricity – approx. **300 GWh*** yearly
- Flood protection - **60-70 cm*** reduction in sea level during 1000 year flood
- Estimated cost of project: **1b£***
- Very low environmental impact

Current partners:

TECHNISCHE UNIVERSITÄT MÜNCHEN

MAREVAL Hamburg

METROTIDAL

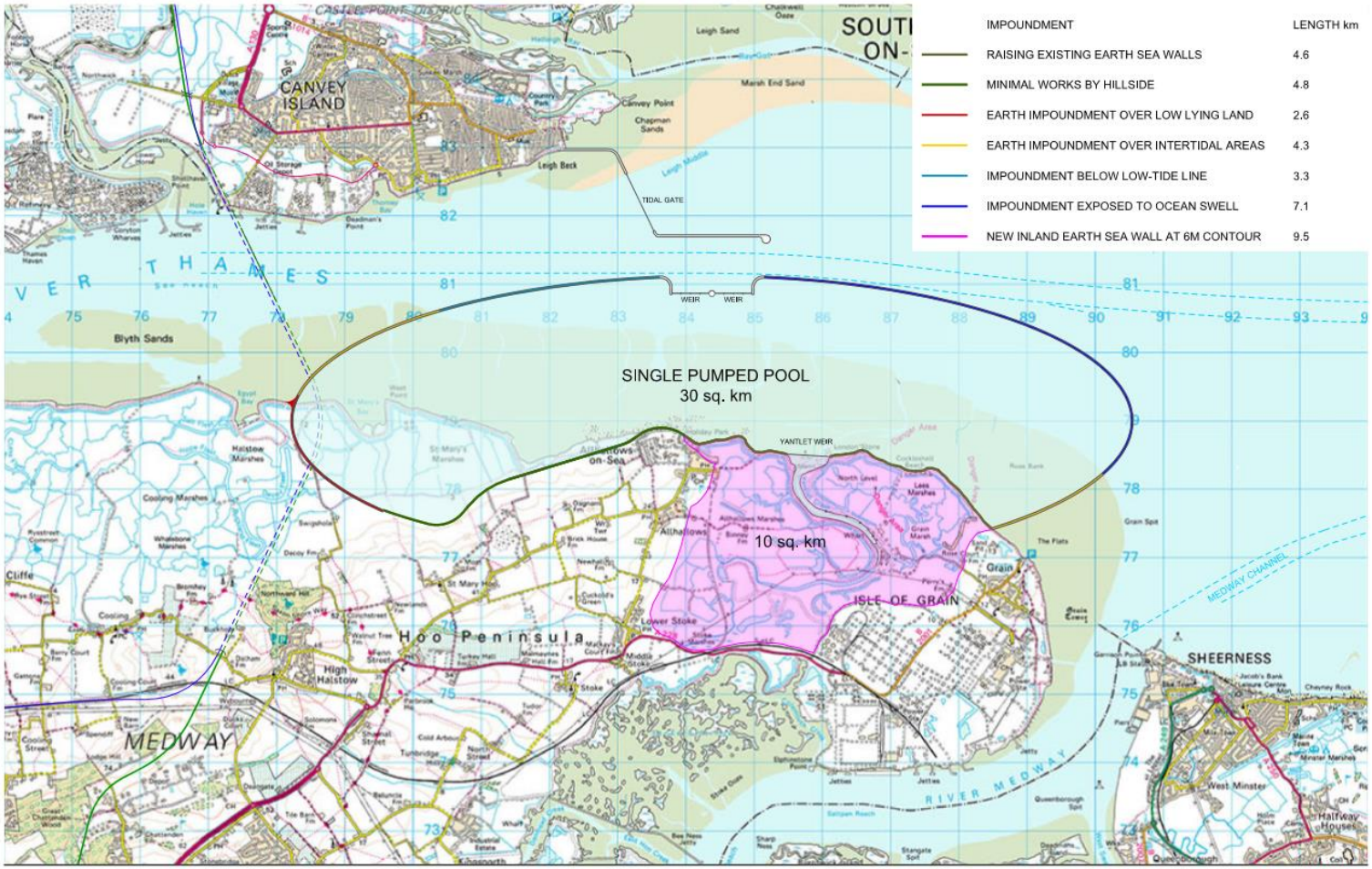
HR Wallingford

TIDETEC
Optimising two-way hydropower

Safe*Coast Eurostar project

METROTIDAL TUNNEL : SINGLE PUMPED POOL IMPOUNDMENT DIAGRAM

NOVEMBER 2015



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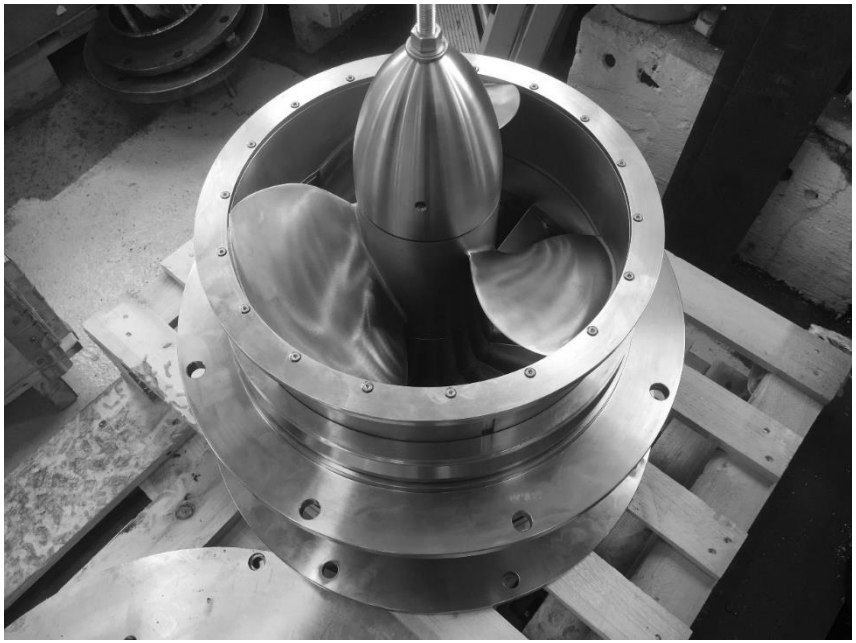
