Environmental Issues and Best Practices for Renewable Energy Systems

USAID plays a key role in the U.S. government s efforts to help developing countries and economies in transition to design effective new strategies to meet growing energy demand. To this end, USAID promotes free market policies that enable more efficient power production, energy conservation, increased use of renewable energy sources, and private sector participation in the energy sector. USAID energy programs assist countries by (1) promoting energy sector reform (2) establishing free market policies (3) instituting improved energy standards, and (4) strengthening institutions that enhance energy development through private sector participation. In addition, USAID provides training and technical assistance to encourage legal and regulatory reform, institutional development, and private investment in energy infrastructure.[1]

Latin America and the Caribbean have the highest electricity coverage (84 percent) of any region in the developing world. Yet there are still 75 million people without electricity, mostly in rural areas; nearly 60 percent of the region s rural population is without electric power.[2] There is a strong correlation between the levels of development and electric power coverage. The countries in the region with the lowest levels of access to electricity are also the ones with the lowest development indices--Bolivia, El Salvador, Guatemala, Haiti, Honduras, Nicaragua, and Peru--where less than 20 percent of rural households have electricity (IADB 1998).

Demand for electricity, which accounts for close to 20 percent of the total demand for energy, grew at an annual rate of 5 percent between 1990 and 1995, and it is expected to continue growing at that pace in the years to come. Primary energy used to generate electricity mainly comes from renewable sources (69 percent hydro and 1 percent geothermal), followed by thermal generation (14 percent oil products, 11 percent natural gas, 3 percent coal, 2 percent nuclear). The industrial and household sectors consume most of the electricity (46 percent and 31 percent), although these percentages vary significantly from one country to another.

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1 See www.usaid.gov, Increasing the Provision of Environmentally Sound Energy Services.

2 A large percentage of the energy consumed in rural areas still comes from biomass used for cooking.

Demand for power is growing at an average rate of 5 percent per year.

Demand for power is growing at an average rate of 5 percent per year. In 1997, the Inter-American Development Bank estimated that approximately 80 GW of new installed capacity would be needed to meet the projected demand in 2006 (IADB 1998).

Public concerns about environmental degradation, including global warming, resulting from conventional non-renewable sources, are making renewable energy sources a more viable and sustainable option.

Small-scale energy development projects are generally designed to improve public health, support education, protect the environment, and improve quality of life for poor people, especially women. They also may have ancillary benefits--such as generating entrepreneurial opportunities--by supplying energy where it was not previously available or by substituting perpetual or self-renewing locally available energy sources for limited non-renewable supplies, which in many cases must be imported.

RENEWABLE ENERGY TECHNOLOGIES

Bioenergy is derived from biomass--a term that generally refers to any plant or animal matter. Bioenergy in the form of heat or electricity can be produced by using biomass directly as a fuel or by converting it to biogas or liquid biofuels. Bioenergy sources include: dry wood, bark, hog fuel, bagasse, municipal solid waste

Wind turbines generate power from several blades revolving around a horizontal axis and are mounted on towers. A wind turbine converts the energy in the wind into mechanical or electrical energy. Small-scale hydropower systems capture the energy in falling water and convert it into electrical or mechanical energy. The amount of energy that can be captured is a function of the vertical distance the water drops and the volume of water.

Semiconductors that convert solar energy directly into electricity are called photovoltaic (PV) devices or solar cells. Although there are about 30 different types of PV devices under development, there are three main technologies in commercial production: monocrystalline cells, polycrystalline cells, and thin-film cells.

Solar thermal systems collect the sun s energy directly to create both high temperature steam (greater than 100°C) and low temperature heat (less than 100°C) for use in a variety of heat and power applications. High temperature solar thermal systems use mirrors and other reflective surfaces to concentrate solar radiation. Parabolic dish systems concentrate solar radiation to a single point to produce temperatures in excess of 1000°C. Low temperature solar thermal systems collect solar radiation to heat air and water for industrial applications.

