

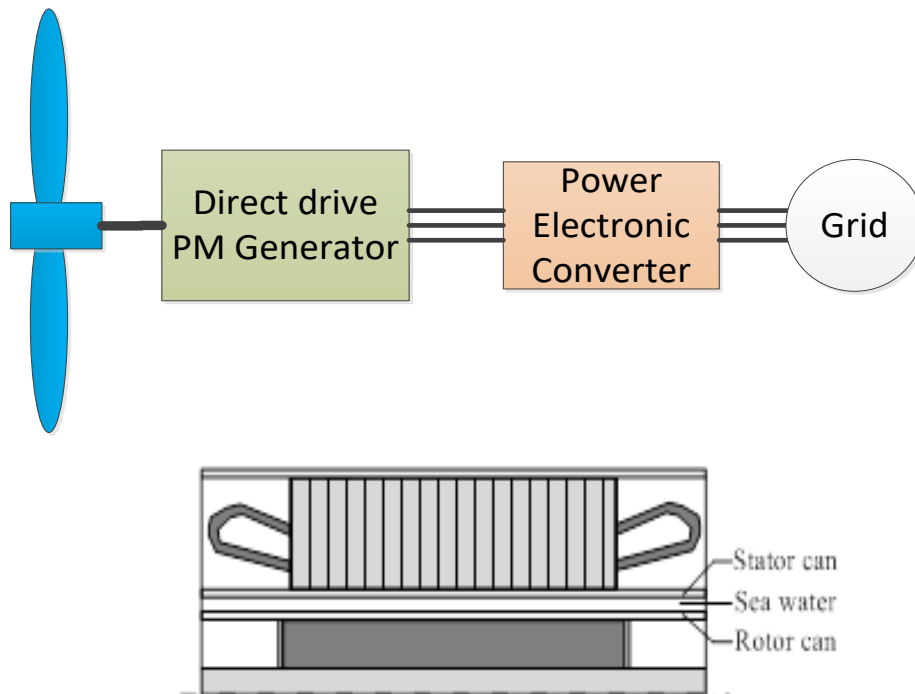
Generator Systems for Tidal Energy

Annual Ocean Energy Platform Meeting
Delft, 31 Jan 2019

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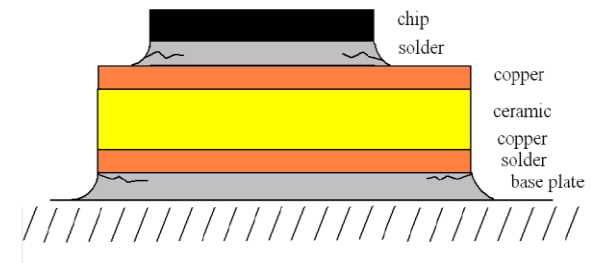
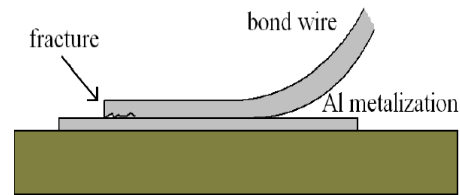
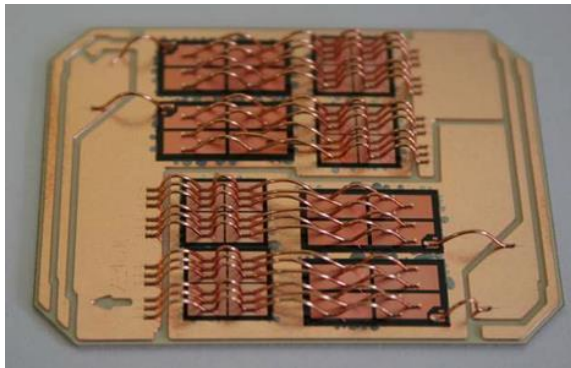
Research Areas

- Horizontal Axis Tidal Turbine systems
- Electromagnetic and thermal design aspects of seawater flooded permanent magnet Generator
- *Focus: Difference from conventional airgap generators in terms of modelling/analysis, structure, types of materials that can be used, etc.*