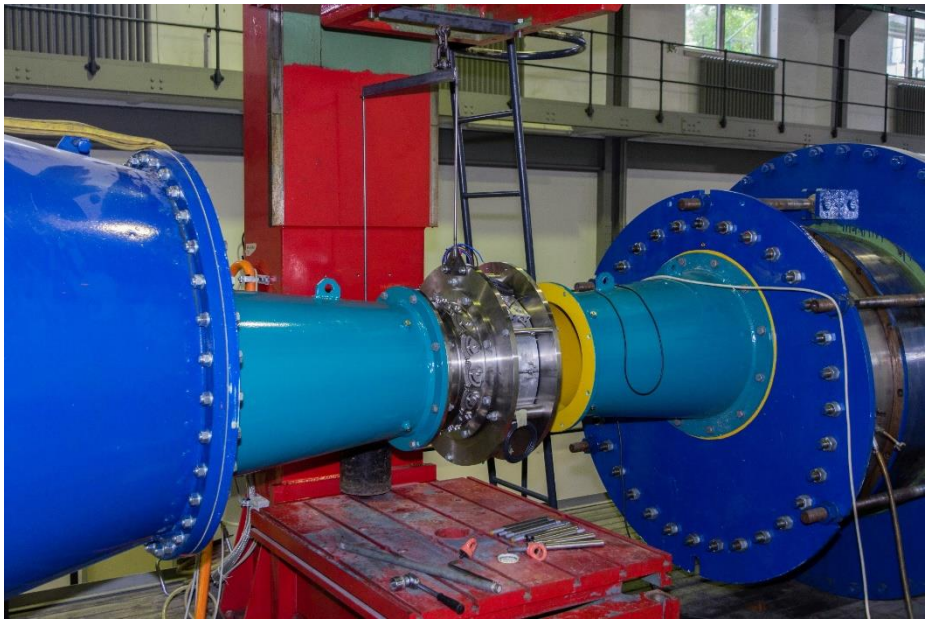
Optimising two-way hydropower

Model turbine and prototype tested and patented
Eurostar project 1.9MEUR





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2.0 DESIGN BASIS

PURPOSE

This prototype is intended to simulate a large scale barrage or lagoon application for a low head hydro turbine. The device will be tested in a tidal stream environment, but the full size application is intended for barrage and lagoon tidal power plants.

