REAL WORLD DEMONSTRATION OF A NEW, AMERICAN LOW-HEAD HYDROPOWER TURBINE

Wayne Krouse
Hydro Green Energy
wayne@hgreenenergy.com
February 2017
Real World Demonstration of A New, American Low-Head Hydropower Turbine: Fabricate, install and operate an interchangeable Modular Bulb Turbine™ at a low-head hydropower project site at an existing non-powered dam.

The Challenge:

• Growth in the low-head hydropower sector has been stymied over the decades for a variety of reasons, the most critical being the high LCOE associated with building low-head, lower power hydropower plants.

• New turbine systems, inexpensive civil structures and low-impact installation methods are needed to ensure the robust development of the greatly untapped low-head hydropower sector.

Partners: Mechanical Solutions Inc.
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)

**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

**The Impact**

- Reduce the civil engineering costs associated with installing and maintaining small hydropower projects
- Validate this full-scale commercial technology to successfully deploy hundreds of commercial units at over 20 low-head hydropower sites resulting in approximately 350-400 MW of new, low-impact hydropower generation in the United States
- The valuable knowledge gained, and lessons learned, from this proposed project will also work to advance the industry as a whole given the large untapped potential of the small hydropower sector.
1. Design & Pre-Assembly Activities

- **Licensing and Permitting:** Obtain all necessary licenses and permits (e.g. Federal Energy Regulatory Commission [FERC] license, Clean Water Act [CWA] Section 401 and 404 permits, U.S. Army Corps of Engineers [USACE] 408 permit)

- **Preliminary Full-Scale Design:** Validate the scale model and existing full-scale hydraulic and mechanical design based on the scale model testing results

- **Critical Design:** Finalize the full-scale turbine hydraulic flow path design yielding the final flow path component geometry and performance curves

- **Civil and Structural Design:** Prepare final design drawings and applicable construction specifications in support of civil, structural, mechanical, and electrical construction activities.
2. Fabrication, Assembly, and Civil Site Preparation

- **Hardware Procurement**: Identify all hardware required for assembly and installation, and procure materials.
- **Assembly**: Test and assemble generator frame modules, modular bulb turbines, turbine frame modules, and large frame module (LFM), and prepare for shipment.
- **Site Preparation Activities**: Drive sheet pile for LFM shelf, remove silt, pump in tremie concrete section, form/reinforce/place concrete section, and prepare LFM mountain face on upper pool site of weir.
3. Installation, Performance Testing, Commissioning, and Startup

- **Installation**: Install the LFM, complete construction of reinforced concrete cap on weir, install turbine and generator sub-modules
- **Testing and Commissioning**: Perform hydraulic (IEC 62006) and operational tests (PTC-18)
- **LCOE Analysis**: Calculate LCOE of the full-scale turbine and compare to an original equipment manufacturer turbine.
Accomplishments and Progress

- Completed drilling program at site – SEP16
- Rock property lab test completed NOV16
- Negotiating EPC contract now

Project Test Site – Topic 1.2
Braddock Lock and Dam - 5.25 MW
Seven (7) units rated at 750 kW each
• Project original initiation date May 2016 and project planned completion date May 2018
• USACE agreements required by FERC that were to take 90 days actually took 365 days
• Multiple milestones from Tasks 1.1 to 1.6 (which is securing all contractors for project construction)
### Project Budget

#### Budget History

<table>
<thead>
<tr>
<th></th>
<th>FY2017</th>
<th>FY2018</th>
<th>FY2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOE</td>
<td>Cost-share</td>
<td>DOE</td>
<td>DOE</td>
</tr>
<tr>
<td></td>
<td>$375K</td>
<td>None to date</td>
<td>None to date</td>
</tr>
</tbody>
</table>

- No project budget variances to date
- Approximately 75% of Budget Period 1 has been spent to date
Partners, Subcontractors, and Collaborators: Mechanical Solutions Inc.

Communications and Technology Transfer: NA
Next Steps and Future Research

FY17/Current research: Preliminary and final full-scale design

Proposed future research: Milestone: 1.1.e – Issuance of River and Harbors Act Section 408 Permit
Milestone: 1.2 – Component, equipment and system test plans complete
Milestone: 1.3 – Preliminary design complete
Milestone: 1.4 – Critical design review complete and delivery of report documenting results
Milestone: 1.5 – Civil and structural design complete. Release ready for construction drawings of civil, structural elements to support turbine for procurement