Response Template:

BASIC AND TECHNICAL REQUIREMENTS

IN-STREAM TIDAL ENERGY DEMONSTRATION PROJECT PROPOSAL

(Excerpt)

Section Two: The Project

1. Technology to be Deployed

Provide a full description of the technology to be used, including diagrams. Include details of at least the following:

- Manufacturer's brand name of the device
- Proof of ownership/licence for proposed technology
- Has the technology been manufactured and deployed in any other locations.
- Main collector elements - how do the device's main collector elements move in response to the forces exerted on them by the moving water?
- Reaction - how does the device obtain its reaction force?
- Power take-off- explain how the movement of the main collector element is converted into electrical energy (supply energy conversion steps, and estimate the conversion efficiency)
- Directionality- describe how the device responds to changes in the direction of the input energy flux
- Survivability strategy - include maximum exposure design limitations
- Fixing system details (anchoring, mooring or other- include physical seabed requirements)
- Previous R&D (including results and outstanding issues)
- Footprint of demonstration device
- Redundancy (for maximum failure situations)
- Certifications- provide copies of certifications obtained from national and international certifying institutions. Developers are expected to obtain and provide copies of any certifications applicable to their device(s) that may be available from national or international bodies. Given the nascent nature of the tidal energy industry certifications may not be available for all devices at time of submission to the RFP. If applicable, developers are expected to obtain any applicable certifications, which may include DET NORSKE VERITAS- Offshore Service Specification – 312 (DNV-OSS-312) certification. In the future developers are expected to obtain any relevant certifications under International Electrotechnical Commission Technical Committee 114 (IEC-TC-114).
- Fit for purpose certification will be required prior to deployment

Developers can also bid on the demonstration of more than one device; however, the devices must be of different technology designs.

Tidal Arrays

Construction of a tidal array to improve cost competitiveness through economies of scale and help build a local value chain in Atlantic Canada is encouraged. For Developers interested in deployment of a tidal array at the berth site, the following will also need to be considered:

- What modeling was used to develop the array? What considerations and assumptions were used in developing the model? What were the results from the modeling?

- How many devices are included in the array? What is their proximity to each other? How are they connected? How will the connections be made? If one device is not functioning, is the energy generated from the other devices impacted?

- What is the plan for the deployment of the array? What is the timeline for deployment? Will the devices be deployed at the same time, or will one device be deployed first, analyzed for a period of time, a second device connected and deployed, analyzed for a period of time, etc.?

The technology for this development will be the ANDRITZ HYDRO Hammerfest (AHH) HS1000 Mk1 tidal stream device. This turbine, with a rated power of more than 1.5 MW for the prevailing site conditions, is a horizontal axis, 3 bladed, seabed mounted tidal turbine developed as an iteration of the HS1000 pre-commercial demonstrator at EMEC, which itself was based on the successful HS300 machine.

The HS1000 Mk1 design represents the next generation in tidal turbine development for ANDRITZ HYDRO Hammerfest incorporating a number of new features both to tailor the device for operation in the Bay of Fundy, but also to ready the device for commercial scale deployment.

Design development has been based on the extensive experienced gained from previous technology deployments:

- The HS300 (with rated power of 300kW) turbine was successfully designed, built and operated since 2003 in Norway. This makes ANDRITZ HYDRO Hammerfest the first company in the world to successfully convert kinetic energy from a tidal flow to electricity. The HS300 delivered power to the national grid for more than 17,000 operating hours, with an availability, during the last year of operation, of more than 95%. The extensive testing and development programme for the HS300 enabled the company to develop the next generation HS1000.

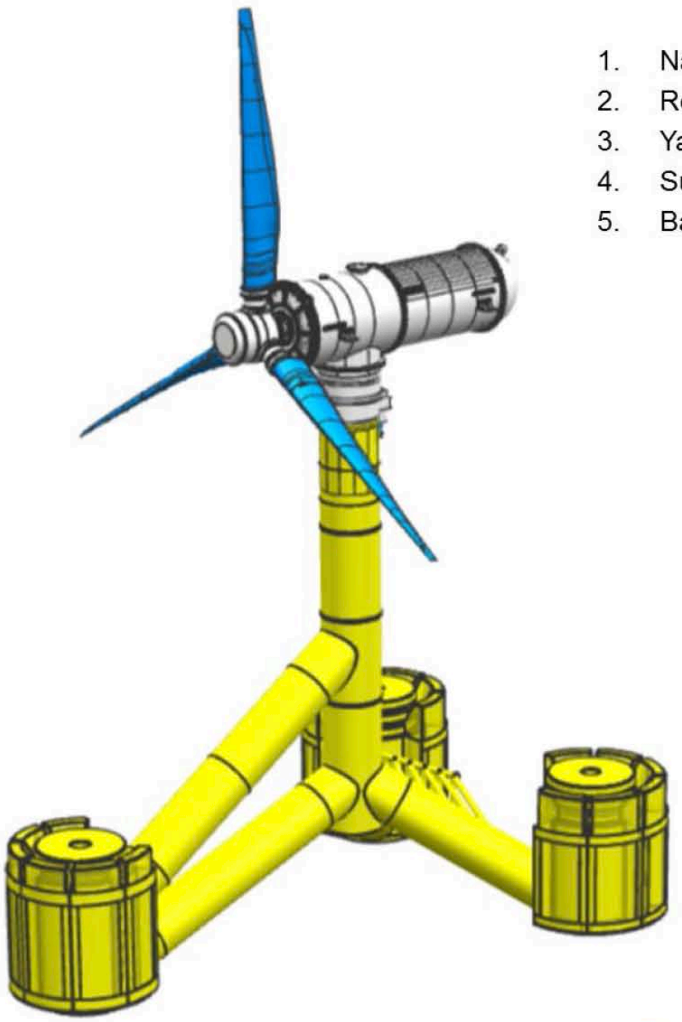
- The HS1000 is a full-scale pre-commercial demonstrator device installed at EMEC, designed for extremely rigorous wave and tidal regimes that are specific for UK waters but not dissimilar to the conditions expected in the Bay of Fundy. The machine was successfully installed at the end of 2011 during the most severe winter conditions with strong winds and high waves. The machine went through a thorough testing and commissioning process followed by an autonomous operation period from October to December 2012. The turbine was retrieved as planned in January 2013, for its scheduled 6 month inspection and maintenance cycle. The device was subsequently reinstalled in August 2013 and has been continuously generating power to the national grid since.

