Harnessing the Hydro-Electric Potential of Engineered Drops

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Harnessing the Hydro-Electric Potential of Engineered Drops :

- **The Objective:** Design, develop, permit, and operate an Archimedes Hydrodynamic Screw (AHS) low-head hydro-electric facility on an existing engineered drop of a large irrigation canal

- **The Challenge:**
  - To successfully deploy the first hydro plant of this type on a canal in the United States, one of the largest capacity AHS plants in the world
  - Demonstrate AHS plants are simple, robust, and economical, and do not negatively impact ongoing irrigation operations

- **The Unexpected Obstacle:**
  - Executing a Power Purchase Agreement in Colorado above $70/MWh or receiving additional funding to permit economic viability of plant.

Project Overview

Partners

- Uncompahgre Valley Water Users Association – Plant Operations and Input
- U.S. Bureau of Reclamation – Lease of Power Privilege and Design Input
- J-U-B Engineers, Inc. – Civil/Structural Design
- 3-Helix and Dirk Nuernbergk – Turbine System Selection and Analysis
- N.E.I. and Delta Montrose Electric Association – Interconnection Design
- Rehart Gmbh and Rehart U.S.A –Turbine System Supplier

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

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The Impact

- A new but proven low-head technology is demonstrated in the United States and further advancements are underway for AHS

Desired Result: The local canal association successfully operates the plant and provides a public "showplace" for the new technology

- Plant provides revenue to improve their aging infrastructure, with no negative impacts to ongoing irrigation operations

Final Project Deliverable: A large Archimedes Hydrodynamic Screw Plant is successfully constructed and operating in the United States.

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The Impact

- The well-proven steel Archimedes turbine is successfully deployed at low-head engineered drops in the United States

Desired Result:

- AHS technology is adopted in the United States as a leading low-head plant solution for hundreds of other plant sites across the country
- New distributed capacity is added to the U.S. hydropower fleet with ultra-low environmental impact utilizing existing man-made drops and infrastructure.

Project Scope: Deploy the low-head AHS technology in the United States

- Permit/License, Design, Develop, Construct, Operate
- First Archimedes Hydrodynamic Screw Hydroelectric Plant on Irrigation Canal in U.S.
- One of Largest (nameplate capacity) AHS Plants in World

Impact of Project

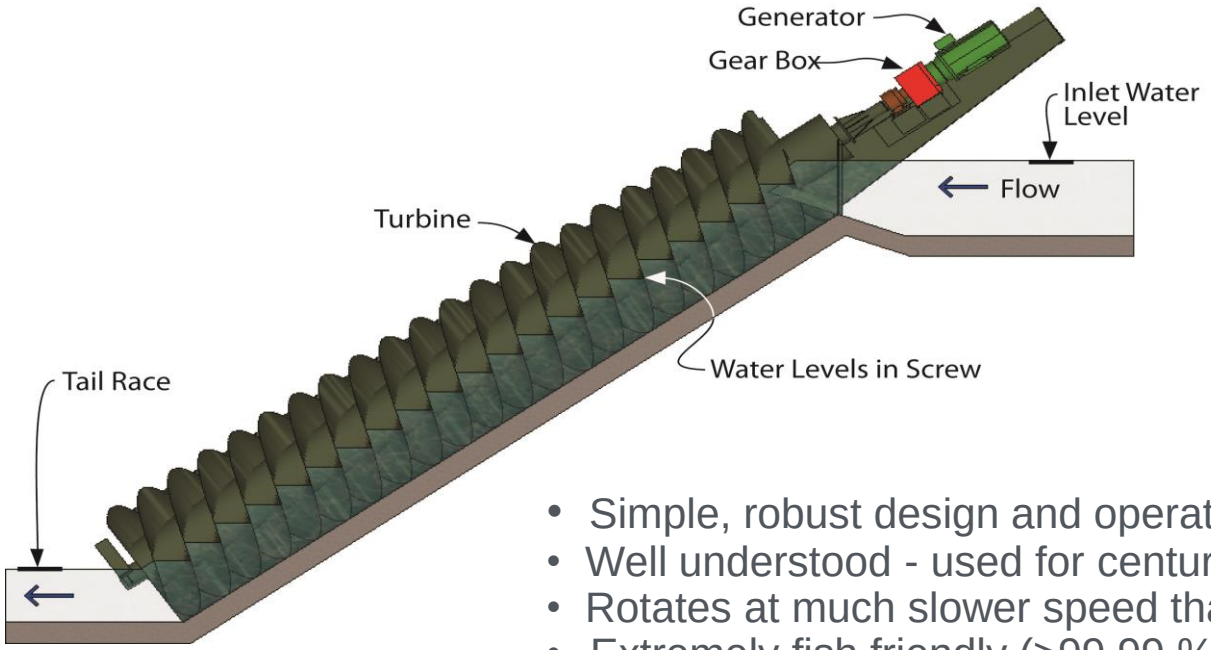
- Demonstrates to federal agencies, irrigation districts, and other irrigation system owners and operators that the AHS technology is simple, robust, economical, and does not negatively impact canal operations
- Supports development of new small hydropower projects by making previously marginal low-head sites viable
- Potential for broad applicability of this lower cost technology system to man-made and natural low head drops across the United States.

