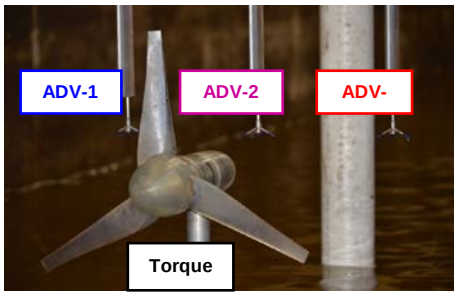
Advanced Turbulence Measurements and Signal Processing for Hydropower Flow Characterization

The turbulence measurements group has extensive experience and expertise in turbulent flow measurements, signal processing and analysis of bulk and mean flow properties of turbulent flows. Experience includes measurements and flow characterization within full scale conventional hydropower systems, at marine and hydrokinetic (MHK) development sites and around scaled MHK turbine technologies in the laboratory. These measurements are critical for turbine inflow characterization, hydrokinetic energy resource assessment, turbine performance testing, and computational fluid dynamics (CFD) model validation.

Synchronized ADV Arrays



- ORNL pioneered the use of synchronized acoustic Doppler velocimeter (ADV) arrays that allow a detailed characterization of turbine inflows and wake flows not possible with a single ADV measurement. In addition to quantifying the mean velocity and turbulence statistics at multiple points, these measurement systems allow calculation of the spectral coherence of turbulence to assess the effects of large scale turbulent eddies on turbine performance, structural loading, and fatigue.

Signal Post-Processing Algorithms for Acoustic Doppler Velocimetry and Profiling

- ORNL has developed signal post-processing algorithms for ADVs and acoustic Doppler current profilers (ADCP) for filtering noise and calculating turbulence statistics, turbulence spectra and spectral coherence. These algorithms, which incorporate all current industry standard protocols, are fully documented in Gunawan and Neary (2011), Gunawan et al. (2011) and Neary et al. (2011).

Representative Projects

- *Effects of Large Scale Energetic Eddies on MHK Turbine Performance* – ORNL measured the effects of large scale eddies on machine performance and wake recovery in partnership with St. Anthony Falls Laboratory. The study quantified expected reductions in performance by these eddies and observed accelerated recovery of the near wake flow due to increased turbulent mixing.
- *Error Quantification of Shipboard ADCP Measurements* – ORNL quantified the errors associated with shipboard ADCP measurements and developed a data post-processing method to reduce the cost of flow and turbulence measurements at MHK development sites using this technique.
- *Synchronized ADV Measurements at Verdant Power's RITE Site* – ORNL provided a synchronized ADV system and setup, and post-processing support for turbulence measurements at hub height of the Verdant turbine at the RITE site in the East River, New York City. Results include spectral coherence and energy dissipation rate calculations to support inflow turbulence models used for MHK turbine design.
- *ADV Measurements around Model MHK turbine Blades* - ORNL measured the flow field around model MHK turbine blades for larval fish strike experiments conducted at the ORNL aquatics laboratory to gain greater insight into the effects of the mean flow field and turbulence on larval fish passage and strike.

References

- Gunawan, B. and Neary, V.S. (2011) ORNL ADCP post-processing guide and MATLAB algorithms for MHK site flow and turbulence analysis. ORNL/TM-2011/404, September 2011.
- Gunawan, B., Neary, V.S. and McNutt, J.R. (2011). ORNL ADV post-processing guide and MATLAB algorithms for MHK site flow and turbulence analysis. ORNL/TM-2011/338, September 2011.
- Neary, V.S., Gunawan, B., Richmond, M.C., Durgesh, V., Polagye, B., Thomson, J., Muste, M. and Fontaine, A. (2011). Field measurements for MHK site development: Best practices manual ORNL/ TM-2011/419, September 2011.

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