FOCUS

The focus of this prototype is the turning application, and the method of turning the device, not the turbine itself. As many different turbines can be modified to fit inside the turret, we have not focused on the turbine as a first priority. In addition we have designed the prototype so the turbine can be replaced, and changed to accommodate different turbines.

SIZE

The size of the prototype is chosen to accommodate a 340mm low head hydro turbine. This is a typical size for turbine testing in the hydro industry, and therefore a suitable size for our first prototype. A 340mm model of the Tidetec turbine will be produced at a later stage, at the Technical University in Munich after CFD-simulation and testing.

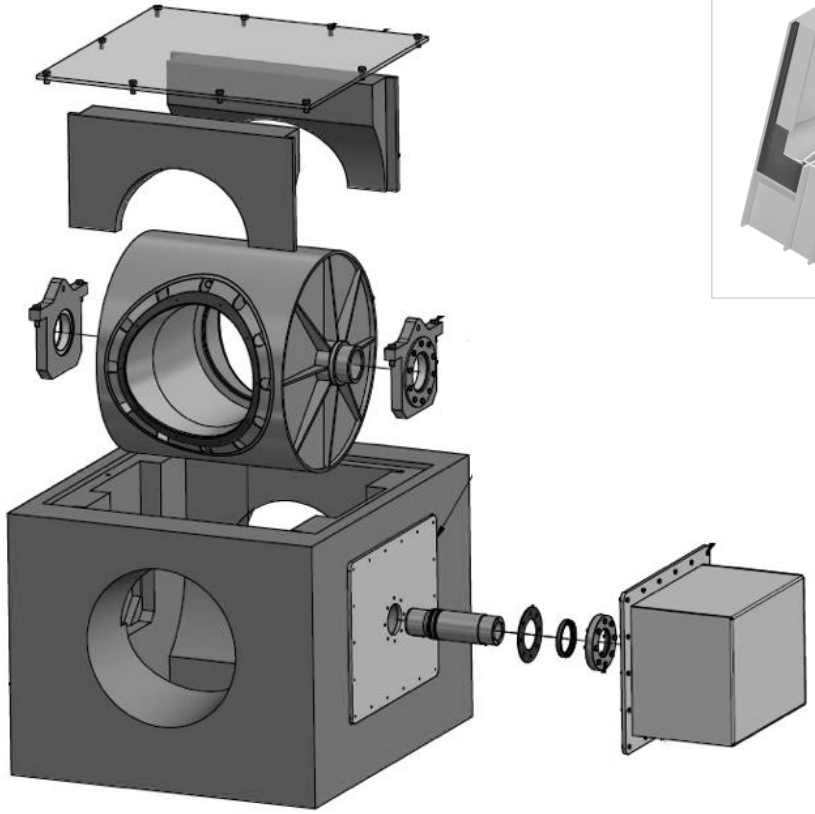
RESTRICTIONS

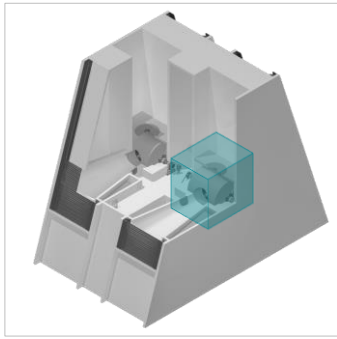
As the prototype is intended to simulate a large scale barrage system, many of the solutions and materials are chosen with this in mind. However, for some solutions it has been more practical to choose simpler or less costly solutions than what we would have for the full scale version.

ENGINEERING

Significant engineering effort has gone into design and contraction of this prototype, but we have planned for a larger engineering project for the full scale version.