The intention of the proponents is to install 3 HS1000 Mk1 turbines in the Bay of Fundy using a ballasted gravity base; the nacelles will be approximately 24 meters above the seabed and each is expected to generate 1.5MW at the generator terminals at its rated operating point of 3.15 m/s.

The tripod substructure will support a vertical spine which routes the cable from the nacelle to the subsea export cable. The nacelle incorporates a yaw mechanism and is a single retrievable unit that interfaces with the vertical support spine. The yaw mechanism allows the nacelle to rotate during slack tide to ensure the rotor is facing the tidal flow in both flood and ebb directions optimizing efficiency and power production. The yaw strategy is not continuous as in conventional wind turbines (continuously reacting to small detected changes in flow direction), but is binary in operation only activating once at each turn of the tide.

The yaw mechanism is bolted to the nacelle housing that incorporates all the main components such as generator, gearbox and ancillary equipment. The nacelle is sealed against the marine environment and connected via the main shaft to the hub, housing the electrical pitch mechanism that allows the rotation of the three blades during operation. The blades can be adjusted in their position for optimized efficiency and for safety purposes. The three blades are connected through the spindles to the hub connection.

Overview of the HS1000Mk1



1. Nacelle
2. Rotor
3. Yaw
4. Substructure
5. Ballast

Figure 2.1.a: HS1000 Mk1 Tidal Turbine

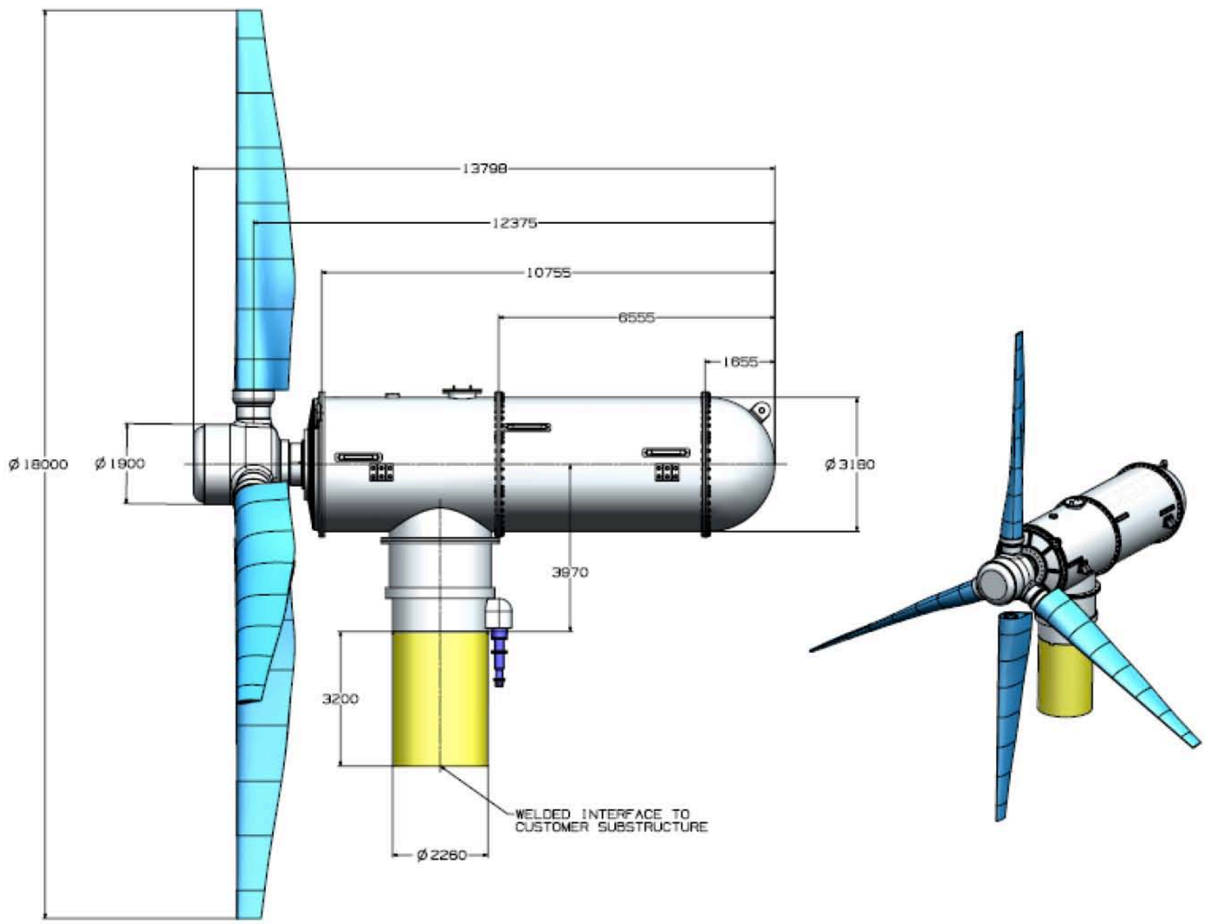


Figure 2.1.b Principle Nacelle Dimensions

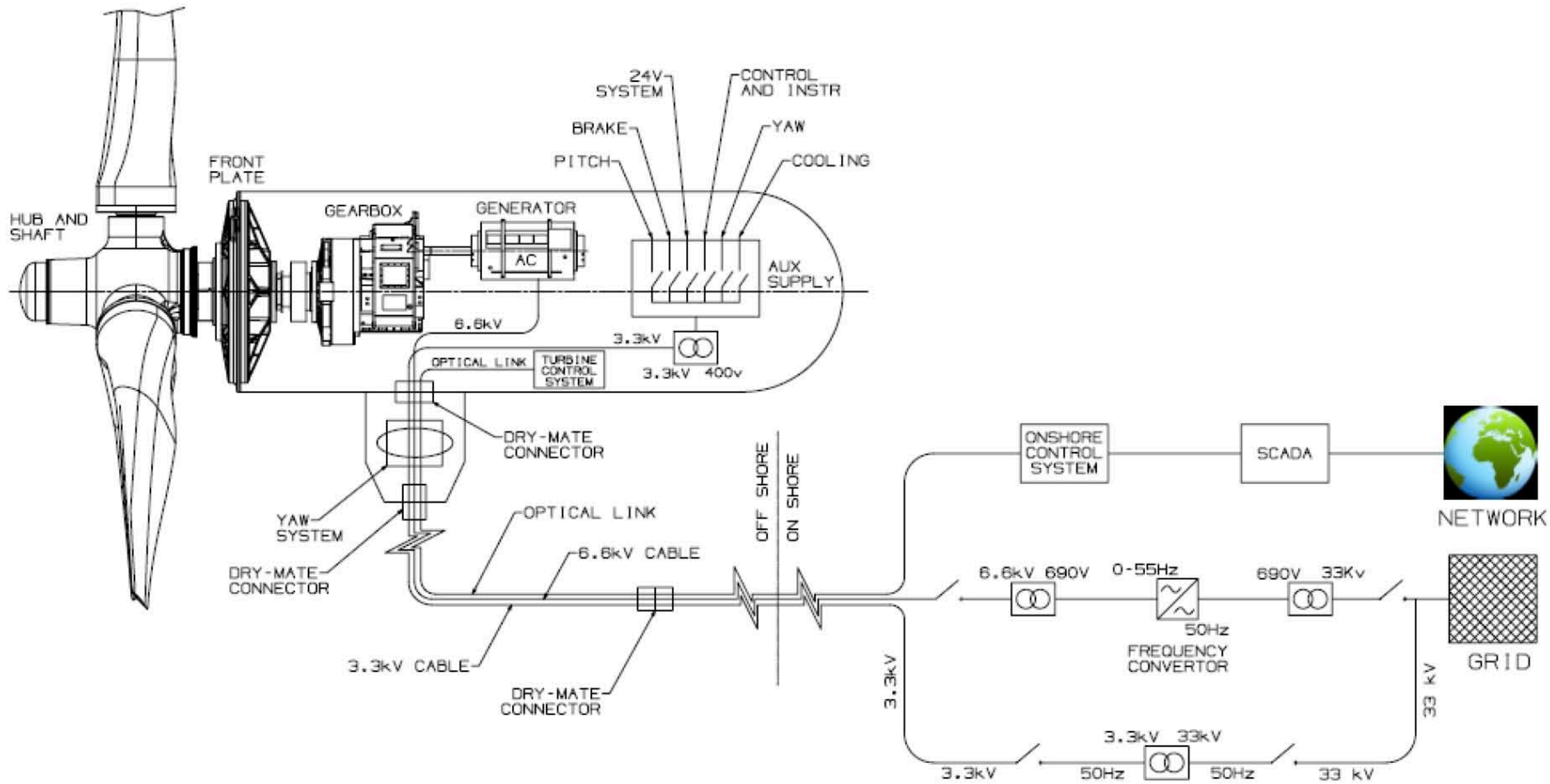


Figure 2.1.c Single Line Diagram

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Provide a full description of the technology to be used, including diagrams. Include details of at least the following:

- Manufacturer's brand name of the device

HS1000 Mk1

- Proof of ownership/licence for proposed technology

Deployed turbines, ongoing development activities and pending patent applications.

- Has the technology been manufactured and deployed in any other locations.

Yes, the HS300 was installed in Norway in 2003. The HS1000 pre-commercial demonstrator was installed in EMEC in 2011. Both machines are currently in operation and generating electricity to their respective national grids.

- Main collector elements - how do the device's main collector elements move in response to the forces exerted on them by the moving water?