The focus of small-scale renewable energy activities is often on improving cooking efficiency with wood or wood-derived fuel by, for instance, promoting improved cook stoves or substituting an alternative energy source such as biogas or solar energy. Other projects focus on providing alternative sources of electricity--solar, small-scale hydro, biogas--to power lighting, appliances, and microenterprises for rural communities that lack access to electricity grids. Dependable electricity can enable families, especially adult women, to develop additional income-generating activities by working at home after dark. Lighting also facilitates education and is a valued convenience--it makes night cooking and bathing easier.

Public concerns about environmental degradation, including global warming, resulting from conventional non-renewable sources, are making renewable energy sources a more viable and sustainable option.

This chapter addresses environmental issues and best practices for renewable energy activities such as solar, photovoltaic, biogas, and wind (section A) and small-scale hydropower (section B).

A. Biomass, Biogas, Solar, and Wind Activities

Potential Environmental Impacts

The environmental impacts of renewable energy technologies are considered to be small in comparison to the impacts generated by fossil fuels and other traditional sources of energy. However, no technology is without impact. Carefully planning and siting facilities and incorporating environmentally sound design practices (see Chapter 1: Introduction in this manual) can prevent or mitigate most impacts associated with these technologies.

Deforestation of rainforests and temperate forests for fuelwood or charcoal is one of the greatest impacts of biomass energy consumption in Latin America and the Caribbean. The region lost forests rapidly in 1990-95, the most recent period for which there is complete data. The Caribbean lost 8.5 percent of its forests (400,000 hectares), Central America lost 6 percent (4.8 million hectares), and South America lost 2.5 percent (56.3 million hectares). Nearly two-thirds of the region s overall deforestation was a result of harvesting for fuelwood and charcoal–60 percent in South America and 85 percent in Mexico and the Caribbean (FAO 2000). Much of this fuelwood and charcoal is used by urban consumers, often far away from where the deforestation is occurring.

Deforestation can also cause significant declines in agricultural productivity (loss of soil from increased erosion, destruction of watersheds) and biodiversity (loss of wildlife habitat and species diversity) and contributes to the greenhouse effect (stored carbon released, reduced carbon sequestration capacity).

Combustion of biomass and biogases causes air pollution. Particulates resulting from the incineration of municipal solid waste can contain toxic ash. Consequently, the use of biomass fuels for indoor cooking can have serious health impacts due to the high particulate levels created.

Wind energy is the most benign of the renewable energy technologies. Its principal environmental impacts are noise nuisance, bird and bat mortality, and aesthetic concerns.

The manufacture and disposal of the photovoltaic cells create environmental concerns for solar energy production. Large-scale solar thermal systems can also create land-use conflicts, as they require extensive stretches of land.

Geothermal systems can pollute air and water and create hazardous waste. These large-scale systems exploit hydrothermal (hot steam or water) energy trapped below the earth s surface. Closed-loop systems, where the gases or fluids extracted are injected back underground once the energy has been extracted are generally less environmentally harmful than open-loop systems, which can generate solid waste and noxious fumes and release contaminated cooling waters into nearby surface waters.

Table 6.1 Potential Environmental Impacts of Renewable Energy Technologies

Renewable Energy Technology	Potential Environmental Impacts
Biomass (wood crop residue, manure, sewage, and municipal solid waste) and biogas (sewage treatment plants, landfills, and manure management facilities)	• Can produce more particulates that fossil fuel, depending on the energy content to weight ratio of the material being incinerated • Release of hazardous ash and particulates resulting from the burning of some municipal solid waste plastics, heavy metals, chemicals • Deforestation and associated erosion, sedimentation, and soil nutrient depletion • Odors
Wind	• Land requirement issues and land use conflicts for large-scale wind energy farms • Tree clearing, road cutting, and increased logging in wooded areas • Noise • Visual impacts • Bird and bat mortality
Solar (photovoltaic, solar thermal)	• Worker risk from hazardous chemicals such as arsenic and cadmium used during photovoltaic cell production • Increased energy use during photovoltaic cell production • Environmental problems to landfills if not recycled or disposed of with required safeguards • Land-use conflicts resulting from utility-scale solar systems
Geothermal (hydrothermal)	• Noxious fumes (hydrogen sulfide, benzene, radon, ammonia, and boron) created by open-loop systems; metals (mercury and arsenic), minerals, and gases leaching into the geothermal steam or water • Hazardous solid waste • Injection of fluids (in closed-loop systems) into the ground causing localized seismic activity • Land subsidence

