Small Hydropower Technology:

Summary Report on a Summit Meeting Convened by Oak Ridge National Laboratory, the National Hydropower Association, and the Hydropower Research Foundation

Washington, DC
April 7-8, 2010

Introduction

There is a renewed interest in the development of conventional hydropower in the U.S.. An interim assessment of technically feasible hydropower potential by the U.S. Department of Energy (DOE) identified 372 GW of undeveloped resources, distributed among upgrades, retrofits, new projects, and pumped storage. To this end, the DOE Water Power Program has set a goal of increasing U.S. hydropower capacity by 100 GW before 2050. To accomplish this goal, the efforts of the DOE Water Power Program center around two areas: 1) Technology Development and Deployment and 2) Market Acceleration. Analyses of the barriers to developing small hydropower are important for DOE to determine where federal resources can advance the industry. Small hydropower is defined as producing between 1 and 30 MW. Currently, 92% of existing turbines are classified as small or low power. These types of development account for 20% of existing hydropower generation, but they are a much larger proportion of the country's undeveloped potential.

In order to accelerate the development of environmentally sound hydroelectric power production, it will be important to understand the current state of the small hydropower industry and the technological and marketing challenges facing it. A group of experts in several different areas of the small hydro field met in Washington, DC on April 7 and 8, 2010 to share their perspectives on a key question – ***what will it take to develop the potential small hydropower resources in the U.S. before 2030?*** Participants in the Small Hydropower Summit (SHS) meeting came from diverse backgrounds, including developers, owners, operators, manufacturers, academics, investors/financiers, and government laboratory scientists and engineers. Facilitated discussions considered current technological issues, gaps, and market barriers faced by the industry; how these relate to other (regulatory, environmental) barriers; how barriers could be addressed through further research and development; and how sustainable development of new projects can be accelerated (Table 1). For the purposes of the SHS meeting, Small Hydro was defined as those technologies that utilize a combination of head and flow to generate hydroelectricity at either existing, non-powered dams or at new dams or diversions.

This report is a summary of the presentations and discussions that took place during the 2010 SHS meeting.

Definitions and Current Issues

Increasing the contribution of hydropower to U.S. energy supply is an important goal that can be accomplished in a variety of ways, including efficiency and capacity upgrades at existing power plants, retrofits in non-powered dams, and new small/low-power projects.

There are numerous barriers to small hydropower development that must be overcome, potentially requiring policy, perception, and education changes. The National Hydropower Association's (NHA) Small Hydro Council assessed the barriers to small hydropower development and then developed working groups to address the barriers. Working groups were established for Regulatory – FERC issues, Regulatory – Other Agencies (Federal/State) issues, Marketing/Financing/Funding issues, and Research and Development and New

Table 1. Agenda for the Small Hydro Summit

DAY ONE – Wednesday, April 7, 2010	
Time	*Agenda*
8:00 am	**Introduction and Direction to Participants**
8:15 am to 10:00 am (105 minutes)	**1. PROJECT DEVELOPMENT** • What are the challenges facing small hydro? Presentation of NHA's Small Hydro Council's matrix of issues. • The owner/operator's perspective on the difficulties of operating existing facilities in a cost effective manner and where new technologies could allow for additional financial flexibility. • Technology challenges faced regarding existing Small Hydro facilities, new development, and repowering of existing dams. • ***Facilitated discussion of alternative views***
	Break
10:15 am to Noon (105 minutes)	**2. MARKETS & FINANCING** • How the wind industry is dealing with and has overcome financial and technological hurdles (ISO power markets). • Discussion of the issues, costs, and lead time for interconnection to local grids. • Wall Street finance • alternative financing views • ***Facilitated discussion of alternative views***
	Lunch
1:00 pm to 2:45 pm	**3. MANUFACTURERS – SUPPLIERS OF EXISTING TECHNOLOGY** • Discussion of electrical/generators • The perspective of the current technologies for the small-low head hydro industry • The perspective of the current technologies for the small-low head hydro industry (part 2) • Discussion of the new cofferdaming and work in the wet techniques currently being used and being researched
	Break
3:00 pm to 4:45 pm	**4. RESEARCH & DEVELOPMENT – SUPPLIERS OF NEW TECHNOLOGY** • Current research and potential future technologies advancing the industry. • Current research in electrical/electronics that could be of interest to the industry. • New topics in the materials field such as coatings, blade manufacturing, advanced plastics/polymers, alloys, etc.
4:45 pm to 5:00 pm	Charge to attendees

