CONF-801203--4

SMALL SCALE HYDROELECTRIC DEVELOPMENT AND THE ENVIRONMENT: ISSUES, CHALLENGE, AND OPPORTUNITY

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A small scale hydroelectric (SSH) facility is defined as an existing dam that can be retrofitted to produce 25 MW or less capacity. An estimate of the total SSH potential in the United States indicates there are 4,979 sites with 8,775 MW capacity and 25,126 GWh average annual energy[2]. Appropriate site-specific analyses of environmental constraints to SSH development are necessary to ensure that this resource is developed in an environmentally acceptable manner.

ISSUES

Some of the major environmental issues that must be analyzed to determine potential for adverse impact at SSH sites include dredging, fish passage, water level fluctuation, and instream (minimum) flow. If dredging is required to reclaim reservoir storage capacity, to clear intake structures, or to construct/repair powerhouses, tailraces, and headraces, adverse impacts on aquatic systems can occur. Major sources of these impacts include increased suspended solids and siltation, habitat removal, changes in water and sediment chemistry including mobilization of contaminants, and dredged material disposal practices[3]. Increased suspended solids and turbidity can reduce photosynthesis, clog the gills or feeding structures of fish, mussels, and zooplankton, and reduce fish spawning success and production of benthic organisms. The substrate material removed during dredging may alter the habitat available for benthic organisms. If the sediments to be dredged contain contaminants (pesticides, metals, etc.) which will be released to the water column, toxic effects on aquatic biota should be evaluated. Mitigation measures include proper choice of dredging equipment and the scheduling of dredging operations at times of year when biological productivity is lowest.

If development of a SSH site will interfere with both upstream and downstream movement of migratory fish species, the need for fish passage facilities must be evaluated. The capability to design facilities to pass fish upstream around dams (fishways, fish locks, fish lifts) is available. Care must be taken, however, to ensure that species-specific biological criteria (swimming speed, behavior, water quality requirements) are incorporated into design specifications[4]. Basic unit costs for passage facilities range from approximately $6,000 to $30,000 per vertical foot (30.5 cm) of head. The possible adverse impact on fish populations resulting from downstream migrants passing through turbines also warrants concern. Most available data on turbine mortality come from studies of larger scale hydro facilities. Information on mortality from passage through tube and bulb turbines is not readily available. Clearly, research on the significance of this issue for SSH sites and an evaluation of mitigation techniques are needed.

Water level fluctuation from operating a SSH facility in a store and release (peaking) mode can adversely affect aquatic biota in both reservoirs and tailwaters[5]. Potential impacts on physical and chemical characteristics of reservoirs include resuspension and redistribution of bank and bed sediment; leaching of soluble organic matter from sediment in the littoral zone; and changes in water quality resulting

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from changes in sediment and nutrient trap efficiency. Potential impacts on reservoir biota include habitat destruction and the resulting partial or total loss of aquatic species; changes in habitat quality which result in reduced standing crop and production of aquatic biota; and shifts in species diversity. The potential physical effects of water level fluctuation on tailwaters are streambed and bank erosion and water quality problems related to resuspension and redistribution of these materials. Aquatic populations below dams can be adversely affected by changes in (1) current velocity, (2) habitat availability, and (3) food supply. The need to maintain instream flows for protection of fish and wildlife resources is a critical issue at peaking facilities. Considerable research is in progress to develop criteria to establish instream flow needs.

CHALLENGE AND OPPORTUNITY

From the environmental perspective a major challenge in developing SSH sites is to determine the magnitude of environmental studies necessary to evaluate the significance of potential impacts at the pre-feasibility study phase. Financial resources can then be optimized to address significant issues that may require mitigation. Many SSH sites can be developed with minimal adverse impact, or mitigation plans can be included to ensure environmental acceptability. With proper front-end planning and communication with regulatory authorities and interested parties, and with an appropriate level of site-specific analysis, environmental issues should not be an absolute barrier to SSH development at many sites. Possible exceptions to this generalization include development of sites on rivers designated as wild and scenic, at sites where critical habitat for endangered species is an issue, or at sites where satisfactory mitigation for passing migratory fishes is not feasible. Development of the SSH resource represents a good energy investment. Net energy analysis of 7 Department of Energy SSH demonstration projects revealed net energy ratios (output:input) between 8.6 and 32.9:1. Development of SSH sites can be more energy efficient than other electrical generating methods[6]. Hydroelectric power represents a renewable energy resource. The estimated SSH resource in the United States represents approximately 1% of existing total installed electrical capacity from all sources. The attributes of renewable energy, good energy investment, and the emphasis on existing dams as opposed to new dam construction are positive features from the environmental standpoint.

[1]Research sponsored by the Office of Hydroelectric Resources Development, U. S. Department of Energy, under contract W-7405-eng-26 with Union Carbide Corporation. Environmental Sciences Division, ORNL.

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