Sources: Union of Concerned Scientists and U.S. Department of Energy, Energy Efficiency and Renewable Energy Network.

Program Design--Some Specific Guidance

Renewable energy technologies must satisfy several criteria. They should be simple, affordable systems adaptable to individual and private enterprise development at the community level. While the installed cost of an alternative energy technology may be a constraint, operating costs tend to be much lower than conventional energy systems. In some cases credit schemes can help address the capital cost barrier, allowing long-term cost advantages to be realized.

The following issues should be considered during the initial planning of renewable energy activities:

- Has an energy or biomass analysis been conducted for the country? What is the current energy-use pattern in the immediate project area?
- Are there existing tax or incentive programs that could be used, publicized, or modified to increase the use of renewable resources and decrease dependence on petroleum-based fuels and wood energy?
- Have local communities been consulted? Their suggestions and needs may be of critical importance in project development.
- What are the long-term energy development aspirations of local governments, industries, enterprises, and residents on energy? Will fuelwood alone accommodate them?
- Who will be the project s customers? Will the project benefit local households or other sectors?
- If it is a fuelwood project, how accessible will the fuelwood be to the area where it will be consumed? What are the transportation costs of the project?
- What are the socioeconomic incentives and constraints of the project, such as tree-tenure systems, community ownership, and credit availability?

Renewable energy technologies ... should be simple, affordable systems adaptable to individual and private enterprise development at the community level.

Environmental Mitigation and Monitoring Issues

Fuelwood

Assess biomass. Where available, mapping techniques of remote-sensing global positioning systems and geographic information systems can used be for this purpose. Establish baseline conditions and identify patterns of deforestation over time. Provide information on promising energy initiatives in the area.

Develop biomass strategy. Based on the biomass assessment, the strategy should identify areas that require technical assistance and policy reforms, ascertain practical incentive and disincentive systems, and indicate where conditions are appropriate for use of economical energy sources other than fuelwood.

Develop action plans. Implement plans at local and national levels that combine measures aimed at increasing production (tree nurseries, agroforestry), reducing consumption (more fuel-efficient cooking stoves), and enhancing protection and management of remaining forest resources. The plans should foster a multi-sectoral planning approach for the management of forest resources.

Ensure community participation. Insufficient farmer, family, and community participation is a common weakness of fuelwood projects, adversely affecting their sustainability. Ensure that local people have early input into project design and implementation.

Reflect economic value. Whenver possible, support adjustments to fuelwood and charcoal prices to reflect the true value of forest resources through application of natural resource and environmental accounting. Often the biological, economic, and social values of forest resources are not incorporated into the total price of fuelwood.

Protect resources. Safeguard existing sources of fuelwood in natural forests by involving neighboring communities in sustainable forest management and sharing of forest resources.

Provide for ownership of fuelwood resources. Participate in a policy dialogue to establish legislation that provides for private or communal ownership and management of fuelwood resources.

RESTRUCTURING ENERGY MARKETS

In Guatemala, USAID is helping the government restructure its energy sector to open up markets to renewable energy technologies. A USAID-supported nongovernmental organization in Guatemala has increased the use of solar energy for more than a dozen village institutions, including water-pumping installations, schools, and health clinics.

Another USAID-supported nongovernmental organization acts as an information clearinghouse on renewable energy for Guatemala and neighboring countries.

