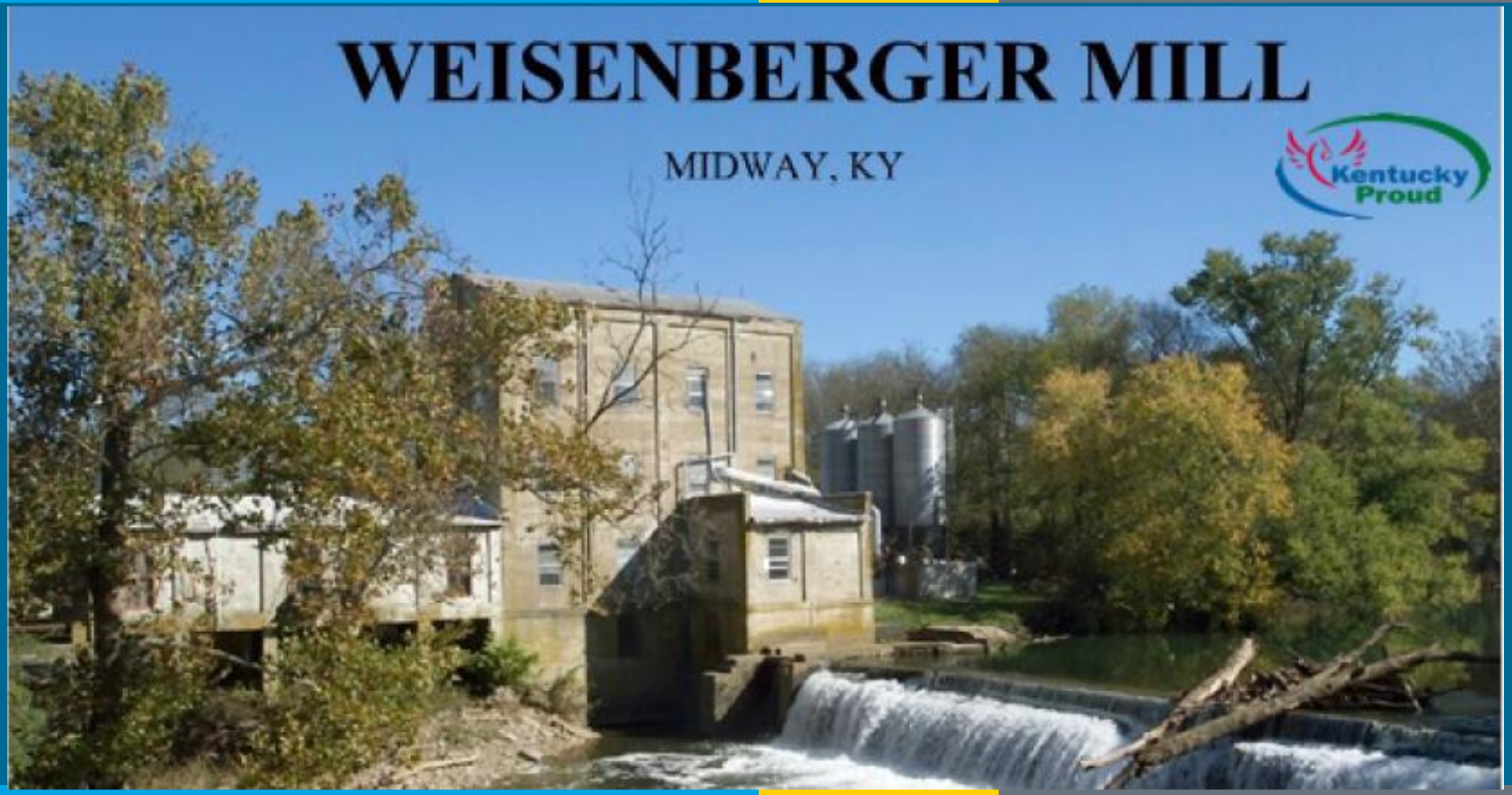

Demonstration of Variable Speed Permanent Magnet Generator at Small, Low-Head Hydro Site

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Project Overview

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

Demonstration of Variable Speed Permanent Magnet Generator at Small, Low-Head Hydro Site:

Small hydro developers face a limited set of bad choices when choosing a generator for a small low-head hydro sites, leading to low project efficiencies. This project demonstrates a solution from the Wind Industry that can be applied to Hydro Industry – Variable Speed Generators. Increased efficiency from variable speed technology could make many more small hydro sites economically feasible to develop.

The Challenge: Increase turbine efficiency at small hydro sites with variable head by using variable speed generators.

Partners: Shaker Landing Hydro Associates – Project Installation
Potencia Industrial, S.A – Technology Supplier
Center For Applied Energy Research – Data Collection and Analysis
Kentucky Utilities Co. – Independent Data Collection

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
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- Prepare the incoming hydropower workforce

The Impact

This project showed that the use of a variable speed generator can significantly increase overall project efficiency at small, low-head hydro sites. The technology is available today. If this technology were adopted by the hydropower industry, efficiency and energy output could be improved at low-head sites, and more small sites could become economically feasible to develop.