DAY TWO – Thursday, April 8, 2010	
8:00 am to 8:30 am	**Review of Day One**
8:30 am to 10:00 am	**5. ROUNDTABLE DISCUSSION AND SYNTHESIS – identification of additional issues and strategies for overcoming barriers** • What are the most significant barriers to new small hydro development ? • What specific research and development will help address these barriers ? • Where would additional funding for R&D be best directed to achieve the necessary technological developments and bring about substantial development in the Small Hydro arena by 2030?
	Break
10:15 am to Noon	Continue discussion and prepare for briefing DOE – what are the key messages?
Noon	Adjourn meeting

Technology Issues. Potential barriers to small hydropower development that were identified by NHA included:

1) Complex regulatory processes – project permitting/licensing/exemptions by the Federal Energy Regulatory Commission (FERC) are time consuming and costly. Regulatory costs can exceed equipment costs.
2) A lack of integration and communication among agencies leads to redundancies. The consultation process takes too long – the studies needed to build new projects may take years.
3) Lack of standards,
4) Some regulations hinder or block development. FERC did an analysis of the costs and resources associated with licensing, and found that Section 401 Water Quality Certification (under the Clean Water Act) was a major cost driver for projects. The Integrated Licensing Process (ILP) may not be useful for developing new projects.
5) Grid connection difficulties.
6) Limited incentives for development. The DOE application process is too complex for small hydropower projects, and the short window to submit paperwork can present difficulties. Financial companies don't fully understand hydropower attributes and lifetimes. Installed costs are only a part of the levelized cost of energy; financing, operations and maintenance, and other factors all play roles.
7) An absence of designs specific to small hydropower. Industry would benefit from new designs/materials for drop-in turbines.

Project Development and Operation

Among the issues faced by owners and operators of small hydro projects are financing, operating, regulatory, labor, and development costs. Operating costs are an area where technology can have an impact through gains in efficiency and decreasing maintenance costs.

Financing – The issues in successful financing and power sales contracts are important to the successful implementation of new small hydropower projects and technologies. Lenders focus on environmental issues (permitting), site control, hydrology studies, regulatory/legal, technology, construction completion risks, the revenue model, the operations plan, and the quality of the management team.

The primary challenge for hydropower financing is the long development timeline and uncertainty about requirements of the permitting process. Uncertainty in the permitting process affects developers, power purchasers, and lenders in a circular manner because each entity needs assurances to enter into new ventures and agreements. Banks won't invest in the projects if simple timelines cannot be provided. Power purchasers won't sign Power Purchase Agreements (PPAs) until a timeline is established. Developers are hesitant to start new projects due to the uncertainty and costs associated with permitting and the inability to obtain PPAs early in the development.

Lenders are very risk averse; if a lender has to take risks, then the financing rates will be higher. Lenders look only to the project assets and the benefits generated by those assets when determining repayment capability. Additionally, financing is dependent on the output or repayment potential typically set by the Power Purchase Agreement (PPA), which doesn't always accurately represent the hydropower resource lifetime. A PPA of at least 30 years is desirable over the current shorter term agreements. A "Green" bank that would use combined resources to finance hydropower projects could help reduce the high costs of finance.

Hydropower should be equitably incentivized when compared to other renewable energy technologies. Presently, hydropower faces issues of incentivized power generation limits, lower prices for hydropower electricity, and exclusion from other incentives. For example, State Renewable Portfolio Standards often put limitations on the inclusion of hydropower projects; for example, applying only to projects less than 10MW. Hydropower is not eligible for some incentives from which other renewable projects benefit. Some incentives pay of 1.1 cents per kWh for hydro, but 2.1 cents per kWh for other renewable energy technologies.

Possible solutions to financing issues include 1) eliminating or minimizing uncertainty through more clearly defined metrics, incentives, and processes; 2) investigating ways to facilitate the permitting process; 3) implementing type-specific permitting solutions so small hydropower projects won't be evaluated in the same manner as large projects; 4) reexamination of the DOE loan guarantee conditions to maximize effectiveness and help reduce uncertainty; 5) encouraging government agencies to enter long term PPAs in order to provide a boost to development; 6) provide federal incentives/assistance to encourage small hydropower in the same way as other renewables; and 7) integrating wind and hydropower to couple the uncertainty of wind with the stability of hydropower.