Source: www.usaid.gov

Select tree species. If trees are to be planted for fuelwood, select the most appropriate ones, drawing on local and national expertise. The short rotation for fast-growing exotic tree species allows increased production of fuelwood, but rapid growth can also deplete soil nutrients or water resources. Fertilizer use should be considered for plantations of rapidly growing species. Match species to local soil and climatic conditions. In areas of low or sporadic rainfall (arid and semi-arid zones) avoid species that require more water. Carry out detailed economic and market analyses before promoting plantations for fuelwood.

Assess potential for improved cookstoves. Another means of encouraging fuelwood conservation is through commercialization of improved fuelwood or charcoal cookstoves. Typically built of metal with an insulated clay lining, charcoal stoves trap heat, causing charcoal to burn more efficiently and reducing charcoal consumption significantly.

Consider alternative uses. Many tree species serve multiple wood and non-wood purposes, and fuelwood is a secondary product. For example, pruned branches from some *Prosopis* species can be used for firewood while the trees themselves can be used as living fences.

Solar Energy

The sun is an important source of clean and abundant energy, but the use of solar energy is not yet widespread for both technical and economic reasons. While the cost of converting solar energy into electricity continues to fall, current prices still constrain its wider application in Latin America and the Caribbean. Nevertheless, in locations far away from power grids where the costs of electrical generation from diesel engines are high, solar energy can be economically competitive. Adverse environmental impacts of solar energy include pollution caused during the manufacture of solar devices, acid battery spillage, and improper battery disposal. These impacts, usually manageable, should be weighed alongside their potential to reduce deforestation and improve air quality. Several solar energy devices have specific potential environmental impacts.

Solar water heaters. Substantial amounts of (usually) non-renewable energy are used to heat water in households, restaurants, health centers, and small businesses. Increasingly, governments, utilities, and the private sector are promoting residential solar water heating systems in places with low cloud cover. In these areas they are, over the long term (10-20 years) economically competitive with water heaters using electricity or gas--though initial installation costs may be significantly higher.

Photovoltaic cells. In remote locations, photovoltaic cells can offer an alternative to conventional power sources for applications such as lighting, cold-chain vaccine refrigeration, and radio and microwave communication. Maintaining a photovoltaic system is limited to regular cleaning of panel surfaces, but trained individuals must do the cleaning to avoid damaging the cells. Systems must also be protected from theft and vandalism. The principal environmental impacts associated with photovoltaic cells result from their manufacture, which can require the use of toxic materials and their disposal. Recycling and proper disposal of used photovoltaic cells is necessary to prevent environmental impacts at a disposal site or landfill. Batteries that store solar energy also need to be recycled, as they contain highly toxic elements such as lead and cadmium. Alternative battery technologies (those that contain nickel-iron, nickel-metal hydride lithium-ion, and chloride) should be explored because they pose less of an environmental risk.

Biogas

Technologies used to convert organic materials to biogas, such as anaerobic digestion, are not new. Their application is also not widespread. Biogas production involves the biological fermentation of organic materials--agricultural wastes, manures and industrial effluents, municipal solid waste--in an oxygen-deficient environment to produce methane, carbon dioxide, and hydrogen sulfide. The gas can be used directly for combustion in cooking or lighting or indirectly in fuel combustion engines delivering electrical or motor power. The slow diffusion of this technology is a result of initial construction costs, lack of organizational and community involvement, insufficient training opportunities in construction and maintenance, and difficulties in maintaining sufficient and consistent raw material inputs.

According to recent trends, an increase in the production of bioenergy crops is occurring. This practice can produce beneficial and adverse environmental impacts. Bioenergy crops can re-vegetate barren land, reclaim waterlogged or salinated soils, and stabilize erosion-prone land. They can provide habitats and increase biodiversity if managed properly. However, they may also displace agricultural production, contribute to deforestation, and even introduce invasive, potentially harmful, non-native species.