Technical Approach

Demonstration of Variable Speed technology done on a small hydro generator (50 KW), to be scaled up to large systems if successful.

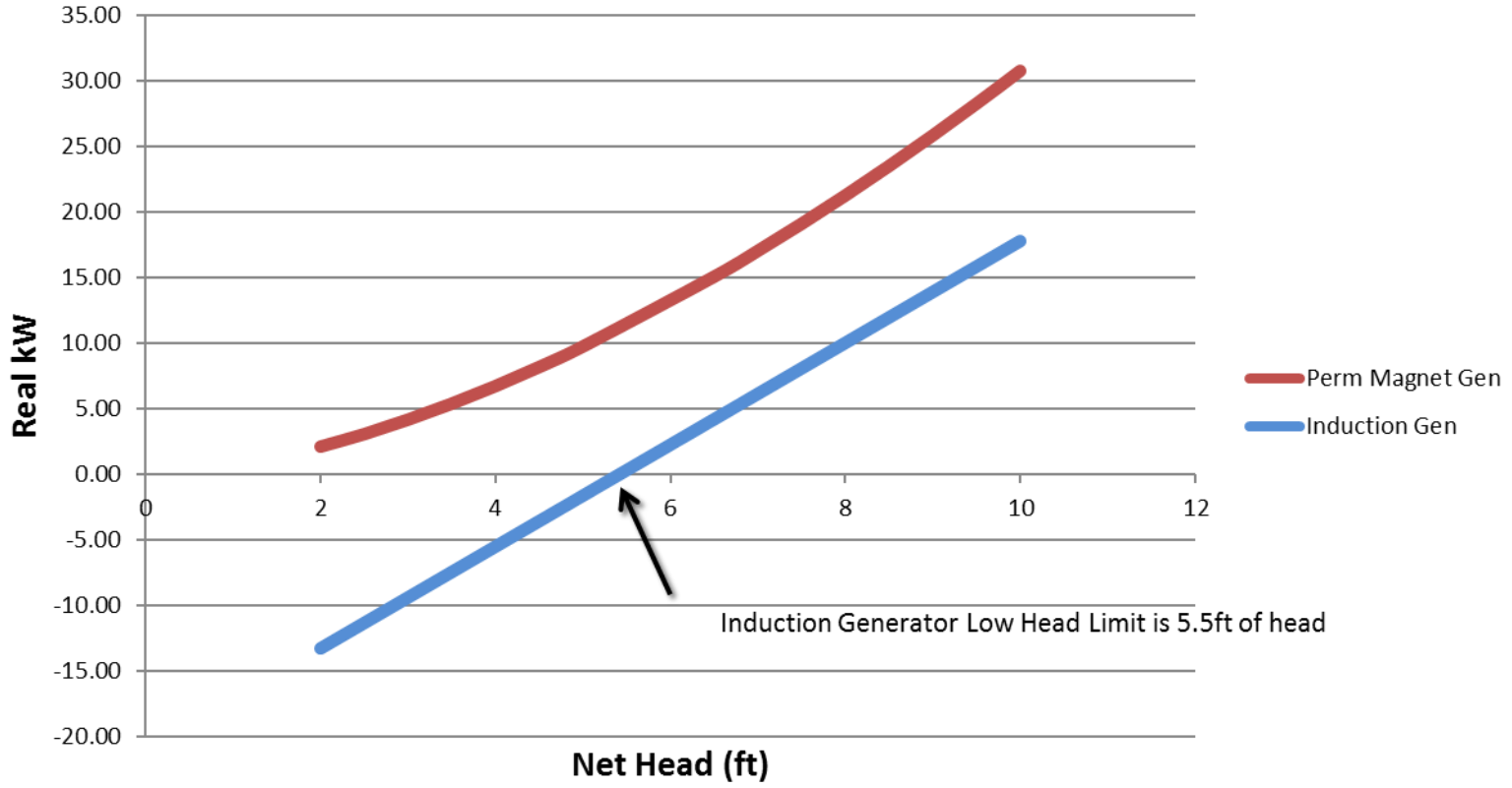
Provides an “Apples-to-Apples” comparison of an existing fixed speed induction generator to a new Variable Speed Permanent Magnet Generator. Steps taken:

1) Install data collection system
2) Collect data on existing system
3) Remove old induction generator system
4) Install Variable Speed Permanent Magnet Generator (PMG) system
5) Collect data with new PMG system
6) Analyze data
7) Publish results