Operations and Maintenance – The scale of small hydropower power plants makes maintenance relatively costly because no electricity is generated when the power plants are taken off line to perform maintenance. Development of service outage plans can reduce costs by allowing facilities to reduce down time and would facilitate more effective maintenance by giving a clear plan to maintenance issues to be addressed during the down time.

Along with outage planning, a better assessment of hydropower component replacement timelines and costs can lead to decreased maintenance costs. Bearings and seals fail and lead to costly maintenance. The age of many of the dams is a concern, because it involves safety issues, and long-term upgrades are the biggest capital costs.

Regulatory – Regulatory costs have increased six times over the past thirty years. They have gone from 5% to 25-30% of the total costs and include licensing, post-licensing, relicensing, environmental, and Section 401 (Clean Water Act water quality certification) mandates. Section 401 is widely interpreted by individual States on a case-by-case basis, which increases the uncertainty and regulatory costs for each project. The permitting processes should be examined to determine the conditions that cause them to be so complicated and lengthy. A good first step would be to investigate ways to facilitate the permitting process, for example by working with states like WI, IL, MI, IA, and CO that are receptive to hydropower. The goal would be to standardize the states' approach to these regulations.

A possible solution involves setting a bar for R&D best practices to create a baseline for expediting Section 401 compliance. This would allow development projects to meet a standard and would facilitate the screening of projects earlier in their development process, thereby saving time and reducing costs. Different assessment criteria for large vs. small hydropower projects could encourage growth in the small hydropower segment. A focus on community relations can alleviate regulation restrictions resulting from local issues and concerns.

Labor – Labor costs could be reduced through increased automation. Additionally, educating operators about the available markets (RECS, capacity, etc.) and automation can help maximize facility value.

Development Opportunities – Because lenders are risk averse and often unwilling to take chances on new technology, DOE could take the lead on installing and testing new technologies. Testing machines is very expensive; the costs are nearly the same for small hydropower projects as they are for large projects. DOE-funded demonstration projects would provide real-world examples to lenders and would mitigate concerns over installing new technology. This could effectively "buy down" the risk associated with new development and make financing more available.

Business interruption insurance would be another method of reducing risk for new project development. Development of best practices could reduce maintenance costs and regulatory costs while increasing revenues by maximizing operating and down time efficiencies. Additionally, best practices would give a clear indication of necessary parts would relieve delays caused by the unavailability of parts.

The development of standards for interconnection of small renewables to the grid is essential for furthering small hydropower development. Currently, small hydropower is treated the same as large hydropower, which can be a barrier for development because system dynamics and transients requirements that are not a problem for large hydropower development can be prohibitive for small hydropower. There is a need to develop specific standards for small hydropower. Numerous organizations are involved with grid interconnection standards, including both national organizations (FERC, NERC, IEEE, NEC, NESC, UL, NARUC, NRECA, and IREC) and state organizations. The requirements for interconnections can vary, and this variability increases the costs of design. How can we effectively manage grid connected power producers?

There are many standards and guidelines either available or in development for other renewables, especially wind and solar technologies. However, small hydropower has largely been ignored or the existing regulations and guidelines are not applicable. For standards development, it was recommended that the IEC and European organizations be examined and possibly used as a model, because they are presently building more new hydropower than the U.S. Canadians use the IEC codes for hydropower - how should the U.S. use the IEC standards? IEC standards are primarily used for turbine testing. Under the current standards, component testing is expensive. There is considerable overlap between ASME and IEC codes, so this could be a starting point for further standards development.

Manufacturing and Construction

Manufacturers offer a state of the art perspective on the current technologies for the small-low head hydropower industry. While hydropower is considered a mature industry, there are many opportunities for improvement and innovation. There are three types of turbines in use: impulse turbines (for high head and low flows), propeller-turbines (for low head and high flows) and Francis turbines (for intermediate heads and flows). Even for small hydropower applications, the turbines are very large machines that are designed and manufactured to last 50 years. These combined factors require a substantial investment in technology, personnel, and manufacturing in order to produce hydropower equipment.

Among other issues faced by manufacturers are competitive bid contracts that place much of the commercial and technical risk on the manufacturers. There are legal risks including indemnification, consequential damages, warranty language, limitation of liabilities, and insurance that further increase costs of manufacturing. Finally, there are commercial risks such as liquidated damages, payment terms, and price escalations of raw materials. Steel prices were noted as particularly influential on hydropower manufacturing.