The operation of a biogas digester presents several potential environmental problems, but these problems can be minimized with proper planning and operation. Special precautions are required, for example, if human or hog wastes are used in digesters. Humans and some animals share similar feces-borne parasites and pathogens. For this reason, some authorities warn about the dangers of raw fecal waste and do not recommend applying sludge to soil where root and vegetable crops are cultivated. To minimize health risks, the digester should be built close to a lavatory or livestock shed so that the excrement may be deposited directly without unnecessary handling.

The disposal of liquid overflow (supernatant) from the digester may occasionally have adverse effects. Normally this liquid is clear and odorless and has some value as a dissolved fertilizer. If water is scarce, the supernatant may be recycled into the digester with new organic feedstock. Otherwise, it can be used to water plants or moisten compost materials. But in an improperly working digester, the supernatant may be dark and offensive. If it is not recycled, this liquid should be buried or mixed with soil in an isolated spot.

As with natural gas, biogas composition should be tested, and precautions taken to prevent leaks and losses. Surveillance is also important, since biogas is usually odorless and difficult to detect. In closed rooms, leaking gas can lead to asphyxiation or explosion.

In areas where manure or dung is a free community resource, the installation of biogas digesters may cause unanticipated social impacts. If manure becomes a valuable commodity, lower income families may no longer be able to afford it. In the initial planning stages, the question of who stands to lose or gain from an energy project deserves careful attention. Community input is important.

Strict air emissions and ash disposal regulations should be followed to avoid the emission of hazardous ash and compounds resulting form the burning of plastics, heavy metals , chemicals and other substances encountered when incinerating municipal solid waste.

Ethanol

Liquid fuel in the form of ethanol can be produced through the fermentation of biomass such as sugar cane leaves or bagasse. The production of ethanol involves washing, fermenting, and distilling biomass.

Solid residues from ethanol production can be disposed of easily as a high-protein dietary supplement for livestock. However, the disposal of liquid residues--which may amount to 12-13 times the volume of the final product--is more difficult. This thin stillage has a strong odor and high acid content and contains many organic solutes. Land application of thin stillage could be harmful to many types of soils, especially those with high clay content. It should not be disposed of in areas where it can flow into lakes and streams.

Significant amounts of water are used in the production of ethanol. For every unit volume of ethanol produced, approximately 16 units of water are needed to generate steam. This demand for water must be evaluated against its available supply and the merits of alternate uses. Additionally, long-term economic costs and benefits need to be weighed carefully prior to developing these systems.

If properly designed and well placed, wind turbines can provide a reliable source of energy.

Wind Power

If properly designed and well placed, wind turbines can provide a reliable source of energy. A wind-powered water pump can be used for irrigation and potable water. However, an economic cost-benefit analysis comparing wind energy with alternative energy sources is needed before selecting wind power as an energy source. The strength and constancy of wind is especially important in this calculation, as is the proven ability of the machinery to withstand high winds. Since historical meteorological data is often absent in many Latin American countries, use of wind power needs to be approached cautiously.

One potential adverse effect associated with wind-driven water pumps is that standing water around the pump from spillage can become a health risk. An automatic shut-off mechanism can solve this problem. As with any water system, groundwater depletion and overgrazing near the water supply can be serious problems, especially in arid and semi-arid environments.

B. Small-Scale Hydropower

Brief Description of the Sector

Small-scale hydro is a renewable electricity generation technology with great potential in Latin America and the Caribbean, particularly in remote rural areas.[3] Small-scale hydro installations range in size from a few to a hundred kilowatts. They are of two general types:

- Run-of-the-river small-scale hydro installations involve no reservoir. They rely instead on the natural flow of the river or stream to provide power to turbines. They typically involve diverting a portion of river flow through a spillway, side channel, or pipeline. The diverted water is returned to the river downstream of the turbine.
- Impoundment small-scale hydro installations use a reservoir to stabilize electricity supply against variations in flow and provide greater head, or pressure, to power turbines.