The three bladed rotor is exposed to the water forces absorbing the energy in form of lift and drag forces. The rotational forces are taken up through the main shaft, gearbox, high speed shaft into the generator. The generator resistance force are taken up by the structure inside the nacelle and transferred through the yaw mechanism into the structure to the seabed.

All other thrust and moments are taken up the front plate, transferred through the nacelle into the yaw mechanism, the structure and the seabed.

- Reaction - how does the device obtain its reaction force?

Structure, ballast weight and footing on the seabed will provide resistance against sliding forces and turning forces.

- Power take-off- explain how the movement of the main collector element is converted into electrical energy (supply energy conversion steps, and estimate the conversion efficiency)

The rotor rotational moment is transformed into electrical energy at the generator inside the nacelle at a three phase variable frequency voltage of up to 6.6kV. The power is then transmitted to shore into a Medium Voltage Convertor located at the substation and which is producing a grid compliant power at a constant frequency at a voltage of 6.6kV.

- Directionality- describe how the device responds to changes in the direction of the input energy flux

A yaw mechanism is mounted between the nacelle and the substructure aligning the device with the flow during slack periods.

- Survivability strategy - include maximum exposure design limitations

The load cases for the 25 years operation will include the following events:

- Power Production
- Fault cases such as i.e. grid loss, generator short circuit, accidental braking
- Start up
- Normal shutdown
- Emergency shutdown
- Idling
- Parked
- Installation / Retrieval / Transportation

These load cases will be simulated under chosen sea conditions (Hs, Wave Period), flow speeds and direction.

The device will be designed to operate with speeds of up to 5.3m/s and a maximum significant wave height of 3m.

Beyond these limits, the device will go in to a fail safe mode where the blades pitched so as to minimize the forces on them. The survival loads will be significantly higher than any anticipated conditions in the Bay of Fundy, such as during an extreme wave event i.e. 100 year return wave period or extreme events due to a faulty components.

- Fixing system details (anchoring, mooring or other- include physical seabed requirements)

Gravity based foundation. The ballast weight and the footing will be designed to accommodate site specific parameters, including levelling tolerances of the turbine.

- Previous R&D (including results and outstanding issues)

HS300 deployed in Kvalsundet Norway

Aim: Proof of concept;
Result: Successful and two years of continuous and autonomous operation with availability above 95%.

