Hydropower RFI Response -- DE-FOA-EE0000406

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Topic 1: Small Hydro Technology

- Highest priority technology needs for small hydro development?
  TESTING OF NEW TURBINES AND GENERATORS, EVALUATION PROTOCOLS AND PROCEDURES A number of new small hydro turbine and generators have been developed in recent years. A common issue that many of them have is the lack of established testing protocol or procedures for evaluating this new technology. This results in the developers experiencing difficulty commercializing their product, and potential purchasers being at a loss to effectively evaluate the claims of these developers as to the performance of their new technology.
  INFORMATION NEEDS As described below, there is a paucity of information on: 1) the resource potential (particularly for in conduit), 2) the turbine characteristics needed to access this potential, 3) the interconnection and permitting requirements, and 4) the market for the power generated.
- Current technological barriers to development of new small hydropower projects?
  INTERCONNECTION REQUIREMENTS The installation of small hydro generation often requires the same utility (grid) interconnection requirements as other generation sources, despite being substantially smaller. This financial burden discourages the development of small hydro resources.
  PERMITTING REQUIREMENTS In conduit hydro generation within existing water distribution systems has a negligible environmental impact, yet it has to go through the same permitting and environmental studies as large, on stream projects. This financial burden discourages the development of small hydro resources.
  MARKET FOR POWER Small hydro is geographically dispersed, and finding an acceptable market/purchaser for the power generated is often a threshold burden that dooms the development of these resources.
- What are the major gaps between available technologies and advanced technologies that can overcome current barriers? DEVELOPMENT OF IN CONDUIT TECHNOLOGIES The process and technology for installation of small hydro at existing dams and impoundments is relatively mature. The development of in conduit (both in pipe and

open channel) generation is relatively immature but has tremendous potential. In conduit requires different turbines (often smaller size and lower pressure than traditional hydro generators), different installation techniques, and different interconnection requirements.

- How can new development/R&D activities by DOE, Reclamation, and other federal agencies be designed to help overcome technological barriers?
  RESOURCE INVENTORY There has not been a general assessment of the resource potential of in-conduit hydroelectric generation, either open channel or in pipe generation. Federal agencies should commission a study that identifies the potential and sites for in conduit generation within their facilities. Without knowing the resource potential, it is difficult for turbine developers to attract interest in developing or proving new turbines, the economic potential is too uncertain.
  TURBINE NEEDS Once a resource inventory has been completed, federal agencies could take the information from the inventory (sites, flows, pressure) and develop desirable characteristics to utilize the available resource at those sites. A "turbine needs summary' would be very useful for evaluating the potential of existing turbines and spurring the development of new turbines.
  TECHNOLOGY REVIEW There are a multitude of small hydro turbines and generators, depending upon the characteristics of the water pressure (head) and flow, yet there exists no comprehensive inventory of available turbines or generators, nor their applicable applications.
- What actions should federal agencies take to accelerate sustainable development of undeveloped small hydro resources in the U.S.?
  INFORMATION DEVELOPMENT The establishment of a small hydro data base that listed potential sites and their hydrologic characteristics would greatly enhance the development of this market.
  MARKET FOR POWER Federal agencies should establish a market for the purchase of small hydro power. This would allow federal agencies to meet their green mandates (often from their own facilities) and provide an established revenue source for small hydro development.

Topic 2: Environmental Mitigation Technology

- Even though in conduit small hydroelectric generators are considered "categorically exempt" they still have to obtain a FERC license. The required FERC consultation takes approximately six months or more and tens of thousands of dollars, a significant barrier to the development of small hydro generation facilities. The FERC process is set up for traditional hydroelectric generators, not in-conduit. In-conduit hydro generation is actually a system efficiency improvement since it aims at capturing energy that would otherwise be wasted. These systems are implemented on manmade conduits where a pressure reduction valve is already located. Fish or other aquatic organisms are not present in these systems. Hence, there are virtually none of the environmental impacts associated with traditional hydro generation, yet the extensive FERC consultation process adds time and a layer of complexity that dissuades many potential generation sites from even pursuing the option.

Topic 3: Demonstration-Ready Hardware and Software

- What are the hydro technologies that are being used outside the U.S. and what are the barriers for deployment of these technologies within the U.S.?
  SE ASIA/Africa/Central and South America – in most of these areas, small hydro is installed as a standalone system, directly serving local loads, due to the non existence of a regional electric grid. As a standalone system, these generators provide their own frequency control and voltage. While these generation technologies will work in the U.S., the electronic controls of grid integration will need to be integrated with available technologies.
- What types of advanced efficient pump units are used as turbines for small hydro?
  Pumps can be quite effective as turbine generators for small hydro. Compared with site designed turbines they are less expensive, the pump and motor can be used as a turbine and generator set, they are available for a specified range of heads and flows, and they use standard pipe fittings for easy installation. Integration with the electric grid requires additional electronics to ensure compatibility. The main issue in using a pump as turbine is that the pump head and flow is much higher than the turbine head and flow (pump manufacturers don't provide turbine curves with their pumps like they do pump curves), determining the correct pump to be used for a particular site can be a problem, and the pumps are not optimized for turbine performance and efficiency.
- What types of advanced generator designs can efficiently generate for the full range of turbine operation including generators suitable for the above mentioned turbines? UC Davis is currently investigating three promising new turbine designs:
  Holden turbine – combination impulse and reaction turbine can work over a much greater range of pressures and flows that either pumps or existing turbines. Scaleable from kW to about 30 MW. http://holden-hydro.com/turbine.html
  Powerpipe turbine - an in-pipe, spherical vertical axis turbine that does not require high pressures to operate. Generation in the multiple kW range.
  http://www.lucidenergy.com/water/northwest-powerpipe/technical.html
  Aquajet (Broome) turbine - an undershot impulse-jet water turbine that is suited for open channel, low head installations. Generation in the multiple kW range.
  http://www.faqs.org/patents/app/20090175723
- What types of sites and industry partnerships should the federal agencies be looking at for future demonstration and testing of these advanced turbines, generators and ancillary equipment? Demonstration and testing should be under the supervision and direction of non affiliated, objective research organizations like federal labs and universities to provide objective evaluations of the technology.
- What are potential federal and non-federal sites where new technologies could be demonstrated and/or tested? The federal system maintains a large open channel water distribution that would be perfect for demonstrations of that technology (along with similar state water distribution systems). Pipe in conduit generation sites are available on state and local water distribution systems.