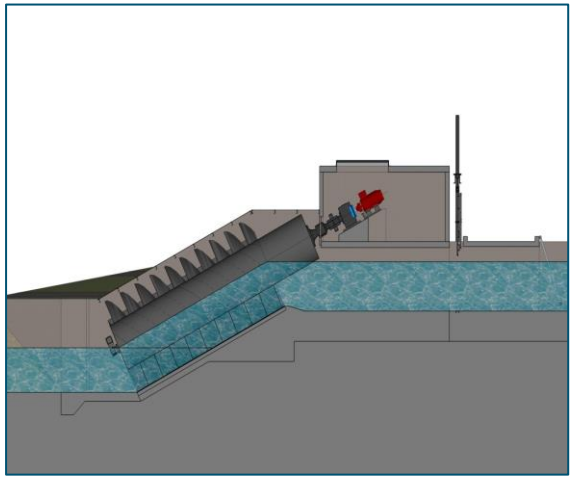
South Canal Drop 2 of the Uncompahgre Valley Project selected and approved for the AHS Demonstration Plant

- 100-year-old canal in SE Colorado
- Utilize 15.9 feet of head and 1000 cfs design flow
- 1 MW plant will produce ~4,000 MWhs annually
- Must import turbine system from Europe (currently no U.S. supplier)
- Conceptual, preliminary and detailed designs completed.

We involved the canal operators, Reclamation, and local utility throughout the process to ensure their input, comfort level, and approval

Archimedes Hydrodynamic Screw Turbine





- Simple, robust design and operation
- Well understood - used for centuries to "lift" water
- Rotates at much slower speed than Kaplan turbines
- Extremely fish friendly (>99.99 % survival)
- Can tolerate large debris so less trash screening

