EE0008389– Water Horse Hydroelectric Harvester Development

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Project Overview

Project Summary

- The Water Horse is a vertical oscillator, hydrokinetic harvester designed by Renerge, Inc to harvest energy from turbulent water conditions, previously deemed as unrecoverable. Technology focus is on small, remote riverine applications where deployment of larger hydrokinetic energy converters is challenging due to water depth limitations.

Intended Outcomes

- The intended outcome is to advance the TRL of the Water Horse from 5 to 7 and produce quantitative and qualitative data about the performance of the system at the kW scale in a real river environment.
- Experimental data from testing 2 - 1.5 kW scale oscillating energy harvesters in riverine environment. Numerical model validation. Power converter development.

Project Information

Principal Investigator(s)

- Jeremy Kasper

Project Partners/Subs

- Lisa Weiland, Renerge Inc.

Project Status

Sunsetting

Project Duration

- 01 June 2019
- 31 January 2023

Total Costed (FY19–FY21)

- $835k

Project Objectives: Relevance and Approach

Relevance to Program Goals:

- System Design and Validation: focused on industry developed tech at a scale relevant to Remote and Islanded Communities
  - Developing new, marine energy-enabled technologies to address and relieve power constraints in markets and applications in the blue economy
- Improving methods for safe and cost-efficient installation, grid integration, operations, monitoring, maintenance, and decommissioning: developed power electronics for grid integration and developed/tested/improved potentially low-cost/low-maintenance system, in situ fisheries impacts monitoring
- Supporting the development and adoption of international standards for device performance and insurance certification: adopted and applied IEC TS62600-300 for power performance assessment, including use of push tests to expand range of velocities. Will feedback to IEC Standards Committee
- Supporting the early incorporation of manufacturing considerations into device design processes: engaged in co-design process with fabricators
- Leveraging expertise, technology, data, methods, and lessons from the international marine energy community and other offshore scientific and industrial sectors: standard instrumentation and data collection processes adherent to IEC TS62600-300

Approach:

- This approach differs from similar systems, in that only the bluff body is submerged, enabling a break-away system to mitigate debris impacts while also positioning the PTO mechanism and electronics above the waterline.

Project Objectives: Expected Outputs and Intended Outcomes

Outputs:

- Power Conditioning System (PCS) developed and lab-tested
- 15 days of field test data from Single and Dual Systems including PCS
    - Electrical – voltage, resistance, current
    - Mechanical – angular position, accelerometer, spring force
    - Hydrodynamic – velocity and turbulence velocity from ADV and ADCP
    - Archival at MHKDR (after clearing with Renerge, Inc.)
- Publications
    - Masters Thesis
    - IEEE and IEMDC papers
    - ICOE 2021 poster
    - Planned:
        - Presentation at METS 2022.
        - ASME OMAE manuscripts (for PhD thesis).

Outcomes:

- Short term outcomes – evaluation of suitability of gallop approach for Alaska rivers – efficiency (12%), reliability, cost ($4.38/kWh).
- Comparison of performance at kW-scale (Reynolds Number > 500,000) to numerical modeling based on flume and CFD data.
- Iterative design improvements based on in-water testing (clutch, PTO, smaller bluff body, spring pack, suspension).

Project Timeline

FY 2019

1.5kW system numerical modeling, power converter simulation, mechanical design

FY 2020

Field testing of single oscillator 1.5 kW system, identification of design improvements

FY 2021

Field testing of dual oscillator 1.5kW systems with improved PTO and power converter

2-publications on power electronics, ICOE poster

Project Budget

Total Project Budget – Award Information		
DOE	Cost-share	Total
$1,000K	$112K	$1,112K

FY19	FY20	FY21	Total Actual Costs FY19–FY21
Costed	Costed	Costed	Total Costed
$87K	$439K Includes lab and field testing, design of power converter, MS thesis work, analysis	$309K Lab and field tests, Publication of MS work, presentations, analysis	$835K Remaining budget for analysis, reporting and conference presentations including 2 additional PR publications as part of a PhD thesis

End-User Engagement and Dissemination

- At this low TRL, stakeholder and end-user engagement is limited to disseminating the results via
  - Peer Review Publications
    - IEEE
    - IMDC
    - Planned: ASME OMAE
  - Technical Meeting Presentations
    - ICOE, METS, UMERC, PMEC annual meetings
- Project results will be shared via MHK Data Repository and Renerge, Inc to inform commercialization decisions.