Illustration: Prototype exploded view





Model turbine Technical University Munich

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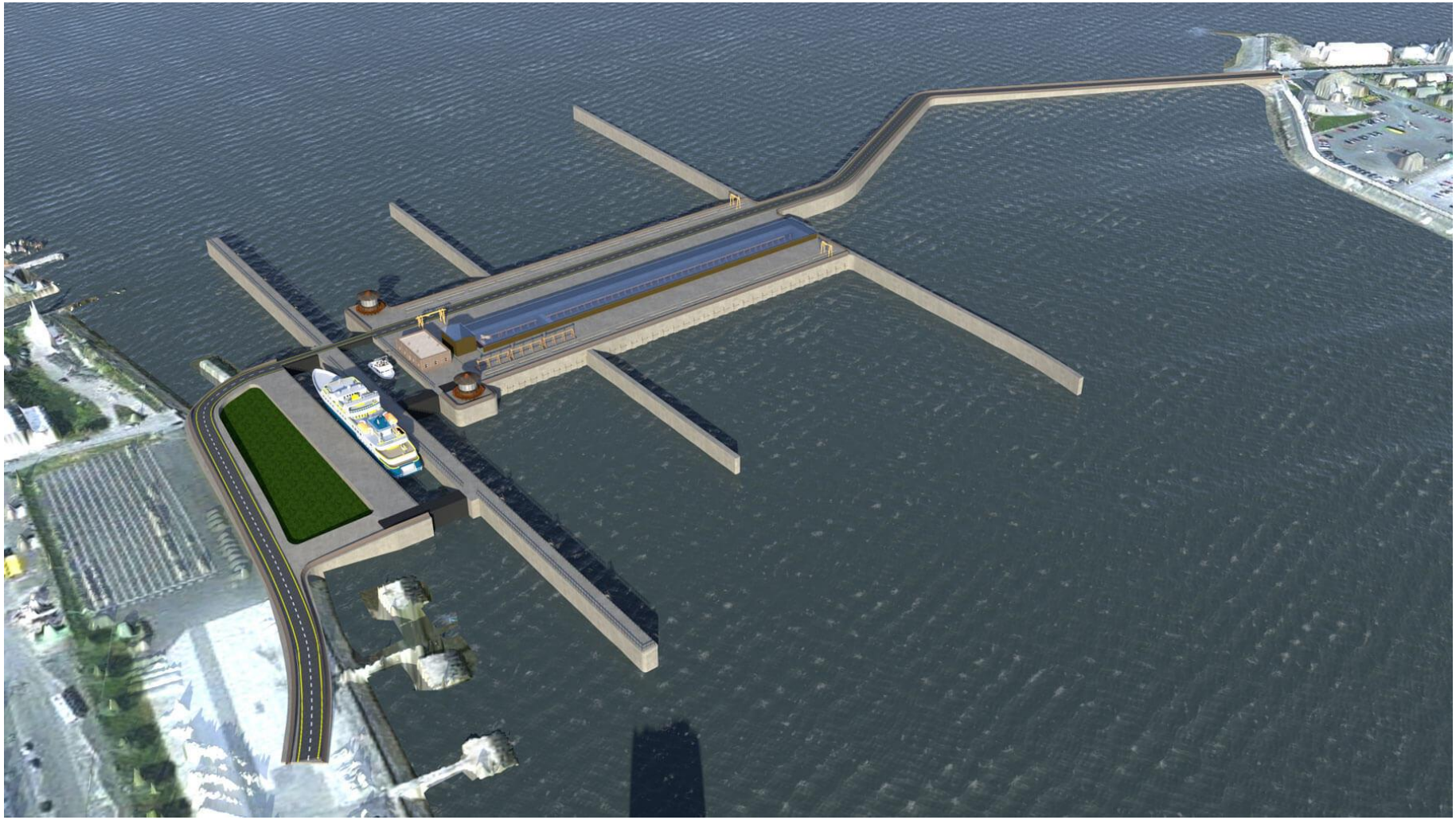
Pathfinder Project- overview

Project key figures

- Installed capacity: **100 MW (= 25 windmills)**
- Annual production: **150 GWh (50.000 households)**
- Capeex 250M£



Tidetec pre-qualified to provide –

- Turbine and turret solution
- EPCI
- Financing - GIEK/Export Credit,

All organized under a Norwegian Consortium

If successful, the Pathfinder project will kickstart other significantly larger barrage projects in UK, potentially the entire 25GW market

