CAPE SHARP TIDAL
VENTURE

Nova Scotia Department of Energy

Technology description

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1. Project Plan:

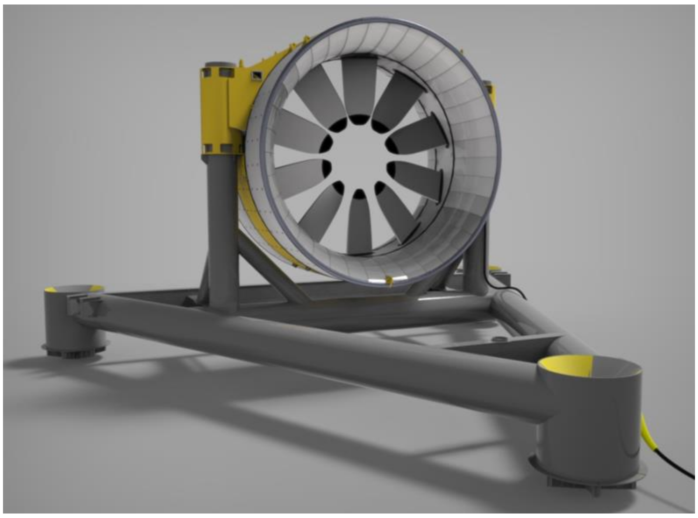
The project plan is the same as that described in OpenHydro Technology Canada's submission in response to the Department of Energy's Request for Proposals for In-stream Tidal Energy Demonstration at FORCE Berth D, submitted on 10th December 2013.

A copy is appended to this document.

2. Technology Description:

The proposed technology that will be used for this Project is the OpenHydro Open-Centre Turbine which is a shrouded, horizontal axis turbine, with four key components: a horizontal axis rotor, a direct-drive permanent magnet generator, a hydrodynamic duct and a subsea gravity base type support structure. Simplicity is a key advantage of this device, with no lubricant, seals, or gearbox, meaning reduced maintenance requirements. Seawater is used for both generator cooling and lubrication. This general arrangement provides smooth reaction torque and is relatively easy to seal from the surrounding seawater, as well as being flexible in that it may be configured to produce different voltage outputs.

The turbines, supported by subsea base structures, are placed directly onto the seabed, deep enough so as not to pose a hazard to shipping. Each Open-Centre Turbine can be rated at up to 2.0MW, depending on precise site conditions and detailed economic assessment.



Open-Centre Turbine

Key design features of the Open-Centre Turbine include:

- **Simple and robust construction:** manufactured from a small number of components – only a single moving part - the rotor - whose design has been optimized including the removal of the inner ring.
- **Standardisation of Design**: in order to move into industrial production, the turbine is now designed so that it can be deployed in any of the project locations that OpenHydro is developing world wide.
- **Permanent magnet generator:** the advanced permanent magnet generator removes the requirement for a gearbox – a common cause of failure in large scale wind turbines.
- **Bi-directional:** the turbine operates in both the ebb and flood direction without the need to yaw to orientate itself into the tide.
- **Scalable:** OpenHydro has demonstrated that the technology is scalable by increasing the diameter from 3m to 6m and again from 6m to 10m. The latest 16m diameter design was installed in Paimpol-Bréhat, France for further testing in December 2013. Larger diameter turbines result in higher power outputs and improved economics.

The support structure for the OpenHydro Open-Centre Turbine is an unpinned gravity base structure, which is installed along with the turbine as one assembly. There is no seabed preparation required prior to deployment or seabed reparation required post decommissioning. OpenHydro has developed a specialist methodology for installing its Open-Centre Turbines, allowing all preparatory works to be performed in the safe and controlled working environment of a harbour.

Blades & Rotor optimisation

The blades are of a simple and robust design which has been developed to generate energy at a slow rotational speed. Computational Fluid Dynamic (CFD) modelling for the turbine has shown that there is a pressure drop and associated reduction in flow velocity when approaching the blades. This also reduces the potential for collision by approaching marine mammals or fish. The CFD model also shows that preferential flow is via the open centre and around the outside of the venturi which provides an exit or escape route for marine life.

Following a detailed review of the system design it was identified that a simplification of the rotor design – *i.e. the removal of the inner ring,* could bring a number of important benefits as follows:

- The hydrodynamic performance of the simplified rotor increases turbine performance.
- This simpler design requires fewer components and a reduction in assembly time and complexity.

OpenHydro has initiated a staged testing programme to fully validate the cantilever rotor design prior to deployment in the Bay of Fundy.

16m Open-Centre Turbine

Venturi

The Open-Centre Turbine is completely bi-directional, with symmetrical blades and venturi sections resulting in equal performance from the front and rear. The venturis are designed to straighten and intensify the flow of water. In addition, extensive CFD analysis has shown that the turbine can operate with no decrease in efficiency at incoming flows of up to 30° off axis. This provides a significant advantage when considering the variation of around 10° in ebb tide directions observed from harmonic predictions carried out by OpenHydro in the Bay of Fundy at FORCE. The ability to operate in off-axis conditions has also been verified experimentally at the test facility in EMEC, where ebb flow sets in at approximately 60° to the main direction, that off-axis flow of a few 10s of degrees causes a negligible effect in generation due to the venture.

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OpenHydro's certified design loading derivation considers the separate contributions of tide, waves, storm and turbulence to the currents imparted on the turbine. This analysis also takes into account the changing magnitude of these contributions across all angles in the horizontal plane. Together with an understanding of deployment tolerances and how coefficients of thrust and torque vary with inflow angle, a clear factor of safety is obtained on the global stability of the device and subsea base. This allows the turbine and SSB to be placed at a pre-determined location without any preparation of the landing surface. An algorithm is used to analyse the bathymetry across the entire development site and screen out any deployment positions which would result in problematic levels of tilt (in excess of 5°) or seabed protrusion within the Subsea Base foot-print (in excess of 1.8 m from the base of the feet). Together with the proven accuracy of the deployment methodology, this method allows problematic areas of the seabed to be safely avoided.

The Subsea Base which will support the turbine will have a length and width of no more than 40 m. Final dimensions will be chosen by consideration of the footprint and ballast required to prevent overturning.

Subsea Base, Cherubini Metal Works, Dartmouth, Nova Scotia (2010)