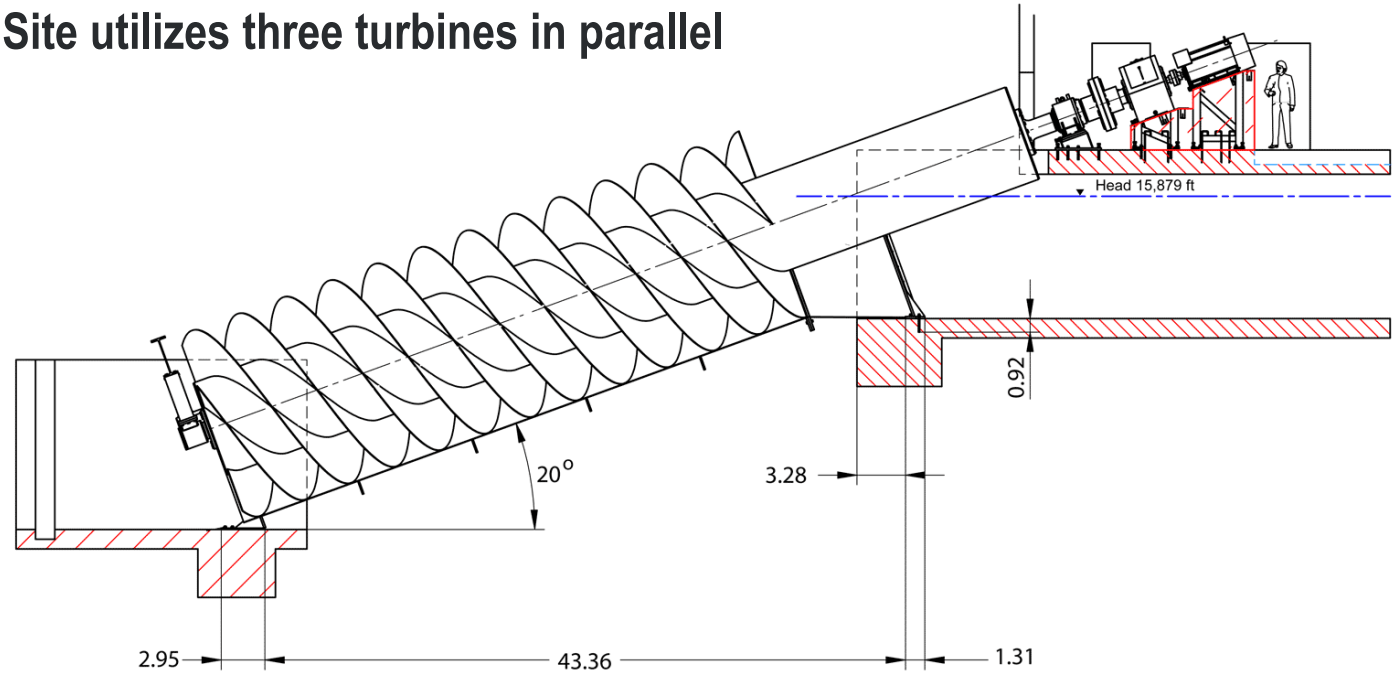
Technical Challenges of Selected Site

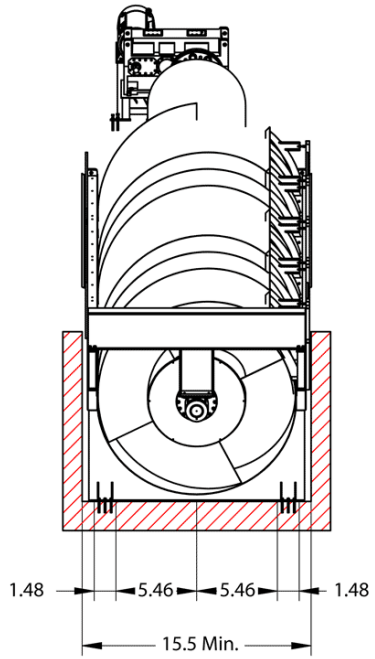
- Replace existing canal and stay within canal easement if possible
- Require full bypass around turbines – selected Obermeyer Gate
- Geotechnical surveys determined expansive clays that dictated special structural design and additional concrete.