Research Areas

- Reliability of submerged power electronic converters
- Focus: Expected lifetime before failure due to thermal stress induced failures in semiconductor devices; other modes of failure
- *Modelling of passively cooled submerged power electronics*
- *Reliable design: Identifying critical load conditions (good characterization of tidal resource), design-for-reliability approach, preventive design for “more likely” failure modes*



Industrial Collaboration



- TIPA project

Funded under EU Horizon 2020 R&I programme



- ❑ Aims at reducing LCOE by 20%
- ❑ Aim Lifetime > 20 years
- ❑ Maintenance interval > 2 years

- ❑ Direct-drive design—flooded generator
- ❑ Submerged Power Electronics

LCOE-Levelized cost of energy

TIPA PROJECT
<http://www.tipa-h2020.eu/>

BACKGROUND

This project will validate in a real-world environment, an **innovative direct drive Power Take-Off (PTO)** for a tidal turbine that will move tidal energy a step closer to competing on a commercial basis with other renewable sources of energy generation. The PTO is the component that translates the mechanical power in the prime mover (the tidal turbine rotor) into electricity that is exported into an electricity network.

A project of this nature requires the involvement of organisations with a wide range of skills coming together and working closely in collaboration as a Consortium. The starting point for this project is a tidal turbine with a conventional drive train, as developed and demonstrated by Nova Innovation in partnership with SKF and Siemens; which has been deployed and operated in Nova's grid-connected tidal site in The Shetland Isles, Scotland. In parallel, Nova has carried out research with the University of Edinburgh to develop a direct-drive PTO designed to replace the existing PTO and make a step-change improvement in the performance, reliability and survivability of the turbine.

Figure : Conventional PTO vs TIPA PTO

The focus of this project will be to replace the gearbox and conventional generator in the turbine with a PTO featuring a high efficiency, low-maintenance direct drive generator.

Successful development of a direct-drive PTO will significantly increase the commercial viability of tidal turbines. Reducing the cost of operation and maintenance of tidal arrays will increase Return on Investment for turbine customers, allowing turbine technology development companies to sell more devices into an emerging global market.

AIM AND OBJECTIVES

The Consortium's aim is to **reduce the lifetime cost of tidal power by 20%**, demonstrated by accelerated life testing of a next-generation tidal turbine PTO solution. The expected outcome of this project is successful validation of a world-leading, commercially viable PTO solution for a tidal turbine.

Project outputs will be independently verified, with the objective of achieving :

- **Improved performance:** Experimental validation of 20% Lifetime Cost of Energy improvement over conventional PTO;
- **Improved reliability:** Accelerated testing showing that PTO can extend service intervals from 2 years; and
- **Verified survivability:** Accelerated testing to demonstrate PTO lifetime of 20 years.