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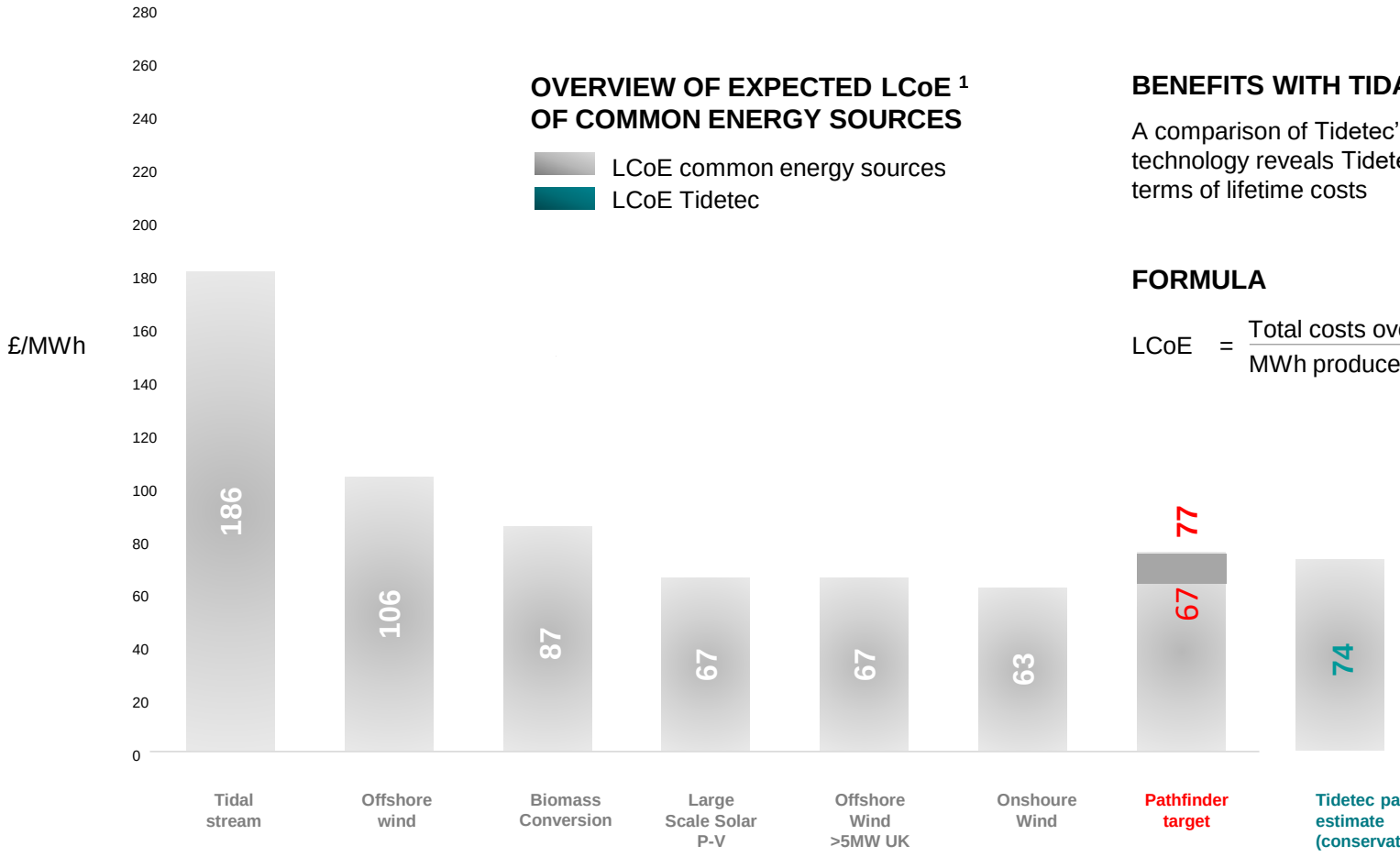
Levelized Cost Estimates for Projects Commissioning in 2020



OVERVIEW OF EXPECTED LCoE [1] OF COMMON ENERGY SOURCES

LCoE common energy sources

LCoE Tidetec

BENEFITS WITH TIDAL ENERGY

A comparison of Tidetec's solution for tidal technology reveals Tidetec's advantage in terms of lifetime costs

FORMULA

$$\text{LCoE} = \frac{\text{Total costs over lifetime}}{\text{MWh produced over lifetime}}$$

Figure: BEIS_Electricity_Generation_Cost_Report.pdf , Nov 2016, Page 22

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Mersey project 2019 – 3 schemes

Tidetec performed 0-D simulations
Outline businesscase to be published 2020

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Several large prospects are coming up near-term in UK and Asia

