Optimized Composite Prototype for Archimedes Turbine Manufacture
Optimized Composite Prototype for Archimedes Turbine Manufacture:

The Objective: Develop “next gen” Archimedes Hydrodynamic Screw (AHS) turbines using advanced components/composite materials and establish U.S. manufacturing capability with new protected IP

The Challenge: To decrease the levelized cost of energy/installed capital costs of this proven technology significantly enough to make many more low-head hydro plants viable in the United States

Partners:
- Pacific Northwest National Lab – Computational fluid dynamics (CFD), finite element analysis (FEA), materials consultation
- Hertelendy Research Associates, Inc. (HRA) – Blade/mold design and fab
- Mid Columbia Engineering, Inc. (MCE) – Bench scale test/turbine assembly
- Utah Water Research Lab/Utah State University (UWRL/USU) – Prototype testing
- Dr. Chris Rorres and Dr. Dirk Nuernbergk – Modeling and analyses
- Ershigs, Inc. – Central tube
Next Generation Hydropower (HydroNEXT)

**Optimization**
- Optimize technical, environmental, and water-use efficiency of existing fleet
- Collect and disseminate data on new and existing assets
- Facilitate interagency collaboration to increase regulatory process efficiency
- Identify revenue streams for ancillary services

**Growth**
- Lower costs of hydropower components and civil works
- Increase power train efficiency for low-head, variable flow applications
- Facilitate mechanisms for testing and advancing new hydropower systems and components
- Reduce costs and deployment timelines of new PSH plants
- Prepare the incoming hydropower workforce

**Sustainability**
- Design new hydropower systems that minimize or avoid environmental impacts
- Support development of new fish passage technologies and approaches
- Develop technologies, tools, and strategies to evaluate and address environmental impacts
- Increase resilience to climate change
Next Generation Hydropower (HydroNEXT)

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**The Impact**

- Optimum AHS turbine designs are developed, modeled and performance tested
  - More efficient, lighter weight, environmentally friendly, and economically viable.
- **Desired Result**: Lower cost, optimum efficiency turbines are manufactured in the United States instead of being imported, and are rapidly deployed at hundreds of existing low-head sites.
- **Final Project Deliverable**: Fabricate, Test and Deliver a fully-validated prototype CAHS turbine system for permanent field demonstration.
Next Generation Hydropower (HydroNEXT)

**Sustainability**
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  - Support development of new fish passage technologies and approaches
  - Develop technologies, tools, and strategies of evaluate and address environmental impacts
  - Increase resilience to climate change

**The Impact**
- The extremely fish-friendly Archimedes turbine is further improved and optimized for viable deployment in the United States.
- Desired Result:
  - Lighter weight turbine assemblies and new modular on-site installation methods are developed for fish-friendly AHS turbines
    - Smaller plant footprints, reduced construction times, costs and environmental impacts.
  - New distributed capacity is added to the U.S. hydropower fleet with ultra-low environmental impact utilizing existing man-made drops and infrastructure.
Technical Approach

Project Scope:
Design, Fabricate and Test an Optimized AHS Turbine Prototype using advanced materials and methods

• Utilize iterative approach
  • Theoretical mathematical models
  • Experimental results on water tests of bench-scale turbines
  • Computational Fluid Dynamics (CFD) modeling
  • Finite Element Analyses (FEA) using pressure maps from CFD
  • Water testing of larger Prototype assembly
• Focus on delivering the most power output per unit cost of the turbine assembly
• Pay closer attention to entrance/exit effects
• Utilize bench-scale tests to cost-effectively validate selected optimized designs before scaling up.
Technical Approach

• Bench Scale Testing provides hands-on insight
• Enables validation of CFD modeling
• Will provide cost-efficient testing of design optimizations
Accomplishments and Progress

**Project underway since March 2016**

- Completed bench-scale water testing on 3 turbines (over 800 data sets)
  - Including first ever testing of “strake” design by Rorres (patent pending)
- Completed mathematical modeling and selected parameter sets for 4 optimized prototypes (to move onto CFD/FEA modeling by PNNL)
  - Currently analyzing initial CFD/FEA results by PNNL
- Developed and approved first mold/blade design for prototype manufacture.

**Project is on schedule**

- Additional bench-scale tests to be performed on optimized designs for cost effective validation/refinement prior to fabricating larger prototype.

**Recognition**

- Entrepreneurial Award to Percheron by Richland Rotary/Chamber of Commerce (sponsored by Pacific Northwest National Laboratory)
- Several news articles featuring project in local/regional press and television
- High-profile municipality in Colorado plans to run permanent demonstration of prototype following successful lab testing.
Project Plan & Schedule

Project on Schedule

• Started March 1, 2016 and planned completion February 28, 2018
• All milestones to date achieved as scheduled
• One Go/No-Go Decision Point for Project in Month 15 (June 2017)
  • Readiness to Proceed with Testing of Prototypes at Utah Water Research Laboratory
### Project Budget

- **Total Budget:** $1,111 K DOE; $278 K Cost-share
- **30% of the project budget expended to date**
  - Project is on schedule and within budget
- **Matching funds being contributed by all team members** (Percheron, MCE, HRA, UWRL/USU, consultants)
- **Additional funding through DOE Small Business Voucher and PNNL Technology Assistance Program for PNNL support.**

#### Budget History

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Communications and Technology Transfer:
- Technical Paper drafted for submittal to Journal of Hydraulic Engineering
  - Present bench-scale test set-up and results
- Optimum turbine design details to be protected data/IP, as per contract terms
  - Goal is competitive manufacture of advanced AHS turbine in United States.
Next Steps and Future Research

**FY17/Current research:**
- Compare model predictions and test results to select optimized designs
- Fabricate prototype turbine blade assemblies
- Develop/procure remaining turbine system components
- Receive Go/No-Go approval from DOE for testing (6/2017)
- Perform in-water performance testing at UWRL/USU.

**Proposed future research:**
- Develop systems model for optimum turbine design
- Develop and test improved efficiency powertrain
- Continue development of entrance/exit optimizations
- Develop flexible test facility for permanent in-water testing of optimized low head turbines.