PROJECT APPROACH

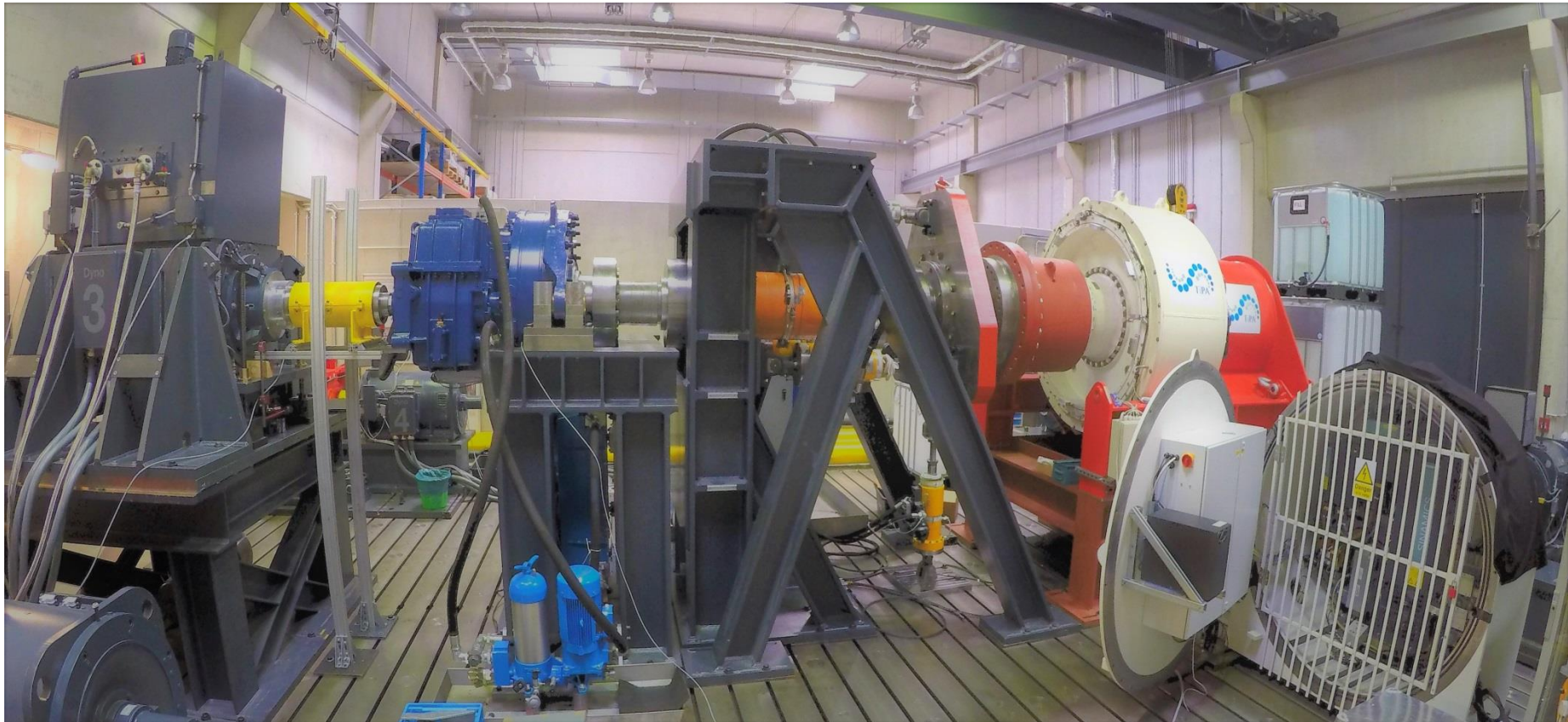
This project is being delivered using an **integrated research and development approach** that brings together world-leading partners with a wide range of expertise with the aim of developing an innovative PTO solution for the tidal energy sector.

Research:

Industrial Collaboration



- PTO Lab testing (Aachen, Germany)



Industrial Collaboration



- In-Sea testing (Edinburgh, UK)



- **TU Delft Contribution**

Design, Reliability and Optimization of Power Take-off System

PUBLICATIONS (So far):

- ✓ *F. Wani, U. Shipurkar, J. Dong and H. Polinder, “A Study on Passive Cooling in Subsea Power Electronics”, IEEE Access, 2018.*
- ✓ *F. Wani, J. Dong and H. Polinder, “Fast Rotor Loss Calculations in Fractional-Slot Permanent Magnet Machines”, in Proceedings of the International Conference on Electrical Machines, 2018.*
- ✓ *F. Wani, J. Dong, A. Yadav and H. Polinder, “Comparing Different Materials for Rotor-Can in Flooded Generators”, in Proceedings of the International Conference on Electrical Machines, 2018.*
- ✓ *F. Wani and H. Polinder, “A Review of Tidal Current Turbine Technology: Present and Future”, in Proceedings of the 12th European Wave and Tidal Energy Conference (EWTEC), pp. 1133-1-7, 2017.*

Under progress:

- *Lifetime Analysis of Passively Cooled Power Electronic Converters Coupled to Tidal Turbines*
- *Calculation of PWM-Induced Rotor Losses in Flooded Generators*