UK

SWANSEA BAY
Design completed
Installed capacity (MW): 320

CARDIFF II
Feasibility study completed
Installed capacity (MW): 3000

WYRE
Planning phase
Installed capacity (MW): 100

NEWPORT
Feasibility study completed
Installed capacity (MW): 1600

CHURCHILL BARRIERS
Feasibility study completed
Installed capacity (MW): 26

SOUTH-KOREA

GAROLIM
Design completed
Installed capacity (MW): 520

INCHEON
Feasibility study
Installed capacity (MW): 1440

GANGHWA
Pre-feasibility study
Installed capacity (MW): 26

SIHWA
Completed (2011) and operational
Installed capacity (MW): 254 1-way production

ULDOLMOK
Completed (2009) and operational
Installed capacity (MW): 1.5

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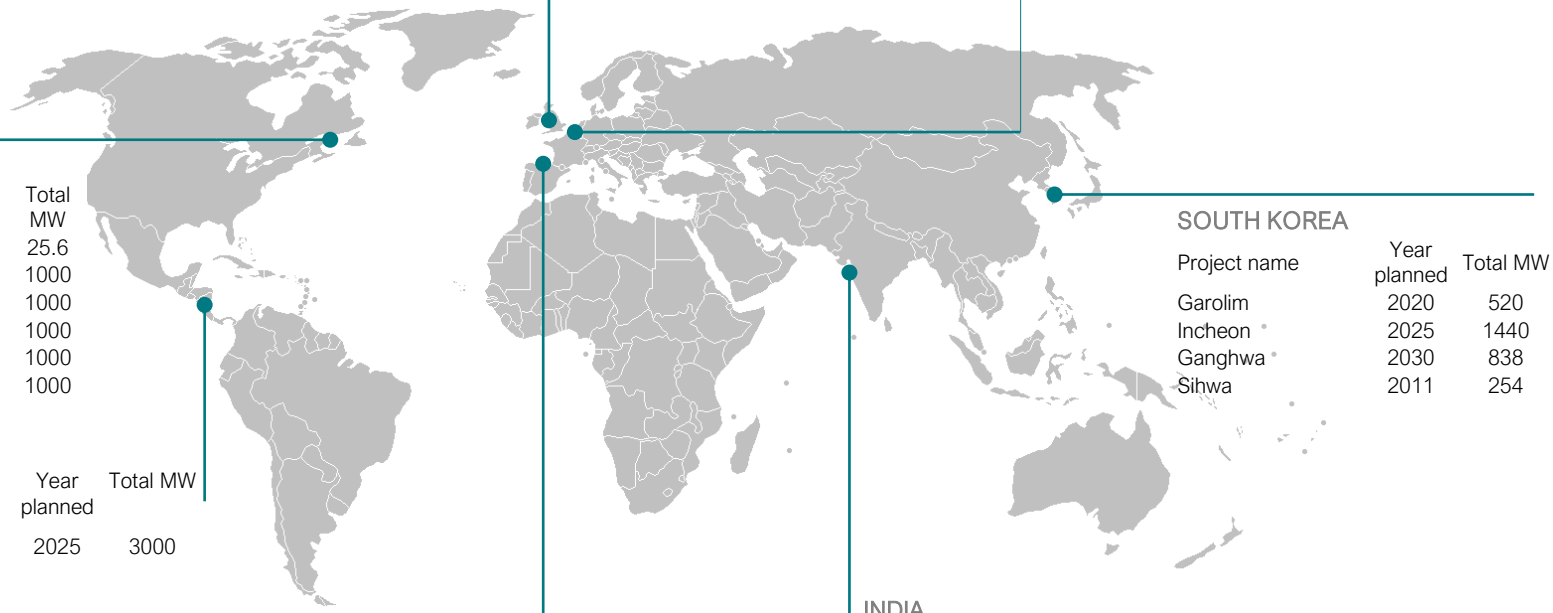
Market potential

Academic studies have identified over 300GW of potential tidal range capacity globally.