HS1000 deployed in EMEC, Scotland

Aim: Validation of Loads, Components and Performance;

Result: Successful. Validation of Loads completed, Validation of Performance curve completed, Validation of components carried out during overall inspection of turbine after 1 year at sea.

Test Bed Testing

- Pitch system testing for HS1000Mk1 ongoing
- Yaw testing for HS1000Mk1 under design
- Hydrofoil testing for HS1000Mk1 ongoing
- Rotor testing in the wind tunnel completed for HS300 and HS1000
- Full scale blade testing completed for HS1000 including fatigue
- 3 PhD's in Blade design, Electrical modeling and Condition Monitoring ongoing

- Footprint of demonstration device

The footprint of the device on the seabed is approximately 13m x 19.5m. A diagram of the base is included in **Appendix D - Technical Specification and Drawings**.

- Redundancy (for maximum failure situations)

A summary of redundancy and major failure response modes is given below:

Issue	Description of Accidental Load Case	Mitigation / Redundancies
Stuck pitch	A mechanical failure or a software error could lead the pitch to fail in an unfavorable position increase the blade forces during operation.	The design envelop will cover for that failure. A "stuck pitch" that cannot be remotely reset will result in turbine retrieval for maintenance.
Stuck gearbox	A gearbox could mechanically fail resulting in a sudden mechanical torque in the drive train and forces in the structure.	Two torque limiting elements (high speed and low speed shaft) will limit the maximum torque. The design envelop will cover for that failure.
Generator Short-circuit	A short circuit in the subsea cable, the onshore substation or the offshore cabling could lead to a generator short-circuit introducing mechanical forces onto the drive train and the structure.	Two torque limiting elements (high speed and low speed shaft) will limit the maximum torque. The design envelop will cover for that failure.
Blade failure i.e. Blade impact	Impact from a submersible object such as a container could lead to sudden shock	Two torque limiting elements (high speed and low speed shaft) will limit the maximum

	loads onto the drive train.	torque. The design envelop will cover for that failure.
Grid loss	Grid loss will lead to an immediate shutdown of the turbine.	A redundant UPS system in the nacelle will safely shutdown the turbine in case of a grid loss.
Yaw stuck half way	The yaw mechanism could fail in its worst position (perpendicular to the flow) with regards to the loading of structural components.	An UPS system will drive the yaw back to its safe position aligned with the flow. In case of a stuck yaw mechanism, load cases will cover for that failure.
Survival	100 year wave return period coincide with the strongest tide.	This unlikely combination of water conditions are covered in the load conditions. The turbine will be shut down during such conditions awaiting conditions within the operating envelope.
Emergency shut-down	Critical failures in the turbine will lead to an emergency shut-down	An independent emergency controller will safely shutdown the turbine independent from the main controller.

- Certifications- provide copies of certifications obtained from national and international certifying institutions. Developers are expected to obtain and provide copies of any certifications applicable to their device(s) that may be available from national or international bodies. Given the nascent nature of the tidal energy industry certifications may not be available for all devices at time of submission to the RFP. If applicable, developers are expected to obtain any applicable certifications, which may include DET NORSKE VERITAS- Offshore Service Specification – 312 (DNV-OSS-312) certification. In the future developers are expected to obtain any relevant certifications under International Electrotechnical Commission Technical Committee 114 (IEC-TC-114).

The HS1000 has a full DNV Prototype Certification following completion of design reviews, manufacturing surveillance and attendance at the testing and commissioning stage. A copy of the DNV Certificate is attached in **Appendix E - DNV Certification**.

- Fit for purpose certification will be required prior to deployment

Please refer to attached DNV Prototype Certification attached in **Appendix E - DNV Certification**.

Developers can also bid on the demonstration of more than one device; however, the devices must be of different technology designs.

The proponent is only intending to demonstrate the HS1000 Mk1 device.

Tidal Arrays

Construction of a tidal array to improve cost competitiveness through economies of scale and help build a local value chain in Atlantic Canada is encouraged. For Developers interested in deployment of a tidal array at the berth site, the following will also need to be considered:

- What modeling was used to develop the array? What considerations and assumptions were used in developing the model? What were the results from the modeling?

DP Energy propose to deploy a three turbine array, with the Tidal Energy Converter devices aligned in parallel across the flow. Cross-flow rotor spacing calculations have confirmed that sufficient area is provided by the Berth to achieve this. An indicative layout for the turbines is given below:

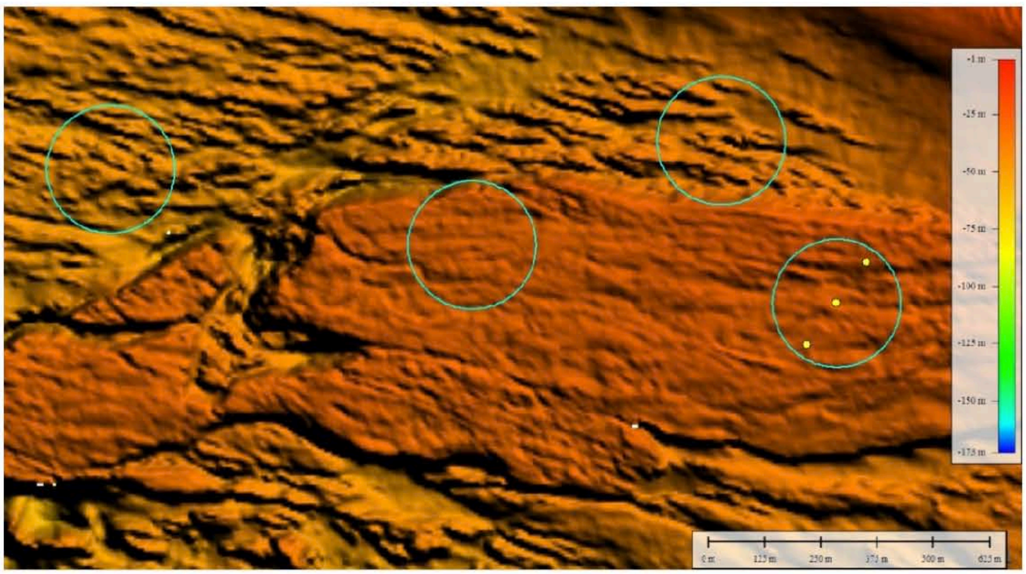

Figure 2.1.D: Indicative Layout With 5m Resolution Bathymetry

A detailed hydrodynamic model of the site, together with calibration against additional data gathering during the site characterization phase will allow micrositing of the turbines. The hydrodynamic modelling will be conducted in collaboration with Acadia University and a full description of the work to be carried out can be found in Section Three: Project Plan.