Given all these risks, it is important to find ways to ensure that hydropower manufacturing remains profitable. Areas identified where the DOE can impact hydropower manufacturing include 1) defining what constitutes small hydropower; 2) defining electricity production objectives between maximum output and Renewable Energy Portfolio Standards; 3) support of early education and University level studies to solidify and develop hydropower as an environmentally acceptable energy source; 4) fostering government procurement and contracting; and 5) establishing the U.S. Government as a hydropower business.

Hydropower manufacturing research and development is highly competitive with many opportunities for innovation. Identified opportunities for improvement include:

1. Standardized designs – Design and production costs would go down with more standardized turbines. Presently most equipment has some elements that must be custom designed for each hydropower project, which does not maximize economies of scale.
2. New materials – Installed costs are the highest cost component. The DOE can have some impact on this through research done to reduce costs; however, the turbines will be less conventional (plastic turbines, for example), which highlights the necessity for demonstration projects of new technology.
3. Maximizing efficiency within the operating parameters –
4. Adjusting operations to be optimized with the turbine power curve – Flattening the turbine power curves is the desired direction for small hydro development because this allows more flow adjustment flexibilities while maintaining efficiency.

5. Education of owners and operators of the best operating ranges so that the turbines can be operated as efficiently as possible, and
6. Deploying an optimal mix of unit types based on peaking ability versus flexibility.

Issues related to electrical systems and generators include costs, interconnection, and new technologies. With competitively bid projects, it is more important to work on lowering costs than maximizing efficiencies. Variable speed generator technologies are available and optimize efficiency by flattening the power curves; however, they are not often used owing to their higher costs. R&D could bring down the costs of variable speed generators for locations with substantial head fluctuations. With similar manufacturing and installation costs, small hydropower projects are at a disadvantage compared to large scale projects because revenues for large hydropower projects are greater.

Similarly, the costs for grid interconnections for small projects are equal to those for large projects. Forming a node with an independent system operator or public utility is costly. The costs of $400,000 - $500,000 are the same for small and large hydropower projects. Required interconnection equipment is not optimized and is usually of a larger scale than is required for most small hydropower projects. In order to be eligible, the output usually must be 10MW or larger, which excludes some small hydropower. Feeding directly to an end user improves cost effectiveness, but still must deal with varying requirements and requires a nearby end user with a high load demand. In addition to a lack of small hydropower-specific standards for interconnections, each installation site can have varying requirements set by states and utilities, which further drive up costs and require custom designs. Excitation equipment is designed for large hydropower, so small hydropower projects must modify the equipment, which is not cost effective. Solutions to these needs and challenges are necessary to further commercialize small hydropower.

Regarding new technologies, older, oil-using hydraulic governors are still commonly used in U.S. installations to control flow into the turbines. These are costly to maintain but have proven reliability. High pressure hydraulic units have been developed which offer promising functionality and reductions in scheduled maintenance, but their durability is unknown owing to the relatively new nature of the technology. Electrical governors are new technologies that don’t require oil, but they are not widely used yet.

The development of new technologies specifically for low-head hydropower could be a key research area for maximizing hydropower deployment in the U.S. Low-head hydropower can be developed on constructed waterways and existing low dams, with the primary barriers being costs and environmental issues. One estimate calculates over 7.2 GW available for low-head hydropower projects. The benefits of low-head hydropower include: a baseload renewable energy source that is distributed and predictable; sites are typically on constructed waterways (e.g. irrigation canals) with minimal environmental impacts; many sites already have access to roads and power infrastructure; the abundance of suitable sites creates a large aggregate capacity from relatively small installations; and it is typically able to interconnect to the distribution grid, lowering interconnection costs.

The technology challenges presented by low-head hydropower are standardization of installations, lowering the equipment and installation costs, maintaining safe fish passage conditions, delivering high performance as flow chokes off, and scaling between small and large water flows where the head is constrained between 5 and 30 feet. For example, a modified impulse turbine is being tested that is 75 to 80% efficient, doesn't cavitate, can operate a hydraulic head of up to 30 feet, and is very scalable.

Research and Development

Small hydropower presents significant opportunity for increased electricity generation. EPRI and INL performed resource assessments and found 23 GW and 30 GW of available hydropower resources, respectively, in addition to a large number of currently non-powered dams with retrofit potential. DOE is conducting a survey of opportunities for advanced technology to impact the hydropower industry, with the goal of reducing the cost of energy. The cost of energy can be reduced by increasing energy production through efficiency improvements, low-power designs, and wider operational ranges that maximize efficiencies over a range of flow and head. Beyond turbine designs, there are opportunities to increase efficiencies at small hydropower sites by improvements in bearings and power electronics.