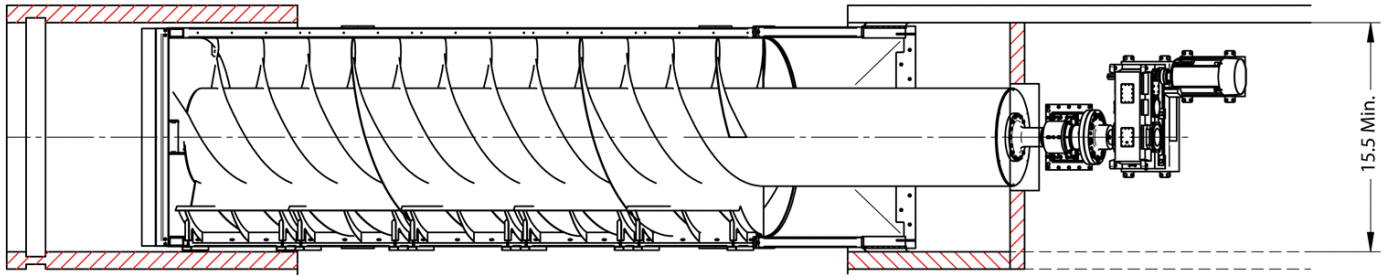
Archimedes Turbine Size for Drop 2

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

- **Each turbine assembly is over 70 feet long and, 15.5 feet in diameter and weighs ~ 35 tons**
- **Site utilizes three turbines in parallel**







Project Schedule

- Started December 1, 2012 and planned completion November 30, 2017
- Design and Permitting Fully Complete
  - Site Surveys and Geotechnical Surveys/Design Complete
  - Civil/Structural Detailed Design 100% Complete
  - Detailed Design Reviewed/Approved by UVWUA and Reclamation
  - National Environmental Policy Act Categorical Exclusion received from Reclamation and DOE
  - Preliminary and Final Lease of Power Privilege executed with Reclamation
- Interconnection Design Complete and IA executed
- Procurement and Construction
  - Request for Proposals and Specifications developed
  - Bids solicited, evaluated and contracts negotiated and executed
    - Turbine System Supply Agreement - Rehart Gmbh
    - Drop 2 Construction – Kissner General Contractors, Inc.

Project On Hold Pending Power Purchase Agreement

- Percheron joined with local co-op utility in attempting to interconnect as a PURPA Qualifying Facility (QF) despite co-op's existing contract with wholesale supplier
  - Federal Energy Regulatory Commission (FERC) ruled in DMEA/Percheron's favor (that DMEA must purchase the QF power and at negotiated rates regardless of their wholesale contract)
  - Percheron and DMEA executed Memorandum of Understanding for PPA in June 2015
  - Wholesale supplier petitioned FERC to charge "penalty" fee to DMEA/ local co-op utility to recover their power cost if co-ops buy QF power
  - FERC said no and wholesale supplier requested rehearing – final order still pending before FERC
- Percheron diligently pursued multiple other off-takers
- Project viability based on >$70/Mwh prior to award in 2012
  - Published rates of local utility and wholesaler now ~ $38/MWh
  - Other utilities >$100/MWh but require multiple "wheels"

Project Budget

Budget History					
FY2014		FY2015		FY2016	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$ 248K	$ 155K	$ 435K	$ 123K	$ 69K	$6K

- Total Budget: $1,495K federal; $3,690K match
- 70% of the federal project budget expended to date
  - Project construction on hold pending PPA
- Matching funds to date of $602K contributed by Percheron, Rehart, J-U-B Engineers, 3-Helix
- Requests for additional funding to maintain original cost share and permit plant viability at lower PPA price not successful

Research Integration & Collaboration

Partners, Subcontractors, and Collaborators:

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Communications and Technology Transfer:

- Numerous presentations on project throughout Western United States
- Expressions of interest in new AHS plants from canal operators in four other states (representing > 100 sites)

Next Steps and Future Research

FY17/Current research:

- Follow-up on workarounds to achieve viable PPA and/or additional funding
- Construct Drop 2 Plant as soon as irrigation canal is empty next Fall.

Proposed future research:

- Perform site assessments and develop “pipeline” of follow-on low head sites for future AHS plants
- Develop lower cost optimized composite AHS turbine and modular civil works
- Develop and test improved efficiency powertrain
- Develop Flexible Test Facility for permanent in-water testing of optimized low head turbines.