- How many devices are included in the array? What is their proximity to each other? How are they connected? How will the connections be made? If one device is not functioning, is the energy generated from the other devices impacted?

The eventual array will consist of three devices spaced at approximately 100m across the flow. Each device will be cabled individually ashore, with no connection between them. This will provide additional redundancy in the power generation, meaning that if one of the cables or devices should fail, the power generation and transmission to shore from the other two is unaffected.

- What is the plan for the deployment of the array? What is the timeline for deployment? Will the devices be deployed at the same time, or will one device be deployed first, analyzed for a period of time, a second device connected and deployed, analyzed for a period of time, etc.?

It is planned to deploy a single device in the first instance, followed by an additional two devices after a successful period of operation. The deployment schedule is detailed in **Appendix F - Project Gantt Chart**.

2. Previous Deployment/Testing

Provide details of at least the following with respect to any previous deployments and/or testing:

- Location
- Dates of deployment/tests
- Device deployed/tested:

  a) brand name
  b) scale or size of device
  c) diagram of device
  d) differences between device(s) tested and device proposed for deployment
  e) results of tests

- Results of the previous physical deployments, including evaluations
- Contact information of any organizations/individuals which conducted independent monitoring/evaluation of previous deployment
- If possible, please also provide reference letters.

Project:	**HS300 Deployment**
Location:	Kvalsund, Finnmark, Norway
Dates of deployment / tests:	1st deployment in 2003 2nd deployment in 2009
Device deployed / tested:	Tidal turbine
Brand name:	HS300
Scale / power rating:	300 kW
Site water depth	50m
Site Conditions	• Nominal water velocity (nominal design point): 1.7 m/s • Max. water velocity: 2.5 m/s • Max. significant wave height: 2 m

	• Turbulence intensity: up to 14 % measured.
Results of Deployment	• Total at sea hours are around 38 000 hours. • One removal after 4 years in 2007 for maintenance, reinstallation in 2009. • Total generating hours are: 16 811 hours. • Longest uninterrupted generating window was 800 hours. • Total generated MW: 2 238.3 MWh. • Highlight: very high availability achieved, > 95% after maintenance over a period of 2 years.

Project:	**HS1000 Deployment**
Location:	EMEC, Orkney, Scotland
Dates of deployment / tests:	1st deployment in December 2011 2nd deployment in August 2013
Device deployed / tested:	Tidal turbine
Brand name:	HS1000
Scale / power rating:	1 MW
Site water depth	50m
Site Conditions	• Nominal water velocity (nominal design point): 2.7 m/s • Max. water velocity: 4 m/s • Max. significant wave height: 9m • Turbulence intensity: up to 14% measured.
Results of Deployment	• Total at sea hours are more than 6000hrs (per August 2013). • Removal for validation and maintenance after nearly 12 months of operation end 2012 and redeployed end of August 2013 • Successful completion of commissioning and validation.

	• Several months of successful autonomous operation producing power into the grid. • 260MWh generated to the gird so far (per August 2013). • Expected performance parameters were achieved.
Independent Testing and Monitoring Contact Details	*Scottish Power Renewable, Barry Carruthers, Marine Energy Development Manager, Tel: +44 (0) 141 614 3044, bcarruthers@ScottishPower.com* *DNV, Claudio Bittencourt, Senior Principal Surveyor, Tel: +44 (0) 20 7716 6663, Claudio.Bittencourt.Ferreira@dnv.com*

6. Project Plan

Describe the **approach and/or process** proposed to address the service requirements. Include any notable methodologies, tools and techniques, and their respective suitability to this project.

Also provide a **project plan** with reasonable detail that reflects your proposed approach/process and demonstrates your ability to meet the milestones. Provide a detailed project plan with Gantt chart, showing all key tasks and their time frames, including details on at least the following:

- Physical site preparation
- Installation and commission of the device
- List, in detail the purpose of the demonstration project (gaps in information to be addressed)

Purpose of the Demonstration Project

DP Energy proposes to demonstrate an array of three HS1000 Mk 1 turbines supplied and installed by ANDRITZ HYDRO Canada Inc. Each of the devices will have a rated power of 1.5 MW giving a total installed capacity of 4.5 MW for the proposed array.

The objective of the project is to fast track the demonstration of the technical, environmental and commercial viability of developing large-scale tidal energy parks in the Bay of Fundy.

The proposed array will be installed in two phases as follows:

- **Phase 1**: Installation of an initial HS1000 Mk1 device in Spring/Summer 2015. The device will be used to demonstrate the successful operation of the modifications and upgrades of the Mk1 device over the pre-commercial demonstrator installed at the EMEC test facility. The Testing & Commissioning stage will also be used to provide feedback for the control algorithms for Turbines 2 and 3 thereby allowing programming and pre-delivery testing prior to installation.

- **Phase 2:** Following a successful period of operation of the initial device, an additional two devices will be installed incorporating control enhancements. The monitoring of the array performance and review of the wake interactions of the three devices will be invaluable in informing future array design and deployment.

The joint objective of both DP Energy and ANDRITZ HYDRO Canada Inc. is to use the Berth D array demonstration project as an enabler towards securing future rights and consents to develop a commercial scale in-stream tidal energy park in the Bay of Fundy, either as an expansion to the demonstration array site at FORCE or as a standalone project. There is potential for the development/consenting activities for a commercial scale array to commence in parallel with Phase 2 of the demonstration project, once the first turbine has been successfully deployed and operated.