Costs can also be lowered through technology innovation and by standardizing designs and processes. Recent technology advancements have occurred both in the civil works and construction areas and the electrical and mechanical areas. DOE's national laboratories are a resource that could be utilized by the hydropower industry for innovative research into materials, machines, power systems, sensors and controls, and ecological impacts. Much of the high-risk R&D related to these issues would not be cost effective for private industry. For example, the national labs could help with advanced manufacturing methods and the development of large hydrodynamic (greaseless) bearings. A potential model for collaboration comes from the automobile industry - Ford, Chrysler, and GM work together on a common area to a pre-determined point, and then the technologies diverge as they are privately developed. Industry-lab partnerships can be based on Cooperative Research and Development Agreements (CRADAS), which are used to protect industry technology intellectual property when working with DOE.

There are vast hydropower resources in North America for small and low-head applications, but only a fraction is currently used. Progress in developing these resources could be made by cooperating with international associations and task forces, and greater cooperation between the U.S. and Canada. Further, of the existing installations, some need refurbishment or upgrading. Replacement of existing turbines with radically new turbine designs is unlikely owing to high civil costs, but owners and operators should work with engineers and manufacturers to re-build or replace components and install high efficient turbines.

Beyond refurbishments and updates, new technologies are in development to fill a variety of abundant niche applications. Very low-head turbines are being developed that operate with 1.4-2.8m of head and high flow rates; these designs are available and widely applicable, and further testing would establish their cost effectiveness. Fish-friendly, variable speed low-head hydro turbine and generator systems are being developed for demonstrations at sites where flow speed and head are highly variable. In addition to these turbine developments, innovation is being pursued in exit stay apparatus, integration of hydrokinetic devices with conventional hydropower, micro-hydro and control systems, modular automatic control, governing and protection systems, and tools for site assessment and design. Further development of small hydropower will largely rely on emerging technologies with increased reliability and efficiency, lower up-front costs, and reduced environmental impacts.

New topics in the materials field such as coatings, blade manufacturing, advanced plastics and polymers, and alloys, could provide innovations for the small hydropower industry. Research into hard and soft coating applications has shown reductions in cavitation and erosion effects.

While new research is important for innovation, it is also important not to overlook existing knowledge that can be applied to small hydropower. Hydropower is a conservative industry, relying on proven solutions. There has been some interesting materials research, but manufacturers still used stainless steel for commercial production. Nobody wants to be the first to install a plastic turbine. Consequently, innovations often focus on process improvements. It is important to optimize costs for the entire project; because equipment costs are only a fraction of the overall project costs, methods of equipment design are being researched for ways to reduce other project costs like installation, maintenance, and environmental challenges. Double digit efficiency gains were realized from new equipment acquired through the Manufacturing Tax Credit.

Environmental R&D initiatives are also underway to enhance the acceptability of hydropower. Turbine aeration methods have been extensively researched to help enhance the amount of oxygen contained in the water being discharged by the hydro plant. Three different methods for aeration are in use: distributed aeration, central aeration, and peripheral aeration. New, fish-friendly turbine designs produce 40% fewer fish injuries. The DOE sponsored research into the first, truly fish-friendly turbines, which has resulted in the development of the Alden turbine having greater than 90% efficiency and a fish mortality rate of less than 5%. DOE funding for similar R&D projects can be an important driver for further technology innovation.

Superconductor innovations for generators can provide performance gains and are smaller in size and weight compared to conventional generators. Superconductors conduct electricity with no resistance, resulting in nearly 100% efficiency and 100 times the current carrying capacity. Compared to conventional generators with copper coils, generators with superconducting coils are 1/3 the size, 1/6 the weight, have ~98% efficiency, have a flatter efficiency curve, and have greatly improved "part-load" performance. Additionally, because superconducting generators don't require a gearbox, they have higher reliability, lower maintenance, and produce very little noise. Because of their decreased size and weight, superconductors are advantageous for retrofit applications and applications with space constraints. Superconductors must be maintained cryogenically and have higher costs than conventional generators; presently, about 1% of the energy production would be needed for cooling, but economies of scale could bring that down to 0.5%. If the superconductor cooling fails, the system must be shut down within 2 hours. DOE funding for this successful project has ended, but further development and demonstration of this high-risk technology would benefit from government funding.