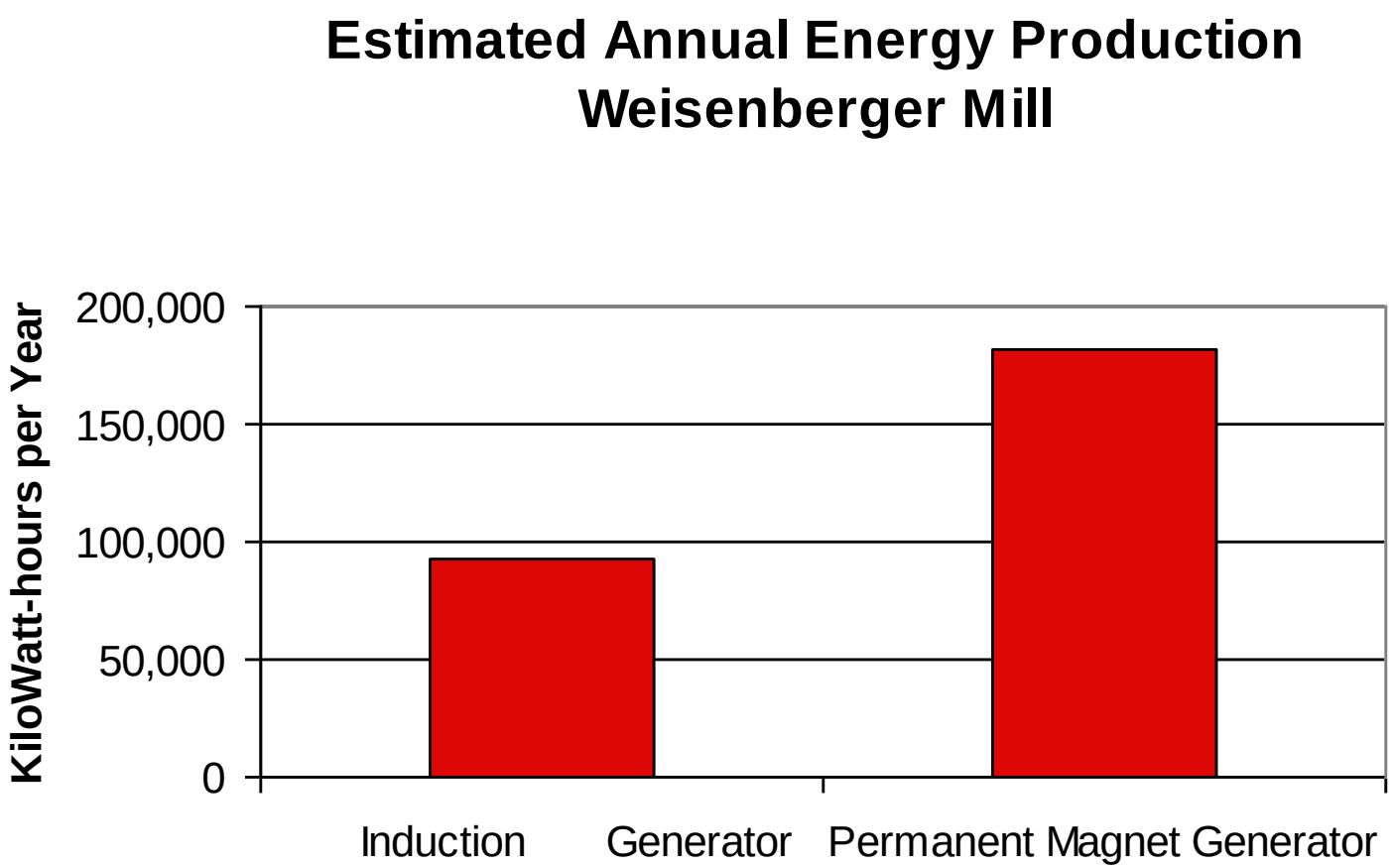
Technical Approach

Important Results

Average kW vs Net Head



Important Results



Project Plan & Schedule

- Project started – Q1FY12
- Initial planned completion – Q4FY14
- Project actually completed – Q4FY15
- Project Delayed due to:

  a) Drought delayed initial data collection about one year

  b) Problem getting Variable Speed Drive (VSD) to work with PMG

  (VSD eventually changed to a different type)

  c) Sagging Mill floor threatened equipment

  (equipment eventually suspended from above)

Project Budget

Budget History					
FY2014		FY2015		FY2016	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$16.92k	$46.271k	$2.851k	$36.997k	$0	$0

- Project was completed in FY2015.
- Project Budget:

  DOE - $56k - 50.0%

  Cost Share - $56.1k - 50.0%

  Total - $112.1k - 100%
- Final Project expenditures:

  DOE - $56k - 33.6%

  Cost Share - $100.1k - 66.4%

  Total - $166.5k - 100%

Research Integration & Collaboration

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

Partners, Subcontractors, and Collaborators:

Shaker Landing Hydro Associates – Project Installation and Oversight
Potencia Industrial, S.A – Technology and Equipment Supplier
McCleer Power – Technology Implementation Consultant
Center For Applied Energy Research – Data Collection and Analysis
Kentucky Utilities Co. – Independent Data Collection

Communications and Technology Transfer:

Presentation of Technical Paper: HydroVision International 2012

Presentation of Technical Paper: HydroVision International 2016

University of Kentucky Video News Release - 2016

Next Steps and Future Research

FY17/Current research: None

Proposed future research:

1) Variable Speed Drives will be installed on turbine-generators at two new 2.64 MW plants being built on the Kentucky River (10 generators total). On-site construction is scheduled to begin in the summer of 2017.

2) Future research needs to focus on retrofitting Variable Speed Drives onto existing generators at existing plants. Plant output could be increased significantly without replacing existing turbines or generators.