Small-scale hydro is a renewable electricity generation technology with great potential in Latin America and the Caribbean.

Potential Environmental Impacts

Run-of-the-River

For run-of-the-river operations, the greatest impacts occur during the construction phase. The primary concerns are the impacts on the stretch of river from which water is diverted to support the small-scale hydro operation, the method of returning the water back to the stream, and effects on downstream users. Impacts are generally on-site and easy to assess (table 6.2).

3 The material presented in this section is adapted from Pérez and Menczer 1996.

Table 6.2 Environmental Impacts of Run-of-the-River Small-Scale Hydro

Activity phase	Impact
Construction	• Movement of soil may increase erosion, which may increase the sedimentation waterways. • Increased activity along the stream and transmission route may disrupt wildlife. • Construction and placement of pipeline may block waterway temporarily or permanently. • Construction and placement of pipeline and construction of transmission route may disturb wetland, floodplains, or agricultural land. • Increased activity along the stream and transmission route may disrupt recreational, cultural, and subsistence activities that normally take place there. Transmission lines may destroy wetlands or other sensitive habitats. • Increased erosion may result in increased sedimentation, affecting downstream users human, fisheries, wildlife. • Decrease in downstream waterflow may affect downstream users human, fisheries, wildlife.
Operation	• Decrease in stream flow between point of diversion and point of return may affect fisheries and wildlife. • Decreased stream flow between point of diversion and point of return may change the flooding regime, resulting in adverse changes to wetlands. • Re-entry pipe may cause increased scouring of stream bank where water is returned to the stream.

Impoundment Small-Scale Hydropower

The single most important issue in determining the extent of environmental impacts from small-scale hydro projects is whether or not an impoundment needs to be created. If the project requires an impoundment, potential environmental impacts may be greater than from run-of-the-river systems. As with run-of-the-river installations, environmental impacts may result during the construction and operation phases. Primary concerns are the stretch of the river from which water is removed, the area that is being flooded, and downstream users, including humans, fish, and wildlife. Impoundment small-scale hydro typically triggers an environmental assessment under USAID s environmental procedures (table 6.3).

Table 6.3 Environmental Impacts of Impoundment Small-Scale Hydro

Activity phase	Impact
Construction	• All construction impacts generated by run-of-the-river hydro (see table 6.1). • Movement of soil at the impoundment location may increase erosion. • Increased activity at the impoundment location may disrupt wildlife, recreational and cultural activities, and the lifestyle of inhabitants. • Impoundment construction may disturb wetlands, floodplains, or agricultural land.
Operation	• Change in water temperature may affect the quality of water within the impoundment and discharged from the impoundment. • Submersion of land area covered by impoundment, with associated destruction of existing and creation of new habitats and ecosystems. • Possibly create a breeding ground for pests and disease. • Changes in the water flow regime, which may alter water flow in the stream. • Change in general hydrology of the area, altering riparian habitat. • Flooding, erosion, and downstream destruction if impoundment fails.

Program Design--Some Specific Guidance

In all small-scale hydropower projects, as with all community development activities, community involvement is essential to design, implementation, and monitoring.

Given the fact that impoundment small-scale hydropower is likely to incur environmental assessment requirements, the full range of alternatives to achieving project results should be considered. For small-scale hydropower, this includes identifying and analyzing the following factors:

- What options are available to meet the objectives of the project?
- Are other methods available to produce power?
- Are there other locations where the project might be constructed?
- Would any other options result in less environmental impacts than the proposed activity?

Environmental costs of the project should be weighed against economic benefits. To estimate the costs and benefits a number of questions should be answered.