Findings on Small Hydro Technology

In a final roundtable session, participants reviewed the information presented in the first day of the meeting and organized that into key findings. General priorities were assigned by consensus, but these were not meant to be absolute statements of the overall importance of specific topics. Nevertheless, priorities do represent the order in which limited R&D investments should be allocated to achieve development goals, at least as seen by participants at the meeting. The key findings of the Small Scale Hydropower Summit Meeting were as follows.

First-Priority Topics

Regulatory Hurdles **–** Regulatory costs are 25-30% of project costs. Organizations like DOE can assist by helping reduce study requests. The federal agencies should cooperate in finding ways reduce regulatory restrictions. The DOE should continue to play a larger role as a catalyst to pull various groups together. Financial incentives from the government should be available for hydropower as well as for the other renewable energy sources.

Generators **–** Areas needing investigation include the development of advanced insulation, superconductors, and especially variable speed generators for small hydropower projects. Superconductors can shrink the size and weight of the generators and result in major efficiency gains. Variable speed generators can have a very large impact where there are changing flow rates so that efficiencies can be optimized for better peak and aggregate performance.

Turbines **–** Development and demonstration of advanced materials for the construction of small turbines would be valuable to small hydropower. Environmental studies to analyze how turbines interact with the environment would be valuable to provide a baseline and contribute to cost reductions. Low-head small hydro is the most expensive electricity to develop but there is much potential. Improvements in manufacturing processes, new materials, variable speed turbines, and environmentally friendly turbines would all be major benefits to small hydropower.

Project Financing **–** The price of energy is so low that PPAs are difficult to negotiate, thereby complicating project financing. Revenue uncertainty, low energy prices, and high upfront costs affect development. Because cost reduction is an important revenue component, DOE could help by assisting with some of the costs of new designs for small hydro. The manufacturing industry is very good right now because utilities expanding their renewables portfolios and upgrades are more prevalent. But the uptick in activity is at risk because of recent fluctuations in energy prices.

Second-Priority Topics

Demonstration projects **–** Government funding is needed to properly perform and publicize the results of demonstration projects. In order to reduce costs and get technology developed, demonstration projects will be important. DOE-funded demonstration projects would go a long way toward advancing new technologies. For example, we need to generate more interest in, and deployment of fish friendly turbines. There are substantial development costs, and the public wants assurances that the new designs are truly fish friendly.

Construction methods – Research could bring costs down in the construction area (installed costs benefits). Fifty percent of the installed costs for (small?) hydropower are in the civil works. For example, coffer dams constitute a huge portion of the costs; this is an area where research could help drive down costs. Drop-in units are one option with potential benefits. Inflatable dams to temporarily increase hydraulic heads have saved money.

Education – Education and training should be available for developers, communities, and students, and should include training on turbine designs/options, optimization of equipment and operations, and the regulatory process. Industry conferences are important, but the involvement of universities is an underutilized area. Training graduate students in hydro is a good step. Additional education/training is needed for owners and operators in technologies that optimize efficiency and minimize down time. Voith has seminars for maintenance and operations personnel that are well-attended. Access to a turbine test facility could be a helpful addition. Facilitating training efforts by DOE could be beneficial if small hydro is commercialized. The government sector also needs education – licensing is still a large issue because so many agencies have a hand in it; the industry and regulators need a handbook for navigating through the complex licensing process.

Grid Interconnection – Electrical connections can affect both costs and income of projects, especially for small hydropower, where the potential for high costs of paying for the distribution lines constrains development. A portion of installation costs is interconnection – this portion has been getting larger in recent years because, in the absence of standards, utilities want customized grid connections. Often there is a bottleneck to getting connected to the grid (MISO).

Third-Priority Topics

Bearings and Seals – There are environmental and O&M costs benefits to advances in these components

Excitation systems – Special equipment should be designed/refined for small hydropower projects.

Governor Systems – New electric governors are much better than old oil pressure systems. Electric governors are primarily useful for new projects.

Additional, Lower-Priority Topics

In addition to the topics above, other issues that are affecting small hydropower development include availability of better resource assessments to show developers where the best undeveloped sites are located, laws that require domestic manufacturing (i.e., the Buy American Act), and technology transfer or general lack thereof.