Performance: Accomplishments and Progress

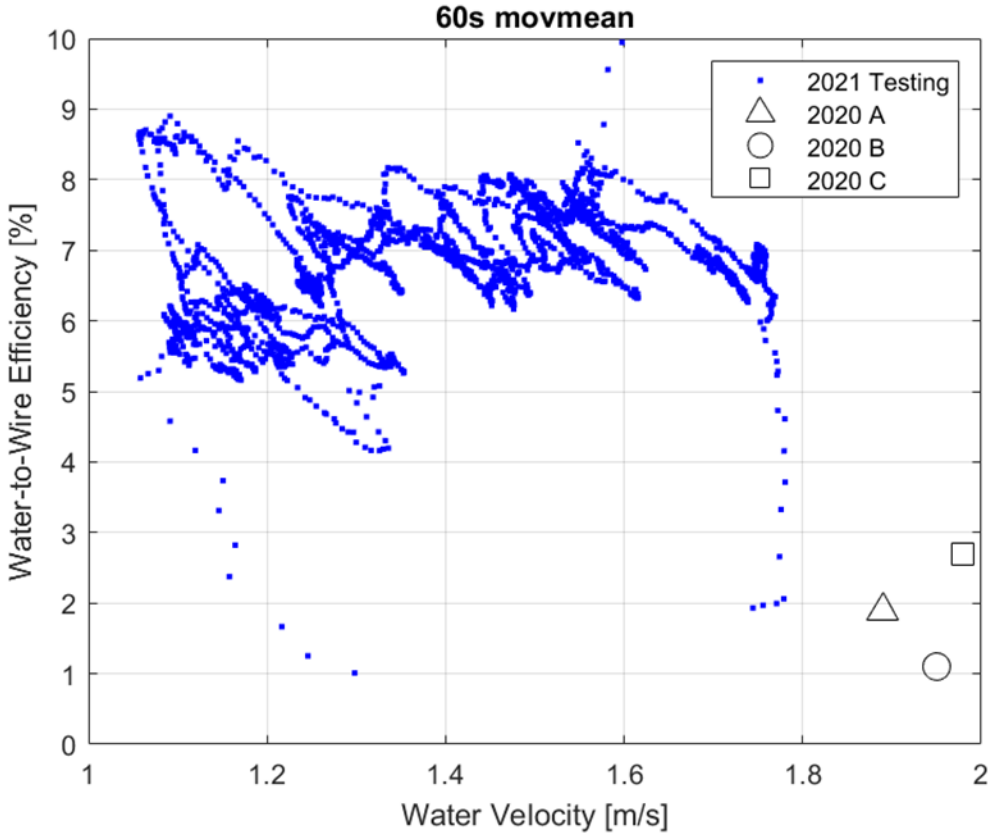
- Numerical Model
  - Algebraic model using lift and drag coefficients to estimate impact of design parameters on performance.
- Power Converter
  - Method of converting pulsed power output of oscillator into usable DC or AC power.
- Single oscillator prototype
  - Initial field tests at scale. Proof of concept, revealed shortcomings of PTO and limitations of floating platform deployment. Max average power of 400W compared to 1500W target.
- Dual oscillator prototype
  - Incorporated improved PTO and better frequency matching to reduce barge heave.
- Field testing data – power and efficiency benchmarks
  - Prototype 1 - max average power of 400W comparted to 1500W target.
  - Prototype 2 – tested at lower velocities, achieved water-to-wire efficiency of 12%

Performance: Accomplishments and Progress

2020 Prototype – single oscillator off barge transom

2021 Prototype – dual oscillators through barge moonpool

Performance: Accomplishments and Progress



Water-to-wire efficiency vs velocity.
2020 system – symbols at lower right.
2021 testing – blue dots, preliminary data.

Performance: Accomplishments and Progress (cont.)

- Peer-reviewed Journal Articles
  - Wise, Michael, et al. "A Novel Vertically Oscillating Hydrokinetic Energy Harvester." *2021 IEEE Conference on Technologies for Sustainability (SusTech)*. IEEE, 2021.
  - Wise, Michael, and Maher Al-Badri. "Energy Conversion Unit for Low-Speed Vertical Oscillator Hydrokinetic Energy Harvester." 2021 IEEE International Electric Machines & Drives Conference (IEMDC). IEEE, 2021.
  - A poster titled “Water Horse Galloping Energy Harvester Field Testing” was presented at ICOE 2021 virtual conference.
- Masters Thesis
  - Wise Jr, Michael A. Development of a Vertical Oscillator Energy Harvester: Design and Testing of a Novel Renewable Resource Power Conversion System. University of Alaska Fairbanks, 2020.
- Invention Disclosure
  - PTO design improvements

Q&A