Roles and Responsibilities

A Nova Scotia registered SPV (Special Purpose Vehicle) will be established for the purposes of managing the proposed Berth D Demonstration Array Project.

A Project Board will be appointed from the directors of the SPV and selected others, but as a minimum will include representatives from both DP Energy and ANDRITZ HYDRO Canada Inc. The Project Board will be the decision-making authority that provides overall direction of the project. The responsibilities of the Project Board include:

- Ultimate responsibility for the Project;
- Ensure risks are being appropriately managed;
- Ensure objectives are being met;
- Delegate the day to day management of the project to the Project Manager within a defined set of parameters;
- Review and approval of all plans before commencement of work stages;
- Authorize the commitment of resources to the project; and
- Ensure a clean, orderly closure to a project.

One member of the Project Board will be the designated Health and Safety (H&S) Director who will be the have overall responsibility for ensuring the appropriate HSE Management is in place for the safe delivery of the project.

Reporting to the Project Board will be the Project Manager, the H&S Manager and the Grant and Funding Specialist.

The H&S Manager will report directly to the appointed H&S Director and to the Project Board in general. They will be responsible for developing the H&S Plan, managing its implementation and monitoring adherence. The HSE Management role will be undertaken by the qualified HSE Manager from within ANDRITZ HYDRO Canada Inc.

The high-level management organogram for the project is given in Figure 3.6.1 below:

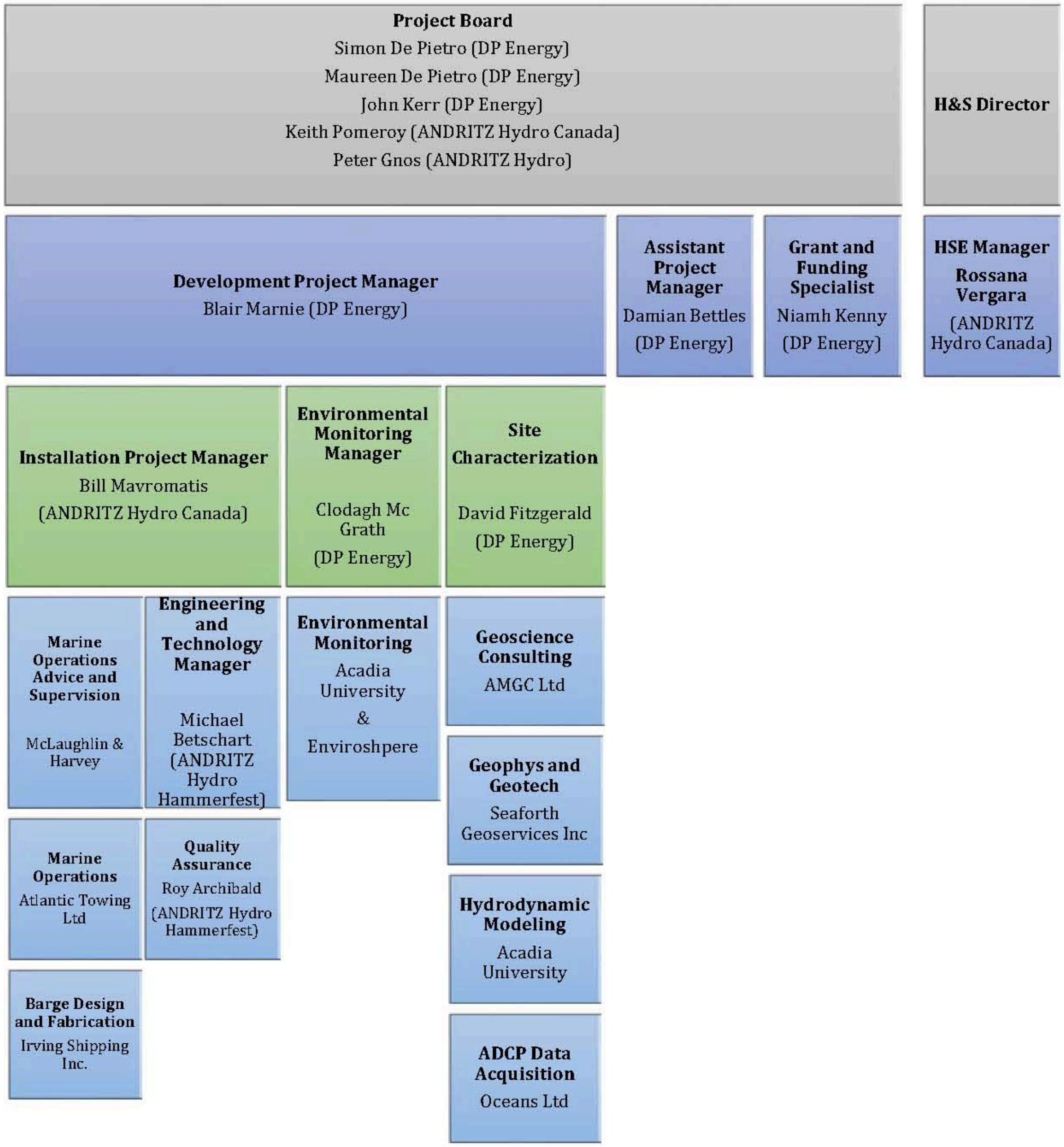

Figure 3.6.1 Project Management Organogram

The Project Manager will be responsible for the day-to-day management of the project within the tolerances set by the Project Board. This will include:

- Developing the project plan
- Managing the project team
- Managing the project risk
- Managing the project schedule
- Managing the project budget
- Managing project quality

Reporting to the Project Manager will be a number of functional and technical managers skilled in the various specialist aspects of the project's delivery as identified in Figure 3.6.1 above. The Project Manager will be supported by an Assistant Project Manager and a number of project administration staff.

Each specialism manager will oversee the work of a number of internal staff, subcontractors and consultants for delivering the work packages within their specialism. The Work Packages are described in more detail below.

The Grant and Funding Specialist will be responsible for identifying grant and funding opportunities relevant to the project and technology. There will be a particular focus on opportunities with SDTC (Sustainable Development Technology Canada). She will be responsible for implementing and managing the appropriate monitoring and reporting structures for any successful applications.

