Current Profiling Advances Improve Tidal Energyâ€™s Competitiveness

The rapid growth of interest in tidal energy has highlighted the role of current profilers, able to measure the speed and direction of currents with increased accuracy in some of the harshest marine environments in the world. While the turbines produce the power, current profiling technology plays an important role in maximising the efficiency, and hence competitiveness, of this promising area of renewable energy.

The use of seabed-mounted turbines to generate power from tidal currents has been steadily progressing through the experimental stage, with just a handful of small projects dotted around the world. However, this is a sector that is poised to play a significant role in power generation, where tidal conditions are right.

The tidal industry has huge potential thanks to recent technology improvements and the push to bolster renewable energy production in all areas of the world. Assessing the extent of global tidal resources remains a speculative exercise, but the International Renewable Energy Agency (IRENA) reports that the technically exploitable portion of these resources close to shore could total as much as 1 terawatt of capacity.

Ensuring the Correct Turbine Orientation

Power companies are gearing up for commercial production, testing turbines that can be installed in arrays on the seabed in suitable conditions. However, placing the turbines in the right locations and with the correct orientation to maximise the throughput of water – and thus the amount of power generated – requires sophisticated measurement and analysis of ocean currents.

The latest acoustic Doppler current profilers (ADCPs) are able to produce high-quality data that can determine the best locations for future tidal generators and how existing designs should be modified to maximise their efficiency. These ADCPs can also perform increasingly complex tasks depending on the needs of the user, such as allowing concurrent measurements of the velocity profile and the distance to the surface, which improves our understanding of the interaction between waves and currents.

ADCPs work by sending out acoustic pulses from transducers on the head of the instrument, which bounce back to it from particles suspended in the water. Measurements can be taken at various points throughout the water column by recording the time it takes for the sound waves to bounce back, while the differing frequencies of the outgoing and returning pulses allow the Doppler shift to be calculated. With this information, current speeds can be derived throughout the water column.

The tidal turbine developer OpenHydro has deployed one of the latest versions of ADCP technology, the Signature500 made by Nortek AS, on its full-scale demonstration arrays in Europe and North America.

Resilient Technology

OpenHydro’s demonstration array sites have been selected precisely because of their extremely aggressive flow conditions, but they remain well within the operational envelopes of both the ADCPs and the turbines.

The ADCPs, which are around 27cm by 22cm at their widest, have been fully integrated into the turbine systems.

On each OCT, OpenHydro has deployed two Signature500 units at the height of the rotor centre, pointing horizontally into both the flood and ebb tides. These devices are mounted to project three of the device’s five acoustic beams within the horizontal plane upstream of the device, sampling the incoming flow.

In this deployment configuration, any two of the three beams in the horizontal plane can be used to derive the two relevant components of velocity at the 'hub-height' of the rotor, at a number of points progressing further upstream of the turbine.

The use of a third beam provides an insight on smaller scales and higher frequencies of turbulence. It also provides a redundant component of velocity to determine the accuracy of the other two components; and it also provides overall redundancy within the sensor system, should one of the three transponders fail for any reason.

The profiler's fourth and fifth beams can be used in vertical deployments, where there are stronger motivations to derive three-dimensional components of velocity and turbulence.

The faster sampling rates of the new wave of profilers – up to 8Hz on the Signature500 model used in Paimpol-Bréhat and 16Hz on other models – permit an increase in the amount of information that can be gathered compared to older 4Hz models. This simplifies the detection of variations in currents, permitting the collection of many more independent current profiles in quick succession.

AD2CP Flexibility

These latest instruments use AD2CP broadband technology and employ frequency-based coding techniques, which allow more freedom to define the appropriate transmission frequencies. This is particularly useful in long-range applications, where broadband frequency measurements, covering a range of 600m, are interleaved with narrowband frequency measurements, covering a range of 1,000m or more in ideal conditions. This results in a full 1,000m-plus profile with the first 600m detailing high-resolution velocity measurements with very low noise characteristics.

Indeed, this is just one illustration of the flexibility of the AD2CP platform. It is a multi-functioning system, capable of high sampling rates (max. 16Hz), concurrent measurements, and the production of highly detailed current/turbulence/wave data. It is also capable of producing measurements beyond currents and waves, covering applications involving ice measurements (draft and movement), bottom tracking (DVL range) and biomass movement and distribution (echo sounder). Nortek have taken out an 'AD2CP' US patent (7911880), which covers the concept of this multi-function device.

The platform is a lot smaller, lighter and less power hungry than other equipment of this nature produced to date, so the platform lends itself very well to longer, stand-alone operations in the field.

Another important development has been the application of Ethernet-based communications. With smarter interfaces, AD2CP instruments are capable of syncing relatively easily and accurately (10μs or 7.5mm). This has enabled OpenHydro to use an online interface through which all ADCPs in the array can be accessed, settings can be changed easily and instruments within the array can be synced within microseconds.

The AD2CP electronics platform is sufficiently powerful and versatile that Nortek plans on using it over the next 5-10 years as a basis for all of its future developments.

Collaborative Process

OpenHydro and Nortek have worked together for almost 10 years in the lead-up to their current full-scale projects. These projects included test deployments in Bay of Fundy off Nova Scotia and Phase 1 at Paimpol-Bréhat. Throughout this time, Nortek staff have helped OpenHydro to ensure the sensors are deployed correctly and provide the expected outputs.

For the most recent integration of the ADCPs, the project started with a meeting at OpenHydro's technical centre in Ireland, after which Nortek provided support, opening a direct line of contact between the oceanographers at OpenHydro and the engineers, and R&D department at Nortek. That resulted in a close collaboration which will continue through the rest of the project, as detailed analysis gets under way.

By improving the understanding of the environmental conditions in which each turbine operates, data from a current profiler improves the level of certainty in power performance assessment and provides essential information for the validation of load derivation methods.

Such improvements offer the promise of higher efficiency, and thus lower cost tidal power. The extent of gains will depend on the circumstances of each individual project, which will become clearer as more tidal facilities are developed.