- What benefits does the stream provide in its natural state? Water supply, fisheries, wildlife habitat, commercial or recreational fishing, attenuation of floods, tourism, cultural values? Will any of these benefits be affected by the activity?
- What is the present land use at the impoundment location? What benefits are offered at the location? Crop production, wildlife habitat, residential dwellings, cultural activities? Will impoundment construction affect these benefits and land uses?
- For the land traversed by the transmission system, or, if batteries will be used, the area affected by transporting the batteries to the production activity: What benefits does the area offer? What is the land used for along the affected path--agriculture, wildlife habitat, tourism, recreation, housing? Will the present land uses be affected by using this route to transmit power to the production activity?
- What are the present downstream activities and land uses that may be affected by the activity? Will the small-scale hydroelectric project affect any of these adversely?

In 1996, the LAC Bureau Environmental Officer approved environmental guidelines for the for small-scale hydroelectric projects under USAID/ Dominican Republic s PVO Co-Financing Project (517-0247).[4] The guidelines are extensive and cover several topics, including environmental conditions in grant review and approval processes, frameworks for environmentally sound design, assessment of environmental impacts, key environmental issues for run-of-the-river and impoundment projects, environmental mitigation plans, and system maintenance and monitoring planning.

Environmental Mitigation and Monitoring Issues

The mitigation and monitoring issues and measures that apply to small-scale construction also apply to construction of small-scale hydro installations (see Chapter 2: Small-Scale Infrastructure). General mitigation measures of particular relevance to small-scale hydropower include:

- Avoid stockpiling soil in wetlands or floodplains. Keep soil in already disturbed areas.

4 The complete guidelines are reproduced in the CD-ROM accompanying this manual.

- Do not block stream flow during construction. For temporary stream diversion, use concrete forms rather than soil. Concrete forms cause less stream sedimentation.
- After construction, return topsoil to its original location and restore land contours to match the original topography.
- Avoid construction during wildlife breeding seasons.
- Ensure that construction does not adversely affect the habitats of endangered or threatened species.

Mitigation of operational impacts depends on proper design and proper operation and maintenance (O&M) of the system. For impoundment structures, proper O&M is especially critical to maintaining critical downstream flows and safeguarding the integrity of the impoundment structure. The water in the reservoir must not be allowed to exceed the rated level, and required maintenance must be performed promptly. Thus, O&M itself is dependent on an adequate monitoring program.

Both types of small-scale hydropower installations require monitoring for the operational impacts outlined above. Impoundment hydropower requires a water quality testing regime and monitoring of the quantity of downstream flows. Plans should detail:

- Criteria used in testing
- Frequency of testing
- Process used to correct problems in the system

In addition, the integrity of the impoundment structure must be monitored on a regular basis.

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Web Sites

Defenders of Wildlife.

This site discusses potential environmental impacts on wildlife habitats and offers practices to prevent and mitigate these impacts for biomass, wind, and geothermal energy. Online: www.defenders.org/habitat/renew.html.

Intermediate Technology Consultants.

The ITC site offers information on renewable energy resources. Online: www.itcltd.com/energy.htm.

Solar Cooking International.

A comprehensive resource on solar cooking, the Solar Cooking Archive features news, publications, multimedia presentations, discussions, and plans for different cooker designs, including designs for the breakthrough Cook-it Foldable Family Stove (solar) created by Roger Bernard and Barbara Kerr. Online: http://solarcooking.org/. (Digital copy of the Cook-it Stove design included.)

The Green Power Market Development Group.

The Green Power Market Development Group is a collaboration of 10 private corporations and the World Resources Institute aimed at building corporate markets for green energy. This site provides good, current information on renewable energy and clean technology and describes potential environmental impacts of biomass, landfill gas, wind, solar, and fuel cell power systems. The site also provides many useful links for developing renewable energy activities. Online: www.thegreenpowergroup.org.

Union of Concerned Scientists.

The UCS site analyzes and advocates environmentally and economically sustainable energy solutions. Online: www.ucsusa.org/energy.

U.S. Department of Energy.

The DOE s Energy Efficiency and Renewable Energy Network offers a comprehensive look at the Department of Energy s renewable energy and energy efficiency information, as well as a wide range of links and documents. Online: www.eren.doe.gov.