The CVs for all key personnel identified in Figure 3.6.1 above are included in **Appendix B - Project Personnel Resumes**.

Principal Scope of Work

The first attempt at installing a Tidal Energy Converter (TEC) device in the Bay of Fundy was a powerful lesson in the importance of having an accurate data set of the sites characteristics.

Having reviewed the available data for Berth D, there has clearly been an extensive data gathering exercise, however, there are gaps that need to be addressed. The first stage of the project would be to gain a full understanding of the site conditions at Berth D, requiring a detailed Site Characterization phase which would include the following:

Hydrodynamic Modelling	Richard Karsten will lead a research team at Acadia University to develop a detailed hydrodynamic model of Berth D using the existing available data. This model will be used to identify the optimum turbine sites in terms of flow characteristics and potential yield. This would potentially include the following items of work: We would complete an initial characterization of the flow at the berth site using our validated oceanographic model. This would include long-time 2D simulations, in particular covering the entire planned deployment time. The results of these simulations would be used to examine the variation of the flow speed and direction from the minute/hourly time scales, to the flood/ebb cycle, spring/neap cycle, seasonal cycle and finally the inter-annual cycle. Using the power and thrust curves for the turbines, we will estimate the turbine performance at potential deployment locations across the site. As well, we would complete 3D simulations of selected times during the deployment (i.e., the strong spring tides) to examine how the vertical profile of the tidal current varies during the tidal cycle. This will be important in determining the optimal hub height of the turbines and the final design of the supporting structure. This initial work will contribute to the choice of the final deployment location of the turbine(s). After sites are chosen and further measurements of the flow at these sites are made, we would refine our numerical grid to have its highest resolution at the specific sites (on the scale of the turbine). The refined model would be validated against the data and once again be used to

	make long-time predictions. The model would also be used to simulate power extraction at the deployment site and to examine the effect of blockage, the velocity deficit in the turbine wakes, the increase in flow around the turbines, any potential interactions of the turbines (i.e., wake merging) and any potential interactions with the other berths. The data would be used to optimize the turbine array, plan the deployment and assist with operations and maintenance. During both of the previous steps, the flow data generated from our simulations would be shared with other members of the project team to be used as input to their modelling efforts. In particular, we would provide data on the flow variations that generate turbulence to the project team members working on designing the turbine and the layout of the array.
Geoscience Interpretation	DP Energy intend to use the services of Canadian company Atlantic Marine Geological Consulting Ltd (AMGC) to provide geoscience interpretation, cross referenced with the hydrodynamic model data, for the purposes of micrositing of devices. Services would include mapping and characterization of bedrock and seabed sediments and an understanding of their properties and stability. AMGC will provide guidance on the type, collection methodology and processing of data required for site selection and environmental assessment. AMGC will describe the bedrock geology, overlying surficial geology and interpreted seabed processes. The emphasis will be to provide detailed information on the morphology, properties, thicknesses and dynamic seabed conditions of bedrock affecting foundations and placement of the devices and cabling.
Geophysical and Geotechnical Data Acquisition	Nova Scotia based Seaforth Geosurveys Inc., in conjunction with AMGC and ANDRITZ HYDRO, will undertake a detailed gap analysis to identify the additional data requirements for the siting and design of the turbines' gravity base substructures. Seaforth Geosurveys will define the data collection methodology and undertake the required geophysical and geotechnical surveys. Geophysical data collection at the FORCE Crown Lease Area and specifically at the Berth D location for the purpose of site characterization presents significant challenges in planning, methodology and implementation of data acquisition. The strong tidal currents and associated sea conditions found throughout the site adversely affect data quality, vessel navigation and positioning, deployment and recovery of towed or fixed sensors and create risks to health and safety. As a result, specific consideration is given to mission planning, vessel selection, deployment and recovery methodologies and to the types of sensors to be deployed at the site. While multiple surveys with similar objectives have been conducted in the immediate area, development of methodologies to acquire the necessary data continues to evolve and will be the focus of the survey program at Berth D.

Additional ADCP Data Acquisition	Reviewing the data made available by FORCE, ADCP data has been collected at a point of the centroid of the Berth D site area. This data will be used, together with data available for adjacent sites to produce the initial hydrodynamic model for micrositing. Once the locations have been selected, DP Energy will commission a further deployment of ADCP devices at each of the locations to gain pinpoint accurate data and recalibrate the hydrodynamic model. The intention is to work with Oceans Ltd.'s Nova Scotia based office for the ADCP deployment and data acquisition, although DP Energy will be watching with interest the progress of the VECTRON trial undertaken at FORCE in partnership with Nortek Scientific. In addition to measurement of current data, the ADCPs would be used to measure turbulence and, if deemed necessary, wave data.

Once the **Site Characterization** phase is complete, this will allow ANDRITZ HYDRO Hammerfest to complete the necessary **Engineering Design** works which would include the following:

Engineering Design	• Establishment of the basis for design; • Define operating envelope and philosophy; • Blade selection and design; • Load calculations for technology selection confirmation; • Principal electrical and mechanical layout design; • Completion of the high-level installation method statement; • Finalize certification plan; • Confirmation of budget costs. • Specification of drive train and electrical components; • Specification of C&I components; • Specification of structural components; • Specification of blade design and manufacturing; • Specification for assembly and testing; • Manufacturing engineering of electrical, blade, mechanical, structural and C&I components; • Production engineering including ITP, tools and processes; • Detailed marine installation engineering; • Operating sequence development and turbine control; • Manufacturing engineering of assembly and testing; • Design certification.

The nacelle assembly and blades will be manufactured by selected companies of the ANDRITZ HYDRO Group facilities in Europe due to the embedded expertise, specialist testing facilities and completed DNV manufacturing surveillance. These will be transported overland by train to a load-out facility in Rotterdam, from where they will be transported by sea to Canada. If required, the nacelle and blades will be transported by truck and trailer to the quayside staging point for final assembly.