UK

Project name	Year planned	Total MW
Swansea Bay	2018	320
Cardiff	2020	3000
Wyre	2020	120
Newport	2022	1600
Churchill Barriers	2022	26
Colywyn Bay	2024	1600
Picardy coastline 1	2025	2000
Picardy coastline 2	2025	2000
Scots bay	2025	1100
North Wales	2025	2000
Bridgwater	2026	1600
West Cumbria	2028	1600

NETHERLANDS

Project name	Year planned	Total MW
Grevelingendam	2022	80

CANADA

Project name	Year planned	Total MW
Pennamaquan Project	2019	25.6
Bay of fundy 1	2030	1000
Bay of fundy 2	2030	1000
Bay of fundy 3	2030	1000
Bay of fundy 4	2030	1000
Bay of fundy 5	2030	1000

SOUTH KOREA

Project name	Year planned	Total MW
Garolim	2020	520
Incheon	2025	1440
Ganghwa	2030	838
Sihwa	2011	254

MEXICO

Project name	Year planned	Total MW
Baja California, Mexico	2025	3000

FRANCE

Project name	Year planned	Total MW
Cotentin Peninsula 1	2025	2000
Cotentin Peninsula 2	2025	2000
Cotentin Peninsula 3	2025	2000

INDIA

Project name	Year planned	Total MW
The Gulf of Khambhat 1	2022	5500
The Gulf of Khambhat 2	2022	5500

Areas eligible for tidal energy generation

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Tidetec's Team

CORE TEAM

Arne H. Kollandsrud
CEO Tidetec, Co-founder and Investor

Arne has been working as the CEO since 2013 and is a co-owner of Tidetec. He has been Member of the Board in Tidetec since his father Per Kollandsrud founded the company in 2000.

Bjørn Olav Brelin
Strategy advisor
Chairman Tidetec

Investor and top-level executive
with background from leading positions in the international Solar Energy Industry. Current: co-founder and CEO of circular economy venture Nuvosil AS. Former: CEO and General Counsel of Norwegian wafer manufacturer NorSun AS, General Counsel of Scatec AS and partner at Langseth Law DA

Arne Ziegler
Analysis Engineer, MSc
Partner& General Manager
Femkuber AS

Arne has 20 years of experience with structural and mechanical engineering predominantly within the oil&gas industry. He has been leading analysts and engineers on a large variety of projects. He also has experience as a Warranty Surveyor from high-value projects mainly in the Norwegian offshore industry. His Femkuber team is at Tidetecs disposal

ADVISOR

Frederik W. Mowinckel
Strategy and network advisory

Frederik has over 25 years' experience as an investor, board member and advisor with numerous environmental businesses. Frederik sits on the board of a number of cleantech companies and maintains a wide international network of contacts focused within environmental business.

What are we looking for:

Industrial partners/investors to support activities next 1-2 years, until the UK barrage market kicks off

Preparing fundraise q4 2019

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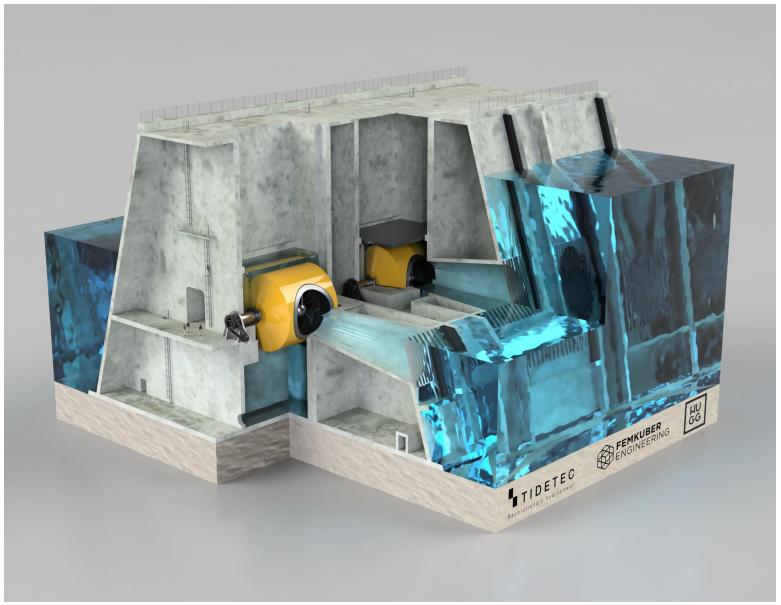

Thank you!

T I D E T E C

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