The Substructure and Ballast will be procured locally, with fabrication inspection by ANDRITZ HYDRO Technical Advisors. Transportation to the quayside staging point for installation will be by truck and trailer.

The principal stages of the installation are described below:

Detailed Installation Planning	McLaughlin & Harvey, based on their previous experience in defining and managing a successful deployment and recovery methodology in the Bay of Fundy, would provide expert advice to, and supervision of, the installation contractor for the Detailed Installation Planning Stage. Planning would include: • Method statement review and refinement; • Risk assessment review and further mitigation; • Heavy lift plan review; and • Review of H&S plan.
Design and Fabrication of Installation Barge	The functional specification of the installation barge will be prepared by ANDRITZ HYDRO with expert advice supplied by McLaughlin & Harvey. Early engagement discussions have taken place with Nova Scotia based Atlantic Towing Limited to act as the Marine Operations contractor for the installation work. At this stage two potential options exist for the provision of a specialist installation barge: • Modification of an existing fleet vessel; or • Fabrication of a bespoke vessel. For the demonstration array at Berth D, the economics could favor the modification of an existing vessel. However, if consideration is given to the potential for future commercial scale arrays, a bespoke vessel could optimize the installation process. Whichever option is selected for this project, the intention is to subcontract the work to Atlantic Towing's sister company Irving Shipbuilding Inc.
Installation	Installation of the devices would be undertaken under the supervision of ANDRITZ HYDRO Canada Inc., with marine operations supervised by McLaughlin & Harvey and performed by Atlantic Towing Ltd. This combination provides local knowledge and expertise, the experience of performing multiple deployment and retrieval operations of in-stream tidal devices and the major construction project management experience of ANDRITZ HYDRO. The installation of each device will be undertaken in three steps by moored barge: • Installation of the Substructure • Installation of the Ballast • Installation of the Nacelle and Blade Assemblies The Deployment Schedule is given in Section 2.7 below and the proposed installation methodology is attached in **Appendix G -**

	Installation and Retrieval Methodology. The installation work package will be repeated for both phases.
Commissioning	Commissioning will consist of the following activities: • Powering up of nacelle auxiliary system i.e. 400V and 24V supply to equipment. • Functionality check of electrical and mechanical systems and relevant instrumentation • Onshore interface checks and system interlock checks • No load rotation • System tuning with onshore frequency convertor • Part load operation • Alarm and system shut-down functionality check • SCADA system check • Full load operation • Supervised autonomous operation • Autonomous operation • Final SAT
Performance Testing	The Device Performance Test will be carried out on completion of the Device Functionality Test for establishing the Device Measured Power Curve used to confirm the rated output of the Device for relevant water velocities. The Device Performance Test shall be carried out over a period of one lunar cycle and will be generally based the IEC standard IEC 62600-200, however, with the following exclusions: • Generated power will be measured at the generator terminals (variable frequency) • Water velocity will be measured only with one single onboard water velocity measurement device which is suitably calibrated against one single water velocity measurement device which is either sea bottom mounted or vessel mounted.

Subsequent to the completion of the Performance Testing, the project will move into the Operation and Environmental Monitoring phases. General day-to-day operation will be carried out by the local DP Energy office with technical support from ANDRITZ HYDRO as required. Operational monitoring that will be carried out will include the following:

- Analysis and rectification of upcoming alarms;
- Analysis and optimization of condition monitoring system; and
- Frequent check on system and component operating performance values.

The Environmental Monitoring Plan (EMP) will be developed through further consultation with the regulatory authorities and proposed collaboration with Acadia University and is described in more detail in Section Three, Point 8: Research and Monitoring below.

The Maintenance Interval for the devices will be five years, requiring device retrieval and return to shore. The Nacelle and Blade assembly retrieval will be a reverse of the installation process, and will require heavy lifting equipment and a servicing hall. Maintenance will be carried out by ANDRITZ HYDRO in the first instance with the marine operations again subcontracted out. In the future there is the potential for the maintenance to be carried out by a local subcontract under ANDRITZ HYDRO's supervision.

The Decommissioning Phase will essentially be a reversal of the installation phase and is described in detail in the Decommissioning Plan attached as **Appendix H - Decommissioning Plan**.

As is stated, the intention is to use this demonstration project as a stepping stone to developing a commercial scale array. Where feasible, DP Energy would look to commence the development/consenting activities for a commercial scale array in parallel with the demonstration project at Berth D.

7. Deployment Schedule

Detailed deployment plan including, but not limited to:

- the types of vessels and equipment to be used;
- the sequence of the deployment and details for each step;
- the times associated with the deployment steps and for the overall deployment; and
- contingency plans for partial or unsuccessful deployment.

This will also include plans for retrieval and removal of devices.

A proposed methodology for the deployment and retrieval of the devices is given in **Appendix G - Installation and Retrieval Methodology**.

A summary of operations and vessels required is given below:

Step	Vessel	Time	Contingency
Cable preparation of FORCE	DP or moored multicat	42 hrs	Cutting of cable and remobilisation at another date
Transportation of substructure and ballast	Crane barge Multicat	Depending on manufacturing location	Transportation when suitable
Setup of moorings	Multicat	24 hrs	Lay when suitable
Mooring up on site	Crane barge Multicat	8 hrs	Waiting for next weather window
Lowering Substructure and ballast in place	Crane barge	24 hrs	Waiting for next weather window
Demob	Crane barge, Multicat	8 hrs	N/A
Transportation of nacelle from RTD to the installation	Transportation vessel	2 weeks	Transportation when suitable

location			
Final assembly of turbine at a harbour	Flat top barge Crane barge	2 weeks	Assemble when suitable
Transportation of nacelle to site	Crane barge Multicat	Depending on assembly location	Waiting for next weather window
Mooring up on site	Crane barge Multicat	8 hrs	Waiting for next weather window
Lowering of nacelle onto the substructure	Crane barge	12 hrs	Waiting for next weather window
Cable connection onboard the vessel	Multicat	6 hrs	Waiting for next weather window
Lowering of cable in place	Multicat	6 hrs	Waiting for next weather window
Demob	Crane barge, Multicat	8 hrs	N/A